Государственное образовательное учреждение
высшего профессионального образования
**«Томский государственный университет
систем управления и радиоэлектроники»**

# ТЕМАТИЧЕСКИЙ РЕФЕРАТИВНЫЙ СБОРНИК № 18-2/3

## “Radar Target Detection”
## («Обнаружение РЛ целей»)

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## "An optimal edge detector for bridge target detection in SAR images"

This paper describes an optimal edge detection method for synthetic aperture radar (SAR) images, which combines the ratio and gradient of averages (RGoA) edge detector and the optimal threshold selection method. We call the method modified RGoA (MRGoA). In MRGoA, two edge strength maps, ratio edge strength map (RESM) and gradient edge strength map (GESM), are computed by using the RGoA method. RESM can be considered as a normalized image, and GESM is a gray-level image. The ratio and gradient thresholds can be optimally selected by using histogram based methods, such as maximum correlation criterion (MCC). Finally, edge maps are obtained by using the ratio and gradient thresholds. In the proposed method, the criterion for determining edge pixels is somewhat different from that in the RGoA edge detector. Experimental results on SAR images have shown the effectiveness of our proposed method. [C2067]

## "Optimal detection of high-velocity targets in forward scattering radar"

Optimal algorithm to detect very small radar cross-section high-velocity targets for bistatic forward scattering radar is considered. Structure of optimal correlation-filtering processing of forward scattering target return for the case of continuous quasi-harmonic probe signal is discussed. [C2068]

## "A novel method to identify multi-target by transformable periods LFM waveform"

A novel method to identify multi-targets for automotive collision avoidance radar (ACAR) by using transformable periods and symmetrical linear frequency modulation (TPS-LFM) waveform is proposed. In addition, a method to generate the signal source based on a triple tuned frequency synthesizer (TTFS) is discussed. Theoretical derivation shows that the false detections of unnecessary targets and failures to detect necessary targets, which used to be major problems in detection performance, have been substantially reduced, and the high resolution of range and velocity for the target may be obtained simultaneously. Its usefulness in eliminating the false targets is confirmed. [C2069]

## "Recent flight test results of active-vision control systems"

This tutorial session covers recent results using methods that utilize 2D and 3D imagery (e.g., from LADAR, visual, FLIR, acoustic-location) to enable aerial vehicles to autonomously detect and prosecute targets in uncertain 3D environments. This includes segmentation approaches, active contours, adaptive control, estimation theory, and optical flow. Recent flight test results utilizing a small glider and a small helicopter as well as a high-fidelity simulation of multiple airplanes are discussed. [C2070]

## "The application of adaptive digital beamforming in LFMCW system"

The anti-jamming performance of array systems can be improved markedly by the technique of adaptive digital beamforming (ADBF), which is applied widely in modern radar and communication systems. In linear frequency modulation continuous wave (LFMCW) systems, the target information is usually extracted by range-Doppler processing. In this paper, the application problem of ADBF in the LFMCW system is discussed, and the system schemes of ADBF combining range-Doppler processing are proposed. It is proved that the schemes are feasible and effective, and the signal detection performance can be improved markedly. [C2071]

## "Environmental perception and situation assessment for an advanced highway assistant"

Environmental perception through sensor fusion for automotive applications is an intensive research area. Since the advent of the first driver assistance systems researchers have worked on multi sensor systems that perceived the whole surrounding traffic scene. At Volkswagen research diverse sensor and fusion configurations have been under examination over the last few years. Currently a Highway Assistant is being under development that focuses on well structured environments and ultimately aims to automate certain driving tasks.

This paper describes the perception part from sensors and sensor fusion up to situation and risk assessment. [C2072]

## "Modeling on a gimbal with an antenna"

A model of an azimuth driving servo system with a flexible antenna in a tracking system was derived in this work. The validity of the model was verified by comparing the results of the model with experimental results. When modeling the dynamics of a gimbal with an antenna, the antenna should be considered as a flexible body. The effect of reducing the magnitude of the backlash that results in extending the bandwidth in a system with a flexible antenna is smaller than the effect of reducing the magnitude of the backlash in a system with a stiff antenna. When there is a need to reduce the weight and extend the bandwidth, the derived model enables the design of a tracking system to be optimized [C2073]

## "Analysis of passive targets detection using CDMA signal"

The use of a non-cooperative code division multiple access (CDMA) transmitter as the illuminator for a bi-static radar system is investigated. A signal-processing scheme is developed to detect moving targets. This scheme uses the Doppler shift of targets echoes to estimate the targets' speed and time delay. The system contains two separate but collocated receivers where Doppler and cross-correlation processing is applied to the direct path and target signal path. We implement the cross-correlation processing using fast Fourier transform (FFT) instead of direct integration. [C2074]

## "New blind beamforming and moving target tracking techniques guided by the matrix-pencil/CDMA DOA algorithm"

The least squares constant modulus algorithm, LS-CMA, array blind beamformer has the main drawback of typically capturing the signal that has the greatest power among the received cochannel users. Hence, the capture process should be guided by controlling the initial beam steering. On the other hand, the matrix pencil (MP) algorithm is used to estimate the direction of arrival of all users incident in the array antenna. It uses a single snapshot to estimate the DOA and is not affected by correlation sources problem. Also, the matrix pencil algorithm when combined with CDMA is able to separate the DOA of the different users based on the orthogonality of the used spreading codes. The first presented technique in this paper is to use the MP-CDMA to blindly estimate the initial beam steering of the LS-CMA array, this combination allows to steer the initial beam of LS-CMA array antenna toward the desired user's direction. Therefore the desired user will have a dominant power at the array output and LSCMA will capture it. This technique is called MP-CDMA guided LS-CMA algorithm. The second presented technique to use the MP-CDMA combined with the minimum square (MS) beamforming for moving target (user) detection and tracking. The MP-CDMA is used to blindly estimate the steering matrix response of all the incident signals on the array at every snapshot and estimates the update array weight using MS beamforming. Computer simulations show the high efficiency of the proposed MPCDMA-LSCMA in separating CDMA signals of co-channel users. Also, we show that the MP-CDMA combined with MS beamforming can be efficiently used for tracking a moving user operating with other stationary users [C2075]

## "Single station passive instantaneous ranging based on blind source separation"

The passive instantaneous ranging estimation technique using a single station has been studied in this paper, which is very important in electronic warfare system. In this paper, we propose the technique using blind source separation (BSS) to estimate the ranges of targets by non-cooperative sources such as broadcast signals and analysis the performance of the new passive ranging method. The proposed method is verified via computer simulation, which proved that the new passive instantaneous ranging approach is efficient and feasible. [C2076]

## "Tracking of multiple maneuvering targets in clutter with possibly unresolved measurements using IMM and JPDAM coupled filtering"

We present a (suboptimal) filtering algorithm for tracking multiple highly maneuvering targets in a cluttered environment using multiple sensors. We concentrate on the case of two targets which may temporarily move in close formation, giving rise to a single detection due to the resolution limitations of the sensor. The proposed filtering algorithm is developed by applying the basic interacting multiple model (IMM) approach and the joint probabilistic data association with merged measurements (JPDAM) technique and coupled target state estimation to a Markovian switching system. The algorithm is illustrated via a simulation example. [C2077]

## "A smoothing Rao-Blackwellized particle filter for tracking a highly-maneuverable target"

In this paper we apply a new smoothing Rao-Blackwellized particle filter to track a highly maneuverable target in

a multiple-sensors network. The scenario of a highly-maneuverable target moving through a field of multiple sensors is addressed. The target is tracked through the sensors filed using both Rao-Blackwellized particle filter and the proposed smoothing filter. In a simulation comparison, the smoothing Rao-Blackwellized particle filter yields performance improvements when tracking a highly-maneuverable target. [C2078]

## "Clutter mitigation in weather radar systems filter design & analysis"

One of the factors limiting the performance of weather radar systems is the presence of "clutter" in the received signal. Clutter is the group of signal components caused by reflections from objects other than weather targets; it is undesirable because it can obscure meteorologically interesting signals from actual weather targets. Objects that cause clutter are usually stationary, so the signal components with zero and near-zero Doppler shifts are usually clutter. Most weather radar systems use digital high-pass filters to reduce clutter by severely attenuating the zero and near-zero frequency components of the received signal. An alternative and relatively new technique for reducing clutter is frequency-domain filtering, where the Doppler velocity spectrum of the received signal is calculated and manually altered below a certain velocity. The frequency-domain filter performs the same task as the high-pass digital filter but never removes too much of the signal, as the digital filter sometimes does, because an appropriate cutoff frequency is calculated for each spectrum. The performance of a frequency-domain filter is compared with a digital high-pass clutter filter, and the frequency-domain filter is shown to remove more clutter from the radar signal. [C2079]

## "Multiplicative multifractal modeling of sea clutter"

Sea clutter refers to the radar returns from a patch of ocean surface. Accurate modeling of sea clutter and robust detection of low observable targets within sea clutter are important problems in remote sensing and radar signal processing applications. In this paper, we introduce a multiplicative multifractal process for modeling the sea clutter. Through analysis of 392 amplitude time series of 14 sea clutter datasets measured under various sea and weather conditions, we show that the data are consistent with multifractals over certain time scale range, and that the generalized dimension spectrum Dqaccurately detects low observable targets within sea clutter. The method is computationally very fast and practically easily implemented. These attributes strongly suggest that the method may be developed into an automated target detector within sea clutter. [C2080]

## "CWLFM millimeter-wave radar for ISAR imaging with range coverage"

CWLFM radars have become very interesting systems. Although its functioning is known long ago, some new applications have been arisen thanks to some technological improvements. These improvements allow to work in higher frequencies what gets much better operational features for this kind of systems. High frequencies facilitate to work with wider bandwidths what improves the range resolution thus, important features of the targets can be extracted in order to classify them or even to obtain radar images of them. This paper pretends to show the implementation and some results of a MMW band radar with a range coverage of a few kilometers. [C2081]

## "Power-law sensitivity to initial conditions in sea clutter"

Understanding the nature of sea clutter is crucial to the successful modeling of sea clutter as well as to facilitate target detection within sea clutter. To this end, an important question to ask is whether sea clutter is stochastic or deterministic. In the past decade, Haykin et al. have carried out analysis of some sea clutter data using chaos theory, and concluded that sea clutter was generated by an underlying chaotic process. Recently, their conclusion has been questioned by a number of researchers. To reconcile ever growing evidence of stochasticity in sea clutter with their chaos hypothesis, Haykin et al. have further suggested that the non-chaotic feature of sea clutter could be due to many types of noise sources in the data. To test this possibility, McDonald and Damini have tried a series of low-pass filters to remove noise; but again they have failed to find any chaotic features. While most of these studies are conducted by comparing measured sea clutter data with simulated stochastic processes, we use the direct dynamical test for deterministic chaos developed by Gao and Zheng to analyze 280 sea clutter data measured under various sea and weather conditions. The method offers a more stringent criterion for detecting low-dimensional chaos, and can simultaneously monitor motions in phase space at different scales. However, no chaotic feature is observed from any of these scales. But more interestingly, we find that sea clutter can be conveniently characterized by the new concept of power-law sensitivity to initial conditions (PSiC), which generalizes the defining property for chaotic dynamics, the exponential sensitivity to initial conditions (ESIC). We show that PSIC offers a powerful method for detecting targets within sea clutter. [C2082]

## "Complex spatial/temporal CFAR"

The conventional cell averaging constant false alarm rate (CFAR) criterion and its variations work well only in

strictly spatially stationary environments. In non-homogeneous environments, clutter map (scan-by-scan) processing is deployed. The performance of this method degrades in the presence of slow targets. In this paper, a hybrid procedure for CFAR is proposed, which combines the advantages of both spatial and time averaging. The detection probability is derived and the related plots are given for different values of L, the number of persistence scans. A method is presented to choose the parameter of the hybrid CFAR to have the lowest self-masking effect. [C2083]

## "Reachability guidance: a novel concept to improve mid-course guidance"

Reachability guidance is a new concept developed from a combination of robot and missile guidance using shortest path techniques. It has been developed to improve mid-course guidance in medium range tactical, missile to missile, engagements. This paper considers the limitations of a range of missile guidance genres in solving challenging missile to missile engagements and identifies that the ability of the missile to reach the target is a common area of uncertainty. Using the SAM versus supersonic sea-skimming ASM problem as an illustrative example, a novel technique which employs the earliest intercept line (EIL) to facilitate reachability ('R') guidance is introduced. [C2084]

## "Database generation of bistatic ground target signatures"

Automatic target classification has been an area of active study due to many of its significances. With there advent of bistatic technology in radar, the research into target classification in bistatic scenario seems quite timely. But the study of any classification algorithm demands for a suitable database. Due to the unavailability of suitable field collected bistatic database, computer simulation of such a database is quite pertinent. The present work discusses the approach towards the generation of a similar database, using FEKO as the electromagnetic simulation tool. Various special needs of such a project and the answers of FEKO to those needs, have been discussed. The results conclusively show the suitability of FEKO for the project. [C2085]

## "Deep ground penetrating radar (GPR) WIPD-D models of buried sub-surface radiators"

The proliferation of strategic subsurface sanctuaries has increased the need for enhanced remote sensing techniques providing for the accurate detection and identification of deeply buried objects. A new ground penetrating radar (GPR) concept is proposed in this paper to use subsurface radiators, delivered as earth penetrating non-explosive, electronic "e-bombs", as the source of strong radiated transmissions for GPR experiments using ground contact or airborne receivers. Three-dimensional imaging techniques for deeply buried targets are being developed based on two-dimensional synthetic aperture radar (SAR) data collection techniques. Experiments over deep mine shafts have been performed to validate the 2D SAR processing algorithms. WIPL-D models have been used to verify the significant enhancement in the received signal-to-noise ratio obtained by burying the transmitter under the surface of the earth. Simple ray-tracing techniques have also been used to confirm the enhancements. [C2086]

## "Modeling of ground-penetrating radar for detecting buried objects in dispersive soils"

A three-dimensional (3-D) time-domain numerical method is used for simulation of ground penetrating radar (GPR) on Debye-dispersive soil. The radar unit is modeled with two transmitters and one receiver in order to eliminate undesired signals. The impact of radar frequency, soil parameters and object depth upon the ability to detect buried targets is investigated through several FDTD simulations. [C2087]

## "Automatic detection of targets using fractal dimension"

{no data available} [C2088]

## "Polarization discrimination for improving foliage-camouflaged target detection"

{no data available} [C2089]

## "A novel prescreening method for UWB SAR target detection using adaptive nonlinear filters"

{no data available} [C2090]

## "Subsurface water-filled fracture detection by borehole radar: a case history"

Borehole radar is a special mode of ground penetrating radar. It has several distinguished features from surface radar. For examples, by means of borehole access to deep regions below the surface, the radar sonde can be

located relatively close to the anomalies or targets to be measured, this results in more precise targets response than surface measurement. The experimental site is located on the top of a granite hill west of Beijing, China. There are a group of boreholes intersected by many fractures. The measured single-hole reflection data are processed and interpreted. The radial detecting range is more than 30 meters at this site. The subsurface fracture distribution can be imaged very clearly. Many fractures can be "seen", and their distance from borehole and their dip angle can be determined. The azimuth determinations for these fractures are possible in some situations. It is concluded that the borehole radar is an effective tool for subsurface imaging. [C2091]

## "Signal processing method for detection of subsurface objects by ultra-wideband SAR"

The problem of subsurface target detection has been studied. Modifications of a damped exponential model has been applied for reducing the clutter due to a rough boundary. Utilizing numerical simulations, a sensitivity analysis is performed to investigate the features of detection of low-contrast targets. The dependence of the received signal on the properties of an inhomogeneous medium, rough surface and the locations of the objects has been studied. The calculations have been performed for randomly buried objects. It has been found that it is possible to significantly improve the ratio between the scattered signal from subsurface objects and the scattering from a rough boundary. [C2092]

## "Aircraft detection and tracking using intelligent cameras"

Systems that provide ground movement management at airports, maintaining ground safety and increasing air traffic capacity, are called A-SMGCS (advanced surface movement guidance and control systems). However, common A-SMGCS systems, based on surface movement radars (SMR), are affected by limitations in their coverage due to reflections or shadows from objects on the airport surface. Hence, the use of a complementary system is necessary to act as a "gap-filler", i.e. to provide accurate ground movement information for these problematic areas. This paper aims to present a novel cost-effective video-based system to act as a "gap-filler" for existing A-SMGCS systems. The proposed system consists of a network of intelligent digital cameras, which are able to detect the presence of an aircraft or vehicle in specific locations within their fields of view, and then provide this information to a multiple hypothesis tracking (MHT) algorithm to extract target tracks. [C2093]

## "A multiple intelligent software agent based technique for improving radar detection of low observable small craft in sea clutter"

The current method of detection of a radar target is based on the setting of a threshold determined by the average of the background returns in the region of interest. Problems arise with this method when attempting to detect small targets in littoral waters since in designing the detector it is necessary to make assumptions concerning the statistical behaviour of the background clutter. Since only long term data is available and short term prediction is required there is an inevitable missed detection/false alarm problem. The problems associated with detecting low observable targets using track-before-detect systems based on Hough transform or dynamic programming techniques are reviewed. An alternative self-adaptive spatio-temporal CFAR system and a multiple hypothesis tracker based on multiple intelligent software agents are described. The process is not perfect but, by assuming that there will be too few data measurements to establish the clutter statistics accurately, a robust sub-optimal solution is formed. The process reported is not restricted to radar returns but has potential applications in infra-red and electro-optical systems, and for processing images in particle physics and astronomy. [C2094]

## "A novel approach for the detection of punctual isolated targets by means of the wavelet transform"

The detection of an isolated localized structure in a noisy background, with no a priori information about its presence, nor its shape presents multiple drawbacks. Nevertheless, this problem is present in a great number of applications as, for instance, ship detection from satellite radar imagery. Conventional algorithms for ship detection are conceived to discriminate an exceptionally bright localized pattern according to an established decision rule, expressed by the determination of a threshold. But the adjustment of thresholds involved in the decision step is complicated and relies on the existence of a considerable contrast between the vessels and the surrounding sea clutter which is not always reached. Thus, a novel method, based on the intrascale dependencies between wavelet coefficients in the different subbands, is proposed, justified and successfully tested on simulated and real images. [C2095]

## "Target detection in Rayleigh-distributed sea clutter environment based on Hough transform"

The detection and false alarm probabilities of the Hough transform-based detector for nonfluctuating and four types of Swerling fluctuating targets in the Rayleigh-distributed sea clutter environments are derived in this paper. Simulation scenario and procedure are designed. Then random data obeying Rayleigh distribution is generated as surrogate of the sea clutter. The performance of target detection in surrogate data environment

based on Hough transform-based detector is analyzed through Monte Carlo simulation runs. The simulative results show that, for a specified PD which is greater than 0.5, the target model sorted ascending for the required SCR is Swerling II, IV, nonfluctuating, Swerling III, I. [C2096]

## "GPR clutter reduction and buried target detection by improved Kalman filter technique"

The reduction of background signal, or clutter, from ground penetrating radar (GPR) measurements is an area of active research. The weak reflection signal obtained from subsurface targets is usually blurred by such strong clutter, which mainly comes from flat or rough ground surfaces, underground inhomogeneities, and coupling between the transmitting and receiving antennae. In this paper, the improved Kalman filter techniques have been studied and applied to reduce the background interference signals and detect the buried targets in GPR dataset. The effectiveness and validities of the proposed improvement methods in this paper for processing GPR detection data are studied. The processed results prove that the proposed methods are effective and adaptive for reducing clutter and detecting subsurface targets. [C2097]

## "Evaluation of an array type directional borehole radar system"

An array type directional borehole radar system employing passive sensors, optical electric field sensors was developed. The system uses a dipole antenna for transmission and four optical electric field sensors for reception. Four sensors are evenly arranged in the circumferential direction to constitute an antenna array. Although an optical electric field sensor itself does not have directivity, azimuth angle of a target can be known from phase differences among the four sensors. Difficulty of this approach lies in the fact that, due to the size of a borehole, the spacing between sensors is limited to a few centimeters that is significantly smaller than the wavelength. As a result, phase difference to be extracted is small and easily subject to noise. In addition, mutual coupling between the antenna elements may causes distortion of target signal. In this paper, we discuss feasibility of target azimuth detection. A laboratory experiment was carried out to examine capability of extracting a small phase difference and to evaluate the mutual coupling between antenna elements. [C2098]

## "Naval radar in a littoral environment"

The changed political situation in the world forces navies to reconsider their roles and missions. As a consequence, the naval operation areas shift from warfare on the open sea to littoral warfare. In modern scenarios full scale, multiple engagements attack on a naval convoy is less likely. Instead, the threat is more likely to come from weapons launched from the land or small, high-speed ships. Additionally, detection and tracking of surface targets becomes a more important sensor function. This paper discusses the impact of littoral warfare on the design of naval radar. The main aspects discussed in this paper are the benefit of accurate Doppler information, high radar stability, use of Doppler-polarimetry and sensor flexibility. [C2099]

## "Retrodirective noise-correlating radar at X band: first demonstration of small target detection"

This paper reports the realization of a four-channel retrodirective noise correlating radar operating in X band around 10 GHz. It is designed for rapid detection of small targets at short range. Detection times less than 50 ns are demonstrated for a 30-caliber bullet, and the autotracking capability of the RNC radar is demonstrated for the first time with the bullet in motion. [C2100]

## "Radar imaging using noncoherent sensors"

This paper presents a method to retrieve a 2D picture from the output of several noncoherent radar sensors. In the special case presented, three 24 GHz PN sensors, spaced so that they would fit into the bumper of a car, acquire distance and amplitude information, each sensor separately. From this information, the processing unit calculates the target locations within a 2D-field. The field of view in the presented case is 30 degrees, and the theoretical maximum range is 169 m. [C2101]

## "Bistatic radar imaging system for sea surface target detection"

This paper presents an original approach to the bistatic SAR processing. Polarized electromagnetic field received is considered and used in a bistatic RDA processing. Then, some bistatic SAR image characteristics are presented. Latter, a model describing bistatic reflectivity of sea surface is introduced. This model is used in the bistatic SAR processing in order to introduce the speckle effect and to simulate targets on sea surface detection. [C2102]

## "Detection of moving targets by ground bistatic radar"

The paper proposes a mathematic model to describe signals in antenna output (signatures) in a bistatic microwave intrusion link. The theory deploys Rayleigh's method to describe electromagnetic wave diffraction on the moving silhouette of an intruder in scalar approximation. The model uses 2D Fourier transform and it is easy to calculate using fast Fourier transform algorithm. Theoretical results were compared with experimental signatures obtained with a 3-cm bistatic radar. They are in a good agreement. [C2103]

## "SAR ground moving target imaging based on keystone transform without interpolation"

{no data available} [C2104]

## "Bistatic GPR by using an optical electric field sensor"

In order to apply to land mine detection effectively, bistatic GPR using an optical electric field sensor as a receiver has been developed. The optical electric field sensor is very small and uses optical fiber instead of metallic coaxial cable. With the combination of these advantages and the bistatic radar system, it can be possible for an operator to measure quite flexible and safely. The sensor has been tested in stepped frequency radar system with frequency which consists of a vector network analyzer, a fixed double ridged horn antenna as transmitter and computer controlled receiver-positioner for 2D scanning. For considering effectiveness in real field, we applied impulse radar system, which consist of a digital oscilloscope and an impulse generator to produce the impulse with 250 psec pulse width and the diffraction stacking has been adopted for 3D image reconstruction. Detection of a PMN2 mine model was carried out by the impulse radar system at a sand pit with two modes of data acquisition: the stepped data acquisition and the continuous data acquisition. The PMN2 were detected clearly with sufficiently high resolution in TM mode measurement in both modes, the target contrast was almost the same while the scanning time decreased down to 1/18, 9 min/m2 in case of continuous data acquisition mode which satisfies the requirement for practical use. [C2105]

## "Clutter effects on ground moving targets' interferometric phase"

{no data available} [C2106]

## "Vehicle detection combining gradient analysis and AdaBoost classification"

This paper presents a real-time vision-based vehicle's rear detection system using gradient based methods and Adaboost classification, for ACC applications. Our detection algorithm consists of two main steps: gradient driven hypothesis generation and appearance based hypothesis verification. In the hypothesis generation step, possible target locations are hypothesized. This step uses an adaptive range-dependant threshold and symmetry for gradient maxima localization. Appearance-based hypothesis validation verifies those hypothesis using AdaBoost for classification with illumination independent classifiers. The monocular system was tested under different traffic scenarios (e.g., simply structured highway, complex urban environments, varying lightening conditions), illustrating good performance. [C2107]

## "Moving targets detection and velocity estimation via multi-channel along-track interferometry"

{no data available} [C2108]

## "Radar signal detection in non-Gaussian distributed clutter by Bayesian predictive densities"

We present a coherent radar signal detection scheme in non-Gaussian distributed clutter and its simulation results. In this scheme the clutter is modeled by compound Gaussian distribution and unknown parameters, i.e. target amplitude and clutter, are estimated based on a posteriori distribution with a noninformative prior. Also a technique called Bayesian predictive densities is employed. In order to investigate the performance, we carried out the Monte Carlo simulation and its results are also compared with conventional detection schemes such as maximum likelihood and maximum a posteriori estimator. The simulation results show its usefulness. [C2109]

## "Moving target motion estimation and focusing in SAR images"

The phase history for a target with general motion can be calculated fairly simply when the SAR system moves along a straight line, and when the motion is reasonably small. The resulting phase history is a sum of two terms: one term depends directly on the range motion, while the second term depends on the azimuth motion multiplied with the platform motion. The two terms cannot be separated based on the phase history alone. The resulting expressions show that the SAR image will contain signatures corresponding to changing frequencies. Accordingly, time-frequency methods may be used to analyze the signatures. An experiment was designed with such signatures in mind. A target moved along a trajectory approximately in the azimuth direction, with

superimposed oscillations in the range direction. The resulting signature was an azimuth smear in agreement with the predictions. The smear was very similar to a signature corresponding to a building. Using time frequency methods, the signatures could be transformed to the time-frequency domain, where a clear difference could be seen. The moving target was essentially a linear chirp with oscillations superimposed, entirely in agreement with predictions. The building signature showed a more complex structure, indicating a combination of scattering mechanisms from the building. All were different from the moving target signature. Time-frequency methods may thus be used to analyze possible moving target signatures. The methods help to discriminate between moving and stationary targets, as well as focusing and relocating them within the image. Ultimately, the processing should contribute to increased probability of recognition and possibly detection of moving targets. [C2110]

## "New target fluctuation models and their experimental"

In this paper we address the design, the analysis, and the experimental validation of statistical models for the description of target fluctuations. We first review some classical distributions commonly employed for the statistical characterization of the target amplitude returns. Then we focus on the shadowed rice and the two state Rayleigh-Chi target models discussing their physical justification and relevant analytical properties. We also study the capabilities of the considered models to fit real target data collected by the McMaster IPIX radar in 1993. Finally we assess the performance of the optimum detector (in the Newman-Pearson sense) for targets with uniformly distributed phases in the presence of shadowed rice and two state Rayleigh-Chi fluctuations providing analytical expressions for the detection probability. [C2111]

## "Adaptive change detection in coherent and noncoherent SAR imagery"

This paper is concerned with change detection in averaged multi-look SAR imagery. Averaged multi-look SAR images are preferable to full aperture SAR reconstructions when the imaging algorithm is approximation based (e.g., polar format processing), or motion data are not accurate over a long full aperture. We study the application of a SAR change detection method, known as signal subspace processing, that is based on the principles of 2D adaptive filtering (M. Soumekh, January 1999) and we use it to recognize the addition of surface landmines to a particular area under surveillance. We identify the change detection problem as a trinary hypotheses testing problem, and identify a change signal and its normalized version to determine whether there is i) no change in the imaged scene; ii) a target has entered the imaged scene; or iii) a target has exited the imaged scene. A statistical analysis of the error signal is provided to show its properties and merits. Results are provided with a realistic X band SAR platform using averaged noncoherent multi-look and coherent single-look SAR imagery. [C2112]

## "Nonparametric permutation tests versus parametric tests in radar detection under k-distributed clutter"

Permutation detectors (tests) are nonparametric CFAR (constant false-alarm rate) detectors if clutter samples are independent and identically distributed (IID). The optimum statistic for the parametric detector is also optimum for the permutation detector. In this paper, we analyze the performance of some permutation tests (PTs) under an ideal k-distributed clutter model and nonfluctuating (NF) and Swerling II (SW-II) target models. Also, we compare the PTs results against their parametric counterparts under the same conditions. We analyze the detector performances in terms of detection probability (Pd) versus signal-to-clutter ratio (SCR) for different parameter values: the number of integrated pulses (N), the clutter reference samples (M), the false alarm probability (Pfa) and the shape parameter (v) of the k-distributed clutter. The conclusions obtained from the analysis of the different results are discussed. [C2113]

## "Adaptive along-track multi-channel SAR interferometry for moving target detection and tracking"

Along-track interferometry (ATI) is a SAR technique that can be used to detect moving targets and estimate radial velocities. This paper examines the possibility of generating the MTI statistic by utilizing a multi-channel ATI processing method. This method is based on a 2D adaptive filtering algorithm, called signal subspace processing, which was developed to blindly calibrate two channels of an along-track monopulse SAR system. The merits of this method are studied using both simulated data and real data from multi-channel airborne radar measurement (MCARM) system. [C2114]

## "Design and analysis of a knowledge-based radar detector"

In this paper we introduce and assess a knowledge-based (KB) radar detector composed of three elements: a geographical information system-based (GIS-based) data selector, which eliminates static outliers from the secondary data exploiting the a-priori information concerning the topography of the observed scene, a data-

adaptive training selector which removes dynamic outliers from the training data, and an adaptive radar detector which performs the final decision about the target presence. The performance of the new algorithm is analyzed on real radar data collected by the McMaster University IPIX radar. The results show that the new KB system achieves a satisfactory performance level and can outperform some previously proposed adaptive detection schemes. [C2115]

## "Geometrical and signal processing aspects using a bistatic hitchhiking radar system"

Bistatic hitchhiking radar system concepts have been object for extensive research both for military and civilian applications. Hitchhiking systems are in principle easy to construct and can be used without introducing any interference, or being seen by a possible enemy. This paper addresses how to handle the geometry such systems are faced together with using proper signal analysis strategies for obtaining optimum target detection. The main motivation for doing bistatic measurements is to be able to see signals from the target that are scattered in other directions than backwards, due to target shape. For large bistatic angles the target forward scattering region can give serious enhancement due to the Babinet principle. Experimental results from bistatic hitchhiking radar are shown for the purpose of aircraft detection. The data presented has been processed non-coherently. For suppression of device noise and scan-to-scan stationary clutter a signal analysis method called "target back propagation technique" has been used. Sampled radar data containing 6 aircrafts is presented. The technique is used on an image with bistatic geometry averaged over 3 scans and with target back propagation locally applied for each aircraft. All aircrafts are sharpened in the image and this illustrates the usefulness of the "target back propagation technique" for suppression of device noise and stationary clutter, even if just three scans are integrated. [C2116]

## "A dual-threshold ATI-SAR approach for detecting slow moving targets"

The high false alarm associated with conventional along-track interferometric synthetic aperture radar (ATI-SAR) is a big concern for any valuable military radar. To reduce the false alarm rate, this paper proposes a dual-threshold approach that combines the conventional interferometric phase detection with the SAR image amplitude detection. This yields two results: (1) the interferometric phase map (including target velocity information) obtained by applying the interferometric phase detection only to the pixels selected by the amplitude detection; and (2) the amplitude map (including target strength information) obtained by applying the amplitude detection only to the pixels selected by the interferometric phase detection. The concept is illustrated by the results obtained using the Jet Propulsion Laboratory's (JPL) AirSAR ATI data, collected in the Monterey Bay area, California. The ATI-SAR processing requires also a precise calibration of the platform's crab angle. This paper presents a simple blind-calibration method that does not require any knowledge of the background and/or the actual crab angle. [C2117]

## "Image preconditioning for a SAR image reconstruction algorithm for multipath scattering"

Recent analysis has resulted in an innovative technique for forming synthetic aperture radar (SAR) images without the multipath ghost artifacts that arise in traditional methods. This technique separates direct-scatter echoes in an image from echoes that are the result of multipath, and then maps each set of reflections to a metrically correct image space. Current processing schemes place the multipath echoes at incorrect (i.e., ghost) locations due to fundamental assumptions implicit in conventional array processing. Two desired results are achieved by use of this image reconstruction algorithm for multipath scattering (IRAMS). First, the intensities of the ghost returns are reduced in the primary image space, thereby improving the relationship between the image pattern and the physical distribution of the scatterers. Second, a higher dimensional image space that enhances the intensities of the multipath echoes is created which offers the potential of dramatically improving target detection and identification capabilities. This paper develops techniques in order to precondition the input images at each level and each offset in the IRAMS architecture in order to reduce multipath false alarms. [C2118]

## "Non-cooperative target identification of battlefield targets-classification results based on SAR images"

Non-cooperative target identification (NCTI) has become more and more important during the last years. So it is essential to develop robust classification schemes, which can be applied reliably in military operations. The major problems are the clutter (which is not present in air), the unknown target orientation (aspect and elevation angle), the high variability of the target scatterers and the possible multiple variants of the target. In this paper we concentrate on analysis and comparison of classification rates for target identification, the former detection process of the targets in the observed SAR scene will not be discussed. We focus on SAR images of single separated stationary and moving ground targets. To be able to compare our classification results with results published in literature we start our evaluation with the public MSTAR dataset, which is used since many years

for ATR evaluation and identification. In addition to this we worked with a second dataset from another field measurement campaign which was performed by QinetiQ, UK. We quantify the influence of some fundamental key aspects on the classification rate. These subjects are target centering (using center of mass algorithms), image segmentation (target, clutter, target shadow), different applied classifiers (nearest neighbour classifier, support vector machines, SVM), the image resolution and the target orientation (knowledge of the aspect angle). Additionally we analyse the influence of clutter and target shadow on the classification rate when using again the MSTAR and QinetiQ datasets. For this purpose the data were segmented in a part containing the target (or target shadow) and another part containing only the surrounding clutter. For the QinetiQ dataset the classification rates drop from 79% to 70% when only the target (separated from the clutter) was used as a feature. The MSTAR dataset shows similar results. Thus obviously the identical background of each of the targets in the test and reference database contributed a lot to the reported high classification rates. That again shows that realistic expressions on the capabilities of target classification can only be based on independent test and training data. By introducing the image clutter content, ICC, we quantify the influence-of the separated clutter on the classification rate. Furthermore the target shadow can be used for additional information dependent on the depression angle. Finally we come to the conclusion that the main work is not only choosing and applying the classifier, but concentrate on the data collection (that means good data quality), preprocessing and feature extraction processes. [C2119]

## "Imaging of subsurface targets using a 3D quadtree algorithm"

The imaging of subsurface targets using ground penetrating radar (GPR) is becoming an increasingly important area of research. Conventional image formation techniques expend large amounts of computation to resolve a region fully, even a region of clutter. However, by using multi-resolution techniques, e.g, quadtree algorithms, potential targets and clutter can be discriminated in a computationally efficient way. Prior work has focused on the development of 2D quadtree algorithms for surface targets. For mine detection, target depth adds another dimension; thus, we have developed a 3D quadtree algorithm, and applied a multi-stage detector that uses the energy change between quadtree stages to discriminate target and clutter regions. This algorithm is then tested on computer-generated data, as well as experimental data collected from a model mine field. Results show that target location information can be obtained even under near field and small aperture conditions. [C2120]

## "Clutter scattering function estimation and ground moving target detection from multiple STAP datacubes"

Methods for estimating the clutter scattering function and detecting ground moving targets, using pulse-Doppler surveillance radar data, are described. The imaging problem is cast as one of structured covariance estimation with time-varying measurement models and illumination patterns. An expectation-maximization (EM) algorithm is derived and the computational issues arising from its use are discussed. The detection algorithm uses the estimated clutter statistics and a time-varying target model in a standard generalized likelihood ratio test (GLRT). [C2121]

## "Scheduling multiple sensors for tracking a highly maneuvering target in clutter"

The problem of multiple sensor scheduling for tracking a highly maneuvering target in clutter is considered. The objective is to schedule the sensors one or multiple time steps ahead so that the overall tracking performance of the system can be improved while minimizing the cost of resources. In the proposed scheduling algorithm, under the constraint that only one sensor may be used at any time step, we predict the expected cost one or multiple time steps ahead as a function of the candidate sensor scheduling sequences, and pick the sequence that minimizes an expected performance metric. We use a random sampling approach coupled with switching multiple kinematic models for target motion, to generate future (pseudo-)states and (pseudo-) measurements which allows computation of the relevant performance metric. Tracking of highly maneuvering target is achieved by an effective suboptimal filtering algorithm based on an interacting multiple model (IMM) filtering approach combined with probabilistic data association (PDA) technique and the proposed sensor scheduling scheme. The proposed algorithm is illustrated via a simulation example involving two geographically distributed radar sensors. [C2122]

## "Application of hidden Markov model and neural network approach for radar target detection"

The recent evolution of radar and sonar is obvious, as that of most of the technical domains, by the extremely fast development of the information processing capacities. To answer for increasing necessities of the users, this evolution led to endow the radar and the sonar of several modes of functioning. In this article, two classical methods of data processing are suggested in detection of radar target domain. The first technique is based on hidden Markov model "HMM", so for the second is based on the neuron network approach "ANN", which

inspired originally from intellectual functioning of the human being [C2123]

## "Simulating data generated by a network of track-while-scan radars"

The echoes generated by single conventional rotating track-while-scan beam radars can be approximately described by a stream of uniformly sampled data. However, the combined stream of a multisite radar network can only be represented by non-uniformly sampled data. To combine several data streams a rigorous calculation of the sampling instants is necessary. The ability to simulate the data produced by a radar network permits to study the performance of tracking algorithms when operating under irregular sampled data. To simulate the radar network we employ the heterogeneous flow system specification (HFSS), a modeling and simulation formalism designed to represent dynamic structure hybrid systems. We present the performance of a α-β filter based on the data obtained through the simulation of a network of three track-while-scanning radars. [C2124]

## "Two new approaches for detecting a maneuvering air target in strong sea-clutter"

Two new approaches for detecting a maneuvering air target in strong sea-clutter are proposed in this paper. One is based on the adaptive chirplet decomposition, and the other is inspired by the spectral subtraction. Experiments with real-world data samples show that both methods presented in this paper can effectively enhance the Doppler radar signals from maneuvering air targets though each has different strength and weakness. [C2125]

## "Geometrical considerations for terrain mapping in SBR applications"

Knowledge aided signal processing calls for the use of existing information such as digitized image maps to further suppress clutter in a typical radar detection operation. In the context of space based radar (SBR) applications, given the SBR parameters and the look angles the first problem is to translate these parameters into a data point on a map. This is realized by converting these parameters into conventional latitude and longitude and then using the corresponding image intensity to estimate the clutter covariance matrix. Using this approach, it is possible to pre-compute the desired weight vector for a location of interest on earth that the SBR is assigned to visit. As a result, using the measured data together with the weight vector, it is possible to test for target detection hypothesis accurately at the time of visit by the SBR. [C2126]

## "Development of novel transmit waveforms for SAR-based target detection"

This paper demonstrates methods of optimizing a sequence of radar transmit waveforms for a synthetic aperture radar (SAR) based upon specific knowledge of a targets radar cross section (RCS). The intent is to maximize target detection performance. It is required to have a priori knowledge of targets radar cross section (RCS). Two approaches are evaluated, the matched waveform and the variable chirp waveform. Examples are shown for each approach for a synthetically generated target data set. [C2127]

## "Detection of low observable targets within sea clutter by structure function based multifractal analysis"

Sea clutter is the backscattered returns from a patch of the sea surface illuminated by a radar pulse. Robust detection of targets within sea clutter is of significant importance to our coastal and national security, to navigation safety, and to environmental monitoring. However, no simple and reliable methods for detecting targets within sea clutter have been proposed. We apply the structure function based multifractal theory to analyze 392 sea clutter datasets measured under various sea conditions. The method developed is mathematically rigorous, conceptually elegant, computationally fast, and, practically, easily implementable. Our results demonstrate that the method can robustly detect low observable objects within sea clutter. [C2128]

## "Non-myopic approaches to scheduling agile sensors for multistage detection, tracking and identification"

The paper addresses the problem of sensor scheduling for simultaneous target detection, tracking and identification. We consider sensors with agility in waveform and pointing direction. Scheduling decisions are made using an information based approach, where the merit of competing actions is judged by the information expected to be gained when taking the action. We focus on non-myopic scheduling, where the long-term ramifications of scheduling decisions are accounted for in decision making. Since an exact non-myopic solution is computationally prohibitive, we investigate two approximate approaches: direct approximation of Bellman's equation; reinforcement learning. We show, via simulation, that both techniques provide substantial gains over myopic scheduling. [C2129]

## "MTD detector using convolutional neural networks"

A detector based on joint time-frequency signal analysis and convolutional neural networks is proposed for radar detection in highly complex and nonstationary cluttered environments. This detector is coherent and monocell, i.e. it works with the complex envelope of the echoes from the same range cell, and exhibits joint CFAR and MTD characteristics. It includes a pre-processing time-frequency block which provides a constant false alarm rate (CFAR) behaviour regarding the clutter power when normalization is utilized. Multiple targets can be also resolved in the same resolution cell (MTD) if the neural network presents multiple outputs. [C2130]

## "Ground tracking using a variable structure multiple model particle filter with varying number of particles"

This paper studies the problem of ground tracking using a-priori information about the road structure. It presents an efficient variation of the variable structure multiple model particle filter, in which the number of active particles is allowed to vary. The proposed technique decreases the algorithmic computational intensity and can be generalized and used in various multi-model particle filters. [C2131]

## "SAR moving targets detection based on the Chirp-Fourier transform"

Synthetic aperture radar (SAR) is an active, all-weather capable system to produce high resolution images of the ground. The two imaging directions are range and azimuth (flight direction). The relative motion between platform and ground is exploited for image generation in the azimuth. In SAR processing it is assumed that the ground is static. Moving targets cause errors in SAR images, like defocusing and displacement, depending on the direction of their motion. Since detection, identification and tracking of moving objects in SAR signals are necessary in both civil and military applications, the errors need to be corrected. In this paper, we propose the method based on the Chirp-Fourier transform (CFT) to detect moving targets. Processing steps of this method and simulated results are given in detail. Simulation results show this method can detect moving targets and estimate its parameters in noise case effectively. [C2132]

## "Computationally-efficient range-dependence compensation method for bistatic radar STAP"

We address the problem of detecting slow-moving targets using space-time adaptive processing (STAP). The construction of the optimum weights at each range implies the estimation of the interference-plus-noise covariance matrix. This is typically done by straight averaging of snapshots at neighboring ranges. However, in most bistatic configurations, snapshot statistics are range dependent. Straight averaging results thus in poor performance. In an earlier paper, we proposed a range-dependence compensation method that provides optimum performance. However, this implies a large computational cost. In this paper, we adapt the method to provide optimum performance at low computational cost. [C2133]

## "Sea and air moving target measurements using a GSM based passive radar"

A passive radar is essentially a receiver-only radar that does not transmit signals; it only receives and thus operates independently without the direct synchronization from the non-cooperative illuminator. GSM base station transmitter as the illuminator of opportunity in a passive radar offers a covert means of uninterrupted surveillance where the major advantage is that the emitters of such transmissions are abundant. This paper presents an overview description of a low-cost experimental GSM based passive radar developed and implemented in Nanyang Technological University, Singapore. It describes the hardware architecture design and integration as well as the associated signal processing scheme of this experimental passive radar. Numerous field experiments were conducted with interesting results on sea and air moving target Doppler frequency detection and tracking presented to demonstrate and ascertain the performances and operating capabilities of the GSM based passive radar. [C2134]

## "Dim target detection based on keystone transform"

In this paper, a novel motion compensation method based on keystone transform is presented, which can correct range migration without the exact target velocity. As a result, the accumulation time isn't subject to the restriction due to target motion. Thus radar's system design turns more flexible. Keystone transform is a technique of range migration correction in the field of SAR. However, it hasn't reported to apply this method to PD radar. At the same, because of the increase of accumulation time, the Doppler resolution of radar is improved greatly, which provides an approach for mini-Doppler resolution. Therefore, it is hopeful to apply keystone transform to the field of decoy identification. [C2135]

## "Empirical mode decomposition of micro-Doppler signature"

Micro-Doppler induced by mechanical vibration or rotation of structures in a radar target is potentially useful for target detection, classification and recognition. In order to exploit the time-varying micro-Doppler signature, time frequency analysis techniques are used. However, they can not represent this useful information clearly all the time. In this paper, we introduce a novel algorithm to extract the micro-Doppler signature using a technique called empirical mode decomposition. Both simulation and the experimental results indicate that EMD provides us an effective way to give better time frequency representation of the micro-Doppler signature. [C2136]

## "Multi-perspective target classification"

Traditional radar classification is based on a single aspect view of the target. It is remarkably sensitive to the particular direction under which the target is sensed. A network of radars offers means of collecting backscattered radiation of a range of viewing angles. This offers multi-perspective data sets as an aid to improve radar target classification. By definition, this will provide a data set with higher information content. In this paper we examine whether this approach is useful for classification purposes. Results using full scale turntable demonstrate significant improvements in performance over and above the monostatic case. [C2137]

## "Signal processing for automotive radar"

With rising accident rates, researchers are looking for solutions to reduce fatalities. Some enhance car designs to protect drivers more adequately. Some propose improvements to the traffic and road systems to reduce the chances of accidents. Still others propose the installation of special gadgets to improve the situational awareness of drivers and to alert them to dangerous circumstances. A motor vehicle may be equipped with a radar sensor that checks the spatial environment around the vehicle. The radar is the most commonly adopted sensor for this purpose due to its all-weather capability. In this paper, a 77-GHz FMCW automotive radar signal processor is developed and implemented using the Renesas (previously Hitachi) SH7615 solutions engine development board. The project includes building additional required hardware, the DSP algorithm and a data simulator program to generate test data for testing. The main purpose of the automotive radar signal processor is to detect legitimate targets from unwanted clutter (e.g. road surfaces), and to extract target information from the radar returns. In this paper, the application of the new AND-OR CFAR is also introduced. The simple mathematical fusion models of the AND-OR CFAR are provided and explained here as well. This manuscript is divided into sections. The first section will delve into the basics and the building blocks of the automotive radar. The signal processing portion of this work will be presented in the second section. The data simulator built to simulate testing data is explained in the third section. Results from testing are put forward in section four. Conclusions drawn from the experience are presented in the last section. [C2138]

## "Modified JDL with Doppler compensation for airborne bistatic radar"

In this paper, we study issues associated with applying space-time adaptive processing (STAP) techniques in bistatic airborne applications. For ground moving target indication (MTI) radar, the clutter Doppler frequency depends on range for all array geometries other than linear sidelooking. This range dependency leads to problems in clutter suppression through STAP techniques. One aspect is that the STAP filter becomes range dependent. This paper proposes Doppler compensation using interpolation, in the angle-Doppler domain, for the modified joint domain localized (JDL) processor. Simulation results show that a significant improvement in processor performance is obtained throughout the whole frequency spectrum. [C2139]

## "Pre-filtering for clutter rejection in beamspace STAP"

Several space-time adaptive processing algorithms have been proposed to detect weak targets in the presence of strong interference, especially clutter and jamming. Except for displaced phase center array (DPCA) processing, radar signal processing algorithms ignore the fact that the location of the clutter ridge in angle-Doppler space is known, given the platform speed and direction. This paper introduces our attempt to exploit this a priori knowledge in conjunction with the joint domain localized processing algorithm. Using a two-dimensional filter, clutter is rejected in a first, non-adaptive stage, followed by adaptive processing in the angle-Doppler domain. [C2140]

## "Detecting moving target based on reflectivity displacement method and wavelet transform"

The reflectivity displacement method is one of the generally used methods to detect the moving target in the SAR system. However, in low signal-noise ratio (SNR) environment, it is still difficult to estimate the moving target's parameters correctly. To improve the estimating performance, wavelet transform is adopted as a further processing step to eliminate the noise of graphs obtained from the reflectivity displacement method in this paper.

Simulation results demonstrate that it is effective to estimate the parameters of the moving target with the method proposed. [C2141]

## "A novel characteristic detection method for radar target"

In this paper, a novel method of radar target detection based on 2-dimensional (2-D) fractal dimension is proposed. The proposed approach exploits both range information and azimuth information to estimate fractal dimension. Moreover, the approach can increase the number of the data points. The above two merits result in the fractal dimension estimated by this method is more accurate and robust than the previous method. The detection performance is also better than the previous one, which only makes use of 1-dimensional (1-D) information to estimate fractal dimension. Theoretical analysis and experimental result show that the proposed method performs well in strong clutter background. The proposed method is also validated by real-life radar data, and the better result has been achieved. [C2142]

## "Estimation of range-dependent clutter covariance by configuration system parameter estimation"

The range-dependent nature of the surface clutter power spectrum observed in monostatic or bistatic airborne radar systems results in a mismatch of the clutter covariance matrix (computed from a secondary set of range-cell data) relative to that of a possible target test cell, with attendant degradation of space-time adaptive processing (STAP) performance. In this paper, we develop a new method for predicting the test cell clutter covariance matrix by estimating the configuration system parameters that directly influence the clutter power spectrum. The method uses a multiple complex sinusoid model whose parameters are related to the configuration system parameters, which are then optimized to match the radar return pulse-train data in a least-squares sense. The estimated configuration parameters are then used to predict the clutter covariance matrix in the test cell, which is then used with traditional STAP methods. Computer simulation results are presented that demonstrate the significantly improved STAP performance obtained by the method developed here compared to the conventional method of using the sample covariance matrix estimated from secondary data. [C2143]

## "Performance comparison of three recent STAP methods"

In this paper, we present a comparison of target detection performance for normalized adaptive matched filter (NAMF), normalized parametric adaptive matched filter (NPAMF), and normalized low-rank adaptive matched filter (LRNAMF) for space-time adaptive processing. Test statistics for these algorithms as functions of range bins and filter outputs as functions of Doppler beam position (DBF) and azimuth angle (AZ) are computed for the KASSPER L-band datacube, which is simulated for the airborne linear phased array radar application. First, we illustrate that when the signal-to-noise ratio is used as a target-detection parameter, LRNAMF outperforms NAMF and NPAMF under weak conditions of training data contamination. Next, we demonstrate the target cancellation effect when the training data are contaminated by competing targets (outliers). Finally, we present a scenario for target detection in heterogeneous radar clutter when there is spatio-temporal steering vector uncertainty. In this scenario, we show that there is substantial broadening in the filter outputs as functions of DBP and AZ for these algorithms. [C2144]

## "Convergence of ESM sensors and passive covert radar"

This paper explains the convergence of ESM sensors and passive covert radar (PCR) by presenting the results of field tests with the application of an experimental wideband digital ESM receiver as a sensor in bistatic configuration for PCR. Exploitation of an a priori unknown radar illumination gives the principal possibility of detecting moving targets. A LPI radar with FMCW signals is used as the illuminating source in the field tests. Various high-speed tank ammunitions are the investigated targets. The interception and analysis of the signal source as the ESM task, the problems arising from the non-synchronized operation of source and receiver and the derived adaptive signal processing for target detection as the PCR task are shown. [C2145]

## "Improved genetic algorithm for the design of the optimal antenna division in sub-arrays: a multi-objective genetic algorithm"

In this paper a novel approach to the optimisation of the ECCM (electronic counter measures) capabilities of a phased array radar has been proposed. The division in sub-arrays for adaptive digital beamforming is performed by a MOGA (multi-objective genetic algorithm) which aims to find optimal trade-offs between competitive objectives (detection probability, accuracy of the target angular estimation, level of the side lobes, etc.). The solutions obtained after several cycles of the algorithm for a study case (square phased array antenna with 64 radiating elements) are presented. [C2146]

## "Experimental wideband multi-channel cancellation performance"

For future radars with a wideband capability, effective electronic protection algorithms are required to perform target detection and discrimination. The Radar Division of Naval Research Laboratory has developed a flexible, adaptive wideband (400 MHz) multi-channel digital receiver/canceller test bed to investigate a radar's capability to reject interference. The effects of varied inter-channel hardware mismatches and intra-channel analog-to-digital aliasing on wideband cancellation performance are investigated. It is found that 23 dB of self-cancellation can be achieved with a proper combination of receiver implementation and cancellation configuration. [C2147]

## "Multi-static coherent sparse aperture approach to precision target detection and engagement"

Radar systems have long been plagued by poor cross range (azimuthal) resolution due to the standoff range of the sensors and limitations of aperture size and beamwidth. This problem is especially an issue for sensors operating in the VHF and UHF bands due to the large physical aperture required to achieve reasonable beamwidths. A coherent sparse sensor network can improve both angle and range resolution of radar systems while limiting the required system bandwidth. In fact, a key advantage of the proposed technique is that the target localization achievable, both in range and cross range, is not limited by the bandwidth or aperture of the individual receiver systems employed in the sensor network. This paper discuss the benefits and performance of coherent sparse aperture techniques. In addition the impact of system errors on performance and error mitigation techniques are discussed. [C2148]

## "3-D short-range localization device by low-cost CW-Doppler radar"

Low cost and short range detection/localisation devices arouse a growing interest for civil and military applications such as automotive anti-collision radars or target detection devices used in active shielding. This field of application is principally devoted to FMCW radars, which allow a direct range measurement like pulsed radars, but are less expensive. In this paper we show that it is also possible, under some conditions, to perform a real time localisation based on CW radars only, by means of an adequate signal processing. The targeted application deals with short range localisation of very fast moving targets in order to engage an instantaneous riposte. In the second section of this paper, a principle for extracting the information of the position of a target from a Doppler signal is presented. Some algorithms that perform an estimation of the position within the time restrictions of our application is given in the third section. The following section focuses on the information theory, and gives some useful indications about the optimal configuration of such a detection device and the maximal theoretical performance achievable for it. Sections 5 and 6 are devoted respectively to some realisation aspects and to a few simulation results. Finally, some concluding remarks are provided in the last section. [C2149]

## "Feature-enhancement of SAR images by Bayesian regularization"

SAR imaging has an increasing interest in the surveillance and aircraft combat fields. The final aim is generally automatic target detection and recognition applications for assisted interpretation. To help these recognition processes it is important to get good quality SAR images, without loss of resolution. Particularly, we propose to enhance the image feature by reducing the sidelobe artefacts and smoothing the speckle. The methodology is the resolution of an ill-posed inverse problem by Bayesian regularization. The solution is then the value which minimizes a well-chosen penalised criteria. The originalities are minimization algorithm choice and real data applications. [C2150]

## "Target detection in first-order regions by bistatic radar"

This paper deals with first-order-region detection of target by bistatic system, which is a delicate problem for radar developers. A new bistatic model was presented, and the model-based method was developed to eliminate blind-speed zones. With analyzing the bistatic model geometry, by trigonometric cosine law, slave-radar data was utilized to restore target information if main-radar first-order sea echoes smeared the ship target. To get target signal from the slave radar, the ship target was firstly located in the slave radar roughly according to its last position in the main radar. Then for the candidate ship, the agreement of azimuth, distance and radial velocity between array-measured results and equation-solved values was used as acceptance criterion. The method shows good performance on the data recorded by ocean state measurement and analysis radar, a bistatic system manufactured in 2003 (OSMAR2003). [C2151]

## "Farsighted sensor management strategies for move/stop tracking"

We consider the sensor management problem arising in using a multi-mode sensor to track moving and stopped targets. The sensor management problem is to determine what measurements to take in time so as to optimize

the utility of the collected data. Finding the best sequence of measurements is a hard combinatorial problem due to many factors, including the large number of possible sensor actions and the complexity of the dynamics. The complexity of the dynamics is due in part to the sensor dwell-time depending on the sensor mode, targets randomly starting and stopping, and the uncertainty in the sensor detection process. For such a sensor management problem, we propose a novel, computationally efficient, farsighted algorithm based on an approximate dynamic programming methodology. The algorithm's complexity is polynomial in the number of targets. We evaluate this algorithm against a myopic algorithm optimizing an information-theoretic scoring criterion. Our simulation results indicate that the farsighted algorithm performs better with respect to the average time the track error is below a specified goal value. [C2152]

## "An evidential model of multisensor decision fusion for force aggregation and classification"

This paper describes airborne sensor networks for target detection and identification in military applications. One challenge is how to process and aggregate data from many sensor sources to generate an accurate and timely picture of the battlefield. The majority of research in data fusion has focused primarily on level 1 fusion, e.g., using multisensor data to determine the position, velocity, attributes, and identity of individual targets. In this paper we present a novel approach to military force aggregation and classification using the mathematical theory of evidence and doctrinal templates. Our approach helps commanders understand operational pictures of the battlefield, e.g., enemy force levels and deployment, and make better decisions than adversaries in the battlefield. A simple application of our approach is illustrated in the simulated testbed OTBSAF and RETSINA system. [C2153]

## "Surveillance by means of a random sensor network: a heterogeneous sensor approach"

A distributed approach to the surveillance is presented. A clustering architecture is modelled and the behavior of the corresponding heterogeneous random network with self-organizing capability is investigated. Two types of sensors, simple and complex, spread out over the surveillance area. Simple sensors can only compute binary information (yes or no detection); complex sensors, instead, are able to form a target track. A two-way efficient local communication among sensors is hypothesized. From it, a global coherent behaviour of the network emerges, and the resulting network is able to track the moving objects. Benefits and drawbacks of our solution are analysed by means of Monte Carlo simulations. [C2154]

## "The impact of tropospheric propagation on data fusion from multiple radars"

Data fusion from spatially separated radars is increasingly being considered within network centric warfare to mitigate complex threats. Propagation of signals from spatially separated radars through differing atmospheric environments, however, can introduce significant errors in target positioning and ranging. For example, simulations illustrate that two radars separated by 100 km viewing the same single target through different tropospheres could place the single target in positions separated by over 200 m. Attempts at fusing the data and resolving the information into a single object could result in operational deficiencies due to classification and discrimination errors. Additionally, anomalous propagation conditions such as tropospheric ducting can lead to radar coverage holes and hence the perception of faulty radars and system level fusion errors. These errors must be characterized and, as far as possible, eliminated if the operational effectiveness of cooperative radar engagements and capabilities are to be optimized. This paper illustrates the type and magnitude of these errors, and their likely impact on system level fusion. The architecture of a potential correction system is outlined. [C2155]

## "Optimal signal detection for false track discrimination"

Optimal signal detection for false track discrimination is determined by simulation using the integrated probabilistic data association (IPDA) algorithm. The IPDA algorithm is an efficient probabilistic data association algorithm with estimates of target existence probabilities that can be used to distinguish true and false tracks. The rate of confirmed false tracks is held constant and the optimal signal detection probability is determined by the maximum confirmed true tracks for a given signal to noise ratio. This allows the determination of the optimal detection probability which is reported for a range of signal to noise ratios. [C2156]

## "The modified Riccati equation in target tracking: some recent results"

Some recent results on the modified Riccati equation are studied in this paper. This modified Riccati equation has already been associated with tracking a target under measurement uncertainty. We consider the special case of tracking a target without clutter, but with a probability of detection of less than one. This special case has received quite some attention recently, especially in relationship with Cramer Rao bounds, or equivalently expected performance. Furthermore, in some other recent works, new theoretical results on the modified Riccati

equation have been derived. We will compare these results and point out their importance for performance assessment and prediction in a target tracking context. [C2157]

## "Multi hypothesis track extraction and maintenance of GMTI sensor data"

This contribution presents an application of a multi hypothesis tracking (MHT) algorithm to the case of ground moving targets detected by GMTI (ground moving target indicator) sensors. We describe in some detail how the following tracking tasks are performed: track extraction, prediction, filtering, track maintenance and retrodiction (smoothing). The experimental implementation has been successfully tested in a NC3A (NATO Consultation, Command and Control Agency) testbed with simulated GMTI data of various ground surveillance sensors. Ongoing developments and improvements are discussed. [C2158]

## "Fusion center with neural network for target detection in background clutter"

Analysis of radar signals for target detection in background clutter involves the use of different algorithms. These algorithms provide different levels of detection probability and false alarms as a function of the clutter present. This paper provides a solution to the problem of selecting the appropriate algorithm for target detection in background clutter with high probability of detection and low false alarms. The approach is based in parallel execution of CA-CFAR (cell averaging constant false alarm rate), GO-CFAR (greatest off) and SO-CFAR (smallest off) algorithms and a fusion center based on a neural network with different fusion rules. Results with simulated and real data are presented and discussed. [C2159]

## "New detection algorithm of extended targets for radar and electro optical sensors"

This paper presents a new technique able to detect extended targets (small ones and big ones) (Ostrovityanov and Basalov, 1985), under very low signal to noise ratios (SNR) and signal to clutter ratios (SCR) with a high probability of detection and a low probability of false alarm. The method is based on the calculation of some modified statistical descriptors (Gonzalez and Woods, 2002), and the peak plots (Rihaczek and Hershkowitz, 2000) from raw sensor image. The peak plots are extracted by means of the shift-and-convolution technique (Perez Martinez et al., 2001). Experimental results are also presented demonstrating the quality of this technique. Experimental results have been obtained with ARIES radar (Perez et al., 2002), a surface marine and coast surveillance LFM-CW high resolution radar (HRR) (Wehner, 1995) developed by INDRA SISTEMAS S.A. in collaboration with the Technical University of Madrid. The Spanish Ministry of Defence has founded this research. [C2160]

## "A pedestrian detection system based on thermopile and radar sensor data fusion"

Automotive pedestrian protection systems will be introduced in the EU in short term to reduce the number of accidents and injury fatalities. As with any safety issue, a comprehensive approach comprising both active and passive safety elements should be followed and it is also valid for pedestrian protection. Passive safety short term solutions can be contact sensor systems that trigger raisable engine hoods. This paper discusses an innovative approach for pedestrian detection and localization, by presenting a system based on two short range radars and an array of passive infrared thermopile sensors, aided with probabilistic techniques for detection improvement. The two short range radars are integrated in the front bumper of the test vehicle. They are able to observe and track multiple targets in the region of interest. However, one difficulty is to distinguish between pedestrians and other objects. Therefore, a second sensor system is required to classify pedestrians reliably. This system consists of spatial distributed thermopile sensors which measure the object presence within their respective field-of-view independently. These measurements are then validated and fused using a mathematical framework. Thermopiles are excellent to detect the thermal radiation emitted by every human. However, a robust signal-interpretation algorithm is mandatory. In this work a statistical approach combining Dempster-Shafer theory with occupancy-grid method is used to achieve reliable pedestrian detection. Thermopile and radar sensors use independent signature-generation phenomena to develop information about the identity of objects within the field of view. They derive object signatures from different physical processes and generally do not cause a false alarm on the same artifacts. The integration of the sensor readings from the radar and thermopile system is conducted using unifying sensor-level fusion architecture. [C2161]

## "A precrash system based on sensor data fusion of laser scanner and short range radars"

The growing interest toward active safety systems leads to a rapid development of different sensors and systems. One key aspect for all systems is the knowledge about the car environment. This knowledge is essential for safety applications such as PreCrash. A PreCrash system generates information about location, moving direction and relative velocity of critical objects in the car environment immediately before an imminent and inevitable accident happens. Different types of actuators can benefit from this information for in-time

deployment and the choice of the right deployment energy. In this paper a PreCrash system is proposed, which uses two short range radars and a laser scanner to obtain the required environmental data. The short range radars and the laser scanner will be mounted in the front of a test vehicle. The sensors are able to observe multiple targets within a field of view in front of the car. To develop a highly reliable environment sensing system, competitive fusion approaches using different types of sensors are appropriate. The challenge in realizing such a fusion system is the optimal utilization of the detection performance of each sensor type and the developing of a fast architecture for using it in the automotive environment. As two examples for such a fusion strategy a commonly utilized decision level fusion approach is discussed and a newly developed grid fusion approach is introduced. It is based on a virtual grid in front of the car in which the sensor readings are mapped into. The architecture of the grid is directly adapted to the requirements of the application and the sensor specifications. The data extraction out of the grid is based on simple and well known strategies. Decision strategies to increase the certainty of object identity are also proposed in this paper. [C2162]

## "Unscented Kalman filter design for curvilinear motion models suitable for automotive safety applications"

Research in automotive safety leads to the conclusion that modern vehicle should utilize active and passive sensors for the recognition of the environment surrounding them. Thus, the development of tracking systems utilizing efficient state estimators is very important. In this case, problems such as moving platform carrying the sensor and maneuvering targets could introduce large errors in the state estimation and in some cases can lead to the divergence of the filter. In order to avoid sub-optimal performance, the unscented Kalman filter is chosen, while a new curvilinear model is applied which takes into account both the turn rate of the detected object and its tangential acceleration, leading to a more accurate modeling of its movement. The performance of the unscented filter using the proposed model in the case of automotive applications is proven to be superior compared to the performance of the extended and linear Kalman filter. [C2163]

## "Joint Integrated PDA Avoiding Track Coalescence"

Joint PDA approach is very effective in tracking multiple targets in data association environment, with clutter measurements and missed detections. Joint IPDA has built upon this by including the probability of target existence as a track quality measure to enable automatic tracking and track maintenance in data association environment. Both JPDA and JIPDA suffer from the problem of track coalescence, where tracks following targets whose trajectories don't separate for extended time start following "center" of these targets. JPDA*is an extension of JPDA which combats coalescence by pruning possible measurement to track allocation hypotheses. Following JPDA*derivation, this paper derives JIPDA*, an extension of JIPDA which also combats track coalescence. JIPDA*updates the probability of target existence as the track quality measure. A simulation study verifies the effectiveness of this approach and compares JIPDA*with JIPDA and IPDA when tracking crossing targets in an environment of heavy clutter. [C2164]

## "Manoeuvring target tracking with the IMM-VDA algorithm"

This paper describes an algorithm for tracking a manoeuvring target in heavy clutter and/or with a low probability of detection. It is known that when tracking under such adverse conditions multi-scan tracking algorithms, such as the multi-hypothesis tracker (MHT), provide improved performance over single-scan trackers. This paper uses a computationally efficient algorithm for multi-scan target tracking based on the Viterbi algorithm, known as the Viterbi data association (VDA) algorithm. In this paper it is shown how the VDA algorithm can be combined with the well-known interacting multiple model (IMM) method to create an effective multi-scan manoeuvring target tracker. The performance of the IMM-VDA algorithm is shown by simulation. It is compared to another manoeuvring target algorithm based on the VDA approach which uses a hard decision manoeuvre detection scheme. In addition, it is compared to a single-scan tracking algorithm based on the probabilistic data association method. [C2165]

## "Non parametric target tracking in non uniform clutter"

Target tracking algorithms have to operate in an environment of uncertain measurement origin, in the presence of randomly detected target measurements as well as clutter measurements from unwanted random scatterers. Most data association target tracking algorithms incorporate a measure of clutter density. Quite often the clutter density is non-uniform, especially in ground target tracking, or when the radar beam "touches" the ground. Non-parametric target tracking assume a priori unknown clutter density, however the assumption is that it is uniform within the selection gate. Complex selection gates, which are created for a number of multi-scan and/or multi target tracking algorithms, can encompass a large volume where the clutter density will vary widely. We propose an alternative clutter density estimation scheme for non-parametric target tracking, which does not assume

uniform clutter within the selection gate. Instead, clutter density is estimated on a measurement by measurement basis, prior to a posteriori target track update. The scheme is adaptive and has no bias in estimated inverse of clutter density at the measurements coordinates. A simulation study shows the benefits of adaptive clutter estimation based on single target tracking algorithms in an environment of heavy and non-uniform clutter. [C2166]

## "Radar absorbing material (RAM) and shaping on radar cross section reduction of dihedral corners"

How far can a radar system detect an object depends the radar cross section (RCS) of the target. Corner reflectors are the major scattering centers in the radar signatures of vehicles. The monostatic return from such structures can be reduced by ensuring that surfaces never meet at right angles and by application of radar absorbing materials (RAM). This paper deals with the RCS reduction of dihedrals by shaping and by application of RAM. RCS from dihedrals were compared before and after the application of radar absorbing coating. RAM is based on conductive carbon black dispersed in rubber matrix. [C2167]

## "Blind separation of audio sources using modal decomposition"

{no data available} [C2168]

## "Integrated probabalisitic data association tracker for enhanced active sonar detection"

{no data available} [C2169]

## "CRLB with Pd"

This paper presents mathematical procedures to calculate the Cramer-Rao lower bound (CRLB) for a target track obtained by fusing two tracks given by two interactive multiple model (IMM) trackers filtering the plots received by two radars. The target under tracking is a ballistic target (BT) in reentry phase and it is assumed that the two sensors could have a detection probabilities Pd less than 1. Accurate BT tracking is required for: (i) impact point prediction, (ii) support to the kill assessment, and (iii) threat classification. Note that, to improve the performance, the method can be extended to the fusion of more than two sensor tracks. The paper is organized as follows: the problem is introduced in section 1; section 2 briefly recalls the models of BT dynamic and of the radar measures. Section 3 presents the tracking algorithm based on the IMM approach; section 4 contains the description of the CRLB evaluation problem and section 5 the results achieved in comparing the fusion of two BT tracks (each track is obtained from the IMM algorithm described in section 4) with the CRLB; Monte Carlo simulations is also used to quantify the fused track accuracies. Section 6 is pertinent to conclusions and follows on of the activity while references are reported in section 7. [C2170]

## "Differential Geometry Measures of Nonlinearity for Ground Moving Target Indicator (GMTI) Filtering"

The ground moving target indicator (GMTI) radar is widely used to detect, geolocate, track, and classify ground-moving targets in all weather, day-night, and cluttered conditions. The measurements of a GMTI radar are slant range, azimuth, and range-rate or Doppler. These measurements are nonlinear functions of the target state. Until recently, a quantitative measure of the degree of nonlinearity (DoN) for nonlinear filtering problems was lacking. Recently, the DoN of a filtering problem with a nonlinear measurement model has been quantified using the differential geometry based measures of nonlinearity such as the parameter-effects curvature and intrinsic curvature. We calculate three types of parameter-effects curvature and intrinsic curvature for the nonlinear GMTI filtering problem for a variety of scenarios. We vary the distance between the target and the GMTI sensor in these scenarios using simulated data. We demonstrate that the state estimation mean square error (MSE) increases with increase in the DoN [C2171]

## "Over-the-horizon radar target tracking using MQP ionospheric modeling"

As over-the-horizon radars use ionosphere reflection to detect and track targets, they are faced with a possible appearance of multipaths and difficulties to estimate the target ground location. To solve these problems we propose to use a ionosphere model called multi-quasi-parabolic (MQP) model. Introducing the coefficients of the MQP model into a target tracking algorithm leads to nonlinear evolution and measurement equations. Furthermore we only have estimation, through ionosphere measurements, of these parameters values. To take into account MQP parameters in a target tracking algorithm, we propose two different approaches built on the same algorithm: the unscented Kalman filter. In the first approach, we use a joint unscented Kalman filter and in the second one we use an unscented particle filter applied on both target state space and MQP parameters space (we could call this a joint unscented particle filter). We compare these two approaches and present our

conclusions illustrating them by numerical simulations on the French over-the-horizon radar nostradamus. [C2172]

## "Online multitarget detection and tracking using sequential Monte Carlo methods"

In this paper, we present a new sequential Monte Carlo (SMC) algorithm for online joint multitarget tracking (MTT) and detection in the presence of spurious objects, e.g., clutter. The proposed method provides an efficient solution to deal with two major challenges in MIT problems: 1) time-varying number of targets, and 2) measurement-to-target association. By detecting regions of interest within the surveillance region and monitoring their appearance and disappearance, we are able to estimate the number of targets, even when the environment is hostile with low target detection probability and high clutter density. Adopting an efficient 2-D data assignment algorithm that computes all feasible assignments subject to certain constraints, we are able to efficiently and effectively marginalize the association hypotheses from the likelihood junction. Subsequently, we utilize SMC methods, also known as particle filters, to recursively and jointly estimate the multitarget states. Computer simulations and performance evaluation demonstrate the robustness of the proposed method for multitarget detection and tracking within a hostile environment in terms of high clutter density and low target detection probability. [C2173]

## "Multiple target tracking with possibly merged measurements modeled by point processes"

Generally, sensor resolutions are finite, and hence any measurement may originate from two or more objects. Recent advances in sensor signal processing technology have made it possible to estimate the number of objects that may originate from a given detection for a certain type of sensor. With these new methods, it may be possible to associate each, possibly merged, measurement with state components of an unknown number of objects from which the measurement originates. One suitable mathematical model for an unknown number of object states is a finite point process that can be defined by a family of permutable (symmetric) probability distributions together with the probability of the number of the objects. In this paper we will show how general multiple hypothesis tracking systems, usually designed with the assumption that measurements are all resolved, may be extended to process possibly merged measurements modeled by point processes. [C2174]

## "Probability hypothesis density filter for multitarget multisensor tracking"

Multiple target tracking techniques require data association that operates in conjunction with filtering. When multiple targets are closely spaced, the conventional approach (MHT/assignment) may not give satisfactory results, mainly due to the difficulty in deciding the number of targets. Recently, the first moment of the "multi-target posterior density", called the probability hypothesis density (PHD), has been proposed to address the multi-target tracking problem. Particle filtering techniques have been applied to implement the PHD based tracking. In this paper, we explain our interpretation of the PHD, and then investigate its performance on the problem of tracking unresolved targets from multiple sensors. In the set-up, there are two different radars, which monitor the targets, and the PHD is fed sequentially by these scans. In the scenario, we investigate 3 different levels of complexity in terms of measurement extraction methodologies of sensors when there are unresolved targets 1) Sensor model reports a measurement with variance σmono2. (Sensor is not capable of sensing any abnormality in radar return). 2) Sensor model gives a single measurement with a larger variance σazi2≥σmono23) Sensor model uses a multi-target measurement extractor. Unresolved targets create separate measurements with variance σmono2. Simulation results for two-dimensional scenario are given to show the performance of the approach. Based on our simulation results, we also discuss difficulties the PHD algorithm seems to encounter, especially as is reflected in the target "death" event. [C2175]

## "Autonomous Control of Multiple UAVs for the Passive Location of Radars"

This paper describes an algorithm that has been used for the autonomous control of multiple UAVs tasked with the high level objective of locating a radar subject to a number of real world constraints. The distributed, fully autonomous, cooperative control of the multiple UAV system was executed using sensor input from a heterogenous network of miniaturised Electronic Surveillance (ES) payloads. An ES sensor onboard one UAV detected a radar target and cross-cued ES receivers onboard two other UAVs. Based on the information shared between these UAVs the target radar was approximately located by each UAV Once the UAVs had coarsely located the target they autonomously, dynamically, and continuously adapted their flight trajectories to progressively improve the accuracy with which they were able to co-operatively locate the radar target. The UAVs were able to accurately locate the radar while simultaneously avoiding no-fly zones, one another and remaining within communication range. [C2176]

## "Integrable ultra-compact, high-resolution, real-time MEMS LADAR for the individual soldier"

Laser radar (LADAR) has many advantages over other methods of target detection and analysis, both in combat and commercial applications. Because it uses a shorter wavelength than microwave radar and has significantly greater angular resolution, it is capable of a greater degree of accuracy and more precise target resolution to a level that allows for high-resolution image acquisition. The development of a next generation LADAR unit that is lightweight, ultra-compact, portable, and power-efficient real-time 3D LADAR unit would be a significant advance with many potential military and civilian applications. This paper describes a novel LADAR device that would be small, compact, field practical, eye safe, and integrable into a soldier's helmet. This would be achieved by using a 2-axis MEMS (micro-electro-mechanical system) scanner with an optical system that will extend the field of view (FOV). This next generation time-of-flight (TOF) LADAR design utilizes a novel angle amplification mechanism that uses a pre-compensating positive lens and a subsequent negative lens to overcome the small scanning range of MEMS mirrors where scan angles as small as 6deg can be increased to over 40deg. Also, with conventional digital zoom, a portion of an image is used to create a larger but much lower resolution image, while the LADAR zoom technology discussed in this paper will have a tighter field of view for a high-resolution zoom image. Other innovation is a relatively inexpensive and compact laser driver that can generate subnanosecond pulses of varying repetition frequency. Our analyses demonstrate that this portable LADAR device would work in close proximities as well as distances over 100 meters, could have a range resolution of less than a centimeter and a FOV greater than 40deg, and be able to display 320times240 pixel real-time images at a frame rate of 15. Such a LADAR unit could be enhanced to also record and transmit range, intensity, and GPS/vector data to a remote comp--uter. By using the same soldier for capturing LADAR images and data from multiple locations or multiple soldiers, a computer program could analyze and integrate the data so as to build a 3D survey of the combat field with in-depth target information. In this potential scenario even occluded (camouflaged) targets could be revealed and identified with appropriate signal processing. Also, as the intensity (amplitude) and range (time interval) data are being quickly processed, graphically enhanced 3D images could he transmitted hack to the soldiers in the field [C2177]

## "Near-field radar 3D synthetic aperture imaging based on Stolt interpolation"

Synthetic aperture processing for radar data can improve resolution of radar image, and increase the detecting ability of radar. Utilizing phase and amplitude information recorded over a 2D aperture can reconstruct a focused 3D image of the target. Quasimonostatic mode is used and the transmitting antenna transmits in step frequency. A new Stolt interpolation method which can increase accuracy of interpolation is presented. Also the method requires little computation time. 3D image of the target is achieved through the fast Fourier transform after interpolation. The algorithm is described in detail and numerous imaging results from simulations and experiment are presented. These results show that the algorithm for 3D image-reconstruction based on this interpolation method presented can produce a microwave 3D image with high resolutions. [C2178]

## "Multi-target detection in FMCW radar based on six-port technology"

The traditional FMCW radar has its own limitation in multitarget detection. Six-port radar is proposed as a new way to solve this problem because of its phase measurement capability. The structure of six-port radar is given and the operating principle of the six-port as direct conversion receiver in FMCW radar is discussed. How six-port radar suppresses false alarm is analyzed in this paper. Computer simulations prove that the analysis is correct and the method is practical. [C2179]

## "Ultrawideband multisite radar systems: peculiarities of target detection, resolution and coordinate measurement"

Because target radial dimensions are, as a rule, much larger than a range resolution cell of ultrawideband (UWB) radars, each radar receives the so called "range profile" of a target. Target detection, resolution and coordinate measurement of such targets significantly differ from the corresponding procedures for narrowband multisite radar systems (MSRSs) and have not been sufficiently discussed in known literature. These important peculiarities are considered. Noticeable advantages of UWB MSRSs have been shown when range profiles of a target may be expected to be equal with respect to all radars [C2180]

## "Analysis of forward scattering radar for ground target detection"

This paper describes aspects of ground target detection using a forward scattering micro radar (FSR). It begins with a brief description of the system, followed by a more detailed analytical study of FSR in terms of power budget analysis and potential cross-range resolution. From this analysis, theoretical models are constructed and compared to the experimental data [C2181]

## "An Influense of Passive Noises on Radar Detection Characteristics"

The correlations for analysis of radar with selector of moving targets detection characteristics working during an influence of passive noises from turbulent meteors, is given. [C2182]

## "Ocean surface feature extraction and targets detection from SAR images using neural network"

In this paper, a novel system is presented for the targets detection from synthetic aperture radar (SAR) images of ocean. The proposed system consists of two neural networks. The first network cluster the extracted target fractal feature vectors in smaller sub-portions of the image, and the second GA RBF network integrates the information from the first network to determine the presence or absence of a target in the entire image [C2183]

## "Synthetic aperture processing of buried object scanning sonar data"

Synthetic aperture processing improves the resolution and signal to scattering noise performance of buried object scanning sonar (BOSS) imagery. Time delay focusing coherently sums acoustic data measured by a line hydrophone array located in the wings of the BOSS vehicle. Synthetic aperture processing improves the along track spatial resolution by coherently summing the data over a sequence of transmissions. SAS (synthetic aperture sonar) motion compensation is implemented by calculating the changes in projector and hydrophone positions between transmissions using IMU (inertial measurement unit) and DVL (Doppler velocity log) data. The coherent summation is performed at each location in a 3D volume of focal points including the upper meter of sediments and the sediment-water interface. Sonar images are projections of the 3D data set onto orthogonal planes. A set of three cylinders with diameters of 5,7.5 and 10 cm, buried in sand, are used to measure the relationship between SAS aperture length and the SNR and spatial resolution of BOSS imagery. The BOSS data sets containing the cylindrical targets were collected in September 2004 as part of SAX-04 (Sediment Acoustics Experiment-2004), located off Fort Walton Beach, Florida. [C2184]

## "Integrated Marine Mammal Monitoring and Protection System (IMAPS)"

The IMAPS mission is to establish a global solution for protecting the marine environment through the development and implementation of a modular assessment and protection system. The limitations of current technologies are based on them being individually inadequate to fully achieve the mitigation objectives. All the sources of information related to the detection and classification of marine mammals such as active sonar, passive sonar, radar, visual and distribution databases need to be fused to provide a robust protection system. In order to successfully standardize, transport, interface and fuse the information being supplied and requested by the diverse sensor modalities, two essential took of the IMAPS global system are being developed: the Integrated Tracker and the Integration Architecture. The Integrated Tracker employs a data fusion algorithm that combines sensor information to refine estimates of target position, velocity, identity to provide integrated tracking and classification. A data fusion architecture has been chosen and a Bayesian approach for fusion and classification is developed. A data fusion and transport approach has been taken to develop a set of IMAPS prototypes that consist of simulated active sonar, passive sonar, radar and visual modalities communicating in real-time via the Integration Architecture, and to supply the sensor data, and other information necessary for the fusion, to the Integrated Tracker. The main functionality of the Integration Architecture is to provide information transport and common services in the form of a 'plug and play' capability, implemented with a software framework developed upon the Test & Training ENabling Architecture (TENA). The TENA software framework provides for the implementation of common software interfaces to disparate sensor modalities, thereby enabling the integration of different data sources using a common data representation and transport medium. Sensor outputs such as target detections and environmental information are being transformed in object-orientated data representations that are easily interpreted, manipulated, and interfaced. In addition to the Global IMAPS initiative, the active sonar modality was designed, built, and tested during the MAST 04 experiment producing detect- ions of whales and preliminary synthesis of whale tracks. [C2185]

## "Parallel multi-level fast multipole algorithm with combined field integral equation on distributed memory system"

Although the multilevel fast multipole algorithm (MLFMA) has been the most popular method in electromagnetic field computation, the limitation of both CPU speed and memory size make it still difficult to solve the scattering problems from very large scale structures using this method. In this paper, we implemented the CFIE (combined filed integral equation) into our parallel MLFMA solving the electromagnetic scattering problem of an electrical-large PEC targets on the message passing interface (MPI) in a cluster system. A lot of numerical results are represented in this paper. From the numerical result presented a very good convergence speed is achieved, and the scattering from a very large scale problem which has about 1 million unknowns is solved. Finally, the result is presented and discussed in this paper. [C2186]

## "Application of DRFM in high frequency ground wave radar"

Compared with the traditional analog delay, to conveniently control the time delay of responder of high frequency ground wave radar and obtain duplicate signal with better coherence, the digital radio frequency memory (DRFM) which consists of FIFO is designed to sample the received signal of radar at high speed continuously and simulate the target at any distance. This design is proved to meet the demand of responder of radar well [C2187]

## "Polarization target detection algorithm based on instantaneous Stokes sub-vector"

Firstly, the statistics of random polarized wave's instantaneous Stokes sub-vector is analyzed and its probability density function (PDF) is obtained. Secondly, the target detection problem is skillfully translated into the detection problem of three equivalent polarization signals. Thereby, a novel fusion detection algorithm is presented based on the difference statistical distribution of Stokes sub-vector between targets and clutters. Experimental results show that no matter the target is random polarization or invariable polarization, the algorithm is effective. Its performance can be comparative to that of the optimal polarization detector (OPD) and better than that of the polarization white filtering detector (PWF). Considering variable conditions of polarimetric measurements, it can be used more widely than the optimal polarization detector [C2188]

## "Coherent change detection with SAR"

In the context of investigating coherent SAR data for battle damage assessment, we examine the ability to detect changes in objects using synthetic-aperture radar (SAR) observations. The emphasis is on targets which are a few resolution cells in extent. Both coherent and non-coherent methods are studied. Coherent methods are effective when clutter coherence is high. The correlation between intensity images may also be used to detect changes. Practical performance limits are set by sources of phase noise, such as the temporal coherence of clutter, and the spatial resolution of the sensor compared with the target/change dimensions [C2189]

## "Applications of polarimetric interferometric ground-based SAR (GB-SAR) system to environment monitoring and disaster prevention"

Polarimetric and interferometric ground-based synthetic aperture radar (Pol-GB-SAR, In-GB-SAR) system has been developed. In this paper, two measurements of outdoor test sites in polarimetric and interferometric configurations are introduced and results are presented. In the developed In-GB-SAR system, the technique of differential interferometry is used to detect small changes at different times and under different conditions. Experimental results demonstrate that the system is very efficient and can detect small changes of the scale of 2 cm at the range distance of 5 m. Polarimetric analysis was done using the Pol-GB-SAR system with a coniferous tree as a target. The system has superior ability in polarimetric applications. Applying polarimetric and interferometric analysis which were developed for spaceborne and satellite radar remote sensing datasets, we can find detailed scattering mechanisms and detect deformations. The GB-SAR has a wide range of applications like environmental monitoring, resources management as well as monitoring of different natural phenomena [C2190]

## "A novel approach for the automatic detection of punctual isolated targets in a noisy background in SAR imagery"

Several distinctive capabilities of satellite-based synthetic aperture radar (SAR) systems make them a powerful tool for Earth observation purposes. In fact, SAR systems can provide an efficient, quick and cost effective coverage of any area independently from weather effects and from the day-night cycle. Nevertheless, the automatic interpretation of SAR images usually constitutes a complicated task due to the presence of speckle and to the reduced dimensions of the target compared to the sensor resolution. This papers aims at presenting a novel algorithm for the detection of punctual isolated targets in a noisy background based on the wavelet theory. It will be shown that this can be useful for example for ship detection purposes [C2191]

## "Adaptive Radar Detection of Distributed Targets in Homogeneous Noise plus Subspace Interference"

This paper addresses adaptive radar detection of distributed targets embedded in homogeneous Gaussian noise and interference which is assumed to belong to an either known or unknown subspace of the observables. At the design stage we resort to either the GLRT or the so-called two-step GLRT-based design procedure and assume that a set of noise-only data is available (the so-called secondary data). Detection algorithms have been derived modeling noise vectors, corresponding to different range cells, as zero-mean, complex normal ones,

sharing the same covariance matrix. The common covariance matrix is unknown at the receiver. The performance assessment, carried out by Monte Carlo simulation, confirms the effectiveness of previously-proposed ones [C2192]

## "A Novel Algorithm to Identify Air and Sea Targets in Coastal Radars"

{no data available} [C2193]

## "The modelling and exploitation of spatial correlation in spiky sea clutter"

A physically based sea clutter model is used to calculate the statistics of sea clutter. The mean radar cross section (RCS) is found to match experimental results and the second moment is found to be consistent with the resolution dependence of the clutter shape parameter. The correlation structure predicted by the model is found, on average, to be consistent with real data, but the latter also shows significant transient coherence. This property may be exploited for sea spike suppression and target detection improvement [C2194]

## "Design and representation of suboptimum methods for radar space-time adaptive processing (STAP) techniques using a canonical framework"

Space-time adaptive processing (STAP) is a technique used by moving radars to detect slow moving targets. The goal is to reject interference and noise. However, rejection requires a great number of training samples and a large computational cost. To keep the task manageable, suboptimum STAP methods (SOMs) have been proposed by several authors. We have developed a framework to encompass all these methods in a canonical structure. In the appendices, some famous SOMs will be described using the canonical framework. The canonical framework can also be seen as a tool that can be used to design new techniques. This paper is a guideline for designing suboptimum STAP techniques using the framework. Choices that designers have to make are presented in regard with the impact of these choices [C2195]

## "Signal error analysis of multiple antenna radars"

In this paper, we analyse various topologies of multiple antenna systems in radars. The results are presented by means of a novel detection theoretic approach to track the detection capability of radars. The new detection approach is more tractable than conventional 'probability of detection analysis' and is based on modelling of radar target as a modulator in an analogous communication system. This method is called the analogous communication system for a radar (ACSR) and quantifies 'detection' as being inversely proportional to bit error rates (BER) of the resulting communications channel [C2196]

## "On the merits of using spatial and waveform diversity for target detection in ultra wideband radars"

This paper presents experimental results of using spatial and waveform diversity schemes applied to ultra wideband (UWB) short-range radars. Spatial diversity provides multiple views of the target, enhancing the content of information received. The use of waveform diversity scheme is compared with spatial diversity by transmitting different UWB signals from different antennas. An experimental and simulation study is presented, which claims a maximum of 13 dB gain in the target signatures with respect to a single bistatic radar. It is also shown that spatial and waveform diversity schemes acting together can possibly lead to further improvement in radar detection capability [C2197]

## "Experimental results of ground moving target detection achieved with the multi-channel SAR/MTI system PAMIR"

The airborne experimental multichannel SAR/MTI system PAMIR (phased array multifunctional imaging radar) has been designed and developed by FGAN-FHR in order to demonstrate some capabilities of future reconnaissance systems. One main feature of these radars is the surveillance of wide areas for moving targets. Since 2003, a special scan-MTI mode has been implemented in the PAMIR system and experimentally tested: to improve the moving target detection performance, radar bursts are transmitted at five different carrier frequencies, which allows to avoid blind velocities, to resolve velocity ambiguities and to increase the probability of target detection. Some specific algorithms are currently under development in order to process the scan-MTI data gathered during the flight campaign of November 2003. This paper presents some experimental scan-MTI results achieved with the PAMIR system. After an overview of the PAMIR experimental system and of the GMTI experiment conducted, the scan-MTI signal processing algorithm is described. Then, some results obtained after processing of the data acquired during the experiment are shown [C2198]

## "Characterization of radar targets in resonance domain with a reduced number of natural poles"

In resonance domain, the radar scattering response can be modeled by natural poles of resonance, with the formalism of the singularity expansion method. The mapping of poles gives useful information for the discrimination of radar targets. In this paper, we show that a reduced number of poles is sufficient to characterize an object. Furthermore, we propose a procedure for selecting poles actually contributing to the scattering response. Results are presented for different canonical targets [C2199]

## "Detection of slow moving targets in SAR images using STAP processing with two-channel sigma-delta antenna"

To obtain moving target detection in SAR images, strong signals from nonmoving objects (ground clutter) have to be removed. In the classical approach for single channel SAR data, simple FIR filtering or frequency-domain filtering is used. The disadvantage of this approach is significant weakening or masking of moving target echo (by either wide transition band or limited attenuation in stopband), which makes the detection possible only for targets that are strong and well separated in frequency domain. This can be overcome by STAP technique for multi channel SAR data. In this paper, the analysis of channel mismatch influence on slow moving target detection is performed for the case of two channel sigma-delta antenna [C2200]

## "Reduced-rank signal-dependent classification of training data for space-time adaptive processing"

Nonhomogeneous and nonstationary training data are two of the key technical challenges facing space-time adaptive processing (STAP) for target detection using space-based radar. We describe a technique for training data selection that seeks to classify the available data in a reduced-rank subspace based on the multistage Wiener filter (MWF). The method builds on previous work by allowing each data sample to associate with multiple covariance classes within the separate subspaces defined by the signal and the class, thereby enabling larger sample support for each class. Performance of the new method is assessed using simulated data based on a monostatic space-based radar scenario. Comparison is made with conventional training data selection techniques [C2201]

## "Orthogonal pulsing schemes for improved target detection in space based radar"

Two phenomena that degrade the performance of ground moving target detection (GMTI) capabilities of space based radars (SBR) are (i) range foldover effects associated with multiple data points originating from different range bins due to the radar pulse stream and (ii) Earth's rotational effect on clutter Doppler frequency. The degradation in performance due to these phenomena is quantified in this paper and methods to minimize their effect are discussed. In this context, transmit pulsing schemes involving waveform diversity is proposed for improved target detection capabilities [C2202]

## "Ground Surveillance Radar Target Classification Based On Fuzzy Logic Approach"

The fuzzy logic approach to the automatic classification of moving target detected by ground surveillance radar is presented in this paper. The real audio Doppler signatures of various targets are analyzed by spectrogram. As a result of analysis, input and output variables with corresponding membership function are defined. The set of fuzzy rules is established. The defuzzification of the output fuzzy set is performed by computing the "fuzzy centroid". The three target classes (walking man, running man and wheeled vehicle) are successfully classified [C2203]

## "Robust cascaded canceller using projection statistics for adaptive radar"

Adaptive radar requires independent and identically distributed (i.i.d.) training data, or snapshots, in order to obtain fast SINR convergence performance in the presence of correlated interference such as jamming and/or clutter returns. Targets, clutter discretes, and impulsive jamming are examples of non i.i.d., real-world data components that corrupt interference training data. Such data are considered to be statistical outliers. Recent outlier detection work for space time adaptive processing (STAP) training data selection has involved use of the generalized inner product (GIP) test statistic. In this paper, we use a prewhitening method followed by a robust projection statistics (PS) algorithm for 2D outlier removal prior to each building block in a reiterative adaptive cascaded canceller. SINR performance is shown to be superior using 2D PS compared to 2D GIP to excise multiple outliers [C2204]

## "A hybrid approach for online joint detection and tracking for multiple targets"

In this paper, we present a new approach for online joint detection and tracking for multiple targets. We combine

a deterministic clustering algorithm for target detection with a sequential Monte Carlo method for multiple target tracking. The proposed approach continuously monitors the appearance and disappearance of a set of regions of interest for target detection within the surveillance region. No computational effort for target tracking is expended unless these regions of interest are persistently detected. In addition, we also integrate a very efficient 2D data assignment algorithm into the sampling method for the data association problem. The proposed approach is applicable to nonlinear and nonGaussian models for the target dynamics and measurement likelihood. Computer simulations demonstrate that the proposed hybrid approach is robust in performing joint detection and tracking for multiple targets even though the environment is hostile in terms of high clutter density and low target detection probability [C2205]

## "Sequential Monte Carlo filtering for multi-aspect detection/tracking"

We propose in this paper a mixed-state sequential Monte Carlo (SMC) filter for joint multiframe detection and tracking of multiaspect targets in cluttered image sequences. The proposed detector/tracker is a sampling/importance resampling (SIR) particle filter that uses resampling according to the weights to combat particle degeneracy and also includes an additional Metropolis-Hastings (MH) move step to avoid particle impoverishment. The dynamic models for target motion and target aspect and the statistical model for the spatially correlated background clutter are assumed as prior knowledge in the design of the filter. The performance of the algorithm is investigated using simulated image sequences generated from real infrared airborne radar (IRAR) data [C2206]

## "Array deformation performance impacts on a LEO L-band GMTI SBR"

Space based radar (SBR) has been investigated for decades and has once again made an appearance as a viable method for performing the moving target indication (MTI) mission. Large arrays are needed for this application in order to provide adequate energy on target for detection and to minimize the observed ground clutter Doppler spread. Large phased arrays in space are likely to experience mechanical deformation both at the sub-array panel level and across the structure as a whole. The impact of antenna deformations on antenna pattern, peak directive gain, and signal to interference plus noise ratio loss (SINRL), which shows impact on minimum discernable velocity (MDV), is demonstrated. This paper address the deformations when applied to a low earth orbit (LEO) based L-band radar concept of interest to the US Air Force (USAF) and NASA [C2207]

## "Space based radar technology challenges"

Space based radars are gaining significant acceptance for world-wide, all-weather, on-demand surveillance and earth resources monitoring. The main impediment has been affordability, followed closely by the limitations by satellite communications for providing near real time target detection data to the users. Recent advances in active electronic scanned arrays and on-board signal processing are enabling SBR development for both surface and fixed target imaging and moving target detection. The real challenge is for future surveillance of airborne targets. This paper outlines some critical SBR design architectures, and a roadmap for developing the enabling technologies to meet future surveillance needs [C2208]

## "Detection of Targets in Foliage Clutter, Based on Multiresolutional Denoising"

We address here the problem of detection of targets obscured by foliage clutter using X-band portable continuous wave radar. The weak signal, backscattered from the target and the impulsiveness nature of the foliage clutter are the two problems which make the reliable detection not so easy task. The impulsive foliage clutter is more accurately modeled with the symmetric alpha stable distribution, compared to the most used distributions in the radar community. With this more accurate model and giving an account that the Doppler statistic can not be considered as simple stationary system, we investigate here the applicability of new multiresolutional approach recently proposed from Donoho and Yu (2000), namely a kind of pyramid transform based on median interpolation. We also derive computational effective approximation for the computation of the optimal thresholds for the last approach [C2209]

## "Imaging of subsurface targets using a 3dDquadtree algorithm"

{no data available} [C2210]

## "Autonomous Ground Target Tracking by Multiple Cooperative UAVs"

With the recent advent of moderate-cost unmanned (or uninhabited) aerial vehicles (UAV) and their success in surveillance, it is natural to consider the cooperative management of groups of UAVs. The problem considered in this paper is the optimization of the information obtained by a group of UAVs carrying out surveillance of several

ground targets distributed over a large area. The UAVs are assumed to be equipped with ground moving target indicator (GMTI) radars, which measure the locations of moving ground targets as well as their radial velocities (Doppler). In this paper, a cooperative control algorithm is proposed, according to which each UAV decides its path independently based on an information theoretic criterion function. The criterion function also incorporates target detection probability and survival probability for sensors corresponding to hostile fire by targets as well as collision with other UAVs. The control algorithm requires limited communication and modest computation [C2211]

## "Detection and Localization of Curbs and Stairways Using Stereo Vision"

We present algorithms to detect and precisely localize curbs and stairways for autonomous navigation. These algorithms combine brightness information (in the form of edgels) with 3-D data from a commercial stereo system. The overall system (including stereo computation) runs at about 4 Hz on a 1 GHz laptop. We show experimental results and discuss advantages and shortcomings of our approach. [C2212]

## "Waveform based detection of anti-personnel mines with an UWB radar"

The present paper deals with feature-based landmine detection by means of UWB ground penetrating radar (GPR). A waveform of target response is used as a discriminative feature for two feature-based detection schemes. The output of each DPS is a confidence map obtained by means of energy projection of a 3D distributed feature onto a 2D surface. An automated detection is made over the obtained confidence maps and mines detectability is analyzed on the basis of the receiver operation characteristic curves. Performances of the feature- and energy-based data processing schemes (DPS) applied to the experimental data are compared. It is shown that suggested waveform based detection is stable to the change of the environment. [C2213]

## "A novel distributed CMLWLC CFAR detector"

In the past applications, the centralized CFAR, which used in the multi-sensor information fusion system, brings an overload communication burden, therefore the distributed CFAR detector becomes a developing and important field. In current distributed CFAR detectors, most of them assume that every sensor in the detector have same signal to noise ratio (SNR). In this paper, we study the case that every sensor in the detector have different SNR. Corresponding to this case, a novel distributed adaptive CFAR detector termed as CMLWLC is presented. In the scheme, a local test statistic, which is the ratio of its test sample level and a designated censored mean level (CML) of its reference samples, is calculated by distributed sensors, and then each sensor transmits its local test statistic to the fusion center. At the fusion center, the global decision is made based on weighted linear combining (WLC). Since the weights are adjusted according to different SNR, adaptively, the proposed detector can available in the case that the target echo and noise/clutter have different level for every sensor. Meanwhile, for a Swerling II fluctuating target in Gaussian noise of unknown level, its closed-form expressions of false alarm probability and detection probability are derived. Comparison numerical results show that the CMLWLC detector has good detection performance in both homogeneous and multi-target backgrounds. [C2214]

## "Software Model of the Signal Processing Unit in the Conventional Radar"

Some results of research project related to software model of the signal processing unit in the conventional radar was presented in this paper. Also, the concept of estimation of Doppler frequency for real targets on the basis of FFT and MUSIC is proposed [C2215]

## "Sensor data fusion in a simulated sensor environment"

This paper addresses the development of automatic target recognition (ATR) algorithms that have the potential to fuse information from multiple sensors to improve acquisition, tracking, and discrimination of threat objects in a simulated sensor environment. A powerful and versatile simulated sensor environment was created to investigate the ATR algorithms presented in this paper. ATR algorithms were chosen and implemented based upon a mid-course ballistic missile defense (BMD) scenario. Algorithms implemented include variations of the sample importance resample particle filter and Bayesian jump-diffusion. The particle filter algorithms handle detection and tracking for this scenario and performed to -10dB SNR for a single IR sensor and better than -18dB for fused IR sensors. The jump-diffusion algorithms were used for target discrimination and performed at as low as -1dB SNR for a single IR sensor and -1.5dB for fused IR and LADAR sensors [C2216]

## "An alternative approach to multichannel radar detection and location"

Space based radar (SBR) surveillance concepts have been investigated for decades and have once again made an appearance as a viable means of performing the ground moving target indication (GMTI) mission. From the

signal processing perspective, a number of unique technical challenges must be addressed. These include a larger Doppler clutter spread, which will cause moving targets to be more likely in the endoclutter region, larger target densities, and nonhomogeneity and/or nonstationarity of the collected data. These and other phenomenology impact the ability of algorithms implemented by the system to perform target detection and parameter estimation. Various adaptations of space-time adaptive processing (STAP) have been put forward as the primary, if not only, solution to detect and locate ground moving targets (GMTI) in complex clutter environments from airborne and/or space based radar platforms. Most, if not all, of the proposed variations can be optimized to work in specific environments but suffer degradation when called upon to perform in a different setting. The reason for this appears to be inherent to the process itself. In order to overcome the difficulties described above, an alternative approach to the current STAP paradigm has been developed and studied for target detection and location in multichannel radar systems. The new technique is based on an adaptation of a previously developed technique, used in passive arrays for angle of arrival (AOA) estimation, in conjunction with a knowledge based array calibration technique. When combined together, these two algorithms provide a powerful new tool for the detection and location of moving targets in complex clutter environments [C2217]

## "Bistatic SAR: theory and simulation"

At present, the most used configuration for synthetic aperture radar imaging is the monostatic one (i.e. transmitter and receiver use the same antenna). However, the multiplication of stealth radar targets and the need for more accurate observations imply new radar imaging configurations and processing developments. The bistatic configuration, i.e. operation with separated transmitting and receiving antennas, should overcome the monostatic limitations. The transmitting antenna can also be used in a monostatic configuration, and consequently it is possible to combine monostatic and bistatic data. Bistatic data acquisition provides additional qualitative and quantitative characteristics of scattering targets. The paper presents bistatic SAR images obtained by bistatic RDA (range Doppler algorithm) processing applied to the polarized electromagnetic field detected by the receiver. The proposed model is qualitatively compared with results already published in the literature (Soumekh, M., 1998; 1999), and quantitatively validated from the analytical resolution equations. [C2218]

## "Single snapshot signal subspace method for target location"

A signal subspace approach is developed for the passive sensing problem of locating radiation-emitting point sources from a single statistical realization or snapshot of the superposed radiation as detected at a receiving antenna array, and for the active sensing problem of locating point scatterers or "targets" from the multistatic response matrix (MRM) of the targets as measured either by a coincident array of "same transmit/same receive" antennas or by a non-coincident array where different elements are used for transmit and receive. Two applications are emphasized: (1) passive location of M [C2219]

## "On the use of energy density spectra for discriminating between landmines and clutter objects"

The paper studies the use of energy density spectra (EDS) derived from ground penetrating radar (GPR) measurements on a sub-surface target to discriminate between landmines and clutter objects. The GPR used to collect the data is frequency swept and has a bandwidth of 1.4 GHz. Our investigation indicates that the EDS reveals distinct characteristics between landmine targets and many clutter objects, and hence can be exploited for their discrimination. Experimental results based on data measured at a government test site corroborate the effectiveness of the proposed approach. [C2220]

## "Radar cross-section of concave-convex targets in random media for circular polarization"

We have postulated the scattering problems of plane waves incident on targets in free space and random media for circular polarization. The RCS of target with concave-convex cross-section was calculated for different incident angles and SCL. We have made clear the effects that have observed influence on the RCS, they are: the target configuration and the SCL. These characteristics are realized apart from the incident angle and the circular polarization as well as the case with linear polarizations. The behavior of RCS undergoes smooth fluctuations in both cases of free space and random medium. However this oscillated behavior is less than that in case of H-wave incidence. We have made clear the fact that RCS behaviour depends remarkably on the polarization of incident waves. Therefore, we stress that using H-wave incidence should be avoided for detecting targets with low frequency limit and instead E-wave or C-wave incidence should be used. [C2221]

## "A simple approach to detecting migration through range-resolution cell for ship ISAR imaging"

Inverse synthetic aperture radar (ISAR) imaging consists of two stages. The first stage is motion compensation applied for transforming the relative motion between radar and moving target into the radar's rotating motion around the target on the turntable. The second stage is range-Doppler (R-D) image formation of the target.

Conventional R-D imaging requires that during the coherent integrated time period, the migration of scatters on the target should not be through one range-resolution cell. However, in the case of high-speed angular motion like ship motion with roll, pitch and yaw, the rotating angle may suddenly be increased greatly within the fixed coherent time, which may result in scatter migration through the range resolution cell. This paper presents a method, based on a 1D range profile, to detect whether the change of equivalent profile width exceeds one resolution cell. The approach can select coherent integrated time adaptively so as to satisfy the rotating angle condition. The approach is described and an example is also given to show the efficiency with good focusing in ship ISAR imaging. [C2222]

## "Radar imaging of PEC targets using limited scattered information"

Electromagnetic scattering information of a PEC target has been popularly used in modern radar systems. Among all the kinds of aircraft detection theory, target imaging has attracted increasing interest because it can give more particular details of the shape or location of the aircraft than others. The theory of inverse scattering identity using physical optics (PO) approximation was discussed by N.N. Bojarski as early as in 1982. He established a Fourier transform relationship between the PEC target and a form of the scattering field, but the method is hard to satisfy in practice. We mainly discuss 2-dimensional (2D) target imaging. We introduce inverse scattering theory based on PO. We then discuss the influence of the limited frequency, and use Pade-extrapolation to approximate the scattering information in all directions around the target from the result of limited scattering directions, which can be conveniently obtained in practical applications. [C2223]

## "Optimum polarization for foliage camouflaged target discrimination using a genetic algorithm"

The coherent scattering model can be ran for many realizations of foliage around a hard target to obtain the statistical variations of foliage and target response in a Monte Carlo simulation. Foliage camouflaged target detection at low microwave frequencies is investigated, using a powerful foliage and hard target simulation tool which accounts for near-field interactions between the hard target and foliage. Based on fully polarimetric simulation results of a foliage camouflaged metallic target a polarization synthesis optimization method for improving signal to clutter is examined. A genetic algorithm is implemented for finding an optimal set of radar transmit and receive polarizations that maximizes target backscatter to clutter ratio [C2224]

## "Surface effects on ground penetrating radar imagery"

Ground penetrating radar (GPR) is emerging as viable technology for rapid and accurate landmine detection. Although GPR has been successfully used for land mine and subsurface object detection, the performance of GPR is affected by surface roughness of the soil medium. There have been theoretical studies showing that surface roughness degrades GPR performance, but few empirical studies have been performed. In this paper, we report on an empirical study of the effect of rough, flattened, and smooth surfaces on GPR images of an easily understood target. [C2225]

## "Front and rear vehicle detection and tracking in the day and night times using vision and sonar sensor fusion"

Active research into vehicle detection and tracking using a vision sensor are done for driver assistance systems (DAS)-collision warning and avoidance, vision enhancement, etc. The vehicle detection and tracking algorithm for DAS requires a robust feature extraction and tracking method regardless of the light and road conditions and an exact estimation of vehicle position and velocity regardless of the distance from the ego-vehicle. But most research was carried out in the day time with good lighting conditions and the little research done so far in the night time assumed no interference of headlights from other vehicles. This paper proposes a new robust vehicle detection and tracking method regardless of the light and road conditions at any distance using vision and sonar sensors. We use the sonar sensor for detection and distance estimation within 10 m and the image sensor over 10 m. First, this paper proposes a simple method that can determine the light condition by observing several images and this light condition is used by selecting one of several detection methods. The proposed vehicle detection method in the day time image can extract the shadow region represented by the boundary between a vehicle and the road and further verify using other vehicle features, such as symmetry rate, vertical edge, and lane information. The vehicle tracking method in the day time uses online template matching using the mean image created by several consecutive detection results. The vehicle detection method in the night time extracts bright regions caused by the headlights, taillights, brake lights, etc. and these candidates are verified by observing several consecutive frames. [C2226]

## "Experimental results on target detection in cluttered medium using electromagnetic time-reversal techniques"

We describe an experimental technique that can be used to improve the detection performance of a radar system in cluttered environments. The detection algorithm depends on time-reversal techniques. By using time-reversal, the response from cluttered medium is first nulled. When the target enters into the medium, the electromagnetic energy focuses around the target so that a stronger echo is obtained. The initial experimental results show that using time-reversal techniques, we can improve the signal-to-noise ratio of the return-echo due to the target compared to conventional change-detection radar. [C2227]

## "Optimum switching of a phase-switched active radar absorber"

In conventional radar absorbent materials, the incident electromagnetic energy is absorbed and converted into heat. Several recent papers (Tennant A., 1997; Chambers, B. and Tennant, A., 2002), however, have considered an alternative technique for achieving an apparent reduction in the level of the electromagnetic energy reflected from a surface, using the so-called "phase-switched screen" (PSS). At resonance, the ideal single layer PSS presents a periodic reflection coefficient, ρ(t) = ±1, to an electromagnetic wave incident on its surface in such a way that the time-averaged value of ρ(t) is zero. This is achieved by applying binary phase modulation to the reflected wave with the result that the energy is redistributed into sidebands with, ideally, none remaining at the original carrier frequency fc. Hence, by adjusting the frequency of the waveform that controls the surface reflection coefficient, these sidebands may be positioned so that they lie outside the pass-band of a receiver tuned to fc. However, the amplitude of some of the sideband components is still high enough that they could aid detection of a PSS-coated target; hence, the paper aims to formulate the optimum switching strategies for the PSS so as to prevent this. [C2228]

## "Indirect method of RCS estimate of conducting target in random medium"

This paper discusses an indirect estimate of the RCS of a conducting cylinder with a partially convex cross-section under the condition that the backscattering enhancement occurs in a random medium. Once we evaluate the spatial coherence length (SCL) of incident waves around the cylinder in random medium, we may approximately estimate the RCS from the RCS in free space with beam wave incidence in which the spot size equals the SCL. This method is restricted only to the case where the SCL is larger than the target size [C2229]

## "MBE grown mid-infrared HgCdTe avalanche photodiodes on Si substrates"

Modern weapon systems need to detect, recognize, and track a variety of targets under a wide spectrum of atmospheric conditions. They include stationary and mobile targets against complex backgrounds and landmines. A number of active systems like hybrid LIDAR-RADAR systems, heterodyne detection as well as passive systems like thermal imagers have been proposed and developed to meet this objective. Most ground-based and air-based systems would operate at long distances. The return laser signal from the target is not only attenuated by absorption, reflection and scattering by air-borne gas, dust and liquid particles, but also by the emissivity and reflectivity variations of the target surface. High bandwidth detectors with internal gain are required. Avalanche photodetectors (APDs) are best suited for this purpose due to their high gain-bandwidth characteristics. Robust silicon-APDs are limited to visible and very near infrared region, while InGaAs works well up to certain wavelengths. On the other hand, it is important to realize that the atmospheric attenuation is wavelength dependent. Local changes in the air density yield random fluctuations in the refractive index, diverging the laser signal. Consequently, longer wavelength (MWIR: 3-5mum and LWIR: 8 -12mu m) source-detector systems are required to overcome the practical and seasonal conditions of the atmosphere. Previous efforts on HgCdTe APDs has been based on expensive CdZnTe substrates . The paper reports on the first HgCdTe based MWIR (3-5mum) APD grown on Si substrates by molecular beam epitaxy(MBE) [C2230]

## "Special GPR antenna developments for landmine and UXO surveys"

Ground penetrating radar (GPR) is a promising technique for detecting and identifying buried landmines and UXOs. The antenna plays a critical role in determining the performance for tasks and requires to have a broad bandwidth, minimal ground dependency, fast or no antenna ring-down, desirable polarization and pattern characteristics. Three unique UWB dual-polarization GPR antenna designs are discussed. A dielectric rod antenna, covering from 1 GHz to 6 GHz, is suitable for shallow (less than 12 inches) targets, such as landmine detection/identification. The other two antennas, covering frequencies from 20 MHz to 800 MHz, are suitable for general GPR applications, such as the detections of pipes, utility lines, UXOs, AT mines, etc. [C2231]

## "Enhanced detection and classification of buried mines with an UWB multistatic GPR"

We present a resonance-based classification technique for the identification of plastic-cased antipersonnel (AP) land mines buried in lossy and dispersive soils under rough surfaces by a stepped-frequency ultra-wideband

(UWB) downward-looking ground penetrating radar (GPR) with an array of receivers. For this application the multistatic ground probing sensor is positioned just above the ground surface and operates from UHF to C-band frequencies. Novel physics-based models based on the finite difference frequency domain (FDFD) technique simulate the characteristic resonating multi-aspect target frequency responses for several realistic buried land mine detection scenarios. Matched filter detection results are presented which assess the GPR's performance in identifying a simulated mine buried under a rough surface at varying depths in dry sand and a dispersive clay loam soil and distinguishing them from false targets such as buried rocks. [C2232]

## "A noncoherent system approach to through-the-wall radar imaging"

A noncoherent, stepped-frequency, through-the-wall radar system approach, based on a trilateration technique, is presented. This approach involves multiple independent radar units and, as such, provides flexibility in positioning the units with various stand-off distances and inter-element spacing. We demonstrate the proposed noncoherent system approach in an indoor environment using real data. The experimental results show that the radar is able to detect and locate multiple targets behind walls. [C2233]

## "Through-wall measurements of a Doppler and direction-of-arrival (DDOA) radar for tracking indoor movers"

We demonstrate the use of a low-cost, two-element receiving array for tracking human movements in indoor surveillance applications. The concept entails simultaneously resolving the Doppler frequencies and the directions of arrival (DOA) of the returned signals from moving targets. The carrier frequency is 2.4 GHz, as it provides significant through-wall penetration. Moving target detection up to 30 feet distance through a 15-inch brick wall is demonstrated. Through-wall data of multiple movers is also collected using our system. [C2234]

## "Recognition of the predetermined random signals involving the unknown signals"

Some practical peculiarities of random signals recognition methods are considered for non-traditional cases when the signals with unknown probabilistic characteristics are presented for recognition along with the signals predetermined in a probabilistic sense. The distinctive peculiarities of the present work is that it considers the solution signals recognition problem on the basis of different probabilistic models-in the form of autoregression processes, mixtures of standard distributions, expansions in orthogonal functions of random signals. The data on decision of recognition problems are considered. In particular, that is decision the different problems of recognition signals for radio control, recognition of any types of targets by signals features using narrow-bend signals and recognition signals for medical diagnostic [C2235]

## "Positioning a time-varying number of targets by a wireless sensor network"

In this paper we address the problem of positioning of multiple targets based on measurements obtained by sensors comprising a sensor network. The measurements represent a superposition of signals that carry information about the positions of the various targets. The sensors send the sensed information to a fusion center that combines the received data from all the sensors and carries out necessary computations. The number of targets may vary with time in an unknown way. We propose a particle filtering-based method for detecting the number of active targets and for estimating their positions. The particle filtering was carried out on data that represent measurements of acoustic signals, but it can also be applied to other types of signals. We provide simulations that show the performance of the particle filtering method in scenarios with one and two targets. [C2236]

## "Peak picking losses in radar detectors"

In this paper we analyze the peak picking losses induced by conventional radar signal processors, which assume a point target model for detection and tracking. As demonstrated through simulations, the performance degradation under the point target assumption can be significant for high-resolution radars, where targets extend across several detection cells. Interpolation of nearby data around the detected peak provides only a slight improvement. This paper presents a maximum likelihood estimator (MLE) to reduce the peak picking losses. By comparing the variance of the estimator with the Cramer Rao lower bound derived in this paper, it has been shown that the maximum likelihood estimator significantly reduces peak picking losses [C2237]

## "Sonar processing for short range, very-high resolution autonomous underwater vehicle sensors"

In an attempt to improve manual and automated sea mine classification results, autonomous underwater vehicles (AUV) are being outfitted with short-range, very high-resolution sonar sensors. To improve pattern classification results in this regime, artifacts caused by platform motion, sonar beam pattern, and the ocean bottom clutter are

first removed from the image. Several preprocessing steps for high-resolution imagery are developed and integrated to help isolate and discover the enduring features of high value targets. Classical denoising, segmentation, and feature-based equalization preprocessing techniques for target localization are adapted and demonstrated. [C2238]

## "An algorithm or the neural fusion of IRST & radar for airborne target detection"

This paper investigates in to the possibility of using a BAM correlating encoding based neural fusion of IRST and radar at the point of the IRST's maximum range. During training phase (in peace time or at a safe place or range), intermittent appearance of a target on IRST display can be recorded in a temporal array. Corresponding intermittent appearance on radar will also be recorded on another array. Treating IRST array as horizontal array and radar array as vertical one, these two binary arrays will be made bipolar by replacing 0s with 1s and multiplied and square or rectangular arrays obtained. A large number of sets can be obtained like this representing the entire representative situations and corresponding square matrices added to form a general weight matrix. Data corresponding to the intermittent appearances of targets and other objects on radar display will be kept in the forms of binary arrays as database. In application phase, if a target is detected through the radar at the maximum range where target appears on the IRST display, radar can be switched off. IRST display will show intermittent appearances of the target, which may be difficult to track or even to discriminate from nearby bird or far off planet/star. The data collected for a number of frames for a single target's estimated intermittent appearance will be stored in an array as binary data. This binary array will be multiplied with the general weight matrix and resulting vertical matrix after thresholding represents an estimated radar data. This approximated radar binary array can be compared with stored radar representations and nearest class can be declared the class of the object present in the scene. As a further improvement, this whole experiment can be performed in a peaceful condition and the estimated radar representation obtained can be compared with exact radar representation and error calculated. Another neural model (like multilayer perceptron) can be used to provide a feedback to correct the errors in the radar estimation. The process basically works as an adaptive filter and predicts a radar array corresponding to the IRST array. The success of the algorithm depends on the training (selecting representative situations) and the implementation methods. Optical implementatio- n with optical associative memories can also be experimented for faster processing. [C2239]

## "Ultra narrow band adaptive tomographic radar"

This paper addresses the issue of spatial diversity in radar applications. Typically, information concerning ground and air targets is obtained via monostatic radar. Increased information is often equated with increased bandwidth in these radar systems. However, geometric diversity obtained through multistatic radar operations also affords the user the opportunity to obtain additional information concerning threat targets. With the appropriate signal processing, this translates directly into increased probability of detection and reduced probability of false alarm. In the extreme case, only discrete ultra narrow band (UNB) frequencies of operation may be available for both commercial and military applications. With limited spectrum, UNB in the limiting case, the need for geometric diversity becomes imperative. This occurs because the electromagnetic spectrum available for commercial and military radar applications is continuously being eroded while the need for increased information via radio frequency (RF) detection of threat targets is increasing. In addition, geometric diversity improves target position accuracy and image resolution, which would otherwise remain unavailable with monostatic radar. [C2240]

## "Vehicle classification by vibration analysis using millimeterwave sensors"

Vibration signatures of battlefield vehicles are strong criteria to discriminate real targets and decoys (Ebert, 2002). To implement vibration detection in a fire control radar system, it is important to analyse the behaviour of vibration signatures over a respective frequency range. This paper shows the first results of a pilot study which analyses vibration signatures of real battlefield targets at 10 GHz, 35 GHz and 94GHz. [C2241]

## "An augmented state SLAM formulation for multiple line-of-sight features with millimetre wave RADAR"

Millimetre wave RADAR can penetrate certain non-metallic objects, meaning that multiple line-of-sight objects can sometimes be detected, a property which can be exploited in mobile robot navigation in outdoor unstructured environments. This paper describes a new approach in predicting RADAR range bins which is essential for simultaneous localisation and map building (SLAM) with millimetre wave RADAR. The first contribution of this paper is a SLAM formulation using an augmented state vector which includes the normalised RADAR cross sections (RCS) and absorption cross sections of features as well as the usual feature Cartesian coordinates. The term "normalised" is used as the actual RCS is incorporated into a reflectivity parameter. Normalisation results as it is assumed that the sum of this reflectivity parameter and the absorption and

transmittance parameters is unity. This is carried out to provide feature rich representations of the environment to significantly aid the data association process in SLAM. The second contribution is a predictive model of the power-range spectra (often referred to as range bins), from differing vehicle locations, for multiple line-of-sight targets. This forms a predicted power-range observation, based on estimates of the augmented SLAM state. The formulation of power returns from multiple objects down-range is derived and predicted RADAR range spectra are compared with real spectra, recorded outdoors. This prediction of power-range spectra is a step towards a full, RADAR based SLAM framework. [C2242]

## "Space-time adaptive processing for space based radar"

Spaced-based radar space-time adaptive processing (STAP) in a heterogeneous clutter environment is addressed. An efficient Kalman Filter implementation of the normalized form of the parametric adaptive matched filter (NPAMF) is introduced and shown to perform well against a detailed, ground moving target indication (GMTI) simulation. The number of secondary data range cells required by NPAMF is much smaller than the product of spatial channels and pulses and, thus, NPAMF is attractive for low sample support applications. Results indicate that the same minimum detectable velocity can be realized with about half the SBR aperture if conventional Doppler processing is replaced with STAP, in particular, NPAMF. [C2243]

## "Modelling of sea clutter with Gaussian mixtures and estimation of the clutter parameter"

In order to model sea clutter, we propose to use a generalized distribution which is valid for different background statistics, like low and high sea states. The envelope detector's input statistics are assumed to be a Gaussian-mixture (GM). A new background probability density function (pdf) resembles Rician mixtures. In order to detect targets using adaptive techniques, clutter background statistics should be known a priori. In practice, however, background statistics are typically not known a priori. Thus, a joint estimation and detection process is employed whereby the background statistics are estimated before target detection. We estimate the parameters using a maximum likelihood (ML) based method from the output of the envelope detector. Performance analysis is presented using real sea clutter data. [C2244]

## "Solid or not solid: vision for radar target validation"

In the context of combining radar and vision sensors for a fusion application in dense city traffic situations, one of the major challenges is to be able to validate radar targets. We take a high-level fusion approach assuming that both sensor modalities have the capacity to independently locate and identify targets of interest. In this context, radar targets can either correspond to a vision target- in which case the target is validated without further processing- or not. It is the latter case that drives the focus of this paper. A non-matched radar target can correspond to some solid object which is not part of the objects of interest of the vision sensor (such as a guard-rail) or can be caused by reflections in which case it is a ghost target which does not match any physical object in the real world. We describe a number of computational steps for the decision making of non-matched radar targets. The computations combine both direct motion parallax measurements and indirect motion analysis- which are not sufficient for computing parallax but are nevertheless quite effective- and pattern classification steps for covering situations which motion analysis are weak or ineffective. One of the major advantages of our high-level fusion approach is that it allows the use of simpler (low cost) radar technology to create a combined high performance system. [C2245]

## "Radar clutter suppression using adaptive algorithms"

Radar clutter is the extraneous return waveform from the radar background environment. Because the clutter has a large cross-section, radar clutter can seriously degrade target detection. Conventional radar systems assume the clutter is stationary with its energy concentrated at low frequencies. Thus, a fixed high pass filter (HPF) is used to filter out the clutter. This approach has two major problems: (1) it degrades detection of a slow moving target, and (2) it cannot filter out the high frequency clutter. To overcome the difficulties of conventional radar clutter suppression algorithms, This work proposed two adaptive clutter suppression schemes to enhance the target detection probability. Computer simulations are used to evaluate the performance of the proposed clutter suppression algorithms. [C2246]

## "Radar sensors and sensor platform used for pedestrian protection in the EC-funded project SAVE-U"

The automotive industry and sensor suppliers have responded to the European Commission's request to reduce the road fatalities by 50% until 2010 and they are developing advanced systems for road safety. Short range radar (SRR) sensors in the 24 GHz domain allow coverage of the surroundings of the vehicle, complementing the existing 77 GHz radars used for adaptive cruise control (ACC) systems since 1999. This paper deals with a

special variant of pre-crash systems, namely: "pre-crash for vulnerable road users protection". The target is the protection and collision mitigation of pedestrians and bicyclists versus a vehicle. To achieve trigger information for automatic protection systems (like automatic braking or other reversible systems) as well as warning information for drivers, a high performance sensor platform is necessary. This paper presents approaches from the EC-funded project SAVE-U (sensors and system architecture for vulnerable road users protection) of the fifth framework program of the European Commission. The sensor platform consists of short range radar sensors, cameras in the visible and infrared domain. The focus is located on a high- and low-level- data fusion architecture to fulfill the strong requirements. The intension of this paper is mainly to describe the 24 GHz short range radar sensor development for the detection capability of pedestrians in ranges up to 30 m and the sensor fusion technique. [C2247]

## "A method for detecting RGPO/VGPO jamming"

This paper proposes a general approach to detect the presence of deceptive counter measures such as RGPO or VGPO. The method which is based on the Kalman filter lays its foundation on drift between Doppler measurement and the Doppler information obtained from the range measurement of a target in track. By measuring this drift by Mahalonobis distance metric and comparing it with a predefined threshold; detection is performed. The performance of the proposed approach is illustrated through a simulation. [C2248]

## "TWT phase noise reduction techniques"

The traveling wave tube amplifier (TWTA) is widely utilized in RF amplification for radar transmitters. This application requires very low phase noise in order to distinguish a moving target from strongly reflected clutter. This paper provides better understanding of the phase noise behavior of a TWTA and discusses new methods to substantially suppress this noise. [C2249]

## "Target Tracking 2004: Algorithms and Applications"

First Page of the Article [C2250]

## "The advanced protection of vulnerable road users (APVRU)-project information sheet"

Summary form only given. The aim of the APVRU project is to develop a sensor system capable of detecting a pedestrian (or other vulnerable road user) and to distinguish vulnerable road users from the road environment. This sensor system may eventually provide the technological link between detection and a driver warning system or activation of a suitable safety system on the exterior of the vehicle. The sensor system that is currently under development comprises radar units to determine the range and bearing of an object. Infra-red sensors then determine whether or not the object is a vulnerable road user by analysing the size, shape, position and distribution of the infra-red image. The information regarding the relative position of the vulnerable road user, as well as information on the car's speed, will be processed using algorithms that will decide when an active safety system should or should not deploy. [C2251]

## "Weak target detection by multiscale space-time adaptive processing"

STAP is a recent popular research field in which a multichannel and multipulse radar system is utilized to enhance the performance of radar detection under severe clutter and jammer conditions. Real-time STAP requires an intelligent lower dimensional processor realizable from a computational point of view. Several "reduced-dimension (or partially adaptive) STAP" techniques have been introduced to represent the noise sub-space and reduce the dimension of the weight vector. Beside these approaches, we introduce a new technique which is based on modeling the radar clutter as a multiscale stochastic process. Our approach is shown to be capable of outperforming the popular partially adaptive STAP algorithms although the computational complexity is significantly reduced. [C2252]

## "Buried object detection by using GPR"

The process of detecting buried objects using ground penetrating radar (GPR) is presented. Background removal, filtering and correlation within a window are used to reveal the target's reflected energy. When a considerable increase in the reflected energy is observed, a detection warning signal is created, depending on a parameter explained in the algorithm. The warning signal is activated over the buried objects, until the energy level falls to its initial trigger level. Thus, the buried object position is determined. A pulsed GPR system with 1 GHz bandwidth is used. [C2253]

## "Detection of sea targets from thermal images"

The sea target detection problem from thermal (IR) images is solved by using statistical classification methods. Background modelling is achieved via principle component analysis (PCA) followed by a two-class Bayes classification step, i.e., target or sea. A wavelet-denoising block is added to the system resulting in a significant increase in the detection performance. K-means clustering is also implemented to explore the target detection accuracy without training. It is concluded that the PCA training provides high detection accuracy while the K-means clustering mostly fails to classify sea targets. [C2254]

## "UWB applications for through-wall detection"

Preliminary experimental investigations on the application of UWB electromagnetic signals for through-wall detection are presented. Measurements are conducted using pulses with a full-width half-maximum (FWHM) nearly equal to 85 ps. This corresponds to a spatial resolution of about 26 mm. A simple signal processing approach is also introduced to extract the target image from the reflected fields. [C2255]

## "Joint Doppler and polarization characterization of moving targets"

In through-the-wall imaging radar systems, the synthesized images may not provide sufficient range and cross-range resolution for visual classification and identification of the targets. Target movement and target Doppler characteristics can be used to combat resolution limitations and improve object discrimination. However, slowly moving targets and targets moving perpendicular to the incident waves render target motion ineffective in high-resolution imaging. We utilize the target's polarization properties and introduce time-varying polarization signature estimation based on polarization time-frequency distribution. [C2256]

## "Ground moving target detection for along-track interferometric SAR data"

This paper investigates different metrics for ground moving target indication (GMTI) with a multichannel synthetic aperture radar (SAR). These metrics are especially sensitive to targets that have an across-track component of velocity, vy, although they can also detect targets with an along track velocity component, vx. Not only are the metrics suitable for fully SAR compressed data, they are also meaningful when computed for range (pulse) compressed but Doppler uncompressed data (raw data). The use of both data domains allows for target detection over a larger vyrange than either used individually. For large vy, side-lobe suppression in fully SAR compressed data simultaneously suppresses the targets, giving an advantage to the raw data domain. For low vy, and especially with low RCS targets, the SAR compression gain facilitates detection, giving an advantage to the SAR compressed domain. By viewing the SAR compression as the application of a linear filter, the metrics are shown to be suitable for target detection after any linear filtering of the raw data, such as a linear time-frequency filter, or a simple transformation into the Doppler domain using an FFT filter. The metrics have in common that they are all based on the eigenvector decomposition of the sample covariance matrix. Their statistical properties are analytically compared and their detection capabilities are demonstrated on measured two-channel airborne SAR data in a variety of data domains. Some metrics are shown to allow target detection with low false alarm rates even in heterogeneous terrain, such as in urban areas, without compromising the probability of detection. [C2257]

## "Multi-band antenna technology"

Enhancing the operational capability of current sensors and radar systems to detect targets at long ranges and map the terrain in all kinds of weather is a well-accepted measure. Multi-target tracking would require multi-beam, multi-band scanning phased array antennas. Therefore, in order to meet the current challenges, current sensor systems and radar systems must be expanded and strengthened to support the ever-increasing military requirements. Phased array antennas have emerged as the most viable solution for these important applications that include surveillance, tracking targets on the ground and for high-resolution ground mapping when operating at a sufficient altitude. Active phased array radar uses an advanced antenna system that not only employs electronic phase shifters to provide beam steering, but also contains solid-state RF amplifiers and low noise amplifiers for signal reception. Such phased array radar systems provide an excellent alternative to conventional radar systems on unmanned airborne vehicles (UAVs) or other air-platforms for surveillance and reconnaissance. In addition, the active array radar system offers advantages in the areas of power management and efficiency, reliability, signal reception, beam steering target detection and system performance. [C2258]

## "Development of an ultra wideband ground penetrating radar (UWB GPR) for nondestructive testing of underground objects"

A compact ground penetrating radar (GPR) using an impulse waveform is developed. The UWB GPR system is

composed of an impulse generator, ultra wideband transmitting and receiving antennas, high speed digitizer, and a laptop computer for data storage and image processing. By considering the maximum measuring depth and soil properties, a proper impulse generator is made and then a novel compact traveling wave monopole antenna is designed to transmit the impulse and receive the reflected signal. Also, image processing for visualization of buried targets is performed. For verification, a UWB GPR prototype is built and tested. It is shown that the system has very good depth and spatial resolution. [C2259]

## "Target detection and tracking using a UWB sensor web"

This paper describes the experimental and simulation studies that were conducted to locate and track a target inside a UWB sensor web system. The sensor web was designed using second generation UWB prototype devices and the simulation software was developed using MATLAB and C language. Return scans from the UWB devices were analyzed to determine the noise floor and the signal strength. Using the noise floor level, a threshold level is set above which the alarm is triggered to indicate the presence of a target. The probability of false alarm (PFA) is also determined using the signal-to-noise ratio and the threshold. The PFA was varied to minimize the false alarm level. The noise statistics of the sensor web system was also analyzed using the Kolmogorov-Smirnov (KS) test. [C2260]

## "A 1GHz CMOS analog-front-end for a partial-response read channel"

An analog front-end including a continuous-time equalizer to shape the received waveform into a 6-sample target, and a DFE-driven timing recovery loop is presented. With soft Viterbi detection, sensitivity is within 1.5dB of simulations at a rate of 24/25 and user density of 3.4. The 0.35 µm CMOS chip consumes 240mW at 800MHz, and 380mW at 1 GHz clock rates. [C2261]

## "L-band SBR moving target detection in SAR-GMTI modes"

Space Based Radars (SBR) are being considered for a wide range of area surveillance tasks due to the global, all weather capability to image and detect moving targets. SBR has the capability of detecting either slow moving ground targets or high speed airborne targets, in addition to the familiar synthetic aperture radar (SAR) imaging mode. However, due to the high satellite velocity and long wavelength of an L-band SBR, detection of slow moving targets is very difficult. Two radar modes are being considered: Multiple-Channel Ground Moving Target Indication Space Time Adaptive Processing (GMTI STAP), and Along Track Interferometry (ATI) SAR. The system implications and mode requirements are reviewed for efficient wide area surveillance. [C2262]

## "An assessment of multi-static radar remote sensor networks"

Bistatic radar has been considered for many years as an element of ground based air defense systems to counter against low observable airframes. To achieve these benefits, it is necessary to deploy the network of bistatic radar elements across an area where a large proportion of the reflected energy is anticipated. For security and vulnerability reasons this network is typically deployed within safe, protected areas. This requirement limits the range of applications to which bistatic and multi-static radar can be applied. The recent emergence of unattended ground sensors (UGS) and uninhabited air vehicle (UAV), systems shows that these platforms are sufficiently mature for consideration as remote receiver/transmitter sites. However for this to be realized it is essential that the cost, capability and vulnerability of these sensors is considered. Within This work a multi-static radar tool which is used to compare a range of multi-static radar network distributions is described. This tool is used to assess detection capability and hence indicate comparative costs for two geometric targets frying a linear path. [C2263]

## "The best linear unbiased with greatest of selection (BLUGO) CFAR algorithms"

This work presents a new CFAR detector with greatest of selection based on best linear unbiased method (BLUGO-CFAR). This CFAR detector has the ability of CFAR algorithms with greatest of selection to control the rise of false alarm rate at clutter edge, it also has the advantage of CFAR algorithms based on order statistics in multiple targets situation. The analytic results show that the performance of BLUGO is evidently superior to that of OSGO both in homogeneous background and in multiple targets situations, resulting by an increase in the number of order statistics to estimate the noise power level. Since the reference window is split into two sub-windows, the sample sorting time is reduced as half as that of OS. If Ml=M2=0, Nl=N2=0, BLUGO reduces to GO, if M1=N1=O, BLUGO reduces to MX-CMLD. [C2264]

## "Precision dynamic SAR testbed for tactical missiles"

The United States Army is currently investigating the feasibility/utility of a high resolution Synthetic Aperture

Radar (SAR) mode for the detection and subsequent engagement of targets by tactical missiles. A precision dynamic SAR testbed has been designed, constructed and installed by the United States Army Aviation and Missile Command's (AMCOM) Aviation and Missile Research, Development and Engineering Center (AMRDEC) at Redstone Arsenal, Alabama. The purpose of the testbed is to allow the development and evaluation of image formation algorithms, motion compensation techniques, and autofocus algorithms in a controlled and repeatable environment. [C2265]

## "Target classification based on near-distance radar sensors"

Automotive radar systems offer the capability to measure very accurately target range, relative velocity, and azimuth angle of all objects inside the observation area. For future automotive applications like pedestrian safety systems, collision warning, turning-off and lane-changing assistance it will be necessary to have more detailed information about the target type. Therefore, a target classification technique, which is purely based on the range profile measured by a near-distance radar sensor, is presented in this paper. [C2266]

## "Multi-target multi-object tracking, sensor fusion of radar and infrared"

This paper presents algorithms and techniques for single-sensor tracking and multi-sensor fusion of infrared and radar data. The results show that fusing radar data with infrared data considerably increases detection range, reliability and accuracy of the object tracking. This is mandatory for further development of driver assistance systems. Using multiple model filtering for sensor fusion applications helps to capture the dynamics of maneuvering objects while still achieving smooth object tracking for not maneuvering objects. This is important when safety and comfort systems have to make use of the same sensor information. Comfort systems generally require smoothly filtered data whereas for safety systems it is crucial to capture maneuvers of other road users as fast as possible. Multiple model filtering and probabilistic data association techniques are presented and all presented algorithms are tested in real-time on standard PC systems. [C2267]

## "Linear and nonlinear spatial selection methods for small low speed target in sea clutter observation improvement"

In the process of detection of small surface objects in clutter, some specific problems appear. The main cause is the fact that useful signal amplitude is commensurable and in some cases is less than the amplitude of reflections. Most of all, for slow surface objects the desired signal spectrum is situated inside the sea clutter one. In that case, both spectral and amplitude selection and detection methods become ineffective. As is known, signal reflected from the sea surface is characterised by spatial periodic structure. At the same time, sizes of most surface objects do not exceed a radar resolution element and they can be considered as dotted ones. Therefore, to improve radar observation of small objects in sea clutter, it is possible to use information about noise spatial performances. The usage of spatial periodicity of sea-echoes allows one to improve efficiency of the small low speed targets in sea clutter observations. [C2268]

## "The arrival angle performances for signals scattered by the targets and sea surface and their usage for detection efficiency improvement"

The target angular noise is used for detection reliability improvement or as a criterion for pattern recognition. The experimental research of angular fluctuations is conducted using the impulse 8 millimeter-wave radar. Results have shown that the small surface target signals are characterised by a much smaller range of azimuth fluctuations in comparision to that of from the sea surface. While the average value of the surface target bearing coincides with right direction and has a rather small variance of fluctuations, the marine surface is characterised by arrival angle roaming in the limits of the whole highlighted area. Application of the angular noise for target detection is based on its statistical performance modification, when the compact reflector (surface target) appears on the background of spatially distributed sea surface reflections. [C2269]

## "A hybrid measurement fusion algorithm for multisensor target tracking"

In order to improve the target tracking consistency and the anti-jamming ability of ship-borne surveillance and fire control system, a centralized multisensor target tracking system was constructed. The system comprised a four-band radar working in frequency hopping mode, a passive infrared angular tracker, a television angular tracker, and a laser distance detector. All the sensors are mounted on the same platform. A hybrid measurement fusion algorithm is presented, which firstly compresses the measurements of the same type, and then updates the target track by using sequential multisensor probabilistic data association (MSPDA) method. Numerical simulation results show that the hybrid fusion algorithm improves the tracking accuracy significantly and requires much less computation than the sequential MSPDA method. [C2270]

## "On the debugging of a high clutter tracking system"

The Raytheon High Clutter Tracker (HCT) enables conventional marine radars to detect and track small targets such as swimmers, life rafts and open boats in heavy seas and at long range. In this article a general introduction to the project is given. Then, three debugging and diagnosis software tools are presented. Examples are given to demonstrate the ideas and how the tools are helpful for real world system diagnosis and system performance tuning up. [C2271]

## "A switching constant false alarm rate technique for high frequency surface wave radar"

A novel constant false alarm rate (CFAR) technique is proposed as a near optimal solution for detection in mixed homogeneous and nonhomogeneous environments. This CFAR technique explores both the advantages of cell averaging CFAR and order statistics CFAR detectors. We introduce a criterion to derive a near-optimal target detector for high frequency surface wave radar. The effectiveness of the new technique is demonstrated by comparing its performance with traditional CFAR technique using data collected from the HFSWR network on the east coast of Canada. [C2272]

## "A novel method for clutter reduction in the FLGPR measurements"

A new method of removing rough-surface clutter in forward looking ground penetrating radar (FLGPR) is proposed based on the physical optics model. The Wigner-Ville distribution (WVD) is proposed to perform a time-frequency analysis. The instantaneous power is worked out to do further processing. By imaging the instantaneous power, we can detect a target more accurately. The treatment comparisons of the experimental data show that the clutter-reduction method presented is better than the conventional method. [C2273]

## "A hybrid approach for target detection using CFAR algorithm and image processing"

In ship detection, a key aspect is to keep a low level constant false alarm rate combined with a high detection probability in presence of clutter background, caused by reflections from wave tops on the sea, rain, snow or fog. Generally, the constant false alarm rate (CFAR) algorithm is applied, which is based on the assumption that clutter background can be modeled using a Gaussian distribution, generating a high level of false alarms in presence of non Gaussian clutter. This problem has been addressed under two independent approaches: modeling the environment noise (sea clutter) with independent non Gaussian models or using variations of CFAR detection algorithm. Both approaches provide good results only for specific characteristics of clutter. We discuss a hybrid approach for target detection that use three probabilistic models of clutter associated to sea state (Gauss, Weibull and K distributions), detection algorithms with adaptive threshold for CFAR, classification algorithms that associate a noise model with a specific CFAR algorithm according to the sea state, and low level morphological operations to generate an image of targets. The goal of this approach is provide an automatic mechanism to associate a clutter model with a specific CFAR algorithm according to sea state in order to obtain radar images without clutter. The proposed detection approach is evaluated by high level simulation. Results are presented and discussed. [C2274]

## "Automatic detecting system for ship wakes in SAR images"

An automatic system based on localized Radon transform was proposed for detecting ship wakes in SAR images. Ship pixels in SAR image were masked out during pre-process in order to eliminate their own disturbance. Then localized Radon transform windows around ship targets were selected. At last, normalized line integrals were calculated within the localized Radon transform windows and the extremum in Radon transform space was the corresponding ship wake coordinates. This automatic system can detect ship wakes in SAR images accurately and quickly. So, the algorithm efficiency is very high. [C2275]

## "Discrimination of subsurface targets with a plane of symmetry using polarimetric bistatic radar"

First Page of the Article [C2276]

## "Real-time vision based ego-motion estimation for outdoor mobile robot"

Ego-motion estimation is a key issue of outdoor mobile robot navigation, especially in the demand of moving object tracking. In this paper, we proposed correspondence based method, which apply iterative closest point (ICP) algorithm to match feature points on ground plane. However the outliers in the scene contribute false measurement for estimation, thus we introduce a stereovision-based method to detect free-space on the road plane. Then we extract edge points in the free-space as primitives, which avoid the limit of the rigid scene hypothesis. This method has been tested on THMR-V (Tsinghua mobile robot V), which is an outdoor mobile

robot developed by Tsinghua University. Through various experiments we successfully demonstrate its real-time performance and high robustness. [C2277]

## "Buried target signature extraction from ground penetrating radar signal based on the equivalence principle"

First Page of the Article [C2278]

## "VPH: a new laser radar based obstacle avoidance method for intelligent mobile robots"

Real-time obstacle avoidance is one of the key issues in successful application of mobile robot systems. Some new real-time obstacle avoidance methods for mobile robots have already been developed and implemented. This paper introduces the developments in this area, and summarizes Potential Field method (PFM) and the Enhanced Vector Field Histogram method (VFH+), which are widely used for autonomous mobile robot obstacle avoidance. After a brief introduction of laser measurement system (LMS), a new radar-based obstacle avoidance method for mobile robots, based on the combination and improvement of PFM and VFH+ method, is presented. This method, named the Vector Polar Histogram method (VPH), uses laser radar to detect obstacles and takes the physical meaning of the vector polar into account, so as to get the best avoidance choice. The new method permits the detection of unknown obstacles and avoids collisions in real time while simultaneously steering the mobile robot towards the target. [C2279]

## "Analysis of clutter distribution in bistatic high frequency surface wave radar"

In high frequency surface wave radar (HFSWR), surface target detection is mainly limited by ocean clutter and ionospheric clutter. In order to investigate further the nature of both clutters and to develop potential strategies to enhance target detection, an experiment was conducted to operate a radar simultaneously in both monostatic (transmitter and receiver are co-located) and bistatic (transmitter and receiver are far from each other) modes. Experimental results from bistatic HFSWR are compared to those from monostatic HFSWR. It is shown that the ionospheric clutter has different distributions for the two modes. This difference may potentially be exploited to enhance the performance of the radar. A comparison between the predicted Bragg frequency and measured Bragg frequencies has been undertaken and it is shown that the Bragg frequency has a curvature along the range due to the side scattering experienced in bistatic operation. [C2280]

## "Beamforming and signal processing with sparse, random arrays for space based radar"

We investigate moving target detection with a space-based cluster of radar satellites, modeled as a random sparse array. For a linear array which moves along its axis, the optimum space-time processing leads to a DPCA-like solution. We analyze the performance degradation with array pitch (satellite cluster rotation) and yaw (Earth rotation) and known random element position errors. Results show that the signal/clutter improvement factor is an extremely sensitive function of the pulse repetition frequency and that it varies over a large dynamic range. Achievable improvement factor maxima are moderately degraded by array pitch and strongly degraded with increasing position errors. Yaw effects appear to be negligible. In general, with increased randomness, fewer elements contribute to form DPCA pairs so that satellite usage efficiency (and SNR) is degraded. [C2281]

## "Selection's algorithms of regulyariziruyushey spatial harmonic of noise jamming in the system of spatial-polarization of signals-processing"

The analysis of selection's algorithms of regulyariziruyushey spatial harmonic of noise jamming in the combined system of adaptive spatial-polarization signals-processing is represented in the work. Successive inclusion of spatial, and polarization adaptive filters, that allow to decide the task of detection of radio location target in general sense, when the spatial spectrum of power of active noise jamming has an arbitrary structure. [C2282]

## "Anomaly subspace detection based on a multi-scale Markov random field model"

We introduce a multi-scale Gaussian Markov random field (GMRF) model and a corresponding anomaly subspace detection algorithm. The proposed model is based on a multiscale wavelet representation of the image, independent components analysis (ICA), and modeling each independent component as a GMRF. The anomaly detection is subsequently carried out by applying a matched subspace detector (MSD) to the innovations process of the GMRF, incorporating a priori information about the targets. The robustness of the proposed approach is demonstrated with application to automatic detection of airplanes on synthetic cloudy sky backgrounds. [C2283]

## "Optimal cooperative placement of GMTI UAVs for ground target tracking"

With the recent advent of moderate-cost unmanned (or uninhabited) aerial vehicles (UAV) and their success in surveillance, it is natural to consider the cooperative management of groups of UAVs. The problem considered in this paper is the optimization of the information obtained by a group of UAVs carrying out surveillance of several ground targets distributed over a large area. The UAVs are assumed to be equipped with ground moving target indicator (GMTI) radars, which measure the locations of moving ground targets as well as their radial velocities. In this research, the Fisher information, obtained from the information form of Riccati equation, is used in the objective function. Sensor survival probability and target detection probability for each target-sensor pair are also included in the objective function. The optimal sensor placement problem is solved by a combination of deterministic as well as randomized optimization. Simulation results on two different scenarios are presented for four different types of prior information. [C2284]

## "A Monte Carlo simulation based approach to a priori performance prediction for target detection and recognition in cluttered synthetic aperture radar imagery"

Multi-sensor systems for wide area surveillance and tracking are an area of increasing interest for civil and military applications. In order to design these systems to reliably achieve a specification, performance models are required for each of the system components, to allow synthesis of the overall system performance. The work presented in this paper addresses the problem of a performance model for the target detection and recognition performance of a SAR sensor component in a surveillance system. A Monte Carlo simulation based approach is described which is used to predict the receiver operating characteristic (ROC) as a function of the target, the clutter background and the sensor specification for a template matching recognition algorithm. Some initial results from an experimental validation trial are presented and it is concluded that there is sufficient similarity between the current model's predictions of performance and the actual performance achieved with representative real data to encourage further development work. [C2285]

## "Control of false track rate using multiple hypothesis confirmation"

A modem surveillance radar system is likely to return several hundred plot detections per radar scan, especially if the system is searching for targets of low radar cross section such as sea skimming missiles against a background of sea clutter. The track extractor must take this plot data and present a track picture that is sufficiently clean of false and clutter tracks that it can be readily understood. Techniques based upon "tentative tracks" are shown to have limitations in their ability to confirm tracks in clutter, and multiple hypothesis techniques are demonstrated that overcome these problems. [C2286]

## "Investigation of video marine radar signal"

In the article true and digital video radar signal are presented. Limits and possibilities of radar signal detection and errors, which can occur, are especially important for target tracking in ARPA. A radar picture presented on the monitor depends on processor programming, which can sometime have limits. [C2287]

## "Moving target indication"

The function of the moving target indication is to suppress the radar returns from static or slow-moving unwanted objects and to pass, for further processing, the echoes from the aerial or sea surface moving objects or targets. The moving target indication adaptability facilitates the radar sensor to adjust its operational capabilities to the current weather conditions in the area swept by radar surveillance envelope. [C2288]

## "Measurement of distance and velocity of a moving target by short-range high-resolution radar utilizing standing wave"

In this paper, we propose a radar using standing wave, and describe the measurement principle and experiment results. This radar does not use a time delay like usual radars but uses the amplitude of the standing wave. As a result of experiments, this radar could measure the distance and velocity of a moving target using bandwidth of only 76 MHz permitted by the specification of low-power radio equipment to detect moving objects (24 GHz band). The bandwidth of the radar is narrower than that of a millimeter wave radar. [C2289]

## "Anomaly detection based on an iterative local statistics approach"

We introduce an iterative anomaly detection algorithm. The algorithm is based on an iterative characterization of the clutter in a feature space of principal components, and a single hypothesis scheme for the detection of anomalous pixels. The iterative procedure gradually reduces the false alarm rate while maintaining a high

probability of detection. Morphological operators are subsequently employed for extracting the sizes and shapes of anomalous clusters in the image domain, and identifying potential targets. Experimental results demonstrate the robustness of the proposed approach with application to sea-mine detection in sonar imagery. [C2290]

## "On estimation of performance of track-before-detect algorithm for 3D stacked-beam radar"

In this paper a non-simulation approach to estimation of performance of a track-before-detect (TBD) technique for a 3D stacked-beam (SB) radar is presented. The TBD algorithm performance is analytically described using a simple model of detection in the SB radar. A method for calculation of trajectory templates for low-observable tactical ballistic missiles detection is proposed. Finally, equivalent processing gains are estimated for particular TBD structures. [C2291]

## "Passive multi-static radiometric detection of moving targets"

The paper presents the concept of passive detection of moving targets based on thermal radiation in the microwave region. The fundamental problem istinction between stationary and moving targets is solved by range-Doppler correlation between signals obtained from different localizations in multi-static radiometric antenna constellations. The range equation and other limitations of the presented method are also discussed in the paper. [C2292]

## "Physics-based airborne GMTI radar signal processing"

The Knowledge-Aided Sensor Signal Processing and Expert Reasoning (KASSPER) program aims to improve airborne ground moving target indicator (GMTI) radar performance by taking into account all available prior knowledge. One powerful piece of information is that the radar return signal is a superposition of near-ideal plane-waves. A plane-wave signal and clutter model or sampled GMTI radar data can be used to calibrate the receive array, suppress clutter, and detect moving targets. Each range gate is processed independently. Sample covariance matrices are unnecessary. The synthetic KASSPER challenge datacube is processed to demonstrate performance. [C2293]

## "Improving knowledge-aided STAP performance using past CPI data [Cradar signal processing]"

A technique for incorporating past coherent processing interval (CPI) radar data into knowledge-aided space-time adaptive processing (KASTAP) is described. The technique forms Earth-based clutter reflectivity maps to provide improved knowledge of clutter statistics in nonhomogeneous terrain environments. The maps are utilized to calculate predicted clutter covariance matrices as a function of range. Using a data set provided under the DARPA knowledge-aided sensor signal processing and expert reasoning (KASSPER) program, predicted clutter statistics are compared to measured statistics to verify the accuracy of the approach. Robust STAP weight vectors are calculated using a technique that combines covariance tapering, adaptive estimation of gain and phase corrections, knowledge-aided pre-whitening, and eigenvalue rescaling. Several performance metrics are calculated, including signal-to-interference plus noise (SINR) loss, target detections and false alarms, receiver operating characteristic (ROC) curves, and tracking performance. The results show a significant benefit to using knowledge-aided processing based on multiple CPI clutter reflectivity maps. [C2294]

## "A knowledge-aided GMTI detection architecture [Cradar signal processing]"

Space-time adaptive processing (STAP) plays an important role in ground moving target indication (GMTI). Heterogeneous clutter environments prevent STAP from achieving its theoretical performance bounds. The incorporation of a priori knowledge into the signal processing architecture holds the potential to greatly enhance detection performance by mitigating heterogeneous clutter effects. In this paper we propose one possible knowledge-aided STAP approach comprised of the following elements: a knowledge-aided prediction/estimation filter, a discrete matched filter, and a partially adaptive STAP applied to the clutter residual, assisted by knowledge-aided training. We focus our discussion on justifying the aforementioned elements and independently characterizing their performance potential. Using both measured and simulated data, we find the potential for substantial performance improvement. [C2295]

## "Classification of training data with reduced-rank generalized inner product"

Selection of training data for space-time adaptive processing in radar systems remains one of the critical problems to be solved. The practical application of optimal detection theory relies on a large number of i.i.d. training samples. The required homogeneity is typically assumed to be satisfied by range cells adjacent to the cell under test. This is typically not valid in real-world applications. The generalized inner product has previously been proposed to assist in training data selection. This paper introduces two innovations: (1) the generalized

inner product in the data-adaptive reduced-rank subspace of the multistage Wiener filter; and (2) classification of the available data into distinct, self-homogenous sets. Injected targets in recorded data from the MCARM program are used to assess performance. Training with data classified within the multistage Wiener filter subspace, also known as the Krylov subspace, is shown to outperform the conventional technique of selecting adjacent training cells. [C2296]

## "Simultaneous use of multiple pseudo random noise codes in multistatic CW radar"

In multistatic continuous wave radar, the choice of codes and frequencies used for transmission has a strong influence on detection and ease of parameter extraction. The paper describes the various effects of using single and multiple codes in a number of separated transmitters, either with the same or separated carrier frequencies. To visualize some of the results, synthetic radar data have been generated and used in the processing. [C2297]

## "Multi-resolution signal processing techniques for airborne radar"

Synthetic aperture radar (SAR) exploits very high spatial resolution via temporal integration and own-ship motion to reduce the background clutter power in a given resolution cell to allow detection of non-moving targets. Ground moving target indicator (GMTI) radar, on the other hand, employs much lower resolution processing, but exploits the physical aperture and relative differences in the space-time response between moving targets and clutter for detection. Therefore, SAR and GMTI represent two different temporal processing resolution scales which have typically been optimized and demonstrated independently to work well for detecting either stationary (in the case of SAR) or exo-clutter (in the case of GMTI) targets. Based on this multi-resolution interpretation of airborne radar data processing, there appears to be an opportunity to develop detection techniques that attempt to optimize the signal processing resolution scale (e.g., length of temporal integration) to match the dynamics of a target of interest. The paper investigates signal processing techniques that exploit long CPIs (coherent processing intervals) to improve the detection performance of GMTI radar. [C2298]

## "SAR image formation algorithm with multipath reflectivity estimation"

Recent analysis has resulted in an innovative technique for forming synthetic aperture radar (SAR) images without the multipath ghost artifacts that arise in traditional methods. This technique separates direct-scatter echoes in an image from echoes that are the result of multipath, and then maps each set of reflections to a metrically correct image space. Current processing schemes place the multipath echoes at incorrect (i.e., ghost) locations due to fundamental assumptions implicit in conventional array processing. Two desired results are achieved by use of this new image reconstruction algorithm for multipath scattering (IRAMS). First, the intensities or the ghost returns are reduced in the primary image space, thereby improving the relationship between the image pattern and the physical distribution of the scatterers. Second, a higher dimensional image space that enhances the intensities of the multipath echoes is created which possesses characteristic information about the scene being imaged. These auxiliary "delay" image planes offer the potential or dramatically improving target detection and identification capabilities. This paper develops a robust IRAMS implementation that is based upon the cross-range drift in conventional SAR imagery of the multipath scattering events with respect to changes in the relative aspect angle. The resulting analysis is validated via simulated frequency response data that includes the effects of multipath scattering. [C2299]

## "Efficient robust AMF using the enhanced FRACTA algorithm: results from KASSPER I & II [Ctarget detection]"

This paper presents further developments and results of the FRACTA algorithm which has been shown to be robust to nonhomogeneous environments containing outliers. The main focus here is upon the detection of targets in the KASSPER I challenge data cube which possesses dense clusters of targets and the highly nonhomogeneous KASSPER II data in which severe clutter is present over all ranges and Dopplers thereby hindering the identification of a dominant clutter ridge. The KASSPER II dataset is further exacerbated by dense clusters of targets as well as the presence of several deep shadow regions that not only prevent target detection but may also skew covariance matrix estimation. A doppler-dependent thresholding technique is developed which is then incorporated into the FRACTA.E framework and then applied to the KASSPER II dataset. Simulation results are compared with the standard sliding window scheme as well as when clairvoyant knowledge of the covariance matrices is employed. Results verify the improved performance of the FRACTA.E algorithm. [C2300]

## "Filter algorithm for visual tracking of maneuvering target"

A filter algorithm is presented in this paper for visual tracking of a maneuvering target. Emphasis is given to rind a solution for the degradation in relative position and orientation estimation, which is incurred by the measurement noise in the image coordinates of feature points. Superior to previous approaches that were

limited to the assumption that the target motion is slow and smooth, this algorithm is implementable for a maneuvering target that acts in an unknown manner. First, by analyzing the effect of noise in 2-D images on the position and orientation estimation, linear measure equations based on the sequence of motion parameters are given. Then, two filter schemes are introduced respectively. The first filter uses maneuver detection technique, in which optimized detectors for fast and slow maneuver are deduced respectively, and limited memory filtering is adopted to update the filter. The second filter uses numerical differentiation technique, in which a fading factor is adaptively estimated to restrain the divergence caused by truncation errors of estimate model of numerical differentiation. Finally, generalized pseudo Bayes algorithm is employed to combine the two filters for a higher tracking precision. Simulation and experiment results illustrate the capacity of this algorithm. [C2301]

## "Mathematical model of missile defence system"

Radar system plays an important role in country's defense system. There are three major parts in the missile defense system. They are radar, functional computer and launch base. Radar system could sense fine missile as soon as some part of the missile comes into the system. Here a mathematical model is constructed for the detection and destruction of foreign missiles, using geometrical approach. [C2302]

## "Non-coherent detection of slow-moving targets in high-resolution sea clutter"

The radar detection of targets in the presence of sea clutter has historically relied heavily upon the radial velocity of targets with respect to the radar platform, either by estimating the relative target Dopplers (such as for STAP) or by examining the path which targets traverse from scan to scan. However, for targets with little or no radial velocity component, it can become quite difficult to differentiate targets from the surrounding sea clutter. The paper addresses the detection of slow-moving targets in sea clutter and develops an approach for the non-coherent detection of such targets when high range resolution is available. [C2303]

## "A CFAR thresholding approach based on test cell statistics"

A new constant false alarm rate (CFAR) detection algorithm, that takes into account the statistics of the sample in the test cell for reference sample selection, is proposed and analysed. The new CFAR algorithm, designated as switching CFAR (S-CFAR), is designed to operate in a homogeneous environment and multiple targets with clutter transition situations. Mathematical analysis in an homogeneous environment shows that the S-CFAR processor has very small CFAR loss compared to the conventional cell-averaging CFAR processor. Monte-Carlo simulations in a non-homogeneous environment demonstrate that the S-CFAR processor has improved robustness against interference targets and clutter power transitions. The S-CFAR processor is also simple to design and implement, since no sample ordering is required. [C2304]

## "Adaptive thresholding of non-homogeneity detection for STAP applications"

An adaptive thresholding algorithm is presented that can be used in conjunction with the multi-pass generalized inner product (GIP)-based editing method to eliminate non-homogeneities from the training data used for STAP applications, such as adaptive radars. The algorithm exploits a property of the generic structure of the ordered GIP statistic, along with a single user-specified parameter related to the type I error of incorrectly excising target-free training data, to determine adaptively the thresholds for excising target-contaminated training data. The performance of the method is demonstrated using high-fidelity site-specific simulated data, with both ideal and realistic waveforms, as well as measured data from the multi-channel airborne radar measurement (MCARM) experiment. [C2305]

## "The Earth rotation effect on a LEO L-band GMTI SBR and mitigation strategies"

Space based radars (SBR) have been used to accomplish a number of civilian and military missions. Most recently, SBR concepts have been considered to perform ground moving target indication (GMTI) radar modes. Unlike airborne surveillance platforms, SBR clutter returns are affected by the high satellite velocity and Earth rotation. The phenomenology of the Earth's rotation, and its impact on clutter Doppler returns, are discussed for a Low Earth Orbit (LEO) L-band radar concept. The USA Air Force's Research Laboratory Space Time Adaptive Processing Tool (RLSTAP) high fidelity radar modeling tool is used to provide simulated data in order to demonstrate the Earth rotation effects, and resulting clutter rejection impact on slow moving target detection. [C2306]

## "Ubiquitous radar: an implementation concept"

Contemporary signal processing combined with phased array technology using digital beamforming enables the development of an important new radar system class that provides a continuous and uninterrupted multifunction

capability within a coverage volume. The central idea of ubiquitous radar is to "look everywhere all of the time". It requires the illumination of a wide coverage volume while continuously receiving signals from a "pincushion" of narrow beams filling the volume. There are no gaps either in coverage space or in time, so that all targets can be detected at the earliest time and tracks initiated. Conceptually, this technology can combine surveillance, tracking and weapons control. The paper summarizes and reviews a concept study for implementing ubiquitous radar. [C2307]

## "Performance assessment of along-track interferometry for detecting ground moving targets"

Along-track interferometry (ATI) is an interferometric synthetic aperture radar technique that can be used to measure Earth-surface velocities. As such, the ATI technique holds promise for the detection of slowly moving ground targets. However, the models often used to characterize ATI performance were developed mainly in the context of mapping ocean currents, and they do not necessarily apply to the case of discrete, moving ground targets amidst clutter. We provide expressions for more accurately modeling the behavior of an ATI system in the context of ground moving target indication. Analysis and design equations are given for topics including target defocus, signal-to-noise and signal-to-clutter ratios, interferometric correlation, interferometric phase bias, target detection, geolocation accuracy, and area coverage rate. [C2308]

## "Countermeasures of command and control (C2) capabilities in a hostile environment"

For a military airborne platform to survive in a hostile battlefield environment, the rapid detection and geo-location of an enemy (or terrorist) gunner is highly desirable. One approach is to develop an electronic countermeasure system against the gunner's command and communication (C2) capabilities, specifically the usage of modern wireless phones. Such countermeasure system would conduct a quick detection and geo-location of the targeted (hostile) mobile wireless subscriber, allows the airborne platform to make appropriate decisions: (1) to divert and avoid potential military conflicts, (2) to cue artillery supports and prepare for attack, or (3) to relay the coordinates of the potential threat to his own command and control units. In this paper, we will discuss the technical approach of the countermeasure system, especially in two design areas: (1) detection and tracking of enemy C2 signals and (2) geo-location of a targeted communication link. [C2309]

## "Phase noise reduction techniques of radar's TWTA"

The reduction of phase noise of TWTAs in radar transmitters is imperative because strongly reflected clutter can mask the signal of a moving target. This paper provides better understanding of the phase noise behavior of a TWTA and proposes two new methods to substantially suppress this noise. Multi-PSK digital communication and modern radar transmitters have stringent requirements on their power amplifier amplitude and phase stability response. The TWTA in radar systems is operating at fully saturated power, causing the phase noise to be the dominant noise component. We propose two novel methods that can be complementary to further reduce the overall phase noise. These methods are superior to the present complicated noise filtering devices because of their simple implementation, lightness and inexpensiveness. [C2310]

## "Proceedings of the 2004 IEEE Radar Conference (IEEE Cat. No.04CH37509)"

{no data available} [C2311]

## "Advanced SAR GMTI techniques"

Synthetic aperture radar (SAR) systems are designed to produce high quality imagery of a stationary target on the ground. These systems are not designed to handle moving targets and perform poorly in the areas of detecting and imaging moving targets. The paper presents advanced techniques developed to handle the detection and refocusing of moving targets for SAR systems. [C2312]

## "ADC spurious signal mitigation in radar by modifying the LO"

Analog-to-digital converters (ADCs) used in MTI or pulse Doppler radars generate spurious signals from large clutter echoes because of the non-linear ADCs. These spurious signals can appear as real moving targets in the Doppler passband of a radar. The paper shows mathematically how these spurious signals are mitigated and a means of implementing the process is provided. [C2313]

## "Waveform generation and signal processing for a multifunction radar system"

A multifunction, single platform RF sensor capable of performing target acquisition and tracking, combat identification, high data rate communications, and active protection is of interest to the USA army. The sensor

ultimately must tie affordable and the size minimized to meet the demands of a rapidly deployable force. To address these needs, the Army Research Laboratory has built and tested a multifunction radar test bed capable of performing multiple tasks simultaneously at Ka-band. The system has integrated high-end RF components together with commercial-off-the-shelf (COTS) signal processing technology. Key elements of the test bed are a commercial direct digital synthesizer (DDS) for adaptable waveform generation, multiple COTS field programmable gate array (FPGA) processors for real-time data acquisition and signal processing, a COTS FPGA based multi-port input/output (I/O) board programmed for radar timing and control, and an electronically scanned antenna (ESA) based upon a Rotman lens beam-former with active elements for multi-beam generation. The radar is capable of transmitting and receiving two simultaneous and independent beams in azimuth with up to 3 GHz of bandwidth and up to 8 watts of average power. The current configuration uses one beam for a radar target acquisition function and the other for a high data rate communication channel. The emphasis of this paper is on the radar's waveform generation and signal processing capability. [C2314]

## "Adaptive beam-domain processing for space-based radars"

This paper discusses beam-domain space-time adaptive processing (STAP) algorithms for a low-Earth-orbit (LEO) space-based radar (SBR). The performance of the subarray-based joint-domain-localized (JDL) algorithm is first examined for various processor parameters. Then, a combined beam-domain STAP algorithm approach that combines JDL with difference (Δ) beams is presented. It is shown that the combined JDL-Δ algorithms offer less system complexity and yield performance similar to that of JDL that uses higher degrees of freedom. It is also shown that the Earth's rotation induces a crab angle to the platform, which makes the clutter range-Doppler spectrum vary with range. Illustrative examples show that this crab angle severely degrades the signal-to-interference-plus-noise ratio (SINR), thereby reducing the minimum detectable velocity (MDV) of STAP systems. [C2315]

## "CoreTracking: an efficient approach to clustering moving targets and tracking clusters"

Detecting the activities and predicting the tendencies of large groups of targets in wide battlefields are critical inputs to formulating sound military decisions. Modern airborne radar sensors can provide wide-area surveillance coverage of battlefield ground activities. When obscured by terrain or other factors, some objects may only be detectable at intervals, generating intermittent radar data and creating difficulties for tracking groups over time. We present an algorithm, termed CoreTracking, which dynamically groups individual targets into clusters and tracks the clusters over time. Most traditional clustering techniques are static-object-oriented. We propose a "core member" concept to support dynamic-object-oriented clustering and to mitigate the effects of data intermittence. Observing the movement of the core cluster members, we can track the clusters across frames and predict their future movements. The performance and results of applying the CoreTracking algorithm to CASTFOREM data sets is also presented. [C2316]

## "Analysis of advanced data association techniques for ASDE radar"

The paper analyses and evaluates the application of different techniques to the data association problem for ASDE (airport surface detection equipment) radar. Data association for this sensor requires the removal of the classical one-to-one constraints and should allow tracks to be updated by sets of blobs. Different innovative alternatives, based on recent advanced techniques, have been formulated and tried to solve this problem in complex scenarios. Simulation results show the capabilities achieved in terms of tracking robustness, accuracy and required computation. [C2317]

## "Low-cost radar surveillance of inland waterways for homeland security applications"

Low-cost radar systems have been developed for homeland security missions. These detect and track small maneuvering craft in the water. The systems consist of a conventional marine radar, a capture card that digitizes the radar signals, and a computer that processes them. We have an experimental system that can monitor western Lake Ontario. It runs in real time, with operator controls, and can store captured radar video. The achieved detection and tracking is demonstrated with recorded datasets. The combination of lower thresholds plus a sophisticated multi-target tracker gives excellent performance. [C2318]

## "Millimetre Wave RADAR spectra simulation and interpretation for outdoor SLAM"

Millimetre Wave RADARs are more robust than most other sensors used in outdoor autonomous navigation in that their performance is less affected by dust, fog, moderate rain or snow and ambient lighting conditions. This paper describes a method to accurately simulate the range spectra using the RADAR range equation. This is very important in robot navigation (eg. SLAM) for generating predictions of what can be observed from different sensor locations and correspondingly, providing an interpretation for observed targets. To understand the MMW

RADAR range spectrum and to simulate it accurately, it is necessary to know the noise distributions in the RADAR spectrum. A detailed noise analysis during signal absence and presence is carried out which shows various sources of noise affecting MMW RADARs. RADAR range bins are then simulated using the RADAR range equation and the noise statistics and are compared with real results in controlled environments. It is demonstrated that it is possible to provide realistic predicted RADAR power/range spectra, for multiple targets down range. Feature detection from the RADAR spectra based on target presence probability is then explained. The detection technique uses binary hypothesis testing. Results are shown comparing a new probability based feature detection with other standard feature extraction techniques such as constant threshold on raw RADAR data and Constant False Alarm Rate (CFAR) techniques. The results show that the proposed algorithm is more robust compared to other detection techniques as it does not require human assistance. This work is a step towards robust outdoor SLAM with MMW RADAR based continuous power spectra. [C2319]

## "Steering vector mismatch: analysis and reduction"

In adaptive radar systems, optimal processing for target detection is only possible when the target location in angle and Doppler is used to build the processing filter. When this location is not exact, losses occur. These losses translate into a reduction in detection probability. After development of analytical expressions to quantify the effects of this mismatch, two techniques are examined for reducing these effects. These techniques are tested against losses due to Doppler mismatch. The first technique involves the use of temporal windows and reduces mismatch losses at the expense of reducing the overall signal-to-interference-plus-noise ratio (SINR) of the target. The second technique involves the use of additional filters, and achieves a reduction in mismatch losses without sacrificing maximum SINR. A brief overview of the problems associated with multidimensional (angle and Doppler) mismatch is also presented. [C2320]

## "3-dimensional STAP performance analysis using the cross-spectral metric"

Research done in recent years has clearly demonstrated large improvements in clutter suppression and target detection by including elevation adaptivity, otherwise described as 3-dimensional (3D) STAP. The paper further quantifies the performance gains garnered by 3D STAP by fixing the degrees of freedom (DOF) and varying the array dimensions to include the equivalently sized linear array. The focus is placed on performance bounds established by matched filter and 3D cross-spectral metric (CSM) SINR curves generated with known covariances. The mathematical extension of the CSM from 2D to 3D is shown to be straightforward, thus allowing the CSM to serve as a partially adaptive performance bound for eigenvalue-selection based 3D STAP algorithms. [C2321]

## "Coordinated search and track by multiple phased array radars"

This paper addresses the search and track coordination problems of multiple shipboard radars. The proposed approach first exploits the physical characteristics of a single phased array radar to improve its effective capacity. Its effective capacity is abstracted by a closed-form equation called a schedulability envelope. Using the schedulability envelope for each radar, we deal with search and track coordination as a relative-load-balancing problem in a multiresource environment. The simulation results show that the proposed approach significantly improves the overall capacity of a multiship multiradar system. [C2322]

## "Adaptive conformal array radar"

This paper considers the novel application of space-time adaptive processing (STAP) to conformal array radar. Using numerical simulation, we characterize the performance potential of two candidate conformal array designs: a tapered, belly-mounted canoe and a conformal array taking the shape of a chined radome. We find the nonlinear nature of the conformal array design induces clutter angle-Doppler nonstationarity. This nonstationarity leads to covariance matrix estimation errors and a consequent degradation in STAP performance potential. We find these additional losses reside in the range of 4-10 dB for the two array designs under consideration. Finally, we briefly investigate several ameliorating solutions based on localized processing and time-varying weights, achieving performance gains on the order of several decibels to fully mitigating nonstationary behavior over regions of the detection space. [C2323]

## "Range sidelobes suppression for wideband randomly discontinuous spectra OTH-HF radar signal"

Over-the-horizon (OTH) HF radars work in a heavily congested HF band. It is quite difficult to find broad clear frequency bands for system requirements. The randomly discontinuous spectra (RDS) signal is employed to combat spectrum congestion since it can evade the external interferences in the frequency domain. However, the spectra discontinuity of the signal gives rise to high range sidelobes when matching the reflected echo, which is much more difficult for target detection. So it is indispensable to investigate the technique for sidelobes

suppression of the range profile when an RDS signal is utilized. In this paper, we introduce a new signal processing technique, that is radically different from the conventional technique, to lower range sidelobes based on suppressing the self-clutter of the radar range ambiguity function (AF) by mismatch filtering. Simulation results show that the peak sidelobe level can be reduced to -30 dB while the frequency bands span up to 400 kHz. [C2324]

## "A novel two frequency MTI radar"

A new design for two-frequency MTI radar is introduced. The suggested system can change its frequency in each pulse. Therefore, the system is very resistant to electronic warfare. The analytical results of our calculation show that the system has a very high blind speed and in realistic situations it increases signal-to-noise ratio, although it widens clutter bandwidth and detects some spurious targets. [C2325]

## "Low rank adaptive signal processing for radar applications"

This paper addresses the problem of radar target detection in heterogeneous clutter environments. We present the performance of the low rank normalized matched filter (LRNMF) test and the low rank normalized adaptive matched filter (LRNAMF) in a background of disturbance consisting of clutter having a covariance matrix with known structure and unknown scaling plus background white Gaussian noise with unknown variance. It is shown that the LRNMF test retains invariance with respect to the unknown scaling as well as the background noise level and is approximately CFAR. Analytical expressions for calculating the false alarm and detection probabilities are presented. Performance analysis of the LRNAMF test using simulated data from the KASSPER program is presented. Issues of sample support for subspace estimation, constant false alarm rate (CFAR) and detection performance are presented. [C2326]

## "Range sidelobe suppression technique for randomly intermittent spectra radar signal"

The randomly intermittent spectra (RIS) signal is a technique that is increasingly employed to combat spectrum congestion in radar and other radio services, to evade the external interferences. However, the spectra discontinuity of the signal gives rise to high range sidelobes when matching the reflected echo, which is much more difficult for target detection. So it is indispensable to investigate techniques for sidelobe suppression of the range profile when an RIS signal is utilized. In this paper, we introduce a new processing technique, based on time domain filtering, to lower the range sidelobes. A robust and effective algorithm is adopted to solve the coefficients of the filter, and the restriction on the desired response of the filter is derived. The simulation results show that the peak range sidelobe can be reduced to -27 dB from -9.5 dB while the frequency span band is 200 kHz. [C2327]

## "On indirect method of RCS calculation of conducting targets in random media"

One of the random medium effects is the enhancement in radar cross-section (RCS) of targets, and it can be explained by the coherent addition of doubly scattered waves. In several earlier studies (Tateiba, M. and Tomita, E., 1992; El-Ocla, H. and Tateiba, 2001, 2002, 2003), we have proved that the spatial coherence length (SCL) of waves around the target in a random medium, together with the target configuration, affects the RCS and backscattering enhancement, apart from the polarization of the incident waves. This conclusion is important in radar detection and remote sensing applications. These results need a lot of computation time if we use our method directly. We propose an indirect estimate for the RCS by using a beam wave incident on a conducting target in free space. This method presents an approximate solution to the scattering problem in a random medium. This indirect estimate reduces the processing time that is so important in radar detection, especially in real time applications. H-wave scattering is quite different from E-wave scattering, especially in the resonance region, because of waves creeping along objects. Therefore, we need to analyze the scattering for both polarizations. The time factor is assumed and suppressed. This method is applicable for low and high frequency ranges. [C2328]

## "Simulation of radar scattering from electrically large objects under tree canopies"

A model is developed to investigate the scattering behavior of hard targets embedded inside a forest canopy, at high frequencies. Wave penetration through, and scattering from, a forest canopy is calculated, using a coherent scattering model which makes use of realistic tree structures (Yi-Cheng Lin and Sarabandi, K., IEEE Trans. Geosci. Remote Sensing, vol.37, p.440-51, 1999). A physical optics (PO) approximation is used to estimate the equivalent current on an electrically large, perfectly electrically conducting (PEC) object, located above a ground plane and under a tree canopy. In this model, the reciprocity theorem is used effectively in order to derive the backscattering from the target above the ground plane, and also to calculate the interaction of the target scattered field with the foliage. [C2329]

## "Spatially coded signal model for active arrays"

This paper addresses the problem of target detection and localization by radar or active sonar systems. A novel configuration, in which the transmitted signals are spatially coded, is proposed. The main advantages of this new configuration are: avoiding beam-shape loss, having a larger virtual array aperture and therefore narrower beams, increasing the angular resolution, and having the ability to detect and localize a greater number of targets. This configuration enables array processing in the transmit mode in addition to the receive mode. The generalized likelihood ratio test (GLRT) and the maximum-likelihood (ML) estimator are derived for target detection and localization according to the new model configuration. The performance of the array processing algorithms for this problem is studied theoretically and via simulations. [C2330]

## "Optimal detection theory applied to monopulse antennas"

Estimation of the direction of arrival of a signal source by means of a monopulse antenna is one of the oldest and most widely used high resolution techniques. Although the statistical performance of this estimation technique has been extensively investigated, it has never been analyzed from the viewpoint of a two-sensor system. This deficiency is responsible for the form of the common solution (detector/estimator) which restricts the accessible performance. Applying the optimal detection theory to this problem, when a Raleigh-type signal source is present, shows that changing the detector is necessary to optimize the overall performance. The analytical performance of the new solution has been established, thus complementing the existing characterization of the common solution. [C2331]

## "A novel spread clutter suppression algorithm based on multiple-dimension matched field processing technique [Cover-the-horizon radar]"

High-frequency skywave over-the-horizon radar (OTHR) can provide a wide coverage over the horizon by means of the refraction within the ionosphere. However due to the complex propagation conditions of electromagnetic waves in the HF band, many disadvantageous effects, such as phase path contamination and multimode propagation, cause the target to be submerged by the neighboring spread clutter. In this paper, the spread effect of identical clutter, backscattered from the adjacent dwell illumination region (DIR), has been discussed. On the basis of the existing matched field processing (MFP) method developed for this problem, the multiple-dimension cross-relation method, using the multiple channel signals, has been proposed and used for the temporal data directly. Experimental simulations are given to demonstrate that the improved method is effective in suppressing the spread clutter. [C2332]

## "A robust algorithm for automatic target recognition using passive radar"

The goal of this research is to add automatic target recognition (ATR) capabilities to existing passive radar systems. We do so by comparing the radar cross section (RCS) of detected targets to the precomputed RCS of known targets in the target class. The precomputed RCS of the targets comprising the target class is modeled using a multi-step process involving programs such as the fast Illinois solver code (FISC). Advanced refractive effects prediction system (AREPS) and numerical electromagnetic code (NEC2). A Rician likelihood model compares the power profile of the detected target to the precomputed power profiles of the targets in the target class; this comparison results in target identification. Thus far, the results of simulations are encouraging, indicating that the algorithm correctly identifies aircraft with high probability at the anticipated noise level. Performance can be expected to decline as the noise power surpasses the maximum signal power. [C2333]

## "New implementation of the Billingsley clutter model for GMTI data cube generation"

Internal clutter motion (ICM) places significant limits on the effectiveness of STAP clutter suppression techniques, for example in achieving the smallest minimum detectable velocity in GMTI radar surveillance applications. To simulate this effect with maximum fidelity, the required correlation must be impressed on the returns from individual scatterers during the construction of the data cube. Doing so can represent a substantial computational burden on the simulation process when a clutter scene is characterized by many millions of individual pixels. Such numbers are typical when using high fidelity SAR maps as the basis of the clutter model. The paper reports on a fast computational technique for wind-blown clutter simulation that works within a flexible data-generation system employing real high-fidelity IFSAR maps with co-registered elevation data as ground truth. [C2334]

## "Application of the Cramer-Rao lower bound for bearing estimation to STAP performance studies"

The performance of space-time adaptive processing (STAP) radar is a strong function of array geometry and the

particular algorithm implementation. Traditionally, detection performance has been of paramount importance, but recently interest has grown in the accuracy of target direction of arrival (DOA) estimates. This paper describes an evaluation of the Cramer-Rao lower bound (CRLB) for DOA accuracy. The CRLB is useful for bounding the bearing estimation performance of candidate array architectures and STAP algorithms, but often generates counter-intuitive results. Anomalous characteristics of the CRLB are investigated, explained, and placed in the context of maximum likelihood estimation (MLE) properties. The end product is a tool that can be applied to comparative analyses with confidence. The paper concludes by demonstrating the utility of the CRLB in both array and algorithm studies. [C2335]

## "Closed-loop person tracking and detection"

First Page of the Article [C2336]

## "Sparse, random array processing for space-based radar"

We investigate moving target detection with a space-based cluster of radar satellites, modeled as a random sparse array. Results show that improvement in signal to interference is a sensitive function of the pulse repetition frequency and varies over a large dynamic range. Achievable improvement factor maxima are moderately degraded by array pitch (satellite cluster rotation) and strongly degraded with increasing position errors. In general, with increased randomness, fewer elements contribute to form DPCA pairs so that satellite usage efficiency and SNR are degraded. [C2337]

## "Radar applications of low rank signal processing methods"

This paper addresses the problem of radar target detection in severely heterogeneous clutter environments. Specifically we present the performance of the normalized matched filter (NMF) test in a background of disturbance consisting of clutter having a covariance matrix with known structure and unknown scaling plus background white Gaussian noise. It is shown that when the clutter covariance matrix is low rank, the NMF test retains invariance with respect to the unknown scaling as well as the background noise level and is CFAR. Performance of the test depends only upon the number of elements, number of pulses processed in a coherent processing interval and the rank of the clutter covariance matrix. Analytical expressions for calculating the false alarm and detection probabilities are presented. Performance of the method is shown to degrade with increasing clutter rank especially for low false alarm rates. An adaptive version of the test is developed and its performance is studied with simulated data from the KASSPER program. Issues of sample support for subspace estimation, constant false alarm rate (CFAR) and detection performance are presented. [C2338]

## "Efficient tapering methods for STAP"

The sample support problem in space-time adaptive processing (STAP) arises from the requirement to adapt to a changing interference environment where the available wide-sense-stationary sample support is severely limited for direct implementation of adaptive algorithms. In this paper we outline several approaches to address the sample support problem by utilizing efficient covariance matrix tapering (CMT) methods to retain the a-priori known structure of the covariance matrix. By combining efficient tapering approaches along with terrain knowledge based STAP and other preprocessing schemes such as subarray-subpulse, relaxed projection method, it is possible to reduce the data samples required in a nonstationary environment and consequently achieve superior target detection. In addition, the application of Khatri-Rao product to the data domain implementation of CMT is also introduced thus expanding the class of robust algorithms for real-time STAP implementation. [C2339]

## "A multiple hypotheses testing approach to radar detection and pre-classification"

This work presents a single-scan-processing approach to the problem of detecting and pre-classifying a radar target that may belong to different target classes. The proposed method is based on a hybrid of the maximum a posteriori (MAP) and Neyman-Pearson (NP) criteria and guarantees the desired constant false alarm rate (CFAR) behavior. The targets are modeled as subspace random signals having zero mean and given covariance matrix. Different target classes are discriminated based on their different signal subspaces, which are specified by their covariance matrices. Performance is investigated by means of numerical analysis and Monte Carlo simulation in terms of probabilities of false alarm, detection and classification. The extra signal-to-noise power ratio necessary to preclassify a target once a detection has occurred is also derived. [C2340]

## "Canonical framework for describing suboptimum radar space-time adaptive processing (STAP) techniques"

We address the problem of detecting slow moving targets from a moving radar system using space-time adaptive processing (STAP) techniques. Optimum interference rejection is known to require the estimation and the subsequent inversion of an interference-plus-noise covariance matrix. To reduce the number of training samples involved in the estimation and the computational cost inherent to the inversion, many suboptimum STAP techniques have been proposed. Earlier attempts at unifying these techniques had a limited scope. In this paper, we propose a new canonical framework that unifies all of the STAP methods we are aware of. This framework can also be generalized to include the estimation of the covariance matrix and the compensation of the range dependence; it applies to monostatic and bistatic configurations. We also propose a new decomposition of the CSNR performance metric that can be used to understand the performance degradation specifically due to the use of a suboptimum method. [C2341]

## "Comparison of the radar clutter cancellation performance of post- and pre-Doppler STAP for ground moving target identification from an experimental airborne surveillance radar"

Within this paper we report our study that compared the performance of pre-Doppler and post-Doppler STAP processing algorithms applied to the same radar trials data, collected by QinetiQ's Enhanced Surveillance Radar. The performance of these algorithms was quantified by clutter cancellation ratios and target signal improvement factors (the ratio of the signal to clutter plus noise ratios with and without STAP processing). We have shown that pre-Doppler and post-Doppler STAP may be tuned to give the same level of clutter cancellation. We present results in which bright target signatures are seen to affect the STAP processors and reduce the overall clutter cancellation. We have found that for our two phase center trials radar data, PRI staggered post-Doppler STAP gives greatly enhanced clutter cancellation compared to the simple fixed window post-Doppler STAP. The application of either moving window or auxiliary bin post-Doppler STAP was found to degrade the processor output. The importance of normalizing the final range Doppler map to prevent the amplification of thermal noise and remove the weight-norm variation as a function of Doppler is shown to be a critical step to allow interpretation and application of detection algorithms after STAP processing. [C2342]

## "An alternating transmit approach for STAP with short antenna arrays"

The approach of alternating the transmission between a leading and a trailing antenna sub-aperture from pulse to pulse (ALTX) is presented for radar systems equipped with digital beamforming. ALTX is shown to improve detection and DOA estimation performance with respect to standard transmission with the whole antenna aperture for systems with a short antenna array and a limited number of receiving channels. [C2343]

## "Enhanced maneuvering targets detection via polynomial phase modeling in over-the-horizon radars"

This paper describes a processing algorithm based on polynomial phase modeling scheme that increases visibility of maneuvering targets in HF over-the-horizon radar (OTHR). For the presence of the echo backscattered by the target that has significantly varying radial velocity within a coherent integration time (CIT), it is difficult for traditional coherent processing to centralize energy and peak in Doppler spectrum. Due to the polynomial property of the phase of maneuvering target radar echo, a polynomial phase signal (PPS) is introduced to model the complex Doppler variation of maneuvering targets. As an effective method to estimate the parameters of PPS, a high-order ambiguity function (HAF) based algorithm is applied. And a compensation process follows to eliminate the coherent processing loss (CIL) caused by irregular motion of targets. The experimental results are given to illustrate the validity and efficiency of the proposed method. [C2344]

## "Detection and tracking of ballistic target"

Some aspects of detection and tracking of ballistic targets are analysed in this paper. In particular, the RCS model versus aspect angle is obtained for a notional target starting from its CAD model. Subsequently, the kinematic model of the ballistic target is derived; it includes the main forces acting on it, namely, the thrust, the drag and the gravity. On the basis of these two models it is possible to determine the detection probability of a notional L-band radar during the target flight and to build up an interactive multiple model (IMM) for target tracking. The performance evaluation of the design IMM tracking algorithm is obtained via Monte Carlo simulation. In particular, highly manoeuvring aircraft and ballistic targets in the boost phase are used to check the capability of the IMM. [C2345]

## "A new approach for target location of through the wall radar imaging in the presence of wall ambiguities"

A technique for target locations in the through-the-wall radar imaging application is presented. The algorithm

corrects for the shifts in target positions due to ambiguities in the wall thickness and dielectric constant. Imaging is obtained using wideband beamforming with the antennas placed against the wall. The imaging is performed for different assumed sets of wall parameters and using two different structures of transmit and receive arrays. For each structure, a trajectory of the shifts in the target locations is formed. The target position is estimated as the intersection of the two corresponding trajectories. The paper shows the close proximity of the target estimated and true positions. The performance of the proposed technique is robust to the target location behind the wall and to various array structures. [C2346]

## "Detection and velocity estimation of aircrafts in bistatic radar data using target back propagation technique"

"Target Back Propagation Technique" overcomes the problem occurring when radar targets migrate out of the resolution cells during scan integration time for surveillance radars. This paper addresses the technique where the idea is simply to back propagate possible targets with different velocities over the scans selected for integration and then detect the strongest response. Sampled radar data containing 6 aircrafts is presented. The technique is used on an image with bistatic geometry averaged over 3 scans and with target back propagation locally applied for each aircraft. All aircrafts are sharpened in the image and this illustrates the usefulness of the "Target Back Propagation Technique", even if just three scans are used. [C2347]

## "Stochastic boats generated acoustic target signal detection in time-frequency domain"

This paper is devoted to theoretic algorithms development and experimental research of automatic target detection of acoustic signals, especially for boats generated signals. In this paper, an observation space is created by sampling and dividing input analog acoustic signal into multiple frames and each frame is transformed into frequency domain. In the created observation space, a median constant false alarm rate (MCFAR) and post detection integration algorithms have been proposed for an effective automatic target detection of boat generated acoustic signals, in which a low constant false alarm rate is kept with relative high detection rate. The proposed algorithms have been tested on real boat generated acoustic signals. The statistical analysis and experimental results showed that the proposed algorithm has kept a very low false alarm rate and relatively high detection rate. [C2348]

## "Ocean clutter suppression using one-class SVM"

This paper presents a new algorithm based on pattern classification technique to suppress ocean clutter of high frequency ground wave radar (HFGWR). We first decompose radar returns as weighted sum of several chirp-like signals and then extract chirp rates and initial frequencies of these chirps to construct the feature space. The support region of ocean clutter in this feature space is calculated by one-class support vector machine (OCSVM). New data that falls inside this support region are labelled as ocean clutter and are discarded. We validate our method by conducting experiments on real radar data. The result shows that the selected features can discriminate between ocean clutter and target echo effectively and our classifier can suppress ocean clutter successfully by defining a fine support region of ocean clutter in that feature space [C2349]

## "A solution for fast radar target detection with high detection probability using dynamic polarization method"

For every radar station location we can make a library of the elements of the radar target scattering matrix (CBEM1,2,3,...N) combinations, which have the ability to give a high detection probability (PD). In dynamic polarimetry mode, we have PDiwith each CBEMj, at the certain j polarimetry state (PSj) j=1,...,M. If M is a number of the PS, we have PDmaxj=max{PDi} then we can calculate max{PDmaxj}=PDmaxmax,. Here PDmaxmaxis the highest PDvalue for the selected CBEM. [C2350]

## "Multi-target tracking in clutter without measurement assignment"

This paper presents a new approach for multitarget tracking in a cluttered environment. Optimal all neighbour multi-target tracking (MTT) in clutter enumerates all possible joint measurement-to-target assignments and calculates the a posteriori probabilities of each of these joint assignments, e.g. J(I)PDA and MHT. The numerical complexity of this process is exponential in the number of tracks and the number of measurements involved. Our approach starts with an all-neighbour single-target tracking (STT) filter which provides the a priori probabilities of measurement origin; e.g. IPDA, IMM-PDA, ITS. These probabilities are used to modify the clutter density at the location of the selected measurements. In effect, the STT filter is transformed into a MTT filter with a numerical complexity which is linear in the number of tracks and the number of measurements. Measurement features, such as amplitude, can also be incorporated. Simulations are used to verify the approach when tracking crossing

targets in an environment of heavy and non-uniform clutter. [C2351]

## "A changeable moving step method based on level set algorithm"

Level set algorithm (LSA) is one of the efficient tools of edge detection and contour extraction, which has been applied to medical radar and other images processing successfully. However, the process procedure using LSA will cost a lot of time when applied to high-resolution images. This paper provides a novel approach that can enhance the detection speed by changing the moving step of the contour in LSA dynamically. The moving step enlarges when the contour is far from the real boundary of specific targets, while the moving step reduces when the contour is near the real boundary in the image. Experimental results using Radarsat ScanSAR images show the effectiveness of this new method and verify the improved velocity in contour detection compared with the standard LSA. [C2352]

## "A new method for target detection of MMW radar"

In the modern MMW radar detection system, the problem on interference of cross-terms became extremely severe. In the paper, we proposed a new method named p0order Choi-Williams-distribution (p0-CWD) transform based on the fractional Fourier transform (FRFT). The analysis of auto-terms and cross-terms of p0-CWD shows the result that the interference of cross-terms could be zero under certain condition. The algorithm avoids time-consuming coherent processing and sophisticated motion compensation due to the implementation of FRFT. The performance of the method is evaluated in terms of signal-to-noise ratio (SNR) of output signal. The simulation results revealed 0.5 m resolution even in the case of low SNR of input signal equal to -9 dB. [C2353]

## "Study on the angle glint suppression technology for high resolution dual polarization radar seeker"

For the high resolution dual polarization guidance radar, a new glint suppression technology is proposed in this paper. The technology can notably ameliorate the angle measurement precision and improve the anti-jamming ability of the radar. The basic idea is that the effective scattering centers in radius of the extended target are separated based on the twice detection of amplitude and polarization in order to eliminate the effect of interference scattering centers firstly, then the angles of each effective scattering centers are measured according to mono-pulse method, finally the average geometer position of the target is determined by weighting the measured angles of the effective scattering centers and tracking reliability of the target is realized. The signal model and specific angle glint suppression algorithm are given, and the effectiveness of the algorithm is testified by simulation. [C2354]

## "The new algorithm for passive radar MTD based on the fractional correlation"

In terms of the relationship between fractional correlation and two-dimensional correlation function, fractional correlation is introduced to the computation of the polar representation of two-dimensional correlation function. A new algorithm for passive radar MTD based on fractional correlation is presented. The advantage of the algorithm is that target scanning can be done in certain circular sector of the two-dimensional plane in the polar form. Meanwhile, the location and grid density of the sector can be adjusted by the chirp-Z transform. This decreases the computation cost and makes the target detection more flexible. The simulation results also prove the effectiveness and practicality of the algorithm. [C2355]

## "SAR moving target detection method based on CLEAN in frequency domain and Radon-STFT transform"

The Radon-STFT transform could effectively detect several LFM signals. However, when the energy of these LFM signals diverges greatly, it is quite difficult to detect all LFM signals with the Radon-STFT transform. In this paper, a signal detection method based on CLEAN in frequency domain and spectrum-Radon transform is proposed. By using this method, all LFM signals can be detected. It means that this method has high practicable value. Simulation results verify the effectiveness of this method. [C2356]

## "Novel method of parameter estimation for moving target in millimeter-wave short-range linear FMCW radar"

Aiming at the Doppler spectrum aberration and range-velocity coupling phenomena in accelerated moving environment for millimeter-wave short-range linear FMCW radar, a novel method is presented which can estimate the target's acceleration, velocity and range effectively. The method can also compensate the Doppler signal with the estimated acceleration, solve Doppler aberration and range-velocity coupling, and improve the detection performance and parameter estimation precision of the accelerated targets. The method has less computation and has a solid arithmetic. [C2357]

## "LFMCW radar multi-target acceleration and velocity estimation method"

In the LFMCW radar system, the echo signal of moving target with acceleration has Doppler aberration. It causes target detection performance deterioration and parameter estimation loss. The polynomial phase transform (PPT) can only estimate the single target acceleration in the same range cell. This paper presents a method, which modified the PPT algorithm to process the Doppler signal of multiple targets in the same range cell. It can accurately estimate the acceleration and velocity of multi-target and improve the detection performance with less calculating quantity. [C2358]

## "A method for characterizing a target in polarimetric radar remote sensing"

A method for characterizing a target is proposed in this paper, based on the eigenvalue decomposition of a scattering matrix. From this method, a set of parameters is derived. The parameters are not only independent of the spans of the scattering matrices, but also independent of the target orientation angles. With these parameters, we enhance the contrast between the road and forest of a SAR image, demonstrating the effectiveness of the proposed parameters. [C2359]

## "Naval radar in a littoral environment"

First Page of the Article [C2360]

## "Application of STFT ridges and RT to moving targets detection in SAR"

Synthetic aperture radar (SAR) is an active, all-weather capable system to provide the capability to map the ground with high resolution and is used in both civilian and military applications. Moving targets with respect to the stationary background cause smeared and ill-positioned images. Detection and imaging of moving targets in SAR signals are necessary. We propose the method that combined the ridges of the short-time Fourier transform (STFT) and Radon transform (RT) to detect moving targets. Processing steps of this method and simulated results are given in detail. Simulation results show this method can detect moving targets and estimate its parameters in noise case effectively. [C2361]

## "Detection and estimation of target on using polarization signal processing"

It is very important to find an effective method for measuring the target range and estimating the target's power in the environment where the signal/clutter ratio (SCR) is small. In order to solve this problem, some new methods such as 'position by polarized angle' (PPA) and 'probability estimate polarization (PEP) filter are proposed based on the estimation of the polarization state of the clutter in this paper. The principle of these new kinds of polarization processing and their performance evaluation with experimentally derived data are discussed. The results from computer simulation indicate that the SCR can be improved above 20dB and the correct probability of tracking target can be increased from less than 10% to more than 97%. [C2362]

## "Seeing beyond the perimeter: the Advanced Exterior Sensor (AES)"

The system design of the Advanced Exterior Sensor (AES), test data and Sandia National Laboratories' current work on the AES is described. The AES integrates three sensor technologies (thermal infrared waveband, visible waveband, and microwave radar) in a Remote Sensor Module communicating with three motion detection target trackers and a sensor fusion software module in the Data Processor Module to achieve higher performance than single technology devices. Wide areas are covered by continuously scanning the three sensors 360 degrees in about one second. The images from the infrared and visible detector sets and the radar range data are updated as the sensors rotate each second. The radar provides range data with approximately one-meter resolution. Panoramic imagery is generated for immediate visual assessment of alarms using the Display Control Module. There is great potential for site security enhancement using the AES, which was designed for low-cost, easy use and rapid deployment to cover wide areas beyond typical perimeters, possibly in place of typical perimeter sensors, and for tactical applications around fixed or temporary high-value assets. Commercial-off-the-shelf (COTS) systems have neither the three sensor technologies nor the imaging sensor resolution. Cost and performance will be discussed for different scenarios. [C2363]

## "Proceedings. 33rd Applied Imagery Pattern Recognition Workshop"

{no data available} [C2364]

## "Minimizing uncertainty in determinants and ratios of determinants for invariant relationships

## employed in SAR imagery pattern recognition"

Invariant relationships involving ratios of determinants have been proposed for the classification of an object in SAR imagery. The target detection decision-making process depends on the uncertainty involved in the measurements. At fixed experimental resolution, some determinants are simply better than others because they are much less sensitive to uncertainty. A geometrical interpretation of determinants is applied to assess the minimum relative uncertainty expected for a determinant employed in invariant relationships. Because much larger relative uncertainties can occur in some determinants, a method based on the perturbation of eigenvalues is proposed to identify determinants that are less sensitive to element errors. Symmetric alpha-stable probability distribution functions are employed to characterize error distributions in ratios of determinants. [C2365]

## "Unexploded ordnance detection by measuring object symmetry via linear prediction"

Humanitarian demining has become a serious international issue nowadays due to the post-war buried unexploded ordnance (UXO) and land mines. In this research, a new technique based on linear prediction is proposed to discriminate UXO from non-UXO targets. The proposed technique takes into account the symmetry of the ground penetrating radar (GPR) signal returning from a buried object. We use the GPR data set collected by Battelle company and the Ohio State University from the Jefferson Proving Ground (JPG), U.S.A. in the experiments The results evaluated in terms of receiver operating characteristic (ROC) curves show that our proposed technique has a better detection performance than a traditional detection technique based on energy. The false alarm reductions at 100% detection by the baseline technique and the proposed technique are about 11% and 23%, respectively, compared to a situation where no technique is applied. [C2366]

## "Some new experimental research of HF backscatter propagation in CRIRP"

This paper describes some new experimental research of HF backscatter propagation in CRIRP. This new experimental research includes the detecting of a target with two different polarization arrays using the Faraday rotation effects, the detecting of the HF Doppler spectrum of sea and land by an HF backscatter propagation experimental system (HF BPES) in CRIRP. Airplanes as far away as 2000 km are frequently successfully detected by the HF BPES with two different polarization arrays. The track points of the airplane were compared with that detected by VHF radar, and the difference of the two tracks is very small so that the square root difference is σ=13 km. The illuminated range by HF BPES is from land, by land, the sea boundary, and the sea over a long distance. The HF Doppler spectrum of ground, the sea echo Doppler spectrum and the HF Doppler spectrum of sea boundary and land are probed. It indicates the identification of both sea and ground. [C2367]

## "A sidelobes suppression technique for spectra discontinuous HF radar signal based on spectra compensation algorithm"

The discontinuous spectra frequency hopped pulse waveform (DS-FHPW) signal is employed to combat spectra congestion in radar and other radio services to evade external interference in high-frequency (HF) and ultrahigh-frequency (UHF) bands. However, the spectral discontinuity of the signal gives rise to high range sidelobes when matching the reflected echo, which is much more difficult for target detection. The technique for radar range sidelobe suppression by a spectral compensation algorithm is introduced in detail. By estimating the signal at polluted frequency bands and filling the actual received signal with the estimated signal, The discontinuities of the received signal can be diminished, thus the range sidelobes can be suppressed. Simulation results show that the range sidelobes of a DS-FHPW radar signal can be suppressed significantly by the algorithm. [C2368]

## "The united detection of the stationary or slow-moving-speed targets in the clutter based on the high range resolution (HRR) and Doppler beam sharpening (DBS) technique"

During air-to-ground guided missile scanning of the area of interest and detection of targets, mass ground clutter enters the radar receiver with the target echoes, so that the radar cannot distinguish targets from the clutter. Therefore, the radar's detection capability is seriously influenced by the clutter. Because the ground clutter has a space-time two-dimensional property, traditional detection techniques cannot be used. The paper presents a united detection technique based on high range resolution (HRR) and Doppler beam sharpening (DBS) to fulfill the detection. The united detection technique uses simplified range-Doppler arithmetic to get the signal-to-clutter ratio gain and get the two-dimensional multiple scatterer image, thereby improving the radar's detection capability in clutter. A computer simulation has been done and the results demonstrate that the united detection technique achieves good results, and the technique is valid and easy to perform. [C2369]

## "A CFAR algorithm for radar detection under severe interference"

A new radar constant false alarm rate (CFAR) detection algorithm operating under severe interference is

developed in this paper. The new CFAR algorithm, designated as switching CFAR (S-CFAR), is presented and analysed in closed-form based on Swerling I nonhomogeneous clutter and target model. Mathematical analysis demonstrates that the S-CFAR is robust when up to half of the search region is occupied by interfering samples. The S-CFAR algorithm is useful in applications where a radar performs detection in a clear region of its range and/or Doppler profile with an unknown number of interfering target (and possibly jamming) samples. S-CFAR implementation is also simple since no sample ordering is required. [C2370]

## "Fusion aspects of the rapid route and area mine neutralisation (RRAMNS) mine detection system"

Rapid route and area mine neutralisation system (RRAMNS) is a capability technology demonstrator (CTD) conducted by the Defence Science and Technology Organisation (DSTO) in Australia and industry partners Tenix Defence Industries and Minelab Electronics Inc. The detection system consists of three sensors: a metal detector array; a ground penetrating radar array (GPR); a forward-looking infrared and visual imaging system. Each sensor in this multisensor platform is targeting to detect different properties of buried and surface landmines. Fusion of detections from all sensors provides a complete automatic target detection system for a wide variety of threat mines. The paper describes the fusion architecture implemented to RRAMNS multisensor system for automatic target detection. [C2371]

## "Heterogeneous high performance computer emulation of a space based radar on-board processor"

This paper presents the successful emulation of an on-board processor (OBP) to support space based radar (SBR). The emulation is demonstrated on the forty-eight node dual Xeon heterogeneous high performance computer (HHPC) operated by the Air Force Research Laboratory (AFRL) located in Rome, New York. Each node in the HHPC supports one Annapolis Wildstar II board composed of 2 Xilinx Virtex II 6 Million gate field programmable gate arrays (FPGAs). As system complexity increases, debugging the software of tera-scale systems with hundreds to thousands of processors is poorly supported by time consuming simulations. However, the advent of large FPGAs allows a powerful new tool to assist in the architecture development effort-emulation. For the case at hand, the 96 FPGAs of the HHPC are capable of emulating at 8% of the actual system clock speed (20 MHz of 250 MHz) and close to 15% of the 2560 individual processors of the proposed SBR system. Even at this reduced scale, this emulation provides a testing environment roughly a million times more capable than HPC-based simulation for early software bug detection and correction. Further, this framework allows for experimenting with architecture enhancements and changes, and ultimately will ensure a low cost, reliable, fully reprogrammable product produced without re-spins. The embedded system architecture of this SBR OBP is based on AFRL's dual processor, power efficient, programmable, wafer scale signal processor (WSSP). Target tracking and discrimination algorithms were developed and demonstrated on an earlier 96-processor embodiment of this architecture. For SBR, the algorithm set is being extended to include synthetic aperture radar (SAR) image formation and moving target indication (MTI) algorithms. [C2372]

## "Study on reducing false targets for automotive radar"

New waveform for millimeter-wave automotive anti-collision radar is proposed. It greatly improves the response characteristic of radar system and partly reduces the false alarm of the radar. The effective algorithm is introduced to further eliminate false targets in multiple targets circumstances. Simulation results show that the method is effective. [C2373]

## "Robot detection with multi-target tracking"

We propose a vision-based method for detecting and tracking a mobile robot in dynamic, complex and unstructured environments, such as an office. When there are many moving objects (e.g. robot and persons) in the environment, and they interact with each other, it is not easy to estimate the correct correspondence between detected moving objects and individual targets. We introduce GPF (generic particle filter) to discard and multiply possible hypotheses about which moving object is the robot. Also, we utilize MCMC-PF (Markov chain Monte Carlo-based particle filter) to track multiple targets efficiently and robustly by predicting interactions between targets. As a result, we have achieved robust detection and efficient tracking of targets. [C2374]

## "The feasibility of searching for contraband materials using a gamma-ray 'radar' system"

A technique for searching for contraband materials that may be hidden behind a barrier is described. This imaging technique is based on the detection of one of the two annihilation photons produced by a positron-emitter that has scattered in the target, in coincidence with the detection of the second photon in a position-sensitive scintillation counter. The results of a feasibility study will be presented in which a 1mCi source was used to illuminate a 1times1 m2area to provide a two dimensional image of the line-of-sight density within this

object. The spatial-resolution achievable is -1times1 cm. Details of the detector design envisaged for this application will be described and the images generated through Monte Carlo simulations presented. [C2375]

## "Joint detection and tracking of multiple maneuvering targets in clutter using random finite sets"

Joint multi-target detection and tracking is a challenging problem due to several factors such as the number of targets being an unknown time-varying random parameter, and the target generated measurements being obscured by clutter. The theory of random finite sets permits an elegant formulation of the joint multi-target detection and tracking problem in a Bayesian framework, in particular, the random finite set formalism leads to the probability hypothesis density (PHD) filtering method, which realizes Bayesian joint detection and tracking in a suboptimal but numerically tractable manner. In this paper the PHD filter is applied to jointly detect and track multiple maneuvering targets. The tracking performance fidelity of the PHD filter is demonstrated by numerical results. [C2376]

## "Tracking initiation and data association of multi-target passive tracking based on information fusion"

Tracking initiation and data association are key techniques of multi-target passive tracking by a single observer. A new adaptive passive tracking initiation algorithm based on information fusion is proposed In this work. First, according to multiple features of the target, a multidimensional dynamically variable tracking gate is built for adaptive detection. Further, the sequential probability ratio test (SPRT) rule is used to confirm the track. And also, a new data association algorithm based on information fusion is proposed. Based on the information fusion of multiple features of a single valid observation, the decision of synthetic data association of all the targets is made. With the help of computer simulations, the tracking initiation algorithm is proven to be correct and effective, and the data association algorithm is proven to be superior to the NN method. [C2377]

## "Study on simulation technique of laser detector"

A simulation method is introduced to test a laser detector. Firstly, the target and background characteristics are analysed, aimed at a certain laser proximity detector, and the simulation algorithm of the detected target and background characteristics is presented. Then we accomplish the mathematical modeling, 3D visualization modeling and the target engagement modeling of the simulation. The simulation interface and program flow chart are designed tentatively. A graphics software platform for the simulation, based on OpenGL, is created under the Visual C++ 6.0 development workspace to realize the visualization simulation and show the relationship between engagement status and output data. The modeling and simulation algorithm mentioned is proved to be feasible by a simulation experiment and to be an effective method to estimate the performance of the laser detector. [C2378]

## "Preliminary research on target detection in first-order peaks with adaptive cancellation"

HFSW radar can detect oceanographic parameters based on electromagnetic waves diffracting along the sea surface. A difficulty arises in detecting slowly-moving targets because of the strong ocean clutter. For wide-beam HF radar, broadened first-order peaks complicate target detection further, so no effective detection algorithm in first-order peaks has yet been put forward. The paper examines the Bragg peaks of wide-beam HF radar. The reason why the first-order Bragg peaks are broadened is analyzed, and then the conclusion that the two first-order peaks from a distant sea cell with unitary current are profile-correlative is drawn. Based on the conclusion, a new method is presented for target detection in first-order peaks. The method performs well both on simulated data and on real data with the HF system OSMAR2000. [C2379]

## "M3 filter with adaptive mode probabilities control for low sampling rate tracking"

This paper proposes the Multiple Maneuver Model (M3) filter with recalculation of residual covariance in mode probabilities calculation. The conventional M3filter had a problem that mode probabilities oscillate in the long range radar with long sampling period. The oscillation is caused by extremely low likelihood functions of target models at the measurement in mode probabilities calculation. For controlling the oscillation under clutter and frequent miss detection environment, the M3filter that calculates the residual covariance in mode probabilities calculation is proposed. The residual covariance is calculated in advance using the overlap coefficient that indicates how error ellipses are overlapped. It is shown that the proposed M3filter has capability of controlling the oscillation without residual information and improving the tracking quality for maneuvering target. [C2380]

## "The enhanced FRACTA algorithm with knowledge-aided covariance estimation"

The enhanced FRACTA (FRACTA.E) algorithm has been shown to be an effective space-time adaptive

processing (STAP) methodology for the airborne radar configuration in which there exists non-homogeneous clutter, jamming, and dense target clusters. In this paper, the FRACTA.E algorithm is supplemented with knowledge-aided covariance estimation (KACE) in order to reduce the required sample support, which may be necessary in severely non-homogeneous environments. The resulting algorithm is applied to the KASSPER I challenge data cube where it is shown via simulation that KACE enables FRACTA.E to achieve essentially the same level of detection performance with considerably less training data. [C2381]

## "Detecting multiple slow-moving targets in SAR images"

Ground moving target indication (GMTI) radars can detect slow-moving targets if their velocities are high enough to produce Doppler frequencies distinguishable from the surrounding stationary clutter. However, no reliable technique is currently available to detect targets that fall below the minimum detectable velocity (MDV) of GMTI radars. Detecting slow moving targets in synthetic aperture radar (SAR) images has also not ceded a reliable solution. Reflected energy from the target is spread over many pixels in the image due to its motion, degenerating the detection process. The addition of clutter from surrounding stationary objects or ground features further complicates detection. Several techniques for SAR imaging of moving targets have been attempted. These techniques require pre-detection, which, in turn, requires sufficient signal-to-stationary ground clutter ratio (SCR). Other attempts such as adaptive, model-based approaches face exponential combinatorial complexity. Exponential computational cost results from having to consider a large number of combinations between multiple target models and the data. The dynamic logic algorithm (DLA) presented below detects multiple slow-moving targets simultaneously in SAR images with low signal-to-clutter ratio, no minimum velocity requirement, and without combinatorial complexity. The mathematics underlying the algorithm is based on biologically inspired signal processing concepts. [C2382]

## "Target detection improvement using blind channel equalization OTHR communication"

In this paper, we introduce a blind channel equalization method for over-the-horizon-radar (OTHR) system based on the sea clutter signal. First, we establish that the radar signal, at different time recurrences, can be represented by a MIMO model taking into consideration the propagation parameters (Doppler, delay and attenuation) of the multipath channel. Then, we show that thanks to the Doppler diversity, one can separate the two components of the sea clutter (referred to as Bragg lines) which allows us to reduce the problem to a SIMO one. A CMA-like blind equalization algorithm is then applied to invert the system and combine coherently the channel multipaths. The channel and Doppler information are finally used to mitigate the sea clutter interference and the multipath effect and hence improve the detection and Doppler estimation of the desired target signal. [C2383]

## "System on reconfigurable chip for automatic detection and tracking radar"

Using a mixed system of digital signal processor (DSP) and reprogrammable field programmable gate arrays (FPGA) with efficient hardware design techniques, we propose the implementation of automatic detection and tracking radar in a system on a reconfigurable chip (SoRC) for providing the trajectory and predicting the future position of multiple moving targets. Combining the functionality of a pulsed Doppler radar for target detection and tracking radar for future position prediction and tracking in an SoRC our system implementation revolves around automatic detection of targets for the removal of clutter and interference, track initiation, track association, track smoothing using Kalman gain components and track termination. [C2384]

## "Optimal detectors for nonfluctuating targets under spiky K-distributed clutter in radar applications"

The optimum parametric detector structure for nonfluctuating target models in spiky K-distributed clutter is proposed and analyzed by computer simulations. The performance of this new detector (the clipping detector) is considerably better than the performance of the linear and quadratic detectors. Monte Carlo simulations have been used for the estimation of false alarm and detection probabilities, nevertheless importance sampling technique has been used for the estimation of very low false alarm probabilities (e.g., less than 10-5). Also, a detailed discussion of the simulation results will be provided and some conclusions compiled at the end of the paper. Furthermore, results for Swerling II target model are presented. [C2385]

## "Performance analysis of optimum nonparametric rank tests for radar detection under K-distributed clutter"

This paper deals with a comparative analysis of optimum rank tests versus optimum parametric tests for radar detection, under K-distributed clutter, and nonfluctuating and Swerling II target models. The performance analysis is carried out under independent and identically distributed clutter samples. Some results of detection probability (Pd) versus signal-to-clutter ratio (SCR) are presented in curves for different detector parameter values. Also, a

detailed discussion of the simulation results is provided and some conclusions are summarized at the end of the paper. [C2386]

## "Automatic target detection using a dynamic learning neural network"

Automatic detection of targets in a radar image is an important problem with many applications. The radar echoes from a target have to compete with the echoes from the clutter. A clutter signal can be modeled by a nonlinear deterministic dynamical system. A dynamic learning neural network is used to approximate the nonlinear system in terms of the polynomial basis function. As an example, the neural network is applied to a SAR image from the MSTAR public release data set for target detection. The results suggest that the proposed approach provides better detection evaluation measures, including detection rate, false detection rate, and lose detection rate than those of the conventional CFAR detector. [C2387]

## "HF ground wave radar sea clutter cancellation based on chaotic prediction"

In the background of signal detection for HF radar, the sea clutter is quite significant and can mask some weak target signals. This paper reports a chaotic local prediction based sea clutter cancellation method to improve the SNR of the target. Recent observation shows that HF sea clutter may be modeled as a nonlinear deterministic dynamical system. Then it can be assumed that the chaotic prediction error of target echo is greater than the prediction error of sea clutter. A local chaotic predictor is used to construct a sea clutter cancellation technique. Real sea clutter, simulated target data and real target data were used to show that a chaotic prediction based clutter cancellation method is a promising technique to suppress sea clutter and enhance target detection. [C2388]

## "Time-frequency analysis of polarimetric vector signal and its application in radar target recognition"

The time-frequency analysis technology for polarimetric vector signal is discussed in this paper. Considering the particularity of polarimetric vector signal, a series of time-frequency transforms for this kind of vector signal are presented. With these transforms, both the description of its energy property and of its polarization property can be obtained in the time-frequency domain, while using conventional methods, only the former can be obtained. Then, we apply these new methods to target recognition experiment, and the recognition results show that these new methods have better performance than conventional ones. [C2389]

## "A review of ship detection algorithms in polarimetric SAR images"

In this paper, we take a brief review of the different approaches used for ship detection in polarimetric synthetic aperture radar (POL-SAR) images. After an introduction of the standard polarimetric detectors (SPDs) used in polarimetric detection for general targets, four main types of polarimetric detection algorithms with special respect to ship targets are summarized: the coherent target decomposition algorithm (CTD), polarimetric entropy (PE) algorithm, polarimetric detectors based on fusion, and segmentation based polarimetric method. Preliminary conclusion is drawn from the performance comparison of each type and indicates how these algorithms applied for ship targets respectively. [C2390]

## "Distributed adaptive OSWCA CFAR detector"

In the sense of likelihood ratio test (LRT), a weighted adaptive OSWCA CFAR detector using distributed sensors is proposed in this paper. In the scheme, a local test statistic, which is the ratio of its test sample level and a designated order statistic (OS) of its reference samples, is calculated by each sensor, and then each sensor transmits its local test statistic to the fusion center. At the fusion center, the final decision is made based on weighted cell averaging algorithm (WCA). Since the weights are adjusted according to different signal-to-noise/clutter ratio (SNR), adaptively, the proposed detector can be available in the case of that the target echo and noise/clutter that have different level for each sensor. Unlike many current distributed CFAR detectors, which assuming that all noise/clutter samples satisfy independent identical distributed (IID) and have same SNR for each sensor. Meanwhile, for a Rayleigh fluctuating target in Gaussian noise of unknown level, we obtain its closed-form expressions for the false alarm probability and the detection probability. The numerical analysis results indicate that the proposed OSWCA scheme can be available. [C2391]

## "Impulse wave estimation based on analytic wavelet in UWB-radar"

A method is discussed in this paper for analysis of received ultra wideband pulse in noise based on analytical wavelet transform. Using analytical version of wavelet, the feather of the impulse shape and position can be identified from the transform results. The impulse samples can be reconstructed and have a noise reduction by employing a thresholding technology to deal with the coefficients. The echo time delay of dispersed target

components can be estimated in favor of further processing of range profile of UWB-radar. [C2392]

## "Performance analysis of multidimensional clutter map CFAR"

It is difficult for radar to detect targets moving slowly on the ground or flying slowly with low altitude. In order to increase the detection probability of weak targets among strong clutter, it is useful to accumulate the echo signal of the target using Doppler information, and to adopt an effective CFAR procedures. Here a novel multidimensional clutter map CFAR (MDCM-CFAR) algorithm is proposed, compared with the traditional clutter map CFAR (CM-CFAR) and mean level CFAR algorithms. MDCM-CFAR has better detection performance. [C2393]

## "A new GPR targets feature extraction based on kernel method"

A new ground penetrating radar target feature (GPRTF) extraction method based on kernel method is proposed. This paper also explains that the unsupervised methods (PCA or KPCA) aren't fit for the GPRTF extraction. The conventional GPRTF extraction method is the LDA (also called as FDA).It can minimize the within class scatter and maximize the between class scatter, but it extracts the GPRF in the low dimension GPR data space and the discriminability is limited. The kernel method can map the GPR data to the high dimension space by the non-linear transformation and can so enhance the discriminability. Combine the virtue of the kernel and the LDA and make up for the flaws of them will benefit for the GPRTF extraction. The treatment comparisons of the measurement data show that the method proposed is superior to the others. [C2394]

## "Three-dimensional passive location algorithm of the OTHT [Cover-the-horizon target]"

Three dimensional passive location and tracking of the over-the-horizon target (OTHT) is a key problem in recent years. It can influence the long-distance detection, location and precision attack capability of military equipment. So This work studies the problem, and presents a new method, which uses active tracking technology and a time difference of arrival (TDOA) location method to track the OTHT. Simulation results show that the over-the-horizon target can be located and tracked by the method proposed In this work. [C2395]

## "Study on target detection technique of chaos-based modulation [Cradio fuze application]"

In order to enhance the anti-jamming and detecting capability of a radio fuze, a means, which applies a chaotic signal to the detecting technology of a radio fuze, is presented in the paper. The system structure of a chaos modulation radio fuze is given; the characteristics of the reflected signal and the selection of the basic parameters are analyzed. Several key techniques, such as the correlative demodulation and so on, are studied. The result shows that it is feasible to apply the chaotic signal to the wave modulation of a radio fuze to enhance its anti-jamming and detecting capability. [C2396]

## "UWB impulse distance detector"

With the development of ultra-wideband (UWB) technology, a number of different applications have been discussed in the literature. The paper gives a UWB application to detect the distance between the detector and the target, presenting a distance gate detector. The distance detector system consists of oscillating circuit, impulse generator, transmitter, receiver, ADC, signal processing and UWB antennas. UWB signal characteristics are introduced simply. Because the speed of the analog-to-digital converter (ADC) limits the signal digitization, a better solution to the limited ADC speed is introduced briefly. On the detector, the receiver is mainly introduced and a simple target distance algorithm is given; through the simple algorithm in the signal processing cell, the target can be found quickly and accurately. [C2397]

## "How to use the C/A code of GPS to detect the exospheric passive radar target"

This paper presents a novel missile-borne passive radar system for the detection of exospheric intercepting target. For meeting the need of stealth the C/A code of GPS signal is applied to the passive radar for acting as the signal of transmitter. The system mechanism and the framework of the GPS signal receiver and scattering wave receiver for the passive radar is described for the next in-depth study. And the key performance of system, the problem of Doppler compensation for the passive radar and the performance analysis of anti-jamming are also elucidated. [C2398]

## "Fusion of radar and AIS data"

The AIS system that will be brought into effect can improve shipping security for its more accurate information of target position and target identification. On applying AIS making use of the fusion of radar and AIS data should

be attached important to. A method of fusion of radar and AIS data is proposed in this paper. The membership degree, on which the adaptive correlation-detecting function is constructed, is calculated by fuzzy C-mean clustering algorithm. It has been shown by simulations that reliable associations of track-to-track could be achieved. [C2399]

## "Research on the underwater laser fuze target detecting technique"

Regarding a submarine as the target object, with blue and green laser as the detecting field, This work completes the design of an underwater laser fuze for a torpedo. It establishes an underwater target identification standard, an anti-interference standard and a direction identification standard, which can be used as the basic fuze signal handling standard. Using this standard as a foundation, the signal handling electronic circuit was designed. As proof, this project can satisfy the requirements of the underwater laser fuze war skill index. [C2400]

## "IFSAR: an airborne interferometric SAR simulator"

The IFSAR is an airborne SAR simulator for extended targets developed by INTA. This tool generates simulated signal data of an artificial three-dimensional scene as collected by an interferometric SAR with a fully configurable system oriented to airborne applications. Scene is made of points and triangular extended targets, over a selected ellipsoid, and it can be drawn using common CAD software. GPS motion records of plane and moving point targets, extended targets, associated scattering patterns, chirp signal, antenna patterns and TxRx diagram can be simulated too. Experimental results comparing interferograms from real and simulated missions shows that the tool is extremely accurate and requires few computer resources. It is used to calibrate of MOCO algorithms and interferometric processors, to probe new techniques and solve problems in real acquisitions of interferometric airborne SAR data [C2401]

## "Detection of surface mines using hyperspectral sensors"

Hyperspectral imaging is an important technology for the detection of surface and buried land mines from an airborne platform. For this reason, hyperspectral was included in the two experiments that were executed by the Army RDECOM Night Vision and Electronic Sensors Directorate (NVESD) in Fall 2002 and in Spring 2003. The purpose of these experiments was to bring together a wide variety of airborne sensors for the detection of mines, with well ground-truthed targets. The hyperspectral sensors included the Airborne Hyperspectral Imager (AHI), a University of Hawaii LWIR HSI sensor and the Compact Airborne Spectral Sensor (COMPASS), an NVESD VNIR/SWIR sensor. These experiments were carried out at sites where an extensive array of buried and surface mines were deployed. At the first experiment called Forest Fusion I, the mines were deployed against several different backgrounds ranging from bare dirt to long grass. For the second experiment, called Desert Fusion, the mines were placed on backgrounds ranging from loose sand to mixed sand and vegetation. The COMPASS and AHI sensors were both placed on the Twin Otter aircraft, and data was collected with the airplane at a variety of altitudes. In this paper, the data collected on surface mines are reviewed, and specific examples from each background type presented. Spectral detection algorithms are applied to the data and the results of the algorithm processing are presented [C2402]

## "Improving landmine detection using frequency domain features from ground penetrating radar"

Landmine detection is an important and yet challenging problem remains to be solved. Ground penetrating radar (GPR) is an effective sensor to detect landmines that are made of plastic or have low metal content. Most GPR signal processing algorithms apply processing in the time (depth) domain. This paper proposes to use the frequency domain features from the GPR signal to improve the detection of weak plastic mines and to reduce the number false alarms due to clutter objects. The motivation comes from the fact that the energy density spectrum may be different between mine targets and clutter objects, although both may have strong GPR signal return in the time domain. Experimental results based on clutter lane data collected at a test site corroborate the effectiveness of the proposed spectral features to increase the accuracy for landmine detection [C2403]

## "High resolution DBS imaging and the moving target trajectory forming with raw SAR/GMTI Data"

DBS (Doppler beam sharpening) technique is widely used in military. In this paper, the basic theory of DBS imaging is introduced at first, and a conclusion is reached by analysis that range cell migration correction technique and azimuth dechirping technique can improve image quality effectively on SAR/GMTI (synthetic aperture radar/ground moving target indication) mode. And it is possible to form the moving target trajectory on the image because of the high resolution. Lastly, some satisfactory results based on the raw radar data are presented [C2404]

## "SAR based products for the implementation of humanitarian aid and development assistance projects within the UNOSAT project"

The UNOSAT service is an ESA Earth Observation Market Development initiative whose objective is to encourage, facilitate, accelerate and expand the use of accurate geo-information derived from EO satellite imagery by professionals involved in the implementation of humanitarian aid and development assistance projects. In this paper, we focus on the role of SAR within this context. Space-borne SAR has a particularly good potential to support disaster management and humanitarian relief projects thanks to its all-weather capability, its capabilities for change detection, the large existing data archives, and, of course, the geometric and thematic information content of the images. Basic processing techniques, including precision image co-registration, multi-temporal analysis, terrain corrected geocoding, interferometry, and radargrammetry are well developed and operational. Advanced techniques like differential interferometry and interferometric point target analysis (IPTA) became more and more operational during the last years and provide unique information about terrain stability and deformation [C2405]

## "Near real time vessel detection using spaceborne SAR imagery in support of fisheries monitoring and control operations"

The system components for the operation supply of maritime target positions detected in SAR imagery are described, together with their implementation details and practical performance parameters. Integration of detected target information within European fisheries monitoring systems based on VMS is demonstrated [C2406]

## "Application of texture feature classification methods to landmine/clutter discrimination in off-lane GPR data"

Recent advances in ground penetrating radar (GPR) fabrication and algorithm development have yielded significant performance improvements for anti-tank landmine detection in government sponsored blind tests. However, these blind tests are typically conducted over well-maintained homogeneous testing lanes specifically designed to test landmine detection performance in low-clutter population situations. New GPR data collections over targets emplaced in un-maintained off-lane soils have much higher GPR anomaly populations and provide more stringent tests of landmine detection algorithms. In this work, we focus on the application of feature-based class separation techniques to lower false alarm rates in heterogeneous off-road soils. In particular, we explore the application of texture feature coding methods (TFCM), which have previously shown promise in fields like tumor detection [C2407]

## "Fast imaging of a target in inhomogeneous media for pulse radar systems"

Many works have been done to develop efficient imaging algorithms for ground penetrating radars. We have developed a new imaging algorithm SEABED for homogeneous media and confirmed its performance. This algorithm has an advantage that the calculation time is quite short because it is based on a reversible transform. However, its performance for inhomogeneous media has not studied yet. In this paper, we examine the performance of SEABED for inhomogeneous media [C2408]

## "A highly automatic underwater target classifier system"

Due to the complicated watery environment and the limitation of the detecting method to the underwater target, recognizing them precisely is always a hard problem to all countries. In this paper, we design a genetic-based classifier system (CS), which recognizes a target utilizing audio fingerprints. Audio fingerprint technology can extract some unique feature from a given sound clip, and it is similar to that one man's fingerprint can identify a unique person himself, dissimilar sound leading to different fingerprint. All these have none business with the sound object's store way (analog or digital) or format (MP3, WAV, WMA, etc.). Compared with traditional CS, the proposed comparing and matching algorithm would give the fitness value more explicitly statistical meaning, which would make us easier to explain the rules with background knowledge. The proposed hyperplasia operator can handle those instances, which have not been emerged before. It gives the system persistent learning abilities, so the system may be more compatible with the surroundings. The proposed refining classifier merges those redundant rules and shrinks the rule set. In addition, we set an alterable mutation probability to the genetic algorithm in the CS, and the experiment shows that this strategy increases the speed and the accuracy of the classifying operation. We propose a highly automatic underwater target classifier system, and we keep improving it. We expect it can be competent in the recognition with minimum hardware requirements. [C2409]

## "Weighted fourth order cumulant slice based adaptive dynamic line enhancer"

To overcoming the difficulty of selecting higher order cumulant slices and to suppress Gaussian noise effectively, weighted fourth-order cumulant slice is defined using fourth-order cumulant different slices and updated by the leakage iteration algorithm. The weighted fourth-order cumulant slice-based adaptive line enhancer is proposed. Simulation tests with the underwater target-radiated noise are also carried out The simulation results have shown that the proposed algorithm can perform a drop about from 13dB to 26dB for colored Gaussian noise and that the performance of the proposed algorithm can be improved by governing the weighted coefficients of fourth-order cumulant different slices. Therefore, this algorithm is considered to be suitable for retrieving the underwater moving target-radiated line spectrum signals embedded in highly colored Gaussian noise. [C2410]

## "Clutter statistical analysis for high resolution SAR data"

The ONERA RAMSES system (Radar Aeroporte Multi-spectral d'Etude des Signatures) is a flexible SAR system in constant evolution developed mainly as a test bench for new technologies and to provide specific data for TDRI (Target Detection, Recognition and Identification) algorithm evaluation. It is flown on a Transall C160 platform operated by the CEV (Centre d'Essais en Vol). Recently, the system was upgraded to include a very high resolution mode in X, Ku and Ka bands. The resolution cell is then only a few wavelength wide and the usual hypothesis underlying the speckle phenomena, i.e., a large number of scatterers per resolution cell, is not verified. This work presents the analysis made on the clutter statistical behavior and contrasts the change of behavior observed when shifting from medium resolution to high resolution to very high resolution. It is based on actual radar data acquired with the RAMSES radar system. A new parameter identifying the largest spatial resolution for which the natural surface can no longer be considered homogeneous (in a speckle based criteria) is proposed. This parameter characterizes the scale of the contributing scatterers. [C2411]

## "Improved ship detection using polarimetric SAR data"

The improvements in ship detection performance that can be obtained by using polarimetric synthetic aperture radar (SAR) data as compared to single-channel SAR data are investigated. Statistical decision theory is used to define decision variables that quantify the trade-off between the probability of missed detection and the probability of false alarm; performance is characterized by calculating receiver operating characteristics from single-channel and polarimetric SAR data by using likelihood ratio tests with the Neyman-Pearson criterion. It is shown that improvements in detection performance can be obtained with polarimetric SAR data as compared to single channel SAR data. We evaluate the results of these algorithms applied to single channel, dual channel amplitude only, dual channel with amplitude and phase, and fully polarimetric SAR data of known ships. In this way, the relative improvement in ship detection performance that is realized by introducing polarimetric information is quantified [C2412]

## "Algorithms for ship detection and tracking using satellite imagery"

Ship detection and tracking are important to maintain a Recognized Maritime Picture (RMP). Satellite surveillance provides wide area coverage but is often limited by revisit times and by the time taken to process the imagery, analyze it and send messages in an appropriate format to update the RMP. The paper describes the development of a new ship detection and tracking program that is designed to analyze processed imagery rapidly and inexpensively and to deliver messages automatically by email in the OTH Gold format. The message can include ship position, length, heading and speed. The program structure is designed to be versatile, flexible and extendable and a RADARSAT image can be loaded and analyzed and a message sent typically in less than one minute [C2413]

## "Exploration assessment in a petroleum frontier area offshore the Amazon River mouth using RADARSAT-1 images"

The study discusses the use of RADARSAT-1 images to identify oil seepage in the Foz do Amazonas Basin, an oil and gas exploration frontier in the Brazilian Equatorial margin. An unsupervised semivariogram textural classifier algorithm was used to enhance areas of smooth texture and low radar backscatter, indicative of these targets. Complementary information related to cloud top temperature, wind velocity, and modelling for the tidal regime (all obtained as close as possible to the RADARSAT-1 images acquisition) was used to support image interpretation and to exclude false-targets. Together with previously discovered sub-commercial shallow water oil accumulations, the detection of seepage slicks an additional evidence of oil generation in the study area. Results also indicate that radar remote sensing can be used as a tool to reduce risks in the exploration of frontier areas like the Foz do Amazonas Basin [C2414]

## "Radar signatures of road vehicles"

Development and modeling of the road vehicle detection algorithms for SAR images requires the knowledge of

the radar cross section of these targets. The radar signatures of the parked cars were derived experimentally from airborne E-SAR image data collected during two flight campaigns. First examples of the catalogue of radar signatures for road vehicles are presented. [C2415]

## "Sea SAR image analysis by fractal data fusion"

SAR images from space-borne platforms have proved to be helpful data for identification of oil spills and other surface anomalies, such as low wind areas, man-made targets, and natural films. The use of fractal dimension, which is related to the concept of surface "roughness", as a feature for classification, improves the detection of anomalies, since enhances texture discrimination. In the particular case of oil slicks, the surface tension of seawater is increased and the surface wave motion is significantly depressed. This effect relatively reduces the sea surface roughness, decreases the radar backscattered energy and enables oil slicks to be discernible from the radar image. Several algorithms may be applied for local fractal dimension estimation, but most solutions are tailored for specific applications and are characterized by estimation accuracies depending on the adopted image model and also on the value being estimated. This paper describes a decision-based fusion approach for local fractal dimension estimation of SAR images of the sea surface. Three different estimation algorithms are considered and the three resulting fractal maps are fused by means of a weighted average. The weights are calculated from the performance characteristics of the three algorithms measured on synthetic fractal surfaces. The experimental results carried out on ERS-2 SAR images prove the effectiveness of the proposed decision-based fusion approach [C2416]

## "Iceberg and ship discrimination with ENVISAT multipolarization ASAR"

Spaceborne synthetic aperture radar (SAR) can provide wide area and all-weather surveillance for iceberg and ship targets. However, the discrimination between icebergs and ships in SAR imagery, especially in the single polarization imagery that has been available over the past decade, is not always reliable. This is especially true when vessel and iceberg size are on the order of the pixel spacing. Present requirements for ocean surveillance with SAR data include a high detection and classification accuracy due to the necessity of comparable performance with other reconnaissance methods, such as aerial. ENVISAT advanced SAR (ASAR) data offers a potential solution to the iceberg-ship discrimination problem. ASAR data has comparable swath and resolution to other operational SAR systems and in addition offers an alternating polarization (AP) mode. AP targets offer more information than single polarization with respect to radar scattering mechanisms. The AP ship and iceberg targets in this study were observed to have considerably different polarization responses. In particular, ship targets in the HH and HV channels were comparable. In contrast, iceberg targets had at best, weak HV responses compared to the HH channel. Two methods for target discrimination were investigated: a multipolarized area ratio and HV signal-to-clutter ratio (SCR). [C2417]

## "LPI waveforms for active sonar?"

The idea of a low probability of intercept (LPI) waveform is that its form is chaotic. It can of course be recalled by the transmitter (platform), and matched to what is received; but to the target it appears only as noise, and consequently the robust target receiver can only detect a rise in energy. However, the platform pays a heavy two-way attenuation penalty: its signal to noise ratio (SNR) is far lower than that at the target. It is not immediately apparent that how these two factors trade off against one another, and that is the topic of this paper. [C2418]

## "Sea mine neutralization using the AN/AWS-2 rapid airborne mine clearance system"

The AN/AWS-2 Rapid Airborne Mine Clearance System (RAMICS) is currently under development to neutralize sea mines from an MH-60S helicopter for the United States Navy. RAMICS provides a new capability to the Navy and reduces the need for Explosive Ordnance Disposal personnel to neutralize floating/moored sea mines. RAMICS utilizes a lidar to reacquire surface and subsurface mines and mine-like objects. The targeting subsystem trains a MK44 Bushmaster 30mm gun to the target. Once the firing solution is achieved and target confirmed, the operator fires the gun and neutralization is achieved by deflagration, sinking, or detonation of the target. This will provide a quick method of clearing threat mines and confirming neutralizations. [C2419]

## "Influence from polarized galactic background noise on L-band measurements of the sea surface salinity"

The polarimetric EMIRAD radiometer, based on novel digital down conversion and detection techniques, has been installed on a C-130 aircraft from the Royal Danish. Air Force during the L-band Ocean Salinity Airborne Campaign (LOSAC) in 2001 and 2003. Full 360° circle flight patterns around the same target area as well as

clover leaf patterns have been measured, and both provide an azimuth signature of the ocean at a constant incidence angle. The resulting azimuth signatures show significant variations in all the three first Stokes parameters, and a correlation is found between the downwelling galactic background signal and the measured results. The measured 3rdStokes parameter has variations of the same order of magnitude as the two linear polarizations, and to verify this result, an experiment for direct observation of the sky over long time is set up. This experiment confirms the presence of a polarized galactic background signal, and conclusions are made with respect to the necessity for polarimetric corrections in future measurements over the sea at L-band. [C2420]

## "Height retrieval by using a pseudo-differential approach in SAR interferometry preliminary results with actual SAR data"

In SAR interferometry a new approach to height retrieval has been defined, with the aim to obtain the elevation of selected targets in the scene without performing phase unwrapping procedures in the space domain. Following our preliminary simulations, in the paper the results of a first experimentation of this approach with actual SAR data will be introduced [C2421]

## "The improvement of the conventional GMTI method with single-channel SAR"

SAR/GMTI (synthetic aperture radar/ground moving target indicator) can detect targets with low velocities and provide images of the area covered by a scanning antenna with high revisit rates. By the conventional GMTI method, the estimated velocity of the moving target is not accurate. The authors improve it by a new idea which uses a series of moving windows. This paper shows the new method's results by processing raw radar data and analyzes its performance finally. A conclusion is drawn that the improved method is more effective and accurate for GMTI. [C2422]

## "SAR image segmentation by 2-D fussy entropy"

In the process of SAR (synthetic aperture radar) ATR (automatic target recognition), segmentation is the core procedure. In this paper, analyzing the characteristics of SAR images, we introduced a new method for segmenting SAR images. The method is based on 2D c-partition fussy entropy and adaptive genetic algorithm. 2D fussy entropy is used as the fitness function, and adaptive genetic algorithm is used for optimizing thresholds. The results of the segmentation procedure are presented in this paper and it shows a promising output [C2423]

## "Signatures of vessels in ENVISAT AP-mode imagery"

A series of ENVISAT AP mode data has been collected over the Nome field off the coast of central Norway. An oil production vessel has been imaged with different ASAR beams and polarisations to study how its signature changes with varying imaging parameters. Cross-polarised data gives better contrast for automated detection compared to co-polarised data, when the incidence angle is small. [C2424]

## "Data fusion: remote sensing for target detection and tracking"

As part of an ongoing research program in data fusion applied to the multisensor environment for iceberg detection on the east coast of Canada, this paper describes the efforts to use modeling of iceberg movement to perform iceberg detection data fusion. Data fusion and sensor combination are integral parts of a cost effective ice management regime for safe offshore oil and gas recovery programs. This paper addresses data fusion in the form of associations of detections to create tracks from multiple sensor sweeps of an area. The Coupled Ice Ocean (CIO) Model of Iceberg Kinematics from the Canadian Ice Services (CIS) is used as a maneuvering model to the tracking process. The fusion system was tested using iceberg detections from the 2003 ice season. All data were collected in the Grand Banks area of Newfoundland, Canada. [C2425]

## "Synthetic aperture radar for search and rescue: polarimetry and interferometry"

The use of synthetic aperture radar (SAR) provides an opportunity to assist search and rescue in the location of downed airplanes in particular in the northern areas of Canada. This paper presents results of examining the detection of crashed aircraft targets using airborne SAR data. Considerations for decreasing the number of "false targets" using a combined polarimetric and interferometric analysis have been tested with results indicating a promising approach for target detection using these SAR techniques. [C2426]

## "Multi-channel along track interferometry"

In this paper we introduce an algorithm for velocity estimation of a ground moving point target using a multi-

channel along-track interferometry (MC-ATI) system. The presented results are relative to a multi frequency system, but the algorithm can be used also for a multi-baseline one. The performance of the system is evaluated by presenting also the probabilities of detection. [C2427]

## "Multisensor tracking of a maneuvering target in clutter with asynchronous measurements using IMMPDA filtering and parallel detection fusion"

We present a (suboptimal) filtering algorithm for tracking a highly maneuvering target in a cluttered environment using multiple sensors dealing with possibly asynchronous (time delayed) measurements. The filtering algorithm is developed by applying the basic interacting multiple model (IMM) approach, the probabilistic data association (PDA) technique, and asynchronous measurement updating to a state-augmented system for the target motion. A state augmentation approach is developed to estimate the time delay between local and remote sensors. A multisensor probabilistic data association filter is developed for parallel sensor processing for target tracking under clutter. The algorithm is illustrated via a highly maneuvering target tracking simulation example where two sensors, radar and an infrared sensor, are used. Compared with an existing IMMPDA filtering algorithm designed for synchronous (no delay) sensor measurements processing, the proposed algorithm achieves considerable improvement in the accuracy of track estimation. [C2428]

## "Multiple-input multiple-output (MIMO) radar: performance issues"

The application of multiple-input multiple-output (MIMO) techniques to multistage radar offers a number of advantages, including improved resolution and sensitivity. Depending upon the radar's mode of operation, the array design and the environment, these advantages may or may not be significant. In this paper, a simple analytic model for ground moving target indicator (GMTI) radar detection is presented and its predictions are compared with simulation. Conventional single-input multiple output (SIMO) and MIMO GMTI radars are compared in terms of minimum detectable velocity, area-search rates and array sidelobes. Optimal waveform cross-correlation matrices are identified for MIMO radars, given different performance criteria. Finally, bounds are developed for MIMO arrays with uniformly sampled virtual apertures. [C2429]

## "Detection and tracking of multiple targets within a three-dimensional medium"

One of today's problems in signal processing is the identification of direction of arrival (DOA). The need for estimating direction-of-arrival (DOA) of energy wave fields within a three-dimensional medium has led to great interest in areas outside of military use. For most real-world applications however, a target tends to lie within three-dimensional medium. A method for detection and tracking of multiple moving targets within a three-dimensional medium has been developed. [C2430]

## "Minimum radar cross section bounds for passive radar responsive tags"

A common problem in ground moving target indication (GMTI) radar is detecting a target with even a large radar cross section (RCS) when its line-of-sight velocity falls below the minimum detectable velocity (MDV) for that radar system. In a cooperative scenario, a target may employ a tagging device, which can shift or spread its Doppler signature to become more detectable. In this paper we develop a bound on the minimum modulatable RCS of a passive (non-amplifying) device needed to be detectable as a function of radar and mode parameters, and compute this bound for specific GMTI and SAR radar modes. [C2431]

## "Non-coherent integration losses of wideband target detection"

First Page of the Article [C2432]

## "MIMO radar theory and experimental results"

The continuing progress of Moore's law has enabled the development of radar systems that simultaneously transmit and receive multiple coded waveforms from multiple phase centers and to process them in ways that have been unavailable in the past. The signals available for processing from these multiple-input multiple-output (MIMO) radar systems appear as spatial samples corresponding to the convolution of the transmit and receive aperture phase centers. The samples provide the ability to excite and measure the channel that consists of the transmit/receive propagation paths, the target and incidental scattering or clutter. These signals may be processed and combined to form an adaptive coherent transmit beam, or to search an extended area with high resolution in a single dwell. Adaptively combining the received data provides the effect of adaptively controlling the transmit beamshape and the spatial extent provides improved track-while-scan accuracy. This paper describes the theory behind the improved surveillance radar performance and illustrates this with measurements from experimental MIMO radars. [C2433]

## "Performance of MIMO radar systems: advantages of angular diversity"

Inspired by recent advances in multiple-input multiple-output (MIMO) communications, this paper introduces the statistical MIMO radar concept. The fundamental difference between statistical MIMO and other radar array systems is that the latter seek to maximize the coherent processing gain, while statistical MIMO radar capitalizes on the diversity of target scattering to improve radar performance. Coherent processing is made possible by highly correlated signals at the receiver array, whereas in statistical MIMO radar, the signals received by the array elements are uncorrelated. It is well known that in conventional radar, slow fluctuations of the target radar cross-section (RCS) result in target fades that degrade radar performance. By spacing the antenna elements at the transmitter and at the receiver such that the target angular spread is manifested, the MIMO radar can exploit the spatial diversity of target scatterers opening the way to a variety of new techniques that can improve radar performance. In this paper, we focus on the application of the target spatial diversity to improve detection performance. The optimal detector in the Neyman-Pearson sense is developed and analyzed for the statistical MIMO radar. An optimal detector invariant to the signal and noise levels is also developed and analyzed. In this case as well, statistical MIMO radar provides great improvements over other types of array radars. [C2434]

## "Techniques for detecting and tracking airplanes using weather radar WSR-88D"

For the first time, weather radar echoes from point scatterers (airplanes) in a non-stormy environment are investigated in the time and frequency domains and compared to model simulations to build a background for differentiating these echoes from weather signals and to develop procedures for data censoring. [C2435]

## "A concept for hip prosthesis identification using ultra wideband radar"

Ultra wideband (UWB) radar has been extensively investigated both theoretically and practically for the identification buried artifacts. Ground probe radar (GPR) concentrates on the identification of lightly buried land mines, unexploded ordnance (UXO) and archeological targets. The same technology is proposed in a similar context for the rapid identification of in vivo implanted metallic prostheses. The technique is based on resonance based target identification and the paper investigates UWB scattering from a metallic hip prosthesis in free space as a first step in the identification process. [C2436]

## "The next generation of GUIDAR technology"

The next generation of Guided Radar (GUIDAR) is based on Ultra Wide Band (UWB) radar signal processing. Just as spread spectrum technology has revolutionized the communications industry, UWB is dramatically changing radar signal processing. These advanced signal-processing techniques are adapted to leaky coaxial cable technology in the next generation GUIDAR to provide new features and enhanced performance. At the core of the new technology is an ultra high-speed digital correlator implemented in a Field Programmable Gate Array (FPGA). Complementary orthogonal codes based on Golay codes are used to produce thumbtack correlation functions simultaneously in multiple range bins. The net result is "near continuous wave (CW)" performance in forty to eighty 11.6-meter long-range bins with targets located within one meter along the length of cable. This is a dramatic improvement over the 3% duty cycle of the original GUIDAR and the typical 100 to 200 meter long zones of current CW leaky cable sensors. Orthogonal complementary codes are transmitted on each of two leaky coaxial cables. The response from two parallel receive cables is fed to a full synchronous detection receiver. The orthogonal nature of the code allows the composite coded pulse response to be de-multiplexed into the independent response for each of the two cables. This ultra-high speed correlation process involves the addition and subtraction of the sampled in-phase and quadrature-phase responses to the multiple range bin accumulators at 10 million samples per second. [C2437]

## "Field tests of a buried cable sensor with intruder location"

A new buried cable sensor developed at Southwest Microwave, Inc. has been added to the Intrepid family of outdoor perimeter intrusion sensors. The sensor with the trademarked name "MICROTRACK" is similar to the "MICROPOINT" fence sensor with precise detection location, sensitivity leveling and free format zoning. Intruder location is accomplished with low-power ultra wideband frequency stepped radar driving the sensor cables. Target range resolution also allows the use of sensitivity leveling for each individual range bin. This will compensate for differences in soil conductivity along the length of the cable and for metal objects, which may be located in the near field radiation. The design of the MICROTRACK sensor was presented at the 2002 Carnahan Conference in Atlantic City. It has been described as an FM-CW radar, however it differs from the generic form in that the frequency is stepped rather than continuously swept and phase code modulation is added to discriminate against interference. The wide bandwidth of the MICROTRACK sensor fills in the s typical of a single frequency radar and provides a more uniform field profile along the entire length of the sensor cables.

This paper describes the testing that has been performed to characterize the system for different environmental conditions. Southwest Microwave, Inc. has procured an open field site of 31 acres of tlat desert land for testing the buried cable. Another site in Canada is used for testing with an additional set of weather and soil conditions. Detection patterns, proximity to stationary objects, and various environmental factors will be discussed. Extensive measurements of both electric and magnetic fields along the length and perpendicular to the sensor cables show a detailed map of the multiple frequency surface wave. When the cables are buried, the uniformity of the field is degraded slightly but no deep s are observed. Site testing has confirmed major benefits of the MICROTRACK sensor: uniform detection zone; elimination of deep s; precise target location and sensitivity leveling. [C2438]

## "Two-parameter power-variable-training STAP"

Airborne ground moving target indicator (GMTI) radars must employ a method of radar clutter mitigation to separate moving objects from stationary ground clutter. Two-parameter, power variable training STAP effectively combines two distinct STAP methods to improve clutter suppression, target detection, and angle estimation. Power variable training STAP utilizes a clutter covariance scaling factor to prevent clutter overing and undering that can degrade radar performance. Two-parameter STAP augments power variable training STAP by implementing an adaptive clutter projection for the highest power clutter, thus limiting breakthrough clutter discretes while preserving MDV. Results are illustrated with radar data collected from the Tuxedo airborne radar. [C2439]

## "Evaluation of coding's methods for the development of a radar sensor for localization and communication dedicated to guided transport"

To explore possibilities of new exploitation modes of automatic guided transport, our laboratories designed formerly a sensor radar called DIREP (Detection et Identification des Rames En Panne: detection and identification of broken-down trains). This system is founded on the principle of a co-operative radar using a transponder inside targets. It is based on a numerical correlation receiver and has a very broad band from 50 to 100 MHz. which remains unexploited. Thus we propose to benefit from this band to establish high flow communication. The proposed system is made of microwave transmitting and receiving equipment fixed on each train, one ahead and other behind. The two trains exchange data and specific signals coded that make the system able: to deduce the distance between the trains; to identify the state of the train (broken-down or not); and to allow the transmission of pictures or audio-video records with a high data flow. The aim of this work is to propose technical solutions for multiplexing communication data and localization code in order to allow high data flow transfer. Simulations are computed to evaluate the system's performance: BER, computing time and complexity. [C2440]

## "A characteristic of target cognition using marine radar"

The radio detection and ranging (RADAR) is one of the useful instruments which a navigator uses for attempting safe navigation at poor weather conditions. In case of poor weather and there are lots of similar targets, they sometime make an error for its direction when they find the target in the landscape from RADAR information-target's direction, distance, echo size, echo shape, sweep and relationship among targets' echo. We have to prevent the errors for attempting safe navigation. The purpose of this paper is to find characteristics of the target cognition using marine RADAR with three steps: 1) to propose the navigator's model of the RADAR target cognition, 2) to evaluate the errors of the target cognition on the RADAR monitor and its judgment in the landscape, 3) to discuss the errors with the parallax. [C2441]

## "Naval radar in a littoral environment"

First Page of the Article [C2442]

## "Recognition of objects on their complex natural resonance at ultra wideband sounding"

In this report, the RSO (radar subsurface objects) complex resonance frequencies are used as features of their recognition proposed. From these features the basis of the prior information about identifiable object scattering characteristics is described. However, for practical implementation of described algorithm of RSO recognition it is necessary to explore and to take into account effect of some complicating factors such as deformation of observed data. Thus from this report the algorithm of recognition of RSO is designed. [C2443]

## "Comparative analysis of the narrowband and wideband methods of target recognition"

Results of comparative study of radar recognition with the use of narrowband and wideband signals as well as various recognition signatures are presented. The advantage of wideband radar signals is emphasized. The

results show that use of wideband signals allow increasing the accuracy of radar measurements and radar immunity against interference providing the same detection range. [C2444]

## "Signal processing in UWB radars of small distance"

In the paper, the methods of signal processing with reference to ultrawide band (UWB) radars designed for detection and remote measuring parameters of moving objects at short ranges (tens of centimeters-several meters) are considered. It is shown that the relative changes of an oscillation frequency filling an outgoing pulse and duration of these pulses originating at reflection from a moving target are very small; that makes impossible their practical measurement. Therefore, for detection of signals reflected from a moving target the phase method is chosen. [C2445]

## "Wideband radar remote sensing of the atmosphere: a data interpretation problem"

Wideband radar application for the remote sensing of the atmosphere is considered. Features of distributed targets as objects of wideband radar observations are shown. The difficulties of the retrieval meteorological information from the returns are discussed. Prospect of UWB radar for remote sensing is reviewed. [C2446]

## "Wideband radar (advantages and problems)"

Review of advantages and problems of wideband radar is given. Some criteria of wideband (UWB) radar are discussed to avoid misunderstanding when only the relative signal bandwidth is used as a criterion. Brief historical outline of the first and follow up experiments by different authors is presented. Advantages and disadvantages of bandwidth widening can be compared using the computer simulation of scattering. Experience of various simulation methods use, their applications to the target detection, tracking and recognition problems are briefly discussed and compared with experiment. Interference immunity, electromagnetic compatibility, stealth of radiation (low probability of intercept- LPI) for radar, and the possibility of creation of antiLPI passive radar are also discussed. [C2447]

## "Simulation of target detection using a high range resolution radar"

The use of wideband radar signals is sometimes more preferable for solving not only the tasks of target resolution, recognition, measurement, and the illumination stealth, but the traditional task of detection too. The latter is due to the decreased fluctuations of echoes. However, if the signal has an excessively wide bandwidth, the losses of noncoherent integration increase and the threshold signals rise. We investigate the detection threshold signals for the targets of different sizes, for illumination signals of various bandwidths, and for detection of different type. [C2448]

## "Ultra-wideband radar"

Here, we present a description of a block scheme, characteristics, specific features of design and results of testing for a prototype of the ultrawideband (UWB) radar, which has been developed by Russian UWB group researchers at Moscow Aviation Institute at "analog and digital radio systems" department (www.uwbgroup.ru). The prototype was designed within a research work, which we are conducting on the state order from one of Russian federation state institutions. The UWB radar is intended for detection of moving targets at a distance of several kilometers. The radar design is divided into two stages. In the first stage, we have produced a radar prototype, which incorporates a low power narrow-pulse generator (NPG). During laboratory test, the prototype has afforded the detection of moving targets at the distance of up to one hundred meters. Thereby, the validity of technical solutions used for the whole radar's and radar unit's design was confirmed. In the second stage, we plan to conduct field tests of the radar prototype equipped with a high power NPG. [C2449]

## "The eigenvector-based identification of shallow buried targets in ground penetrating radar"

A new approach to the super-resolution eigenvector method implementation, in step-frequency ground penetrating radar (GPR), is proposed. The pseudospectrum determination, fulfilled by the eigenvector algorithm, is followed by a procedure of more precise signal parameter estimation. Accordingly, the distance to the object obtained by the eigenvector algorithm is considered more reliable. Then, complex amplitudes of the determined signal components are calculated, which allows distinguishing different types of buried objects. [C2450]

## "Complementary code ISAR technique for stealth target detection and identification"

In this paper an original ISAR technique for stealth target detection and image reconstruction is analyzed. Geometry of 2-D ISAR scenario and analytical expressions for trajectory target determination are suggested. A

model of the complementary phase code ISAR signal reflected by environment in the presence of the stealth target is created. Autofocusing procedure using first point with the lower intensity is applied. Correlation range compression and FFT azimuth compression image reconstruction is performed. To verify the correctness of the model and ability of the ISAR technique for stealth target detection and image reconstruction numerical experiment is accomplished. [C2451]

## "ISAR technique for stealth target detection and image reconstruction"

First Page of the Article [C2452]

## "Form optimization of the UWB pulses in radar technology for accuracy increasing of angular measurements"

This work describes how the angular coordinates measurement precision of hardly noticeable radar targets increases due to the choice of an optimum form of UWB signal. The optimization, which has been carried out on the basis of known reflecting properties of the targets, allows the choice of the necessary ratio between maximal value of UWB signal and width of antenna pattern. [C2453]

## "Range errors due to occlusion in non-coaxial LADARs"

A prerequisite for mobile robot navigation is a reliable sensing mechanism. Laser detection and ranging sensors or LADARs are widely used in mobile robotics. When processing LADAR data for the purposes of feature extraction and/or data association, most previous work models such device as processing range data which follows a normal distribution. In this paper, it would be demonstrated that commonly used LADARs suffer from incorrect range readings at range discontinuities, which can have a much more detrimental effect on feature extraction or data association algorithms than random noise. LADARs with separated transmitter and receiver configuration can introduce a significant occlusion effect, as the reflected laser energy from the target can be partially occluded from the receiver. This paper would demonstrate that false range values can result from LADARs and that the occurrence of these values can be reliably predicted by monitoring the received signal strength. A useful design criterion for the optical separation of the transmitter and receiver is also derived for non-coaxial LADARs. The parameters, which are related to range errors, are quantified so that such errors can be reliably predicted. [C2454]

## "A modified bow-tie antenna design for step-frequency subsurface radar applications"

A modified bow-tie antenna for step-frequency ground penetrating radar is proposed. The flared dipole arm consists of a metal sector gradually converting into a strip-slot structure loaded by resistive films. For the comparison, a TEM horn is used. The synthesized pulse waveform is computed from the frequency-domain data using a calibration procedure and inverse Fourier transform. The antenna performance is demonstrated in several examples of detecting small shallowly buried subsurface targets. [C2455]

## "Detection of targets above rough surfaces using millimeter-wave bistatic radars"

In this paper, we report on a new set of indoor measurements aimed at characterizing the bistatic radar return from rough surfaces at Ka-band. The polarimetric response over the entire upper hemisphere, at both low and high incidence and scattering angles, and at near forward and backward directions are reported. This first of a kind data reveals the angular dependence of various polarimetric quantities such as the copolarization ratio, the crossto copolarization ratio, and the correlation between various polarized radar returns. It can be used to validate existing or new surface scattering models and to identify and evaluate bistatic configurations for radar operation. The potential of bistatic radars in detecting the presence of targets embedded in clutter is also demonstrated experimentally using a simple target above a rough surface. [C2456]

## "Ground penetrating radar (GPR) studies at the ElectroScience Laboratory (ESL)"

There are a number of factors to be considered in making many GPR measurements. These include (a) electronic hardware (b) antenna systems (c) electromagnetic properties of the ground (d) target identification arid remote sensing concepts and (e) use of numerical simulations. The purpose of this paper is to review the contributions made at the ESL for these factors and to discuss future potential advances in the state of the art. [C2457]

## "New implementation of the correlation function of the PN code for application in automotive radars"

This paper presents a new method for implementing the shifting of the PN code to calculate the correlation

function which is used to measure the target range in the spread spectrum automotive radar. The new method results In higher resolution without increasing the chip rate of the PN code (which necessitate increasing the bandwidth). This new method has the facility of variable resolution without increasing the complexity of the system. [C2458]

## "Investigation of side looking EM field scattering from a buried metallic object to support UXO discrimination"

Detection and identification of buried unexploded ordinance (UXO) remains a challenging problem. Despite limitations due to clutter and ground coupling, ground penetrating radar has shown considerable virtues for UXO discrimination. Recent UWB field tests between 10's of MHz and 100's of MHz have demonstrated that certain of the target's dimensions can be estimated from analysis of complex natural resonances in the signal. The problem becomes much more complicated when objects are placed in layered ground and oriented vertical to the antenna, so the incident field cannot excite currents along the major axes and the scattered field from the object cannot easily be separated from the layer interface response. To investigate this, we pursue simulations here designed to test side looking EM field scattering from a buried object placed in layered ground. The numerical calculation is done using the finite difference time domain (FDTD) method in conjunction with the generalized perfectly matched layer GPML. The results are analyzed for a cylinder placed in a uniform and layered earth. [C2459]

## "Target recognition using wavelets decomposition"

Radar target recognition continues to be a challenging problem which has yielded considerable algorithmic and hardware advances, particularly in military applications. It has been known for many years that the echo received from a remote object in response to illumination by a radar system is dependant on the nature and shape of the object, leading to the idea that a system could be devised for an eventual recognition of objects of differing shapes from radar echoes. In the development of automatic target detection and recognition systems, the issue of image data interpretation commonly yields to very difficult deciding situations. This paper addresses the problem of radar target recognition using models and images along with a matching approach involving the radar cross section signature. [C2460]

## "FDTD simulations of multiple GPR systems"

In this work, a multiple-GPR detection system has been simulated. The main advantage of such a system is that it saves time by detecting both the transverse and the longitudinal positions of the target by a B-scan measurement, whereas the same detection can be achieved by a C-scan with a single-GPR system. FDTD method is employed to perform the simulations, in which the ground is homogeneous and the target is perfectly conducting. [C2461]

## "A new method for detectability of signals in K-distributed clutter"

In this paper, we introduce a new method to analyze the detection performance of radar systems, operating in K-distributed clutter and thermal noise. A parametric approximation of cumulative distribution function (CDF), and probability density function (PDF) in terms of weighted sum of exponentials for detection probabilities are obtained, using a finite amount of sample random variables in the environment. The method proposed here is based on approximating CDF of the sample variates by a linear combinations of complex weighted exponentials. This method simplifies the detection problem and is directly applicable to many problems in the simulation of communication systems to determine density functions. [C2462]

## "Optimum coherent integration time for a surface target with periodic acceleration"

In this paper we consider the effect of surface target dynamics on the detection performance of coherent radar. The echo from a surface target traveling with a constant velocity, that is not radial to the radar look direction or constant rate acceleration is represented in the form of chirp function. This is a simplistic model that must be extended to account for other periodic accelerations acting on the target. The dominant periodic acceleration is the radial surge component that may result in the smearing of the targets Doppler. This radial surge component is a result of the interaction of the target with the ocean wave. This effect must be taken into account when determining the optimum coherent integration time (CIT). In this paper we extend the model to accommodate an echo from a periodic accelerating target with a frequency-modulated signal that represents the surge component. The optimum CIT is derived based on maximizing the signal-to-noise ratio (SNR) at the matched filter output. The results are verified based on data collected from a high frequency surface wave radar (HFSWR) operating at 15 MHz. [C2463]

## "A new adaptive polarization-space-time domain radar target detection algorithm for nonhomogeneous clutter environments"

A new adaptive radar target detection algorithm, called the polarization-space-time localized generalized likelihood ratio (PSTL-GLR) test shall be exploited, which is of significant use in nonhomogeneous clutter environments. The key idea of the PSTL-GLR algorithm is that the degree of freedom (DOF) is controlled to avoid a serious detection loss due to limited secondary data vectors by transforming the data from space-time domain to angle-Doppler domain, while maintaining high performance of the joint polarization-space-time processing. The detection performance of the proposed algorithm is derived analytically in terms of the probabilities of detection and false alarm, along with numerical evaluation to illustrate its efficiency in limited secondary data environments. [C2464]

## "Time-frequency analysis for maneuvering target detection in over-the-horizon radars"

A novel linear time-frequency representation method is proposed for source detection and classification in over-the-horizon radar (OTHR) systems. Of particular interest is the estimation and identification of the multipaths of maneuvering targets described as multicomponent time-Doppler signatures in the presence of strong clutter. By approximating the time-Doppler signatures as chirp signals in each block of time period, chirp signal analysis is used to estimate the chirp parameters (chirp rates and center frequencies) of the clutter and target signal components. Clutter components, which are localized around the low chirp rates and frequencies, are effectively suppressed through subspace projections. The target signals are then dechirped, which is followed by either conventional DFT transform or high-resolution spectrum estimation methods for center frequency estimation. [C2465]

## "Target number detection based on a order Choi-Willams distribution"

A new method is proposed to obtain accurate detection of moving targets in the synthetic aperture radar (SAR) imaging. The proposed algorithm is based on the a-order Choi-Willams-distribution -Hough (a -CWDH) transform introduced in this work. The a -CWDH transform avoids the usual trade-off between the auto-term concentration and cross-term interference for linear, chirp-like auto-components due to time-frequency distribution in the fractional Fourier domain. We can still get the clear image of targets even in the case of low SNR (-12dB). The method avoids a long time of coherent processing and sophisticated motion compensation by performing on the echo within one burst of step frequency signal. Simulation results indicate that the method can precisely detect the target number of a group. [C2466]

## "Stepped frequency continuous wave radar-data preprocessing"

Radar systems have been paid a lot of attention since the end of WWII. Along with performances improvement one has witnessed a diversification of their applications, which range from target detection and parameter measuring to navigation systems, anti-collision systems and subsurface sensing. The last application has had a great importance for humanitarian demining purposes taken into account the number of landmines spread across the world and the danger they pose to humans. Both, continuous wave and pulse radar have been employed for landmine detection. This paper deals with stepped frequency continuous wave (SFCW) radar that operates from 400 MHz to 4845 MHz, in steps of 35 MHz. The novelty of the system, built at International Research Center for Telecommunication-transmission and Radar (IRCTR), consists in the fact that 8 frequencies are transmitted simultaneously, which drastically decreases the data acquisition time. Because of the strong reflection from the air-ground interface one may face some difficulties to "see" the landmines, which are lying on, or just below of the surface. If the antenna system footprint is much more larger than the size of the mine, this is even more difficult as the signal from the mine will be buried in the clutter signal. In order to remove the clutter signal and to improve signal to clutter ratio, average clutter subtraction and synthetic aperture radar have been investigated. [C2467]

## "Neural networks trained by scattered electromagnetic data for GPR applications"

This paper is intended to give a presentation of the first results we have achieved in the field of reconstructing buried objects starting from the data extracted from the time-domain waveform of the scattered electromagnetic field which can be available at the receiving terminals of a GPR equipment. To this aim, neural network methodologies are exploited to face the inverse scattering problem. The main attention has been devoted to identify sets of data that can be "easily" extracted from the transient field. These data, however, represent the "electromagnetic signature" of the investigated scenario and thus they be chosen to be closely related to the geometric as well as the dielectric properties of the target. Preliminary results are shown concerning the localisation of the target and the reconstruction both of its dimension and of its relative dielectric permittivity.

[C2468]

## "Antenna development and a stepped-frequency GPR system for landmine detection"

A project for developing a compact size GPR system for landmine detection was started. It will be based on stepped-frequency radar system for wider application in various kinds of soil conditions. We have developed a prototype stepped-frequency for fundamental evaluation of the system. This system uses a broadband Vivalidi antenna and operates at 2-6 GHz. The system was tested in laboratory and could be used for imaging buried mine-like targets by high resolution. Series of tests were carried out by using sand with rough surface and inhomogeneous soil. We discuss the ability of GPR for landmine detection. [C2469]

## "A comparison of segmentation techniques for target extraction in ground penetrating radar data"

In a typical GPR survey, a great amount of data is collected, and only a small percentage of this amount represent useful data (i.e. target data) whereas the majority of the data is considered non-useful. The first of the post-processing stages, which relies heavily on a skilled operator, involves pointing out the areas that may contain targets and suppressing others. Consequently, this process consumes considerable amounts of time and effort, apart from the fact that the existence of the human factor at this critical stage invariably introduces inconsistency and error into the interpretation. In this paper, three techniques for automatic GPR data segmentation are discussed and compared. The techniques rely on the computation of certain features from which a neural network can then arrive at a decision to classify the data segments in question as targets or otherwise. The first technique is based on extracting three statistical features from A-scan segments while the second technique computes statistical features from B-scan regions to produce the discrimination bases for the neural classifier to distinguish targets from non-targets. In the third technique, some regional properties of B-scan segments accompanied by the statistical features are used to achieve discrimination not only between targets and non- targets, rather between hyperbolic-shaped and non-hyperbolic-shaped targets as well. All three techniques were on different types of GPR data collected from a variety of sites, and they proved to be very efficient to form a robust automatic technique for data reduction and segmentation. [C2470]

## "Phase-based detection of small 3-D dielectric objects beneath rough surfaces"

This paper discusses the detection of small three-dimensional (3-D) dielectric objects with low contrast (relative to their surrounding media) buried near the 3-D rough ground surface by means of stand-off ground penetrating radar. This case scenario was derived from the requirements on detecting small non-metallic anti-personnel (AP) mines in realistic minefields, where AP mines are buried a few centimeters beneath rough ground surfaces. If the dielectric contrast between the objects and their surrounding media is low, and if the objects are small and buried just beneath rough ground surfaces, then scattering from the rough ground surfaces will dominate and hence mask the weaker scattering from these buried objects. Various analyses and numerical simulations have shown the considerable complexity of scattering from rough surfaces and/or the targets buried beneath rough surfaces. In this paper, we present the methodology using measured GPR phase data to deal with this complex problem without using a-priori knowledge about the target and/or ground characteristics. [C2471]

## "77GHz MMIC transceiver modules with thick-film multi-layer ceramic substrate for automotive radar applications"

A 77GHz MMIC transceiver module has been developed for automotive radar applications by using a low-cost thick-film multi-layer ceramic substrate. The module accommodating all MMIC-based transceiver functions in a single-cavity housing for improved manufacturability can be either assembled with built-in Tx/Rx antennas or mounted on external antenna sheet, depending on required antenna beam width. The module, measuring 25Ч25Ч3.4mm3with 3.3g in weight, has demonstrated >150m target detection capability when evaluated in a radar system, compatible with our current production-type radar. [C2472]

## "LADAR-based detection and tracking of moving objects from a ground vehicle at high speeds"

Detection and tracking of moving objects (DATMO) in crowded urban areas from a ground vehicle at high speeds is difficult because of a wide variety of targets and uncertain pose estimation from odometry and GPS/DGPS. In this paper we present a solution of the simultaneous localization and mapping (SLAM) with DATMO problem to accomplish this task using ladar sensors and odometry. With a precise pose estimate and a surrounding map from SLAM, moving objects are detected without a priori knowledge of the targets. The interacting multiple model (IMM) estimation algorithm is used for modeling the motion of a moving object and to predict its future location. The multiple hypothesis tracking (MHT) method is applied to refine detection and data association. Experimental results demonstrate that our algorithm is reliable and robust to detect and track pedestrians and different types of moving vehicles in urban areas. [C2473]

## "Generalized optimization of polarimetric contrast enhancement"

The optimization of polarimetric contrast enhancement (OPCE) is one of important problems in radar polarimetry. The traditional OPCE is to choose optimal polarization states for enhancing a desired target versus an undesired target/clutter. The contrast enhancement enables us to discriminate or distinguish the desired target from background or from the undesired target. We propose a generalized OPCE (GOPCE). For the GOPCE problem, we need to find not only three coefficients such that the ratio of two factors associated with the desired target and clutter is maximal, but also optimal polarization states such that the received power ratio of the target and clutter is maximal. Both the factors consist of three parameters, i.e., the Cloude entropy (Cloude, S.R. and Pottier, E., IEEE Trans. Geosci. Remote Sensing, vol.35, p.68-78, 1997) and two special similarity parameters (Yang, J. et al., Electron. Lett., vol.37, p.193-4, 2001). The optimal coefficients of the GOPCE are obtained by solving an eigenvalue problem. Using an example, we demonstrate that the GOPCE can be employed for detecting roads in a forest area by using polarimetric SAR data. [C2474]

## "LIDAR-based vehicle tracking for a virtual mirror"

Low visibility conditions and blind zones induce hazards to driving and have been shown to be a cause of many automobile crashes every year. In order to reduce these effects, the virtual mirror, a computer-generated display that uses a high-accuracy DGPS system coupled with an onboard geo-spatial database, was used to render the view that the driver would see in a mirror-like display. In order to correctly display and integrate the information (lane boundaries, etc.) from the database with the sensed objects, a real-time method of locating and tracking nearby vehicles was developed. This paper outlines the algorithms and equipment used to achieve real-time vehicle tracking based on a scanning laser range sensor, and the experiments performed to determine the accuracy of the virtual mirror's ability to correctly display moving vehicles in the sensor's field of view. [C2475]

## "Retro-directive noise correlation radar with extremely low acquisition time"

A new retro-directive antenna based search radar system has been introduced. The suggested system uses a novel noise correlation technique. Simulation and analytical results show an order of magnitude improvement in the acquisition time of the radar when compared to a phased array antenna based radar system with the same specifications, except transmit power. To the best of knowledge of the authors, no radar of a comparable acquisition time has been designed to date. The power versus acquisition time tradeoff has been compared with the phased array radar for evaluating the performance of the system. The radar system is self-tracking due to retro-directivity of the antenna array, and is much easier to implement, as it does not require any phase shifters etc. [C2476]

## "Activity recognition using the dynamics of the configuration of interacting objects"

Monitoring activities using video data is an important surveillance problem. A special scenario is to learn the pattern of normal activities and detect abnormal events from a very low resolution video where the moving objects are small enough to be modeled as point objects in a 2D plane. Instead of tracking each point separately, we propose to model an activity by the polygonal 'shape' of the configuration of these point masses at any time t, and its deformation over time. We learn the mean shape and the dynamics of the shape change using hand-picked location data (no observation noise) and define an abnormality detection statistic for the simple case of a test sequence with negligible observation noise. For the more practical case where observation (point locations) noise is large and cannot be ignored, we use a particle filter to estimate the probability distribution of the shape given the noisy observations up to the current time. Abnormality detection in this case is formulated as a change detection problem. We propose a detection strategy that can detect both 'drastic' and 'slow' abnormalities. Our framework can be directly applied for object location data obtained using any type of sensors-visible, radar, infrared or acoustic. [C2477]

## "CRLB with pd"

First Page of the Article [C2478]

## "Tracking system performance assessment"

First Page of the Article [C2479]

## "Context-sensitive state estimation"

First Page of the Article [C2480]

## "Temporal impulsive noise excision in the range-Doppler map of HF radar"

In this paper we present an effective scheme to excise impulsive noise pixels from a range-Doppler image or map. The temporal impulses in high frequency ocean surveillance radar (HFOSR) Doppler spectrum image arise due to local lightning discharges or man-made sources. Previous work focused on locating the noise position (detection) and applying a simple blanking technique, thereby burying targets in the noise spectrum. Built on these prior approaches, our current work develops an additional key step that uses weighted or block prediction method to estimate the possible true values of the destroyed ones. A range-Doppler image with much higher signal to clutter and noise ratio (SCNR) results. Another direct advantage over the former scheme is the improved robustness. Experimental images verify both the effectiveness and advantage of our method. [C2481]

## "Highway overhead structure detection with on-line camera pitch bias estimation"

A radar-based forward collision warning system has the draw back of not being able to distinguish a stopped vehicle from the false alarms caused by highway overhead structures. A vision-based overhead structure detection system has previously been developed that detects and tracks horizontal edge features from the overhead structures. The system also estimates the height of the structures and their distance to the host vehicle, which can be used to help reject false alarms from radar caused by the overhead structures. The algorithm used in this system relies on accurate calibration of the in-vehicle video camera, and the so-called reference horizon in particular, which can vary depending on the camera pitch bias. In this paper, we present an algorithm for on-line estimation of the reference horizon, and consequently the pitch bias of the camera. An enhanced system combining overhead structure detection and reference horizon estimation, and steps towards real-time implementation are also presented. [C2482]

## "Tracking separating targets with a monopulse radar: idealized resolution"

First Page of the Article [C2483]

## "Radar in the quantum limit"

Deep space tracking radars, such as the Arecibo radar, have Terawatt class EIRP, and are the scale of a small village. As such it seems surprising that one would ask whether their performance is dictated by quantum theory. However in this talk we show that it is, due to the very large losses in link budget. In this talk we discuss the quantum limits of radar performance for deep space tracking and other radars. A radar is said to be a quantum radar if at the detector level we have insufficient RF target photon density to invoke classical physics by means of the Gaussian central limit theorem. We discuss the performance modeling in this regime and in particular look at how quantum theory informs the dish verses array trade. [C2484]

## "ISAT-innovative space-based-radar antenna technology"

ISAT is the innovative space-based-radar antenna technology program of the Defense Advanced Research Projects Agency (DARPA). The goal of the ISAT program is to develop antenna technology to enable tactical grade space-based GMTI (ground moving target indicator) radar-particularly from higher (-10,000 km) orbits which facilitate constellations with fewer satellites. [C2485]

## "Optimum detection of the radar-tracking targets by means of super short impulses"

It is shown that the detection distance for the radar-tracking targets with absorbing coatings is augmented at the expense of selection of optimum performances of a radar radiation and shape of super short pulses. The optimum performances of a system are on the basis of data concerning reflecting properties of the radar-tracking targets. [C2486]

## "A target tracking system based on radar and image fusion"

First Page of the Article [C2487]

## "Influence of the operating mode on noise stability of nonlinear radar"

This paper describes the influence of the operating mode on noise stability of nonlinear radar. Nonlinear radiolocation is a simple way to discriminate electronic targets (semiconductors). All electric devices contain semiconductors. Its voltage-current characteristic is nonlinear, so the probing signal spectrum is upgraded with harmonics. Efficiency of such transformation is small. There are the objects capable to create a handicap in a frequency band of a nonlinear location. Reception of a weak signal on a background of handicaps is conducted.

It is usual narrow-band interferences. Therefore, a locator should have ability of a choice of a radio channel in the range of channels 1..m with a minimum level of handicaps. Results of researches of problems of an automatic choice of the channel with a minimum level of handicaps use swept-frequency modulation of a signal and the synchronous detecting are submitted. [C2488]

## "Experience of antenna complexes creation for the radars of distant detecting and space area monitoring"

Air defense radars using reflector antennas for area surveying were not found suitable for operating new targets. Antennas with great aperture surface and electrical beam moving were required. Antenna complexes of "Dunay-3" and "Dunay-3U" radars are presented in this paper. It operates in the decimeter wave band and consists of two antenna systems located in two sites-the transmitting one and the receiving one. The antenna is also an active array with linear radiators. The "Dunay-3" radar antenna uses 200 radiators while the "Dunay-3U" consists of 100 linear radiators. The main radar element is an antenna made as a phased antenna array on relatable system for the upper semi-sphere observation. The antenna array is divided at sub arrays with an analogue beam forming way and the full antenna pattern is formed with an adaptive digital way. Another antenna complex presented in this paper is the "Volga" radar. The "Volga" radar is the new generation of distant detection stations operating in continuous radiation regimen: the radar illuminates a target and receives reflected signals simultaneously. [C2489]

## "The perspective directions of the technical modernization of inter-period signal processing systems of pulse ATC radars"

The engineering solutions improving detection of air targets against the clutter background in pulse radars of ATC are substantiated and analyzed. [C2490]

## "Maintaining multimodality through mixture tracking"

In recent years particle filters have become a tremendously popular tool to perform tracking for nonlinear and/or nonGaussian models. This is due to their simplicity, generality and success over a wide range of challenging applications. Particle filters, and Monte Carlo methods in general, are however poor at consistently maintaining the multimodality of the target distributions that may arise due to ambiguity or the presence of multiple objects. To address this shortcoming this paper proposes to model the target distribution as a nonparametric mixture model, and presents the general tracking recursion in this case. It is shown how a Monte Carlo implementation of the general recursion leads to a mixture of particle filters that interact only in the computation of the mixture weights, thus leading to an efficient numerical algorithm, where all the results pertaining to standard particle filters apply. The ability of the new method to maintain posterior multimodality is illustrated on a synthetic example and a real world tracking problem involving the tracking of football players in a video sequence. [C2491]

## "A joint space-borne radar technology demonstration mission for NASA and the Air Force"

NASA and the Air Force are currently studying joint technology demonstration concepts for large aperture Space Based Radar (SBR) systems. The mission focuses on elements of NASA's earth science enterprise strategic plan and Air Force long term needs for global airborne and ground moving target indication (GMTI and AMTI) surveillance, and represents an unprecedented multi-agency approach to scientific and technological advancement of spaceborne radar. The preliminary design for the system specifies a low center frequency such as L-band, a large physical aperture between 50 and 150 square meters, and on-board processing capability for synthetic aperture radar (SAR) and moving target indication applications. The key technologies requiring demonstration of technical maturity and affordability are the active electronic scanned aperture (AESA) and the realtime On-Board Processing (OBP). The system concept incorporates active metrology for measurement of the shape of the aperture, and electronics and processing capability for active compensation of the aperture surface deformation. The goal of the mission is to demonstrate the ability to maintain coherence in a very large aperture in the space environment, to show scalability to larger apertures, and to demonstrate the ability to deliver fault-tolerant real-time products in space. The systems also permit characterization of spaceborne L-band phenomenology and validate adaptive processing for moving target detection. This paper describes the trades and a technology risk addressed in this study, and highlights those elements in that could be developed in concern with other SBR programs. The work is being conducted jointly by Jet Propulsion Laboratory, California Institute of Technology, and the Air Force Research Laboratory, both under contract with NASA. [C2492]

## "Multi-target linear converter-mlc"

First Page of the Article [C2493]

## "Computer simulation of target backscattering as element of perspective radar design"

Method of computer simulation of aerial target backscattering is described. It is used for comparative study of wideband and narrowband radar signals in application to radar recognition, detection, coordinate measurement, and tracking. It is shown on the basis of examples that computer simulation becomes an important element of the perspective radar design. [C2494]

## "Unified Bayes multitarget fusion of ambiguous data sources"

The fact that evidence can take highly disparate forms has been a major stumbling block in multisource-multitarget data fusion. Evidence can have at least three forms: unambiguous data (easily amenable to probabilistic analysis); ambiguously-generated data (difficult to characterize probabilistically); and ambiguous data (difficult to even model mathematically). We summarize a unified, systematic, and fully probabilistic methodology for fusing all three data types with the aim of detecting, tracking, and identifying multiple targets. The basic tool is the generalized likelihood function, which hedges against the inherent uncertainties associated with ambiguous and ambiguously-generated data. [C2495]

## "Target discrimination in the S.A.R. systems by using radar polarimetry"

For a SAR system that coherently transmits and receives both signals from an orthogonally polarized antenna pair, the elements of the resulting scattering [S] matrix can be measured. As a result, polarimetric processed imagery is visually much clearer than single-polarization channel imagery. In addition, fully polarimetric SAR imagery improves the performance of an ATR system, compared to the performance achieved by using single-polarization channel imagery. This paper gives a brief description of some polarimetric tools and techniques used to analyze and process polarimetric data. Several polarimetric discrimination results are displayed, demonstrating the potential capability of characteristic polarization imaging and the usefulness of polarimetric radar in the target discrimination process. [C2496]

## "Adaptive radar signal processing-the problem of exponential computational cost"

We provide a survey of space-time adaptive processing for radar target detection. Specifically, early work on adaptive array processing from the point of view of maximum signal-to-noise-ratio and minimum mean squared error perspectives are briefly reviewed for motivation. The sample matrix inversion method of Reed, Mallet and Brennan is discussed with attention devoted to its convergence properties. Variants of this approach such as the Kelly GLRT, adaptive matched filter and ACE tests are considered. Extensions to handle the case of nonGaussian clutter statistics are presented. Current challenges of limited training data support, computational cost, and severely heterogeneous clutter backgrounds are outlined. Implementation and performance issues pertaining to reduced rank and model-based parametric approaches are presented. [C2497]

## "Small target detection using enhanced SAR images"

This paper investigates the impact of SAR image enhancement on the performance of small target detection in SAR images. Three SAR image enhancement algorithms are evaluated on large SAR image data-sets. The evaluation results show that image enhancement can greatly improve the performance of false alarm mitigation, and that the level of performance improvement is correlated with the resolution and background suppression of the enhanced images. The higher the resolution and the level of background suppression, the higher the level of performance improvement. [C2498]

## "Radar cross section reduction of dihedral and trihedral comer reflectors coated with radar absorbing materials (8-12 GHz)"

Corner reflectors form the major scattering centers in the radar signatures of ships, aircraft and vehicles. The radar cross section (RCS) reduction of these "flare spots" (corner reflectors) plays an important role in the design of these targets with reduced detectability in radar. This paper deals with the RCS reduction of square dihedral and trihedral corner reflectors, coated with radar absorbing material (RAM). The measurements were carried out in an anechoic chamber at Centro Tecnico Aeroespacial (CTA)-Ministerio da Defesa facilities, and the RAM coating was manufactured at Divisao de Materiais of Instituto de Aeronautica e Espaao (IAE)/CTA. The processed RAM applied on a flat plate was evaluated by reflection coefficient measurements by using the RCS self-calibrated technique. [C2499]

## "Non-linear STAP filters based on adaptive 2D-FIR filters"

This paper presents a non-linear adaptive approach to the cancellation of clutter echoes in modern AEW radar

systems equipped with digital beamforming. Two new STAP schemes are conceived by using different non-linear functions that are applied to the output of a bank of adaptive 2D FIR filters. The STAP schemes are shown to yield better detection performance than previously known schemes when operating in a non-stationary clutter background containing interfering targets. Since they require a limited increase of the computational load, compared to the single 2D-FIR filters, the proposed schemes can be regarded as practical solutions for robust and effective STAP of radar data. [C2500]

## "Performance evaluation of two polarimetric STAP architectures"

Space-time adaptive processing (STAP) is a powerful technique for detecting slowly moving targets in strong clutter. However, STAP performance is limited when used on radars with small apertures. Past research suggests polarization's potential to effectively discriminate between targets and clutter, thereby improving detection performance. We evaluate two methods of incorporating polarization into STAP, modeled after the polarimetric matched filter (PMF) and the polarimetric whitening filter (PWF). Our analysis serves to unify various proposed approaches to combining STAP and polarization, and benchmarks the benefits of polarization to GMTI detection. Using measured clutter and target characteristics from published sources as a baseline, we found that the PMF technique offers up to 6-dB improvement over STAP. This significant advantage is realized in the center of the clutter spectrum, and the impact on minimum detectable velocity (MDV) is modest. However, the PWF offers increased performance over the entire Doppler spectrum, and can be easily implemented as a STAP post-processor. [C2501]

## "Mitigating the effects of chaff in ballistic missile defense"

In this paper, an algorithmic (schema) approach for detecting and tracking targets in highly cluttered environments is presented. The approach is to accurately track the centroid of the chaff cloud using a combination of medium band (MB) and wide band (WB) range resolution radar waveforms. At moderate pulse repetition frequencies (PRFs), differential target velocities (about the centroid of the chaff cloud) are detected and tracked via Doppler banks of transversal filters that are tuned to detect the target velocity differences. Through sensitivity analysis using Matlab models, the theoretical lower bound on detectable differential target velocity as a function of the chaff cloud composition (e.g., clutter cross section, clutter spectral width, number of dipoles, and clutter velocity standard deviation) and radar related parameters (e.g., waveform frequency, bandwidth, integration times, PRFs, and signal-to-clutter ratio) is presented. [C2502]

## "Improved HRR-ATR using hybridization of HMM and eigen-template-matched filtering"

A new 1-D hybrid automatic target recognition (ATR) algorithm is developed for high range resolution (HRR) profiles. The proposed hybrid algorithm combines eigen-template based matched filtering (ETMF) and hidden Markov modeling (HMM) techniques to achieve superior HRR-ATR performance. In the algorithm, each HRR test profile is first scored by ETMF which is then followed by independent HMM scoring. The first ETMF scoring step produces a limited number of "most likely" models that are target and aspect dependent. These reduced number of models are then used for improved HMM scoring in the second step. Finally, the individual scores of ETMF and HMM are combined using maximal ratio combining to render a classification decision. The results demonstrate that the hybridization technique achieves improved recognition performance when compared to the independent performances of either ETMF or HMM. [C2503]

## "Proceedings of the 2003 IEEE Radar Conference (Cat. No. 03CH37474)"

First Page of the Article [C2504]

## "Detection improvements with CFARs having expanded amplitude inputs"

This paper addresses some differences in performance of cell averaging, constant false alarm rate (CA-CFAR) processors as a function of whether the input signal has linear, square-law, or a higher order response relative to the output of a linear receiver. For brevity, these CFAR inputs are herein referred to as A, A2, A4, etc., signals. Specifically, the CFAR input voltage is assumed to be of amplitude AN, where A is the amplitude of a linearly received signal. When using conventional in-phase (I) and quadrature (Q) channels, A = (I2+ Q2)12/. Emphasis is on CA-CFAR performance when the threshold is set for rejecting very spiky clutter which, for this study, is defined as having Weibull statistics with the parameter a = 5. Under these conditions, analyses indicate that for detecting a target in noise, a square-law (N=2)CA-CFAR input signal may provide 9.3 dB better detection sensitivity than does a linear (N=1) CFAR input. Also for targets in noise and a Weibull a = 5 clutter threshold setting, it appears that fourth order (N = 4) CFAR input may yield nearly 20 dB improvement over linear input. [C2505]

## "A moving target detection filter for an ultra-wideband radar"

A time modulated ultra-wideband (TM-UWB) through-wall impulse radar currently has been developed at Time Domain Corporation, Huntsville, AL, which detects the motion of people in range and azimuth through non-metallic walls. The radar operates in real-time with 3Hz update rate. In order to detect the motion of people moving with different velocities, a digital moving target detection (MTD) filter has been developed which is implemented in the software of the radar. The MTD filter is an IIR high-pass filter and it helps reject the stationary (time history invariant) clutter. Results on the time vs. slow-frequency (Fourier transform of slow-time response) distribution for targets moving at different velocities are presented for a given update rate. The transfer function of the MTD filter as a function of a target velocity is also presented for a given update rate. [C2506]

## "Adaptive space/frequency processing for distributed aperture radars"

This paper deals a preliminary investigation into space-time-waveform adaptive processing for waveform diverse distributed apertures. The large baseline of such a distributed radar results in angular resolution that is orders of magnitude better than resolution of a monolithic system (single large radar) with the same power-aperture. This capability comes at the cost of grating lobes (multistatics with evenly spaced apertures) or high sidelobes (multistatics with randomly spaced apertures). This paper develops some preliminary solutions to these drawbacks associated with distributed apertures. In particular, the use of approximately logarithmic spacing with each aperture transmitting orthogonal waveforms provides excellent detection performance. [C2507]

## "Configuring a sparse aperture antenna for spaceborne MTI radar"

Sparse arrays provide potential for improving the minimum detectable velocity (over 3 m/s improvement for sidelooking radar) of spaceborne moving target indication radar for a given physical aperture. This paper examines the benefits and some of the challenges resulting from employing sparse arrays: grating lobes introduce ambiguities that may create Doppler blind zones; area coverage rate may reduce due to a narrower antenna main beam for coherent transmission; and intrinsic clutter motion may reduce the usable fraction of the Doppler space. We consider the application of orthogonal transmit waveforms to increase area coverage rate, as well as frequency diversity and aperiodic subarray spacings to mitigate Doppler blind zones. [C2508]

## "A multistage nonhomogeneity detector"

This paper introduces a new space-time adaptive processing architecture for nonhomogeneous radar environments that exploits the multiresolution analysis of the multistage Weiner filter by interleaving the generalized inner-product. The simplest form of this architecture results in performing the generalized inner-product within the generalized sidelobe canceller. In general, the new architecture provides a signal-dependent generalized inner-product which intends to detect only those inhomogeneities that degrade the estimation of the colored noise and interference that passes through the steering vector. The filter structure and interpretation of the multistage Weiner filter provide the framework for this innovation. Nonhomogeneity detection and adaptive processing performance are assessed by using the Monte Carlo trials of simulated data with known inhomogeneities. [C2509]

## "Operations of an airborne bistatic adjunct to space based radar"

Space to air bistatic concept of operations for area surveillance has renewed potential to extend the capability of space-based radars. However, design considerations of antenna size, number of simultaneous receive beams, and bistatic geometries must be analyzed in terms of area coverage rate and target signal to noise ratio. The clutter spectrum, observed from a space bourne transmitter to airborne receiver depends on both bistatic range and receiver look geometries, and changes rapidly due to the satellite velocity. Bistatic space-time adaptive processing (STAP) is required to cancel the severe clutter, and is characterized by the required degrees of freedom (DOF) to obtain target detection probability and minimum detectable velocity (MDV). Demands on the receiver's digital beamforming and STAP are presented, including the characteristics of digital signal processing. Finally, an estimate is made of the throughput requirements on a real-time processor. [C2510]

## "Time series processing of FLIR imagery for MTI and change detection"

The paper addresses the problem of calibrating FLIR images of a scene that are acquired at different time points to construct information for moving target indication (MTI) and change detection. A signal model is developed to identify variations and imperfections of an FLIR sensor in time. This model is utilized to compensate for relatively slow variations of a bias in the FLIR sensor via a Fourier-based processing. Furthermore, a two-dimensional adaptive filtering method is developed to compensate for variations of the image point response (IPR) of a FLIR sensor as well as sub-pixel changes in the relative coordinates of the sensor-target over time. Results with time

series FLIR, data of a scene with an airborne helicopter and a ground target are provided. [C2511]

## "New methods for handling the range dependence of the clutter spectrum in non-sidelooking monostatic STAP radars"

We address the problem of detecting slow-moving targets using a non-sidelooking monostatic space-time adaptive processing (STAP) radar. The construction of optimum weights at each range implies the estimation of the clutter covariance matrix. This is typically done by straight averaging of neighboring data snapshots. The range-dependence of these snapshots generally results in poor performance. We present two new methods that handle the range-dependence by exploiting the geometry of the direction-Doppler curves. [C2512]

## "SAR image enhancement for small target detection"

The paper investigates the impact of SAR image enhancement on the performance of small target detection in SAR images. Three SAR image enhancement algorithms are evaluated on large SAR image data-sets. The evaluation results show that image enhancement can greatly improve the performance of false alarm mitigation, and that the level of performance improvement is correlated with the resolution and background suppression of the enhanced images. The higher the resolution and the level of background suppression, the higher the level of performance improvement. [C2513]

## "A Multi Target Track Before Detect Application"

This paper deals with a radar track before detect application in a multi target setting. Track before detect is a method to track weak objects (targets) on the basis raw radar measurements, e.g. the reflected target power. In classical target tracking, the tracking process is performed on the basis of pre-processed measurements, that are constructed from the original measurement data every time step. In this way no integration over time takes place and information is lost. In this paper we will give a modelling setup and a particle filter based algorithm to deal with a multiple target track before detect situation. In simulations we show that, using this method, it is possible to track multiple, closely spaced, (weak) targets. [C2514]

## "Employing fractionally-spaced equalizers (FSE) for magnetic recording channels"

We propose and investigate the performance of an FSE (oversampled) system in longitudinal and perpendicular recording channels. Results show that the proposed system outperforms the conventional (symbol rate) one whenever there is excess bandwidth, like in longitudinal recording. [C2515]

## "Maneuvering target detection in over-the-horizon radar by using adaptive chirplet transform and subspace clutter rejection"

In over-the-horizon radar (OTHR) target detection, the signal-to-clutter ratio (SCR) is very low, typically from -50 dB to -60 dB. Furthermore, for maneuvering targets, such as aircraft and missiles, Doppler frequencies of their radar return signals may be time-varying. In this case, the Fourier transform based techniques and super resolution spectrum estimation techniques may not work well since they use sinusoidal signal models. We propose a signal subspace clutter rejection algorithm combined with an adaptive chirplet transform technique for maneuvering target detection with OTHR. Simulation results of adding simulated maneuvering targets into raw OTHR clutter data are presented to illustrate the effectiveness of the proposed algorithm. The simulation results show that moving targets with -53.5 dB SCR can be detected. [C2516]

## "Multiple target detection and estimation by exploiting the amplitude modulation induced by antenna scanning. Part II: detection"

This work deals with the problem of detecting and estimating multiple radar targets present in the same range-azimuth resolution cell of a surveillance radar system with a mechanically rotating antenna. First, the target parameters are estimated assuming a maximum number of possible targets. To this purpose we use the asymptotic maximum likelihood (AML) RELAX estimator derived in the first part (for pt. 1 see ibid., p. 529-532 (2003)). Subsequently, these estimates are used in a sequential hypotheses test (SHT) procedure. The statistic of the test at each step of the SHT procedure is derived using an asymptotic expression of the generalized likelihood ratio test (GLRT) statistic. An upper bound of the false alarm probability is derived in closed form, whereas detection performance of the proposed SHT detector is investigated through Monte Carlo simulation. [C2517]

## "Biparametric clutter-map CFAR processor independent of original clutter distribution"

The traditional CFAR processors are based on the sliding-window concept, which have substantial performance degradation under nonhomogeneity. Owing to temporal processing and the exploitation of the local homogeneity of the map cell, the clutter-map procedure acquires enhanced robustness with little CFAR losses. In this paper, a Gaussian biparametric clutter-map constant false alarm rate (GBCM-CFAR) processor is proposed which merges the clutter-map technique and noncoherent integration together. It can approximately achieve CFAR independent of the original clutter distribution. The performance in the presence of fast point targets is assessed, in the examples of Weibull and lognormal clutter, in order to elicit the effect of the system parameters. Its performance is close to that of the optimum Neyman-Pearson detector with little CFAR losses in homogeneous environments. It is also suitable to deal with the nonhomogeneous situation. [C2518]

## "Multiple target detection and estimation by exploiting the amplitude modulation induced by antenna scanning. I. Parameter estimation"

First Page of the Article [C2519]

## "High resolution time-frequency distributions for maneuvering target detection in over-the-horizon radars"

A novel high-resolution time-frequency representation method is proposed for source detection and classification in over-the-horizon radar (OTHR) systems. A data-dependent kernel is applied in the ambiguity domain to capture the target signal components, which are then resolved using the root-MUSIC based coherent spectrum estimation. This method is particularly effective to analyze a multi-component signal with time-varying time-Doppler signatures. By using the different time-Doppler signatures embedded in the multipath signals, this proposed method can reveal important target maneuvering information, whereas other linear and bilinear time-frequency representation methods fail. [C2520]

## "Detection and imaging of slowly moving target of airborne SAR based on the GMCWD-Hough transform"

In this paper, the features of airborne SAR moving target echoes are analysed, the Generalized-marginal Choi-Williams Distribution-Hough transform (GMCWD-HT) is also introduced. According to the echoes model of airborne SAR, a new method of detecting and imaging the slowly moving target of airborne SAR based on the (GMCWD-HT) is proposed. Computer simulation results show that this method can be used to perform the slowly moving target detection and imaging of airborne SAR in the low signal to clutter ratio; its detecting performance is better than the common method based on Wigner-Ville distribution. [C2521]

## "A least squares multiple constraint direct data domain approach for STAP"

Traditionally, statistical space-time adaptive processing (STAP) approaches have been implemented to detect targets using an airborne radar system. These approaches typically assume a wide sense stationary environment and utilize auxiliary training data to estimate the statistics of the interference. Unfortunately the airborne radar environment can be highly non-stationary and may contain coherent interferers, which could drastically impact statistical STAP performance. Various approaches have been investigated to address this problem. One approach is the direct data domain least squares (D3LS) approach. This deterministic least squares adaptive signal processing technique operates on a "snapshot-by-snapshot" basis to determine the adaptive weights for ing interferers and estimating signals of interest (SOI). Due to the reduced training data set (one range ring only-the range ring under test) and because of the particular least squares techniques employed, this approach can readily be implemented in real time in field deployable sensor signal processing systems. This paper presents an improvement to the existing D3LS approaches for radar processing. By implementing multiple space-time constraints system gain is maintained on the signal of interest when the signal arrives slightly off-set in angle, Doppler, or both. To illustrate this concepts an airborne radar simulation is used to generate radar data, and the D3LS processing results are presented. [C2522]

## "Sidelobe reduction for matched filter range processing"

Linear frequency modulation (LFM) matched filtering results in range sidelobes. These sidelobes are often objectionable because they may mask small targets or may be mistaken for targets themselves. Various methods of sidelobe control are investigated and their performance is measured. The methods of sidelobe reduction include dual apodization, spatially variant apodization, and leakage energy minimization. Nonlinear frequency modulation (NLFM) matched filtering is also investigated. A simulation was run to compare LFM with sidelobe control and NLFM, all using moderately low pulse compression ratios. Results suggest that generally, NLFM matched filtering has better detection and estimation characteristics than LFM with sidelobe control.

[C2523]

## "Feasibility analysis of GSM signal for passive radar"

Passive radar makes use of an 'illuminator of opportunity' already present in the environment for other purposes (TV transmission, broadcast systems, etc) to detect targets as well as estimating target parameters. This radar has the merit of being a completely covert radar system, which does not advertise the presence of either the receivers or transmitting stations. One such existing radio transmission that may be utilize for this purpose is that of the GSM system. This paper is intended to access the feasibility and suitability of using the GSM downlink signals from the GSM base station as the 'transmissions of opportunity' in an experimental passive radar system. The analysis of the GSM signal as a radar waveform for the passive radar systems design and its associate signal processing scheme is investigated. Simulations and preliminary experimental results demonstrate that the detection of ground moving targets can be indeed be achieved, affirming that this system is indeed viable and for certain does offer a novel and unique kind of passive detection that is outside the scope of other current approaches. [C2524]

## "FOPEN scene generation using numerical electromagnetic analysis"

This work develops the high-fidelity simulation capability for foliage penetration (FOPEN) synthetic aperture radar (SAR). The simulation is based on a method of moments (MOM) numerical electromagnetic analysis of target scenes including foliage. The ability to accurately model the interaction of foliage and target is crucial for an accurate simulation. Example scenes for isolated metal targets are provided in addition to scenes with dielectric and combined metal and dielectric targets. As expected, the effect of the surrounding foliage is shown to have a significant impact on the reconstructed target image. This approach will be useful in FOPEN applications for the prediction of target signatures under various conditions of concealment. [C2525]

## "A technical assessment of ADS-B and multilateration technology in the Gulf of Mexico"

Two aircraft surveillance technologies, multilateration and ADS-B, have emerged during the past few years and now appear to be possible alternatives to traditional primary and secondary radar systems. Multilateration has been tested extensively for airport surface applications-e.g., test in Atlanta (1996) and Federal Aviation Administration (FAA) tests at Dallas-Forth Worth (1998-1999). The FAA plans to deploy multilateration/ADS-B systems as part of the airport surface detection equipment-X (ASDE-X) system now scheduled for installation at 25 non-ASDE-3 equipped airports. There is, however, limited experience with multilateration for tracking of airborne aircraft. HITS, based on commercially available equipment, forms the ground segment of a dual-technology multilateration and ADS-B aircraft tracking system. Multiateration utilizes signals from air traffic control radar beacon system (ATCRBS) (Modes A and C) and Mode S transponders, and requires no changes in current aircraft equipage. HITS also operates with signals from ADS-B Mode S extended squitter transponders now being considered for operation in the National Airspace Systems (NAS). To assess the performance of HITS, technical requirements were derived from ATCBI-6 SSR to compare the technical performance of HITS against FAA secondary radar. The evaluation criteria include coverage volume, probability of detection, positional accuracy, code performance, and target resolution. These criteria were derived to assist the FAA in assessing the technical feasibility and possibly developing certification criteria for these two potential non-radar surveillance alternatives. The results from this test and evaluation will provide important data to the FAA as it attempts to determine the feasibility of implementing multilateration and ADS-B in terminal and en route environments. This paper details the technical results and the HITS system performance. [C2526]

## "New solutions to the problem of range dependence in bistatic STAP radars"

We address the problem of detecting slow-moving targets using a space-time adaptive processing (STAP) radar. The construction of optimum weights at each range implies the estimation of the clutter covariance matrix. This is typically done by straight averaging of neighboring data snapshots. However, in bistatic configurations, these snapshots are range-dependent. As a result, straight averaging results in poor performance. After reviewing existing methods exploiting the precise shape of the bistatic direction-Doppler curves. [C2527]

## "Processing and analysis of polarimetric ground penetrating radar landmine signatures"

The paper presents an analysis of landmine signatures acquired with a polarimetric ground penetrating radar (GPR). First, preprocessing was applied to isolate the target signatures from other reflection events. This included a frequency-wavenumber (f-k) filter to remove unwanted side reflections, followed by background subtraction to remove the direct wave and the ground reflection. The obtained polarimetric signatures of the landmines indicated that these can contain significant cross-polar components, which is in contrast to expectation for a target with a cylindrical casing and most likely a result of internal structure. Making use of the

reciprocity property of the scattering matrix, the polarimetric signatures were transformed into the target frame, yielding signatures that are independent of target orientation. From the transformed signatures target impulse responses were estimated using a newly developed deconvolution algorithm. The novelty of the deconvolution algorithm lies in the fact that it computes impulse responses, which adhere to a physical model. Accordingly, the computed impulse responses can be related to mine properties such as size and dielectric permittivity. An interesting application of this is the estimation of a mine's permittivity from its impulse response and the impulse response of a calibration target, of which an example is given. [C2528]

## "Analysis of target responses and clutter based on measurements at test facility for landmine detection systems located at TNO-FEL"

Target responses and natural clutter have been analyzed based on GPR measurements performed in July 2002 at the test facilities for landmine detection systems located at TNO-FEL. The object responses of four different types of antipersonnel mines (surface laid and buried at depths of one, five and six centimeters) in three different types of ground have been analyzed for different polarizations of incident and scattered wave, for different pulse durations and for different antenna configurations. Clutter levels have been defined for two different presentations of raw data and have been determined for three different types of ground. It is shown that detectability of targets by GPR is limited not by the sensitivity or the dynamic range of the radar, but by the clutter. It is demonstrated that it is possible to detect targets below clutter level using the statistical data analysis. [C2529]

## "Phased array technology for GPR antenna design for near subsurface exploration"

The geophysical explorations for near surface investigations for buried objects are carried out by ground penetrating radar (GPR) using sensors operating at radio and microwave frequencies. It is well realized that focused beaming from an antenna into subsurface yields high resolution (with improved illumination of the target area) and results in better delineation of the subsurface targets. ASTRON (the radio astronomy research center of the Netherlands) has been engaged in developing a new generation of all-sky, full sensitive, multibeam radio telescopes for astronomical research at radio frequencies. Using a highly sensitive tapered slot THEA antenna, measurement beams on the sky are electronically formed and steered as desired. Experimental data show great promise in detecting moving objects in the sky. The existing know-how of focused beaming using phased array technology developed at ASTRON could be extended for better illumination of non-moving subsurface objects for GPR investigations. Stacking (adding) of the data gathered using both the beam-forming transmitting and receiving GPR antennas would result in reduced surface clutter effects and in enhanced detection of the near surface targets. In this paper, the concept of phased array technology in a bistatic mode of operation for GPR application is described. [C2530]

## "Proceedings of the 2nd International Workshop on Advanced Ground Penetrating Radar (IEEE Cat. No.03EX680)"

First Page of the Article [C2531]

## "STW project "Advanced relocatable multisensor system for buried landmine detection""

Delft University of Technology has just finished its major efforts in a most challenging project, supported by the Dutch Technology Foundation STW. This four-year project entitled "Advanced relocatable multi-sensor system for buried landmine detection" was the largest project in STW history. Within the scope of this project we have built up a unique expertise and knowledge in the whole GPR chain starting from all aspects in GPR technology and finishing with target classification and soil characterization. The paper describes the goals and results within this project. [C2532]

## "Monopulse radar detection and localization of multiple targets via joint multiple-bin processing"

If several closely-spaced targets fall between two matched filter samples in range, monopulse information from both of these samples can and should be used for estimation, both of angle and of range (i.e., estimation of the range to sub-bin accuracy). Here, a model is established and a maximum likelihood (ML) extractor is developed. A limit of the number of targets that can be estimated is established, and indeed it will be shown that the new extractor can detect up to five targets in a range extent of one resolution cell, meaning from detections in two adjacent matched filter samples. A minimum description length (MDL) criterion is used to detect the number of targets between the two matched filter samples. Simulations are presented to show the performance of the new extractor. [C2533]

## "Target detection in heterogeneous airborne radar interference using 3D STAP"

Heterogeneous interference is common-place in the airborne radar problem. Space-time adaptive processing fundamentals have struggled in the presence of such data. Originally, the solution involved simply increasing secondary data support, essentially "drowning" out heterogeneous interference effects. Research then progressed into identifying specific range cells containing heterogeneous interference and excising these cells from interference estimates. Yet, the target detection problem within heterogeneous interference remained. Therefore, research efforts abandoned statistical techniques and shifted towards deterministic methods with some success. Finally, the advent of a two-dimensional hybrid approach combined the diverse statistical and deterministic techniques into a single framework. This research effort continues in this vein by expanding the method into three-dimensions: azimuth, Doppler, and elevation. A 23 dB improvement over the three-dimensional joint domain localized method (3D-JDL) is shown for a specific heterogeneous interference case. [C2534]

## "A radically new target detection process"

Conventional radar detection of a target in the presence of external interference and thermal noise follows the classic matched filter approach by spatially and temporally processing multiple samples of the received signals. This process is sometimes referred to as the space time adaptive process (STAP). This process has two deficiencies in that multiple somewhat stationary time samples are required and that the process does not work well when both the interference and target are collocated in the mainbeam of the radar. In contrast, a very promising new target detection technique is developed in this paper, which is capable of detecting and extracting signal characteristics using only single time samples from multiple antenna elements. This process inherently does not require any of the signals to be stationary because only one instant of time is used and furthermore the process allows target detection even when the interference is not resolved in angle because the process does not require a to be placed on the interference. Although the new process is computationally intense, the current development of active digital array radars and hardware technology make the processing of this detection technique possible in the near future. [C2535]

## "Dynamic detection capability of a mobile bistatic weapons locating radar"

In this paper a bistatic radar concept using an airborne, mobile receiver is proposed for an artillery-location application. The performance of such a conceptual system is dependent on tracking the artillery projectile for a sufficient flight time to enable accurate determination of the complete trajectory. We report dynamic coverage and flight time detection results for a range of bistatic configurations and radar and target parameters. This has been accomplished using a two-dimensional bistatic radar computer simulation developed especially for this analysis,. The model incorporates bistatic RCS data to simulate realistic target reflection characteristics. It is shown that a bistatic system using a single mobile receiver is effective for the required task over a large surveillance range and is a viable alternative to current monostatic systems. Potential improvements to the system are discussed. [C2536]

## "High fidelity modeling of space-based radar"

Space based radar design are becoming more affordable given new technologies of solid state active apertures and advanced digital signal processing. However, it is important to be able to synthesize the design of the system with sufficient detail to anticipate the radar system's operation and interference effects expected in a space environment. This includes simulation of site specific clutter with realistic Earth rotation and statistical variation, wideband propagation of the signal from multiple phase center aperture, and impact of channel match and errors on adaptive processing for detecting targets. The research laboratory space time adaptive processing (RLSTAP) has been developed as a variable fidelity radar simulation tool to captures these effects. The paper will describe results of modeling an L-band multimode space based radar, including effective of ambiguities from antenna subarrays, and range and Doppler waveforms on adaptive processing. [C2537]

## "Robust adaptive signal processing methods for heterogeneous radar clutter scenarios"

This paper addresses the problem of radar target detection in severely heterogeneous clutter environments. Specifically we present the performance of the normalized matched filter (NMF) test in a background of disturbance consisting of clutter having a covariance matrix with known structure and unknown scaling plus background white Gaussian noise. It is shown that when the clutter covariance matrix is low rank, the NMF test retains invariance with respect to the unknown scaling as well as the background noise level and is approximately CFAR. Performance of the test depends only upon the number of elements, number of pulses processed in a coherent processing interval and the rank of the clutter covariance matrix. Analytical expressions for calculating the false alarm and detection probabilities are presented. Performance of the method is shown to degrade with increasing clutter rank especially for low false alarm rates. An adaptive version of the test is

developed and its performance is studied with simulated data. A technique known as self censoring reiterative fast maximum likelihood/adaptive power residue (SCRFML/APR) is presented to overcome the problem of outliers in training data for heterogeneous clutter scenarios. [C2538]

## "Maximum likelihood angle extractor in the presence of sea-surface multipath"

In the presence of sea-surface multipath, the standard monopulse ratio technique to extract elevation angle of target produces large bias. In this paper we propose a maximum likelihood (ML) angle extraction technique for low elevation targets above the sea surface, of known average signal strength having a Rayleigh fluctuation. The procedure is then modified for targets having unknown average signal strength. The resulting modified angle extractor has only a small performance degradation compared with the known average signal strength case, but it performs much better than the monopulse ratio based estimator. This angle extractor reduces the root mean square error (RMSE) by more than 50% in the signal processing stage when used for low flying target tracking scenarios. Further improvement is achieved by using the predicted average target signal power in dynamic scenarios where a significant reduction in the tracker RMSE performance can be achieved, as shown in the simulations presented. [C2539]

## "New detection algorithm for poor signal-to-noise conditions"

A new detection algorithm for radar signal processing is presented. Especially in fighter applications, well-performing detection algorithms play a crucial role for enhancing situational awareness. By utilizing the local characteristics of the received signal more efficiently, better performance can be achieved. As phenomena-considered-disturbances in the received target signal are often discarded, valuable information is lost. However, this associated information can benefit the system, although even the latest statistical inference and modeling, are applied in practice with synthetic array radar (SAR) image processing. The usefulness of this new approach is demonstrated. [C2540]

## "Multistatic radar as a means of dealing with the detection of multipath false targets by airport surface detection equipment radars"

An evaluation of the applicability of multistatic radar concepts to the performance of airport surface detection equipment (ASDE) was performed via proof-of-concept (POC) experiments at Baltimore-Washington International Airport (BWI) during spring 2002. Multistatic radar configurations offer an effective means of mitigating against the detection of multipath false targets that often affect the performance of ASDE radars, particularly through their impact on automated alerting systems designed to warn controllers of runway incursions during takeoff and landing procedures. This paper identifies key features of a multistatic radar system for this application and presents a number of experimental results obtained during the POC. In order to test the efficacy of the concept, a bistatic receiving and recording system (BRRS) was designed and built to receive and record bistatic scattered energy derived from transmissions emanating from the ASDE-3 Ku-band radar. This system and other supporting instrumentation used for the POC are also included. The results of the POC demonstrated that multistatic radar concepts applied to ASDE-type radars are realizable and are useful for mitigation against the detection of multipath false targets. [C2541]

## "Blind adaptive detection of distributed targets in compound-Gaussian clutter"

This paper considers the problem of detecting distributed targets in the presence of compound-Gaussian noise with unknown statistics. At the design stage, in order to cope with the a priori uncertainty, we model clutter returns as Gaussian vectors with the same structure of the covariance matrix, but possibly different power levels. Hence, resorting to the method of sieves, we devise a fully blind detector, which ensures the constant false alarm rate (CFAR) property with respect to the disturbance power levels. Moreover the performance analysis confirms the capability of the novel receiver to operate in scenarios of practical interest for radar systems. Finally the comparison with the plain modified generalized likelihood ratio test (MGLRT), devised assuming Gaussian disturbance, and shows that even in the presence of Gaussian clutter, the newly proposed detector achieves satisfactory performance. [C2542]

## "Target detection in sea clutter using convolutional neural networks"

A detector based on convolutional neural networks is proposed for radar detection of floating targets in highly complex and nonstationary cluttered environments. This detector is coherent and monocell, i.e. it works with the complex envelope of the echoes from the same range cell. It includes a pre-processing time-frequency block implemented by the Wigner-Ville distribution, which provides a constant false alarm rate (CFAR) behavior regarding the clutter power when normalization is utilized. Simple theoretical models for the clutter and targets were allowed to study the impact of the correlation and Doppler of both target and clutter on its performance.

This detector has also been tested with real-life sea clutter with an improved performance compared to classic detectors. [C2543]

## "Radar applications of low rank signal processing methods"

This paper addresses the problem of radar target detection in severely heterogeneous clutter environments. Specifically we present the performance of the normalized matched filter (NMF) test in a background of disturbance consisting of clutter having a covariance matrix with known structure and unknown scaling plus background white Gaussian noise. It is shown that when the clutter covariance matrix is low rank, the NMF test retains invariance with respect to the unknown scaling as well as the background noise level and is approximately CFAR. Performance of the test depends only upon the number of elements, number of pulses processed in a coherent processing interval and the rank of the clutter covariance matrix. Analytical expressions for calculating the false alarm and detection probabilities are presented. Performance of the method is shown to degrade with increasing clutter rank especially for low false alarm rates. An adaptive version of the test is developed and its performance is studied with simulated data from the KASSPER program. Issues of sample support for subspace estimation, constant false alarm rate (CFAR) and detection performance are presented. [C2544]

## "A performance evaluation of autoregressive clutter mitigation methods for over-the-horizon radar"

Wide-area surveillance over-the-horizon radar (OTHR) requires minimizing the dwell time in each search region without compromising Doppler resolution of targets from clutter. Low-order autoregressive (AR) modeling of the clutter spectrum has been proposed to unmask targets from clutter using shorter coherent integration times (CITs). We compare the performance of three methods using AR parameters to maximize signal-to-clutter-to-noise ratio (SCNR) with shorter CITs. In particular, we consider AR-based data extrapolation (DATEX), minimum variance clutter pre-whitening (MV-CPW), and a method called HOPPLER, which consists of pre-whitening, conventional Doppler processing, and re-insertion of the clutter spectrum. We compare the methods using real data from a mid-latitude OTHR with a target beacon embedded in sea-clutter. [C2545]

## "Ubiquitous MIMO multifunction digital array radar"

Radar equipment specifications are often driven by the need to detect small targets in clutter. Relevant specifications include dynamic range, phase noise, system stability, isolation and spurs. Furthermore, the desire for low probability of intercept radar operation also influences the radar hardware design. This paper describes how digital array radars can be used to manage radar time and energy, thereby simplifying radar equipment design. Digital arrays enable both highly focused transmit beams (e.g., for track) and broad transmit illumination (e.g., for search). Regarding the latter, multi-input multi-output (MIMO) techniques, which allow wide angular coverage, are described. [C2546]

## "The processing of target resolving for radar extended target detection"

Based on the target plots data acquired from detection of the antiship guidance radar receiver, the phenomenon of extended target split caused by the radar high resolution characteristic is discussed. The repeated detection phenomenon of target and its influences brought by the feature of radar antenna scanning mode are described. At the same time, analyzed that the different target plots spread leads to the uncertainty between detected target numbers obtained by radar acquisition and actual target numbers (i.e. cause redundant target plots).The valid algorithm that agglomerating target split plots and implementing multi-target resolving is proposed. [C2547]

## "Adaptive detection of targets on the sea surface based upon range-compressed SAR data"

This paper addresses adaptive detection of possibly-extended targets on the sea surface based upon range-compressed SAR data. The detection problem has been re-cast in the context of space-time adaptive processing and an adaptive detector, capable to operate in uncertain scenarios, has been proposed. The proposed detector takes advantage of signature diversity, namely of the fact that possible useful signals from different range cells span a vector space whose dimension is greater than one. The performance assessment shows that it can be a viable means to cope with realistic scenarios. [C2548]

## "Multiresolution GMTI radar"

The detection and tracking of ground moving vehicles from airborne radar can be challenging at slow target velocities due to the close space-time (angle-Doppler) proximity of strong competing mainbeam clutter. Moreover, in complex non-stationary clutter environments, conventional space-time adaptive processing (STAP) cannot be relied upon to provide precision ing. In this paper, we re-examine GMTI radar from a multiresolution

perspective resulting in a hybrid radar mode combining elements of synthetic aperture radar (SAR) with STAP GMTI. In particular, acute sources of clutter interference are resolved via quasi-SAR processing, and then combined with STAP GMTI to significantly reduce minimum detectable velocities, reduce the required DOFs, increase available training set size, and lower SINR loss and false alarms. [C2549]

## "Polarimetric optimisation applied to permanent scatterers identification"

In this work, the potential of full-polarimetric SAR data to enhance the performance of permanent scatterers candidates (PSC) detection is investigated. In particular, the problem of finding the polarisation states that maximise the signal amplitude inverse coefficient of variation (ICV) is analyzed. Under the hypotheses of Rice statistics and high signal to clutter ratio (SCR), the problem can be cast into a form equivalent to the optimisation of the ratio between PS (target) and clutter backscatter. Then, solution can be derived for the optimal transmit and receive polarisation states. In the paper, selected typologies of PS and clutter are investigated. The approach is validated through Monte Carlo simulation of the multitemporal polarimetric response of PS-like SAR pixels. Results indicate that optimal ICV values of polarimetrically complex PSC pixels are higher than in the ERS case of the single VV channel, thus leading to increased stability of the subsequent parameter retrieval. Moreover, simulation of ICV vs. SCR suggest that a higher number of PSC may be detected by using optimal polarisation states than in the conventional VV channel alone. [C2550]

## "Scene characterization using sub-aperture polarimetric interferometric SAR data"

In this paper, a fully polarimetric analysis method is introduced to decompose synthesized interferometric SAR images into sub-aperture data sets, which correspond to the scene responses under different azimuthal look-angles. A statistical analysis of polarimetric parameters permits to clearly discriminate media showing a nonstationary polarimetric behavior during the SAR integration. A method is proposed to observe the polarimetric interferometric properties of anisotropic targets. [C2551]

## "Ultra wideband endfire synthetic aperture radar for landmine detection"

The detection of landmines is an important and challenging application for remote sensing technologies. The use of ground penetrating radar is an established technique but requires close coupling between the antennae and the ground and generally suffers from a poor area coverage rate. In order to clear mines rapidly along a route using a vehicle mounted system, a forward looking sensor is required that can operate effectively in a stand off configuration and detect surface laid, flush and buried mines. Reliable detection is required against a background of vegetation and other, surface and buried mines. Reliable detection is required against a background of vegetation and other, surface and buried, clutter. The Remote Minefield Detection System (REMIDS) is a technology demonstration programme funded by the UK Ministry of Defence designed to use an Ultra Wideband Synthetic Aperture Radar (UWBSAR) and a polarimetric infrared camera. The UWBSAR is a 3GHz bandwidth impulse radar with onboard data collection and offline image processing. The UWBSAR has been successfully trialled against landmines. Previous trials have mounted the radar on an airship and employed a conventional side-looking imaging geometry. In contrast, for the trials reported in this paper, the radar was amounted on a trolley to simulate a ground vehicle and operated in a forward-looking mode. The resulting use of an endfire synthetic aperture radar rather than the more conventional broadside aperture is the principal development reported in this paper. This coarsens the resolution and introduces a left-right ambiguity into the data. Previous trials have also highlighted the lack of a comprehensive data set containing controlled targets and a range of clutter conditions. The current trials were therefore conducted on a purpose built 80m test track which contained five different soil types, a range of surface conditions and over 200 targets of varying types and burial depth. The trials campaign collected over 500 data sets by varying the conditions of data collection in terms of polarisation, antenna height, antenna separation, incidence angle, power levels and pulse repetition frequency. The experimental configuration allowed the track of the platform to be repeated to sufficient accuracy to allo- w the synthesis of multiple baselines in the vertical and horizontal. The principal conclusions from the trials analysis are 1) that the data set collected is of good quality and comprehensive in terms of targets and background; 2) the endfire synthetic aperture configuration worked as anticipated; and 3) the left-right ambiguity can be resolved if a suitable antenna configuration is used. [C2552]

## "Parallel detection fusion for multisensor tracking of a maneuvering target in clutter using IMMPDA filtering"

We present a (suboptimal) filtering algorithm for tracking a highly maneuvering target in a cluttered environment using multiple sensors. The filtering algorithm is developed by applying the basic interacting multiple model (IMM) approach and the probabilistic data association (PDA) technique to a two sensor (radar and infrared, for instance) problem for state estimation for the target. A detection fusion approach is followed where the raw

sensor measurements are passed to a fusion node and fed directly to the target tracker. A multisensor probabilistic data association filter is developed for parallel sensor processing for target tracking under clutter. A past approach using parallel sensor processing has ignored certain data association probabilities leading to an erroneous derivation. Another existing approach applies only to non-maneuvering targets. The algorithm is illustrated via a highly maneuvering target tracking simulation example where two sensors, a radar and an infrared sensor, are used. Compared with an existing IMM-PDA filtering algorithm with sequential sensor processing, the proposed algorithm achieves significant improvement in the accuracy of track estimation. [C2553]

## "The SSCM for ship characterization using polarimetric SAR"

Ship characterization is investigated using the symmetric scattering characterization method (SSCM), which was introduced by Touzi and Charbonneau (2002). The SSCM method appears to be very promising for ship identification. Identification of ship targets with significant symmetric scattering is shown to lead to accurate pitch measurement, under certain conditions. [C2554]

## "Detection of chlorophyll fluorescence in vegetation from airborne hyperspectral CASI imagery in the red edge spectral region"

This work provides a description of the investigations conducted to assess the detection of chlorophyll fluorescence from hyperspectral CASI data. The viability of retrieval of solar-induced fluorescence through airborne imaging spectrometer measurements of radiance of targets under natural illumination is studied. A method based on in-filling of fluorescence signals in atmospheric oxygen absorption lines is applied to study sites of corn crop grown under different stress conditions due to variation in nitrogen treatment. Results of the relationships found between measurements of laser-induced fluorescence and chlorophyll concentration at the ground level with the in-filling of the 762 nm oxygen band and optical indices calculated from CASI imagery R685/R655, derivative D730/D706, and the double-peak derivative f/reflectance index Dpi (D688·D710)/ D6972are presented. [C2555]

## "A modified quasi-best weighted order statistics CFAR algorithm with greatest of selection"

In order to improve the performance of OSGO or GOSGO, a CFAR algorithm based on quasi best weighted (QBW) order statistics CFAR method is proposed in this paper. The analytic results show that the performance of QBWGO is evidently superior to that of OSGO or GOSGO both in a homogeneous background and in multiple target situations. If the number of interfering targets is 4, the CFAR loss of QBWGO is 4.659, the CFAR loss of OSGO is 5.357, and an improvement of nearly 1 dB by QBWGO is obtained. In the special case of M1=M2=0, N1=N2=0, QBWGO reduces to GO, and in the case of M1=N1=0, QBWGO reduces to MX-CMLD. [C2556]

## "An improved ratio edge detector for target detection in SAR images"

Edge detection is usually an important step of speckled SAR image processing, such as target detection. A few ratio-based edge detectors, such as MRoA edge detector, and the RGoA edge detector using predefined thresholds, have been developed for speckled SAR images. In this paper, RGoA method is modified for target detection in SAR images. The algorithm of the modified version of RGoA (called MRGoA), and the method for automatically determining the ratio threshold are developed. The MRGoA method differs from the RGoA method in definition of an edge pixel and the automatic threshold determining method. A real SAR image is used to verify our method. Experimental results show that the proposed method is effective and it will facilitate target detection. [C2557]

## "Scattering of ultrashort electromagnetic pulses by nonlinearly reflecting targets"

Nonlinear radiolocation is very promising for future remote sensing systems and it has been proposed for sensible determination and recognition of objects, including elements with different nonlinear electromagnetic characteristics. It is based on the fact that generation of higher harmonics occurs under scattering of electromagnetic waves by nonlinearly loaded conducting targets. Investigating re-reflected harmonics, one can determine a nonlinear object, and also obtain additional information. The paper investigates numerically the scattering of ultrashort electromagnetic pulses by the following models of nonlinear scatterers: nonlinearly loaded vibrator; two-dimensional plate. The calculations give the possibility of determining optimal values of electromagnetic probing pulse duration needed to obtain the maximal useful reflected signal. [C2558]

## "Investigations with SECAR-a bistatic HF surface wave radar"

This paper describes a bistatic HF surface wave radar, designated SECAR, which was deployed near Darwin,

Australia, and used to conduct a variety of scientific investigations related to radar design, siting and target detection, as well as providing a test-bed for evaluating the operational utility of HFSWR as an element of a national surveillance network. The scientific results are significant because of their implications for improved radar design and effective deployment. [C2559]

## "Surveillance coverage of sensor networks under a random mobility strategy"

We consider the problem of surveillance of a region undertaken by a group of mobile sensors. Random mobility strategies are discussed in terms of coverage efficiency, communication and reliability in hostile environments. Under a Brownian motion random mobility strategy for the sensor grid, the distribution of the time-until-detection of slowly moving (point) targets is studied. Both two and three dimensional environments are considered. We obtain explicit formulas in three dimensions and bounds in two. [C2560]

## "Integer coded genetic algorithm design of staggered sampling MTI"

The stagger time-variant algorithm is an effective method to reject clutter and alleviate the blind speed problem. Selecting the suitable stagger-code to make the first notch shallow can avoid the lost of target. This paper presents a novel integer coded genetic algorithm (GA) to select the best stagger-code. By compared with other traditional algorithm, GA is a global stochastic searching method and can converge quickly. The simulation and performance analysis demonstrate the feasibility and validity of this algorithm. [C2561]

## "Analyzing the dependence between RADARSAT-1 vessel detection and vessel heading using CFAR algorithm for use on fishery management"

The National Oceanic and Atmospheric Administration (NOAA) National Environment Satellite, Data, and Information Service (NESDIS) provides synthetic aperture radar (SAR) derived products under a demonstration project named the Alaska SAR Demonstration (AKDEMO) to the US government community. The AKDEMO near real-time data and products include SAR wind images and vectors, hard target locations, and ancillary data. The hard target locations are available for use in fishery management by agencies such as the Alaska Department of Fish and Games (ADF&G), the National Marine Fisheries Service ( NMFS) and the United States Coast Guard (USCG). Vessel positions are obtained form hard target signatures through the use of a constant false alarm rate (CFAR) vessel detection algorithm developed by Veridian Systems Division. This algorithm has gone through testing and validation, using fleet information and vessel observer reports, during the Red King Crab fisheries in Alaska in 1999 and 2000. The goal was to maximize the number of ships found while minimizing the number or false alarms. Using general fleet location information, it was found that the minimum vessel size detected by the CFAR algorithm was 36 m using RADARSAT-1 ScanSAR wide mode data with a nominal spatial resolution of 100 m. Still, when comparing the CFAR results with the actual positions reported by the ship observers, vessels over 36 m were not always detected. This led to the hypothesis that the heading and perhaps wind conditions may have affected the ability of the SAR to detect the vessels. In 2001, vessel observers again reported their positions during SAR overpasses, this time also reporting heading and wind conditions. Unfortunately, due to high winds and waves, SAR was not able to detect the fishing fleet. In 2002, this was repeated, resulting in 3 days during the fishery opening when RADARSAT-1 was able to image the fishing fleet in the ScanSAR wide B mode. Approximately twenty ships each day in the area covered by the RADARSAT-1 data reported their position and heading. Results showing the dependence between RADARSAT-1 vessel detection and vessel heading are presented using the GIS platform. [C2562]

## "Multisensor & spectral image fusion & mining: from neural systems to applications"

We have continued development of a system for multisensor image fusion and interactive mining based on neural models of color vision processing, learning and pattern recognition. We pioneered this work while at MIT Lincoln Laboratory, initially for color fused night vision (low-light visible and uncooled thermal imagery) and later extended it to multispectral IR and 3D ladder. We also developed a proof-of-concept system for EO, IR, SAR fusion and mining. Over the last year we have generalized this approach and developed a user-friendly system integrated into a COTS exploitation environment known as ERDAS Imagine. In this paper, we have summarized the approach and the neural networks used, and demonstrate fusion and interactive mining (i.e., target learning and search) of low-light visible/SWIR/MWIR/LWIR night imagery, and IKONOS multispectral and high-resolution panchromatic imagery. In addition, we had demonstrated how target learning and search can be enabled over extended operating conditions by allowing training over multiple scenes. This has been illustrated for the detection of small boats in coastal waters using fused visible/MWIR/LWIR imagery. [C2563]

## "A target discrimination algorithm for high resolution SAR imagery"

Target discrimination is an important stage of automatic target recognition (ATR). A region of interest (ROI)

segmentation algorithm based on CFAR technique is described first. Then, a novel discriminator, the extended fractal (EF) discriminator, is proposed. At last, a discrimination algorithm composed of EF feature, target region area, and peak power ratio is designed to discriminate target from clutter ROIs. Experimental results using the MSTAR dataset show that this discrimination algorithm can eliminate most of the false alarms while maintain a high detection rate. [C2564]

## "CFAR detection of targets under directional noise background"

For a radar or sonar system, target detection is a basic function of the system. In sensor array processing, target detection is facilitated by examining the beamformer output of the received signal. The conventional method integrates the beam power observations by simple summation or linear integration and no statistical information is used. However, if the noise environment is directional, this will result in non-CFAR (constant false alarm rate) detection performance. In this paper, we exploit generalized likelihood ratio test (GLRT) to design the detector. We divide the data sequence from all the sensors into different segments and calculate the power observation of each segment. Then the probability distributions of the power observation under both hypotheses are derived. The unknown parameters of the signal model can be estimated by moment estimation based on statistical properties of the observations. Compared with the conventional processor, the GLRT detector can normalize the background of the output test statistic so that it shows CFAR property. Under the noise with directionality, the new detector we developed can still work well while the conventional one will show a false result due to the directionality of the noise when the SNR is low. Simulation result shows that the GLRT detector can also be used for multiple targets situation. [C2565]

## "Detection of small targets in ocean wave clutter using panchromatic time series imagery"

Visual detection of small objects on or near the ocean surface from an aircraft is important for search and rescue, and detection of stealthy boats and other militarily important targets. This is made difficult by a combination of the rapidly moving sensor platform and the typically high level of modulations in scattered light at the surface. To achieve reasonable search rates, the observer must scan through modest grazing angles (i.e., look towards the horizon) where the ocean clutter that limits detection performance is varying light from wave facets and white caps. This paper describes a technique for significantly improving the signal-to-clutter ratio. A time series of images is mapped to a common reference frame at the level of the mean ocean surface, separating time and space variations, and the temporal dwell is utilized. For moored targets, the signal may be simply integrated up in time, while for drifting and powered targets, it must be integrated along the appropriate target velocity vector. Specific examples are provided for navigation buoys, small surface floats and slowly moving boats, most of which are difficult if not impossible to find in any single image frame. Achieved gain using panchromatic images is shown to approach 20 dB in cases where the velocity vector is known or can be calculated from the data. [C2566]

## "Bistatic mapping radar BISAR"

Synthetic aperture radar (SAR) is a system of active prints that are loaded in a sensor able, to carry out the cartography of natural scenes with a better resolution. SAR supplies images based on the waves reflected by the Earth's surface that do not appear on classical optical images. Indeed, radar waves may describe drifted ice in aquatic surfaces; they can penetrate under vegetation and even slightly into the basement. However, the main problem with this approach is the interpretation of the radar image that is different from usual graphics. When the radar is composed of a simple antenna, we speak about a monochromatic configuration. The antenna works in alternative it will function as a transmitter and then switch to a receiver. The radar can be designed to operate with two separate antenna to perform the transmit and the receive functions, and this may be called bistatic radar. The bistatic system has particular features coming from the separation between the transmitter and the receiver. In this configuration, the transmitter illuminates the scene with beam pointed to its centre. The diffused signal is then picked up by the receiver. Technological progressions enabled to place the receiver and the transmitter aboard satellites, ships, planes or other carrier. The delocalisation of both the transmitter and receiver makes it possible to improve the capacity of detection and identification of the radar, and thus to increase the detection capacity of a furtive target. This paper presents the potential scientific objective of the bistatic synthetic aperture radar (BISAR). First, it begins by an extension of modelling, proposed by literature such as monostatic scalar radar model and vertical model (that take in account the polarisation wave in the transmitter and the receiver) are presented. Then, the next part will be devoted to the development of two bistatic methods that are an extension of monostatic approaches. Namely, method of coherent summation and method of adapted filtering. [C2567]

## "Applying fractional Fourier transform to radar imaging of moving targets"

A fractional Fourier transform based method for radar imaging of moving targets is presented in this paper. Compared with the traditional joint time-frequency approaches, it can achieve a better result of clutter cancellation by using optimal filtering in the fractional Fourier domain due to linear and rotational properties of this transform. By using this method, we can carry out moving targets detection, LFM signal parameters estimation as well as clutter cancellation at the same time under the time-frequency analysis. The effectiveness of this method has been tested through simulation. [C2568]

## "VHF/UHF synthetic aperture radar-principles and motivation"

At frequencies below 1 GHz, vegetation is becoming transparent, the more so the lower the frequency. Tree clutter on the other hand tends to be as strong as in the microwave regime as at frequencies above 200 MHz. Below 100 MHz, i.e. in the VHF band, tree clutter levels are significantly smaller. Foliage penetration SAR is feasible at both UHF and VHF but has to overcome significant challenges. For one, resolution must be high, viz. of meter order at VHF and submeter order for UHF. In both cases resolution of wavelength order is thus called for, requiring special processing methods which will be discussed here. Secondly, the signal-to-noise budget is critical due to the severe radio frequency interference below 1 GHz. In fact SAR operation at these frequencies is not feasible unless there are some means to identify and remove the RF1. Thirdly, for SAR surveillance the target detection method is crucial. VHF resolution is too low to make any target recognition scheme effective as a means to reduce clutter false alarms. At UHF, even though resolution can be made high, intense forest clutter level creates a very difficult environment for target discrimination. These concerns and their remedies are discussed in the paper. [C2569]

## "Adaptive detection algorithm of the moving pin-point targets on the clutter background with high period-to-period correlation factor"

In the paper, the adaptive optimal detection algorithm of the moving targets on the clutter background has been carried out. Some results of modeling were described. The offered adaptive algorithm is more effective than the standard method of target selection. [C2570]

## "Dim target detection in IR maritime surveillance systems"

In this paper we present an automatic procedure for the detection of long-range airborne targets in maritime naval surveillance systems. The algorithm performance is investigated via simulation and compared to the one of the classical moving window detection algorithm. [C2571]

## "Improvement research on texture-detection in full-polarization SAR image filter"

The Polarimetric Whitening Filter (PWF) method for speckle reduction in polarimetric synthetic aperture radar (SAR) is stated with some traditional covariance matrix parameter estimate methods. Aimed at their defects in parameter estimation, an enhanced auto-adaptive edge-detection method for parameter estimating is presented. Because of the lack of point target and line detection in the above-mentioned methods, a new parameter estimation method is then introduced. Finally, results of the above-mentioned methods applied in PWF are submitted. Detail analyses and comparisons are also given. It is proved that the new parameter estimation method is the most robust. [C2572]

## "Impact of ScanSAR images' radiometric calibration on vessels and identification"

Image quality and radiometric calibration of several RADARSAT ScanSAR processors has been compared to assess impact of different processors on the vessel cross section and on the background, respect to the automatic detection as well. Several ocean scenes processed by four different ScanSAR processors have been analysed and some variability in image quality and radiometric calibration have been found. In this study cross sections of the same targets, present in the selected images and identified thanks to the Vessel Monitoring System (VMS) data, have been analysed to find out the differences among them and where it is possible to link these differences to some specific parameters. [C2573]

## "Analysis of GPR scattering by multiple subsurface metallic objects to improve UXO discrimination"

Detection and identification of buried unexploded ordinance (UXO) is an emerging problem worldwide. Recent ultra wideband (UWB) field tests between 10s of MHz and 100s of MHz have demonstrated that certain of the target's dimensions can be estimated from analysis of complex natural resonances in the scattered signal. However, the problem becomes much more complicated at highly contaminated UXO sites where clutter items, from which subsurface UXO must be distinguished, appear simultaneously within the field of view of the sensor. This often occurs in realistic field conditions, where GPR discrimination capabilities are typically limited by

ground clutter, coupling between antenna and ground, and limited view of the target due to innocuous items. Under extreme shielding by clutter, the incident field cannot excite strong currents on the target and in turn the scattered field from the object cannot easily be separated from the responses of the clutter. To investigate this, we pursue simulations here designed to test subsurface side-looking EM field scattering from multiple buried objects placed in a uniform ground. The numerical calculation is performed using the finite difference time domain (FDTD) method in conjunction with generalized perfectly matched layer GPML. The results are analyzed for a cylinder and plate placed in a uniform ground. [C2574]

## "A novel multi-channel SAR moving targets detection and image method"

Provides a novel multi-channel SAR moving targets detection and image (MTDI) method. After clutter is cancelled by using three apertures, two ways of signals through which moving targets can be detected are gained. Then Doppler centroid and Doppler frequency rate can be estimated, so both the real positions and velocities of moving targets will be acquired. Finally some typical computer simulation results are presented which illustrate the method's validity. [C2575]

## "Combining GPR and EMI data for discrimination of multiple subsurface metallic objects"

Cleanup of subsurface metallic objects such as unexploded ordnance (UXO) constitutes an urgent problem worldwide. The heart of the problem is discrimination, as opposed to detection. Ultra-wideband electromagnetic induction sensors (UWB EMI), operating from a few Hz up to 100s of kHz, have shown considerable promise in subsurface discrimination of metallic objects. Unfortunately, a great many objects, including widespread clutter items, produce very broad, smooth EMI signal patterns, over a number of decades of frequency. Shape identification is complicated by the sensitivity of EMI fields to metal type. UWB ground penetrating radar (GPR) has also shown definite discrimination capability for characterizing subsurface metallic targets. Uninfluenced by metal type, GPR is capable of registering complex natural resonances from which target length can be estimated. Further, examination of the spatial patterns of GPR signals can indicate the (X,Y,Z) locations of targets, even of multiple targets present simultaneously in the incident beam. In this paper we consider potential collaborative roles of UWB GPR and UWB EMI for discrimination of multiple subsurface metallic objects. Rigorous 3-D FDTD models demonstrate GPR's ability to estimate target positions, orientations, and length even when reflections overlap. These data can then be used to constrain inversion of UWB EMI patterns. Processing of EMI measurements based on prior estimates of object location and orientation successfully extracts distinct frequency response signatures for two very closely spaced objects. [C2576]

## "Target detection accuracy improvement in synthetic aperture radar"

This paper proposes a decision method to improve the target identification accuracy in a synthetic aperture radar processing algorithm. In the imaging algorithm, Fourier based processing algorithm is used to obtain the processed image from the measured 2D cartesian backscattered frequency domain data. In practical applications, the measured data is limited in frequency band and aspect angle interval and this leads to radar images with limited resolution. Besides, the noise in measured data affects the target identification accuracy. In this paper, a decision rule is proposed to improve the target identification accuracy by comparing the processed image with the images in the data bank. With the decision rule, one can assign a well known target distribution to the processed image. In this work, the effects of noise, frequency and aspect angle limitation in the decision accuracy are investigated and the results are presented. [C2577]

## "An approach to multistatic spaceborne SAR/MTI processing and performance analysis"

Multistatic spaceborne SAR offers in addition to powerful Earth imaging and remote sensing the possibility to detect the presence of slowly moving objects due to the large baselines. In contrary to monostatic multi-subaperture systems with classical STAP processing the multi-satellite system overcomes the problem of blindness against certain directions of target motion. Moreover velocity and direction of target motion can be estimated with considerably higher accuracy when taking advantage of the geometry of the multistatic configuration. For this purpose non-classical algorithms have to be developed. Furthermore, the application of optimum detection schemes and the exact analysis of MTI performance are challenging tasks. Indeed the high system complexity and the huge amount of data to be analysed make the MTI processing exceedingly difficult. Therefore only sub-optimum methods can be implemented. In this paper we propose a sub-optimum approach for multistatic spaceborne moving target detection. First of all we define a signal model for both moving targets and clutter proceeding from an arbitrary multistatic configuration. Secondly, we present the sub-optimum statistical processing based on the exploitation of the covariance matrix describing the common statistical properties of the random vector composed of a selected number of resolution cells in the range-Doppler-space for all sensor channels. Then we analyse the MTI performance of representative multistatic configurations. Finally

this method is applied to simulated data of multistatic satellite systems. [C2578]

## "Development of the ultra-wideband LORA SAR operating in the VHF/UHF-band"

LORA (low-frequency radar) is a new airborne VHF/UHF-band radar which has both synthetic-aperture radar (SAR) and ground moving target indication (GMTI) modes. The main motivation for the system is to facilitate detection of man-made objects in a variety of conditions, i.e. stationary or moving, located in open terrain or in concealment under foliage. The LORA system will operate in several configurations extending from 20 MHz to 800 MHz. Initial flight trials during 2002 were successfully conducted using the 200-400 MHz band. SAR image examples are shown including both forested areas and man-made objects. A second band, 400-800 MHz, has also been completed but not yet flight tested. A third band, 20-90 MHz, is being added and will be completed during 2003. [C2579]

## "Preliminary design of a SAR-GMTI processing system for RADARSAT-2 MODEX data"

The RADARSAT-2 satellite includes an experimental mode, called the moving object detection experiment (MODEX), which is to be used to perform ground moving target indication (GMTI) using a C-band synthetic aperture radar (SAR). During MODEX operation, the SAR antenna is partitioned into two subapertures along the satellite track to sequentially observe the same scene from the same spatial point. By appropriate processing of the returned signals from each channel, detection of temporal changes in the scene (i.e. moving targets) can be accomplished. The MODEX configuration will be used by the Canadian Department of National Defense RADARSAT-2 GMTI demonstration project, which aims to develop a SAR-GMTI processing system to investigate the military and commercial utility of space-based moving target measurements. This paper discusses a conceptual SAR-GMTI processor design in terms of selected algorithms and their performance, such as along track interferometry (ATI), displaced phase center antenna (DPCA) and iterative moving target (terrain) matched filtering (MTMF). Processing issues arising in space based radar (SBR) GMTI are also discussed. It is anticipated that the ultimate processor design will incorporate these algorithms as independent processing configurations, along with selection rules that will optimize their use to the contents of the image scene. [C2580]

## "Raw data based two-aperture SAR ground moving target indication"

This paper investigates the capability of classical two-channel SAR ground moving target indication (GMTI) techniques, such as displaced phase center antenna (DPCA) or along-track interferometry (ATI) when implemented on azimuth-uncompressed SAR data, rather than the processed SAR image. By transforming the data into the Doppler frequency domain complete target detection and parameter estimation scheme is proposed. In contrast to the conventional image based algorithms, the proposed techniques are able to detect even fast movers. The GMTI feasibility is demonstrated with measured airborne data. [C2581]

## "Clutter effects on ground moving target velocity estimation with SAR along-track interferometry"

The SAR interferogram, defined as the product of the first channel and the complex conjugate of the second, is one way of comparing two SAR channels. When the two sub-apertures are aligned along the flight path, targets with non-zero radial velocities can be detected by exploiting the phase information of the interferogram. This paper examines the effect of clutter interference on the interferometric phase and provides a simple method for mitigating the clutter contamination by using time-frequency (TF) analysis techniques and a velocity-offset matched filter (VOMF). Both simulated and airborne results are presented. [C2582]

## "Impact of ground clutter on buried object detection by ground pentertaing radar [Cpentertaing read penetrating]"

We performed careful analysis of the measure data to determine the clutter level and responses of different targets in different types of soils under different environmental conditions. We found that even in a dry sand ground clutter level is higher than responses of many types of antipersonnel mines. As a result, the signal-to-clutter ratio for GPR targets becomes nonsufficient for reliable detection by widely used detection procedures. A new detection algorithm, which should partly overcome this problem, has been developed. The performance of the algorithm on real GPR data is encouraging. [C2583]

## "Landmine detection by a broadband GPR system"

Most of the landmine detection techniques by GPR use a monostatic type radar system, which is suitable for detecting landmines buried in shallow soil, which is normally less than 10 cm. The shallow target is difficult to detect by conventional GPR due to its low range resolution. We developed a broadband Vivaldi type antenna, which operates at 1GHz-10GHz. Using this antenna, we made a prototype of a GPR system, which operates at

2GHz-5GHz. By scanning the antenna on a 2D plane, we could obtain clear 3-D images of mine-like targets buried in dry sand. We proposed an array signal processing technique using CMP method, and found it is effective for rejection of the ground surface clutter, even if the ground surface has roughness. [C2584]

## "Effective clutter removal for detecting non-metallic mines in various soil fields"

In this paper, an effective method for removing the clutter effects from the data collected using a stand-off impulse GPR with a small electromagnetic probe is presented. The method requires no a priori knowledge about the target and/or ground characteristics. Essentially, it combines successive processing and spatial variable moving averaging (SVMA) to eliminate the clutter and to enhance the detection of small land mines shallowly buried in different soils. In addition, this method can use measured GPR data to infer the effective soil permittivity. [C2585]

## "Multisource image fusion by using the redundant wavelet decomposition"

We propose in this paper a method for combining simultaneously multispectral (XS), panchromatic (P) and radar (SAR) images by suing conjointly the Intensity Hue Saturation (HIS) transform and the Redundant Wavelet Decomposition (RDW). The fusion is accomplished through two steps. Firstly, XS images are represented in the HIS system in order to isolate the spectral components (H,S) from the spatial information (I) component. Secondly, features coming from P and SAR images are incorporated into the (I) component by using the RWD. The obtained fused images show the contribution of the P image for discriminating lines and edges. While the SAR image provides an information on the surface roughness and the detection of point targets as houses, boats, and water-land transitions. [C2586]

## "Target detection and analysis based on spectral analysis of a SAR image:a simulation approach"

First Page of the Article [C2587]

## "GPR for archaeological investigations: real performance assessment for different surface and subsurface conditions"

This paper assesses GPR (Ground Penetrating Radar) performance for archaeological investigations. We exploit extensive data acquisition campaigns to characterize the instrument behavior in different operative conditions and we select ad hoc processing techniques to optimally extract target signatures from the collected data. The extensive analysis demonstrates the real effectiveness of GPR surveys in archaeological investigations. [C2588]

## "Phenomenology of millimeter-wave signal propagation and scattering for detection of targets camouflaged under foliage"

In this paper, we report on a series of foliage penetration experiments aimed at demonstrating the potential application of nadir looking, millimeter-wave radars in detecting targets under foliage cover. An algorithm is developed that classifies the radar return and isolates the radar return from hard targets. [C2589]

## "Host medium transformation of the early-time radar response of a buried dielectric target"

This paper addresses the problem of predicting the early-time radar response of a low-metal content landmine buried in a lossy soil given its response in a lossless soil. To make the problem tractable, we consider plane wave scattering from a homogeneous dielectric target embedded in a layered host medium with a global loss model. Using similarity analysis and the Born approximation, a transformation law for the scattered field is derived which relates the early-time target response in the lossy host medium to that in a corresponding lossless host medium. We also present a transformation law for the target impulse response, which follows directly from the transformation for the scattered field. The derived transformation law is tested using early-time responses of a mine-like target obtained from 3D finite-difference time-domain (FDTD) simulations. Based on these tests, the ability of the transformation law to predict changes in the early-time response of a non-metallic landmine as a result of changes in the electromagnetic properties of the host medium is discussed. [C2590]

## "Characterization of shallow underground targets using wideband microwave reflectometry"

In this paper, the use of a combined signal processing technique of target discrimination for the step-frequency ground penetrating radar is investigated. To construct the radar range profile from the backscattered signal, a real part of the inverse discrete Fourier transform is multiplied by the pseudospectrum obtained from the same data via eigenvector method. The signatures of small underground objects can be subdivided in four categories designated conditionally as front wall; back wall; inclusion of high density; inclusion of low density. Experimental

studies have shown that the technique is valid for both strong and weak scatterers. The approach can be extended to the discrimination of complex targets such as landmines by creating a set of templates. [C2591]

## "A multiple-sweep-frequencies scheme based on eigen-decomposition to compensate ionospheric phase contamination"

This paper presents an improved scheme to compensate nonlinear phase path contamination when the backscattered signal propagates through the ionosphere in high-frequency skywave radar systems. The ionospheric variation often causes the spread of the ocean clutter spectrum in the frequency domain. The energy of the first-order component of ocean clutter dominates in Doppler spectrum, and thus its spreading may submerge the neighboring low-velocity target easily. The instantaneous frequency (IF) estimating algorithm based-on eigen-decomposition has been introduced to estimate the frequency fluctuation due to ionospheric phase path variation and the compensation is carried out before the coherent integration. In the proposed multiple-sweep-frequencies scheme we construct a new "sweep-frequency" dimension by using different transmitting frequencies, and because of the different variation of Doppler frequencies for the target echo and ocean clutter first-order Bragg lines with the varying transmitting frequencies, that can be considered as different "sweep-frequency angles", the full-rank autocorrelation matrix used in eigen-decomposition can be formed. Better estimation accuracy is achieved and significant spectral sharpening can be observed in the resultant spectrum. To avoid the additional systemic complexity due to the multiple frequencies sweep operation, a segmenting range transform in an assistant channel is proposed to obtain the "sweep-frequencies" dimension data and estimate the ionospheric contamination. Experiments show that the proposed scheme is effective and its performance is discussed. [C2592]

## "Advantages and problems of wideband radar"

The paper addresses the definition, properties and modeling requirements of wideband and ultra-wideband radars. It begins by establishing the criteria by which the designation 'wideband' might be specified, since the common definition based purely on relative bandwidth fails to invoke some important associations. Next, the role of simulation is discussed and a representative simulation environment is described. The advantages and disadvantages of increasing the signal bandwidth are then evaluated quantitatively in the context of signal detection, parameter measurement, and the recognition of aerial target classes and types, with reference to specific classes of interest. In practice, certain other issues arise, including the degree of immunity to interference and electromagnetic compatibility. These topics are discussed in terms of their dependence on signal bandwidth and the associated signal acquisition and processing. In addition, an emerging problem is the need to take into account the possibility of signal exploitation and LPI (low probability of intercept). The essence of the theory of unauthorized signal detection that limits the LPI possibilities is briefly considered. [C2593]

## "An overview of space-time adaptive processing for radar"

The paper provides a survey of space-time adaptive processing for radar target detection. Specifically, early work on adaptive array processing from the point of view of maximum signal-to-noise-ratio and minimum mean squared error perspectives are briefly reviewed for motivation. The sample matrix inversion method of I.S. Reed et al. (see IEEE Trans. on Aerospace and Electronic Systems, vol.10, p.853-63, 1974) is discussed with attention devoted to its convergence properties. Variants of this approach, such as E.J. Kelly's GLRT (see IEEE Trans. on Aerospace and Electronic Systems, vol.22, p.115-27, 1986), adaptive matched filters and ACE tests, are considered. Extensions to handle the case of non-Gaussian clutter statistics are presented. Current challenges of limited training data support, computational cost, and severely heterogeneous clutter backgrounds are outlined. Implementation and performance issues pertaining to reduced rank and model-based parametric approaches are presented. [C2594]

## "Efficient reiterative censoring of robust STAP using the FRACTA algorithm"

This paper presents further developments of the FRACTA algorithm (S.D. Blunt et al, NRL Tech. Rep. 10.059), which has been shown to be robust to nonhomogeneous environments containing outliers. The focus here is on the efficient implementation of the FRACTA algorithm. The key development is a censoring stopping mechanism whereby the number of reiterative steps can be minimized and computation is reduced. We introduce a data-dependent stopping rule that demonstrates excellent results as evidenced by the detection of targets in the KASSPER challenge data cube. We also present some other enhancements to the FRACTA algorithm that further improve both efficiency and performance. [C2595]

## "An experimental study on a ground-penetrating radar for detecting water-leaks in buried water transfer pipes"

In this paper, the feasibility of ground penetrating radar (GPR) probing technology was experimentally investigated. Polyvinyl chloride (PVC) tank filled with dry and homogeneous sand is installed in the laboratory. Within meaningful frequency band of the transmitting signal, the electrical properties of the material under test (MUT), such as dry sand and acryl used in experiment, are measured by using an open-ended coaxial probe method. The electrical properties of the drysand are similar to that of acryl. Therefore, to maintain precise position of the buried targets, support is made of acryl and filled with the dry sand. Leaking water could saturate the surrounding medium of leaky pipes. In experiment, however, it is very difficult to maintain moisture content and distribution of wet sand. Equivalent model instead of wet sand is necessary. The electrical property of the wet sand under saturation is very alike that of methanol. Therefore, the box is made of acryl plates and filled with methanol. The box with methanol filling is equivalently considered as water leakage model. We perform B-scan surveys with various situations. And we have investigated the possibility of GPR on detection water leakage as well as the pipe. [C2596]

## "An application of MUSIC algorithm in no-cooperative passive location"

In this paper, the use of a non-cooperative FM broadcasting transmitter as illuminator for the bistatic radar system was investigated. A signal processing scheme is developed that allows airborne targets to be detected and tracked using the sound carrier of the FM broadcast. This scheme requires no synchronization with the transmitter, and uses MUSIC algorithm to estimate the directions and time delays of several targets from received echoes. The simulation results show that targets can be detected correctly. [C2597]

## "Compact long-path absorption laser radar system for measuring greenhouse molecular concentration"

A compact long-path absorption laser radar system has been developed incorporating a single-mode optical parametric oscillator with the PPMgLN crystal for methane concentration measurements. Spatial distribution can be derived using topographic targets as the reflectors at several directions. [C2598]

## "Ship and shipwake enhancement in coastal surveillance radar systems using target back propagation technique"

Rotating incoherent radar systems are usually used for coastal surveillance of vessels. Signal to clutter/noise enhancement is obtained by averaging a number of scans. Because the vessels move and thus migrate out of the radar resolution cells, the number of scans that can be averaged is limited by this effect. This paper exploits a target back propagation technique to overcome this problem. Measurements show that a significant enhancement of the ship image quality is achieved using this technique. Also the ship wake is made clearly visible and is subject for further study in the wavenumber domain and Radon transform domain for detection and feature extraction. [C2599]

## "Backscattering enhancement of partially convex targets of large sizes in continuous random media for E-polarization wave"

In this paper we have analyzed numerically the normalized RCS (NRCS) of partially convex conducting targets of large sizes of about five wavelengths in continuous random media. Here, we assume that waves around target are incoherent and the SCL keeps a finite value. In this work, we considered the case when the incident wave illuminates the convex portion of a concave-convex target. Here, we could analyze numerically the ERCS in three regions of ka compared to SCL. For ka ≪ SCL, NRCS equals two due to the double passage effect on waves in random media. For ka ≃ SCL, NRCS oscillates irregularly and obviously close to two. On the other hand, for ka >SCL, NRCS oscillates approaching to certain values that depend on the SCL. Furthermore, these values become closer to two with large SCL. As a result, we can conclude that in the regions ka ≪ SCL and ka ≫ SCL, the ERCS is almost two due to the double passage effect; and in between these two regions ERCS deviates from two depending on SCL and target configuration. [C2600]

## "Transient ultra wide band measurement applications: radar cross section, synthetic aperture radar, electromagnetic compatibility"

The Electronic Armament Centre (CELAR: Centre d'Electronique de L'Armement) and the Research Institute of Microwave and Optical Communications (IRCOM: Institut de Recherches en Communications Optiques et Micro-ondes) has evaluated the use of ultra-wide-band (UWB) short pulse measurement facilities to characterize target electromagnetic signatures. A first device is capable of determining the radar cross section (RCS) within a 200 MHz to 1.2 GHz frequency band. A second device, an UWB synthetic aperture radar (SAR), is dedicated to pulse measurements on outdoor targets (buried mines) and low frequency clutter. These transient techniques are

soon used for EM coupling applications on various systems. [C2601]

## "Ionospheric propagation effects on ground and space based radars"

This paper discusses the application of EM propagation theory to account for observations of scintillation from equatorial satellite beacon and radar measurements of transionospheric propagation. Satellite beacon measurements from the wideband satellite experiment are used to calculate the degradation caused by scintillation in the radar coherent integration process. Coherent integration will be required in any space based radar to achieve separation in Doppler of moving targets from the large return of the earth. Measurements of ionospheric scintillation in the equatorial region taken with the VHF/UHF ALTAIR radar in the Marshall Islands are described. These measurements support the use of the strong scatter limit of the parabolic wave equation that accounts for certain features of the observations. A technique is illustrated to calculate realizations or sample functions of wide bandwidth radar signals that have passed through the ionosphere. This technique gives realizations that are consistent with the ALTAIR observations. Results are given for radar performance of target detection for several different radar signal combining techniques. [C2602]

## "A dual adaptive channel STAP scheme for target detection and DOA estimation"

This paper presents a dual cancelled channel approach to the target detection and estimation with a digital beamforming radar. The proposed STAP (space-time adaptive processing) scheme is shown to yield comparable detection performance to previously known schemes and higher accuracy in the estimation of the target direction of arrival. Moreover, it has a lower computational cost, since it does not require the numerical maximization of a functional. [C2603]

## "A generalized smallest of selection CFAR algorithm [Cradar signal processing]"

A generalized smallest of selection CFAR (constant false alarm rate detection) algorithm (TMSO), based on the trimmed mean (TM) method, is proposed in this paper. It takes the smallest local estimation of either the leading or lagging window, which applies the trimmed mean method as a noise power estimation to set an adaptive threshold. Thus, the smallest of selection (SO), the generalized ordered statistic smallest of (GOSSO), or the ordered statistic smallest of (OSSO), is the special case of TMSO. It is shown that the performance of TMSO in homogeneous background and in multiple target situations is improved over that of GOSSO or OSSO. [C2604]

## "Performance bounds for angle-only filtering with application to sensor network management"

First Page of the Article [C2605]

## "Application of GPS to exospheric target detection using missile-borne passive radar"

A novel missile-borne passive radar is proposed for the detection of exospheric target. For meeting the need of stealth, the universal GPS signal is applied to the passive radar for acting as the signal of transmitter. The system mechanism and the framework of the GPS signal receiver and scattering wave receiver for the passive radar is described for the next in-depth study. And the key performance of system and the problem of Doppler compensation for the passive radar are also elucidated. [C2606]

## "Recognition of the underwater target with an improved genetic-based classifier system"

Due to the complicated watery environment and the limitation of the detecting method to the underwater target, recognizing them precisely is always a hard problem to all countries. In this paper, we design a genetic-based classifier system (CS) and apply it to recognize the underwater target. This is an attempt to solve this problem with machine learning way. Compared with traditional CS, the proposed Comparing and Matching Algorithm will give the fitness value more explicit statistical meaning, which will make us easier to explain the rules with background knowledge. The proposed Hyperplasia Operator can handle those instances which are not emerged before. It gives the system persistent learning abilities, so the system may be more compatible with the surroundings. The proposed Refining Classifier merges those redundant rules and shrinks the rule set. In addition, we give and discuss an alterable mutation probability to the genetic algorithm in the CS, which increases the speed and the accuracy of the classifying operation. At last, the experiments to examine the system with the sample data which are collected from sonar echo samples. Experiments show that the recognizing results are satisfying. [C2607]

## "A genetic algorithm for optimizing the segmentation in subarrays of planar array antenna radars with adaptive digital beamforming"

Modern phased array radars (PAR) should usually assure full performance in target detection and location also in presence of electronic counter measures (ECM). The radar signal processor of a PAR must provide then an adaptive technique to cancel the disturbance coming from jammers (A. Farina, 1992). The requirements on detection and location are particularly hard to fulfil when the power of jamming signal gets into the radar receiver from the main beam of the antenna pattern. To counteract the performance degradation due to main beam jammers (MBJ), the radar processor can adaptively combine digital signals coming from different subsets of the elementary radiators of the antenna, called subarrays, to form one or more beams with s in the directions of the jammers. This technique is known as adaptive digital beamforming (ADBF) (A. Farina, 1992). Fixed the complexity of the antenna (number of elementary radiators and subarrays), finding a set of subarrays that maximizes the detection and location performance of the PAR in presence of MBJs is a compelling challenge, because the function to optimise is irregular and includes a large number of parameters. Genetic algorithms are recognized as robust searching techniques: they are effective with very irregular functions and they guarantee much better efficiency than enumerative methods (D.E. Goldberg, 1989). They can explore different solutions in parallel, minimizing the probability to remain trapped in local maxima, and act directly on the functional to optimize, not on its derivates. Genetic algorithms have been used in various radar applications. In this paper an example of genetic algorithm for finding a optimized set of subarrays for ADBF is presented in details. Some results obtained with an antenna consisting in a square planar array of 64 radiators divided in 4 subarrays are also shown. [C2608]

## "STRAAP: space-time-radiating array adaptive processing"

This paper provides an overview of the physical and mathematical approach to the synthesis and analysis of a multidimensional adaptive radar system. Using a paradigm of distributed sensors, the characterized concept leverages the dimensional advantages gained in such a system by exploiting the inherent, space, time, and waveform domains for adaptive processing. Execution of space-time-radiating array adaptive processing (STRAAP) makes use of the full parametric domain. Data analysis within this extended space suggests system performance advantages in radar target detection, object isolation, and scenario depiction. [C2609]

## "Track fusion in over-the-horizon radar networks"

First Page of the Article [C2610]

## "Design of a new dual-polarization antenna on missile"

Dual-polarization antenna on missile is useful in some applications such as target detection and counter-countermeasure. But it is difficult to design and fabricate because of the limited space in the missile. This paper discusses the design of a new X band dual-polarization Cassegrain antenna for guidance radar on missile, including the calculation of the parameters of the ortho-mode transducer. The ortho-mode transducer is adopted, which enables the antenna to transmit and receive vertical and horizontal polarization signal. The measurement of the new antenna shows that its polarization isolation is high enough to meet the need and the other performances are almost the same as those of the original simple-polarization antenna. [C2611]

## "Research on RCS measurement under non-far field condition"

While stealth technologies for large scale targets were researched, RCS static measurement method was adopted, which is often used under non-far field condition. Therefore a theoretical premise was deduced, and a stepped frequency pulse compression system was designed for RCS measurement, especially a novel RF channel was designed to keep the system stable. Not only the simulation but also the experimental result is presented LU the paper; at the same time, some practical difficulties are designated. [C2612]

## "Backscattering enhancement of partially convex targets of large sizes in continuous random media for e-polarization wave"

In this paper, it is analyzed numerically the normalized RCS (NRCS) of partially convex conducting targets of large sizes of about five wavelengths in continuous random media. Here, we assume that waves around target are incoherent and the SLC keeps a finite value. In this work, we considered the case when the incident wave illuminates the convex portion of a concave-convex target. Here, it is analyzed numerically the ERCS in three regions of ka compared to SCL. For ka >SCL, the ERCS is almost due to the double passage effect; and in between these two regions ERCS deviates from two depending on the SCL. [C2613]

## "Development of a UWB GPR system for detecting small objects buried under ground"

A ground penetrating radar (GPR) using short-pulse is developed in order to detect small and shallow metal

objects buried under the ground. A bistatic mode in which the GPR system uses separate transmitting and receiving antennas is applied. A modified fat dipole antenna is developed for the transmitting and receiving antennas,. The prototype of the system is tested in real environment and 2D visualization of raw data is achieved. It is shown that the developed system has a good ability in detecting underground metal objects, even small targets of several centimeters. [C2614]

## "Wavelet based signal processing algorithms for early target detection"

Detection of radar target earlier, that is, at a longer distance, amidst noise is a major issue since the received echo signal has very low input signal to noise ratio of the received signal. Further, it becomes very difficult due to unknown statistics and nonstationary nature of the received signal. This paper deals with the wavelet based signal processing algorithms which could detect target even with very weak received signal. Since the signals with identical spectra may have different time-frequency image in time-frequency domain. The algorithms use optimum bandwidth relative to the signal spectral width to maximize the output signal to noise ratio and hence probability of detection. Simulation results show that the wavelet filtering algorithm and entropy based basis algorithms are able to detect target from the input signal to noise ratio of -10dB. [C2615]

## "CFAR techniques for over-the-horizon radar"

Since the OTHR background noise is too strong, the target echoes would be embedded in sea clutter and environment noise. In order to detect targets such as ships or aircrafts from radar returns, a range Doppler CFAR schemes is presented, the identical Doppler frequency resolution cells over adjacent range or azimuth resolution cells are used to form a sliding window for targets detection. Since the OTHR range resolution cells is very large and so do the azimuth resolution cells, the total number of range Doppler resolution cells that forms sliding window is limited in order to guarantee stationary. Some CFAR algorithms such as CA, CM, TM, BLU and QBW methods that are suitable for OTHR are compared and analyzed versus different total range or azimuth resolution cells number. If the total range Doppler resolution cells number is small (less than 12), CA-CFAR is preferred in order to get the good detection performance. In multiple targets situation, CM-CFAR or TM-CFAR are suggested which trims the largest samples that possibly be interfering targets. [C2616]

## "Bistatic synthetic aperture radar with application to moving target detection"

Bistatic radar involves the use of a physically separated transmitter and receiver. This paper describes a bistatic radar system which uses the combination of a spaceborne synthetic aperture radar transmitter on board the European Space Agency's Envisat satellite, and a low-cost, stationary, groundbased receiver. The advantages of this variant of the bistatic configuration involve the passive and therefore undetectable nature of the receiver, in addition to standard bistatic considerations such as forward scatter. Experimental results obtained using the receiver, and an analysis into the utility of the system for moving target detection in the presence of clutter, based on a simulation in Matlab of the electronic Displaced Phase Centre Antenna technique are both presented. It is found that the DPCA method considered has a possible signal-to-clutter-and-noise ratio after cancellation and processing of approximately 10dB although this is with the assumption of adequate received pulses and so integration gain, to offset the signal-to-noise ratio degradation caused by the canceller. A discussion of future experimental work, including the possible use of two such receivers for an investigation into interferometry concludes. [C2617]

## "Demonstration of reduced false alarm rates using simulated L-band polarimetric SAR imagery of concealed targets"

Coherent scattering calculations have been performed to produce L-Band SAR images of targets below a forest canopy. The calculations, which are fully polarimetric, are described. High clutter levels permit detection of all concealed targets only at the cost of a very high false alarm rate. The simulated imagery is analysed using the entropy-alpha polarimetric decomposition technique. Using alpha and entropy in addition to a co-polar intensity channel, and combining the results of separate CFAR algorithms, the number of false alarms is reduced dramatically. The consequences for application of polarimetric SAR to concealed target detection and identification are considered. [C2618]

## "Performance evaluation for modern radars"

Modern radar systems are procured with tight specifications on a large number of different parameters. It is in the interests both of the customer and of the supplier that the procedures used evaluate radar performance are mathematically rigorous, precise and as cost-effective as possible. This paper describes some methods of evaluating the performance of different modes of modern radar system and discusses the accuracy of which they are capable. The important place of modeling within these methods is emphasized. [C2619]

## "The choice of operating frequency in HF surface wave radar design"

Radars operating in the HF band (3-30 MHz) are primarily of interest because of their ability to provide an over-the-horizon (OTH) surveillance capability. There are two types of such OTH radars-skywave (typically capable of detecting. targets at ranges of thousands of kilometres) and surface wave (typical detection ranges of hundreds of kilometres). Skywave radars, which are generally large, complex and expensive, rely on the ionosphere to refract signals beyond the horizon. The dynamic nature of the ionosphere places considerable demands on the radar, one of them being a very wide operating bandwidth (e.g., several octaves). Surface wave radars, on the other hand, are generally less expensive and complex, and can operate robustly over a somewhat narrower band, easing the constraints on RF and antenna design. This leaves the radar designer with an interesting choice with regards to the system operating frequency and bandwidth. The paper discusses the various factors that influence that choice and highlights some of the difficulties of selection. [C2620]

## "Optimal adaptive waveform selection for target detection"

Modern phased array radars are able to adaptively modify their performance to the environment. To make full use of this capability, scheduling algorithms need to be designed. This paper poses the problem of adaptive waveform scheduling for detecting new targets in the context of finite horizon stochastic dynamic programming. The result is a scheduling algorithm that minimises the time taken to detect new targets, detecting these targets in accordance with importance, while minimising the use of radar resources. [C2621]

## "Use of STAP techniques to enhance the detection of slow targets in shipborne HFSWR"

This paper addresses the detection of low velocity targets from a shipborne HFSWR (high frequency surface waves radar). In a shipborne configuration, as a consequence of the ship motion, the first order of Bragg lines is spread in the useful Doppler interval where detections of a ship target are expected to appear. Space time techniques like STAP, usually studied for airborne radar purposes, are candidates to reduce the effect of ship motion. The influence of pitch and roll components is also discussed. Simulations of STAP techniques are given, based on a conventional architecture of processing. Estimation of the clutter covariance matrix is studied with respect to the characteristics of the radar waveform. Interleaving between the classical HFSWR waveform and a wide band learning waveform is proposed, to enable the covariance estimation. [C2622]

## "Stochastic modeling and simulation studies for the surface wave high frequency radars: problems and challenges"

Modeling and simulation strategies for the Surface Wave High Frequency Radars (SWHFR) are discussed in this tutorial paper. Their potential application areas are summarized, together with problems related to ground wave propagation, radar cross section (RCS) prediction, clutter elimination, noise and interference cancellation, etc. Challenges in SWHFR system design, antenna requirements, signal processing techniques as well as detection and tracking approaches are reviewed. [C2623]

## "Clutter simulation in maritime environments"

Knowledge of clutter characteristics are an important factor in determining radar system performance, especially for target detection. Clutter may be modelled as a random process, with the clutter characteristics embodied in the statistics of the process. Most modern pulsed-Doppler radars utilize range-Doppler maps in their detection schemes, and so it is crucial to understand the statistical properties of clutter in these maps in order to develop effective target detection algorithms. In this paper, we discuss the simulation of the sea clutter seen on the range-Doppler map or an X-band pulse-Doppler radar operating in a maritime environment. We shall implement the compound K-distribution model for maritime clutter returns and incorporate temporal and spatial correlations in clutter map realizations. [C2624]

## "Adaptive modelling of sea clutter and detection of small targets in heavy clutter"

This paper describes and compares three methods for detection of low RCS radar targets in heavy sea clutter using a high PRF radar. Two methods are based on auto-regressive processes, one on Karhunen-Loeve decomposition. Experiments have been performed on DSTO sea clutter dataset using these methods and the results are presented in this paper. [C2625]

## "L-band wide area surveillance radar design alternatives"

Wide area surveillance systems are becoming more important for border and homeland security, earth resources

monitoring and mitigation of natural disasters such as floods and seismic activity. As the frequency spectrum is being utilized for communications and business networking, the available bandwidth for these important efforts is more difficult. Historically, airborne surveillance radars have been fielded at either UHF or S-Band for airborne vehicle detection, and at X-Band for surface vehicle imaging and moving target detection. This paper will examine the impact of new technologies on the design of L-Band surveillance radars that employ solid state active arrays, multiple phase center apertures and adaptive processing to enable fixed and moving target detection from air and space platforms. The operational advantages of the use of small apertures on business jets, medium apertures on high altitude platforms and very large apertures in space will be contrasted. [C2626]

## "HF surface wave radar operation in adverse conditions"

For the past 12 years the Canadian Department of National Defence and Raytheon Canada Limited have collaborated on a cost-shared programme to develop an Integrated Maritime Surveillance (IMS) system based on HF Surface Wave Radar (HFSWR). The primary objective behind the programme was to demonstrate the capability of HFSWR to continuously detect and track surface targets (ships and icebergs) as well as airborne targets, at all altitudes, to ranges in excess of 200 nautical miles, reliably and consistently in real time and in all weathers. A secondary objective was to demonstrate the concept of IMS, involving the fusing of data from HFSWR radars and other sensors. This paper reviews techniques and methods used in the processing of HFSWR data to ensure that performance is maintained, even under adverse operating conditions. [C2627]

## "Development of over-the-horizon radar in the United States"

This paper provides a chronology of the development of high-frequency, over-the-horizon radar in the United States. [C2628]

## "Performance analysis of an airborne high PRF phased array radar in a jamming environment"

This study focuses on algorithms currently available for a high PRF airborne phased array radar, where the system is designed to unambiguously detect fast targets, such as fighters, under intense jamming. It is shown that under the constrained conditions, the best processing option is not the well known space time adaptive processor (STAP), but a dual processor which provides the optimal solution at lowest possible computational cost maintaining the overall optimal performance. [C2629]

## "Performance analysis of the weighted window CFAR algorithms [Cradar signal processing]"

With the deterioration of radar operation environment and the enhancement of menace to radar, the task of radar target detection becomes more complicated. Such as the detection of airplane, ship or cruise missile in over the horizon radar (OTHR), and the detection of moving targets in synthetic aperture radar (SAR). Therefore, it is necessary to make a further study of CFAR algorithms. The performance of the conventional cell averaging (CA) algorithm is the best in a homogeneous background since it uses the maximum likelihood estimate of the noise power to set the adaptive threshold. But if the interfering target is present in the reference window with a target return in the test cell, severe masking of targets appears due to increased threshold. In order to overcome this problem, the ordered statistic (OS) and the trimmed mean (TM) algorithms, using a trimmed technique, are proposed. If the reference sample number is not too big, the CFAR loss of OS and TM increase greatly. This case can usually be encountered in a complicated environment and lower SNR situation. In this paper, a weighted window techniques such as rectangle, stepped and trapezium windows are discussed. The analysis results show that the weighted window technique can greatly improve in a homogeneous background and obtain an immune ability to interfering targets to some extent. [C2630]

## "Design and implementation of an experimental GSM based passive radar"

Passive radar is a special kind of radar system that utilizes electromagnetic radiation already present in the environment to detect targets as well as estimate target parameters. This paper discusses the use of GSM base station as a non-cooperative illuminator for bistatic passive radar operation. The design and implementation of this novel passive radar system is introduced. Some initial experimental results show the viability of using GSM signal to detect ground moving targets. [C2631]

## "Millimetre-wave radars in targeting and data linking operations"

Millimetre-wave (W-band=75-110 GHz) radars are poised to form an important component of autonomous vehicle operations because high frequency systems are able to provide the conformal miniaturized solutions necessary for many robotic applications. A serial programmable integrated radar threat simulator (SPIRTS) that transmits 95 GHz centred emissions for investigating air-to-surface target threats has been developed and the

performance of this unit in a targeting role is projected. Targeting operations at W-band are compared with those at lower Kaand X band frequencies. The upsides and downsides of W-band operation in clutter generation and in multi-path signal fading, important for future high frequency communication links, are highlighted. Clear air propagation effects for datalinking operations are also discussed for W band emissions. [C2632]

## "A Doppler-based target classifier using linear discriminants and principal components"

This paper describes the design of the automatic target classifier which has been introduced into the AMSTAR battlefield surveillance radar. It discusses the requirements which have driven the design of the classifier, the data which is used to make the classification, the choice of linear discriminant analysis as the classification technique and the use of principal components analysis to simplify the training of the discriminator. It also discusses the testing of the classifier and the performance achieved. [C2633]

## "Results from an experimental continuous wave low probability of intercept bistatic radar-the first steps toward multistatic radar"

The Norwegian Defence Research Establishment (FFI) has developed an experimental continuous wave (CW) low probability of intercept (LPI) bistatic radar. The radar is transmitting a CW binary phase coded signal at a maximum power of 1 W. The radar has been used to detect different targets in various trials. Selected results are presented, and future work is indicated. [C2634]

## "The analysts' detection support system for deploying a network of target detection and recognition algorithms in SAR exploitation"

A novel software system that assists analysts to find small targets in SAR imagery is described. The system consists of a set of image processing algorithms and a framework to undertake synchronisation, control and data flow between the algorithms. The system is designed to operate in near real-time, allowing processing on very large images to occur whilst sensor data collection proceeds. It allows algorithms to be connected in arbitrary ways and has functionality to facilitate system performance measurement. This paper discusses the design of the framework. [C2635]

## "Low elevation sea-surface target tracking using IPDA type filters"

The integrated probabilistic data association (IPDA) type filters provide estimates of the underlying target probability of existence/perceivability/visibility, apart from track state maintenance. These quantities are conveniently used as a track quality measure and can be used for track confirmation and termination. The sea-surface induced multipath fading reduces the detection probability of the target at certain ranges, which can lead to track loss. In this paper, we use IPDA type filters for tracking a target in such a scenario. The primary results presented in this paper are encouraging for a further study in the future. [C2636]

## "Prescreening algorithm assessment within the analysts' detection support system"

This analysts' detection support system (ADSS) contains a suite of target detection algorithms for wide area aerial surveillance using synthetic aperture radar (SAR) imagery. The ADSS provides a framework to combine the operation of these algorithms in user-specified configurations. This paper compares and contrasts the performance of the various prescreening algorithms singly and in combination within the ADSS framework on a broad range of SAR imagery. The algorithms include adaptive threshold, K-distributed CFAR, average grey absolute difference magnitude map, and segmenting K-distributed CFAR. The performance of these algorithms is compared on polarimetric imagery to assess the contribution of polarimetry to target detection. [C2637]

## "Analytical solution for target location using bistatic multi-transmitter and multi-receiver techniques"

The 3D bistatic radar solution determines the coordinates of a target from bistatic radar measurements, where the transmitter and receiver are at different positions. This involves the solution of non-linear equations. The conventional approach is linearising these equations. In this paper, we propose a direct solution of the non-linear equations. This allows the evaluation of the multiple solutions, study of singularities and the design of geometric configurations which lead to unique solutions. The solution is demonstrated for satellite based transmitters which are used as sources of opportunity. [C2638]

## "Passive detection of aircraft utilising shadowing techniques"

This paper introduces the possibility of passively detecting aircraft, based on the radiation shadows cast by targets illuminated by non-dedicated satellite borne transmitters (e.g. GPS, LEOs communication satellites).

Various aspects of the system are considered, from frequency selection based on diffraction, to power considerations for the signals involved. The effect of the sea surface is also taken into consideration, and preliminary conclusions about modelling techniques are given. [C2639]

## "Metrics for SAR-GMTI based on eigen-decomposition of the sample covariance matrix"

This paper investigates different metrics for indication of ground moving targets in multi-channel SAR data (SAR-GMTI). These metrics have in common that they are all based on the eigen-decomposition of the sample covariance matrix. Their statistical properties are analytically compared and their detection capabilities, demonstrated on measured two-channel airborne data. [C2640]

## "Target association using detection methods"

This paper presents a residual-based scheme for solving the radar track association problem using bearings-only measurements. To accomplish track association between two stations, we analyze the residuals of a bank of nonlinear filters called modified gain extended Kalman filters (MGKEFs). Once the tracks have been associated between two stations, tracks from additional stations may be associated with tracks from the first two stations by checking algebraic parity equations. Traditional track association methods rely on the local stations' estimated target positions and error variances, which may be quite inaccurate when using bearings-only measurements. Our methods bypass this difficulty, since our filters use raw data from two stations. An example illustrates the effectiveness of our methods. [C2641]

## "A multiple model multiple hypothesis filter for systems with possibly erroneous measurements"

In this paper a novel method to deal with possibly erroneous measurements is presented. In target tracking applications it may be the case that measurements that are obtained are incorrect in the sense that they do not comply with the measurement model. Examples in (radar) target tracking are: Glint, Multipath, Ambiguous Doppler, etc. The method that we present here is able to detect these non-normalities and modifies the measurement model in such a way that these non-normalities do not blur the track filter output. The method is based on a multi hypothesis assumption w.r.t. to the correctness of the measurement model. This new method is also shown to outperform classical methods for dealing with possibly erroneous measurements. We demonstrate our method by an extensive example of a surveillance radar tracking system with unreliable (or sometimes false) Doppler measurements. [C2642]

## "Target tracking and radar health monitoring for highway vehicle applications"

This paper focuses on the improvement of radar reliability for automated highway vehicle applications. In particular, we address the topics of radar health monitoring and improved target tracking. Radar health monitoring poses a special challenge because a radar measures the distance to target vehicles whose motion is unknown in the absence of inter-vehicle communication. Traditional observer-based methods therefore cannot be used for the health monitoring task. A number of new approaches are summarized in this paper, including the use of a geographic database of known roadside targets, the detection of abrupt failures during target tracking and the use of a cheap redundant sensor. The use of a cheap redundant sensor is shown to be extremely valuable in the radar health monitoring task. The paper develops a new adaptive tracking algorithm to achieve good target tracking with a poor resolution sensor. An additional important problem addressed in the paper is that of tracking multiple targets which have crossing maneuvers. The paper proposes a new algorithm for tracking of multiple targets in which symmetric measurements are combined together with acceleration estimation so as to improve the stability properties of the existing Symmetric Measurement Equations (SME) technique for multiple target tracking. [C2643]

## "Autonomous hierarchical control of multiple unmanned combat air vehicles (UCAVs)"

In this paper we present a hierarchical control scheme that enables multiple UCAVs to achieve demanding missions in hostile environments autonomously. The objective is to use a swarm of UCAVs for a SEAD type mission: fly the UCAVs in a formation to an enemy territory populated with different kinds of threats, collect enemy information or destroy certain targets, and return to the base, all without human intervention. The scheme is an integration of four distinct components, including: (1) high level Voronoi diagram based path planner to avoid static threats; (2) low level path planner to avoid popup threats; (3) differential flatness based trajectory generator to generate dynamically feasible trajectory; and (4) semi-globally stable formation control algorithm to maintain the formation. The scheme was implemented in Matlab and demonstrated very effective path planning, trajectory generation, and formation flying capabilities. We also developed an interface from Matlab to IWARS, a high fidelity battlefield simulation environment developed by Boeing. This enabled us to study the effectiveness of our scheme under various battle scenarios using IWARS. [C2644]

## "Model-based principal component techniques for detection of buried landmines in multiframe synthetic aperture radar images"

Here we consider the use of model-based methods for the detection of buried objects from a sequence of synthetic aperture images obtained by a radar sensor moving linearly down a track. The scattering physics of the underlying sensing modality cause the relevant target signatures to change in a complex yet predictable manner from one image to the next. To arrive at a tractable processing scheme that exploits these motion-induced changes, we develop a flexible parametric model capable of capturing the full variation of these signatures. A detection scheme based on a principal components analysis of estimated model vectors is then derived. Results are demonstrated using field data from a forward-looking sensor. [C2645]

## "Characterization of symmetric scattering using polarimetric SARs"

Cameron's coherent target decomposition (CTD) and classification are discussed in the context of SAR, and the limitations of Cameron's classification are examined. It is shown that these methods may lead to a coarse and misleading scattering segmentation because of the large radiometric dispersion tolerated in each of the elemental scatterer classes, as well as the implicit assumption on the coherence nature of target scattering. A new method, named the symmetric scattering characterization method (SSCM), is introduced to better exploit the information provided by the largest target symmetric scattering component, under coherent conditions. The SSCM, which expressed the symmetric scattering in term of the Poincare sphere angles, permits a better characterization of target symmetric scattering and the generation of coherent scattering segmentation of much higher resolution, in comparison with Cameron's segmentation. [C2646]

## "Demonstration of current measurements from space by along-track SAR interferometry with SRTM data"

We present one of the first studies in which interferometric synthetic aperture radar (InSAR) data from the Shuttle Radar Topography Mission (SRTM) are analyzed with regard to the detectability of ocean surface current variations. The InSAR system of SRTM was designed for high-resolution topographic mapping, using two SAR antennas on a Space Shuttle with a cross-track separation of 60 m. For technical reasons, there was an additional along-track antenna separation of 7 m, which results in a time lag of about 0.5 ms between the acquisitions of images by the two antennas. In theory, this time lag causes additional phase differences, which are proportional to the line-of-sight velocity of moving targets and can thus be exploited, to some extent, for measuring oceanic currents. Indeed, some SRTM images acquired over water exhibit clear signatures of typical flow patterns. We show an example of an X-band phase image of the Dutch Waddenzee and discuss the plausibility of interpreting it in terms of sea surface height or current variations or the effect of waves. We find that only currents can be responsible for phase variations of the observed magnitude on spatial scales of a few 100 meters. We convert the data into a surface current field, which is found to be consistent with the theoretical current field at the time of the SRTM overflight according to a current atlas. Based on this encouraging result and theoretical findings, we discuss the general potential of SAR interferometry from space for oceanic applications. [C2647]

## "Detection of targets from electro-optical and SAR data using chaotic predictors and optimal CFAR detectors"

This paper presents a new clutter suppression and target detection technique for locating small land targets in SAR and electro-optical images. The method is based on adaptive nonlinear (chaotic) predictors which provide an estimate of the local SAR and electro-optical clutter and uses this estimate to suppress the clutter and hence increase the signal to clutter power. The residual errors between clutter estimates and actual data correspond to either clutter noise or target signatures. Hence, dedicated models are employed for clutter noise and targets. The modelling is performed using generalized statistical probability density functions. Statistically optimal Constant False Alarm Rate (CFAR) detectors are used to separate the targets from the residual noise. Although, some similarities may be found in the detection process, when multispectral and multipolarized SAR data are employed, the clutter and target statistics are quite different. The paper presents detection approaches that extend those presented in the literature by including threshold statistics, clutter suppression techniques and generalized statistics. Finally, the issue of detection fusion from dissimilar sensors is addressed. For CFAR detection the optimal Order Statistics, Cell averager, Optimal Weibull, Optimal K-pdf and Optimal Generalized Gamma CFAR detectors are employed. The last three have been developed at A.U.G. Signals Ltd. [C2648]

## "Elimination of false positives in vessels detection and identification by remote sensing"

The article describes how to eliminate the false positives generated by the basic model of an fast automatic algorithm for fishing areas control and vessel detection. [C2649]

## "Radar detection improvement by integration of multi-object tracking"

This paper presents a new and simple approach to the problem of multiple sensor data fusion. We introduce an efficient algorithm that can fuse multiple sensor measurements to track an arbitrary number of objects in a cluttered environment. The algorithm combines conventional Kalman filtering techniques with probabilistic data association methods. A Gauss Markov process model is assumed to handle sensor outputs at various sampling frequencies and random nonequidistant time intervals. We applied the algorithm to post-process the digital range returns of radar sensors to improve their quality. Since the static noise returns have near-zero velocity, the algorithm associates a certain track with each digital return, and estimates the track velocity, thereby allowing for removal of false returns originating from static pattern noise. [C2650]

## "ALMA: a new approach to data initial association"

An adaptive limited memory approach (ALMA) is proposed to deal with the data initial association problem in tracking-while-scanning systems in high clutter environments. By using measurements in the window limited memory and exploiting the target detection probability and receiver noise sampling information, the initial track number is estimated. It in turn can be adopted to adjust the initial correlation region and the normalized residual square threshold adaptively; many false initial trajectories are therefore restrained. Computer simulation demonstrates that the real time data initial association problem can be settled by a combination of radar's dynamic characteristics and limited window measurements. [C2651]

## "Synchronized GMTI radar collection management in a coalition environment"

Surveillance of ground targets from airborne systems is increasingly of interest in tactical operations. Collection management synchronization can provide improved tactical data products for multi-platform operations. Synchronization of collection management is considered for coalition operations involving multiple airborne GMTI radar systems. An emerging synchronization collection management planning capability is evaluated for application to surveillance using GMTI radar systems. Several examples are provided which illustrate the capability and benefits of synchronized collection management. [C2652]

## "Adaptive method for low velocity moving target detection"

In radar signal processing, when a target moves with a low velocity, it generates so small a Doppler frequency shift that the target reflected signals are submerged by clutter signals, and the radar cannot detect the target, especially under low signal-to-clutter ratio (SCR) environments. Because of its good performance in intelligent signal processing, an adaptive method is used to eliminate the clutter signals from the received signals in the signal's power spectrum figure according to the power spectrum distribution of the clutter. [C2653]

## "Information fusion aspects related to GMTI convoy tracking"

Tracking of ground moving vehicles with GMTI radar is a challenging task, which calls for efficient exploitation of all information sources available. For well-separated vehicles as well as for convoy targets we focus on information fusion aspects comprising both, fusion of data from multiple dislocated sensors as well as incorporation of background information (refined models of the sensor performance, road maps, terrain screening, and simple tactical rules). Under suitably formulated modeling assumptions algorithmic solutions within the context of Gaussian sum approximations are discussed. Methods originally proposed for well-separated vehicles can be embedded into an expectation-maximization approach for dealing with collectively moving convoy targets. By this in particular, early detection of a stopping event is alleviated. [C2654]

## "Multi-sensor multi-target tracking using out-of-sequence measurements"

Out-of-sequence measurements (OOSMS) arise in a multi-sensor central-tracking system due to communication network delays and varying preprocessing times at the sensor platforms. During the last few years a great deal of research has focussed attention on the OOSM filtering problem. However, research in the multi-sensor multi-target OOSM tracking involving data association, filtering, and hypothesis management is still lacking. Some previous efforts have used buffering and measurement reprocessing to handle the OOSMs. In this paper, we present single-model multiple-lag OOSM algorithms for data association, likelihood computation, and hypothesis management for a dwell-based multi-sensor multi-target multi-hypothesis tracking (MHT) system that handles missed detections and clutter. We present numerical results using simulated multi-sensor ground moving target indicator (GMTI) radar measurements. [C2655]

## "Signal parameter estimation based on one-bit quantized data from multiple sensors"

We consider the problem of signal parameter estimation using a collection of distributed sensors. Each sensor quantizes its data to one-bit information and sends it to a fusion processor for the estimation of the parameter. Estimation of a constant signal in additive noise is considered. Since the emphasis is for the case of a moderately large number of sensors, we consider in this study two cases of estimation with 8 sensors and 20 sensors. We formulate several estimators based on one-bit sensor data and evaluate their mean squared error performances through simulation studies. Two parametric noise densities are simulated to ascertain the efficacies of various estimators. Results from this study show that robust estimation of parameter is possible by using a moderately large number of one-bit quantized sensor data. [C2656]

## "An efficient sequential procedure for detecting changes in multichannel and distributed systems"

In the conventional formulation of the change-point detection problem, there is a sequence of observations whose distribution changes at some unknown point in time, and the goal is to detect this change as quickly as possible, subject to false alarm constraints. It is known that in the case where the observations are i.i.d. and the change point is modeled as deterministic but unknown, the cumulative sum (CUSUM) detection procedure of Page (1954) and the randomized Shiryaev-Roberts detection procedure proposed by Pollak (1985) minimize the expected detection lag, subject to a constraint on the false alarm rate. In this paper, we are interested in the two generalizations of this problem. The first is the generalization regarding multichannel systems. Here all the channels are either statistically identical or the change occurs in one of them at unknown point in time. It is necessary to detect the change in distribution as soon as possible after it occurs, while controlling the rate of false alarms at a given level. The second generalization corresponds to the multi-sensor situation where the information available for decision-making is distributed across a set of sensors. The sensors send quantized versions of their observations to a fusion center where the change detection is performed based on all the sensor messages. We propose multi-channel and distributed versions of the CUSUM procedure and prove that they are asymptotically optimal as the average frequency of false alarms goes to zero. The general results are applied to the two important application areas-target detection in surveillance systems and attack/intrusion detection in distributed computer networks. Experimental results show that the proposed detection methods are highly efficient. [C2657]

## "MMW collocated detectors by fusing active and passitive detection"

The article considers an actual millimeter microwave (MMW) collocated detector applied in a, AHM (anti-helicopter mine) weapon by fusing active and passive detection. There is strong compensation between active detection (radar) and passive detection (radiometer). The value and width of the MMW radiation signal represents the property of target material and its size. The center of the target can be aimed at accurately by passive detection. The target's height and azimuth can be precisely detected by radar. Based on the echo envelope curve of the signal return of MMW radar, the steady bi-spectral estimation can be acquired, representing information of target scatter. In this paper, methods of identifying targets such as helicopters using radar and a radiometer are introduced individually, then the active and passive information fusion technique is discussed. A scheme for acquiring target parameters by monostatic active sensor(s) is introduced. [C2658]

## "Estimation accuracy of a landing point of a ballistic target"

This paper studies the problem of tracking a re-entry ballistic object by means of radar measurements. Practical applications are in the fields of surveillance for defense and for safety against the re-entry of old satellites. In particular, the investigation determines the estimation accuracy of the impact point of a ballistic target by processing radar measurements during the re-entry phase of the target. In practice, the radar measurements are available only for a limited part of the re-entry trajectory; while it is of interest to estimate the target landing point and its accuracy. This problem is tackled via non linear filtering technique and by resorting to the theory of Cramer-Rao lower bound (CRLB) recently developed for such filters. [C2659]

## "Power budget study for passive target detection and imaging using secondary applications of GPS signals in bistatic radar systems"

Signals from satellite systems like GPS, IRIDUM and Globalstar that are reflected from moving or stationary objects are utilised for their detection in a synthetic aperture bistatic radar system (SAR). The movements of the satellite and its position at different coordinates with respect to time can serve as a base for a synthetic aperture. This paper focuses on the development of a system based on the analysis of indirect signals, in particular GPS signals. The main concern in this study is the low power of the GPS signal at the earth's surface (typically about -160 dB). Due to the nature of the reflector/target, some power will be absorbed, and hence result in a further

reduction in signal strength reflected by the target. However, the other equally important concern here is the ground and sea clutter, which is 18-22 dB stronger than the direct signal level. Here we present theoretical results of both the maximum detection range and land clutter contributions of the air target detection by bistatic SAR that utilizes the existing GPS satellite as the transmitting signal source. [C2660]

## "ISAR imaging in strong ground clutter by using a new stepped-frequency signal mode"

In this paper we have presented a new mode of stepped-frequency signal. By using this signal, which transmits two pulses of the same earner frequency at each burst and with this carrier frequency stepped up a Δf in each subsequent burst, the ground clutter can be cancelled by using simple first-order cancellation. A computer simulation is given to illustrate the effectiveness cif the proposed method. [C2661]

## "AOA with merged measurements from monopulse data"

A key assumption in monopulse based angle-of-arrival (AOA) estimators is that at most one return is present in each range cell, or equivalently in each sample of the matched filter output used to implement range compression. These algorithms break down if the data consists of merged measurements-multiple target returns contained in the same range cell. The proposed technique makes use of data from a three channel monopulse radar to estimate the AOA of merged measurements. The paper focuses on the development of the new algorithm along with computer simulations that demonstrate its viability. [C2662]

## "SAR/MTI radar mapping from ships and ground based vehicles"

In this paper, the performance of MTI/SAR radar in ships and ground vehicle applications is analysed. If a single antenna beam scans a sector, significant degradations in MTI sensitivity and SAR resolution occurs due to the reduced dwell time on target. Full performance can be achieved by using an ESA antenna with multiple beam generation, or high speed scanning. SAR needs accurate phase error compensation by inertial measurements or auto-focusing due to the non-linear movement path of the antenna. [C2663]

## "Analysis of backscattering enhancement for partially convex targets in random media for plane and beam wave incidences"

Fields due to electromagnetic waves propagating in continuous random media are calculated efficiently, by a method that uses a current generator, M. Tateiba et al. (1992). This method solves the problem of wave scattering from targets in random media as a boundary value and this technique of solution is important for radar detection of a target of finite size. This method uses two operators: the current generator that transforms the incident wave falling on the target into the surface current and Green's function in the random medium. In earlier investigation, Z. Q. Meng et al. (1996), numerical results for radar cross-section (RCS) of conducting convex bodies such as circular and elliptic cylinders have elucidated that the spatial coherence length (SCL) of incident waves around a target is one of the key parameters for the clarification of random media effects on the RCS. The shape of the target is one of the parameters that constitute an important factor in the radar detection problem. Recently we have presented numerical results for the backscattering enhancement in RCS of conducting cylinder with a concave-convex cross-section. It has been found that the target configuration together with the SCL of the incident wave around the target play a leading role in determination of the RCS of partially convex targets. To render a satisfactory understanding of the backscattering enhancement behavior for the concave-convex targets in random media, we analyze the scattering problems for plane wave propagating in continuous random media and beam waves in free space for vertical polarization. [C2664]

## "Velocity estimates from fully polarimetric SAR"

Fully polarimetric SAR data provides sufficient information so that some level of feature attribute classification, is usually possible for signatures found in these images. In particular, polarimetric analysis can provide structural information from SAR image signatures for some target types Additionally, although not commonly recognized, there is evidence that polarimetric SAR data collected from systems similar to the C/X SAR (and the future RADARSAT 2) can also provide velocity information. This velocity information is not an attribute of the polarimetric ellipse information, but rather a consequence of the system's data acquisition method and the provision that the reciprocity relationship is assumed. Here, an example is presented which indicates that this velocity information is likely available in polarimetric data. This capability has great potential for classification purposes, since both velocity and structural properties of an imaged feature may be deduced from the same data acquisition. While the velocity estimates may have some limitations compared to Along-Track InSAR systems, this information is readily available from fully polarimetric SAR systems, such as the future RADARSAT 2. [C2665]

## "Analysis of radial velocity effect on synthetic range profile of stepped-frequency waveform"

The stepped-frequency waveform is able to obtain large effective bandwidth by sequentially changing the carrier frequency in steps over pulses. However, this waveform is very sensitive to the radial velocity between the radar and the target. In this paper, the effect of the radial velocity on the synthetic range profile is discussed first, and then the range spread in terms of the processed range bin is defined differently from others, which is validated by the simulation. Furthermore, the relation between the processed range bin and the range resolution is also discussed. [C2666]

## "Multi-aperture coherent Doppler lidar for mitigation of turbulence and vibration induced speckle effects"

Summary form only given. A 1.55 μm coherent Doppler laboratory lidar system has been developed to study the enhancement in the measured lidar SNR through the use of a dual aperture balanced heterodyne array using incoherent and coherent summation of the detected array signals. A 30 mW, 1.55 μm, single frequency diode laser is used as the main excitation source. The beam is split into a LO channel and a main projected beam followed by a 27 MHz acousto-optic shifter. The main portion is sent to a rotating target and the reflected backscatter is collected by two spatially separated single mode, polarization preserving fibers. The two collected signals are branched into in-phase and quadrature signals for balanced heterodyne detection. The four channels are detected and the electrical signals are analyzed using spectrum analyzers, channel oscilloscopes, and then computer interfaced. We have studied the effects of target rotation on the Doppler center frequency, spread of the Doppler shifted signal, and the influence of the geometrical and velocity aspects of the target. [C2667]

## "Test results from a 1319-nm laser radar with RF pulse compression"

We report the results of a three-year, NASA-funded project at The University of Kansas Radar Systems and Remote Sensing Laboratory on the development of a laser radar that uses RF pulse compression to significantly improve system performance. Receiver sensitivities of less than -90 dBm have been demonstrated by applying heterodyne optical downconversion and RF pulse compression. With the improved sensitivity, the required transmit power is significantly reduced. This system approach also permits multi-kilohertz pulse-repetition frequencies that enable spatially dense range measurements. Compared to lidars like GLAS and MOLA, this sensor requires a lower peak transmit power while providing orders of magnitude more measurements per second. In the receiver design, we have evaluated two detection schemes: envelope detection and direct downconversion. Envelope detection provides the benefit of discarding the effects of optical phase variations on the detected signal consequently avoiding many temporal correlation issues, however it is less efficient in terms of the resulting signal-to-noise ratio (SNR). Direct downconversion to baseband is more SNR efficient, however the baseband signal contains the effects optical phase variations, which include laser phase noise, effects of atmospheric turbulence, and frequency shifting due to Doppler effects. We have demonstrated the feasibility of using a linear array of optical fibers in the telescope's focal plane to launch and receive the optical signals. Using separate fibers for transmit and receive while sharing telescope optics, we have achieved the required transmitter-receiver isolation of a bistatic system without the accompanying alignment difficulties. With our breadboard system ranging measurements from both man-made and natural extended targets have been made and the results are presented. These results support the feasibility of a satellite-based altimeter (600 km altitude), capable of making more than 4000 range measurements per second with 10 cm accuracy using less than 10 W peak transmit power. While the present breadboard operates at 1319 nm, the overall concept is wavelength independent. Benefits of this development may include increased system reliability, reduced power requirements, smaller sensor mass a- nd volume, improved eye-safety, and lower probability of signal detection. [C2668]

## "Improved radar revisit time control to observe ballistic missile mode transitions"

For systems that can be modeled using multiple models and Markovian switching probabilities, an interacting multiple model (IMM) estimator is a good approach to state estimation and mode detection. For good mode detection, it is desirable to maintain the mode-probability set so that one of the probabilities is near unity. For radar tracking a ballistic missile, the mode probability is dependent on the so-called revisit time defined as the elapsed time between each measurement. It is shown that selecting a revisit time that controls the value of a mode-switching coefficient yields acceptable performance in terms of both the mode probability and tracking error. The potential robustness of the method to tracking conditions is demonstrated through a mid-fidelity, physics-based radar simulation using targets that differ in both type and radar-to-target geometry. The results show that the proposed adaptive-revisit method performs well during boost, boost-to-coast transition, and ballistic coast, as measured by tracking error when compared to both a constant revisit interval and an ad-hoc, altitude-based revisit schedule. [C2669]

## "A new maximum likelihood generalized gamma CFAR detector"

The Generalized Gamma Model has as special cases the Rayleigh, Weibull and Lognormal models. It also closely approximates the K-pdf model. Radar Clutter is often approximated in one of these forms. It is therefore quite useful to develop CFAR (Constant False Alarm Rate) detectors that perform well under this clutter model. In this paper, a Maximum Likelihood Generalized Gamma (MLGG) CFAR detector has been developed. This MLGG detector uses the Maximum Likelihood Equations, both locally and globally, in order to estimate the parameters of the Generalized Gamma clutter. These estimated parameters are then used to estimate the local mean of the detector. The mean of the local CFAR window is then taken as the first moment of the Generalized Gamma distribution evaluated with the estimated parameters. In the examples it is shown that in homogeneous Generalized Gamma clutter, with point targets, the MLGG detector outperforms our standard test detectors, Cell Averager, Ordered Statistic and Optimized Weibull. [C2670]

## "Exploiting the polarimetric information for the detection of ship targets in non-homogeneous SAR images"

Ship detection in polarimetric SAR images of non-homogeneous sea areas is considered. We demonstrate the impact of non-homogeneous sea features on the false alarm rate and the need of extracting the image structure. We thus introduce polarimetric segmentation procedures that cooperate with high-resolution polarimetric detection features for the control of the false alarms. Different polarimetric segmentation-plus-detection procedures are tested over real data to devise the appropriate method to exploit the polarimetric information. [C2671]

## "Possible military requirements and applications of active and passive imaging sensors at micro- and millimeterwave frequencies"

In order to reveal the differences between military and civil applications of remote sensing common military user requirements for the detection, recognition, identification, and revisit time of military targets are discussed. Typical application examples of imaging SAR and radiometer systems are given as well as design examples for advanced sensor systems demonstrating the technological realisation and limits. [C2672]

## "The Global Hawk UAV Australian deployment: imaging radar sensor modifications and employment for maritime surveillance"

The Global Hawk system is a high altitude endurance unmanned aerial vehicle developed under the United States Air Force Advanced Concept Demonstrator program primarily as a reconnaissance system for use against fixed and mobile targets. The Global Hawk system deployed to Australia in April 2001 for six weeks and in this period conducted 11 missions with the focus on maritime surveillance. The Australian deployment was the culmination of two years collaboration between the United States and Australia that included modifications to the radar sensor, system control and exploitation to support a surveillance focus. This paper presents aspects of the Australian contribution to the Global Hawk deployment including the rationale behind the sensor modifications and employment that achieved a surveillance capability with a system primarily designed for land reconnaissance. [C2673]

## "Multi-channel airborne radar"

This paper examines two applications of a multi-channel airborne radar system, or an array-based synthetic aperture radar (SAR). The first mode involves a stripmap SAR array whose electronically-steered beam patterns are exploited to achieved the azimuth resolution of its single element while maintaining a relatively high radar power; this system has applications in foliage penetrating (FOPEN) SAR. The second array-based SAR utlilizes two or more elements in the along-track domain to detect moving targets. Signal processing issues associated with these two array-based SAR systems are discussed. [C2674]

## "Some fundamental statistics associated with ocean surface current measurement using a dual station, long-range, high-frequency ground wave radar system"

Raytheon Systems Canada Limited, in association with Northern Radar Inc (NRI), have designed and built two long-range High Frequency Ground Wave Radar (HFGWR) facilities at Cape Race and Cape Bonavista, NF, Canada. Even though these systems can routinely monitor offshore target activity, the data stream for target detection can also be used to generate surface currents. Since each station is capable of providing estimates of the radial components of the surface current field, the vector current field can be reconstructed from the radial data via geometric considerations. To explore this possibility, sample datasets from both stations were collected

in June of 2000 and subjected to a dual station analysis scheme. The treatment presented here will discuss some of the statistics associated with the radial current data as well as the dual station technique used to generate the surface current field. Finally, the radar current estimates will be compared with current meter data collected near the Hibernia platform. [C2675]

## "Electromagnetic field simulation of target detection by high-resolution radar"

The electromagnetic field simulation of the target detection by high-resolution radar is performed by incorporating the asymptotic waveform evaluation (AWE) technique and the compression technique of a chirp signal. The electromagnetic field simulation is very helpful for revealing the multi-scattering mechanism of wide-band radar signal between targets or within a target. Our current simulation involves three major steps, in the first step, AWE technique is used to calculate the scattering far field over a wideband at which a radar is operated; in the second step, the frequency response of scattering field is multiplied by the spectrum of the chirp signal transmitted by radar to get the frequency response of radar system; in the third step, the system response is multiplied by the conjugate of the spectrum of the chirp signal and then transformed into time domain by inverse FFT. In this way the target detection by chirp radar can be accurately simulated using electromagnetic field. Numerical examples are presented. [C2676]

## "The ONERA RAMSES SAR system"

The ONERA RAMSES system (Radar Aeroporte Multi-spectral d'Etude des Signatures) is a flexible SAR system in constant evolution developed mainly as a test bench for new technologies and to provide specific data for TDRI (Target Detection, Recognition and Identification) algorithm evaluation. It is flown on a Transall C160 platform operated by the CEV (Centre d'Essais en Vol). This paper gives an overview of the system and its recent upgradings. [C2677]

## "Parameter estimation for the phase statistics in interferometric SAR"

In interferometric SAR applications, the complex coherence between two channels, $\rho e^{j\theta}$, and the effective number of looks, n, are required to describe the joint channel statistics. Accurate modeling of the statistics is critical in the determination of Ground Moving Target Indication (GMTI) CFAR detection rules in along-track interferometry, and the estimation of topography accuracy in across-track interferometry. In this paper, we propose a method for estimating n and $\rho$ based on the interferometric phase density function. We validate the robust, real-time implementable method with real SAR data in various types of terrain. Particularly, we show how the method can be extended to model the phase distribution even in extremely heterogeneous terrain. We show that the estimation relies only upon the multi-looked interferogram, without reference to the individual channels thereby reducing data storage requirements. [C2678]

## "The inversion of subsurface VETEM data-theory and practice"

Very early time electromagnetic system (VETEM) is an efficient tool for the detection of buried targets in very lossy medium. In this paper, we will discuss the inversion of VETEM data using a combination of one-dimensional (1D) and three-dimensional (3D) inverse scattering techniques, where the Born iterative method and distorted Born iterative method have been applied. In order to expedite the 3D inversion, an extended Born-type approximation is made in the forward solver, together with FFT acceleration technique. The 1D inversion provides a gross image of the subsurface, but the 3D inversion helps to resolve the subsurface image better. [C2679]

## "Results from the Crusade ship detection trial: polarimetric SAR"

An experiment was conducted in March 2000 offshore of the Newfoundland, Canada coastline which involved several radar data sets. The objective of the experiment was to assess ship detection capabilities for several radar systems. In particular, image data were collected from RADARSAT, the polarimetric C/X SAR and the High Frequency Surface Wave Radar (HFSWR) at Cape Race, Newfoundland. These data were acquired over a period of ten days while three staged ships remained on site at specified positions. These types of experiments are very rare and hence the results from this experiment will be invaluable for validating ship detection techniques and providing direction for future research and experiments. HH and HV polarizations were found to be optimal for wide area ship detection applications. A moment method and polarimetric decomposition methods provided high ship detection rates. Polarimetric target decomposition results indicate potential capability for recognizing targets and reducing false alarm rates. [C2680]

## "Treatment of broadband and multi-object electromagnetic induction scattering using high

## frequency approximations"

Wideband electromagnetic induction (EMI) sensing shows increasing capability and promise for characterizing subsurface metallic objects, such as UXO. While EMI has some advantages over radar, such as superior penetration of moist soil, the field problem is still difficult due to the frequent occurrence of multiple targets in close proximity. The numerical modeling problem, even for a single object, is complicated by the fact that transmitted ("primary") fields typically penetrate the target, but will often only do so slightly. In most of the established numerical treatments, the scale of discretization is dominated either by the dimensions of the thin subsurface layer of electrical activity, or, more or less equivalently, by the range over which a Green's function decays, based on the characteristics of the metal. Resolution at this scale is often computationally prohibitive, particularly for magnetic materials, even though external fields of interest have only mild gradients. We approach the problem using the Thin Skin Depth Approximation (TSA). The TSA assumes an exponential form for the internal normal magnetic field component, as a function of distance inwards from the object surface. Despite the fact that it is designed to treat a state of affairs characteristic of relatively high EMI frequencies, results based on the TSA turn out to be accurate across the entire EMI band when the relative permeability of the scatterer material is high (e.g. as for steel). [C2681]

## "Naval 3D radar in C band"

3D pulse-coherent radar with electronic beam scanning working in the C band will be the main source of information for a ship's defence systems. A functional model of this radar system has been built. The system enables automatic detection and tracking of over 100 maritime and air targets. Output data from the radar with full information about the target is transmitted to the ship's command systems or directly to automatic defence systems. Scanning in elevation is achieved using phase shifters. In azimuth it is solved by mechanical rotation and additionally by changing the frequency of the signal. [C2682]

## "Efficient determination of thresholds via importance sampling for Monte Carlo evaluation of radar performance in non-Gaussian clutter"

An efficient importance sampling simulation method is presented for estimating the thresholds to achieve very low probabilities of false alarm for radar receivers in clutter modeled as a non-Gaussian, spherically invariant random vector. Thresholds at false alarm probabilities of 10-6and lower are estimated with only 10,000 trials for both known and unknown clutter covariance matrix cases. [C2683]

## "Airborne sensor concept to image shallow-buried targets"

This paper develops an airborne sensor concept to detect and image shallow-buried targets with a focus on the remote sensing of landmines. Our ongoing ground-based bistatic ground-penetrating radar (GPR) experiments have demonstrated deep penetration and subwavelength resolution. Simulation software (ground penetrating radar processing-GPRP) was developed and validated using experimental results. Extrapolation of the experimental results to higher frequencies using the simulation software indicates the ability to provide high-quality images of shallow-buried targets. [C2684]

## "Performance characterization of space-time adaptive processing algorithms for distributed target detection in non-ideal environments"

The use of adaptive algorithms to mitigate the detrimental effects of noise on receivers employing antenna arrays is instrumental in modern day radar systems applications. In most of these algorithms, the target is assumed to be confined to only one range cell. Under practical operating conditions, the target can actually be distributed across several range cells. This signal contamination causes the performance of the adaptive algorithm to degrade. Also, a covariance matrix is used for clutter-plus-noise in the design of the adaptive algorithm. This quantity is usually characterized by using samples taken from range cells surrounding the test cell. Performance suffers if the underlying test cell covariance matrix is different from the average covariance matrix of the surrounding range cells. We analyze a space-time adaptive processing (STAP) algorithm designed to utilize signal contamination to the advantage of the receiver. Expressions for performance, incorporating the possibility of covariance matrix mismatch, are developed for such distributed target scenarios. Numerical analysis illustrates that the presented algorithm functions significantly better than traditional STAP algorithms in signal contaminated environments. This investigation also shows how variations in the parameters that describe covariance matrix mismatch affect performance. [C2685]

## "STAP with angle-Doppler compensation for bistatic airborne radars"

We study issues associated with applying space-time adaptive processing (STAP) techniques in bistatic airborne

applications. We consider the performance of several STAP approaches in different scenarios. Specific consideration is given to the effects of bistatic clutter spectral dispersion on covariance estimation and the algorithm's resulting clutter rejection capability. Our prime focus emphasizes adaptive processing methods capable of high performance with efficient utilization of training data. A deterministic two-dimensional spectral compensation is used to align the clutter spectral centers and thus enhance the performance of the proposed approaches. Algorithm performance is assessed using the output signal-to-interference-plus-noise ratio (SINR) compared to that of the matched filter with known covariance. [C2686]

## "Statistical analysis of the nonhomogeneity detector for non-Gaussian interference backgrounds"

We derive the nonhomogeneity detector (NHD) for non-Gaussian interference scenarios and present a statistical analysis of the method. The non-Gaussian interference scenario is assumed to be modeled by a spherically invariant random process (SIRP). We present two methods for selecting representative (homogeneous) training data based on our statistical analysis of the NHD for finite sample support used in covariance estimation. In particular, exact theoretical expressions for the NHD test statistic probability density function (PDF) and its moments are derived. Additionally, we note that for SIRP interference, a simple transformation of the NHD test statistic admits an elegant representation as the ratio of a central-F distributed random variable and a beta distributed loss factor random variable. Performance analysis of the NHD is presented using both simulated data and measured data from the MCARM program. [C2687]

## "Moving target detection in over-the-horizon radar using adaptive chirplet transform"

In over-the-horizon radar (OTHR) moving target detection, the signal to clutter ratio (SCR) is low. One method to detect a moving target is to first reject the clutter and improve the SCR before the detection, such as the adaptive Fourier transform developed by Root (see SPIE Conference, San Diego, p.19-24, July 1998) when a target moves uniformly. When a target does not move uniformly, the Fourier based techniques for the target detection including super resolution techniques may not work well. We replace the Fourier transform by the adaptive chirplet transform in the Doppler processing in OTHR when a target moves non-uniformly. [C2688]

## "Radar resource management for UESA"

This paper describes how a circular UHF electronically scanned array like that being considered by the US Navy could be used to simultaneously perform both airborne early warning (AEW) searches and high update rate tracking of a few targets. Taxonomies of the various search and track modes are reported, and an example radar resource configuration is described in detail. [C2689]

## "Model-based adaptive detection and DOA estimation using separated sub-arrays"

The potential performance of adaptive detection and direction-of-arrival (DOA) estimation using a certain class of sparse linear arrays, characterized by two widely separated sub-arrays, in combination with model-based techniques, is investigated. With this array structure, a large baseline is obtained with a limited amount of hardware. It is found that the very narrow main-lobe obtained by separating the sub-arrays can be utilized to obtain accurate DOA estimates, high angular resolution, and good detection performance even in close vicinity of a localized interference source. However, the presence of grating lobes deteriorates the performance at low SNR and also when the angular separation between two targets, or between a target and an interfering source, corresponds to an integer times the distance between the grating lobes. [C2690]

## "FOPEN SAR imaging of ground moving targets using rotational time-frequency-radon transforms"

In this paper, we introduce the basic concept of the rotational Fourier transform, the bilinear rotational time-frequency transforms, and the Radon transform. Based on a certain model of radar returns from moving targets, we propose a method using a rotational time-frequency-Radon transform for synthetic aperture radar imaging of moving targets in foliage. [C2691]

## "Using a wavelet basis for a spectrally tunable phased array"

Conventional phased array radars traditionally use digital filters that are adaptive in frequency on receive and use a fixed transmit pattern to illuminate their targets. Unfortunately such an approach does not take into consideration the spatial diversity of targets and interference sources that the phased array observes as it is electronically pointed throughout its search area. We propose a methodology that uses a wavelet filter bank to selectively transmit and receive radiation that is directionally dependent on the phased array's pointing direction. Such an approach allows us to illuminate with and receive radiation from targets in a way that is frequency selective depending on the pointing direction of the array and also more efficiently detect targets due to the

compact spectral model produced by the wavelet filter bank. [C2692]

## "Maritime target and sea clutter measurements with a coherent Doppler polarimetric surveillance radar"

Doppler polarimetry in a surveillance radar for the maritime surface picture is considered. This radar must be able to detect low-RCS targets in littoral environments. Measurements on such targets have been conducted with a coherent polarimetric measurement radar in March 2001 and preliminary results from that campaign are presented. The system provides estimates of the scattering matrix per range-Doppler bin. Several physical quantities that can be exploited to discriminate target echoes from sea clutter responses are discussed and an impression is given on their effectiveness. [C2693]

## "MATLAB simulation for computing probability of detection"

This paper presents a MATLAB simulation that computes the probability of detection for a radar. It allows the user to input a wide range of radar characteristics. The target detection method has the capacity for handling fluctuating targets. This is important because actual targets are observed to scintillate and the probability of detection decreases as the signal-to-noise ratio decreases. This paper also considers characteristics of the operational mode of the radar system, such as its PRF (pulse repetition frequency), number of pulses processed, and the necessary range resolving ratio. The simulation utilizes formulas for detection probability associated with a target's range and uses the Swerling cases to model the! target's fluctuating cross section. The goal is to build a MATLAB simulation that can display radar observations in a format that facilitates analysis in range versus azimuth. [C2694]

## "A polarimetric adaptive detector in non-Gaussian noise"

We address polarimetric adaptive detection of targets embedded in compound-Gaussian clutter with unknown covariance matrix. To this end we assume that a set of secondary data, free of signal components and with the same covariance structure of the cell under test, is available. We resort to a design procedure based upon the generalized likelihood ratio test (GLRT): first we derive the GLRT assuming that the textures are known, then we plug into the derived test suitable estimates of these parameters. Remarkably, the newly proposed detector has the constant false alarm rate (CFAR) property with respect to the texture statistical characterization. Moreover, even though it does not ensure the CFAR property with respect to the clutter covariance matrix, a sensitivity analysis shows that the probability of false alarm is only slightly affected by variations in the clutter correlation properties. Finally, the performance assessment, conducted via Monte Carlo simulations, confirms the capability of the receiver to operate in real radar scenarios. [C2695]

## "A new solution to polarimetric radar discrimination problem"

A new solution is proposed for polarimetric radar discrimination problem by using cross-entropy to measure the difference between two scatterers. Two cross-entropy measures in favor of one scatterer over another are obtained for two independent probability mass functions that indicate the average scattering mechanism and the scattering randomness, respectively. These probability mass functions are formed by the modified similarity parameters and the eigenvalues of target coherency matrix. The cross-entropy measures utilize the polarimetric information efficiently to show the difference between scatterers. The advantage of using cross-entropy for solving polarimetric radar discrimination problem is demonstrated by the simulation results. [C2696]

## "Feature analysis using millimeter-wave real beam and Doppler beam sharpening techniques"

A challenging problem in digital signal and image processing is that of automatic target recognition (ATR) and object classification. In defense operations in particular, rapid object discrimination is critical. While this problem has been studied extensively, it remains a challenge, due to the complex and time-intensive methods of typical approaches. This study involved constructing features from the range profile signal returns, identifying the "best" set of features and performing ATR. Confusion matrices are presented for the targets of interest for simulation. Although the selection techniques for the features were not optimized, the results for ATR are promising [C2697]

## "Multifractal features of sea clutter"

Sea clutter refers to the backscattered returns from a patch of the sea surface illuminated by a transmitted radar pulse. Since the complicated sea clutter signals depend on the complex wave motions an the sea surface, it is reasonable to study sea clutter from nonlinear dynamics, especially chaos, point of view, instead of simply based on random processes. In the past decade, Dr. Simon Haykin's (1997) group at the McMaster University of Canada carried out analysis of some sea clutter data using chaos theory, based on the the assumption that a

chaotic attractor is fully characterized by a non-integer fractal dimension and a positive Lyapunov exponent. Thus, they concluded that sea clutter signals are chaotic. In other words, the complicated sea clutter waveforms are generated by nonlinear deterministic interactions of a few modes (i.e., number of degrees of freedom). However, a numerically estimated non-integral fractal dimension and a positive Lyapunov exponent may not be sufficient indication of chaos. Cowper and Mulgrew (see Proc. UCNN, vol.4, p.2633, July 1999), Noga (see Ph.D thesis, Cambridge University, 1998), and Davies (1994) separately have questioned the chaoticness of the radar sea clutter. We show, using the direct dynamical test for deterministic chaos developed by Gao and Zheng, which is one of the more stringent criteria for low-dimensional chaos, a two minute duration sea clutter data is not chaotic. We also carry out a multifractal analysis of this sea clutter data set, and find that the original sea clutter amplitude signal is approximately multifractal, while the envelope signal, formed by picking up the successive local maxima of the amplitude signal, thus measuring the energy of successive waves on the sea surface, is well modeled as multifractals. These behaviors determine that the amplitude signal follows approximately log-normal distribution while the envelope signal, and thus the energy of the successive waves of the sea surface, is log-normally distributed. Approximate log-normal distributions for the amplitude signal has been observed earlier. However, by using the multiplicative multifractal theory, there is theoretical justification for the log-normal distribution of sea clutter, as discussed. The implications of the multifracta- l nature of sea clutter may have relevance for the detection of point targets on the sea surface. [C2698]

## "Application of fast projection techniques without eigenanalysis to STAP"

In ground surveillance from an airborne or space-based radar it is desirable to be able to detect small and slowly moving targets, within severe ground clutter. For operational moving target indication (MTI) systems the clutter filter coefficients have to be updated frequently due to rapidly changing interference environment. This paper examines the small sample size performance of different fast fully adaptive space-time processors (STAP) and compares it to the optimum-detector performance. These previously proposed techniques, named matrix transformation based projection (MTP) and lean matrix inversion (LMI), were originally developed to provide fast jammer suppression in phased array radars with many elements. For this application they have been proven to operate with near-optimum performance, yet with a computational expense extremely reduced from that of the optimum detector in most practical cases. The investigation herein focuses on the performance achieved when only a very few data samples are available to adapt (update) the clutter filter coefficient. [C2699]

## "Block Toeplitz with Toeplitz block covariance matrix for space-time adaptive processing"

Interference covariance matrix estimations and computational complexity are two main concerns in space-time adaptive processing (STAP). This paper deals with the two problems by exploring a structured covariance matrix. First, a conjugate gradient iterative algorithm (CGIA) with reduced computational complexity is presented, which is based on FFT by using a block Toeplitz with Toeplitz block (BTTB) structure of the interference covariance matrix. To ensure the convergence of CGIA, an iterative BTTB (IBTTB) covariance matrix approximation is also proposed. Based on the approximated BTTB matrix, the corresponding STAP algorithm provides superior and robust performance both in limited sample support and in the presence of system errors. [C2700]

## "GMTI STAP in target-rich environments: site-specific analysis"

We address the problem of training data corruption in space-time adaptive processing (STAP) for ground moving target indication (GMTI) radar scenarios characterized by high densities of ground targets. A site-specific clutter simulation is used to demonstrate the impact that target signals in the training data have on STAP performance. Measured MCARM data results are presented that reveal similar performance trends as those observed in the simulations. A strategy for mitigating the deleterious effects of targets in the training data using a priori knowledge of the radar environment (e.g., locations of roads) to edit the training data is presented. [C2701]

## "Acceleration compensation by matched filtering"

High radar sensitivities are required in the detection of small cross section targets or in ECM environments. An effective way of improving the radar sensitivity is to use long coherent integration times. Results of the work to be presented include studies of target decorrelation using actual magnitude/phase flight test data from aircraft and the resolution of the "filter fly-through" problem due to translational acceleration. The acceleration compensation technique described in this radar generates matched filters that compensate for each acceleration. The matched filters optimize the signal-to-noise ratio by weighting and combining the Doppler filters over which the target is spreading. Both coherent and non-coherent matched filters can be formed. This provides direct and precise measurement of target acceleration for enhanced detection and tracking of maneuvering targets. [C2702]

## "Projection approach for STAP"

The sample support problem in space-time adaptive processing (STAP) applications arises from the requirement to adapt many spatial and temporal degrees-of-freedom (DOF) to a changing interference environment that includes clutter and jammers. Often, in heterogeneous overland strong clutter environments, the available wide sense stationary sample support is severely limited to preclude the direct implementation of the sample matrix inverse (SMI) approach. We outline an approach to address the sample support problem by utilizing projection methods-alternating projections or relaxed projection operators onto desired convex sets-to retain the a-priori known structure of the covariance matrix. Our initial analysis shows that by combining these approaches with eigen-based techniques, it is possible to reduce significantly the data samples required in non-stationary environment and consequently achieve superior target detection. In fact, multiplicative improvement in data reduction compared to direct eigen-based methods can be obtained at the expense of negligible loss in space-time aperture. [C2703]

## "Theoretical and simulation analysis of random noise monopulse radar"

Coherent random noise radar technology has been implemented successfully in buried object detection, Doppler estimation, SAR imaging, and ISAR imaging. These applications verified the desirable characteristics of random noise radar for stationary target applications. Since the system is phase coherent, we have demonstrated that it can be used for radar interferometry. We are currently developing a random noise monopulse system for angular tracking of moving targets in real time. This paper provides a preliminary analysis of compatibility of random noise radar with conventional phase-comparison monopulse. [C2704]

## "Radar target identification subject to its polarization properties"

Considers questions for the development of radar target identification systems subject to polarization portraits. The authors analyze the correlation of polarization portrait parameters with target characteristics. The structure of the identification system is adaptive to low-informative parameters of the received signal. An analysis is made of the potential performances of target identification subject to the statistical properties of the received signal, adaptation circuit errors and limited observation period. [C2705]

## "3-D short pulse scattering by moderately rough dielectric interfaces via quasi-ray Gaussian beams"

In the context of ground penetrating radar illumination of moderately rough interfaces, we have recently developed a number of physics-based, computationally efficient, forward scattering models for both time-harmonic and pulsed excitations, using Gabor-based narrow-waisted Gaussian beam algorithms. These forward solvers, so far restricted to two-dimensional configurations, have subsequently been incorporated into adaptive subsurface sensing techniques aimed at detecting, localizing and classifying shallow-buried low-contrast targets. In this paper, we extend the 2D short-pulse physical-optics (PO)-based forward scattering model to the more challenging and realistic case of 3D (vector) configurations. [C2706]

## "Quasi-ray Gaussian beam algorithms for subsurface sensing in the presence of a moderately rough air-soil interface"

A major source of variability in ground penetrating radar (GPR) interrogating signals is related to reflection from, and (double) transmission through, the rough unknown air-soil interface which obscures the useful target-scattered signals. These considerations motivated our recent investigations toward a more robust, physics-based, adaptive approach to subsurface imaging in the presence of a moderately (both in height and slope) rough air-soil interface. The proposed approach entails prior estimation of the deterministic gross features of the rough interface and subsequent exploitation of this information to enhance underground target imaging. So far, this approach has been applied to two-dimensional (2D) frequency-stepped and pulsed GPR configurations, for slightly lossy soils and low-contrast mine-like targets, yielding encouraging results. In this paper, we briefly review the proposed framework and discuss some representative results. [C2707]

## "Detection of dielectric targets buried in a very lossy Earth"

In this paper, we propose an efficient method to reconstruct the dielectric objects buried in the lossy Earth using the Born approximation and the Born iterative method. For the detection of buried targets, the diffraction tomographic (DT) algorithm has been an efficient tool. It is fast and stable, and can be used for on-site detection. However, the exact DT algorithm is only valid in the lossless case. Although it was later generalized to the lossy case, the Earth conductivity still cannot be very high. Also, DT algorithms require high-frequency spectrum. Our study shows that DT algorithms provide high-resolution images if the upper frequency is larger than 50 MHz. When the upper frequency is smaller than 30 MHz, DT algorithms become invalid. In this paper, an efficient

inversion method is proposed using the least-square minimization and Tikhonov regularization technique, which is valid for the VETEM system. Based on the fast forward solver for buried dielectric objects we developed (Cui et al. 2002), the inversion algorithms are very fast. For a 8 Ч 8 Ч 8 pixelled reconstruction domain, only 10 seconds are required for the Born-approximation inversion, and 160 seconds for each Born iterative scheme. Reconstruction examples are given to test the efficiency of the inversion algorithm. [C2708]

## "Optimal detection and estimation in FMCW radar"

The paper is mainly concerned with detection of an accelerating target echo by FMCW radar. The processed signal is modeled as a polynomial phase signal, contaminated either by white or colored additive Gaussian noise. Obtained tests, optimal in the Neyman-Pearson sense, are linked with the maximum likelihood estimation procedures dealt with in earlier papers. An example shows the importance of properly suiting the test to the noise statistics. [C2709]

## "Radar target detection-identification by multifrequency and fluctuating portraits in multifrequency radiation radars"

The development of optimum statistical pattern recognition of a radar target by using fast digital processing procedures of regularly correlated portraits and Levinson's algorithm of matrix decomposition on the partial multiplicands are considered. [C2710]

## "Experimental investigations of digital signal processing techniques in an FMCW radar for naval application"

Recently we have observed increased interest in frequency modulated continuous wave (FMCW) radars, mainly because of their low probability of intercept (LPI) properties. In such radars the information on range of targets appears in the frequency domain and it is obtained on the basis of spectrum analysis carried out for a so called beat signal. The beat signal is a product of mixing the received signal with the transmitted signal in the receiver of homodyne configuration. In the paper we briefly describe the principle of operation and design of the FMCW radar. Special attention is paid to digital processing of the beat signal. A prototype of an FMCW radar for naval application was made in the Telecommunications Research Institute. The prototype was tested among other things for optimisation of digital signal processing in a real sea environment. The noncoherent processing comprises FFT, CFAR thresholding, binary integration and scan-to-scan correlation. The paper deals with an experimental study on how different algorithms influence signal detection. The method consists of estimating the detection performance under various conditions. We examine the detection performance in relation to, for example, the kind of smoothing window in FFT, length of FFT, length of CFAR window, and rule of integration. The results obtained are presented. [C2711]

## "The data fusion approach to the priority assignment in the multifunction radar"

The paper deals with the problem of the multifunction radar resources management (MFR RM). MFR RM consists of target ranking and tasks scheduling. The paper is focused on the data fusion approach to the target ranking. The data from the radar (object's velocity, range, altitude, direction etc.), IFF system (identification friend or foe) and ESM system (electronic support measures-information concerning a threat's electro magnetic activities) are used to decide of the importance assignment for each defected target. The problem is also known as a threat assessment. The main problem consists of the multiplicity of various types of the input information. The information from the radar is of the probabilistic or ambiguous imperfection type and the IFF information is of evidential type. To take advantage of these information sources an advanced data fusion system is necessary. The paper describes a comparison between the fuzzy and the neural network systems which were used in order to perform the threat assessment. [C2712]

## "An effective polarimetric detection of small-scale man-made radar objects on the sea surface"

The effectiveness of object detection by polarimetric radar is demonstrated. The experiments were focused on small-scale and man-made radar objects floating on the sea surface. The method of the polarization detection is described based on measurements of polarization invariant parameters of the radar object. The Neyman-Pearson criterion is used for the theoretical evaluation of small-scale polarimetric target detection. The results of experimental data processing confirm the high effectiveness of using radar objects polarization invariants for this detection problem. [C2713]

## "Foliage attenuation and ground reflectivity measurements in forest stands at millimeter-wave frequencies"

In this paper, outdoor experimental procedures as well as two-way foliage attenuation and ground reflectivity data acquired using a nadir-looking radar operating at 35-GHz are presented. The outdoor measurements were conducted at Aberdeen, Maryland, on two distinct forest stands, one being deciduous (Spesutie Island test site) and the other one mostly coniferous (Edgewood test site). The foliage parameters of these stands, including tree density, height, trunk diameter, location, foliage coverage, etc., were also characterized accurately. This type of data is the first of its kind and has not been reported before in the open literature. It was collected during a foliage-covered target detection experiment. [C2714]

## "Detection of UWB signals reflected from complex targets"

The questions of detection of radar-tracking signals are discussed, which parameters are unknown. The method for detection of radar signals which parameters are unknown is considered. The method is based on correlation processing of signals received in the adjacent periods of sounding-the interleaved periodic correlation processing (IPCP). [C2715]

## "Future of radars"

Military requirements and civil air traffic control have driven radar development. Many radar functions such as locating aircraft will be taken over by satellite based locating systems. We examine how increasing system bandwidth can provide many new capabilities for civil applications and recommend specific research objectives for future radar research. [C2716]

## "Fusion of multipath tracks for a network of over-the-horizon radars"

Over-the-horizon radar (OTHR) provides wide area surveillance coverage beyond the line-of-sight horizon by the propagation of HF signals via the ionosphere. Targets with a radial velocity relative to the radar site are detected by the Doppler component of the received radar signal. A network of OTHRs with overlapping coverage provides for the detection and tracking of targets irrespective of target velocity. When tracks are formed by each radar in the network, multi-radar track fusion is necessary to clarify the surveillance picture. In addition, multipath ionospheric propagation conditions may yield multiple tracks for each target and for each radar. In this paper, a multi-radar multipath track fusion algorithm (MRMPTF) is outlined, extending the single radar multipath track fusion (MPTF) algorithm previously developed. The impact of OTHR track registration errors is discussed, and the equivalence of alternative OTHR track fusion architectures is shown. [C2717]

## "Nonhomogeneity detection and the multistage Wiener filter"

This paper introduces the multistage Wiener filter for radar space-time adaptive processing, combined with the generalized inner-product as a preprocessor in nonhomogeneous environments. By using recorded data from the Multichannel Airborne Radar Measurement program, the performance of the multistage Wiener filter and sample matrix inversion are assessed both with and without the preprocessor. The constant false-alarm rate test statistic is computed for each range bin and the performance metric used in this analysis is the ratio of the target value to the root mean square value of the noise values. Both high and low sample-support environments are considered. The reduced-rank multistage Wiener filter is demonstrated to outperform full rank sample matrix inversion, even with the generalized inner-product preprocessor. Additionally, the multistage Wiener filter is shown to have its largest impact when used in conjunction with the preprocessor in the low sample-support environment. In this case, it nearly achieves the performance obtained by the full-rank and high sample-support case. [C2718]

## "SAR-MTI processing of multi-channel airborne radar measurement (MCARM) data"

This paper addresses the problem of developing signal processing, moving target detection, and image formation algorithms, for an airborne array radar system, called Multi-Channel Airborne Radar Measurement (MCARM), developed by the Air Force Research Laboratory at Rome, New York. Our approach is based on interpreting the MCARM data via a multichannel SAR system. SAR imaging and blind calibration of a dual along-track SAR-MTI system are then used for the MCARM data. [C2719]

## "Coordinated target assignment and intercept for unmanned air vehicles"

Presents an end-to-end solution to the battlefield scenario where M unmanned air vehicles are assigned to strike N known targets, in the presence of dynamic threats. The problem is decomposed into the subproblems of (1) cooperative target assignment, (2) coordinated UAV intercept, (3) path planning, and (4) feasible trajectory generation. The design technique is based on a hierarchical approach to coordinated control. Detailed simulation results are presented [C2720]

## "Far field RCS prediction by near field RCS measurement"

The near field system can not only be used for measuring the performance of antennas, it can also be used for RCS (radar cross section area) measurement except for multipath and range power decay. Time gating can reduce the problem of multipath between radar and target. The range correction table can compensate the problem of near field range power decay. Far field RCS can be generated by the transformation of measured near field data. In this paper the concept of transformation is applied for obtaining the far field RCS of the radar target from the near field measurement data. The processing technique is be used to generate the far field RCS pattern. The results of the far field RCS by this proposed technique is in quite good agreement with that obtained by direct far field measurement. [C2721]

## "Radar obstacle detection: finding moving targets in noisy range data"

Short-range ( 2-7 meter) integrated radar units in the 24 GHz (wavelength 1.2 cm) regime are now available as production prototypes, and are soon expected to be very inexpensively available to large commercial users (e.g., automobile manufacturers). We recently had an opportunity to examine the applicability of several pilot units as potential components in a "situational awareness" sensor suite for automobiles in urban traffic. The system goal is to detect, distinguish, and appropriately respond to nearby vehicles (cars, bicycles, etc.), life forms (pedestrians, dogs, etc.), and movable and fired features of the environment (trash cans, lamp posts, etc.). The question is whether the first generation radar prototypes, with all the warts typical of pioneering technologies, are nevertheless useful complements to an existing system that employs relatively mature sensor technologies, e.g., panoramic video analysis, stereo image analysis, laser rangefinding, ultrasonic range finding, integrated by an existing and reasonably well developed sensor fusion architecture. Our answer, based on a few experiments with three prototype units arranged in two geometries, is a definite maybe. [C2722]

## "Ultra wideband radar systems: advantages and disadvantages"

This review paper discusses the differences of ultra wideband (UWB) radars from conventional narrowband radars. The features are shown of generation, radiation and processing of UWB radar signals evoked by change of signal waveform in the process of location, by appearance of the mutual dependence between signal waveform and antenna directivity and others. The opportunity of reception of the target radioimage is shown. [C2723]

## "Radar tracking for a maneuvering target using neural fuzzy based Kalman filter"

A fast target maneuver detecting and highly accurate tracking technique using a neural fuzzy network based on Kalman filter is proposed in this paper. In the automatic target tracking system, there exists an important and difficult problem: how to detect the target maneuvers and fast response to avoid miss-tracking ? To solve this problem, neural network and fuzzy algorithms have been issued recently. However, the normal neural networks such as backpropagation networks usually produce the extra problems of low convergence speed and/or large network size, and the fuzzy algorithms are not easy to partition the parameters. To overcome these defects and to make use of neural learning ability, a developed standard Kalman filter with a self-constructing neural fuzzy inference network (KF-SONFIN) algorithm for target tracking is presented in this paper. Without having to change the structure of Kalman filter for modeling the maneuvering target, SONFIN algorithm, can always find itself an economic network size with a fast learning process. Simulation results show that the KF-SONFIN is superior to the traditional IE and VDF methods in estimation accuracy [C2724]

## "Tracking closely-spaced, possibly unresolved, Rayleigh targets: Idealized resolution"

In monopulse radar systems, the situation of merged measurements from closely-spaced targets results in angle-of-arrival (AOA) estimates that may be far from any of the actual targets. A monopulse processing technique for estimating the direction-of-arrivals (DOAs) for two unresolved targets from corrupted monopulse measurements was recently developed for a single angular coordinate. In this paper, that technique for DOA estimation for two Rayleigh target is extended to two angular coordinates. A procedure for incorporating possibly merged measurements into an optimal 2-D measurement-to-track assignment algorithm is developed for the case of idealized resolution (i.e., either targets are completely resolved or the measurements are fully merged). Simulation results of the new algorithm will be presented to show the improved data association performance. [C2725]

## "Performance of order statistic clutter map CFAR"

Cell average clutter map CFAR (CACM-CFAR) is analyzed at first. CACM-CFAR has better performance in the

inhomogeneous clutter environment, but is affected by interference and self-masking which will cause the low probability of detection. To solve these problems, a novel algorithm named order statistic clutter map CFAR (OSCM-CFAR) is proposed, in which the clutter map is updated by the k-th ranked cell in the clutter map cell. The performance analysis shows that the probability of detection for slow moving targets is increased by using the OSCM-CFAR algorithm. And the same case occurs in the multi-target environment when the new method is used. [C2726]

## "A preliminary research into the data fusion of double model homing head"

According to the characteristic of an air defense missile, the data fusion structure of an infrared/millimeter wave double-model homing head is analyzed. A double-layer fusion project, which includes characteristic fusion and strategic decision fusion, is used in detecting and tracking targets. The methods of characteristic fusion and strategic decision fusion are given. [C2727]

## "Detection and estimation of moving targets based on fractional Fourier transform"

The key part of classical MTD is the filter bank based on FFT. Generally, a moving target moves in the way of segment constant acceleration. Thus, its echo can be approximately regarded as a chirp signal, which is a typical nonstationary signal. The traditional Fourier transform cannot handle chirp signals. Therefore, time frequency analysis is a more appropriate method than FFT in such an application. Furthermore, WVD have the best time frequency centralization performance among all the time frequency distributions. Instead of FFT, we can employ WVD to analyze the echo of moving targets. WVD for multiple chirp signals, however, produces inevitably some cross terms, which lead to the appearance of false targets. A method of radar moving target detection and estimation based on the fractional Fourier transform is proposed in this paper. Compared with the MTD based on WVD, the MTD based on FRFT need not consider the cross-term interference in the case of multi moving targets, and therefore reduces the computation burden, simplifies the processing procedure and improves the performance of detection. The experiment results verify validity of the method. [C2728]

## "Phase coded continuous wave radar echoes analysis and recognition based on chaotic dynamics"

A detailed analysis is presented on the chaotic dynamics of moving target echoes produced by phase coded continuous wave (PCCW) radar. Based on real sampled data, the chaotic dynamics of different kinds of target are proved by three principal chaotic invariants, namely, correlation dimension, Lyapunov spectrum, and Kolmogorov entropy. The feasibility of target recognition based on these extracted features is discussed. [C2729]

## "Nonreciprocal retro-reflective array antenna"

Scattering properties of various bodies in a radar wavelength range are investigated now, basically, for cases when conditions of the theorem of reciprocity are satisfied. Display of nonreciprocal properties of scattering medium in nature conditions occurs rather seldom. In these conditions, creation of the artificial radar reflectors having strongly pronounced nonreciprocal properties, allows to solve a problem of detection of the target by polarizing attributes on a background of spreading surface. This article considers the analysis of polarizing properties of the nonreciprocal reflector made in the form of short-circuited horn antenna, with the ferrite core placed inside. [C2730]

## "Radar weak target detection and location based on Hough transform"

The Hough transform (HT) is analyzed and applied to radar weak target detection and location in this paper. The literature, in which only search radar is used, is extended to more general radar system. The theoretical analysis and experimental results used real-life radar data show that the presented method performs well in the strong clutter background, and robust to the clutter distribution. [C2731]

## "Target detection performance of PDI considering the change of the target distance"

In radar systems, PDI (post-detection integration) techniques are widely used to improve the target detection performance. In a conventional PDI, targets are assumed to be stationary, that is the distance between a radar platform and a target is almost constant. Conversely, if the target distance changes, the target detection performance of PDI deteriorates. To resolve the above problem, we have proposed shift PDI method. In this method, we conduct the PDI processing, based on the various assumptions of target velocity, which results in the increase of PFA (probability of false alarm rate). In this paper, we conduct the numerical formula to calculate the PFA for shift PDI procedure. Moreover, we estimate the target detection probability of the shift PDI with considering the increase of PFA in the shift PDI procedure. [C2732]

## "Electro-optic identification research program"

Electro-optic identification (EOID) sensors provide photographic quality images that can be used to identify mine-like contacts provide by long-range sensors, such as sonar systems. To help support the transition of these sensors to the fleet as well as to aid in the development of future EOID sensors, the Office of Naval Research (322-OP) has funded a five-year research program to investigate the performance properties of existing EOID sensors as a function of ocean environment. This paper describes the EOID research program and its objectives along with a brief discussion of supporting tasks such as validating existing electro-optic models, development of performance metrics, and development of computer aided identification and automatic target recognition algorithms. In addition, data from the recent field test are presented. [C2733]

## "Underwater target identification using GVF snake and zernike moments"

This paper is focused on the development of robust object segmentation and shape-dependent feature extraction methods for automatic water target classification and identification using electro-optical imagery data. The sensor used for acquiring the data is the Streak Tube Imaging Lidar (STIL) that offers both range and contrast images with high resolution. In this paper, the gradient vector flow (GVF) snake is employed to segment the detected objects. The snake converges to the actual object boundary and provides a closed contour of the object even when some of the edges are missing. To reduce the distortion as a result of missing edges, the union of the binary silhouettes for contrast and the range images is obtained. Zernike moments are then computed for the combined silhouette of the segmented object. These moments provide shape-dependent features with high discriminatory ability, which are invariant to object rotation, translation and size scaling in the image. This set of features is then used for target identification from the STIL imagery data. To aid discrimination of different objects with potentially similar shape dependent features, mean and variance of the contrast and range images are also computed within the closed contour and then used as additional features for classification. Then the extracted features are applied to a multi-layer back-propagation neural network (BPNN) that performs target classification/identification. Different neural network structures are tried to determine the optimum classifier. The effectiveness of the developed algorithms is demonstrated on several data sets and the corresponding confusion matrices are also developed. [C2734]

## "A detection adaptive filtering algorithm with interacting multiple model for multisensor tracking"

A maneuvering target tracking algorithm for a multisensor system using an image sensor and other different sensors is presented; it combines a variable dimension filter (VDF) with an interacting multiple model (IMM). This technique uses an IMM estimator instead of the single model filter used in VDF when the maneuver detector declares an onset of maneuver. The performances of this approach, and of the VDF and IMM algorithms are investigated and compared. During a nonmaneuvering period, this approach is better than the IMM algorithm and equal to the VDF algorithm. During a maneuvering period, especially right after the end of a maneuver, this approach provides better estimations than the VDF algorithm. [C2735]

## "Adaptive radar detection of extended targets via signature diversity"

The paper addresses adaptive detection of extended targets in Gaussian noise with unknown statistics. It is assumed that the radar can change the transmitted signal in azimuth. More precisely, it makes use of N N-dimensional signatures; the possible useful signal from each radar cell is a coherent pulse train while the disturbance is a Gaussian process, independent from cell to cell, but with the same (unknown) covariance matrix regardless of the illuminated one. Based on the above model, we propose an adaptive detector designed according to a two-step procedure. Its performance assessment and the comparison with a previously-proposed detector show that the proposed one can be a viable means to cope with uncertain scenarios. [C2736]

## "Conference Record of the Thirty-Sixth Conference on Signals, Systems and Computers (Cat. No.02CH37387)"

First Page of the Article [C2737]

## "A system for detection, identification and tracking of a dense cluster of targets based on matched illumination and function filters"

We discuss a system based on a set of "function filters" which makes it possible to divide the target cluster into smaller groups so as to ease the tracking task. The concept of function filters is illustrated. [C2738]

## "Adaptive spatial filtering with data-dependent training for improved radar signal detection and

## localisation in structured interference"

Adaptive spatial filtering is applied in modern surveillance radar systems to improve the detection and localisation of desired signals embedded in severe and dynamic interference from clutter as well as jamming. In practical situations of interest, the interference can only be cancelled to sufficiently low levels by significantly compromising the sidelobe response of the adapted pattern. Attempts to effectively stabilise the sidelobes, by means of diagonal loading or rank-reduction for example, gives rise to suboptimal patterns which potentially lead to intolerable degradations in interference suppression. On the other hand, the application of an adaptive pattern with unregularised sidelobes to a test cell containing a signal that is not incident from the system steer direction may cause an unwanted detection or false alarm. This paper proposes a data-dependent training strategy for adaptive spatial filters which provide enhanced interference rejection with a reduced likelihood of false alarms while simultaneously avoiding target self-ing when the beam is pointed in the signal direction. [C2739]

## "Ultra wide band synthetic aperture radar for the detection of mined areas"

This article begins with a presentation of the concept of the ultra wide band (UWB) low frequency short pulse radar, its potential applications, advantages and limitations. To illustrate this, the article describes the work undertaken by the Centre Electronique de l'Armement (Defence Electronics Centre-CELAR) on the experimental UWB PULSAR radar for the detection of targets masked by vegetation and the measurement of clutter at low frequencies. Results of detection of mined areas are presented. [C2740]

## "Comparison of Doppler clutter cancellation techniques for naval multi-function radars"

We describe a comparison of fixed and adaptive clutter cancellation processes applied to measured multi-function radar (MFR) data in a littoral environment. The adaptive filters require estimates of the clutter covariance and comparisons of different strategies for obtaining this are made. The results for the adaptive filters generally show substantially improved target detection over the non-adaptive filters. [C2741]

## "A comparison of radar sea clutter models"

Radar performance prediction has always been an important part of the design and development of radar systems. Performance prediction offers a way of extending limited trials results obtained for the environmental conditions on the day to the full envelope of desired operation. The analysis of radar performance in free space is well documented and understood but the modelling of the radar target in a clutter environment is still an area of active research. This paper concentrates on airborne maritime radar. The key to obtaining realistic predictions of the probability of detecting a target on the sea surface is governed by the spatial and temporal statistics and correlation properties of the sea clutter. Radar detection is governed by the combination of the mean radar cross-section of the clutter and the temporal fluctuations of the pulse-by-pulse radar returns about the mean. Here, two models for the mean radar cross-section of the clutter are compared. [C2742]

## "Analysis of spectrum variability in sea clutter"

Naval radar systems commonly employ Doppler processing to separate targets from clutter. A widely used system is the moving target detector or MTD system (Skolnik 1981) which performs a frequency analysis of a sequence of returns in each range gate. A threshold is then determined by some form of constant false alarm rate (CFAR) algorithm for the contents of each Doppler channel based on the returns in neighbouring range gates. It is normally assumed that the clutter spectrum is the same in each range gate; however, if this is not the case, it will clearly affect the threshold-setting process. It has been shown previously by Miller (2000) that there may be considerable variation in spectra for sea clutter observed at low grazing angles. In the above paper, an initial attempt was made to model this variability. The current paper applies this model to data collected by QinetiQ, Portsdown West and discusses enhancements to the original model. [C2743]

## "Study on mechanism of dynamic programming algorithm for dim target"

An important problem in the field of radar signal processing, and a sequence of infrared images detection which arouses people's attention widely is the detection and tracking of dim moving targets in very low signal-to-noise ratio (SNR) or signal-to-clutter ratio environment. Track-before-detect (TBD) is especially useful for detecting and tracking moving targets in the condition of low SNR. In fact, dynamic programming is a problem of multi-stage decisions, and the dynamic programming algorithm (DPA) is an effective approach, which was adopted during the process of TBD. In the current work, the mechanism of the dynamic programming algorithm is analyzed, and a number of technical innovations that improve the performance of DPA are presented. Simulation results show this approach has high ability of detection for dim moving targets, and achieve 3  5 dB SNR gains comparable to those from other detection algorithms. [C2744]

## "Passive coherent detection via exploiting illuminator of opportunity"

An experimental passive coherent target detecting system via exploiting illuminator of opportunity (also can be considered as external illuminator, such as broadcast, television etc.) is constructed, based on this experimental system, the principle of coherent receiving is analyzed and its power coverage is estimated, also, an applicable signal processing scheme is described. With the help of real data collection and processing, researches on the influence of direct signal rejection, channel properties and multi-path clutter rejection on the performance in passive coherent detection are investigated, results show the effectiveness of such system can be implemented by employing elaborated system allocation and advanced signal processing. [C2745]

## "On motion compensation for weak radar reflected signal detection"

Detection of a weak radar reflected signal is to enhance the target echo against background noise or clutter using a long-term integration technique. During the integration duration, the target echo may migrate from one cell to another across the radar's resolution cells, e.g., range cell migration and Doppler cell migration; thus motion compensation must be considered to achieve better detection performance. If the radar can work in a long dwelling mode of the antenna pattern or have a slowly scanned antenna pattern, a new framework for detecting radar returned signals can be proposed. The method presented employs motion compensation based on range stretching and joint time frequency processing in the case of both range and Doppler cell migration. A practical realization of such a detector is suggested and performance analysis is given. Demonstrations on a real data set confirm its effectiveness. [C2746]

## "Object detection for surface landmine with mobile robot"

Most landmine detection problems using mobile robots have been solved as a standard navigation and target identification problem implemented for the application of landmine detection. This paper solves the problem of landmine detection using low cost mobile robot from a direct perspective. Locating the object is solved using a grid based map and exhaustive search strategy that is effective in terms of accuracy. The advantage of this method is that the data reduction and analysis is done in real time. [C2747]

## "Dim point target detection"

Presents a method to incorporate jitter information to a precise position score function that allow us to detect very slow moving targets. For analyzing the TBD algorithm output data, we suggest building a filter that would match the target signature and test similarity between it and suspected high local maximas. Running that algorithm, we achieved detections within 90% of higher similarity scores for SNRs>2. These results are very promising and we now intend to examine the described algorithms for more difficult scenarios and conditions. [C2748]

## "Modern synthetic aperture radar systems"

Synthetic Aperture Radar (SAR) is a side looking airborne radar sensor that provides high-resolution microwave images of selected ground areas. It is an all weather day and night sensor. Additional features include stand-off capabilities (long range) and fast coverage rate. Stationary ground targets are clearly visible upon a SAR image and can also automatically be detected. SAR sensors are used for reconnaissance and remote sensing applications. In this article a new generation of advanced SAR systems is presented. It features high performance reconnaissance and Zooming SAR modes as well as dedicated modes for display overlay of moving targets upon SAR images. It processes the radar raw data on-board and transmits SAR images via data-link. That on board processing capability greatly reduces the data link bandwidth. Those advanced systems operate upon fighter and transport aircrafts and upon unmanned vehicles ( RPV's). A derivative of SAR for airborne fire control radars and for airborne maritime patrol applications is also presented. [C2749]

## "GRASP: an object-oriented approach to sonar performance modeling and tactical ASW search planning"

The Genetic Range-dependent Algorithm for Search Planning (GRASP), developed by the Naval Research Laboratory, is a software tool developed to objectively determine near-optimal tactics for the detection of submerged and moving targets from a moving sonar sensor. Early prototypes of GRASP were developed to exploit high-resolution acoustic modeling of inhomogeneous environments, in order to predict sonar system performance. At its core, GRASP uses the Genetic Algorithm (GA) to determine the optimal search tactic (e.g. tracks, depths, modes, etc.) for a sensor that maximizes a user-selected measure-of-effectiveness against a hypothesized threat distribution. This paper describes the integration of GRASP, with the Mission Planning

System (MPS), developed by the Naval Surface Warfare Center. MPS is a development tactical decision aid and for the purpose of this discussion provides a graphical user interface through which GRASP's capabilities may be accessed. This amalgamation, called the ASW Mission Planning Tool (AMPT) is a Web-centric, client/server system, designed to address an entirely new set of requirements. The result is a fully integrated, completely automated, flexible, reconfigurable, deployable, and scalable system that seamlessly performs oceanographic database extraction, sonar performance modeling, and optimal ASW search planning. [C2750]

## "FDTD analysis of plane wave scattering by slots on conducting targets loaded with anisotropic material"

This paper presented the finite-difference time domain (FDTD) algorithms of anisotropic material. Using this algorithm, the RCS of conducting targets slotted with different anisotropic material can be calculated. The characteristics of the electromagnetic scattering from negative and positive uniaxial material filled in the slot of the target were calculated and shown in this paper. [C2751]

## "An improved algorithm for the detection of vehicle group targets in high-resolution SAR images"

In this paper, the detection of vehicle group targets in high-resolution SAR images has been investigated. Theoretical analysis has been carried out by statistical methods and the formulas of threshold and parameter estimations of three detection algorithms are obtained. The results show that global parameter estimation is of good effect and there are more false alarms in conventional two-parameter CFAR and single look standard CFAR detection algorithms. We present an improved multi-look de-speckling CFAR detection algorithm, which shows exact target detection, little false alarm and clear target details. The parameter selection and optimal parameters are also given. [C2752]

## "The method of range profile for step frequency MMW radar based on wavelet transform power spectrum estimator"

The range profile method for step frequency MMW radar targets based on a wavelet transform power spectrum estimator is studied. This method can successfully measure the power spectrum in samples for which traditional methods often fail because the samples are finite sized, have a complex geometry, or are varyingly sampled. We apply this method to the practical step frequency MMW radar target echo signals, and on the condition of the same sampling frequency and sampling data length, it can achieve a one dimensional range profile with profile resolution superior to FFT. Compared with the FFT algorithm using a wavelet spectrum estimator of short data series, we can achieve high resolution, high accuracy, and low SNR threshold. The experimental results make clear that the DWT estimator is a sensitive tool in range profile of step frequency NMW radar. [C2753]

## "Doppler compensation for JDL for airborne bistatic radar"

In airborne bistatic radar the clutter Doppler is range dependent. STAP processor using training data from other range gate will experience widening of clutter notch. Widening of the clutter notch causes a major problem in detecting slow moving target. In this paper, Doppler compensation using interpolation in the angle-Doppler domain, for joint domain localised processor (JDL) is proposed. Comparison is made with Doppler compensated processor proposed by Kreyenkamp and Klemm (see IEE Proceedings: Radar, Sonar and Navigation, vol.148, no.5, p.253-58, 2001). Significant improvement in processor performance is observed across the whole frequency spectrum. [C2754]

## "Fade: a vehicle detection and tracking system featuring monocular color vision and radar data fusion"

This paper presents Fade, a vehicle detection and tracking system featuring monocular color vision and radar data fusion. Its main originality resides in its low-level fusion system. At each step and for each target, the fusion system fuses the results of four different image processing algorithms and radar information by automatically combining 12 different features and generating many possible target position proposals. It generates a belief network organized in three layers: sources, position proposals, and correlation between proposals. An inference algorithm is then used to find out the actual position of the target, by deducing which observations are wrong. The overall system runs in real time and has been evaluated on a variety of scenarios recorded in a real car using RTMaps. Fade yields very good detection results in most cases. [C2755]

## "Vision-based vehicle detection and tracking method for forward collision warning in automobiles"

We describe a vision-based vehicle detection and tracking method for forward collision warning in automobiles. The approach is based on a set of edge-based constraint filters that assist in the segmentation of vehicles from

background clutter. The detected vehicles are then tracked using a combination of distance based matching, sum-of-square-of-difference in intensity (SSD) and edge density of detected vehicle regions. The computational load for tracking is minimized using a vehicle-clustering algorithm. Experimental results are presented to illustrate the performance of the algorithm. [C2756]

## "Sensor fusion for target detection and tracking"

Multipath can be a significant contributor to poor detection performance in radar ground moving target tracking systems. Recently, ground multisensor networks have been used to detect and track targets. Unfortunately, such networks can only be deployed in a limited area compared with the coverage possible using a radar. We show how, in those areas where multipath contributes to detection errors, the ground sensor network performance can be improved. Using integrated radar and ground sensor networks significantly improves the performance of radar target detection in a multipath environment. Such improvement in performance has implications for using more varied type of sensors to support the radar with statistics that complement the radar's receiver operating characteristic. [C2757]

## "Using optical imagery to enhance radar tracking performance"

A difficult problem with ground moving target indicator (GMTI) radar detection is how consistently to track targets moving through non-homogeneous regions of clutter such as forest and urban boundaries. Although attempts have been made to mitigate this detection problem using terrain mapping data, such data does not give current clutter information due to changes in vegetation, roads, buildings, and seasonal variations. We propose to use electro-optical imagery to enhance the detection performance of GMTI radar We use a multiresolution Markov model to represent both target and background clutter. This multiresolution structure allows us to match GMTI clutter accurately with the geographically registered electro-optical imagery for consistent moving target detection through clutter boundary areas. [C2758]

## "Histograms method: a new concept of DOA finding"

In telecommunication, radar, and underwater acoustic fields, a wide range of emerging applications encounter non-Gaussian signals. A novel method of target detection and direction finding, based upon source histogram analysis, is therefore proposed. It provides an increased number of localized sources for phased arrays with a limited number of antennas. Working on the geometrical properties of the joint probability density functions of the sources, it requires a low cost implementation, and is available for both linear and 2D arrays. First results obtained on synthetic signals are presented; they validate the theoretical results in terms of detection/counting. [C2759]

## "Multiple moving targets indication"

The use of moving target indication (MTI) and moving target detection (MTD) is an important aspect in radar detection systems. Delay cancelers is a class of such detection systems which is part of a radar receiver sub-system. Various delay canceler configurations and frequency responses were explored using Matlab. Simulations were performed in Matlab and verified with the experimental results using Signal Processing Workbench (SPW) before the final implementation of the MTI/MTD processing. Various optimization techniques were explored in an effort to reduce the processing time. [C2760]

## "Adaptive ground clutter cancellation of slowly moving targets with the multi-channel airborne SAR"

The detection of slowly moving targets and the estimation of their position and velocity are difficult problems for conventional airborne SAR systems with a single antenna, due to the spread of the clutter Doppler spectrum caused by the platform motion and the ambiguity between the cross motion and azimuth position. These problems can be solved via the use of multi-channel SAR and the space-time adaptive processing technique (STAP). In this paper, the clutter model and moving targets model suitable for airborne multi-channel SAR are presented and an efficient algorithm is proposed. Simulation results are illustrated, applying data produced by the proposed clutter model and moving targets model. [C2761]

## "Higher-order cumulants based maneuver detection in Kalman filter"

Maneuver detection is a key issue in multiple-model target tracking applications. In the Kalman filter, the conventional maneuver detection algorithm fails when the maneuver is almost buried in noise. The multiresolution approach behaves well for maneuver detection, but the time delay limits its application. We suggest a new algorithm for maneuver detection based on the third-order cumulant of the measurements. As cumulants are blind to Gaussian noise, the maneuver is easy to detect in the cumulant domain. Using sliding

window processing, the maneuver detection algorithm is real-time without any time delay. Simulation results demonstrate the effectiveness of the algorithm over the conventional one, especially at low SNR. [C2762]

## "Bottom mounted active sonar for detection, localization, and tracking"

A bottom-mounted, wideband active sonar system designed to detect unfriendly vessels entering a closed area is described. We present signal processing algorithms for target detection, classification, localization, and tracking, and present performance predictions based on simulations. These algorithms are shown to be effective with state of the art, realizable sonar systems. The signals are binary phase shift keyed (BPSK) with a range resolution of approximately 0.01 m and Doppler resolution of 0.5m/s. Received signals from multiple directional receive beams are basebanded and Hilbert transformed to obtain complex representation. These signals are correlated with replicas of the transmitted signal time compressed or dilated to represent a number of different hypothetical target Dopplers, giving a processed signal with three dimensions: time, channel, and target Doppler. Background interference is estimated using a block-transversal filter. The processed signal is divided by the estimated background to obtain signal-to-interference ratio (SIR) and SIR threshold crossings are detected and contiguous detections are clustered. Range is estimated using arrival time. Bearing is estimated using amplitude comparison for adjacent receive beams. Elevation is estimated using split beam phase between signals from elements separated vertically. Finally, the crossings are clustered by location and Doppler. Clusters are classified based on amplitude and estimated physical extent and shape. Clusters with sufficiently high classification are passed to a tracking algorithm that computes a Kalman filter track using clusters derived from sequential transmissions. This filter operates using linked line of sight (LOS) coordinates, a technique long used in radar. The LOS coordinates used in this application are range, range rate, bearing, and elevation. Use of such coordinates is advantageous in this application because the errors in the coordinates are nearly independent of one another. Performance of this algorithm was investigated using active acoustic signals synthesized by the Sonar Simulation Toolset (SST), a digital program written by Robert Goddard at the Applied Physics Laboratory. This program generates a complex baseband representation of the acoustic signal in each chan- nel. This signal is processed by the detection, classification, and tracking algorithms. SST simulates effects of acoustic propagation including refraction and scattering and reflection from a target. Several simulated encounters with different target geometries are presented to illustrate detection, localization, and tracking performance. [C2763]

## "Improvement of high frequency ocean surveillance radar using subspace methods based on sea clutter suppression"

We present a new direction finding scheme for slow targets embedded in sea clutter that combines subspace methods (MUSIC and Root-MUSIC) and time domain sea clutter and noise suppression. The ocean surface behaves as a distributed source in contrast to ships that are point sources. By mapping data to eigenspaces, the sea clutter level decreases due to its non-deterministic behavior while point targets' levels remain unchanged while enhancing estimation performance. Since subspace methods have a higher threshold and are degraded heavily by the correlated sea clutter, clutter and noise suppression is introduced to enhance algorithm performance. Both simulated and real ship targets are used to show the lower threshold and higher estimation performance of the proposed algorithm. [C2764]

## "Joint optimal Tx-Rx design for multiple target identification problem"

A design methodology for jointly optimizing the transmit waveform and receiver filter for multiple target identification is presented. The methodology is applied and illustrated for various multi- 'target' ID problems. The resulting probability of correct classification is significantly better than that achieved by a conventional chirp or any other waveform. Unlike the classical radar case, the choice of transmit pulse shape can be critically important for the identification of extended targets in presence of additive channel noise. [C2765]

## "Environmental effects on MCM tactics planning"

A successful anti-submarine warfare search planning tool, the Genetic Range-dependent Algorithm for Search Planning (GRASP), is adapted and evaluated for the purpose of planning near-optimal reconnaissance plans for the mine counter-measures community. High-fidelity range- and azimuth-dependent sonar performance predictions over a high-resolution grid are ingested by a genetic algorithm, which uses Monte Carlo simulation and Bayesian detection statistics, to evaluate and refine proposed search paths against a given target distribution. In essence, GRASP simulates a Darwinian evolution of reconnaissance paths to obtain the statistically best path based on Cumulative Detection Probability (CDP). In previous proof-of-concept work, GRASP provided a ladder-like solution in an environment where such solution was expected by search theory. Further, as the environment was perturbed slightly (just outside the bounds for which search theory can determine the optimal path), GRASP produced a path that was a variant on, and an improvement over, the

intuitively expected path. In the present work, the efficiencies of acoustically blind and acoustically sensitive mine clearance strategies are compared in a real environment. The GRASP results reveal improvement in search coverage obtained by exploiting the environment with respect to sonar performance. [C2766]

## "Multiping detection performance against bottom mines"

Sonar performance predictions often ignore the aspect dependence of target strength and echo return signal structure. In many cases, a single value is used to represent the target strength of a particular target or target type, or at best, a random fluctuation is attributed to the received target echo level on successive pings. Inclusion of the actual target aspect dependence is a straightforward procedure for a single ping sonar-mine encounter, given measured target strength over sufficient aspect angles. Estimation of multiping detector performance is somewhat more complicated when multiple looks at the target echo level and/or signal structure are available. This paper describes a procedure that uses measured target strength data to generate Receiver Operating Characteristics (ROC) curves describing expected sonar performance over a specified number of pings and arbitrary aspect angle sector width. [C2767]

## "Theory of search for moving objects"

The objectives of the paper are a development of a system of rules called "theory of search for moving objects", and a development of a new class of search problems for moving objects within the frames of this system, rather than a selection, classification or enumeration of all published articles, manuals, monographs, tasks statements and other in the theory of search area. The following issues are considered in the paper: (1) analysis and classification of search problems; (2) an axiomatic basis of the research approach; (3) axioms of the theory of search; (4) common theorem of additivity; (5) theorems of multiplicity; and (6) computer prototype for the theory of search. The case of a complex observation system integrated within one carrier is a core of the proposed approach. A case of two different observation systems is considered, when an observation zone for the second system (contact detector like a laser) is approximated as a line or a rectangle. It is possible to determine a probability area of target localization when one or both observation systems detected the target (theorem of multiplicity). A computer prototype of the theory of search for moving objects has been designed based on the object-oriented approach. It appeared to be a useful tool for any theoretical research and a flexible media for the further development of the theory of search for moving objects. It is also shown that it can be implemented for an adequate computer interpretation of search problems. [C2768]

## "A comparison of two non-homogeneity detection methods for space-time adaptive processing"

The paper undertakes a comparison of two non-homogeneity detection (NHD) methods and addresses their impact on the performance of the adaptive matched filter (AMF) method and the normalized adaptive matched filter (NAME) method in severely non-homogeneous clutter scenarios. Performance analysis is carried out using simulated data as well as measured data from the US Air Force Research Laboratory's MCARM (multi-channel airborne radar measurement) program. Specific consideration is given to the computational cost of the NHD method and the sample support requirements. The paper presents a technique for speeding up the computations in the NHD. Performance is reported in terms of the probability of detection versus signal-to-noise ratio (SNR) for simulated data analyses. [C2769]

## "Joint estimation of target number and DOA using reversible jump MCMC in sea clutter"

We address the problem of detection of a small target in high frequency ocean surveillance radar using the method of reversible jump Monte Carlo Markov chain. The number and the directions of arrival of targets are estimated simultaneously. However, the existence of sea clutter makes the traditional RJMCMC inefficient, and an adaptive preprocessing is preferred in combination with the original RJMCMC to achieve better detection. The performance of the proposed method is analyzed through several experiments with real data. [C2770]

## "Small ship detection with high frequency radar using an adaptive ocean clutter pre-whitened subspace method"

We propose a novel scheme for using high frequency ocean surveillance radar (HFOSR) to detect slow weak target echoes embedded in temporally correlated sea clutter having a continuous spectrum. General Doppler processing CFAR detection of ships in ocean surveillance radar is usually inhibited by the continuous high order sea clutter. Conventional subspace methods can be utilized to enhance the detection, but they deteriorate dramatically in the presence of correlated sea clutter. In our paper an adaptive sea clutter filtering is introduced which improves the threshold and accuracy of the subspace detection method. Both simulated and real ship targets are used to verify the effectiveness of our proposed method. [C2771]

## "Extraction of multiple-bounce echoes in SAR image formation"

This analysis develops an innovative SAR image formation algorithm that separates direct-scatter echoes in an image from echoes that are the result of multiple bounces, and then maps each set of reflections to a metrically correct image space. Current processing schemes place the multiple-bounce (MB) echoes at incorrect (i.e., ghost) locations due to fundamental assumptions implicit in conventional processing. Two desired results are achieved by use of this new Image Reconstruction Algorithm for Multi-bounce Scattering (IRAMS). First, ghost returns are eliminated from the primary image space, thereby improving the relationship between the image pattern and the physical distribution of the scatterers. Second, a set of auxiliary "delay" image planes containing only MB echoes is created which possesses characteristic information about the scene being imaged. These auxiliary image planes offer the potential of improving target detection and identification capabilities. [C2772]

## "Non-homogeneity detector for Gaussian and non-Gaussian interference scenarios"

This paper presents a statistical analysis of two schemes for intelligent STAP training data selection in Gaussian and non-Gaussian interference backgrounds. Performance analysis of the two methods is carried out using simulated as well as measured radar data. [C2773]

## "Secondary data partitioning via maximum likelihood estimation: extensions"

Adaptive beamforming based on sample matrix inversion requires the availability of a secondary data set for "training" (i.e., estimating the sample covariance matrix). For each snapshot processed, near-optimal detection performance can be achieved as long as the training data is independent, identically distributed, and free of target-like signals. Oftentimes, however, the available set of secondary data is contaminated by an unknown heterogeneous mixture of clutter, jamming, electromagnetic interference, and strong targets. Previously, the author and his colleagues applied maximum likelihood estimation (MLE) to pre-screen the available secondary data, identifying subsets having similar clutter and jamming statistics, and using these subsets for adaptive beamformer training. This paper extends the basic MLE approach to cases where the secondary data may contain electromagnetic interference and/or strong targets. [C2774]

## "The stability of polarimetric features for target classification from SAR imagery"

This study investigates the information content of polarimetric SAR imagery for use within automatic target detection and classification algorithms. Key questions such as the stability of polarimetric information and its relationship with image resolution are addressed. Using relatively simple polarimetric features, such as the percentage of pure odd and even bounce scattering events, we show how it is possible to identify the differences between two classes of military vehicle. The use of the radial power spectral density is proposed as a measure of the spatial distribution of these odd and even bounce scattering events, again enabling the two classes to be distinguished. [C2775]

## "Bistatic synthetic aperture radar"

Synthetic aperture radar (SAR) is becoming increasingly important in many military ground surveillance and targeting roles because of its ability to operate in all weather, day and night, and to detect, classify and geolocate objects at long stand-off ranges. Bistatic SAR, where the transmitter and receiver are on separate platforms, is seen as a potential means of countering vulnerability. This paper provides an overview of QinetiQ's on-going research into the processing techniques for bistatic SAR, the fundamental problems it introduces, and ways to overcome them. [C2776]

## "Real time detection and compensation of registration errors in a network of radars"

This paper describes an algorithm designed to automatically compensate for the angular and positional misalignment of the members of a network of radars using nothing more than the operational data. The method is based upon the simple observation that within any given observation period a significant number of the target aircraft will take flight paths along lines of constant bearing. By using such sets of straight line motion, observed commonly by a pair of radars, it is possible to arrive at an estimate of the relative azimuthal bias between the two. By conducting this estimation for each radar in the network with reference to one nominated member, all the relative azimuthal offsets can then be computed. Once the rotational biases have been resolved it is then feasible to calculate any x, y offset in the actual position of the radars relative to their published coordinates using the same data. [C2777]

## "Radar 2002 (IEE Conf. Publ. No.490)"

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## "Qualitative and quantitative characteristics of deghosting in advanced radar systems"

Deghosting, i.e. elimination of false targets during data processing in multi-sensor tracking of jamming targets, is a crucial process for effective use of air defence systems. It is particularly important for radar systems operating in passive mode because of their excellent properties against present-day electronic warfare techniques and tactics (especially jamming equipment and anti-radiation missiles). A deghosting algorithm based on bearing association/compounding strategy is outlined. A method of deghosting effectiveness evaluation using the ghost eliminator operating characteristic (reference to the receiver operating characteristic from statistical theory of signal detection) is presented. Such an approach enables to compare performances of various deghosting procedures in different operational conditions or scenarios. [C2779]

## "Target ranging and identification using timing modulation of a mode-locked laser"

The U.S. Air Force has an ongoing interest in improved techniques for ranging and high-resolution depth profiling of ground and air targets. We have investigated the feasibility of a target ID system based on a mode-locked laser and a high-speed detection system. Mode-locked lasers easily produce multi-Watt output with pulsewidths in the tens of ps for excellent resolution, and repetition rates in the tens of MHz allowing signal averaging over multiple pulse trains to improve sensitivity. While peak powers may be high, average powers are well below the damage thresholds of typical optics. One drawback inherent in this approach is aliasing caused by the high repetition rate. This is easily remedied by modulation of the laser output with a pseudo-random pattern. [C2780]

## "Tradeoffs in radar networking"

The networked radar air picture is built using input from radars in many different locations. In an ideal world, each radar can track every target continuously. However, the laws of physics do not permit this. Target fades, terrain blockage, and spurious signals all conspire to make the situation not ideal. As a result, in general, no one radar is able to create a complete surveillance picture-hence the need for networking. Various alternatives have been considered for radar networking. This paper attempts to organize and categorize the alternatives and quantify the differences between them. Three fundamental radar networking characteristics are considered: the data distribution process (robustness and capacity), data grouping approach (measurement-to-track and track-to-track), and data-sharing approach used. [C2781]

## "Surface modelling using 2D FFENN"

This paper is concerned with the development of a two-dimensional feed-forward functionally expanded neural network (2D FFENN) surface modeller. New nonlinear surface basis functions are proposed for the network's functional expansion. A network optimization technique based on an iterative function selection strategy is also described. Comparative simulation results for surface mappings generated by the 2D FFENN, multi-layered perceptron (MLP) and radial basis function (RBF) architectures are presented. The main purpose of this work is the development of a two-dimensional system, able to produce surface data mappings. The main application area of interest for the proposed system is sea surface modelling and target detection by sea clutter suppression. [C2782]

## "Simulation modelling and research of TBM trajectory detection"

Detection of TBM (tactical ballistic missile) type targets by typical long-range search radars is very difficult and is sometimes impossible to carry out. It results from the fact that such radars are usually projected and constructed in order to detect targets of fighter class. Difficulties concerning TBM detections result from their higher than a fighter radial speed and their lower than a fighter radar cross section (RCS) value that fluctuations are very complicated. Signal processing algorithms relating radar echoes from TBMs in a radar with stacked beams for receiving are described in the paper. Moreover a simulation model of such echoes is considered here too. The presented research results should be treated as introductory. Among others they give information about their future optimisation possibilities. [C2783]

## "Ship detection and tracking using HF surface wave radar"

The Canadian Department of National Defence (DND) conducted a joint trial involving multiple sensors in the detection and tracking of ships in the Grand Banks of Canada in March 2000, including the HF surface wave radar (HFSWR) system at Cape Race, Newfoundland. One objective of the trial was to evaluate the detection and tracking capabilities of the HFSWR system. Three co-operative ships were used: a Canadian Navy patrol

frigate named Ville de Quebec and two small fishing vessels named Anne S. Pierce and Arctic Pride. We present some results of the detection and tracking of these co-operative ships using the HFSWR. The radar had difficulties tracking ships near Bragg lines, i.e., the first-order sea echoes of the radar. A revised algorithm is also presented to detect ships near Bragg lines. [C2784]

## "Forward scatter radar detection"

The forward scatter signature of a target provides the radar systems designer with an alternative approach to the detection of 'very low radar cross section (RCS)' targets. This paper outlines the rationale for a forward scatter radar system, the forward scatter principle, and the architecture of a forward scatter radar systems performance model. This model has been developed to analyse the effect of variations in the choice of operating frequency, transmitter and receiver characteristics, detection and tracking algorithms. The paper discusses these aspects with results from modelling and performance predictions for target forward scatter signature, transmit and receive antenna designs, analogue to digital converter (ADC) performance and coverage for a forward scatter radar system operating in the ultra high frequency (UHF) band. [C2785]

## "Some aspects of design and environmental management in HF surface wave radar"

With the current emphasis on the surveillance of coastal waters, particularly for economic exclusion zone (EEZ) applications, there has been an increased interest in the capability of HF surface wave radar (HFSWR) to detect targets beyond the conventional radar horizon. The surface wave mode is generated where a vertically polarised high frequency electromagnetic wave is launched over a saline water surface; this then behaves in a manner such that there is significant propagation of the field around the curvature of the Earth. As this propagation mode relies on the surface currents in the conducting media of the sea, the resulting additional propagation loss has a dependence on the water salinity, surface roughness and frequency. A comparison of two-way HFSW loss with frequency over a smooth surface is shown. As the operating frequency increases, the additional propagation losses increase; however many other system constraints ease as the wavelength grows smaller (e.g. antenna size and target Doppler shift). This paper highlighted and provided some analysis for the frequency management and impulse suppression techniques that should be implemented in an effective HFSWR. [C2786]

## "Aspects of measurement scheduling for tracking"

Many target tracking subsystems have the ability to schedule their own data rates: essentially they can "order" new information whenever they need it, and the cost is in terms of the sensor resource. Uniform sampling, in which a new measurement is requested periodically and regularly, is the most commonly-used sampling scheme. Nonuniform schemes are seldom studied: it is "common knowledge" that they exhibit inferior performance and are too bizarre to consider seriously. In this paper, however, we show that such schemes may have been discarded prematurely: a nonuniform sampling can have its benefits. Specifically, the nonuniform and uniform sampling schemes are compared for two kind of trackers: the PDAF (probabilistic data association filter), which updates its track based on a single scan of information at a time: and N-D assignment (an optimization-based implementation of the MHT (multi-hypothesis tracker)), in which the sliding window involves many scans of observations. We show that, given the ground rule of maintenance of the same overall scan rate (i.e. the same sensor effort), uniform sampling is always optimal for the single-scan tracker in the sense of track life. However, a nonuniform sampling can outperform uniform sampling if a more sophisticated multi-scan tracker is used, particularly when: (i) the target has a high process noise: and/or (ii) the false alarm density is high; and/or (iii) the probability of detection is high. [C2787]

## "Next generation technologies to enable sensor networks"

Examples are advances in ground moving target indicator (GMTI) processing, space-time adaptive processing (STAP), target discrimination, and electronic counter-countermeasures (ECCM). All these advances have improved the capabilities of radar sensors. Major improvements expected in the next several years will come from exploiting collaborative network-centric architectures to leverage synergies among individual sensors. Such an approach has become feasible as a result of major advances in network computing, as well as communication technologies in both wireless and fiber networks. The exponential growth of digital technology, together with highly capable networks, enable in-depth exploitation of sensor synergy, including multi-aspect sensing. New signal processing algorithms exploiting multi-sensor data have been demonstrated in non-real-time, achieving improved performance against surface mobile targets by leveraging high-speed sensor networks. The paper demonstrates a significant advancement in exploiting complex ground moving target indicator (GMTI) and synthetic aperture radar (SAR) data to accurately geo-locate and identify mobile targets. [C2788]

## "2002 7th International Conference on Control, Automation, Robotics and Vision (IEEE Cat.

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First Page of the Article [C2789]

## "An efficient adaptive sequential procedure for detecting targets"

Wald's sequential probability ratio test (SPRT) is known to be optimal for simple hypotheses. However, the hypotheses in target detection applications are usually composite, because, as a rule, the models are only partially known. A major method traditionally used for testing composite hypotheses is based on a generalized likelihood ratio. However, the generalized SPRT suffers from a crucial drawback-it is very difficult to select thresholds in order to guarantee prescribed levels of false alarms and missed detections. We consider an adaptive approach that allows us to overcome this problem. At each stage, unknown parameters are replaced with an estimator which is based on previous observations, but not on the current observation. It is shown that the adaptive test is uniformly asymptotically optimal in the sense that it minimizes the average sample size for all parameter values when probabilities of errors are small. The general results are applied to the problem of detecting a target with unknown intensity in clutter with unknown variance. [C2790]

## "Research on fast ATR algorithms applied to AAM at endgame"

ATR has been the most important part of the research plan for detecting and recognizing targets in many countries. In this paper, we address fast ATR algorithms for air-to-air missiles (AAMs) flying at endgame. These algorithms can be used to detect, recognize and track a target as well as determine the vulnerable components of an object. It can estimate engagement parameters such as Tgo (time to go) and adaptively control burst-point in various missile and target encounter models. Experimental results have showed that the performance and the real-time of algorithms are both satisfied to general demand of missiles. [C2791]

## "Target-aided fixed-quality-of-service compression of SAR imagery for transmission over noisy wireless channels"

We present a target-aided, fixed-quality-of-service (FQoS) system for coding synthetic aperture radar (SAR) imagery, whereby regions of interest and background information are coded independently of each other. A multiresolution, constant-false-alarm-rate (CFAR) detection scheme is used to discriminate between target regions and natural clutter. Based on the detected target regions, we apply less compression to targets, and more compression to background data. This methodology preserves the relevant features of targets for further analysis, and preserves the background only to the extent of providing contextual information. The background data is coded using channel-optimized trellis-coded quantization (COTCQ), while the target regions are coded using a combination of COTCQ and channel coding, depending upon the channel state. The combination of COTCQ and channel coding provides fixed target detection performance at the decoder, independent of the channel bit error probability. Additionally, all-pass filtering is employed, which significantly increases the detection performance at low encoding bit rates, while increasing the security level of the encoded bit stream. The proposed coder is evaluated in terms of target detection performance on the decoded SAR image for a wide variety of channel conditions and encoding bit rates. The resulting system dramatically reduces the bandwidth requirements of digital SAR imagery, and is shown to provide outstanding performance in adverse channel conditions. [C2792]

## "Intrepid MicroTrack leaky cable sensor"

Intrepid MicroTrack is the first leaky coaxial cable sensor to utilize FM CW radar techniques to detect and locate intruders. The first leaky coaxial cable sensor, introduced at the 1976 Carnahan Conference in Lexington, Kentucky, used pulse radar techniques to detect and locate intruders. Since then, there have been numerous papers on CW leaky cable sensors that detect, but do not locate intruders. Like Southwest Microwave's MicroPoint, the acoustic cable sensor introduced at the 1994 Carnahan conference, MicroTrack offers several new features, including the ability to precisely locate intruders. These features greatly improve sensor performance. This paper describes the technology and its broad range of applications including buried, surface and barrier mounted. MicroTrack is an ultra wide band (UWB) HF terrain-following radar. FM CW radar techniques are well known and have been widely used in radio altimeters and police radar for many years. However, it is only with the advent of low cost direct digital synthesis (DDS) chips, high speed and high resolution analog to digital converters (ADC) and digital processing components that it is now practical to apply FM CW radar techniques to leaky cables. MicroTrack uses a fast Fourier transform (FFT) to translate the swept frequency response into precise target location. The frequency diversity associated with the ultra wide bandwidth assures uniform detection along the length of the sensor cable. MicroTrack complies with radio regulatory requirements for low power swept frequency field disturbance sensors in the HF band. [C2793]

## "Nonparametric algorithm for a detection of random process disorder in the signals of radar remote sensing"

A new nonparametric algorithm of radar signal disorder detection is considered. The algorithm is based on spectral estimation of a few signal samples of some close windows and application of a nonparametric Wilkockson's test to compare them. The algorithm can be used for radar signal detection specifically in the tasks of turbulence detection in clouds and precipitation as well as for moving target detection. The efficiency of the new algorithm is analyzed. [C2794]

## "Automatic target detection using PMMW and LADAR imagery"

The need for air-to-ground missiles with autonomous target acquisition (ATA) seekers is in large part driven by the failure of pilot-guided bombs in cloudy conditions (such as demonstrated in Kosovo). Passive-millimeter wave (PMMW) sensors have the ability to see through clouds; in fact, they tend to show metallic objects (such as mobile ground targets) in high contrast regardless of weather conditions. However, their resolution is very low when compared with other popular ATA sensors such as laser-radar (LADAR). We present an A TA algorithm suite that combines the superior target detection potential of PMMW with the high-quality segmentation and recognition abilities of LADAR. Preliminary detection and segmentation results are presented for a set of image-pairs of military vehicles that were collected for this project using an 89GHz, 18" aperture PMMW sensor and a 1.06 μ very-high-resolution LADAR. [C2795]

## "Bayesian smoothing and filtering for multiframe, multiaspect target detection and tracking"

We introduce a new Bayesian algorithm for joint multiframe detection and tracking of multiaspect targets that move randomly in cluttered digital image sequences. Two versions of the algorithm are derived: a batch Bayes smoother and an on-line Bayes filter. Performance results with a simulated image sequence generated from real infrared airborne radar (IRAR) data show an improvement over the association of a bank of correlation detectors and a Kalman-Bucy tracker in a scenario with a heavily cluttered multiaspect target. [C2796]

## "A target detection method in range-Doppler domain from SAR echo data"

The direct evidence of radar target recognition is the backscatter energy and its distribution of objects, which is concluded by the imaging process of synthetic aperture radar (SAR) in a two-dimension image domain. Thus, the issues about automatic target recognition of SAR are often a "post-process" following SAR imaging. A method of target detection in the state of non-imaging based on analyzing the features of all kinds of targets on SAR echo data is presented in this paper, where the targets are defected in range-Doppler domain (RDD). Based on the analysis of target features in RDD, an algorithm of target detection in a RDD image is developed. The experimental results indicate the validity of the algorithm for special kinds of target detection. The algorithm is simple, able to recurrent, easy for real-time processing and hardware implementation. It can also be applied to getting target alarm with real-time SAR data for the pre-selected targets and do the imaging process selectively at the same time. [C2797]

## "Optimization of detection performance"

This paper develops a new, simple, general analytical method for optimizing the detection performance of a radar. The method applies to any target fluctuation model, any pulse integration type (coherent, noncoherent, or mixed coherent/noncoherent), and any number of pulses integrated. The method provides long-missing insight into the optimization of detection performance and guidelines for efficient detection design. The results obtained provide a firm theoretical basis for the commonly accepted empirical rule-of-thumb of providing nominally 13 dB of signal-to-noise ratio to obtain efficient detection. [C2798]

## "Results of flight tests of a two-channel radar system with real-time MTI processing"

In synthetic aperture radar (SAR), only fixed targets are mapped on their correct positions. Moving targets are displaced in azimuthal direction due to the Doppler frequency shift caused by target velocities. The detection and correct positioning of moving targets within SAR images is a problem that can be solved by using multiple antennas and multi-channel receivers. For the detection of slow moving targets or moving targets that are backfolded into the clutter spectrum, a good suppression of fixed target echoes is necessary to gain subclutter visibility. Space-time adaptive processing (STAP) shows good performance in clutter suppression and is state of the art. However, the main disadvantage of conventional STAP techniques is the very high computational load. Therefore, performing STAP in real-time for the purpose of on-board subclutter moving target indication (MTI) requires special techniques. To estimate the true azimuthal positions of moving targets, phase differences between receiver channels can be evaluated e.g. by using the well-known monopulse method. Alternatively,

STAP can be applied to solve this problem as well. STAP in real-time is discussed for two applications. First, STAP can be used for suppressing clutter and jammers. Moreover, clutter filter coefficients gained by STAP can be used for the purpose of correct positioning of moving targets within SAR images. Results of this real-time STAP technique as well as results of the moving target repositioning technique are presented: the clutter suppression quality and the moving target repositioning accuracy are demonstrated with real SAR data and moving targets recorded during a measurement campaign. [C2799]

## "Target detection in ground clutter with W-band stepped frequency polarimetric radar system"

This paper presents a constant false alarm rate (CFAR) target detection scheme in ground clutter at W-band (94 GHz), making use of clutter decorrelation bandwidth and co- and cross-polarized received data. The scheme, based on the concept of a CFAR matched subspace detector, yields a CFAR with respect to clutter amplitude distribution. In order to investigate the detection performance, we carried out a Monte Carlo simulation and experiments using the W-band stepped-frequency polarimetric radar system. The results are also compared with the conventional CFAR detector. [C2800]

## "Wavelet detection of low observable targets within sea clutter"

We observe scattering events in the Doppler domain via a continuous wavelet transform (CWT). By minimising the uncertainty in velocity and time, the dominant event in the non-stationary instantaneous Doppler spectrum can be isolated. Considering the returns to be discrete in nature leads to a physically motivated detection statistic termed 'persistence' that measures the observed lifetime of the scatterers. A Doppler detection scheme is formulated at low velocities within the clutter spectrum, an area neglected by current Doppler filtering. When operated on real data containing an oil drum target, results appear to be complementary to simple intensity thresholding; this suggests detection is made on secondary effects such as wake disturbance. [C2801]

## "Adaptive radar detection of distributed targets in non-Gaussian noise"

This paper deals with the problem of detecting distributed targets in non-Gaussian noise with unknown statistics. At the design stage, in order to cope with the a priori uncertainty, we model noise returns as Gaussian vectors with the same structure of the covariance matrix, but possibly different power levels. We also assume that a set of secondary data, free of signal components, is available to estimate the covariance matrix of the disturbance. Since no uniformly most powerful (UMP) test exists for the problem at hand we devise and assess two detection strategies based on the Rao test and the Wald test respectively. Remarkably these detectors ensure the constant false alarm rate (CFAR) property with respect to both the structure of the covariance matrix as well as the power levels. Moreover, the performance assessment, conducted also in comparison with the generalized likelihood ratio test (GLRT) based receiver proposed in Conte et al. (2002), shows that the Wald test outperforms the others and is very effective in scenarios of practical interest for radar systems. [C2802]

## "Detection and imaging of arbitrarily moving targets with single-channel SAR"

In synthetic aperture radar (SAR) images, moving targets cause imaging errors like defocusing and/or displacement, depending on the direction of their motion. In order to get a correct and focused image of the moving targets, the knowledge of the target parameters position and velocity is necessary. Here, an algorithm for detection, parameter estimation, and imaging of ground-based targets, moving in arbitrary directions, is presented. The algorithm is based on evaluation of a sequence of single-look SAR images which is generated from conventional, single-channel SAR raw data. Position and velocity of the moving targets are estimated by applying two observation models, whereby aliasing due to a motion-induced Doppler shift is considered. In this way, the moving targets can be detected almost independent of their moving direction. The estimated parameters are used to compensate for the imaging errors in the SAR images. Finally, the real motion of the targets in the scene is visualised in a compensated image sequence. [C2803]

## "A comparison of track initiation with PDAF and PMHT"

A problem with many algorithms for target tracking is that they are designed to update tracks under the assumption that the tracks correspond to real targets, and that the initial conditions of the targets are known. In practice, this is not the case, and practical algorithms must be capable of track initiation and termination. One method of solving these problems is to introduce a Markov model to estimate the validity of each track. This approach has been referred to as target visibility. This paper compares the single target track initiation performance of the probabilistic data association filter (PDAF) with the probabilistic multi-hypothesis tracker (PMHT) when each uses the visibility target model. [C2804]

## "Pattern synthesis for moving target detection with TechSat21-a distributed space-based radar system"

We have explored a novel approach for pattern synthesis in angle-frequency space, which is applicable for highly thinned arrays. It exploits the double periodicities of the grating lobes in the angular domain and the radar pulses in the frequency domain and allows substantial clutter suppression. Gains from 7 to 17 dB relative to a randomly, thinned array appear feasible. Further improvements in signal/clutter ratio can be achieved by joint array and filter weight optimization and by narrow-band Doppler filtering. [C2805]

## "The use of track-before-detect in pulse-Doppler radar"

This paper describes the theory and a new method for using the track-before-detect (TBD) process in a pulse-Doppler radar. The approach uses dynamic processing techniques via a modified Viterbi algorithm. The process has been applied to a number of real and modelled scenarios using a variety of radars, threats and environmental conditions. The process has been shown to give an increase in detection range equivalent to a signal-to-noise (S/N) gain of up to 10 dB. The process has also been shown to vastly reduce the workload of a tracker, and therefore increase its effectiveness, by reducing the occurrence of false alarms caused by clutter breakthrough. [C2806]

## "GMTI performance estimation for airborne E-scan radar employing DPCA motion compensation"

Ground-moving target indication (GMTI) clutter rejection performance is conveniently represented by the signal-to-interference-ratio improvement factor. The effects which limit the SIR improvement factor, including clutter spectral width, platform motion and radar instability are reviewed and quantified. Calculation of the SIR improvement factor and consequent detection performance are described and illustrated for an E-scan radar employing DPCA for clutter motion compensation. [C2807]

## "Optimised tracking systems for naval weapon control"

The multi sensor approach to providing a fire control solution against targets ranging from sea skimmer missiles to high diving missiles in a naval environment has been discussed. This approach can be effective, affordable, and capable of being installed on a large range of naval vessels. [C2808]

## "A peak detector that picks more than peaks"

The sensor measurement data supplied to an automatic tracking system is often provided by a peak detector or peak picker. Here it is assumed that digital processing is used for all steps from signal processing onwards. The peak detector follows the signal processing step and converts the received signals into radar measurements. It does this by interpolating the position about local peaks which are above a detection threshold. The peak detector output gives target and clutter measurements which are described by different probability density functions (PDFs). The probabilistic data association filter (PDAF) uses a priori models for the target and clutter distributions. The PDAF has since been extended to include a nonuniform clutter distribution. This paper outlines this extension and also describes another peak detector derived parameter, namely the curvature of a peak. It shows the difference between the peak curvature PDFs for targets and clutter from experimental over-the-horizon radar (OTHR) data. The extension of the PDAF to effectively use peak curvature is then outlined. The examples of performance show the impact of including these extra parameters from a peak detector. These results are based on data recorded from Australia's OTHR, Jindalee. [C2809]

## "A planar antenna for omnidirectional GMTI radar"

For airborne surveillance and early warning radars 360° coverage is a desirable feature. Future military airborne radars will have omnidirectional coverage combined with ground moving target indication (GMTI) capability, for instance by using STAP (space-time adaptive processing) for detection of slow moving targets. In this contribution a randomly thinned array antenna for use with STAP is proposed. For achieving 360° azimuthal coverage subarrays including dipoles with rotational symmetry are used. Real-time STAP processing is achieved by using an overlapping subarray concept. It can be shown also that range ambiguous clutter returns are cancelled through vertical ing. The slow target detection performance is analysed, and the directivity patterns are shown. [C2810]

## "Effect of Doppler ambiguities on GMTI tracking"

We focus on the effect of Doppler ambiguities on target tracking with airborne GMTI radar. Even after platform motion compensation by STAP techniques, GMTI tracking proves to be a challenging task. Unless appropriately

handled, Doppler blindness can cause serious problems, which seem to be even more difficult in the presence of Doppler ambiguities producing multiple clutter notches. We develop an appropriately modified GMTI sensor model and evaluate its impact on the GMTI tracking process. By this approach the minimum detectable velocity (MDV) and the pulse-repetition frequency (PRF) explicitly enter into the GMTI tracking algorithms. [C2811]

## "Effect of ambiguities on GMTI radar"

We focus on the effect of range and Doppler ambiguities on the ability to detect slow moving targets by STAP radar. This work has been conducted in the context of international projects such as SOSTAR and AMSAR.The detection of moving targets by a moving radar (air- or spaceborne) is seriously degraded by strong clutter returns. Space-time adaptive processing (STAP) techniques can implicitly compensate for the motion induced Doppler shift and thereby improves the capability of slow target detection. The effect of ambiguities on the target tracking capability of a STAP radar is discussed in conjunction with a companion paper by Koch (see Radar 2002, Edinburgh, Scotland, October 2002). [C2812]

## "Space based radar moving target detection challenges"

Space based radar (SBR) systems are growing in importance to provide world-wide detection and tracking of ground and surface vehicles, for both civilian and military applications. However, there are several technical challenges that need to be addressed before these systems can be considered affordable. This paper outlines a current assessment of the development needs for reducing the technical risk of SBR to meet the future surveillance requirements. The presentation provides tradeoff analysis in the areas of active electronically scanned antennas, adaptive onboard processing, and satellite power generation and distribution. [C2813]

## "A comparison of partially adaptive STAP techniques for airborne element digitised phased array radar"

In future there will be a growing requirement to use high levels of spatial and temporal sampling to enable the use of space time adaptive processing (STAP) to improve target detection in complex interference environments. However, in practice, the processing power and training data requirements will restrict the degrees of freedom (DOF) that can be used. A number of algorithms have been developed to take advantage of phased array architectures employing many DOF without suffering from slow processing, poor beam pattern control or inadequate training data. This can be achieved using either adaptive or non-adaptive DOF reduction techniques. We evaluate a number of partially adaptive techniques via simulations with airborne element digitised array radar (EDAR). [C2814]

## "Adaptive antenna for ground penetrating radar applications"

A concept of adaptive antenna for ground penetrating radar applications is presented. The adaptation is achieved with respect to the antenna footprint in the ground. The shape and size of the subsurface footprint of the antenna can be changed to improve detection and localization of buried targets. The adaptive antenna is based on a wire bow-tie structure since this structure makes it possible to switch on/off its wire elements in order to form a bow-tie antenna with certain flare angle. By adjusting the flare angle in this way, the shape and size of the subsurface footprint can be varied. [C2815]

## "Wide swathe multi-channel GPR systems for mine detection"

Many national and international programmes are underway to develop more effective detection and clearance system for buried mines. Results from the US national programmes on mine detection suggest that radar can outperform conventional metal detectors, which only respond to the metal content of a mine and hence are insensitive to minimum metal mines. Radar, and in particular ground penetrating radar, used in conjunction with other sensor arrays can result in a improved fused performance in terms of reduced false alarm rate. This paper reviews some key aspects of the performance of radar as a wide swathe sensor, in particular the system design, antenna characteristics, signal and image processing as well as detection performance. Examples of the radar images of mines and the factors that influence the image quality are presented. Current demonstrator radar systems can detect buried AT mines with some confidence, but the reliable detection of AP mines will require further development of antennas, clutter rejection algorithms and target detection methods. [C2816]

## "High-resolution full-polarimetric video impulse radar for landmine detection"

A full-polarimetric ultra wideband GPR front-end has been developed. The front-end is suitable for subsurface imaging with resolution sufficient for antipersonnel mine detection and recognition. In comparison with commercially available video impulse GPR systems the key advantages of the front-end are considerably larger

bandwidth, ability to measure the polarimetric structure of the scattered field and very high precision of scattered field measurements. A principally new antenna system design and an ability to perform quasi-simultaneous measurements with two transmit polarizations and in two different frequency bands are main novelty aspects of the radar. [C2817]

## "Localized three-dimensional adaptive spatial-temporal processing for airborne radar"

Radar space-time adaptive processing (STAP) techniques have classically focused on azimuth-Doppler adaptivity while placing minimal emphasis on elevation. Elevation adaptivity offers significant clutter suppression improvement, allowing further suppression of interference sources having identical Doppler and azimuth as the expected target. This work incorporates elevation adaptivity using two approaches: (1) a factored approach and (2) a joint domain approach, both greatly improving clutter suppression performance. The proposed concepts are validated using results based on simulated range ambiguous airborne radar data. Target detection improvements on the order of 8 dB and 10 dB (as compared to standard 2D-JDL processing) are demonstrated for the factored and joint domain approaches, respectively, using an 8 Ч 8 non-uniform rectangular array. [C2818]

## "UWB multi-static SAR with image stackng for land mine detection"

We investigate techniques for improving the signal to clutter ratio of an ultra wide-band SAR designed to detect small mine-like objects in the surface of the ground. In particular we collected images using different bistatic antenna configurations in an attempt to decorrelate the clutter with respect to the targets. The images were converted to a reference depression angle, summed, and then converted to ground coordinates. The resulting target strengths were then compared with the amplitude distribution of the ground clutter to show the improvement obtained. Use of the bipolar response to further enhance target to clutter ratios was also considered. Whilst some improvement was demonstrated, this was for the relatively easy scenario of targets on the surface partially obscured by grass. [C2819]

## "Target detection in ground clutter with stepped frequency CFAR detector at millimeter-wave"

This paper presents a constant false alarm rate (CFAR) stationary target detection scheme in ground clutter at millimeter-wave frequencies. The proposed scheme makes use of the clutter decorrelation bandwidth considered in the stepped-frequency radar system and the concept of a CFAR matched filter for the received data projection onto the signal and clutter subspace. Therefore, the scheme achieves the CFAR, where the knowledge of the clutter covariance matrix is not needed preliminarily. In order to investigate the detection performance, we carried out experiments with a W-band stepped-frequency polarimetric radar system at 94 GHz with a bandwidth of about 300 MHz. The results are discussed and compared with conventional CFAR detectors [C2820]

## "Scan-to-scan integration-correlation for the detection of small fast targets"

Conventional scan-to-scan integration-correlation (SIC) algorithms comprise a signal weighting part, scan-to-scan integration (SI), together with a signal selection part, scan-to-scan correlation (SC). Such currently used SIC algorithms can detect "small, stationary" targets, i.e., targets with low signal-to-clutter ratio and zero or low speed, but not "small, fast" targets, i.e., "small", relatively high speed targets. However, detection of these "small, fast" targets is the primary purpose of SIC. This paper presents a new SIC algorithm which fulfils this aim [C2821]

## "Target detection of high resolution and full polarization based on PWF and scattering points"

The target detection of high resolution and full polarization radar is discussed. Signal-to-clutter ratio is a determining factor for the detection problem. Raising SCR can bring about an improvement. Here, a cascaded detection scheme is presented. The enhancement of SCR at each stage result in the ultimate improvement of detection performance. At first, by exploiting polarization information, the fused and enhanced one-dimensional range profile is obtained. Then the target's detection is transformed to that of scattering points owing to the high resolving property. Finally, a simulation experiment verifies that the ultimate detection performance is improved [C2822]

## "An effective method of anti-impulsive-disturbance for ship-target detection in HF radar"

This paper presents an effective method against impulsive disturbances resulting in the spectral base wholly rising, which may cover the spectra of ship target returns. The first-order sea clutter in the time domain is always dominant in amplitude and the impulsive disturbances would usually be covered. In order to eliminate impulsive disturbances, the first-order sea clutter is first cancelled in the frequency domain and then those impulsive

disturbances which are dominant in amplitude in the time domain can be eliminated. The remainder is basically the weaker background noise and ship target echoes and signal detection becomes possible, especially for weaker targets [C2823]

## "The modification of intelligent target detection in nonstationary clutter"

In non-stationary background, like sea clutter, the intelligent detection method independent of the statistical model, has the obvious advantages. Based on the strategy by Haykin (1997), a new intelligent detection scheme is proposed to improve the detection performance, in which the Kohonen neural network (NN) and the modified fuzzy NN are used. A variety of comparison experiments have been done with both the simulated data and the real sea clutter data between our proposed scheme and Haykin's scheme, which show clearly our method has a higher detection ability and a lower false-alarm rate [C2824]

## "Novel method of decreasing influence of phase noise on FMCW radar"

In the last decade, the frequency-modulated continues wave (FMCW) radar has been widely used both in military and civil (automotive) applications. Using low peak power it is possible to build reliable, low cost radar, which can measure target position, radial velocity and also the target radial acceleration. The radar sensitivity, accuracy and sub-clutter visibility (SCV) are limited by the transmitted power and the presence of phase noise in a transmitted signal. The influence of transmitter phase noise on FMCW radar performance has been investigated. The low-frequency 1/f type phase noise of FMCW radar free running oscillator degrades significantly the target velocity spectrum estimated by the 2-dimensional FFT of the video signal and thus limits the radar ability to detect moving targets against heavy ground clutter. To improve the radar performance the new method of low frequency phase noise compensation, based on the polynomial phase modeling concept has been worked out. On the basis of the received signal, assuming that ground clutter echoes are present in the signal, the low frequency phase noise polynomial model parameters are estimated. The estimated parameters are further used for digital correction of the video signal phase, which leads to a sharpened echo velocity spectrum and increased SCV and accuracy of velocity estimation. The presented concept can also be used for attenuation of synchronous interference in FMCW radar [C2825]

## "A new method for small target detection over chaotic background"

Based on the chaos of sea clutter, a nonlinear prediction method is used to transform the classic binary decision problem to the analysis of prediction error in radar target detection, and a fuzzy min-max neural network-based detection scheme is proposed. The simulation experiment results show that this method is effective even in very low signal to clutter ratio background [C2826]

## "Two generalized greatest of selection CFAR algorithms"

The conventional cell-averaging (CA) CFAR detector gives a minimum loss of detection power in homogeneous background, but it exhibits intolerable rise in false alarm probability during abrupt transitions of clutter power levels and significant degradation in detection probability in the presence of interfering targets. The ordered statistics (OS) CFAR processor may resolve multiple targets quite well, but it lacks effectiveness in preventing excessive false alarms during clutter power transitions and its sample sorting time is too long. Therefore, some algorithms such as OSGO and GOSGO are proposed. The advantage of applying greatest of selection logic lies in controlling the rise of false alarms at clutter edges. If several ordered samples are linearly combined to give the noise power estimation for the leading or lagging sub-window, better detection performance can be made than with a single ordered sample as considered in OSGO. In this paper, two new greatest of CFAR schemes (TMGO and QBWGO) are proposed. They split the reference window into two sub-windows and uses TM or QBW methods to create two local noise power level estimations, the greatest value of them is used to set an adaptive threshold. It is shown that the detection performance of TMGO and QBWGO is superior to that of OSGO both in homogeneous background and multiple targets situations [C2827]

## "2D-OS-CFAR detector for cloud clutter suppression"

The problems of CFAR processing are investigated by means of real cloud clutter data. Based on FFT processing techniques, a comparison of cloud clutter suppressing performance is made between CAGO-CFAR detectors, 3D-CLUTTER MAP-CFAR detectors and MX-OS-CFAR detectors. A new robust 2D-OS-CFAR detector is developed to resolve existent problems, with CFAR processing on a two-dimensional R-Fd (range-Doppler frequency) plane in place of the conventional one-dimensional range. Order statistics are used to estimate clutter amplitude at the same time. The processing results of real cloud clutter and target simulation signals have verified excellent performances of the 2D-OS-CFAR detector [C2828]

## "A simple method for estimating the velocity based on the Doppler shift"

A simple method for estimating the velocity of a moving target is presented, based on the Doppler shift. The relationship between the ML estimation and the FFT is exploited to obtain a practical implementation. With the help of adaptive noise canceling to increase the input SNR of the FFT, high-precision analysis for the single-frequency signal is easily accomplished. Simulation shows that the method presented meets the high demand required in practice [C2829]

## "A real-time effective method for infrared point-target detection in spatially varying clutter"

This paper presents an algorithm of designing an effective image sequence processing scheme, which based on analyzing the targets and background model correctly. This algorithm will successfully detect very small (point) target in spatially varying clutter background when both the target and clutter are moving through the image scene. This method focuses on reducing the cost of computation, tracking the target in real-time, enhancing the SNR, and suppressing the clutter [C2830]

## "The modelling of sea clutter and its application to the specification and measurement of radar performance"

This paper concentrates on the problem of specifying and measuring the performance of airborne maritime surveillance radars that are required to detect small targets against a background of sea clutter. In particular, the need is identified for the very careful specification of the clutter models used for predicting and comparing the performance of competing radars. It is also shown how the appropriate specification of modelling or simulation methods can address some of the dynamic performance measures that are not covered by traditional specifications. Finally, the role of models in assessing performance is discussed [C2831]

## "Segmentation and recognition of bridges in high resolution SAR images"

Based on analyzing the features of SAR images, this paper presents a novel algorithm for automatic segmentation and recognition of bridges in high-resolution SAR images according to the idea of detecting the targets along the edges of the image. At the same time, wavelet analysis is successfully used in prefiltering and denoising; good recognition results are thus obtained [C2832]

## "Optimal design of clutter rejection filters for MTI system"

Transversal digital high-pass filters are considered for extracting moving target signals from clutter. A new approach is suggested for the analytical design of clutter rejection filters. Based on the required filter pass-band response, a procedure for selecting suitable PRI (pulse repetition interval) values has been used. According to the requirements of the filter rejection-band response, a kind of high pass filter has been suggested as the prototype for determining the optimal filter weighting coefficients [C2833]

## "A comparison of sea waves in open sea and coastal waters"

Detection of small targets in coastal waters is generally more difficult than in open waters. One reason for this might be the different behaviour of the sea waves as the sea waves are not fully developed in closed waters. The paper presents a comparison of measured sea clutter and wave rider buoy data in open sea and coastal waters [C2834]

## "The hybrid signal applied for low-flyer detection and tracking"

This paper addresses a method for the design and processing of a hybrid signal for low-flyer detection. We combine the LFM (linear frequency modulation) signal and random hopped frequency signal together to form the hybrid signal, which possesses high-range-resolution (HRR) ability and better ECCM character. In the course of the signal processing, a two-stage pulse-compression technique is applied in order to get the range resolution less than 10 cm. Finally, the paper gives the actual experimental result that proves the correctness of the method [C2835]

## "An efficient method of radar target detection in complex background"

An efficient method of radar target detection based on multifractals and a neural network is proposed and applied to armored target detection in a complex background. The detection experiment results are encouraging and show that the proposed method is superior [C2836]

## "Distribution of the received voltage's phases in the cross-polarized channel case"

The concept of the equiphase curve is introduced for the cross-polarized channel case. In general, the equiphase curves are a series of half circles on the Poincare sphere, and all these curves have two common ends. Based on the introduced concept, this paper demonstrates the distribution of the received voltage's phases on the Poincare sphere [C2837]

## "A powerful practical coherent adaptive radar detector"

An adaptive detector for the case of a radar target with unknown Doppler and unknown complex amplitude in AR (autoregressive) noise of unknown parameters has been derived. The secondary data is also used to improve the detection performance. The proposed detector has the form of a detector bank. The computational load of efficient realization of this detector bank is also presented. Finally the performance of the proposed detector is evaluated using both simulated and real clutter data [C2838]

## "Netted radar sensing"

In this paper we consider a number of aspects illustrating how networks of radar sensor systems (rather than a single monostatic radar) can offer a counter to stealth technology whilst simultaneously providing more detailed information for improved target detection, classification and location. The netted radar equation is developed, coverage, detection and location performance are quantified, and the potential utility of additional information offered by a network together with countermeasure capability are discussed [C2839]

## "HF shipborne over-the-horizon surface wave radar background clutter statistics"

Sea clutter statistics are very important in designing target detection algorithms in both shore-based SWR (surface wave radar) and shipborne SWR. The sea clutter statistical characteristics in shore-based SWR have been discussed (see Barrick, D.E. and Bsnider, J., IEEE Trans. on Antennas and Propagation, p.19-28, 1997), but the statistics of sea echo in shipborne SWR radar have not been reported. The statistical models of first-order Bragg lines and the second order components of sea echoes, which include the effect of motion of the radar platform, are established for shipborne SWR. The effects of radar platform motion on the statistics of sea echoes are analyzed and the results are verified by measured data. This provides a theoretical basis for some Gaussian-based target detection techniques to be used in shipborne SWR [C2840]

## "Use ultra wideband radar systems for increase information about target"

This review paper discusses the differences of ultra wideband (UWB) radar from conventional narrowband radar. The generation, radiation and processing of UWB radar signals evoked by change of signal waveform in processing of location, by appearance of the mutual dependence between signal waveform and antenna directivity are shown. The reception of the target radioimage is shown [C2841]

## "Stealth "radar""

The system presented in this paper has the purpose of airplane detection including stealth airplanes. The system is sensitive to any natural emission of energy or background noise coming from anything beyond the targeted airplane. In contrast to conventional radar that illuminates the target with microwaves, the targeted airplane does not receive any signal that it has been detected by this new system. The algorithm for computing of what is being detected considers that the airplane causes a shade on the background noise and this shade indicates the position of the airplane. The polar diagram of sensitivity of the detector may be the narrowest possible, however it does not need to be narrower than the solid angle of the airplane because it will always disturb consistently the reception of the background noise [C2842]

## "An approach to detecting the targets of aircraft and ship together by over-the-horizon radar"

The paper discusses the selection of over-the-horizon radar (OTHR) parameters for detecting aircraft and ship separately. Then, a method of detecting a high-flying target (i.e., aircraft) and a slow-speed target (i.e., ship) in parallel by OTHR is presented. The combination of range-Doppler 2-dimensional CFAR and superresolution techniques is the main problem in the process of detection. Simulation results of real (OTHR) data demonstrate the efficiency of the proposed method [C2843]

## "Bistatic matched illumination radar involving synthetic aperture and synthetic pulse for signal to clutter enhancement and target characterization"

The "Radar Fence" is a bistatic multi frequency radar system. Based on the principles of frequency coding, time coding and space diversity we detect and characterize objects and geophysical phenomena. The system's capability is illustrated with results from detection of internal wave wake produced by a submerged vehicle. and aircraft identification [C2844]

## "Advanced technology on radar signal processing"

The task of radar signal processing is the extraction of the target information from the radar echo. The functions of radar extend from the target detection and the coordinate measurement (range, angle of azimuth and elevation) to the measurement of Doppler frequency, the judgement of target property, anti-jammer anti-deception and anti-ARM and so on. This means that modern radar should work in wide band or multi-band, look everywhere all the time, and possess multi-functions. Then it must use advanced signal processing technology to improve the capability of catching the target information. The advanced technologies of. radar signal processing involve the advanced processing algorithms and advanced digital processing hardware and software [C2845]

## "Skywave over-the-horizon backscatter radar"

Skywave over-the-horizon backscatter radar (OTHR) has great potential for detecting such targets as cruise missiles, stealth aircraft, the powered trajectory of ballistic missiles and aircraft carriers over long distances and at the same time. This paper evaluates the detectability of OTHR for small targets through experimental research and emulation, and then brings forth directions for improvement to some shortcomings of this radar. Also, this paper inquires into several key considerations of this system for synthetic design of cost and effect [C2846]

## "A novel transmit signal based on high range-resolution concept for FLAR or AICC system applications"

In this paper, a coded stepped-FMCW signal for mm-wave automotive collision warning radar (FLAR or AICC systems) applications is proposed, which offer high range resolution and multiple target detection probability, and good anti-interference capability can be obtained as well. The waveform is easy to generate digitally and its signal processing reduces the requirement of computational speed compared to conventional high resolution radars. We also suggest an error approach algorithm for multiple vehicle target detection and confirm its usefulness in eliminating false targets by computer simulation [C2847]

## "Short-duration pulse radar experimental system integration and basic experimental research on the target detection"

The concept of high power microwave (HPM) short-duration pulse radar may have possibilities with the rapid development of HPM techniques. Short-duration pulse HPM radar has the advantages of high ECCM ability long range detection ability, high range resolution and high ability to detect targets in heavy scatter backgrounds. The DSP method is relatively simple. In this paper, the function, structure and constitution of a short-duration pulse radar experimental system which has been developed is presented. A method for creating, transmitting and receiving the short-duration pulse microwave signal is explored. A high range-resolution detection experiment for an air target and ground target is also preliminarily studied [C2848]

## "On the increasing importance of simulations in the conception of new naval radar systems"

The purpose of this paper is to explain the increasing importance of adequate simulation tools in the design of new high-resolution radar systems for defence purposes. Changing demands on radar performance imply the need for a new scale of representation in simulations. To meet these new demands, the classical macroscopic descriptions no longer provide enough information. The radar chains, as well as the targets and environments, have to be represented on a microscopic scale, allowing for more detail [C2849]

## "Detecting of anti-radiation missile by applying changeable-sample ratios technology in the AEW system"

Changeable-sample ratios technology is applied to detecting an anti-radiation missile in the AEW (airborne early warning) system. First, we analyze the signal model and, when it is in the active flight time and in the passive flight time respectively, we use special processing methods. At the same time, the AEW tracking process of the antiradiation missiles is analyzed. Finally, the simulation experiment is also given. The simulation results show that in AEW system, anti-radiation missiles can be detected effectively by changeable-sample ratios technology [C2850]

## "Global optimalization in CFAR system and data fusion to merge detection of extractors of the 2.5D surveillance radar"

In February 1946 Zoltan Bay, a Hungarian radar scientist succeeded in getting an echo from the Moon. In the period when the US Army Signal Corps project Diana also detected an echo from the Moon. Today Hungarian radar designers would like to achieve new success in the field of radar data fusion. In this article our aim is to develop and analyse new signal processing algorithms which are capable of collecting or making optimal data fusion of five collected radar signals in order to increase the probability of target detection and decrease the false alarm rate. The radar used for measurements is equivalent to 5 co-located radar working at different frequencies, with different elevation pointing. The detection of these 5 radar is fused to obtain global data on wider elevation coverage. The average beam coverage coefficient can be greater than three by optimal adjustment of the antenna system can [C2851]

## "An approach to developing the new weather avoidance mode of airborne weather radar"

This paper is an approach to a new operational mode-the weather avoidance (WX AVOID) mode. The paper presents conceptual ideals concerning the acquisition of vertical information on weather (WX) targets, the manner of azimuth scanning while scanning vertically, weather data filtering and an indication scheme for quasi-three-dimension weather information [C2852]

## "A new HPRF mode with highly accurate ranging capability for future airborne radars"

A new radar mode has been developed which estimates the target velocity unambiguously and which estimates the range via the time delay of the pulses as in a MPRF mode. To do this, the lengths of the range gates are reduced to approximately the range extent of airborne targets such as fighters. In comparison to common HPRF modes we have now many distinguishable range gates inside the unambiguous range. The resolution of range ambiguities is then done by varying the pulse repetition frequency from burst to burst. The algorithm for the ambiguity resolving considers the fact that during a PRF change, targets can move to the next range gate or can cross one or more adjacent range gates. In addition, the unambiguous velocity measurement is used in an algorithm to compensate the target range migration in order to reduce the false alarm rate [C2853]

## "A 3 mm-wave battlefield surveillance radar for the mini-UAV"

This paper describes the configuration, operation principles and the performance of battlefield surveillance radar for the mini-UAV (unmanned vehicle). It is a light-weighted, coherent pulse-Doppler radar, which operates in both high resolution ground mapping (HRGM) and moving target detection (MTD) modes. The transmitting pulse power of the radar is 35 W, while the range resolution is 4.5 m, and the azimuth resolution is 0.4°. It can provide a forward azimuth coverage of ±20°. The range of detecting a jeep is 2~3 km. The radar can be used for reconnaissance and surveillance missions with good performance even in adverse weather conditions or a smoky battlefield environment. It is especially suitable for the operation on an unmanned surveillance air vehicle [C2854]

## "Wideband coherent airborne radar systems: performances for moving target detection"

In this paper, the main advantages and limitations of unambiguous instantaneous wideband (10%) coherent radar systems for air-ground and air-air applications are analysed in detail, and validated through simulations of targets in realistic clutter [C2855]

## "Adaptive search strategy in phased array radars"

In this paper, an adaptive region search strategy and its performance are studied. Firstly, the optimal illumination interval and the optimal search performance with the known target appearance probability are derived. Next, the influence of the target distribution density's estimation error on the optimal region search performance is analyzed and an adaptive search method, and its performance are investigated. Finally, the simulation results are provided [C2856]

## "An automatic tracking system for marine navigation"

A fully automatic tracking system is discussed in this paper. Compared with conventional tracking systems, a new detection approach based on image recognition is proposed for rejecting ground clutter. The multiple hypothesis tracking (MHT) method is applied in sea or weather clutter background to keep tracks more reliable and more stable. Tracking performance is improved. Thus, the major problems of clutter interference that mainly prevents the realizing of automatic tracking are solved. Finally, track presentation logic is discussed in detail

[C2857]

## "Automatic mapping of linear structures in 3-dimensional space from ground-penetrating radar data"

Non-invasive geophysical techniques such as ground-penetrating radar allow rapid and low-cost investigation of the shallow subsurface for the detection of such features as utilities and plant. This paper presents a pattern recognition approach based on the 3-dimensional Hough transform for the detection of extended linear targets in ground-penetrating radar data. By transforming spatially extended patterns into spatially compact features in parameter space, a difficult global detection problem in data space becomes a more easily solved local peak detection problem in parameter space. Due to the sparseness and variability of the data, the accumulator peak detection stage is replaced by a novel algorithm called the adaptive non-accumulated Hough transform (ANHT) 3-dimensional clustering algorithm. This technique allows the combination of qualitative site information and ground truth in order to increase the accuracy of the final result. The user is presented with a 3-dimensional site survey report detailing the length, depth and orientations (azimuth and zenith) of any pipes, cables or the like. The ANHT performs substantially superior to the standard Hough transform implementation in computer memory requirement. Our experimental results on the artificial 3-dimensional linear objects indicate that method works quite well under various background conditions. The automatic mapping of linear structures in 3-dimensional space from ground-penetrating radar data is achieved by implementing the ANHT in the detection of linear targets in ground penetrating radar data [C2858]

## "The study of the statistical characteristics of monopulse ratio"

In many monopulse radars, the angular information of targets is abstracted from the monopulse ratio, so the statistical characteristics of the monopulse ratio influences the tracking effect directly. This paper derives in detail the mean, variance and distribution of the monopulse ratio for a Rayleigh target and explains their physical meaning. Unlike most of the previous investigation, complex DOA is taken in here to make the conclusion more generalized [C2859]

## "STAP adaptive weight training using phase and power selection criteria"

This paper addresses the issue of adaptive weight training in space-time adaptive processing (STAP) algorithms for airborne radar in non-homogeneous clutter environments, while avoiding the inclusion of target signals in the training. A common method of ensuring STAP clutter cancellation performance in the presence of strong clutter discretes is to train the STAP adaptive weights using the returns with the largest power for a given Doppler bin. The presumption is that the strongest returns are from the strongest clutter. Many times, however, targets are also present whose inclusion in the STAP weight training results in significant target self-nulling as well as a degradation in clutter mitigation performance. A new STAP training method is presented that excises targets from the training set based on an interferometric measurement of phase for each potential STAP training sample. The resulting training method based on both phase and power selection criteria is shown to offer significant performance gains on experimental data [C2860]

## "FPGA implementation of the ray tracing algorithm used in the XPATCH software"

Ray tracing is one of the most popular and powerful image synthesis technique for creating photo-realistic images. In this research, we focus on the time critical application of ray tracing in the XPATCH software for high-resolution radar simulation and detection. Of particular interest to us is the ray/box intersection algorithm employed in the XPATCH ray tracer for achieving faster execution time. The ray/box algorithm is used to determine whether a ray hits or misses the target enclosed in a rectangular bounded volume [C2861]

## "Detecting and tracking of multiple targets in IR image sequences in heavy background"

This paper constructs a real-time IR signal processing system, which consists of hardware design and software algorithm. The algorithm can detect and track not only point targets but also spot targets and large targets at the same scene. The algorithm presents a new idea, which applies row-mean-minus to eliminate temperature nonlinear distribution in. spatial and aggregate points after a high-pass filter. The hardware is designed to satisfy complex computation and real time requirement [C2862]

## "Long-time coherent integration based on sparse-array synthetic impulse and aperture radar"

Sparse-array synthetic impulse and aperture radar (SIAR) adopts the isotropic radiation scheme, thus can perform the long-time coherent integration. However, there are some problems in the process. In this paper, an effective method for long-time coherent integration is presented, which includes a simply implemented motion

compensation and time-frequency analysis. The result shows that the novel method has good performance for weak target detection [C2863]

## "A novel high-resolution polarization target detection method based on intense scatterer integration"

The problem of wideband high-resolution radar target detection in cluttered circumstances is studied. A high-resolution polarization target detection scheme is presented based on intense scatterer integration. Because of the intrinsic high-resolution characteristic of the wideband waveform, a one dimensional range profile of a radar target can be obtained. In connection with the target's polarization characteristics, the number and distribution of intense scatterers in the target's echo can be estimated. SCR (signal-to-clutter ratio) can be improved efficiently by integration of these intense scatterers in corresponding resolution cells. Experimental results show that the radar's detection performance can be improved significantly by using the presented algorithm [C2864]

## "Fast data association algorithm for passive multisensors"

A data association algorithm for multiple passive sensors is presented in this paper. The algorithm is based on the intensity of space intersection made by measurements. Dividing the set of all possible targets into several subsets, starting with the subset which has the best probability under the restraint of data association rule, the real target can be found quickly. Numerical simulation with perfect detection probability and zero false alarm has been carried out and the results show that the algorithm has excellent performance in terms of computation time [C2865]

## "Study on multitarget tracking algorithm in passive cross location systems"

When the coordinates of the target are obtained by direction-finding location through multiple passive sensors, the associated bearing measurements must be the same time detection of these sensors. But these sensors may have different sampling intervals, and the time of these sensors beginning to receive the target signal may be also different. In this case, the first problem one must solve in direction-finding location is measurement synchronization. The paper studies this problem and proposes a method to solve it. An improved least distance method is used in this paper to eliminate the false intersection points. The methods of track initiation and maintenance in multitarget tracking are also discussed in this paper. The simulation results show that passive sensors can track multiple targets at the same time using the methods discussed in this paper [C2866]

## "Speckle reduction in SAR imagery by Lp normed filtering"

The presence of speckle in SAR images increases the probability of false alarms in image prescreening algorithms designed to automatically detect small targets. In order to reduce the level of speckle in SAR images a wide variety of image processing techniques have been developed. Speckle reduction has been accomplished via low pass filtering, median filtering, adaptive filtering, wavelet based filtering, and various iterative techniques such as the gamma filter. For this paper we develop an Lpnormed filter structure. The filter weights are adaptive, based upon a conventional multiplicative noise model of the speckle phenomena in SAR imagery. The adaptive filter for the Lp, p=2 case, is equivalent to the "Frost" filter, and is based upon second order statistics of the multiplicative noise and assumed image model. The filter is tested against SAR data and is shown to reduce the number of false alarms as compared to several other speckle reduction filters [C2867]

## "Identification of Air Targets by using Secondary Application of Terrestrial TV"

Numbers of bistatic radar systems based on non-cooperative TV transmitter are known currently. These systems provide air target detection and tracking but none of them have target identification ability. It is proposed in the paper a technique of air target identification based on the system transfer function parameters estimation. Modern terrestrial TV stations in Europe are operating mainly in UHF band with channels spacing not less than 20MHz. Using, as an example, 4 channel transmitter operating at 480 -540 MHz, the singularity expansion method is introduced. The technique based on the signatures of resonance models is suggested. These signatures are robust to range and aspect angle of targets and the method could be applied in practice. [C2868]

## "Discrimination of Near-Surface Targets in Step-Frequency Radar"

An improved frequency domain method for detecting and discriminating shallow subsurface targets is presented. Conventional signal processing technique in step-frequency ground penetrating radar (GPR) is based on inverse fast Fourier transform (IFFT) of reflection coefficient. However, the synthetic range profile generated by IFFT often cannot be used to detect shallowly buried objects due to lack of resolution. Simple modification of the expression for the synthetic range profile that takes into account both amplitude and phase of IFFT results in

enhanced resolution and allows discriminating targets according to their reflectivity phases. Further improvement of the performance of the method has been achieved by extracting the reflection from the ground surface. To this end, radar system has been calibrated using optimization procedure, where input data are reference signals measured with the antenna positioned at different distances from metal plate. Free space has been used as another calibration standard. After calibration, the ground surface response can be easily subtracted revealing shallow objects. Experimental examples are given to illustrate the method performance. [C2869]

## "Radar Technology for Mine Detection"

Much attention is being given to the challenge of detecting buried non-metallic mines and National and International programmes are underway to develop more effective detection and clearance systems. Reported results from the US national programmes on mine detection suggest that radar can outperform conventional metal detectors, which only respond to the metal content of a mine and hence are insensitive to minimum metal mines. Radar, and in particular ground penetrating radar, used in conjunction with other sensor arrays can result in an improved fused performance in terms of reduced false alarm rate. This paper reviews key aspects of the performance of radar as a sensor, in particular the system design, antenna characteristics, signal and image processing as well as detection performance. Examples of the radar images of mines and the factors that influence image quality are presented. Current demonstrator radar systems can detect buried AT mines with some confidence, but the reliable detection of AP mines will require further development of antennas, clutter rejection algorithms and target detection methods. [C2870]

## "Frequency Modulated Coupled Oscillator Arrays"

A linear array of oscillators each connected to a radiator to combine output power of the oscillators in free-space can be used in order to scan the radiated beam electronically by controlling free-running frequencies of both end oscillators. We applied this technique to Frequency Modulated Continuous Wave (FMCW) radar to perform electronically beam scanning to detect angle information in addition to range and speed information of the target. A two-element coupled voltage controlled oscillator array with frequency modulation capability was constructed at 10.4GHz. The radiation beam could be scanned 24Г‚В° continuously. [C2871]

## "Incoherent Detection of a Distributed Target"

A detection of a Rayleigh range distributed target in a white Gaussian noise is analyzed. The detection procedure includes two steps: incoherent matched filtering and likelihood ratio test detection. For random number of scattering centers the structure of an optimal detector is given. [C2872]

## "Adaptive power-managed FMCW emitter detection performance against low-RCS ships"

The design of a modern 9.3 GHz homodyne triangular-FMCW emitter for detection of low radar cross section (RCS) ships is described. Both searchand track-mode processing are described including a description of transmit and receive waveforms. Tradeoffs in emitter design are examined as a function of the modulation bandwidth. To predict target detection capability, clutter and target models are developed as the emitter is flown at 300 m/s in a scenario that starts at a range of 15 nmi from the target. To evaluate the feasibility of detecting low RCS ships at the horizon, a low-RCS ship design is examined. Each sea state (0-4) is characterized by using a second-order polynomial that describes the normalized mean sea backscatter coefficient as a function of the grazing angle. The emitter transmit power is adapted in time to measure the target characteristics. The emitter transmit power level is consistent with the RCS and range to the target while keeping a target-to-clutter power ratio at 20 dB. For detection analysis, 50, 100 and 500 m2 RCS values are considered [C2873]

## "Efficient implementation of comb filters using block processing"

First Page of the Article [C2874]

## "A multiple perspective spectral approach to object detection"

Many applications for detection of objects such as video analysis require that candidate objects be observed over a range of perspectives in 3 dimensional space. As a result we must have a robust model and detection process for these objects in order to accurately detect them through a range of geometric transformations. In order to keep our detection process computationally efficient, we use a compact multiresolution model to represent the range of geometric transformations possible in the object to be detected. Additionally, we form an integrated likelihood ratio detection statistic to optimize the detection performance over the entire space of targets being examined. To demonstrate the performance of this algorithm we apply our results to a compressed video sequence and show the improvement of our integrated three dimensional model as a function of model

order [C2875]

## "Application of local discriminant bases to HRR-based ATR"

Wavelet-based signal classification and compression techniques have gained substantial popularity due to their low computational costs, excellent localization properties, and the ability to choose from a large number of bases for signal representation. A difficulty with applying wavelet-based techniques is determining the best wavelet type and basis. For compression, the best-basis algorithm has been proposed to find the wavelet-packet basis with maximum energy compaction. The local discriminant basis (LDB) was previously introduced in the context of signal classification to find the best wavelet-packet basis with maximum class discrimination. In this paper, we apply the LDB to the problem of automatic target recognition. We describe the mechanics of the LDB as applied to one- and two-dimensional signals, and introduce a novel classification scheme that is tolerant to image scaling and moderate image translations and dilations [C2876]

## "Effects of RFI on UWB-SAR using LFM waveforms"

The dual requirement of ultra-wide band synthetic aperture radar (UWB-SAR) for high range resolution and low frequency penetration proposes the problem of radio frequency interference (RFI) suppression. Although careful design of the receiver hardware can reduce this difficulty, a great amount of RFI will still distort the actual target returns. The effects of RFI on both of the design of hardware and the task of signal processing are studied. We focus our analysis on the basic pulse compression in linear frequency modulated (LFM) UWB-SAR. The output of a typical sinusoidal RFI after pulse compression is derived and proved to be closely related to the frequency of the RFI. Computer simulations successfully verify our conclusions [C2877]

## "Moving target detection in wide band SAR"

A likelihood ratio test is proposed for moving target detection in a ultra wide frequency band and wide antenna beam (wide band) SAR systems. The developed method combines time domain fast backprojection SAR processing methods with moving target detection. It saves the computational load when all relative speeds can be tested using the same clutter suppressed sub-aperture beams. The proposed method is tested on narrow band radar data [C2878]

## "Target detection based on D-S evidential theory using fusion of SAR & optical images"

In this paper both SAR and optical images are used, based on D-S (Dempster-Shafer) evidential theory, to detect targets such as linear objects and homogenous regions. We give the algorithm of mass function on D-S evidential theory and use the orthogonal rule to combine the two evidences. The experimental results on selected images, which are marked by different colors to discriminate different target areas, demonstrate its potential usefulness [C2879]

## "Local data fusion for single-base multi-sensor"

A fuzzy data synthesis algorithm is studied for single-base multi-sensor's local data fusion. It provides a capability to differentiate between inferior and fine data of the multi-sensor, and to associate the last available data. The results shows that using this method can improve the data accuracy with low tracking loss probability [C2880]

## "Maneuvering weak target tracking using wavelet transform"

The difficulty for tracking maneuver target is to decide whether a maneuver occurs and when the target begins to maneuver. Since target tracking is a real. time problem, the crucial factor is to detect the target maneuver as accurately and quickly as possible. A new approach for the target maneuver detection is presented, especially for the weak target maneuver detection in heavy noise. The algorithm is based on the criterion where the maneuver detection delay is made minimum, which replaces the original measurements by those of the average interpolation to reduce the delay to avoid tracker divergence, and uses wavelet transforms to increase the probability of detection. Simulation results demonstrate the superior performance of our scheme especially for tracking weak maneuvering targets in heavy noise [C2881]

## "Radar waveform design and target detection using wavelets"

The projection of the conventional radar waveform in wavelet space is comparatively complex, which complicated the wavelet decomposition of the radar waveform. A novel radar waveform design method is proposed. The proposed approach uses the wavelet function of a specific scale as the waveform and thus the

inter-dependency of the wavelet coefficients in different subspaces is reduced. Better detection performance is achieved when only two wavelet decomposition coefficients are used. Through theoretical analysis and simulation results it is shown that the proposed approach has improved adaptation to non-stationary noise and the echos of the large target has a smaller negative effect on the adjacent range cell [C2882]

## "Pole patterns of radar-target scattering model based on ultra-wideband Gaussian pulses"

Time domain and frequency domain analysis of a radar-target scattering model based on ultra-wideband Gaussian pulses are presented. The scattering model is a useful tool for computing the range profile, or image, of a complex target that is illuminated by electromagnetic impulses. Computer plots of range profiles and pole patterns are obtained for a complex target that is composed of a finite number of scattering centers. The range profiles and the pole patterns are valuable information for radar-target classification and identification [C2883]

## "Design and implementation of an ultra-wide band pulse compression signal generation system"

The generation of ultra-wide-band pulse compression signals is a very important technology for microwave imaging, buried targets detection, and target identification. Direct digital waveform synthesis (DDWS) enables the waveform agility to be realized easily, and the signal bandwidth can be enlarged by additional orthogonal modulator and double frequency chain circuits. An ultra-wide-band pulse compression signal generation system is introduced, which generates LFM/NLFM signals with a 400 MHz bandwidth at 1200 MHz radio frequency. The test results show that spurious components and harmonics below -55 dB and -50 dB respectively [C2884]

## "Optimal sampling of linear FM and conversion to digitized waveform having predictable sidelobe patterns"

Several advantages are achieved when discrete phased codes are used instead of continuous waveforms. The discrete structure of the phase code signal enables one to increase the freedom of waveform design when pulse compression scheme is considered. This may lead to an arbitrary design of the resultant sidelobe patterns and possibly wide dynamic range responses can be achieved for various applications. This paper shows how a particular sampling rate for linear FM signals may lead to a significant reduction of the peak sidelobe level (PSL) as well as the integrated sidelobe level (ISL) in pulse compression operation [C2885]

## "State estimation with feedback information in a hybrid multisensor system"

In order to improve the tracking performance of sensors, this paper addresses the issue of optimal state estimation in a hybrid multisensor data fusion system with feedback information for similar and dissimilar synchronous sensors. In this system, part of the sensors process their data locally to produce local tracks while another part of the sensors only provide detection reports. These tracks and detection reports are communicated to a central site where track fusion and state estimation are performed. The fusion results are then returned to some sensors, so that the tracking performance of the sensors might be improved [C2886]

## "Speckle reduction for SAR images based on soft-morphological filter with omni-directional multiple structuring elements"

A method on reducing speckle in high resolution single-look synthetic aperture radar (SAR) images is put forward in this paper. Based on soft-morphology, the method is called soft-morphological filter with omnidirectional multiple structuring elements. It substitutes omni-directional multiple structuring elements for common structuring elements. Using it, point targets are detected and preserved and single-look SAR images with high spatial resolution and high radiometric resolution can be obtained. Its efficiency is testified with SAR raw data [C2887]

## "Maximum likelihood approach to the estimate of target angular co-ordinates under a main beam interference condition"

Modern phased array radars are required to detect, locate and track targets in the presence of natural and intentional interference. This paper illustrates the application of the MLE to determine the target direction of arrival (TDoA) in the presence of main beam interference (MBI) and the related CRLB (Cramer Rao lower bound) angular accuracy. Two different sets of high gain beams are considered. The first set includes three high gain beams: the sum and the two difference beams (azimuth and elevation); the second comprises also the so-called double difference beam. In this paper the following results are shown: conception of the MLE of the target angular coordinates and MLE implementation via the Newton-Raphson recursion; CRLB of the target angular coordinates; evaluation of the mean value and the standard deviation of the estimation errors via Monte Carlo simulation and comparison with the CRLB results [C2888]

## "The radar clutter processor with wavelet floating threshold"

According to the theory of wavelet multiscale analysis, we have done some research on how to construct a radar clutter processor by means of a floating threshold. We provide some results of radar signal processing, which demonstrate the method's effectiveness [C2889]

## "Ground short range slowly moving target detection of airborne fire-control radar"

In the short range slowly moving target detection of airborne fire-control radar, the space-time trajectory of clutter varies with range due to the variation of elevation angle and show high non-homogeneity. In such cases, good detection performance can not be obtained by using either conventional or STAP processing. In this paper, a compensating method of clutter trajectory is proposed. Transforming data of different range with different frequency-shift, it can weaken the non-homogeneity effectively and make the clutter energy shrink to a very small area in the space-time plane. The computer simulation results show good performance and high improvement factor can be obtained when it is used as the pre-processor of STAP and it has the advantages of low complexity and ease of application [C2890]

## "Realization of an airborne radar parallel signal processing system"

In order to fulfil real time signal processing tasks such as clutter rejection, moving target detection (MTD) and constant false alarm rate (CFAR) control in airborne radar, an airborne radar parallel signal processing system (ARPS2) is proposed with DSP chips as its kernel processing nodes. The DSP chips are used with parallel architecture. Each node has its private input and output memory. It adopts several parallel techniques, such as parallel storage, parallel processing, parallel code loading and parallel data organization to achieve high efficiency. It has a simple structure, excellent flexibility and easiness in developing. ARPS2 is going to be applied to an airborne radar. It can also be applied to perform high-speed real time signal processing algorithms in other kinds of radar [C2891]

## "Space time adaptive processing for domain factorised element-digitised array radar"

Due to limitations of current radar system hardware, digitisation and adaptive beamforming are usually performed at the subarray level of large phased array radar. In the long term, technology will permit development of element digitised array radar (EDAR), although this may not necessarily lead to adaptive processing being performed at the element level. The large computational requirements for adaptive processing, which vary with the cubed power of the number of digital channels, and the large data training set required, will restrict the number of digital channels employed. However, with element digitisation we are free to choose arbitrary degrees of freedom (DOF) reduction schemes to maximise adaptive beamformer performance. It has already been shown that DOF reduction schemes using domain factorisation (DF) give performance advantages in high clutter airborne intercept (AI) environments. We extend the DF technique described by Paine (see IEE Proceedings Radar, Sonar & Navigation, vol.148, no.2, p.81-88, 2001) to space-time adaptive processing (STAP) and demonstrate the detection of slow moving targets that are ambiguous with main beam and strong nadir clutter [C2892]

## "A new algorithm of automatic target-position acquisition for long-range surveillance radar"

As an important component of a modem radar system, the automatic target-position acquisition (ATPA) sub-system is responsible for estimating the radar targets' center positions. Among all the ATPA algorithms, the old-fashioned binary-processing (BP) algorithm is in an almost-obsolete state. Today the most widely used algorithm is the area-center (AC) algorithm. But the centroid algorithm has gained more and more attention because it has better precision and requires simpler data structures. However, all the above algorithms are unable to completely solve the problem of signal expansion in the range dimension, which is caused by pulse-compression techniques. For long-range surveillance radar systems, if this problem remains unresolved, it is impossible to achieve high resolution of azimuth and range. We propose a 2-dimensional centroid algorithm based on the: original centroid algorithm, which is only 1-dimensional. We have also designed a simplified peak-searching (PS) algorithm according to the characteristics of long-range surveillance radar. Analysis and simulation shows that this algorithm has relatively high estimation precision, and its implementation scheme is very easy. It has already been successfully used in a long-range surveillance radar system [C2893]

## "Direct data domain STAP algorithm for airborne radar applications"

STAP has been widely studied for airborne radar as an approach to adaptively detect small target competing with ground clutter. Non-homogeneous interference is currently an important aspect of STAP. The discrete non-homogenates due to strong interference or target separating from the clutter ridge accounts for much of the

degradation in urban and spiky clutter scenarios. The use of adaptive weights with the hybrid algorithm is widely applicable to discrete non-homogeneity problems, which is a hybridization of a two-dimensional non-statistical method with statistically based methods. This paper presents a new direct data domain processor with a prefilter attenuating clutter to strengthen suppression for discrete non-homogeneous interference. The desirable performance of STAP to discrete non-homogeneous interference is observed [C2894]

## "Frequency bandpass disparity of space-time adaptive array system"

The problem of inevitable frequency bandpass disparity (FBD) for an adaptive array system in an actual non-uniformity circumstance is researched in this paper. From different forms of characteristic analysis, the frames of the eigenvalue and power spectrum are developed, expressions of the adaptive filter characteristics and system improvement factor are also obtained. Such works are confirmed by computer simulation and have provided several feasible references in performance improvement for adaptive array system in circumstances of nonuniformity [C2895]

## "Maximum likelihood angle extractor for two closely spaced targets"

In a scenario of closely spaced targets special attention has to be paid to radar signal processing. We present an advanced processing technique, which uses the maximum likelihood (ML) criterion to extract from a monopulse radar separate angle measurements for unresolved targets. This processing results in a significant improvement, in terms of measurement error standard deviations, over angle estimators using the monopulse ratio. Algorithms are developed for Swerling III models of radar cross section (RCS) fluctuations. The accuracy of the results is compared to the Cramer Rao lower bound (CRLB) and also to the monopulse ratio technique. A novel technique to detect the presence of two unresolved targets is also discussed. The performance of the ML estimator was evaluated in a benchmark scenario of closely spaced targets-closer than half power beamwidth of a monopulse radar [C2896]

## "Target-to-clutter contrast enhancement using radar Doppler polarimetry"

The connection between Doppler and polarimetric characteristics of targets is studied. It is shown that the Doppler polarimetric formalism provides more complete radar object description. These conclusions are supported by the model of simple compound object as well as by the radar observations of ground clutter. It is also shown that the clutter suppression which is based on Doppler polarimetric object description gives better contrast enhancement than the polarimetric optimization techniques [C2897]

## "A general signal processing algorithm for MTI with multiple receive apertures"

Moving target indication (MTI) is demonstrated for general antenna arrays, especially sparse 3D arrays. The framework for space-time adaptive processing (STAP) is generalized to include frequency (fast-time) data and array elements offset in cross track dimensions. The degrees of freedom (rank) needed to represent clutter are derived for general systems. The clutter rank compared to the number of independent samples collected by a radar determine whether MTI is achievable. The optimum detector and the minimum norm eigen canceler (MNE) are implemented through simulation to demonstrate effective clutter cancellation [C2898]

## "Clutter suppression in radar by quasi-continuous complex signal and processing algorithm structure optimization"

The synthesis algorithm of a pair of signal-linked filters for navigational radars with one antenna using a complex amplitude-phase modulated waveform of long duration with coherent processing in the receiver is considered. A harmful influence of the ambiguity function (AF) sidelobes on target detection and parameter measurement is a significant obstacle to using the long pulse duration complex modulated waveform in marine radars. We discuss waveforms and linked processing for clutter suppression by means of AF sidelobe reduction. Some relationships for the quasi-continuous complex signal synthesis of amplitude-phase modulated waveform (APW) are given. The received signals are processed by a mismatch filter. The synthesis criterion of the mismatch filter structure was a root mean square minimization of the output signal sidelobe level. The computer synthesis software of the quasi-optimum mismatch processing structure has been developed. We give some examples of the waveform and mismatch algorithms of their professing which could be used in marine and coastal radars for surveillance of surface targets and navigation [C2899]

## "Radar imaging of ground moving targets"

We analyze the effect of target motion on synthetic aperture radar images and discuss how a multi-aperture radar can detect, focus and relocate moving targets in clutter. AN/APY-6 radar data is used for analyzing the

radar imaging of ground moving targets. Some applications of the time-frequency transform to detect and focus moving targets are also discussed [C2900]

## "Dual frequency measurements of ocean forward scatter with an ultrawideband radar"

This paper presents an experiment description, along with data examples, for ultrawideband radar measurements of low grazing angle forward scatter associated with a test target mounted above a wind-disturbed sea surface. The measurement radar used sub-nanosecond transmit pulses (0.15 ns and 0.25 ns 3 dB pulse widths) at center frequencies of 9 and 4 GHz to achieve resolutions finer than 3 cm in the range dimension. This resolution was sufficient to fully resolve direct and multipath (both single and double bounce) contributions to the signal reflecting from a tower-mounted retro reflector. The geometry produced a nominal 3 degree grazing angle for forward scatter. Dual frequency measurements for a wind-disturbed ocean surface highlight changes in the magnitude and the location of the scatter components with time [C2901]

## "PEOD: Pade estimated optimum (radar) detector"

An expression for the optimum non-Gaussian radar detector is derived from the non-Gaussian SIRP model (spherically invariant random process) clutter and a Pade approximation of the characteristic function of the SIRP. The SIRP model is used to perform coherent detection and to modelize the non-Gaussian clutter as a complex Gaussian process whose variance is itself a positive random variable (r.v.). The probability density function (PDF) of the variance characterizes the statistics of the STEP and after performing a Pade approximation of this PDF from reference clutter cells we derive the so-railed Pade estimated optimum (radar) detector (PEOD) without any knowledge about the statistics of the clutter. We evaluate PEOD performance for an unknown target signal embedded in K-distributed clutter and compare it with optimum detector performance (optimum in particular clutter statistics such as Optimum K Detector-OKD-in K-distributed clutter) [C2902]

## "Track maintenance and positional estimation via ground moving target indicator and geolocation data fusion"

In modern tactical environments, information from a variety of sensors may be simultaneously utilized to improve target detection and tracking procedures. Towards this goal, two data fusion algorithms are developed that implement such processing. First, a GMTI (ground moving target indicator)/geolocation algorithm is derived to assist with track maintenance during periods of GMTI data blackout. Next, a geolocation estimator is presented which fuses time difference of arrival (TDOA), frequency difference of arrival (FDOA), and angle of arrival (AOA) measurements. These algorithms lead to improved positional estimation, track accuracy, and track maintenance. They also potentially reduce the number of platforms required to successfully locate and track targets [C2903]

## "Integration of Bayes detection and target tracking in real clutter image sequences"

We present an optimal Bayesian algorithm for integrated, multiframe detection and tracking of dim targets that move randomly in spatially correlated, cluttered image sequences. The algorithm consists of a multiframe minimum probability of error Bayes detector integrated with a multiframe maximum a posteriori (MAP) position estimator. The design of the detector/tracker incorporates the models for target signature, target motion, and clutter; it uses recursive spatio-temporal processing across all available frames to make detection decisions and to generate position estimates. A simulation with an artificial target template added to a real clutter background shows that the proposed algorithm outperforms the association of a standard single frame image correlator and a linearized Kalman-Bucy filter in a scenario of heavy clutter [C2904]

## "Adaptive detection in dense target environments"

We consider the impact of target signals corrupting the covariance estimate when implementing STAP in ground moving target indication (GMTI) scenarios. Herein, we propose a model for seeding the radar data cube with target signals and calculate both asymptotic and finite training data detection losses. In general, both the location and strength of the corruptive target signals influence performance: under practical conditions, SINR loss can exceed 10 dB. Measured MCARM data confirms the presence of ample ground moving target signals in the radar field of regard under typical operating conditions. We conclude by briefly considering several mitigating strategies as well [C2905]

## "GMTI performance of ΣΔ-STAP for a forward-looking radar"

The GMTI performance of ΣΔ-STAP for a forward looking phased array radar is analyzed using the simulation tool RLSTAP. ΣΔ-STAP processes the returns from sum and difference antenna channels. When used in conjunction with partially adaptive STAP methods ΣΔ-STAP is shown to achieve good GMTI performance

[C2906]

## "Performance comparison of fast-scan GMTI/STAP architectures"

This paper presents a study on multibeam radar architectures to provide wide-area fast-scan ground moving target indicator (GMTI) coverage. The minimum dwell time of a GMTI radar system is often determined by the Doppler processor. The revisit rate can be lowered, while still meeting dwell time constraints, by using multibeam techniques to cover more area in each dwell. The two multibeam techniques examined here are: (1) to spoil the transmit beam with a quadratic phase and digitally beamform on receive; and (2) to break each transmitted pulse into sub-pulses each with different center frequencies, pointed in different directions, and to beamform in the corresponding direction on receive. Space time adaptive processing (STAP) is used with these GMTI architectures to mitigate main beam clutter and to enhance detection of targets in severe interference environments. The antenna sub-arraying, used for beamforming and STAP, generates grating lobes in the receive pattern in multibeam systems. This can degrade performance because grating lobes cannot be suppressed in more than one direction at a time. Two different antenna designs are studied to determine the effect of grating lobes for each of the above fast-scan architectures; non-overlapping (contiguous) sub-arrays and 75 percent overlapping sub-arrays which allows greater control of grating lobes at the cost of greater array complexity. This paper presents signal-to-interference ratio loss (SIRL), probability of detection (P d) and minimum detectable velocity (mdv) for each system. A narrowband interference source is swept in angle to determine system performance degradation due to the grating lobes [C2907]

## "Selection of the radar waveform from tracking considerations"

The conventional approach for tracking system design is to treat the sensor and tracking subsystems as completely independent units. However, the two subsystems can be designed jointly to improve system (tracking) performance. It is known that different radar signal waveforms result in very different resolution cell shapes (for example, a rectangle versus an eccentric parallelogram) in the range/range-rate space, and that there are corresponding differences in overall tracking performance. We develop a framework for the analysis of this performance. An imperfect detection process, false alarms, target dynamics and the matched filter sampling grid are all accounted for, using the Markov chain approach of Li and Bar-Shalom (1991). The role of the grid is stressed, and it is seen that the measurement-extraction process from contiguous radar “hits” is very important. A number of conclusions are given, perhaps the most interesting of which is the corroboration in the new measurement space of Fitzgerald's (1974) result for delay-only (i.e., range) measurements, that a linear FM upsweep offers very good tracking performance [C2908]

## "SIREV- Sector Imaging Radar for Enhanced Vision"

SIREV (Sector Imaging Radar for Enhanced Vision) is an innovative radar system which can supply high-quality images of a sector in front of an aircraft under almost all weather conditions. In contrast to synthetic aperture radar (SAR) systems, no relative motion between sensor and targets is required in SIREV. The high frame repetition frequency in SIREV allows us to detect even very rapid changes in the imaged scenes. Besides a map of the Earth's surface, the complex-valued radar images can be further processed to supply additional information about the topography and objects in the field of view. A fast processing algorithm has been developed for SIREV which allows a very accurate, phase-preserving and efficient image formation. Raw data were obtained by a first demonstration flight using a helicopter, as a platform and the data processing results show good agreement with the theory. Motion errors of the platform could be extracted from the range compressed raw data avoiding the need of an inertial navigation system. After the image formation, coherent and incoherent image averaging processes have been applied to improve the image quality. The evaluation of the computational effort shows that a real-time hardware realization can be carried out using off-the-shelf digital components [C2909]

## "Buried object detection using ground penetrating radar"

A wide variety of sensors could be considered to aid this situation, and generally each will have a particular niche role but the sensor that is of most universal value is ground penetrating radar, or ground probing radar. Its main advantage is that it allows all types of objects to be detected irrespective of their material, operates over a sufficient bandwidth to allow target classification procedures to be implemented and makes use of modern digital electronics allowing wide areas to be searched rapidly. Other sensors provide complementary information that can be fused with radar data to provide a more complete view of the underground environment. [C2910]

## "The eclipsing zone problem in the chirp radar"

Eclipse effect analysis is performed for the chirp radar using the chirp signal ambiguity function. A new approach

to sidelobe suppression for the radar compression filter response is proposed, which enables better detection and tracking of the targets within the eclipsing zone [C2911]

## "Adaptive resolution of mainlobe and sidelobe detections using model order determination"

This paper presents the development and performance evaluation of a methodology for distinguishing between mainlobe and sidelobe detections that arise in adaptive radar systems operating in adverse environments. Various adaptive detection test statistics such as the adaptive matched filter (AMF), the generalized likelihood ratio test (GLRT) and adaptive coherence estimate (ACE), and combinations of these, have been previously analyzed with respect to their sidelobe rejection capabilities. In contrast to these methods, which are based on detecting a single target with known direction and Doppler, the present method uses model order determination techniques applied to the AMF or GLRT data observed over the range of unknown angle and Doppler parameters. The determination of model order, i.e., the number of signals present in the data, is made by using least-squares model fit error residuals and applying the Akaike information criterion. Comprehensive computer simulation results are presented which demonstrate substantial improvement in sidelobe rejection performance compared to previous methods [C2912]

## "Markov modeling of transient scattering and its application in multi-aspect target classification"

Transient scattered fields from a general target are composed of wavefronts, resonances and time delays, with these constituents linked to the target geometry. A classifier applied to transient scattering data requires a statistical model for such fundamental constituents. A Markov model is employed to characterize the transient scattered fields-for a set of target-sensor orientation over which the transient scattering is stationary-utilizing a wavefront, resonance, time-delay "alphabet". The Markov model is utilized in a classifier developed for multi-aspect transient scattering data, with a hidden Markov model (HMM) employed to address the generally non-stationary nature of the multi-aspect waveforms. Each state of the HMM is characteristic of a set of target-sensor orientations for which the scattering statistics are stationary, the statistics of which are characterized via the Markov model. The wavefront, resonance and time-delay features are extracted via a modified matching-pursuits algorithm [C2913]

## "Change detection through subspace projection using independent component analysis to track moving targets in scenery"

The majority of change detection algorithms for imagery require a differencing of recorded intensity or phase values between images. For these algorithms to properly function, geometric alignment must be performed between the images. For moving targets this is not always possible. The technique presented does not require that the images be perfectly aligned. The method of performing change detection is based upon the concept of image subspace projection. A set of “basis” image maps are formed when combined with a mixing matrix can recreate the original image. The subsequent images are then projected into the base image. The projected image is then subtracted from the original image to perform the change detection. The basis images are computed by applying independent component analysis (ICA) to the sampled image. A spatial filter and then an adaptive threshold filter are applied to pass the locations of changes in the images into the tracking filter. Tracking is performed through the use of multiple motion models. The filter's motion models are adaptive added or deleted as required by the moving object's dynamics. The moving object's state is estimated through extended Kalman filtering [C2914]

## "Space based GMTI using scanned pattern interferometric radar (SPIR)"

A method of performing space based Ground Moving Target Indication (GMTI) using radar interferometric processing is presented. The algorithm, referred to as Scanned Pattern Interferometric Radar (SPIR), uses the high angular variability of a sparse array Point Spread Function (PSF) to collect sufficient data from the signal return that the clutter and targets can be separated without an a priori assumption of the clutter statistics. It is shown that clutter within the main lobe of the individual aperture pattern can indeed be separated from the targets, using the deterministic geometric relationship between observation direction and clutter Doppler shift. If the computational domain is extended to the side lobes of the gain pattern, clutter entering through these lobes can also be extracted. Constraints on the cluster geometry are derived from the invertibility of the PSF matrix [C2915]

## "Opportunity of reduction of objects visibility using diffraction-reflecting coverings in conditions of application laser detection systems"

We consider a single-channel locator without accumulation of an uninterrupted signal, this is, actually, close

enough to a real situation, when the target is immobile and the value of Doppler shift of frequency is given, as far as it is determined by the rate of the movement of the receiving system. Further we use the characteristics of the laser heterodyne locator produced by Rockwell, which has the parameters close to the heterodyne locators of MTL complexes as an example [C2916]

## "A numerical waveform design approach to decorrelate target and noise"

Traditional radar detection relies on predefined models for assessment of probability of detection and probability of false alarm. These models assume a target uncorrelated with clutter or other sources of interference. This assumption concerning decorrelation between the target and interference is not strictly true. We propose an iterative approach to design “optimal” waveforms that maximally decorrelate target and clutter returns while still keeping target signal-to-interference-plus-noise ratios (SINR) levels maximized [C2917]

## "Shadow-feature-enhanced ML-CFAR detection for a Swerling 1 target in Weibull clutter"

This paper describes a shadow-feature-enhanced technique for the maximum-likelihood CFAR (ML-CFAR) detector, which is known to have a low CFAR loss. A general 15 dB signal-to-clutter ratio detection enhancement for a shadow length of 5 bins is obtained for a Swerling 1 target in Weibull clutter across a wide range of detection rates [C2918]

## "New imaging modalities for laser-based systems"

Laser-based electro-optical sensors can gather spatial information (imagery) as well as a variety of other types of information. These include motion detection (including vibration), color sensing, and sensing of the effects of the illuminated object on the polarization of the incident illumination. Such systems can have several advantages over sensors that rely on reflected or emitted light. Laser-based systems can gather a full 3D image of an object on a single pulse. The sensors can gather this information in a covert manner because of the high directionality of the laser illumination. Also, a laser-based sensor can gather information with high resolution. In addition, the ability to control the illumination source, the receiver, and the optical aperture can lead to new sensing modalities. We describe various spatial and non-spatial sensing concepts and discuss hardware implementations. In particular we highlight the ability of laser-based systems to produce imagery at very low light levels. The utility of low light level imagery in 2D is discussed and the potential benefits of 3D low light level imagery is assessed. The effect of intervening obscurants on low light level systems are considered. Characteristics of systems that can implement such concepts are also described [C2919]

## "Efficient data fusion for multi-sensor management"

This paper is concerned with the development of a general framework for the management of multiple sensors in tracking a single target. To achieve this aim we draw on concepts from data fusion, particle filtering and heuristic optimization. Previous work gave the multi-sensor fusion management algorithm which provided a rigid scheme under which sensors were placed to maximize the probability of detecting the target. We present an adaptation to this scheme in which sensor placements are chosen to minimize a measure of uncertainty in the target position. We demonstrate the algorithm in an anti-submarine warfare scenario in which we use passive sonobuoys to generate bearings and frequency (Doppler) data, We show that the quality of the track increases dramatically with the combined use of the two data sources and that the new sensor management algorithm further improves the track, and uses significantly fewer sensors in the process [C2920]

## "MFR-IRST integration in the naval environment"

A low elevation threat can potentially exploit degradations in radar performance on naval platforms caused by multipath effects and sea clutter. Particularly in littoral environments and when electronic countermeasures are deployed, the use of radar with dissimilar (passive) sensors promises significant improvements in target detection and tracking capability. This paper provides an insight into a research project that has investigated the interactive integration of the Multifunction Electronically Scanned Adaptive Radar (MESAR2) and infrared search-and-track (IRST) sensor, based on the Air Defence Alerting Device, in a technology demonstrator trials programme. The sensor integration was achieved using the sensor fusion and tracking system known as TOTS (Target Oriented Tracking System) [C2921]

## "Enhancements of NP-3 UHF image quality using digital spotlighting technique"

This paper is concerned with signal processing issues that are associated with foliage penetrating (FOPEN) USA Navy NP-3 ultra-wideband (UWB) synthetic aperture radar. The digital signal processors that were developed for the NP-3 data commonly used a radar beamwidth angle that was limited to 35 degrees. Provided that the NP-3

radar beamwidth angle was 35 degrees, the NP-3 SAR system would approximately yield alias-free data in the slow-time Doppler domain. We show that the NP-3 data possess a 50-degree beamwidth angle within the entire 215-730 MHz band of the NP-3 radar that is imposed by the radar (radial) range swath gate. The 50-degree beamwidth of the NP-3 system results in slow-time Doppler aliasing within the frequency band of 444-730 MHz. We outline a slow-time processing of the NP-3 data, that we refer to as digital spotlighting and PRF upsampling, to minimize the Doppler aliasing. The digital spotlighting is also used for in-scene target calibration [C2922]

## "Proceedings of the 2001 IEEE Radar Conference (Cat. No.01CH37200)"

The following topics were dealt with: radar systems; emerging technology; signal processing; radar subsystem technology; STAP; target tracking; data processing; antennas; SAR imaging [C2923]

## "Estimating the length of a radar shadow in shadow-feature-enhanced detection using a fuzzy system"

Shadow-feature-enhanced radar detection algorithms potentially allow the probability of target detection to be substantially increased when a target casts a radar shadow across a region of clutter beyond it. However, when the length of the radar shadow is not correctly known, much of the potential performance gain may be lost. We demonstrate a method for estimating the length of the radar shadow using a simple fuzzy system. We apply the shadow length estimation to the shadow-feature-enhanced maximum-likelihood constant false alarm rate (ML-CFAR) detector, showing that its performance can be greatly improved when the shadow length is not known a priori [C2924]

## "A spectral approach to image-enhanced moving target radar detection"

A difficult problem with ground moving target radar (GMTI) detection is how to consistently track targets moving through non-homogeneous regions of clutter such as forest and urban boundaries. Although attempts have been made to mitigate this detection problem using terrain mapping data, such data does not give current clutter information due to change in vegetation, roads, buildings, and seasonal variation. We propose to use synthetic aperture radar (SAR) imagery to enhance the detection performance of GMTI radar. We use a multiresolution Markov model to represent both target and background clutter. This multiresolution structure allows us to accurately match GMTI clutter with the geographically registered SAR imagery for consistent moving target detection through clutter boundary areas [C2925]

## "Netted radar sensing"

We consider how networks of radar sensors can offer a counter to stealth technology whilst simultaneously providing more detailed information for improved target classification. Specifically, it is shown how multiple independent sensors can provide an energetically more efficient collector of radar scatter. Further, the relative merits of non-coherent and coherent dependent networks are discussed particularly emphasising the balance between increased performance and increased complexity and cost [C2926]

## "Test results from the AN/APY-6 SAR/GMTI surveillance, tracking and targeting radar"

The AN/APY-6 is an X-band radar developed by Northrop Grumman under ONR (Office of Naval Research) sponsorship. It was developed to provide all-speed target detection, location, tracking, imaging and exploitation. It was installed in a USA Navy NP-3 aircraft in July 1999 and continues to undergo testing and demonstration in the NP-3. This paper presents test results in the form of SAR, GMTI and tracking imagery obtained from programs in which the NP-3 has participated. These include the DARPA Affordable Moving & Stationary Target Exploitation (AMSTE) GMTI precision location program and a number of USN fleet battle exercises (FBE) and the NATO Clean Hunter 2000 exercises [C2927]

## "Fractal dimension as an indicator of track seduction"

A modern scanning radar is designed with sufficient sensitivity to detect small targets, and as a consequence will produce plot returns from many clutter objects. Much of the clutter, such as land clutter returns from large fixed objects, will produce a plot on almost every scan and algorithms may be designed to track and remove such clutter. However, many clutter sources such as sea or rain clutter produce plots having little or no correlation in position from scan to scan. If a track is seduced by such clutter plots, or if a false track starts within such an area of clutter, then the track may be maintained using random plots for some considerable time before failing to associate for sufficient scans to cause deletion. Indeed, the instability of the track will reduce the level of track smoothing, increase prediction error and open up association gates to make track maintenance more likely with each update. It is required to identify tracks that are maintained by random clutter; this paper

shows that a measure of fractal dimension provides a suitable mechanism for identification. [C2928]

## "Waveform optimisation for efficient resource allocation in airborne AESA radar systems"

In an AESA radar, highly efficient search and track operations can be achieved when the agile beam-steering capability of the E-scan antenna is used to implement an alert-confirm target detection and acquisition strategy, and dynamic management is employed to optimise the resources devoted to track maintenance. The full operational benefits are best realised when multiple waveforms, individually optimised for search detection, for target confirmation/track formation and for track maintenance are employed. Furthermore, an appropriate balance in characteristics and performance must be established between these waveforms in order that radar resources are used efficiently. Criteria guiding the choice of waveforms for air-to-air search, target confirmation and tracking functions in an airborne AESA radar are discussed, and an approach to determining the optimum balance of waveform sensitivities described. The level of performance improvement possible is illustrated for a typical example, using results from an AESA radar simulation and performance model. [C2929]

## "Real time detection and compensation of registration errors in a network of radars"

This paper describes an algorithm designed to automatically compensate for the angular and positional misalignment of the members of a network of radars using nothing more than the operational data. The method is based upon the simple observation that within any given observation period a significant number of the target aircraft will take flight paths along lines of constant bearing. By using such sets of straight line motion, observed commonly by a pair of radars, it is possible to arrive at an estimate of the relative azimuthal bias between the two. By conducting this estimation for each radar in the network with reference to one nominated member, all the relative azimuthal offsets can then be computed. Once the rotational biases have been resolved it is then feasible to calculate any x,y offset in the actual position of the radars relative to their published coordinates using the same data. This paper is illustrated with a set of data gathered from five typical air defence radars during a thirty minute period of normal operation. A colour keyed latitude/longitude plot of all the radar reports is shown; the misregistration of the radars can be seen quite clearly. The reports from the radar designated as the reference are those shown in black. This is a good test data set in that, compared to the reference, one radar has only a slight offset, two have very substantial azimuthal bias and one of these is also located some tens of seconds adrift from its published location; finally one has only a limited area of coverage common to the designated reference. [C2930]

## "The effectiveness of monostatic and bistatic deployment of low frequency active sonar"

The simplest means of exploiting low frequency active sonar involves the deployment of both transmitter (Tx) and receiver (Rx) from a single platform, albeit at potentially different depths. If a second Rx array (at a different location) is available, then it is of interest to determine the benefit of deploying it in such a position as to receive echoes in a bistatic geometry. This paper illustrates the relative merits of monostatic and bistatic geometries in terms of the evasion probability for area and barrier searches, which in turn depend on the area coverage of a single transmission (or sequence of transmissions), and the lateral sweep width, respectively. Detection probabilities are calculated by generating signal excess surfaces (vs target range, depth and bearing) for a given sonar geometry. The deployment geometry is first optimised by choosing it so as to maximise the total area in which a target can be detected. Coupled to the theoretical optimization of the relative geometries of transmitter and receivers is the practicality of maintaining these geometries while undertaking operational tasks such as area search. Modelling has been undertaken to look at the effects of operational tasks and their interaction with submarine avoidance tactics. We illustrate the methodology by presenting results for a deep-water environment, namely the Greenland-Iceland-UK gap, assuming a transmission frequency of 2 kHz. [C2931]

## "Velocity-based track discrimination algorithms"

Velocity-based track discrimination is posed as a detection problem. Four discrimination algorithms are presented and compared in terms of their discrimination performance and computational load. One of these algorithms is an optimal, though computationally complex, Bayesian likelihood ratio detector. It turns out that one of the other three approximates the optimal performance, while requiring only a fraction of the computational load associated with the optimal one. [C2932]

## "Improved particle filter for multitarget-multisensor tracking with unresolved observations"

Multi-sensor tracking of multiple targets, in clear but with some observations unresolved, is considered. The approach considered is based on the "particle filter", representing the target-state distributions by random samples. The improvements suggested here, namely choice of predicted samples and introduction of bounds on acceleration and speed, allow reduction of the number of mistaken detections and percentage of lost targets, as

well as improving average tracking performance with unresolved observations. [C2933]

## "Adaptation to the clutter environment by airborne maritime surveillance radars"

Airborne maritime surveillance radars must detect small targets against a background of sea clutter whilst maintaining surveillance over a large area of sea. This task is very demanding and requires the radar to dynamically adapt to the local environment in order to obtain the best possible detection sensitivity. An aircraft flying at, say 3000 ft would be able to observe an area of sea of about 49,000 km, with a range to the horizon of about 124 km. Over this area, the clutter characteristics observed the radar will be continuously changing as a function of range and look direction. These characteristics will vary in a manner dependent on the prevailing conditions, the radar characteristics and the viewing geometry. In practice, the radar must cope with a very wide dynamic range of signal amplitude, with amplitude statistics varying from those of thermal noise to very spiky sea clutter and land. Continuous adaptation to this environment is required as a function of range and bearing. The dynamic behaviour of the radar as it adapts in this way is often a much more relevant measure of performance than more traditional static measures such as detection range. Methods used to adapt to the environment are surveyed in this paper, together with indications of how their dynamic behaviour can influence performance. [C2934]

## "Optimal transmission pulse shape for detection and identification with uncertain target aspect"

This paper investigates the optimization of the transmission radar pulse shape to maximize either target detection or identity discrimination between the T-72 and M1 tanks under conditions of aspect uncertainty. Significant performance improvements in detection and identification are obtained using optimized transmission waveforms over that of standard chirped pulses [C2935]

## "New techniques for radar coherent range ambiguity resolution"

A new method of target coherent range ambiguity resolution is presented which is substantially different from previously proposed methods. The new target ranging eliminates the generation of target ghosts associated with most conventional techniques. A range-ambiguous radar with a medium to high pulse repetition frequency is assumed. Clutter is assumed to be present in multiple range intervals. The method utilizes constant frequency pulses that change phase pseudo-randomly from pulse to pulse. The phase progression of the received pulses are correlated with a bank of matched filters constructed using phase progressions representative of the different range intervals. Performance degradation of target detection using the pseudo-random phases is also examined. Target detection with strictly pseudo-random phases is found to degrade in comparison to the conventional constant phase methods. A technique that utilizes both constant phase and pseudo-random phases is proposed that performs both detection and target ranging well [C2936]

## "Effects of various image enhancement techniques on FOPEN data"

An investigation of FOPEN target discrimination performance is summarized using UHF SAR data gathered at Grayling, MI by the USA Navy's P-3 SAR Sensor. The fully polarimetric data are processed using polarimetric whitening; superresolution processing is then applied to enhance the resolution of the whitened data. Several superresolution approaches are investigated and target discrimination performance achieved using superresolution processing is quantified. Discriminator ROC curves showing probability of detection versus probability of false alarm are used to compare performance; an eigenvector-based superresolution approach is shown to provide the best performance improvement [C2937]

## "Development of a digital array radar (DAR)"

Twenty-first century littoral and open-sea missions present USA Navy (USN) shipboard-radar systems with the challenge of detecting small targets in severe clutter and against multiple sources of interference. In fiscal year 2000 (FY00), the Office of Naval Research (ONR) sponsored a program to develop an active array radar that includes a digital beamforming (DBF) architecture. The DBF radar system has the potential for improved time-energy management, improved signal-to-clutter (S/C) ratios, improved reliability and reduced life-cycle costs. This paper summarizes the latest developments of the program during FY00 [C2938]

## "SAR prescreening using both target and shadow information"

The utility of fusing shadow and intensity detections in a SAR prescreener is evaluated over the MSTAR database. We use either power ratio, GLRT or two-parameter CFAR tests to extract the two detections. For any testing strategy, the addition of shadow information improves performance [C2939]

## "Modeling imprecise detection parameters as fuzzy numbers for a Rician target in Rayleigh background"

The performance of a radar detector may become inaccurate when key parameters of the system are imprecise. Imprecise parameters are modeled here as fuzzy numbers. The fuzzy integrator detector is constructed for a Rician target in Rayleigh background. Results indicate that the precision of the detection performance decreases as parameter imprecision increases. The false alarm rate is particularly sensitive to parameter imprecision at low false alarm rate; 5% imprecision in the parameters can give rise to more than 300% imprecision in the false alarm rate at nominal false alarm rates below 10-5 [C2940]

## "Ship detection in SAR images: a segmentation-based approach"

This paper deals with the problem of detecting ship targets in medium- and high-resolution SAR images. Achieving a controlled false alarm rate is a major problem for the presence of a highly non-homogeneous sea clutter environment due to the highly variable environmental and weather conditions in closely spaced areas. After highlighting the problems of conventional techniques, a new approach is proposed based on cascading a segmentation stage and a local CFAR detection stage. The former estimates the homogeneous backscattering regions, while the latter detects the ship targets inside the fairly homogeneous identified regions [C2941]

## "SAR image processing for moving target focusing"

A novel synthetic aperture radar (SAR) image processing technique has been developed to refocus the ground moving target signature from its smeared response in the SAR image of the stationary ground. The technique implements a matched moving target filter that is derived from the signal history along the target range-Doppler migration path mapped onto the SAR image from its real-space trajectory. The spatial filter is specified by both the apparent target range in the image and the magnitude of the relative target-to-radar velocity. Range dependence may also be eliminated in image filtering by performing the inverse Fourier transform of the SAR image data spectrum after a spatial frequency coordinate transformation [C2942]

## "Moving target imaging in foliage using polarimetric multi-frequency antenna array SAR"

Because of the low signal-to-clutter ratio, it is a difficult problem to detect and image moving targets in foliage. A multi-frequency multi-aperture polarimetric SAR (MFMA POLSAR) system is proposed for imaging of moving targets in foliage. The MFMA POLSAR extends the multi-frequency antenna array SAR (MF-SAR) system to multiple polarizations. Full polarization is used in MFMA POLSAR to achieve an optimal polarization adaptive to the environment, such that the images obtained by different apertures are of the best coherence that is used to obtain the highest accuracy of the phase estimation. It is also shown that the MFMA POLSAR can not only accurately locate both slow and the fast moving targets, but also reveal moving targets in foliage [C2943]

## "Development of a complete radar system model"

This paper describes an approach to modelling synthetic aperture radar (SAR) and ground moving target identification (GMTI) modes that is applicable to both monostatic and bistatic operation. We describe an extensible method for modelling large complex radar systems that can be used to model platform and target motion, analogue and digital electronic components and complex signal processing algorithms. The key to this approach is a common data file format that allows the user to exchange simulated datasets for real flight trials data or combine the two without any recompilation of the modelling [C2944]

## "Bistatic surveillance concept of operations"

Space-based radars are being considered for civilian and military surveillance of ground and air moving vehicles because of their worldwide field of regard, and their inherent potential for surveillance of locations denied to other radars for political or geographical reasons. Monostatic radars will provide detection and tracking of moving objects, but are limited by affordable aperture sizes to large target cross sections or infrequent revisit rates. Several authors have postulated that bistatic operation between a space-based illuminator and airborne receiver is one effective method of improving on these limitations. However, the ability to fully utilize the area coverage rate of the bistatic hybrid space-based radar is limited by a small receiver footprint as compared to the spaceborne transmitter. This paper develops the bistatic area coverage radar range equation, as compared to the monostatic equivalent. A description of multibeam receiver operation is presented along with the radar signal processing to provide the necessary signal-to-noise ratio for target detection. Finally, a first-order consideration of the waveform design approach to enable bistatic STAP processing for target detection is presented [C2945]

## "An adaptive algorithm for enhanced target detection for bistatic space-based radar"

The use of space-based bistatic radar has many attractive features (particularly related to covert observation and survivability) over that of conventional monostatic systems. However (if detection performance is to approach the monostatic case) these advantages come at the price of inherently more complex hardware and processing algorithms. In particular, when considering a bistatic system that utilizes a space-based transmitter/ground-based receiver architecture, obtaining detection ranges of practical value is problematic without having unrealistic requirements for space-based transmitter ERP or ground-based receiver antenna size. A predetection signal processing scheme is postulated which adapts to the nature of the bistatic signal, thus allowing for longer coherent integration times and correspondingly larger signal processing gain [C2946]

## "Preliminary interferometric images of moving targets obtained using a time-modulated ultra-wide band through-wall penetration radar"

A time modulated ultra-wide band (TM-UWB) wall penetrating impulse radar currently being developed at Time Domain Corporation, Huntsville, AL, is used to generate two-dimensional (2D) interferometric images (II) of moving targets. The goal is to determine the location of moving people behind walls or non-metallic visually opaque boundaries in real time using such a handheld wall penetrating radar operating under FCC Part 15, Class B limits. Interferometric images of an adult male person walking and crawling on the floor are presented for different types of common walls in front of the radar [C2947]

## "Comparison of GLR and maximal invariant detectors under structured clutter covariance"

There has been considerable recent interest in applying maximal invariant (MI) hypothesis testing as an alternative to the generalized likelihood ratio (GLR) test. This interest has been motivated by several attractive theoretical properties of MI tests including: exact robustness to variation of nuisance parameters, finite-sample min-max optimality (in some cases), and distributional robustness. However, in the deep-hide target detection problem, there are regimes for which either of the MI and the GLR tests can outperform the other. We discuss conditions under which the MI tests can be expected to outperform the GLR tests in the context of a radar imaging and target detection application. We also show that the relative advantage of the MI tests is robust to boundary estimation errors [C2948]

## "Statistical properties of L-band sea clutter measured with a polarimetric synthetic aperture radar"

The limiting factor affecting the performance of most airborne radar systems in detecting targets on or near the surface of the sea is return echoes from the sea surface or sea clutter. The objective of this paper is to provide an analysis of the statistics of Australian sea clutter for an L-band VV-polarised airborne radar system from sampled measured values. Polarimetric synthetic aperture radar (POLSAR) image of the North-West region of Australia, acquired in 1996 by the Jet Propulsion Laboratory (JPL) was used to study, the backscattered statistics of the sea surface. Using this POLSAR image, a number of different candidate distribution functions have been investigated, and their goodness-of-fit have been carried out using the Kolmogorov Smirnov goodness-of-fit test. The log-normal, Weibull and K-distributions have been applied to model the statistical properties of multi-look polarimetric SAR sea clutter. The K-distribution has been found to have good agreement with the observed sea clutter intensity distributions [C2949]

## "Discrimination between low metal content mine and non-mine-targets using polarimetric ultra-wide-band radar"

In this paper we show that wide band radar polarimetry can be used for discrimination between surface laid AP mine and non-mine targets. To do this we employ two types of coherent radar decomposition theorem applied to wide band chamber measurement data from the European Microwave Scattering Laboratory (EMSL). Our main conclusion is that radar polarimetry should be further investigated as an important way to secure low false alarm rate from radar sensors in stand off mine detection [C2950]

## "IGARSS 2001. Scanning the Present and Resolving the Future. Proceedings. IEEE 2001 International Geoscience and Remote Sensing Symposium (Cat. No.01CH37217)"

The following topics were dealt with: soil moisture remote sensing; archaeology; global clouds and aerosols; remote sensing; data compression and coding; SAR; floods and disasters; Antarctica; Arctic; classification, labelling and inference; visualization; advanced sensors and measurement techniques; missions and programs; skin sea surface temperature; agriculture, coastal lakes and rivers; hyperspectral environment; geoscience; Global Change Observation Mission; environmental degradation and Earth systems; student prize paper competition; processing and analysis methods; interferometry; Africa; Radarsat 1; sensor calibration; oceans;

Australian applications; aquatic and submerged ecosystems; hyperspectral and multispectral mineral exploration; advanced lidar systems; Tropical Rainfall Mapping Mission; clouds and precipitation data fusion; thermal remote sensing; biophysical modelling; Shuttle Radar Topography Mission; forestry; fires; passive remote sensing; state communities; active remote sensing; snow; local communities; geospatial data fusion; multisource vision; knowledge based systems and unmixing; tropospheric refractivity estimation; radar polarimetry; ocean color; sea ice, snow and glaciers; short wind waves; topography, DTM and cartography; arid zone; rangelands; lidar technology; ozone; clouds and precipitation; inverse problems; spaceborne scatterometers; differential SAR interferometry; antipersonnel landmine detection and classification; landcover change; air-sea interaction; knowledge based systems and unmixing; Bayesian techniques; data formats, archiving and retrieval; EOS-Terra mission; ocean waves; agriculture; salinity; urban studies; hydrology; soils; geoscience; atmosphere; climate; large scale thematric products; emission and scattering; image processing and enhancement; GPS reflection; electromagnetics; AIRSAR and PACRIM; synthetic aperture techniques; processing systems; policy, education and societal issues; GPR; ocean winds; disaster assessment; target detection; environmental degradation; coastal landscapes and fisheries; biophysical modelling; neural networks, expert system systems; inverse problems [C2951]

## "Optimization of waveform and detection threshold for target tracking in clutter"

We formulate an optimization problem to obtain the combined sequence of waveform parameters (pulse amplitudes and lengths, and FM sweep rates) and detection thresholds for optimal target tracking in clutter. The optimal combined sequence minimizes a tracking performance index under a set of parameter constraints. The performance index can include the probability of track loss and the estimation accuracy. The effect of the false alarms and clutter interferences is taken into account in quantifying the performance index. A measurement model is developed based on the resolution cell in the delay-Doppler plane for a Gaussian pulse. Numerical experiments were performed to solve the optimization problem for several example problems [C2952]

## "Detection of ships using cross-correlation of split-look SAR images"

One of the main problems in ship detection is the presence of sea clutter inherent to coherent imagery. A traditional approach to differentiate a target embedded in noise is to utilize the statistical property of the clutter with some success. In this paper, we propose a new technique of ship detection based on cross-correlating split-look SAR images. If the inter-look images consist of the correlated images of a ship and clutter, the degree of mutual correlation increases, and from the difference in correlation, the ship can be identified. Applying the present method to RADARSAT (Standard 1) images, we have found the minimum detectable size of ships is 62.6 m. The SAR data used in this application were acquired under fairly calm sea states, such that the ships can be identified by the naked eye. Thus, the method has not been tested in an extreme limit of high sea states, and remains as a further study [C2953]

## "Validation of a CFAR vessel detection algorithm using known vessel locations"

The National Oeanic and Atmospheric Administration (NOAA)/National Environmental Satellite, Data, And Information Service (NESDIS) is in the second year of a two-year demonstration of Synthetic Aperture Radar (SAR) derived products called the Alaska SAR Demonstration (AKDEMO). This demonstration provides near real-time SAR data and derived products, including wind images and vectors, hard target locations, along with ancillary data, to specific users in the government community. One of the derived products are vessel positions obtained from a constant false alarm rate (CFAR) vessel detection algorithm developed by Veridian ERIM. This algorithm has been tested and validated to maximize the number of ships found while minimizing the number or false alarms on one SAR image of the Red King Crab fishery in Bristol Bay on October 18, 1999. This resulted in using a detection statistic threshold of about 5.5, depending on image resolution used. Until now, this validation has been done with only general knowledge of fishing fleet size and location, but no in situ vessel information. This paper presents the results of a validation of the SAR vessel detection algorithm using observer reported vessel positions along with information on vessel size and local wind speed [C2954]

## "Remote Minefield Detection System (REMIDS): a UK programme for airborne minefield detection"

The UK Remote Minefield Detection System (REMIDS) Technology Demonstration Programme (TDP) is nearing the end of a five year programme that has developed emerging remote sensing technologies into an integrated system to demonstrate a capability for the reliable detection of minefields and mined areas from an airborne platform. The multi-sensor system demonstrator is being managed by DERA on behalf of the UK MoD. A novel Ultra Wide Band Synthetic Aperture Radar (UWB SAR) and a full Stokes Vector Time-parallel Polarimetric IR camera (IRPC) have been developed and a commercial VIS-NIR hyperspectral sensor is being considered for inclusion in the final system trials. While the UWB SAR is the lead sensor, with a capability for foliage

penetration and target identification, confirmation and additional target discrimination is provided by polarimetric IR imaging to give a 24 hr capability. A ground station processor, based on COTS systems, has been developed to fuse all sensor outputs in a decision level process through a variety of target detection and identification algorithms. Probabilistic analysis is used on the resulting outputs to define the extent of a minefield to the system operator. In this paper we report on the development of the REMIDS programme by DERA from inception through to sensor trials, providing an overview of the sensor technologies developed and a discussion of the preliminary results [C2955]

## "Adaptive radar clutter suppression"

The clutter return presents a severe problem in target detection for radar systems. Conventional radar systems assume the clutter is stationary, with energy concentrated in the low frequency domain. To minimize the effect of clutter, radar systems use a fixed high pass filter (HPF) to eliminate the clutter. When the target Doppler frequency is below the cutoff frequency of the high pass filter, or the clutter energy does not concentrate on the low frequency domain, the performance of radar system is severely degraded. This paper proposes an adaptive clutter suppression scheme. This scheme provides more efficient clutter suppression for non-stationary clutter and provides the ability to detect a slow moving target. The computer simulation is presented to compare the performance of this adaptive clutter suppression technique and the fixed clutter suppression filter [C2956]

## "U.S. CELRAP laser radar design considerations"

In the U.S. CELRAP laser radar program, an eyesafe laser radar has been designed and built using designator-class laser technology and linear multiple channel detector arrays. Functions include obstacle detection, target profiling, and range mapping [C2957]

## "Design of a high performance laser range finder"

The design aspects of a high performance laser range finder capable of ranging targets up to 20 km with ±5 in accuracy are presented. The system features a forced air-cooled 5 Hz Nd:YAG laser transmitter and a 110 mm aperture optical receiver with threshold detection [C2958]

## "DInSAR applications to landslide studies"

Operational monitoring of slope instabilities by SAR interferometry poses a number of challenges due to the limited spatial extent of the landsliding areas and the rainy conditions usually associated with mass movement events. In this work, we present applications of DInSAR techniques to the assessment of the stability of landslide-prone areas. A long-term analysis over single, stable scatterers can be attempted, in order to overcome the intrinsic low-coherence conditions associated with landslide sites. The technique, known as the permanent scatterers approach, has been shown to give excellent results over areas with high densities of man-made targets. In this work, some aspects of the PS processing are reviewed and possible improvements are proposed to bring the method to give reliable results over sites with low urbanization such as the rural settings associated with landslide-prone areas in Southern Italy [C2959]

## "Electro-optical systems for image recognition"

Detection and classification of targets by means of electro-optical sensors has been of interest for both defense and civilian applications for a number of years. In this presentation we emphasize two areas: extraction of more information from the sensors by polarimetric and frequency diversity, and reducing the processing and storage requirements by exploiting invariant attributes for detection and classification [C2960]

## "Detection of the number of signals in super-resolution ocean surface current algorithm for OSMAR2000"

Super-resolution ocean surface current algorithm based on MUltiple SIgnal Classification (MUSIC) is used for current mapping of Wuhan University's ocean state measuring and analyzing radar (OSMAR2000), in which MUSIC is applied to estimate the bearings of the first-order sea echo signals. The premise of MUSIC processing is that the number of signals is known in advance. In fact, the number of signals is unknown, and needs to be estimated from received data. In the case of discrete targets, the problem can be perfectly solved using information theoretic criteria such as the Akaike Information Criterion (AIC) or the Minimum Description Length (MDL) criterion. However, these criteria are proved unsuccessful for sea echo signals both in simulation and in actual application, since sea surface is essentially a continuum. Therefore, an ad hoc method of detection of number of signals, a bit different from the existent methods, is developed for the current algorithm of OSMAR2000. The underlying idea is to determine the number of signals based on the variance of MUSIC

spectra structure under different candidate number of signals [C2961]

## "Preparing the Joint Multi-sensor Mine-signatures project database for data fusion"

The Joint Multi-sensor Mine-signatures (MsMs) project was started in the year 2000 and has as its main goal to organize and execute an experimental campaign for collecting data of buried land-mines with multiple sensors. These data sets are being made widely available to researchers and developers working amongst else on sensor fusion, and signal processing for improved detection and identification of land-mines. The. outdoor test facility (6Ч80 m) of the Joint Research Centre (JRC) of the European Commission, located at Ispra (Italy), houses the test minefield. Six test strips of 6Ч6 m consisting of different soil types (cluttered grassy terrain, loamy soil, sandy soil, clay soil, soil with high content of organic matter and ferromagnetic soil) are complemented with one reference test strip of 6Ч6 m consisting of pure sand. The list of objects buried in the minefield includes mine simulants of three different dimensions with either a low or a high metal content, reference targets for position referencing and calibration checking, and clutter objects including empty bullet cartridges, metal cans, barbed wire, stones, wood, plastic boxes, etc. This test minefield is going to be left intact for a long period, in order to be able to perform multiple runs on it. For the test campaign of the year 2000, the core sensors were a metal detector a ground penetrating radar, a microwave radiometer and several thermal infrared imagers. The first data sets are in the process of being released right now. This paper aims to prepare the first results to be obtained by fusing the data coming from these different sensors, by presenting the available datasets [C2962]

## "A synthetic moving target generator for calibration of Radarsat 2 Moving-Object Detection Experiment (MODEX)"

The Moving-Object Detection Experiment (MODEX) of the Radarsat 2 platform will allow object motion extraction and measurement by partitioning the radar antenna into fore and aft apertures. Accurate extraction of object motion requires compensation to produce two equivalent radar channels. Calibration of MODEX signals is best accomplished by a transponder that receives and measures the signal transmitted by the satellite and uses the captured radar waveform to generate moving point-target signals with precisely known properties. We are proposing to use a computed approach to implement a synthetic target generator (STG) as a transponder for the motion calibration of Radarsat 2 MODEX. With this approach, the incoming pulses are digitized, manipulated using a fast digital signal processor (DSP) to synthesize signals simulating moving point-targets, and then converted back to analog for transmission. This paper reviews theoretical considerations for the synthesis of moving-object signals, demonstrates the concepts with simulations, and discusses implementation issues [C2963]

## "Polarimetric detectors of extended targets for ship detection in SAR images"

This paper deals with polarimetric detection of ships in SAR images of medium/high resolution (about meters). The aim is to develop detection techniques able to exploit the polarimetric information in order to improve the detection capability of ships or generally man-made targets modelled as extended targets (i.e. occupying multiple pixels). Both a decentralized and a centralized approach are considered for the fusion of the polarimetric information and their performance are characterized [C2964]

## "Waveform design principles for automotive radar systems"

This paper presents a high performance 77 GHz FMCW radar sensor for automotive applications. Powerful automotive radar systems are currently under development for various applications. Radar sensor based comfort systems like Adaptive Cruise Control (ACC) are already available on the market. The main objective from a radar sensor point of view is to detect all targets inside the observation area and estimate target range and relative velocity simultaneously with a high update rate. FMCW radar sensors have the advantages of very high range resolution but a serious task occurs in multiple target situations to suppress so-called ghost targets. In classical FMCW waveforms this has been solved in using multiple chirp signals with different slope. But in this case a long measurement time (approximately 50 ms) is needed which is a contradiction to a high update rate. Therefore, in this paper a new waveform design is presented which has all advantages of FMCW radars but needs an extremely low measurement time (10 ms) in a radar sensor with 3 different antenna beams [C2965]

## "Concurrent polarization operation mode of location system"

Equipment for active location with optical and radar wave bands receives information on the object from the formation of sounding signals and the analysis of scattered signal. Radar systems are successfully used in monitoring environment, remote sensing of polarization characteristics, measurement of hydrometeor characteristics. Laser locators (lidars), on the basis of polarization measurements, allow one to estimate the characteristics of atmospheric aerosols, to control for atmospheric pollution. The high frequency of laser radiation

provides very narrow diagrams of lidar direction, the formation of impulse sounding signals of short duration and the following peculiarities: great time of the operating region review; strong weakening by atmosphere of the sounding laser radiations and those reflected from the target; most of the targets are spacially distributed. Superposition of radar and optical channels in a complex location system (CLS) allows one to avoid the limitation of each of the systems. The paper describes the concurrent polarization operation mode of a CLS system [C2966]

## "Potential and methodology of satellite based SAR for hazard mapping"

SAR and InSAR data have a high potential for change detection due to their "all weather" capability and the day/night access of the sensors. Here we investigate the potential and methodology for forest storm, flood, and avalanche mapping with ERS1/2 data. In our methodology process models are used to describe the targets before, during and/or after the hazard event. Very important are the good relative calibration and accurate coregistration of the different information layers. The presented results demonstrate the good potential of multitemporal SAR and InSAR data for hazard mapping [C2967]

## "Moving target detection by along-track interferometry"

In this paper we consider the detection of a moving point target using along-track (AT) InSAR systems. We consider two cases: conventionally and one bit coded raw data. The performance of the system is evaluated by comparing the probabilities of false alarm and detection [C2968]

## "Use of an adapted marine radar for the short-range detection and tracking of small birds in flight"

As part of a project to develop an inexpensive songbird tracking and identification system, we have modified the antenna system of a standard marine radar to estimate the three dimensional position of point targets. Although the radar formally gives only two coordinate parameters, we show how the Incorporation of other information about the targets allows estimation of the full three dimensional position. We present two independent methods for this estimation. We have used this system in several field experiments at Prince Edward Point, Picton County, Ontario, Canada, where we have tracked various targets including a C-130 Hercules aircraft (RCS = 11 m2) and 10-40g birds (RCS = 7-22 cm2). Target locations were verified using an array of acoustic receivers to provide an independent measure of location [C2969]

## "A study of judging target extinction in target tracking"

It is important for target tracking to judge targets' extinction in clutter environment. When a target is in clutter domain, the conventional method of sliding window detection cannot judge target extinction in the clutter domain appropriately, because it considers nothing but target existence probability in gate when a target is in clutter environment. To solve the problem, we propose a new target extinction judgement method which is determined by clutter density, target detection probability and target existence probability in gate. The effectiveness of the proposed method is confirmed through computer simulation [C2970]

## "A sequential detection method for moving targets under low SNR environments"

This paper proposes a moving target detection algorithm using the sequential detection approach. Radar target detection under low SNR (signal-to-noise ratio) environments is known as a highly difficult problem. To resolve these subjects, sequential detection algorithm using position and Doppler frequency measurements are proposed. Through several simulations, validity of this algorithm has been confirmed [C2971]

## "Reconstruction parameters of underground objects based on FDTD and optimization method"

The inverse of the parameters of underground targets is still highly in expectation in ground penetrating radar (GPR) applications. In this paper, the FDTD method and time-domain optimization algorithm have been used to reconstruct the permittivities of underground multiple targets. An iterative optimization algorithm has been put forward. The forward scattering data are also calculated by a 2.5 D-FDTD algorithm in order to better simulate the practical GPR situation. The relationship between the convergent rates of the inverse algorithm and the initialization values are studied [C2972]

## "A Kalman filter-based approach to detect landmines from metal detector data"

Metal detectors play a significant role in landmine detection. Automatic sensor fusion is required to improve the performance of ground penetrating radar (GPR)-metal detector multi-sensor systems. The existing version of the Kalman filter-based detection algorithm has been adapted for automatic detection and discrimination of

landmines in metal detector data. In this algorithm, multi-channel metal detector output data are fused to produce a distribution of probabilities of the presence or absence of a target. Performance of this algorithm has been assessed using data obtained by burying a number of simulant landmines, canonical targets and shrapnel in different soil types [C2973]

## "Reduction of cardinal effects in SAR imagery of densely populated urban areas by suppressing strong multiple returns"

In SAR imagery, strong returns from a group of man-made reflectors obscure adjacent target areas leading to a significant loss of information. The wide dynamic range of response levels from urban area is the source to degrade the SAR image characteristic. In this paper, we explore a way to interpret this problem in SAR imaging and propose a waveform design technique to improve target detection performance [C2974]

## "An advanced STAP implementation for surveillance radar systems"

Space-time adaptive processing (STAP) has emerged as a key technology for improving the performance of radar systems required to operate in the presence of severe and dynamic interference which generally includes clutter as well as jamming. While the theory of optimum STAP is well known, practical issues, such as interference heterogeneity, finite sample support, mismatched signal models and computational load, need to be overcome when it comes to implementing STAP in operational radar systems. This paper proposes an advanced STAP formulation which addresses important issues facing practical implementation and then tailors this general formulation for the case of interference rejection in over-the-horizon (OTH) radar to evaluate experimentally its target detection and localisation performance [C2975]

## "Feature discovery and sensor discrimination in a network of distributed radar sensors for target tracking"

A spatially distributed network of radar sensors is being used for target tracking and for generating a single integrated aerial picture (SIAP). In such a network generally each sensor sends whatever target track/association information it has to every other sensor. This has the disadvantage of requiring more communication bandwidth and processing power. One of the ways to reduce the communication bandwidth and the processing power is to discover features that would improve the target detection/track accuracy and activate those sensors that would provide the missing information and, form clusters of sensors that have consistent information. We describe a minimax entropy based technique for feature discovery and within class entropy based technique for feature/sensor discrimination. After discovering the features, those sensors that can provide the discovered features are activated. The decision based on the sensor discrimination is used in cluster formation. The experimental details and simulation results that are provided here indicate that these metrics are efficient in discovering features and in discriminating sensors. The techniques described are dynamic in nature-as it acquires information it is making a decision on whether it is from a good sensor in terms of consistency. This has the advantage of discarding non-valid information dynamically and making progressive decision [C2976]

## "Short range spectral lidar using mid-infrared semiconductor laser with code-division multiplexing technique"

Summary form only given. A short-range spectral lidar based on the code-division multiplexing (CDM) architecture using mid-infrared Sb semiconductor lasers for remote sensing has been demonstrated with near detector-limited performance. The system principle is similar to optical-CDMA for communications and applicable to any number of wavelengths, but was demonstrated with two wavelengths similarly to conventional DIAL (Powers et al, Appl. Opt. vol. 39, pp. 1440-1448, 2000; McRae and Kulp, Appl. Opt. vol. 32, pp. 4037-4050, 1993). An experiment using <20-mW transmitter average power could detect an open-air acetylene gas leak from 10 m away with dynamic, random, noncooperative backscatters. We believe this is among the first demonstrations of this semiconductor spectral lidar with orthogonal CDM architecture, as well as the first demonstration of mid-IR Sb lasers used in open path, noncooperative target remote sensing [C2977]

## "Target tracking with passive IR sensors"

A new practical solution for target tracking in air space with passive infrared (IR) sensors is presented. A suggested filter is based on an interacting multiple models (IMM) algorithm and angle-only measurements from passive missile sensors using point IR detectors [C2978]

## "Polynomial phase signal based detection of buried landmines using ground penetrating radar"

Put simply, the global landmine problem is massive. Ground penetrating radar (GPR) is just one engineering

solution currently being investigated. A polynomial amplitude-polynomial phase model is fitted to GPR returns. It is observed that the second order phase coefficient shows deviations from background-only levels when a buried target is present. A bootstrap-based detection scheme is proposed that tests for this change. The technique is applied to real GPR data, with encouraging results [C2979]

## "Signal processing techniques for clutter parameters estimation and clutter removal in GPR data for landmine detection"

Ground penetrating radar (GPR) has become widely accepted as a major technique for subsurface investigations, mainly in civil engineering. Considerable efforts are put in the development of GPR systems for the detection of shallow buried landmines. However, the GPR performs inadequately due to clutter, which dominates the data and obscures the mine information. The clutter varies with surface roughness and soil conditions and lead to uncertainty in the measurements. It is therefore necessary to overcome these surrounding effects when processing GPR data for detecting small, shallow buried objects. We present improved signal processing techniques which can be used to reduce the clutter through data preprocessing. Several approaches are proposed for the GPR clutter reduction techniques, most of them model the clutter statistically. The proposed clutter reduction technique models the clutter using parametric modeling. The clutter contained in the measurements is treated as an ARMA model. The advantage of such approach lies therein that once the clutter is satisfactorily known, any target will show up as a small anomaly in against the known clutter background. This method suggests that the clutter shows a certain amount of correlation. Experimentally it is shown that the dominant interference in GPR data is correlated clutter, i.e., interference, which has a large correlation coefficient for tags greater than zero. However, the clutter environment cannot be considered completely stationary. An ideal filter would then be an adaptive filter, which estimates the slowly varying local clutter parameters, all the time ignoring the small parameter jumps caused by the buried targets to be detected. Kalman filtering is used for the estimation of the clutter parameters in the presence of random noise, detects jumps that occur at unknown points in time, and provides estimates of the new parameter values, without altering the target return [C2980]

## "Fractal selection of artificial objects from radar images on inhomogeneous background"

In addition to radar images signatures, it is promising to use fractal signatures as informative and stable characteristic features providing efficient object identification. Target detection can be based on such features as a full fractal signature, its part or its slope. In this report, we focus on measurements of fractal characteristics of optic and radar image of natural objects and present results of computer simulations of detecting artificial objects observed against a background of fractal terrain [C2981]

## "Intelligent compression of SAR imagery using multiresolution Markov models"

We present a system for coding synthetic aperture radar (SAR) imagery, whereby regions of interest and background information are coded independently of each other. A multiresolution constant-false-alarm-rate (CFAR) detection scheme is utilized to discriminate between target regions and natural clutter. Based upon the detected target regions, we apply less compression to targets, and more compression to background data. This methodology preserves relevant features of targets for further analysis, and preserves the background only to the extent of providing contextual information. The resulting system dramatically reduces the bandwidth/storage requirements of the digital SAR imagery, while preserving the target-specific utility of the imagery [C2982]

## "Determining the importance of learning the underlying dynamics of sea clutter for radar target detection"

Existing evidence for and against sea clutter being chaotic and nonlinearly predictable is briefly discussed. Despite the uncertainty surrounding the chaotic nature of sea clutter, and its nonlinear predictability, the purpose of this paper is to examine what the best design criterion is for a nonlinear predictor which is to be used to detect targets against clutter which is known to be chaotic: mean square error performance or capturing the chaotic clutter's underlying dynamics. Single pulse detection analysis using a Swerling I target and chaotic "clutter" is carried out using predictor-based detectors in an attempt to determine which criterion is most suitable. The predictor detectors are compared with standard detection strategies [C2983]

## "Reduction of interference in automotive radars using multiscale wavelet transform"

A technique is presented to minimise false decisions in automotive radars operating in close proximity. The technique also reduces the requirement on the power of the radar as signals can be detected with very low signal to noise ratios. The signal processing is achieved in real time using a field programmable array [C2984]

## "Particle filter based detection for tracking"

We present a new method to perform detection and tracking of a possible target in noise. We perform tracking not on the basis of the standard measurements but on the raw radar video data. Detection then is based upon the a posteriori information, i.e., the probability density of the state given these past measurements (in this case video data). This way of data processing/tracking is also referred to as track before detect (TBD) for obvious reasons. An advantage of this method over classical tracking is that in this TBD approach the decision whether a target is present or not is based on integrated and kinematically correlated energy. This method is better suited for tracking weak targets in noise than the classical method. As this problem statement leads to a nonlinear non-Gaussian filtering problem classical filtering methods (e.g. Kalman filtering) will result in poor performance. A particle filter is used to deal with the nonlinearities and the non-Gaussian nature of the noise. The same particle filter output is also used to perform detection based on a likelihood ratio test [C2985]

## "Blind detection of targets from LADAR data"

We propose a method of blind detection of targets of defense interest from LADAR images. Each pixel of the image is represented by a feature vector computed from a co-occurrence matrix defined over a neighborhood of the pixel. Usual co-occurrence based features are modified to make them independent of gray-scale quantization and a new feature based on Weber's law of contrast perception is suggested. A set of 14 features are first computed and from there a set of 5 features are selected using a feature selection multilayer perceptron (FSMLP) network. A classifier is trained using only the selected features; we use a multilayered perceptron (MLP), but our system will work with almost any crisp or fuzzy classifier. For an image with unknown content, we then compute the five selected features for each pixel and assign a class label using the trained classifier. Then we find the dense regions in the image, that is, regions having high membership to the target class and declare each such dense region as a possible target. Our simulation results are quite encouraging [C2986]

## "A tomographic framework for LIDAR imaging"

Detection and localization of underwater mines remains a challenging and important problem for safe operation of naval platforms. A number of new technologies exploit airborne LIDARs, which can penetrate the air-water interface and optically detect and localize underwater mines. Such systems process the received optical field generated by scattering within the water column, and have proven to be an effective technology for mine detection and localization. We consider the use of multiple looks at a single target to form a three-dimensional representation of the scatterers within the water column. To form such images, we account for the integration within the receive sensors, and formulate the problem in a tomographic framework. We present preliminary image formation results generated from data collected at sea with a state-of-the-art navy mine imaging system [C2987]

## "Time-domain reconstruction of moderately rough dielectric interfaces via quasi-ray Gaussian beams"

The problem of determining the properties of rough surfaces from electromagnetic scattered field data arises in many importance subsurface sensing problems such as underground imaging using data from a ground penetrating radar (GPR). In GPR systems, arrays of above-ground transmitters and receivers illuminate areas of interest and receive backscattered signals from shallowly buried objects from surface reflections. The shape of the air-ground interface is unknown, and it is a principal corruptor of the backscattered signal from subsurface targets of interest. In order to enhance subsequent detection, classification and inverse scattering processing, it is important to compensate for the distortion introduced by the air-ground interface. As a first step toward this goal, we previously addressed the problem of estimating the profile of one-dimensional (1D) moderately rough dielectric interfaces from a limited number of multifrequency measurements under time-harmonic excitation. In this paper, we extend the approach to the case of time-dependent (short pulse) excitation. The proposed extension is based on a developed Gabor-based narrrow-waisted pulsed-beam representation of short-pulse scattering by moderately rough surfaces [C2988]

## "On the frequency-band selection for ground-penetrating radars operating over lossy and heterogeneous grounds"

The finite-difference time-domain (FDTD) method and the the perfectly-matched layer (PML) absorbing boundary conditions (ABCs) is applied to demonstrate the conductivity frequency relations in it three-dimensional ground-penetrating radar (GPR) problem involving lossy and heterogeneous ground. The selection of the center frequency of the source signal can influence the GPR measurements if these measurements are performed above a highly-conducting soil. However, since the skin depth of a typical ground model, with a conductivity value around 0.1 S/m, does not change rapidly, the enhancement of the target detection is not certain with the

alteration of the center frequency [C2989]

## "Millimeter-wave radar detection of partially obscured targets"

We demonstrate the ability of millimeter-wave (MMW) radars in detecting partially obscured targets. In addition, we introduce two techniques; the first is a data acquisition and processing technique aimed at resolving the obscured target from foliage. The second technique is a post-processing technique that can enhance target detection by reducing the polarimetric distortions incurred by the foliage on the target signature. The techniques are particularly advantageous to MMW radar mounted on land vehicles. The analysis is performed on radar data measured indoors of partially obscured canonical point targets [C2990]

## "Simulation of TRT-configured ground-penetrating radars over heterogeneous grounds"

The transmitter-receiver-transmitter (TRT) configuration of the ground-penetrating radar (GPR) is a powerful tool to degrade the large undesired signals that dominate the total-received signal. Ground inhomogeneities, especially the ones in the surface of the ground, influence the measurements. However, the signals scattered from the target are still observed at the receiver [C2991]

## "Mine detection under rough ground surfaces using 2-D FDTD modeling and hypothesis testing"

This paper attempts to investigate hypothesis test performance in mine detection, based on numerically simulating the wideband scattering of experimentally measured ground penetrating radar (GPR) signals by realistic, dispersive soil interfaces. We employ a 2D finite difference time domain (FDTD) method to analyze the delay and amplitude characteristics of ground-scattered waves as a function of roughness parameters. In addition, we apply binary hypothesis tests to the signals obtained using physics-based signal processing techniques to investigate the presence of the target at certain depth. We quantify the detection performance in terms of the spatial distribution of transmitter and receiver [C2992]

## "Bi-mode time-space multiplexing antenna array for multi-targets detection in automotive application"

A novel antenna array scheme BTSM is proposed where time-space multiplexing technology is used and advantages of panorama and detail modes are combined. Compared with conventional MAA, this array has high capability for multi-target detection, smaller size, lower cost and smaller computation. BTSM FMCW radar systems will allow lane prediction and the classification of objects, thus making possible the intelligent interpretation of traffic scenes [C2993]

## "Potential enhancements to the performance of ASDE radars derived from multistatic radar principles"

Airport surface surveillance systems, such as airport surface detection equipment (ASDE) radars, are susceptible to multipath propagation and scattering effects that can result in the placement of false targets located at critical locations on airport surfaces such as runways and taxiways. Such false targets can readily compromise the performance of these radars and lead to highly undesirable controller reactions, including unnecessarily aborting landing and takeoff operations when such multipath false targets are located on runways. These situations affect the efficiency of operations and also reduce user confidence in ASDE radar and related systems, thereby adversely affect safety. Evaluation of this problem led to consideration of enhancing ASDE radar performance by transforming the current monostatic radar to a multistatic configuration (ASDE-MP). Multistatic radar provides for multiple detection of targets as well as significant differential responses to the multipath scattering phenomenon responsible for false target detection. The latter property diminishes the detection of false targets by combining information from a number of radar receivers, positioned at different locations to provide surveillance over common areas of interest on the airport surface [C2994]

## "(Automatic) target detection in synthetic aperture radar imagery via terrain recognition"

Surveillance of large areas of the Earth's surface is often undertaken with low resolution synthetic aperture radar (SAR) imagery from either a satellite or a plane. There is a need to process these images with automatic target detection (ATD) algorithms. Typically the targets being searched for are vehicles or small vessels, which occupy only a few resolution cells. Simple thresholding is usually inadequate for detection due to the high amount of noise in the images. Often the background has a discernible texture, and one form of detection is to search for anomalies in the texture caused by the presence of the target pixels. To perform this task a texture model must be able to model a variety of textures at run time, and also model these textures well enough to detect anomalies. We accomplish this with our multiscale nonparametric Markov random field (MRF) texture model

[C2995]

## "Time-frequency analysis as a tool for improving neural detectors for low probability of false alarm"

This paper deals with the application of time-frequency analysis for transforming the received radar echoes in order to facilitate a neural network classification task. So as to compress the time-frequency representations maintaining most of the information, a feature extractor is designed. The proposed detector is compared with a single Multilayer Perceptron (MLP). The results show that time-frequency decompositions improve the performance of neural networks for slow fluctuating radar targets detection, specially for low values of Probability of False Alarm. The performance of the new detector is nearly independent on the Training-Signal-to-Noise-Ratio (TSNR) and the training initial conditions [C2996]

## "Implementation of radar CFAR-based target detection algorithm in a real-time multiprocessor environment"

The implementation of radar CFAR-based target detection algorithm in a real-time multiprocessor environment is presented. For this purpose, a radar extractor has been developed. Two digital signal processors (DSPs), installed on a target board are used, with a PC computer as a host. The complete detection algorithm is divided into two parts and is being executed in real-time on the target board. The results of target detection are reported to the host [C2997]

## "A microwave radio for Doppler radar sensing of vital signs"

A microwave radio for Doppler radar sensing of vital signs is described. This radio was developed using custom DCS1800/PCS1900 base station RFICs. It transmits a single tone signal, demodulates the reflected signal, and outputs a baseband signal. If the object that reflects the signal has periodic motion, the magnitude of the baseband output signal is directly proportional to the periodic displacement of the object. When the signal is reflected off a person's chest, this radio with appropriate baseband filters can detect heart and respiration rates from a distance as large as one meter from the target [C2998]

## "A wavelet packet basis optimization approach to radar waveform design"

We describe the process of convolving a transmitted wide bandwidth chirp signal with a simulated target and then show how the result of this convolution can be decomposed using a basis optimization approach algorithm. We then show how the wavelet packet basis set can prioritize the bandwidth in the chirp signal to those frequencies that represent the target while removing other frequencies that might contain clutter and noise. Finally we compare the resulting radar signal to the signal not prioritized by the basis optimization and show improvements in the detection performance of the target at the reduced bandwidth [C2999]

## "Fully-polarimetric ground penetrating radar application"

The ground penetrating radar (GPR) has broad applications in the fields of geology, civil engineering, archeology and military . It is usually used as a non-destructive inspection sensor for monitoring, inspecting and characterizing obscured objects by means of electromagnetic radiation, propagation and scattering. Unlike radars operated in the open air, the medium between the GPR and the target usually determines the performance instead of the target and the radar. The sensitivity of GPR applications is limited by clutter instead of noise or radar system. The increasing needs for better detection and discrimination capability have driven GPR users and researches to investigate the pattern and polarization characteristics of the GPR antenna designs. New GPR antenna designs were developed to provide improved sensitivity and stability. An example of fully-polarimetric GPR application that has not been seen previously is presented. Some important issues such as clutter sources, radiation patterns and propagation efficiency faced by the most GPR applications are also discussed [C3000]

## "Clutter adaptive tracking of multiaspect targets in IRAR imagery"

We present in this paper a clutter adaptive, multiframe Bayesian algorithm for joint detection and tracking of a multiaspect target in cluttered image sequences. The target template is randomly translated, rotated, scaled and sheared from frame to frame. Tracking performance studies with a sequence generated from real data infrared airborne radar (IRAR) imagery show a reduction in the steady-state position estimation error and in the target acquisition time when the Bayes detector/tracker is compared to the association of a bank of matched filter detectors and a linearized Kalman-Bucy tracker. [C3001]

## "Target-aided compression of SAR imagery for transmission over noisy wireless channels"

We present a target-aided, error-resilient system for coding synthetic aperture radar (SAR) imagery, whereby regions of interest and background information are coded independently of each other. A multiresolution constant-false-alarm-rate (CFAR) detection scheme is utilized to discriminate between target regions and natural clutter. Based upon the detected target regions, we apply less compression to targets, and more compression to background data. This methodology preserves relevant features of targets for further analysis, and preserves the background only to the extent of providing contextual information. The resilience to channel errors is obtained without the use of channel coding or error concealment techniques. The robust nature of the coder eliminates the appearance of impulsive channel-error-induced artifacts in the decoded imagery, while increasing the security level of the encoded bit stream. The proposed coder is evaluated in terms of target detection performance on the decoded SAR image for a wide variety of channel conditions and encoding bit rates. The resulting system dramatically reduces the bandwidth requirements of the digital SAR imagery, and is shown to provide outstanding performance in adverse channel conditions. [C3002]

### "Optimal transmit signal design for active sonar/radar"

This work is concerned with the optimization of an active sonar or radar transmit signal, to maximize the probability of detecting a nonmoving point target in the presence of signal-dependent reverberation and colored ambient noise whose power spectral densities are known. An analytical solution first reported by Kooij (1968) is corrected and extended. A simple example for the white ambient noise case is included to provide insight into the transmit signal optimization. This example shows that the effect of the solution is to "pre-emphasize" the transmit signal, which results in the whitening of the signal-dependent reverberation power spectral density. [C3003]

### "Bayesian optimum radar detector in non-Gaussian noise"

A theoretical expression of the optimum nonGaussian radar detector is derived from the non-Gaussian SIRP model (spherically invariant random process) clutter and a Bayesian estimator of the characteristic function of the SIRP. The SIRP model is used to perform coherent detection and to model the clutter as a complex Gaussian process whose variance is itself a positive random variable (r.v.). The PDF of the variance characterizes the statistics of the SIRP and after performing a Bayesian estimation of this PDF from reference clutter cells we derive the Bayesian optimum radar detector (BORD) and its statistical asymptotic form without any knowledge about the statistics of the clutter. We evaluate BORD performance for an unknown target signal embedded in K-distributed clutter and compare with optimum detectors performance (such as optimum K detector-OKD-in K-distributed clutter). [C3004]

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