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ТЕМАТИЧЕСКИЙ РЕФЕРАТИВНЫЙ СБОРНИК № 40-1

“Radar Phased Array”
(«РЛ фазированные антенные решётки»)

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"An Improved Quality-Guided Phase-Unwrapping Algorithm Based on Priority Queue"

Phase unwrapping is one of the key problems in reconstructing the elevation map of a scene from interferometric synthetic aperture radar or interferometric synthetic aperture sonar (InSAS) data. In this letter, an improved quality-guided phase-unwrapping algorithm is proposed, which depends on the quality value and its surrounding quality information to guide the path of unwrapping more accurately. In order to design highly efficient quality-guided algorithm, a guided map deduced from the quality map is introduced and taken as the new quality map which the quality-guided algorithm should completely depend on. A quantized quality-guided method is designed, which adopts the quantized new quality map and the priority queue designed to optimize the process of unwrapping. The quantized quality map establishes the relation between the quality values and the indexes of array, which can save the time of inserting one pixel into the priority queue according to its integral quality value. Priority queue keeps all the pixels by their quantized quality in a nondecreasing order by maintaining the doubly linked lists in an increasing order. An optimized strategy is used to accelerate the process of finding the pixel with the highest quality value in the priority queue. Tests performed on real InSAS data and simulated interferograms confirm the accuracy and efficiency of the proposed algorithm, and the improved algorithm is suitable for our real-time processing InSAS system. [J1]

"A Microphysics-Based Simulator for Advanced Airborne Weather Radar Development"

Incorporating dual-polarized operation and microphysics-based processing is becoming a challenge to future scientific and commercial airborne weather radars. This paper introduces a Monte Carlo simulation-based approach to address the theoretical basis and uncertainties of hydrometeor scattering along with sensor platform properties. Detailed characterizations of mixed-phase aviation hydrometeor hazards (rain, snow, hail, and mixtures) and the impact of melting on polarimetric radar signature at X-band frequency are discussed. A "single resolution cell" Monte Carlo dual-polarization variable simulation technique is described and then applied in different radar scanning scenarios based on numeric weather prediction model output weather fields. The produced dual-polarization signatures of an X-band array radar for different scan scenarios are analyzed. [J2]

"Bias Correction and Doppler Measurement for Polarimetric Phased-Array Radar"

This paper discusses ways to avoid and/or mitigate biases in polarimetric variables inherent to agile-beam planar phased-array radars. Two bias-avoiding schemes produce unbiased estimates of the polarimetric backscattering covariance matrix which are then combined into bias-free polarimetric variables. One concerns full polarimetric measurements and calls for adjusting the amplitudes and phases of the array elements so that the transmitted field equals that generated by a mechanically steered polarimetric weather radar antenna; this is followed by an additional adjustment of the received fields. The second scheme is also applicable to full polarimetric measurements but involves adjustments only of the received fields. Crucial to both schemes is decoupling of the Doppler effects from the terms of the covariance matrix. It is a significant part of the bias issue that had not been previously addressed. A scheme to reduce bias applicable to nondepolarizing media (i.e., diagonal backscattering matrix) is also addressed; it calls for multiplication of the fields received by each dipole as opposed to a combination of multiplication and addition required for full correction. The schemes are applied to the alternate transmission and simultaneous reception polarimetric mode and the simultaneous transmission and simultaneous reception mode. [J3]

"Mapping Three-Dimensional Surface Deformation by Combining Multiple-Aperture Interferometry and Conventional Interferometry: Application to the June 2007 Eruption of Kilauea Volcano, Hawaii"

Surface deformation caused by an intrusion and small eruption during June 17-19, 2007, along the East Rift Zone of Kilauea Volcano, Hawaii, was three-dimensionally reconstructed from radar interferograms acquired by the Advanced Land Observing Satellite (ALOS) phased-array type L-band synthetic aperture radar (SAR)

(PALSAR) instrument. To retrieve the 3-D surface deformation, a method that combines multiple-aperture interferometry (MAI) and conventional interferometric SAR (InSAR) techniques was applied to one ascending and one descending ALOS PALSAR interferometric pair. The maximum displacements as a result of the intrusion and eruption are about 0.8, 2, and 0.7 m in the east, north, and up components, respectively. The radar-measured 3-D surface deformation agrees with GPS data from 24 sites on the volcano, and the root-mean-square errors in the east, north, and up components of the displacement are 1.6, 3.6, and 2.1 cm, respectively. Since a horizontal deformation of more than 1 m was dominantly in the north-northwest-south-southeast direction, a significant improvement of the north-south component measurement was achieved by the inclusion of MAI measurements that can reach a standard deviation of 3.6 cm. A 3-D deformation reconstruction through the combination of conventional InSAR and MAI will allow for better modeling, and hence, a more comprehensive understanding, of the source geometry associated with volcanic, seismic, and other processes that are manifested by surface deformation. [J4]

"Classification of Tropical Vegetation Using Multifrequency Partial SAR Polarimetry"

This letter presents a case study addressing the comparison between different synthetic aperture radar (SAR) partial polarimetric options for tropical-vegetation cartography. These options include compact polarization (CP), dual polarization (DP), and alternating polarization (AP). They are all derived from fully polarimetric (FP) SAR data acquired by the airborne SAR (AIRSAR) sensor over the French Polynesian Tubuai Island. The classification approach is based on the support vector machine algorithm and is further validated by several ground surveys. For a single frequency band, FP data give significantly better results than any other partial polarimetric configuration. Among the partial polarimetric architectures, the CP mode performs best. In addition, the DP mode shows better performance than the AP mode, highlighting the value of the polarimetric differential phase. The combination of different frequency bands (P-, L-, and C-bands) holds the most significant improvement: The multifrequency diversity adds generally more information than the multipolarization diversity. A noticeable result is the major contribution of the C-band at VV polarization (the only polarization available at C-band with the AIRSAR data set used in this letter) to the classification performance, due to its ability to discriminate between Pinus and Falcata. [J5]

"Sparse Learning via Iterative Minimization With Application to MIMO Radar Imaging"

Through waveform diversity, multiple-input multiple-output (MIMO) radar can provide higher resolution, improved sensitivity, and increased parameter identifiability compared to more traditional phased-array radar schemes. Existing methods for target estimation, however, often fail to provide accurate MIMO angle-range-Doppler images when there are only a few data snapshots available. Sparse signal recovery algorithms, including many l1-norm based approaches, can offer improved estimation in that case. In this paper, we present a regularized minimization approach to sparse signal recovery. Sparse learning via iterative minimization (SLIM) follows an lq-norm constraint (for 0 <; q≤ 1), and can thus be used to provide more accurate estimates compared to the l1-norm based approaches. We herein compare SLIM, through imaging examples and examination of computational complexity, to several well-known sparse methods, including the widely used CoSaMP approach. We show that SLIM provides superior performance for sparse MIMO radar imaging applications at a low computational cost. Furthermore, we will show that the user parameter qcan be automatically determined by incorporating the Bayesian information criterion. [J6]

"Electromagnetic Land Surface Classification Through Integration of Optical and Radar Remote Sensing Data"

We present a nonhierarchical electromagnetic (EM) land surface classification method through the integration of satellite multispectral high-resolution optical and polarized radar images of central Alberta near the Saskatchewan border. We implement a conventional supervised land surface classification method and a principal component analysis to a QuickBird image. The EM properties are then assigned to the classified surfaces to produce hierarchical EM land classification maps. To further classify a hierarchical EM surface (i.e., dielectric constant), we calculate the root-mean-square surface height with a Shuttle Radar Topography Mission 3-arc-second digital elevation model and the temperatures from a thermal band of a Landsat-5 Thematic Mapper image. We also calculate the backscattering coefficients from the Advanced Land Observing Satellite Phased Array L-band Synthetic Aperture Radar image. Using these estimated values, we calculate the intrinsic weighting factors with the Dubois (1995) model for less vegetated land areas and the Ulaby (1986) model for open water areas. By applying these weighting factors to the hierarchical EM surface, we generate a nonhierarchical higher resolution EM surface map of the study area. [J7]

"A Signal Level Simulator for Multistatic and Netted Radar Systems"

Efficient analysis of modern multistatic and netted radar systems requires a new generation of dedicated radar simulation software. Key requirements for such software are simulation accuracy and flexibility in choosing system parameters. In this paper, algorithms for the simulation of raw radar return signals are presented based on interpolation and modification of the transmitted signal and modelling of the radar hardware and environment. This method supports simulation of pulsed and CW systems; monostatic, multistatic, and netted systems; phased-array radars; and most physically realizable radar system configurations. [J8]

"Signal Modeling and Analysis of a Planar Phased-Array FMCW Radar With Antenna Switching"

A frequency-modulated continuous-wave (FMCW) radar system with a planar phased array based on antenna switching is considered. The radar system consists of N_{1}linear antenna arrays where each linear antenna array consists of N_{2}receiving antennas. In each cycle, the receiving antennas on each linear antenna array are switched to the single receiving channel in turn from the first antenna to the N_{2}th antenna. An accurate and detailed system model for the radar system is addressed. The Cramйr-Rao lower bound (CRLB) analysis on the accuracy of estimating the azimuth angle, elevation angle, velocity, and range using the radar system is presented. [J9]

"Through-Wall Opportunistic Sensing System Utilizing a Low-Cost Flat-Panel Array"

A UWB through-wall imaging system is proposed based on a planar low profile aperture array operating from 0.9 GHz to 2.3 GHz. The goal is to provide a lightweight, fixed array to serve as an alternative to synthetic aperture radars (SAR) that require continuous array movement while collecting data. The proposed system consists of 12 dual-linear printed elements arranged within a triangular lattice, each forming a "flower" shape and backed by a ground plane. The array delivers half-space radiation with wideband performance, necessary for imaging applications. UWB capability is realized by suppressing grating lobes via the introduction of virtual phase centers interwoven within the actual array feeds. The proposed system is demonstrated for through-wall imaging via a non-coherent process. Distinctively, several coherent images are forged from various fixed aperture locations (referred to as "snapshot" locations) and appropriately combined to create a composite scene image. In addition to providing a unique wideband imaging capability (as an alternative to SAR), the system is portable and inexpensive for collecting/storing scattering data. The array design and data collection system is described, and several through-wall images are presented to demonstrate functionality. [J10]

"Phased-MIMO Radar: A Tradeoff Between Phased-Array and MIMO Radars"

We propose a new technique for multiple-input multiple-output (MIMO) radar with colocated antennas which we call phased-MIMO radar. The new technique enjoys the advantages of the MIMO radar without sacrificing the main advantage of the phased-array radar which is the coherent processing gain at the transmitting side. The essence of the proposed technique is to partition the transmit array into a number of subarrays that are allowed to overlap. Then, each subarray is used to coherently transmit a waveform which is orthogonal to the waveforms transmitted by other subarrays. Coherent processing gain can be achieved by designing a weight vector for each subarray to form a beam towards a certain direction in space. Moreover, the subarrays are combined jointly to form a MIMO radar resulting in higher angular resolution capabilities. Substantial improvements offered by the proposed phased-MIMO radar technique as compared to the phased-array and MIMO radar techniques are demonstrated analytically and by simulations through analyzing the corresponding beam patterns and the achievable output signal-to-noise-plus-interference ratios. Both analytical and simulation results validate the effectiveness of the proposed phased-MIMO radar. [J11]

"Source Localization and Sensing: A Nonparametric Iterative Adaptive Approach Based on Weighted Least Squares"

Array processing is widely used in sensing applications for estimating the locations and waveforms of the sources in a given field. In the absence of a large number of snapshots, which is the case in numerous practical applications, such as underwater array processing, it becomes challenging to estimate the source parameters accurately. This paper presents a nonparametric and hyperparameter, free-weighted, least squares-based iterative adaptive approach for amplitude and phase estimation (IAA-APES) in array processing. IAA-APES can work well with few snapshots (even one), uncorrelated, partially correlated, and coherent sources, and arbitrary array geometries. IAA-APES is extended to give sparse results via a model-order selection tool, the Bayesian information criterion (BIC). Moreover, it is shown that further improvements in resolution and accuracy can be achieved by applying the parametric relaxation-based cyclic approach (RELAX) to refine the IAA-APES&BIC estimates if desired. IAA-APES can also be applied to active sensing applications, including single-input single-output (SISO) radar/sonar range-Doppler imaging and multi-input single-output (MISO) channel estimation for communications. Simulation results are presented to evaluate the performance of IAA-APES for all of these

applications, and IAA-APES is shown to outperform a number of existing approaches. [J12]

"GMTI clutter cancellation using real non-ideal data"

The performance of displaced phase centre antenna (DPCA), adaptive DPCA (ADPCA) and joint domain localised space time adaptive processing (JDL-STAP) was examined when applied to data that were not gathered for ground moving target indication (GMTI) purposes, and using very few array elements. Three different methods to be applied at the pre-processing stage to match pulses from different spatial channels were compared. The ADPCA method was shown to be the most robust in the presence of signals leaked from other range cells while traditional DPCA proved to be the most effective at attenuating stationary targets in non-ideal conditions, providing that pre-processing, using a pulse shift and a ramp in phase, was applied to the data. Quantitative results are presented, which are drawn from real experiments using real airborne radar data and which provide a valuable insight into the tolerance of DPCA, ADPCA and STAP when put to use with few spatial channels on non-ideal data. The study shows that all three GMTI algorithms used with few antenna elements can successfully resolve moving targets from clutter in such data and discusses the limitations of each in suppressing unwanted stationary peaks. [J13]

"Measurement of Ionospheric TEC in Spaceborne SAR Data"

The propagation of spaceborne radar signals operating at L-band frequency or below can be seriously affected by the ionosphere. At high states of solar activity, Faraday rotation (FR) and signal path delays disturb radar polarimetry and reduce resolution in range and azimuth. While these effects are negligible at X-band, FR and the frequency-dependent path delays can become seriously problematic starting at L-band. For quality assurance and calibration purposes, existing L-band or potential spaceborne P-band missions require the estimation of the ionospheric state before or during the data take. This paper introduces two approaches for measuring the ionospheric total electron content (TEC) from single-polarized spaceborne SAR data. The two methods are demonstrated using simulations. Both methods leverage knowledge of the frequency-dependent path delay through the ionosphere: The first estimates TEC from the phase error of the filter mismatch, while the second gauges path-delay differences between up and down chirps. FR, mean (direct current) offsets, and noise contributions are also considered in the simulations. Finally, possibilities for further methodological improvements are discussed. [J14]

"MIMO-OFDM radar for direction estimation"

Multiple-input-multiple-output (MIMO) radar makes use of orthogonal signals to obtain the phase delay for each transmitting/receiving antenna pair, and thus increasing the accuracy of direction estimation. The previously proposed MIMO radar assumes narrowband signals that guarantee the waveform orthogonality during the signals- transmission, propagation and reception. However, a narrowband system is unstable in target localisation because of the fluctuation of the target-s radar cross section. An MIMO-OFDM radar is proposed for target localisation. It adopts the OFDM technique to simultaneously transmit and receive a set of multiple narrowband orthogonal signals at orthogonal frequencies. A practical model accommodating a physical target is presented to simulate the MIMO-OFDM radar. As an example, a composite target composed of five infinite dielectric cylinders is localised by a four-element uniform linear array. The performance of the MIMO-OFDM radar is investigated by examining the estimation error for different numbers of sub-bands, different signal-to-noise ratios and different target directions. It is demonstrated by simulation that the MIMO-OFDM radar gives more statistically stable estimation by spreading the signal power over a wider spectrum. [J15]

"Recently Published Books [JBook/Software Reviews]"

This listing is intended to bring to the attention of the readers a sample of some recently published books within the field of interest of IEEE Microwave Magazine. For information on submissions, contact the column editor at m.gupta@ieee.org. [J16]

"MMIC-Based Quadrature Hybrid Quasi-Circulators for Simultaneous Transmit and Receive"

This paper presents a new type of monolithic microwave integrated circuit (MMIC)-based active quasi-circulator using phase cancellation and combination techniques for simultaneous transmit and receive (STAR) phased-array applications. The device consists of a passive core of three quadrature hybrids and active components to provide active quasi-circulation operation. The core of three quadrature hybrids can be implemented using Lange couplers. The device is capable of high isolation performance, high-frequency operation, broadband performance, and improvement of the noise figure (NF) at the receive port by suppressing transmit noise. For passive quasi-circulation operation, the device can achieve 35-dB isolation between the transmit and receive port with 2.6-GHz bandwidth (BW) and insertion loss of 4.5 dB at X-band. For active quasi-operation, the device

is shown to have 2.3-GHz BW of 30-dB isolation with 1.5-dB transmit-to-antenna gain and 4.7-dB antenna-to-receive insertion loss, while the NF at the receive port is approximately 5.5 dB. The device is capable of a power stress test up to 34 dBm at the output ports at 10.5 GHz. For operation with typical 25-dB isolation, the device is capable of operation up to 5.6-GHz BW at X-band. The device is also shown to be operable up to W-band by simulation with ~15-GHz BW of 20-dB isolation. The proposed architecture is suitable for MMIC integration and system-on-chip applications. [J17]

"Experimental Verification of SAR-GMTI Improvement Through Antenna Switching"

Recently, theoretical investigations have shown that switching between parts of the transmit and/or receive aperture in a pulse-to-pulse cycle may improve the ground moving target indication (GMTI) performance of a two-channel radar system. This paper intends to verify these findings experimentally for the switching concept for the first time. Accordingly, six different GMTI modes were implemented in the system PAMIR (phased-array multifunctional imaging radar) of the Fraunhofer Institute for High Frequency Physics and Radar Techniques (Fraunhofer FHR) including three switching modes. An experiment was conducted using six cooperative vehicles following a predefined scenario to compare the GMTI performance and, in particular, the positioning accuracy of the different GMTI modes. The results of this experiment as well as the underlying signal processing are presented in this paper. The analysis is based on a multilook constant false-alarm rate detection scheme. Due to the heterogenous nature of the considered scene, the well-known test statistic for homogeneous terrain had to be extended accordingly, and a novel test statistics is proposed. [J18]

"Design and Performance of a 24-GHz Switch-Antenna Array FMCW Radar System for Automotive Applications"

We develop a 24-GHz switch-antenna array frequency-modulated continuous-wave (FMCW) radar system composed of a single transmitter, a single transmitting antenna, four receiving antennas, a single-pole four-throw (SP4T) switch, and a single receiving channel. The antennas are integrated with radio-frequency (RF) and intermediate-frequency (IF) circuits to reduce the interconnection loss and realize a compact whole size. The receiving antennas are periodically switched to the single receiving channel. The performance of the developed system is evaluated using beamforming methods to estimate the angle, range, and velocity. [J19]

"Bistatic SAR Experiments With PAMIR and TerraSAR-X-Setup, Processing, and Image Results"

The spatial separation of the transmitter and the receiver in bistatic synthetic aperture radar (SAR) enables a variety of data acquisition geometries to achieve benefits like the increased information content of bistatic SAR data. In the case of hybrid bistatic SAR constellations where the transmitter is spaceborne and the receiver is onboard an aircraft, one has to deal with a huge discrepancy between platform velocities. This paper presents bistatic spaceborne/airborne SAR experiments, where the radar satellite TerraSAR-X is used as a transmitter and the airborne SAR sensor Phased Array Multifunctional Imaging Radar (PAMIR) of the Fraunhofer Institute for High Frequency Physics and Radar Techniques (FHR) is used as a receiver. Both sensors are equipped with phased-array antennas, which offer the possibility of beam steering and could be used for the first time for the "double sliding spotlight mode." In this mode, the space- and airborne sensors operate with different sliding factors (ratio between footprint and platform velocity). The performance of two different experiments is analyzed, and the novel double sliding spotlight mode is presented. This paper describes the experimental setups, the synchronization system, and the data acquisition. The image results were processed by a modified backprojection algorithm and a frequency-domain algorithm. The analysis of the final bistatic images comprises the spatial resolution and the scattering behavior of selected objects. Parts of the bistatic SAR images are compared with the corresponding monostatic images of PAMIR and TerraSAR-X. It will be shown that hybrid bistatic SAR is a worthwhile and helpful addition to current monostatic SAR. [J20]

"Topographic Correction for ALOS PALSAR Interferometry"

L-band synthetic aperture radar (SAR) interferometry is very successful for mapping ground deformation in densely vegetated regions. However, due to its larger wavelength, the capacity to detect slow deformation over a short period of time is limited. Stacking and small baseline subset (SBAS) techniques are routinely used to produce time series of deformation and average deformation rates by reducing the contribution of topographic and atmospheric noise. For large sets of images that are presently available from C-band European Remote Sensing Satellites (ERS-1/2) and Environmental Satellite (ENVISAT), the standard stacking and SBAS algorithms are accurate. However, the same algorithms are often inaccurate when used for processing of interferograms from L-band Advanced Land Observing Satellite Phased Array type L-band SAR (ALOS PALSAR). This happens because only a limited number of interferograms is acquired and also because of large spatial baselines often correlated with the time of acquisition. In this paper two techniques are suggested that can be used for removing

the residual topographic component from stacking and SBAS results, thereby increasing their accuracy. [J21]

"Fundamental Limit of Sample Generalized Eigenvalue Based Detection of Signals in Noise Using Relatively Few Signal-Bearing and Noise-Only Samples"

The detection problem in statistical signal processing can be succinctly formulated: given m (possibly) signal bearing, n -dimensional signal-plus-noise snapshot vectors (samples) and Nstatistically independent n-dimensional noise-only snapshot vectors, can one reliably infer the presence of a signal? This problem arises in the context of applications as diverse as radar, sonar, wireless communications, bioinformatics, and machine learning and is the critical first step in the subsequent signal parameter estimation phase. The signal detection problem can be naturally posed in terms of the sample generalized eigenvalues. The sample generalized eigenvalues correspond to the eigenvalues of the matrix formed by ?whitening? the signal-plus-noise sample covariance matrix with the noise-only sample covariance matrix. In this paper, we prove a fundamental asymptotic limit of sample generalized eigenvalue-based detection of signals in arbitrarily colored noise when there are relatively few signal bearing and noise-only samples. Specifically, we show why when the (eigen) signal-to-noise ratio (SNR) is below a critical value, that is a simple function of n, m, and N, then reliable signal detection, in an asymptotic sense, is not possible. If, however, the eigen-SNR is above this critical value then a simple, new random matrix theory-based algorithm, which we present here, will reliably detect the signal even at SNRs close to the critical value. Numerical simulations highlight the accuracy of our analytical prediction, permit us to extend our heuristic definition of the effective number of identifiable signals in colored noise and display the dramatic improvement in performance relative to the classical estimator by Zhao We discuss implications of our result for the detection of weak and/or closely spaced signals in sensor array processing, abrupt change detection in sensor networks, and clustering methodologies in machine learning. [J22]

"A 44-GHz SiGe BiCMOS Phase-Shifting Sub-Harmonic Up-Converter for Phased-Array Transmitters"

A compact 44-GHz phase-shifting direct up-conversion transmitter for phased-array transmitters, based on a doubled local oscillator (LO) phase-shifting approach, is fabricated in a 0.18-??m silicon germanium BiCMOS process. The upconverter includes a frequency doubler, an LO phase shifter, double balanced mixers, and an output driver. The upconverter has a conversion gain of 18 dB and continuous 360?? phase shift with a baseband in-phase/quadrature bandwidth of 1 GHz. Its maximum RF output power is -1.7 dBm in a 50-?? load with a total current consumption of 180 mA from a 4.4-V power supply. The active area is 940 ?? 700 ??m2. [J23]

"The Phased Array Is the Maximum SNR Active Array [JLecture Notes]"

Active arrays are widely used in many sensing applications, including radar, sonar, and medical imaging. It is often stated without proof that the phased array maximizes the SNR at a given focal point over the class of possible active arrays. The proof here of this statement, under various conditions, provides new insight into the use of active arrays in diverse sensing applications. Courses that may benefit from this article include array signal processing, radar, sonar, and medical imaging. [J24]

"Reduced-Rank STAP Schemes for Airborne Radar Based on Switched Joint Interpolation, Decimation and Filtering Algorithm"

In this paper, we propose a reduced-rank space-time adaptive processing (STAP) technique for airborne phased array radar applications. The proposed STAP method performs dimensionality reduction by using a reduced-rank switched joint interpolation, decimation and filtering algorithm (RR-SJIDF). In this scheme, a multiple-processing-branch (MPB) framework, which contains a set of jointly optimized interpolation, decimation and filtering units, is proposed to adaptively process the observations and suppress jammers and clutter. The output is switched to the branch with the best performance according to the minimum variance criterion. In order to design the decimation unit, we present an optimal decimation scheme and a low-complexity decimation scheme. We also develop two adaptive implementations for the proposed scheme, one based on a recursive least squares (RLS) algorithm and the other on a constrained conjugate gradient (CCG) algorithm. The proposed adaptive algorithms are tested with simulated radar data. The simulation results show that the proposed RR-SJIDF STAP schemes with both the RLS and the CCG algorithms converge at a very fast speed and provide a considerable SINR improvement over the state-of-the-art reduced-rank schemes. [J25]

"AMSAR-A European success story in AESA radar"

DGA, BWB and D&ES initiated a radar programme, called AMSAR (Airborne Multi-role Solid-state Active-array

Radar) to demonstrate the enormous potential of Active Electronically Scanned Array (AESA) radar. This describes all stages of the AMSAR project and the results obtained. The AMSAR demonstrator is still the only European, forward-looking multi-channel active array radar with the capability of recording the outputs of more than 4 quadrants. [J26]

"Radiation From Rectangular Waveguide-Fed Fractal Apertures"

We investigate the properties of fractal apertures fed by a rectangular waveguide. The self-similarity and space-filling properties of fractals have been exploited to achieve multi-band radiation. Some self-affine fractal geometries, suitable for waveguide-fed apertures, have been proposed and investigated. It is shown that the scale factor of the fractal geometry can be used as a design parameter for controlling the resonant frequencies. The problem has been solved using method of moments (MoM) and the numerical results are verified through simulation on HFSS and experimental measurements. [J27]

"The TerraSAR-X Satellite"

TerraSAR-X is a versatile synthetic aperture radar (SAR) satellite with active phased array antenna technology and represents the backbone of the German national radar Earth observation mission. With its large variety of different SAR imaging modes and its high operational flexibility, TerraSAR-X ideally serves the scientific community and users from the industrial sector and governmental institutions. The innovative satellite system design combines the rich experience from past German and European SAR space missions like X-SAR, SRTM, ERS 1 and 2, and Envisat combined with state-of-the-art Earth observation bus technology as used, e.g., on the CHAMP and GRACE satellites. [J28]

"Final TerraSAR-X Calibration Results Based on Novel Efficient Methods"

TerraSAR-X is a satellite mission for scientific and commercial applications operating a highly flexible X-band synthetic aperture radar (SAR) instrument with a multitude of different operation modes. As product quality is of crucial importance, the success or failure of the mission depends essentially on the method of calibrating TerraSAR-X in an efficient way during commissioning the entire system in a restricted time. Only then, product quality and the correct in-orbit operation of the entire SAR system can be ensured. This paper describes the in-orbit calibration method for TerraSAR-X and dedicated activities performed during the commissioning phase as well as final results derived from all calibration procedures. [J29]

"Advanced Land Observing Satellite (ALOS) and Monitoring Global Environmental Change"

The Advanced Land Observing Satellite (ALOS) was developed for detailed observation of the Earth's surface and frequent monitoring of global environmental changes, using high-resolution optical (visible and near infrared push-broom) and active microwave sensors (L-band synthetic aperture radar). ALOS has four mission objectives: cartography, regional observations, disaster observations, and resource exploration. It has been operational since its launch in January 24, 2006, and is acquiring a large amount of land-surface data supported by the Ka-band intersatellite communication system that downlinks to ground receiving stations. A global systematic acquisition strategy is implemented for all three sensors to enable consistent data collection over all land areas on a repetitive basis. Through its three sensors, acquisition strategy, and communication infrastructure, the ALOS mission is aimed to contribute to monitoring water, carbon, and global climate change. In this paper, we describe ALOS and its contribution to global environmental monitoring. [J30]

"On a Novel Approach Using MLCC and CFAR for the Improvement of Ship Detection by Synthetic Aperture Radar"

Multilook cross correlation (MLCC) is a useful technique in extracting the images of ships embedded in heavy sea clutter by synthetic aperture radar (SAR). In the ship detection experiment in 2006 by Phased Array L-band Synthetic Aperture Radar (PALSAR) on board the Advanced Land Observing Satellite, we applied MLCC to PALSAR data in order to extract small fishing boats. The result was that some boats were detected by thresholding MLCC coherence images under favorable conditions. However, it was also found that the threshold method was not suitable to automatically determine the threshold levels corresponding to the desired false alarm rate (FAR) values. In order to overcome this problem and to improve the accuracy of ship detection by MLCC, we propose a new and simple technique of MLCC-constant FAR (CFAR) or gamma-CFAR. In this method, CFAR is applied to interlook coherence images produced by MLCC. We tested this method using simulation and PALSAR data and then found out substantial improvement in signal-to-noise ratio and FAR in comparison with the coherence image alone. In this letter, we summarize the MLCC-CFAR algorithm and the experimental results. [J31]

"The Periodic Half-Width Microstrip Leaky-Wave Antenna With a Backward to Forward Scanning Capability"

The periodic half-width microstrip leaky wave antenna (MLWA) with a backward to forward scanning capability is presented in this paper. The proposed antenna consists of a series of half-width MLWA. The radiating periods place on the different sides of the transmission line. The radiating period works in cutoff region of the first higher order mode, the periodic construction radiates the slow wave out along the edge. The experimental results show the main lobe scans electronically and continuously from 149?? to 28?? in H-plane (y-zplane) toward end fire (+ zdirection) when the operating frequency increases from 4.2-.9 GHz. [J32]

"TerraSAR-X Instrument Calibration Results and Extension for TanDEM-X"

Spaceborne remote sensing with synthetic aperture radar (SAR) has become an essential source of high-resolution and continuous Earth observation. Modern satellites like the German TerraSAR-X system provide state-of-the-art radar images with respect to operating flexibility and imaging quality. The outstanding performance of TerraSAR-X image products is achieved by an innovative calibration approach that minimizes systematic antenna and instrument characteristics. The active phased array X-band antenna is fed by 384 transmit/receive modules for electronic beam steering and shaping in the azimuth and elevation direction. The flexible radar instrument hosts an internal calibration system which guarantees the high radiometric stability of all SAR products. New techniques for antenna performance control have been successfully implemented, setting a high standard for next-generation SAR missions. This paper summarizes all essential calibration results of TerraSAR-X that cover internal instrument behavior. Furthermore, we give an outlook on the required bistatic calibration techniques for the future TanDEM-X mission that faces additional performance challenges when calibrating two TerraSAR-X satellites flying in close formation. [J33]

"First Analysis of TerraSAR-X Along-Track InSAR-Derived Current Fields"

We present the first analysis of surface current fields derived from TerraSAR-X along-track interferometric synthetic aperture radar (along-track InSAR, ATI) data. The images were acquired over the mouth of the Elbe river (Germany) during six satellite overpasses in spring and summer 2008, using the experimental "aperture switching" mode of TerraSAR-X. In this mode, the phased-array synthetic aperture radar (SAR) antenna is split into two halves for receiving, but in contrast to the "dual receive antenna" mode, which uses two independent receivers in parallel, a single receiver is multiplexed to process signals from the two antenna halves in an alternating manner at a doubled pulse repetition frequency. The effective ATI baseline is on the order of 0.8 m. The SAR/ATI raw data processing is described in another paper in this issue. This paper focuses on the conversion of the basic interferograms into line-of-sight surface current fields, which includes an elimination of ship signatures, identification, and correction (as far as possible) of imaging artifacts, additional filtering and smoothing, and a subtraction of contributions of wave motions to detected velocities according to a theoretical model. We evaluate the quality of the results by comparison with current fields from a numerical flow model and with available in situdata. The ATI performance of TerraSAR-X is found to be basically consistent with theoretical expectations. After applying the same data processing algorithms to all six images, mean differences between TerraSAR-X-derived currents and reference currents in our main test area range from -0.11 to + 0.08 m/s in five of the six cases with one outlier at +0.42 m/s. The spatial current variations within the TerraSAR-X-derived current fields are consistent with the model in three cases, but unrealistically strong variations across the images are found in the other three cases. We attribute this to shortcomings of our preliminary raw data processi--ng algorithms, which can probably be fixed after some more detailed analysis and testing. The results obtained so far encourage us to believe that our internal performance goal of a typical current measuring accuracy of 0.1 m/s at an effective spatial resolution better than 1 km can be met. [J34]

"Optical Millimeter-Wave Signal Generation Via Frequency 12-Tupling"

This work demonstrates the feasibility of optical millimeter-wave signal generation using frequency 12-tupling. Optical millimeter-wave signal with two sixth-order optical sidebands are generated using frequency quadrupling optical millimeter-wave generation along with optical four-wave-mixing. 210- and 120-GHz two-tone optical signals with optical carrier and undesired harmonic distortion suppression ratios of 20 and 30 dB are experimentally demonstrated. The proposed system provides an attractive method for millimeter-wave applications such as optical up-conversion in radio-over-fiber (RoF) communication systems at millimeter-wave band, phase-array antennas, optical sensors, radars, and tera-hertz applications. [J35]

"Fore and Aft Channel Reconstruction in the TerraSAR-X Dual Receive Antenna Mode"

The TerraSAR-X satellite is a high-resolution synthetic aperture radar (SAR) system launched in June 2007

which provides the option to split the antenna in along-track direction and sample two physical channels separately. Modern SARs are equipped with active phased array antennas and multiple channels. In order to keep costs low, TerraSAR-X uses the redundant receiver unit for the second channel such that fore and aft channel signals are combined by a hybrid coupler to form sum and difference channel data. The dual receive antenna (DRA) mode can either be used to acquire along-track interferometric data or to acquire signals with different polarizations at the same time (Quad-Pol). Fore and aft channel reconstruction is necessary if ground moving target indication (GMTI) algorithms such as the displaced phase center antenna technique or along-track interferometry shall be applied, and in order to separate the horizontally and vertically polarized received signal components. The proposed approach uses internal calibration pulses from different calibration beams in order to estimate and compensate the hardware impact. The theoretical framework together with the results from the experimental data evaluation for the fore and aft channel reconstruction of the TerraSAR-X DRA mode are presented. The impact of the receive hardware transformation matrix estimation accuracy on errors in the reconstructed fore and aft channel image data is studied, and first examples on the GMTI capability of the TerraSAR-X DRA mode are given. [J36]

"Time Reversal in Multiple-Input Multiple-Output Radar"

Time reversal explores the rich scattering in a multipath environment to achieve high target detectability. Multiple-input multiple-output (MIMO) radar is an emerging active sensing technology that uses diverse waveforms transmitted from widely spaced antennas to achieve increased target sensitivity when compared to standard phased arrays. In this paper, we combine MIMO radar with time reversal to automatically match waveforms to a scattering channel and further improve the performance of radar detection. We establish a radar target model in multipath rich environments and develop likelihood ratio tests for the proposed time-reversal MIMO radar (TR-MIMO). Numerical simulations demonstrate improved target detectability compared with the commonly used statistical MIMO strategy. [J37]

"Transmit Subaperturing for MIMO Radars With Co-Located Antennas"

We present a transmit subaperturing (TS) approach for multiple-input multiple-output (MIMO) radars with co-located antennas. The proposed scheme divides the transmit array elements into multiple groups, each group forms a directional beam and modulates a distinct waveform, and all beams are steerable and point to the same direction. The resulting system is referred to as a TS-MIMO radar. A TS-MIMO radar is a tunable system that offers a continuum of operating modes from the phased-array radar, which achieves the maximum directional gain but the least interference rejection ability, to the omnidirectional transmission based MIMO radar, which can handle the largest number of interference sources but offers no directional gain. Tuning of the TS-MIMO system can be easily made by changing the configuration of the transmit subapertures, which provides a direct tradeoff between the directional gain and interference rejection power of the system. The performance of the TS-MIMO radar is examined in terms of the output signal-to-interference-plus-noise ratio (SINR) of an adaptive beamformer in an interference and training limited environment, where we show analytically how the output SINR is affected by several key design parameters, including the size/number of the subapertures and the number of training signals. Our results are verified by computer simulation and comparisons are made among various operating modes of the proposed TS-MIMO system. [J38]

"Iterative Adaptive Approaches to MIMO Radar Imaging"

Multiple-input multiple-output (MIMO) radar can achieve superior performance through waveform diversity over conventional phased-array radar systems. When a MIMO radar transmits orthogonal waveforms, the reflected signals from scatterers are linearly independent of each other. Therefore, adaptive receive filters, such as Capon and amplitude and phase estimation (APES) filters, can be directly employed in MIMO radar applications. High levels of noise and strong clutter, however, significantly worsen detection performance of the data-dependent beamformers due to a shortage of snapshots. The iterative adaptive approach (IAA), a nonparametric and user parameter-free weighted least-squares algorithm, was recently shown to offer improved resolution and interference rejection performance in several passive and active sensing applications. In this paper, we show how IAA can be extended to MIMO radar imaging, in both the negligible and nonnegligible intrapulse Doppler cases, and we also establish some theoretical convergence properties of IAA. In addition, we propose a regularized IAA algorithm, referred to as IAA-R, which can perform better than IAA by accounting for unrepresented additive noise terms in the signal model. Numerical examples are presented to demonstrate the superior performance of MIMO radar over single-input multiple-output (SIMO) radar, and further highlight the improved performance achieved with the proposed IAA-R method for target imaging. [J39]

"Automatic Extraction of Traffic Flows Using TerraSAR-X Along-Track Interferometry"

Spaceborne synthetic aperture radar (SAR) offers great potential for the measurement of ground traffic flows. A SAR with multiple receiving apertures aligned in flight direction repeatedly images the same ground area with a short time lag. This allows for an effective detection of moving ground objects, whose range variation translates into an interferometric phase signal between the receiving channels. The high-resolution German SAR satellite TerraSAR-X offers several ways to create multiple along-track apertures. We exploit this to demonstrate satellite-based traffic-flow measurements using along-track interferometry (ATI) and Displaced Phase Center Array techniques. In this paper, we address the usage of different TerraSAR-X ATI modes for data acquisition and describe an automatic near-real-time processing chain for the extraction of traffic information. The performance of this TerraSAR-X traffic processor is significantly driven by incorporating a prioriknowledge of road networks. We present examples of automatic traffic detection as well as empirical evaluations thereof using different kind of reference data. [J40]

"Minimum Entropy via Subspace for ISAR Autofocus"

In this letter, a novel approach to autofocus for inverse synthetic aperture radar (ISAR) imaging called minimum entropy via subspace autofocus is presented. This scheme uses the weighted signal subspace to express the phase errors left in the echoes after range-bin alignment and estimates the optimal weights sequentially via an optimization algorithm based on an entropy minimization principle, and its robustness and convergence can be ensured by the optimization method. Both the theoretical analysis and processing results of the real ISAR data have confirmed the feasibility of this new scheme. [J41]

"Signaling Strategies for the Hybrid MIMO Phased-Array Radar"

The hybrid MIMO phased array radar (HMPAR) is a notional concept for a multisensor radar architecture that combines elements of traditional phased-array radar with the emerging technology of multiple-input multiple output (MIMO) radar. A HMPAR comprises a large number, MP, of T/R elements, organized into M subarrays of P elements each. Within each subarray, passive element-level phase shifting is used to steer transmit and receive beams in some desired fashion. Each of the M subarrays are in turn driven by independently amplified phase-coded signals which could be quasi-orthogonal, phase-coherent, or partially correlated. Such a radar system could be used in an airborne platform for concurrent search, detect, and track missions. This paper considers various signaling strategies which could be employed in the notional HMPAR architecture to achieve various objectives quantified by transmit beampatterns and space-time ambiguity functions. First, we propose a method to generate multiple correlated signals for uniform linear and rectangular arrays that achieve arbitrary rectangular transmit beampatterns in one and two dimensions, while maintaining desirable temporal properties. Examples of the range of transmit beampatterns possible with this technique are illustrated for an array of MP=900 elements, arranged using different values of M and P. Then the space-time, or MIMO, ambiguity function that is appropriate for the HMPAR radar system is derived. Examples of ambiguity functions for our signals using a one-dimensional HMPAR architecture are given, demonstrating that one can achieve phased-array-like resolution on receive, for arbitrary transmit beampatterns. [J42]

"Optimal Joint Target Detection and Parameter Estimation by MIMO Radar"

We consider multiple-input multiple-output (MIMO) radar systems with widely spaced antennas. Such antenna configuration facilitates capturing the inherent diversity gain due to independent signal dispersion by the target scatterers. We consider a new MIMO radar framework for detecting a target that lies in an unknownlocation. This is in contrast with conventional MIMO radars which break the space into small cells and aim at detecting the presence of a target in a specified cell. We treat this problem through offering a novel composite hypothesis testing framework for target detection when 1) one or more parameters of the target are unknown and we are interested in estimating them, and 2) only a finitenumber of observations are available. The test offered optimizes a metric which accounts for both detection and estimation accuracies. In this paper, as the parameter of interest we focus on the vector of time-delays that the waveforms undergo from being emitted by the transmit antennas until being observed by the receive antennas. The analytical and empirical results establish that for the proposed joint target detection and time-delay estimation framework, MIMO radars exhibit significant gains over phased-array radars for extended targets which consist of multiple independent scatterers. For point targets modeled as single scatterers, however, the detection/estimation accuracies of MIMO and phased-array radars for this specific setup (joint target detection and time-delay estimation) are comparable. [J43]

"APC Trajectory Design for "One-Active" Linear-Array Three-Dimensional Imaging SAR"

This paper discusses the antenna phase center trajectory (APCT) design for the "one-active" linear-array 3D imaging SAR (LASAR). First, we discuss the principle of the one-active LASAR and demonstrate its feasibility by experiment. To describe the 3D spatial resolution of the one-active LASAR, the relationship between the 3D

ambiguity function (AF) of the one-active LASAR and the system parameters is discussed in detail. Based on the analysis, we divide the APCT design into three topics: the direction of the linear array, the length of the linear array, and the switching mode of the active element [named as antenna phase center function (APCF)]. On the first topic, we conclude that, when the range, along-track, and cross-track directions are orthogonal to each other, the ambiguity region of the one-active LASAR attains minimum, and the 3D spatial resolution can be separated into the range, along-track, and cross-track resolutions. On the second topic, we find that the cross-track resolution is determined by the length of the linear array and the frequency of the carrier. To ensure that the length of the linear array is acceptable, the carrier should be W-band wave or millimeter wave. On the third topic, the effect of APCF is researched, and we find that both the periodic APCF and the pseudorandom APCF can produce 3D resolution, except for the periodic rectangle APCF. For the pseudorandom APCF and the periodic APCF with short period, the cross-range 2D AF is or can be approximated as the product of two 1D AFs in the along- and cross-track directions. Finally, the distribution of the pseudorandom APCF is optimized by the Lagrange multiplier method under the minimum variance criterion, and we find that, when the pseudorandom APCF obeys the parabolic distribution, the cross-range 2D AF is optimal. [J44]

"MIMO Radar Waveform Constraints for GMTI"

Ground moving-target indication (GMTI) provides both an opportunity and challenge for coherent multiple-input multiple-output (MIMO) radar. MIMO techniques can improve a radar's angle estimation and the minimum detectable velocity (MDV) for a target. However, the challenge of clutter mitigation places significant constraints on MIMO radar waveforms. In this paper, the loss of target return because of clutter mitigation (signal-to-noise ratio (SNR) loss) is the driving performance metric. The ideal, orthogonal repeated-pulse waveform is shown not to exist. Pulse-to-pulse time-varying waveforms, such as Doppler-division multiple access (DDMA), are shown to offer SNR loss performance approaching ideal MIMO systems. [J45]

"Estimation Method for InSAR Interferometric Phase Based on Generalized Correlation Steering Vector"

We propose a new method, based on the generalized correlation steering vector, to estimate synthetic aperture radar interferometry (InSAR) interferometric phase. In this method the generalized correlation steering vector with a large coregistration error is determined according to the joint data vector. The generalized correlation steering vector is then used to estimate the InSAR interferometric phase. The method can simultaneously auto-coregister the synthetic aperture radar (SAR) images and reduce the interferometric phase noise. Theoretical analysis and computer simulation results show that the method can provide an accurate estimate of the terrain interferometric phase (interferogram), even if the coregistration error reaches one pixel. [J46]

"MIMO Radar Moving Target Detection in Homogeneous Clutter"

A multiple-input multiple-output (MIMO) radar approach employing widely dispersed transmit and receive antennas is studied for the detection of moving targets. The MIMO radar transmits orthogonal waveforms from the different transmit antennas so these waveforms can be separated at each receive antenna. For a moving target in colored Gaussian noise-plus-clutter, we quantify the gains from having widely dispersed antennas that allow the overall system to "view" the target simultaneously from several different directions. The MIMO radar performance is contrasted with that of a traditional phased-array approach, which employs closely spaced antennas for this purpose. The MIMO radar approach is well suited to handle targets that have small radial velocities for scenarios in which colocated sensors cannot separate the target from the background clutter. Both a centralized processing and a simple distributed processing form of the MIMO radar approach are developed and studied, and the gains from the centralized version, which come at the price of additional complexity, are clearly demonstrated and explained intuitively. The constant false alarm rate (CFAR) property of an adaptive version of the MIMO moving target detector is also demonstrated for homogeneous clutter. [J47]

"Photonic Beamformer Receiver With Multiple Beam Capabilities"

A multiple-beam photonic beamforming receiver is proposed and demonstrated. The architecture is based on a large port-count demultiplexer and fast tunable lasers to achieve a passive design, with independent beam steering for multiple beam operation. A single true time delay module with four independent beams is experimentally demonstrated, showing extremely smooth RF response in the -band, fast switching capabilities, and negligible crosstalk. [J48]

"Matching Space Antenna Deformation Electronic Compensation Strategies to Support Structure Architectures"

Radar systems are engineered to achieve a complex, yet functional, balance between diverse subsystems and competing requirements. One important trade for large deployable space radar antennas is between antenna dimensional stability and electronic signal processing for deformation compensation. This trade is first investigated for several different electronic compensation methods, and compensation capabilities are mapped into structural requirements. Second the structural requirements are translated into appropriate structural architectures. The scope of this study is limited to space radar systems, where loads causing antenna deformations differ significantly from terrestrial systems. Compensation strategies that allow structural requirements to be reduced by several orders of magnitude are identified. When considered early in the systems engineering process, the methods presented herein can be used to form a rationale for the selection and the development of a complementary combination of compensation electronics and structural architectures. [J49]

"Interference Cancellation and Signal Direction Finding with Low Complexity"

We propose a novel beamforming algorithm for a three-element system that suppresses an interference signal while still being able to measure a target's interferometer phases. Unlike most direction-of-arrival (DOA) estimation algorithms, our algorithm does not use a grid search. Instead the estimates result from a closed-form solution, a great advantage in time-sensitive applications. The derivation of the algorithm is presented, and its statistical performance is examined with simulations. Additionally, our numerical results demonstrate that our algorithm is capable of achieving more reliable DOA estimates than those found with the well-known multiple signal classification (MUSIC) algorithm. Finally, a radar signal processing example is presented. [J50]

"Systemic approach explored in the context of passive target tracking"

For obvious reasons of cost, discretion and reliability costs, locating and tracking aerial targets under an electromagnetically completely passive paradigm, relying exclusively on illuminators of opportunity, is very appealing not only for military but also for civilian tasks. Such a passive radar system could exploit signals emitted by existing commercial television or radio stations or even satellite signals, such as the ones belonging to the global positioning system. This study considers target locating and tracking using a network of passive receivers and/or non-cooperative illuminators (a multi-static radar configuration) by making use of the Doppler shift only. A concept, the systemic approach, is used to combine and interpret information available from different sensors. Both the formalisation of the problem and the hardware and software implementation are presented. Implementation makes use of multi-component polynomial-phase signal models and genetic algorithms. For increased performance, implementation on field programmable gate array is envisaged. [J51]

"Reducing the Number of Amplitude Controls in Radar Phased Arrays"

The need to reduce the number of active elements in radar arrays claims for developing new synthesis approaches able to reduce the control points, i.e., the number of transmit/receive modules (TRM) needed to fulfill the design constraints, is presented. As the large part of the TRM costs are related to the active parts (HPA-high power amplifier), a hybrid method for reducing the number of amplitude controls is proposed. This allow the design of new array architectural solutions where the scanning capabilities only rely on phase controls. [J52]

"Tunable SIW cavity backed active antenna oscillator"

A substrate integrated waveguide (SIW) cavity backed active slot antenna oscillator is proposed, the operation frequency of which can be tuned by means of a properly connected varactor. The cavity backed structure permits overcoming potential problems such as heat dissipation and unwanted surface wave modes in large array implementations, and may provide better phase noise performance. The use of SIW technology permits a cost-effective fabrication process and simple implementation at millimetre-wave frequency, for radar and communication applications. Full-wave FEM-based analysis is used for the design of the radiating structure, while harmonic balance and transient simulations are employed in the design of the active antenna oscillator and in the study of the stability of its steady-state solutions. Tunable active antenna prototypes have been implemented and measured. [J53]

"Beacon-Aided Adaptive Localization of Noise Sources Aboard a Pass-By Railcar Using a Trackside Microphone Array"

A new adaptive "beamforming" signal-processing algorithm is developed to locate the loudest noise sources aboard a railcar that passes by a trackside immobile microphone array. This proposed microphone-array beamformer tracks the railcar's spatial movement with the aid of two inaudible acoustic beacons placed aboard the railcar. The proposed scheme then localizes the noise sources with reference to the railcar's coordinates. No auxiliary infrastructure (e.g., no radar or video camera) is needed besides the onboard beacons. Monte Carlo simulations and anechoic chamber experiments verify the efficacy of the proposed scheme. [J54]

"Analysis and design of wideband widescan planar tapered slot antenna array"

Phased arrays have been required to operate over wide bandwidths and wide scan angle to support multifunction operation in both telecommunication and radar. In response to that need, this study firstly analyses the performance of the connected planar tapered slot antenna array and finds that the mutual coupling is essential and has good effect in wideband antenna array design. Then the authors design a wideband widescan planar tapered slot antenna array system with novel dual-parabola tapered slot antenna elements and feed network. This array can operate from 1.6 to 9 GHz and scan angle up to 45 . Both simulation and measurement results are shown to certificate the performance of the proposed antenna array. [J55]

"Millimetre wave multi-polarised microstrip antenna array and application example"

A millimetre wave multi-polarised microstrip antenna array based on linearly polarised subarrays and its applications are presented. The theoretical analysis of the far-zone electric field of the antenna array is also presented, which indicates that the polarisation of the far-zone electric field can be configured by adjusting the feed amplitude and phase of each subarray. The measured results show that the beamwidth of the cross-polarisation level less than -15 dB varies with the location of the field point and the number of subarrays. The millimetre wave multi-polarised microstrip antenna has obvious advantages that the layout and the feed network are simple and easy to be manufactured, which is suitable for millimetre wave miniature radars and detectors. [J56]

"An Evaluation of the ALOS PALSAR L-Band Backscatter-Above Ground Biomass Relationship Queensland, Australia: Impacts of Surface Moisture Condition and Vegetation Structure"

Focusing on woody vegetation in Queensland, Australia, the study aimed to establish whether the relationship between Advanced Land Observing Satellite (ALOS) Phased Array L-band SAR (PALSAR) HH and HV backscattering coefficients and above ground biomass (AGB) was consistent within and between structural formations (forests, woodlands and open woodlands, including scrub). Across these formations, 2781 plot-based measurements (from 1139 sites) of tree diameters by species were collated, from which AGB was estimated using generic allometric equations. For Queensland, PALSAR fine beam dual (FBD) 50 m strip data for 2007 were provided through the Japanese Space Exploration Agency's (JAXA) Kyoto and Carbon (K&C) Initiative, with up to 3 acquisitions available for each Reference System for Planning (RSP) paths. When individual strips acquired over Queensland were combined, `banding' was evident within the resulting mosaics, with this attributed to enhanced L-band backscatter following rainfall events in some areas. Reference to Advanced Microwave Scanning Radiometer-EOS (AMSR-E) data indicated that strips with enhanced L-band backscatter corresponded to areas with increased effective vegetation water content (kg m-2) and, to a lesser extent, soil moisture (g cm-3). Regardless of moisture conditions, L-band HV topographically normalized backscattering intensities backscatter (σfo) increased asymptotically with AGB, with the saturation level being greatest for forests and least for open woodlands. However, under conditions of relative maximum surface moisture, L-band HV and HH σfowas enhanced by as much as 2.5 and 4.0 dB respectively, particularly for forests of lower AGB, with this resulting in an overall reduction in dynamic range. The saturation level also reduced at L-band HH for forests and woodlands but remained similar for open woodlands. Differences in the rate of increase in bo--th L-band HH and HV σfowith AGB were observed between forests and the woodland categories (for both relatively wet and dry conditions) with these attributed, in part, to differences in the size class distribution and stem density between non-remnant (secondary) forests and remnant woodlands of lower AGB. The study concludes that PALSAR data acquired when surface moisture and rainfall are minimal allow better estimation of the AGB of woody vegetation and that retrieval algorithms ideally need to consider differences in surface moisture conditions and vegetation structure. [J57]

"Components and technologies for T/R modules"

This presents new developments and perspectives in Phased Arrays Radars and Electronic Warfare for the next generations of T/R modules (medium/long term), in order to decrease the mass production cost, while increasing the level of performance and reliability. In terms of physical architecture, even if the brick concept is more current at mid-term, the tile concept is investigated for conformal and/or multifunction phased array antennas: a 3-dimensional module will lead to a drastic reduction of size and weight of the antennas. MMICs are always the key components, with evolution toward multifunction chips, and new processes like GaN, SiGe, MEMS power switches. Concerning the packaging, a technological roadmap indicates different capabilities: 1) thick film multilayer ceramic circuits, 2) co-fired ceramics based on LTCC or HTCC processes, 3) surface-mounted packages on printed circuits boards, and 4) 3D architectures. For the interconnections domain, it is now more important to be compatible with the level of integration required for the microwave modules: fuzz buttons, flex,

sub-miniature connectors. AH of these technologies mastered by Thales are dual use for Airborne and Space, Military and Civilian applications. [J58]

"The Kyoto & Carbon Initiative-A Brief Summary"

The Kyoto & Carbon (K&C) Initiative is an international collaboration led by the Japan Aerospace Exploration Agency (JAXA) that revolves primarily around the Advanced Land Observing Satellite (ALOS) Phased Arrayed L-band SAR (PALSAR). The Initiative builds on the experience gained from the Global Rain Forest Mapping (GRFM) and Global Boreal Forest Mapping (GBFM) projects [1], [2], in which SAR data from the Japanese Earth Resources Satellite (JERS-1) were used to generate consistent image mosaics over the entire tropical and boreal zones of Earth. While the GRFM and GBFM projects were undertaken already in the mid 1990s, they demonstrated the utility of L-band SAR data for mapping and monitoring forest and wetland areas and the importance of providing spatially and temporally consistent satellite acquisitions for regional-scale monitoring and surveillance. [J59]

"Study on Q-RAM and Feasible Directions Based Methods for Resource Management in Phased Array Radar Systems"

Our recent progress and results on optimal real-time resource allocation in phased array radar systems are reported. A previously proposed discrete resource allocation approach, the Quality of Service based Resource Allocation Model (Q-RAM), is analyzed and is observed to generate nonoptimal results. We identify the shortcomings of this method and first extend it using the Karush-Kuhn-Tucker (KKT) optimality conditions for the single resource type case. We obtain an algorithm that delivers a globally optimal solution. We later generalize this further for the multiple resource type case. The Q-RAM approach has its origins in the quality-of-service domain and is fundamentally limited to sampled cost functions. The availability of empirically obtained samples of convex tracking performance curves for phased array radar and the feasibility of continuous approximations to these samples lead our study to the consideration of well formulated alternative methods from the optimization literature belonging to the class of methods of feasible directions. In particular we successfully apply the gradient-projection algorithm for the more general multiple resource type case. Our experimental studies using simulated radar performance data (formulated as a calibration data set) show that superior performance can be obtained in achieving closeness to optimality, while also maintaining similar algorithm execution speeds. Performance can even be increased further if additional computational complexity can be tolerated. In particular improvements in closeness to optimality become significant for dense target scenarios with large number of targets. [J60]

"Ground Array Calibration using Lunar InSAR Imagery"

A new technique of phase calibrating the uplink of a ground array consisting of large reflector antennas is studied. The Moon is selected as a calibration target since it falls within the array far-field and avoids the positioning error problem encountered by low-Earth orbit (LEO) calibration targets. As a distributed radar target, the Moon cannot be directly used like point targets. A planetary synthetic aperture radar (SAR) imaging technique is employed to divide the antenna footprint on the lunar surface into many small pixels. Each array element can form its own SAR image of each pixel and the phase differences (interferograms) among these images can be used to perform phase calibration. Orthogonal pseudonoise (PN) codes are used at different array elements to distinguish their signals at a common receiver. A practical design of the calibration system parameters is illustrated. In order to evaluate the performance of this calibration technique, a high-fidelity 3-D lunar surface profile and scattering model is developed. Simulation results are presented to show the effects of multi-pixel averaging, surface undulation, baseline separation, and image misregistration on the proposed calibration performance. [J61]

"Generating Large-Scale High-Quality SAR Mosaic Datasets: Application to PALSAR Data for Global Monitoring"

This paper proposes a mosaicking algorithm to produce large-scale radiometrically and geometrically calibrated Synthetic Aperture Radar (SAR) datasets as a base for environmental monitoring of terrestrial biospheric and cryospheric changes. Features of the proposed method are thematic inclusion of a) long-strip processing of the SAR data, b) ortho-rectification and slope correction using a digital elevation model, c) suppression of differences in intensity between neighboring strips, and d) preparation of metadata (e.g., dates from launch, local incidence angle, radar shadow, layover, and valid/invalid data) to support dataset interpretation. The performance of the proposed method is evaluated using Advanced Land Observing Satellite (ALOS) Phased Array type L-band SAR (PALSAR) mosaics for Southeast Asia, Australia, and Africa. [J62]

"Ortho-Rectification and Slope Correction of SAR Data Using DEM and Its Accuracy Evaluation"

This paper proposes an accurate ortho-rectification and slope correction method for Synthetic Aperture Radar (SAR) images using a digital elevation model (DEM). Since SAR observation is performed in the squint condition, the image is distorted both geometrically and radiometrically (e.g., through foreshortening, range and azimuth shift, layover, radiometric modulation associated with slope, and shadowing). Furthermore, the pixel height cannot be retrieved directly even when orbital data are accurate. The proposed method calculates the geometric and radiometric distortion components from a comparative process between the DEM-based Simulated SAR Image (DSSI) and the SAR slant range image. When applied to Advanced Land Observing Satellite (ALOS) Phased Array Type L-band SAR (PALSAR) data, the geometric accuracy of the ortho-rectified SAR image at the off-nadir angle of 34.3° was high, with a Root Mean Square Error (RMSE) of 11.9 m when evaluated against Ground Control Points (GCPs) deployed globally. The slope correction effectively reduced the radiometric variation caused by the terrain height variation. The proposed method can be applied to a range of SAR data to support a diversity of applications. [J63]

"Reducing Complexity in Indoor Array Testing"

The problem of developing alternative methods for large arrays indoor testing is discussed. The key point is to generate plane waves across the antenna aperture such to simulate an incoming signal from the far field zone. The main contribution of this communication (with respect to previous publications from the same authors) deals with the realization of a plane wave generator over a 2D antenna under test domain. [J64]

"A Low Complexity Blind Estimator of Narrowband Polynomial Phase Signals"

Consider the problem of estimating the parameters of multiple polynomial phase signals observed by a sensor array. In practice, it is difficult to maintain a precisely calibrated array. The array manifold is then assumed to be unknown, and the estimation is referred to as blind estimation. To date, only an approximated maximum likelihood estimator (AMLE) was suggested for blindly estimating the polynomial coefficients of each signal. However, this estimator requires a multidimensional search over the entire coefficient space. Instead, we propose an estimation approach which is based on two steps. First, the signals are separated using a blind source separation technique, which exploits the constant modulus property of the signals. Then, the coefficients of each polynomial are estimated using a least squares method applied to the unwrapped phase of the estimated signal. This estimator does not involve any search in the coefficient spaces. The computational complexity of the proposed estimator increases linearly with respect to the polynomial order, whereas that of the AMLE increases exponentially. Simulation results show that the proposed estimator achieves the Cramer-Rao lower bound at moderate or high signal to noise ratio. [J65]

"Design and Performance of Frequency Selective Surface With Integrated Photodiodes for Photonic Calibration of Phased Array Antennas"

The design, fabrication, and integration of a frequency selective surface (FSS) with integrated photodiodes to allow for photonic calibration of phased array antennas is presented. The design includes embedding electrically short dipole antennas in each unit cell of the FSS, with a zero-biased photodiode placed across the gap of the diode. Fibers from an optical distribution network are passed through the honeycomb core of the frequency selective surface and pigtailed to the photodiodes. The RF performance of the frequency selective surface with integrated optics is investigated via simulations and measurements, and the results show that the structure maintains RF-transparency. [J66]

"Focused Sessions"

{no data available} [J67]

"Passive and Active L-Band Microwave Observations and Modeling of Ocean Surface Winds"

L-band microwave backscatter and brightness temperature of sea surfaces acquired using the Passive/Active L-band Sensor during the High Ocean Wind campaign are reported in terms of their dependence on ocean surface wind speed and direction. We find that the L-band VV, HH, and HV radar backscatter data increase by 6-7 dB from 5 to 25 m/s wind speed at a 45° incidence angle. The data suggest the validity of Phased Array type L-band Synthetic Aperture Radar (PALSAR) HH model function between 5 and 15 m/s wind speeds, but show that the extrapolation of PALSAR model at above 20 m/s wind speeds overpredicts A0and a1coefficients. There is wind direction dependence in the radar backscatter with about 4 dB differences between upwind and crosswind observations at 24 m/s wind speed for VV and HH. The passive brightness temperatures show about a 5-K change for TVand a 7-K change for THfor a wind speed increasing from 5 to 25 m/s. Circle flight data suggest a

wind direction response of about 1-2 K in TVand THat 14 and 24 m/s wind speeds. The L-band microwave data show excellent linear correlation with the surface wind speed with a correlation better than 0.95. The results support the use of L-band radar data for estimating the wind-driven excess brightness temperature of sea surfaces. The data also support the applications of L-band microwave signals for high-resolution (kilometer scale) observation of ocean surface winds under high wind conditions (10-28 m/s). [J68]

"An Array Error Estimation Method for Constellation SAR Systems"

In practice, unavoidable array errors, consisting of phase and position errors, significantly degrade the performance of constellation synthetic aperture radar (SAR) systems. Therefore, methods are required to estimate these errors. In constellation SAR systems, the clutter spectrum components within a Doppler bin can be used as calibration sources with known directions. In this letter, it is observed that the steering vectors of the spectrum components in one Doppler bin are conjugate with those of the spectrum components in its contrary Doppler bin on condition that each SAR operates in side-looking mode and its nominal left coordinate is zero, which is easy to realize. We obtain a new phase error estimation method based on this observation. An array error estimation method, which estimates phase and position errors simultaneously, is proposed via combining the new phase error estimation method with the least squares method for estimating position errors. The advantages of the proposed method include its capability to directly estimate phase and position errors without joint iteration between the estimations of phase and position errors; thus, it performs well, while the conventional method behaves unstably because it may converge to a local optimal solution, when position errors are large. Furthermore, mathematical analysis indicates that the proposed method has less computational load. In addition, computer simulations show that it performs better than the conventional method. The only cost is that it employs twice as many Doppler bins as the conventional method does, which is endurable because there are numerous Doppler bins. [J69]

"Signal level Simulator for netted text radar waveforms evaluation"

When evaluating the performances of radar waveforms, it is crucial to understand how the signal is affected by multiple interactions with the environment and the system hardware. Analysis of complex radar systems, such as multistatic and netted designs (see Figure 1) is often intractable without the application of a dedicated radar simulation system. Recent research into radar simulation has focused primarily on synthetic aperture radar (SAR) systems [1] and is not entirely applicable to traditional radar systems concerned with the location and tracking of remote targets. A complete simulator has been designed for the accurate simulation of raw returns in complex, multistatic, and netted radars, and is applicable to pulsed and continuous wave (CW) systems, and both active and passive radar systems. The Flexible Simulator for Multistatic Radars (FERS) can be used to simulate radar systems with arbitrary waveforms and arbitrary numbers of receivers, transmitters, and scatterers. Herein, algorithms for the simulation of raw radar return signals are presented, based on interpolation and modification of the transmitted signal and modeling of the radar hardware and environment. The algorithms are expected to be especially valuable for the simulation of emerging radar technologies, such as Passive Coherent Location (PCL) [2], netted radar and phased array radar. Preliminary results, presented herein, suggest that these algorithms can simulate physical systems with excellent accuracy. [J70]

"An ISAR Imaging Method Based on MIMO Technique"

With the inverse synthetic aperture radar (ISAR) imaging model, targets should move smoothly during the coherent processing interval (CPI). Since the CPI is quite long, fluctuations of a target's velocity and gesture will deteriorate image quality. This paper presents a multiple-input-multiple-output (MIMO)-ISAR imaging method by combining MIMO techniques and ISAR imaging theory. By using a special M-transmitter N-receiver linear array, a group of Morthogonal phase-code modulation signals with identical bandwidth and center frequency is transmitted. With a matched filter set, every target response corresponding to the orthogonal signals can be isolated at each receiving channel, and range compression is completed simultaneously. Based on phase center approximation theory, the minimum entropy criterion is used to rearrange the echo data after the target's velocity has been estimated, and then, the azimuth imaging will finally finish. The analysis of imaging and simulation results show that the minimum CPI of the MIMO-ISAR imaging method is 1/MNof the conventional ISAR imaging method under the same azimuth-resolution condition. It means that most flying targets can satisfy the condition that targets should move smoothly during CPI; therefore, the applicability and the quality of ISAR imaging will be improved. [J71]

"Institutional Listings"

{no data available} [J72]

"Polarimetric SAR Data in Land Cover Mapping in Boreal Zone"

This paper compares ALOS PALSAR fully polarimetric and dual-polarized data in the application area of land cover mapping. To assure versatile comparison of the data, different classification methods and different features of data are used. Two of the classification methods used are based on supervised classification and two on unsupervised classification. Polarimetric data are used in three ways: (1) as fully polarimetric data; (2) features calculated from fully polarimetric data; and (3) intensity data of selected channels. Combinations of six (water, field, sparse forest, dense forest, peat land, and urban areas), five, four, and three classes were used for classification. Fully polarimetric data gave better results (87.5%-84.7% with three classes; open land areas, forest, and water) than intensity data only (83.6%-78.6%), but the differences in the overall accuracies between the methods were not more than 7.6%. Kappa coefficients of agreement are moderate for all the classifications. Supervised classification can be expected to perform better than unsupervised classification, given that the training areas can be selected accurately. Dual polarization data were found to be an attractive alternative in cases where fully polarimetric data are not available or it is of low resolution. With intensities of selected polarimetric features, it was possible to obtain a high classification accuracy as with fully polarimetric data. This also opens possibilities for nonspecialist users to benefit from polarimetric information in classification. [J73]

"A 3-D X-Band T/R Module Package With an Anodized Aluminum Multilayer Substrate for Phased Array Radar Applications"

This paper presents the design and development of a compact 3-D transmit/receive (T/R) module with a selectively anodized aluminum multilayer package for X-band phased array radar applications. The proposed multilayer package consists of anodized aluminum substrates and vertical interconnects with embedded vias. The proposed package platform is based on thick anodized aluminum oxide layers and active bare chips directly mounted on bulk aluminum substrates for high electrical isolation and an effective heat sink. With its combination of thin-film embedded passive components and multilayer structure, the proposed module features a compact size of 20 mm Ч 20 mm, with a package height of 3.7 mm. To transfer radio-frequency (RF) signals vertically, we used coaxial hermetic seal vias with characteristic 50 Ω impedances and embedded anodized aluminum vias with a solder ball attachment and flip-chip bonding. The optimized vertical interconnect structure demonstrates RF characteristics with an insertion loss of less than 1.55 dB and a return loss of less than 12.25 dB over a broad bandwidth ranging from 0.1 to 10 GHz. The fabricated X-band 3-D T/R module has a maximum transmit output power of 39.81 dBm (9.5 W), a maximum transmit gain of 41.25 dB, and a receive gain of 19.15 dB over the 9-10 GHz frequency band. The RF-signal phase amplitude control is achieved by means of a 6 bit phase shifter with an rms accuracy of more than 5° and a gain setting range of 24 dB with an rms accuracy of more than 1.5 dB. The proposed multilayer aluminum package has the advantages of reducing the module size, decreasing the cost, and managing the thermal problem for X-band high-power T/R module package applications. [J74]

"Angular Backscatter Variation in L-Band ALOS ScanSAR Images of Tropical Forest Areas"

Scanning synthetic aperture radar (ScanSAR) systems provide continuous information over large areas, but for effective use of such products in tropical forest, the decrease of radar backscatter with large variation of incidence angles requires attention. This letter analyzes the dependence of radar backscatter on incidence angle for L-band ScanSAR images of tropical forest. We investigated and modeled the angular backscatter effect per land-cover class in three ScanSAR images of the Colombian Orinoco. We found that there is an evident effect of incidence angle on radar backscatter, depending on land-cover class, moisture content, and physical structure of the reflecting targets. To normalize the angular backscatter variation, we proposed two methods. The first one applies a cosine correction estimated through linear regression. The second one models the radar backscatter of flooded forest considering second-order signal interactions. The model explains the observed backscatter of flooded forest areas in the rainy season (R2that is larger than 0.77). [J75]

"Low Probability of Intercept Antenna Array Beamforming"

A novel transmit array beamforming approach is introduced that offers low probability of intercept (LPI) for surveillance radar systems employing phased array antennas. Radar systems are often highly visible to intercept receivers due to the inherent two-way versus one-way propagation loss. In this paper, the traditional high-gain antenna beam scanned across a search region is replaced with a series of low-gain, spoiled beams. Keeping the transmit antenna gain low reduces the radar visibility, but the radar's antenna performance remains unchanged as the original high-gain beam can be formed by processing the set of spoiled beams. Large transient power density radiated in a traditional scan is replaced with low power density persistently radiated at the target throughout the scan time. The detection performance of the radar is not affected since the total energy on the target is the same. Derivation of the complex weights to synthesize the high-gain patterns from the low-gain basis patterns is presented for both one-way and two-way beam patterns. [J76]

"Radiometric, Geometric, and Image Quality Assessment of ALOS AVNIR-2 and PRISM Sensors"

The Advanced Land Observing Satellite (ALOS) was launched on January 24, 2006, by a Japan Aerospace Exploration Agency (JAXA) H-IIA launcher. It carries three remote-sensing sensors: 1) the Advanced Visible and Near-Infrared Radiometer type 2 (AVNIR-2); 2) the Panchromatic Remote-Sensing Instrument for Stereo Mapping (PRISM); and 3) the Phased-Array type L-band Synthetic Aperture Radar (PALSAR). Within the framework of ALOS Data European Node, as part of the European Space Agency (ESA), the European Space Research Institute worked alongside JAXA to provide contributions to the ALOS commissioning phase plan. This paper summarizes the strategy that was adopted by ESA to define and implement a data verification plan for missions operated by external agencies; these missions are classified by the ESA as third-party missions. The ESA was supported in the design and execution of this plan by GAEL Consultant. The verification of ALOS optical data from PRISM and AVNIR-2 sensors was initiated 4 months after satellite launch, and a team of principal investigators assembled to provide technical expertise. This paper includes a description of the verification plan and summarizes the methodologies that were used for radiometric, geometric, and image quality assessment. The successful completion of the commissioning phase has led to the sensors being declared fit for operations. The consolidated measurements indicate that the radiometric calibration of the AVNIR-2 sensor is stable and agrees with the Landsat-7 Enhanced Thematic Mapper Plus and the Envisat MEdium-Resolution Imaging Spectrometer calibration. The geometrical accuracy of PRISM and AVNIR-2 products improved significantly and remains under control. The PRISM modulation transfer function is monitored for improved characterization. [J77]

"Interferometric methods for three-dimensional target reconstruction with multipass circular SAR"

The authors consider three-dimensional (3-D) target construction from SAR data collected on multiple complete circular apertures at different elevation angles. The 3-D resolution of circular SAR systems is constrained by two factors: the sparse sampling in elevation and the limited azimuthal persistence of the reflectors in the scene. Three-dimensional target reconstruction with multipass circular SAR data is further complicated by non-uniform elevation spacing in real flight paths and non-constant elevation angle throughout the circular passes. The authors first study parametric spectral estimation methods that extend standard IFSAR method of height estimation to apertures at more than two elevation angles. Next, they show that linear interpolation of the phase history data leads to unsatisfactory performance in 3-D reconstruction from non-uniformly sampled elevation passes. The authors then present a new sparsity regularised interpolation algorithm to preprocess non-uniform elevation samples to create a virtual uniformly spaced array. The authors illustrate the performance of the proposed method using data from EM simulations and data collected from a wideband X-band airborne sensor. [J78]

"Target Localization Accuracy Gain in MIMO Radar-Based Systems"

This paper presents an analysis of target localization accuracy, attainable by the use of multiple-input multiple-output (MIMO) radar systems, configured with multiple transmit and receive sensors, widely distributed over an area. The Cramer-Rao lower bound (CRLB) for target localization accuracy is developed for both coherent and noncoherent processing. Coherent processing requires a common phase reference for all transmit and receive sensors. The CRLB is shown to be inversely proportional to the signal effective bandwidth in the noncoherent case, but is approximately inversely proportional to the carrier frequency in the coherent case. We further prove that optimization over the sensors' positions lowers the CRLB by a factor equal to the product of the number of transmitting and receiving sensors. The best linear unbiased estimator (BLUE) is derived for the MIMO target localization problem. The BLUE's utility is in providing a closed-form localization estimate that facilitates the analysis of the relations between sensors locations, target location, and localization accuracy. Geometric dilution of precision (GDOP) contours are used to map the relative performance accuracy for a given layout of radars over a given geographic area. [J79]

"Clear-Cut Detection in Swedish Boreal Forest Using Multi-Temporal ALOS PALSAR Backscatter Data"

An extensive dataset of images acquired by the Advanced Land Observing Satellite (ALOS) Phased Array type L-band Synthetic Aperture Radar (PALSAR) is investigated for clear-cut detection in the county of Vajsterbotten, Sweden. Strong forest/non-forest contrast and temporal consistency were found for the Fine Beam Dual HV-polarized backscatter in summer/fall. In consequence of a clear-cut between image acquisitions, the HV-backscatter dropped in most cases between 2 and 3 dB. Thus, a simple thresholding algorithm that exploits the temporal consistency of time series of HV-backscatter measurements has been developed for clear-cut detection. The detection algorithm was applied at pixel level to ALOS PALSAR strip images with a pixel size of

50 m. The performance of the detection algorithm was tested with three different threshold values (2.0, 2.5 and 3.0 dB). The classification accuracy increased from 57.4% to 78.2% for decreasing value of the threshold. Conversely, the classification error increased from 3.0% to 9.7%. For about 90% of the clear-felled polygons used for accuracy assessment the proportion of pixels correctly detected as clear-felled was above 50% when using a threshold value of 2.0 dB. For the threshold values of 2.5 and 3.0 dB the corresponding figures were 80% and 65%, respectively. The total area classified as clear-felled during the time frame of the ALOS PALSAR data differed by 5% compared to an estimate of notified fellings for the same period of time when using a detection threshold of 2.5 dB. The performance of the simple detection algorithm is reasonable when aiming at detecting clear-cuts, whereas there are shortcomings in terms of delineation. [J80]

"A Virtual Antenna Beamforming (VAB) Approach for Radar Systems by Using Orthogonal Coding Waveforms"

An innovative approach is introduced to form virtual transmitting and receiving radar antenna beams simultaneously by transmitting orthogonal coding waveforms from the antenna elements and digitally processing of their echoes at the receiver. Multiple virtual transmitting-receiving beams can be formed simultaneously by employing an equal number of beamforming filters without increasing transmitting power or antenna gain or resolution loss. The virtually formed antenna beams can provide equivalent antenna gains and spatial resolutions as the conventional phased arrays of the same size. Because the actual antenna radiation pattern can be made almost isotropic, the new system has low probability of intercept (LPI) property. With both transmitting and receiving beams virtually implemented through digital filtering, costly radiation phase shift used in phased arrays is not needed for beam scanning in the proposed system. [J81]

"Adaptive Phased-Array Tracking in ECM using Negative Information"

Target tracking with adaptive phased-array radars in the presence of standoff jamming presents both challenges and opportunities to the track filter designer. A measurement likelihood function is derived for this situation which accounts for the effect of both positive and negative contact information. This likelihood function is approximated a? a weighted sum of Gaussian terms consisting of both positive and negative weights, accounting for the positive and negative contact information. Additionally, recent theoretical results have been reported which have derived an accurate measurement error covariance in the vicinity of the jammer when adaptive beamforming is used by the radar to null the effects of the jammer. We compare the impact of using a likelihood function that accounts for negative contact information and the corrected measurement error covariance by comparing five Kalman filter-based trackers in five different scenarios. We show that only those track filters which use both the negative contact information and the corrected measurement error covariance are effective in maintaining track on a maneuvering target as it passes through the jamming region. This approach can also be generalized to any target tracking problem where the sensor response is anisotropic. [J82]

"An L-Band Ocean Geophysical Model Function Derived From PALSAR"

This paper examines L-band normalized radar cross section (NRCS) dependence on ocean surface wind. More than 90 000 match-ups, each consisting of the L-band HH NRCS, incidence angles, wind speeds, and wind directions, were collected from the Phased-Array L-Band Synthetic Aperture Radar (PALSAR) and scatterometer wind vectors. Based on the match-ups, the L-band HH NRCS dependence on incidence angle and wind vector is modeled for 0-20-m/s wind speeds and 17deg-43deg incidence angles. The derived relation indicates that the wind sensitivity of the L-band NRCS is less than that of the C-band at moderate winds and large incidence angles, whereas comparable at stronger winds ((>10 m/s) and small incidence angles. The upwind-crosswind difference is amplified in the 10-15-m/s range followed by an almost zero amplitude from 4 to 8 m/s, which represents a clear phase shift with the C-band VV and Ku-band HH models. Wind speeds are then estimated from the match-ups, based on the derived model function. A comparison with the reference scatterometer winds reveals a 0.05-m/s bias and a 1.85-m/s root mean square error, where crosswind data give rise to large errors due to low wind sensitivity at wind speeds of around 10 m/s, particularly at large incidence angles. The L-band NRCS behavior in strong winds (>20 m/s), at which the C-band is saturated, was not determined in the current model due to the limited number of the match-ups. [J83]

"Time-Switched Array Analysis of Phase-Switched Screens"

In this correspondence, an analysis of phase-switched screens (PSS) based on time-switched array theory is presented. Unlike conventional transmission line analysis, the time-switched array approach allows finite-sized PSS to be analyzed. New modulation schemes for finite-sized PSS based on selective antiphase switching are introduced and analyzed. Modulation sequences in which 50% of the PSS is switched in antiphase are shown to operate differently to conventionally modulated PSS and produce zero backscattered energy at harmonic

frequencies. Measurements from an experimental PSS operating at an incident frequency of 10 GHz and time-switched at 5 MHz are presented. [J84]

"Antenna Mask Design for SAR Performance Optimization"

In this letter, an effective technique for synthetic aperture radar (SAR) antenna mask design is presented for optimizing the system performance of an active phased array SAR. The SAR antenna radiation pattern has an important effect on the system performance. Therefore, the authors derived the quantitative equations for the SAR antenna mainlobe and sidelobe mask design on the basis of the system performance measures such as the range-to-ambiguity ratio (RAR), the noise-equivalent sigma zero (NESZ), and the radiometric accuracy. The antenna mask template should be designed to minimize the ambiguous signals reflected from the antenna sidelobes and maximize the system sensitivity, i.e., the NESZ, determined by the antenna mainlobe. The simple iterative method such as random-mutation hill climbing was utilized to successfully assign the sidelobe level at each ambiguous area using the derived equations. Finally, the antenna patterns were synthesized with reference to the optimized antenna mask templates using the particle swarm optimization, and the swath width, RAR, and NESZ performances were evaluated in order to confirm the effectiveness of the proposed technique. [J85]

"Angle density functions for active sensor imaging"

A new target density function (TDF) is proposed for active sensor imaging. The TDF, called the angle density function, is studied by utilising the angular distribution of targets at a fixed range. Active sensor imaging based on the angle density function is achieved using a phased array radar system. The phased array system is arranged for stationary radar-stationary target configuration. The imaging algorithm is applied for the whole target area. Instead of pointwise imaging, an approach including the whole target area globally is developed. An advantage of the technique is the use of standard Fourier-based analysis. This makes it possible to use of simple functions for global radar imaging. Although the imaging is accomplished by way of the phased array radars, beamforming is not necessary with the proposed technique. [J86]

"Interleaved Array Antennas for FMCW Radar Applications"

An effective and robust strategy for concurrently designing the transmit and receive antennas of a frequency-modulated, continuos-wave radar is discussed. The aperture architecture is based on the use of non-periodic, interleaved sub-arrays. Deterministic element placement is employed for ensuring design efficiency. The procedure yields controllable sub-array radiation patterns and two-way side-lobe levels below-30 dB, that are also stable over a wide frequency range. [J87]

"Polarimetric SAR Internal Calibration Scheme Based on T/R Module Orthogonal Phase Coding"

Two important aspects of internal calibration of polarimetric synthetic aperture radar (SAR) are discussed, i.e., individual transmit/receive module (TRM) calibration and system gain calibration. The system has a general structure utilizing a phased array antenna composed of dual-channel TRMs. TRM gain and phase calibration is carried out using orthogonal phase coding (OPC). The signal of the individual TRM is phase-encoded according to a set of orthogonal codes to be separated from the composite calibration signal. OPC uses 1 bit of a digital phase-shifter for encoding, without the need for additional encoding hardware. Performance of the method is examined. Calibration results are developed both theoretically and through simulation in case of TRM amplifier or phase-shifter failure. Zero-padding is used to eliminate calibration error of the first TRM. A crosstalk model is proposed to investigate the effect of imperfect isolation between the two polarization channels of each TRM, and a way to reduce this error is also given. At last, system path gain variation is measured utilizing the internal calibration loop. The OPC method has an accuracy of 0.2 dB for gain and better than 2deg for phase, with 10-dB signal-to-noise ratio and perfect isolation between the two polarization channels. The error due to imperfect isolation is usually small and can be ignored. The simple way to detect TRM malfunction is verified through simulation, and it is also in accordance with TerraSAR-X in-orbit calibration outcomes. The proposed OPC method is shown to be an effective way of internally calibrating TRMs of a phased array antenna. [J88]

"Designing Unimodular Sequence Sets With Good Correlations-Including an Application to MIMO Radar"

A multiple-input multiple-output (MIMO) radar system that transmits orthogonal waveforms via its antennas can achieve a greatly increased virtual aperture compared with its phased-array counterpart. This increased virtual aperture enables many of the MIMO radar advantages, including enhanced parameter identifiability and improved resolution. Practical radar requirements such as unit peak-to-average power ratio and range compression dictate that we use MIMO radar waveforms that have constant modulus and good auto- and cross-correlation properties. We present in this paper new computationally efficient cyclic algorithms for MIMO radar waveform

synthesis. These algorithms can be used for the design of unimodular MIMO sequences that have very low auto- and cross-correlation sidelobes in a specified lag interval, and of very long sequences that could hardly be handled by other algorithms previously suggested in the literature. A number of examples are provided to demonstrate the performances of the new waveform synthesis algorithms. [J89]

"A Study on the Application of Time Modulated Antenna Arrays to Airborne Pulsed Doppler Radar"

The time modulated (TM) linear arrays with variable aperture sizes (VAS) are applied to the airborne pulsed Doppler (PD) radar system in this paper. The VAS arrays which have great flexibility in the control of the aperture excitations are employed to synthesize low/ultra-low sidelobe patterns in the PD radar system, and the optimized time sequences obtained via the differential evolution (DE) algorithm is used to minimize the average power loss due to the time modulation. Numerical simulation results of the signals transmitted and received by PD radar based on the VAS arrays show that the time modulation changed the waveforms of the signals in time domain but the received signals also contain the correct range and velocity information of the moving target. [J90]

"A Millimeter-Wave (40-45 GHz) 16-Element Phased-Array Transmitter in 0.18- m SiGe BiCMOS Technology"

This paper demonstrates a 16-element phased-array transmitter in a standard 0.18-mum SiGe BiCMOS technology for Q-band satellite applications. The transmitter array is based on the all-RF architecture with 4-bit RF phase shifters and a corporate-feed network. A 1:2 active divider and two 1:8 passive tee-junction dividers constitute the corporate-feed network, and three-dimensional shielded transmission-lines are used for the passive divider to minimize area. All signals are processed differentially inside the chip except for the input and output interfaces. The phased-array transmitter results in a 12.5 dB of average power gain per channel at 42.5 GHz with a 3-dB gain bandwidth of 39.9-45.6 GHz. The RMS gain variation is < 1.3 dB and the RMS phase variation is < for all 4-bit phase states at 35-50 GHz. The measured input and output return losses are < -10 dB at 36.6-50 GHz, and <-10 dB at 37.6-50 GHz, respectively. The measured peak-to-peak group delay variation is plusmn 20 ps at 40-45 GHz. The output P-1dBis -5plusmn1.5 dBm and the maximum saturated output power is-2.5plusmn1.5 dBm per channel at 42.5 GHz. The transmitter shows <1.8 dB of RMS gain mismatch and < 7deg of RMS phase mismatch between the 16 different channels over all phase states. A-30 dB worst-case port-to-port coupling is measured between adjacent channels at 30-50 GHz, and the measured RMS gain and phase disturbances due to the inter-channel coupling are < 0.15 dB and < 1deg, respectively, at 35-50 GHz. All measurements are obtained without any on-chip calibration. The chip consumes 720 mA from a 5 V supply voltage and the chip size is 2.6times3.2 mm2. [J91]

"Rapid Method for Finding Faulty Elements in Antenna Arrays Using Far Field Pattern Samples"

A simple and fast technique that allows a diagnosis of faulty elements in antenna arrays, that only needs to consider a small number of samples of its degraded far-field pattern is described. The method tabulates patterns radiated by the array with 1 faulty element only. Then, the pattern corresponding to the configuration of failed/unfailed elements under test is calculated using the error-free pattern and the patterns with 1 faulty element. The configuration with the lowest difference between the calculated and the degraded patterns is selected. Comparison of the performance of this method using an exhaustive search and a genetic algorithm for an equispaced linear array of 100 lambda/2-dipoles is shown. Mutual coupling as well as noise/measurement errors in the pattern samples were considered in the numerical analysis. [J92]

"A Review of Phased Array Steering for Narrow-Band Electrooptical Systems"

Nonmechanical steering of optical beams will enable revolutionary systems with random access pointing, similar to microwave radar phased arrays. An early approach was birefringent liquid crystals writing a sawtooth phase profile in one polarization, using 2pi resets. Liquid crystals were used because of high birefringence. Fringing fields associated with voltage control required to implement the 2pi resets have limited the efficiency and steering angle of this beam steering approach. Because of steering angle limitations, this conventional liquid crystal steering approach is usually combined with a large angle step-steering approach. Volume holograms, birefringent prisms or sawtooth-profile birefringent phase gratings, and circular-type polarization gratings are the large angle step steering approaches that will be reviewed in this paper. Alternate steering approaches to the combined liquid crystal and step-steering approach exist. Microelectromechanical system mirrors, lenslet arrays, electrowetting, and a variable birefringent grating approach will be reviewed and compared against the conventional liquid crystal and step-steering approaches. Step-steering approaches can also be combined with these approaches. Multiple nonmechanical steering approaches are developing that will allow high-efficiency steering, excellent steering accuracy, and wide fields of view. [J93]

"Characterizing L-Band Scattering of Paddy Rice in Southeast China With Radiative Transfer Model and Multitemporal ALOS/PALSAR Imagery"

Rice is a major food supply in southeast China. With increased population and urbanization, reliable rice mapping is critical in this region. Because of frequent cloud cover and precipitation during the rice-growing season, it is difficult to conduct large-area rice monitoring with optical remote sensing techniques. L-band synthetic aperture radar (SAR), with its all-weather day and night imaging and canopy penetration capabilities, provides a unique alternative. In this study, a first-order radiative transfer model was developed to simulate L-band scattering properties of paddy rice. Three Advanced Land Observing Satellite (ALOS)/Phased-Array-Type L-band Synthetic Aperture Radar (PALSAR) images in dual-polarization mode (HH and HV) acquired in early tillering (June 28, 2007), tillering (August 13, 2007), and heading (September 28, 2007) stages were processed to test the temporal variation of rice backscatter. It was found that plant height and leaf mass amount were the two major structural parameters that contributed to rice backscatter in PALSAR images. The variation of the simulated HH backscatter matched with PALSAR observations in sample fields, although the simulated backscatter coefficients were around 3 dB lower than image-extracted values. Leaf volume scattering and leaf-ground double bounce were found as the two major scattering components in L-band HH polarization and increased with leaf layer height and density. This paper demonstrated that L-band HH backscatter was more sensitive to rice's structural variation than the VV backscatter and may therefore be more useful in rice mapping and modeling studies. [J94]

"Measurement of Ionospheric Faraday Rotation in Simulated and Real Spaceborne SAR Data"

The influence of the atmosphere on a frequency-modulated electromagnetic wave traversing the ionosphere is becoming increasingly important for recent and upcoming low-frequency and wide-bandwidth spaceborne synthetic aperture radar (SAR) systems. The ionized ionosphere induces Faraday rotation (FR) at these frequencies that affects radar polarimetry and causes signal path delays resulting in a reduced range resolution. The work at hand introduces a simulation model of SAR signals passing through the atmosphere, including both frequency-dependent FR and path delays. Based on simulation results from this model [proven with real Advanced Land Observing Satellite Phased Array L-band Synthetic Aperture Radar (PALSAR) data], estimation of FR in quad-polarized SAR data using the given approach is shown for raw, range-compressed, and focused radar images. Path delays and signal chirp bandwidth effects are considered. Investigations discuss the suitability of raw and compressed data versus combination of total electron content maps with the Earth's magnetic field for FR estimation and deduced from a large number of analyzed PALSAR data sets. [J95]

"Analysis by Wavelet Frames of Spatial Statistics in SAR Data for Characterizing Structural Properties of Forests"

Spatial statistics (texture) in SAR backscatter data of forested areas bears information on structural and geometric properties that could be useful in mapping forest extent, species type, and stages of regeneration or degradation. Based on a previously published theoretical approach in deriving texture measures from SAR data using wavelet frames, experiments are reported that aim to characterize, from a purely observational point of view, wavelet texture measures' sensitivity with respect to target structural properties and SAR configurations. Suitable analytical tools are introduced to represent dependences in the combined space-scale-polarization domain through signatures that condense information in graphical form. Moreover, class separability, afforded by wavelet texture measures in a supervised classification setting and based on the Fischer linear discriminant analysis, is considered. This paper focuses on two structurally different forest types (tropical rain forest in the Central Africa Congo Floodplain and mixed-species wooded savanna in Queensland, Australia) and uses data from orbital radars, particularly from the Japanese Advanced Land Observing Satellite Phased Arrayed L-band Synthetic Aperture Radar. The analysis indicated that textural information from spatial statistics can provide, in some cases, better class separability in forest mapping with respect to one-point statistics, although spatial resolution in texture products is reduced. However, dependences of texture measures on the polarization state are detected, particularly in forests where a greater diversity of scattering mechanisms occurs. [J96]

"Measurements of Faraday Rotation Using Polarimetric PALSAR Images"

For spaceborne synthetic aperture radar (SAR) systems operating at L-band frequencies or lower, the ionosphere may have a significant impact on the SAR images. The largest effect at L-band is caused by Faraday rotation (FR). Several studies have modeled the effect of FR and/or devised models to measure and correct FR. With the launch of the fully polarimetric L-band system Phased Array-type L-band SAR (PALSAR), it has become possible to test both models and measurement techniques on real SAR data. In this letter, the quality of calibrated polarimetric PALSAR data is assessed, and FR is measured. It is found that residual crosstalk and channel imbalance are small in the PALSAR data. Two methods are used to measure FR, the first

using in-scene distributed targets and the second using large trihedrals. The two methods show very good agreement. The measurements are compared with values of the total electron content using a linear model. It is found that the model and measurements are in good agreement, with a root-mean-square error of 0.3degor 15% of the mean FR angle. [J97]

"On the Relationship Between MIMO and SIMO Radars"

This correspondence explores the close relationship between multiple-input multiple-output (MIMO), single-input multiple-output (SIMO), and phased-array radars. It is shown that under certain conditions, the signals received by a MIMO radar and by a properly defined SIMO radar are identical. Several equivalent variations of MIMO and SIMO radars are presented. These relationships make it possible to study MIMO radars in terms of their equivalent SIMO radars, using the extensive body of algorithms and performance analysis which have been developed for SIMO radars. [J98]

"Optimal Polarized Beampattern Synthesis Using a Vector Antenna Array"

Using polarized waveforms increases the capacity of communication systems and improves the performance of active sensing systems such as radar. We consider the optimal synthesis of a directional beam with full polarization control using an array of electromagnetic vector antennas (EMVA). In such an array, each antenna consists of pges 2 orthogonal electric or magnetic dipole elements. The control of polarization and spatial power patterns is achieved through carefully designing the amplitudes and phases of the weights of these dipole antennas. We formulate the problem in a convex form, which is thus efficiently solvable by existing solvers such as the interior point method. Our results indicate that vector antenna arrays not only enable full polarization control of the beampattern, but also improve the power gain of the main beam (over the sidelobes), where the gain is shown numerically to be linearly proportional to vector antenna dimensionality p. This implies that EMVA not only offers the freedom to control the beampattern polarization, but also virtually increases the array size by exploiting the full electromagnetic (EM) field components. We also study the effect of polarization on the spatial power pattern. Our analysis shows that for arrays consisting of pairs of electrical and magnetic dipoles, the spatial power pattern is independent of the mainbeam polarization constraint. [J99]

"On the Use of Auxiliary Receive Channels for Clutter Mitigation With Phased Array Weather Radars"

Phased array radars (PARs) are attractive in weather surveillance primarily because of their capability to electronically steer. When combined with the recently developed beam multiplexing (BMX) technique, these radars can obtain very rapid update scans that are useful in monitoring severe weather. A consequence is that the small number of contiguous samples of the time series obtained can be a challenge for temporal/spectral filters used for clutter mitigation. As a result, the accurate extraction of weather signals can become the limiting performance barrier for PARs that employ BMX in clutter-dominated scattering fields. By exploiting the spatial correlation of the auxiliary channel signals, the effect of clutter contamination can be reduced in these conditions. In this paper, three spatial filtering techniques that used low-gain auxiliary receive channels are presented. The effect of clutter mitigation was studied using numerical simulations of a tornadic environment for changes in signal-to-noise ratio, clutter-to-signal ratio, number of time series samples, varying clutter spectral widths, and maximum weight constraints. Since such data are not currently available from a horizontally pointed phased array weather radar, experimental validation was applied to an existing data set from the turbulent eddy profiler, which is a vertically pointed PAR. Although preliminary, the results show promise for clutter mitigation with extremely short nonuniform sampling. [J100]

"Frequency-Selective Surface to Prevent Interference Between Radar and SATCOM Antennas"

Interference between neighboring antennas operating in nearby frequency ranges can lead to damage of the front-end electronics. This letter presents the design of a frequency-selective surface (FSS) aimed at preventing the saturation of the low noise amplifiers of a phased-array radar antenna due to the carrier of a satellite communication antenna located in its proximity. A fast design was possible thanks to the integral equation method for the derivation of multimode equivalent networks (IEMEN) and was then validated by reflection and transmission measurements of a hardware demonstrator. [J101]

"Microwave Photonics"

Broadband and low loss capability of photonics has led to an ever-increasing interest in its use for the generation, processing, control and distribution of microwave and millimeter-wave signals for applications such as broadband wireless access networks, sensor networks, radar, satellite communitarians, instrumentation and warfare systems. In this tutorial, techniques developed in the last few years in microwave photonics are reviewed

with an emphasis on the systems architectures for photonic generation and processing of microwave signals, photonic true-time delay beamforming, radio-over-fiber systems, and photonic analog-to-digital conversion. Challenges in system implementation for practical applications and new areas of research in microwave photonics are also discussed. [J102]

"Automatic Detection of Terrain Surface Changes After Wenchuan Earthquake, May 2008, From ALOS SAR Images Using 2EM-MRF Method"

A method of two-threshold expectation maximum and Markov random field is presented to automatic detection of terrain surface changes after the Wenchuan earthquake, on May 12, 2008, using multitemporal ALOS PALSAR images. As an example in the Beichuan area, three kinds of terrain surface changes, i.e., scattering enhanced, reduced, and no-changed, are automatically detected and classified. By using the tool of Google Earth, the surface change situation after the earthquake can be shown in multiazimuth views as an animated cartoon. The detection and classification are also compared with optical photographs. [J103]

"An Efficient Method for Performance Monitoring of Active Phased Array Antennas"

Modern synthetic aperture radars (SARs) are equipped with active phased array antennas to electronically generate various antenna beams. The TerraSAR-X satellite is a high resolution SAR system launched in June 2007. Its active phased array X-band antenna hosts 384 transmit/receive modules (TRMs) for controlling the electronic beam steering in azimuth and elevation direction. The precise modeling of the antenna performance is only possible if the actual characteristics of each individual TRM are monitored. TerraSAR-X has been equipped with an innovative characterization mode based on a coding technique, which is the so-called pseudonoise gating method. The individual and simultaneous characterization of all TRMs is realized under most realistic conditions with power supply loads like in nominal radar operation. For the first time, this novel technique has been applied on a spaceborne SAR system. [J104]

"Waveform-Agile Sensing and Processing [JFrom the Guest Editors]"

The focus of this special issue is the development of signal processing techniques that are able to take full advantage of advances in radar systems. Phased array radars and space-time adaptive processing illuminate the value of waveform diversity with respect to time, space, frequency, and polarization. [J105]

"Waveform Diversity in Radar Signal Processing"

This article shows that suitably transmitted and processed, radar waveforms based on Golay sequences provide new primitives for adaptive transmission that enable better detection and finer resolution, while managing computational complexity at the receiver. The ability to exploit space-time adaptive processing is limited by the computational power available at the receiver, and increased flexibility on transmission only exacerbates this problem unless the waveforms are properly designed to simplify processing at the receiver. [J106]

"On Detection Performance of MIMO Radar: A Relative Entropy-Based Study"

Based on Stein's lemma, we use relative entropy as a measure of error exponent to study detection performance of Neyman Pearson (NP) detectors for both multiple-input multiple-output (MIMO) radar and phased array radar. In high signal-to-noise ratio (SNR) region, we introduce the concept of diversity order to get insights of results. In low SNR region, we give instructive approximations for analytical results of relative entropy. Finally, we use relative entropy measure to study the problem of choosing the number of transmitters and receivers for MIMO radar. [J107]

"Phased Array Radar Polarimetry for Weather Sensing: A Theoretical Formulation for Bias Corrections"

It is becoming widely accepted that radar polarimetry provides accurate and informative weather measurements, while phased-array technology can shorten data updating time. In this paper, a theory of phased array radar (PAR) polarimetry is developed to establish the relation between electric fields at the antenna of the PAR and the fields in a resolution volume filled with hydrometeors. It is shown that polarimetric measurements with an electronically steered beam can cause measurement biases that are comparable to or even larger than the intrinsic polarimetric characteristics of hydrometeors. However, these biases are correctable if the transmitted electric fields are known. A correction to the measured scattering matrix that removes biases in meteorological variables is derived. The challenges and opportunities for weather sensing with a polarimetric PAR are discussed. [J108]

"Idealized Radar GMTI Detection with Space-Time Processing"

A new and somewhat different approach is utilized here for determining an upper-bound on ground moving target indication (GMTI) radar performance with two-dimensional space-time processing. An idealized clutter model and other simplifying assumptions are employed. It is shown that the elements of the clutter covariance matrix can be obtained from cross-correlations of the convolution of transmit and receive aperture functions at different times and locations. This feature could provide improved physical insight on how the aperture illumination functions influence performance. Results can be expressed in terms of dimensionless parameters which do not explicitly require the specification of antenna length, radar frequency, platform speed or even target range. Some representative simulation results for idealized and conventional processing are presented and compared. [J109]

"Verification of Polarimetric Calibration Method Including Faraday Rotation Compensation Using PALSAR Data"

The spaceborne Phased Array L-band Synthetic Aperture Radar (PALSAR) needs polarimetric calibration in order for PALSAR data to be utilized for various applications such as geophysical analysis. In case of a PALSAR system using L-band, the Faraday rotation (FR) effect, which rotates the polarization plane of radio waves, becomes a problem when full-polarimetric observation data are used, such as target classification using polarization synthesis. Therefore, we need to estimate and remove both antenna distortion matrices and the FR effect. In this paper, we propose a polarimetric calibration method taking both channel imbalance and crosstalk of receiving and transmitting antennas and FR effect into consideration using two reference reflectors, namely, polarization preserving reflector and polarization rotating one. Then, we apply our calibration method to PALSAR data and derive antenna distortion matrices and FR angle simultaneously. Our calibration results show that the estimated antenna distortion matrices are almost equal to the calibration results from the Japan Aerospace Exploration Agency and that the estimated FR angle has a reasonable value. [J110]

"Bistatic clutter analysis and range ambiguity resolving for space time adaptive processing"

The clutter characteristics of bistatic airborne radar are more complex than those of monostatic airborne radar. The clutter spectra not only vary severely with range, but also vary with bistatic configuration. The problem of range dependence is more serious in monostatic airborne radar. In this paper, the geometry of arbitrary bistatic airborne radar configuration is firstly analysed, and a formula for Doppler frequency calculation with the variables of azimuth angle and bistatic range is deduced, which is an efficient tool for bistatic clutter analysis. Because of the severe clutter range dependence, the processing of compensation is indispensable in space time adaptive processing (STAP). However, when range ambiguity occurs, the compensation is difficult to be applied to each clutter range cell. To solve this problem, a range ambiguity resolving approach is further proposed by utilising azimuth elements in phased array. Because this approach will result in spatial degrees of freedom (DOF) loss, the overlapped subarray processing is introduced in order obtain enough spatial DOF for STAP. By doing so, the compensation for mitigating range dependence can be applied effectively to bistatic clutter. [J111]

"A New Method for Correcting ScanSAR Scalloping Using Forests and Inter-SCAN Banding Employing Dynamic Filtering"

The Scanning Synthetic Aperture Radar (ScanSAR) is very useful for Earth observation because of its wider imaging swath and shorter revisit time. However, ScanSAR is sometimes affected by the following three artifacts: (1) scalloping, which often appears as repeating weak azimuth stripes at both edges of the focused burst image; (2) azimuth ambiguity (i.e., a form of ghosting that appears over the adjacent uniform area when the pulse repetition frequency is below the Doppler bandwidth); and (3) radiometric discontinuity (i.e., banding) between two adjacent scans. This paper proposes three methods to correct these artifacts, which are, specifically, the proposal for scalloping correction using Amazon Rainforest data, band limitation, and the correction for the inter SCAN banding using the dynamic gain correction algorithm. Several corrected sample data sets of the Phased-Array L-band SAR onboard the Advanced Land-Observing Satellite are presented to demonstrate the validity of the proposed methods. [J112]

"The PALSAR Polarimetric Mode for Sea Oil Slick Observation"

A study on sea oil slick observation by means of L-band polarimetric synthetic aperture radar (SAR) data is accomplished. It is based on different sea surface scattering mechanism expected with and without surface slicks. Polarimetric measurements are processed by means of a simple and very effective filtering technique which is electromagnetically based on the Mueller scattering matrix. Moreover, some polarimetric features, evaluated on both slick-free and slick-covered sea surfaces, are analyzed for confirming the filter output.

Experiments are accomplished on the polarimetric SAR data acquired by the Phased Array-type L-band Synthetic Aperture Radar (PALSAR) sensor, mounted on board of the Advanced Land Observing Satellite (ALOS), and are relevant to oil slick, due to a tank accident, and look-alikes. Results demonstrate for the first time that L-band polarimetric SAR measurements are useful for oil slick observation purposes and witness the capability of the ALOS PALSAR data for such application. [J113]

"Polarimetric PALSAR Calibration"

Polarimetric Phased-Array-type L-band Synthetic Aperture Radar (PALSAR) system parameters are assessed using data sets collected over several calibration sites. The data collected over the Amazonian rain forest help validate the hypothesis that Faraday rotation is zero near the equator. The analysis of the Amazonian forest data and the response of the corner reflectors deployed there during the PALSAR acquisitions lead to the conclusion that the antenna is highly isolated (better than -35 dB). These results are confirmed using the data collected over calibration sites located in Sweden and Canada. The 5-m-height corner reflector deployed at the Remningstorp (Sweden) calibration site by Chalmers University of Technology provides accurate measurement of antenna parameters and detection of a (2deg -3deg) Faraday rotation during day-time acquisitions, whereas no Faraday rotation was noted during night-time acquisitions. Small Faraday rotation angles (2deg-3deg) have been measured using acquisitions over the DLR Oberpfaffenhofen and the Ottawa calibration sites. The presence of small but still significant Faraday rotation (2deg-3deg) induces a corner reflector return at the cross-polarization HV and VH that should not be interpreted as the actual antenna crosstalk. These results show that the PALSAR antenna is highly isolated (better than -35 dB), and diagonal antenna distortion matrices (with zero crosstalk terms) can be used for accurate calibration of PALSAR polarimetric data. [J114]

"Nanotechnology radar thermal management"

Active phased array antennas in state-of-the-art radars, adopt many high power amplifiers. High power transmit-receive modules are assembled in dense electronic environments and have to cope with severe environmental operative condition. Radar state-of-the-art systemic signal processing requires growing and enormous power calculation in order to obtain unprecedented hard real-time performances as well as implementing adaptive knowledge-based algorithms. Unfortunately, the present steady growth of the micro-processors performance are reaching a saturation point due to the approaching limit of miniaturizations. Present and future active phased array antennas and signal processors have large and increasing heat dissipation problems. Nanotechnologies are emerging as enabling technologies that will provide a revolution in the sectors of sensors and radar systems. These innovative technologies could enable new solutions and improve weight, size, speed, power consumption, efficiency, and so on. In addition, the nanotechnologies could solve the increasing heat dissipation problems by adopting Carbon NanoTubes CNT ropes or arrays for thermal management and interconnection. [J115]

"Phased array technology in Australia"

Australia has been developing and fielding phased array appUcations since the early 1950s. The application areas range from radio astronomy and atmospheric sciences, through over-the-horizon radar (OTHR), surface wave, microwave ship, and airborne systems. Given Australia's unique geographical size, position, single continent, and national identity, it is not surprising that much of this effort has focused on long range over-the-horizon technology both for environmental observation and surveillance of the extensive land and maritime regions of national interest and responsibility. This discussion will draw focus on just a few of the historical and current programs finishing with an overview of the current application of actiive phased array developments for ship defence. [J116]

"Institutional Listings"

{no data available} [J117]

"Models and performance evaluation for multiple-input multiple-output space-time adaptive processing radar"

Signal and clutter modelling and optimum performance evaluation for multiple-input multiple-output (MIMO)-based space-time adaptive processing radar is addressed. A signal model is developed to account for both code diverse MIMO (c-MIMO) and frequency diverse MIMO (f-MIMO), and a general framework on performance evaluation is presented to take into account various waveform configurations including phased array (PA), partially correlated MIMO and ideally orthogonal MIMO. The proposed framework evaluates the system performance through optimum processing (OP) gain and transmit array (TA) gain. The OP gain is in turn evaluated by the number of available space-time measurements (ASMs) that depends on the number of clutter degrees of freedom (clutter NDoF) relative to the system degrees of freedom (system NDoF). The waveform

diversity introduced by MIMO, especially f-MIMO, could significantly enhance the OP gain by increasing the number of ASMs. Hence, in OP-gain-limited scenarios, where the overall performance significantly degrades despite the TA gains, the preferable configuration in terms of optimum performance would be ordered as f-MIMO, c-MIMO, and last, PA, that is, no MIMO. [J118]

"The German satellite mission TerraSAR-X"

TerraSAR-X is Germany's first national remote sensing satellite being implemented in a public-private partnership between the German Aerospace Centre (DLR) and EATS Astrium GmbH. TerraSAR-X was launched on June 15, 2007 and will supply high-quality radar data for purposes of scientific observation of the Earth for a period of at least five years. At the same time, it is designed to satisfy the steadily growing demand of the private sector for remote sensing data in the commercial market. [J119]

"Potential technological breakthroughs for phased array antennas"

This reports on the analysis of technologies opening avenues for potential technological breakthroughs in phased array antennas. We report on recent results on the insertion of hardware technologies such as RF MEMS and RF photonics, in the front-end of phased array antennas. Future prospects for the insertion of nanotechnologies are presented. [J120]

"Coordinate Conversion and Tracking for Very Long Range Radars"

The problem of tracking with very long range radars is studied in this paper. First, the measurement conversion from a radar's r-u-v coordinate system to the Cartesian coordinate system is discussed. Although the nonlinearity of this coordinate transformation appears insignificant based on the evaluation of the bias of the converted measurements, it is shown that this nonlinearity can cause significant covariance inconsistency in the conventionally converted measurements (CM1). Since data association depends critically on filter consistency, this issue is very important. Following this, it is shown that a suitably corrected conversion (CM2) eliminates the inconsistency. Then, initialized with the converted measurements (using CM2), four Cartesian filters are evaluated. It is shown that, among these filters, the converted measurement Kalman filter with second order Taylor expansion (CM2KF) is the only one that is consistent for very long range tracking scenarios. Another two approaches, the range-direction-cosine extended Kalman filter (ruvEKF) and the unscented Kalman filter (UKF) are also evaluated and shown to suffer from consistency problems. However, the CM2KF has the disadvantage of reduced accuracy in the range direction. To fix this problem, a consistency-based modification for the standard extended Kalman filter (E1KF) is proposed. This leads to a new filtering approach, designated as measurement covariance adaptive extended Kalman filter (MCAEKF). For very long range tracking scenarios, the MCAEKF is shown to produce consistent filtering results and be able to avoid the loss of accuracy in the range direction. It is also shown that the MCAEKF meets the posterior Carmer-Rao lower bound for the scenarios considered. [J121]

"Institutional Listings"

{no data available} [J122]

"Position Correction Using Echoes From a Navigation Fix for Synthetic Aperture Sonar Imaging"

In synthetic aperture sonar (SAS), the platform position must be known sufficiently accurately for signals to be added coherently along the synthetic aperture. Often, the onboard navigation system is insufficiently accurate by itself, so corrections are needed. A well-known method is the displaced phase center antenna (DPCA) procedure for correcting platform position using seabed echoes. DPCA methods have the advantage of insensitivity to changing interference patterns, moving specular reflection, and changing occlusion, with aspect. However, when seabed echoes are unusable, either because they are too weak, or because they are corrupted by multipath, the seabed DCPA method may fail. Therefore, we present an alternative DPCA method using sonar echoes from a suitable navigation fix, based on an object detected after standard beamforming. In our proposed system, look angle is obtained by tracking the centroid of the rectified image of the fix object. When the standard DPCA correction equations are modified for a fixed reflector, it turns out that they provide incremental range and look-angle errors, precisely the values required when the target itself is used as the navigation fix. Moreover, the values obtained are then self-compensating for errors in estimating seabed depth or forward motion of the platform. The navigation fix is selected by bracketing in range, and beamforming overlapping subsets of the receiver array. In this paper, we present experimental results at transmitter frequencies of 25 and 100 kHz where our method enabled well-focused SAS images to be generated with little recourse to other navigation information. Hence, SAS can be carried out, even when a sophisticated inertial navigation system (INS) is not available. [J123]

"PALSAR Radiometric and Geometric Calibration"

This paper summarizes the results obtained from geometric and radiometric calibrations of the Phased-Array L-Band Synthetic Aperture Radar (PALSAR) on the Advanced Land Observing Satellite, which has been in space for three years. All of the imaging modes of the PALSAR, i.e., single, dual, and full polarimetric strip modes and scanning synthetic aperture radar (SCANSAR), were calibrated and validated using a total of 572 calibration points collected worldwide and distributed targets selected primarily from the Amazon forest. Through raw-data characterization, antenna-pattern estimation using the distributed target data, and polarimetric calibration using the Faraday rotation-free area in the Amazon, we performed the PALSAR radiometric and geometric calibrations and confirmed that the geometric accuracy of the strip mode is 9.7-m root mean square (rms), the geometric accuracy of SCANSAR is 70 m, and the radiometric accuracy is 0.76 dB from a corner-reflector analysis and 0.22 dB from the Amazon data analysis (standard deviation). Polarimetric calibration was successful, resulting in a VV/HH amplitude balance of 1.013 (0.0561 dB) with a standard deviation of 0.062 and a phase balance of 0.612deg with a standard deviation of 2.66deg . [J124]

"Operational Large-Area Forest Monitoring in Siberia Using ALOS PALSAR Summer Intensities and Winter Coherence"

Focusing on Siberia, the feasibility of using Advanced Land Observing Satellite Phased Arrayed L-band Synthetic Aperture Radar (PALSAR) summer-intensity and winter-coherence images for large-area forest monitoring was investigated. Fine beam dual horizontal/horizontal and horizontal/vertical (polarization) intensity strip images were acquired during the summer of 2007. The processing consisted of radiometric calibration, orthorectification, and topographic normalization. The coherence was estimated from interferometric pairs with 46-day repeat-pass intervals. The pairs were acquired during the winters of 2006/2007 and 2007/2008. During both winters, suitable weather conditions that allow for low temporal decorrelation had been reported. By using PALSAR intensities and winter-coherence data, areas of forest and nonforest were separated. By combining both data types, a minimal overlap of the class signatures was observed, even though the analysis was conducted at the pixel level and no speckle filter was applied. The study concludes that the operational delineation of forest cover using PALSAR data is feasible. By applying a segmentation-based classification, an accuracy of 93% was obtained. [J125]

"MIMO radar: Snake oil or good idea?"

MIMO communication is theoretically superior to conventional communication under certain conditions, and MIMO communication also appears to be practical and cost-effective in the real world for some applications. It is natural to suppose that the same is true for MIMO radar, but the situation is not so clear. Researchers claim many advantages of MIMO radar relative to phased array radars (e.g., better detection performance, better angular resolution, better angular measurement accuracy, improved robustness against RFI, ECM, multipath, etc.). We will evaluate such assertions from a system engineering viewpoint. In particular, there are serious trade-offs of MIMO vs. phased array radars relative to cost, system complexity, and risk considering numerous real world effects that are not included in most theoretical analyses. Moreover, in many cases one can achieve essentially the same radar system improvement with phased array radars using simpler, less expensive, and less risky algorithms. We evaluate roughly a dozen asserted advantages of MIMO radar relative to phased arrays. [J126]

"A Single Polarized Triangular Grid Tapered-Slot Array Antenna"

A triangular grid single polarized tapered-slot array antenna for radar applications is studied. Compared with a rectangular grid an equilateral triangular grid allows a larger unit cell without any onset of grating lobes. Since single polarized tapered-slots in triangular grids support guided modes, which cause scan blindness, the increase in unit cell size is smaller than the optimal 15%. The design presented in the paper is capable of scan angles out to 60?? from broadside in the E and H planes. To improve the match over the radar band a local minimum in the active reflection coefficient is positioned at the most critical scan direction, resulting in a reflection coefficient that is less than -12 dB in the X-band. To reduce the radar cross section for the cross-polarization an absorbing layer is positioned above the ground plane, which affects some of the guided modes that lead to scan blindnesses. An experimental antenna with 16 ?? 16 elements was built, and it was found that the H-plane performance for large scan angles for the finite antenna deviates more than expected from the infinite array approximation. Otherwise both mutual coupling measurements and embedded element patterns agrees well with the numerical results. [J127]

"Relationship Between PALSAR Backscatter and Surface-Roughness Parameters From Iron

Laterites in CarajЂs, Amazon Region"

The objective of this investigation was to evaluate the influence of micro- and macrotopography on PALSAR fine-beam dual backscattering in the characterization of iron laterites in Carajas Province, Amazon Region. The moderate linear correlation between sigma0and surface roughness indicated that, only for L-HH polarization, sigma0was modulated by the morphology of the geological surfaces. [J128]

"Azimuth Phase Center Adaptation on Transmit for High-Resolution Wide-Swath SAR Imaging"

Synthetic aperture radar (SAR) systems with multiple receive channels allow for high-resolution wide-swath imaging thus overcoming a fundamental limitation of conventional single-aperture SAR. By using multiple apertures in azimuth, additional samples are received for each transmitted pulse. This allows for a reduced pulse repetition frequency (PRF) thereby enabling a wider swath. However, a nonoptimum PRF is associated with a nonuniform sample spacing in azimuth and needs to be compensated by a multichannel reconstruction algorithm. For strong deviations from the optimum PRF, the inverse character of such an algorithm might result in a degraded performance. This can be overcome by an innovative advanced transmit antenna architecture which allows for a pulse-to-pulse shift of the phase center. Such an antenna enables the adaptive adjustment of the system's phase center positions to the respective PRF, thereby ensuring constant performance over a clearly extended PRF range. In particular, in combination with conventional multichannel processing strategies, this technique represents the next step toward a fully active multiple-input multiple-output (MIMO) SAR and has a great potential for future systems. [J129]

"Comparative Study on the Performance of Multiparameter SAR Data for Operational Urban Areas Extraction Using Textural Features"

The advent of a new generation of synthetic aperture radar (SAR) satellites, such as Advanced SAR/Environmental Satellite (C-band), Phased Array Type L-band Synthetic Aperture Radar/Advanced Land Observing Satellite (L-band), and TerraSAR-X (X-band), offers advanced potentials for the detection of urban tissue. In this letter, we analyze and compare the performance of multiple types of SAR images in terms of band frequency, polarization, incidence angle, and spatial resolution for the purpose of operational urban areas delineation. As a reference for comparison, we use a proven method for extracting textural features based on a Gaussian Markov Random Field (GMRF) model. The results of urban areas delineation are quantitatively analyzed allowing performing intrasensor and intersensors comparisons. Sensitivity of the GMRF model with respect to texture window size and to spatial resolutions of SAR images is also investigated. Intrasensor comparison shows that polarization and incidence angle play a significant role in the potential of the GMRF model for the extraction of urban areas from SAR images. Intersensors comparison evidences the better performances of X-band images, acquired at 1-m spatial resolution, when resampled to resolutions of 5 and 10 m. [J130]

"RF MEMS on the radar"

This article gives an overview of applications of radio frequency (RF) microelectromechanical system (MEMS) technology in radio detection and ranging (radar). RF MEMS components for radar include attenuators, limiters, (true-time-delay) phase shifters, transmit/receive (T/R) switches and tunable matching networks. Radar subsystems that benefit from RF MEMS technology include active electronically scanned arrays (T/R modules), passive electronically scanned arrays (lenses, reflect arrays, subarrays, and switched beamformers), and radomes. Using a bottom-up approach, the figures of merit for RF MEMS technology are related to the figures of merit for radar subsystems. The article also discusses ultrawideband RF MEMS reflect array and T/R module design as examples. First, electronically scanned array, radar and RF MEMS fundamentals are briefly introduced. [J131]

"The Contribution of ALOS PALSAR Multipolarization and Polarimetric Data to Crop Classification"

Mapping and monitoring changes in the distribution of cropland provide information that aids sustainable approaches to agriculture and supports early warning of threats to global and regional food security. This paper tested the capability of Phased Array type L-band Synthetic Aperture Radar (SAR) (PALSAR) multipolarization and polarimetric data for crop classification. L-band results were compared with those achieved with a C-band SAR data set (ASAR and RADARSAT-1), an integrated C- and L-band data set, and a multitemporal optical data set. Using all L-band linear polarizations, corn, soybeans, cereals, and hay-pasture were classified to an overall accuracy of 70%. A more temporally rich C-band data set provided an accuracy of 80%. Larger biomass crops were well classified using the PALSAR data. C-band data were needed to accurately classify low biomass crops. With a multifrequency data set, an overall accuracy of 88.7% was reached, and many individual crops were classified to accuracies better than 90%. These results were competitive with the overall accuracy

achieved using three Landsat images (88.0%). L-band parameters derived from three decomposition approaches (Cloude-Pottier, Freeman-Durden, and Krogager) produced superior crop classification accuracies relative to those achieved using the linear polarizations. Using the Krogager decomposition parameters from all three PALSAR acquisitions, an overall accuracy of 77.2% was achieved. The results reported in this paper emphasize the value of polarimetric, as well as multifrequency SAR, data for crop classification. With such a diverse capability, a SAR-only approach to crop classification becomes increasingly viable. [J132]

"Calibration of Polarimetric PALSAR Imagery Affected by Faraday Rotation Using Polarization Orientation"

For spaceborne polarimetric synthetic aperture radar (SAR), it is important to ensure the removal of both polarimetric system distortion and the effect of Faraday rotation. This paper proposes a new calibration method to derive the system distortion using polarization orientation (PO) induced in built-up areas and applies to Phased-Array-Type L-Band SAR (PALSAR) calibration. Faraday rotation is corrected by the circular-polarization-based method from the distortion matrix (DM)-calibrated data. The derived DMs do not coincide with those by the Japan Aerospace Exploration Agency (JAXA), but our calibration results compare well to JAXA's results in PO angles and calibrator's responses. The two results satisfy polarimetric calibration requirements, and the cross-polarized isolation improves by more than 5 dB after Faraday rotation correction following DM calibration-even in the case of small Faraday rotation (-2deg to -0.5deg). The proposed method is robust to noise and is useful when using an area of mixed polarimetric response for calibration. This method is also applicable to a large crosstalk system and the case of large Faraday rotation. [J133]

"Signatures of ALOS PALSAR L-Band Backscatter in Swedish Forest"

The Phased Array type L-band Synthetic Aperture Radar onboard the Advanced Land Observing Satellite has, since its launch, been acquiring an extensive data set of images over two forest test sites in Sweden. The sites of Remningstorp (Lat. 58deg30' N, Long. 13deg40' E) in the south and Krycklan (Lat. 64deg14' N, Long. 19deg50' E) in the north of Sweden are characterized by hemiboreal and boreal forests, respectively. In this paper, we have investigated the signatures of standwise backscatter measurements from forests with different growth stages in relation to polarization, environmental conditions, image viewing geometry, and spatial resolution. The HV backscatter presented stronger sensitivity to the forest growth stage than the HH and VV backscatter. Under unfrozen conditions, the dynamic range of fine-beam data acquired at 34.3deg was 8-9 dB for the HV polarization and 6-7 dB for the HH polarization. At 21.5deg, in the polarimetric mode, the dynamic range was 6, 7, and 9 dB at VV, HH, and HV polarizations, respectively. Regardless of the specific polarization, the backscatter was temporally consistent under unfrozen conditions, with a small increase of backscatter in regrowing young forest for wet conditions. Under thawing and frozen conditions, repeated measurements were available only for the HH backscatter at 34.3deg. For thawing conditions, the backscatter level was similar to the unfrozen conditions even though the signatures differed depending on temperature dynamics, snow-cover properties, and precipitation. Under frozen conditions, the signatures varied depending on temperature. For images acquired when the temperature was well below the freezing point, the backscatter was low, and the dynamic range was small (2-4 dB); nonetheless, the measurements were consistent. Images acquired when temperature was close to the freezing point presented a behavior similar to unfrozen conditions. The sensitivity of the backscatter to the image viewing geometry for d--ifferent growth stages was studied for data acquired under dry unfrozen conditions. The backscatter difference increased for increasing look angle because of the increase in volume scattering and the decrease of ground-surface backscatter. The largest difference was observed at 41.5deg with 2.5-4-dB difference for the HH and 4-5-dB difference for the HV case. Loss of spatial resolution (20-50 m) did not have any effect on the backscatter signatures in Krycklan, whereas in Remningstorp, the smallest stands were affected. [J134]

"Phase-Based Clutter Identification in Spectra of Weather Radar Signals"

A novel method for suppression of ground clutter (GC) in weather radar is presented. The novel identification scheme is entirely phase based, unlike power-based schemes that are generally used. GC contributions to the Doppler spectrum are identified from the differential phase between complex spectral coefficients of two spectra estimated for odd- and even-indexed half-sequences of the original time series. Phase values near zero are used as indicators of clutter contributions for Doppler bins close to zero velocity. Indicated Doppler bins are notched from the original spectrum, and the moments are then obtained. The identification scheme is motivated by spectra of an electronically steered phased array of the National Weather Radar Testbed (NWRT) and requires a sufficient number of pulses/samples for spectral analyses. However, the method can be used with a mechanically steered antenna with an appropriate adjustment compensating smearing due to antenna rotation. The method was tested on several NWRT data sets obtained in clear air and in precipitation. One example of clutter-filtered power in precipitation is shown here. There is no baseline for comparison, as the NWRT does not

have clutter filtering at the present time. Nonetheless, for a comparison of power- and phase-based identification schemes, a power-based clutter filter similar to the one used by the National Weather Service on the network of mechanically steerable Weather Surveillance Doppler radars WSR-88Ds is implemented on NWRT and used as a preliminary baseline for comparison. [J135]

"Radar Revisited (review of "Radar Handbook, 3rd ed." by Merrill Skolnik) [JBook Reviews]"

This is the third edition of an established handbook, edited by one of the most-recognized names in the field of radar technology. The volume is a compilation of 26 chapters, authored by individuals with a thorough command of, and incredible credentials in, the topics of their chapters. Most chapters have a large number of figures (up to several dozen) and extensive bibliographies. Chapters range from fairly quantitative and mathematical ones to cursory and descriptive ones. Some sections of the handbook represent a concise and readable summary of the state-of-the-art of knowledge on their topics; others are a sketchy collection of remarks for which it is difficult to identify the benefits to be derived by the reader. There is little coordination between chapters where similar topics may be discussed, and a lack of any cross-referencing. There are also weaknesses in the index, as well. While the older, classical radar topics receive much attention, the book overlooks newer areas such as coverage of automotive radars. This volume will appeal to the generalists with interest in the conventional radar subjects, and to others as a starting point for locating sources with more detailed information. [J136]

"An X- and Ku -Band 8-Element Phased-Array Receiver in 0.18- SiGe BiCMOS Technology"

This paper demonstrates an 8-element phased array receiver in a standard 0.18-mum SiGe BiCMOS (1P6M, SiGe HBT ftap 150 GHz) technology for X- and Ku-band applications. The array receiver adopts the All-RF architecture, where the phase shifting and power combining are done at the RF level. With the integrations of all the digital control circuitry and ESD protection for all I/O pads, the receiver consumes a current of 100 ~ 200 m A from a 3.3 V supply voltage. The receiver shows 1.5 ~ 24.5 dB of power gain per channel from a 50 Omega load at 12 GHz with bias current control, and an associated NF of 4.2 dB (@ max. gain) to 13.2 dB (@ min. gain). The RMS gain error is < 0.9 dB and the RMS phase error is < 6deg at 6-18 GHz for all 4-bit phase states. The measured group delay is 162.5 plusmn 12.5 ps for all phase states at 6-18 GHz. The RMS phase mismatch and RMS gain mismatch among the eight channels are < 2.7deg and 0.4 dB, respectively, for all 16 phase states, over 6-18 GHz. The 8-element array can operate instantaneously at any center frequency and with a wide bandwidth (3 to 6 GHz, depending on the center frequency) given primarily by the 3 dB gain variation in the 6-18 GHz range. To our knowledge, this is the first demonstration of an All-RF phased array on a silicon chip with very low RMS phase and gain errors at 6-18 GHz. The chip size is 2.2 times 2.45 mm2including all pads. [J137]

""Reduction of Aperture Blockage in the Center-Feed Alternating-Phase Fed Single-Layer Slotted Waveguide Array Antenna by E- to H-Plane Cross-Junction Power Dividers""

The alternating-phase fed single-layer slotted waveguide array antenna, which dispenses with the electrical contact between the narrow walls and the slotted plates, has been developed for low cost wireless communication systems, radar systems, etc. The center-feed is introduced to increase antenna bandwidth by having the long line effects associated with the end-feed one. However, the large blocking area at the center of the array aperture causes high first side-lobe levels (about -10 dB). In this paper, the authors propose a cascade of "E- to H-plane cross-junctions" as a new single-layer feed waveguide with reduced blockage. It is in single-layer without inductive posts and is mass producible by die-casting techniques. The antenna characteristics and sidelobe reduction are confirmed by simulation and experiment. [J138]

"A Dual-Mode Millimeter-Wave Folded Microstrip Reflectarray Antenna"

A dual-mode folded microstrip reflectarray antenna was developed and demonstrated in this paper. The proposed folded reflectarray antenna contains three parts: a planar main reflector, a planar subreflector, and printed feed antennas. The main reflector is used to produce twisted reradiated fields and to provide phase compensation for focusing. The subreflector parallel with the main reflector is made of a substrate printed with high-density metal grid lines, which is transparent to perpendicularly polarized fields, but would reflect the parallel ones. Three fixed-position patch antennas with polarization parallel to the grid lines are created for the radar mode, so that the radiation beam is switchable. Another patch with perpendicular polarization is designed for communication. A simple approach was proposed for simulating and designing the folded reflectarray. Measured results show good agreement with the calculated ones. [J139]

"A -Band Four-Element Phased-Array Front-End Receiver With Integrated Wilkinson Power Combiners in 0.18- SiGe BiCMOS Technology"

A four-element phased-array front-end receiver based on 4-bit RF phase shifters is demonstrated in a standard 0.18-mum SiGe BiCMOS technology for Q-band (30-50 GHz) satellite communications and radar applications. The phased-array receiver uses a corporate-feed approach with on-chip Wilkinson power combiners, and shows a power gain of 10.4 dB with an IIP3of -13.8 dBm per element at 38.5 GHz and a 3-dB gain bandwidth of 32.8-44 GHz. The rms gain and phase errors are les1.2 dB and les8.7deg for all 4-bit phase states at 30-50 GHz. The beamformer also results in les0.4 dB of rms gain mismatch and les2deg of rms phase mismatch between the four channels. The channel-to-channel isolation is better than -35 dB at 30-50 GHz. The chip consumes 118 mA from a 5-V supply voltage and overall chip size is 1.4times1.7 mm2including all pads and CMOS control electronics. [J140]

"Metric tensor approach to surveillance analysis of phased array radar"

The author shows that the metric tensor galphabetais sufficient to accurately derive some of the most important system surveillance characteristics of static and rotating phased array radars. The author presents a novel and generalised method using metric spaces on Riemann manifolds as a viable approach for investigating phased array radar system design characteristics that is mathematically tractable and avoids complex iterative and non-analytic procedures. [J141]

"Bispectral analysis of atmospheric radar signals"

The bispectral analysis techniques have been applied on signals received from the back-scattered signals by the MST radar. The results of this analysis are compared with that of the conventional power spectral analysis using the fast Fourier transform (FFT) technique. Our results showed that there is a significant advantage in using the bispectral technique over the conventional FFT technique. This study focuses on the importance of bispectral analysis in applications to atmospheric signals. [J142]

"Automatic Phase Correction of Phased Array Antennas by a Genetic Algorithm"

An automatic phase correction method for phased array antenna (PAA) systems is presented. It is based on finding the optimal phases that maximize the receiving power for a source in a given direction. The optimal phase set is estimated by a genetic algorithm (GA). To test this method we constructed a PAA breadboard with a linear 16 -element operating at the X-band, and 4-bit digital phase shifters. The results of several correction tests show good performance. [J143]

"Institutional Listings"

{no data available} [J144]

"Refractivity Retrieval Using the Phased-Array Radar: First Results and Potential for Multimission Operation"

In this paper, an investigation of the potential of rapid refractivity retrieval is presented. The retrieval technique utilizes radar phase measurements of ground clutter to derive near-surface refractivity, which has been commonly used as a proxy for humidity, given its close relation to vapor pressure. Surface humidity is an important meteorological parameter and has been known to play an important role in convective initiation. In this paper, the refractivity retrieval technique is exploited by using smaller numbers of samples for phase calculation, which is a fundamental process in refractivity retrieval. The impetus for this paper is to explore the possibility of rapid refractivity retrieval by exploiting the rapid beam-steering capability of a phased-array radar. Using the National Weather Radar Testbed in Norman, OK, a 64-pulse per radial raw-data set was collected for conventional refractivity processing. Then, subsets of the 64 samples were extracted to emulate shorter dwell periods and the corresponding more rapid experiments. The test cases that were considered are 2, 4, 8, 16, and 32 samples. Refractivity fields retrieved using smaller numbers of samples are compared against the reference field, which was obtained using the entire 64-sample data set. It will be shown that, statistically, significant refractivity fields can be obtained from as short as a two-sample dwell. [J145]

"Determination of Dimensions and Shape of a Planar Aperture for Forming of Orthogonal Beams"

A technique is proposed for determining dimensions and shape of a planar aperture which allows forming orthogonal beams arranged in the nodes of a general skew Cartesian periodic lattice specified in the plane of direction cosines. The technique is based on constructing an auxiliary lattice reciprocal with respect to the beam lattice, and on using one cell of the reciprocal lattice as the aperture required. The proof of orthogonality of the beams formed by the aperture chosen according to the technique proposed is given. Some examples are considered and characteristics of the orthogonal beams formed by an equilateral hexagon as an important

special case are presented. [J146]

"Waveform Synthesis for Diversity-Based Transmit Beampattern Design"

Transmit beampattern design is a critically important task in many fields including defense and homeland security as well as biomedical applications. Flexible transmit beampattern designs can be achieved by exploiting the waveform diversity offered by an array of sensors that transmit probing signals chosen at will. Unlike a standard phased-array, which transmits scaled versions of a single waveform, a waveform diversity-based system offers the flexibility of choosing how the different probing signals are correlated with one another. Recently proposed techniques for waveform diversity-based transmit beampattern design have focused on the optimization of the covariance matrix of the waveforms, as optimizing a performance metric directly with respect to the waveform matrix is a more complicated operation. Given an, obtained in a previous optimization stage or simply pre-specified, the problem becomes that of determining a signal waveform matrix whose covariance matrix is equal or close to, and which also satisfies some practically motivated constraints (such as constant-modulus or low peak-to-average-power ratio constraints). We propose a cyclic optimization algorithm for the synthesis of such an, which (approximately) realizes a given optimal covariance matrix under various practical constraints. A numerical example is presented to demonstrate the effectiveness of the proposed algorithm. [J147]

"Millimetre-wave monopulse antenna incorporating substrate integrated waveguide phase shifter"

A compact planar E-plane monopulse antenna is proposed and realised at 36.5 GHz for millimetre-wave radar or direction-finding system application, which is built on the substrate integrated waveguide (SIW) technology. A phase shifter having a non-uniform SIW width configuration is self-consistently made of a periodically embedded via array and it can achieve good performances over a relative broad bandwidth. A 180deg directional coupler incorporating this proposed phase shifter structure is developed in the design of an integrated feeding network for the monopulse antenna. Four elements array based on the configuration of antipodal linearly tapered slot antenna is designed as radiator, offering a pair of 'sum' and 'difference' beams along the long direction of the substrate. Measured gain of the 'sum' beam is higher than 16 dBi, whereas the zero depth of the 'difference' beam is lower than -38 dB. This type of monopulse antenna presents an excellent candidate in the development of intelligent millimetre-wave directional- finding system. [J148]

"RadarCon 2008 in Rome"

{no data available} [J149]

"Post-adaptive processing time-delay beamforming for clutter suppression in airborne radar"

A novel beamforming architecture is presented in which time delay steering is applied after the application of space-time adaptive processing (STAP) in a phased array for airborne radar. Improved clutter suppression and slow moving target detection performance can be achieved over that associated with STAP and conventional time delay steering in wideband sideways looking applications. The architecture also provides a computationally efficient means of applying time-delay beamforming in conjunction with STAP in applications where multiple receive beams are required. [J150]

"Multidimensional Waveform Encoding: A New Digital Beamforming Technique for Synthetic Aperture Radar Remote Sensing"

This paper introduces the innovative concept of multidimensional waveform encoding for spaceborne synthetic aperture radar (SAR). The combination of this technique with digital beamforming on receive enables a new generation of SAR systems with improved performance and flexible imaging capabilities. Examples are high-resolution wide-swath radar imaging with compact antennas, enhanced sensitivity for applications like alongtrack interferometry and moving object indication, and the implementation of hybrid SAR imaging modes that are well suited to satisfy hitherto incompatible user requirements. Implementation-specific issues are discussed and performance examples demonstrate the potential of the new technique for different remote sensing applications. [J151]

"Artificial Neural Network and Analytical Method-Based Control of Higher Harmonic Radiation From Active Antenna Arrays"

The mean-square error (MSE) criterion combined with the Lagrange method and an artificial neural network (ANN) technique are proposed for the reduction of the radiation of the higher harmonic signals generated in active antenna arrays. [J152]

"A Systematic Construction for Radar Arrays"

The radar array problem arises from the need to design frequency hopping sequences with small out-of-phase autocorrelations. It assumes the reflected signals have negligible Doppler shifts, so the correlations are calculated along the time axis only. In this correspondence, a systematic construction for radar arrays is provided by means of homogeneous uniform difference matrices. A systematic construction for properly centered permutation matrices, a special kind of homogeneous uniform difference matrices, is also provided, which partially solves the open problems posed by Zhang and Tu. [J153]

"Ranging in a Single-Input Multiple-Output (SIMO) System"

In this letter, optimal ranging in a single-input multiple-output (SIMO) system is studied. The theoretical limits on the accuracy of time-of-arrival (TOA) (equivalently, range) estimation are calculated in terms of the Cramer-Rao lower bound (CRLB). Unlike the conventional phased array antenna structure, a more generic fading model is employed, which allows for the analysis of spatial diversity gains from the viewpoint of a ranging system. In addition to the optimal solution, a two-step suboptimal range estimator is proposed, and its performance is compared with the CRLBs. [J154]

"Results from trials of a planar, incoherent, synthetic aperture sonar for underwater imaging"

Synthetic aperture sonar (SAS) techniques can yield high-resolution images with a small physical array. Their application in the underwater environment is usually confined to the deployment and synthesis of linear apertures. Incoherent SAS processing is a suboptimal approach compared with coherent SAS processing as the absence of phase information results in an inferior along-track resolution and a higher sidelobe level. The absence of phase information implies that incoherent processing is not constrained by phase-aliasing. Incoherent SAS can accommodate non-uniform inter-ping spacing and is tolerant to trajectory estimation errors of the order of the range-compressed pulse length. This presents new opportunities for a robust surveying system. Apertures of nonlinear shapes can be synthesised depending on the nature and requirement of the specific application and environment. Surveys can be conducted with minimal hardware deployment, such as by a diver. On the basis of this concept, tank trial results of a 3-dimensional incoherent SAS technique utilising the synthesis of 2D apertures are presented. Broadband pulses are employed to achieve optimal survey resolution. The feasibility of this technique is demonstrated for both monostatic and single-transmit, multiple-receive configurations. Practical results are shown for arbitrary-surface apertures sampled at non-uniformly separated positions. [J155]

"Transmit beamforming for MIMO radar systems using signal cross-correlation"

Proposed next-generation radar systems will have multiple transmit apertures with complete flexibility in the choice of the signals transmitted at each aperture. Here we propose the use of multiple signals with arbitrary cross-correlation matrix R, and show that R can be chosen to achieve or approximate a desired spatial transmit beampattern. Two specific problems are addressed. The first is the constrained optimization problem of finding the value of R which causes the true transmit beampattern to be close in some sense to a desired beampattern. This is approached using convex optimization techniques. The second is the problem of designing multiple constant-modulus waveforms with given cross-correlation R. The use of coded binary phase shift keyed (BPSK) waveforms is considered. A method for finding the code sequences based on random signaling with a structured correlation matrix is proposed. It is also shown that by restricting the class of admissible waveforms one reduces the set of possible signal correlation matrices. [J156]

"Temporal coherent adaptive target detection for multi-input multi-output radars in clutter"

The superiority of multiple-input multiple-output (MIMO) radars over conventional phased-array radars has been recently shown in many aspects. The MIMO radars have better detection performance and can extract target information more precisely than phased-array radars. The problem of adaptive target detection using temporal coherent pulse train in the presence of nonhomogeneous clutter (different clutter statistics in receivers) is considered for MIMO radars. This problem has been formulated as a hypothesis test. For clutter with unknown statistics three adaptive decision rules have been developed using the generalised likelihood ratio test. The results show the superiority of the MIMO radars with temporal coherent processing over conventional phased arrays in the presence of clutter. [J157]

"Adaptive update interval tracking based on adaptive grid interacting multiple model"

The update interval is adjustable in the phased array radar system. An adaptive update interval algorithm based on the adaptive grid interacting multiple model is proposed. The moving step size of mid-model's parameter is utilised to adapt the update interval to the target's behaviour. Furthermore, a controllable parameter is introduced

to balance the tracking precision and the system load. The effectiveness of the algorithm is verified through simulation. The simulation results also demonstrate that the proposed algorithm can save much system resource while achieving the same tracking quality as the fixed update interval algorithm. [J158]

"The Hybrid CramЙr-Rao Bound on Broadside DOA Estimation of Extended Sources in Presence of Array Errors"

In this correspondence we derive explicit expressions for the hybrid Cramer-Rao lower bound (HCRB) on the estimation accuracy of signal direction of arrival (DOA) from data collected by randomly perturbed arrays. The presence of a wavefront spatial decorrelation, which is modeled as a multiplicative correlated noise, has also been taken into account in the data model, since it is typical in those applications involving extended sources. In particular, we consider perturbations in sensor positions. Existing approaches to DOA HCRB calculation do not consider the presence of multiplicative noise and are referred to the assumption of small perturbations only, still not being worked out explicitly. Here, we assume that the impinging wavefronts are coming from broadside or more generally from a narrow DOA sector, allowing the explicit derivation of the HCRB for any variance of the sensor positioning errors in the line-of-sight direction. This scenario corresponds to the typical operative condition of remote sensing systems such as synthetic aperture radar (SAR) multibaseline interferometers, for which a few HCRB sample curves are reported. [J159]

"Application of metric tensors to conformal arrays"

Using the metric tensor galphabeta, the author derives the scattering parameters appearing in the field equations of the uniform theory of diffraction (UTD). The method presented allows us to derive these field parameters in terms of tensors whose general form can be applied to high-frequency electromagnetic scattering problems or more specifically to the analysis of conformal arrays. All the parameters in the field solutions are related to the array manifold properties that are derived via the use of the metric tensor are shown. The expressions for the Frenet-field tensors and the generalised Fock parameter and the shortest path propagated by the fields along the array manifold using the metric tensor in the calculus of variations are determined. The method enables UTD mutual coupling calculations to be performed for various phased array manifolds. [J160]

"Optimum configurations for static and rotating phased arrays"

We introduce a method for comparing the system surveillance characteristics of static and rotating phased array radars that also includes subregions of a given total surveillance area. The search function is obtained for different hemispherical regions based on the number of active/nonactive array faces. We derive the surveillance occupancy functions for a typical scenario consisting of 4 search sectors under various constraints and consider the number of radiating elements required for surveillance purposes. We derive an expression for the accurate determination of the surveillance volume and average beam dwell times for different scan angles based on the theory of manifolds and consider the impact of various window functions on the broadside dwell times. [J161]

"Institutional listings"

{no data available} [J162]

"A Fast Robust Chinese Remainder Theorem Based Phase Unwrapping Algorithm"

A robust phase unwrapping based on the Chinese remainder theorem (CRT) has been proposed lately, and it has applications in synthetic aperture radar (SAR) imaging for moving targets. It also leads to a type of robust CRT. This algorithm requires a two-dimensional searching. In this letter, we propose a new and fast algorithm that only does one-dimensional searching and therefore reduces the complexity significantly. [J163]

"Target detection and parameter estimation for MIMO radar systems"

We investigate several target detection and parameter estimation techniques for a multiple-input multiple-output (MIMO) radar system. By transmitting independent waveforms via different antennas, the echoes due to targets at different locations are linearly independent of each other, which allows the direct application of many data-dependent beamforming techniques to achieve high resolution and excellent interference rejection capability. In the absence of array steering vector errors, we discuss the application of several existing data-dependent beamforming algorithms including Capon, APES (amplitude and phase estimation) and CAPES (combined Capon and APES), and then propose an alternative estimation procedure, referred to as the combined Capon and approximate maximum likelihood (CAML) method. Via several numerical examples, we show that the proposed CAML method can provide excellent estimation accuracy of both target locations and target amplitudes. In the presence of array steering vector errors, we apply the robust Capon beamformer (RCB) and doubly constrained

robust Capon beamformer (DCRCB) approaches to the MIMO radar system to achieve accurate parameter estimation and superior interference and jamming suppression performance. [J164]

"Ground Moving Target Indication With Tandem Satellite Constellations"

Ground moving target indication (GMTI) from space by existing dual-channel radar systems such as TerraSAR-X and RADARSAT-2 has been shown to perform only insufficiently with respect to the relocation error of targets to their true ground position. Only two parallel receiver channels are too little to suppress the severe ground clutter and to estimate the target's parameters. Although this deficiency may partly be alleviated through antenna aperture switching, the resulting positioning accuracy is still not adequate for effective traffic monitoring purposes. Satisfactory results are only achievable with extended apertures, primarily with satellite constellations. This letter presents a statistical analysis of the performance of different concepts for cooperating back-to-back flying satellite systems. Particularly in anticipation of TanDEM-X, which will form the first operational GMTI-capable coherent synthetic aperture radar constellation after its launch in 2009. [J165]

"Comparison of Processing Algorithms for a Delay/Doppler Altimeter"

The use of a radar altimeter is to measure the height of the reflecting surface when the instrument passes overhead. A delay/Doppler altimeter (DDA) reduces the along-track resolution cell using correlation of pulses within burst, as in a synthetic aperture radar, with the net effect of synthesizing an array with a narrower lobe. The processing of DDA data therefore implies the correction of the phase delay of pulses, which is said to be Dopplerbeamsharpeningsince it can be reduced to a DFT in the along-track direction. The noise term on Doppler echoes is decreased by incoherent summing of contributions of different bursts. Summation of these contributions requires that pointing of each beam is directed toward a given output grid of samples on ground, and this can be a nontrivial task, depending on the topography profile. In this letter, a comparison between different beam sharpening algorithms is presented: Two of them are similar in their basic idea even if with different implementations; the third one can be considered as reference since no approximations are needed in principle, but is computationally inefficient. What results is that the first couple can be considered basically equivalent in terms of precision and computational efficiency, with little differences at the change of the environmental conditions. Results based on simulated data of simple and complex scenarios are presented as support of the reasoning. [J166]

"On the Radiation Tolerance of SiGe HBT and CMOS-Based Phase Shifters for Space-Based, Phased-Array Antenna Systems"

We report the first irradiation results on high-frequency SiGe HBT and CMOS phase shifters for space-based, phased-array antennas used in radar or wireless communication systems. Both phase shifter circuits remain functional with acceptable dcand RF performance up to multi-Mrad proton exposure, and are thus suitable for many orbital applications. In addition, simulation results probing the limits of phase shifter performance in a radiation environment are presented. These results show that both CMOS and SiGe HBT based phase shifters can be used for space-based applications without any specific radiation hardening techniques. [J167]

"RF Characterization of Zero-Biased Photodiodes"

The characteristics of zero-biased InGaAs p-i-n photodiodes were studied for use as optical transducers in an in situ phased array radar calibrator. Radio frequency (RF) operation is especially important for the intended application in which the zero-biased photodiodes drive patch antennas embedded in a radome. The photodiodes act as sources for real-time calibration of the phase and amplitude of each array element and will operate with only optical input from a modulated optical fiber link. Unfortunately, little is known of the RF performance of photodiodes operated without voltage bias. In this paper, both the dc and RF performance of a particular photodiode were studied to determine the optimum operating conditions and to understand the type and severity of any limitations. [J168]

"Development and testing of a 10 GHz phased-array cylindrical-antenna transmitting system incorporating a least-squares radiation-pattern synthesis technique"

This research presents the development and testing procedures for an experimental phased-array cylindrical-antenna transmitting system, operating at 10 GHz. The antenna-element excitation phases are set at the intermediate-frequency stage, and are determined by using a least-squares radiation-pattern synthesis technique. The antenna-element excitation amplitudes are taken to be equal and fixed. The system provides steerable main lobes and nulls at predefined directions, including control of the sidelobes at specified levels. It can be used for communications and radar applications with interference-rejection requirements. [J169]

"A Scalable 6-to-18 GHz Concurrent Dual-Band Quad-Beam Phased-Array Receiver in CMOS"

This paper reports a 6-to-18 GHz integrated phased- array receiver implemented in 130-nm CMOS. The receiver is easily scalable to build a very large-scale phased-array system. It concurrently forms four independent beams at two different frequencies from 6 to 18 GHz. The nominal conversion gain of the receiver ranges from 16 to 24 dB over the entire band while the worst-case cross-band and cross-polarization rejections are achieved 48 dB and 63 dB, respectively. Phase shifting is performed in the LO path by a digital phase rotator with the worst-case RMS phase error and amplitude variation of 0.5deg and 0.4 dB, respectively, over the entire band. A four-element phased-array receiver system is implemented based on four receiver chips. The measured array patterns agree well with the theoretical ones with a peak-to-null ratio of over 21.5 dB. [J170]

"Phase-Difference Ambiguity Resolution for a Single-Frequency Signal"

In this letter, we propose a novel method to disambiguate the phase-difference of a single-frequency signal observed between a pair of spatially separated sensors, with inter-sensor spacing exceeding half the wavelength (lambda/2) of the signal. We mathematically prove that, in a noiseless case, the true phase-difference can unambiguously be estimated utilizing a third collinear sensor, provided that the absolute difference between the two smaller inter-sensor spacings is less than lambda/2. The performance of the method is characterized by estimating the probability of failure in noisy cases. [J171]

"A Transmission Double-Line for the Calibration System of X-Band Active Phased-Array Antennas"

A transmission double-line, with low attenuation and low voltage standing wave ratio (VSWR) for the calibration of X-band active phased-array antennas, was designed and manufactured. The transfer function from a fed element of active phased-array antennas to the double-line was measured. The transmission double-line is used to monitor and correct the element phase error of an active phased-array antenna. Radiation patterns before compared to after calibration show that the approach is useful. [J172]

"A phase shifter with one tunable component for a reflectarray antenna"

The combination of a dipole and a tunable varactor forms a phase shifter with one tunable component that provides a phase shift over a wide range, from 0deg to nearly 360deg. The dipole, loaded with a tunable varactor, is used as a patch component of a low-profile reflectarray antenna. An economic assessment shows that the production price of the suggested phase shifter with one tunable component is more than 10 times smaller than the price of the traditional phase shifter, based on p-i-n diode components. The design of such a phase shifter is the goal of this paper. Simulations of the phase shift and loss of the reflected wave as a function of control voltage applied to the varactor were used, based on an analytical model verified by fullwave analysis. The results of simulations are in agreement with measurements. The fast and correct simulation of the reflection coefficient from the dipole loaded with the tunable varactor can be used for the design and optimization of a low profile steerable reflectarray antenna. [J173]

"A 22-24 GHz 4-Element CMOS Phased Array With On-Chip Coupling Characterization"

This paper presents a 22-24 GHz CMOS 4-element phased array based on the all-RF architecture with very low power consumption and chip area. The measured array performance, done at the system level at 22-24 GHz, shows an input and output match of <-13 dB, 9-12 dB gain, 7.5-8.0 dB NF, an IIP3 of -9.5 to -12.5 dBm, and a 4-bit phase control with an rms gain and phase error of <1.2 dB and <6deg, respectively (<0.5 dB and <3deg at 23.5-24.5 GHz). The chip consumes 76.5 mA from a 1.5 V supply and is 3 mm2in area. Extensive coupling measurements show that the dominant on-chip coupling components result in system-level gain and phase errors which are proportional to the LNA gain. To our knowledge, this is the first analysis of on-chip coupling effects on phased array performance, and the first demonstration of an all-RF mm-wave CMOS phased array with full amplitude and phase control on each element. The application areas are in high data-rate communications and automotive radars. [J174]

"Rotman lens design and simulation in software [JApplication Notes]"

Since its invention in the early 1960s (Rotman and Turner, 1963), the Rotman Lens has proven itself to be a useful beamformer for designers of electronically scanned arrays. Inherent in its design is a true time delay phase shift capability that is independent of frequency and removes the need for costly phase shifters to steer a beam over wide angles. The Rotman Lens has a long history in military radar, but it has also been used in communication systems. This article uses the developed software to design and analyze a microstrip Rotman Lens for the Ku band. The initial lens design will come from a tool based on geometrical optics (GO). A second stage of analysis will be performed using a full wave finite difference time domain (FDTD) solver. The results

between the first-cut design tool and the comprehensive FDTD solver will be compared, and some of the design trades will be explored to gauge their impact on the performance of the lens. [J175]

"High-Efficiency Angled-Dipole Antennas for Millimeter-Wave Phased Array Applications"

A high-efficiency microstrip-fed endfire angled-dipole antenna has been developed for millimeter-wave phased array applications. The antenna is built on both sides of a Teflon substrate (epsivr= 2.2) and this allows a wideband feed from the single-ended microstrip line to the differential dipole. The design results in wide radiation patterns for scanning purposes with a gain of around 2.5 dB at 20-26 GHz and a cross-polarization level of < -15 dB at 24 GHz. A mutual coupling of < -23 dB is measured between adjacent elements with 6.8 mm center-to center spacing (0.50-0.54 lambda0at 22-24 GHz). A variant of the angled-dipole antenna with a magnetic ground plane edge was also developed, and shows a measured gain of > 6 dB at 23.2-24.6 GHz and very low mutual coupling between elements (<-23 dB for a 6.8 mm spacing). Both antennas result in a radiation efficiency of > 93% when referenced to the microstrip line feed (including mismatch loss). The usefulness of these antennas as phased array radiators is demonstrated by several eight-element linear arrays at 22-24 GHz with scan angle up to 50 degrees. The application areas are in automotive radars and high data-rate communication systems. [J176]

"The Radiation Properties of a Novel Wire Antenna for the Security Fence Radar"

The radiation properties of a novel wire antenna are investigated. The main part of this antenna is a sinusoidal wire undulator, which radiates by coupling electromagnetic energy from a Goubau line located near the antenna. Far-field patterns and S-parameters composed of three sets of antenna are measured. The measured patterns are compared with the calculated ones and the phase and attenuation constants of all the antennas are calculated. Frequency behavior and the dependency on the antenna dimensions of those wave parameters are investigated. Measured and calculated field patterns are also compared with the MoM patterns and some properties of the wave propagating along structure are explained by using MoM current distributions. It is shown that a broadside transversal radiation occurs in a narrow frequency band. The radiation intensity strongly depends on the coupling distance between the Goubau line and the sinusoidal undulator. This antenna is used as the basic element of the security fence radar antenna array working at 1.25 GHz in the L-band, which detects intruders approaching the fence. The performance of the antenna in the array is investigated and the near field distribution of the array is measured. The received signals caused by an intruder are given. The effects of rain and wind are also considered. The results suggests that the security fence radar introduced in this study can be used for the perimeter control of closed areas such as airports, malls, etc. [J177]

"Genetically Optimized Metasurface Pairs for Wideband Out-of-Phase Mutual Response"

This letter deals with the design of a pair of metasurfaces made of dense periodic arrays of electric dipoles laid on thin metal-backed dielectric substrates, capable of maintaining out-of-phase reflection coefficients over a wide frequency band. Our design is based on the genetic optimization of the dipole dimensions and spacings, and the substrate thickness. For performance assessment and illustration of potential applications to reduction/control of radar cross-section signatures, we present an example involving Bragg-scattering suppression in strip arrays. [J178]

"A Silicon-Germanium Receiver for X-Band Transmit/Receive Radar Modules"

This work investigates the potential of commercially-available silicon-germanium (SiGe) BiCMOS technology for X-band transmit/receive (T/R) radar modules, focusing on the receiver section of the module. A 5-bit receiver operating from 8 to 10.7 GHz is presented, demonstrating a gain of 11 dB, and average noise figure of 4.1 dB, and an input-referred third-order intercept point (HP3) of -13 dBm, while only dissipating 33 mW of power. The receiver is capable of providing 32 distinct phase states from 0 to 360deg, with an rms phase error < 9deg and an rms gain error < 0.6 dB. This level of circuit performance and integration capability demonstrates the benefits of SiGe BiCMOS technology for emerging radar applications, making it an excellent candidate for integrated X-band phased-array radar transmit/receive modules. [J179]

"Evaluation and Bias Removal of Multilook Effect on Entropy/Alpha/Anisotropy in Polarimetric SAR Decomposition"

Entropy, alpha, and anisotropy (H/alpha/A) of the polarimetric target decomposition have been an effective and popular tool for polarimetric synthetic aperture radar (SAR) image analysis and for a geophysical parameter estimation. However, multilook processing can severely affect the values of these parameters. In this paper, a Monte Carlo simulation is used to evaluate and remove the bias generated by the multilook effect on these parameters for various media composed of grassland, forest, and urban returns. Due to insufficient averaging,

entropy is underestimated, and anisotropy is overestimated. We also found that the bias in the alpha angle can be either underestimated or overestimated depending on scattering mechanisms. Based on simulation results, efficient bias removal procedures have been developed. In particular, the entropy bias can be precisely corrected, and the amount of correction is independent of the radar frequency and SAR systems. Data from L-band Advanced Land Observing Satellite/phased array type L-band SAR, German Aerospace Research Center (DLR)/enhanced SAR, Jet Propulsion Laboratory (JPL)/airborne SAR, and X-band polarimetric and interferometric SAR are used for demonstration in this paper. [J180]

"Submicrosecond Scan-Angle Switching Photonic Beamformer With Flat RF Response in the C and X Bands"

A wideband (>10 GHz) beamformer, based on a photonic true-time-delay, with submicrosecond scan-angle switching is reported. The smooth microwave transmission (ripples <0.5 dB and <3deg) and superb uniformity among the elements (<0.1 dB and <0.5deg) are then used for the processing of 1 GHz-wide linear frequency modulation (LFM) signals in both the C and X bands with excellent performance. This performance is also maintained under dynamic operation, where a fast tunable laser is employed to provide <300 ns wavelength-controlled angle scanning. Based on these characteristics, an optimized architecture, where a photonic beamformer feeds a series of classical subarrays, can offer high performance in both the time and spatial domains for large, wideband phased-array antennas, with wide scan angles. [J181]

"High-Speed High-Isolation 2 2 Fiber-Optic Switch for Wideband Radar Photonic Beamforming Controls"

A new high-performance 2 x 2 fiber-optic switch is designed and demonstrated for wideband radar photonic beamforming controls. The switch deploys two bulk acoustooptic deflectors (AODs) in an imaging free-space symmetric optical design that exploits image inversion control via a Dove prism to form a 2 X 2 fully reversible low crosstalk noise high-speed switching structure. Experiments at the 1550-nm test wavelength show the switch to handle 0.5-W level optical input powers, < 2.2-mus switching time, <2.6-dB fiber-to-fiber optical loss, better than 56-dB optical crosstalk levels, and <0.2-dB polarization-dependent loss (PDL).and <0.2-dB polarization-dependent loss (PDL). Index terms-delay lines, optical switches, phased-array radar. [J182]

"Scattering of -polarized Wave by a Periodic Array of Thick-Walled Parallel Plate Waveguides"

A study is made of electromagnetic wave scattering by a periodic array of semi-infinite thick-walled parallel plate waveguides. The scattered field in the free-space region above the waveguides is sought in the form of a series of spatial harmonics in accordance with Floquet's theorem, whereas in the waveguide regions it is sought in the form of parallel plate waveguide modes. To satisfy the boundary and edge conditions in the free-space region, Fourier series expansion with corresponding coefficients being properly chosen Legendre functions is used. As a result, the amplitudes of spatial harmonics are given in the form of an infinite series of Legendre functions with unknown coefficients being the solution of certain doubly infinite system of linear equations. The exact solution of this system cannot be constructed and numerical calculations were performed to find the expansion coefficients approximately. [J183]

"Radar Imaging of Urban Areas by Means of Very High-Resolution SAR and Interferometric SAR"

In remote-sensing applications, the monitoring of urban areas by means of synthetic aperture radar (SAR) sensors has grown into a valuable and indispensable tool. Although SAR imaging with a spatial resolution down to 1 m is widespread, a resolution as fine as 10 cm and below is offered only by very few SAR sensors worldwide. In this paper, the potential of very high-resolution radar imaging of urban areas by means of SAR and interferometric imaging will be demonstrated and discussed. Results of urban SAR imaging down to subdecimeter resolution will be shown. Even though the immanent layover situation in urban areas is an obstacle to simple image understanding, a remedy can be found by using interferometric SAR imaging. Interferometric results based on very high-resolution SAR images acquired over urban areas, partially with a severe layover situation, will be presented. The corresponding data was acquired with the phased array multifunctional imaging radar (PAMIR), the X-band demonstrator of the Research Institute for High Frequency Physics and Radar Techniques (FHR), Forschungsgesellschaft fur Angewandte Naturwissenschaften (FGAN), Wachtberg, Germany. It can be stated that high-resolution interferometric SAR will be an important basis for upcoming radar-based urban analysis. [J184]

"The Compact Polarimetry Alternative for Spaceborne SAR at Low Frequency"

In spaceborne synthetic aperture radar (SAR), a single-polarization on-transmit offers twice the swath width

compared to full polarization. This is linked to SAR system design issues, and, without getting into the technical details deserving by themselves a full paper, we can just mention the swath characteristics of ALOS PALSAR (the Advanced Land Observing Satellite, Phased Array L-Band Synthetic Aperture Radar), reducing from 70 km for the dual-pol mode to 30 km for the full polarization mode. The reduced coverage in the full polarization mode has a harmful impact on the revisit time, which is always a major drive for the Earth-observing community. The options chosen up to now for dual-pol system designs (or single-polarization on-transmit) rely on a linear polarization on-transmit [either horizontal (H) or vertical (V)], with two orthogonal polarizations on-receive. Souyris and Raney in earlier papers proposed more pertinent alternatives for the selection of the transmit polarization leading to a better characterization of the scattering mechanisms. In this paper, the analysis is pursued in more depth by including the effect of the ionosphere on the wave propagation and extending the applications to polarimetric interferometry SAR (PolInSAR). A compact mode is developed where the transmit polarization is circular, whereas the only constraint on the two receiving polarizations is independence. Indeed, the choice of the polarizations of the two receive channels does not matter, as any polarization on-receive can be synthesized from these two measurements. This is, however, not the case for the unique transmit polarization. At a low frequency, where the ionosphere has a significant effect, the circular transmit polarization is the only sensible option, as it provides an effective constant polarization as seen by the scattering surface. This is an essential condition for a meaningful multitemporal analysis. Both the polarimetric SAR applications and the PolInSAR appl--ications in the context of this compact polarimetry (CP) mode are explored. A pseudocovariance matrix can be reconstructed following Souyris' proposed approach for distributed targets and is shown to be very similar to the full polarimetric (FP) covariance matrix. The reconstruction of the cross-polarized Sigma0 is shown to be reliable and to have very low sensitivity to Faraday rotation. A PolInSAR vegetation height inversion for P-band is presented and applied to the CP data with a level of performance that is similar to the one derived from FP (a 1.2-m root-mean-square height error on the ONERA Airborne radar (RAMSES) data over the Landes Forest). A procedure is developed to correct for the ionospheric effects for the PolInSAR acquisition in the FP or CP mode and is assessed on the data simulated from an airborne acquisition. The results demonstrate that the technique is efficient and robust. The calibration of CP data is identified as an important challenge to be solved, and some clues are provided to address the problem. [J185]

"Range Compression and Waveform Optimization for MIMO Radar: A CramЙr-Rao Bound Based Study"

A multi-input multi-output (MIMO) radar system, unlike standard phased-array radar, can transmit via its antennas multiple probing signals that may be correlated or uncorrelated with each other. This waveform diversity offered by MIMO radar enables superior capabilities compared with a standard phased-array radar. One of the common practices in radar has been range compression. We first address the question of ldquoto compress or not to compressrdquo by considering both the Cramer-Rao bound (CRB) and the sufficient statistic for parameter estimation. Next, we consider MIMO radar waveform optimization for parameter estimation for the general case of multiple targets in the presence of spatially colored interference and noise. We optimize the probing signal vector of a MIMO radar system by considering several design criteria, including minimizing the trace, determinant, and the largest eigenvalue of the CRB matrix. We also consider waveform optimization by minimizing the CRB of one of the target angles only or one of the target amplitudes only. Numerical examples are provided to demonstrate the effectiveness of the approaches we consider herein. [J186]

"Time-Domain Optimized Near-Field Estimator for Ultrasound Imaging: Initial Development and Results"

For nearly four decades, adaptive beamforming (ABF) algorithms have been applied in RADAR and SONAR signal processing. These algorithms reduce the contribution of undesired off-axis signals while maintaining a desired response along a specific look direction. Typically, higher resolution and contrast is attainable using adaptive beamforming at the price of an increased computational load. In this paper, we describe a novel ABF designed for medical ultrasound, named the time-domain optimized near-field estimator (TONE). We performed a series of simulations using synthetic ultrasound data to test the performance of this algorithm and compared it to conventional, data independent, delay and sum beamforming (CBF) method. We also performed experiments using a Philips SONOS 5500 phased array imaging system. CBF was applied using the default parameters of the Philips scanner, whereas TONE was applied on per channel, unfocused data using an unfocused transmit beam. TONE images were reconstructed at a sampling of 67 m laterally and 19 m axially. The results obtained for a series of five 20-m wires in a water tank show a significant improvement in spatial resolution when compared to CBF. We also analyzed the performance of TONE as a function of speed of sound errors and array sparsity, finding it robust to both. [J187]

"Correction to “Synthesis of Sparse Planar Arrays Using Modified Real Genetic Algorithm”"

{no data available} [J188]

"W-Band Fresnel Zone Plate Reflector for Helicopter Collision Avoidance Radar"

A high gain Fresnel zone plate reflector is presented for helicopter collision avoidance radar at 94 GHz. The antenna system consists of a compact, airtightness and low return loss primary source illuminating a printed reflector with Fresnel plate zone phase correction. In order to increase the overall efficiency, the reflector combines 8 correcting zones in its center and 4 on the border. Reflected phase of over 360deg is achieved by means of circular ring or combined circular and ring patches. The reflector is fabricated using standard photolithographic techniques. The primary source consists of a small FSS made by a double slot array antenna pasted on the aperture of a standard WR-10 waveguide. Antenna measurements were conducted using a compact base arrangement. The antenna performs 37.8 dBi at the center frequency of 94 GHz with a maximum value of the return loss value not exceeding -25 dB. The frequency bandwidth at -3 dB in gain and return loss is of 9% [J189]

"Experimental investigation of directional characteristics for ionospheric clutter in HF surface wave radar"

The unwanted radar echoes from the ionosphere are collectively called ionospheric clutter. It has proved to be the greatest impediment to achieve consistently good performance in long-range detection of surface vessels and sea-state monitoring for high-frequency surface wave radar (HFSWR). Field experimental data recorded by the HFSWR OSMAR2003 (Ocean State Monitor and Analysis Radar, manufactured in 2003) has been used in detailed investigations of the directional characteristics for this ionosphere clutter, leading to the development of effective mitigation techniques based on antenna design and adaptive signal processing. Particular attention is given to the amplitude and phase relationship among multiple spatial channels for two types of ionospheric clutter. Preliminary experimental results show that the random gain and phase variation of the antenna pattern overhead null destroyed the amplitude and phase consistency among channels. As a result, no significant measured directivity is observed in this type of specular clutter. For the incidence clutter from a lower elevation angle, it is observed that the spread clutter possesses high directivity. A nonlinear receiving array composed of multiple V-shaped antennas without deep and broad null at near-vertical incidence is proposed for adaptive ionospheric clutter suppression [J190]

"System aspects and transmission impairments of active phased arrays for satellite communications"

The communications link and system aspects of active phased arrays that are used in multiple-beam satellite systems are assessed through measurements and analysis. Three link parameters are investigated and their effects on the overall carrier-to-interference ratio (CIR) are quantified. The first parameter is the intermodulation components that are generated at the nonlinear amplifier outputs and contribute to well-formed interference in the far-field radiation of the array. The second is the bit-error ratio (BER) degradation due to the multi-carrier operation of the active array. Measurement results are shown to demonstrate this effect. The third link parameter is the cochannel interference caused by frequency reuse in multiple-beam systems. The paper starts by reviewing early developments of phased arrays for multiple-beam satellite communications applications. A key component in these developments is the modular monolithic microwave integrated circuit (MMIC) beam-forming matrices that generate a number of simultaneous and independently digitally controlled beams [J191]

"Phased array of large reflectors for deep-space communication"

In this paper the problem of uplink array calibration for deep-space communication is considered. A phased array of many modest-size reflectors antennas is used to drastically improve the uplink effective isotropic radiated power of a ground station. A radar calibration procedure for the array phase distribution is presented using a number of in-orbit targets. Design of optimal orbit and the number of calibration targets is investigated for providing frequent calibration opportunities needed for compensating array elements phase center movements as the array tracks a spacecraft. Array far-field focusing based on the near-filed in-orbit (low Earth orbit (LEO)) calibration targets is also presented and array gain degradation analysis based on the position error of the array elements and in-orbit targets has been carried out. It is shown that errors in the in-orbit targets positions significantly degrade the far-field array gain while the errors in array elements positions are not very important. Analysis of phase errors caused by thermal noise, system instability, and atmospheric effects show insignificant array gain degradation by these factors [J192]

"Measurement of electrically large array antennas in small anechoic chambers [JMeasurements Corner]"

A post-processing procedure that yields accurate array-antenna radiation-pattern estimations is described. By resorting to this strategy, measurements of large array antennas inside small anechoic chambers become feasible. The method employs an adequate phase-correction derived from an optical ray approach, under the assumption that the elementary radiators themselves are electrically small and can be measured under far-field conditions inside the relevant anechoic chamber. The effectiveness of the proposed technique is demonstrated by examining the case of a nonuniform linear array antenna. [J193]

"Short Courses"

{no data available} [J194]

"Intellectual Property and Patent Abstracts"

A collection of 12 patents is listed along with abstracts and diagrams where applicable. Also listed are inventors, assignees, and dates filed. Covers some of the following technologies, techniques, theories, and schemes: antenna doe ultra-wide band communications; a low-sidelobe dual-band and broadband flat endfire antenna; a wideband phased array radiator; a dual band slot antenna; antennas for multicarrier communications and multicarrier transceiver; antenna configurations for reduced radar complexity; and a low-profile lens antenna. [J195]

"Design, optimization, and validation of a planar nine-element Quasi-Yagi antenna array for X-band applications [JAntenna designer's Notebook]"

A planar antenna array, based on nine identical quasi-Yagi elements, is presented in this paper. Contrary to conventional designs, the feeding network is composed of three-way power dividers, which are carefully designed in order to provide synchronized output signals over a wide frequency range. The use of spline-shaped microstrip lines suppresses coupling effects by parallel lines. Thus, signal distortions within the feeding network are minimized. Compared to conventional designs with eight elements, the additional antenna element will enhance the gain of the array, which is between 10.5 dBi and 13 dBi in the X band. The input return loss of the antenna array is below -15 dB over most parts of the relevant spectrum, with a total bandwidth of 45%. The planar antenna array is well suited as a radiating element in linear phased arrays for multifunction radars, including SAR and MTI. Additionally, the suitability of this antenna for phased-array applications is studied by an experimental setup consisting of five antenna plates. [J196]

"An Efficient Implementation of a Robust Phase-Unwrapping Algorithm"

A robust phase-unwrapping algorithm has been recently proposed and applied to accurately locate fast moving targets in multifrequency antenna array synthetic aperture radar imaging. This algorithm is based on two dimensional (2-D) searching and its complexity may be high. In this letter, we propose an efficient implementation of the robust phase-unwrapping algorithm. We show that the range of the 2-D searching, and therefore the complexity of the robust phase-unwrapping algorithm, can be significantly reduced [J197]

"Guest Editorial"

The 18 papers in this special issue are expanded forms of ones presented during 2006 European Microwave Week, which was held in Manchester, U.K., in September 2006. [J198]

"Coherence- and Amplitude-Based Analysis of Seismogenic Damage in Bam, Iran, Using ENVISAT ASAR Data"

The sensitivity of synthetic aperture radar (SAR) and interferometric SAR (InSAR) to surface properties, especially changes in height and roughness, combined with an all-weather capability, makes radar remote sensing a potential tool for mapping urban damage caused by earthquakes. With InSAR, surface displacement has been mapped successfully and in detail, but for urban-damage mapping, results have so far been less conclusive. ENVISAT Advanced SAR images of Bam, Iran, that were acquired before and after the 2003 earthquake were used. Between preseismic and coseismic image pairs, coherence decreased with increasing damage levels. However, contrary to previous studies, earthquake damage caused both increases and decreases in amplitude. Therefore, its absolute value, which correlated with damage level, was used. Individually, coherence difference led to better results than absolute amplitude change, although still with limited accuracy. The combination of both resulted in an overall accuracy of 52%. Since vegetation causes decorrelation, a predisaster Advanced Spaceborne Thermal Emission and Reflection Radiometer image was used to mask out vegetated areas, which improved the accuracy by 4%. The ground-truth map showed damage levels per district instead of

per pixel. Therefore, the ratio of pixels classified as "damage" and "nondamage" was calculated for each damage class of the map, and a clear relation was found. This shows that the aggregation level of the map partly explains the low-accuracy figures of the pixel-based evaluation. Although improvement was made, InSAR techniques for urban-damage mapping do not yet provide the accuracy levels needed for disaster mitigation. However, substantial improvements can be expected from instruments with higher spatial resolution, such as the recently launched Phased Array type L-band SAR and Terra SAR-X [J199]

"Ultrawideband Double Rhombus Antenna With Stable Radiation Patterns for Phased Array Applications"

A broadband microstrip-fed printed antenna is proposed for phased antenna array systems. The antenna consists of two parallel-modified dipoles of different lengths. The regular dipole shape is modified to a quasi-rhombus shape by adding two triangular patches. Using two dipoles helps maintain stable radiation patterns close to their resonance frequencies. A modified array configuration is proposed to further enhance the antenna radiation characteristics and usable bandwidth. Scanning capabilities are studied for a four-element array. The proposed antenna provides endfire radiation patterns with high gain, high front-to-back (F-to-B) ratio, low cross-polarization level, wide beamwidth, and wide scanning angles in a wide bandwidth of 103% [J200]

"Wideband Antenna Patterns and Impulse Response of Broadband RF Phased Arrays With RF and Photonic Beamforming"

The general expression for a monochromatic antenna pattern is extended to a two dimensional function with dependence on both space and time. Expressions for the wideband antenna pattern in space and the impulse response in time are developed. The effects of random errors in the spatial domain and errors common to all elements with fluctuations in the frequency domain are analyzed. Examples are given, including RF beamformers and elements in finite arrays, but with an emphasis on a photonic beamformer, which shows improved performance relative to its RF counterparts in both the spatial and time domains [J201]

"Grating Lobe Suppression of Narrow-Wall Slotted Hollow Waveguide Millimeter-Wave Planar Antenna for Arbitrarily Linear Polarization"

A high-gain and high-efficiency slotted waveguide planar antenna is developed in the millimeter-wave band. Forty-five degree inclined polarization is required for automotive radar systems. In the design of slotted waveguide array for arbitrarily linear polarization, slot spacing is one guide wavelength which is larger than a wavelength in free space. Consequently, grating lobes appear in the radiation pattern. So, we developed a slotted waveguide planar antenna composed of post-loaded narrow-wall slots and a single-layer alternating-phase feeding circuit. A planar antenna with suppressed grating lobes has been fabricated and its RF performance has been measured. The measured gain is 33.2 dBi and antenna efficiency is 56% at 76 GHz. Grating lobe level is -28.6 dB lower than main lobe level. Since the proposed structure remains simple, the antenna is expected to be manufactured by metal injection molding for low cost [J202]

"Estimation of Multicomponent Polynomial-Phase Signals Impinging on a Multisensor Array Using State–Space Modeling"

This contribution addresses the problem of estimating the parameters of multicomponent polynomial-phase signals when impinging on a multisensor array. An original approach is proposed based on a state-space modelization of the signal and the application of an extended Kalman filter for the state estimation. The use of a multisensor array allows the exploitation of a spatial information and leads to the consideration of multiple filters with different observation equations. Computer simulations are used to demonstrate the effectiveness of the proposed algorithm [J203]

"Theoretical Evaluation of Several Possible Along-Track InSAR Modes of TerraSAR-X for Ocean Current Measurements"

The German satellite TerraSAR-X, scheduled for launch in late 2006, will permit high-resolution ocean current measurements by along-track interferometric SAR (along-track InSAR) in various experimental modes of operation, using different sections of its X-band SAR antenna array with a total length of 4.8 m as individual receive antennas. Depending on antenna and receive-chain settings, effective InSAR time lags of about 0.17 to 0.29 ms can be realized in combination with different noise levels, single-look resolutions, swath widths, and incidence angles. We give an overview of the characteristics of the possible InSAR modes and evaluate their suitability for current measurements on the basis of simulated data products. Our results indicate that the quality of interferometric stripmap data from TerraSAR-X will be clearly superior to the quality of the existing data

acquired over the Dutch coast during the Shuttle Radar Topography Mission; accurate current retrievals can be expected at effective spatial resolutions on the order of 500 m. However, in modes using a multiplexed single receive chain, the effective swath width of stripmap data will be limited to only 15 km, while dual receive-chain operation offers a swath width of 30 km for stripmap data and promises a reasonable data quality even for ScanSAR data with a maximum swath width of 100 km. Finally, we consider fundamental relations between along-track baseline, instrument noise, and resulting InSAR phase noise to discuss the potential for current measuring performance improvements of TerraSAR-X follow-on satellites [J204]

"Ultrawideband Hybrid EBG/Ferrite Ground Plane for Low-Profile Array Antennas"

The design and analysis of an ultrawideband and low-profile hybrid electromagnetic band-gap (EBG)/ferrite ground plane is presented for implementation with antenna systems in airborne foliage penetrating radar and EW applications. The hybrid EBG/ferrite ground plane consists of an EBG structure with a ferrite slab placed on top of the structure's perfect electric conductor (PEC) ground plane. Reflectivity and phase analyses show that the hybrid EBG/ferrite ground plane offers ultrawideband operation beginning in the 100s of MHz with one design version offering an operational bandwidth exceeding 22:1 starting at 170 MHz. Additionally, analysis of the hybrid ground plane implemented with dipole antennas verifies that the hybrid ground plane effectively produces uni-directional radiation for bi-directional radiating antennas. The designed hybrid ground plane is also simulated with Raytheon's long slot array antenna and the obtained results further verify its ultrawideband performance [J205]

"Optical Summation of RF Signals"

We present two concepts dedicated to the optical summation of RF signals for radar applications. The first technique relies on a photodiode simultaneously illuminated on its top and back sides. We experimentally demonstrate the summation of two signals covering the whole 25-GHz photodiode bandwidth with amplitude and phase errors below plusmn1dB and plusmn4deg, respectively. The heterodyne beating noise, which occurs in this type of summation device, is also discussed. The second technique is based on a traveling-wave detector array. We experimentally demonstrates the summation of four signals in the whole 25-GHz photodiodes bandwidth. However, the "summation bandwidth" is limited to 10 GHz due to amplitude and phase errors [J206]

"A 2-D Van Atta Array Using Star-Shaped Antenna Elements"

A new passive 2-D Van Atta array is introduced with star-shaped antenna elements. The star-shaped antenna is proposed for low mutual coupling in the array. A single antenna element designed at 5.8 GHz has two orthogonal feeding ports with 23 dB port return loss and 28 dB isolation between ports. The mutual coupling among the antenna elements is less than -15.5 dB, which is 5 dB better than the conventional square patch antenna. Experimental results show that this array keeps a constant retrodirective characteristic at arbitrary injection polarization and direction. A stable bistatic radar cross section (BRCS) within 120deg angle can be achieved at 5.8 GHz [J207]

"Suppression of Surface Clutter Interference With Precipitation Measurements by Spaceborne Precipitation Radar"

The sidelobe surface clutter along the nadir direction severely interferes with the rain echo in the off-nadir angle observations made using a spaceborne Precipitation Radar (PR). A new method to suppress this sidelobe clutter interference is introduced. A characteristic of the 1-D phased array antenna system is that high sidelobes arise along the beam scan plane. The proposed method tilts the antenna beam scan plane from the nadir such that these high sidelobes would not be directed along the nadir direction, along which a specular component of the backscattering radar cross section of the Earth's surface is dominant. The simulation results using the designed parameters of a Ka-band spaceborne PR indicate the validity of this method, which is also quantitatively confirmed using Tropical Rainfall Measuring Mission/PR observation data sets [J208]

"Scan-based emitter passive localization"

This paper investigates the problem of estimating the position of a scanning emitter using a passive scan-based geolocation technique. This is achieved by taking advantage of the geometric constraints introduced by the uniform rotating motion of the antenna main beam as it sweeps across a number of separate receivers. A detailed analysis of the estimation process and accuracy of the emitter position is given and a number of computer simulations showing the benefits of this geolocation technique are also included [J209]

"Analysis of a Rectangular Waveguide, Edge Slot Array With Finite Wall Thickness"

A method to analyze a one-dimensional array comprising tilted edge slots cut in the narrow wall of a rectangular waveguide is presented. The fields in the slots are calculated from a hybrid finite element-boundary integral (FE-BI) equation method. The boundary surface integrals on both the interior and exterior surface of the slots are computed from a spectrum of two-dimensional solutions (S2DS), which allows the influence of both the interior and exterior structure of the waveguide to be included rigorously. For initial array design, the mutual coupling between slots in the exterior region is treated approximately with an infinite array assumption modeled by two slots surrounded by periodic boundary walls with an imposed linear phase progression. A short, finite slot array is designed based on the infinite array assumption and fabricated. Results from full-wave analysis of the array and measurements are presented [J210]

"Low-Cost Microstrip-Line-Based Ferrite Phase Shifter Design for Phased Array Antenna Applications"

High-gain, electronically scanned phased array antennas are commonly used for radar and communications applications. These systems often require thousands of radiating elements, thousands of phase shifters, and hence, reduction in cost, size, and weight of the phase shifters are important goals in reducing the cost of the overall system. This letter presents a new ferrite phase shifter design based on microstrip-line technology that provides reduction in cost, size, and weight as compared to typical ferrite (analog) phase shifters. The design is based on the use of three microstrip lines arranged and fed with phase differences so as to produce circular polarization in the ferrite region. The proposed ferrite phase shifter was designed and simulated at 3 GHz to achieve a phase shift of approximately 360deg in less than an effective wavelength. A prototype was designed and fabricated to provide optimal circular polarization in the ferrite region and measured results show 309deg of phase shift in a wavelength, thus fulfilling the requirements. It is also shown that after calibrating measured values to account for the ratio between the applied external Ampere/turn values to the internally applied H-field value used in the high-frequency structure simulator (HFSS), good agreement may be seen between the simulation and experimental results. Based on this successful initial development, suggestions are made for further design improvements including reducing the number of turns in the biasing coil and minimizing the required input power [J211]

"Eli Brookner [JExceptional Service Award]"

Describes the career and professional achievements of Eli Brookner, who is the recipient of the IEEE Aerospace and Electronic Systems Society Exceptional Service Award. [J212]

"Multistatic Ground-Penetrating Radar Experiments"

A multistatic ground-penetrating radar (GPR) system has been developed and used to measure the response of a number of targets to produce data for the investigation of multistatic inversion algorithms. The system consists of a linear array of resistive-vee antennas, microwave switches, a vector network analyzer, and a 3-D positioner, all under computer control. The array has two transmitters and four receivers which provide eight bistatic spacings from 12 to 96 cm in 12-cm increments. Buried targets are scanned with and without surface clutter, which is a layer of rocks whose spacing is empirically chosen to maximize the clutter effect. The measured responses are calibrated so that the direct coupling in the system is removed, and the signal reference point is located at the antenna drive point. Images are formed using a frequency-domain beamforming algorithm that compensates for the phase response of the antennas. Images of targets in air validate the system calibration and the imaging algorithm. Bistatic and multistatic images for the buried targets are very good, and they show the effectiveness of the system and processing. [J213]

"Comparison of scheduling algorithms for multifunction radar"

The management of radar resources in a multifunction radar is central to unlocking the potential offered by electronic scanning. Scheduling is an important sub-problem of radar resource management because of the strong correlation between how tasks should be performed, as well as the time available to carry them out and their timeliness. Two scheduling algorithms previously reported in the literature are compared in order to investigate differences in their performance. This provides new insights which may be invaluable in the development of future optimal schedulers. A detailed model of a multifunction radar has been developed to enable comparison using the same operational conditions. The radar is assumed to operate in both 'underload' and 'overload' situations. When not fully loaded (i.e. underload), the two scheduling algorithms perform in significantly different ways. However, in the more important case of overload situations, where there are insufficient radar resources to carry out all necessary tasks, both algorithms provide similar performance. Nevertheless, there still remain differences that require careful understanding when selecting the most appropriate scheduler. [J214]

"A Persymmetric GLRT for Adaptive Detection in Partially-Homogeneous Environment"

This letter deals with the problem of adaptive detection in Gaussian disturbance with unknown but persymmetric structured covariance matrix. A partially-homogeneous environment is considered at the design stage, and a receiver based on the generalized likelihood ratio test (GLRT) is derived. At the analysis stage, the performance of the new receiver is assessed, also in comparison with the unstructured GLRT, showing that the a-prioriinformation on the covariance structure can lead to a noticeable performance improvement. [J215]

"An Offset Linear-Array-Fed Ku /Ka Dual-Band Reflectarray for Planet Cloud/Precipitation Radar"

A Ku/Ka band dual-frequency offset array-fed microstrip reflectarray antenna using thin membranes has been developed. This antenna is a demonstration model for the next generation titan cloud precipitation radar and altimeter (TCPRA) and is intended to enhance the capability of the future cloud and precipitation remote sensing system for Earth and other planets. The reflectarray has a dimension of 0.5-m square and a flat aperture that emulates a cylindrical reflector antenna. Two sets of linear arrays with linearly polarized microstrip elements and having low cross polarization and low sidelobe levels (SLL) are placed along the focal line to illuminate the reflectarray. One set is for Ku-band, while the other is for Ka-band. Within each set, the wide-swath scanning capability of the antenna is provided by the two fixed-beam feed arrays with one for broadside beam and the other one for a 20deg tilted beam. The unique feature of this paper is that this is the first offset-fed reflectarray that has ever been practically developed to emulate a cylindrical/parabolic type of reflector antenna. In addition, new dual-concentric-ring elements and ring-patch elements are uniquely applied here to achieve the desirable wide phase variation characteristics. Tests of feed arrays and the reflectarray in the anechoic chamber of Texas A&M University result in good pattern performance and the successful demonstration of beam scanning at both frequency bands. [J216]

"Doppler and direction-of-arrival (DDOA) radar for multiple-mover sensing"

A low-cost two-element receiving array concept is investigated for detecting multiple moving targets in indoor surveillance applications. Conventional direction-of-arrival (DOA) detection requires the use of an antenna array with multiple elements. Here we investigate the use of only two elements in the receiver array. The concept entails resolving the Doppler frequencies of the returned signals from the moving targets, and then measuring the phase difference at each Doppler frequency component to calculate the DOA of the targets. Simulations are performed to demonstrate the concept and to asses the DOA errors for multiple movers. An experimental system is designed and constructed to test the concept. The system consists of a two-element receiver array operating at 2.4 GHz. Measurement results of human subjects in indoor environments are presented, including through-wall scenarios. [J217]

"A Fixed-Frequency Beam-Scanning Microstrip Leaky Wave Antenna Array"

A novel two-element fixed-frequency beam-scanning microstrip leaky wave antenna (MLWA) array is presented in this letter. By controlling the phase shifter, the mainlobe of the microstrip leaky wave antenna array is steered at the fixed frequency. The measured H-plane radiation patterns and the simulated results show that the mainlobe can be scanned from 41^{circ}to 62^{circ}continuously when the operating frequency fixes at 7 GHz. This new MLWA array can be used as a collision avoidance system or automotive radar system. [J218]

"MEMS Electronically Steerable Antennas for Fire Control Radars"

Large apertures are of great benefit to applications that are prime powered limited as is found on aerostat and other airborne platforms. Electronically scanned array antennas are often proposed for these applications. However, increasing the aperture area with conventional array technology is met with prohibitive cost, weight, and prime power increases because of the dense spacing of phase shifters and/or active T/R modules. This discusses the recent development of RF MEMS (Microelectromechanical System) switch technology and the use of these switches in a Radanttrade lens configuration for arrays of approximately 10 m2at X-band. A proof-of-concept 0.4 m2MEMS Electronically Steerable Antenna (ESA) containing 25,000 MEMS switches has been successfully designed, fabricated, and tested. The 0.4 m2MEMS ESA was then integrated with an AN/APG-67 radar system to form the MEMS Demonstration Radar System. The MEMS Demonstration Radar System successfully detected both airborne and ground moving targets during a series of extensive radar demonstrations. This is believed to be the first large scale employment of MEMS switches in a scanning antenna and radar system. The low-cost, lightweight, and low power technology demonstrated can enable weight and power constrained platforms with electronic steering. [J219]

"Reconfigurable Fresnel-Zone-Plate-Shutter Antenna with Beam-Steering Capability"

A reconfigurable Fresnel-zone-plate (FZP) antenna, capable of dynamic beam scanning, is introduced. The FZP consists of a series of thin metal shutters, which discretize the antenna aperture into a number of reconfigurable transparent and opaque zones. The shutters are individually controlled to focus the beam at a desired location. Beam scanning of at least +40deg from broadside with a small degradation in gain is possible in one plane using this design. This paper examines the effects of zone discretization on the ideal radiation patterns using full-wave numerical modeling. These effects are then verified by the measurements of a prototype antenna designed at 23 GHz. [J220]

"Framework and Taxonomy for Radar Space-Time Adaptive Processing (STAP) Methods"

The goal of radar space-time adaptive processing (STAP) is to detect slow moving targets from a moving platform, typically airborne or spaceborne. STAP generally requires the estimation and the inversion of an interference-plus-noise (I+N) covariance matrix. To reduce both the number of samples involved in the estimation and the computational cost inherent to the matrix inversion, many suboptimum STAP methods have been proposed. We propose a new canonical framework that encompasses all suboptimum STAP methods we are aware of. The framework allows for both covariance-matrix (CM) estimation and range-dependence compensation (RDC); it also applies to monostatic and bistatic configurations. Finally, we discuss a taxonomy for classifying the methods described by the framework. [J221]

"Improved Global Range Alignment for ISAR"

An improved global range alignment is presented for inverse synthetic aperture radar (ISAR) imaging. The shifts of the echoes are modeled as a polynomial, and the coefficients of this polynomial are chosen to optimize a quality measure of range alignment. The shift in the time domain is carried out by introducing a phase ramp in the frequency domain in order to remove the limitation of integer steps. Because the quality measure of range alignment is calculated directly in the frequency domain, this method is computationally more efficient than the original global method. [J222]

"An Integrated Ultra-Wideband Timed Array Receiver in 0.13 μm CMOS Using a Path-Sharing True Time Delay Architecture"

A fully integrated CMOS ultra-wideband 4-channel timed array receiver for high-resolution imaging application is presented. A path-sharing true time delay architecture is implemented to reduce the chip area for integrated circuits. The true time delay resolution is 15 ps and the maximum delay is 225 ps. The receiver provides 11 scan angles with almost 9 degrees of spatial resolution for an antenna spacing of 3 cm. The design bandwidth is from 1 to 15 GHz corresponding to less than 1 cm depth resolution in free space. The chip is implemented in 0.13 mum CMOS with eight metal layers, and the chip size is 3.1 mm by 3.2 mm. Measurement results for the standalone CMOS chip as well as the integrated planar antenna array and the CMOS chip are reported. [J223]

"Fast Evaluation of the Radiation Patterns of True Time Delay Arrays With Beam Steering"

A multilevel algorithm for the computation of the transient radiation patterns of true time delay (TTD) conformal arrays over a range of observation and beam steering directions is presented. The multilevel algorithm is based on hierarchical decomposition of the array into smaller sub-arrays of elements. At the finest level of decomposition, the angular-temporal radiation patterns of single-element sub-arrays are obtained over a sparse angular grid of directions and short temporal duration, by either measurement or calculation. Subsequent steps of the algorithm comprise multilevel aggregation of delayed sub-array contributions. This process continues until the transient radiation pattern of the whole array is obtained. At each level, the radiation pattern is interpolated to a finer angular grid of observations and steering directions followed by temporal delay compensation. The multilevel array decomposition algorithm attains a computational complexity substantially lower than that of the direct evaluation. Furthermore, the algorithm is particularly efficient for large arrays with large numbers of elements. [J224]

"Thin AMC Structure for Radar Cross-Section Reduction"

A thin artificial magnetic conductor (AMC) structure is designed and breadboarded for radar cross-section (RCS) Reduction applications. The design presented in this paper shows the advantage of geometrical simplicity while simultaneously reducing the overall thickness (for the current design). The design is very pragmatic and is based on a combination of AMC and perfect electric conductor (PEC) cells in a chessboard like configuration. An array of Sievenpiper's mushrooms constitutes the AMC part, while the PEC part is formed by full metallic patches. Around the operational frequency of the AMC-elements, the reflection of the AMC and PEC have opposite phase, so for any normal incident plane wave the reflections cancel out, thus reducing the RCS. The same applies to specular reflections for off-normal incidence angles. A simple basic model has been

implemented in order to verify the behavior of this structure, while Ansoft-HFSS software has been used to provide a more thorough analysis. Both bistatic and monostatic measurements have been performed to validate the approach. [J225]

"Weather Radar Equation Correction for Frequency Agile and Phased Array Radars"

This paper presents the derivation of a correction to the Probert-Jones weather radar equation for use with advanced frequency agile, phased array radars. It is shown that two additional terms are required to account for frequency hopping and electronic beam pointing. The corrected weather radar equation provides a basis for accurate and efficient computation of a reflectivity estimate from the weather signal data samples. Lastly, an understanding of calibration requirements for these advanced weather radars is shown to follow naturally from the theoretical framework. [J226]

"Noise-correlating radar based on retrodirective antennas"

A new retrodirective antenna-based search radar system has been introduced. The suggested system uses a noise correlation technique to detect the presence and the direction of the target. Simulation and analytical results show an order of magnitude improvement in acquisition time of the radar when compared with a phased array antenna-based radar system with the same specifications, except transmit power. To the best knowledge of the authors, no radar of a comparable acquisition time has been designed to this date. Power versus acquisition time tradeoff has been compared with a phased array radar for evaluating performance of the system. The radar is self-tracking due to retrodirectivity of the antenna array, and is much easier to implement, as it does not require any phase shifters etc. [J227]

"Low elevation sea-surface target tracking using IPDA type filters"

When detecting a target using radar in the presence of multipath fading, the signal to noise ratio (SNR) at receiver can be dramatically reduced at certain ranges due to multipath signal cancellation, which leads to a significant drop of the detection probability at those ranges. The detection of a low elevation sea-surface target (LESST) is one example. For target tracking, this special case contrasts to the usual situation where we may often assume a constant probability of detection. Automatic target tracking requires a measure of track quality to discriminate between true and false tracks. This track quality measure should take both the existence of target and the SNR of the sensor into account, and be consistent with tracking performance. This paper investigates automatic target tracking using the integrated probabilistic data association (IPDA) type filters in the presence of multipath fading. Several existing single-scan probabilistic data association (PDA)-based filters, which calculate the probabilistic measure of track quality while estimating the track state, are evaluated in the scenario of tracking a nonmaneuvering LESST in the presence of both multipath fading and clutter. In addition, a variable Markov chain (VMC) IPDA tracker (IPDA-VMC), which has joint merits of both IPDA and the IPDA with a three state Markov chain (IPDA-M2), has been designed and evaluated here. In the derivation of track quality measure of both IPDA-M2 and 1PDA-VMC, the possibility that a target is present but is temporarily unable to be detected has been explicitly considered. A tracker using this track quality measure for false track discrimination has significantly improved LESST tracking performance. A simulation study verifies that both IPDA-M2 and IPDA-VMC have better capability to handle the LESST tracks and have an improved tracking performance over other PDA-based tracking algorithms under consideration. [J228]

"Radar Systems Considerations for Phased Array Aperture Design Using Conformal Transformations on Riemannian Manifolds"

Static and rotating phased array radars are analyzed using conformal co-ordinate transformations on Riemann manifolds. By the use of a suitable metric tensor on a Riemann surface we obtain an expression for the parametric distance between two points that is used to calculate the area of surveillance mapped on to the vv-plane. The invariance of the beamwidth in vv-space allows us to determine the total number of beams required for scanning while the total search function time is obtained as an integral representing the volume under a Riemann time-manifold. Co-ordinate transformations are obtained for rotating arrays based on Sanson-Flamteed projections and we derive the corresponding search function times for each radar type. The packing densities of the beams are examined for both static and rotating arrays and we examine the number of radiating elements that are required so that free-space surveillance time is maintained on the basis of the number of array faces in simultaneous use. [J229]

"Walled LTSA Array for Rapid, High Spatial Resolution, and Phase-Sensitive Imaging to Visualize Plastic Landmines"

We propose a walled linearly tapered slot antenna (LTSA) array to visualize plastic landmines. Previously, we reported an adaptive nonlinear visualization system based on a complex-valued self-organizing map (CSOM) that deals with complex amplitude texture in reflection images at multiple frequencies. The system distinguishes landmines from clutter by paying attention to textural features obtained by high spatial resolution and wideband reflection measurement. Because the system employed a mechanical scan of a pair of horn antennas, the measurement required a long time. An array antenna can reduce the time. The antenna element to be used there should therefore be compact and wideband. This paper reports the design and fabrication of a walled LTSA array visualization system. The antenna element has a 14 times 28 mm aperture size, and works at the 8-12 GHz frequency band. Because the structure is a simple combination of glass epoxy substrates and metal plates, we can easily fabricate low-cost and lightweight arrays. Electrical switches realize a high-speed scanning of 12 times 12 = 144 elements in total. We also report the results of a visualization experiment, in which plastic landmines are clearly visualized with the array in combination with the adaptive CSOM processing. Detection of landmines at frequencies of 10 GHz is only likely to be possible for targets buried a few centimeter deep or where the soil attenuation is very low. This might be a severe limitation of applicability of the method, as in field conditions soil attenuations of 10 dB or considerably more are commonly encountered, requiring the radar to operate at frequencies below 2-3 GHz. The best solution may be a multisensor system comprising these complementary high- and low-frequency radars. [J230]

"A Novel Directional Borehole Radar System Using Optical Electric Field Sensors"

A directional borehole radar system using an array antenna connected to passive optical electric field sensors was developed and evaluated by laboratory and field experiments. This system uses a single dipole antenna for a transmitter and a four-dipole element circular array for a receiver. The received signals are transmitted through optical fibers from optical electric field sensors. The receiver array measures the phase differences between four dipole antennas and estimates the azimuth direction of the incoming reflection wave. The accuracy of the phase measurement was first evaluated in a laboratory test and then tested in a field experiment. To compensate for the sensitivity differences among the sensors, we propose an in situcalibration technique. The dominant operating frequency of the system is 70 MHz. Subsequently, we used borehole radar for subsurface measurements in a vertical borehole in granite. Estimation of the azimuth orientations of subsurface fractures was successfully demonstrated. [J231]

"On Probing Signal Design For MIMO Radar"

A multiple-input multiple-output (MIMO) radar system, unlike a standard phased-array radar, can choose freely the probing signals transmitted via its antennas to maximize the power around the locations of the targets of interest, or more generally to approximate a given transmit beampattern, and also to minimize the cross-correlation of the signals reflected back to the radar by the targets of interest. In this paper, we show how the above desirable features can be achieved by designing the covariance matrix of the probing signal vector transmitted by the radar. Moreover, in a numerical study, we show that the proper choice of the probing signals can significantly improve the performance of adaptive MIMO radar techniques. Additionally, we demonstrate the advantages of several MIMO transmit beampattern designs, including a beampattern matching design and a minimum sidelobe beampattern design, over their phased-array counterparts. [J232]

"MIMO Radar with Colocated Antennas"

We have provided a review of some recent results on the emerging technology of MIMO radar with colocated antennas. We have shown that the waveform diversity offered by such a MIMO radar system enables significant superiority over its phased-array counterpart, including much improved parameter identifiability, direct applicability of adaptive techniques for parameter estimation, as well as superior flexibility of transmit beampattern designs. We hope that this overview of our recent results on the MIMO radar, along with the related results obtained by our colleagues, will stimulate the interest deserved by this topic in both academia and government agencies as well as industry. [J233]

"Adaptive Robust DOA Estimation for a 60-GHz Antenna-Array System"

Direction-of-arrival (DOA) estimation in a phased-array system is considered for a non-Gaussian noise environment. In this paper, a robust M-estimation scheme based on Huber's loss function with an adaptive threshold is proposed. The method is evaluated using experimental data from the University of California, Los Angeles, 60-GHz antenna-array system. It is shown that the proposed method enables a decreased sensitivity of the DOA estimates with respect to noise components having heavy-tailed distributions. [J234]

"Radar Conference Awards [Jpresented to Dr. Eli Brookner, Dr. Joseph Guerci, and Dr. Michael

Picciolo]"

{no data available} [J235]

"ALOS PALSAR: A Pathfinder Mission for Global-Scale Monitoring of the Environment"

The Advanced Land Observing Satellite (ALOS) is Japan's new-generation Earth Observation satellite, launched in January 2006 by the Japan Aerospace Exploration Agency. ALOS carries two optical instruments (Panchromatic Remote-sensing Instrument for Stereo Mapping and Advanced Visible and Near-Infrared Radiometer type 2) and, to maintain Japan's commitment to spaceborne L-band Synthetic Aperture Radar (SAR), the Phased Array L-band SAR (PALSAR). The successor to the SAR onboard the Japanese Earth Resources Satellite (1992-1998), the PALSAR instrument provides enhanced sensor characteristics, including full polarimetry, variable off-nadir viewing, and ScanSAR operations, as well as significantly improved radiometric and geometric performance. As important as the technical improvements and the reason PALSAR here is referred to as a pathfinder mission for global environmental monitoring is the systematic data-acquisition strategy which has been implemented for ALOS. With a priority second only to emergency observations, the PALSAR observation strategy has been designed to provide consistent, wall-to-wall observations at fine resolution of all land areas on the Earth on a repetitive basis, in a manner which has earlier been conceived only for coarse- and medium-resolution instruments. [J236]

"On Parameter Identifiability of MIMO Radar"

A multi-input multi-output (MIMO) radar system, unlike a standard phased-array radar, can transmit multiple linearly independent probing signals via its antennas. We show herein that this waveform diversity enables the MIMO radar to significantly improve its parameter identifiability. Specifically, we show that the maximum number of targets that can be uniquely identified by the MIMO radar is up to Mttimes that of its phased-array counterpart, where Mtis the number of transmit antennas. [J237]

"A Sparse Retrodirective Transponder Array With a Time Shared Phase-Conjugator"

With the recent emergence of various radio frequency identification (RFID) applications, the desire for simpler, more efficient, and lower cost passive transponders has increased. Retrodirective arrays have been demonstrated as a good candidate for such systems due to their unique function of high-speed, automatic source tracking. A four-element, high-performance retrodirective transponder array is presented in this paper. The architecture uses a sparse array design to reduce the amount of radiating elements. A time sharing switching feature is used in conjunction with this architecture to further reduce RF hardware requirements and cost of the system. The switching network can also serve as a built-in modulator for simple data transfer tasks. [J238]

"TerraSAR-X technologies and first results"

TerraSAR-X is a satellite that is scheduled to be launched in October 2006 and is currently being built in the framework of a public-private partnership between the German Aerospace Centre (DLR) and EADS Astrium GmbH Germany and will carry an X-band synthetic aperture radar (SAR) instrument equipped with an active phased array antenna. Its operational flexibility will allow the use of the instrument for scientific and commercial applications. High amplitude and phase stability of the radar instrument is achieved by a carbon fibre reinforced plastic slotted waveguide radiator and a high precision transmit/receive module. Additionally, internal calibration hardware will allow for determination of the residual drifts. Precise central electronics controls the radar instrument, provides an arbitrary transmit chirp and receives the radar echo with selectable bandwidth and raw data compression ratio. The ground station's multimode SAR processor is supported by a novel satellite steering law to reduce the attitude-dependent mean Doppler shift. This article summarises the EUSAR 2004 TerraSAR-X contributions. [J239]

"Monitoring and surveillance potentialities obtained by splitting the antenna of the COSMO-SkyMed SAR into multiple sub-apertures"

The authors discuss the potentialities obtained by splitting the antenna of the COSMO-SkyMed synthetic aperture radar (SAR), developed by Alenia Spazio under contract to the Italian Space Agency and Italian Ministry of Defence, into multiple sub-apertures. The modified sensor has the capability to detect slowly moving ground targets that compete with the clutter Doppler spectrum. Special attention is devoted to a preliminary analysis of the signal processing techniques to be used. Moreover their capabilities for surveillance purposes are characterised based on theoretical and simulated results. Moreover the modified sensor is shown to allow sea current/wave monitoring by along-track SAR interferometry, relocation of moving targets in high resolution SAR

images, and fully polarimetric imaging. Some practical implementation issues related to the possible modification are also briefly discussed. [J240]

"Improved CFAR performance in the littoral"

Littoral operation of radars poses severe signal processing difficulties due to the highly stressing, inhomogeneous clutter. This report describes an initial investigation into the feasibility of utilising site-specific radar modelling to provide a localised estimate of the clutter statistics which can then be used to predict the required threshold to maintain a given false alarm rate. The technique has been applied to littoral clutter recordings obtained from the experimental S-band phased array radar, MESAR2. Results are presented for the technique in comparison with a conventional, non-adaptive, cell averaging CFAR. This paper concludes that significant performance enhancements are possible through the use of this new technique. [J241]

"A fast hybrid asymptotic and numerical physical optics analysis of very large scanning cylindrical reflectors with stacked linear array feeds"

A novel hybrid combination of an analytical asymptotic high-frequency method with a numerical physical optics (PO) procedure is developed to efficiently and accurately predict the far zone fields of extremely long, scanning, very high gain, offset cylindrical reflectors of arbitrary cross-section, with large stacked finite periodic linear phased array feeds, for spaceborne applications. In this method, the field generated by each finite length linear feed array is represented as a spectral integral and the induced current on the cylindrical reflector surface due to this illumination is obtained via the PO approximation. The reflector surface is divided into thin, long, piecewise planar strips along the generator of the cylindrical reflector, and the radiation integral over each strip is evaluated asymptotically in closed form, yielding an eight-term ray solution for the radiated fields. What remains is simply the superposition of the contributions of each strip and linear array in the feed stack. The proposed approach is shown to be extremely efficient and accurate as compared to the conventional PO integration technique. In addition, the method is sufficiently versatile to account for the reflector edge treatments (e.g., using resistive cards), as well as to account for a twist in the reflector surface due to thermal distortions in space. [J242]

"Binary optical true-time delay based on the white cell: design and demonstration"

An optical true-time delay device that uses a binary counting system in a modified White cell is demonstrated. The switching engine uses four spherical mirrors and a three-state digital micromirror array. The delay part, as designed, provides 6 bits of delay ranging from 78 ps to 5 ns, using a combination of dielectric blocks for short delays and lens trains for longer ones. Long lens trains are folded for compactness. The authors describe the design and demonstrate two of the 6 bits of delays experimentally. Delays were accurate to within the measurement resolution of 1.25 ps. The insertion loss varied from 3.1-5.2 dB, depending on delay. It was found that the micromirrors do not contribute significantly to the loss. [J243]

"X-band experimental airborne radar-Phase II: synthetic aperture radar and ground moving target indication"

Defence Research and Development Canada, Ottawa, has completed Phase II of a multifunction X-band wideband experimental airborne radar. The system consists of a high average power transmitter, a digital waveform generator, two wideband 8-bit channels for synthetic aperture radar (SAR)/inverse synthetic aperture radar and two narrowband 14-bit channels for ground moving target indication (GMTI). The reflector antenna uses a novel multimode feedhorn to derive two phase centres displaced in azimuth. The radar was designed to support research into SAR imaging of fixed and moving targets (ocean and land), time-frequency analysis of moving targets, clutter suppression for GMTI radar and ocean surveillance for small and large target detection. Highlights of the data collection capabilities, include a swath width 16 K points wide in the single-channel SAR modes, 8 K points wide in the two-channel integrated SAR-GMTI modes and 4 K points wide in the GMTI surveillance modes. The architecture of the radar, its modes of operation with respect to the SAR and GMTI data collection capabilities, the MATLAB-based GMTI processor, and the real-time kernel developed for the SAR processor are discussed; and results from its high resolution stripmap, landspot, seaspot and GMTI modes are presented from trials in July 2003. [J244]

"Radiation Performance of Switchable Ferrite Microstrip Array Antenna"

This letter reports radiation performance of switchable microstrip planar array of 6 $,times,$6 element circular patch antenna printed on NiГ‚ВїAl ferrite substrate with a normal magnetic bias field. The extra degree of freedom offered by the biased ferrite can be used to obtain a number of novel characteristics including switchable and tunable radiation from a microstrip antenna with a single feed point. Under certain bias

conditions, most of the power is converted into magnetostatic waves and little radiates into air. Under such circumstances, the antennas are highly inefficient, in the sense that they are effectively absent as radiators. The bias dependent properties of a switchable antenna in S band (3.5 GHz) are investigated. [J245]

"Demonstration of advanced reconnaissance techniques with the airborne SAR/GMTI sensor PAMIR"

PAMIR (Phased Array Multifunctional Imaging Radar) is an experimental airborne radar system that has been designed and built by the Research Institute for High Frequency Physics and Radar Techniques (FHR) of Forschungsgesellschaft fьr Angewandte Naturwissenschaften (FGAN). The goal is to meet the growing demands for future reconnaissance systems with respect to flexibility and multi-mode operation by the use of an electronically steerable phased array antenna. The X-band system with a bandwidth of 1.8 GHz serves as a platform for different tasks. One of the main objectives is to demonstrate synthetic aperture radar (SAR) imaging at a very high resolution and for a long range. The fine resolution will also be applied for inverse SAR (ISAR) imaging of ground moving targets. Moreover, five parallel receiving channels allow array processing techniques like ground moving target indication (GMTI) via space-time adaptive processing, electronic counter-counter-measures and interferometric SAR with a very high 3D-resolution. A multi-channel scan-MTI mode with a range resolution adapted to the target size allows for a wide area GMTI operation that can be complemented by target tracking. Together with the predecessor system AER-II, operating at a frequency band contained in that of PAMIR, the possibility of experimental investigation of bistatic SAR is given. SAR images of large urban areas and ISAR images of moving objects, both with finest resolution down to the sub-decimetre scale, are presented. Results of GMTI in a wide area scanning mode and broadband bistatic experiments including true bistatic SAR processing are shown as well. [J246]

"Component-oriented radars with probabilistic timing guarantees"

In recent years, many modern phased-array radars are built with commercial off-the-shelf components, and the functions of many hardware components are also reimplemented by software modules. In such systems, radar tasks could be modeled as distributed real-time tasks which require end-to-end deadline guarantees and have precedence constraints. Different from most previous work on either algorithms with restrictions in resource utilization or heuristics without analytical ways for schedulability guarantees, the objective of this paper is to propose a joint real-time scheduling algorithm for both transmitter/receiver and signal processor workloads with an analytical framework for offline probabilistic analysis and online admission control. The strength of our approach is verified by analysis results and a series of experiments based on a real phased-array radar for air defense frigates [J247]

"Compact light weight UHF arrays using long slot apertures"

A wideband low profile phased array using long slot aperture was recently developed for radar and EW applications. A prototype UHF array with 4 Ч 8 (32) elements (1.12 мЧ2.24 мЧ23 cm) was built and tested for 150-600 MHz operation. Array patterns, gain, and cross-pol level were measured. Excellent performance was observed. The array is 23 cm thick, and it weighs 7 kg (2.8 kg/m2). Lossy loading material may be used to make it thinner, but this is believed to be the lightest and thinnest UHF array reported for wideband applications without gain penalty. [J248]

"SSB-Type Frequency Scattering From a Single-Layer PSS With Interlaced Element Modulation"

Experimental results are been presented to show that when a phase-switched screen (PSS) is configured so that alternate rows of the its active surface are modulated with independent square-wave signals, single side-band (SSB)-type frequency modulation can be imposed onto signals scattered from the PSS surface. By adjusting the phase-offset between the two modulating signals, selective suppression of individual upper and lower sidebands can be achieved [J249]

"A compact single layer monopulse microstrip antenna array"

A compact single layer monopulse microstrip patch antenna array for the application of monopulse radar has been designed, manufactured and tested. The array, the monopulse comparator and the feed network are placed on the same layer, resulting in a very compact structure. The limitation of this structure is discussed. The effects of spurious radiation and blockage caused by the comparator on the sidelobe level are estimated. A space mapping (SM) technique is applied to design microstrip subarray. The bandwidth (VSWR [J250]

"Finite sample size effect on minimum variance beamformers: optimum diagonal loading factor for

large arrays"

Minimum variance beamformers are usually complemented with diagonal loading techniques in order to provide robustness against several impairments such as imprecise knowledge of the steering vector or finite sample size effects. This paper concentrates on this last application of diagonal loading techniques, i.e., it is assumed that the steering vector is perfectly known and that diagonal loading is used to alleviate the finite sample size impairments. The analysis herein is asymptotic in the sense that it is assumed that both the number of antennas and the number of samples are high but have the same order of magnitude. Borrowing some results of random matrix theory, the authors first derive a deterministic expression that describes the asymptotic signal-to-noise-plus-interference ratio (SINR) at the output of the diagonally loaded beamformer. Then, making use of the statistical theory of large observations (also known as general statistical analysis or G-analysis), the authors derive an estimator of the optimum loading factor that is consistent when both the number of antennas and the sample size increase without bound at the same rate. Because of that, the estimator has an excellent performance even in situations where the quotient between the number of observations is low relative to the number of elements of the array. [J251]

"A multiband, compact, and full-duplex beam scanning antenna transceiver system operating from 10 to 35 GHz"

This paper presents a compact phased-array antenna transceiver system that can operate over a wide bandwidth from 10 to 35 GHz with the abilities of beam scanning and full-duplex communication. The system consists of ultrawide-band Vivaldi antennas, a multiline PET-based phase shifter, a six-channel microstrip multiplexer, and monolithic microwave integrated circuit (MMIC) amplifiers. The multiplexer routes 10, 19, and 32 GHz signals to the transmit path and 12, 21, and 35 GHz signals to the receive path. The multiplexer shows insertion loss between 2.2 and 3.4 dB for all six channels and together with wide-band MMIC amplifiers plays an important role to build a compact, multifrequency, and full-duplex transceiver system. The system should have many applications in multiband satellite communication systems and radar systems. [J252]

"Resonance analysis of a circular dipole array antenna in cylindrically layered media for directional borehole radar"

In this paper, we discuss the influence of a resonance on estimating direction of arrival (DOA) with a circular dipole array in a borehole (CAB). The resonance is caused by the phase-sequence of currents on the dipole antennas. Making use of method of moments (MoM) analysis, we predict resonant frequencies of the CAB and describe a mechanism for the resonance theoretically, making use of the fact that a plane wave can be broken down into cylindrical harmonics. In order to examine the agreement between the MoM and experimental data, we propose a signal processing method to extract phase-sequence components from the actual received array signal. This method is useful for confirming excitation of the phase-sequence resonance in experimental data, as predicted by the MoM. Using the MoM, we examine the influence of the resonances on DOA estimation, and we conclude that the resonances give some spurious solutions. In order to confirm these results, we conduct experiments at a field test site. We arrange the CAB, which consisted of seven receiving dipole antennas. In this experiment, a plane wave is incident on the CAB from a transmitter in another borehole. We apply the proposed signal method, and the measured results demonstrate the existence of the phase-sequence resonance in a physically real CAB. The spurious solutions found to occur in the DOA estimation at the resonant frequencies are also found experimentally. [J253]

"A tutorial on microwave photonic filters"

Microwave photonic filters are photonic subsystems designed with the aim of carrying equivalent tasks to those of an ordinary microwave filter within a radio frequency (RF) system or link, bringing supplementary advantages inherent to photonics such as low loss, high bandwidth, immunity to electromagnetic interference (EMI), tunability, and reconfigurability. There is an increasing interest in this subject since, on one hand, emerging broadband wireless access networks and standards spanning from universal mobile telecommunications system (UMTS) to fixed access picocellular networks and including wireless local area network (WLAN), World Interoperability for Microwave Access, Inc. (WIMAX), local multipoint distribution service (LMDS), etc., require an increase in capacity by reducing the coverage area. An enabling technology to obtain this objective is based on radio-over-fiber (RoF) systems where signal processing is carried at a central office to where signals are carried from inexpensive remote antenna units (RAUs). On the other hand, microwave photonic filters can find applications in specialized fields such as radar and photonic beamsteering of phased-arrayed antennas, where dynamical reconfiguration is an added value. This paper provides a tutorial introduction of this subject to the reader not working directly in the field but interested in getting an overall introduction of the subject and also to the researcher wishing to get a comprehensive background before working on the subject. [J254]

"Folded multilayer microstrip reflectarray with shaped pattern"

A folded multilayer printed reflectarray with shaped pattern is demonstrated. The configuration consists of a multilayer twister reflectarray, a centered feed embedded in its structure and a polarizing grid, which acts as reflector and radome for each polarization, respectively. A design procedure, valid for obtaining any arbitrary shaped pattern, has been implemented. In order to achieve the pattern specifications along a frequency band, initially a multifrequency pattern synthesis method, which relies on a phase-only synthesis, is applied to obtain the required phase-shift on the reflectarray surface. Afterwards, each stacked patch is individually optimized to generate the required phase-shift previously synthesized. The method has been successfully applied to a LMDS base station antenna, characterized by a sectorial cosecant squared beam in the band 24.5-26.5 GHz. A breadboard consisting of a folded 3-layer circular reflectarray is presented. Measurements show a good concordance with theoretical patterns at 25 GHz, and good shaping of the beam along 24-26 GHz. [J255]

"Spatial diversity in radars-models and detection performance"

Inspired by recent advances in multiple-input multiple-output (MIMO) communications, this proposal introduces the statistical MIMO radar concept. To the authors' knowledge, this is the first time that the statistical MIMO is being proposed for radar. 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. Radar targets generally consist of many small elemental scatterers that are fused by the radar waveform and the processing at the receiver, to result in echoes with fluctuating amplitude and phase. 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. This paper focuses 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. It is shown that the optimal detector consists of noncoherent processing of the receiver sensors' outputs and that for cases of practical interest, detection performance is superior to that obtained through coherent processing. 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. [J256]

"Optimal number of array faces for active phased array radars"

The number of array faces is an important factor in determining antenna and radar system performance, cost, and manufacturing complexity. The subject of determining the optimum number of antenna faces has been addressed previously by several authors (Knittel,1965) using various figures of merit. For active phased array radars performing tracking and discrimination functions, the important figure of merit for antenna performance is power-aperture-gain (PAG) product. We determine the optimal number of faces by choosing PAG product as the figure of merit for the same tracking and discrimination performance at maximum scan angles. Given equal antenna performance at maximum scan angles in the coverage area, cost is the primary basis for comparison in the selection of the number of faces for a modern active phased array radar system. [J257]

"Design and demonstration of an optical true-time-delay device based on an octic-style white cell"

A methodology for designing an octic-style optical true-time-delay (TTD) device based on the White cell (WC) is investigated. The octic cell is a "polynomial" cell, one of the two classes of TTD White cells. This octic cell is designed to produce a maximum of 6399 delays in 17 bounces, with a unit delay of 3 ps. Glass blocks are used for short delays, white lens trains are used for the longer delays. The octic cell is designed to use a microelectromechanical tip/tilt micromirror array to direct light beams into various delay paths. [J258]

"Demonstration of a continuously variable true-time delay beamformer using a multichannel chirped fiber grating"

A continuously variable true-time delay beamformer based on a multichannel chirped fiber grating (MCFG) is demonstrated. The beamformer is capable of wide-band squint-free operation and demonstrates beam steering of a four-element array over ±40°. The use of an MCFG provides a significant reduction in the length of the chirped grating required, eliminates spurious signal transmission, and utilizes narrow-band tunable laser sources. In addition, the effect of grating errors on the antenna pattern is examined and the tolerance on performance is presented. [J259]

"Knowledge-based resource management for multifunction radar: a look at scheduling and task prioritization"

In this article, we consider two related aspects of radar resource management, scheduling and task prioritization. Two different methods of scheduling are examined and compared and their differences and similarities highlighted. The comparison suggests that prioritization of tasks plays a dominant role in determining performance. A prioritization scheme based on fuzzy logic is subsequently contrasted and compared with a hard logic approach as a basis for task prioritization. The setting of priorities is shown to be critically dependent on prior expert knowledge. By assessing the priorities of targets and sectors of surveillance according to a set of rules it is attempted to imitate the human decision-making process such that the resource manager can distribute the radar resources in a more effective way. Results suggest that the fuzzy approach is a valid means of evaluating the relative importance of the radar tasks; the resulting priorities have been adapted by the fuzzy logic prioritization method, according to how the radar system perceived the surrounding environment. [J260]

"Performance analysis of conformal conical arrays for airborne vehicles"

Conformal array apertures have great potential for providing high performance, low weight systems with little or no impact to the aerodynamic design of the air vehicle. A performance analysis of conformal conical arrays for a national airborne radar application is presented. The conical array geometry is chosen for its similarity to an aircraft or missile nosecone. Performance capabilities are analyzed for a number of antenna performance parameters including scan volume, sidelobe levels, grating lobes, beamwidth, directivity, element count, and cross-polarization [J261]

"Family of multicarrier bi-phase radar signals represented by ternary arrays"

A K times L ternary array, comprised of the elements {0, 1,-1}, with some unique features, represents a multicarrier radar signal with favorable autocorrelation and ambiguity functions. Constructing such an array using Galois fields is described. As in a Costas binary array, only one frequency is transmitted at any time slot, but in our array the same frequency is repeated in several time slots, yielding a signal with considerably larger pulse compression than a Costas signal that uses the same number of frequencies [J262]

"Schedulability Envelope for Real-Time Radar Dwell Scheduling"

This paper proposes novel techniques for scheduling radar dwells in phased array radar systems. In order to handle complex physical characteristics such as dwell interleaving, transmitting duty cycle constraint, and energy constraint, we propose a notion of schedulability envelope. The schedulability envelope designed offline hides the details of complex radar dwell scheduling and provides a simple measure for the schedulability check. Using the schedulability envelope, the proposed technique can efficiently perform the admission control for dynamic target tracking tasks. The simulation results show that the proposed approach can significantly improve the system utilization by taking advantage of dwell interleaving while guaranteeing the schedulability and physical constraints [J263]

"Beamforming for Phased Arrays on Vibrating Apertures"

A beamforming approach for phased arrays on vibrating apertures is proposed. The essence is to dynamically calibrate the antenna element position errors due to aperture vibrations. This is achieved by estimating element positions through the aid of a few near field reference sources attached to the antenna. The reference sources need to be mounted on rigid frames and be impervious to vibrations. The estimated position information is then substituted into the beamforming process to correct the distorted pattern of the antenna array. To validate the proposed concept, a 5.8 GHz eight-element array with artificially displaced element positions is built to emulate the vibration effect. The proposed calibration approach gives, a close estimate of position errors with deviations under 4% of the free space wavelength. Based on the estimated information, an array pattern with desired features is constructed [J264]

"New titles in Antennas & Propagation from Wiley and the IEEE press"

{no data available} [J265]

"A 77-GHz Phased-Array Transceiver With On-Chip Antennas in Silicon: Transmitter and Local LO-Path Phase Shifting"

Integration of mm-wave multiple-antenna systems on silicon-based processes enables complex, low-cost systems for high-frequency communication and sensing applications. In this paper, the transmitter and LO-path

phase-shifting sections of the first fully integrated 77-GHz phased-array transceiver are presented. The SiGe transceiver utilizes a local LO-path phase-shifting architecture to achieve beam steering and includes four transmit and receive elements, along with the LO frequency generation and distribution circuitry. The local LO-path phase-shifting scheme enables a robust distribution network that scales well with increasing frequency and/or number of elements while providing high-resolution phase shifts. Each element of the heterodyne transmitter generates +12.5 dBm of output power at 77 GHz with a bandwidth of 2.5 GHz leading to a 4-element effective isotropic radiated power (EIRP) of 24.5 dBm. Each on-chip PA has a maximum saturated power of +17.5 dBm at 77 GHz. The phased-array performance is measured using an internal test option and achieves 12-dB peak-to-null ratio with two transmit and receive elements active [J266]

"Correspondence"

Extraction of elevation information with phased array search radar in the presence of specular reflection from sea surface is presented. Specular reflection from sea causes large peak errors in the measurement of low elevation angle. An algorithm based on complex indicated angle is derived to reduce specular reflection component. From the complex indicated angle and the exactly known or approximately known data, the authors can generate a specular reflection error finding function (SREFF). SREFF clearly indicates where the measurements are much affected by the specular reflection in the complex indicated angle data [J267]

"Coherence- and Amplitude-Based Analysis of Seismogenic Damage in Bam, Iran, Using ENVISAT ASAR Data"

The sensitivity of synthetic aperture radar (SAR) and interferometric SAR (InSAR) to surface properties, especially changes in height and roughness, combined with an all-weather capability, makes radar remote sensing a potential tool for mapping urban damage caused by earthquakes. With InSAR, surface displacement has been mapped successfully and in detail, but for urban-damage mapping, results have so far been less conclusive. ENVISAT Advanced SAR images of Bam, Iran, that were acquired before and after the 2003 earthquake were used. Between preseismic and coseismic image pairs, coherence decreased with increasing damage levels. However, contrary to previous studies, earthquake damage caused both increases and decreases in amplitude. Therefore, its absolute value, which correlated with damage level, was used. Individually, coherence difference led to better results than absolute amplitude change, although still with limited accuracy. The combination of both resulted in an overall accuracy of 52%. Since vegetation causes decorrelation, a predisaster Advanced Spaceborne Thermal Emission and Reflection Radiometer image was used to mask out vegetated areas, which improved the accuracy by 4%. The ground-truth map showed damage levels per district instead of per pixel. Therefore, the ratio of pixels classified as “damage” and “nondamage” was calculated for each damage class of the map, and a clear relation was found. This shows that the aggregation level of the map partly explains the low-accuracy figures of the pixel-based evaluation. Although improvement was made, InSAR techniques for urban-damage mapping do not yet provide the accuracy levels needed for disaster mitigation. However, substantial improvements can be expected from instruments with higher spatial resolution, such as the recently launched Phased Array type L-band SAR and Terra SAR-X. [J268]

"Radix-2 DIF fast algorithms for polynomial time-frequency transforms"

The polynomial time-frequency transform (PTFT) converts a one-dimensional polynomial-phase signal (PPS) into a multi-dimensional (MD) output array in the frequency domain from which the phase coefficients are estimated. To significantly reduce the prohibitive computational complexity to deal with high order PPSs, effective decomposition of the overall computational task is important for any practical applications. This paper derives a radix-2 decimation-in-frequency (DIF) fast algorithms for any order of the PPSs by using the periodic and symmetric properties of the PTFT. Compared with other reported fast algorithms, the proposed one is simple in concept and achieves a significant reduction of the required computational complexity [J269]

"Phase Corrections of Small-Loop HF Radar System Receive Arrays With Ships of Opportunity"

This paper is an extension of other work that addresses the use of radar echoes from ships of opportunity to determine the proper phase corrections for small-loop phased-array antennas used within high-frequency (HF) ground-wave radar systems. This technique also yields estimates for unknown ship bearings that (for cases where there is adequate signal-to-noise ratio of 20 dB or more) are consistent to within 2deg-3deg among measurements from independent radar frequencies. Within this paper, phase corrections gathered from actual ships of opportunity are compared to phase corrections gathered during a calibrated transponder run, in which the ship bearing is known. The phase corrections derived from the ship of opportunity presented in this paper were consistent with the known phase corrections to within 13.2deg (for the worst case). Furthermore, the estimates of the ship bearings collected from the two usable radar frequencies were consistent to within 1deg of

each other [J270]

"Remote Observation of the Spatial Variability of Surface Waves Interacting With an Estuarine Outflow"

This paper explores the application of phased-array high-frequency (HF) radars to identify locations of enhanced local waveheights. Measurements of the near-surface current velocities and waveheights were obtained from HF radars deployed near the mouth of the Chesapeake Bay in the fall of 1997. The radar-derived near-surface velocities were compared with the upper bin (2-m depth) of four upward-looking acoustic Doppler current profilers (ADCPs). The slopes of the linear correlations were close to one and the root-mean-square (rms) differences were similar to previous studies. Significant waveheight (Hs) estimates from both radars were compared with a laser height gauge. The largest differences were observed during low winds due to overestimates at one of the radar stations and during storms when the laser measurement failed. Further analysis focused on the HF radar results from the more reliable of the two sites. The rms difference between this radar and the in situ sensor was 0.29 m. Synoptic observations of Hs over the Chesapeake Bay revealed regions of current-induced wave shoaling and refraction. Hs over the estuarine outflow increased between 19-50% relative to the incident Hs in light onshore winds (~5 m/s). In stronger winds (>10 m/s), Hs also increased by up to 25% when there was a tidal outflow in the surface layer, although the near-surface currents were responding to both the wind and the ebbing tide. Hs was not enhanced when the outflow was below a thicker layer (>5 m) of wind-forced onshore flow [J271]

"Demonstration of a quartic cell, a free-space true-time-delay device based on the white cell"

The authors report on a design and demonstration of a quartic-style optical true-time-delay device based on a White cell. This device is designed for 81 sequential time delays with an incremental delay of 243 ps and a maximum delay of 19.683 ns. The time delays are implemented by free-space translations, with lens trains as needed for beam containment. A digital microelectromechanical tilting micromirror array is used to send the light into different delay paths [J272]

"Closed-form solutions for number of beams in static and rotating phased array radars"

Closed-form solutions for the number of beams required to scan a volume of space for both static and rotating phased array radars are presented. The total number of array beams for n-array faces to perform a 360° volume surveillance can then be obtained in a straightforward manner. [J273]

"Overview of generalized monopulse estimation"

Monopulse is an established technique for radar angle estimation. One can show that monopulse estimation is based on a general approximation derived from maximum likelihood (ML) estimation. This tutorial provides a derivation of this relation and presents extensions of this monopulse principle to multi-dimensional array and parameter estimation problems, in particular to space-time adaptive processing (STAP) with reduced dimension, subarrays and generalized sidelobe canceller (GSLC) configurations. The performance of these monopulse applications can be predicted by exploiting the distribution of the monopulse ratio. It is demonstrated that this distribution is more realistic than the Cramer-Rao bound (CRB). Several examples of performance of monopulse estimators are given for thinned and fully filled planar arrays, adaptive beamforming with and without low sidelobes, GSLC, and STAP. Finally, conditions for estimates with low variance are discussed [J274]

"A new DOA estimation technique based on subarray beamforming"

A new direction-of-arrival (DOA) estimation technique using subarray beamforming is proposed. Two virtual subarrays are used to form a signal whose phase relative to the reference signal is a function of the DOA. The DOA is then estimated based on the computation of the phase shift between the reference signal and its phase-shifted version. Since the phase-shifted reference signal is obtained after interference rejection through beamforming, the effect of cochannel interference on the estimation is significantly reduced. The proposed technique is computationally simple, and the number of signal sources detectable is not bounded by the number of antenna elements used. Performance analysis and extensive simulations show that the proposed technique offers significantly improved estimation resolution, capacity, and accuracy relative to existing techniques [J275]

"Photonic RF phase shifter and tunable photonic RF notch filter"

A new photonic RF phase shifter structure for phased array antennas is presented. It is based on a single dual-output modulator and two optical switches and optical attenuators. This can realize continuous phase shifting of 0°-360° without altering the signal amplitude. It has the advantages of wide bandwidth, fast response time, and

fine tuning resolution. Experimental results demonstrate phase shifts over a 360° phase range, with RF signal power changes of less than 0.2 dB, which is in close agreement with predictions. A tunable photonic RF notch filter, which is based on the new phase shifter, is also presented. Experimental results demonstrate continuous tuning of the photonic notch filter over a wide tuning range, which covers the full free spectral range, which is in good agreement with predictions. [J276]

"New titles in antennas & propagation from Wiley & the IEEE press"

{no data available} [J277]

"Silicon-Based Ultra-Wideband Beam-Forming"

Ultra-wideband (UWB) beam-forming, a special class of multiple-antenna systems, allows for high azimuth and depth resolutions in ranging and imaging applications. This paper reports a fully integrated UWB beam-former featuring controllable true time delay and power gain. Several system and circuit level parameters and characterization methods influencing the design and testing of UWB beam-formers are discussed. A UWB beam-former prototype for imaging applications has been fabricated with the potential to yield 20 mm of range resolution and a 7deg angular resolution from a four-element array with 10 mm element spacing. The UWB beam-former accomplishes a 4-bit delay variation for a total of 64 ps of achievable group delay with a 4-ps resolution, a 5-dB gain variation in 1-dB steps, and a worst case -3-dB gain bandwidth of 13 GHz. Overall operation is achieved by the integration of a 3-bit tapped delay trombone-type structure with a 4-ps variable delay resolution, a 1-bit, 32-ps fixed delay coplanar-type structure, and a variable-gain distributed amplifier. The prototype chip fabricated in a 0.18 mum BiCMOS SiGe process occupies 1.6 mm2 of silicon area and consumes 87.5 mW from a 2.5-V supply at the maximum gain setting of 10 dB [J278]

"Short Courses"

{no data available} [J279]

"Bistatic SAR Processing and Experiments"

Bistatic synthetic aperture radar (SAR) uses a separated transmitter and receiver flying on different platforms to achieve benefits like exploitation of additional information contained in the bistatic reflectivity of targets, reduced vulnerability for military applications, forward-looking SAR imaging, or increased radar cross section. Besides technical problems such as synchronization of the oscillators, involved adjustment of transmit pulse versus receive gate timing, antenna pointing, flight coordination, and motion compensation, the development of a bistatic focusing algorithm is still in progress and not sufficiently solved. As a step to a numerically efficient processor, this paper presents a bistatic range migration algorithm for the translationally invariant case, where transmitter and receiver have equal velocity vectors. In this paper, the algorithm was successfully applied to simulated and real bistatic data. The real bistatic data have been acquired with the Forschungsgesellschaft fur Angewandte Naturwissenschaften (FGAN)'s X-band SAR systems, namely the Airborne Experimental Radar II and the Phased Array Multifunctional Imaging Radar, in October 2003 [J280]

"A Low-Power, -Band SiGe HBT Low-Noise Amplifier for Near-Space Radar Applications"

A low-power, X-band low-noise amplifier (LNA) is presented. Implemented with 180 GHz silicon-germanium (SiGe) heterojunction bipolar transistors (HBTs), the circuit occupies 780times660 mum2. The LNA exhibits a gain of 11.0 dB at 9.5 GHz, a mean noise figure of 2.78 dB across X-band, and an input third-order intercept point of -9.1 dBm near 9.5 GHz, while dissipating only 2.5 mW. The low-power performance of this LNA, together with its natural total-dose radiation immunity, demonstrates the potential of SiGe HBT technology for near-space radar applications [J281]

"Radar modelling to improve CFAR performance in the littoral"

Littoral operation of radars poses severe signal processing difficulties due to the highly stressing, inhomogeneous clutter. This report describes an initial investigation into the feasibility of utilising site specific radar modelling to provide a localized estimate of the clutter statistics which can then be used to predict the required threshold to maintain a given false alarm rate. The technique has been applied to littoral clutter recordings obtained from the experimental S-band phase array radar, MESAR2. Results are presented for the technique in comparison with a conventional, non-adaptive, cell averaging CFAR. The paper concludes that significant performance enhancements are possible through the use of this new technique [J282]

"Simultaneous beam steering and formation with coupled, nonlinear oscillator arrays"

The ability of coupled, nonlinear oscillator arrays to produce simultaneous beam steering and generation is presented. This technique, which extends the capabilities of such arrays to include interference suppression, is realized through a generalization of Steyskal's method of pattern ing by phase perturbation. An illustrative example is provided. [J283]

"Time reversal imaging of obscured targets from multistatic data"

The methods employed in time-reversal imaging are applied to radar imaging problems using multistatic data collected from sparse and unstructured phased array antenna systems. The theory is especially suitable to problems involving the detection and tracking (locating) of moving ground targets (MGT) from satellite based phased array antenna systems and locating buried or obscured targets from multistatic data collected from phased array antenna systems mounted on unmanned aerial vehicles (UAV). The theory is based on the singular value decomposition (SVD) of the multistatic data matrix K and applies to general phased array antenna systems whose elements are arbitrarily located in space. It is shown that the singular vectors of the K matrix together with knowledge of the Green function of the background medium in which the targets are embedded lead directly to classical time-reversal based images of the target locations as well as super-resolution images based on a generalized Multiple-Signal-Classification algorithm recently developed for use with the K matrix. The theory is applied in a computer simulation study of the TechSat project whose goal is the location of MGTs from an unstructured and sparse phased array of freely orbiting antennas located above the ionosphere. [J284]

"Linear antenna arrays with bidirectional phase center motion"

The theoretical and experimental studies of linear antenna arrays with bidirectional phase center motion (BPCM) is presented. BPCM is achieved by exciting only part of the linear array elements and sweeping the excited part from one end to the other and back. The sidelobes of the linear arrays with BPCM experience both upper and lower Doppler frequency shift effect in turn, as compared to linear arrays with unidirectional phase center motion (UPCM). Numerical results show that linear arrays with BPCM are also capable of synthesizing low/ultralow sidelobes, but with a much lower excitation dynamic range ratio as compared to that in conventional arrays. In addition, some characteristics, such as passband bandwidth or sideband levels, are better than those of arrays with UPCM or time modulated variable aperture size arrays. An L-band 16-element printed dipole linear array with BPCM was designed. Experimental results show that a -35 dB relative sidelobe level (SLL) can be achieved. [J285]

"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 (97% duty cycle) 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 responses from the parallel receive cables are fed to a direct digital 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. Synchronous sampling at twice the chip rate ensures that each target is observed in three adjacent sample bins. The phase and amplitude response in the three adjacent samples are combined to precisely pinpoint (within 1 meter) the locations of targets along the length of each of the two cables. The ability to precisely locate and track multiple simultaneous targets on each of two cables leads to numerous new features and performance benef--its relative to existing leaky cable sensors. With a separate calibrated threshold for every meter of cable the sensor sensitivity is much more uniform and installation restrictions on burial depth, cable spacing, and medium homogeneity can be relaxed. Potential sources of nuisance alarms can easily be located and overcome. The pinpoint location can be used to provide better CCTV assessment, target capture for video motion sensors and more effective response to intrusions. Through the use of parallel cables the sensor can be used to detect the direction of crossing and to classify targets such as small animals, people, and vehicles. This patented next generation of GUIDAR technology represents a dramatic step forward from that which was introduced at the 1976 Carnahan Conference in

Lexington, Kentucky, and the numerous CW leaky coaxial cable sensors that evolved from that work. This technology effectively addresses residential, commercial, industrial, and governmental requirements including those relating to homeland security, military operations, and prisons. [J286]

"Design considerations and technology assessment of phased-array antenna systems with RF MEMS for automotive radar applications"

Planar array antennas are attractive for use in future automotive radar systems due to their flexibility in design and control of radar beams. The complexity and cost of a radar front-end phased array can be decreased by applying a beam-steering/switching concept, which reduces the number of parallel RF and baseband signal paths. RF-microelectromechanical systems (MEMS) subsystems are employed because of their excellent RF properties and potential low-cost manufacturability. We present design considerations for prototypical automotive applications of RF-MEMS-based automotive radar front-ends using phased-array antennas based on phase shifters or a Rotman lens. The single RF-MEMS switch is optimized with respect to its RF and thermomechanical behavior taking into account automotive requirements. The respective RF-MEMS subsystems, i.e., phase shifters and single-pole-multiple-throw switching networks are presented in conjunction with packaging and mounting approaches. We evaluate two different wafer-level packaging technologies using glass-frit sealing or polymer sealing. Finally, functional packaged devices are demonstrated: a glass-frit-sealed and flip-chip-mounted RF-MEMS switch and a benzocyclobutene-packaged single-pole-quadruple-throw switch network. [J287]

"Rank-deficient robust Capon filter bank approach to complex spectral estimation"

We consider nonparametric complex spectral estimation using an adaptive filtering-based approach where the finite-impulse response (FIR) filter bank is obtained via a rank-deficient robust Capon beamformer. We show that, by allowing the sample covariance matrix to be rank deficient, we can achieve much higher resolution than existing approaches, which is useful in many applications, including radar target detection and feature extraction. Numerical examples are provided to demonstrate the performance of the new approach as compared to the existing data-adaptive and data-independent FIR filtering-based spectral estimation methods. [J288]

"Active transmitting phased antenna arrays"

The benefits of using transmitting phased array antennas for radar systems are examined. Accurate performance prediction for the transmitting phased array antennas requires theories describing both the antenna system and the power generation devices. These theories were created and applied to the design and performance evaluation of the Russian 3-D mobile solid-state surveillance radar 67N6E (GAMMA-DE), a PAA designed for long-range air defense. [J289]

"A coplanar X-band AlGaN/GaN power amplifier MMIC on s.i. SiC substrate"

This work presents a two-stage high-power amplifier monolithic microwave integrated circuit (MMIC) operating between 9 GHz and 11 GHz based on a fully integrated AlGaN/GaN high electron mobility transistor (HEMT) technology on s.i. SiC substrate and is suitable for radar applications. The MMIC device with a chip size of 4.5Ч3 mm2yields a linear gain of 20 dB and a maximum pulsed saturated output power of 13.4 W at 10 GHz equivalent to 3.3 W/mm at VDS=35V, 10% duty cycle, and a gain compression level of 5 dB. Further, dc reliability data are given for the MMIC HEMT technology. [J290]

"Dual tapered meander slot antenna for radar applications"

A dual tapered meander slot antenna (TMSA) is designed for use as an element in a phased array antenna system for RF and microwave sensors and radar applications. The novel design of dual TMSA element, excited by a coplanar waveguide (CPW) feed, provides a wide band and high efficiency characteristics with 50 Ω input impedance at 10 GHz operating frequency. [J291]

"Wavelength-controlled photonic true time delay for wide-band applications"

A radio frequency subcarrier modulated wavelength-controlled dense wavelength-division-multiplexing-based photonic true time delay module, with very low phase (±4°) and magnitude (±0.5 dB) ripples over a bandwidth of several gigahertz, is demonstrated to achieve wide-band linear frequency modulation transmission (600 MHz) with -37-dB sidelobe suppression and signal-to-noise exceeding 80 dB/MHz. [J292]

"Phase noise characterization by carrier suppression techniques in RF photonic systems"

We propose and demonstrate a novel approach to measure the phase noise in radio-frequency photonic

systems by employing a suppressed carrier technique. With this technique, the flicker phase noise floor is reduced by 36 dB. To the best of our knowledge, this is the first time that the phase noise of a photodetector is measured, and found to be -126 dBc/Hz at 1 Hz from the carrier at 8.4 GHz. [J293]

"Optimum number of faces for phased array radar in constant dwell surveillance"

In this paper the problem of finding the optimal number of phased array faces for performing horizon surveillance scanning under conditions of a constant dwell and where a particular bearing accuracy is required is investigated [J294]

"Real-time dwell scheduling of component-oriented phased array radars"

A multifunction phased array radar must search and track suspicious targets in its surveillance space in a real-time fashion. With inefficient scheduling implementations in many traditional systems, much radar resource is wasted with a very limited performance gain. This paper targets one of the most important issues in the design of modern phased array radars: real-time dwell scheduling. We formalize the typical workload of a modern phased array radar and propose a rate-based approach to schedule radar dwells in a real-time fashion. We show how to reserve radar resources to guarantee the minimum radar operation without sacrificing the stability of the system. The strength of our approach is verified by a series of simulation experiments based on a real phased array radar for air defense frigates [A. G. Huizing et al. (1996)]. A significant improvement in the performance of phased array radars was shown. [J295]

"Daytime interference ing of OSMAR"

In order to cancel the daytime interference of Ocean State Monitoring and Analyzing Radar, which appears in some consecutive days, we analyze the interference characteristic. Based on the characteristic the sidelobe cancellation technique and the orthogonal expansion method are proposed to cancel the interference. Both methods increase the sea-echo-to-interference ratio, but the latter achieves better effect in the far distance, which confirms the orthogonal expansion is the best method to remove the interference. [J296]

"Effects of platform rotation on STAP performance"

The effects of platform rotation, and in particular antenna rotation, on the performance of space-time adaptive processing (STAP) in clutter limited, forward looking airborne radar applications are considered. It is shown that there are two principal mechanisms. One involves the change of shape of the clutter surface in angle-Doppler space as the antenna rotates. STAP appears much more resilient to roll than yaw when this mechanism is dominant, although the problems of yaw can be alleviated by the application of motion compensated phase delay steering. The other mechanism involves the presence of discontinuous sharp transitions across a STAP data vector, for which one possible cause is non-ideal motion compensated steering of the antenna. These discontinuities effectively increase the bandwidth and can result in significant performance deterioration [J297]

"An optimal determination of variable antenna height and power for in-orbit SAR operations"

An optimal power and antenna height determination over a wide range of incidence angles is proposed for in-orbit operations of the spaceborne stripmap synthetic aperture radar (SAR) with variable antenna height and variable radiating element power. The antenna height and the average transmitted radio-frequency power of a radiating element for each incidence angle are determined so that the mapping area can be maximized with the constraints on the signal-to-noise ratio, ambiguities, and swath width, given the SAR geometry (an altitude and incidence angles) and radar wavelength. With the receive-chain power consumption of one transmit/receive module (Pr=10 mW) and the SAR instrument power consumption without the phased array antenna (PI=5 W), the illustrative design example shows that the mapping area of the proposed SAR for the maximum incidence angle ($\eta max=75°$) is about 269.1% of that resulted from utilizing only the variable antenna height. The proposed optimization would have a more beneficial effect on applications that need the high-incidence-angle operations. [J298]

"Statistical resolution limits and the complexified Cramer-Rao bound"

Array resolution limits and accuracy bounds on the multitude of signal parameters (e.g., azimuth, elevation, Doppler, range, cross-range, depth, frequency, chirp, polarization, amplitude, phase, etc.) estimated by array processing algorithms are essential tools in the evaluation of system performance. The case in which the complex amplitudes of the signals are unknown is of particular practical interest. A computationally efficient formulation of these bounds (from the perspective of derivations and analysis) is presented for the case of deterministic and unknown signal amplitudes. A new derivation is given using the unknown complex signal

parameters and their complex conjugates. The new formula is readily applicable to obtaining either symbolic or numerical solutions to estimation bounds for a very wide class of problems encountered in adaptive sensor array processing. This formula is shown to yield several of the standard Cramer'r-Rao results for array processing, along with new results of fundamental interest. Specifically, a new closed-form expression for the statistical resolution limit of an aperture for any asymptotically unbiased superresolution algorithm (e.g., MUSIC, ESPRIT) is provided. The statistical resolution limit is defined as the source separation that equals its own Cramer'r-Rao bound, providing an algorithm-independent bound on the resolution of any high-resolution method. It is shown that the statistical resolution limit of an array or coherent integration window is about 1.2·SNR-14/ relative to the Fourier resolution limit of 2pi/N radians (large number N of array elements). That is, the highest achievable resolution is proportional to the reciprocal of the fourth root of the signal-to-noise ratio (SNR), in contrast to the square-root (SNR-12/) dependence of standard accuracy bounds. These theoretical results are consistent with previously published bounds for specific superresolution algorithms derived by other methods. It is also shown that the potential resolution improvement obtained by separating two collinear arrays (synthetic ultra-wideband), each with a fixed aperture B wavelengths by M wavelengths (assumed large), is approximately (M/B)12/, in contrast to the resolution improv- ement of M/B for a full aperture. Exact closed-form results for these problems with their asymptotic approximations are presented. [J299]

"A new array pattern synthesis algorithm using the two-step least-squares method"

This letter presents a new array pattern synthesis algorithm using the two-step least-squares method. The algorithm utilizes the randomness of the desired pattern phase to design an array pattern. Several numerical examples are presented to illustrate this algorithm. [J300]

"Multifunction millimeter-wave systems for armored vehicle application"

There is an emerging need for millimeter-wave capabilities on military vehicles; in order to make such capabilities more affordable, we have been experimenting with the notion of combining multiple functions into a single device. The functions to be performed simultaneously include: 1) active protection (AP) radar for point defense against antitank threats; 2) surveillance radar for airborne and ground targets; 3) trunking radio for mobile ad hoc networking at a high data rate (>100 Mb/s); and 4) combat identification (ID). Due to a unique combination of characteristics, millimeter-wave radios, radars, and other sensors are attractive for military vehicle use. These characteristics include: 1) smaller profile/footprint of the high-gain antennas; 2) adequate weather penetration; 3) antijam, low probability of intercept, low probability of detection; and 4) wide bandwidth. For the combination of applications identified, this need is best met via a system operating near the 35-GHz atmospheric transmission window. Current mobile millimeter-wave ground-based systems (AP radar, wide-band communication, and combat ID) utilize highly directional steerable beams. Mechanical beam steering is usually done, resulting in restricted beam agility. Nevertheless, mechanical beam-steering performance is acceptable for AP radar and combat ID systems (but not for Joint Tactical Radio networked communications). A true multifunction system, however, requires beam-steering speeds that far exceed capabilities of even the best mechanical technologies. This is due to the need to support either networking or simultaneous multifunctions via time-shared beam steering. Thus, a true multifunction system must steer its beam anywhere in the upper hemisphere in less than 1 ms. Phased arrays are the obvious solution to these needs. Unfortunately, past phased-array technologies were unaffordable for Army vehicle application-hence, the multiplicity of systems. However, a new trend in development of affordable phased-array Ka-band antennas enables development of affordable Ka-band multifunction systems. [J301]

"A quick microwaver's tour of the Historical Electronics Museum"

{no data available} [J302]

"A fully integrated 24-GHz phased-array transmitter in CMOS"

This paper presents the first fully integrated 24-GHz phased-array transmitter designed using 0.18-μm CMOS transistors. The four-element array includes four on-chip CMOS power amplifiers, with outputs matched to 50 Ω, that are each capable of generating up to 14.5 dBm of output power at 24 GHz. The heterodyne transmitter has a two-step quadrature up-conversion architecture with local oscillator (LO) frequencies of 4.8 and 19.2 GHz, which are generated by an on-chip frequency synthesizer. Four-bit LO path phase shifting is implemented in each element at 19.2 GHz, and the transmitter achieves a peak-to- ratio of 23 dB with raw beam-steering resolution of 7° for radiation normal to the array. The transmitter can support data rates of 500 Mb/s on each channel (with BPSK modulation) and occupies 6.8 mm Ч 2.1 mm of die area. [J303]

"Timed arrays in a nutshell"

Timed arrays are the time-domain counterpart of phased arrays, where each array element is excited by wideband instead of narrowband signals. By referring to idealized, but meaningful canonical configurations, the array parameters in the transmit and receive mode are defined in a simple way, by following a purely time-domain intuitive analysis. Obtained results extend steady-state concepts of beamwidth, directivity, gain, effective receiving area, Fresnel and Fraunhofer regions to the case of transient excitation. Application is made to both real and synthetic arrays. The final main conclusion is that the role of the carrier wavelength associated with narrowband excitation is taken by the spatial width of the (carrierless) pulse. This result appears to be rather robust, because it turns out to be independent from the different norms used in the definition of the antenna parameters: it sheds light on the physics of the transient radiation and may be very useful for initiating a more technical analysis of the array performance. [J304]

"A compact dual-polarized multibeam phased-array architecture for millimeter-wave radar"

A broad-band dual-polarized phased array is presented, which allows for independent beam control of the vertical and horizontal polarization with multibeam scanning in azimuth and elevation. The system is based upon a compact tray architecture with element spacing of 0.6λ. Using stereolithography, a miniature dual-polarized waveguide front end was fabricated, which provides a low-loss transition to the microstrip phase-shifting circuitry. A p-i-n diode switch followed by a low-noise amplifier is implemented for each tray to allow for the electronically controlled beam scanning with a 49° field of view. The phased array demonstrates broad-band characteristics from 34 to 40 GHz with better than 20-dB cross-polarization signal discrimination. [J305]

"Adaptive imaging for forward-looking ground penetrating radar"

Most of the current forward-looking ground-penetrating radar (FLGPR) systems use conventional delay-and-sum (DAS) based methods to form radar images for detection of the target (such as a landmine). However, DAS is a data-independent approach which is known to suffer from low resolution and poor interference and clutter rejection capability. We present a data-adaptive imaging approach for FLGPR image formation based on APES (amplitude and phase estimation) and rank-deficient RCB (robust Capon beamforming). Due to the data-adaptive nature of both APES and RCB, our approach has better resolution and much better interference and clutter rejection capability than the standard DAS-based imaging methods. The excellent performance of the proposed method is demonstrated using experimental data collected via two FLGPR systems recently developed by PSI (Planning Systems, Inc.) and SRI (Stanford Research Institute). [J306]

"Ultra-wideband low-cost phased-array radars"

Emerging radar applications require phased arrays that can operate over wide bandwidths to support multiband/multifunction operation. In response to that need, this paper presents a cost-effective implementation for extremely wide-band phased-array radars. Two designs are demonstrated, one operating from 3 to 12 GHz and the other operating from 8 to 20 GHz. These designs incorporate ultra-wideband antipodal tapered slot antennas, a novel cross-polarization suppressed array architecture, piezoelectric true-time-delay phase shifters, and broad-band high-power monolithic amplifiers. The resulting systems provide target detection and beam steering over the complete operating bandwidths. These results exceed the state-of-the-art for phased-array radars in terms of bandwidth and cost and should have direct applications in the development of ultra-wideband and multifunction radar systems. [J307]

"Parallel hardware implementation of RADAR electronics equipment for a LASER inspection system"

An amplitude modulated laser radar has been developed by the Italian Agency for New Technologies, Energy and the Environment for periodic in-vessel inspection in large fusion machines (International Thermonuclear Experimental Reactor). The system is able to obtain a complete three-dimensional mapping of the in-vessel surface. A first digital signal processing system was developed to modulate the laser beam and to detect both the amplitude of the backscattered light and the phase difference between it and the modulation signal. This system is based on commercial digital receiver and parallel digital signal processing boards on a VME bus. It reaches a speed of 100 K measures/s, showing good accuracy and stability. Starting from this, a further development has been done to increase the speed up to 2.328 M measures/s. Reaching the submicrosecond speed was necessary to implement the mathematical algorithm in a highly parallel hardware architecture using a field programmable gate array (FPGA). Based on the good results of the previously developed system, it was decided to maintain the same acquisition front-end though using the last release of analog-to-digital converters, to increase the operating frequency from 80 up to 200 MHz. The software algorithm previously used was completely redesigned and optimized to be used in the FPGA hardware architecture [J308]

"Short Courses"

{no data available} [J309]

"Adaptive array beamforming with robust capabilities under random sensor position errors"

The problem of adaptive array beamforming with multiple-beam constraints in the presence of steering error caused by random sensor position errors is considered. First the statistical relationship between the random sensor position errors and the induced random phase perturbation is derived. Based on the result, a cost function consisting of terms which utilise a posteriori information owing to the received array data and a priori information owing to the probabilistic distribution of the resulting phase perturbation, respectively, is constructed. Then, an appropriate estimate of the actual phase angle vector associated with each of the desired signals can be obtained by performing a nonlinear optimisation problem. An implementation algorithm is further presented to solve iteratively the problem. Theoretical analysis regarding the convergence property of the iterative procedure is also investigated. Finally, several computer simulation examples are provided for demonstrating the effectiveness of the proposed technique [J310]

"Multibaseline cross-track SAR interferometry using interpolated arrays"

{no data available} [J311]

"Reflectivity tuning in multi-layer phase-switched active radar absorbers"

An 'array' polynomial approach is used to predict the positions of the reflectivity s for an ideal phase-switched screen (PSS) having many active layers. Several layer-switching schemes are examined and it is found that the resulting position diagrams exhibit bifurcation behaviour similar to that found in many dynamical systems. The chaotic state is never achieved, however, since the ideal PSS is a linear system. [J312]

"Electromagnetic time-reversal imaging of a target in a cluttered environment"

Electromagnetic time-reversal imaging is addressed for a target situated in a cluttered background. We first investigate the theory of electromagnetic time-reversal imaging, followed by an experimental demonstration. A transmitter-receiver antenna array is connected to a network analyzer and applied to transmit wideband waveforms for detecting a target within a cluttered environment. We assume the cluttered background is fixed, thus the target signature is extracted by observing changes manifested by the introduction of a target. A numerical algorithm is required for computation of the Green's function employed within the time-reversal imager, with this implemented here via ray tracing. Example time-reversal images of different cluttered backgrounds and different targets are presented using measured data, with comparisons to a traditional radar imaging technique. Results show that the time-reversal imagery yields good focusing at the target, significantly better than when the background is not accounted for. [J313]

"Decades of improvements in re-entry ballistic vehicle tracking"

This paper deals with a missile defense challenge, which has been studied extensively for decades and still remains a topic of active research, the tracking of a ballistic vehicle in its re-entry phase. With Anti-Ballistic Missile or Anti-Tactical-Ballistic Missile goals, most of missile defenses need to track re-entry vehicles with a view to locating them precisely and allowing low altitude interception. The re-entry vehicle leaves a quiet exoatmospheric phase and a quasi-Keplerian motion to an endo-atmospheric phase with large aerodynamic loads and a sudden deceleration. The motion is then obviously nonlinear and furthermore both the extent and the evolution of the drag are difficult to predict. Since the sixties, while more and more efficient sensors, such as sophisticated phased-array radars, were developed, the associated data processing techniques have been improved, taking advantage of computer performance increases. Although re-entry vehicle tracking is undoubtedly a non-linear filtering problem, it was firstly solved by rustic linear filters with fixed weight and an assumed drag table. Then, Kalman filters were exploited. Uncoupled and polynomial for a while, they are now fully coupled and really non-linear. They are called Extended Kalman filters, are based on the linearization about the estimated state and are the current efficient and classic solution to non-linear filtering. Moreover, they perform drag estimation which may be useful to the identification capabilities of the missile defense. In the future, even more sophisticated techniques, such as the promising and fashionable particle filtering, are likely to be developed in re-entry vehicle tracking. [J314]

"Integrated Phased Array Systems in Silicon"

Silicon offers a new set of possibilities and challenges for RF, microwave, and millimeter-wave applications.

While the high cutoff frequencies of the SiGe heterojunction bipolar transistors and the ever-shrinking feature sizes of MOSFETs hold a lot of promise, new design techniques need to be devised to deal with the realities of these technologies, such as low breakdown voltages, lossy substrates, low-Q passives, long interconnect parasitics, and high-frequency coupling issues. As an example of complete system integration in silicon, this paper presents the first fully integrated 24-GHz eight-element phased array receiver in 0.18-μm silicon-germanium and the first fully integrated 24-GHz four-element phased array transmitter with integrated power amplifiers in 0.18-μm CMOS. The transmitter and receiver are capable of beam forming and can be used for communication, ranging, positioning, and sensing applications. [J315]

"Smart Phased Array SoCs: A Novel Application for Advanced SiGe HBT BiCMOS Technology"

As BiCMOS IC technology continues to advance in scaling and performance, new applications are continually enabled. One such concept is a smart phased array system on a chip (SoC). The combination of high-performance SiGe heterojunction bipolar transistor (HBT) bipolar devices, well-characterized RF/analog passive components, and dense CMOS digital technology provides the capability to create large multielement, electronically tunable phased arrays with onboard processing intelligence, inside a single die. This SoC will have superior characteristics of lower cost, weight, and size as compared to the large multichip, multitechnology, and multipackage systems in deployment today. Furthermore, using reconfigurable logic and embedded memory, this SoC has the advantage of dynamic software and digital signal processing engine updates, without expensive redesigns of the chip. This publication will describe the necessary ingredients to create such an SoC as well as relevant applications of smart phased arrays that require an SiGe HBT BiCMOS technology. Potential markets for this technology include communications systems, weather tracking, radio astronomy, automotive radar, cellular basestation capacity improvement, satellite and aerial resource imaging, ground-level airplane collision avoidance, as well as military tracking and guidance systems. [J316]

"Fisher information for a complex Gaussian random variable: beamforming applications for wave propagation in a random medium"

We derive a general expression for the Fisher information for a special class of complex Gaussian random variables, whose mean and covariance may be expressed in terms of a specific parameterized linear transformation. The deterministic unknown parameter case is considered. This class is descriptive of signals that propagate in a homogeneous or inhomogeneous medium and also occurs in numerous beamforming applications. The Fisher information derived here encompasses a wide range of previously derived, well-known results for complex Gaussian signals propagating in a homogeneous medium and is also applicable to more recent models for signals propagating in an inhomogenous medium. The conditions for the estimates of the azimuth and elevation to decouple from the estimates of the nuisance parameters are studied for monochromatic plane-wave and spherical-wave propagation in a random medium. For propagation in an anisotropic medium, it is found that, in general, the Cramer-Rao lower bounds (CRLBs) of the entire unknown parameter set will be coupled. For special cases of propagation in an isotropic medium, it is found that for plane waves, the CRLBs of the angles of arrival will be approximately decoupled from the CRLBs of the other unknowns, and for spherical waves, the CRLBs of the angles of arrival will be always be coupled to the CRLBs of all other unknowns, although the couplings may be minimized under certain conditions. [J317]

"An array-compensated spherical reflector antenna for a very large number of scanned beams"

There are many stringent demands imposed on the applications of spaceborne antenna systems. One of the most challenging demands is the generation of multiple beams with the ability to scan a very large number of beamwidths. Since the parabolic reflectors have limitations in this application, a 35-m spherical reflector antenna is proposed for a geostationary radar antenna at Ka-band (35.6 GHz) due to its inherent capability of scanning the beams to very large number of beamwidths. The utility of using planar array feeds for correcting spherical phase aberrations is investigated to overcome the performance degradation effects. Two different methodologies are developed for the array excitation coefficients determination based on phase conjugate matching and the results are compared. Using the compensating feed array, the radiation characteristics of the compensated spherical reflector are simulated for no scan and large scan cases and the results are compared with the uncompensated case to show performance improvement. In order to demonstrate the technological readiness of the concept a 1.5-m breadboard model is designed to be built for experimental measurements. Some important mechanical design tolerances and realistic array feed topologies are investigated. The antenna concept developed in this paper is advocated to be used in the next generation of geostationary satellite antenna systems for remote sensing radar applications. [J318]

"The Rolling Radar"

In the search for a better rotating radar, a self-supporting array that rolls like a wheel can improve mechanical reliability and return higher-definition target resolution. The Rolling Radar concept evolved from the need to design and build a large rotating 3D radar as an alternative to multifaceted fixed radar installations, or large, expensive rotating radar systems. However, the physical act of rotating massive structures weighing many tons introduces a host of load bearing and other mechanical reliability problems. An alternative design needed to be conceptualized. The new concept places the radar array inside a large wheel attached to an axle. A smaller wheel affixed to the axle's other end provides support when both wheels simultaneously roll along electrified concentric rails in order to scan 360 degrees. The array wheel propels itself via a simple gravity drive consisting of a magnetic carriage that rides an electromagnetic rail around the inside circumference of the large array wheel. Displacement of its own weight causes the wheel (and the entire axle) to roll around the railed track with no visible external means of motion. The Rolling Radar achieves its initial objective-to improve mechanical reliability-because the array wheel is self-supporting, which eliminates the need for a large support structure and bearing. There is also no need for traditional electrical slip rings, rotating fluid couplers, motors or gearboxes. With fewer moving parts (compared with conventional rotating radars), reliability is increased and life cycle costs are reduced. Another important benefit is the Rolling Radar's electronic look back capability, and the ability to achieve higher spatial resolution than standard 3D radar. This occurs because the act of rolling about its axis and simultaneously rotating about a circumference sweeps an area larger than the array's physical aperture. The effect is similar to spotlight-mode synthetic aperture radar (SAR), a technique commonly used to produce high-resolution radar maps. The Rolling Radar concept was initially developed to address reliability, life cycle cost, and weight. Although still in the concept development phase, the Rolling Radar shows great promise of increasing functionality while improving resolution and- reliability, and in its simplicity of design. Both the reliability and performance gains are in the process of being evaluated. [J319]

"Wide-band modified printed bow-tie antenna with single and dual polarization for C-and X-band applications"

A modified printed bow-tie antenna is designed to simultaneously cover the operations in the C and X-bands from 5.5 to 12.5 GHz. The presented antenna has an end fire radiation pattern that makes it suitable for integration in single and dual polarized phased array systems. The antenna exhibits small size and wide bandwidth of 91%. The radiation characteristics are presented for a single element and a linear array of this antenna. [J320]

"Chaotic radar using nonlinear laser dynamics"

A novel chaotic radar (CRADAR) system utilizing laser chaos is investigated both numerically and experimentally. Compared with conventional radars, the proposed CRADAR has the advantages of very-high-range resolution, unambiguous correlation profile, possibility of secure detection, low probability of intercept, and high electromagnetic compatibility. Generated by an optically injected semiconductor laser, chaotic waveforms with bandwidths larger than 10 GHz can be readily obtained. In this paper, the time series, the phase portraits, and the power spectra of the chaotic states are presented. The correlation traces between the signal and the reference waveforms are plotted. The peak sidelobe level with different correlation lengths is investigated. The capability of anti-jamming and the performance under additive white Gaussian noise are studied. To show the feasibility of CRADAR, proof-of-concept experiments using a pair of planar antennas with a 1.5-GHz bandwidth covering the range from 1.5 to 3 GHz are demonstrated. A range resolution of 9 cm is achieved, which is currently limited not by the bandwidth of the chaotic states but by the detection bandwidths of the real-time oscilloscope and the antennas used. [J321]

"Novel multiple phase centre reflector antenna for GMTI radar"

Adaptive cancellation of stationary clutter for a ground moving target indicator (GMTI) radar requires antenna sensing using multiple apertures. In essence, simultaneous independent observations of the target plus clutter are required. Conventionally, multiple antenna apertures can be achieved through the use of physically separated antennas, or antennas which can be controlled so that subsections are used to receive. Herein, the use of reflector antennas to effect multiple phase centres is described. Multiple feedhorns pointed laterally from the focal point of the reflector are first reviewed, with capabilities and limitations discussed. A new technique for achieving multiple phase centres with a reflector antenna is then introduced. This technique is based on the excitation and combination of TE and/or TM modes from a single antenna feedhorn. It is shown that, by proper combination of multiple TE modes from a single feedhorn, radiation patterns with separate phase centres can be produced from the same reflector. TE and TM modes can also be combined to effect the same, but this is omitted for brevity. The characteristics of the resulting radiation patterns are analysed with a view towards maximising the separation of the antenna phase centres while maintaining symmetry between the patterns and minimising the reduction in gain and constant phase beamwidth with respect to the reflector's conventional radiation pattern.

[J322]

"A full duplex capable retrodirective array system for high-speed beam tracking and pointing applications"

A retrodirective array capable of full duplex communication is presented. The system is based purely on analog circuits for all signal-processing tasks including target tracking, beam pointing, and carrier recovery. Two types of receiver architectures are used, i.e., AM diode detectors for near-omni directional coverage and a digital beamforming receiver to enhance signal-to-interference ratio. This paper also discusses this technology in the context of development of a radar target/communication device, which is intended to both facilitate radar imaging and establish a self-tracking communication link between the ground terminal and mobile radar station. Demonstration of 10-Mb/s data receiving and transmitting functions are presented along with its automatic beam-steering ability and radiation patterns, as well as details about each major circuit component used in the array. [J323]

"Beam steering of nonlinear oscillator arrays through manipulation of coupling phases"

This paper describes three phase-shifterless beam steering techniques which exploit the synchronization properties of coupled nonlinear oscillator arrays. In each, the control parameters are the coupling phases of the local interactions between elements. The one-dimensional oscillator arrays under consideration are described by Phase Model-type equations, implying the assumption that the amplitude dynamics have achieved a steady state. Linear stability analyzes for each technique are provided which reveal significant differences in attainable scan angles. [J324]

"History of the MERA antenna"

Texas Instruments began development of the molecular electronics for radar applications (MERA) solid-state X-band phased-array antenna for the U.S. Air Force Avionics Laboratory in 1964. Its development is very briefly mentioned. [J325]

"Institutional listings"

{no data available} [J326]

"Polymeric electro-optic digital optical switches with low switching voltage"

Digital optical switches based on electro-optic polymers have been designed and fabricated. They are suited for use as spatial switches in optical-controlled phase-array radars. The switches show step-like responses to driving voltages with 7 V switching voltage for dual-arm driving and high extinction ratio. This nonresonant switch design can be driven by push-pull configurations without bias. [J327]

"MEMS 2-bit phase-shifter failure mode and reliability considerations for large X-band arrays"

RF microelectromechanical systems (MEMS) switch technology used in the fabrication of phase-shifter circuits is examined from the perspective of failure mode and reliability implications on the performance of large X-band array antennas. Amplitude and phase-state failure probability density functions (pdfs) conditioned on switch probability of failure are formulated for both the hybrid-T (switched line) and coupled-line phase-shifter circuit topologies. The pdfs are used to assess the phase-shifter failure impact on overall array level performance in terms of gain loss and the increase in RMS sidelobe level. Reliability and lifetime implications are addressed through considering a probability of switch failure that increases with cycling. The phase-shifter lifetime switching considerations are related to radar system lifetime beam switching requirements consistent with plausible radar system applications. The key findings are that RF MEMS switch mean time to failure 125000 h or longer, consistent with 100-125 phase-shifter state switches per second (1011switch operations), are reasonable expectations for RF MEMS phase-shifter technology to meet in order to be considered viable for a broad range of array antenna applications. [J328]

"Low-cost nonplanar microstrip-line ferrite phase shifter utilizing circular polarization"

A low-cost microwave ferrite phase shifter is proposed in this paper. The phase shifter is comprised of three parallel nonplanar microstrip lines separated from a ground plane by a substrate containing a ferrite rod/slab. The amount of phase shift between the input and output ports is determined by the strength of the magnetic bias field applied to the ferrite. A three-way power divider was designed to feed the microstrip lines with different magnitudes and phases. By combining the effects of the nonplanar geometry and the phase offsets introduced

by the feed network, circularly polarized waves can be produced in the ferrite. These waves strongly interact with the biased ferrite resulting in a large phase shift over a short distance-90°/cm based on current simulation results. This device will be best suited for use in high-gain phased-array radar systems. [J329]

"An optimization technique for sum and difference array factors [Jradar array signal processing]"

Modern high-resolution radars often employ planar phased array antennas. The patterns for these arrays are usually designed to have narrow mainbeams and low sidelobes. This is best achieved by minimizing the total sidelobe energy in the array factor, rather than setting a sidelobe threshold level as is usually done. A method to achieve the minimizing patterns is described here for both sum and difference array factors. We define the optimum array factor for a linear array as minimizing the total array factor energy outside of a specified angular range about the peak of the mainbeam. This optimization technique is at least as easy to apply as the older techniques and is superior for many applications. In addition, the optimization technique has far fewer restrictions on the placement of the elements and is, therefore, more general. We can easily generalize the method to include nonuniform array designs, however an initial look into the performance of nonuniform arrays gave disappointing results for the sum array factor. [J330]

"Bounding the angular scale factor error for adaptive arrays"

When compared with a conventional gimballed antenna a phased-array antenna conveys some important advantages to a tracking radar system, including inertialess beam-steering and the ability to modify the beam pattern to suppress interference. For successful tracking of a radar target the linearity of the antenna angular response must be carefully controlled. The effect of array calibration errors on the linearity of the response of an adaptive phased-array antenna is considered. Through analysis of the maximum likelihood estimate (MLE) of target angle, a lower bound is derived on the variance of the angular scale factor error achievable when tracking a target with an adaptive phased-array antenna in the presence of residual calibration errors and interference. It is shown that while the presence of a sidelobe interferer has little impact on the achievable variance, a strong mainbeam interferer can result in a very significant degradation. [J331]

"Radar "down under""

{no data available} [J332]

"Microwave phase shifter utilizing nonreciprocal wave propagation"

Novel microwave phase shifters are proposed and fabricated utilizing nonreciprocal wave propagation whose insertion loss is independent of the obtained angle in phase shift. The fabricated phase shifter consisted of a ferrite ring resonator whose feeder point can be mechanically adjusted to give 360° phase-shift angle at relatively constant insertion loss. Measurements are compared with calculations. [J333]

"Super-fast scanning technique for phased array weather radar applications"

The authors present a super-fast scanning (SFS) technique for phased array weather radar applications. The fast scanning feature of the SFS technique is described and its drawbacks identified. Techniques which combat these drawbacks are also presented. A concept design phased array radar system (CDPAR) is used as a benchmark to compare the performance of a conventional scanning phased array radar system with the SFS technique. It is shown that the SFS technique, in association with suitable waveform processing, can realise four times the scanning speed and achieve similar accuracy compared to the conventional phased array benchmark. [J334]

"Polarimetric Characteristics of sea ice in the sea of Okhotsk observed by airborne L-band SAR"

The Phased-Array L-Band SAR (PALSAR) aboard the Advanced Land Observing Satellite (ALOS) is capable of globally acquiring fully polarimetric data. In order to confirm the ability of L-band polarimetric synthetic aperture radar (SAR) to investigate sea ice before the ALOS launch, we conducted a field experiment using an airborne Polarimetric and Interferometric SAR (Pi-SAR) in the Sea of Okhotsk in 1999. This paper presents the analyzed results of data acquired in that experiment. The extracted polarimetric parameters of several ice types suggested that polarimetric coherences and phase differences between right-right (RR) and left-left (LL) are good candidates for discriminating ice types. The polarimetric anisotropy as well as the beta angle of the first eigenvector calculated in the polarimetric decomposition procedure are alternative parameters that are sensitive to ice type differences. Due to the low depolarization characteristics of open water, it could be discriminated from sea ice by scattering entropy in all incidence angle ranges. From the relation between ice thickness and the polarimetric parameters, we found that backscattering coefficients and vertical (VV) to horizontal (HH)

backscattering ratio are highly correlated with ice thickness. Since the ratio is sensitive to ice surface dielectric constants, a simple simulation using the integral equation method surface model was conducted by using the physical parameters of typical sea ice. A two-dimensional ice thickness map was derived from an empirical relation between the VV-to-HH backscattering ratio and ice thickness. [J335]

"Radar nomenclature"

Like much of the equipment used by the armed forces, both civil and military radar systems may be allocated an identification resolved from a synonym, mnemonic, project name, number, application notation, or specialised nomenclature and sometimes may even be based upon the whims of an intelligence reporting service. Of these, mnemonics are very popular; whilst of designation systems used by the US armed forces is probably best known, whilst the Russian system is least understood. Other well-known identification systems and schemes are those employed in Sweden, France, and the UK and are amplified in this article. [J336]

"Institutional listings"

{no data available} [J337]

"Operating limits for distortion reduction by the augmentation technique in nonlinear transistor amplifiers"

In airborne military phased array radar systems, detection capability is influenced as much by receiver linearity as it is by system noise performance. The extremely wide dynamic range of the target returns in such systems leads to challenging receiver design compromises between amplifiers exhibiting low distortion or low thermal noise. Conventional methods that are used to improve linearity, such as increasing device size, bias current or supply voltage, inevitably result in enhanced thermal noise, higher power consumption and heat dissipation. In military aircraft, where weight and space are at a premium, these effects are difficult to accommodate. Consequently a method of amplifier linearisation is required that has minimal impact on the power consumption, size and noise figure of the receiver system. A possible solution to this problem, that has recently been advocated, relies on a process termed 'augmentation'. This solution is explored for application to weakly nonlinear receiver amplifiers and easy-to-use relationships are presented to enable designers to assess the frequency limits of the technique for particular devices and processes. [J338]

"Computation of gain, noise figure, and third-order intercept of active array antennas"

In this work a general formulation for the computation of gain, noise figure and third-order intercept of the parallel of a number of branches is presented. These formulas are particularly useful for the characterization of active weighted array antennas, thus for the design of the relevant beam-forming networks. [J339]

"The mean echo and echo cross product from a beamforming interferometric altimeter and their application to elevation measurement"

This paper describes the echo from a beamforming interferometric altimeter from a uniformly scattering surface inclined at an angle to a sphere, underlain by a uniformly scattering volume. The rough "surface" impulse response and the echo and interferometric cross product are determined as functions of the beam direction and the vector surface gradient. These expressions are used to determine the multilooked echo and interferometric phase from such a system. The "effective" number of looks and the multilooked echo coherence, which determine the statistics of the echo power and the interferometric phase, are defined. The dependence of the multilooked echo power and interferometric phase are investigated as functions of the surface vector gradient, surface roughness, volume scattering, and SNR. These behaviors are illustrated using values based on a practical system. The precision of the elevation measurement is examined in the light of the effective number of looks and the coherence of the multilooked echo and cross product. Some conclusions concerning the practical recovery of the range from the echo power are discussed. [J340]

"Sparse frequency transmit-and-receive waveform design"

A computationally efficient algorithm derives complex digital transmit and receive ultra-wideband radar and communication waveforms with excellent arbitrary frequency band suppression and range sidelobe minimization. The transmit waveform minimizes a scalar function penalizing weighted spectral energy in arbitrary frequency bands. Near constant power results from another penalty function for deviations from constant power, or constant power is enforced by a phase-only formulation. Next, a least squares solution for the receive waveform minimizes a weighted sum of suppressed band spectral energy and range sidelobes (for pulse and continuous wave operation), with a mainlobe response constraint. Both waveforms are calculated by iterative algorithms

whose updates require only linear order in memory and computation, permitting quick calculation of long pulses with thousands of samples. [J341]

"Phased array systems in silicon"

Phased array systems, a special case of MIMO systems, take advantage of spatial directivity and array gain to increase spectral efficiency. Implementing a phased array system at high frequency in a commercial silicon process technology presents several challenges. This article focuses on the architectural and circuit-level trade-offs involved in the design of the first silicon-based fully integrated phased array system operating at 24 GHz. The details of some of the important circuit building blocks are also discussed. The measured results demonstrate the feasibility of using integrated phased arrays for wireless communication and vehicular radar applications at 24 GHz. [J342]

"Plane-wave synthesis by an antenna-array and RCS determination: theoretical approach and numerical simulations"

Radar cross-section (RCS) measurements of a target performed in an anechoic chamber with the conventional one antenna calibration technique may yield erroneous results at frequencies lower than those for which the chamber has been initially designed, essentially because the absorbers become ineffective and the field emitted by the antenna no longer satisfies the plane-wave (PW) condition on the target. A possible way to circumvent these difficulties is to use a phased antenna-array that synthesizes a PW in a bounded domain, usually called the quiet zone (QZ). In this paper, we propose a calibration technique that allows an accurate reconstruction of the RCS of a target located in the near-field of the array, even when electrically conducting walls are present. A theoretical study of the problem at hand is presented that allows one to specify clearly the hypotheses that are being made and to identify the parameters that govern the accuracy of the RCS reconstruction. When the target-array, antenna-antenna, and target-walls-target interactions are neglected, it is demonstrated that this calibration technique synthesizes a PW in QZ if the calibration object is a line source (two-dimensional) or an infinitesimal dipole (three-dimensional). Three-dimensional full-wave numerical simulations, that take all the previously mentioned interactions into account, illustrate the efficiency of this technique when the array and conducting walls are a few wavelengths apart from the target. [J343]

"Dennis J. Picard Medal for Radar Technologies & Applications"

Presents the recipients of the Dennis J. Picard Medal for Radar Technologies and Applications, including the 2004 recipient, Dr. David Atlas. Also listed is the recipient of the Fred Nathanson Memorial Radar Award for 2004, Dr. Fulvio Gini. [J344]

"A 32-element 8-bit photonic true-time-delay system based on a 288 Ч 288 3-D MEMS optical switch"

A large-scale three-dimensional microelectromechanical-system optical switch is used for the first time to realize a true-time-delay (TTD) beamformer for phased-array radar applications, with a capacity of 32 antenna elements and eight bits of delay. The 288 Ч 288 optical switch has a median loss of 1.4 dB and all measured 82 944 paths exhibit less than 2.3 dB loss at 1310 nm. The TTD beamformer exhibits a loss variation of 1.5 dB, which is equalized using a mirror-offset technique. [J345]

"Real-time digital signal processing of phased array radars"

With the advance of hardware and software technology, modern phased array radars are now built with commercial-off-the-shelf (COTS) components, and it opens up a new era in real-time resource scheduling of digital signal processing. This paper targets the essential issues in building a component-oriented signal processor (SP), which is one of the two major modules in modern phased array radars. We propose a simple but effective task allocation policy and a real-time scheduling algorithm to address the design objectives of SPs. We are able to bound the number of processing units needed for a component-oriented SP in the design time, while everything was done empirically in the past. A series of experiments was done to demonstrate the strength of our methodology. [J346]

"Comparison between LS and TLS in adaptive processing for radar systems"

Adaptive signal processing strategies have to be developed for cancellation of electromagnetic noise-like interference in modern radar systems. The authors compare two signal processing methods, the least squares (LS) and the total least squares (TLS) algorithms, for adaptive phased-array radar systems. Results are presented which show that the TLS algorithm has a slight advantage over the LS algorithm at a cost of more

computation. The LS algorithm therefore remains the preferred processing method. [J347]

"Two-dimensional planar passive retrodirective array"

A simple passive microstrip array design is introduced comprising four square microstrip patches interconnected with transmission lines to form a Van-Atta retrodirective array suitable as a building block in a larger two-dimensional self-tracking array. The resulting circuit measures 48Ч48Ч0.254 mm, operates at 10.24 GHz and yields 5 dB increase in return signal at bore-sight relative to a flat metal sheet having the same dimensions for incident linear polarisation. The -5 dB monostatic radar cross-section response is ±25° compared to ±12° measured for a flat metal sheet of equivalent dimensions. The reradiation characteristics of circularly polarised signals from the retrodirective structure are briefly discussed. [J348]

"Simple mismatched filter for binary pulse compression code with small PSL and small S/N loss [Jradar]"

We present several binary pulse compression codes to greatly reduce sidelobes while suffering only a small S/N loss. We twice repeat a simple, easy to implement procedure that was first introduced by B.L. Lewis to reduce sidelobes for the polyphase codes of the P1 and P4 codes. We estimate the performance of the newly found binary pulse compression codes estimated by simulation, and find satisfactory results. [J349]

"Nullifying ACF grating lobes in stepped-frequency train of LFM pulses"

An effective way to increase the bandwidth of a coherent pulse-train is to add a frequency step Δf between consecutive pulses. A large Δf implies a large total bandwidth, hence improved range resolution. However, when the product of the frequency step times the pulse-duration tp, is larger than one (tpΔf >1), the autocorrelation function (ACF) of the stepped-frequency pulse-train suffers from ambiguous peaks, known as "grating lobes." It is well known that replacing the fixed-frequency pulses with linear FM (LFM) pulses of bandwidth B can reduce those grating lobes. We present a simple analytic expression for the ambiguity function (AF) and ACF of such a signal and derive from it very simple relationships between Δf, B, and tpthat will place s exactly where the grating lobes are located, and thus remove them completely. [J350]

"Continuously delay-time tunable-waveguide hologram module for X-band phased-array antenna"

Tunable optical true time-delay modules based on a dispersive waveguide hologram are presented to provide continuous radio-frequency beam scanning for an X-band (8-12 GHz) phased-array antenna system. The true time-delay modules operating in the 1550-nm region were fabricated with continuously tunable time delays from 5 to 64 ps. The far-field radiation patterns were measured with different delay combinations and the continuity of the scanning angles from 35° to 55° was experimentally confirmed at X-band frequencies. [J351]

"MIT Lincoln Laboratory Journal: fifty years of radar"

This review assumes that many non-US readers may not be well-informed about the steps and work in radar development in the US after WW II to the present. Many know MIT by name and recall the famous Radiation Laboratory Series. But the more recent technical history has been less in the "public domain." In an attempt to correct this, one of the key institutions in the field, the MIT Lincoln Laboratory two years ago produced a special issue of their regular publication. Although the document currently at hand is not a book in the strict sense, the size, shape, and editorial comprehensiveness of the MIT Lincoln Laboratory Journal's Fifty-Year Anniversary Issue (12, 2, 2000) justifies calling this article being treated as a book review. [J352]

"GRS 2002: German Radar Symposium in Bonn, Germany"

The German Radar Symposium (GRS 2002), organized jointly by the German Institute of Navigation (DGON) and by the Information Technology Society (VDE-ITG), attracted wide interest in the international radar community. It was held from September 3-5, 2002, in Bonn, the former capital city of Germany. The GRS 2002 programme covered a large scale of important radar topics. All classical topics like air traffic control, CFAR, antenna technology, signal processing and simulation papers have been presented and new results were demonstrated. These topics were combined with new applications like meteorology, subsurface, and automotive to underline the increase of interest in radar technology. Phased array antennas are the key elements of high performance multi-function radar systems which are studied all over the world. SAR and ISAR are, nowadays, essential radar techniques for civil and military observation and monitoring. [J353]

"Low-loss 2- and 4-bit TTD MEMS phase shifters based on SP4T switches"

2- and 4-bit microelectromechanical system (MEMS) X- to Ku-band true-time-delay phase shifters with a very low insertion loss are described. The phase shifters are fabricated on 200-μm GaAs substrates and the low loss is achieved using MEMS SP4T switches, which reduce the number of switches in the signal path by half when compared to conventional designs with SP2T switches. Measurements indicate an insertion loss of -0.6±0.3 and -1.2±0.5 dB at 10 GHz for the 2- and 4-bit designs, respectively. The measured losses agreed very well with Momentum simulations and are the lowest reported to date. The 2-bit phase shifter performed well from dc-18 GHz, with -0.8±0.3-dB insertion loss at 18 GHz and a return loss of [J354]

"Synthesis of microstrip reflectarrays as planar scatterers for SAR interferometry"

The use of printed reflectarrays as planar scatterers for SAR interferometry applications is proposed. A phase-only synthesis is applied to obtain a scattered field in a prescribed direction. A reflectarray working at ERS1/2 frequency (5.3 GHz) is simulated to validate the method. Measurements are performed on a 10 GHz size-reduced prototype. [J355]

"Vladimir Yachin and Ildar Urazghildiyev awarded joint chapter grant"

First Page of the Article [J356]

"Robust space-time adaptive processing for airborne radar in nonhomogeneous clutter environments"

Space-time adaptive processing (STAP) holds tremendous potential for the new generation airborne surveillance radar, in which the phased array antennas and pulse Doppler processing mode are adopted. A new STAP approach using the multiple-beam and multiple Doppler channels is presented here for airborne phased array radar. The approach with space-time multiple-beam (STMB) architecture is robust to array errors and has very low system degrees of freedom (DOFs). Hence, it has low sample support requirement and it is very suitable for the practical planar phased array radar under nonhomogeneous clutter environments. Meanwhile, a new nonhomogeneous detector (NHD) based on the correlation dimension (CD) is also proposed here, which is used as an effective method to screen tracing data prior to detection processing. It can further improve the performance of the STAP approach in the severely nonhomogeneous clutter environments. Therefore, a scheme that incorporates the correlation dimension nonhomogeneity detector (CD-NHD) with the STMB is recommended, which we term CD-NHD-STMB. The experimental simulation results indicate that: 1) the STMB processor is robust to array element error and has high performance under nonhomogeneous clutter environments; 2) the CD-NHD is also effective on the nonhomogeneous clutter. As a result, the CD-NHD-STMB scheme is robust to array element error and nonhomogeneous clutter, and therefore available for airborne phased array radar applications. [J357]

"Netted radar sensing"

Future radar applications are beginning to stretch monostatic radar systems beyond their fundamental sensitivity and information limits. Networks of smaller radar systems can offer a route to overcome these limitations; for example, networks of radar sensors can counter stealth technology whilst simultaneously providing additional information for improved target classification. More generally, multiple independent sensors can provide an energetically more efficient collector of radar scatter. The relative merits of non-coherent and coherent networks are introduced and the balance between increased performance, complexity, and cost is discussed. [J358]

"Radar imaging of moving targets in foliage using multifrequency multiaperture polarimetric SAR"

Because of the low signal-to-clutter ratio, it is a difficult problem to detect and image moving targets in foliage. In this paper, a multifrequency multiaperture polarimetric synthetic aperture radar (MFMA POLSAR) system is proposed for imaging of moving targets in foliage. The MFMA POLSAR extends the multifrequency 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 cannot only accurately locate both the slow and the fast moving targets but also reveal moving targets in foliage. [J359]

"RCS reduction technique for reflectarray antennas"

The performance of a concentric ring reflectarray element backed either by a solid metal ground plane or a frequency-selective surface is compared. Simulated and measured results show that the 'in-band' reflection phase response of the two structures is similar; however, the periodic surface reduces the 'out-of-band'

reflectivity of the antenna by more than 4 dB, thereby decreasing its RCS profile to these signals [J360]

"Closed-form four-channel monopulse two-target resolution"

A novel closed-form solution to resolve the directions of arrival (azimuth and elevation) of two sources using a single snapshot (monopulse) of four independent channels is presented. Both phase comparison monopulse and amplitude comparison monopulse are solved. Exceptions where the two targets cannot be resolved are also discussed. Numerical simulation result of a practical phased-array configuration validates the effectiveness of the new solution. [J361]

"Resolution and synthetic aperture characterization of sparse radar arrays"

The concept of radar satellite constellations, or clusters, for synthetic aperture radar (SAR), moving target indicator (MTI), and other radar modes has been proposed and is currently under research. These constellations form an array that is sparsely populated and irregularly spaced; therefore, traditional matched filtering is inadequate for dealing with the constellation's radiation pattern. To aid in the design, analysis, and signal processing of radar satellite constellations and sparse arrays in general, the characterization of the resolution and ambiguity functions of such systems is investigated. We project the radar's received phase history versus five sensor parameters: time, frequency, and three-dimensional position, into a phase history in terms of two eigensensors that can be interpreted as the dimensions of a two-dimensional synthetic aperture. Then, the synthetic aperture expression is used to derive resolution and the ambiguity function. Simulations are presented to verify the theory. [J362]

"Wide scanning phased array antenna design in Ka band"

A millimetre wave active phased array antenna has been developed that is capable of a wide scanning angle in both the E- and H-planes with small deviation in antenna gain. A dipole antenna with parasitic element has been adopted, which may have the capability of adjusting the influence of mutual coupling in the array element pattern. The design of the parasitic element is examined and the effect of its shape on pattern characteristics is confirmed by experiment. Beam scanning angles of ±57.3 degrees in the E-plane and ±68.2 degrees in the H-plane were obtained for each array antenna pattern [J363]

"Noise Radar for range/Doppler processing and digital beamforming using low-bit ADC"

Pulse compression radar is used in a great number of radar applications. Excellent range resolution and high resistance to electronic countermeasures (ECM) can be achieved by long wideband modulated pulses, which spread out the transmitted energy in frequency and time. By using random noise as the waveform, the range ambiguity can be suppressed as well. In this paper, noise radar for Doppler/range indication and digital beamforming is described. Main factors influencing the resolution and sidelobe level in range and Doppler are surveyed. In particular, the possible use of binary or low-bit analog-to-digital converters (ADCs) in noise radar is analyzed, which highly improves the signal-processing rate and reduces the costs. The very significant improvement of sidelobe suppression, when an extra noise signal is added before ADC, is explained theoretically and confirmed by simulation results. Mostly, the random signal is transmitted directly from a noise generating high-frequency source. A sine wave, which is phase or frequency modulated by random noise, is an alternative, giving lower range sidelobes, and higher transmitted mean power when peak-limited transmitters are applied. The dynamic requirements and the bandwidth of the modulating signal can be reduced as well. [J364]

"Techniques for improving STAP performance in high PRF applications"

A novel beamforming architecture is presented in which space-time adaptive processing (STAP) for clutter suppression in airborne radar is implemented with tap delays of multiple PRIs. The resulting output is combined with the unadapted output. This can result in improved detection performance for targets obscured by clutter that covers only a small proportion of the unambiguous Doppler extent, as often occurs in high PRF modes [J365]

"MDL approach for multiple low observable track initiation"

In this paper the track initiation problem is formulated as multiple composite hypothesis testing using maximum likelihood estimation with probabilistic data association (ML-PDA). The hypothesis selection is based on the minimum description length (MDL) criterion. We first review some well-known approaches for statistical model selection and the advantage of the MDL criterion. Then we present one-dimensional examples to illustrate the MDL criterion used in multiple composite hypothesis testing and the performance limit of the ML-PDA for track initiation is interpreted in terms of the sharpness of the hypothesis testing. Finally, we apply the MDL approach for the detection and initiation of tracks of incoming tactical ballistic missiles in the exo-atmospheric phase using

a surface-based electronically scanned array (ESA) radar. The targets are characterized by low signal-to-noise ratio (SNR), which leads to low detection probability and high false alarm rate. The target acquisition problem is formulated using a batch of radar scans to detect the presence of up to two targets. The ML-PDA estimator is used to initiate the tracks assuming the target trajectories follow a deterministic state propagation. The approximate MDL criterion is used to determine the number of valid tracks in a surveillance region. The detector and estimator are shown to be effective even at 4.4 dB average SNR. [J366]

"PAMIR-a wideband phased array SAR/MTI system"

Air- and spaceborne imaging radar systems in forthcoming surveillance and reconnaissance tasks have to meet increasingly severe demands. The next generation of top-level synthetic aperture radar (SAR) systems will comprise, among others, high resolution and long-range imaging capabilities, highly sensitive ground moving target indication and a multitude of sophisticated operational modes. The variety of tasks can be fulfilled only by the use of a reconfigurable phased array antenna together with a comprehensive wideband system design and a multichannel capability. At FGAN a new experimental X-band radar has been conceived, which will possess in its final upgrade an electronically steerable phased array consisting of 16 autonomous and reconfigurable subapertures, five independent receive channels, and a total signal bandwidth of about 1.8 GHz. The sensor is called PAMIR (Phased Array Multifunctional Imaging Radar). It is envisaged to demonstrate SAR imaging at a very high resolution and for a long range. The fine resolution will also be achieved with inverse SAR (ISAR) imaging of ground moving objects. Furthermore, the number of receive channels will allow ground-moving target indication (GMTI) by space-time adaptive processing and single-pass interferometric SAR (IfSAR) with a very high 3-D resolution. In its current stage of extension PAMIR is operable with one receive channel and a mechanically steerable antenna array. The system design and the intended capabilities of PAMIR are described. Ground-based and airborne experimental results concerning high-resolution SAR and ISAR imaging are also presented. [J367]

"Digital beamforming in SAR systems"

The rapid progression in digital hardware and signal processing capabilities stimulates the development of radar systems. The tendency is to move the digital interface toward the antenna, replacing, whenever possible, analog RF-hardware. Based on software codes, these digital systems are more flexible and easier to reconfigure than RF-hardware. This letter illustrates the general concept for digital beamforming (DBF) in synthetic aperture radar systems and investigates their principle capabilities, limitations, and performance parameters. It is shown that using DBF a simultaneous improvement in azimuth coverage and resolution can be achieved. [J368]

"Multitemporal JERS repeat-pass coherence for growing-stock volume estimation of Siberian forest"

Multitemporal radar data from the Japanese Earth Resources Satellite (JERS) satellite from the period 1993 to 1998 have been used to investigate if L-band interferometric coherence with a 44-day temporal baseline is suitable for estimations of growing-stock volume in boreal forest. Two forest regions north of Krasnoyarsk in Siberia have been used as test areas. Seasonal variations in the repeat-pass coherence have been studied, and a comparison with C-band coherence from the European Remote sensing Satellite 1 and 2 (ERS-1/2) tandem missions in 1997 and 1998 has been done. JERS coherence from the winter shows a clear correlation with the forest growing-stock volume. For the summer scenes, the spread in the values is too large to give reliable results. Acquisitions from the spring and fall show large problems with decorrelation caused by temporal changes. The results indicate potential of repeat-pass interferometric L-band coherence in winter, as will be provided by the forthcoming Advanced Land Observing Satellite/Phased Array type L-band Synthetic Aperture Radar (ALOS/PALSAR) to map growing-stock volume in Siberia and boreal forests. [J369]

"Surface-wave radar and its application"

Following a brief review of the problem of detecting drug-carrying aircraft approaching the United States from South America, a short description is given of over-the-horizon radar that makes use of radar pulses reflected from the ionosphere. An alternative, surface-wave radar, is then described beginning with the complete formulas for the electric field transmitted by a vertical dipole erected on the surface of the sea. The backscattered field of a small airplane and of a boat are calculated and the fields received by the array determined. Arrays of vertical dipoles are then described for sending radar pulses along the surface of the Gulf of Mexico. [J370]

"Development of a retrodirective PARC for ALOS/PALSAR calibration"

Polarimetric radar calibration is a procedure that corrects the polarization distortion of a measured scattering matrix by referring to the scattering matrix of a known target. The present paper describes the principle, design,

manufacture and measurement results of a novel retrodirective polarimetric active radar calibrator (PARC). It accommodates both the depolarization characteristic by using dual-polarized antennas and retrodirectivity with the Van Atta array concept simultaneously. The PARC was designed for Phased Array L-band SAR (PALSAR) calibration based on the proposed principle. It consists of a 6Ч6-element antenna array with a 1-m-square aperture and four amplifiers with a 20-dB gain. The whole array is divided into four 3Ч3-element subarrays to form a two-dimensional (2-D) Van Atta array. Retrodirectivity extends the angular width, where the radar cross section exceeds 35 dBm2, which is a preliminary design goal, to almost twice the width of a conventional array reflector of the same size. However, it should be noted that the present design needs at least four times as many amplifiers as a conventional fixed-beam array reflector to be capable of 2-D source tracking. A prototype model of the present retrodirective PARC is manufactured in the L-band to allow Advanced Land-Observation Satellite (ALOS)/PALSAR calibration. The results we obtained through measurement agree well with the theoretical predictions, and substantiate the premise behind the present design of the retrodirective PARC for polarimetric SAR calibration. [J371]

"Broad-band SiGe MMICs for phased-array radar applications"

This paper reports the performances of several broad-band monolithic SiGe monolithic microwave integrated circuits (MMICs) suitable for phased-array radar applications. The amplitude and phase control MMIC designs are based on an optimized SiGe p-i-n diode offered by the IBM 5HP SiGe foundry process. Utilizing this diode, several control circuitries including a broad-band (1-20-GHz) monolithic single-pole double-throw switch, a five-port transfer switch, a 6-bit phase shifter, and a 5-bit attenuator, all operating over 7-11 GHz, are designed. Also, the design and performance of an SiGe heterojunction bipolar transistor variable-gain cascode amplifier that combines the functionality of an amplifier and an attenuator into one MMIC is described. [J372]

"Number theory and bootstrapping for phase unwrapping"

The problem of the phase unwrapping and the estimation of time-varying frequency is considered. The phase is first modeled as a polynomial in time. Using Lagrange interpolation polynomial approximation, for the modulo operation, where the modulus is a prime, a unique estimate for the phase is obtained. This estimate, however, is sensitive to noise. Using the method of bootstrapping, one is able to obtain good estimate even at SNR values as low as 10 dB. The method is applied to several examples, and compared to the minimum mean square polynomial fit for the phase. It is shown that the proposed approach has superior performance [J373]

"Low altitude target model for radar simulation"

A simulation model of antenna array signals from a low altitude target is considered. Explicit expressions for statistical and spectral characteristics of the scattered signals are obtained in the Kirchhoff approximation. The model permits to evaluate the efficiency of different techniques of low altitude target tracking. It benefits the comprehension of the influence of multipath propagation on tracking radars [J374]

"Retrodirective array augmentation for electronic RCS modification"

In this paper, an active Pon type retrodirective array (RDA) is augmented with a passive array in order to provide electronic modification of the transmit function of the combination in response to the influence of an external interrogating signal. By the use of a single phase shifter and level setting control, it will be shown that different types of broadcast mode can be initiated. The first of these is the self-tracking capability normally associated with a Pon heterodyne RDA. Broadside radiation production associated with a conventional in-phase fed passive array operating in transmission mode is also demonstrated. Additionally, new modes of operation which include the use of the configuration are described: 1) as a radiation nulling device; 2) its use as a sidelobe suppressor; and 3) as a beamwidth control device [J375]

"Realization of true-time delay lines based on acoustooptics"

A true-time optical delay line for short radiofrequency (RF) pulses using path length dispersion is proposed. It is an optical implementation of the linear phase-shift theorem of the Fourier transformation. Acoustooptic signal processing is used for conversion into the optical frequency domain and for spatial Fourier decomposition of the pulse. The processing of the pulse is obtained by differentially phase shifting the particular frequency components, followed by a heterodyne reconversion into the RF domain. The optical system is intended to be used for delaying, but also for shaping and filtering of RF pulses, mainly in phased array radar antennas. Theoretical analysis of the system principle is given together with experimental results, demonstrating 2-μs time delay of 0.5-μs-long pulses with maximum optical phase shift of 1.2pi. A detailed theoretical and experimental bandwidth analysis is carried out, pointing to the main technical problems and their solutions [J376]

"Transmit/receive modules"

This paper begins with a discussion of the microwave functions performed by transmit/receive (T/R) modules for phased-array antenna applications. The paper then addresses performance and cost aspects of semiconductor, packaging, and assembly technologies associated with T/R modules [J377]

"Analysis of a grating metal structure with broad back-scattering field pattern for applications in vehicle collision avoidance system"

In this paper, grating metal structures with broad and flat back-scattering field patterns are studied for possible applications in a vehicle collision avoidance system. The two-dimensional TE scattering of a planar grating structure and a curved grating structure are analyzed at a frequency of 77 GHz. For the planar structure, the method of moments and Floquet's theorem are used to solve the induced current and the resultant back-scattering field. Based on the results of the planar structure, the scattering field of the curved grating structure is obtained by using a perturbation method. The influence on the field pattern of the curvature as well as other structure parameters, such as the width and geometry of each period in the grating structure, is investigated [J378]

"Tripulse: A system for determining orientation and attitude of a satellite borne active phased array"

Tripulse is a novel system that is designed to accurately estimate the orientation of a satellite borne phased array relative to one or more Earth stations. It has conceptual similarities to amplitude comparison monopulse systems used in tracking radars. Tripulse differs from monopulse in that it is applicable primarily to transmitting active phased arrays aboard communication satellites. The signaling structure consists of a minimum of three separate time multiplexed coherent pulses. A statistical performance analysis and a description of the methodology for converting multiple ground station orientation data to attitude estimates are presented [J379]

"Digital false-target image synthesiser for countering ISAR"

The paper presents the design of a pipelined, all-digital image synthesiser capable of generating false-target images from a series of intercepted inverse synthetic aperture radar (ISAR) chirp pulses to provide a novel RF imaging decoy capability. The image synthesiser modulates the phase samples from a phase-sampling digital RF memory (DRFM) that stores intercepted ISAR pulses. The synthesiser contains a parallel array of (identical) complex digital modulators with one modulator for each false-target range bin. The binary phase samples from each intercepted ISAR pulse are applied one at a time to the modulator array. To synthesise the image, each modulator requires a set of phase and gain coefficients that are derived from the range-Doppler description of the false-target to be synthesised. An ISAR image compression algorithm is presented to reconstruct the image using the synthesiser output pulses. A ship with 32 range bins is presented as an example of a false-target input, and simulations are used to quantify the image synthesis capability of the architecture. The image quality as a function of the number of ISAR pulses integrated is also numerically evaluated. The programmable design permits real-time alteration of modulation coefficients, allowing rapid and adaptive shifting among different types of targets offering a low-cost decoy capability using readily available DRFM technology. [J380]

"Development of a hand-held forensic-lidar for standoff detection of chemicals"

The design of a forensic-lidar is reported, enabling a single operator to perform the spectral identification of a labeled object at 5 m distance using a compact, hand-held instrument, low-power excitation (1 mW) and short sampling times (under 2 s) from a sample less than 100-mcm thick. The system integrates a modified single-lens-reflex (SLR) telephoto camera with an optical-fiber coupled Raman probe head. Spectral analysis was achieved using an optical-fiber coupled spectrograph employing a volume-phase holographic grating, charge coupled device array detection and visible excitation. Thus, spectra may be acquired from objects encased in transparent packaging or behind glass windows. The use of a modified SLR camera enables accurate sample alignment using the visible spectrum and collection of surface-enhanced resonance Raman scattered flux through the SLR camera lens using epi-illumination. A single operator may acquire fingerprint recognition of a material using a single hand-held unit and spectrum-matching software. The instrument design is reported with preliminary performance such as spectrograph resolution and transmission. A preliminary spectrum is presented at a standoff distance of 5 m. copyright 2002 American Institute of Physics. [J381]

"Low-cost digital adaptive antenna architecture combined with low-sidelobe beam synthesis"

The explosion of growth seen in the mobile telephony market has meant that the electronic components used in the manufacture of mobile terminals are now mass produced, with a commensurate fall in unit cost. By exploiting the functionality of such components in phased array antenna design a truly low-cost phased array antenna can

be realised. An array antenna architecture is presented that exploits low-cost component technologies. A low-cost architecture for enabling an adaptive, or smart, capability is developed. By separation of the beamforming function and spatial adaptive processing function into two separate signal paths an undersampling technique can be used to provide low-cost spatial processing. The performance of an adaptive processing algorithm is investigated for a radar application. Simulations applied to array element patterns measured on a 16-element linear array demonstrate the performance of the antenna in sidelobe suppression and interference cancellation/spatial filtering. A penalty function approach for sidelobe suppression is applied and is shown to enable flexibility between adaptive cancellation of interference and overall sidelobe level. [J382]

"Spotlight MUSIC: super-resolution with subarrays with low calibration effort"

A central problem in applying super-resolution to phased arrays is the knowledge of the 'array manifold', i.e. the complete knowledge of the array outputs for a plane wave impinging on the array from all considered directions. This becomes a problem for large arrays where only subarray outputs are digitised. In the paper methods for determining an array manifold model with minimum knowledge of the subarray channels are investigated. The basic idea is to treat the subarray centres as phase centres of omni-directional 'super-array' elements. Only the location of the centres and the gains have to be determined by calibration. The drawback of the simple model is that only a local super-resolution property is achieved. By steering the look direction of the array, local super-resolution can be applied like a spotlight mode for any direction of interest. The local super-resolution property has the advantage of suppressing uninteresting sidelobe sources and thus simplifying the super-resolution procedure due to the lower target number. Optimised subarray configurations which are determined by post-processing the subarray outputs are investigated. Using the MUSIC method as an example it is shown that no significant advantage can be gained with the optimised approach [J383]

"Multiplicatively processed antenna arrays for DBF radar applications"

Nonlinear multiplicative processing of receiving antenna arrays enables a significant reduction of elements (i.e. thinning), which becomes increasingly important for large digital beamforming (DBF) arrays. In the paper, several (conventional and multiplicative) array configurations are investigated experimentally with respect to DBF radar applications. Radar measurements were carried out at 5.5 GHz and 77 GHz using a flexible synthetic aperture set-up. The results from the multiplicative systems are compared with those obtained with conventional (fully filled) arrays with regard to imaging performance. Multiplicative systems allow thinning rates of the order of 80%, with minor degradations in image quality. Tolerance simulations indicate a higher sensitivity of multiplicative systems in the presence of amplitude and phase errors [J384]

"Improved analysis of nonreciprocal remanence ferrite phase shifter in grooved waveguide"

In this paper, the nodal finite-element method is used to analyze the differential phase shift of a nonreciprocal remanence ferrite phase shifter in a grooved waveguide. Instead of the former twin-slab model, an improved analytical model is adopted, where the effect of every part of a ferrite toroid on the differential phase shift has been considered. This analysis may replace the correcting factor with good agreement with the experimental data. Furthermore, this analysis is employed to investigate the effect of corner chamfering on the figure-of-merit (differential phase shift per decibel insertion loss) of a ferrite phase shifter. The numerical results are found to agree with the experiments in the literatures. [J385]

"Millimeter-wave folded reflector antennas with high gain, low loss, and low profile"

Periodic and quasi-periodic structures, printed on a dielectric substrate, can be employed to control the reflection and transmission properties of incident waves as a function of structure geometry. Local variations of the element geometry on a substrate with backside metallization-resulting in respective variations of the reflection phase angle-can be used to design printed reflectarray antennas. The dual-polarization properties of such antennas, together with polarizing grids or slot arrays, can be exploited for the realization of compact, low-profile folded reflector antennas. Examples of some antennas of this type are presented, covering the 60 GHz range for communication and ISM applications, and 76 to 77 GHz for automotive radars. [J386]

"Extension of the 3-D range migration algorithm to cylindrical and spherical scanning geometries"

A near field three-dimensional (3-D) synthetic-aperture radar (SAR) algorithm specially tailored for cylindrical and spherical scanning geometries is presented. An imaging system with 3-D capability can be implemented by using a stepped-frequency radar which synthesizes a two-dimensional (2-D) aperture. Typical scanning geometries commonly used are planar, cylindrical, and spherical. The 3-D range migration algorithm (RMA) can be readily used with a planar scanning geometry. This algorithm is extremely accurate, preserves the phase, and corrects for the wavefront curvature. The RMA cannot be directly applied with nonplanar scanning

geometries. However, as an alternative solution, we propose to backpropagate the backscattered data onto a planar aperture in the vicinity of the measurement aperture and then apply the 3-D RMA. The proposed imaging algorithm is validated both numerically and experimentally [J387]

"Subarray weighting for the difference patterns of monopulse antennas: joint optimization of subarray configurations and weights"

Given a linear antenna array with an excitation distribution affording a sum pattern, subarray weighting allows the same array also to generate a difference pattern, with minimal alteration of the signal feed circuitry. Previous implementations of this approach have optimized the weights of given subarrays. Here we report the simultaneous optimization of the partition in subarrays and the subarray weights [J388]

"Moving target detection via airborne HRR phased array radar"

We study moving target detection in the presence of temporally and spatially correlated ground clutter for airborne high range resolution (HRR) phased array radar. We divide the HRR range profiles into large range segments to avoid the range migration problems that occur in the HRR radar data. Since each range segment contains a sequence of HRR range bins, no information is lost due to the division and hence no loss of resolution occurs. We show how to use a vector autoregressive (VAR) filtering technique to suppress the ground clutter. Then a moving target detector based on a generalized likelihood ratio test (GLRT) detection strategy is derived. The detection threshold is determined according to the desired false alarm rate, which is made possible via an asymptotic statistical analysis. After the target Doppler frequency and spatial signature vectors are estimated from the VAR-filtered data as if a target were present, a simple detection variable is computed and compared with the detection threshold to render a decision on the presence of a target. Numerical results are provided to demonstrate the performance of the proposed moving target detection algorithm [J389]

"Inline capacitive and DC-contact MEMS shunt switches"

This paper presents inline capacitive MEMS shunt switches suitable for X/K-band and Ka/V-band applications. The inline switch allows for a low- or high-inductance connection to the ground plane without changing the mechanical characteristics of the MEMS bridge. Excellent isolation and loss are achieved with this design, and the performance is very similar to the standard capacitive MEMS shunt switch. Also, a new metal-to-metal contact MEMS shunt switch is presented. A novel pull-down electrode is used which applies the electrostatic force at the same location as the metal-to-metal contact area. A contact resistance of 0.15-0.35 Ω is repeatable, and results in an isolation of -40 dB at 0.1-3 GHz. The measured isolation is still better than -20 dB at 40 GHz. The application areas are in high-isolation/low-loss switches for telecommunication and radar systems [J390]

"An active integrated retrodirective transponder for remote information retrieval-on-demand"

A retrodirective transponder based on a novel compact phase-conjugating mixer with conversion gain has been developed. The active circuit uses one port for both incoming and outgoing signals, enabling a reduction of circuit size, and the balanced structure provides suppression of undesired signals. By using a modulated local oscillator, the circuit can modulate the received signal in order to retransmit local information to the remote site. A microstrip antenna is integrated with the phase conjugator and the whole system was fabricated on a single substrate, enabling a one-card system. A four-element prototype array with 0.5λ0array spacing demonstrated excellent measured retrodirectivity. Additionally, a simplified binary-phase-shift-keying signal transmitted by the array is recovered successfully at the source location, demonstrating great potential for remote tagging and wireless sensor applications [J391]

"RF fiber-optic link performance"

Applications that involve point-to-point routing of analog signals have benefited from the excellent propagation characteristics of optical fiber. Fiber-optic links that remote RF signals to and from phased-array radar antennas must meet especially stringent performance requirements. The past decade has seen significant progress in the performance of the fiber-optic links that distribute RF signals in antenna-remoting applications, as well as in cellular communications and cable television signal distribution networks. This article reviews the present state of the art in RF fiber-optic links [J392]

"Angular superresolution for phased antenna array by phase weighting"

In this paper, a new angular superresolution technique called Phase Weighting Superresolution Method (PWSM) is proposed. The method combines a phase weighting method and a nonlinear spectral estimation algorithm. It is used in conventional phased array radar for improving angle resolution. The motion compensation of radar target

and an analysis of influence of component imperfection in the realization of the method are presented. To evaluate the performance of the proposed method, Monte Carlo simulation has been conducted to estimate the root mean square error (RMSE) of the angle estimates and the spatial resolution signal-to-noise ratio (SNR) threshold in the cases of both non-fluctuating targets and fluctuating targets. The simulation results have been compared to those of beam space MUSIC method and the Cramer-Rao lower bound (CRLB). Numerical and experimental results show that good angular superresolution and high estimation accuracy can be achieved provided that the radar pulse repetition time is small enough so that the echoes can be considered sufficiently correlated. For an X band conventional phased array radar with 139 antenna elements, by using PWSM the angular resolution is improved by a factor of 2 when SNR equals 15 dB [J393]

"Time-delay estimation for sinusoidal signals"

The problem of estimating the difference in arrival times of a complex sinusoid received at two spatially separated sensors is considered. Given the sinusoidal frequency, a simple delay estimator using the phase difference of the discrete-time Fourier transforms of the received signals is devised. Using the periodogram, the algorithm is extended to estimate the delay when the frequency is unknown. The minimum achievable delay variances for the cases of known/unknown frequencies and constant/rectangular envelopes are also derived. Extension to time-delay estimation using real sinusoids is also investigated. The effectiveness of the method is demonstrated by comparing it with the performance bounds for different frequencies, envelopes and noise conditions [J394]

"Accuracy of angle estimation with monopulse processing using two beams"

Expressions are provided for the accuracy of monopulse angle estimation using two beams. It is shown that, if the signal angle is halfway between the angles of the beams, the Cramer-Rao lower bound (CRLB) for monopulse processing is almost as small as the CRLB obtained if the entire array of sensors is used. The monopulse CRLB is considerably poorer if the angle of the signal is equal to that of one of the two beams. The expressions in this correspondence are for a uniformly weighted linear array of M equally spaced sensors, for which N⩾M beams are formed [J395]

"Design considerations for adaptive active phased-array 'multifunction' radars"

Adaptive active phased-array radars are seen as the vehicle to address the current requirements for a true 'multifunction' radar system. Their ability to adapt to the environment and schedule their tasks in real time allows them to operate with performance levels well above those that can be achieved from conventional radar designs in addressing the current and future threats. Their ability to make effective use of all the available RF power and to minimise RF losses also makes them a good candidate for future very long range radars. This paper addresses the design of such radars in terms of the system and its component parts and the operational requirements that drive the design. The paper also considers some futures uses outside the military field [J396]

"Multiple moving target feature extraction for airborne HRR radar"

This study considers the clutter suppression and feature extraction of multiple moving targets for airborne high range resolution (HRR) phased array radar. To avoid the range migration problems that occur in the HRR radar data, we divide each HRR profile into nonoverlapping low range resolution segments. No information is lost due to the division and hence no loss of resolution occurs. We show how to use a vector auto-regressive filtering technique to suppress the clutter. Then a relaxation-based parameter estimation algorithm is presented for multiple moving target feature extraction. Numerical results are given to demonstrate the effectiveness of the algorithm [J397]

"Improved Kalman filter design for three-dimensional radar tracking"

The problem of three-dimensional (3D) radar tracking is considered. The usual tracking filter design relying on first-order (or linear) approximations leads to poor convergence and erratic filter behavior in highly nonlinear situations. Simple filter algorithms that can overcome these ill effects are developed for two different types of 3D radar measurement. For each type of radar measurement, an accurate expression for the measurement covariance is obtained by evaluating inherent nonlinearities of radar measurements via coordinate transformation. Then algebraic manipulations and reasonable approximations are employed to yield a simple filter formulation based on the expression. The resulting filter equations are similar to the extended Kalman filter (EKF) and provide some useful insights into the behavior of linearized Kalman filters designed with radar measurements. Finally, simulation results show that the proposed approach is very effective in accounting for the measurement nonlinearities [J398]

"A low-sidelobe partially overlapped constrained feed network for time-delayed subarrays"

Completely overlapped space-fed subarrays have been shown to provide sufficient pattern control to enable (modestly) wide-band arrays using time delays at the input to each subarray and phase shifters at the array face. These configurations are bulky, but have been proposed for space-based use as well as for certain ground-based applications that do not have severe volume constraints. Other applications for space-based and airborne radar require much more compact, constrained array feed networks, but until now there have been few appropriate constrained networks for inserting time delay at the subarray ports without causing high sidelobes. This paper describes one such network that, at the outset, provided far lower sidelobes than the usual contiguous subarrays, but retained closely spaced high lobes near the main beam. This paper presents a synthesis procedure that alters the subarray patterns and reduces nearly all array sidelobes to levels determined by tolerance errors. Several examples are presented that synthesize sidelobes at -40 dB. The resulting network operates over 70% to 80% of the maximum theoretical bandwidth [J399]

"Continuous transverse stub technology"

Military and civil radar and communication systems utilize phased array antennas that require hundreds or, in some cases, thousands of transmit/receive (T/R) modules. T/R modules, even when low cost, drive the total RF system cost to an undesirable level, resulting in fewer systems being purchased, This paper reviews the application of continuous transverse stub (CTS) antenna technology to reduce the number of T/R modules required and, thus, the overall RF system cost, and military and civil applications and their respective cost savings [J400]

"On a simple method of obtaining sidelobe reduction over a wide angular range in one and two dimensions"

A patented technique for suppressing the sidelobes of an array antenna is considered. This technique involves the addition of two elements, one at each end of the array, which together produce an interferometer pattern used for the cancellation of sidelobes. It is shown here that the technique is most effective for uniform illumination and that there then exists an optimum fixed position for the added elements. The amplitude of the excitation of the auxiliary elements determines the angular location of the region of sidelobe reduction while the phase of the excitation tracks the beamsteering phase of the array. Thus, this technique is seen to be easily implemented in an array controlled by coupled oscillators. The technique generalizes in a straightforward manner to two-dimensional (2-D) arrays in which case a set of auxiliary elements on the perimeter of the array is required. A 2-D oscillator controlled array of this type is described here with which one can produce a main beam and a sidelobe suppression region that can be independently positioned anywhere in a hemisphere provided they do not coincide [J401]

"Receiver antenna scan rate requirements needed to implement pulse chasing in a bistatic radar receiver"

Pulse chasing is a technique implemented by a bistatic or multistatic radar system that allows rapid and efficient search of a desired volume of space whereby the receiving antenna is made to follow or “chase” the transmitted pulse as it travels radially outward from the transmitter antenna. An expression for receiver antenna scan rate requirements is derived that corrects an error in the prior literature. The results give significantly reduced scan rates in the forward scatter region near the baseline showing that pulse chasing is more easily implemented using conventional analog beamformer phased array technology than was suggested by prior work [J402]

"STAP covariance matrix structure and its impact on clutter plus jamming suppression solutions"

The structure of the jamming plus clutter covariance matrix is analysed in the context of space-time adaptive processing (STAP) for sideways-looking airborne radar. A bound on the rank of the matrix is derived under the assumption of idealised conditions. It is shown how the rank deficiency of the matrix can be exploited to derive simple, computationally efficient, processing solutions [J403]

"Development of precipitation radar onboard the Tropical Rainfall Measuring Mission (TRMM) satellite"

The precipitation radar (PR) onboard the Tropical Rainfall Measuring Mission (TRMM) satellite is the first spaceborne radar to measure precipitation from space. The PR, operating at 13.8 GHz, is a 128-element active phased array that allows a fast and sophisticated cross-track scanning over a swath width of 215 km with a cross-range spatial resolution of about 4.3 km. The PR has a minimum detectable rain rate of 0.5 mm/h with

range resolution of 250 m. In order to achieve a reliable and accurate rain echo data for three years mission life, functions for internal and external calibrations are implemented. Through a series of PR flight-model tests on the ground and an initial checkout just after the TRMM launch, it is confirmed that the PR functions properly and meets the performance requirements to quantitatively measure three-dimensional (3D) precipitation distribution from space [J404]

"Moving target feature extraction for airborne high-range resolution phased-array radar"

We study the feature extraction of moving targets in the presence of temporally and spatially correlated ground clutter for airborne high-range resolution (HRR) phased-array radar. To avoid the range migration problems that occur in HRR radar data, we first divide the HRR range profiles into low-range resolution (LRR) segments. Since each LRR segment contains a sequence of HRR range bins, no information is lost due to the division, and hence, no loss of resolution occurs. We show how to use a vector auto-regressive (VAR) filtering technique to suppress the ground clutter, Then, a parameter estimation algorithm is proposed for target feature extraction. From the VAR-filtered data, the target Doppler frequency and the spatial signature vectors are first estimated by using a maximum likelihood (ML) method. The target phase history and direction-of-arrival (DOA) (or the array steering vector for an unknown array manifold) are then estimated from the spatial signature vectors by minimizing a weighted least squares (WLS) cost function. The target radar cross section (RCS)-related complex amplitude and range-related frequency of each target scatterer are then extracted from the estimated target phase history by using RELAX, which is a relaxation-based high-resolution feature extraction algorithm. Numerical results are provided to demonstrate the performance of the proposed algorithm [J405]

"High temperature superconducting ferrite phase shifter with new latching structure"

Superconductor ferrite phase shifters are attractive for phased array radar systems. The huge reduction in size and losses mean that smaller systems are possible. This paper reports a new latching structure for a superconducting ferrite phase shifter which is compact in size and has low losses. The total size of the phase shifter is 6.0 cmЧ3.0 cmЧ2.5 cm including housing. It should be pointed out that two phase shifters can be accommodated in this size. The minimum insertion loss of the designed phase shifter was measured at 0.8 dB. The phase shifter is fabricated using a Yttrium Barium Copper Oxide (YBCO) microstrip meander-line on a one centimetre square low loss sapphire substrate. We press contacted a magnetized ferrite substrate, with a silver ground plane, onto the fabricated YBCO meander-line to obtain non-reciprocal phase shifting. To magnetize the ferrite substrate without causing magnetic field penetration into the high temperature superconductor (HTS), we propose a new latching structure comprising a single ferrite layer with magnetizing coils. This new structure will confine the magnetic field within the ferrite substrate by providing a closed magnetic path. This is achieved by making a large hole at center of the ferrite substrate [J406]

"A maximum-likelihood beamspace processor for improved search and track"

The authors describe a two-stage digital beamforming architecture for use in radar. The first stage uses digitized subarray voltages to form a number of highly overlapped adaptive beams. The beams are themselves adaptively weighted during the second stage. Maximum-likelihood processing is used in the second stage to estimate target amplitude and angle of arrival. It is shown that the new architecture supports improved search and track performance compared to traditional systems that use a single receive beam and monopulse processing to measure angle [J407]

"Evaluation of a weather clutter simulation"

The output of a high-fidelity weather clutter simulation, designed to model a low-PRF X-, C-, or S-band phased array radar, is compared with measurements made by three radar systems. The first comparison demonstrates the simulation's ability to replicate real horizon search measurements in terms of various signal properties. The second comparison demonstrates the simulation's ability to generate signals that reflect the vertical dynamic and thermodynamic structure of stratiform precipitation. The third comparison demonstrates the simulation's ability to create weather clutter signals with exotic power spectrum shapes that do exist in nature. In all three cases the simulation output is found to compare well with the real radar measurements. Thus, this simulation is a very good tool for generating realistic weather clutter signals and as such provides a valuable source of data for applications requiring such signals. In addition, this simulation can be used to add controllable weather clutter to existing experimental measurements that may have been affected by weather if it had been present at the time of measurement. This allows the effects of weather clutter to be considered when analysing any experimental data set [J408]

"Adaptive digital beamforming for angle estimation in jamming"

A radar digital beamforming (DBF) architecture and processing algorithm is described for nulling the signal from a mainlobe electronic jammer and multiple sidelobe electronic jammers while maintaining monopulse angle estimation accuracy on the target. The architecture consists of a sidelobe jamming (SLJ) cancelling adaptive array (AA) followed by a mainlobe jamming (MLJ) canceller. A mainlobe maintenance (MLM) technique or constrained adaptation during the sidelobe cancellation process is imposed so that the results of the SLJ cancellation process do not distort the subsequent mainlobe cancellation process. The SLJ signals and the MLJ signals are thus cancelled sequentially in separate processes. This technique was developed for improving radar processing in determining the angular location of a target, and specifically for improving the monopulse technique by maintaining the accuracy of the target echo monopulse ratio in the presence of electronic jamming by adaptive suppression of the jamming signals before forming the monopulse sum and difference beams [J409]

"Ultrawide-band fiber-optic control of a millimeter-wave transmit beamformer"

An ultrawide-band fiber-optic true time-delay millimeter-wave array transmitter is fully characterized and demonstrated in this paper. The beamformer is based on dispersive-prism optical-delay lines and exhibits squint-free ±60° steering in azimuth across the entire Ka-band (26.5-40 GHz). This is believed to be the first fully functioning demonstration of a photonically controlled wide-band millimeter-wave transmitter system [J410]

"Optimal adaptive processing for domain factorised element-digitised array radar"

For large phased array radar, digitisation and adaptive beamforming are usually performed at the subarray level. The number of subarrays is usually much smaller than the number of array elements thus reducing the number of available adaptive degrees of freedom (DOF). For an element digitised array radar (EDAR), a subarray technique can also be employed to reduce the number of adaptive channels in order to reduce the adaptive processing load. However, EDAR allows greater flexibility in the choice of adaptive channels from the array elements, thus allowing alternative DOF reduction techniques to be investigated. An adaptive technique using a convolution approach, namely `range-dependent gain adaptation using domain factorisation' (RDGA-DF), has been shown to give significant advantages over subarray level adaptive beamforming when cancelling strong sidelobe clutter in the airborne environment. A new implementation of the RDGA-DF algorithm is developed to perform adaptive processing on a domain factorised array. This algorithm, called the `full aperture convolution technique' (FACT), is derived directly from the optimal Wiener filter solution. The performance advantages of FACT over RDGA-DF are demonstrated by simulation [J411]

"Design of self-healing arrays using vector-space projections"

We consider the problem of reconfiguring array antennas whose performance has been degraded by the failure of one or more elements. We show that the method of vector-space projections is well suited for this task and enables the recovery of reasonable antenna performance when as many as 30% of the elements are inoperable [J412]

"Transmit patterns for active linear arrays with peak amplitude and radiated voltage distribution constraints"

Distribution functions used in array antenna design typically synthesize specified pattern characteristics without consideration for either the peak amplitude of the radiating elements or the aperture radiated power. There do exist applications, however, in which the pattern synthesis must employ such constraints. In the transmit mode of active array antennas, for example, it is desirable to radiate as much power as possible subject to a per-element peak amplitude constraint while simultaneously suppressing the outer sidelobes. This paper discusses the design considerations of the constrained least squares (CLS) distribution function. In the CLS distribution, most of the radiating elements near the array center are set to their maximum value while only a few of the outer elements are tapered. A method for generating CLS distributions given constraints on both the peak element amplitude and the total effective radiated voltage (ERV) is discussed. The design involves specifying the desired ERV and a weighting function that allows selectively suppressing sidelobes in specified regions. The effects of these design parameters on the far-field patterns are explored [J413]

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