# Adaptive and Nonparametric Methods of Signal Detection Against the Background of Non-Gaussian Clutter from Underlying Surface

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*Abstract* — **The method for the operating characteristics of the radio systems estimation based on using of model of non Gaussian clutter from underlying surface (sea, land plots) is proposed. This method was done by nested semi-Markov based processes. The characteristics of parametric (Neumann–Pearson, adaptive control of threshold and filter band of moving-target indication) and non-parametric (sign and linear rank) detectors are analyzed theoretically and are compared to results of the experimental investigations.**

## I. Introduction

In earlier papers are devoted to detection systems analysis the problem was solving under the assumption of Gaussian statistic of background scattering from sea and ground. Such assumption is based for the systems that have low resolution for example the CW radars and pulse radars as well when resolution volume is rather large as compared with discontinuities size on underlying surface.

Later it has bin shown experimentally [1, 2], that for the systems having high resolution on distance and azimuth the noise statistic differs from Gaussian one. The real noise for radar that creates the scattering from sea, vegetated ground areas and atmospheric precipitations has heterogeneous spatio-temporal properties is in the general case transient non Gaussian clutter [3,4].

In this connection the models development of nonstationary non Gaussian noise is creating for radiotechnical systems by scattering from underlying surfaces (sea, ground) are in considerable interest. The models are taking into account spectral – polarization and spatial structure of the scattered signal and on the base of them development of methods of system performance analysis.

## II. Parameters Calculation of Signal Acquisition Against the Background of Nonstationary non Gaussian Clutter from Underlying Surface

In papers [4, 5] have been proposed to use confounded semi- Markov process for definition of passive noise of backscattering from ground and sea for radars having high resolution.

Statistical description of scattered signal [6] is based on using of confounded two components random processes $\{\lambda(t), \theta(t)\}$ which has one component $\{\lambda(t)\}$ – continuous, and other $\{\theta(t)\} = \nu_i$- discrete ($t$ - generalized time) [30,31]. These components usually are dependent and non Markov [7]. In each point of time the process could be in one of $k$ possible phase states $H_i \in \nu_1 \ldots \nu_k$ , at that the initial state is supposed as known $\theta_0 = \nu_i$ in a time $t_0$ and one step transition probabilities $\pi_{ij}$; $i,j=\overline{1,k}$ .

To random variable $T_{ij}$ with density of distribution $f_{ij}=(t)$, wich we will call the latency period in state $\nu_i$ till transition to $\nu_j$ each nonzero element $\pi_{ij}$ of transition-probability matrix is compared. Inside of each $\nu_i$ state the process we believe the quasi-stationary and having density of distribution of values $P_i(\lambda)$ and spectrum $S_i(\omega)$. This model allows taking into account special anisotropy and time nonstationarity of the signal is scattered from ground and atmospheric precipitations and could be used for working parameters analysis of detection system. For the short-range radar systems a little observation period of the radar resolution cell is typical. Notably if statistic shaping time is used for decision-making of detecting system is essentially fewer than scale of inhomogeneity characteristic spatial – time on underlying surface (land, sea) or in the atmosphere. For sea surface inhomogeneities are determined of sea wave period and for the land of characteristic dimension of lots that have identical covering.

The signal detection comes at that against the background of noise that is in one of the fixed state $H_i$. Whereas the phase states set is the complete event group we could set down the expression that determines the working parameters of the detecting system linking them to probabilities of correct acquisition $D_i$ and false alarm $F_i$ for each of $i$ noise phase state are realized by this system:

$$D = \overrightarrow{D}\ \overrightarrow{P^*(H_i)} = \sum_{i=1}^{k} D_i P(H_i);$$
$$F = \overrightarrow{F}\ \overrightarrow{P^*(H_i)} = \sum_{i=1}^{k} F_i P(H_i), \tag{1}$$

where $P(H_i) = P_i$ - final probabilities of noise existence in $i$ phase state.