- *Prof. Konstantin Lukin*

- **Workshop :**

Introduction to Noise Radar Technology

(Emerging Radar Technology to Design of LPI Radar Systems for Environment Imaging and Surveillance with High Anti-Jamming and Covert Operation Performance)

Numerous civilian and military operations require from radar systems very often such performance as: High Electromagnetic Compatibility (EMC); Low Probability of Intercept (LPI); Low Probability of Exploitation (LPE); Low Probability of Detection (LPD) of operating radar systems (radar covert operation), and have the best anti-jam characteristics.

Traditional radar systems use conventional *deterministic/regular waveforms.* However deterministic waveforms, *such as impulse/short-pulse and linear/stepped frequency modulated*, do NOT possess above desirable features. That is why radar engineers have to apply **Noise, or Random, or Chaotic/Stochastic** waveforms to get the above radar performances.

Recent decades in the Laboratory for Nonlinear Dynamics of Electronic Systems (LNDES) a new approach to design of Radar has been suggested, namely: NOISE RADAR TECHNOLOGY (**NRT**) which is a radar technology that uses *noise/random/chaotic* continuous or pulsed waveforms as a radar signals and *coherent processing* of radar returns for their optimal reception (matched filtration), i.e. *correlation reception* or *spectral interferometry* method (*similar to Stepped Frequency technique).*

Noise radar is an emerging radar technology that provides the new capabilities in the area of radar sensor and radar imaging design. Its main features are Low Probability of Interception (LPI), low radiating power, very good electromagnetic compatibility with other devices when sharing electromagnetic spectrum.

In the Workshop we briefly describe NRT fundamentals, discuss advantages and main challenges of NRT in design of short range radar sensors, imaging systems and long range surveillance radar. We also present experimental results of such radars to demonstrate their real capabilities. We will discuss in more detail indoor and outdoor SAR imaging with Ground Noise Waveform SAR. Finally, a novel **Radiometric** SAR concept will be described and experiments on coherent radiometric imaging in azimuth-range plain will be presented as well.

The main **attractive advantages of Noise Radar** are as follows:

- Noise/Random/Chaotic waveform enables providing of the following important properties:
- *No side lobes in Ambiguity Function*: It has just *residual fluctuations*, which may be averaged out, for high enough values of time bandwidth product.
- *No range ambiguity for both CW and Pulse Radar*.

Besides in Noise Radar is performed:
Optimal coherent reception of noise radar returns; *High compression rate* of the received signals; and *Independent control of velocity and range* when jointly measuring both Target Range and its Doppler frequency shift.

In addition, NOISE RADAR TECHNOLOGY has an attractive potentiality for design of radar systems having the best performance for civil and military applications, such as:

- Low Probability of Interception (**LPI**) and Low Probability of Exploitation (**LPE**)
- *High resistance against EM jamming* & interference
- Electromagnetic Compatibility (**EMC**): simultaneous operation of many similar Radars within the same area

While it is difficult to detect, the Noise Radar is less vulnerable for jamming and while the transmitting waveforms are random in nature it is much more difficult to provide active intelligence countermeasures against it. Highly desirable properties of radar sensor include its covert operation, unambiguous range- and Doppler-estimation, angular and range tracking, target imaging and classification. Noise Waveform being applied in such systems has the capability to meet these requirements, and in addition, is expected to behave very favorably against electronic countermeasures. In contrast with conventional radar, the EMC requirements of modern sensors can be met easier with noise radar. Noise Radar enables essential enhancements of sensor performance. With the latter we may associate the following: Better performance in LPI and Immunity against interferences and/or jamming; Better electromagnetic compatibility performance between different units and different type radar sensors through better interference immunity; No range ambiguity even for pulse noise radar; Spectrum sharing problem may be easier solved using correlation properties of NW with wide enough power spectrum bandwidth

Nowadays available FPGA technology enables both generation and real-time processing of noise radar returns, which also briefly presented in the Workshop.