Information about a group interested in cooperation with industry
Poland Chapter of IEEE Signal Processing Society (max. two pages)

Name of research group	Research Lab on Radar Technology (RLRT)
Address	Warsaw University of Technology (WUT), Institute of Electronic Systems, Nowowiejska 15/19, 00-665 Warsaw, Poland
Contact person e-mail, tel.	professor Krzysztof Kulpa, kkulpa@elka.pw.edu.pl
Web address	http://ztr.ise.pw.edu.pl/?lang=en
Areas of research, projects, implementation works	radar and digital signal processing and radar technology, especially target detection, parameter estimation, target tracking and radar imaging, SAR and PCL technologies, nonuniform sampling problems, MTI filtering and filter design, Compressed Sensing in radar, as well as programmable logic applications and real-time programming.
Short information about research group – max. 250 words	RLRT, employing almost 20 post-doc researchers, PhD students and staff members, are active in the field of modern radar research, especially synthetic aperture radar (SAR), passive radar (PCL-passive coherent locator) and noise radar. RLRT has succeeded in constructing numerous SAR radars, including the first Polish airborne SAR radar and a few operational demonstrators intended for lightweight carriers and UAVs. Obtained resolution of the SAR images reaches 15 centimeters which places the Group among the world leading entities. The main field of expertise of the RLRT Group members exploited in these constructions were signal processing algorithms, both for pre-processing, image formation and focusing, also implemented for real-time operations. Other relevant experience of the Group encompasses construction of passive radar demonstrators that have proven feasibility of this technology for various tasks from airspace surveillance and airplane tracking (FM radio, DVB-T) to passive assessment or road traffic intensity (GSM). In 2006, the Passive Radar Demonstrator (PaRaDe), working with FM illuminators, was constructed with real-time capabilities and the air-target detection range of 120 km (from the radar). In 2008, the system was successfully tested on the airborne platform. The subsequent works increased the detection range to more than 300 km (from the radar), and added the capabilities of processing DVB-T and GSM signals with the multi-site synchronous receivers. The RLRT Group members also take part in R&D projects in cooperation with the Polish national defense industry (i.e. PIT-RADWAR). The other outstanding achievement of the RLRT Group was passive SAR imaging of ground surface using a non-cooperative SAR radar as an illuminator of opportunity. Successful trials have been with ENVISAT-1 and TerrSAR-X radars as the illuminators of opportunity, as well with the DVB-T transmitters of opportunity. LRRT possesses one of the most experienced academic radar research laboratory in Europe specialized in the radar simulation, radar prototyping and radar demonstrator development.
Key staff (name, degree, position) – max. 5	Professor Krzysztof Kulpa – head of the Research Lab on Radar Technology (RLRT) and Research Group on Radar Signal Processing ; Associate Professors: Dr. Jacek Misiurewicz – head of the Research Group on Radar Resource Optimization and Radar Data Fusion, Dr. Mateusz Malanowski – head of the Research Group on Passive Radars, Dr. Piotr Samczynski – head of the Research Group on Radar Imaging Techniques; Dr. Łukasz Maślikowski

R&D infrastructure	The RLTR's lab – operating since 2000, one of the most experienced university laboratories working on modern radar technology worldwide – is prepared to carry out both theoretical and experimental work. Its equipment includes multichannel RF signal receivers, single- and multichannel arbitrary vector generators and transceivers, handheld vector network analyzer, connectorized components such as filters, mixers and amplifiers and different kinds of antennas that allow field radar experiments. The basic equipment operates up to 6 GHz of carrier frequency but can be extended easily to X band and even above. It allows high-speed data streaming as well as multisite synchronization using GPS receivers. By skillful combination and configuration of these devices one can efficiently build a demonstrator for most modern radar concepts, delivering real measurement data for further signal processing. Powerful computing platforms including multi-core processors, graphic cards and FPGA boards allow implementation of fast processing algorithms working on large data streams. Thanks to a simulator developed in the laboratory, they also offer the possibility of advanced radar scene simulation, including a computation of the SAR signal for large-scale scene. The Digital Signal Processing Laboratory is equipped with state-of-the-art multicore PC computers with NVIDIA graphic cards that can be used to boost up the computations. The computers have the Matlab software installed, that will be used as computational environment. One of the most unique features of the RLRT's lab is the Raw Radar Signal Simulator (RRSS) - a software tool that can simulate the raw radar signals for the very complex scenes. The 3D scene is populated with 3D objects from CAD tools (e.g. Google SketchUp or AutoCad). Each part of the object (a facet) can have a different set of the electromagnetic properties (like a reflection angle, shadowing, transparency etc.) as well as its own motion's characteristics. The radar consists of one (or several) transmitting antennas and one (or several) receiving antennas. Each of them can have its own properties (a gain, illumination pattern, motion, rotation etc.) assigned. The RRSS enables to carry out simulations of the pulse radars or continues wave ones. Up to now this simulator was used for simulating ATYC radars, SAR radars (with the scene 10x10 km, resolution 10x10cm, S, X and W bands), ground base passive multistatic radars and airborne passive radars. Another recent addition to the lab's equipment is a sub-terahertz measurement station consisting of a stable optical table with motorized positioners and terahertz measurement modules for transmit and receive. The motorized positioners allow for target rotation and translation along the X-Y plane of the scene. The system operates in three distinct bands: 75-110 GHz, 220-325GHz and325-500 GHz with respectively two transmitters and three receivers for the 75-110GHz system, two receivers and one transmitter for the 220-325 GHz system and a single receiver and single transmitter for the 325-500 GHz system. This allows for cutting edge research on radars in the still underexplored band of mm-wave and sub Terahertz frequencies. Additionally such setup can be used for conducting downscaled experiments equivalent to the radar measurements in conventionally used lower frequency regions, such as FM radio, DVB-T digital broadcasts and others. This may allow for advanced experiments using complex moving targets (highly detailed scaled-down models of the real life targets) in the controlled laboratory environment using real-life data, prior to more involved measurements in the field. The terahertz system is capable of conducting both monostatic and multistatic experiments. The measurement signals are recorded by an NI PXIe-5122 baseband digitizer and stored on a high speed HDD RAID matrix. The signal paths are complemented with custom-designed analogue intermediary blocks performing signal up- and down-conversion, signal splitting and other specialized tasks. These blocks are implemented using COTS connectorized modules.
Experience (research, projects, implementations)	Projects: - Multichannel Passive ISAR Imaging for Military Applications (MAPIS) – in collaboration, EDA-financed project focused on the passive imaging technique of flying objects using passive coherent radars. The final goal was to work out ISAR

	passive imaging techniques to obtained detailed images of flying and surface objects, like vessels, using ground based passive radars. - Multitech Security System for Interconnected Space Control Ground Stations (SCOUT) – in collaboration, EU FP-7 Grant focused on the detection of different targets using various sensors as e.g. noise radar and passive radar technology for protection of an important infrastructures.
Cooperation	Together with Pit-Radwar S.A, the Polish radar company, the RLRT Group conducts research and implementation works on different active and passive radars, including ATC radars, military-, airborne-, multifunction-, SAR, ISAR, and passive bistatic radars. Selected projects: - Development of a Medium-range Multifunction Prototype Radar with 2D Phase Scanned Beam, for a Surface-to-air Missile System (WISŁA), - Development of Passive Radar System for Air Defense Missile Systems (PCL-PET), - Development of a Prototype of Multi-function Fire Control Radar with Phased Array Antenna for Air Defence Missile System (NAREW). RLRT has been in a long-standing cooperation with several leading research centers in Europe. It also cooperates with the European Defense Agency - EDA (e.g. DAFNE, SARINA and SARAPE projects) and NATO Science and Technology Organization.
The greatest achievements in recent five years (projects, implementations, patents, key publications - max. 10, no. of PhD degrees awarded)	Awards: – the Polish Ministry of Defence (under the auspices of President of the Republic of Poland)'s 3rd prize for the best research and development in the area of defence for ISAR/HiSAR Project *Design and Implementation of Software and Hardware Module for AIS, HiSAR, ISAR, and ECCM Modes in A Multifunction Radar for A Maritime Patrol Airplan*e, 2014, Poland Several patents granted by the Patent Office of the Republic of Poland: – *Method for Calibrating the Circular Array Antenna And a System for Applying the Method,* K. Kulpa *et al.*, Patent no. 222025, issued: 19-08-2015 – *Method of Cancelation Ground Clutter Being Beyond Radar Instrumental Range And Its Hardware Implementation,* K. Kulpa *et al.*, Patent no. PAT.221859, issued: 15-10-2015 – *Method For Signal Synthesis And Analyses For Pulse Radar And Its Implementation,* K. Kulpa *et al.*, Patent no. PAT.221459, Date of the decision: 15-10-2015 – *Circuit For Radar Signal Synchronization, Especially For Pulse Radar,* K. Kulpa *et al.*, P.403218, issued: 13-11-2015 – *The Process of Obtaining the Signals To Determine the Ambiguity Function In Passive Radar And Circuit For Method Implementation*, Kulpa K. *et al.*, P.400194, issued 20-05-2016 – *Receiving Circuit for Passive Radar,* Kulpa K. *et al.*, P.401208, issued: 25-05-2016 Key publications 1. B. Dawidowicz, P. Samczynski, M. Malanowski, J. Misiurewicz, K. Kulpa, "Detection of moving targets with multichannel airborne passive radar", *Aerospace and Electronic Systems Magazine, IEEE*, vol.27, no.11, pp.42-49, November 2012 2. B. Dawidowicz, K. Kulpa, M. Malanowski, J. Misiurewicz, P. Samczynski, M. Smolarczyk, "DPCA Detection of Moving Targets in Airborne Passive Radar", *Aerospace and Electronic Systems, IEEE Transactions on* , vol.48, no.2, pp.1347-1357, April 2012 3. K. Kulpa, M. Malanowski, P. Samczyński, J. Misiurewicz, B. Dawidowicz, "Passive Radar for Airborne Platform Protection", in: *International Journal of Microwave and Wireless Technologies*, Vol. 4, Special Issue 02, April 2012, Cambridge University Press, UK, pp. 137-145 4. D. Gromek, K. Kulpa, P. Samczyński, "Experimental Results of Passive SAR Imaging Using DVB-T Illuminators of Opportunity," in IEEE Geoscience and Remote Sensing Letters, vol. 13, no. 8, pp. 1124-1128, Aug. 2016

	5. D. Gromek, P. Samczyński, M. Wielgo, M. Malanowski K. Kulpa, “Design and validation tests for compact FMCW C-band Analog-Front-End for radar imaging applications”, International Journal of Microwave and Wireless Technologies, Cambridge University Press, 10 pages, published online: 15 June 2016 6. D. Gromek, P. J. Samczyński, K. Kulpa, P. Krysik, and M. Malanowski, “Initial Results of Passive SAR Imaging Using a DVB-T Based Airborne Radar Receiver,” in Proceedings of the European Radar Conference, EuRAD 2014, 2014, 7. D. Gromek, P. Krysik, K. Kulpa, P. J. Samczyński, M. P. Malanowski, „Ground-based Mobile Passive Imagery Based on a DVB-T Signal of Opportunity” in Proceedings of the 2014 International Radar Conference, Radar 2014 8. D. Gromek, P. J. Samczyński, K. Kulpa, J. Misiurewicz, and A. Gromek, “Analysis of Range Migration and Doppler History for an Airborne Passive Bistatic SAR Radar,” in IRS 2014 International Radar Symposium, 2014, 9. K. Kulpa, P. J. Samczyński, M. P. Malanowski, A. Gromek, D. Gromek, W. Gwarek, B. W. Salski, and G. Tański, “An Advanced SAR Simulator of Three-Dimensional Structures Combining Geometrical Optics and Full-Wave Electromagnetic Methods,” IEEE Transactions on Geoscience and Remote Sensing, vol. 52, no. 1, 2014. 10. Bączyk M. K., Misiurewicz J., Gromek D., Kulpa K.: Analysis of Recorded Helicopter Echo in a Passive Bistatic Radar, w: European Radar Conference (EuRAD), 2013, ss. 243-246 11. Samczyński P. J., Kulpa K., Bączyk M. K., Gromek D.: SAR/ISAR Imaging In Passive Radars, in 2016 IEEE Radar Conference (RadarConf), Proceedings, ISBN 978-1-5090-0862-9