Potential of Polish R&D industry in the context of prototyping, design, development and control of a dedicated national satellite SAR system for marine ecosystem monitoring

Technical paper - preliminary study

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Space technology is currently one of the most important elements in the advance of information societies and knowledge-based economies all over the world. The European Space Agency (ESA) is in the focal point of European space activities, while the European Union provides strong financial support for the development of space technologies and applications in its flagship programs. In a domestic scope, the Polish Space Agency (POLSA) is a national aeronautics entity responsible for activities related to development of technologies of the national space sector. Recently, one of the activities which POLSA aims to establish, is the programme of building a system of satellite SAR observations dedicated for Polish users; such as administration, civilian services, and Polish scientific and research entities, that would expand potential use of satellite technologies among numerous Polish beneficiaries. In the context mentioned above, the paper describes the architecture and functional components of an exemplary satellite SAR system, along with the potential of Polish entities to develop such technology.

Keywords: SAR, satellite, system, observations, maritime

1. Introduction

In the past decades, space technology has become the driving force behind the advance of information societies and knowledge-based economies all over the world. This progress has led to the appearance of new scientific disciplines and professions, and causes new areas of industry to be developed, and interdisciplinary projects to be undertaken. In this environment, the European Space Agency is in the focal point of these activities, while the European Union

provides strong financial support for the development of space technologies and applications in its two flagship programs COPERNICUS and GALILEO; and also in HORIZON 2020.

The Polish Space Agency (POLSA) is a national aeronautics entity, founded in 2015, responsible for activities related to technological development of the domestic space sector. The main duties and responsibilities of POLSA cover such issues as: formulating Polish space sector development strategy, formulating the domestic national space programme, and cooperation with technological, industrial, R&D and scientific entities in the above-mentioned context. Recently, one of the programmes POLSA aims to establish, is that of building the system of satellite synthetic aperture radar (SAR) observation dedicated for Polish users such as administration, civilian services, and Polish scientific and research entities.

However, the development of such a system consists of several steps that must be undertaken in order to specify potential user needs; material and non-material benefits incoming from the project, technical requirements, cost and scheduling estimation and, finally, implementation of the system. Another important issue to consider in this context is recognition of the capabilities of domestic industry that can be utilized during this kind of project. In this context, the paper describes basic assumptions of the project, a brief description and preliminary analysis of functional components of the satellite SAR system, and technological potential of Polish entities to develop the system.

2. Satellite SAR systems

The satellite Synthetic Aperture Radar (SAR) imaging systems have known advantages, which are related both to their satellite-basement (very regular imaging repeatability, stable geometry of the acquisition process, and effectively lower cost in comparison with airborne systems), as well as to utilising the radar operating band – from a wavelength of several millimetres to a meter. The latter benefits, in the possibility of imaging objects and structures which are not visible in other bands, and the independence of a survey from the cloud cover or a lack of illumination, which allows for data acquisition both during day and night time under all weather conditions. What is more, utilising the concept of the synthesised antenna allows for significant improvement of along track spatial resolution in comparison with the traditional antenna case. In the Earth observation and remote sensing, the satellite SAR systems have numerous applications [1][2] like topographic mapping, geological applications including monitoring land-surface for motion risks, land use and water monitoring, agricultural classification and assessment, military applications like intelligence gathering, battlefield reconnaissance or weapons guidance, oil spill monitoring, sea ice monitoring, ship detection for maritime security, and mapping to support humanitarian aid and crisis situations.

The overall diagram of an exemplary satellite SAR system, showing the components which would have to be constructed or created, and also the main activities which would have to be done to allow the system operability, is presented in Fig. 1. The system contains:

1) the space segment, which is composed of a single, or alternatively, multiple, satellite platform; all SAR satellite components and subsystems needed to provide its orbital operability are indicated in the diagram;

2) the ground segment responsible for the mission planning and control, as well as the relevant processing and dissemination of the acquired data; its main functions and objectives are also presented in the diagram.

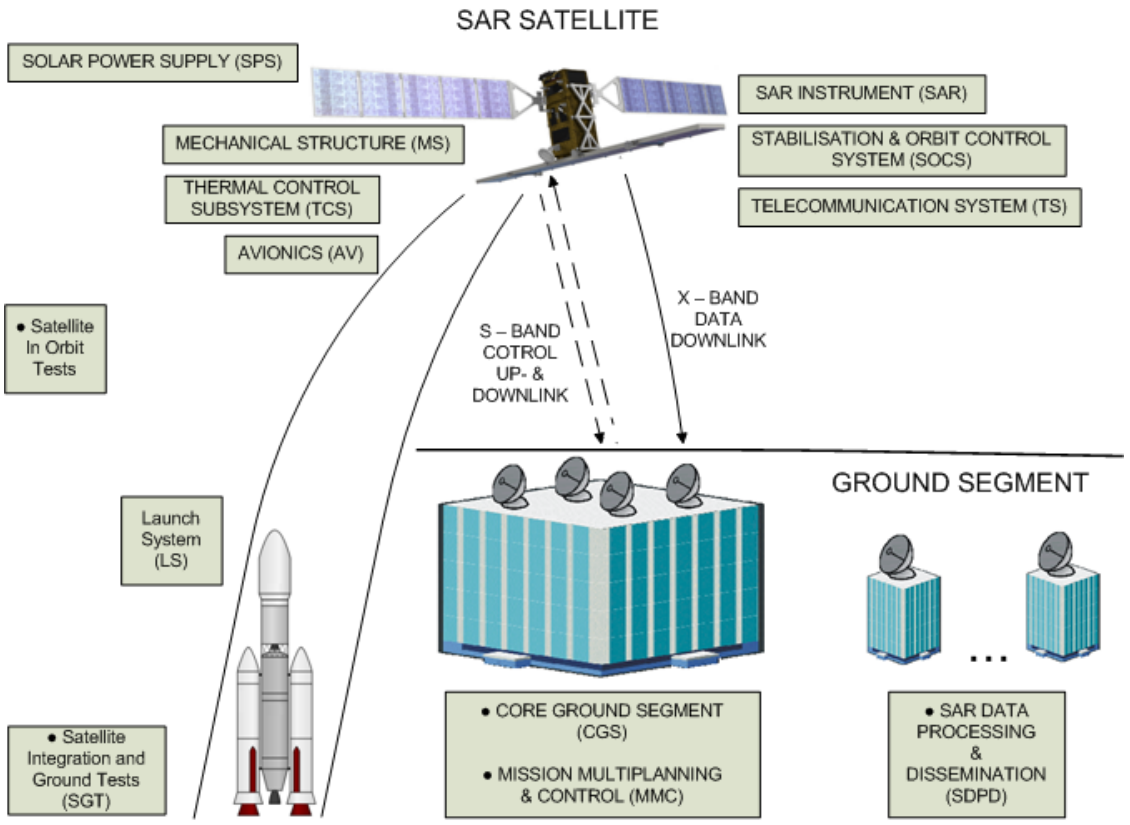

Fig. 1. The SAR satellite imaging system overview.

The key activities, like satellite launching as well their ground and in-orbit tests, are also enclosed in the diagram. The abbreviations of the elements used in Fig. 1 are consistent with the contents of the Table 1 in the section III presenting the potential Polish domestic R&D and industry entities which may participate in the design, construction and implementation of the satellite SAR observation system.

The satellite components are as follows [3]. The mechanical structure subsystem (MS) provides the construction framework for mounting all other satellite subsystems, as well as the interface between the satellite and the launch vehicle. The solar power supply subsystem (SPS) is responsible for collecting the solar energy, transforming it to electrical power using arrays of solar cells, and distributing electrical power to other components of the satellite. The thermal control subsystem (TCS) purpose is maintaining all the satellite platform elements strictly within its operating temperature limits, which depend on the particular type of equipment. The stabilisation and orbit control system (SOCS) consists of several systems (telemetry, tracking, orbit control, propulsion) and is responsible for monitoring and control of the satellite's position, orbit, orientation etc. as well as monitoring the health of various subsystems of the satellite and executing remote control commands to change the platform functions, configuration, and also position, velocity etc. The avionics (AV) is the subsystem containing all on-board electronics allowing satellite fight control, including on-board computers hardware and software. The telecommunication system (TS) contains antennas used for both receiving signals from ground stations as well as for transmitting the information towards them. Typically, in the case of remote sensing satellites, this system is composed of the data downlink responsible for transmitting the acquired images to a ground station (usually operating in X band) and the up- and downlink responsible for exchanging between the satellite and the Earth the monitoring and control information (usually this link operates in S band). In addition, a satellite telecommunication system may be capable of communicating with the Earth indirectly, via the telecommunication geostationary satellites.

And finally, the SAR instrument (SAR) is the main payload of the SAR imaging satellite, and allows for acquiring and pre-processing of SAR images of the Earth using radar electromagnetic band. It consists of several components, including the SAR antenna (usually operating in C band) and the SAR electronics hardware and software responsible for signal demodulation, A/D conversion, digital signal processing including on-board SAR image synthesis, data compression, framing and temporal on-board storage.

After assembling and integration of all the satellite platform elements, a set of ground tests (SGT) must be carried out for verification of the performance of the particular components. After launching to an orbit by launch system (LS), again the in-orbit tests, as well as the calibration of several components is needed.

The satellite SAR system ground segment tasks are as follows. The core ground segment (CGS) is responsible for direct monitoring and control of the satellite flight and for monitoring of the satellite subsystems health and performance. The mission multiplanning segment (MMC) is responsible for performing conflict-free mission planning with respect to several users' needs and orders, according to pre-defined operational scenarios. Also, it ensures the quality of the data products and the performance of the space-borne SAR sensors by continuous monitoring, calibration and validation. SAR data processing and dissemination segment (SDPD) may consist of several, regional, departmental and trade satellite operation centres, responsible for mission planning and execution as well as for specialised data processing and dissemination in concordance with the particular needs of different types of users.

3. Potential of Polish industry entities

Since 2015, POLSA activities have been focused on animating and integrating the cooperation between Polish entities that have expertise in technologies related to the space sector. The Agency was the organizer or co-organizer of several space events such as the IRMAST conference held in Gdańsk, Poland, in April 2015, or the information day for the space sector held in Warsaw in September 2015. POLSA also aims to establish national sector programmes that would expand both the competitiveness and technological know-how of the national space sector, and also its ability to form consortiums and products that could compete in the European market.

As for 2016, it is worth to notice that the Polish industrial sector does not have the capabilities to independently build technological solutions for SAR observation systems. However, since the opening of the entrance to ESA structures, a significant growth of Polish companies' contributions to ESA projects has been observed. As the result of the described strategy, POLSA created a preliminary register of entities that have expertise in particular sub-domains of space, and in particular in satellite SAR technologies, or have knowledge and possibilities to develop appropriate technological solutions in the coming years. At this point it worth observing that the identification of industry potential for the space sector is not a trivial task. The elements of the potential are not only the factors that can be objectively measured, like the staff, equipment, facilities etc., but also the environment in which, and for which it functions, and what is more important, the knowledge and experience.

Therefore, Table 1 shows a preliminary register of the selected R&D entities that may participate in creating a satellite SAR observation system. As it is presented, the process of creating such a system is divided into several sub-domains. Besides the domains related directly to the construction of particular satellite components or subsystems, the table also contains two additional activities regarding:

1) project management and product assurance (MPA),
2) technical specification and design (TSD) with respect to all system components.

It can be observed that the potential of Polish industry is significant in many areas, but only a small number of the mentioned institutions are capable of creating products on a sufficient technology readiness level to be competitive to European companies. Also, there is a need of direct close cooperation on many levels in order to enhance knowledge, state-of-the-art and experience that could be utilized in the next decades so that the Polish industrial sector could acquire knowledge essential for building independent satellite EO systems.

Tab. 1. Register of Polish entities' expertise and capabilities related to SAR satellite development. Entities marked with * are companies owned by European corporations (GMV, EADS, Thales Group) and are probably capable of developing required solutions.

Entity name	**Technological domain**													
	MPA	***TSD***	***MS***	***TCS***	***SPS***	***AV***	***TS***	***SOCS***	***SAR***	***SGT***	***LS***	***CGS***	***MMC***	***SDPD***
Astronika			x	x										
PIAP			x	x						x		x		
Sener		X	x	x				x		x				
Spacive			x	x										
Centrum Badań Kosmicznych	x		x	x	x			x						
Śląskie Centrum Naukowo-Technologiczne Przemysłu Lotniczego			x	x										
Hertz Systems							x							
Instytut Łączności							x							
Politechnika Warszawska	x													
Wojskowa Akademia Techniczna	x			x		x	x		x	x		x		x
Polska Grupa Zbrojeniowa							x					x	x	
Creotech Instruments					x	x		x						x
GMV Innovating Solutions								x						x
Instytut Lotnictwa											x			
ILM											x			
Space Forest											x			
Domar					x									
Astri Polska						x								
Asseco										x				x
Mobica										x				x
N7 Mobile										x				x
SIRC									x					
Politechnika Wrocławska	x						x		x		x			
Politechnika Gdańska	x								x					x
Akademia Górniczo-Hutnicza	x								x					
PIT-Radwar									x					
Instytut Geodezji i Kartografii														x
Państwowy Instytut Geologiczny														x
Evatronix														x
Thales Alenia Space Polska *	x	X	x	x	x	x	x	x	x	x	x	x	x	x
PZL Okęcie - EADS *	x	X	x	x	x	x	x	x	x	x	x	x	x	x
WASAT														x
PIKTIME SYSTEMS						x							x	x
Polski Holding Obronny										x		x		
RadiotTechnika Markeiting					x					x				
Robotic Inventions						x								

At this point it is worth pointing out that this potential can be significantly improved by: adjusting the strategy of domestic space sector development to European policy, i.e. by stimulating the exploitation of space data, and the development of innovative applications

enabling European competitiveness in space, focusing on industrial R&I, emphasizing SMEs; enabling advances in space technologies, ranging from basic technology research to close-to-application technologies for future generations of Copernicus/GMES and Galileo satellites; and, enabling the European R&D cooperation in the context of international space partnerships (e.g. ISS, SSA, global robotic exploration programmes) [4].

Satellite SAR systems enable various applications related to marine and coastal zone area monitoring. One of the most applicable scenarios is ship detection [5] that can be complementary to already operating systems including ARPA [6], AIS [7] and others. However, for many other surveillance applications, such as oil pollution or marine infrastructure monitoring, frequent data acquisition and near–real-time data delivery are of big importance. Many of these applications are very sensitive to external conditions, and therefore during the design phase, much attention must be paid in order to provide a number of data pre-processing tools.

4. Conclusions

In the paper, the preliminary results of investigating the potential of Polish industry in the context of building a dedicated satellite SAR observation system for national needs is presented. The main goal of POLSA activities is to create the appropriate environment to develop a strong, competitive and diversified industrial base improving both employment and know-how of the sector. The authors of the paper propose a technological roadmap for building the system, divided into sub-domains. In this context, analysis of potential capabilities of Polish entities that cooperate with ESA or POLSA is outlined together with technological expertise. Future steps will rely on formulating the general strategy of the programme that will include not only technical aspects, but also the economic, organizational and functional aspects of the satellite SAR EO system, and thus enhance the competitiveness of the Polish space sector among European industry.

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