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ASPECTS REGARDING THE USE OF PASSIVE SENSORS ON AIR SURVEILLANCE MISSIONS

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Passive remote sensing is used to obtain information on objects and phenomena at land surface in order to get their well-defined objective image by means of special and temporal coordinates. Observing land surface represents an on-going activity for the scientific community which is directed towards the understanding of processes and phenomena on our planet as well as towards the monitoring of the impact of natural or human activity on the environment. Passive sensors have technical parameters that help them detect the phenomena and changes on land surface, ensuring the necessary data for the mapping and monitoring of biophysical and geological characteristics of the surface in order to understand the impact of human activity on ecosystems.

The military use of passive sensors is to create detailed maps of areas under surveillance, including the urban ones, to detect early threats, and to ensure the information support for the planning process as well as for the coordination and execution of precise strikes on objectives.

Keywords: remote sensing; passive sensors; air surveillance; surveillance.

Human history has been marked by the use of armed forces as efficient means to solve disputes among conflicting states. Even if the war is a social phenomenon with disastrous impact on belligerent states and peoples, the humanity has not renounced it when solving disputes. Understanding war as a social phenomenon is based on different research criteria which underline its essential characteristics, pinpointing it among other social phenomena. The evolution of war has been marked by the capacity of decision-makers to understand the impact of military resources and means on the conduct of military actions at a certain moment.

The conflicts of the last decades have demonstrated the role of the air component on meeting the objectives of the war, forcing relevant military powers to develop their air forces according to the new operational demands. Accomplishing this involves a constant effort and use of resources to identify and implement new technologies in order to obtain the superiority over the enemy.

In this respect, air forces will be supplied with sophisticated weapons, with high disruptive potential, with great impact on conducting violent armed activities[1].

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At the same time, the evolution of information and communications technology fosters the integrated and unitary use of air forces to accomplish specific missions. The integration of arms systems is possible through the command and control system which provides the necessary information so that the air forces will exercise their influence in the designated space of interest.

Obtaining the information needed to accomplish the air force specific missions involves creating a network of sensors, which includes sensors placed on space, air, ground, and maritime platforms. The information obtained after processing the data furnished by sensors will contribute to building the real image of the area of interest, thus ensuring the rapid identification of objectives and the efficiency of the decision-making process.

The history of military art has demonstrated that war is ”the realm of uncertainty; three quarters of the factors on which action is based are wrapped in a fog of greater or lesser uncertainty”[2]. The uncertainty on the battlefield amplifies the potential of actors involved in the conflict to undertake asymmetrical actions. This potential will increase the possibility of surprise by the actors involved in the conflict, while diminishing this risk which is dependent upon the capacity of surveillance and collection of data from the area of interest. The information obtained will ensure the optimal decision-making processes and coherent actions against the enemy. Obtaining control over the information will lead to decreased uncertainty of the battlefield, contributing to early warning of organic forces when threats occur.

The early discovery of threats to the air environment and the provision of the necessary information to identify and neutralize are the reason why states created and developed systems which are capable to prevent organic forces from being surprized by the enemy.

In this respect, networks of sensors have been created, spread on large geographical areas so that they will enable the permanent surveillance of the areas of interest. Technological advancement has led to the creation of a more sophisticated architecture of sensors in order to meet superior surveillance requirements. Sensors for mission surveillance use remote sensing as a means to obtain data. The data thus obtained are analysed by specialized personnel and equipment, the products resulted being used to create the real image of the battlefield.

Surveillance through remote sensing builds a veridical image of the area under surveillance. Due to better surveillance possibilities, spatial and aerial platforms play an important role in surveiling the areas they fly over by using remote sensing.

Remote sensing is ”an array of technologies used to process data related to objects or phenomena”[3], on Earth or in space. Remote sensing is the sum of physical and engineering applications used to create images of bodies and phenomena, using electromagnetic radiations generated naturally or through different technical devices mounted on spatial and aerial platforms. Remote sensing can be active or passive.

Active remote sensing is meant to obtain data on objects and phenomena on the land surface using, in this respect, specialized instruments to generate electromagnetic radiation. Remote sensing uses as emission means: radar and LIDAR. Regardless of the instrument used, the data obtained are processes and analysed based on a set of elements that allow their qualitative and qualitative analysis obtaining, in the end, a detailed copy of the studied objects and phenomena.

Passive remote sensing is based on complex physical applications that ensure the capture, analysis, and processing of electromagnetic radiation reflected by objects on land surface in order to obtain the information needed to build their image. The evolution of technology fostered the creation and development of sensors that have diversified remote sensing by using different technical principles and methods. Remote sensing uses the following principles[4]:

- The principle of satellite TV;
- The principle of multispectral scanning;
- The principle of radiometry;
- The principle of thermal scanning.

Satellite TV involves the use of TV cameras built for remote sensing. There cameras capture light emitted or reflected by bodies on land surface. Images are obtained by recording simultaneously, on more spectral bandwidth, the data which are then transmitted and processed by ground-located specialized centres [5].

Multispectral scanning is based on the properties of objects and bodies to generate radiations whose wavelengths are dependent upon their physical and chemical properties. Multispectral sensors will record the electromagnetic radiation simultaneously on more spectral bandwidths, the data obtained in the process being transmitted to the processing centres. The images of the targeted objectives have the best spatial and spectral resolution, being obtained through the processing of registered data on all spectral bandwidths in which the sensor can detect the radiations of the specific bodies detected[6].

Radiometry uses special sensors to this purpose, named radiometers, which detect the radiation emitted by bodies located on the land surface, both simultaneously and selectively, on different bandwidths, comparing the wavelengths captured with the standard ones, determined in a lab, for each natural substance or elements. Radiometers ensure the identification of objects according to the recorded spectral behaviour[7].

Thermal scanning refers to the intake of caloric radiations emitted by bodies on the land surface, using sensors which are sensible to their temperature variations and which can record wavelengths that correspond to the thermal infrared. The image of bodies is obtained by processing data, obtained by sensors, in specialized centers located on ground[8].

Sensors located on aerial or spatial platforms ensure passive and active remote sensing of bodies, phenomena or actions undertaken in the air or on land surface, using remote sensing sensors that include the afore-mentioned theoretical principles.

The sensors located on these platforms can supervise extended surfaces, without influencing the remote sensing possibilities of the geographical features. The images obtained as such have superior quality, ensuring the information support necessary to the decision-making processes and to the increased efficiency of organic troops. Mastering the information that is useful for the decision-making process ensures the proper framework for planning and conducting coherent actions with impact on the way and the rapidity in which success is obtained on the battlefield.

Aerial platforms with remote sensing sensors on board are: the planes, helicopters, aerostats, and drones. Aircraft used to this purpose are characterized by increased autonomy, in accordance with the dimensions of the area they have to surveil. Space platforms used in this respect are: satellites, spaceships, space stations, etc.

Designing a spatial platform for the surveillance and early warning has been a constant preoccupation of military powers in the last decades, being focuses on the development of space programs in order to meet this aim. The possibility of using these platforms for civilian activities, for detecting and monitoring the evolution of phenomena, calamities and natural or manmade catastrophes, with impact on the population in the area, contributed to increasing the importance of remote sensing sensors and to the need to build a spatial surveillance system of the land surface.

The developed programs in this respect are the following:

- *Landsat program* is a program launched by the USA and which used a series of 8 satellites, the last one, Landsat 8, being launched on 11th February 2013 and including active and passive sensors to surveil the land surface;
- *IRS program* is a program of surveillance satellites developed by India, which has onboard passive and active sensors, compatible with the detection possibilities of those from Landsat program;
- *SPOT program* is a program developed by France, which includes a series of 7 satellites, the last one, SPOT 7, being launched on July 2014, having onboard active and passive multispectral sensors, which are used in missions of mapping the land surface;
- *ERS program* is a European program with the surveillance satellites ERS 1 and ERS 2, that include remote sensing with infrared, ultraviolet and visible spectrum sensors, sensors to determine the atmosphere composition and radar sensors for the surveillance of land surface;
- COSMOS program includes espionage satellites and was developed by the former USSR, being continued by the Russian Federation, having onboard passive and active remote sensing sensors;

Observing the surface of the Earth has been a constant preoccupation of the scientific community in order to understand the phenomena that take place on our planet, thus building sensors with very good remote sensing, based onboard satellites so that they will permanently keep an eye on the areas of interest. From the afore-mentioned programs, the LANDSAT one was a real success. Launched in 1972, the satellites ensured global, synoptic and repetitive coverage of the land surface, detecting the natural and manmade changes, the data obtained being a very good resource for mapping and monitoring the biophysical and geographical characteristics of the land surface.

From this perspective, we will detail further the aspects regarding passive sensors placed on aerial and spatial platforms. These sensors use specific principles and methods of passive remote sensing in order to provide the data for building the real image of the surveilled area.

In the analysis of passive sensors, we will use the sensors from the LANDSAT program, respectively, those onboard the satellite LANDSAT 8.

Landsat 8 has two imagistic tools that ensure the surveillance of land surface: Operational Land Imager (OLI) and Thermal InfraRed Sensor (TIRS). The approximate dimension of the satellite coverage area is 170 km north-south and 185 km east-west, having a cycle of collecting images of 16 days[9].

Operational Land Imager (OLI) built by Ball Aerospace & Technologies Corporation is a sensor that uses a photosensitive detector capable of detecting wavelengths from 443 nm and 2200 nm. The focalization of incident radiation is performed through an anastigmatic telescope with four mirrors which provides a 15-degree field-of-view covering large land surfaces. The spectral interval on which detection is performed is divided into 9 spectral bands, from which, eight ensure multispectral detection and one panchromatic detection. The images that correspond to these bands have a resolution of 30 meters for the multispectral ones and of 15 meters for the panchromatic one. The incipient radiation is directed to the light detectors, placed as modules aligned with the focal plane, with a special pattern of a ”push-broom” type which will increase its sensibility. The modules are made of 7.000 detectors for each spectral band and 13.000 detectors for the panchromatic one, thus providing very clear images of the land surface[10].

Thermal InfraRed Sensor (TIRS), built by NASA Goddard Space Flight Centre, uses a new technology which applies the theoretical fundaments of quantic physics to detect heat in the form of quantic infrared photodetectors which detect wavelengths between 10-12,5 µm. TIRS detects thermal radiation on two spectral bands with a spatial resolution of 100 m. Quantic infrared photodetectors are arranged in a matrix form, on three modules, with a “push-broom” design, close to the one of the OLI sensors. The focus on thermal radiation is done with refractive optical telescope with a 15-degree field-of-view, ensuring the surveillance that corresponds as dimensions with the values provided by the OLI sensor. Satellite coverage is ensured by three modules which contain, each of them, 640 quantic infrared photodetectors, ensuring a spectral response for the thermal radiations detected on the two dedicated spectral bands[11].

The Landsat program furnishes data with moderated resolution, being not only an important source of scientific research, but also a necessary one for the decision-makers to monitor, make efficient and undertake activities in different fields such forestry[12].

The images obtained provide information on the existence and location of water resources, surveillance of coastal regions, urban zones, farms and agricultural areas, forests, as well as the identification of different types of rocks and lands in geology, the monitoring of changes in ecology, etc.[13]

OLI and TIRS are used to measure the temperature at land surface and provide the data for studies regarding the physical and biological processes, the impact of temperature variations on their behaviour as well as for the understanding of other processes such as evapotranspiration, lakes’ hydrology, monitoring fresh water resources, the impact of climate phenomena on the environment, etc. These data will be an invaluable source of information to manage water consumption, its division into individual consumption and economic one, especially in agriculture for irrigation[14].

The evaluation of agricultural productivity needs data obtained by sensors placed on-board satellites because the refreshing time of data, their precision and accuracy is of great importance in designing accurate prognoses on the behaviour of cultures. The images obtained with passive sensors about the use of fields contribute to the development of important fields of science, from the social point of view, related to the management of natural resources or the change in the use of farmland. The images from space are essential because they ensure the information support for making decisions or for developing programs to improve and diminish the impact of human activity on the environment.

Understanding the changes produced while using land as well as the expansion of human communities has become increasingly important both from the perspective of decision-makers and from the one of the public audience as beneficiary of social and economic activities.

In the last decades, the data provided by the satellites from Landsat program have been applied in different fields such as census, monitoring of urban areas at global level or the evolution of coastal areas as a result of erosion and human activity. The data are used as grounds for making decisions in different fields such as: health, climate, energy, prevention and protection against fire, natural disasters, ecology by tracking the evolution ecosystems and biodiversity [15].

Passive sensors are placed on aerial platforms and have technical parameters similar to those from spatial platforms, the differences residing in the changes that are necessary for them to function in the aerial or spatial medium.

The passive sensors for certain military missions have superior technical parameters than those used on civilian surveillance missions. An example in this respect are the surveillance sensors used within the COSMOS program, which have a special resolution between 0,7 m and 3 m[16].

Air surveillance performed through sensors onboard aerial or spatial platforms ensure the permanent monitoring of established areas and will provide the necessary data for the identification of the objects of interest placed on land surface.

Passive sensors are invaluable to the military due to the quality of the data provided which ensure, after processing, the design of a detailed map of the areas of interest, including urban ones, the detection of combat means and the timely identification of the enemy's intended actions. From the military point of view, an accurate image of the area of interest will ensure the efficiency of the command and control actions of organic forces. Obtaining detailed and accurate images of the battlefield will result in the detailed planning of actions, the increased degree of adaptability of organic forces to the real situation from the theatre of operations as well as in the coordination and execution of precise strikes on identified objectives.

In this respect, surveillance sensors on aerial and spatial platforms are integrated with the equipment that processes the data obtained, with equipment that has access to information and information distribution networks. The integration of these sensors will result in a complex image of the observed phenomenon and will provide decision-makers with the possibility to manage this in all its evolution phases: evaluation and prevention, prediction and alert, intervention and assistance.

As a result, we notice that passive sensors can accomplish both military and civilian missions, ensuring the timely identification of signals preceding the occurrence of a phenomenon or event and ensuring the information support that is necessary to the authorities to perform optimal actions in order to maintain an adequate security level.

In conclusion, we can state that passive sensors mounted on aerial and spatial platforms are useful and efficient tools for the permanent surveillance of land surface. The data contributes to obtaining a real image of the area of interest, in real time, ensuring the information support that is necessary to the efficient decision-making process at military level and of command during the conduct of operations.

At the same time, the data furnished by passive sensors contribute to the understanding of impact of human activities on the environment, thus playing an important role in writing prognoses or in other projects that are meant to reduce the negative influence on ecosystems and to ensure the efficient management of resources. The timely identification of events with impact on the life and activities of humans inhabiting the area where they produce has been one of the purposes for which sensors were created to have superior performances meant to benefit human society by maintaining the security environment adequate for human activities.

NOTES:

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