The Tends in Taking Remote Earth Observation from Space

Petar Radenkov Stoyanov, Svetla Koleva Ivanova, Vencislav Georgiev Markov and Nicolay Lazarov Tchilyanski

Abstract - **The notion "Remote Earth Observation" has been defined. The long-term terms of reference for improving the main technical characteristics of the apparatuses have been also presented. Both purpose and abilities of the optical electronic space apparatuses of new generation WorldView – 1, WorldView – 2 and GeoEye – 1 have been considered as well as the radiolocation systems TerraSAR-X and Cosmo-SkyMed. In addition, the main tends towards the development of the remote Earth's surface observation from the Space have been also enunciated.**

Keywords- **Remote observation, Optical electronic and radiolocation space systems**

I. The Essence of the Remote Earth Observation from Space

The essence of the concept "*Remote Sensing of the Earth from Space*" includes observation and measurement both energy and polarization characteristics of the natural and reflected radiation emitted by the Earth's dry land, ocean, and atmosphere within different parts of the electromagnetic spectra. In accordance with these, the objects' locations could be determined as well as the nature and time dynamics of their development and state. In this way the main nature formations and phenomena, the Earth's natural resources, and the environment are investigated as well as a number of parameters of anthropologic objects and forms. This appears to be the general sense of the remote aerospace researches regardless the different ways they are designated in different languages: "*Remote sensing*" (into English), "*дистанционное зондирование Земли*" (into Russian), "*fernerkundung"* (German), "*teledetection"* (French), etc. Latterly, another term is used frequently which will be used in the presentation next: "*Earth Observation*."

In the contemporary impetuously changing world, we are testifying to continuous revolutionary technological changes. If the 20th century could be referred to as a century of numerical technologies then the 21st century may be described as a century of the space numerical technologies.

Petar Stoyanov, Svetla Ivanova, Vencislav Markov and Nicolay Tchilyanski are from Space Research Institute – BAS, 6, Moskovska St., 1000 Sofia, Bulgaria, E – mail: pstoyanov@abv.bg

First, this has repercussions on continuously improving main characteristics of the apparatus for Remote Earth's Observation (REO) from Space as well as data quality gained through this apparatus. The perspective along these lines is reduced to: Increasing the spatial resolution;

- Widening the dynamic scope;
- Widening the possibilities of stereo pictures receiving;
- Improving images geometrical characteristics;
- Widening multispectral possibilities;
- Improving precision of the initial data without fulcrums usage;
- Increasing the width of the field which is being shot;
- Refining upon the possibilities of taking pictures within a single pass.

Data with high spatial resolution provided by the contemporary space ships (SS) become a main tool in working on practical problems of national, regional, and local governance as well as a geospatial basis decisions at different levels could be made on.

In accordance with classification of the space reconnaissance accepted, the space systems for observation are:

- Space photo reconnaissance;
- Optical electronic space reconnaissance;
- Radiolocation space reconnaissance.

The space photo reconnaissance is the oldest mean of REO. Development of these systems has been done in the 50s of the last century in the USA, Russia, and China later on. It could be stated that as a result of long term maintenance, these systems have reached the apogee at technical, operating, and technological level. This is why a space is provided for the rest two means of REO further down in the paper.

II. New Generation Optical Electronic Space Ships for Remote Earth Observation

The satellite systems designed for optical electronic reconnaissance are intended to provide an arbitrary part of the Earth's surface with continuous survey in order to obtain images with high resolution and transmit them to the center for receiving and processing the information in a time – scale approximately equal to the real one. It is typical that in order to receive an image of the object which is being

observed an optical electronic system should be used instead of camera. The system consists of an optical telescope with long – scale focus, operating as a scanning radiometer, and a photo receiver based on multi-element CCD matrices.

The main features of optical electronic space ships of new generation designed for remote Earth observation are their unprecedented productivity including working at stereo picture regime as well as the possibility of receiving data at spatial resolution better than 0.5 m and precision, in absence of ground fulcrums, better than 5 m (quadratic mean deviation). These are the satellites "WorldView–1," WorldView–2," and "GeoEye–1."

The space apparatus "WorldView–1" (Fig.1) was put into orbit successfully on 18 of September 2007 from airbase Vandenberg (USA).

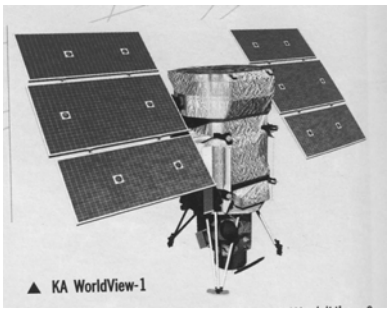

Fig.1. Space apparatus "WorldView–1"

The owner of the satellite is the company Digital Globe (USA). In the project of satellite's building up various companies have taken part such as Ball Aerospace (platform, integration) Eastman Kodak (optical camera), ITT (integration) BAE systems (processing system). The satellite "WorldView–1" has been put into a sun synchronous orbit at height 480 km, providing a passage over an arbitrary region of the Earth each 1-2 days (depending on the geographical latitude). The "WorldView–1" is able to take photos in panchromatic regime only at spatial resolution 0.5 m. The precision of the data received without fulcrums usage is better than 5 m. As compared to its predecessor SS "Quick Bird," (Fig.2)

Fig.2. Space apparatus "QuickBird"

principally new solutions have been utilized onboard providing high productivity of taking pictures, quality and precision of the coordinate conjunction of the images.

The calculated term of orbit stay is more than seven years.

The SS "World View–2" (Fig.3.) owned by the company "Digital Globe" is planned to be put into orbit by the end of 2008.

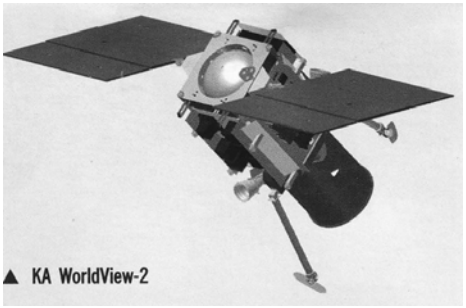

Fig.3. Space apparatus "WorldView–2"

The "World View–2" will allow receiving digital images of the Earth's surface with spatial resolution 0.46 m at panchromatic regime and 1.8 m at multispectral regime when taking photos along nadir. In comparison with SS "Quick Bird" and "WorldView–1," the possibilities of multispectral images receiving have been improved fundamentally. The amount of spectral channels has been increased up to eight. The precision of the data received, without ground fulcrums usage, is better than 5 m, while the calculated term of orbit stay is more than seven years.

The SS "GeoEye–1" (Fig.4) is planned to be put into orbit in April – May 2008.

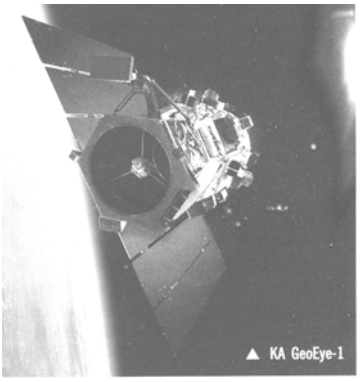

Fig.4. Space apparatus "GeoEye 1

The owner of the satellite is the company "GeoEye" (USA). The satellite is planned to be put into polar sun synchronous orbit at height 68 km providing its passage over an arbitrary region of the Earth each 1-3 days depending on the geographic latitude. The satellite "GeoEye–1" is intended to transmit digital images of the Earth's surface with spatial resolution 0.41 m at panchromatic regime and 1.65 m at multispectral regime while taking photos along nadir. The satellite "GeoEye–1" will possess

high maneuverability which will allow receiving high amount of data at single pass. The main feature of the apparatus appears to be the possibility of receiving high precision images (up to 2 m) without conjunction to the ground. The calculated term for stay on orbit is more than seven years.

It is necessary to say that for all optical electronic new generation SSs, not depending on the fact for entering into rivalry with each other, each of them takes its place. The SS "WorldView–1" has been designed in such way so reaching highest degree of productivity and ability to take photos of large areas, including the regime "stereo," to be possible. Data received from SS "GeoEye–1" will be possessed by highest precision of the characteristics without fulcrums usage, even though its productivity will be in no way both "WorldView–1's" and "WorldView–2's" equal. On its part, the SS "WorldView–2" is going to be the most productive one for REO providing possibility of taking pictures within large number of spectral channels which expands vastly the possibilities of data utilizing for different kind of tasks.

III. New Generation Radiolocation Space Ships for Remote Earth Observation

The radiolocation space systems for observation possess a number of indisputable benefits, more important of which are: the independence from the meteorological conditions and time of the day, the combination of a wide pass band at large distances and high resolution, the multi-regime ability, and the versatile control operation of the Synthesized Aperture Radar (SAR) allowing rapid alteration of the attitude and size of the field of view, resolution and shape the information appears as well as high operating ability of receiving sensing data at time scale almost equal to the real one.

The radiolocation information is unique in case of extreme situations, working out tasks at the Polar Regions, cartography, forestry, oil prospecting, etc. Taking photos within the centimeter X-scope (wavelength up to 3 cm) allows receiving of high detail radiolocation images with quality of the resolution almost equal to the optical ones. The systems working within the decimeter scope (wavelength up to 23 cm) allow taking observation across the trees' leafs. Finally, SAR taken within P-scope (wavelength up to 70 cm) provide for sensing under dry layer of soil.

The main features of the radiolocation space ships working at an extremely high resolution are the spatial resolution up to 1 m, the possibility of taking photos at various polarizations, the possibility of subsequent interferometric processing to obtain high-precision digital models of the lay as well as discovering mobile targets on the Earth's surface. These apparatuses are the satellites "TerraSAR-X" (Fig.5) and "Cosmo-SkyMed" (Fig.6).

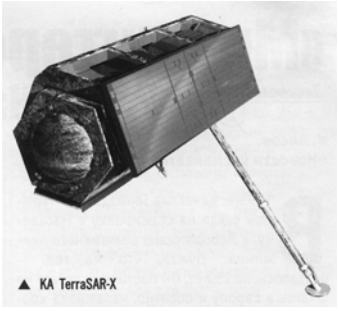

Fig.5. Space apparatus "TerraSAR–X"

The satellite "TerraSAR-X" which has been developed both by the German Aerospace Center (DLR) and the company EADS Astrium GmbH was launched on 15 of July 2007 from Baikonur cosmodrome. The satellite has been put into a sun – synchronous orbit at height 514 km and inclination 97.44º. The calculated orbital term the satellite "TerraSAR-X" must stay within is about five years. That the satellite has been equipped with new radar with synthetic aperture allow interferometric pictures to be taken of the Earth's surface at unprecedented spatial resolution of 1 meter. The radar takes pictures of the Earth's surface in the X-scope (wavelength 3.1 cm) while varying the emitting polarization (HH, VH, HV, VV) at shooting angle from 20º to 55º.

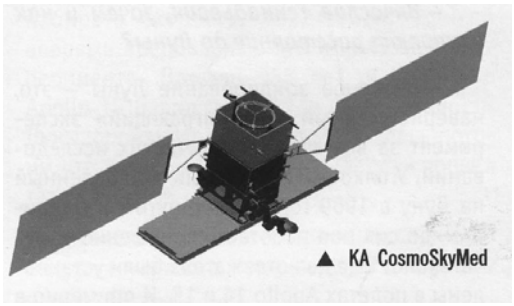

Fig.6. Space apparatus "Cosmo–SkyMed"

The sequence of space ships with dual purpose "Cosmo-SkyMed 1-4" (Constellation of Small Satellites for Mediterranean Basin Observation) that has been developed by the Italian Space Agency (ASI) and the Italian Ministry of Defense (Mod) jointly is going to be completely deployed within next 2-3 years. The first apparatus of the sequence has been put into orbit on 7 of June 2007 from Vandenberg airbase (USA) at height 619.6 km and inclination 97.86º. All satellites of the group are going to be equipped with radars with synthetic aperture allowing taking interferometric pictures of the Earth's surface at spatial resolution better than 1 meter. The radar will shoot at the Earth's surface within the X-diapazon (3.1 cm) while varies the emitting polarization (HH, VH,

HV, VV) within shooting angles from 20º to 50º. The calculated term of orbital stay for each apparatus "Cosmo-SkyMed" is about five years. The satellite is going to be maintained by the Italian company "Telespazio."

IV. CONCLUSION

There are several main tendencies in the advances in the remote Earth observation from Space that could be distinguished:

- Rapid increase in number of the space ships for remote Earth observation flying along orbit;
- Development of the National Programs for remote observation as well as coming into sight of new "players;"
- Development of the systems for receiving, processing, and placing data at users' disposal;
- Improving the main characteristics of the apparatus for remote Earth observation and data quality as well;
- Appearing of new generation space ships for remote Earth observation with over-resolution;
- Appearing of radar space ships for remote Earth observation with extreme high resolution and interferometry processing abilities;
- Increasing the data transmitting speed;
- Shortening the time required for placing data at users' disposal – development the concept of "virtual stations;"
- Wide usage of the net technologies as well as possibilities provided by the Internet.

In this way we could freely add the process of Remote Earth Observation to the high – tech branches developing at extremely high rates. Further progress in this branch will be related at high extent to development of technology of processing and placing huge amount of data at users' disposal as required that is to be received through the new space devices for remote Earth observation. On this part, this has a claim on too high requirements to be met by the knowledge level the users are to be grounded in. This also requires extremely effective work to be done by all divisions of the system for providing the end user with opportune and qualitative geospatial information.

REFERENCES

[1] Кашкин В. Б., А. И. Сухинин, Дистанционное зондирование земли из космоса, Лотос, М. 2001;
[2] Мардиросян Г., Аерокосмически методи в екелогията и изучаването на околната среда, част1, С., Марин Дринов, 2003;
[3] John Alan Rishards, Xinping Jia Rikhausez, Remote sensing digital image analysis, 2006;
[4] www.infoterra.de/;
[5] www.novosti-kosmonavtiki.ru/