Bulgarian Academy of Sciences. Space Research Institute.
Aerospace Research in Bulgaria. 23, 2009, Sofia

AEROSPACE TEST SITES IN BULGARIA – STATE AND PROSPECTS

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Abstract

During the last decades, great attention has been paid to integrated use of ground-based (in situ) and remote sensing data. Practice shows that the trustworthiness and accuracy of the information derived from aerial photos and satellite images depend strongly on the available relevant ground-based (in situ) data, which have great practical importance both during the interpretation of remote sensing data, as well as during the modelling and forecasting of natural and technogenic processes. Therefore, the GEOSS and GMES systems that are now under construction pay great attention to this component. The accumulated international experience in the field of remote sensing of the Earth proves that the most rational way to obtain in situ data is the development of a network of aerospace (subsatellite) test sites, representative of the different climatic areas and featuring diverse vegetation cover, thematic and functional purpose depending on the tasks of test site service. Bulgarian Aerospace Test Sites (BASTSs) pertain to the test type by their functional intention. The first Bulgarian test sites were established in the beginning of the 70-ies of the last century and nowadays their number has reached 7. Many satellite images and aerial photos, spectrometric, radiometric, and ground-based data, which have been acquired for these BASTSs, have been uploaded in the thematically distributed satellite and sub-satellite database of the BASTS Scientific-Information Complex (SIC). A web-based BASTS information system, which is planned to be created in the forthcoming years, will provide an effective solution for integration, access, analysis, and publication of obtained information and data on the web-site.

Keywords: *Web-Based Information Systems, Remote Sensing Methods, Aerospace Test Sites, Sub-Satellite Experiments, Geoinformation Technologies*

Introduction

The modern stage of monitoring the development of ecological systems, forecasting natural and anthropogenic disasters and averages, and concrete decision-taking for their prevention are characterized by the global nature of the set tasks and the active use of data from various sources, whereby great attention is paid to satellite images. A number of international programmes are targeted at resolving these international problems, aiming to integrate regional and national monitoring systems. Earth observation is an improved technology which through the use of space and ground-based equipment provides great opportunities for monitoring environment and environmental security threats by obtaining timely, reliable, and objective information. Since 2005, the international scientific community has started implementing the 10-year programme *The Global Earth Observation System of Systems* (GEOSS). It is coordinated by the Group on Earth Observation (GEO). The major goal of this programme is to substantially complete and particularize at quantitative level our knowledge on Earth geosphere status [1, 2]. The major European contribution to the implementation plan of the GEOSS is the Global Monitoring for Environment and Security (GMES) Project which will provide service of public interest. It has three components: Space segment, *in situ* component, and Services. Their complex use will provide to offer new information services in many areas – precise land use mapping, fast mapping under critical circumstances for the purposes of civil protection or monitoring forests, wild fires, geological threat, atmospheric air etc.

The Global Monitoring for Environment and Security System will provide grounds for the establishment of structures collecting measurements and facilitating their use by a great number of users [3]. The timely and economically efficient information provision depends largely on the successful implementation of Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), which envisages the establishment and exchange of data regarding the application of EU policies, especially in the field of environment preservation [4].

Remote sensing of the Earth's surface from space-based platforms has passed from the stage of scientific research to the stage of wide practical use and development of remote sensing of the Earth (RSE) technology.

Practice shows that the trustworthiness and accuracy of the information derived from aerial photos and space images depend strongly on the available corresponding ground-based (in situ) data. This data obtained by the use of physical (geochemical, phyto-indicative etc.) and spatial measurements or by the use of immediate object observations and studies help to increase the accuracy and relevance of remote sensing data. Therefore, ground-based data are used for control (calibration) during the formation, processing, and interpretation of aero- and space images. Moreover that, as a result of the still somewhat restricted potentials of modern RSE technologies, not all Earth geosphere and status parameters may be measured or observed by them. Therefore, the GEOSS and GMES systems that are now under construction pay great attention to receiving appropriate amounts of *in situ* data, which have great practical importance both during the interpretation of remote sensing data, as well as during the modelling and forecasting of natural and technogenic processes.

The accumulated international experience in the field of the remote sensing of the Earth proves that the most rational way to obtain *in situ* data is the development of a network of aerospace (subsatellite) test sites, characterizing the conditions of various climatic areas and diverse vegetation cover, and featuring characteristic thematic purpose and functional purpose, corresponding to the tasks of test site service. The network of aerospace test sites is an important segment of space research ground-based infrastructure which is envisaged to provide information for the GMES. Such test sites have been established in the USA, Canada, Russia, France, Germany, Spain and other countries.

Aerospace test sites on the territory of Bulgaria

Depending on their function, aerospace test sites can be divided into control and calibration test sites. The control and calibration test sites are used to solve tasks related with the post-start adjustment of the on-board systems' parameters for the purpose of achieving optimal image acquisition mode during the process of the Earth's surface aerospace monitoring and determining the accurate values of the external orientation elements. By their functional intention, the Bulgarian Aerospace Test Sites (BASTSs) pertain to the second, test type. The major problems resolved by such test sites are related with development and certification of various methods for processing, analysis, and interpretation of data acquired by remote sensing of the Earth, development and completion of objects' spectral signature

databases, and conduct of scientific research. For these purposes, individual test sections are chosen on the test sites' territory, each of them having definite (spectral-brightness, geometric etc.) stable characteristics. These characteristics are used during the images' interpretation as reference indicators for the relevant object class. Furthermore, the quantitative values of these characteristics provide for radiometric (brightness) and geometric corrections to be made.

In the beginning of the 70-ies of the last century, on the territory of the *Intercosmos* Programme member-states, a network of aerospace test sites was established, in which multiple international quasi-synchrounous sub-satellite experiments were carried out (Koursk, Gobi-Hangay, Caribe, Telegeo, Tyan-Shan etc.). In 1973, at a technical meeting of representatives of Russian and Bulgarian geodetic offices held under the *Intercosmos* Programme, 5 test sites were appointed (Fig. 1): Pleven, Shoumen, Rila, Plovdiv, and East Rhodopes, [5,6,7,]. Their organization on the Bulgarian side was assigned to the Central Laboratory for Space Research, currently Space Research Institute (SRI) at the Bulgarian Academy of Sciences (BAS). Later, they were supplemented by 2 more – Pchelina Dam and Novi Iskur. The *Pchelina Dam* test site included in 1987 in relation with the implementation of the *Home Water Catchments* Project under the *Intercosmos* Programme. The *Novi Iskur* test site is a new one, established in 2005 with the financial support of the *Scientific Research* Fund at the Ministry of Education and Science (Contract No.1507).

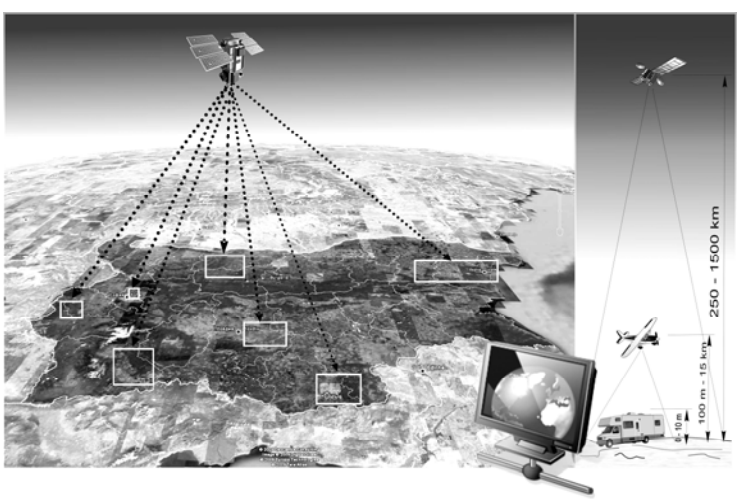


Fig. 1. Aerospace Test Sites in Bulgaria

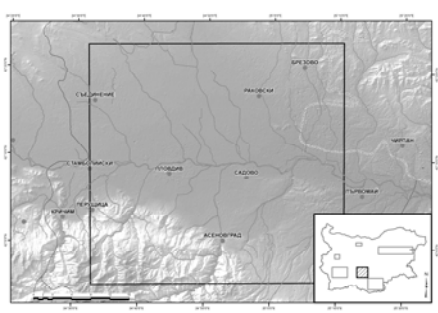
On its territory, studies aiming to improve the methods of landscape-ecological planning using remote sensing are carried out. During these experiments, many images, spectrometric, radiometric, and ground-based data were accumulated, which were uploaded in the thematically distributed satellite and sub-satellite database of the scientific-information complex (SIC) of the (BASTSs). It was established during the period from 16.10.2007 to 16.04.2009 as a result of the joint efforts of scientists from 2 institutes of the BAS, SRI and National Institute of Meteorology and Hydrology (NIHM) (Contract NIK 003/2007 concluded between the SRI-BAS and the Science Research Fund at the Ministry of Education and Science of the Rep. of Bulgaria, with 25% co-financing by the SRI-BAS) [8,9].

During the last four years, at the Ministry of Emergency Situations of the Rep. of Bulgaria, the establishment of a natural disasters space monitoring system is underway, having satellite data as its main information source. The Aerospace Monitoring Centre was established with the financial support of the EU PHARE Programme. However, the structure of its information system does not envisage receiving any *in situ* data.

The BASTSs' information database maybe composed by integrated use of geoinformation system technologies, data processing systems, remote sensing of the Earth methods, and landscape ecology methods is envisaged.

The test sites in North Bulgaria are intended for remote sensing, mainly in the field of agriculture, prospecting of ores and minerals, such as oil-gas depositions and monitoring the anthropogenic changes of the environment. The polygons in South Bulgaria are oriented to development of ore prospecting methods, study of seismo-tectonic phenomena, exploration of a number of neotectonic morphostructures and faults.

Geodatabases for the *Plovdiv*, *Rila*, *East Rhodopes* and *Novi Iskur* test sites have been composed.



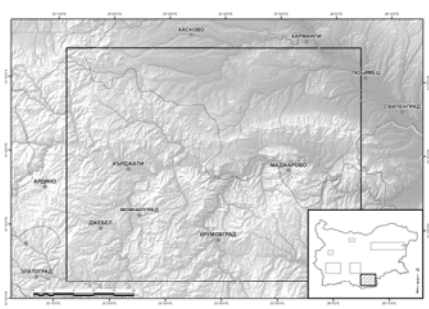
Plovdiv **aerospace test site**

On the *Plovdiv* test site, a number of methodical issues were clarified, related with recognition and mapping of various soil types and soil salination, mapping of land cover dynamics using aerial photos and satellite images [10]. The *Plovdiv* test

site is located in the Upper Thracean lowlands. For the conductance of sub-satellite experiments on the territory of the test site, two test areas are allocated including the land of Bolyarino and Belozem villages.

They are chosen because they have maximal land cover diversity, typical for the studied region of the Thracian lowland; area, meeting the requirements for spatial resolution of the satellite images. The geodatabase for the *Plovdiv* aerospace test site is composed on the base of topographic maps in scale 1:50,000 and 1:10,000 for the key areas and it consists of 31 layers. Six of them contain information about geology, geologic hazard and soil differences; 5 – about the settlements and road network; 5 – about the hydrographic network; 3 – about the relief; 3 – about the phonological development of 3 of the main crops, cultivated in this area (winter wheat, corn and rice); 5 – about the land use and man-induced transformation state and change; 3 – about the test area Bolyarino, containing spectrometric and radiometric data from the conducted synchronous airplane, ground-based and laboratory measurements, vegetation calendars, and data from the local agronomists and terrain studies. It also contains panchromatic and multispectral images – aerial photos, acquired by the cameras MRB, MKF-6 MC etc., and satellite images from Landsat TM, Landsat ETM^{+} and ASTER.

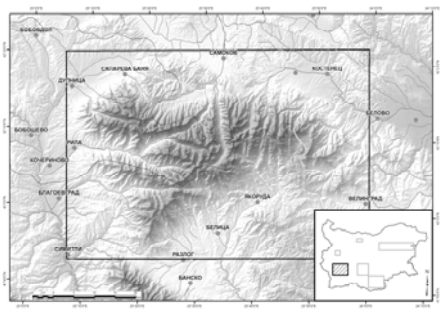
East Rhodopes aerospace test site



The *East Rhodopes* aerospace test site is located in the east part of the Rhodopes massif. The composing of the geodatabase is focused on geologic, geomorphologic studies and geologic hazard. It includes series of vector and raster layers – relief, river network, water bodies, road network, settlements, geology, deposits of ores and mineral resources, fault structures, geomorphologic structures, lineaments, geologic hazard, land cover, panchromatic and multispectral images [11]. The aerial photos are acquired by the cameras MRB, MKF-6 MC and etc., and the satellite images are from Landsat TM, Landsat ETM+ and ASTER. The composed geodatabase for the East Rhodopes comprises the time period from 1977 till 2008. It is used

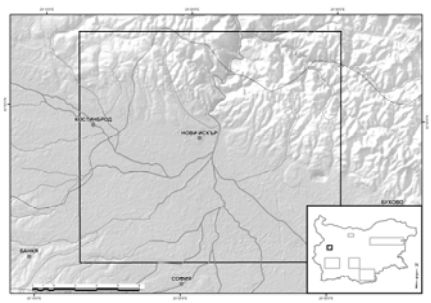
for interpretation of the geomorphologic volcanogenic structures in the area and for studying the geologic hazard [12,13,14].

Rila aerospace test site



For the territory of the *Rila* aerospace test site and the chosen two test areas spatial data bases in vector format as well as raster ones are developed, containing various aerial photos and satellite images. Aerial photos for 4 years: 1966, 1977, 1988 and 1997, for the test area are processed. The forest vegetation for each period was interpreted and mapped and spatial analysis of the temporal changes was made [15]. An orthophoto mosaic of aerial photos was created for the area of Northern Rila with spatial resolution of 1 m [16, 17].

Novi Iskur aerospace test site



The newest aerospace test site, the *Novi Iskur* one, is located in the northwest part of the Metropolitan Municipality. For the territory of the *Novi Iskur* District, a geodatabase was composed, including satellite images and aerial photos for various temporal stages, digital elevation model and its derivatives, as well as vector information for relief, administrative boundaries, land cover and land use, soils, hydrographic network, transport infrastructure etc. Two test areas for the study area were defined for which more detailed geodatabases were composed – the first is the drainage basin of Kutinska River, where *Kutina Pyramids* natural landmark is located and the second one is the land of the Novi Iskur Town. The composed geodatabase for the Kutina drainage basin covers the period from 1940 till 2008 and its aim is to store, manage, visualize, give an opportunity for analysis, creation of models, and select objects by attributes. The designed geodatabase is of file type and it has

been created using the ESRI software product – ArcGIS 9.2 with license ArcINFO. It consists of 7 feature datasets with 21 feature classes, including information about watersheds, soils, hydrographic network, land cover, forest and soils, geomorphology and geology; 1 raster catalog with 385 images from MODIS; 19 raster datasets (topographic maps, archive aerial photos and satellite images from IKONOS, QuickBird, SPOT, ASTER and LANDSAT for various years), 14 tables with forest and climate data, 3 standalone feature classes with information about the location of Rain-Gauging Stations, boundary of the natural landmark and terrain data; and the corresponding topological and relationship classes [18,19]. The composed geodatabase for the Novi Iskur Town includes topographic maps and satellite images with medium and high resolution - IKONOS, QuickBird, SPOT, ASTER and LANDSAT for various years, DTM, vector information for soil, land cover, land use, buildings and road infrastructure, climate data, etc. [20] The database for the aerospace test site and the two test areas is supplied from time to time with new information.

Perspectives for development of the BASTSs.

One of the tasks scientific community is faced with nowadays is to develop a methodology for the construction of a web-based information system for aerospace test sites, complying with the requirements laid out by the approved documents of the GMES and GEOSS Programmes, the INSPIRE Directive, and the regional environmental characteristics. This unified methodology will be included in the requirements of the *in situ* component of the GMES and GEOSS.

A web-based information system for the BASTSs is planned to be created. It will ensure:

- Collection of experimental (in situ) data as well as results from the thematic processing of airplane and satellite images;
- Exchange of aerospace, geospatial - natural-resource and landscape-ecological information about the BASTSs;
- Provision of remote access to the electronic-information resources of the BASTSs' Scientific-Information Complex at the SRI–BAS for the scientific community;
- Development of geoinformation technologies for processing of remote sensing data and their application in Earth studies.

- Collection of data for the preparation of dissertation theses on design and development of methods, instrumentation, and technologies for remote sensing of the Earth.

An effective solution will be proposed for integration, access, analysis, and publication of the obtained information and data on the web-site, using modern procedures for browsing the available massifs of aerospace and geospatial data, providing the users with the possibility to identify their precise requirements.

Acknowledgements

The study is implemented within the framework of the contracts: Establishment of a Scientific-Information Complex for Aerospace Polygons on the Territory of Republic of Bulgaria. Contract N-НИК-003/07 between the SRI-BAS and the Scientific Research Fund at the Ministry of Education and Science, 2007 – 2008.

Res. Fell. Vanya Naydenova, PhD student, PhD student Vassil Vassilev are beneficiaries of a project of Bulgarian Ministry of Education and Science – the OP "Human Resources Development" funded by ESF, Contract BG051PO001/07/3.3-02/63/170608.

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АЕРОКОСМИЧЕСКИ ПОЛИГОНИ В БЪЛГАРИЯ – СЪСТОЯНИЕ И ПЕРСПЕКТИВИ

Е. Руменина, В. Найденова, Г. Желев, В. Василев, Л. Кралева

Резюме

През последните десетилетия се обръща голямо внимание на интегрираното използване на наземни (*in situ*) и дистанционни данни. Практиката сочи, че надеждността и точността на информацията, получена от самолетните и сателитните изображения, зависи в голяма степен от наличието на съответни наземни (*in situ*) данни, които имат голямо практическо значение както при интерпретацията на дистанционните данни, така и при моделирането и прогнозирането на природните и техногенните процеси. Затова системите GEOSS и GMES, които се изграждат в момента, обръщат голямо внимание на този компонент. Натрупаният международен опит в областта на дистанционното изследване на Земята показва, че най-рационалният начин за получаване на *in situ* данни е създаването на мрежа от аерокосмически (подспътникови) полигони, представителни за различните климатични области и притежаващи разнообразна растителна покривка, тематично и функционално предназначение, в зависимост от задачите на полигона. По своето функционално предназначение аерокосмическите полигони в България (АКПБ) принадлежат към тестовите полигони. Първите полигони в България са създадени в началото на 70-те години на миналия век, като в момента броят им е седем. В тематично разпределената спътникова и подспътникова база данни на Научно-информационния комплекс (НИК) на АКПБ са качени много сателитни изображения и самолетни снимки, спектрометрични, радиометрични и наземни данни, които са заснети за тях. Предвижда се в близките години да бъде създадена интернет-базирана информационна система на АКПБ, която ще предоставя ефективно решение за интегриране, достъп, анализ и публикуване на получената информация и данни на Интернет-страницата.