Contents

Corporate Administrative Geoportal

Victor N. Adrov
Racurs, Russia

For years of business activities of companies working in geoinformatics area, they accumulate enormous amount of georeferenced information. As a result there is a situation, when a company possesses a huge amount of information, but has to spend a lot of time and effort for its systematization, visualization and search for necessary data. All of this prevents from timely and effective decision making.

So, for successful decision making, companies' administration and management should have information about available data in simple and visual form, including output results of various data processing systems (for example, PHOTOMOD, etc.)

Suggested software solution in Geoportal form allows companies to organize collecting, storing and analysis of georeferenced data in order to obtain adequate information both interactively and in form of reports.

Geoportal has the following advantages:

- Easy and convenient use
- User friendly web-interface
- Distributed data processing
- Fast access to information
- Data export to unified formats
- Visual reports generation.

The following features encourage productive work using Geoportal:

- Policy of access permissions (security policy)
- Data integration into uniform coordinate system
- Operative access both to data itself and to information on data location in archives
- Flexible adjustment of selected data view considering search options and user interface tools
- Mounting of libraries with economic and legal documentation.

Geoportal is developed using free open source libraries that will allow to adopt and update effectively its software solution in future.

Presented approach to data systematization and analysis in form of Geoportal will assist to create common information space, which will lead to successful development of GIS-business.

Generation of Digital Elevation Models and Detection of Surface Movements via Space Radar Interferometry

Yury B. Baranov, Maxim A. Vanyarkho,
Ekaterina V. Denisevich, Larisa Yu. Kozhina
GazpromVNIIGaz, Russia

We present results of our studies on using space radar surveys (Envisat, Envisat-ERS, ALOS/PALSAR, TerraSAR-X, Cosmo-SkyMed) and space altimetry for the generation of digital elevation models at scales 1 : 100 000 – 1 : 25 000, as well as for the detection of surface movements that can affect engineering objects.

Application of UFV Non-Metric Cameras for On-line Identification of Terrain Changes and Creating Realistic Terrain Models

Alex V. Belenov, Sergey A. Dudkin
Sovzond, Russia

Currently, a large variety of techniques has been practiced in remote sensing that makes it possible to identify terrain changes using images taken in different time intervals.

Images obtained at different times are an indispensable source of objective spatial-temporal information for studying changes in natural and anthropogenic objects. Meanwhile, they provide data about both quantitative and qualitative changes that have occurred in the area under investigation.

For project implementation, Sovzond uses satellite images obtained at different times and multi-time composites based on them when addressing a wide spectrum of issues in various industries such as hydrocarbon production and transportation, agriculture and forestry, water management and civil engineering.

Efforts made in the Russian Federation to form an unmanned flying vehicles (UFV) market, and extended application of UFV-based images make it vitally important to incorporate such information in the technological processes comprising identification of terrain changes demonstrated by satellite imagery data.

This paper will provide experimental findings showing that images obtained by a UFV non-metric camera can be employed in the process of on-line identification of terrain changes along with joint use of spatial super-resolution satellite images. It will also demonstrate the results of 3D modeling based on altitude data derived from stereoscopic pairs of images acquired through UFVs.

Fig. 1. Fragment of a multi-time composite based on UFV images

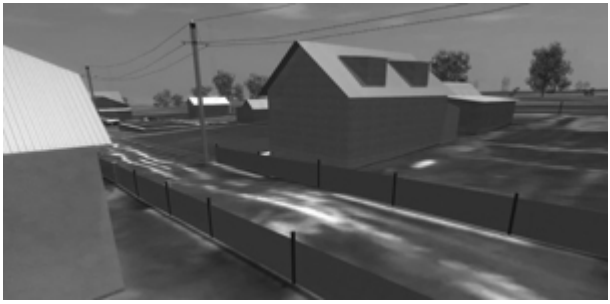

Fig. 2. 3D terrain model based on stereo pairs of UFV images.

Orthomosaic Creation Using Space Images WorldView-2 in PHOTOMOD 5.0 Software Package

Leonid V. Bykov, Andrey L. Bykov
LAG, Russia

The work was performed by NPK "GEO" by request of Omsk oblast Ministry of Construction. The output production included orthomosaics in 1:5,000 scale with images orientation accuracy corresponding to 1:2,000 scale. Two hundred settlements of Omsk oblast had to be mapped.

Our part of work was to perform images reference in field and to research accuracy of images orientation methods.

For orthomosaics creation we used WoldView-1, WoldView-2 and GeoEye images acquired during 2008-2010.

Images georeferencing was performed in winter 2010-2011 by satellite positioning methods. At least six ground control points were provided for each village. Three villages were supplied with ten GCP's for research tasks.

Images photogrammetric processing was performed using PHOTOMOD 5.0 software system. In order to define optimal orientation parameters we carried out some study. We performed images orientation by several methods on territories of three test villages with redundant number of GCP's. The first method used images orientation by universal mode using all ground points as GCP. Field data control was performed using discrepancies in ground points coordinates. In the second method for images orientation we used RPC coefficients without GCP. Interestingly, that accuracy of such orientation was 2.6 m. In the third study method we added one ground control point to RPC, in the fourth – two points, and so on up to seven points. Accuracy was evaluated using check points. You can see the evaluation results on the territory of one of the villages in the table below.

We concluded that it is necessary to use five GCP for images orientation using RPC coefficients.

Table 1. Image orientation errors (Kirsanovo village)

Number of GCP	Number of check points	RMS m.	Mean abs. value m.	Max.value m.
universal mode				
10	0	0.35	0.35	0.35
with RPC coefficients				
1	9	0.72	0.60	1.32
2	8	0.65	0.61	0.99
3	7	0.65	0.63	0.91
4	6	0.57	0.53	0.85
5	5	0.41	0.36	0.68
6	4	0.43	0.39	0.73
7	3	0.42	0.39	0.70

High Performance Cluster Computing with PHOTOMOD HPC Edition

Mikhail A. Drakin
Racurs, Russia

Conventional PHOTOMOD version is tailored to use network resources effectively for distributed processing of computationally intensive tasks (searching for tie points, creating DTMs, image orthorectification, etc). Nevertheless the performance level may be raised further by employing dedicated computer systems (computing clusters) and software adapted specifically for such systems. Fully automatic execution of certain workflows (e.g. creation of seamless orthophotomaps from high-resolution satellite imagery) is also important application of cluster computing. Given the performance of state-of-the-art HPC systems, it allows completing certain tasks for on-line monitoring in nearly real time.

The report focuses on some aspects of creating such hardware and software system and particular qualities of PHOTOMOD HPC Edition which enable it to take advantages of massive cluster data processing.

New Approaches to the Space Monitoring System Based on Earth Remote Sensing

Sergey A. Dudkin
Sovzond, Russia

Space monitoring is the most promising method for observation, analysis and

forecast of natural and anthropogenic objects and processes. It enables information on qualitative and quantitative characteristics of natural and anthropogenic objects and processes to be continuously repeated with accurate gridding by the processing of data received from earth remote sensing (ERS) satellites. Space monitoring helps obtain uniform and quality-comparable information simultaneously for vast areas, which any ground surveys can hardly provide.

Based on this definition, we may specify a number of key space monitoring requirements:

- Monitoring of vast areas and extended objects;
- High spatial resolution (up to 50 cm) and accuracy, including without ground datum points;
- High survey frequency, fast obtaining of baseline and processed ERS data;
- Building of digital relief models and digital terrain models using stereo photography from an ERS satellite;
- Making surveys via a large number of spectral channels;
- Making use of space monitoring materials directly in all standard GIS.

There are a variety of ways to obtain ERS data during space monitoring, the two most popular ones being ordering – desired ERS data from the satellite operator via the distributor and through installation of one's own receiving station, obtaining a license and ERS data reception directly from the satellite.

Ordering the desired ERS data through the distributor is the most popular way of obtaining space monitoring information.

While the option for installation of own receiving stations and direct ERS data reception from satellites seems at first sight to be the most effective one, the analysis of strengths and weaknesses suggests the opposite.

Receiving stations enable ERS data to be received only from some satellites (mainly from those of medium and low resolution), so their use is effective for entities (companies) involved, for example, in handling monitoring tasks by the use of radar data, or for those utilizing ERS weather data. For users that need satellite imagery as a means to tackle practical tasks, such as environmental and agricultural monitoring, large-scale mapping and many others, own receiving stations can hardly be of use and their purchase cost seems excessive.

Globally, personal stations were relevant 10-12 years ago when no the present-day fast data transmission technologies were available and on-board storage memories (SM) had a limited capacity, which implied regular dump of accumulated data on the ground segment to avoid storage overfilling and partial data loss.

At present the world's leading operators use entirely different schemes: data from modern satellites are dumped to one or two operator stations and brought to the user via high speed communication channels using networking technologies. Nowadays personal stations may normally receive data from morally and physically obsolete satellites. As to latest ERS satellite data (WorldView-1.2, GeoEye-1 etc.), they are not transferred to personal receiving stations and the operators of such satellites do not believe they will be in the future.

Public institutions and agencies worldwide (they are typically the primary users of receiving stations) abandon the use of personal receiving stations and tend to approach ERS satellite operators for survey ordering and to receive data directly from them (or through distributors).

A tremendous upgrowth of the ERS industry rendered the two traditional

standpoints unable to tackle the current tasks of space monitoring.

All this requires a revision of the traditional approaches to space monitoring. The new approach offered by Sovzond implies intensive use of virtual data acquisition instruments. This makes traditional distributors (ERS data suppliers) give way to system integrators.

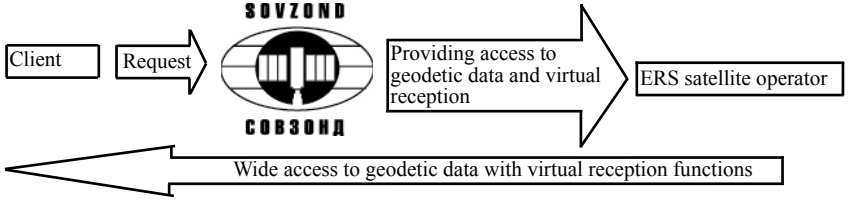

Fig. 1. New approach: direct access to ERS data.

The new approach provides the client with access to ERS data through geoportals and geoservers.

What follows are the key prerequisites giving preference to a direct access system:

- emergence of wideband data communication channels (faster speed, amount, stability and quality of data communication; lower data communication cost);
- emergence of the latest generation satellites:
- super resolution (WorldView-2);
- super resolution, mapping purpose (ALOS);
- super resolution, natural resources monitoring purpose (RapidEye);
- radar, super resolution (TerraSAR-X, TanDEM-X, RADARSAT-2);
- on-orbit deployment of GLONASS domestic navigation system;
- emergence of technologies for high-performance ERS data-flow processing, including a vast number of spectral channels and stereophotography even without any ground reference points;
- emergence of state-of-the-art systems for visualization of geospatial information and decision making support.

The new approach to obtaining ERS data (virtual reception, bypassing the distributor) makes space monitoring especially promising as an information analytic basis for situational centers of various levels. Space monitoring will provide observation of natural resources, industrial and transport facilities. Virtual reception is the key guarantee for fast reception of spatial information in situations requiring urgent decision making (environmental problems, emergencies).

3D Mapping from Space

Prof. em. Dr. Armin Grüen
Institute of Conservation and Building Research, ETH Zuerich, Switzerland

The continued increase in geometrical resolution of satellite-based sensors raises a number of issues in photogrammetry, remote sensing, mapping and cartography,

all related to the question to what extent the traditional techniques and procedures of aerial image-based mapping can be replaced by new approaches, making full use of the new satellite sensors' capabilities.

With IKONOS, Quickbird, GeoEye and WorldView we are operating within the 1/0.5 m GSD stereo domain, and there will be more sensors of similar or even better capacities to come. This presentation intends to investigate into the issue to what extent these sensors can be used for topographic mapping.

With such new technology we have to address a number of problems, which are not necessarily all new, but so far only sparsely treated in R&D.

Among those are: Digital mapping-how much automation is currently possible, 3D mapping — how does this differ from traditional 2.5D mapping, image interpretation — which pixel size do we need in order to bee able to extract features and objects that are required for topomapping at a certain scale, image quality — what are the differences in image quality (and thus interpretability) between aerial and satellite images of the same GSD, orientation/georeferencing — how accurately can we georeference the new satellite images (with and without GCPs) in planimetry and height, DSM generation — what are the expected accuracies in automated DSM generation, which parameters determine the accuracies of the DSMs and what is the reliability of the estimated surface models, DSM-DTM reduction- what are the most successful approaches for DSM-DTM reduction and what are the main problems to be solved.

We will cover to a certain extend all these problems in this presentation. In previous projects we have already collected a lot of experiences in georeferencing and automated DSM generation. We have used SPOT-5, ALOS/PRISM, Cartosat-1, IKONOS and Quickbird images over different testfields worldwide (Germany, Italy, Japan, Switzerland, Vietnam, etc.) and we have experience with automated and semi-automated feature and object extraction, primarily in 3D city modeling and 3D road extraction. We will report in brief form about these results. In georeferencing we have obtained consistently results in the subpixel domain, both for planimetry and height and for all sensors. We could show that RPCs usually provide for very good relative orientation, while the absolute orientation shows substantial systematic errors. These kinds of errors depend on the satellite/sensor. In the best case they just represent a bias (shift in coordinates), in other cases we diagnosed higher order terms. In automated DSM generation by image matching we obtained height accuracies between 1 and 5 pixels, depending on the type of terrain, land cover, image texture and image quality. All computations have been performed with our in-house developed software SAT-PP.

In 3D city modeling we use our semi-automated procedure CyberCity Modeler (CC-Modeler) for building extraction. With some examples derived from IKONOS and Quickbird images we show to what extent and at which resolution these objects can be modeled from satellite imagery.

In road extraction we have developed LSB-Snakes (Least Squares B-Spline Snakes), which allows us to model roads in 3D, also using a semi-automated technique.

In addition we will show how the technique of monoplotting can be used for object extraction.

3D mapping requires totally new approaches to modeling. Most of the traditional procedures and commercial software packages, which have been developed

under 2.5D assumptions will inevitably fail under strict 3D requirements. We will address this issue more in detail, shedding light at some of the problems and possible solutions. Currently we are focusing some of our work on the issues of interpretability for mapping. We will present here results which will indicate what objects can be extracted under which geometrical resolutions.

3D mapping from satellite imagery is still a topic which causes many misconceptions. We hope we can contribute with this presentation to a clarification of some of the issues.

Advances in UAV Photogrammetry

Prof. em. Dr. Armin Grüen
Institute of Conservation and Building Research, ETH Zuerich, Switzerland

UAVs — Unmanned Aerial vehicles have recently become a strong focus of attention, since inexpensive platforms, navigation and control devices and sensors have become available. Nowadays many groups worldwide are engaged in UAV-related research. Platforms range from stratospheric airships to low flying model helicopters, quadrocopters, octocopters, model airplanes and others. Especially the model helicopter, equipped with GPS, IMU, stabilizing platform and digital cameras and (in the future) laserscanners has excellent application prospects. It combines all features which make it attractive as a data acquisition device: Inexpensive, very flexible in operation (can operate in nadir, oblique and quasi-terrestrial mode), stable with respect to wind (as opposed to quadrocopters, balloons and kites), able to fly into confined spaces, operable on-demand and with on-line and real-time processing capabilities.

We see a great interest in all parts of the world in this technology and we expect it to open new and innovative applications for photogrammetry in the near future.

This paper reports about the experiences collected by our group in this area in the past five years. We will address hardware issues, discuss the need and use of advanced photogrammetric software and report about a variety of different applications.

While archaeology and cultural heritage applications still count for most of our projects, we also have used these devices in plant sciences, geology, civil engineering, hydrology, etc. Obviously, the on-line monitoring of damages caused by natural and man-made hazards is another important application.

UAVs give us new sensor platforms at hand which widen significantly our capabilities for efficient data acquisition. With improvements to be expected in hard- and software development, we can safely predict many more interesting applications for the near future.

Project of Space System of Multiposition Radar Observation in Vhf-Band and Its Efficiency for Economics Tasks Decision

Eugen V. Ivashchenko[1], Alexander A. Zhuravlev[1], N. R. Stratilatov[1], S. I. Tkachenko[1], O. V. Goriachkin[2]
1 – TsSKB-Progress; 2 – Volga state university of telecommunication and informatics, Russia.

Space systems of radar imaging, working in frequencies bands from L (λ =23 cm) to X (λ =3 cm) which it is to name most «comfortable» for functioning synthetic aperture radar (SAR) from the point of view of influence of Earth's atmosphere on a probing signal are successfully maintained now.

At the same time, expansion of number of used bands will allow to raise informative of radar images. It is known that vegetative and soil covers have volume scattering of SAR signals in the VHF-band. This property allows to measure vegetation characteristics, and also to carry out detection and monitoring subsurface objects and structures.

Basic problem at realization of SAR systems in the VHF-band is destructive influence of an ionosphere on structure of a probing signal of the given range [1,2].

Development of technologies of multiposition SAR systems opens possibilities on creation of a new class of the radar imaging systems. In the report presented the project of space system (SS) of radar monitoring in the VHF-band. The system should include onboard and ground segments. Onboard segment (on the spacecraft (SC)) should contain the VHF-transmitter. The ground station (GS) should contain the receiver of VHF SAR signal and instruments of formation and processing of radar images (RI). Thus GS should provide reception as the signal reflected from of an area of a terrestrial surface, and the signal coming directly from SC. Use of «direct» signal SC-GS provides indemnification of influence of an ionosphere on coherence of SAR signal.

Owing to specificity of geometry, imaging at such RSE system can be done in frame mode. The size of a frame can be found by calculation a cross-correlation of a phase of signals (destructed by ionospheric effects) between on paths SC-GS and the SC-Earth-GS.

At a rough guess offered SS will have following characteristics:

- spatial resolution of 3-5 m in;
- frame size 5 km in the extent to 7 km (at use of one SC);
- depth of penetration under a surface to 10 m (depending on humidity of soil);
- resolution of height by accuracy to 3 m.

Estimations allow to define possible scopes of application of the radar information offered SS. One of features of system is local character of its use. With its help the radar image of areas of the district which are in a vicinity of place of GS can be received. This fact limits possibility of use SS for the decision of tasks of mapping and monitoring of extensive territories at regional and state levels. At the same time, it is necessary to notice that a some number of tasks of monitoring has local character. So offered SS could provide the decision of following tasks:

a) In interests of oil and gas branch

- monitoring of an ecological condition of territories in extraction and refining areas oil and gas;
- monitoring of a condition and volume of open-cast mines and stacks of a

hydroalluvium of sand in areas of development of an oil and gas infrastructure;
• Earth's displacement monitoring in areas of hydrocarbon extraction and on terrain with underground gas storages.
b) In interests of agricultural branch
• operative control of a condition of crops;
• an estimation of germination, forecasting of characteristics of productivity;
• an estimation of grounds bio-physical parameters.
c) In interests of a forestry
• an estimation of forests biomass;
• monitoring of fires and unapproved cuttings.

Decision of tasks above is efficiently by VHF-band SS due to deep penetration of probing signal under vegetation and ground covers and technologies of differential interferometric observation. The system can be scaled by increase in number of SC for increase of efficiency and increase in number of GS – for increase in the square of covering territory. In the presence of a corresponding infrastructure the GS can function without management of the operator.

Traditional preferences for radar supervision systems are all-weather and all-time-of-day activity. Moreover, offered SS it is possible to carry to advantages:
• low (concerning complexes maintained now) cost of a radar complex and possibility of disposition on small satellites;
• absence of time losses in information delivery, due to forming of radar information direct and only in GS hardware;
• detecting and monitoring of subsurface objects and structures.

Consequently, in the report consider a project of a multyposition space SAR system in VHF-band and shown some economics tasks, which it can decide with high efficiency.

References.

1. Ishimaru A., Kuga Y., Liu J., Kim Y., Freeman T. Ionospheric effects on synthetic aperture radar at 100 MHz to 2 GHz. //Radio Science (USA) – 1999 – vol. 34 – num.1 – p. 257-268.

2. Goriachkin O.V. Azimuth Resolution of Spaceborne P,VHF-Band SAR // IEEE Geoscience and Remote Sensing Letters. – 2004. – Vol.1. - №4. – P.251-254.

3. Akhmetov R.N., Belokonov I.V., Goriachkin O.V., Kovalenko A.I., Riemann V.V., Stratilatov N.R., Tkachenko S.I. Space-based juxtaposition Earth and Circumterrestrial radar monitoring system based on micro-satellites technologies // in Book of abstracts of the First Specialized International Symposium, Limassol, Cyprus, November 2-7, 2009, M., A.A.Maximov Space Systems Research Institute (NIIKS), 2009. – 62 p.

A Comparison of the Performance of Various Digital Aerial Photography Systems in an Aerial Surveys of Large Territories

Sergey A. Kadnichanskiy
Research-and-production aerial survey and geodetic company 'Meridian+', Russia

The planning and execution of aerial surveys of large territories with the purpose

of creation of maps, plans or orthophotomaps of great importance are the costs of the flight of time for performance of the works, as the main economic indicators, affecting their cost. Time costs depend on the specific project and the performance of aerial surveying system.

Under performance of surveying system is understood as the area of the territory, aerial photography which is performed in a unit of time. It is expedient to include this area to one hour of flying time, as it is most revealing. Performance can only be considered in relation to specific conditions: the type and characteristics of the aircraft, specific requirements to the materials of aerial photography. As such requirements should take into account the following:

- map scale;
- appointment of the survey and due to their specific constraints to effective the aerial camera angle of the field of view.

On the scale of the created map or plan depends on the required spatial resolution aerial photo defined, as a rule, the size of a pixel on the ground. This parameter affects the performance of aerial photography.

Under the effective angle of the field of view will understand, angle, limiting the part of aerial photo in the cross to the line of flight direction, which will be used in the end product, for example orthophoto. This parameter in turn depends on how will be used aerial photographs for creating the final product (the creation of orthophotomap, stereoscopic survey), the nature of the terrain and the special requirements of the Customer. So, for example when creating orthophoto depending on the nature of the terrain this angle may be a special requirement in order to minimize the so-called «tilt» of buildings.

When requirements of the end product are specified performance will depend not only on the used aerial camera, but also on the applicable aircraft, its characteristics. Furthermore, when assessing performance should take into account the possible specific conditions of the further processing.

LLC «Research-and-production aerial survey and geodetic company «Meridian+» has a number of digital aerial photography systems of different type: the frame mapping camera DMC, the system scan type ADS40, digital camera medium format RCD30, digital aerial survey system A3.

A comparison of the performance of these various aerial photography systems is carried out under condition of use of them in the same conditions. Made a comparative analysis of the performance of digital aerial photography systems allows to determine the most effective range of use of each of them.

Digital Oblique Images and Their Application. The Possibility of Aerial Survey System A3 in Taking Oblique Aerial Photography

Sergey A. Kadnichanskiy
Research-and-production aerial survey and geodetic company 'Meridian+', Russia

Recently, in connection with the rapid development of information technology, geographic information systems, digital aerial photography and digital methods

of processing of aerial photos oblique aerial photography and the use of oblique pictures acquire a new meaning and of great importance in solving very different tasks, though it is still not universally appreciated.

Oblique aerial photography - aerial photography, the projected and the actual angle of deviation from the vertical optical axis of the camera for which are significantly different from zero values, for example, about 40 degrees.

Geo-referenced digital oblique aerial photos is a fundamentally new type of product, which is a set of digital oblique pictures with elements of external orientation, allowing to observe objects of locality with four or more different angles of view. Compared to the usual vertical pictures they provide even inexperienced users to easily interpret the image and giving fine bump of locality.

When you use these pictures in a special programming environments, you can carry out the necessary spatial dimensions.

What is the oblique aerial photographs can be interesting and useful for comparison with the usual routine aerial photos?

The advantages of perspective pictures:

• represented objects is significantly easier to be recognized,

• they contain much more information about the depicted objects,

• easy to determine the nature of the spatial (in three-dimensional space) the extent and forms of objects,

• easily defined spatial (in three-dimensional space) arrangement of objects and their parts.

As a result: compared usual vertical photos oblique picture provides even inexperienced users to easily decrypt the image and navigate on it on the area becomes easier and quicker decision making in the analysis of visual spatial data.

Especially effective oblique aerial photography, if the subject is photographed from different angles, as a minimum, with four, which allows to observe it from different sides. How and with what technical means are oblique aerial photos taken? Oblique aerial photography, as a rule, is performed simultaneously with the vertical aerial survey and may be accompanied by a lidar survey.

Variants of the decisions of technical solutions:

• complex of two inclined medium format cameras and a full-frame digital camera;

• specialized systems, including 5 medium format cameras on a single platform;

• use of aerial survey system, that allows one to perform the vertical and oblique aerial survey by the same camera.

LLC «Research-and-production aerial survey and geodetic company «Meridian+» has a system of VisionMap A3, as the opportunity to perform at the same time oblique and vertical aerial photography.

Features and advantages of the Vision system Map A3 for taking of perspective photos

• oblique pictures are obtained as a peripheral part of the large quasi panoramic pictures, covering strip –54.8 degrees — +54.8 degrees from the direction of the nadir;

• the relatively large size of the perspective pictures;

• aerial triangulation is performed with the use of all parts of the quasi panoramic image; as a result, the accuracy of the geo-referencing of all parts is comparable and is determined by the accuracy of aerial tringulation;

• high spatial resolution, expressed in the pixel size o the ground is achieved at high altitudes of photographing, that is very important for the aerial survey of urban areas.

The advantages of using the system A3 for oblique survey can count on the high effectiveness of its use for these purposes.

Accelerating a Satellite Image Processing using GPU

Jihoon Kang, In-Hoi Koo, Sang-Il Ahn
Korea Aerospace Research Institute, Republic of Korea

Now a day, the needs about high resolution remote sensing data from a satellite is increased for various application areas. As a satellite image's resolution becomes higher, its image data size also becomes bigger. In general, a low earth orbit observation satellite has about 90 ~ 100 minutes contact interval with a ground station located in polar region. So, at the ground station, the received data should be processed before next contact through powerful computational throughput. In case of a geostationary satellite, it sends image data during 24/7 to a ground station. So, at the ground station, a processing performance should be greater than the data transfer speed of the satellite. Therefore, high performance satellite image processing capability is pre-requisite to process a large size of data in short time at the ground processing facility.

Traditionally, a GPU, which stands for "Graphic Processing Unit", is used to display some images on a screen. So, it didn't require high performance processing capability. However, as 3D graphics market and needs are increased, the GPU has been developed to process massive 3D data in parallel. Moreover, these days, GPU has been used for general computation which is called General Purpose GPU. Especially, a satellite image processing could be one of the best GPGPU application areas because its data volume is very huge and sometime its pixel can be processed in parallel.

In this paper, MTF (Modular Transfer Function) Compensation and an Image Re-sampling algorithm for satellite image, which is one of the most time consuming algorithms, have been developed based on Nvidia C2050 with CUDA. The MTF Compensation and the Re-sampling algorithm could be good candidate for GPU because it contains lots of simple arithmetic operation, less of logical decision, and it can be processed in parallel. Its performance comparisons are also presented in this paper.

Digital Photogrammetry in Bulgaria and Its Relation with PHOTOMOD

Assoc. Prof. Dr. Ivan Katzarsky
Bulgaria

Bulgaria is the first Balkan country to apply photogrammetry. Bulgarian photo-

grammetry has a long and fruitful history, marked by the efforts of four professional generations. Its development passed through all stages of photogrammetry: terrestrial, aerial, cosmic; analogue, analytical, digital; topographic, cadastral and special mapping at different scales, for different purposes, in different form (graphical, digital); close-range photogrammetry. Photogrammetry and remote sensing is a subject in 4 universities and several technical high-schools in Bulgaria.

Digital photogrammetry is applied in 11 production units, 4 universities and one research institute. Six companies and one university have installed optimal number PHOTOMOD workstations.

INTRODUCTION

The aim of this paper is to inform the international photogrammetry community about the development and state of Bulgarian photogrammetry, in particular of digital photogrammetry, and its relation with digital photogrammetric workstation PHOTOMOD.

The contents of the paper is based on different sources [1-7], as well as on the personal impressions of the author being a contemporary person in the photogrammetry activity in Bulgaria and abroad during the last 50 years.

The paper is structured in three main parts:

• Bulgarian Photogrammetry - Stages in development, Beginning and first production, Institutions and education, Photogrammetric production, Photogrammetric technical means and software, Photogrammetric events, Photogrammetric literature.

• Digital photogrammetry in Bulgaria – Selected chronology, Application of digital photogrammetry.

• PHOTOMOD in Bulgaria – Introduction of PHOTOMOD, Experimental projects, Four typical projects.

BULGARIAN PHOTOGRAMMETRY

Bulgaria is the first Balkan country, to apply photogrammetry, only 30 years after the end of Russian-Turkich Liberation War of 1877-1878. The Bulgarian photogrammetry has a long and fruitful history, marked by the efforts of four professional generations.

Stages in the development of photogrammetry in Bulgaria:

• Terrestrial, aerial, cosmic.

• Analogue, analytical, digital.

• Topographic, cadastral and special mapping at different scales, for different purposes, in different forms - graphical, digital.

• Non-topographic applications (Close-range photogrammetry).

Beginning and first production:

• 1908 — Terrestrial pictures taken near the City of Sofia and plotted in Vienna Cartographic Institute by Eduard von Orel by means of his Stereoautograph.

• 1912-1918 – Aerial pictures taken from balloon and terrestrial pictures taken during the Balkan and World War One.

• 1917 — Aerial pictures taken from zeppelin, and in 1926 taken from airplane over the City of Gabrovo.

• 1928 — Terrestrial pictures taken by Phototheodolite Wild on 2.5 sq. km and plotted in Wild Heerbrugg Co. by Autograph A2.

• 1930 — Test area of 50 sq. km covered by aerial pictures for production of topographic map at 1:25 000 scale established.

• 1932 — Topographic map at 1:25 000 scale by terrestrial photogrammetry started.
• 1935 — Photoplan at 1:10 000 scale of Sofia Municipality by aerial photogrammetry produced.
• 1940 — Aerial stereophotogrammetry for producing topographic map at 1:25 000 scale started.

Institutions and education

• 1891 — Topographic Division (now - Military Geographic Service) at Ministry of Defense established.
• 1922 — A Group of Surveyors was established. Since 1965 a Union of Surveyors and Land Managers in Bulgaria has been established with the active participation of Bulgarian photogrammetrists.
• 1930 — First school in photogrammetry at Military Geographic Service was established.
• 1942 — High Technical School was established. Now - University of Architecture, Civil Engineering and Geodesy.
• 1945 — Photogrammetry Department at State Polytechnic {now University of Architecture, Civil Engineering and Geodesy) was established.
• 1947 — The subject Photogrammetry was introduced in Sofia Technical Highschool.
• 1951 — Main Department of Geodesy and Cartography (now- the Agency of Geodesy, Cartography and Cadastre) was established.
• 1952 — Geoplanproject – the largest state company for surveying and mapping, applying photogrammetry, established.
• 1953 — Photogrammetry Department at Geoplanproject was established with the main task of production and revision of Large-scale Topographic Map (1:5000, 1:10 000) and large-scale urban topographic maps (1:1000), as well as other photogrammetric production.
• 1962 — Research Institute of Geodesy and Photogrammetry, established.
• 1968 — Department Geodesy and Photogrammetry at the Road Research Institute, established with the main task of production of large-scale topographic maps (1:2000, 1:1000, 1:500) and photogrammetric measurements of the terrain as an input for automatic road design.
• 1973 — Photogrammetry Department at the National Institute of Culture Monuments, established.
• 1975 — Laboratory of Photogrammetry and Remote Sensing at the Niproruda Institute, established.
• 1976 — Photogrammetry Laboratory at the Mine and Geological University, established.
• 1977 — Photogrammetry Group at the Transport Designing Institute, established with the main task of topographic maps at 1:1000 scale production as basis for designing and reconstruction of railways.
• 1983 — Photogrammetry Department at the National Cadastre Center, established. During the period 1983-1966 orthophotoplans at 1:5000 and 1:10 000 scales of 80 % of Bulgarian territory was produced.
• 2001 — Photogrammetry Department at the Geographic Information System– Sofia Ltd., established.

Now photogrammetry and remote sensing are taught in 4 universities and several

technical high-schools in Bulgaria.

Photogrammetric production

• Updating of topographic map at 1:25 000 scale (1300 sheets), size 50x50 cm.

• Updating of topographic map at 1:5000 scale (19 000 sheets), size 50x50 cm.

• Production and updating of cadastral maps at 1:1000 scale (size 80x50 cm) of urban territories.

• Production of orthophotoplans at different scales.

• Special applications.

Photogrammetric technical means and software used in Bulgaria

• Aircrafts: Antonov AN-30, L-410 Photo-variant, Cessna 404 Titan.

• Aerial cameras: RC-30, RMK A 15/23, as well as RC-10, MRB 15/23, MRB 30/23.

• Film processor: Colenta.

• Photogrammetric scanners: DELTASCAN.

• Digital photogrammetric workstations: PHOTOMOD, SOKET SET, Geomatica OrthoEngine, ERDAS IMAGINE, DVP, DiAP NT, G Karto.

Photogrammetric events in Bulgaria

More than 85 national and international conferences, symposia, seminars and meetings in

Bulgaria have been organised.

Bulgarian photogrammetric literature

• In 1930 – First Bulgarian manual in photogrammetry was published.

• During the period 1930-2006 — 37 books and textbooks ware published.

• During the period 1966-1999 — Doctors theses in Bulgaria – 16.

• During the period 1929-2009 — 38 technical specifications, regulations, manuals were published.

DIGITAL PHOTOGRAMMETRY IN BULGARIA

Selected chronology:

• 1996 — For the Photogrammetry Chair at the University of Architecture, Civil Engineering and Geodesy the digital photogrammtric workstation DVP was delivered. This was the first system in Bulgaria, intended for education. Later two installations — Geomatica OrthoEngine were delivered.

• 1999 — For the Central Military Cartographic Base ERDAS IMAGINE was delivered. This was the first system in Bulgaria, intended for production.

• 2001 — The Portuguese company Esterefoto conceded to Geoplanproject Ltd. the use of a digital system DiAP NT for production of foreign project.

• 2001 — For the Cosmic Investigation Institute at the Bulgarian Academy of Science, Geomatica OrthoEngine system was delivered.

• 2001 — GIS-Sofia Ltd. started investigations for introducing of digital photogrammetry.

• 2001 — GIS-Sofia Ltd. received from Racurs Co. one-month license on all modules of digital photogrammrtic system PHOTOMOD 3.11.

• 2002 — Digital system ERDAS IMAGINE with 5 working places for Forestry University was delivered.

• 2003 — GIS-Sofia Ltd. three systems PHOTOMOD were delivered. These were the first similar system in Bulgaria.

• 2003 — ESRI-Bulgaria Ltd. purchased an IKONOS satellite picture over City of Sofia and produced digital orthophotoplan with ± 1 m RMS error.

• 2003 — GIS-Sofia Ltd. purchase QuickBird satellite pictures over City of Sofia.
• 2004 — Eurosense-Bulgaria Ltd. received from Eurosense-Germany GmbH digital systems SOKET SET.

Application of digital photogrammetry in Bulgaria:
• Production units —11.
• Universities — 4.
• Research institute — 1.

PHOTOMOD IN BULGARIA

Introduction of PHOTOMOD

GIS-Sofia Ltd. (established in 1999) is one of the pioneers in introducing digital photogrammetry in Bulgaria. The Photogrammetry Department (established in January 2001) was the one to introduce the digital photogrammetric workstation PHOTOMOD (Racurs Co.) in Bulgaria.

GIS-Sofia Ltd. started investigations for introducing of digital photogrammetry for urban cadastre. One year theoretical and practical training for the specialists at the Photogrammetry Department was conducted. Two experimental projects were performed. Specialists for additional training in digital photogrammetry and participation in international events were sent abroad. Temporary licenses for working with digital systems of several companies were received.

The specialists of Photogrammetry Department at GIS-Sofia Ltd. tested the following digital photogrammetric workstations:
• ImageStation 2001 and Image Station SSK of Z/I Imaging;
• DVP of Leica-Helava;
• VirtuoZo of Supresoft;
• PHOTOMOD of Racurs Co.;
• Geomatica OrthoEngine of PCI Geomatics;
• ERDAS IMAGINE of Erdas Inc.

The specialists recommended to GIS-Sofia Ltd. the acquisition of PHOTOMOD, with a view to the good balance between capacity and price. In 2001 GIS-Sofia Ltd. purchased two digital systems PHOTOMOD, and later one more. The Photogrammetry Department started working with this digital system, version 3.11. Since then versions have been changed several times. Now PHOTOMOD version 5.1 is in use.

At present, six companies and one university have installed optimal numbers PHOTOMOD workstations. These are GIS-Sofia Ltd., Geocad93 Ltd., Geoconsult Ltd., Mapex Ltd., Geodetect Ltd., Geo2000 Ltd. and University of Architecture, Civil engineering and Geodesy.

Since May 2006, GIS-Sofia Ltd. has been the distributor of PHOTOMOD for Bulgaria. With the exception of the first installation, delivered to Geocad93 Ltd., all other PHOTOMOD workstations were purchased though GIS-Sofia Ltd.

Experimental projects

During 2001 on the territory of the City of Sofia two small experimental projects of 4.5 sq. km each, were performed by GIS-Sofia Ltd. The projects were pre-marked on the terrain with 24 and 77 marks respectively, and these ground control points were measured by GPS. The pictures at 1:4500 scale were taken twice by two analogue aerial cameras with focal length 15 and 30 cm respectively, and the number of the pictures was 18 (3 strips of 6 pictures each). The aerial film was scanned in Oberkochen by photgrammetric scanner PhotoScan2001 of

Z/I Imaging. The aim of the experiment was to clarify the capability of digital photogrammetry, and in particular of PHOTOMOD system, for production of urban cadastre map at 1:1000 scale. The result was very positive.

Four typical projects

1. Satellite photogrammetry. In 2003 GIS-Sofia Ltd. purchased QuickBird satellite pictures over Sofia and produced digital orthophotoplan by software PHOTOMOD with ± 0,78 m accuracy.

2. Aerial photogrammetry. In 2006 GIS-Sofia Ltd. started Vitoshka Yaka Project with area 70 sq. km, located south of Sofia, near Vitosha Mountain. The aim of the project is production of orthophotoplan at 1:1000 scale, maintains up to date cadastral information, and generating DTM. Ground control is pre-marked on the terrain and measured by GPS. Aerial pictures at 1:4500 scale are taken by analogue camera RMK TOP 30/23 of Z/I Imaging. Aerial Kodak Aero color negative film is used. The phtogrammetric process is performed by digital system PHOTOMOD. The quality of othophotoplan was high.

3. Aerial photogrammetry. In 2008 GIS-Sofia Ltd. performed its largest project for updating and maintaining the cadastral information by orthophotoplan at 1:1000 and 1:2000 scale, and generating DTM of Sofia Municipality with the entire area of 1470 sq. km, including 810 sq. km urban territory, 530 sq. km rural territory, and 130 sq. km outside its border which is frequently flooded. Depending on the picture scale the GSD is 10 cm for urban area and 20 cm for rural area. Ground control is pre-marked on the terrain and measured by GPS. Hansa Luftbild, Muenster, executed photo-flight by digital camera DMC of Intergraph. The total number of aerial pictures is 6912 with resolution 13824 x 7680 pixels and 12 x 12 μm pixel size. The images are organized in 36 blocks for processing by PHOTOMOD. They are adjusted separately, and after that regrouped in 6 large blocks. Ground control and check points used in the larger blocks for urban area are 110 and 22, and for rural area are 21 and 9 respectively. All projective centres are included in block adjustment. The achieved accuracy of adjusted blocks with 10 cm GSD is ± 8.5 cm in position and ± 8.5 cm in height, and for blocks with 20 cm GSD is ± 13.7 cm in position and ± 11.5 cm in height.

4. Satellite photogrammetry. GIS-Sofia Ltd., Geodetect Ltd. and Geocad93 Ltd. created digital orthophotoplans of a part of Bulgarian territory on the base of very high resolution satellite images. The product is used for updating the local Land Parcels Identification System of the Ministry of Agriculture and Food. The processed imagery covers 10 zones with total area of 45 183 sq. km, which are around 41 % of the country's territory. The imagery from GeoEye-1, IKONOS-2 and QuickBird are acquired during the 2008-2009 period. The most important data for final orthophotoplans are: Spatial resolution ≤ 1 m; Radiometric resolution ≤ 8 bits per channel; Spectral resolution - color; Cloud cover 5-10 %; Geometric accuracy – RMS error in X and Y ≤ ± 2.5 m. The orthophotoplans are created by digital photogrammetric system PHOTOMOD. In the process of orthorectification DTM, generated from contours of topographic map at 1:5000 scale is used.

CONCLUSION

PHOTOMOD is an up-to-date digital photogrammetric workstation, which meet the requirements of modern photogrammetric production. This digital system has an easy and user-friendly interface. In addition the customer is supplied with detailed and helpful Users Manuals. The most of the processes are automated and

the PHOTOMOD has good build-in vectorisation system.

Thereby, PHOTOMOD is quite comparable with other digital photogrammetric systems and, moreover, exceeds some of them. Special technical and economical merit of PHOTOMOD is the optimal balance between its price and capabilities.

References

1. Ivanova, K., Y. Nikolaeva. Large scale orthophotoplan of Sofia Municipality. IX International scientific and technical conference "From imagery to map: digital photogrammetric technologies. Proceedings. Attica, Greece, 2009.

2. Katzarsky, I. Development and State of Photogrammetry in Bulgaria. ISPRS XVIII Congress, Vienna, 1996. International Archive of Photogrammetry and Remote Sensing, Vol. XXXI, Part B6, Commission VI.

3. Katzarsky, I. RACURS Co. in Bulgaria. VII International Scientific and Technical Conference "From imagery to map; digital photogrammetric technologies". Proceedings. Nessebar, Bulgaria, 2007.

4. Katzarsky, I. Bulgarian Photogrammetry and its Relation with ISPRS (Abstract). VIII International Scientific and Technical Conference "From imagery to map; digital photogrammetric technologies". Proceedings. Porec, Croatia, 2008.

5. Katzarsky, I. PHOTOMOD in Bulgaria. IX International Scientific and Technical Conference "From imagery to map; digital photogrammetric technologies". Proceedings. Attica, Greece, 2009.

6. Madzharova T., Angelov A. Very High Resolution Imagery Orthorectification for Land Parcel Identification System Using PHOTOMOD (Abstract). 10th Anniversary International Scientific and Technical Conference "From imagery to map; digital photogrammetric technologies". Proceedings. Gaeta, Italy, 2010.

7. Petrova. V, M. Koeva. Digital Photogrammetry in GIS-Sofia Ltd. Third International PHOTOMOD Users Conference. Proceedings. Golitsino, Russia, 2003.

Experience of Using Satellite Images to Update the Topographic Mapping of the Nagorno-Karabakh

Andranik R. Khachatryan

Center of geodezy, mapping, land planning and extent, Nagorno-Karabakh

Taking into account the importance of topographic maps in various spheres of life, we make great account of regular updating of the information we have.

Diverging from the methods used in our country during the post-Soviet period, this time we've used the satellite images.

The background information for updating the maps on a scale 1:10 000 was received from the satellite using the remote sensing station. The received photographs have met the following requirements:

- Cloudiness and snow mantle didn't exceed 10 %
- Deflection of the satellite lens against nadir was ±15°.
- Declination of the sun to 30 °.

Image resolutions were 0.8–1.3 m.

To realize the project, it was necessary to provide the creation, condensation and

equalization of compilation survey of satellite images materials.

The layouts of tokens were made on the satellite images enlarged 3-4 times.

Sharp contours and terrain objects were selected as tokens.

The coordinates and heights of the tokens were defined with the application of double-frequency GPS receivers, simultaneously using 2 stations, one if which is permanently acting.

The coordinates of the points of the planned bases were determined in the coordinate system of 1942 and were recalculated into a global geodetic coordinate system WGS -84.The coordinates and heights of the tokens were identified with high accuracy (0.1 mm to scale).

For 1: 10 000 scale, the difference of coordinates for one point didn't exceed 1.2 m, with a tolerance of 2 m, for an interval contours over 5 m. the difference of altitudes was 1.5 m., with the tolerance of 2 m. The heights of the points were identified in the Baltic system of heights of 1977. The average residual errors on the points of geodetic base after the internal orientation of route or panel networks didn't exceed the height of interval to 0.15, and the planned coordinates to 0.2 mm.

The differences of the errors between the planned position of the points didn't exceed 0.3 mm.

The maximum value of the error didn't exceed the triple value of average measures.

The subsequent decryption of satellite images was carried out according to the preliminary design, where the territories to be decrypted by means of field classification have been marked. The field classification was performed on photomaps, applying the means of ground mapping or overall decryption. The latter was applied in the areas of concentration of large amounts of topographic objects. The quality of satellite images, the landscape type and the expertise of the performer substantially influence the quality of satellite images decryption. During the field classification, the following negative peculiarities have been considered:

- The distortion of the configuration of individual objects, as well as properties of decryption (a form of shadows, etc.)
- The deterioration of image quality due to a sharp change in the nature of the landscape and the reflection ability, as well as state of the atmosphere.
- Obstructing or eliminating processes of decryption, clouds expressed on the photos, etc.
- Identifying the angulations of the image (more than 5°) or the difference of the image projection of the central.

The registration of the decryption results were summarized in the layouts: objects with the image of the corresponding symbols, with reports with neighboring sheets, attributes and quantitative characteristics.

Orthophotoplans were created on basis of satellite images with the help of PCI, ORTHONORM program packages applying the method of digital transformation.

The process of obtaining the digital photoplans included:

- The calculation of permissible elements for images input
- Image orientation
- Selection of transformation sites
- Report on images sections, equalization of the shades and receiving the transformed images in the frameworks of the given sheet.

The elements of the external orientation of the digital images were received in

the space of the pre-built photo- triangulation net.

For the digital transformation of the images the necessary relief data were obtained from the digital terrain model of topographic map.

The transformation of the images was made on the usable area within the borders that are contiguous with the lines drawn in the middle zone of transverse and longitudinal coverage.

The accuracy of the created photoplans was estimated by basic and reference photogrammetric point, comparing the coordinates of these points.

On a scale of created photoplan, the magnitude of errors between planned positions of the basic and reference points didn't exceed 0.7 mm, and the inconsistencies of contours in the segments of linear connections didn't exceed 1 mm.

The maximum value of inconsistencies of contours in reports was 1.5 mm.

The topographic maps on a scale of 1:100 000 received in the result of updating were digitalized.

A logbook of the maps was created (60 complete and incomplete sheets)

The digitalized 1:10 000 scale maps will further serve as basis for updating the NK 1:25 000 – 1:100 000 scale topographic maps.

In conclusion, I would like to note that positive results obtained in the process of images transformation for updating the maps were of satisfactory quality. Also, they met the requirements of the time they were created, which can not be said about today.

Participation in such events will allow us to become more familiar with modern technology in this area and create a favorable ground for cooperation with specialized companies to apply newest technologies and methods for their implementation in our conditions.

At the end I want to express my profound gratitude to the organizers of the conference for their warm hospitality and mark out the impeccable level of organization of the event, wide range of topics discussed, which will allow us more clearly imagine the way we still have to pass for the further development of photogrammetric works in our region.

PHOTOMOD 5.2

Alexandra S. Kiseleva
Racurs, Russia

We attentively follow modern technology and innovations in digital photogrammetry, so there is a large variety of new capabilities, allowing to use these technologies with maximum effectiveness.

The first part of the report is devoted to reviewing latest PHOTOMOD achievements and development trends, in the second part we consider 3D-modelling tools in 3D-Mod a little bit more.

PHOTOMOD GeoMosaic 5.2. Great Step in Functionality and Productivity

Dmitry V. Kochergin
Racurs, Russia

PHOTOMOD GeoMosaic is a program used for creating mosaic from georeferenced aerial and satellite images and other rasters (topographic maps, plans, etc.) and transforming rasters into selected scale and map projection. The presentation illustrates main advantages of new version of GeoMosaic 5.2 including:

- big projects optimization (tens of thousands images, unlimited image size);
- new fast and smart automatic seam lines algorithm;
- automatic tie points for merging images of inaccurate source georeference;
- seam lines editing in mosaic preview window along with its redrawing on-the-fly;
- distributed processing optimization;
- standard map sheets generation;
- integration with WMS datasets;
- georeferencing to reference maps and images;
- vector objects editor containing all tools from the *'*main*'* PHOTOMOD system.

New Developments in Geoinformation Technology and Their Impacts on Photogrammetry and Remote Sensing

Emeritus Prof. Gottfried Konecny
Leibniz University Hannover, Germany

Due to the integration of its components geoinformation technology has reached a challenging status, in which the original issues for mapping have greatly expanded.

The cause for this are the advances in:

- Satellite positioning.
- Digital imaging.
- Satellite imaging platforms.
- Laser scanning.
- Rapid computer technology advances.
- Data base technology.
- The worldwide web.
- Mobile communication technology.

There is still no end to these developments and geoinformation technology has the challenge continuously to adapt to these changes.

Remote Sensing Serving Regional Development

Emeritus Prof. Gottfried Konecny
Leibniz University Hannover, Germany

Remote Sensing theory is part of Theoretical Physics, which was developed until the first half of the 20th century. Early remote sensing applications originated as photographic interpretation within photogrammetry.

Due to development of non-optical sensors and space technology remote sensing became an effective tool for earth observation since the first remote sensing satellite Landsat in 1972 as a digital system.

In the last 40 years remote sensing technology improved in spatial resolution by two orders of magnitude and built imaging sensors outside the visible electromagnetic spectrum (thermal, radar).

The restitution capabilities of image processing and spectral analysis were made possible through geographic information system developments.

The effective use of remote sensing products is made possible by databases accessible through the Internet, as shown in the USA and in Europe.

An effective utilization of remote sensing products is the International Charter on Space and Major Disasters.

Kanopus-V Satellite Images Processing Technology in the PHOTOMOD Digital Photogrammetric System

Elena V. Kravtsova
GIA INNOTER, Russia

Described the perspective Kanopus-V satellite:

- basic mission;
- on-board equipment technical characteristics.

Described Kanopus-V SV images processing technology in the PHOTOMOD DPS:

- model photographs creation basing on the Kanopus-V satellite geometric model without regard to the navigational system errors and taking into account the errors, introduced by the navigational system;
- change points automated measurement;
- control survey point input and measurement;
- unit outer orientation block;
- orthophotomaps generation;
- orthophotomaps maximum possible and true accuracy estimation.

Development of Dynamic Geometrical Model of Shooting of Optoelectronic Taking Systems for Perspective Space Complexes

Ekaterina V. Makusheva
NPP VNIIEM, Russia

Nowdays in VNIIEM* operations on creation of a space complex of operative monitoring of technogenic and natural emergency situations which include the space vehicle (SV) distant Earth sounding (DES) Kanopus-V are conducted.

The purpose is the development of the mathematical description for dynamic geometrical model of optical-electronic imaging systems and the implementing software package.

Development of the geometrical model is considered on the assumption of the initial data on a space complex.

The following tasks were solved:

• Gathering, ordering and the analysis of the initial data on KA «Kanopus-V»;

• Obtaining geometrical model mathematical description of imaging panchromatic and polyzonal cameras on perspective space complexes;

• Technology development for the camera calibration parameters estimation under SV constructive characteristics (before the start of SV);

• Development of the software module formation of the pictures modeling received by panchromatic and polyzonal cameras (before the start SV);

• Development of the calibration technology for cameras according to data of imaging polygon (after the start of SV);

• The programming module development estimating coefficients of rational polynomial functions for analyzing pictures in standard photogrammetric packets according to the international requirements;

• The programming module development for ortho-rectification on the basis of the developed geometrical model of SV cameras.

In the paper there is short description of an onboard complex of the target equipment including:

• panchromatic imaging system, providing image receive, formation of a panchromatic video information and its output to the onboard information system;

• polyzonal imaging system, providing the image and video information receive, formation in four spectral zones and its output to the onboard information system.

The singularity of panchromatic imaging system creation consists of that the image in it is formed on an array of micro frames, each forms the image under laws of a central projection. Mosaic formation ortho-rectificationed micro frames is carried out taking into account orbital driving SV. Characteristics of imaging systems are resulted.

The dynamic geometrical model of imaging which represents as the mathematical description of imaging systems allows to receive the pictures adhered to area by the given navigation. Thus the exact geometrical model will allow to generate the special description for picture (RPC — rational polynomial coefficients) for its exact binding in the majority of standard packets (ERDAS, ENVI, etc.) direct to user without disclosure of details in the camera description. RPC (Rational Polynomial Coefficients) were widely adopted as geometrical model scanning high resolution pictures. The description of algorithm of the rational function coefficients generation is resulted.

Development of geometrical model of imaging systems and the imaging itself will allow to expand data application fields by data received from the perspective space complex like Kanopus-V, to raise efficiency of obtaining of the geo adhered information.

*The federal state unitary enterprise The Research-and-Production Enterprise All-Russia Scientific Research Institute of Electromecanics with Factory of a Name of A. G. Iosifjan.

Test Site for Testing of UAV Imaginary for Terrain Mapping and Monitoring

Alexander P. Mikhailov, Vladimir M.Kurkov, Alexander G. Chibunichev
MIIGAiK, Russia

Today UAVs are used for aerial survey, and acquired data is a basis for a variety of tasks in different areas, particularly, for creation maps and digital terrain models, as well as for monitoring both of natural phenomena and human activity results.

Wide range of existing UAVs and navigational hardware installed on them makes necessary developing of theoretic recommendations on selection of aerial survey parameters. They should be selected depending on a mapping scale and needed accuracy of digital terrain models for each aerial survey system involved. It is also necessary to develop recommendations on field survey for airborne data. Obviously, that reliability of these recommendations should be verified by testing and industrial practice.

They most effective and fair way to verify and estimate terrain mapping and monitoring methods, that use data acquired by aerial survey system installed on board of UAV, is to analyze airborne data acquired for test site, which allows to estimate a quality of resulting products using ground control and check points as well as other reference data.

In 2011 Moscow State University of Geodesy and Cartography (MIIGAiK) started the creation of dedicated research site for analysis and evaluation of terrain mapping and monitoring techniques, using aerial survey systems installed on pilotless vehicles.

This site is located in Tulskaya oblast at a distance of 110 kilometers from Moscow and is about 50 sq.km in area. The site territory is chosen to include different natural land forms and man-made objects. The territory covers forested areas, various water bodies, different relief features, agricultural lands and industrial objects. There are also some settlements, such as urban village, villages, suburban and cottage communities. The territory includes rail ways, motor ways, country and field roads, electric power lines of different voltage and pipelines. The site also is covered by quite dense geodetic network.

The site creation includes the following works:

• creation of topobeacons network to provide topographic mapping in 1:10,000 – 1:500 scales. We are going to create topobeacons both as marking figures and as marks on well-defined terrain features.

• creation of digital terrain models and digital mosaics of different accuracy on

the site's territory using aerial and space borne data.

• creation of spatial test-object for field photogrammetric calibration of digital cameras and definition of lens projection center and antenna phase center of GPS, installed on UAVs.

• creation of digital topographic and thematic maps in 1: 10,000 – 1:500 scales on the site territory. Mapping includes complete field topographic and thematic classification.

• creation of different calibration patterns for detecting of aerial images resolution.

By August 2011 we created spatial test-object for field photogrammetric calibration of digital cameras and for calculating of lens projection center and antenna phase center of GPS, installed on UAVs. We started works to create of topobeacons network, digital elevation models and digital orthomosaics.

In July 2011 on MIIGAiK test site we performed research of photogrammetric workflow for mapping in 1:2,000 and 1:500 scales using domestically produced pilotless vehicle PTERO, created by "AFM-Service" for digital airborne survey. Specialists from MIIGAiK and OOO "AFM-Service", researchers of "Racurs" and "GNSS plus" companies took part in the testing works.

On the Technology Interpretation of the Earth's Surface Radar Images

Pavel I. Neyman
OJSC 'RI PI', Russia

The paper considers the technology of aerospace radar images (RI) interpretation, which has a lot of common operations with interpretation of optical images. The technological process of RI interpretation must flow in a certain time frame. To realize the main advantages of radar remote sensing (all-weather, day and night observation) time limits should apply to the whole technological chain RI forming planning and carrying out surveys, delivering information on ground-based receiving and data processing.

RI interpretation technology involves several steps. The first step is formulation of the RI interpretation problem, which is used for formal description of the remote sensing task (FDRST) with the possibility of use for interpretation RI with different wavelengths, needed spatial resolution, radiometric resolution and radiometric sensitivity, allowing to detect and recognize objects with a given value of radar cross section (RCS). We must also consider the possibility of radar observations with the required frequency for the effective change detection in RI.

In the next step of RI interpretation other radar and optical images that can be used for interpretation according FDRST are selected from the available archives. One of the important operations related to this stage is planning the special survey that meets the requirements of the FDRST. For example, for efficient monitoring tasks the special periodic survey is essential.

At the next stage of learning materials together radar imagery using two types of approaches:

1. Visual learning (understanding or interpretation) of RI, which can be regarded as a kind of semantic processing of radar data.

2. Computer processing of RI for the purpose of preparation and solution of inverse problems of scattering of radio waves that allow using mathematical models and experimental data to determine the parameters of objects from the values of the RCS.

For visual interpretation is of great importance in seeing RI by interpreter, which is caused by the nature of the radio waves reflection from the observed objects. An object with diffuse scattering observes on RI of geometric shapes, which facilitates their detection and measurement of geometrical parameters. At the same time, geometric configuration of objects that create mirror reflection, can greatly distort and even split into disconnected fragments, which complicates the identification and recognition of such objects. Therefore, for the visual interpretation of RI is commonly used reference information in the form of topographic maps and optical images. However, supporting information often does not contain the full amount of data required for RI interpretation. Therefore, in many practical situations, there is a need to use reference RI, obtained in earlier times, at other wavelengths and / or with other polarizations. Reference RI may be different resolution and other parameters. These features visual interpretation of RI should be considered when establishing special training facilities, which form an integral part of the interpretation.

The visual interpretation of RI can provide recognition of objects with geometric dimensions that exceed resolution sell of radar. In addition to measuring the linear parameters of the objects in the visual interpretation of the radar can provide a measure of contrast and RCS values, if used with calibrated RI. However, small-sized objects, comparable to the resolution sell, the visual interpretation is generally not accepted. For recognition of small objects using their radar signatures analysis, which constitute the backscattering matrix. The difficulty of obtaining such data make it necessary to use in analyzing radar signatures of the reference information in the form of generalized dependences of the RCS, the calibrated radar data, etc. Requirements for standard information are followed from information features system (IFS) of target representing, interrelated set of direct and indirect interpretive features of the remote sensing task.

Software and hardware for automation of interpretation process are designed to perform specific operations on radar data processing for RI interpretation. The list of tasks for radar data processing consists three groups:

1. The first group is allocated preparation and handling of single RI.

This group of tasks consists of the synthesis RI for a variety of observation modes (Spotlight, ScanSAR, Stripmap), formation of the amplitude and complex RI, radiometric correction and calibration, geometric correction (geo-coding) and the speckle reduce etc.

2. Joint processing of multiple radar images.

The second group includes the problem combining the grids of processed RI (co-registration), color coding, change detection on the processed RI, which may be due to different wavelengths, polarizations, the survey time.

The second group also includes the task of spatial processing, including radar interferometry and RI stereo processing to measure the of landscape height.

Interferometric processing tasks form a separate group, which, depending on the type of Interferometric surveys (one-pass, two-pass) may include the problem of differential interferometry, polarimetric interferometry, as well as along orbit

interferometry for moving target indication (MTI).

The third group consists of task-related interpretation of RI — to detect and recognize objects, the combination of radar and optical images, and other information. The last operation can be used in the processing of single, paired and serial RI.

In general, the report shows the role and place of technology in the radar image interpretation of remote sensing for solving problems of monitoring and mapping the Earth's surface.

3-D Scene Rendering of Urban Areas for Disaster Relief Efforts: LiDAR Case Study for Haiti

Susan Parks
ITT Visual Information Solutions, USA

LiDAR data can be combined with spectral imagery sources to efficiently provide map and information support for relief and recovery in the aftermath of a disaster, such as an earthquake. This paper will explain how LiDAR data can be used for crisis management, including the 3D reconstruction of urban areas in Port-au-Prince, Haiti, following the January 12, 2010 earthquake.

3D maps constructed from LiDAR data aid emergency managements teams in determining the location of collapsed and standing structures, as well as supporting landing and routing tasks. In this study, the E3De LiDAR processing tool was used to extract buildings and significant debris coverage from a dense LiDAR point cloud collection from the aftermath of the earthquake. ENVI was used to fuse image data with the processed LiDAR data for enhanced road extraction efforts. Debris information from E3De was combined with the extracted road layer and used to construct an intact road network for input in ArcGIS Network Analyst to support ground team routing. Debris coverage and 3D urban topography was also used as an input into a helicopter landing zone and to identify areas to focus rescue efforts.

Experiment in Digital Terrain Model Generation Using Stereo Pair of Panchromatic Images from the RESURS-DK 1 Spacecraft

Alexey A. Peshkun, Vladimir Yu. Melnikov
JSC 'Russian Space Systems', Russia

Generation of Digital Terrain Model (DTM) is one of the key tasks for photogrammetry, topography, and other relevant areas. Foreign high-resolution spacecraft such as GeoEye, Ikonos, WorldView perform stereo imagery that enables production of DTM by stereo pair. The Russian high-resolution RESURS-DK 1 spacecraft does not perform stereo collection, however over the 5-year period the spacecraft has imaged more than 20,000 routes and most of them are overlapped. At the Research Center for Earth Operative Monitoring there has been pursued the

experiment to produce DTM using the RESURS-DK 1 pair of overlapping images taken from different orbits.

To create a stereo pair, there have been selected two overlapping panchromatic images of test area near Hobart, Australia. The images were taken both at ascending and descending branches with roll angles of 5°59'12.28" and 3°13'48.41" respectively at sun angles of 63° and 37. The imagery was performed in the day-time with 50-day interval; the spatial resolution on ground is 1.2m. The stereo pair was processed using the Photomod 5.2. digital photogrammetric station. To specify the elements of image exterior orientation there was made phototriangulation at the PHOTOMOD station using 45ground control points and 9 level and plane control points.

The DTM was produced in semiautomatic mode. The first stage provided for construction of digital terrain model in 10m grid interval in automatic mode and then an automatic filtering of the DTM nodes was made using the PHOTOMOD facilities. The next stage provided for checking the DTM generated including the remove of incorrectly formed in automatic mode and program-unfiltered nodes, drawing of structural lines, and adding of missing nodes. The accuracy was evaluated using 49 level and plane control tokens. The maximum discrepancy was 3.1m, and root-mean-square error was 1.38m. The error was less than 1.63m per 75.5% (37) of ground control points located within built-up territories on foothills.

The findings achieved are as follows:

1. The generation of stereo pair using two overlapping images taken from different orbits by the RESURS-DK 1 is feasible;
2. Digital terrain model may be constructed by the stereo pair generated;
3. Digital terrain model created meets the requirements for constructing horizontals with 10-m interval;
4. Taking into account of the similarity of the RESURS-DK 1 and RESURS-P imagery systems, it is possible for the technology developed for images to be taken from RESURS-P to be used.

Updating of Bulgarian Large Scale Topographic Map by Digital Photogrammetric Software PHOTOMOD 5.1

M. Sc. Vanya Petrova
GIS-Sofia Ltd., Bulgaria

High resolution images have always attracted much attention in creating and updating topographic information due to the large capacity of digital photogrammetric systems. Traditional film cameras are gradually being replaced by digital cameras and scanners. Most topographic mapping still relies on sensors based on airborne platforms.

In this paper the main approach for updating urban information using digital photogrammetry, in particular PHOTOMOD system, and GIS data is described. The need for creating new laws and technical specifications concerning this process is emphasized. After a review of the methods used in Bulgaria for this purpose, a pilot project for creation of large scale topographic digital maps is presented.

The project covers the main types of areas - urban, agricultural and forests. The project aims to create new regulations complying with modern standards and technologies, and meet user needs of geodetic and cartographic materials. The pilot project aims to identify the main activities and rules for creating digital large scale topographic maps (1:5000, 1:10 000), map content, processes and procedures. The aim of the project and the analysis thereof is to serve as a solid basis for current technical specifications, regulating the requirements and guidance of technology for creating and updating digital topographic database collection and use of topographic information. The paper contains a detailed description of activities, analyses and conclusions of the project.

The replasement of old working methods by new ones and their high efficiency is emphasized. A comparison between the practice standards and requirements in Bulgaria and abroad are discussed. The paper shows the status of the work and gives an outlook for the generation of high resolution digital technology.

Concerning the digital technology of this century and the steady increase in urban territories, it is necessary to create and update the entire topographic information in Bulgaria. It has to be done under strict regulations which basis is laid down in the work of the pilot project.

Finally a question is whether satellite imagery will replace airborne (digital or analogue) photography for the maps makeing.

Fast Access to More Detail, Better Insight, Accurate Analysis — European Space Imaging and the WorldView Global Alliance

Felix Puls
European Space Imaging, Germany

European Space Imaging (EUSI) and DigitalGlobe have established the WorldView Global Alliance. Through the Alliance, customers have access to imagery from the industry-leading DigitalGlobe constellation of satellites, including the recently launched WorldView-2 satellite and DigitalGlobe's leading ImageLibrary, with over 1 billion square kilometers of high-resolution imagery. The Alliance delivers a full suite of online and offline products and services, with high levels of local customer support.

Launched from Vandenberg AFB, California, on 8 October 2009 and fully operational since 4 January 2010, WorldView-2 is the newest addition to DigitalGlobe's constellation of very high resolution optical satellites. This constellation now comprises of QuickBird, WorldView-1 and WorldView-2.

WorldView-2 is DigitalGlobe's second next-generation satellite. WorldView-2 is equipped with state-of-the-art geolocational accuracy capabilities and is equipped with control moment gyros, which enable increased agility, rapid targeting and efficient in-track stereo collection. This advanced agility combined with an operating altitude of 770 km enable it to collect nearly 1 million km^2 of high-resolution imagery per day, and offer average revisit times of 1.1 days around the globe.

Complementing the large-scale collection capacity is WorldView-2's high spatial

and spectral resolution it is able to capture 46 cm panchromatic imagery, and is the first commercial satellite to provide 1.84 m resolution, 8-band multispectral imagery. The high spatial resolution enables the discrimination of fine details, like vehicles, shallow reefs and even individual trees in an orchard, and the high spectral resolution provides detailed information on such diverse areas as the quality of the road surfaces, the depth of the ocean, and the health of plants. The additional spectral bands enable WorldView-2 to more accurately present the world as the human eye perceives it, creating a more realistic "true color" view of the world.

Multispectral imagery has provided great value in helping to understand the earth and the impacts of natural processes and man-made activities. In the presentation we will look at four major categories of remote sensing applications: feature classification, bathymetric measurements and vegetative analysis, change detection and explore how they can be enhanced with the increased spatial resolution, spectral fidelity and collection capacity of WorldView-2, especially in defence applications.

During February and March 2010 the local European Direct Access Facility (EDAF) for WorldView was set-up at the German Aerospace Center DLR near Munich, Germany. After extensive testing the EDAF became fully commercially operational on 16 April 2010 to:

- locally task both WorldView satellites;
- receive data through a direct down-link;
- process and deliver images and derived products.

The presentation will highlight the advantages of local satellite tasking using EUSI's WorldView ground station and of DigitalGlobe's satellite constellation.

Visionmap A3 LightSpeed — a New Generation of the Ground Processing System

Michael Pechatnikov, Yuri Raizman
Visionmap Ltd, Israel

A new VM A3 LightSpeed ground processing system is a further development of the last version VM Pendulum 2.0 SW and VM DataViewer program.

The system is designated to viewing, analyzing and processing of the aerial survey data received by VM A3 aerial digital camera and enables to carry out the following procedures and create photogrammetric products as follows:

- viewing, analyzing, arrangement and management of the aerial survey data;
- project creation;
- processing job creation;
- cluster servers distribution/assignment for different processing jobs or for different operators;
- aerial triangulation block adjustment without GCPs;
- if necessary — aerial triangulation exterior orientation (and readjustment) with GCPs;
- DSM calculation (correlation) and export;

• orthophoto cut-lines automatic generation with an option for manual editing;
• color (RGB), color infra-red (CIR) and multi-channel (RGB+NIR) orthophoto generation;
• orthophoto radiometric editing in the frames of one or many blocks;
• oriented vertical and oblique images export;
• SLF (Super Large Frame) for stereo compilation creation and export;
• image radiometric calibration;
• different report generation and export.

The A3 LightSpeed system has included not only essential changes on the program level, but constructive changes of the cluster as well. All this has resulted in significant raising of the ground processing productivity.

Additional quantitative amendment is a permissible size of the triangulation block. This new version enables to process blocks with up to 250,000 frames that corresponds to 8.7 sq.km with GSD = 15 cm or 23.8 sq/km with GSD = 25 cm.

The DataViewer program is designated to viewing and analyzing the images. There is a new option — histogram changing, than influences positively visual quality of the images as well as GCPs measurability.

A3 LightSpeed enables 12 bit image processing at all image processing stages. The final orthophoto is exported in 8 bit format.

A new ability – parameters setting for the orthophoto homogeneous radiometric correction. For the differential (non-homogeneous) radiometric correction a new effective concept was developed and realized.

The new program enables generation of 4 channel (RGB+NIR) orthophoto, possessing a wide use in the remote sensing.

The changes have touched not only processing productivity and image quality, but the photogrammetric accuracy of the processing results as well. The last practical results show that the A3 system in general, with use of a few GCPs (4 – 5 for block), ensures the accuracy of 0.2-0.3 pixel at check points.

Amendments have been conducted in the A3 camera program as well. One of the essential is an improvement in exposition control that brings lighter images and lows image's noise.

Processing of Space Images Acquired by GeoEye-1 Satellite in PHOTOMOD System

Yana V. Razumova
SurgutNIPIneft JSC "Surgutneftegaz", Russia

On the balance sheet of OAO "Surgutneftegaz" there are 145 license areas, which occupy more than 137,000 sq. km in Western, Eastern Siberia and northwest region of Russia. Active development and exploitation of new fields, and developing of existing ones requires providing of actual information about the territories, in particular, remote sensing data.

Along with traditional airborne data in different scales, space data is widely used. In case of new distant deposits development it is the most optimal and economically feasible method of data providing.

Since 2010 OAO "Surgutneftegaz" concludes contracts on delivery of high resolution imagery obtained by GeoEye-1 satellite. This sensor was selected due to its maximal space resolution possible in that time, that allows to solve a wide variety of tasks. Besides we take into account high geopositioning accuracy and mobility of the satellite that provide efficient production of survey.

This presentation describes processing workflow of data acquired by GeoEye-1 space satellite using PHOTOMOD system considering delivery particularities of RPC-coefficients for these images, and using of different solutions for adjustment of scanner imagery monoblocks. The presentation also contains accuracy characteristics of each work stage.

UAV Images Processing Capabilities

Yuri A. Sechin
Racurs, Russia

The presentation gives a review of UAV's mostly used in Russia for the aerial survey along with the UAV aerial survey specialties description. There are also recommendations for the flight planning and on-board system (sensor and GPS/IMU) requirements included. The main purpose of the recommendations is to reach maximum accuracy of UAV data photogrammetric processing. The presentation is also devoted to PHOTOMOD specific tools developed for UAV images processing and contains some samples of the UAV projects already done in Racurs.

Space Perspectives of PHOTOMOD System

Victor P. Savinykh, Anatoliy E. Zubarev, Irina E. Nadezhdina
MIIGAiK, Russia

Priority areas of space exploration in MIIGAiK Complex Laboratory of Extraterrestrial Research are surfaces of planets' natural satellites: our closest 'neighbor' — the Moon, Phobos and Deimos (Mars' satellites), Io (Jupiter's satellite), Enceladus (Saturn's satellite).

Effective basis for successful performing of these tasks are sets of space images of extraterrestrial objects surface, acquired by automatic spacecrafts. However these images are quite heterogeneous. They were acquired by different space missions, with significant time interval, by different cameras and using different methods.

For processing of space images of distant Solar system objects our foreign colleagues along with commercial software modules widely use non-commercial photogrammetric software (VICAR, ISIS), specially developed for NASA and ESA projects.

Available commercial digital photogrammetric systems (DPS): INPHO, PHOTOMOD, and Talka were analyzed in MIIGAiK Complex Laboratory of Extraterrestrial Research. It turned out, that none of the systems is orientated for

processing of small space objects images acquired by automatic spacecrafts. The reason is the survey's peculiarity: spacecraft is far away from the object under survey, and spacecraft location on the orbit is known with poor accuracy. These reasons lead to the following processing obstacles:

- algorithm of classic "terrestrial" photogrammetry is based on assumption that relative orientation angles are of small values (less than 5-10 degrees), otherwise errors in object's coordinates fixation are very big;
- for images of low-sized celestial bodies (that are overwhelming majority of Solar system bodies) values of exterior and relative orientation angles may be very big (50-60 degrees). In this case automatic correlation of images is ineffective;
- detection of relative orientation parameters is iterative process and if relative orientation angles are big enough, and iterations may fail if initial guess is not good enough;
- almost all space images have different scales that additionally complicates identification and automation of tie points measurement;
- exterior orientation angles should be detected with high precision, because tie points measurement errors hamper iterative adjustment. Accuracy of exterior orientation angles also defines adjustment method.
- considerable complication of orthorectification procedure due to images perspective distortion.

In cooperation with Racurs company we have developed new algorithms of images processing of Solar system small bodies using DPS PHOTOMOD. The algorithms are highly important for practice and academic research. Today specialists of MIIGAiK Complex Laboratory of Extraterrestrial Research obtained first processing results of Io and Phobos images using Racurs company software.

Operational Space Monitoring and Geoportal Solutions

Marina A. Sergeeva, A. Potapov
RDC ScanEx, Russia

Nowadays Earth observation images from space are one of the most independent and operational sources of data. Service of operational satellite-based monitoring with Earth imaging equipment of middle and high spatial resolution has been quickly developing in the Earth remote sensing industry.

Based on the experience of combination of operational high resolution imagery data of leading satellite programs like SPOT-4/5, IRS, EROS, FORMOSAT-2, RADARSAT-1/2 and ENVISAT-1, ScanEx RDC has developed a technology based on the principles of coordinated control of imagery and data-flow processing of received to the network of ground stations imagery results of several RS satellites of high spatial resolution in near real-time.

For the promotion of this technology ScanEx Center created own network of four data reception and processing centers in Moscow, Megion (Khanty-Mansiysk Autonomous Area), Irkutsk and Magadan, which are equipped with 10 universal small-size UniScan stations ensuring data reception from 14 modern RS satellites at the rate of 320 Mbps (per one channel). Firmware assets of the centralized web-

access enable to do operational remote control of the stations operation from the Center located in Moscow.

Principles of universality and open architecture of the UniScan firmware enabled to simplify and make cheaper the technical outfit of receiving centers as compared to traditional concepts of receiving centers' furnishing with special stations by RS satellites operators.

Web-services based on Kosmosnimki.ru geoportal, created based on GeoMixer technology, are applied for quicker delivery of end products to the customer.

Over the past 3–4 years the company managed to develop and adjust functioning of web-service of operational satellite monitoring; web-services providing access to spatial data (maps, images, analytic information, etc.), web-catalogs of RS data. Different thematic services have been developed today: for satellite monitoring of fire situation, river floods, environmental situation in water areas and emergencies (EMERCOM departmental geoportal "Kosmoplan"), forest management monitoring (Rosleskhoz departmental geoportal), etc. On one hand, geoportals help solving industrial or administration management tasks, on the other they ensure access to a wide range of users to respective data in interactive mode.

A complex of geoportals with open access to its data has currently been operating in the net.

Materials of satellite surveys of ecological and shipping situation in Russian water areas are available at the "Kosmosnimki — Seas of Russia" geoportal (http://ocean.kosmosnimki.ru/).

One may get information about the status of protected natural areas, including the detected infringements, at the "Kosmosnimki — OOPT" resource (http://oopt.kosmosnimki.ru/). Materials of monitoring the stages of Khimki forest highway construction are available here as well.

Data about fire situation in one or another Russian region is updated daily on the "Kosmosnimki — Fires" geoportal (http://fires.kosmosnimki.ru/). Operational satellite-based fire situation monitoring is conducted by ScanEx RDC. Thermal anomalies — probable fire blazes — are detected using MODIS sensors of Terra and Aqua satellites.

Quite often satellite imagery data becomes the only possible source of operational data about the condition of an object/area. For example, based on highly-detailed images, received within the first hours after the tragic Haiti earthquake in January 2010, more detailed maps of the damaged city were prepared. Rescue teams from many countries were able to use these maps in their navigation devices.

Satellite imagery data was used for the rescue operations in the Sea of Okhotsk in January 2011, where On December 31, 2010 several ships reported at the same time that their movement was paralyzed due to heavy ice situation.

When different information started to enter about the explosion near the city of Abadan (Turkmenia) in July 2011, space images confirmed that the emergence occurred at the ammo depot. Detailed images detected destroyed storage houses and craters as a result of explosion.

Under new conditions, when space imagery became an open tool, the combination of user-friendly technological tools (geoportal technology) and active, interested in unbiased information user communities, is capable of becoming a powerful tool of organization of public control of most various aspects of human activities. Already today it is possible to create conditions to form innovation systems for monitoring,

for example, construction of social importance or ecological situation, abidance by the rules of nature use or even tracking down genocide cases (for example, there is a project on monitoring threats for civil population on the territory of the Southern Sudan (http://www.satsentinel.org/about). For example, last year in Russia after summer fires, ScanEx RDC based on the "Kosmosnimki – Fires" service together with OSM community launched a project on digitizing of burnt areas boundaries. Now this data has been used by different organizations for assessment of damage, caused by fire.

In the future the experts expect more involvement of institutes of civil society in creation of similar mechanisms of control. Probably, in the nearest future it will be the needs of different civil thematic user communities that will define the development vector of the industry of remote sensing from space.

Remote Sending Today — Evolution from Pixels to Integrated Solutions

Andrey Shumakov
GeoEye, USA

Today's remote sending industry is considered to be one of the most innovative sectors of the economy that combines the most advanced technology from the space industry with the latest achievements in data processing, analysis and distribution. Latest developments in cloud computing, collaboration tools, and online applications combined with growing demand for timely access to vast amount of geospatial information and deep analytic expertise have encouraged the industry to look for more innovative solutions. The presentation will continue the discussion started at the last year's conference about new approaches to serve and process geospatial information.

Mr. Shumakov will also brief the audience on the status of GeoEye-2, the next generation GeoEye satellite expected to be operational in 2013, and provide an overview of GeoEye's commercial activities and collection campaign in Russia in 2011.

As imagery has evolved and increased in volume, we see now that imagery content has become more difficult to distribute and to maintain. Very large files, complex image formats, and cryptic metadata issues present challenges to even the best I.T. organizations. Viewing and manipulating geospatial content in an enterprise environment also introduces dependencies on specialized server software, which adds to the growing demands placed on today's corporate hardware and network environments.

To address the challenges facing enterprises, and to utilize the newest achievements in geospatial technology, the Earth Observation industry is increasingly more focused toward a customer-driven Internet-based and cloud-based approach to serve and process geospatial information. For example, last year, here at GeoEye we introduced 'EyeQ,' a software-as-a-service platform that provides managed services for searching and acquiring imagery, managing spatial information and enabling collaborative access across an enterprise. EyeQ combines imagery products with on-demand tools for managing geospatial

information and project-based collaboration. EyeQ provides our customers access to secure, timely, and accurate location information seamlessly delivered into their business environment. For our major customers, we are hosting data in a Web services environment so that large numbers of users can access it securely – anytime, anywhere.

Another example of the emerging shift to Information Services would be products and solutions coming out from our new GeoEye Analytics division. GeoEye Analytics provides geospatial predictive analysis, expert insight, intelligence, and information solutions to defense, intelligence and homeland security customers. Their pioneering work takes complex geo-processing capabilities and delivers them to the user as powerful and intuitive applications.

GeoEye Analytics presents synergies with the online, on-demand solutions we are delivering through EyeQ. We believe it will have applications in a number of vertical markets as well – some examples include helping the financial services industry predict fraud, aiding oil and gas exploration companies to prepare for lease block auctions, or helping law enforcement agencies determine where to best position scarce resources to prevent violent crime.

About GeoEye

GeoEye is a leading source of geospatial information and insight for decision makers and analysts who need a clear understanding of our changing world to protect lives, manage risk and optimize resources. GeoEye, Inc. is a premier provider of superior satellite and aerial imagery, location information products and image processing services. Widely recognized as a pioneer in high-resolution satellite imagery, GeoEye has evolved into a complete provider of end-to-end geospatial solutions.

GeoEye owns and operates two color Earth-imaging satellites - GeoEye-1 and IKONOS, and three mapping aircraft with advanced high-resolution imagery collection capabilities.

• GeoEye-1 is the world's highest resolution color and most accurate remote-sensing commercial satellite. It is capable of delivering both panchromatic and multispectral images with an incredible ground resolution of 41 centimeters. GeoEye-1 can map the location of an object to within 3.5 meters of its true location on the Earth's surface.

• The IKONOS satellite produces color imagery with a resolution of 82 centimeters with positional and relative accuracy suitable for virtually all mapping requirements. Its mapping, intelligence analysis and feature extraction capabilities are among the best of any commercial imagery system in its class.

• The company continues development of its next generation GeoEye-2 satellite ahead of schedule. Once operational in 2013, GeoEye-2 will be the world's highest resolution commercial satellite, featuring significant improvements to its predecessors, including enhanced tasking and the ability to collect more imagery at a faster rate with a new ITT camera.

• GeoEye expects to begin construction on GeoEye-3 in 2013 and will add it to the constellation in 2017.

GeoEye Information Services offer global, on-demand subscription access to imagery and other location information. Our new web-based services, EyeQ, can help enterprise organizations share current geospatial intelligence throughout their data network.

Features of Archaeological Works with Using of PHOTOMOD (for Example of Construction DTM Zolotarevka Settlement)

Rustam Singatulin
Saratov State University, Russia

In this work were considered some features of field archaeological works on the Zolotaryovka settlement with use DPS PHOTOMOD in 2010 – 2011.

Zolotaryovsky settlement is the unique medieval archaeological monument, which located 30 km from Penza. In first half XIII century in territory of Zolotarevsky settlement there was a fight which traces can be observed and on the present. The territory of battle located far beyond settlement. Remains of the killed people have been found out on the area 60 000 м^2. Bodies of the lost soldiers and inhabitants of settlement remained tombless. Besides remains of people in the field of fight there was a considerable quantity of the weapon, parts of an armor, details of a horse harness, ornaments, etc. Just tips of arrows is over 2000 pieces for today. Later 7.5 centuries a battle-field, for inexplicable reasons or natural cataclysms, have almost completely kept the primordial form.

In the Middle Ages military battles were obligatory attribute of an inconsistent epoch, and remained till our time a battle-field is the phenomenon of the extreme importance, allowing to solve set of problems in the history and archeology.

The site of ancient settlement is located on high cape (to 20 m), formed by two ravines, and fenced from different directions by shaft with a ditch. Across cape located 4 shaft with ditches, approximately in 30 – 40 m from each other. The height of cross-section shaft reaches 3 m, width – 8 m, depth of ditches – 3 m, width – 5 m. Behind external shaft are a wide strip holes for catch which were a part of the defensive system, located in chessboard order. Diameter of holes on the average 1 m, depth from 0.8 to 1 m. makes the Area of a site of ancient settlement about 2.5 hectares.

To reconstruct chronology of events it is possible only on the basis of construction detailed DTM. And on such DTM it is necessary to fix spatially not only large objects (structures, shaft, coppers, an armor), but more fine details (tips of arrows, beads, disorders of ceramics).

Unfortunately, the current state of the Zolotarevsky site of ancient settlement essentially complicates carrying out of field works for the purpose of creation detailed DTM. Strongly crossed relief, a high grassy cover, a wild-growing bush, blockages and high trees (12 – 18 m) interfere with carrying out of qualitative shooting. The quantity of trees only on sites between shaft exceeds 2000 pieces. Construction DTM with use of the given HIS or UAV is almost impossible. Laser scanning also is excluded. Construction DTM is possible only with use traditional near photogrammetry and with territory splitting on fixed sites for local shooting. However application of the given technology demands the account of some additional factors.

The cores from them in the conditions of field archaeological works are:

- a choice of parameters of shooting with demanded accuracy;
- carrying out of survey in the conditions of a large forest (i.e. without overlapping by trunks of trees).

If the first requirement is obvious, the second condition is connected with impossibility of performance of survey without carrying out of additional survey

to exclude the shaded spaces. However carrying out additional surveys not only is labor-consuming in the conditions of a large forest, but also essentially complicates data processing. Therefore there is a necessity to use some decisions, providing shooting without the shaded spaces. One of such decisions is possibility to make consecutive shooting by means of a special tripod from height 3 – 6 m on a routing network. The technology is simple enough, a little similar to possibilities at surveys from balloons or UAV. The primary factor is possibility of static survey, operative change of height and basis of shooting. At placing of bases in parallel basis of survey, and also with basis approach to object of shooting (i.e. At integration of scale of shooting) all site of district without the shaded spaces can be removed. A lack of the given decision, is complexities at carrying out of shootings of a relief with the expressed difference of heights (ravines, breakages, wells).

The analysis of the carried out works the Zolotaryovsky site of ancient settlement in 2010-2011 by means of DPS PHOTOMOD shows that the program complex allows to solve a complex of archaeological problems from equalizing of a network of a phototriangulation before construction DTM, creation of digital specialized cards, and also to make search works on the basis of comparison of reference points of a relief. For example, as a result of measurement of reference points on one of sites of the Zolotaryovsky site of ancient settlement in 2010 the area of the microrelief connected with the lost construction that have led to the conclusion about necessity of detailed elaboration of works on the given site by means of multispectral technologies has been revealed. At the same time, some possibilities in PHOTOMOD, for example a filtration and editing of binding points on the block of images in module PHOTOMOD AAT, aren't so unequivocally adapted for the decision of specific archaeological problems. As it is natural, since the program intended absolutely for other purposes. However experience of last years works with PHOTOMOD as a part of archaeological expeditions on Uvek (Saratov), Zolotarevka settlement (Penza), Kyryk Oba (Western Kazakhstan region, Republic of Kazakhstan) as a whole makes the good impression of work of software product and allows to hope for occurrence (in new versions) specialized modules for processing of the archaeological information.

Potential possibilities local photogrammetric survey at carrying out of researches on archaeological monuments far aren't settled. In aggregate with adapted DPS (first of all by means of creation of additional specialized modules in DPS PHOTOMOD) and accessible digital chambers, application local photogrammetric survey will serve the further increase of efficiency and quality of carrying out of archaeological works.

References

1. Belorybkin G.N. Zolotarev settlement. – SPb. - Penza: Izd. PGPU, 2001. 200.
2. Ancient Russia. Town, castle, village // Archaeology of the USSR. - M., 1985.
3. Lobanov A., Bruevich P. Phototopography. The ground stereophotogrammetric survey. VINITI, T.10. - Moscow, Nedra, 1975.
4. Plotnikov P.C., Singatulin R.A., Ramsaev A.P. Application of the method of infra-red photogrammetry for identification of underground archaelogical tracks and rests of constructions in urbanist`s conditions // Fourth International Symposium "Turkish-German Joint Geodetic Days". Berlin: Grunding, 2001. P. 339-345.

System of the Joint Analysis Differently-Spectral Remote Sensing Data

Andrey A. Sudorgin, Anton I. Vasilyev
OJSC 'RI PI', Russia

In this work the software intended for preliminary processing, display, analysis and registration of results of interpretation differently-spectral images received by modern remote-sensing instruments of remote-sensing is presented. The complex allows to process the information received in various spectral ranges, including materials of shooting by synthesized aperture radar (SAR).

As the entrance information the program complex accepts set of formats of images, including the most common formats, such as GeoTIFF and IMG. Also as the entrance information the vector data in formats MapInfo TAB, ESRI Shapefile and others is used. As a source of the entrance information services WMS and "popular Internet" services can serve. Also possibility of work with the information placed in databases, HTTP and FTP servers is provided.

Because the majority of modern types of remote-sensing equipment gives the data with a wide dynamic range (10 bits and more) for their correct display the toolkit is required, allowing to work with images of this kind. The complex possesses ample opportunities on visualization of remote-sensing data of a various kind and almost unlimited volume. For increase «interpretive» properties of the image there are some kinds of visualization: grayscale, RGB, RGBA, pseudo-colors. There is a switching possibility between them with a choice of channels for display. Also there is a possibility of fine tuning of perception of the image for the user: histogram correction, gamma correction, change of sharpness and other methods. At realization of the given methods possibilities of modern graphic processors are used that allows to improve speed and quality of visualization.

Joint processing and the analysis occurring at different times and differently-spectral materials of shooting demands their spatial imposition. Practice shows that accuracy of imposition of the images participating in the joint analysis, appreciably defines completeness and reliability of results of interpretation. For the best combination a number of methods of transformation of images is realized:

- Polynomial transformation of various degrees;
- Perspective transformation;
- Rational polynomial transformation;
- Spline transformation.

At realization of methods of transforming the basic emphasis is made on speed. The provided speed allows, moving control points, in a mode of real time to observe of smooth change of geometry of the attached image that is very important at joint binding differently-spectral images where the choice of corresponding fragments is complicated, but the binding by means of visual combination of contours after imposing of images is possible. Also the given approach allows managing the minimum quantity of control points for achievement of demanded accuracy of a binding since at such approach there is a possibility visually to supervise accumulation of an error out of a zone covered with control points.

Radiometric correction is an important stage in remote-sensing data processing as "raw" data not always possesses necessary interpretation properties and quite often happen noisy. For correction of images the wide spectrum of filters is realized:

beginning from the elementary correction of a dynamic range, to nonlinear methods of contrast increase, allowing essentially to improve perception of image. For increase of convenience of work with filters possibility of construction of desirable filter sequence and a mode of viewing of result in a preview window is realized. Also sequence of filters probably to apply to all image, the given operation is carried out in a multithreaded mode that allows to use modern computing means in full.

The analysis of the single image not always allows allocating all necessary signs of object of interest with necessary reliability. For increase of reliability and quantity of allocated properties of object in the given complex the analysis mode differently-spectral and shooting occurring at different times together with a cartographical basis is provided. At joint display modes of display with change of a transparency and an order of layers both raster and the cartographical information are provided. In different layers the diverse information, in various formats, both raster, and vector, with various type of the data and in various projections can contain, and reprojecting is made "on-the-fly". To improvement interpretive properties probably to apply arithmetic operations to various layers that also increases reliability of result. For increase of speed and reliability of interpretation the toolkit of management of database of images and characteristics of reference objects that is especially actual at work with the data received by means of SAR is given. For convenience of interpretation the toolkit of measurement and marking of objects is provided.

Conclusion.

Use of standard formats of files and standard protocols allows cooperating to the software with a great number of external systems that gives the chance uses in a wide spectrum of problems. At realization of all hard problems possibilities multithreaded processors and GPU were used. The system has modular structure that gives the chance to escalate.

Application of NVIDIA Graphic Processor Units for the Mosaic Generating According to the Aerial Photography Data

Anton I. Vasilyev, A. V. Krylov, Andrey S. Sudorgin
OJSC 'RI PI', Russia

For the photogrammetric processing of runs, including thousands/dozens thousands/hundreds thousands of frames (which size is variated from dozens Mb for UAV-shots up to hundreds Mb for DAC-shots), the orthomosaic generating time can take dozen hours. Thus, the speed up of the processing is highly actual direction. Nowadays one of the most perspective ways to solve this task is to use graphic processor units, a fortiori practically any photogrammetric station contains such accelerators.

In OJSC RI PI the parallel data processing software was developed for the photogrammetric processing of the perspective aerial photography (stages of correlation, phototriangulation and transformation). The software is adapted for

the set of graphic processor units NVIDIA GT200/Fermi using NVIDIA CUDA technology. The software is crossplatform and supports the different Windows and Linux operating systems families.

The realized algorithms and the general structural scheme of the parallel data processing with the use of the developed software are considered in the report. Also results of the fully automatic processing for the vertical aerial photography are shown for different digital cameras (Leica, Trimble) and for UAV-cameras (including for twin-lens camera, developed in OJSC RI PI).

Analysis of Desertification Phenomenon Process's and Forest Fires Impact with Satellite Data in Semi Arid Lands in Algeria

Zegrar Ahmed
Centre of Spaces Techniques, Algeria

The Forest in steppe present ecological diversity, and seen climatic unfavourable conditions in zone and impact of forest fires; we notes deterioration of physical environment particularly, deterioration of natural forest. This deterioration of forests provokes an unbalance of environment witch provokes a process of deterioration advanced in the ultimate stadium is desertification. By elsewhere, where climatic conditions are favourable, the fire is an ecological and acted agent like integral part of evolution of the ecosystems, the specific regeneration of plants are influenced greatly by the regime of fire (season of fire, intensity, interval), who leads to the recuperation of the vegetation of meadow- fire. In this survey we used the pictures ALSAT-1 for detection of zones with risk of forest fire and their impact on the naturals forests in region of Tlemcen. A thematic detailed analysis of forests well attended ecosystems some processing on the picture ALSAT-1, we allowed to identify and classifying the forests in their opinion components flowers. We identified ampleness of fire on this zone also. Some parameters as the slope, the proximity to the road and the forests formations were studied in the goal of determining the zones to risk of forest fire. A crossing of diaper of information in a SIG according to a very determined logic allowed classifying the zones in degree of risk of fire in a middle arid in a forest zone not encouraging the regeneration on the other hand permitting the installation of cash of steppe which encourages the desertification.

The Efficient Technology of RSD Application in Geology

Andrew A. Zimov, Dr. Igor B. Movchan
Scientific group "AZOT", Russia

Geological survey of mineral deposits with application of modern surface methods has the ecological and economic risks. Main part of near-surface deposits is supposed to be discovered. The potential resources include just hidden geological objects which are masked or placed at the significant depths. High price

of traditional geological-geophysical methods causes their using within limited areas for evaluative works and certifications. Appearing remote sensing system, providing the stereoscopic multispectrum images of extra-high resolution, allows looking below the Earth surface on the mining depths of geological substratum.

The efficient technology of remote sensing data application in geology is formed by the set of subsequent transforms and reductions of original images and initial geological information. The precision of their parameters fitting and organization of procedures consequence define the optimization of computing tools and rationality degree of its application.

In this paper the first element of original satellite image processing is its radiometric and geometrical reducing which is not considered in details. Next important item is the set of indirect detections discovered in 8-band WV-2 image which admit tracing main landscape components. The last ones are considered as the factors of lithologic substratum masking.

The dense vegetable cover mapped within the whole territory of Russia is traced on the typical absorption band of chlorophyll. The peculiarity of processing consists in the invariance of spectrum heterogeneities of vegetable cover which are caused by geological heterogeneities located by correlation with ferro-aluminosilicate index.

The surface humidification is considered as the high-amplitude modulator of landscape reflecting ability. Relatively homogeneous hydrological conditions reflect the present hydrogeological and structural-tectonic situation, but humidification caused by abundant atmospheric precipitation masks whole underlying surface.

Algorithmic computation is developed in 9-dimensional spectrum space, formed by 8 bands of 2 meters resolution as well as by panchromatic band of 0.5 meter resolution. In the ideal case this space includes additionally the corresponding stereoscopic pair which increases the stability of low-amplitude signal and supplements the information about the heterogeneity of indicatrix of reflection of underlying surface and about its morphology. The structure of final multidimensional matrix defines one of required components taking into consideration the variability of illumination conditions, density of mapped vegetable cover and the intensity of another overlying factors. The procedure includes the composition of file of spectrum vector absolute values in each point of investigated area, centration of required component and composition of file of non-standardized computed index. The standardization is based on the model, developed with consideration of characteristic curve of spectrum bands, and finally it is detailed on the reference areas. In this paper the values of reference areas with snow aren't used.

The geological forecast takes into account the geochemical indexes (for instance, Fe-Al-Si and reductive-oxidative ones) and geomorphological component of satellite image. The space-related analysis of spectrum heterogeneities ordering (connectivity of signature families on the spectrum characteristics) and analysis of structural homogeneity of Fourier spectrum are realized within segmented area. On its base we implement the metallogenic forecast and reconstruction of geological structural cross-section.

On the stages of structural (qualitative) interpretation of multispectrum image and its recomputing into the geological space one has to estimate the positions of

signal extremum and extremum of horizontal gradient and to compute the space-related stationarity parameters. The advantages of 8-band DG satellite image are:

• the work with high-contrast representations of landscape and geomorphological anomalies of different genesis;

• minimization of spline-interpolation procedures with increasing the precision of structural forecast; significant details of structural cross-sections marking the element of structural control of primary ore deposints.

The structural reconstruction has the form of combined algorithm computing, from one side, the spectrum signal transforms and, from another side, the structural peculiarities of signal on the base of eigen values of dispersion matrix. The result is the set of structural-lineament maps, reflecting the modern tectonics of polygon at the different levels of generalization (different levels of details). This stage of processing satellite image includes the primary forecast and geological mapping under minimum a priori information condition. The forecast itself is in tracing hypothetical ore-controlling structural elements within the investigated area, these elements classification with discovering the law of space location of reference objects (ores and deposits of different ranges).

Spectrum processing is focused on the finding the conditionally independent harmonics in the spectrum plane which admits the correct separation of optical density field of satellite image on the different-frequency components. Computing the absolute values of horizontal gradient vector and consequent location of positions of extremum of initial field and its horizontal gradient is the main procedure for mapping the small vicinities of lineament reconstructions. The lineament is the smoothed and linearized element of landscape reflecting the geological fractures of modern activation and near-surface structural-rock complexes. The dispersion matrixes mentioned above are used for transform the quasi-continuous field of optical density into the discrete lineament field. The last one has the "closed" image, formed by smoothed structural elements like linear, arch, S-shaped etc. ones with natural shifts of ancient lineaments with regard to young ones. Within the lineament field one can select the elements of discordant structures, circular structures of different ranges, the wide spectrum of their spacial relations, in particular, the grouping and attraction to the definite linear (axis-like) zones. We proved these structural peculiarities together with reference objects are classified as ore-controlling ones and are parametrized in the problem of primary forecast.

The quantitative (in geological space) continuation of 8-band WV-2 image reduces the initial field of optical density into the cluster map of the areas of space-related stationarity. The last one is the area of constant amplitude-frequency composition of field which is considered in the terms of ultimate depth of geological (density and structural) heterogeneities. Our corresponding algorithm traces in the cross section the elements of stratification, syn-forms and anti-forms as well as the steeply-dipping structural objects associated with fractures.

Within considered region reflected on the figures one can see the correlation or reconstructed structural elements of cross-section with the structural elements of geological cross section formed on the base of geological survey and drilling data. The deep recomputings are based on the wave analogies and is represented as the set of internal waves which is finally considered as structural half-tone cross section like seismic time-related cross section.

Our research results consist of our original algorithms and the family of

interpretation criteria, from one side, and the analysis of interpretational properties of 8-band WV-2 image of high resolution. Their combination gives the interpretation system of new generation applied to both potential and non-potential fields processing under minimum a-priori information condition.

Resume:

Multifunctionality and global character of used methods and algorithms application

The data of satellite WV-2 with use of algorithms of spectrum separation and frequency filtering, confirmed by field operations as well as final mathematical models of natural processes allow to get the next full-coloured and high-detailed spectrum synthesis: “biotic” synthesis, “hygrophyte” synthesis, “lithological” synthesis, “reductive-oxidative” synthesis, synthesis of “landscape stereotype”, synthesis of “land-using”, “anthropogenic” synthesis.