FROM IMAGERY TO MAP:

digital photogrammetric technologies

14th International Scientific and Technical Conference

Conference Proceedings

Organizers

Racurs
(Moscow, Russia)

SmartSpatio Technologies
(Beijing, China)

Supported by

- **International** Society for Photogrammetry and Remote Sensing (ISPRS)
- **Russian** Federal Space Agency
- National Geomatics Center of **China**
- Satellite Surveying and Mapping Application Center of **China**
- **China** Centre for Resources Satellite Data and Application
- GIS-Association **Russia**

Dear colleagues!

We present to your attention the proceedings of the 14th International Scientific and Technical Conference "From imagery to map: digital photogrammetric technologies". One of the features of the conference is its annual change in location. This not only allows for a variety of conference work, but it also opens up new opportunities. The first three conferences were held in Russia, 10 — in Europe, this conference is the first in Asia. We chose China as the venue, taking into account the increased influence of Chinese on the remote sensing and geoinformation market. Currently the Chinese market is one of the most challenging consumers and suppliers of geospatial data.

Traditionally, the main topic of the conference is photogrammetric processing of aerial and satellite images. The related issues also do not go unheeded. More than 40 reports will be presented at the conference. They cover seven main topics:

- Spatial Data Infrastructure
- Modern 3D-modeling
- Aerial Survey equipment and UAS
- Photogrammetric processing of aerial images — methods and algorithms
- Satellite remote sensing systems
- Remote sensing data — algorithms and software
- Modern radar satellites and radar data processing

We hope the conference proceedings will be useful and interesting for you.

Sincerely yours,
the Scientific Committee of
the 14th International Scientific and Technical Conference
"From imagery to map: digital photogrammetric technologies"

Conference Proceedings
14th International Scientific and Technical Conference
From imagery to map: digital photogrammetric technologies
October 20-23, 2014, Hainan, China

RACURS 中科博思 SmartSpatio

2014

CONTENT

Metagrammars Search Method in a Big Data Arrays of Cartographic Information

O. Atakishchev[1], I. Kostogryzov[2], A. Zaichko[3], O. Atakishchev[4], G. Emelianov[5]
[1]*Southwest State University, Kursk, Russia*
[2]*Research Institute of Applied Mathematics and Certification, Moscow, Russia*
[3]*Roscosmos, Moscow, Russia*
[4]*NFTS Center Capital, Kursk, Russia*
[5]*Southwest State University, Kursk, Russia*

Currently, for solving a wide class applications tasks based on remote sensing data a variety of search methods (SM) are used for different kinds of objects [1,2] in arrays of heterogeneous "big map data" (HBMD) [3].

SM, based on statistical, structural-statistical and algebraic structural review methods of the search space is used to truncate the search space, reducing the complexity of the algorithms which can have structural, temporal and statistical characteristics of the space and the search object.

In [4-5] the particular application the metagrammar theory (MG) is discussed for searching and recognition objects in large arrays of complex data in the framework of structural algebraic approach. At the same time, questions of application metagrammars methods for search various types of structured data objects in a dynamically replenished large arrays of diverse map data in the prior art were not considered.

In order to fill this gap the features of the application of the most promising classes metagrammatics methods to deal with this rather new and complex class of searching problems are discussed in the report.

A common feature of these methods is the use of models and metagrammar methods oriented on recognition and management review of the search space. The metagrammar subclass based on models linked to the grammatical network (GN) systems production rules in a single recursive form describing the lexical, syntactic and semantic structure of the object and the search space is isolated. It is suggested to combine the developed models into a single form which can be represented in the following general way:

$G_{ГО} = <\{\{G_{ОПi}\}\{G_{ППk}\}, \{H_{mn}\}, F>$,

$\{G_{ОПi}\}\{G_{ППk}\}$ — the set of a certain type of GN (in most cases — stochastic fuzzy attribute or attribute) describing the objects and the search space,

F — set of coordination rules GN, determining, as a network, the rules of coordination between GS (a certain kind of control and generating mappings between GN);

$\{H_{mn}\}$ — set of matching rules for grammars included in the above private GN.

The report covers the features of the application, developed methods to parse metagrammatics as a procedural framework of the proposed methods of search. The possibility of usage of structural and statistical features in models of heterogeneous metagrammar cartographically referenced data and remote sensing data source, implement effective procedures for parsing MG to control the direction of interconnected by layers of cells and structures enumeration of the search space .

The concrete examples of the search methods based on MG-formalisms and methods of parsing are observed. In comparison with existing methods on specific tasks MG method is more effective in 3.4-4.2 times while maintaining the required parameters the of risk and increase not more than 1.2-1.3 times in the complexity of the search algorithms.

All this leads to the conclusion about the perspectives of further development metagrammars search methods and their application for specific tasks of searching in a big data arrays of cartographic information.

Bibliography.

1. Stefan Edelkamp, Stefan Schrödl Heuristic search: theory and applications. — Morgan Kaufmann Publishers, 2012. — 712 c.
2. Stewart Russell, Peter Norvig Artificial Intelligence: A Modern Approach Artificial Intelligence: A Modern Approach. - 2nd ed. - M: Williams, 2006. — 1408 c.
3. Google Reveals "Hummingbird" Search Algorithm, Other Changes At 15th Birthday Event.
4. Atakishchev O.I. Metagrammars

applications for information and analytical treatment of monitoring data. Proceedings of SouthWest State University, 2014 №1(52), p.16-27.

5. Atakishchev O.I., Atakishchev A.O. Choices of signs in general classification of search methods. Proceedings of SouthWest State University, 2014 №3(54), p.23-29.

6. O.I.Atakishchev [et.all] The use of structural linguistic methods for processing of vector geo-information data in the SXF format. Telecommunications and radio engineering. Begell House Inc,, USA. vol.62, 2004. P.9-21.

Automatic Digital Elevation Models Creation from Raster Topographic Maps

O. Dobroserdov, S. Miroshnichenko
Southwest State University, Kursk, Russia

Digital elevation models (DEM) along with the thematic layers set including buildings and structures, hydrography, greenery, road net are the main components of geographic information systems' (GIS) digital maps (DM) [1, 2]. DEMs are required to solve a wide range of problems in logistics, mobile communications, as well as for surveillance and monitoring performed by air drones for the sake of emergency services, ecological and security organizations.

Raster topographic maps of different scales that were scanned from paper originals contain relief elements which provide information to create DEMs. The key relief elements are isometric lines (isolines) and height marks. Topographic maps provide the most financially efficient way to create DEMs, however it require significant time investments to transform isolines into vectors (vectorize) in case this operation is performed by operator manually (up to one week for a skilled operator to process one map sheet).

Software complexes for computer-aided vectorization reduce time costs in 2-5 times by significant simplification of raster-to-vector isolines transformation process [3], but still have few functional limitations that are blocking the further performance growth (up to several hours per one map sheet):

1. The closely situated isolines can't be automatically separated if the source map region has a saturated relief.
2. Height marks automatic recognition or automatic height assignment for isolines are not provided.
3. Microtopography overlapping with isolines can't be automatically localized or eliminated.
4. Software operator has to be quite highly skilled to provide enough DEM precision.

Consequently, there is an actual problem of further time costs reduction for DEMs creation from topographic maps. This problem can be solved by developing the methods of topographic maps digital processing and recognition that provide close isolines separation, height marks recognition, isolines height assignment and microtopography elimination. More over the advanced topographic maps processing software based on the developing methods will have less requirements for operator skills.

The following topographic elements are used to create DEM from a map [4]:

1. Relief isometric line is a closed line on a map, which any point have the same height from the sea level. The difference between neighbor lines is called the isoline step is determined by the map scale and the shown terrain relief (height transition values). Isolines are displayed by the following colors:

1.1. Brown (close to red) color corresponding to the isolines located on a dry land (fig. 1a).

1.2. Blue color used to mark isolines in the regions of glaciers and mountains snowpacks (fig. 1b), coastlines of constant and varying hydrography (fig. 1c), sea-bed relief (fig. 1d).

2. Height value is numeric sequence corresponding to elevation of certain point or isoline on a map. There are the following height mark types:

2.1. Height mark displays the elevation from the sea level of some neighbor point (generally on a high ground top or a reference point) marked by a special symbol (dot, triangle, rectangle etc). It is drawn by the black color (fig. 1e).

2.2. Shore line height used for varying hydrography and drawn by the blue color (fig. 1f).

2.3. Isometric line height shows the elevation value of a line in which discontinuity it is situated. It is drawn by the brown color (fig. 1g, h).

Microtopography elements (washouts, sand bumps etc) show insignificant relief details with height transitions less than one isoline step and are used only to specify some relief form features.

The described relief element set on a topographic map is used to create DEM automatically by the method containing the following steps:

1. Isolines raster-to-vector transformation.
2. Height values localization, recognition and type identification.
3. Regular DEM creation.

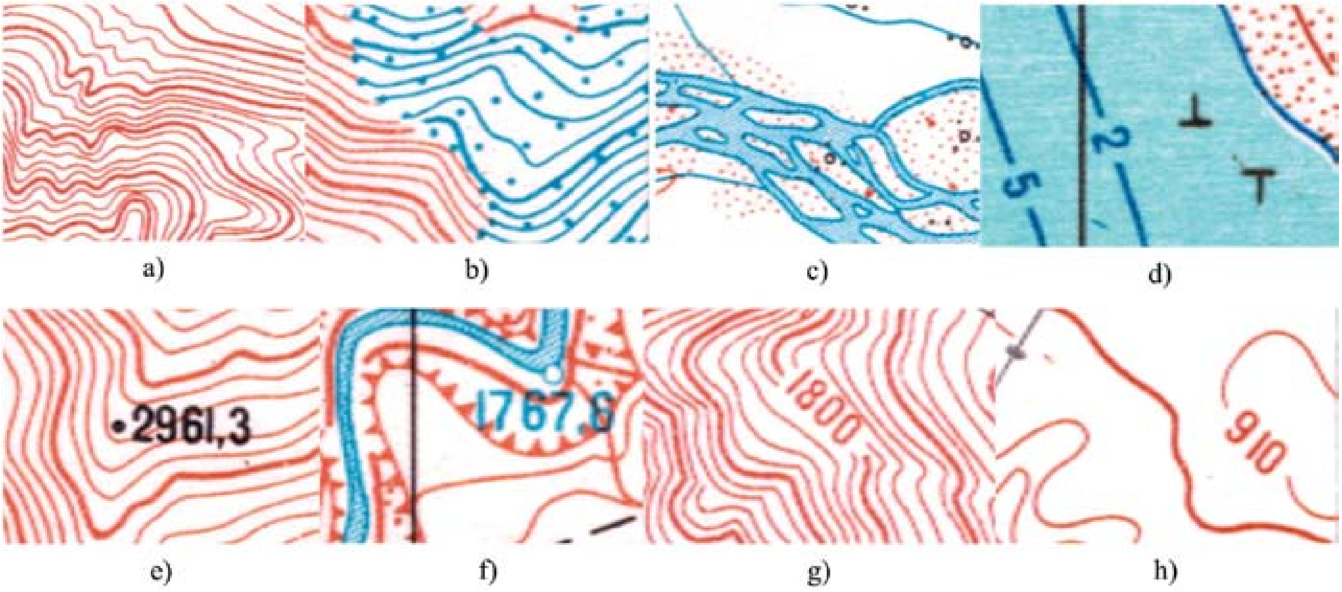


Fig. 1. Main topographic map relief elements

The key to isolines raster-to-vector transformation is the detection of their centers producing singly connected line representation that is the most suitable for vector encoding [5].

The central line part on a topographic map is a brightness function local minimum in orthogonal to line direction in the current point, that in most cases coincide with brightness gradient direction (except regions of line intersections or source media defects).

Using this feature we created the nonlinear dimensional FIR-filter [5], represented by a sliding window of 3 by 3 points size, that provides brightness function local minimums detection in gradient vector direction with step of π/4 radians. Gradient direction is calculated by Elder and Zucker local scale estimating edge detection method using local brightness function features of source topographic map [6]. The result of the filter application is shown on fig. 2.

Detected isolines’ central parts of brown and blue colors are directly encoded into vector representations.

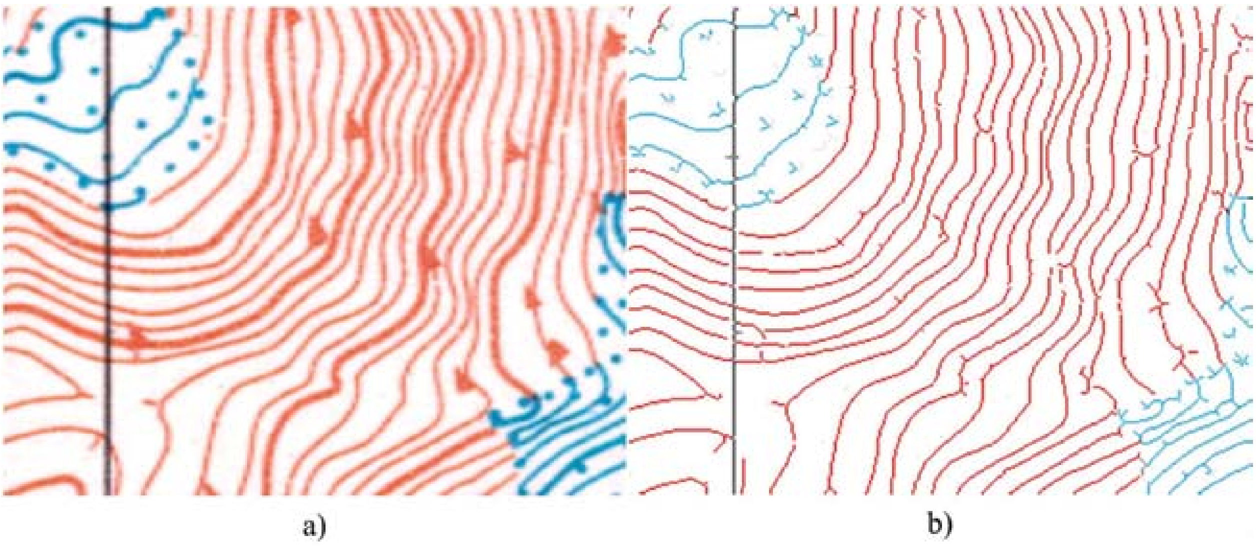


Fig. 2. Isolines center parts detection

Height values detection and recognition are performed using source topographic map color segmentation [5] with further numeric sequences search by contour analysis methods [7].

Raster topographic map color segmentation matches each pixel to one of a priori defined color classes set including brown, blue, green, black and white (fig. 3b). Segments of brown, blue and black colors are transformed into vectors by encoding their borders with other segments and matched to one of digit etalons by a shape comparing with contour analysis methods.

Contour analysis mathematical apparatus provides a calculation of segment similarity degree to digit etalon independently from their mutual scale and rotation angle along with ability to define these parameters. Topographic map segments with similarity degree to one of digit etalons above 80% (fig. 3c) are grouped into numeric sequences representing height values. The following parameters are considered in grouping: digit color, rotation angle and scale related to etalon. Created sequences are semantically verified to avoid possible false recognitions of isolines parts as ones or sevens. The recognized value is checked to comply with permitted height range, isoline step multiplicity (for isoline heights), permitted rotation angles (fig. 3d).

Recognized height values are bound to special markers (dots, circles, rectangles, triangles for height marks or contour dots for shore line heights) and to isolines.

Every isoline height on the map has to be calculated to create a regular elevation model. Isoline height is defined using three most close recognized height values by counting an intersections number of other isolines with vector aimed to each of heights. The obtained non regular model is converted to a regular one (fig. 4) using triangulation.

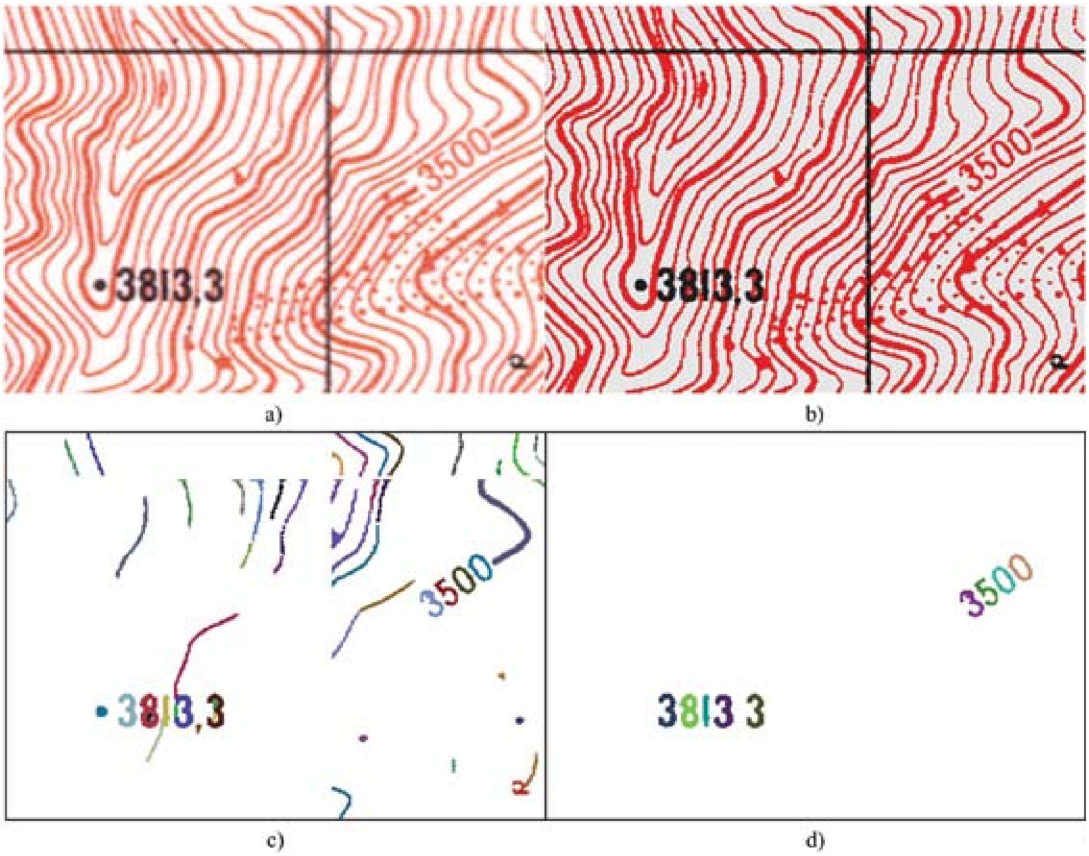


Fig. 3. Source topographic map (a) color segmentation (b), values recognition (c) and numeric sequences creation (d)

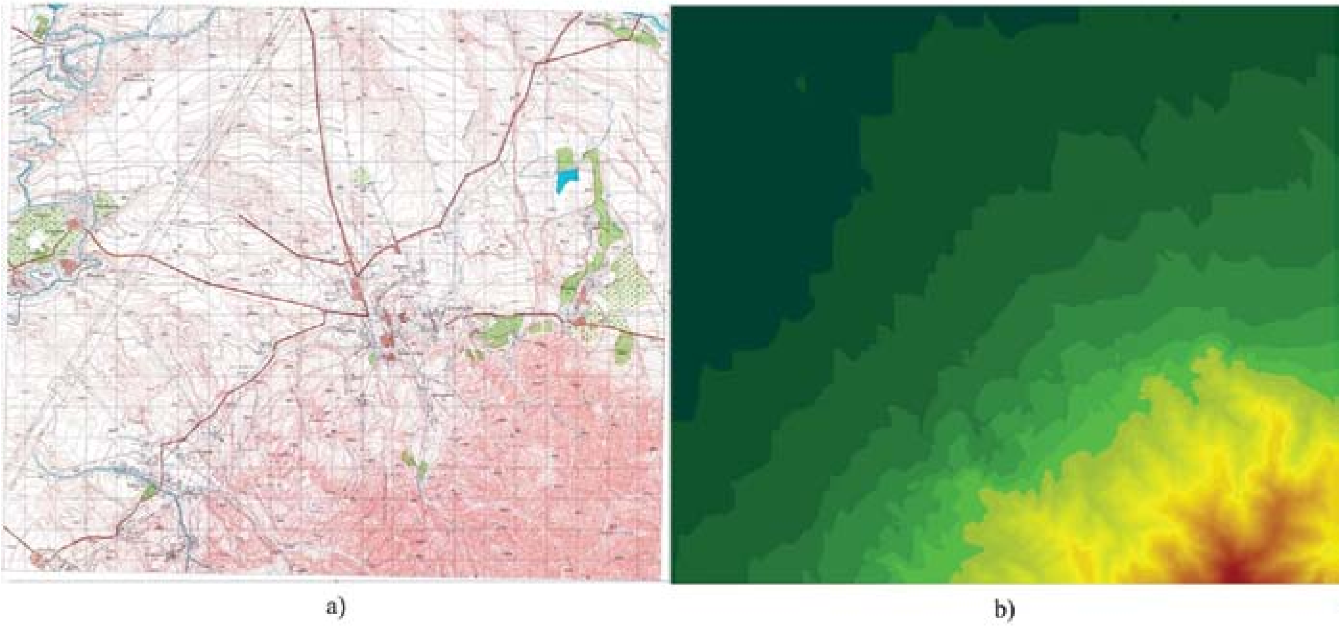


Fig. 4. Regular DEM (b) based on the topographic map (a)

The described methods is taken as basis for software complex for automatic DEM creating from topographic maps that allows to reduce time costs up to several hours per map sheet by automatic close isolines separation, height values recognition and isolines heights calculation.

References

1. D.E. Andrianov, Geoinformatsionnye sistemy: issledovanie, analiz i razrabotka – M.: Gosudarstvennyi nauchnyi tsentr Rossiiskoi Federatsii – VNIIgeosistem, 2004. 184s.

2. A.I.Martynenko, Informatika i elektronnaya Zemlya: fundamentalnye nauchnye problemy / Sistemy i sredstva informatiki. Vyp. 11. – M.: IPI RAN, 2001. PP. 94-112.

3. Easy Trace. Intellektualnoe programmnoe obespechenie dlya vekrorizatsii kart: http://www.easytrace.com/site/russian/news/news.html.

4. Osnovye polozheniya po sozdaniyu i obnovleniyu topograficheskikh kart mashtabom 1:10 000, 1:25 000, 1:50 000, 1:100 000, 1:200 000, 1:500 000, 1:1 000 000. M.: RIO VTS, 1984.

5. R. Gonzalez, R. Woods, Digital Image Processing, Addison-Wesley Publishing Company, 1992.

6. J.H. Elder, S. Zucker, Local Scale Control for Edge Detection and Blur Estimation // IEEE Transactions on Pattern Analysis and Machine Intelligence. Vol. 20, No 7. 1998. PP. 699-716.

7. Ya. A. Furman, Vvedenie v konturnyi analiz i ego prilozhenie k obrabotke izobrazhenii i signalov // M.:FIZMATLIT, 2002. 592s.

Multilevel System of Earth Operational Hyperspectral Monitoring

A. Egorov, A. Raschupkin
JSC SRC "Progress", Samara, Russia

The project on multilevel system of Earth operational hyperspectral monitoring is oriented towards development of regional system of operational hyperspectral monitoring of physicochemical conditions of natural and anthropogenic objects based on data obtained with hyperspectral sensors used in space, aviation and ground facilities in the interest of regional state authority and local government as well as in the interests of enterprises having different form of property to solve a wide range of socioeconomic and scientific tasks.

The system integrates world innovative achievements into the field of hyper- and multispectral observation equipment, space and aviation vehicles with hardware of the specified class, high-precision systems with global coordinate system, analytical methods of physico-chemical compositional analysis and information technology to process hyperspectral images and contained data.

Multilevel system of Earth operational hyperspectral monitoring is composed of space monitoring system (Resurs-P developed by SRC Progress), plane-laboratory produced on the bases of light multipurpose airplane and/or unmanned spacecraft by SRC Progress, ground monitoring systems (system of stationary and mobile physical and chemical laboratories and monitoring systems developed by SSAU).

Current technical problems in highly-detailed hyperspectral equipment development and a lack of experience in usage of hyperspectral data to solve socio-economical and scientific tasks lead to development of three-level monitoring system. Space segment of the operational hyperspectral monitoring system is expected to provide global observation with resolution of 30m. Aviation segment is meant to perform a survey in synchronous mode to validate hyperspectral data received from spacecraft during autonomous operation in order to obtain on-line hyperspectral data with high spatial resolution. Ground segment provides intake of soil samples and water and they are analyzed to form and constantly renew bases of standards "Spectral coefficient of surface reflection – chemical composition". Today such native bases of spectral data are absent.

Novelty of the project defines a lack of real operating experience of the hyperspectral equipment and usage of results of hyperspectral imagery to solve a wide range of tasks in the field of remote sensing in RF, while hyperspectral imagery is wildly used abroad (similar systems are used only in the USA and dynamically developed in EU countries).

Novelty of the offered concept on data acquisition concerning natural and anthropogenic objects as well as recording of their changes is determined with:

-definition of some characteristics of the object in a great number of narrow spectral ranges;

-surface distribution of spectral characteristics in area extent;

-imaging of the object on the bases of spatial data and spectral characteristics integration which enables further to identify objects reliability, to define their characteristics and current condition;

-video data integration of the traditional remote sensing hardware having data measuring component presented as hyperspectral hardware.

New Possibilities in the Field of Acquisition and Processing of Satellite Images

I. Farutin
SCANEX R&D Center, Moscow, Russia

During last year, since the last International Scientific and Technical Conference "From imagery to map: digital photogrammetric technologies" in the French city of Fontainebleau, some serious changes happened on the remote sensing market:

1. SCANEX R&D Center first in the world successfully held series of data reception from very-high resolution KOMPSAT-3 satellite on its own antenna systems. Using Korean satellite with the UniScanTM station enables acquiring date with resolution of 0.7 m in panchromatic and 2.8 m multispectral modes on exceptional terms in real time. High precision of geolocation allows large-scale mapping, whereas the ability of emergency tasking extends the monitoring capability in the case of disasters.

Should mention KOMPSAT-5 satellite launch equipped with Synthetic Aperture Radar, which allows making imagery with resolution of up to 1 m. It will increase the possibility of all-weather monitoring of different processes such as natural and flash floods, ship situation and oil spill detection.

2. The SPOT 7 Earth-observation satellite, designed and developed by Airbus Defence and Space, was launched on 30 June by a Polar Satellite Launch Vehicle (PSLV) from the Satish Dhawan Space Centre in India. It will now join the orbit in which its twin, SPOT 6, and the very-high-resolution observation satellites Pléiades 1A and 1B are located, and will be positioned at 180° in relation to SPOT 6. This event has expanded the line of exclusive remote sensing data for Russia and Belarus, being provided by SCANEX. SPOT data have one of the best price-performance ratio. SPOT 6/7 resolution is close to very-high while its price is at a medium and high resolution data levels. Taking into account the performance of 6 million. sqr. km per day, the constellation (SPOT 6 and 7) becomes a unique resource of remote sensing data on the market.

3. The first Russian private remote sensing satellite developed by SPUTNIKS company (a subsidiary of SCANEX), named TabletSat-Aurora was successfully launched in June 2014.

Weight of the satellite is 26 kg; the minimum estimated lifetime is 1 year. Aurora is equipped with a high-precision three-axis system for orientation and stabilization, and the data are planned to be received by SCANEX ground station network and used for commercial, scientific, educational and environmental projects. Data transmission speed on the ground segment — 70 Mbit / s.

Within two months after Aurora was launched, successful test of the onboard X-band transmitter was carried out. The signal was received by UniScanTM station in Moscow at 11:47 and was sustainably observed during operation time.

4. New (4th) generation of ScanEx Image Processor (SIP) software appeared in the market. Performance of DSM/DTM extraction, orthorectification and many other features was significantly increased. Existing classification algorithms were improved and new ones added. Photogrammetric module was extended with new tools for automatic bundle adjustment of satellite imagery data, for mosaic creation, including automated seam lines creation and color-balancing, etc.

Enhanced functionality and performance made SIP more popular and in demand in the global market, e.g. during the last year it began to be supplied through the distribution network in Estonia, Nepal, China, Mongolia, and some Middle East countries.

Generating 3D Models of Shukhov Towers by Laser-Scanning and UAV Photogrammetry

Prof. em. Dr. A. Gruen
Singapore-ETH Centre, Future Cities Laboratory, Singapore
Chair of Information Architecture, ETH Zurich, Switzerland

Laser-scanning and photogrammetry are relevant techniques for raw data acquisition for 3D modelling in Cultural Heritage and other applications. Mostly these techniques are considered as competitive. But in reality they have complementary properties, which should be used synergetically for high quality model generation. Our paper will report about the recording and 3D modelling of two tall Shukhov towers by terrestrial laser-scanning and UAV- and terrestrial photogrammetry. Within the framework of a large international research project concerning Shukhov's lightweight structures our task consisted in generating accurate and largely complete models of two Shukhov towers, Schabolovskaya and Polibino, both in Russia. For non-technical reasons both techniques are used here independently of each other.

The aim of the project part discussed here is to create an accurate and complete geometric documentation of these towers, to analyze the interdependence of the key elements and to reveal the actual structural behavior. The precise 3D computer models of towers have to be created as a basis for all spatially-related investigations and will allow to generate relevant data, useful for scientific investigations, restoration, analytic and educational tasks.

The measurements have been taken by terrestrial laser-scanning and by using the UAV Falcon-8, equipped with an array of sensors, like GPS, INS, stabilization platform and the Panasonic Lumix LX-5 camera. Although not planned in the beginning, due to special circumstances also terrestrial and elevated cherry-picker photogrammetric images had to be taken. In addition, aerial images over the area around Schabolovskaya are available for modeling the immediate environment of the object.

The processing of the UAV imagery is done jointly by the Institute of Conservation and Building Research (IDB), ETH Zuerich and the Laboratory of Computer Machine Vision of GosNIIAS (State Research Institute of Aviation Systems), Moscow.

The terrestrial laser-scanning and the related point cloud processing was performed by the Center for Virtual History of Science and Technology, a division of the S.I. Vavilov Institute for the History of Science and Technology of the Russian Academy of Sciences, with support of the Trimetari Consulting.

A 3D model of the tower was created based on the results of laser scanning and available documentation (primarily, the measurements of the year 1947). We created both a solid 3D model (only rings and legs), and a meshed 3D model (rings, legs and junctions).

While the laser-scanning data processing and modelling is largely completed, the UAV-based and terrestrial data processing work is still ongoing. We report here about the state of our work and the experiences gained.

Combined 3D Modeling from UAV Aerial Images and Mobile Mapping Laser-Scan Point Clouds

Prof. em. Dr. A. Gruen
Singapore-ETH Centre, Future Cities Laboratory, Singapore
Chair of Information Architecture, ETH Zurich, Switzerland

Both Unmanned Aerial Vehicles (UAV) and Mobile Laser Scanners (MLS) are important techniques for surveying and mapping. In recent years, the UAV technology has achieved significant progress in hardware and system development. Carrying off-the-shelf digital cameras, the UAV can collectimages for the purpose of very high resolution city modeling using photogrammetrictechniques. The MLSon the other hand, mounted on a Mobile Mapping System (MMS) collectshigh density point clouds of ground objects along the roads.

The problem with vertical aerial UAV images is that many objects will be occluded by vegetation and possibly by high-rise buildings, especially in a tropical environment like Singapore. On the contrary, the MMS collects highlyaccurate point clouds of objects from the ground, together with video image sequences. Therefore, both systems are potentially complementary and only by using both systems a complete city model may be obtained.

This paper focuses on the integration of UAV images and MLS data to build both the geometric and texture part of a very high resolution 3D city model.The work we will showis a practical modeling project of the Campus of the National University of Singapore (NUS), which includes DTM, buildings and other man-made objects, roads, and dense tropical vegetation.The purpose of this model building is manifold:

- It serves as a pilot project to refine our data processing algorithms and software
- It acts as a test-bed for demonstrations of technology and products
- It will be applied by a variety of different users for analysis, animation and simulation (autonomous vehicle driving, hydrology, crowd movement, etc.)

The input data for our work is: (1) UAV images; (2) raw point clouds from MMS; (3) video image sequences from MMS, (4) terrestrial images from off-the-shelf cameras; (5)Ground Control Points (GCPs). The output isa 3D hybrid site model, achieved by integration of these input data sources.

The difficulties in our project come primarily from the generation of model parts originating from different types of data and the fusion of those model parts: aerial UAV images, terrestrial images and terrestrial MLS point clouds.

The main steps of our work include:

(a) UAV imagesaerial triangulation/geo-referencing

(b) Integration of UAV-derived data to geo-reference and adjust the MLS point cloud data

(c) Modeling of the roof landscape from UAV images

(d) Merging of DTMdata from UAV images, MLS point clouds and from existing maps

(e) 3D modeling of façades from MLS data

(f) 3D modeling of façadesand other object parts from video sequences and terrestrial photo-grammetric digital images

(g) Fusing façade and roof models to generate a completemodel

(h) Texture mapping

We will describe all procedures and critically analyze their performance and the quality of results. In particular we will report about problems with commercial triangulation software in case of unconventional aerial block structures. We are using CyberCity Modeler for building roof landscapes from UAV images.

Thermal Aerial Survey of Water Objects Using Unmanned Aircraft System Ptero

D. Gryadunov[1], A. Smirnov[2]
[1]AFM-Servers Ltd., Moscow, Russia
[2]Racurs Co., Moscow, Russia

Thermal aerial survey along with some other methods of remote sensing is an important source of information about terrain, including water objects. The use of UAV-borne thermal cameras based on uncooled microbolometers opens up new possibilities for environmental monitoring, mapping and exploration of water objects.

Obtained thermal aerial survey data and results of theirphotogrammetric processingcan be usedfor the following tasks:

- mapping of water objects;
- identification water protection zonesrules violations;
- evaluation of water objects pollutiondegree, pollution source identification and their localization;
- determination of motion path of contaminated sediment; pollution expansion forecast;
- determinationof the ice covercondition;
- identification of water supply sources;
- thermal waters search;
- boundaries determinationof wetland forests, river flood plains, wetlands and upland areas;
- monitoring of power plants cooling ponds;
- monitoring and mapping of flooded areas (including temporary water bodies formed during high water, flooded fields, tailing dumps, sludge storages, etc.);
- identification of objects that are difficult for interpretation by the visible wavelength imagery;
- space survey data validation.

The reportdescribes the features ofthermalaerial surveycarried out by PteroUAS, including preparations for thewater objects survey, and the influence of external factors on thefinal result. Also, it provides examples of photogrammetric processing of thermograms using PHOTOMOD software.

A New Calibration Technique for Non Metric Photogrammetric Cameras

B.G. Ikokou
Tshwane University of Technology, Republic of South Africa

The use of 2D image information to produce 3D measures requires the knowledge of camera parameters that transformed the 3D space into a 2D image. However various forms of distortion are observed in image produced by low cost camera lenses. This includes geometric, curvilinear and anamorphic distortions. Geometric distortions refer to the changes in the peripheral details because of the elongation of the elements of an object. It also refers to the distortion that is created when there is increasingly obliquity of the angle of viewing the object. In curvilinear distortion, straight lines are rendered as curve either inward (pincushion) or outward (barrel) curves. These two forms of distortion result from the asymmetry of lens configuration.

Different models for distortion correction including barrel distortion and respective procedures are available. For example a prism distortion model was proposed by Brown (1971) to correct tangential distortions. A radial lens distortion model was proposed in Tsai (1987) that includes image correction in two directions. Radial and decentring and thin-prism distortion models and their correction procedures were developed by Weng et al., (1992). Based on the pinhole camera model, some of these approaches produce reasonable results in terms of correcting the images obtained from cameras with normal viewing but assumed symmetric radial distortions, which seems to not hold true for cheap lenses with unstable internal geometry. The linear distortion model proposed by Brown (1971) and adopted by these authors have showed limitations to remove distortions towards the edges of the images. In this paper we are presenting a camera model based on the equivalence between two vectors respectively normal to the image and object plans and a division distortion model to improve the limitations of current linear distortions models. The model was tested on photographs of a calibration field located in the Photogrammetry laboratory of the University of Cape Town in South Africa. The test results were very promising with an improvement of quality near the edges of the images.

The A3 Edge Digital Mapping System captures superb quality vertical and oblique images.

With the highest survey and processing productivity, A3 Edge gets your job done as efficiently as possible - saving you valuable resources!

A3 Edge provides a fully automatic solution from capture to final geo-information products.

VISIONMAP
Digital mapping systems

www.visionmap.com

Earth Remote Sensing Space System of The Republic of Kazakhstan

A. Kazkenov
NC "Kazakhstan Gharysh Sapary", Astana, Kazakhstan

Currently, the Republic of Kazakhstan is actively working to create a national space industry.

National company "Kazakhstan Gharysh Sapary" was created according to the Decree of the Government of the Republic of Kazakhstan in 2005 for the implementation of the competitive space technologies for the interests of Kazakhstan.

The company is appointed as the National operator of the ERS space system by the Government of the Republic of Kazakhstan.

The company is involved in the following segments of the space-based services through the implementation of the following projects.

1) design and manufacture of the spacecrafts – project "Assembly, integration and testing complex of spacecrafts in Astana". The created AITC SC will provide closed-loop on assembly and testing of spacecrafts weighing from 100 kg to 6 tons.

2) services on provision of ERS data – "Creation of the Earth remote sensing space system of the Republic of Kazakhstan" project.

3) satellite navigation services – "Creation of the ground infrastructure of High-accuracy satellite navigation system of the Republic of Kazakhstan" project

Today, in the Republic of Kazakhstan our company deployed ground infrastructure of High-accuracy satellite navigation system to provide qualitatitve coordinate and time services to consumers of information in the global navigation satellite systems (GLONASS and GPS).

4) development of scientific and technological basis of space activities – "Creation of science-technological space system" project. This space system is created for the purpose of developing design technologies, assembly and testing of spacecrafts, conducting researches of the Earth's ionosphere, receiving flight history for technological load of its own design.

5) launching services – "Participation in the Dnepr program on the commercial use of IBM RS-20" project.

Today, the company is a shareholder (holding 10% of shares) of the Kosmotras company, which is the operator of the Dnepr program. The Dnepr program provides commercial launches of spacecraft using the conversion IBM RS-20.

ERS space system of the Republic of Kazakhstan was created in cooperation with Airbus Defense and Space. Currently, the system is going through the experimental phase and starting from 2015 it will provide ERS services within the country and around the world.

Spacecraft with a spatial resolution of 1 m was launched on April 30, 2014. This spacecraft contains higher modulation transfer function (MTF) and signal / noise ratio (SNR) comparing to other satellites of high resolution. SC has a high maneuverability and good accuracy of positioning, stereo images are taken at one loop. Performance of SC HR — 220 thousand square kilometers per day.

Spacecraft with a spatial resolution of 6.5 m was launched on 20 June, 2014. Stereo recording is also performed at one loop. Performance of SC MR is 1,000,000 km per day.

Controlling of the spacecrafts and ERS data processing are conducted at the Ground segment which is located in Astana.

In order to develop our ERS space system of the Republic of Kazakhstan it is planned to implement the following projects:

1) Project – creation of the space radar system in the frame of ERS SS development, that will allow to obtain high resolution radar images, duration – 2016 – 2020.

2) Project — replenishment of ERS SS RK constellation of satellites by launching KazEOSat-3 and KazEOSat-4 satellites, duration – 2018-2021.

Our company is a distributor of the world's major suppliers of remote sensing data. Our main customers are government agencies and organizations of the Republic of Kazakhstan. We plan to provide services of remote sensing in the world market and develop a network of distributors.

Our partners are the largest European companies.

Kazakhstan is ready to enter into the world space community with its services to provide remote sensing data which can be used by other countries.

We are open for the dynamic dialogue and mutually beneficial cooperation in the field of ERS data application.

A Combined Method Digital Topographic Plans of Creation for Engineering Structures Geodetic Surveying of Using PHOTOMOD

T. Khlebnikova

Siberian State Geodesy Academy, Novosibirsk, Russia

Currently, for the construction purposes, expansion and reconstruction of electrical small stations (EP) and electric power lines (EL) at the designing stage specialists prepare complex reports on engineering surveys of these objects. In accordance with the standard technical documentation (STD) concerning the construction standards, in the engineering surveying works for construction of EP and EL comprises there are the following stages: engineering geodetic surveying, engineering-geological, engineering hydro-meteorological and engineering and environmental surveying.

Engineering-geodetic surveying for the construction of the above objects should provide surveying data about the land features and existing structures, the areas entities (in digital, graphic, photographic and other forms). This information is required for a comprehensive assessment of natural and technogenie construction site conditions the design studreasoning, the structures maintenance, as well as the creation and maintenance of the state cadastre, the territory management, and real estate transactions. Engineering geodetic surveying results in topographic plans (in digital, graphic, photographic and other forms), profiles and other geodetic documents and data.

In the Novosibirsk branch of LLC «Geoproectiziscanie», as in any other organization engineering industry, one of the main documents of geodetic surveying is a topographic plan with a scale (1: 500 to 1: 5000) in AutoCAD format.

This topographic map (figure) must meet the standard requirements.

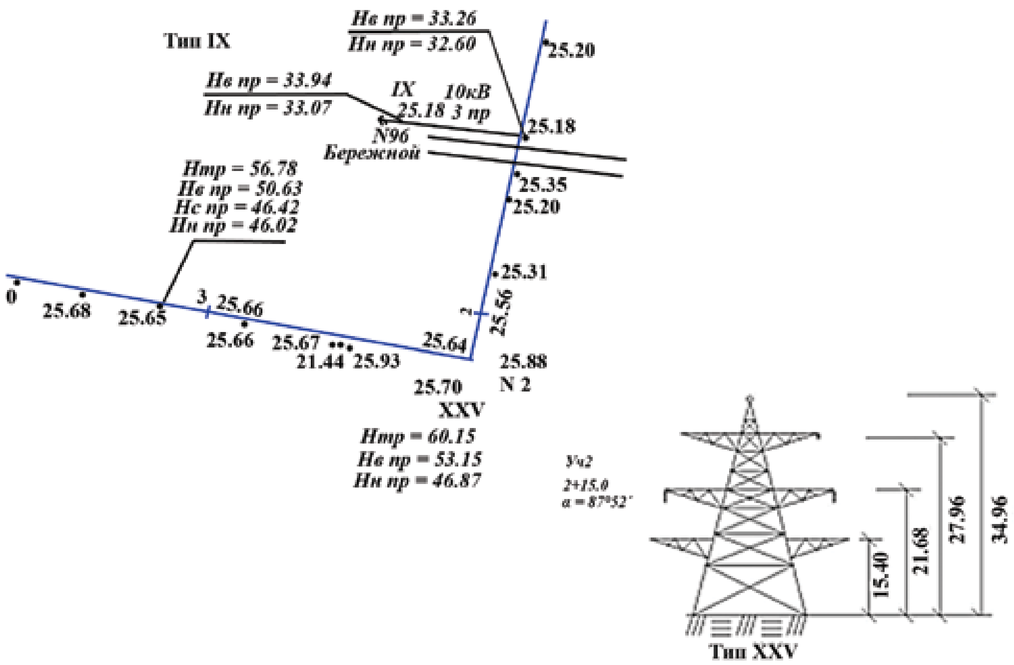


Figure 1. A part of a topographic plan of scale 1 : 2000 with picture support

Survey data are sent to designers who are faced with a particular problem associated with the visualization. In same cases, at the design stage it is necessary visual the objects to present such as explication, bearings, cables, garlands, and also plots of crossing routes with artificial and natural barriers for visual understanding. There appears to examine these objects at a site resulting in additional time and costs.

The complexity of the features displayed on digital topographic plans increases when there is a large number of ground and underground communications for various purposes. As a result in such situations, some authors recommend to make large scale executive survey, bat complex objects have to be accompanied by photographs and to use laser scanners in surveying. Terrestrial laser survey has same advantages and disadvantages.

We propose a combined method of digital topographic plans creation, in which the information of topographic plan has to be supplemented by of the objects three-dimensional models. Three-dimensional models (3D model, three-dimensional videoscan) are the new types of digital geospatial data, that are three-dimensional analogues of real terrain objects.

Application of the combined technique of digital topographic plans will allow the user to obtain additional information in the form of three-dimensional videoscans of same separate parts or same objects. The three-dimensional video scene not only improve the perception and increase the information content of a digital topographic plan, but allow you to perform the measurements. This minimizes field trips. Research on practical application of three-dimensional video scenes in literature reflected poorly.

In connection with the above information, the digital topographic plan technology consists of the following steps:

– the creation of digital topographic plans known in accordance with technological scheme;

– the establishment of schemes of the lots requiring, measuring three-dimensional video scene;

– gathering of information for the DEM and the DMO on the basis of aerial photographs, satellite imagery of high resolution, and also on data received with small non-metric digital cameras for further creation of three-dimensional videoscan of selected areas;

– creating terrain objects and models, three-dimensional video scenes 3D GIS;

– creation of a digital topographic plan, added by the three-dimensional video scenes.

The necessary conditions have been determined under which the digital topographic plans with a combined method will be received.

When creating the DEM and DMO by means of photogrammetric technologies for the in future use in 3D GIS there occurs the task of complex coordination of three-dimensional models created of the site on DFS, at the information level and three-dimensional models of the territory, the construction of which is in the internal structures of 3D GIS based on the input spatial data export.

Based on this research and testing the proposed technology: DPW PHOTOMOD (Racurs, Moscow); and the program of GIS MAP 2011 GIS Panorama (KB Panorama, Moscow) have been selected.

While developing the technology a number of problems have been revealed that are solved in the Siberian State Academy of Geodesy (SSGA).

PHOTOMOD 6.0. Increasing of Performance and Processed Data Volume

D. Kochergin
Racurs Co., Moscow, Russia

In October 2014 Racurs is going to release the full 64-bit version of digital photogrammetric system PHOTOMOD, on which developers have worked quite intensively recently.

The first part of the presentation is devoted to chronological stages of transition from 32-bit to 64-bit of PHOTOMOD system version with change of operating environment.

The main advantage of the 64-bit system version is full and optimal usage of computer random-access memory. While 32-bit applications are limited by 4 GB of RAM, 64-bit software has practically no such restrictions. So you can involve so much memory that is installed on your computer "physically". It is obvious, that when dealing with extremely large volumes of data, processed in contemporary digital photogrammetric systems, usage of 64-bit architecture is practically the first-order condition. The main part of the presentation includes comparison tables of data volumes used in PHOTOMOD x32 and PHOTOMOD x64. This refers to the number of project images and output orthophotos, number of tie points used for phototriangulation procedure, number of pickets for digital elevation model generation and number of vector objects for digital maps creation.

Thus, for example, PHOTOMOD x32 allowed to edit about 6-7 million pickets relatively comfortable for operator. Number of pickets loaded to PHOTOMOD x64 for displaying and editing depends on computer RAM size. The presentation contains illustrations of processing of dozens of millions of pickets using computers with different RAM size. Pickets may either be computed by photogrammetric method, or acquired during laser scanning. Among other advantages of the new system version – overall redraw acceleration of great deal of any type objects on screen, a significant increase in the number of images in space borne scanner survey projects, speeding up of orthorectification and orthomosaicing, as well as optimization of computation operations in distributed processing mode.

Scalable Solutions for Image Information Mining

Prof. em. Dr. G. Konecny
Leibniz University Hannover, Germany

1. **Background:**

The Secretariat of the UN Economic and Social Council (UN-ECOSOC) in New York.

has established the UN Global Geospatial Information Management (UN-GGIM) Secretariat in 2009 as a followup on the UN Cartographic Conferences held between 1955 and 2009. These are governmental conferences, for which the delegations of the UN member countries have to be nominated by the member governments.

UN-GGIM Conferences have been held 2011 in Seoul, 2012 in New York, 2013 in Cambridge, England and now 2014 in New York. The Conferences are supported by UN-GGIM Fora with academic and industrial participants. Fora were held 2013 in Qatar and 2014 in New York. NGO´s are admmitted to both Conference and Fora as observers. Furthermore UN-GGIM has started regional activities, such as UN-GGIM Asia and UN-GGIM Americas. Other regional activities, such as UN-GGIM Europe,

UN-GGIM Africa and UN-GGIM Arab States are in preparation.

2. Own Motivation to Participate in the Activities:

As a participant in the UN Cartographic Conferences since 1976 representing Germany and ISPRS one of the aims was to follow up on UN activities of the

UN Secretariat to determine the state of geospatial information existing in the different countries of the world. While this activity was supported by various resolutions at UN Cartographic Conferences in Asia and the Americas, there was a lack of followup between 1986 and 2009. ISPRS suggested to the UN-GGIM Secretariat to undertale a joint effort in 2009 based on the past resolutions.

3. The UN-GGIM – ISPRS Project on the „Current Status of Geospatial Information“

The project was agreed upon in December 2011 and it started with the joint design of

a questionnaire in January 2012 and the mailing of the questionnaire to the UN member states in April 2012.

The first two questions covered the present coverage of data in the relevant scale

Ranges 1:1000, 1:5000,1:10 000, 1:25 000, 1:50 000, 1:100 000 and 1:200 000 or 1: 250 000 and the dates of the last update of these maps.

The remaining 20 or more questions tried to characterize the infrastructure of Mapping, such as: are the data restricted, are they free of charge or sold, do updateprograms exist, which methodology is used, are there own governmental facilities or is mapping outsourced, is laser and radar mapping used, exists there a cadastral data coverage, are the data available in digital or analog form, are they dissiminated by the Internet?

The response by the UN member states was rather slow. By June 2012 56 countries had responded, by August 2013 it was 69 countries and by August 2014 107 countries.

The first two questions about coverage and age of data were rather sensitive, since many countries do not wish to reveal this information for military reasons. This mainly explains, why 86 countries have still not responded. But even though only 55% of the countries have supplied the information, the analysis of the responses is interesting and useful, sice it reveals global trends.

With respect to the data coverage and its actualization date a cooperation has been initiated between Eastview Geospatial in Minneapolis, Minnesota and the Institute at the University of Hannover. Eastview maintains a confidential data base, but it has agreed to deliver the missing data about coverage and age. In this way the current global status of geospatial data may be determined in cooperation with Eastview.

Of great interest is also the sizable competition created by military and prIvate initiatives to official mapping efforts carried out by governments (MGCP, Google, Microsoft, Here, Tomtom). Again, these data providers are for military or commercial reasons reluctant to share this information with the public. But an international ISPRS working group with members from China, Russia, Europe and the USA was able to collect at least general information to complete the picture.

Only the largest GIS producer in the wold, ESRI, in Redlands, California, is ready to share data on high resolution satellite data coverages and their dates.

4. Visit to Eastview Geospatial in Minneapolis, Minnesota.

Before the UN-GGIM events in New York I visited Eastview Geospatial in Minneapolis.

I had a lenghthy discussion with CEO Kent Lee, which resulted in the following cooperation agreement:

1) Eastview will review the relevance of the UN-GGIM/ISPRS questionnaire and suggests desirable modifications or expansions of the database structure

2) Eastview reviews the correctness of the Hannover Excel database

3) Eastview supplies the desired country percentage coverages and their ages of the missing countries in the database from their own database.

Kent Lee will come to Intergeo in Berlin on October 7, 2014 for a meeting with us.

5. UN-GGIM Forum, August 4 to 5, 2014

The Forum was chaired by the recently appointed Director of the UN Statistics Division, Dr. Stefan Schweinfest and by his predecessor Dr. Paul Cheung From Singapore.

The present challenge lies in the fusion of statistical data with the geospatial data supplied by the surveys and mapping administrations of governments. The provision of these data is slow and costly. Industrial commercial interests offer rapid and cost effective alternatives to the traditional and standardized efforts by governments. This is currently a big challenge.

The presentations to the topic to fuse statistical data with geospatial data by China, Eurostat, Mexico, Australia, South Africa, Germany, USA, Sweden and OECD are downloadable from the web page: www.ggim.un.org/GlobalForum.html

The second day of the Forum was devoted to the Project „Global Mapping“. It originated at the Rio UNCED Conference 1992, when it was decided to crate a homogenized thematic map series at the scale 1:1 000 000 to which many nations contributed. The project will be completed in 2016. At the age, when high resolution satellite images with 25cm have been declassified and WordView3 has started to gather image data world wide at 35cm GSD, the future need will be for global mapping at larger scales, e.g. at 1:50 000. Spain has proposed an update requirement of 3 years for roads and for urban settlements and of 5 years for hydrography. These data, however cannot be made visible at such a small scale as 1:1 000 000.

The US Bureau of Census has managed to integrate population statistics with geodata and to distribute the result over the web.

The International Hydrographic Office IHO in Monaco has raised the issue of a great lack of hydrographic charts in coastal areas oft he globe.

Pasco, Japan has discussed the possibilities by the Japanese Technical Cooperation Agency JICA, to launch mapping projects in developing countries by technical cooperation. Such data are needed rapidly in crisis areas (potential earthquake, flood and war activity areas)

6. UN-GGIM4 Conference, August 6 to 8, 2014.

The Conference was opened by UN-ECOSOC Undersecretary Wu Hangbo and chaired by Vanessa Lawrence, Great Britain.

There were 90 delegations of UN member states with 208 delegates, as well as 57 observers from NGO´s present at the meeting.

The first activity was to draft a resolution for the UN General Assembly to establish a „Global Geospatial Reference Frame GGRF“, an independent spatial reference system oriented to quasars in space, which permits to define and permanently monitor changes of the earth crust (continental drift and rise, tectonic changes of the earth crust, changes of sea level). At present ITRF is determined by voluntary contributions of some scientific institutions in France, Germany, Japan, USA, Norway, Canada, Australia, Britain for science reasons. But the sustainability of funding for the present 32 laser tracking stations with VLBI operations, as well as more than 400 GNSS CORS stations requires a recommendation by the UN General Assembly. About 20 delegations spoke in favour for such a resolution.

Thereafter China presented its „Global Land 30“ Land Cover Project, which will be donated to the UN. It is based on a global cover of Landsat images with 30m GSD for

the years 2000 and 2010. The data were homogenized an verified in part in China, Europe and some African States. The datasets permit to determine land cover changes during the last decade.

This was followed by a discussion on „Core Global Datasets" at national, regional and global level. The contributions by Britain, France, Mexico, Spain, Japan and South Africa are downloadable from the Internet under www.ggim.un.org

Another issue was the desirable population of the „Knowledge Base" at www.ggim.un.org . The reports on the UN-GGIM/ISPRS project „Current Status of Global Geospatial Data" are part of the Knowledge Base and they are downloadable from there.

The President of ICA announced that in August 2015 the „International Map Year" will be launched during the ICA Congress in Rio de Janeiro.

In the final session of the meeting the agenda for the UN-GGIM5 Conference, which has been scheduled for August 3 to 7, 2015 in New York, was discussed.

It was agreed to place a final report on the UN-GGIM/ISPRS Project on the Current Status of Geospatial Data onto the agenda.

The 90 delegations present in New York offered the possibility for personal discussions to sollicit further questionnaire responses for the UN-GGIM/ISPRS project.

Such responses have been promised by 20 such member states:

Antigua and Barbuda, Argentina, Azerbaijan, Barbados, Cambodia, Dominica, Dominican Republic, Grenada, Guyana, Haiti, Indonesia, Kuwait, Lao People´s Republic, Qatar, Saudi Arabia, St. Lucia, St Vincent and the Grenadines, Suriname, Trinidad and Tobago.

7. Meeting with Lawrie Jordan, Director of Imagery, ESRI, Redlands, CA,

August 11, 2014

After a presentation of the Hannover created and compiled Excel database with visualization of the metadata for each country, we disussed future cooperation possibilities.

ESRI has a database within ArcGIS Online , which can display and superimpose map data and (high resolution satellite) imagery and is able to integrate metadata for visualization by countries.

Lawrie Jordan suggested to create a pilot project for the integration of the ESRI and the Hannover UN-GGIM/ISPRS datasets during the next year. The completed system is intended to be placed on the web for free of charge use by scientific users.

8. Meeting with Barbara Ryan, Director of UN-GEO, Geneva during the UNGGIM4 Conference.

Barbara Ryan agreed to place the UN-GGIM/ISPRS Project onto the UN-Geo website for public use.

9. Meeting with Amor Laaribi, UNGGIM Secretariat, New York.

Amor Laaribi agreed to make an annual UNGGIM Secretariat mailing to UN member countries, solliciting updates of the UN-GGIM/ISPRS Project database in cooperation with ISPRS to make the project effort sustainable.

Space Experiment on the International Space Station with P-band SAR

B. Kutuza[1], A. Kalinkevich[1], A. Zakharov[1], V. Stasevich[2], A. Zimov[2], Yu. Smirnov[3]
[1]Kotel'nikov Intstitute of Radio Engineering and Electronics of RAS, Moscow, Russia
[2]NPP "ROBIS", Moscow, Russia
[3]RSC "ENERGY", Moscow, Russia

The problem of building the side-looking P-band SAR on board the International Space Station (ISS) is consi-dered. Proposed space experiment "ISS-SAR(P)" is aimed at the development of SAR research of the Earth from space.

1. Introduction

Proposed experiment is aimed at the development of SAR research of the Earth from space. Satellite experiments conducted in USSR, USA and European countries have demonstrated high efficiency of SAR for remote sensing of the Earth's resources. One of the promising ways to develop radar technique is to extend the waveband used for the remote sensing, especially in low frequency band. The lowest frequency used up to date in spaceborne SAR is 1.3 GHz (wavelength 23 cm), which is L-band. At the same time airborne experiments conducted in Russia (IMARK system), Sweden, France, Germany and other countries have shown the potential of lower frequency band (less than 1GHz) for surface and subsurface remote sensing. It is specified mainly by higher penetration ability of P-band electromagnetic waves in soil, vegetation, snow, ice covers, which makes possible to discover characteristics of the objects located above the ground and at certain depth within it.

2. Motivation

In last decade the next noticable trend toward the change of habitual living Environment on the Earth was observed:

• a severe reduction of forests (forest biomass), af-fecting the carbon balance;

• a considerable reduction of water storage in Earth glaciers, reduction of ice covering in polar water areas;

• a change of sea waters movement direction, e.g. in largest sea currents (Gulf stream, Kuroshio);

• acute pollution of particular inland water reservoirs (Black Sea, Caspian Sea, Azov Sea, Baikal).

The utilization of spaceborne P-band SAR is rather promising for the research of the environment and of its ecological state. It was proved by the results of multiple airborne experiments (see next section). In recent years the problem of building the spaceborne P-band SAR was discussed at many international conferences on radar and Earth remote sensing (BioGeoSAR'2007, EUSAR'2006, '2008, '2010, IGARSS'2010). One of the known prospective projects in this area currently being developed is ESA project "Biomass". Major problems in the development of spaceborne P-band SAR are concerned with difficulties in antenna design and in taking account of the effect of ionosphere.

Conditions of measurements by means of airborne SAR and spaceborne SAR at P-band are considerably different. Sensing from space has number of methodological and technical difficulties. One of the difficulties arises from the need to take into consideration propagation of waves in the ionosphere. When propagating through ionosphere, P-band waves change their phase and polarization plane. Random nature of spatial and time inho-mogeneities makes it difficult to take into account the effect of ionosphere. In our case the performance of "GLONASS" experiment on the International Space Station (ISS) aimed at the study of the ionosphere by means of tomography gives a unique opportunity of taking account of the effect of ionosphere. In-formation on the ionospheric characteristics obtained in this experiment may be used for the interpretation of P-band SAR data.

3. Airborne experiments

Consider an example of airborne studies carried out by means of P-band SAR. Forest biomass is the main storage of vegetation carbon and one of the most important elements of carbon cycle, which is directly connected with the climate of the Earth. Therefore the problem of studying the dynamics of spatial distribution of forest cover over the Earth's surface is very urgent. There are many ways of remote sensing of forest cover spatial distribution variations. The utilization of optical sensors has shown good results in classifying the forest formations (deciduous, coniferous and mixed forests) and in monitoring the changes in deforestation and forest regeneration. However these methods are of little value for measuring with high accuracy the forest biomass, which is mainly contained in trunks and large branches of the trees. The main reason of that is insufficient sensitivity of optical band signals to forest structure. Natural objects effectively interact with electromagnetic radiation if the wavelength within the object is comparable to the object's dimensions. From this perspective most suitable frequency band for measuring the forest biomass remotely is microwave one, and preference should be given to longer wavelength bands (P or VHF), since the wave length here is comparable to size of tree trunks and branches. As an example, Figure 1 demonstrates SAR images of an area in national park Meshchera in Ryazan Region with various natural objects (forests, open and vegetated water bodies, soil covers, peat lands etc.). One can see that P- and VHF-band signal has considerably higher penetration ability in comparison with L-band.

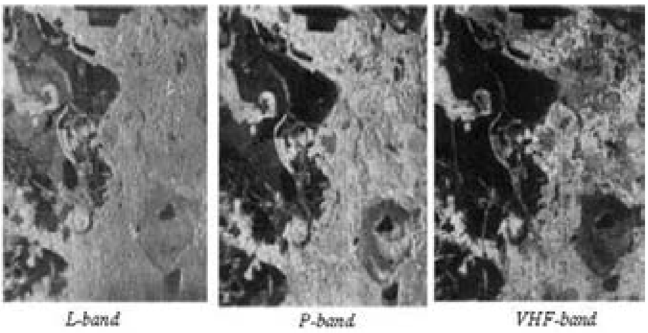


Figure 1: Spas-Klepiki, Ryazan Region. L-, P- and VHF-band SAR images.

As applied to the forest this allows to measure its bio-mass directly. Besides, the use of spaceborne SAR makes it possible to investigate forestlands over the large areas with high resolution.

However the use of P-band SAR is not limited to the studying of forestland. Airborne experiments have demonstrated that this band is unique for marine survey. Analysis of SAR images of sea surface obtained at various wavelengths shows that stratification of sea water movement becomes apparent most clearly at P- and VHF-band images. In Figure 2 SAR images of Barents Sea are given at three frequency bands. One can see that P and VHF bands have high information content. These images reveal:

1 – sea regions with different salinity;
2 – disturbance areas;
3 – whirlpool behind the cliff;
4 – river delta with pollution carry-over.

Thus, the utilization of P-band SAR can be of significant help in the research of sea disturbance, sea currents, river delta processes etc.

From stated above one can conclude that development of spaceborne P-band SAR gives opportunity to obtain an effective tool for solving the actual problems of forestry, geology, oceanology, subsurface sensing at the global scale and at the significantly higher level due to higher penetration ability of the signal.

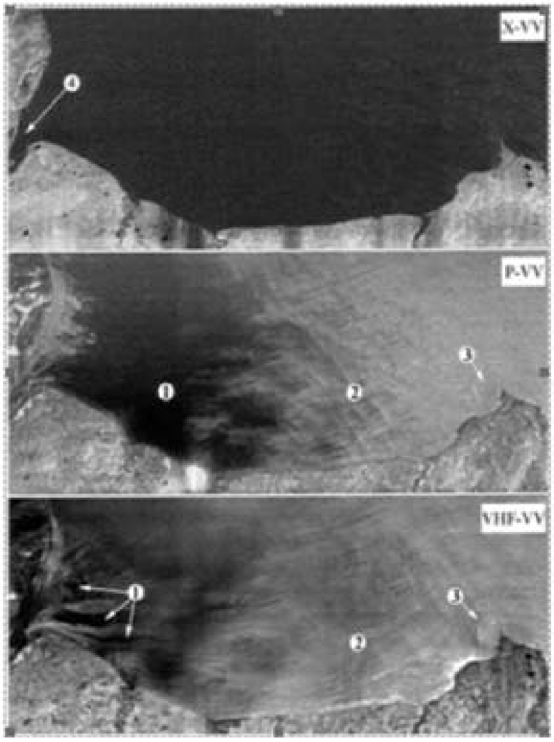


Figure 2: SAR images of Barents Sea area obtained at L-band (wavelength 4cm, VV polarization), P-band (wavelength 68 cm, VV polarization) and VHF-band (wavelength 254 cm, VV polarization).

4. Principles of building the P-band SAR on ISS

The key problems of building the spaceborne P-band SAR are related to the difficulties in antenna system design and in taking account of the effect of ionosphere. An important problem is SAR external calibration also. The conditions of space experiment on ISS have a number of essential limitations. In accordance with the operating procedure of the onboard equipment average power of transmitter should not exceed 50 W. Radar antenna area is restricted by a value of 32 m^2. Inclination of the orbit towards the equator is 51.7°. According to international agreement allowed frequency band for Earth radar is 432-438 MHz. It restricts the slant range resolution by a value of 25 m.

Antenna system is a key element which specifies the relationship between SAR equipment parameters, geometry and characteristics of radar survey areas. On the preliminary stage of this project various acceptable options of antenna design were considered such as mirror antennas and active phased array antennas (APAA) of various dimensions. Up to date it was decided to use the mirror antenna with 32m^2 square. Antenna has double set of elements which enables working at both horizontal and vertical polarizations. Figure 3 represents a scheme of location of antenna on ISS.

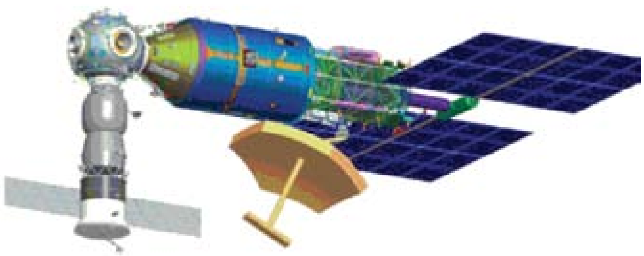


Figure 3: A scheme of location of P-band SAR antenna on the ISS.

The antenna, its feed and the rod for installing the antenna system will be delivered onboard with cargo spacecraft "Progress". Antenna system will be installed on its place by operator during extravehicular activity.

Figure 4 demonstrates the direction of antenna beam relative to the flight direction of the ISS.

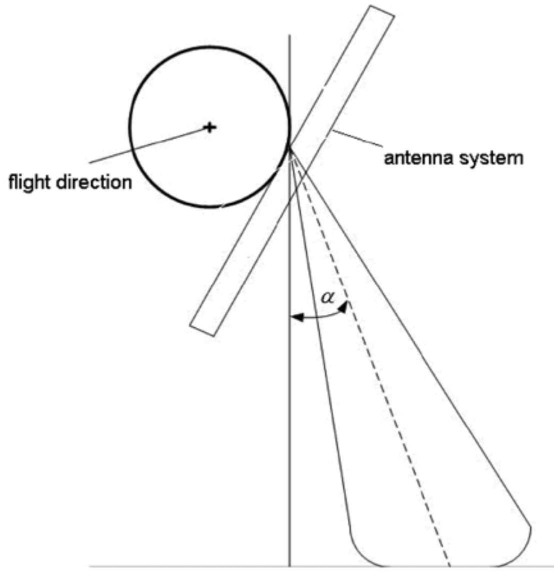


Figure 4: Direction of antenna beam relative to the flight direction of the ISS.

An irradiator in a focal area made as a set of linear phased array of emitters will provide beam scanning in elevation plane. Observation angle α may be selected in the range 100 - 35° . It is expected that width of the radar swath on the ground will be 40-60 km. Five beams of radar antenna will form an observation swath 250 km wide on the ground. Location the antenna system on the left side with respect to the flight direction is favorable for increasing the study area of coniferous forests in Northern hemisphere.

5. Power characteristics

Energy characteristics of the proposed SAR system may be estimated on the basis of survey geometry and antenna parameters. Radar cross section σ_N of noise equivalent may be estimated by formula:

$$(1)\quad \sigma_N = \frac{4^4 \pi^3 r^3 V \Delta F_m K_b T_P \sin\theta}{W_0 G^2(\alpha) \lambda^3 c Y_S T_i f_r}$$

Here r is surface element range, V is vehicle speed, ΔF_m is frequency deviation of chirp signal, K_b is Boltzmann constant, T_P is noise temperature, T_i is duration of sensing impulse, Θ is incidence angle, λ is wavelength, W_0 is emitted power, G *(α)* is antenna pat-tern, c is speed of light, Y_S are losses along the propagation path and in the receiving and processing system, fr is pulse repetition rate. Given formula contains only information on radar system parameters and does not depend on the image parameters or on the processing technique, which makes it preferable for the obtaining of objective characteristics.

Let us estimate maximum antenna gain by its geometric size:

$$G = \frac{4\pi S\eta}{\lambda^2} \quad (2)$$

Here S is antenna area, η is antenna efficiency, which is assumed to be 0.5. For given antenna dimensions G = 25 dB.

Losses along the propagation path and in the receiving and processing system are taken to be Y_S = 2, transmitted radar impulse power W_0 = 50 W, chirp impulse duration T_i = 25 ms, receiver noise temperature T_P = 500°K. Assuming that Doppler frequency band for antenna of given size is equal to 2.4 kHz, pulse repetition rate for polarimetric mode is chosen to be f_r = 4.8- 5.0 kHz.

Under given initial conditions radar sensitivity as noise equivalent radar cross-section σ_N = 30 dB. Working in one polarization mode with the same pulse repetition frequency gives value of σ_N will be 3 dB better.

Swath width for radar looking angle of 30° is 58 km in ground range. Considering that pulse repetition rate is chosen on account of polarimetric mode, ground range ambiguity in polarimetric mode is 64 km, which is enough for range disturbance suppression. Then ground range resolution will be 50 m.

Single polarization mode allows the operation at doubled pulse repetition frequency, what allows increasing the radar sensitivity while working without range ambiguities at larger observation angles, up to 40°. In this case swath width will be 75 km and ground range resolution would be 38 m.

6. Expected results

Taking into account the ISS orbit the following objects can be investigated:

• forests and open soil regions of Buryatia, Mari El Republic, forest regions of southern part of Krasnoyarsk Krai and forestlands at Meshchera test sites;

• forests of equatorial Africa and South America;

• Sea of Okhotsk at various times of a year;

• sea ice properties in winter and sea ice cover dynamics;

• mountain glaciers (crevasses, top layers stratification) of Caucasus, Altai, Alps, Himalayas, including those under snow cover;

• water stratification in the areas of large sea currents, first of all Kuroshio and Gulfstream.

In the course of the space experiment the following issues should be worked out:

• methodical questions of measuring, digital processing and interpreting of backscatter data obtained from space by means of P-band SAR;

• methodical questions of measuring, digital processing and interpreting of data on magnitude and polarization characteristics of P-band signal scattered by point and distributed targets on the ground surface;

• estimation of actual parameters of geometric and polarization distortions arising due to the effect of ionosphere;

• methodical questions related to the account of the effect of ionosphere on the microwaves propagation and to the appropriate correction of obtained data;

• methodical questions concerning external calibration of P-band SAR;

• studying the possibility of estimating the sea disturbance parameters, stratification (including sea currents) and sea surface salinity;

• obtaining data on backscatter from coniferous, deciduous and mixed forests and estimating the possibility of classifying them;

• investigating the possibility of determination of forest biomass using space measurements and correlating them with test site data;

• studying the possibility of obtaining data on hydrological regime of soils;

• studying the possibility of estimating the characteristics of the surface under snow and ice cover;

• investigating the possibility of detecting and studying the large- and medium-scale surface water pollutions.

Features of Point Clouds and Functionalities of Processing Software

M.J.P.M. Lemmens
Delft University of Technology,
Faculty of Architecture and the Built Environment, The Netherlands

To be useful, the millions or even billions of 3D points generated by a variety of active and passive sensors need to be stored, organised, combined, geo-referenced, measured, analysed and distributed within organisations or outward. Initially, the data is unorganised; software has been designed, developed and put on the market place to organise the unorganised and to extract information from the point clouds. In principle, the curved 2D surface can represent any instance such as soil pollution, forest biomass, rainfall, terrain elevation or the seabed. In the field of geomatics, the phenomenon will usually be the terrain surface or the seabed. This paper focuses on point clouds from which DEMs or DSMs can be generated, stemming from sources including airborne Lidar; Terrestrial Laser Scanning (TLS); airborne and spaceborne Radar; close-range, airborne and spaceborne imagery; and sonar.This paper presents first the main features of point clouds and focussesnext on the diverse functionalities of point clouds processing software presently on the market, including : data storage; geo-referencing; the filtering aspect of point-cloud creation; interpolation; andvisualisation and editing.

Features of Point Clouds

A point cloud is a set of data points represented in a preferred coordinate system. The dataset consists of measurements taken at discrete points of a curved 2D surface in 3D space. This 2D surface may be smooth or it may contain discontinuities such as facades of building. The number and density of the points should be such that the 2D surface can be reconstructed, i.e. at every point on the surface a value can be calculated from the measured values of points in the vicinity. In principle, the curved 2D surface can represent any instance such as soil pollution, forest biomass, rainfall, terrain elevation or the seabed. In the field of geomatics, the phenomenon will usually be the terrain surface or the seabed in the form of a digital elevation model (DEM) or digital surface model (DSM).

The data of such a point cloud comprises a set of x,y coordinates to which height/depth values have been assigned: one value per x,y location. Added to height or depth, other attributes may be attached to the x,y component, such as reflection intensities of the laser/sonar pulse or RGB of a colour image recorded by a camera at the same time. As a result, the x,y component and its attributes forms the nucleus of the point cloud and the number of nuclei may run into billions (Lemmens, 2014a). Indeed, as a result of rapid advances in laser scanning and dense image matching it is now relatively easy to produce high-resolution terrain data at very high rates. Returns from the active Lidar systems are first stored in the form of range, angle and time. These are then integrated with 3D location data (latitude, longitude and altitude) collected by on-board GNSS and pose data (roll, pitch and heading) measured by an IMU, which is usually integrated with the GNSS, and if applicable compasses, barometers and odometers. The integration of the raw data is largely automated and results in a geo-referenced 3D point cloud which often needs editing to remove outliers and other improper points. Usually the point cloud is transferred to a 2.5D surface in the form of regular grids or triangulated irregular networks (TIN). These products often act as the basis for input in CAD, BIM and other software tools used by planners, designers, inspectors and others.

Point clouds may also stem from overlapping imagery, captured by nadir-looking or oblique cameras, using photogrammetric image-matching software, such as Pix4Dmapper, Timble'sInpho, Imagine from Hexagon Geospatial or Racurs' Photomod (Lemmens, 2011). The cameras may be mounted in manned or unmanned airborne systems (Lemmens, 2014c).

Functionalities

The functionalities of processing software differ widely. To understand types of use, it is key to gain insight into the ins and outs of the different packages. The functionality may start at the creation of the point cloud itself, as is the case for image matching software which creates a DSM from overlapping imagery. We tag the functionality of point cloud processing software into eight groups:

- Point cloud creation
- Geo-referencing
- Data storage & Interoperability
- Visualisation & Editing
- Interpolation
- Feature Extraction
- Taking Measurements
- Analysis

The sequel to this paper will focus on: data storage; geo-referencing; the filtering aspect of point-cloud creation; interpolation; and visualisation and editing.

Data Storage

A first challenge in the use and exchange of point cloud data is the considerable sizes of the files: a 32-bit operating system can run files of up to several GB, and most computers are not designed for such large datasets. The amount of data produced by today's sensors is growing faster than the processing and storage capacity of database management systems (DBMS). The storage of billions of 3D points is an issue in itself as their collection, archiving and distribution is increasingly becoming a task of governmentalorganisations. Manufacturers of hardware have developed proprietary formats for serving the individual surveyors, but these are not well suited for massive volumes distributed from one central provider to multiple users.The same is true for Oracle Spatial and PostGIS, which are the major DBMSs on the market and as a result organisations store point clouds by dividing them into tiles and strips (Kodde, 2014). Storage as ASCII text files may be appropriate but the files may become large and their access slow while their untroubled use requires good communication on record contents and the definition of separation characters. The ASPRS created the LAS format to address the shortcomings of ASCII for Lidar point clouds (Olsen et al., 2013). The binary LAS format is an open standard, requires less storage space and has become ade facto standard.LAZ is a lossless compressed version of the LAS format, resulting in a reduction of a factor 5 to 10 with respect to the original LAS file size. Also the recently released E57 uses binary storage to reduce storage space. The file size is virtually unlimited and E57supports storage of ancillary data of such imagery next to the point cloud data. As software support for E57 is limited up till now, proprietary formats are often preferred as they are optimised for system-specific outputs.

Geo-referencing

3D patches of point clouds – i.e. individual scans – must be transformed to a single coordinate system to enable geo-referencing or registration, which involves identifying common points in the overlaps. As a geometric transformation model, the 3D similarity (Helmert) transformation is usually applied (three translation parameters, three rotation parameters and one scale parameter). This process requires at least seven coordinates, i.e. two 3D ground control points (GCP) and one heightGCP. To obtain redundancy and thus the ability to detect outliers and to compute precision through error propagation, seven or more GCPs that are evenly distributed along the border of the site are commonly measured, usually with differential GNSS or total stations. The stitching of the single point clouds requires tie points in the overlaps. These are distinctive points in the scene or consist of targets placed, marked or painted in the overlaps. The latter requires a more detailed, accurate and thorough planning of the survey to ensure that the marks are placed in the overlaps and be visible from the point of scanning. Added to this, attention shouldbe paid to make sure that the GCPs are clearly identifiable. In addition to the indirect method described above, direct geo-referencing can also be conducted in some cases. For example, a TLS can be centred over a known point and levelled as if it were a total station. The position can also be determinedusing a GNSS antenna mounted onusing a GNSS antenna mounted on top of a TLS.

Filtering

An important aspect of point-cloud creation is the removal of unwanted points (filtering).

Airborne Lidar, TLS,Radar as well as automatic matching of overlapping imagery capture all objects present on the site, including vegetation, cars, bikes, dogs, fish, shipwrecks and suchlike, all of which will, in general,be irrelevant for the survey at hand and are thus 'noise' from the surveyor's point of view. The software should therefore be able to remove such points, either through manual editing or by automatic filtering. Most software contains tools to quickly and easily reduce such noise. Ground filtering is a specific method aimed atthe removal of points reflected from vegetation when creating a 3D city model, or from vegetation and buildings when creating a bare-ground DEM. In course of time many different filtering methods have been developedsee e.g. Filin and Pfeifer (2006), which is a token of the complexity of the filtering problem (Lemmens, 2011a). The resulting algorithms are based on a wide variety of mathematical modelling of the point cloud data. A broad overview of Lidar ground-filtering methods toguide users in selecting the optimal method for their specific applications is given by Meng et al. (2010).

Interpolation

Usually the continuous surface is reconstructed from the sample points by estimating the height value of individual points by using some interpolation technique. Interpolation techniques are also used to transfer an irregular distributed set of elevation data into a regular raster. Interpolation aims thus at providing elevation data in regions where no data exist or to transfer an irregular distributed set of height points into grid format. Many interpolation techniques have been developed in course of time. These interpolation techniques have similar performance, provided that the data behaves well with respect to point distribution and fluctuations in heights. Nevertheless, selection of a proper interpolation method for a given input dataset is a difficult endeavour (Burrough and McDonnell, 1998). Various geo-science related disciplines have developed a variety of interpolation methods for spatial data of specific types. Sample size, sampling design and other characteristics of the data influence the performance of an interpolation method chosen by the user but it is difficult to determine in advance the effects of the characteristics of the data set on the final result (Li and Heap, 2008). However, for terrain heights one may state, as a rule of thumb, that the closer a known point lies to the unknown point, the more similar the behaviour will be. Of course, the underlying smoothness assumption is violated in cases where buildings and other constructions are present. Here, two nearby positions may have very different heights and this property is used for ground filtering that is the removal ofunwanted objects to arrive at a bare ground representation. In case the smoothness assumption is valid the value of an unknown point is usually computed from measured points in the vicinity using a weighting scheme.It is often feasible to use the inverse of the distances as weightings. The inverse distance weighting (IDW) weights the known points in a search area around the unknown point using distance . The search area may be a circle, a square or any other shape. The result is a distanceweightedmean. Nearest neighbour(NN) uses area as the weightingcriterion. IDW and NN both compute values which are within the range of those of the known points and thus do not generate peaks, pits, ridgesor valleys if they are not present in the input. No action from the user is needed and the output is smooth while the values of the known points are preserved. Another often-used method is Kriging whereby the weighting function is not based on distance or area, but rather on the covariance of the measured points.

Ingeneral, the quality of the computed value of the unknown point of any interpolation method mainly depends on whether the points in the vicinity belong to the same type of points. For example, if the measured points are partly located on a building roof and partly on the street, the height of an unknown street point will be computed somewhere between street and roof level. So, a key issue is the robustness of a certain interpolation technique against the changes in the geo-morphological structure within the vicinity of the point of which the elevation has to be determined. It is important that the points used in the interpolation and the point to be interpolated all belong to the same landscapetype or land use type. For example, when we determine the height value of a point, which is located in a valley from two valley points and one slope point, the interpolated height value may be too large and thus erroneous. So, the goodness of an interpolation can be judged by considering how well the method is insensible to the changes in geo-morphological characteristics of the terrain. Locally adaptive gridding techniques enhance the sensitivity of interpolated regular grids to terrain structure, including ridges and streamlines. Although these methods are certainly an improvement, proper interpolation results can only be warranted by performing a pre-processing stage pinpointed on the segmentation of the point cloud in homogeneous sub-areas in terms of geo-morphological structure based on additional information stemming from other sources and inputfrom a human operator or by using region growing techniques well-known in the realm of digital image processing (Lemmens, 1999a; 1999b).

Visualisation and Editing

The software should be able to visualise and edit point clouds with many billions of points at a reasonable rate; it should not take hours before a view appears on the screen. All the points may be depicted in a single colour and size, but a colour code may also portray the strength of the return signal, the elevation or the RGB values of the same point in animage. Inspection of the point cloud requires zooming, panning, rotating, fly-through and adjusting point size. Editing operations include the mouse-clicking of individual points for the removal of outliers or a group of points, addition of missing points or calculation of distances, angles, areas and volumes. The boundary of the group may be identified by drawing a cube, a rubber surface or other volume shape. Selection of a group of points allows geometric primitives such as planes, spheres, cylinders or NURBS (non-uniform rational basis spline) to be fit using an optimisation method – usually this will be least squares. Selection of a group of points also allows themanual removal of unwanted pointssuch as those reflected on vegetationand buildings if one wants to create a bare-ground DEM. Staking out a baseline enables the extraction of a cross section.

Point Cloud Processing Software

Processing software may be general purpose and handle point clouds from a diversity of sensors, or it may be dedicated to specific outputs such as data acquired by terrestrial laser scanners, airborne Lidar, mobile mapping systems, or sonar. Manufacturers of point cloud-generating sensors have recognised that clients need to process the outputs of their sensors, and have complemented their hardware with proprietary software for managing, geo-referencing, visualising, editing and exporting the outputs to dedicated software. Some software builders have spotted potential in offering tools for creating a broad pallet of end products from a particular sensor type such as Lidar, possibly combined with pixel data, from pixel data alone or sonar.

Other packages stem from the other end of the spectrum, i.e. the application domains. For example, constructors who were used to a certain CAD software package started to appreciate TLS point clouds and asked vendors to add modules for processing them. Some manufacturers discovered new opportunities along the way and built dedicated modules on top of one or more base modules aimed at, for example, the mining industry or 3D models of crash sites. This development process is far from complete, and new tools are being added all the time. However, a generic package which can handle all types of sensor output and generate all types of end product does not exist, because each package has its own peculiarities. Therefore, before purchasing software, it is not only important to look at the functionalities of the software, but also advisable to examine its design ideas, any current or planned extensions, its ability to join modules into one workflow, and interoperability with other software and services provided.

Key for specific, industrial use is not only the manual measuring of length, height, distance, angle, area and volume, but also the extraction of geometric features such as lines and planes andthe fitting of solid models through a set of points. The solid models may include cubes, spheres, cylinders or user-specified objects such as valves and elbows.

Concluding Remarks

Vendors often offer plug-in modules, which provide a sequence of functionalities adapted to particular needs, while othersprovide 'lite' versions aimed at users who do not need all the functions. Fernandez et al. (2007) provides a survey of point cloud processing software focussed on Lidar data. Lemmens (2014b) presents an overview of point cloud processing software aimed at creating DEMs or DSMs and products derived from these from a variety of sources including airborne

Lidar; Terrestrial Laser Scanning (TLS); airborne and spaceborne Radar; close-range, airborne and spaceborne imagery; and sonar.

References

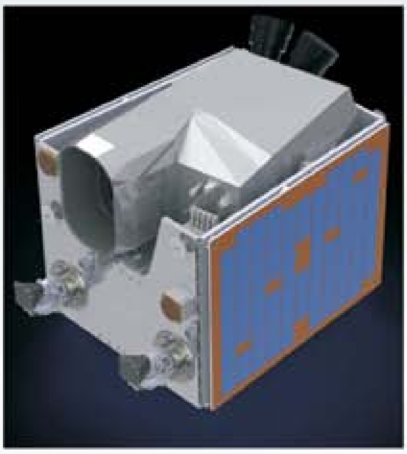
- Burrough, P. A., McDonnell, R. A., 1998, Principles of Geographical Information Systems 2nd Edition, Oxford University Press, New York.
- Fernandez, J.C., Singhania, A., Caceres, J., Slatton, K.C., Starek, M, Kumar,R., 2007, An Overview of Lidar Point Cloud Processing Software, GEM Center Report No. Rep_2007-12-001, University of Florida.
- Filin, S., Pfeifer, N., 2006, Segmentation of airborne laser scanning data using a slope adaptive neighbourhood, ISPRS Journal of Photogrammetry and Remote Sensing, vol. 60, no. 2, pp. 71-80.
- Kodde, M., 2014, Future-proof data storage – File and database storage methods for huge point clouds, GIM International, 28: 7, pp. 16-21.
- Lemmens, M.J.P.M, 1999a, Uncertainty in automatically sampled Digital Elevation Models, Chapter 47, in: Lowell, K., Jaton, A., (Edts), Spatial Accuracy Assessment: Land Information Uncertainty in Natural Resourses, Ann Harbor Press, Chelsea.
- Lemmens, M.J.P.M. 1999b: Quality description problems of blindly sampled DEMs. In Shi, W., Goodchild, M.F. and Fisher, P.F., editors, Proceedings of the International Symposium on Spatial Data Quality '99, Hong Kong Polytechnic University, 210–18.
- Michigan,1 ISBN 1-57504-119-7, pp. 399-407.
- Lemmens, M., 2011a, Geo-information – Technologies, Applications and theEnvironment, Springer,ISBN 978-94-007-1666-7.
- Lemmens, M., 2011b, Digital Photogrammetric Workstations Status and Features, GIM International, 25:12, pp. 28-31
- Lemmens, M., 2010a, Airborne Lidar processing software, GIM International, vol. 24, no. 2, pp. 14-15.
- Lemmens, M., 2014a, Point Clouds (1) – The functionalities of processing software, GIM International, 28:6, pp. 16-21.
- Lemmens, M., 2014b, Point Clouds (2) – Survey of processing software, GIM International, 28:7, pp. 27-33.
- Lemmens, M., 2014c, UAS for mapping – A product survey on systems and features, GIM International, UAS Special, pp. 12-15
- Li, J., Heap, A.D., 2008, A Review of Spatial Interpolation Methods for Environmental Scientists, Geoscience Australia Record 2008/23.
- Meng, X., Currit, N., Zhao, K., 2010,Ground filtering algorithms for airborneLidar data: a review of critical issues,Remote Sensing, vol. 2, no. 3, pp.833-860.
- Olsen, M.J., Roe, G.V, Glennie, C., Persi, F., Reedy, M., Hurwitz, D., Williams, K., Tuss, H., Squellati, A., Knodler, M., 2013, Guidelines for the Use of Mobile LIDAR in Transportation Applications, National Academy of Sciences, ISBN 978-0-309-25914-9.

The Joint-Stock Company «National Company «Kazakhstan Gharysh Sapary»

Creation of earth remote sensing space system of the Republic of Kazakhstan

Spacecraft ***KazEOSat-1*** was launched on 2014, 30 April.

- Spatial resolution in panchromatic mode, m – 1;
- Spatial resolution in multispectral mode – 4;
- Number of multispectral channels – 4;
- Mass, kg – 820;
- Swath, not less than, km – 20;
- Performance of the ERS satellite for the 24 h. day - 220 thousand km.sq.;
- Active lifetime period, years – 7.



Spacecraft ***KazEOSat-2*** was launched on 2014, 20 June.

- Spatial resolution in multispectral mode, m - 6,5;
- Number of multispectral channels – 5;
- Mass, kg – 180;
- Swath, not less than, km – 77;
- Performance of the ERS satellite for the 24 h. day - 1mln. km.sq.;
- Active lifetime period, years – 7.

ERS SS RK geoproducts line:

L1 – satellite images, which include radiometric correction.

L2 – satellite images, which include geometric and radiometric correction.

L3 – orthorectitled satellite images DEM[1].

L4 – product, representing a DEM[2] and DTM.

L5 – mosaic created from geoproducts L3 and L4.

[1] DEM – Digital elevation model

[2] DTM – Digital terrain model

Ground complex of ERS SS RK in Astana

Flight control center in Astana

KazEOSat-1 image of Astana

"The House of Ministries", Entrance 4
Orynbor Street, 8
Astana city, 010000
The Republic of Kazakhstan

Tel.: +7 (7172) 74-34-01,
+7 (7172) 74-34-57,
Fax: +7 (7172) 74-94-65
www.gharysh.kz
info@gharysh.kz

Full Cycle of RS Data Processing in IMC Software Suite

V. Lobzenev, I. Logvanev
Innovative Centre LLC, Moscow, Russia

Nowadays, for socio-economic, scientific and defense purposes, creation and development of space systems and technologies dedicated to remote sensing (RS) is one of the major applications of space equipment. Current Earth remote sensing space systems provide data collection on a global scale with high spatial and spectral resolution.

The provision of an open and commercial access to satellite imagery materials, along with their transfer to digital form has been the most important change in the RS market. The development of computer-based image processing has led to creation of fundamentally new analytical systems – geographic information systems (GIS). Recognition of data by binding to the geographical location provides an ability to receive new information through spatial, temporal and visual complexation.

Satellite imagery is widely used in various fields such as cartography, ecology, land-use planning, area development management, agriculture, forestry, industry, discovery of new mineral deposits, impact assessment on the aftermath of natural disasters, etc.

Currently, there are number of Russian and foreign software products for RS data processing. Usually, specialized software suites allow you to work with one type of the RS material; either picture, a map or GIS. Thus, each software solution is specialized for a certain task and the complete cycle of processing requires 2 or 3 programs which significantly increase time and cost of this process. However, the Russian market provides an innovative solution – "Image Media Center" (IMC) software suite, fully developed by the Russian company "Innovative Centre", which allows the full cycle of RS data processing in a single geographic information space.

The main advantage of IMC software suite is the combination of fully functional geospatial environment, satellite images that can be easily worked with and the ample choice of professional graphics and vector editors.

Image Media Center software suite provides users with the following capabilities:

- Loading of monochrome and color images with different types of data, including 8, 16 and 32-bit, floating point, and complex.
- Support of six color models: Grayscale, RGB, CMYK, HLS, HSB, Lab.
- Support of the following data types: raster images, marks, text, vector images, geo-referencing points.
- Work with layers: transparency, blending mode, the display order, grouping.
- Improvement of the image quality by using filters, direct editing of image pixels, the radiometric characteristics.
- Support of GIS functionality while working with vector data.
- Geo-referencing data.
- Logging of the operations history.
- Customizable interface and availability navigation windows.
- Preparation of report documents, support of profiles.

Modern remote sensing space systems widely use multispectral data. The information content of images is enhanced by using a system of features based on the spectral characteristics of recorded optical radiation.

The combination of high spatial and spectral resolution allows the user to see the world in amazing details and solve thematic problems with a high degree of efficiency. Multispectral high resolution imaging provides better object recognition with greater accuracy and thus contributes to decision-making in public and private economy sectors.

IMC software suit uses radar and optical satellite imagery, including panchromatic, multi- and hyperspectral images, vector masks, and images without geo-referencing and geo-referenced images as data input for thematic RS data processing.

"Image Media Center" supports the most popular formats of raster and vector images: Bitmap Format (*.bmp), Erdas Imagine (*.img), Tagged Image File Format (*.tif), JPEG (*.jpeg), Targa (*.tga), AutoCAD 2007 File (*.dxf); MapInfo Interchange Format (*.mif), Shapefile (*.shp).

Own Image Media File format allows you to:

• store information in a hierarchical structure;

• store multiple layers of different types in a single file, (raster and vector images, marks, text data, etc.)

• save more than one image in a single file;

• use alpha channels of the images;

• save images in different scales;

• work with various types of data;

• work with large files (over 300 GB , such as formats *.imf, *.emg);

• quickly access to data, regardless of file size.

Receiving satellite images is associated with serious technological difficulties. Converting optical signal into digital data is influenced by a number of distorting factors which should be considered and compensated maximally. Therefore, the RS data processing requires special mathematical methods and computational algorithms.

Technology of RS data preprocessing implemented within IMC software suite is fully automated and allows the user to perform the following steps:

• Formation of satellite images mosaic.

• Formation of images composite, obtained in each spectral range of surveying.

• Eliminating the offset between the channels.

• Formation of synthesized color images of individual spectral bands.

• Increasing the detail of panchromatic image by 10-12% if necessary.

• Obtaining complexed images in natural colors with the resolution of panchromatic image (Figure 1).

• Atmospheric correction.

• The brightness and tone correction, elimination of noise in the image.

• Sharpening the image using the algorithm that eliminates defocusing.

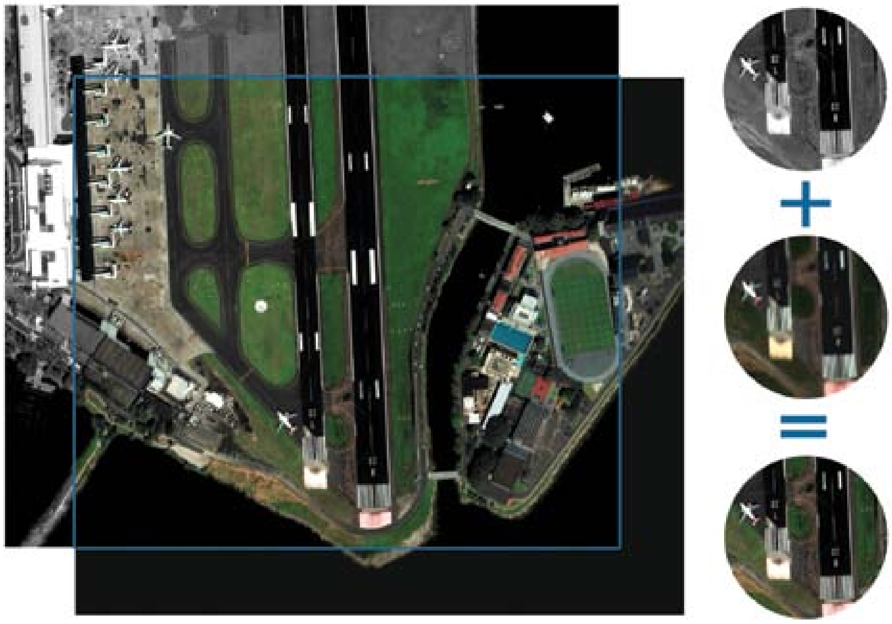


Figure 1. Complexed images in natural colors with a resolution of the panchromatic image.
WorldView-2 spacecraft. Andorra territory.

IMC software suite provides an ability to create thematic maps based on satellite images using the following algorithms:

• Work with color components.

• Formation and analysis of the index images.

• Vectorization and the assignment of display styles.

• Working with vector masks addition / subtraction of vector layers.

• Formation of attribute tables and filling them with content.

• Clustering, interactive supervised classification.

• Multi-temporal monitoring.

• Texture analysis.

• Structural analysis.

• Processing and analysis of an unlimited number of spectral channels.

• Display of spectral curves in tabular and graphical forms.

• Formation of spectrogram libraries.

• Comparison of the spectral curves to each other.

• Search for spectrograms in the library with a certain confidence interval.

• Search for objects in the image on the spectrogram according to the value of the confidence interval.

• Formation of spatial spectrograms by row, column, or arbitrary profile of the image.

Automated processing algorithms implemented in the IMC software suite allow you to analyze not only spatial but also temporal changes occurring in the study area; identifying the most intensive causes and classifying their combinations.

Multispectral data processing technology is implemented based on the formation of both well-known index images (NDVI, NDWI, NDSI, etc.) and specialized ones.

The result of thematic processing are vector layers, containing separate vector objects filled with attributive data.

In recent years, hyperspectral images are used increasingly to identify the qualitative characteristics of terrestrial objects, including hidden ones.

Hyperspectral survey is the evolution of multispectral systems. Due to innovative technologies, the number of multispectral channels increased from 3-5 to 220 (multispectral sensor onboard the spacecraft Hyperion EO-1).

High information capacity of multispectral systems is based on specific differences in the emission spectra of natural and man-made objects.

Figure 2 shows spectrograms of different terrestrial objects based on the hyperspectral image that is taken by Resource-P spacecraft, containing 130 spectral channels.

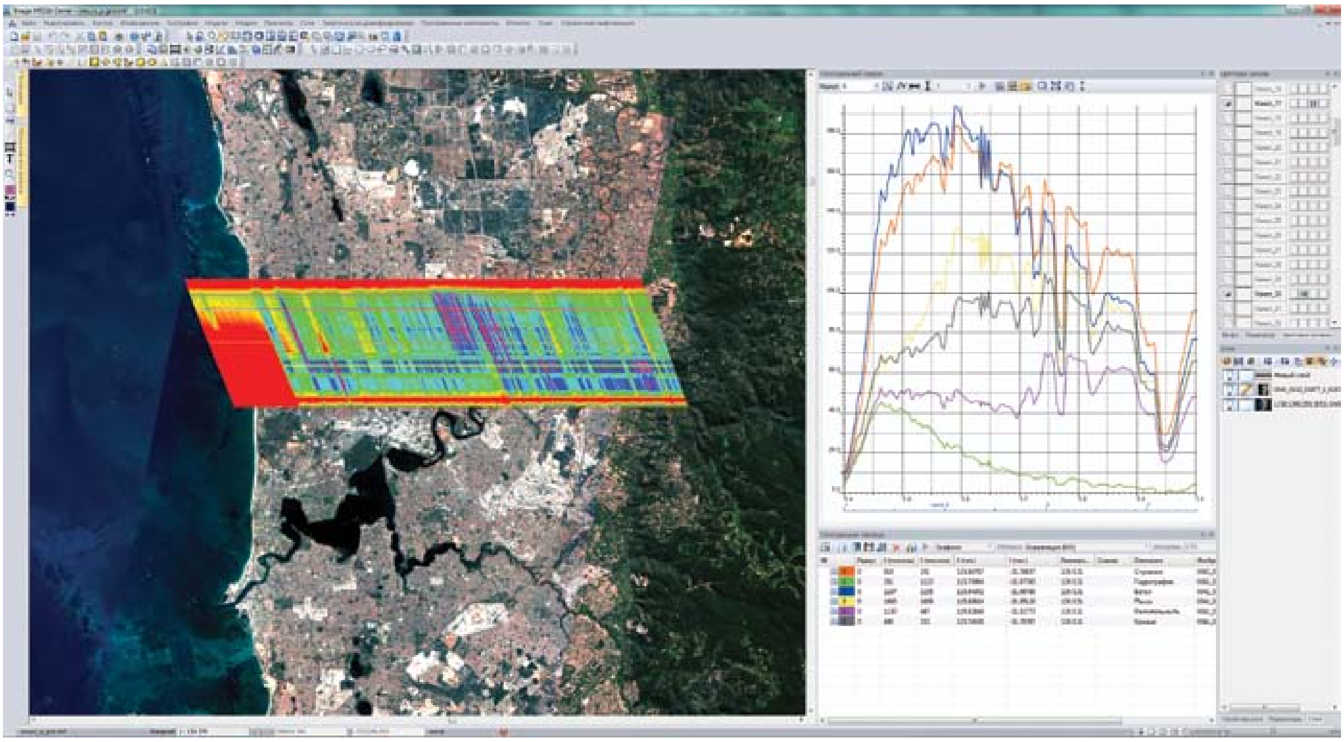


Figure 2: Hyperspectral image taken by Resource-P spacecraft, Australia territory. Formation of spectrogram database of different therrestrial objects using hyperspectral data.

GIS allows you to clearly and interactively conduct multivariate area analysis. Often, even a large amount of information cannot help to solve the problem, unless it is visualized on the map.

Based on the results of test measurements and process simulations and visualized with the help of GIS, it is possible to predict the development of overall situation, identify performance bottlenecks and make quick decisions to rapidly respond to negative changes in various fields of interest.

Dry weather during the hot periods of the year in several regions of Russia often leads to forest and peat fires. Fire suppression effectiveness, especially when there is limited access and high fire danger, is determined by the rapidity of fire detection at an early stage and the course of actions taken for its termination. Detection of thermal anomalies during image processing contributes to the rapid assessment of the situation and early termination of potential ignition sources.

The results of fires and cinders monitoring based on data collected by Landsat-8 spacecraft are represented on the Figure 3. Basic image displayed in the color components of visible spectral range (Fig. 3-a) is not informative. It is required to use multispectral channels, which record radiation in red and infrared range of the spectrum, for fire visualization. As a result of former thematic processing, vector map, on which red represents open fires, and orange – cinders (Figure 3-c) is formed.

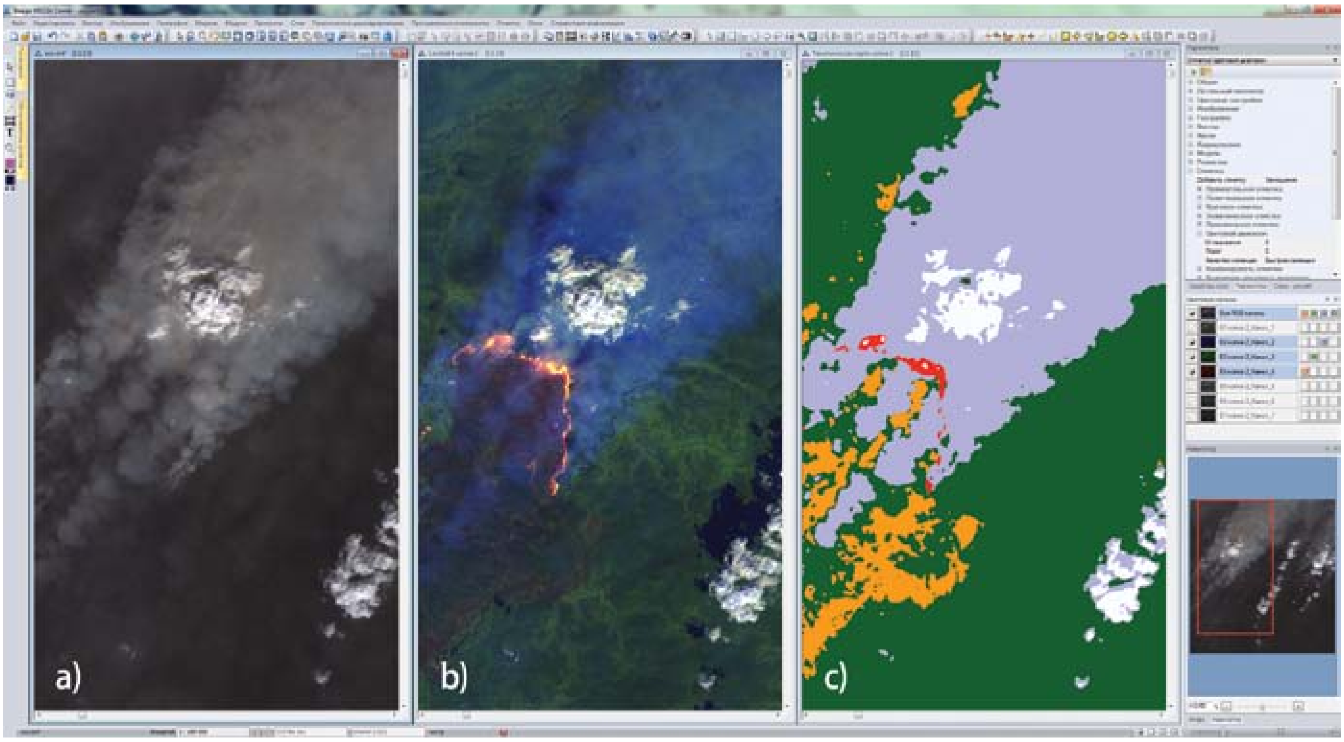


Figure 3: Detection of fires and cinders based on multispectral data collected by Landsat-8 spacecraft, Evenk autonomous territory. a) multispectral image in natural colors;b) the visualization of fire, the combination of multispectral bands 7-6-3; c) the vector map, the result of classification (red – open fire, orange – cinder, blue – smoke plumes, green – vegetation, white – clouds).

IMC software suite allows the user to not only effectively solve tasks, but also provides ample opportunities for the investigation and forecasting of natural disasters. For example, it can be used to identify dangerous areas on the pipeline.

Often, late diagnostics of the territory where pipeline is located results in pipeline damage, which leads to serious consequences. IMC software suite provides the ability to identify the range areas, which require greater attention, using RS data. Image classification is based on highly detailed multispectral data obtained by WorldView-2 spacecraft. During thematic processing, contact between “Pipeline” vector object and vector objects of the map (wetlands, bare soil and water bodies) is performed, which results in the creation of new vector layer displaying possible dangerous fields. On the Fig. 4-b, they are displayed in red.

Figure 5 shows a thematic map, which is based on multispectral data obtained by MODIS Terra spacecraft.

Information on ice consolidation ratio on the area of interest is required for safe navigation in the northern seas. Ice sea travelling routes usually lie through the zones of lesser ice consolidation ratio and thickness, polynyas, cracks, bypass ice gatherings, large ice fields and their debris, barriers, ridges and stains of hummocky ice.IMC software suite provides the ability to create ice maps using optical and radar RS data.

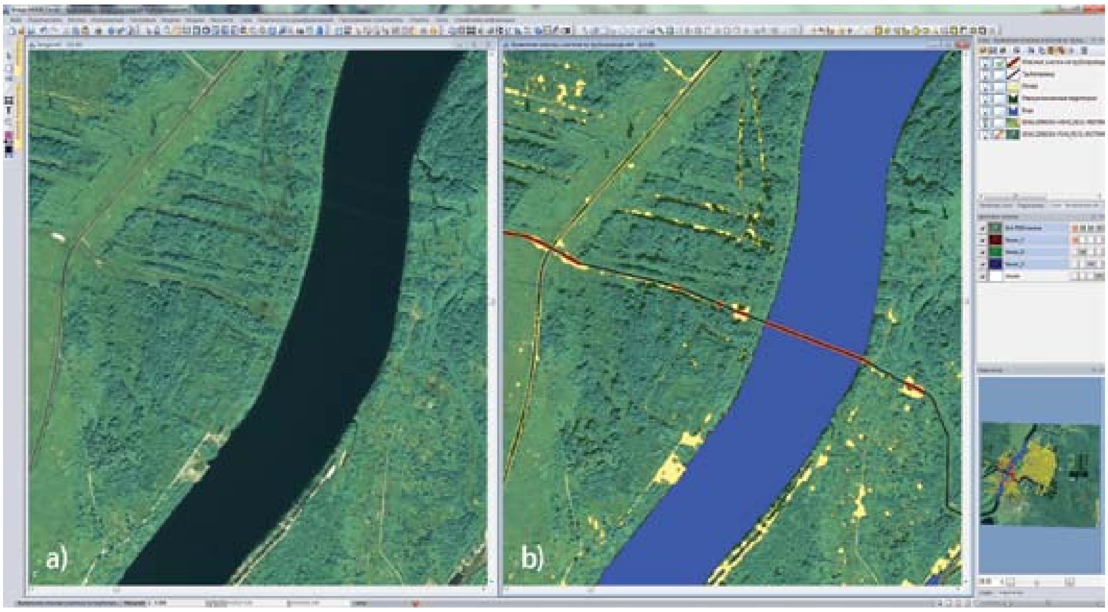


Figure 4: Identification of dangerous areas on the pipeline, based on WorldView-2 cpasecraft data. Kirishsky district, Leningrad region. a) Highly detailed multispectral image in natural colors; b) vector map (linear black object – pipeline, red line – the dangerous areas on the pipeline, blue – water bodies, yellow – soil).

Using IMC software suit as GIS base provides the following opportunities:

• pre-processing of images;

• eliminating defects which emerge during surveying or image digitizing;

• simultaneously working with raster and vector images, overlaying and combining images of different formats, dates and projections;

• creating vector maps using different sets of vector styles;

• performing spatial and attributive queries, solving various analytical problems;

• thematic GIS structuring, setting the content of thematic layers and attributive information about objects;

• developing geographic databases using industrial DBMS;

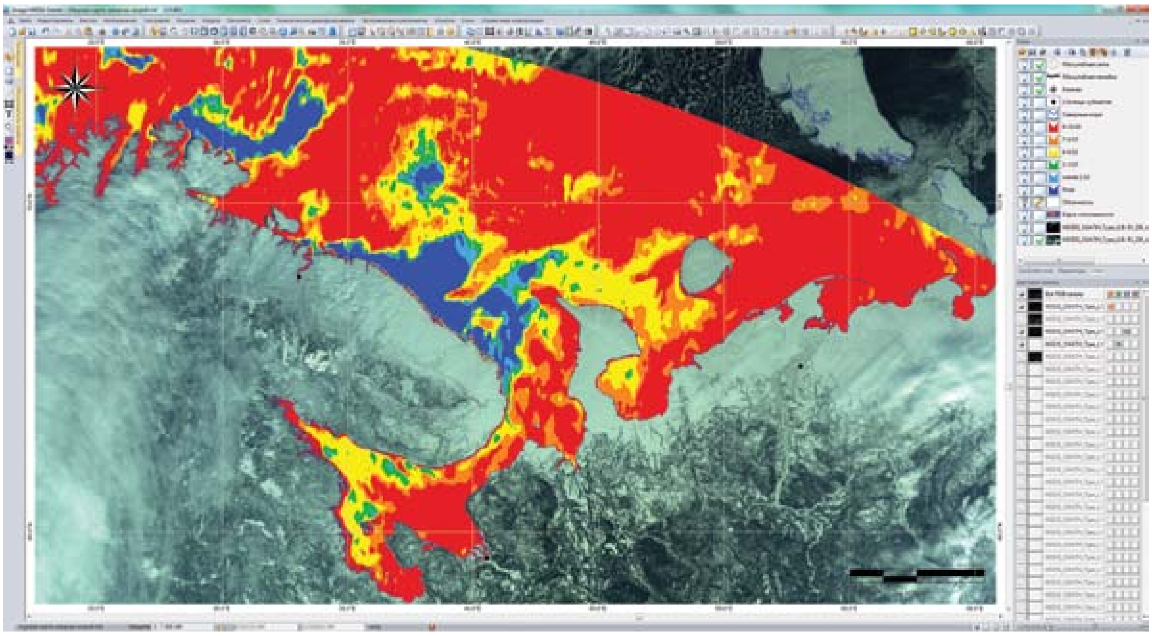


Figure 5: Vector map of ice consolidation ratio, based on optical multispectral data obtained by MODIS Terra spacecraft. Northern seas. (Blue – clean water areas, green, blue – the primary types of ice with consolidation ratio up to 3 points, yellow, orange, red – types of ice with consolidation ratio from 4 to 10 points, according to the international ice maps nomenclature).

- visualizing any spatial object on a digital map, while retaining the ability to work with its attributive (tabular) information;
- performing spatial analysis (analyzing the spatial distribution of objects and their influence on each other, acquiring the exact coordinates of objects);
- visualizing any graphical information and controlling its displaying (selective displaying of thematic layers, the latest special characters/marks/signs, styles, and colors);
- performing measurements and statistical analyzes;
- simulating various processes and phenomena, displaying acquired results on the map.

Unlike most of other existing GIS, the functionality of Image Media Center software suit allows the user to not only pre-treat basic spatial data, which size can reach several hundred Gb, but also create thematic maps with unlimited number of vector and raster layers, as well as output reports based on the results of data processing. Thus, the user receives a unique GIS, which provides an ability to perform the entire cycle of image to map RS data processing in a single geographic information space, which drastically reduces both time and cost of the process.

Maintenance and Updating of Topographic Maps of the Large Scale at the Municipal Level

V. Panarin

Municipal Budget Institution "Urban development", Dzerzhinsk, Russia

Starting from June 2006, according to chapter 7 of Urban development code of Russian Federation, city Administration handles Information System For Urban development Activities based on Management of Architecture and Urban development together with subordinate municipal budget establishment "Urban development". Lets see in more details the subsystem for handling city's topographic sheets which, together with other modules, is the best to demonstrate the possibilities of complex approach used in municipal management using Remote Sensing Data and economic effect of such approach.

The subsystem for handling topographic sheets of city's territory was put into operation, effective since 2008, and used to manage municipal economy and to provide to city's population and organizations with actual topographic maps with scale 1:500 and more smaller scales. The subsystem entered the top ten world's wide projects with usage of software from "Bentley Systems" and was published in digest "The Year in Infrastructure" of 2013. The subsystem includes full cycle of processing, keeping and providing topographic materials covering whole city's territory to users. Area of the city is more than 420 square kilometers, total amount of topographical sheets nomenclatures is more than 7000 sheets. All processing is performed using digital representation of topographical sheets in vector and bitmap forms. The bitmap images as a file are connected to corresponding graphical tables of DBMS Oracle which are represented as pivot points for each sheet and contain full information about sheet creation and all its modifications. Data from the tables and bitmaps are available to all organization departments of city Administration via geoportal. Geoportal was created and is now functioning based on Bentley software GeoWebPublisher and is accessible for users with proper access. On user request the reports and records are automatically prepared either in digital form with publishing on geoportal or in paper form.

As of results of geodetic surveying the employees of department responsible for making changes in topographical sheets are receiving digital reports containing measurement data from devices and multilayered vector data covering the survey territory. This data is processed using BentleyMapEnterprise software. Control of geodetic survey results integrity is done using the same software by collating data from other materials, including high definition satellite images and digital elevation model based on stereo images from spacecraft WorldView-1. The result of the work is digital form of the modified topographical sheet. The processing of high definition satellite images, including the image's basic spectrum analysis with objects recognition, and preparation of different analytic schemes to take urban development decisions regarding deploying investment projects is done using ENVI software.

The subsystem provides execution of government programs tasks in scope of public digital services and digital government system of the city (management of municipal economy based on digital technologies).

Total economic effect:

- Allows to handle all city's topographic sheets using 3 employees
- Provides documents for 10 000 requests per year in average
- Reduces city expenses in times due to reduced cost of public requests handling.
- Provides city budget economy in 2 million rubles yearly comparing to handling topographical sheets in paper form.
- Reduces time of topographical sheet modification handling in hundreds of times
- Reduces expenses on full topographical surveys for 3 million rubles per year
- Total effect of using digital evaluation model covering all city area is at least 500 million rubles of relative economic effect.

Usage of modern digital technologies in analysis and decisions for investment projects deployment on city territories gives not only the huge economic effect but provides much higher quality results in real time scale due to synergy of interaction of different modern techniques and other visual representations of the data.

Resurs-P. Capabilities. Standard Products

A. Peshkun
JSCRussian Space Systems, Moscow, Russia

Resurs-P is the Russian remote sensing spacecraftdeveloped by JSC "RSC Progress".The operating organization is the Research Center for Earth Operative Monitoring (JSCRussian Space Systems).It is planned to create the group of threespacecraftsResurs – P.

The first spacecraft was placed into orbit on June, 25, 2013.

The spacecraft is designed to update the maps, to support economic activity of MNR of Russia, the Russian Emergency Ministry etc., as well as to receive information for the purpose of control and protection of the environmentand other purposes and consumers.

The Sensors

Electrooptical equipment of Geoton – L1 with Sangur – 1 U data-acquisition and conversion system.

Main characteristics:

Focal length, mm	4000
Entrance pupil diameter, mm	500
Aperture	1:8
Fieldofview, deg.	5°18'
Pixel size, µm panchromatic spectral	 6x6 18x18
GSD: panchromatic, m multispectral, m	 1.0 3.0-4.0
Span width, km	38
Spectral bands, µm: panchromatic blue green red red edge NIR	 0.62-0.79 0.48-0.53 0.54-0.59 0.62-0.68 0.72-0.80 0.81-0.88
Number of simultaneously used bands	1-5
Bitperpix	10

Orbit Parameters

Main characteristics:

Type	Circularsun-synchronous
Height, km	470-480
Inclination, deg.	97.28
Revisit time, days	3

Hyperspectral sensor

Main characteristics:

Span width, km	30
GSD, m	25-30
Spectral bands, µm	0.4-1.1
Number of bands	more than 96
Spectralresolution, nm	5-10

Complex of wide-span multispectral sensors

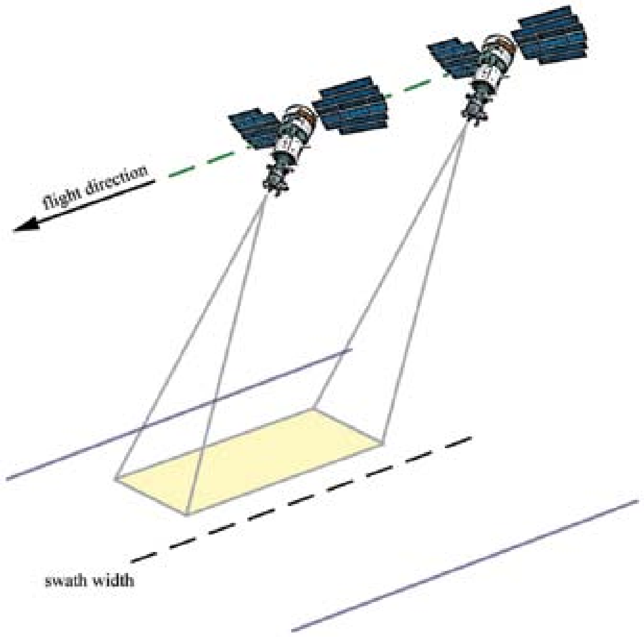
Main characteristics:

Characteristics	Values	
	Medium resolution	High resolution
Opticsystem: Focallength, mm Aperture Fieldofview, deg.	 40 1:4 54°30'	 200 1:3 11°70'
Span width, km	441.7	97.2
GSD: panchromatic, m spectral, m	 59 118	 12 23.8
Spectral bands, µm: panchromatic blue green red NIR 1 NIR 2	 0.43-0.7 0.43-0.51 0.51-0.58 0.60-0.70 0.7-0.9 0.8-0.9	
Pixel size, µm panchromatic multispectral	 5x5 10x10	
bitperpix	12	

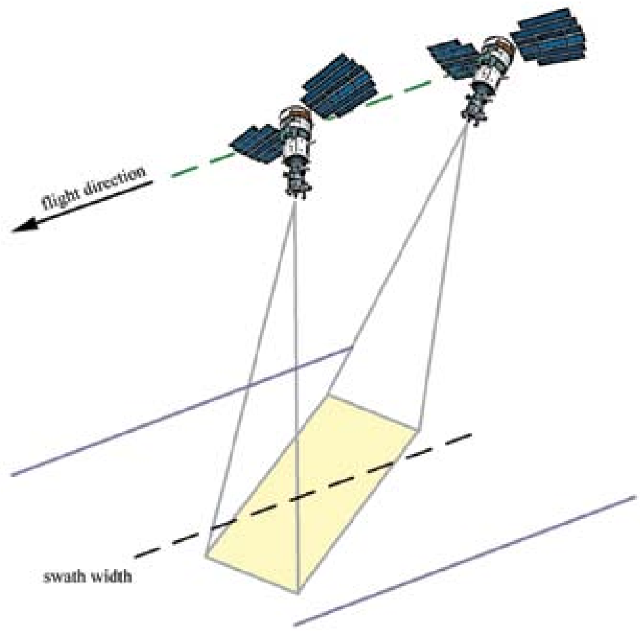
Surveying modes

Route surveying

Route surveying can be performed with a constant roll and pitch, as well as with specified azimuth.Possible spacecraft roll and pitch deviation from the nadir is up to ± 45 °, by yaw is up to ± 60 °. Duration of routes is from 2 to 300 seconds.



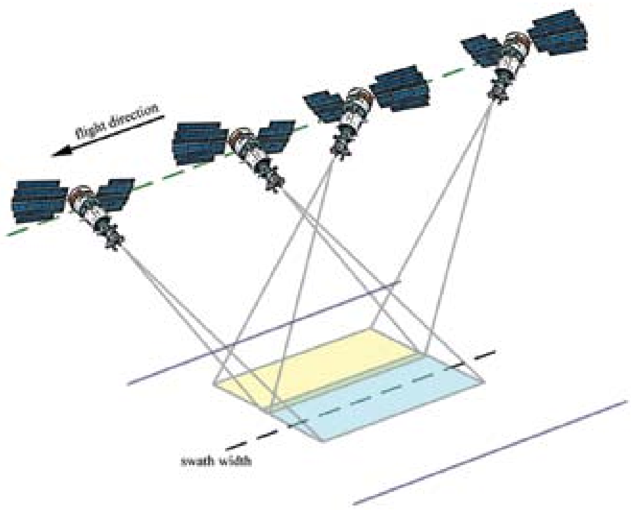
Constant roll and pitch

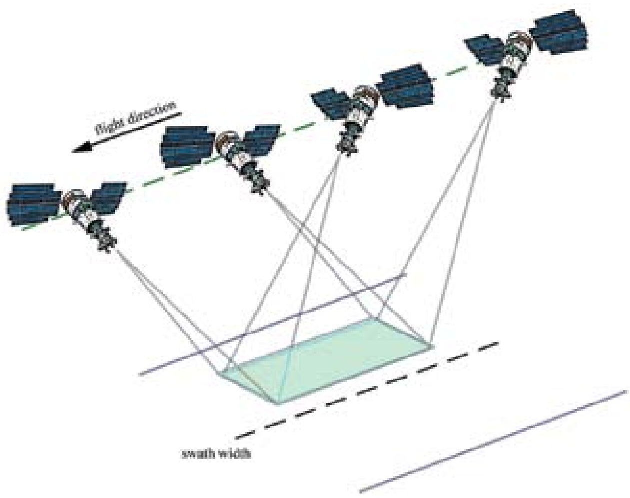


Specified azimuth

Areal surveying

Stereo surveying





Stereoimaging is performed ata single turn with a deviation by pitch.

Length of routes is up to 115 km.

Standard products.
Sensor Geoton-L1

Product level	**Panchromatic** GSD 1m, spectralband 0.62-0.79 µm	**Multispectral** GSD3 m, spectralbands: 0.48-0.53 µm 0.54-0.59 µm 0.62-0.68 µm 0.72-0.80 µm	**Reb bands** GSD3 m, spectralbands: 0.66-0.69 µm 0.70-0.75 µm	**NIR** GSD3 m, spectralband: 0.81-0.88 µm	**File format**
1A	Images by bands withradiometricandgeometriccorrection + RPC.				TIFF, BMP, IMG
1A1		RGB image with radiometric and geometric correction + RPC			TIFF, BMP, IMG
2A	Images by bands with radiometric and geometric correction + RPC, georeferenced to a cartographic projection, transformed by the average height. Accuracy 30-50 m.				GeoTIFF, IMG
2A1		RGB image with radiometric and geometric correction + RPC,georeferenced to a cartographic projection, transformed by the average height. accuracy 30-50 m			
2B	Images by bands with radiometric and geometric correction, georeferenced to a cartographic projection, transformed by using GCP and DTM. Accuracy dependent on the reference data and DTM.				GeoTIFF, IMG
2B1		RGB image with radiometric and geometric correction, georeferencedtoacartographicprojection, transformed by using GCP and DTM.Accuracy dependent on the reference data and DTM.			GeoTIFF, IMG
3A	Mosaic image of the images 2A level.	Mosaic image of the images 2A1 level.			GeoTIFF, IMG
3B	Mosaic image of the images 2B level.	Mosaic image of the images 2B1 level.			GeoTIFF, IMG
4A	Pansharpened image (PAN 2A level + MSS 2A1 level)				GeoTIFF, IMG
4B 4B	Pansharpened image (PAN 2B level + MSS 2B1 level)				GeoTIFF, IMG

Wide field multispectral sensor (high resolution)

Product level	**Panchromatic** GSD 1m, spectralband: 0.62-0.79 µm	**Multispectral** GSD3 m, spectralbands: 0.48-0.53 µm 0.54-0.59 µm 0.62-0.68 µm 0.72-0.80 µm	**File format**
1A	Images by bands withradiometricandgeometriccorrection.		TIFF, BMP, IMG
1A1		RGB image with radiometric and geometric correction.	TIFF, BMP, IMG
2A	Images by bands with radiometric and geometric correction, georeferenced to a cartographic projection, transformed by the average height. Accuracy 50 mforPANand 100 mforMSS.		GeoTIFF, IMG
2A1		RGB image with radiometric and geometric correction, georeferenced to a cartographic projection, transformed by the average height. accuracy 100 m.	GeoTIFF, IMG
2B	Images by bands with radiometric and geometric correction, georeferenced to a cartographic projection, transformed by using GCP and DTM. Accuracy dependent on the reference data and DTM.		GeoTIFF, IMG
2B1		RGB image with radiometric and geometric correction, georeferenced to a cartographic projection, transformed by using GCP and DTM.Accuracy dependent on the reference data and DTM.	GeoTIFF, IMG
3A	Mosaic image of the images 2A level.	Mosaic image of the images 2A1 level.	GeoTIFF, IMG
3B	Mosaic image of the images 2B level.	Mosaic image of the images 2B1 level.	GeoTIFF, IMG
4A	Pansharpened image (PAN 2A level + MSS 2A1 level)		GeoTIFF, IMG
4B	Pansharpened image (PAN 2B level + MSS 2B1 level)		GeoTIFF, IMG

Wide field multispectral sensor (high resolution)

Product level	**Panchromatic** GSD60 m Spectralband: 0.43-0.70 µm	**Multispectral** GSD120 m Spectralbands: 0.43-0.51 µm 0.51-0.58 µm 0.60-0.70 µm 0.70-0.90 µm 0.80-0.90 µm	**File format**
1A	Images by bands withradiometricandgeometriccorrection.		TIFF, BMP, IMG
1A1		RGB image with radiometric and geometric correction.	TIFF, BMP, IMG
2A	Images by bands with radiometric and geometric correction, georeferenced to a cartographic projection, transformed by the average height. Accuracy100 m for PAN and 200 m for MSS.		GeoTIFF, IMG
2A1		RGB image with radiometric and geometric correction, georeferenced to a cartographic projection, transformed by the average height. accuracy200 m.	GeoTIFF, IMG
2B	Images by bands with radiometric and geometric correction, georeferenced to a cartographic projection, transformed by using GCP and DTM. Accuracy dependent on the reference data and DTM.		GeoTIFF, IMG
2B1		RGB image with radiometric and geometric correction, georeferenced to a cartographic projection, transformed by using GCP and DTM.Accuracy dependent on the reference data and DTM.	GeoTIFF, IMG
3A	Mosaic image of the images 2A level.	Mosaic image of the images 2A1 level.	GeoTIFF, IMG
3B	Mosaic image of the images 2B level.	Mosaic image of the images 2B1 level.	GeoTIFF, IMG
4A	Pansharpened image (PAN 2A level + MSS 2A1 level)		GeoTIFF, IMG
4B	Pansharpened image (PAN 2B level + MSS 2B1 level)		GeoTIFF, IMG

Hyperspectral sensor

Product level	Surveying by main sensor GSD 30 m Spectral range 0,4-1,1 nm (130 bands)	File format
1A	Hyperspectral image with radiometric and geometric correction, with color value at entrance pupil.	TIF, IMG,BMP,
2A	Hyperspectral image with radiometric and geometric correction, with color value at entrance pupil,georeferenced to a cartographic projection, transformed by the average height. Accuracy100 m.	GeoTIFF, IMG
2B	Hyperspectral image with radiometric and geometric correction, with color value at entrance pupil, georeferenced to a cartographic projection, transformed by using GCP and DTM. Accuracy dependent on the reference data and DTM.	GeoTIFF, IMG

Resurs-P Spacecraft: Imagery Data Application

A. Rashchupkin, Yu. Zhuravel
JSC SRC "Progress", Samara, Russia

A peculiar feature of the Resurs-P spacecraft that distinguishes it from the most of ERS satellites is that it carries out the integrated observation of the Earth surface with the use of a number of on-board optronic equipment. Capability of simultaneous imaging by different types of equipment increases the efficiency of solving a broad spectrum of socio-economic tasks and applied problems in the field of global monitoring and environmental protection.

The high-resolution equipment permits to acquire images of large areasacross the 38-kilometre swath in panchromatic mode at resolutionnot exceeding 1-metre and in six-narrow-band multispectral mode at 3-metre resolution; this makes it possible to fulfill a broad spectrum of thematic tasks:

− creating and keeping topographic, digital and special maps up-to-date;

− digital photomapping, orthophotomapping and general planning of towns

− 3D and digital terrain modeling;

− inventory and construction monitoring of infrastructure projects;

− forest inventory and management;

− inventory of agricultural lands and planning of land utilization;

− monitoring of transport and power lines;

− exploration of natural resources;

− environmental monitoring;

− nature management;

− etc.

Diverse combinations of spectral bands make it possible to obtain composite images in true and false colors enhancing visual decoding of images, and indexed images, particularly Normalized Difference Vegetation Index (NDVI).

By merging two images acquired from extreme OptronicImage Converters, the focal plane of the high-resolution equipment permits to obtain a stereoscopic image (anaglyph) enhancing visual decoding of target areas.

Large-swath multispectral imaging equipment enables wide-swath detailed imaging at 12-metre resolution across the 97-kilometre swath and at 60-metre resolution across the 441-kilometre swath ensuring simultaneous imaging in panchromatic and 5-band multispectral modes.

Among the main application areas utilizing images produced by the large-swath multispectral imaging equipment:

− creating and keeping medium-sized topographic maps up-to-date;

− thematic mapping;

− monitoring of agricultural lands, including:

− location of sown areas;

− determination of field boundaries;

− crops monitoring;

− crop forecast.

− forest management, including:

− detection of areas damaged by fire, insects and other disasters;

− forest type determination;

− inventory of forest;

− reforestation control;

− detection of unauthorized deforestation.

− monitoring of hazardous natural phenomena (waterlogging, desertification, salinization, etc.);

− detection of forest and steppe fires;

− monitoring of areas subject to flood;

− natural disaster damage evaluation;

− environmental control of water bodies.

Multi-date composite images acquired from the large-swath multispectral equipment can be efficiently merged into sets of vector GIS coverages containing data on changes occurred over wide areas.

Hyperspectral imaging equipment provides imaging in visible and near-infrared ranges in no less than 96 bands at 25-metre resolution across the 25-kilometre swath.

Hyperspectral imagery makes it possible to create thematically associated products in the form of various thematic maps and geographic information systems (GIS) with signatures of physicochemical and biological composition of natural and anthropogenic targets including:

− quality of water in water basins and rivers; mechanical, chemical and biological pollution of water areas;

− soil salinity rate;

− mineral composition and texture of soil, crop-producing power;

− state of plant cover, agricultural lands and forest;

− illegitimate drug plantations;

− chemical and biological discharges into the air, water basins and rivers;

− areas contaminated with sludge of hydrocarbons, chemicals and other harmful substances;

− disposal tips;

− leakages of hydrocarbon, ammonia and other aggressive chemicals from trunk pipelines;

− ecological state of gas, oil and chemistry-companies, heat and power producers;

− state and composition of rocks; open-pit mines; geological exploration;

− objects of cultural and architectural heritage;

− state of coastal zones;

− etc.

Hyperspectral data can be efficiently used for solving difficult-to-formalize problems such as segmentation and classification of targets, integration of diverse information, etc. Knowledge of spectrum signatures of natural and antropogenic objects permits to automate the process of their detection and classification in hyperspectral images.

The report represents the results of the Resurs-P data application for solving a broad spectrum of socio-economic tasks.

Dense DSM Generation Module in PHOTOMOD 6.0

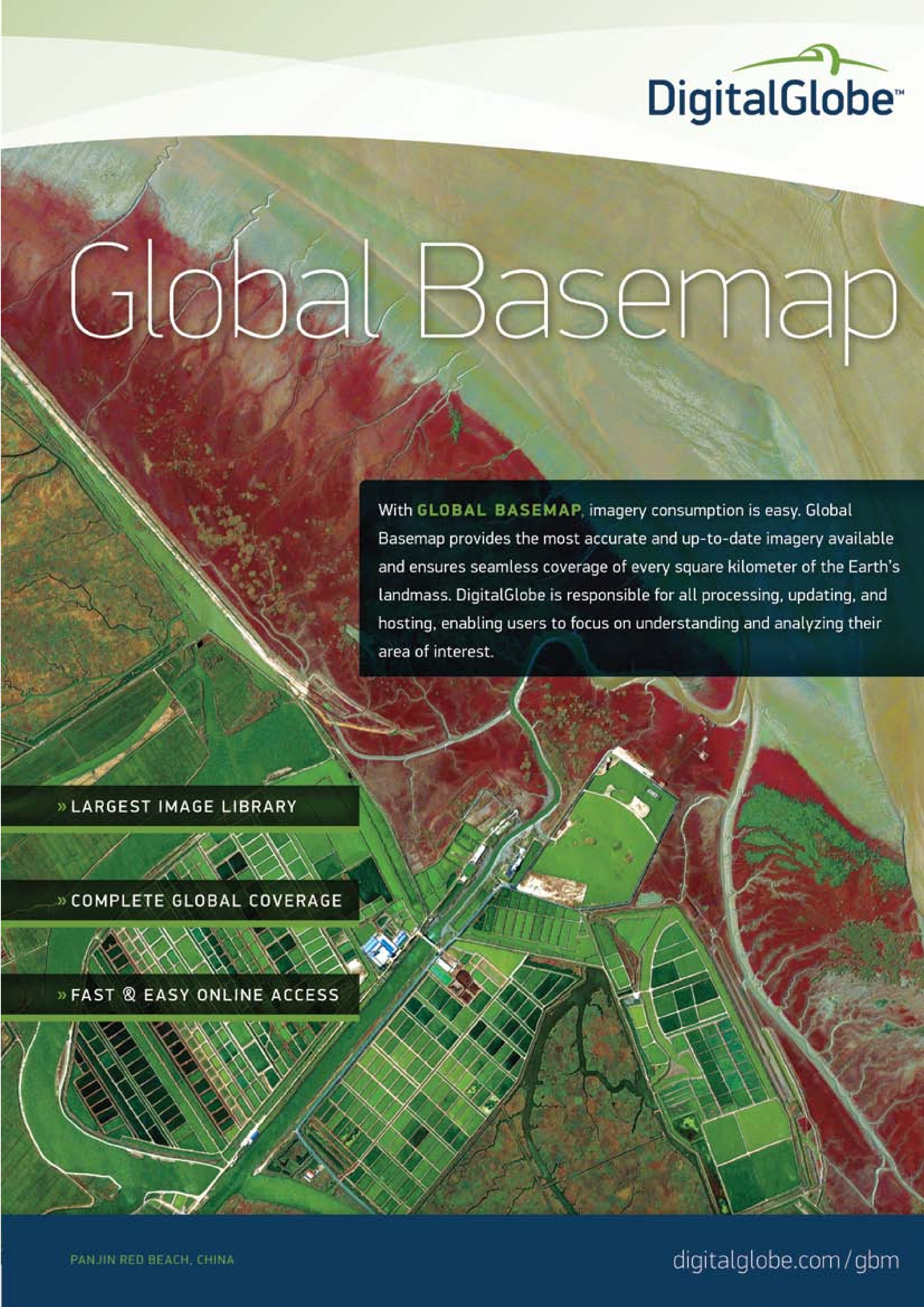
A. Sechin
Racurs Co., Moscow, Russia

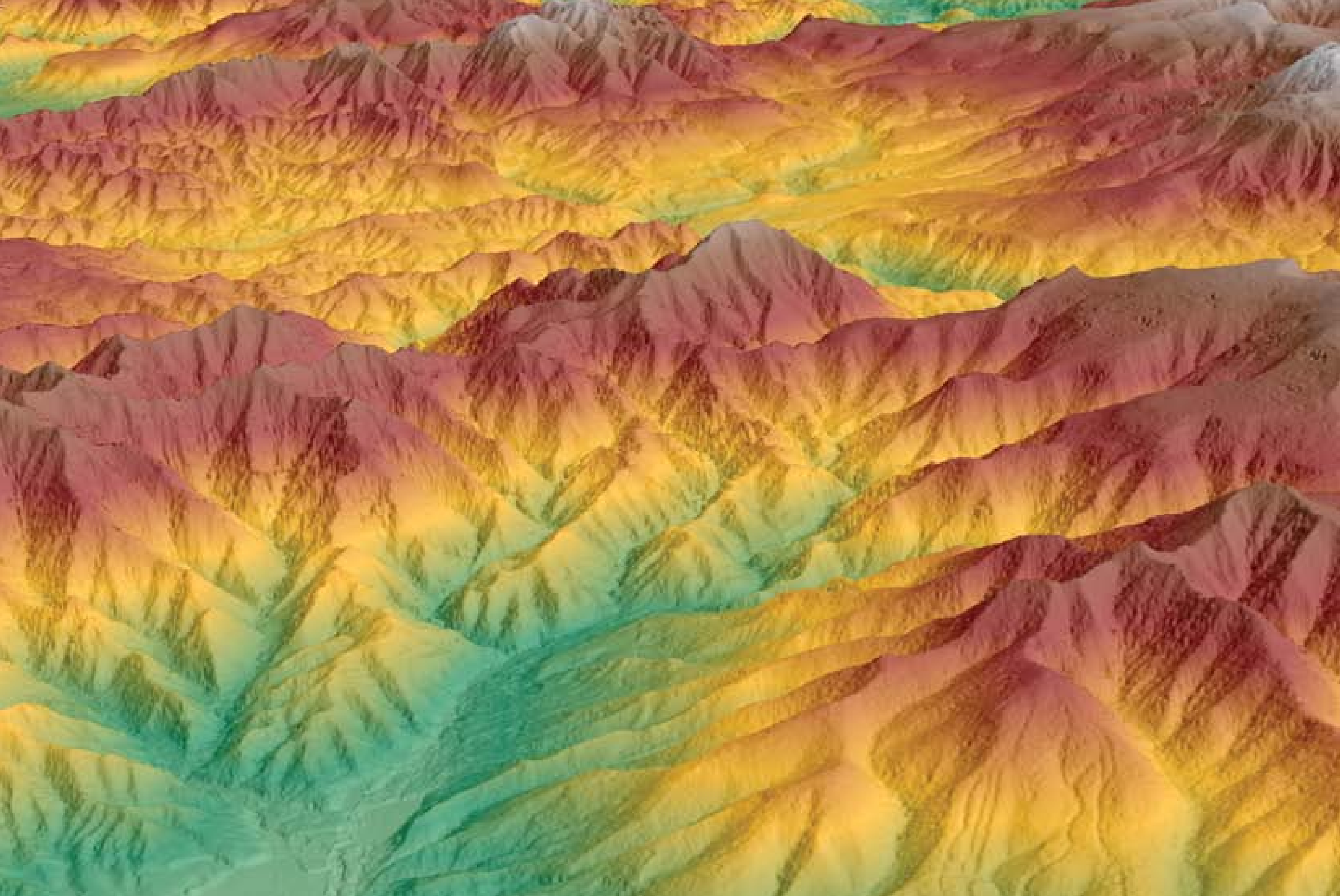
The first dense DTM algorithm was introduced in PHOTOMOD some time ago. It used CUDA technology for speedup and was based on the cross-correlation algorithm. It is well known, that cross-correlation local algorithms produce smoothed buildings and do not give good results in occlusion areas. The calculated DTM needs to be filtered to remove trees and buildings. This DTM is good for orthophoto production and level lines calculations.

The new version of PHOTOMOD 6.0 comes with the new module for dense DSM, the new module requires a special license. The algorithm of this module is based on the idea, that orthophotos calculated from different images must be the same if the correct DSM is used for orthophoto generation. We call this algorithm iterative deformation method (IDM). The resulting DSM accuracy and quality strongly depends on the number of overlaps of images having the same point. It is advisable to have at least quadruple images overlap. When deforming the surface we use special functions to fit building walls and high constructions. Some elements of image recognition theory are also used.

Here is an example of 3D surface for the aerial project of Munich town.

We used orthophoto as a texture – this lead to the building walls not colored correctly. The new DSM module works with aerial and pushbroom images and will be available with PHOTOMOD 6.0 release.


DigitalGlobe™
Global Basemap
With GLOBAL BASEMAP, imagery consumption is easy. Global Basemap provides the most accurate and up-to-date imagery available and ensures seamless coverage of every square kilometer of the Earth's landmass. DigitalGlobe is responsible for all processing, updating, and hosting, enabling users to focus on understanding and analyzing their area of interest.
» LARGEST IMAGE LIBRARY
» COMPLETE GLOBAL COVERAGE
» FAST & EASY ONLINE ACCESS
PANJIN RED BEACH, CHINA
digitalglobe.com/gbm



WorldDEM™

Reaching New Heights

The new standard of global elevation models with pole-to-pole coverage, unrivalled accuracy and unique quality to support your critical missions.

www.geo-airbusds.com/worlddem

AIRBUS DEFENCE & SPACE

Orthorectification Method Using Regular Grid

A. Sonyushkin
SCANEX, Moscow, Russia

Nowadays, real-time ("on the fly") methods of processing satellite and aerial imagery are becoming more and more popular. Amongthe majoradvantagesofthesemethodsistheabilityto monitortheresultsonthescreen, aswellastocanc eloradjusttheprocessingparameters. Thelattera llowstoenhanceperformanceduetothereducedti meneededto save and reload the results, these actions being common when using traditional processing methods. Oneofthemodernreal-timeimageryprocessingmethodsis "onthefly" orthorectification.

One of the ways to orthorectify an image "on the fly" is to automatically replace the currently displayed fragment of the initial image with its rectified version. Such an algorithm is implemented in ArcGIS, and all the calculations are performed in real-time during panning around or zooming in and out of the displayed area.

Another way of "on the fly" orthorectification is to use regular grid which defines the connection between the coordinates in object space and the image (pixel coordinates) space. Thus, precalculated regular geographical grid corresponding to some pixel coordinates of the image is provided by default for some remote sensing data, e.g. ASTER, MODIS, RADARSAT-1, RADARSAT-2, etc.). This grid can be used as a geometry model for the subsequent reprojection of the initial image.

Unlike traditional digital imagery processing methods, using regular grid "on the fly" transformation doesn't result in creating new raster matrix of interpolated pixel values. Instead, the initial photometric values are preserved, which is crucial for automatic imagery interpretation.

If the geometry model for an image is described using external and internal orientation elements, coordinates of the grid nodes are calculated directly by means of reconstructing the bundle of projective beams along and across the scanning direction using a defined step. The same direct method is used if the geometry model is described using an inverse rational function model (RFM), which includes RPC to calculate object coordinates at a defined elevation.

However in practice, especially for high-resolution imagery the orientation elements are not provided to the end user and the image geometry model is described by a forward RFM, whose coefficients allow calculatingthe image coordinates based on the real object coordinates and elevation.

This work proposes a method of calculating the regular transformation grid using RFM coefficients and DEM. A detailed research was conducted to define the accuracy of the proposed method for various acquisition conditions, grid step values, and inclination angles. The optimum grid step was experimentally defined, depending on the DEM nodes density. Furthermore, a comparison of calculations performance was conducted for the proposed and traditional orthorectification methods.

Five multi-temporal QuickBird-2 images were used during the experiment, featuring incidence off-nadir angles from 2 to 35 degrees. Research was conducted on a 100 sq. km filed in the premises of Avignon (France), and 33 instrumentally measured ground control points were acquired. Seven DEMs of various density and accuracy were also used for the experiment.

A pixel-by-pixel comparison of the plane coordinates was conducted for the orthophotoplans received using the proposed (with various grid step values) and traditional methods to define accuracy.

As a result, it was found that the proposed orthorectification method gives highly accurate outputs when the transformation grid step is less or approximately equal to the distance between DEM nodes used for the calculations. It was shown that the greatest coordinates discrepancy coincided with occluded areas and areas with incidence angles exceeding 30 degrees.

Performance comparison showed that the proposed method was 4 – 28 times faster (depending on the DEM density) than the traditional one.

Themethoddescribedabove is now being implemented in ScanEx Image Processor and is planned to appear on the market in one of the next releases.

Spot6/7 and Pléiades Constellation: New Perspectives for Mapping

J. Soubirane, M. Tonon, G. Pichon
Airbus Defence and Space, France

The recent launches of SPOT 7 (end of June, 2014) signals the completion of the new constellation of optical satellites operated by Airbus Defence and Space. It is composed of the 4 satellites Pléiades 1A, Pléiades 1B, SPOT 6 and SPOT 7, and opens new perspectives for mapping projects using satellite data.

The base scales of 1/50,000 and especially 1/25,000 are from now on accessible over large areas using SPOT6 and SPOT 7, which combines large swath (60km) and high resolution (1,5m). Furthermore, the huge SPOT 6/7 acquisition capacity makes possible to acquire vast stereoscopic covers (even in tri-steresocopy locally if needed), allowing the capture in 3D not only of the relief information (contour lines, spot heights, shadowing, DEM) but also of all the map content through stereo-plotting techniques. The constellation with Pléiades permits to complete locally the SPOT 6/7 cover, if necessary where the ground information is very dense, using 0,5 m resolution images.

The Pléiades images offer themselves interesting perspectives for mapping at scale 1/10,000 and 1/5,000 thanks to its unmatched stereoscopic acquisition capacity (2 agile satellites with specific stereoscopic acquisition mode), combined with its high resolution (0,5m) and a very good geometric accuracy.

This paper presents how all these satellites constellation capacities allow to consider mapping project in a different manner, using satellite data to optimize project cost and time period.