INTERNATIONAL FEDERATION OF SURVEYORS (FIG)
SIBERIAN STATE ACADEMY OF GEODESY (SSGA)
TECHNISCHE UNIVERSITÄT BERLIN
IRKUTSK STATE TECHNICAL UNIVERSITY (ISTU)

FIG Commissions 5, 6 and SSGA Workshop

"Innovative Technologies for an Efficient Geospatial Management of Earth Resources"

PROCEEDINGS

23–30 July 2009

Lake Baikal, Listvyanka, Russian Federation

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2009

INTERNATIONAL FEDERATION OF SURVEYORS (FIG)
SIBERIAN STATE ACADEMY OF GEODESY (SSGA)
TECHNISCHE UNIVERSITÄT BERLIN (TUB)
IRKUTSK STATE TECHNICAL UNIVERSITY (ISTU)

Proceedings of the

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Novosibirsk, Russian Federation
SSGA
2009

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About Organizers:

INTERNATIONAL FEDERATION OF SURVEYORS (FIG)

The **International Federation of Surveyors** (**FIG**) is the premier international organization representing the interests of surveyors worldwide. It is a federation of the national member associations and covers the whole range of professional fields within the global surveying community. It provides an international forum for discussion and development aiming to promote professional practice and standards. FIG was founded in 1878 in Paris and was known as the *FédérationInternationale des Géomètres*. This has become anglicized to the International Federation of Surveyors.

FIG is a recognized non-government organization, representing more than 100 countries throughout the world, and its aim is to ensure that the disciplines of surveying and all who practice them meet the needs of the markets and communities that they serve. FIG's activities are governed by a work plan, which is regularly reviewed against a longer-term strategic plan. The current work plan, titled "Building the capacity", which guides the council and commissions activities, focuses on the surveyor's response to social, economic, technological and environmental change. FIG recognizes the particular needs of capacity building in developing countries to meet the challenges of fighting poverty and developing a basis for a sustainable future. FIG also recognizes that markets for surveyors' services are constantly changing.

The plan accordingly lays emphasis on strengthening professional institutions; promoting professional development; and encouraging surveyors to acquire new skills and techniques so that they may be properly equipped to meet the needs of society and the environment. In general, FIG will strive to enhance the global standing of the surveying profession through both education and practice, increase political relations both at national and international level, help eradicating poverty, promote democratisation, and facilitate economic, social and environmental sustainability.

The technical work of FIG is led by ten technical commissions:
Professional Practice, Professional education, Spatial Information Management, Hydrography, Positioning and Measurement, Engineering Surveys, Cadastre and Land Management, Spatial Planning and Development, Valuation and Management of Real Estate, Construction Economics and Management.

Contact information:

Mr. Markku Villikka (MSc. Surv.)
FIG Director
International Federation of Surveyors, FIG
Kalvebod Brygge 31-33
DK-1780 Copenhagen V
DENMARK
Tel. + 45 3886 1081 (office)
Fax + 45 3886 0252 (office)
E-mail: markku.villikka@fig.net
Web: www.fig.net

SIBERIAN STATE ACADEMY OF GEODESY (SSGA)

The **Siberian State Academy of Geodesy (SSGA),** the oldest in Siberia, was founded in 1933. Today it is the recognized leader in training specialists for geodesy, cartography, cadastre, environmental management, exploration of natural recourses, metrology and opto-electronics. There are four institutes in SSGA: Institute of Geodesy and Management, Institute of Cadastre and Geographic Information Systems, Institute of Remote Sensing and Natural Resources Management, Institute of Optics and Optical Technologies. The graduates of **SSGA** receive Bachelor's (**B.Sc**) and Master's Degrees (**M.Sc**., 2 years after B.Sc.) or qualification of Engineer's/Specialist's Diploma. The SSGA offers educational programs, focused on geoinformation management for sustainable development, each with specialization: digital photogrammetry, urban planning and land administration and GIS.

The Academy carries out a large volume of researches and the major fields of them are: surveying, geodetic maintenance for construction and operation of engineering structures, cartography, GIS technologies, digital and thematic map compilation, cadastre, photogrammetry and remote sensing, satellite geodesy, optics and spectrometry, uses of GPS for the purposes of applied geodesy and land cadastre. The main tendency of research activity is to implement the advanced digital technologies, terrestrial 3D laser scanning computer-aided acquisition and processing of geodetic measurements, computer-based simulation, GIS and GPS technologies.

Contact information:

Prof. Dr. Alexander P. Karpik
Rector
Siberian State Academy of Geodesy, SSGA
10, Plakhotnogo Ul.
Novosibirsk, 630108, Russian Federation
Tel: +7 (383) 343-39-37, Fax: +7 (383) 344-30-60
E-mail: rektorat@ssga.ru
Web: www.ssga.ru

TECHNICAL UNIVERSITY OF BERLIN

The **Technical University of Berlin** (**Berlin Institute of Technology** (Technische Universität Berlin) was founded in 1879. With nearly 30,000 students, it is one of the largest technical universities in Germany. It also has the highest proportion of foreign students out of universities in Germany, with 20.9% in the summer semester of 2007, roughly 5,598 students. 6,721 people work at the university: 319 professors, 1,832 postgraduate researchers, and 2,089 personnel work in administration, the workshops, and the central facilities. In addition there are 1,803 student assistants and 161 trainees. International student mobility is applicable through ERASMUS programme or through Top Industrial Managers for Europe (TIME) network.

The TU Berlin has adopted a number of reforms over the past few years to help strengthen its competitive edge, for example by adopting both a seven-school approach and a new fundamental organizational strategy that features an innovative university administration and committee structure. This process is now to be applied to all university endeavors - especially as state funds continue to dwindle and competition between universities increases.

The university courses include several Bachelors and the Master Degrees divided under several faculties or departments:

- Humanities
- Mathematics and Natural Sciences
- Process Sciences
- Electrical Engineering and Computer Science
- Mechanical Engineering and Transport Systems
- Civil Engineering and Applied Geosciences
- Architecture-Environment-Society
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Contact information:

Prof. Dr. Kurt Kutzler
President
Technische Universität Berlin
Straße des 17. Juni 135
10623 Berlin
Tel: +49 (0)30 314-0, Fax: +49 (0)30 314-23222
E-mail**:** kunkel(at)igg.tu-berlin.de
Web:www.tu-berlin.de

IRKUTSK STATE TECHNICAL UNIVERSITY (ISTU)

The **Irkutsk State Technical University (ISTU)** is a dynamically developing higher educational establishment with 75-years history. Today it holds the leading position among other Russian universities and is the largest educational institution over the huge territory of Eastern Siberia and the Far East. ISTU represents the brightest sample of a high-level university complex with well developed infrastructure, management system, scientific and productive environment as well as with multi-level educational system. The University comprises 14 faculties with 78 chairs.

Training is carried out in 83 specialties in technical and economic fields, humanities and arts for 33 000 students (1/3 of the total number of students of the Irkutsk Region). Structural subdivisions of the University such as Technical College, Center for Pre-university Training and Interdisciplinary Regional Center for Professional Enhancement provide the continuity of education while the University branch office and a number of representative offices - its accessibility for citizens of the Irkutsk Region, the Buryat Republic, and the Far East. The training is performed on the levels of Bachelor, Specialist, Master, PhD and Doctorate. The teaching staff of the University is over 1125 people including 92 doctors of science, 501 candidates of science, 105 professors, and 377 associate professors.

Contact information:

Prof. Dr. Ivan M. Golovnykh
Rector
Irkutsk State Technical University, ISTU
83, Lermontova Ul.
Irkutsk, 664074, Russian Federation
Tel**:** +7 (3952) 405-200, Fax**:** +7 (3952) 405-100
E-mail**:** oms@istu.edu
Web: www.istu.edu

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GENERAL THEMES AND TOPICS

- **Prediction of Earth's Surface and Engineering Structures Deformation and Movements in Areas of Tectonically and Technogenically Active Hazardous Zones Using Geodetic Observations**
- **Methods for Studying Hazardous Natural and Technogenic Processes, Their Prediction and Cartographic Modeling**
- **Automated Geodetic Monitoring Systems Applied to Construction of Engineering Structures and Their Maintenance**
- **Terrestrial Laser Scanning Systems Their Usage in Architecture, Civil Engineering, Industry, and Emergency Management**
- **GIS Technologies for Planning, Construction, Operation and Maintenance of Oil-and-Gas, Industrial and Power Plants and Infrastructure**
- **Provision of Geoinformation for Problem Solving in Ecology, Geomorphology, Geology and Geophysics**
- **Geospatial Data Infrastructure**
- **Real time GNNS Application in Development of Oil-and-Gas Fields (for Navigation Transport Solutions)**
- **Airborne Lidar, SAR and Digital Photogrammetric Technologies and Their Application in Geodesy, Civil Engineering and Emergency Situation Prediction**
- **Earth Remote Sensing**

Round-table discussion

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	Chair: Vice Chair	Prof. Dr. **Lothar Gruendig**, Technical University of Berlin, Germany Prof. **Vladimir A. Seredovich**, Siberian State Academy of Geodesy, Russian Federation
	Co-chairs:	Dr. **Ivo Milev**, Technet GmbH, Germany Prof. **Anatoli L. Okhotin**, President of the Baikal Union of Mining Surveyors, Head of the Department of Mine Surveying, Irkutsk State Technical University, Russian Federation Prof. **Eugeny M. Medvedev**, General Manager, Altex Geomatica Company, Moscow, Russian Federation
	Secretary:	**Argina Novitskaya**, SSGA, Novosibirsk, Russian Federation

	Rapporteur: **Christian Clemen and Lothar Gruendig** (Germany): 3D Building Information Efficiently Acquired and Managed Dr. **Ivo Milev** (Germany): EUPOS the Success Guarantee for Rapid Buildup the Infrastructure in the Countries of Central and Eastern Europe **Daina Morgan** (Canada): Using Mobile Lidar to Survey Railway Infrastructure. Lynx Mobile Mapper Prof. **Vladimir A. Seredovich, Alexander V. Seredovich, Michael D. Kozoriz** (Russian Federation): Experience of Using Laser Scanning in Geodesy, Engineering and Industry Dr. **Albrecht Grimm** (Germany): IGI's Systems for the Efficient Collection of Earth Data
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Sunday, 26 July 2009 14:00-15:30 'Mayak' Conference Hotel	**Technical Session 3**
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	Closing ceremony

The Siberian State Academy of Geodesy as a Platform for Development and Realization of Information Technologies in Geodesy, Cartography and Cadastre

Prof. Alexander P. KARPIK, Russian Federation

The Siberian State Academy of Geodesy (SSGA) has always been and still is an active leader and a developer of information technologies that are considered as the basic tool for overwhelming majority of cartographic, surveying and cadastral techniques. Beginning from its foundation in 1933 as the Siberian Institute of Astrogeodesy, the institute's main products were the following: lists of reference points, Earth's figure parameters and its gravity field, topographic and special-purpose maps representing all possible processes, phenomena and objects as well as predictable ones.

Cartographic and geodetic data have gained of great importance at the fronts of the Great Patriotic War in reforming national economy, developing eastern and northern regions, and, particularly, in recent years in formation of land cadastre and real estate. Therefore, the interest to state-of-the-art products like databases and intelligent databases is significant.

The market principles of economic life, sharply increased market participants' community keeping in possession and using immense volumes of real estate, have essentially made difficult the solution of social and economic problems. Today a local coordinate system is the most important in data preparation required for managerial decision-making in the regions and municipal formations. The former techniques for its determination are out of date, therefore, there is a necessity for unique research and development work the results of which are required both by any subject of the Russian Federation and a large city.

The key factor in choosing parameters of a local coordinate system is to minimize its distortions when being referred to the height reference surface. Up to now the vertical reference surface and the central meridian position of cylindrical conformal transversal projection (Gauss-Krüger-Projection) are used. In addition to these parameters we have offered to choose the line orientation of least distortions in order to minimize the distortions on areas having the greatest extent on latitude. There are also some peculiarities, but the most important is a possibility of accurate transformation of a local coordinate system into a national one. To use the last mentioned is always a problem caused by the top secret restrictions as well as by the departmental technical regulations. The technical regulations can have rather conventional character in the version offered except for an access to a key for datum transformation. It should be emphasized that we are dealing with the provision of information and coordinates for any region and populated locality development.

Using databases is of current interest in all spheres of life activity including also land and real estate relations. Today it is necessary to integrate the whole information in the unified coordinate environment in form of databases, the primary layer of which is a digital model of terrain object contours generated by using aerial and satellite imagery data. For example, in one of the "oil" city of Tyumen Region is used a database developed on the basis of FireBird database management system and integrating the databases that contain different sources of information on companies and organizations of the Federal Agency of Geodesy and Cartography (Roskartographia) and the Federal Real Estate Cadastre Agency (Rosnedvizhimost), and local government bodies. In this case the graphic information is represented in various layer scales which are generalized to improve its visual acceptability. The database structure allows its dynamical extension, as well as provides the extension of departmental and private databases, and maintains the system integrity. The above-mentioned confirms the distinctive importance of information products and their role in adequate decision-making and providing population by necessary data.

For the coordination of educational, scientific and production programs in a given field, competitive recovery of domestic information products, the Siberian State Academy of Geodesy together with ITE "Siberian Fair" and supported by the Siberian Branch of the Russian Academy of Sciences (SB RAS), the administration of Novosibirsk Region and Municipal Administration of Novosibirsk have being organized the international forum "GeoSiberia" since 2005. Within the forum a specialized exhibition of equipment, software, innovative technologies, a scientific congress and thematic round-table discussions is hold. The participants of "GeoSiberia-2009", which took place in April, discussed one of the urgent topics "High Rise Building" significant for development of regional construction industry on the round-table "**Engineering Surveys for Construction and Redevelopment of Building Projects**. The key problems in construction of high-rise buildings were a lack of legislation and regulations to be used in maintenance of high-rise building projects, foundation deformations, tilts of buildings, and drawbacks of instrumental monitoring for the ready-built objects as well as the efficiency and reliability of surveying works.

The metro builders participated in the forum have mentioned that the Siberian State Academy of Geodesy's alumni are well-grounded and familiar not only with groundings in theory but software and instrumentation. President of FIG Prof. Stig Enemark and a representative of Leica Geosystems (Switzerland) Joël van Cranenbroeck have appreciated in value the Siberian higher school of surveyors and promised to render the academy and its partners information support in the development of domestic professional education and its integration into innovative production.

Thus, we may courageously affirm that the Siberian State Academy of Geodesy and its alumni are successfully developing "depth of the country" and actively use the best domestic and foreign information technologies.

3D Building Information Efficiently Acquired and Managed

Christian CLEMEN and Lothar GRÜNDIG, Germany

Summary

Reliable information about the buildings interior geometry is necessary for many purposes ranging from facility management applications to the prediction of earthquake induced hazards on man-made structures. But floor plans are often not available, not updated or not acquired in three dimensions. Therefore gathering three-dimensional geometric data of buildings is becoming increasingly important. Traditional surveying techniques are time consuming and expensive. From a practical point of view, indoor surveying is based on designing plots with a CAD tool, where the dimensions are taken from angular and distance measurements. Most often the measurements are taken on site and the drawing is done back at the office. But what should be done if some measurements are wrong or have been forgotten? What should be done if the outer walls of one floor plan do not align with the walls of another floor plan? The surveying staff will eventually have to return to the building for re-measuring.

This presentation shows how to model and parameterize a three-dimensional building geometry in a non-standard form that is suitable for a fast data acquisition based on least squares adjustment as tool of analysis. In contrast to existing CAD or GIS data models, the approach discussed does not use any coordinates, but is based on planes represented by their normal vectors.

As a consequence, the number of unknown parameters is significantly reduced, resulting in fewer measurements needed to be observed. The original measurements are part of the data model enabling software tools to be applied for statistical testing, robust estimation and stepwise refinement of the model precision.

The data model, presented here, addresses the three-dimensional geometric and topological structure of a building in a way that is suitable for all purposes of engineering surveying and least squares adjustment.

During the application it will be easy to determine the intersecting planes in each node, just by traversing the model instance, because the explicitly specified topology is an inherent part of the data model. One plane can carry multiple faces (*plane-sharing*), a normal vector can be referred by multiple planes (*normal-sharing*) and a parameter can be referred by multiple normal vectors (*signed parameter-sharing*).

Introduction

Gathering three-dimensional geometric data of buildings is becoming increasingly important. Virtual 3D city models and Building Information Models (BIM) require reliable information about the buildings interior. Floor plans are often not available, not updated or not acquired in three dimensions. Traditional surveying techniques are time consuming and expensive. From a practical point of view, indoor surveying is designing plots with a CAD tool, where the dimensions are taken from angular and distance measurements. Most often the measurements are taken on site and the drawing is done back at the office. But what if measurements are wrong or have been forgotten? What if the outer walls of one floor plan do not align with the walls of another floor plan? Probably the surveying staff will then have to return to the building for re-measuring.

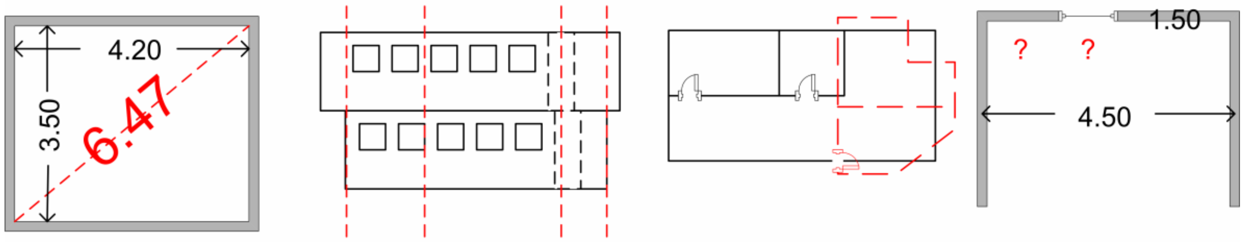

Fig. 1: Common errors during indoor data capture

This short paper shows how to parameterize a three-dimensional building geometry in a non-standard form that is suitable for fast data acquisition and least squares adjustment. In contrast to existing CAD or GIS data models, the discussed approach does not use any coordinates, but describes planes by their normal vectors (Fig. 2).

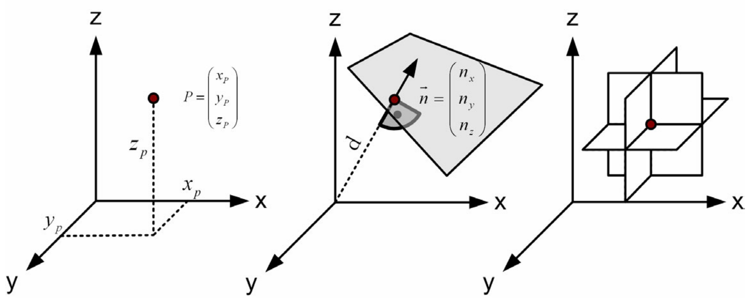

Fig. 2: a) point representation b) plane representation c) plane intersection

Using this approach, the number of unknowns is significantly reduced, resulting in fewer measurements to be observed. The original measurements are part of the data model enabling the software for statistical testing, robust estimation and stepwise refinement of the model precision.

Data model

The data model addresses the three-dimensional geometric and topological structure of a building in a way that is suitable for engineering surveying and least squares adjustment. For these purposes three main assumptions are made:

Firstly, the model must represent visible and observable parts of a building. Therefore Boundary-Representation with its explicitly specified topology was chosen. [Oosterom 2002] gives several reasons for this decision in context of surveying. Entity types of this domain are: Topological primitives *node*, *edge*, *face*, *solid* and the entity types for the topological orientation *half-edge* and *loop*.

Secondly, *stochastic observations* and *deterministic constraints* are integrated into the data model (Fig.3). This is because surveying engineers solve inverse problems.

An inverse problem is estimating the model parameters from a set of measured data. In the case of indoor surveying the model parameters to be estimated are those describing the building geometry. The data given are measurements gathered with surveying instruments. From the surveying engineer point of view, the parameters of the absolute geometry (secondary data) are derived from the original measurements (primary data). What is the benefit of this approach in everyday engineering life? A stochastically correct parameterisation allows for applying statistical tests during the process of geometric and topological generalisation. Storing the original measurements is robust, since gross errors and poor functional models (EDM offset, scale) remain identifiable.

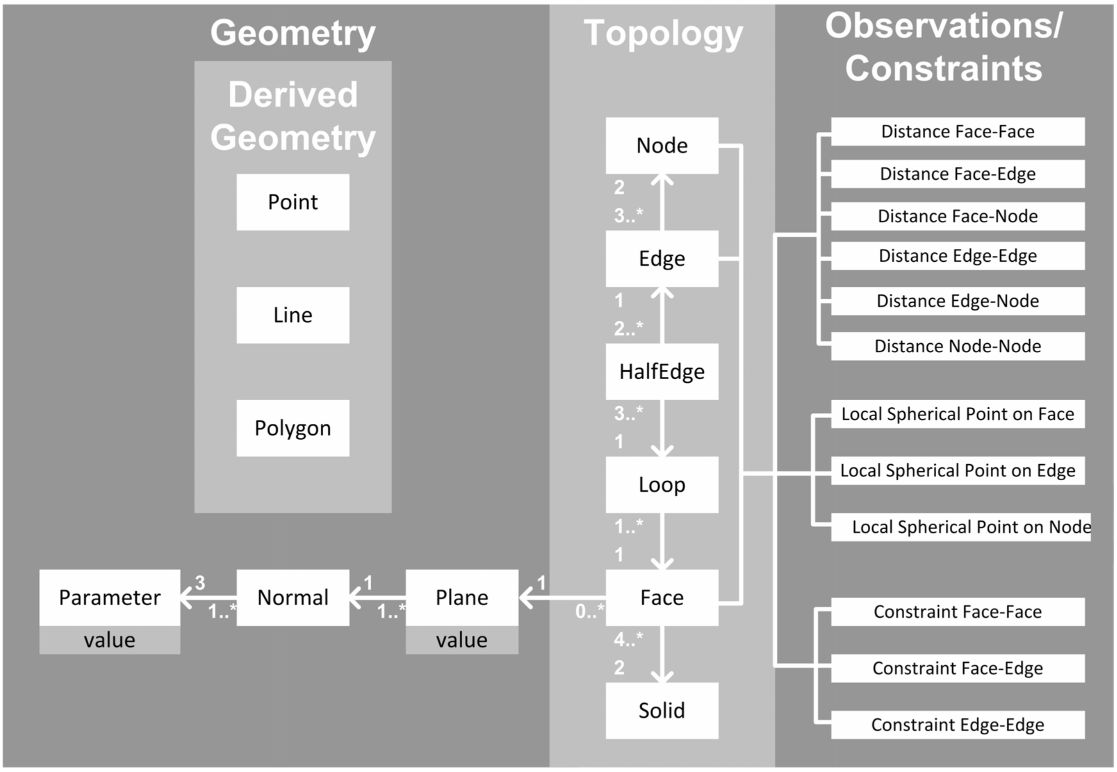

Fig. 3: A plane-based data model for 3D geometry, topology and indoor measurements

Thirdly, geometry is parameterised with planar surfaces [Gründig 2002]. The prevalent method for specifying location is making use of point representation, where every node is attached with three coordinate values *x,y,z* in order to specify its position. Additionally, implicit or explicit assumptions are made on planarity, parallelism and perpendicularity of faces [Kazar 2008]. The main idea of the discussed approach is to reduce geometric redundancy by replacing point representation by surface representation. A plane is represented by the *values* of its normal vector *nx,ny,nz* and the orthogonal distance *d* to the origin. This parameterisation is known as the *Hessian Normal Form*:

$$nx - d = n_x x + n_y y + n_z z - d = 0 \qquad (1)$$

By traversing the model instance, it is easy to determine the intersecting planes in each node, because the explicitly specified topology is an inherent part of the data model. The point coordinates can be calculated "on demand", solving:

$$\begin{bmatrix} n_{ix} & n_{iy} & n_{iz} \\ n_{jx} & n_{jy} & n_{jz} \\ n_{kx} & n_{ky} & n_{kz} \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} d_i \\ d_j \\ d_k \end{bmatrix} \qquad (2)$$

Similar approaches use half-spaces in order to establish a closed polytope algebra that can be represented with finite digital representation of numbers [Thompson 2008]. Please note that in our model one plane can carry multiple faces (plane-sharing), a normal vector can be referred by multiple planes (normal-sharing) and a parameter can be referred by multiple normal vectors (parameter-sharing).

Least Squares Adjustment

Least Squares Adjustment allows for the integration of redundant measurements. The equations of the general method consist of observations, unknowns and constants. Using adjustment techniques in 3D GIS/CAD the model can be attach by mutually checking measurements/constraints, accuracy properties of measurements and unknown parameters. The resulting geometry is reliable and attached with reasonable accuracy information.

Stochastic Observation Equations

Stochastic observations or soft constraints do not have to be fulfilled strictly. For parametric adjustment the observations l and the residuals v (noise) are expressed as nonlinear functions of the unknowns x. This domain of information is considered as being stochastic, because the residuals are considered as random variables and are optimized with the Least Squares Adjustment.

One type of observations are distances (Fig. 4). Distances are measured with ruler, measuring tape, laser distance meter or simply by pacing. Although the following functions describe relations between topological primitives, the corresponding geometric representation can be determined easily by navigating through the topologic-geometric data structure.

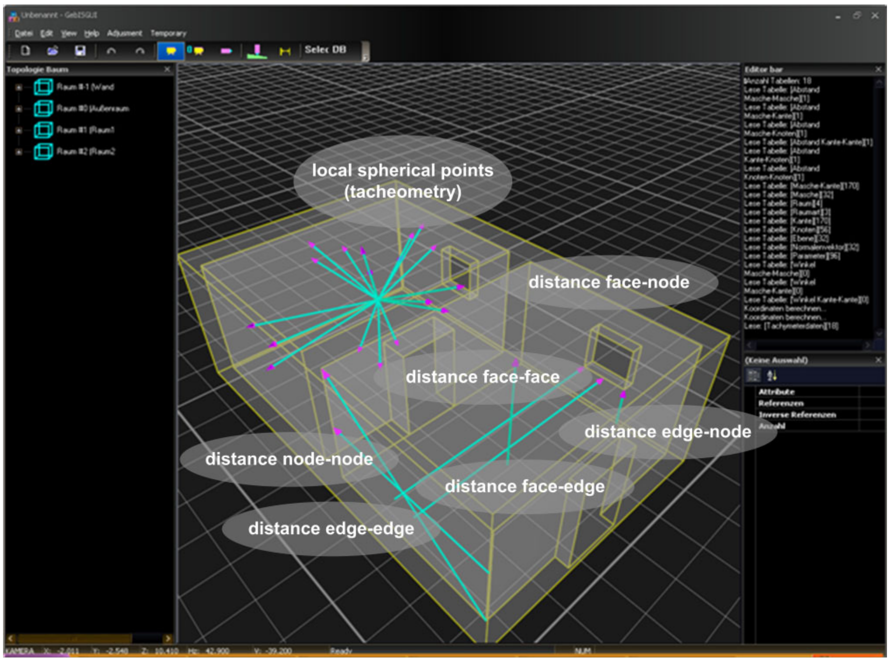

Fig. 4: Visualisation of stochastic observations (inverse picture)

Distance Face-Face. If a distance l between the parallel faces located on planes i and j is measured the observation equation is:

$$l + v = d_j - d_i \qquad (3)$$

Distance Face-Node. If a distance l between the faces i and node $j \cap k \cap l$, that is the intersection of the planes j, k and l, is measured the observation equation is:

$$l + v = \langle n_i, p_{jkl} \rangle + d_i \qquad (4)$$

$$p_{jkl} = \left[\left(n_j, n_k, n_l \right)^T \right]^{-1} \left(d_j, d_k, d_l \right)^T$$

Distance Node-Node If a distance l between node $i \cap j \cap k$ and node $l \cap m \cap n$ is measured the observation equation distance node-node is described as:

$$l + v = \left\| p_{ijk} - p_{lmn} \right\| \qquad (5)$$

$$p_{ijk} = \left[\left(n_i, n_j, n_k \right)^T \right]^{-1} \left(d_i, d_j, d_k \right)^T$$

$$p_{lmn} = \left[\left(n_l, n_m, n_n \right)^T \right]^{-1} \left(d_l, d_m, d_n \right)^T$$

Local spherical coordinates $(r, \theta, \phi)^T$ (Fig. 5) are taken with the total station at position $(x_T, y_T, z_T)^T$. Only one rotational degree of freedom ω remains for each instrumental set up, because the rotating axis of total station is adjusted to the vertical. The three components of $(r, \theta, \phi)^T$ are considered to stochastically independent. The observation equation of type spherical point i on face j is described as a conditional equation:

$$f(x,l+v)=\langle p_i,n_j\rangle-d_j \tag{6}$$

$$=\left\langle \begin{pmatrix}(r_i+v_r)\sin(\theta_i+v_\theta)\cos(\phi+v_\phi+\omega_T)\\(r_i+v_r)\sin(\theta_i+v_\theta)\sin(\phi+v_\phi+\omega_T)\\(r_i+v_r)\cos(\theta_i+v_\theta)\end{pmatrix}+\begin{pmatrix}x_T\\y_T\\z_T\end{pmatrix},n_j\right\rangle-d_j$$

Deterministic Constraints

Deterministic constraints have to be fulfilled strictly; therefore no stochastic part (residual v) is contained in the mathematical function. Deterministic constraints have the advantage of reinforcing the estimated solution by increasing the (stochastic) redundancy. The disadvantage is that wrongly specified or linear dependent constraints could lead to singular equation system.

Normal vector. Since the Hessian Normal Form is valid only if the normal vector is of length 1, the algorithm must ensure the normalisation of the normal vector n .

$$\|n\|=\langle n,n\rangle=\sqrt{n_x^2+n_y^2+n_z^2}=1 \tag{7}$$

Angular Constraints are attached to the model for ensuring the observational integrity (like parallelism of faces that are connected by a distance measurement) and to find a mathematical description for “obvious” situations like “wall perpendicular to floor” or “floor parallel to ceiling”. Angular constraints are of type “Face-Face”, “Face-Edge” or “Edge-Edge”.

Angular Constraints Face-Face. If the planes i and j of two faces are perpendicular an additional constraint is attached to the system of equations. The constraint is given by the normal vectors dot product.

$$\left|\langle n_i,n_j\rangle\right|=0 \ldots perpendicluar \tag{8}$$

The constraints “face-edge” and “edge-edge” are modelled equivalently [Clemen 2008].

A good practice is to process the angular constraints as “soft constraints” in a first step by simply attaching a residual v to each right hand side of the equation. If the condition passes the statistical test, it can be considered as being deterministic in a second step.

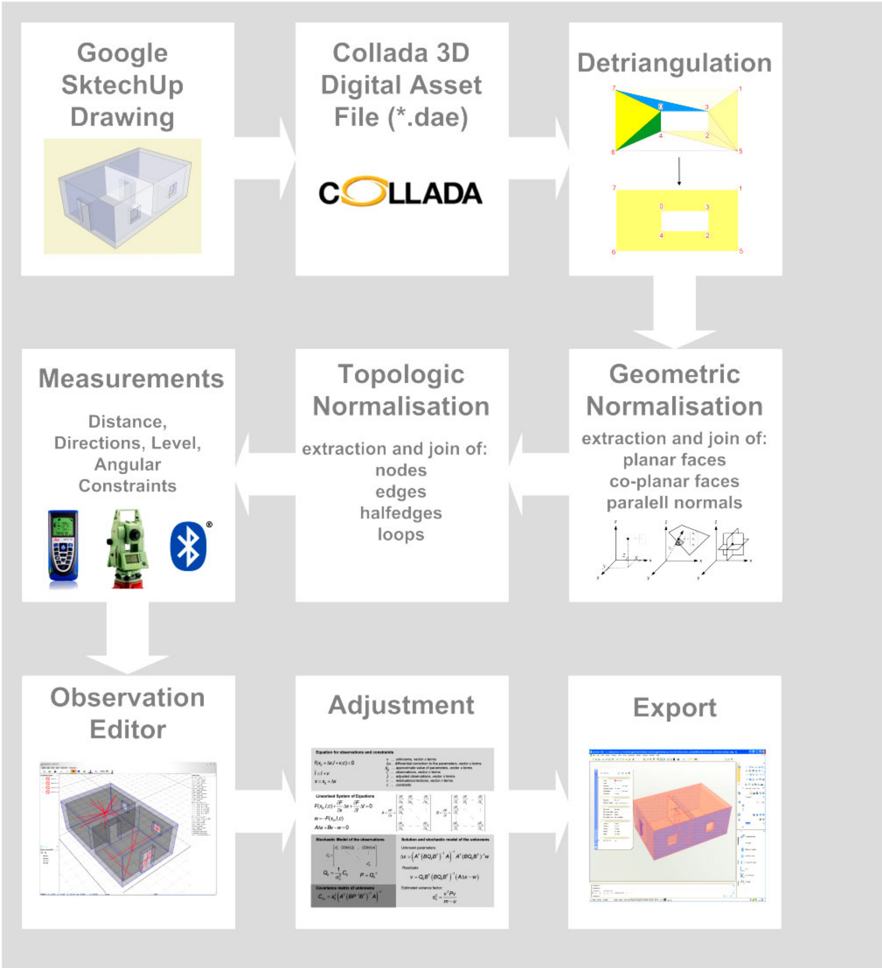

Fig. 5: Exemplary workflow to test the data model

Exemplary Workflow

In order to test the data model (Fig. 5), we use Google SketchUp as "Topology Editor". The 3D Model is draught on site. The exported Colada model is converted to an XML model instance that could be parsed and processed by our OpenGL based "Observation Editor". The measurements are collected using total station and laser distance meter. Back at the office they are adjusted with an "Adjustment Tool" and finally exported to dxf-format.

Future Work

Future work will be done in three domains: Use case evaluation, statistical testing and GUI integration. Evaluating use cases will include larger survey projects, deformation analysis, 3D data enhancement of existing model instances and the data model's application during the design phase of a building. The possibilities of statistical testing are not jet fully explored. Efforts will be made on applying well known test standards to the surface-based parameterisation. Currently we are working on the integration of our C++ algorithms to the Google SketchUp GUI in order to enable the user to work with only one software interface.

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CONTACTS

Christian Clemen
Technische Universitaet Berlin
Institute for Geodesy and Geoinformation Science
Chair of Engineering Surveying and Adjustment Techniques
Seretariat H20
Strasse des 17. Juni 135
10623, Berlin
GERMANY
Tel: +49-30-314-26483
Fax: +49-30-314-21119
Email: christian.Clemen@tu-berlin.de
Web site: http://www.geodesy.tu-berlin.de

Prof. Dr.-Ing. Dr. h. c. Lothar Gründig
Technische Universitaet Berlin
Institute for Geodesy and Geoinformation Science
Chair of Engineering Surveying and Adjustment Techniques
Seretariat H20
Strasse des 17. Juni 135
10623, Berlin
GERMANY
Tel: +49-30-314-22375
Fax: +49-30-314-21119
Email: lothar.gruendig@tu-berlin.de
Web site: http://www.geodesy.tu-berlin.de

Using Oracle Spatial with Coordinate Systems Based on Any Regional Geodetic Datum

Christian MANTHE, Christian CLEMEN, Lothar GRÜNDIG, Germany

Key words: geodetic datum, coordinate systems, oracle spatial

SUMMARY

Oracle Spatial supports many geodetic and non-geodetic coordinate systems, e.g. as defined by the European Petroleum Survey Group (EPSG) data model. Whereas the spheroid dimensions and the algorithms for the projection are well known and implemented (in most cases) the geodetic datum consists of estimated quantities as this transformation is based on multiple reference points.

For historical reasons and due to only local updating, the given standard parameter for coordinate systems is often not good enough with respect to the accuracy of transformed homological points.

This article illustrates the relations of the Oracle Spatial data model that specifies a geodetic datum including tables for spheroid dimensions, projection types and spheroid displacements. It is described how to insert and update a geodetic datum. Essential steps for data-conversion, estimation and validation of the transformation parameters and data base implementation are comprehensively explained by means of an example covering the German Berlin State Coordinate System (Netz88).

1. INTRODUCTION

More and more data are available from a variety of different sources, and more and more people have the means and the need to make use of it. A situation now exists where using a reference system for the means of acquiring data being completely different from the one in which the data will ultimately be required is quite common.

This is a particular problem of combining data sets, in which new data is to be put alongside archive material or of combining an image referenced with GPS with others that have been obtained from published map. Those are different data in different coordinate systems. To combine those data one set has to be transformed into the other. So the combining problem is foremost a transformation problem.

This article by way of an example explains the steps in a user-defined coordinate transformation with parameter estimation in Oracle. In Oracle Spatial two different ways exist to solve such a problem.

On the one hand we can use stored procedures. Here the complete formalism for the transformation between two data sets is to be implemented into a single procedure. This will be a quick solution as long as we have only one target system and not very complex formulas. The disadvantage is that this stored procedure is not reusable with different systems.

On the other hand we can use the features of Oracle Spatial. There we only need some general information about the system and some homological points to estimate the datum parameter. From this we can define the coordinate systems used for the available data sets in Oracle. Finally we apply the given implemented procedures to transform our data sets. The advantage here is that we can transform data with an easily-programmed SQL-statement for most of the given coordinate systems by using the SDO_GEOMERY in Oracle see (Kothuri & Godfrind & Beinat, 2007) or (Oracle, 2007).

```
select
I.PKTNUM Punkt,
SDO_CS.TRANSFORM(I.geom ,83033).sdo_point.x x,
SDO_CS.TRANSFORM(I.geom ,83033).sdo_point.y y
from SOLDNER_BLN I;
```

listing 1: transform Soldner Berlin coordinates into UTM ETRS89

In order to define a coordinate system in Oracle, we first explain some basics of coordinate systems and transformations in section 2. The data model for setting coordinate systems is explained in section 3. Section 4 deals with the estimation of the datum parameters. The SQL statements used to set the special Berlin Soldner coordinate system are given in section 5.

2. OVERVIEW OF COORDINATE SYSTEMS

Basically we can classify coordinate systems in projected and geodetic coordinate systems. Geodetic coordinate systems are referring to spheroids, that can be spherical but mostly are elliptical. The geometric parameter semi-major and semi-minor axis and also the orientation of the ellipsoid (translation and rotation) with respect to a geocentric system define the geodetic datum of a system.

To transform coordinates between two different geodetic systems they must first be converted into 3-dimensional world coordinates. In a second step they are to be transformed by a Helmert-transformation into the target world coordinate system. After that they will finally be converted with the given target ellipsoid into the required target geographic coordinates.

Projected coordinate systems are used for practical reasons. In surveying mostly UTM projection (figure 1) is used because of its metric and conformal features. All projections share definite mathematical rules. So a projected coordinate system is always a mapped geodetic coordinate system. Conversions between geographic and projected coordinates are mathematically clearly defined.

In Oracle several projections are implemented. The user only needs to choose the specific parameters of the projection e.g. scale factor, geographic coordinates of the origin or central meridian and offsets. Those kinds of parameters usually are known.

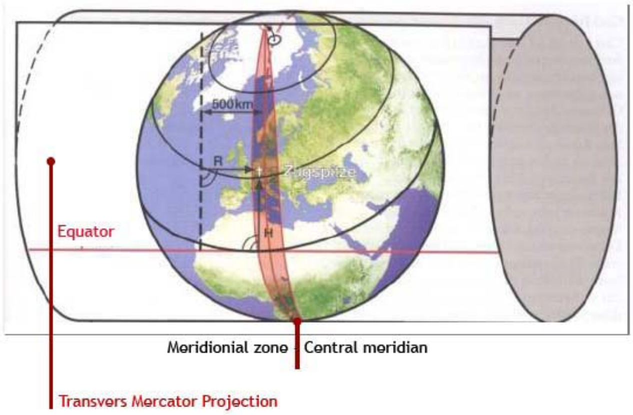

Fig. 1: UTM projection

Because of the historical development in geodesy there exist diverse rotation ellipsoids. These can be orientated differently with respect to their realized local reference frame. In Germany for example we have a common general geodetic system called DHDN (German general triangulation net) for the country as a whole, but with different realizations in the different states. Those can be traced back to individual improvements in the local net evaluation.

GPS facilitates investigating a global best-approximated rotation ellipsoid (see figure 2). The most recent global geocentric datum is the World Geodetic System 1984 (WGS84) and for Europe the European Terrestrial Reference Frame 1989 (ETRF89), both with identical orientation parameters and with the origin in the mass centre of our earth.

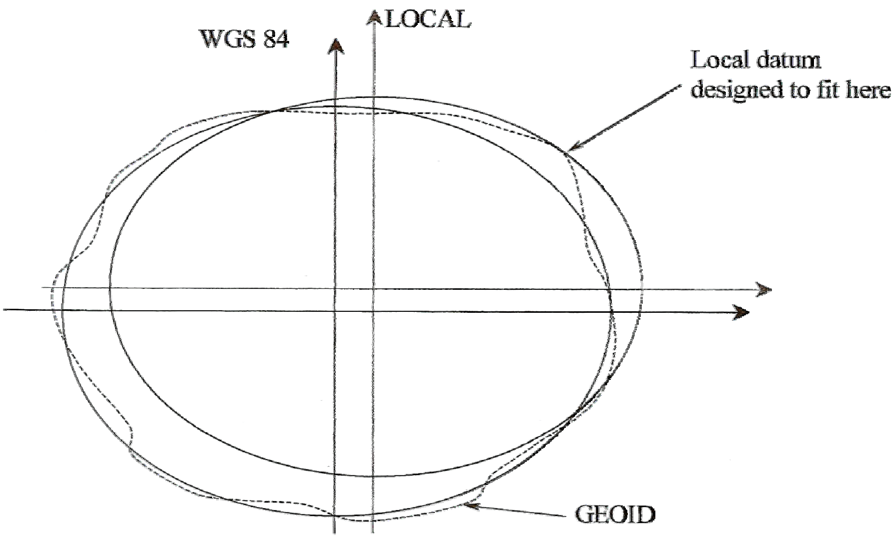

Fig. 2: Spheroid displacements

To obtain a precise transformation result we have to know the specific orientation parameters of the ellipsoid used. A way to estimate these parameters is explained in section 4 but first let's see how Oracle deals with coordinate systems.

3. COORDINATE SYSTEMS IN ORACLE

The data model in Oracle is based on the European Petroleum Survey Group (EPSG) data model and data set, but it is not completely identical with it. Coordinate systems are described in table SDO_COORDREF_SYS. Via foreign keys all information needed is linked with that table (see figure 3).

3.1 Overview

Oracle distinguishes coordinate systems in the following categories: 1-dimensional VERTICAL, 2-dimensional PROJECTED, GEOGRAPHIC2D and 3-dimensional GEOCENTRIC, GEOGRAPHIC3D and COMPOUND coordinate systems.

VERTICAL:	for defining physical height systems
GEODETIC:	for defining coordinate systems based on a individual reference surface
PROJECTED:	for defining a coordinate system based on a geodetic system
COMPOUND:	for defining a projected system with physical height

Typically the geocentric coordinate systems are predefined in Oracle. So we only have to answer the question of instantiate an unknown local system in Oracle. For the later illustration of this we explain here the features of the local Soldner Berlin system.

3.2 Features of the local Soldner Berlin System

Due to the history and the location of Berlin between two different projection zones the Berlin Soldner system is still official. It represents a coordinate system with a special very easy-to-use non-conformal projection developed by the German scientist Johann Georg Soldner in the 19th century. The projection used is also well-known and predefined in Oracle as Cassini projection, which was developed in the18th century by Dominique Cassini in France.

The features of the Berlin Soldner projection are the geodetic coordinates of the origin “Müggelberg” latitude of origin = 52.41864827777778° and Central meridian = 13.62720366666667°, the shift of the origin (false easting 40km and false northing = 10km, made to eliminate negative coordinates called false easting and false northing) and the scale factor.

The underlying geodetic system is called “Netz88” and uses the Bessel rotation ellipsoid as reference surface. It is based on the “Deutsche Hauptdreiecksnetz” (DHDN). The DHDN system is defined so that the vertical deflection in the fundamental point in Rauenberg is zero. This results in the ellipsoid (see figure 2) fitting very well in Germany as a whole (best fitting nationwide).

Based on the DHDN, the new net adjustment solution with new terrestrial and GPS supported observations in the area of Berlin is called “Netz88” (best fitting state-wide).
So the Net88 has different datum parameters from DHDN and even from the geocentric geodetic system.

4. ESTIMATION OF THE ORIENTATION PARAMETERS

For estimating the ellipsoid orientation parameter we need homologous points. These points are known in the local and in the target (in Oracle: ETRS89) coordinate systems. In order to prepare the estimation, the point information in both systems has to be converted into 3D xyz-world coordinates with respect to the projection and the underlying ellipsoid.

4.1 Used points

For the parameter estimation 14 homologous points were used. These are known in the local Soldner Berlin System and the global ETRS89. All points were evenly spread over the area of Berlin to detect possible distortions in the local system.

4.2 Assumptions

We used only 2D-Soldner Berlin coordinates. Height information was not considered. Solving the problem in an easy way, the ETRS89 coordinates are considered as non-stochastic errorless values and the coordinate system is expected to be nearly homogeneous. Based on these restrictions we have to estimate seven parameters (three rotations, three translations and the scale).

4.3 Pre-processing to estimate the datum parameters

To estimate the transformation parameter needed, the coordinates of both systems must be converted into 3D-world coordinates.

Therefore initially the given coordinates were projected back into geodetic coordinates with given formulas (EPSG, 2009). This means that the projected 2D-coordinates were converted into 2D-geodetic coordinates on the reference surface of the underlying ellipsoid.

In a second step the geodetic coordinates must be calculated into 3D-world coordinates observing the geometry of the ellipsoid used (Bessel 41 for Berlin Soldner and GRS80 for ETRS89).
As the origin of the ETRS89 is defined in the middle of the centre of mass these coordinates are called “geocentric.”

Finally, we determined a parameter description of our local best fitted 3D-coordinate system with respect to the spatial geocentric system.

4.4 Estimation of the datum parameters

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix}_{ETRS89} = \begin{pmatrix} \Delta X \\ \Delta Y \\ \Delta Z \end{pmatrix} + mR \begin{pmatrix} X \\ Y \\ Z \end{pmatrix}_{local}$$

equation 1 Helmert transfomation

The Helmert-transformation can be used with different descriptions of the rotations. At the beginning we used the linear description like shown in (equation 2).

$$R = \begin{pmatrix} 1 & \alpha_3 & -\alpha_2 \\ -\alpha_3 & 1 & \alpha_1 \\ \alpha_2 & -\alpha_1 & 1 \end{pmatrix}$$

equation 2 linear Euler rotation

The assumptions here are for very small angles, where the Sine-function will be equal to the angle and the Cosine-function equal to 1.
This linear adjustment model is very easy to realize, however the resulting parameters are not precise enough for satisfactory transformations.

$$R = \begin{pmatrix} \cos\beta\cos\gamma & -\cos\gamma\sin\alpha\sin\beta - \cos\alpha\sin\gamma & -\cos\alpha\cos\gamma\sin\beta + \sin\alpha\sin\gamma \\ \cos\beta\sin\gamma & \cos\alpha\cos\gamma - \sin\alpha\sin\beta\sin\gamma & -\cos\gamma\sin\alpha - \cos\alpha\sin\beta\sin\gamma \\ \sin\beta & \cos\beta\sin\alpha & \cos\alpha\cos\beta \end{pmatrix}$$

equation 3 full occupied Euler rotation matrix

In a second step we developed the non-linear adjustment model with the fully occupied rotation matrix (equation 3). As approximate values for the unknowns we can use 0m for the translations, 0° for the angles and 1.0 for the scale because of the nearly identical orientation of the local datum.

$$R = \begin{pmatrix} q_0^2 + q_1^2 - q_2^2 - q_3^2 & 2q_1q_2 - 2q_0q_3 & 2q_0q_2 + 2q_1q_3 \\ 2q_1q_2 + 2q_0q_3 & q_0^2 - q_1^2 + q_2^2 - q_3^2 & -2q_0q_1 + 2q_2q_3 \\ -2q_0q_2 + 2q_1q_3 & 2q_0q_1 + 2q_2q_3 & q_0^2 - q_1^2 - q_2^2 + q_3^2 \end{pmatrix}$$

equation 4 Quaternion rotation

To control with a different adjustment model and to be independent from approximated values we calculated the parameters also with the rotational approach based on quaternions (equation 4).
The calculations were conducted using MatLab. At the end we estimated the following parameters.

Shift in X 675.239155 m
Shift in Y 25.303490 m
Shift in Z 422.544682 m
Rotation in X -0.717994 sec
Rotation in X -1.766241 sec
Rotation in X -0.719541 sec
Scale -0.245916 ppm

To obtain an adequate description of the implementation, we considered the SQL-statements in the inverse order. By defining our own user-defined system one would consider starting with tables without an undefined foreign key. The following SQL-statements only shows the important lines with descriptions. For detailed information see (Oracle, 2007) and (figure 3).

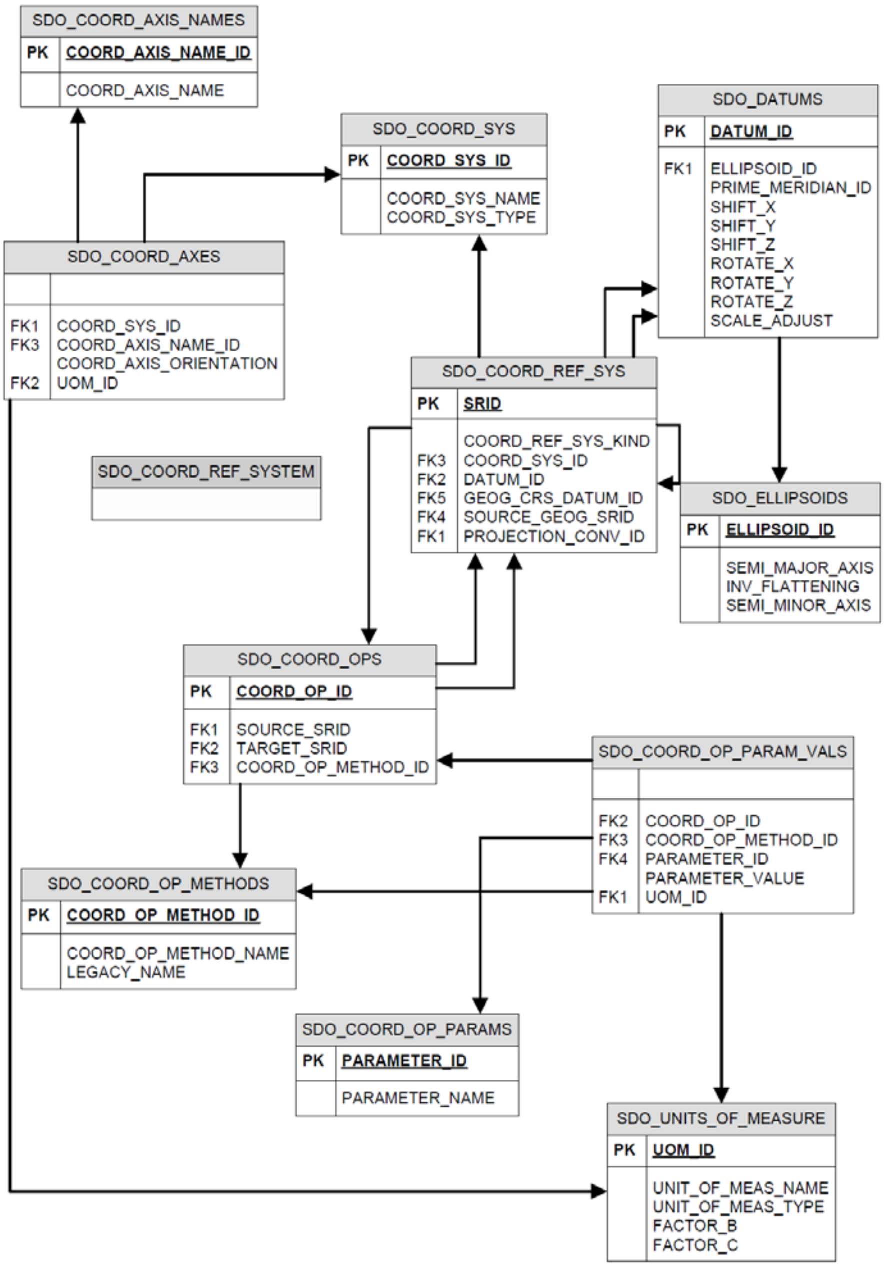

Fig. 3: Oracle spatial coordinate system data model overview

5. SQL-SCRIPT TO IMPLEMENT THE BERLIN SOLDNER SYSTEM

In the first statement we defined a coordinate system in the SDO_COORD_REF_SYS table. SDO_COORD_REF_SYSTEM is a view of the SDO_COORD_REF_SYS table in with we inserted an entry with the name (COORD_REF_SYS_NAME) "Soldner Berlin" with identification number (SRID)

7000001 (bigger then 1000000 because of the self-definition), system kind (COORD_REF_SYS_KIND) as projected, the representation of the coordinates as Cartesian with the unit meter (COORD_SYS_ID), no datum because of the projected system (DATUM_ID), with a specific underlying geodetic system and its datum (SOURCE_GEOG_SRID, GEOG_CRS_DATUM_ID)and the specific Berlin projection (PROJECTION_CONV_ID).

```
INSERT
  INTO MDSYS.SDO_COORD_REF_SYSTEM
      ...
 VALUES
 (
  7000001                        , -- SRID
  'Soldner coordinates (Berlin)'      , -- COORD_REF_SYS_NAME
  'PROJECTED'                       , -- COORD_REF_SYS_KIND
  4530                          , -- COORD_SYS_ID
  NULL                           , -- DATUM_ID
  6000000                        , -- GEOG_CRS_DATUM_ID
  7000000                        , -- SOURCE_GEOG_SRID
  5000000                        , -- PROJECTION_CONV_ID
      ...
   );
```

The underlying geodetic system can be implemented in the following statement into the same view. The features of this system are the different names by SRID. The type of this system is called geographic but also means geodetic. Coordinates are represented as ellipsoidal latitudes and longitudes in decimal degrees. Under the Datum_ID 6000000 the specific Berlin Netz88 Datum is defined. Due to the features of the geodetic system there are no source systems with a Datum or a projection (GEOG_CRS_DATUM_ID = SOURCE_GEOG_SRID = PROJECTION_CONV_ID = NULL).

```
INSERT
  INTO MDSYS.SDO_COORD_REF_SYSTEM
  ...
  VALUES
 (
  7000000                        , -- SRID
  'Geodetic coordinates Netz88 (Berlin)'  , -- COORD_REF_SYS_NAME
  'GEOGRAPHIC2D'                    , -- COORD_REF_SYS_KIND
  6422                          , -- COORD_SYS_ID
  6000000                        , -- DATUM_ID
  NULL                           , -- GEOG_CRS_DATUM_ID
  NULL                           , -- SOURCE_GEOG_SRID
  NULL                           , -- PROJECTION_CONV_ID
   ...
    );
```

In the next step the specific Soldner Berlin projection has to be defined. At first we had to look into the SDO_COORD_OP_METHODS table to check the given projections. Usually we find the Soldner projection under the name Cassini with the COORD_OP_METHOD_ID= 9806. So we do not needed to implement the mathematics of this projection and could start with defining the projection needed under a special COORD_OP_ID in the SDO_COORD_OPS table. The projection type here is a normal conversion of the geodetic system into the projected system and back.

```
INSERT
  INTO MDSYS.SDO_COORD_OPS
   …
 VALUES
 (
  5000000            , -- COORD_OP_ID
  'Soldner Berlin'   , -- COORD_OP_NAME
  'CONVERSION'           , -- COORD_OP_TYPE
    …
    9806                    , -- COORD_OP_METHOD_ID
    …
   );
```

To find out which parameters are needed to describe a Soldner projection, the next statement can be used. For more information see (Kothuri & Godfrind & Beinat, 2007).

```
SELECT
 use.parameter_id || ': ' ||
 use.legacy_param_name
FROM
 sdo_coord_op_param_use use
WHERE
 use.coord_op_method_id = 9806;
```

As a result we got the PARAMETER_ID´s of the Soldner projection which are.

8801: Latitude_Of_Origin
8802: Central_Meridian
8806: False_Easting
8807: False_Northing

Each parameter value has to be set into the SDO_COORD_OP_PARAM_VALS table with the same projection and method number. Also interesting is the unit of the parameter, e.g. decimal degree (UOM_ID=10001) for parameters 8801 and 8802 and meter (UOM_ID=9001) for 8806 and 8807.

```
INSERT
  INTO MDSYS.SDO_COORD_OP_PARAM_VALS
  …
 VALUES
 (
  5000000      ,      -- COORD_OP_ID
```

```
  9806          ,       -- COORD_OP_METHOD_ID
  8801          ,       -- PARAMETER_ID
  52.41864827777778,      -- PARAMETER_VALUE
  NULL          ,       -- PARAM_VALUE_FILE_REF
  10001                   -- UOM_ID
 );
```

In the SDO_DATUMS table the Datum parameters as calculated are defined. At first we set a new Datum number and name. Then we chose the datum type, the Bessel-ellipsoid and the meridian of Greenwich as the prime meridian. The next two lines INFORMATION_SOURCE and DATA_SOURCE contain statements which are only informative for the user of this datum. Essential are the lines with the transformation parameters. They are the units for translations in meters, for rotations in seconds and for the scale factor in parts per million that are important to be mentioned here.

```
INSERT
  INTO MDSYS.SDO_DATUMS
          …
 VALUES
 (
  6000000        , -- DATUM_ID
  'Netz88 (Berlin)', -- DATUM_NAME
  'GEODETIC'      , -- DATUM_TYPE
  8004          , -- ELLIPSOID_ID
  8901          , -- PRIME_MERIDIAN_ID
  'IGG TU Berlin'  , -- INFORMATION_SOURCE
  'IGG TU Berlin'  , -- DATA_SOURCE
  675.239155      , -- SHIFT_X in [m]
  25.303490       , -- SHIFT_Y in [m]
  422.544682      , -- SHIFT_Z in [m]
  -0.717994       , -- ROTATE_X in [sec]
  -1.766241       , -- ROTATE_Y in [sec]
  -0.719541       , -- ROTATE_Z in [sec]
  -0.245916       , -- SCALE in [ppm]
       …
 );
```

Finally, the Steps in the overview are:

1. collect all information needed to define the local coordinate system
2. estimate the best datum parameter by using homologous points applying adjustment calculation
3. Insert the new coordinate system with all needed information into the data model
4. Paste the orginal coordinates into the SDO-Geometry with the link of the new coordinate system see at (Oracle, 2007) or (Kothuri & Godfrind & Beinat, 2007)
5. Transform the coordinates into different systems only by changing the SRID number of the target system (listing 1)

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CONTACTS

Christian Manthe
Technische Universitaet Berlin
Institute for Geodesy and Geoinformation Science
Chair of Engineering Surveying and Adjustment Techniques
Seretariat H20
Strasse des 17. Juni 135
10623, Berlin
GERMANY
Tel: +49-30-314-24147
Fax: +49-30-314-21119
Email: christian.manthe@tu-berlin.de
Web site: http://www.geodesy.tu-berlin.de

Christian Clemen
Technische Universitaet Berlin
Institute for Geodesy and Geoinformation Science
Chair of Engineering Surveying and Adjustment Techniques
Seretariat H20
Strasse des 17. Juni 135
10623, Berlin
GERMANY
Tel: +49-30-314-26483
Fax: +49-30-314-21119
Email: christian.Clemen@tu-berlin.de
Web site: http://www.geodesy.tu-berlin.de

Prof. Dr.-Ing. Dr. h. c. Lothar Gründig
Technische Universitaet Berlin
Institute for Geodesy and Geoinformation Science
Chair of Engineering Surveying and Adjustment Techniques
Seretariat H20
Strasse des 17. Juni 135
10623, Berlin
GERMANY
Tel: +49-30-314-22375
Fax: +49-30-314-21119
Email: lothar.gruendig@tu-berlin.de
Web site: http://www.geodesy.tu-berlin.de

EUPOS the Success Guarantee for Rapid Buildup the Infrastructure in the Countries of Central and Eastern Europe

Dr.-Ing. Ivo MILEV, Germany

EUPOS is an initiative to establish a uniform DGNSS basis infrastructure in Central and Eastern Europe (CEE). Uniform multifunctional DGNSS reference station systems and services are going to be built up in fifteen participating CEE countries. *EUPOS* will in the end cover 25% of the European Union territory and more than 60% of the area of whole Europe. Taking into consideration also the Russian territory in Asia, where this infrastructure will be established, *EUPOS* will be realised for an area of about 10 million square kilometers

This fundamental infrastructure is based technically on a network of DGNSS reference stations and adequate communication lines. The data products can be used in many different applications requiring accuracy better than 3 m up to the 1 cm level in real-time and sub-centimetre precision by post-processing. This 'full scale accuracy' concept aiming all types of users from environmental protection, transport and public security, hydrography, maritime surveying, river and maritime traffic, fishing, machinery and vehicle control, to spatial data infrastructure developers and to geodesy. *EUPOS* is independent of private company solutions and uses only international and unlimited worldwide usable standards. In case international agreed standards do not exist, *EUPOS* is working on the standardisation in the corresponding organisations like the Radio Commission on Maritime Services, Special Committee 104 (RTCM SC 104). *EUPOS* provides the GNSS observation data and real-time corrections for high precise positioning and navigation with guaranteed availability and quality.

Using Mobile Lidar to Survey Railway Infrastructure.
Lynx Mobile Mapper

Daina MORGAN, Canada

Key words: Lidar, Mobile Mapping, Railway, 3D.

Summary
This project proved that the Lynx Mobile Mapper can quickly acquire geo-referenced 3D spatial data on railway infrastructure from a platform mounted on a moving rail car. Lynx Mobile Mapper data meets survey-grade criteria, providing sufficient detail and accuracy to extract essential spatial information for engineering, maintenance and construction applications.

Proof of Solution

When a large-scale project requires survey-grade spatial data, lidar (Light Detection and Ranging) has proven to be the fastest and most accurate technology for mapping and modeling. Over the last decade lidar technology has evolved to meet the needs of a broad range of survey applications. From underground mining to urban planning, hydrographic depth charting, airborne terrain mapping and all the way to the surface of Mars, laser ranging instruments have been accurately measuring distances and capturing images with increasing speed and precision.

Recently, terrestrial lidar imagers (T-Lidar) have advanced from a stationary tripod-mounted set-up to a new stage of mobility, enabling surveyors to capture highly accurate geo-referenced 3D spatial data from a variety of platforms, including land and marine vehicles.

Curious to learn more about this development, Aerial Data Service (ADS), of Tulsa, Oklahoma, contacted Optech Incorporated to test its Lynx Mobile Mapper in an untried application: surveying railway infrastructure from a moving rail car. In some cases, a client may present a surveyor with a detailed set of project requirements. Among these requirements, the client might specify the deliverables: raw data, file formats, Digital Terrain Models (DTM), Digital Elevation Models (DEM), topographic maps with set contour gradients; requirements for accuracy, resolution, density, cost and time estimates. Based on the specified requirements, the planner determines the most efficient and cost-effective survey.

In a new, untested application, however, it may be premature to anticipate highly specific requirements.

In this instance, ADS did not request a detailed set of requirements. Instead, they were interested in a "proof of solution". First and foremost, they wanted to determine whether Optech's Lynx Mobile Mapper could provide 3D spatial data with sufficient detail and accuracy to extract rail information for use by maintenance and inspection services. ADS was particularly interested in examining Lynx Mobile Mapper data for its potential in **monitoring track conditions, switch conditions, inventory, signage, and obstructions such as vegetation encroaching on the rail right-of-way**.

In addition to the areas of interest identified by ADS, the gathered data demonstrated that the Lynx Mobile Mapper offers untapped potential for multiple uses in railway surveying applications. A number of key areas are identified as being especially suitable for further exploration. These areas include rail **corridor design, corridor monitoring, hydrostatic and hydrokinetic monitoring**. Some of these potential uses are discussed in this paper. It should be noted, however, that in the absence of specific requirements, the acquired data has not yet been subjected to rigorous test standards.

Rail corridor design

Figure 1: Rail corridor surveyed by Lynx Mobile Mapper outside Tulsa, Oklahoma

The design of new railway sidings is crucial to improving traffic flow along existing rail lines. Rail sidings provide train engineers with the necessary space to either stop and wait for higher priority traffic to pass on a single rail line, or drop cargo for transfer or unloading. In either case, the need to add rail sidings to existing track means that an accurate survey is required before proper design of the new rail siding can proceed. Conventional survey methods are time-consuming and require either that the line be shut down for safety reasons, or that data collection be interrupted to let traffic pass. Mobile terrestrial-based lidar offers a solution to performing this task safely and efficiently, without interruption.

Attempts to use airborne lidar for monitoring and designing railroad infrastructure have been made in the past. However, the accuracy of the lidar data collected from an airborne platform was less than adequate (Fateh and Jones). Now, with the advent of mobile terrestrial-based lidar, a more accurate and cost effective method of collecting railway corridor data for design purposes is available.

In order to test the performance capabilities of the Lynx Mobile Mapper, ADS arranged to scan a section of railway outside Tulsa, Oklahoma. The Lynx Mobile Mapper was mounted on a speeder (track-maintenance car) where it traveled approximately 5.5 km (3.4 mi) of tracks, scanning the area surrounding the rail line with one of its lidar sensors (Figure 2).

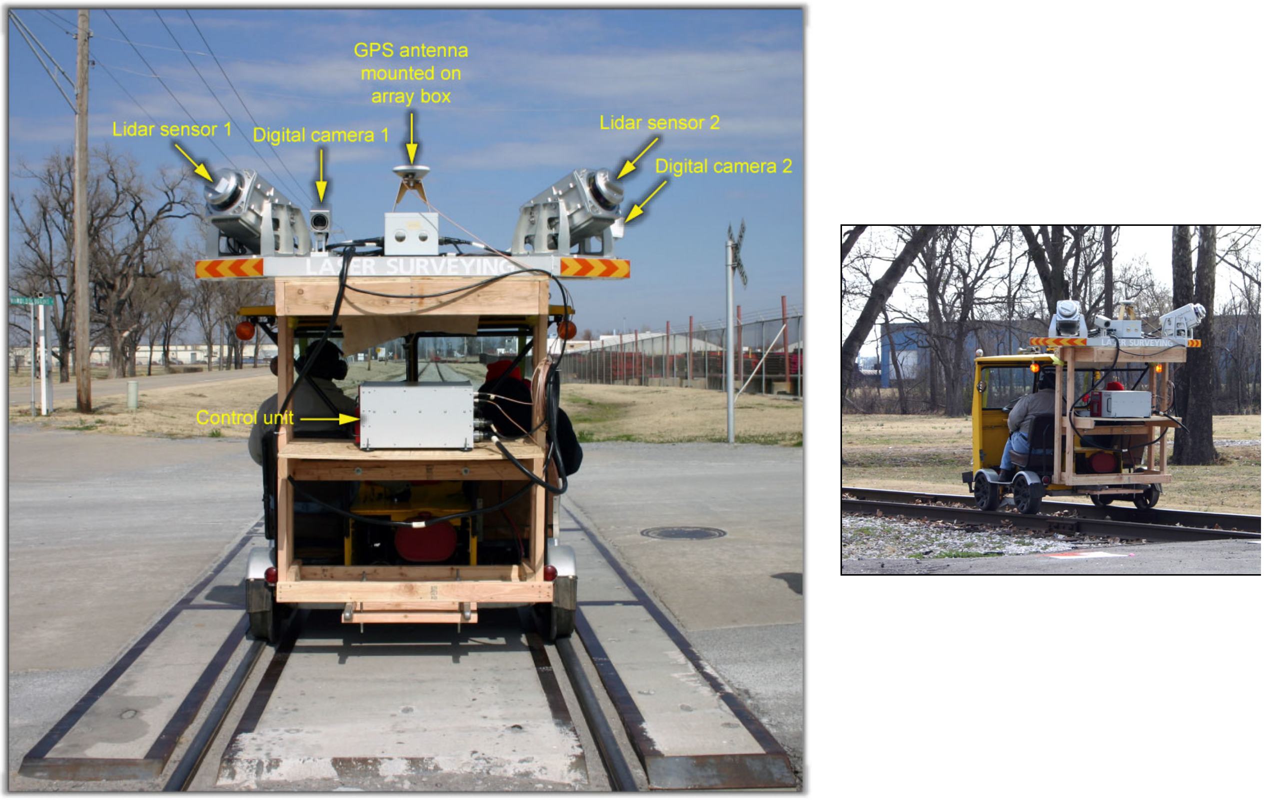

Figure 2: Lynx Mobile Mapper mounted on railway speeder

From the data collected during this project, several useful portions were extracted from the resultant point clouds. Topographic contour maps (e.g., Figure 3) of the surveyed rail line were output after processing the raw XYZi (Northing, Easting, Height and Intensity) data using the commercially available software package, Terrasolid.

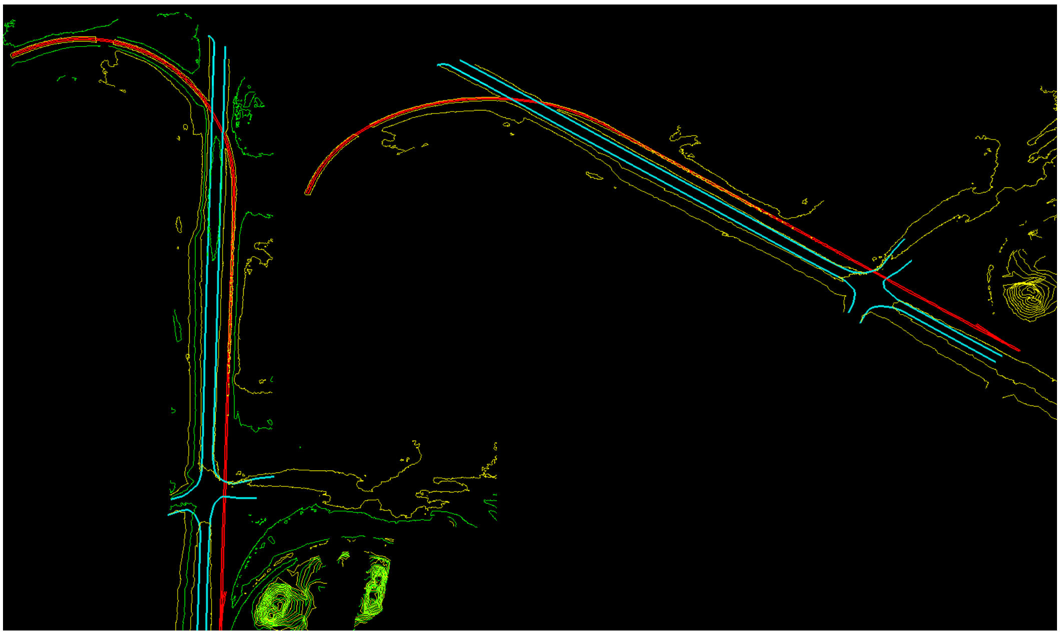

Figure 3: Contour lines made from Lynx Mobile Mapper data captured from a moving speeder on a section of railway track; contour separation 0.5 ft. (left), 1-ft. (right)

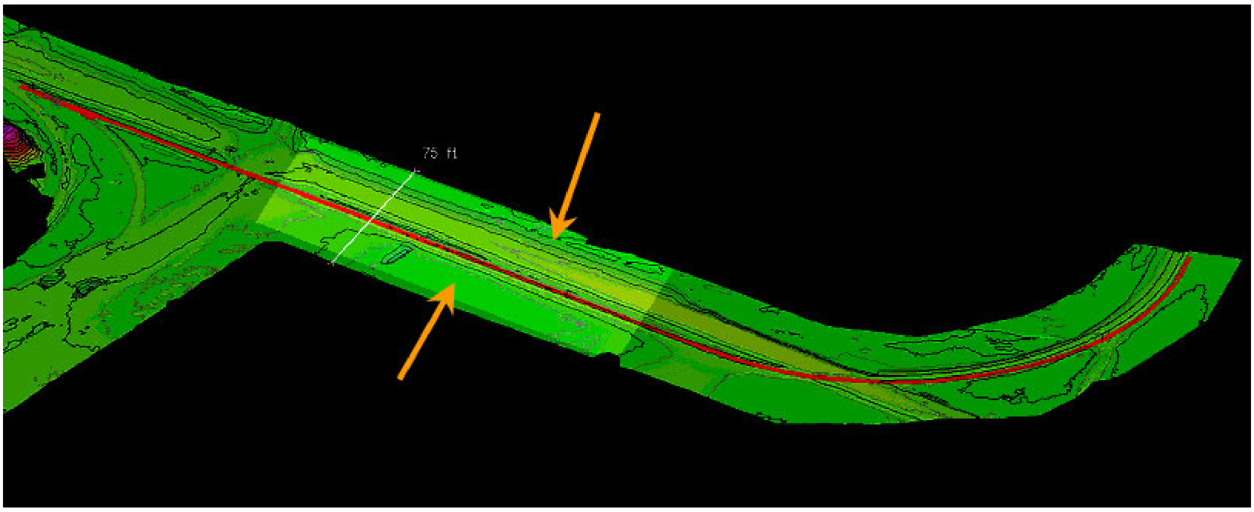

Figure 4: Triangulated Irregular Network (TIN) model with 1-foot contour lines showing a 75-foot corridor along a section of rail line

These topographic maps and models give surveyors and engineers a starting point from which a number of different design and monitoring projects can be based. As shown in Figure 4, the map can be used to estimate the volume of fill that will be needed when adding a siding or spur line to the existing structure.

For planning purposes, the information gleaned from these topographic maps is invaluable. For example, in Figure 4, the tightly banded contour lines in the highlighted area above the (red) track reveal a more pronounced change in elevation. Therefore, the grade in this area may be too steep to accommodate a parallel set of tracks. Similarly, the more broadly spaced contour lines below the track suggest flatter terrain, more suitable for laying additional track; however, if this area is very low it could be subject to flooding, so engineers would have to determine the suitability of the surface material for supporting any additional tracks.

Diesel train engines cannot easily climb grades steeper than 2% (Beranek); therefore, new rail sections must closely match the elevation of the existing track. The advantage that lidar data provides to the designer is the ability to repeatedly extract height differences directly from the original point cloud. The 75 ft. cross-section in Figure 4 can be moved to any point of interest so that the surveyor can examine details at any point along the scan.

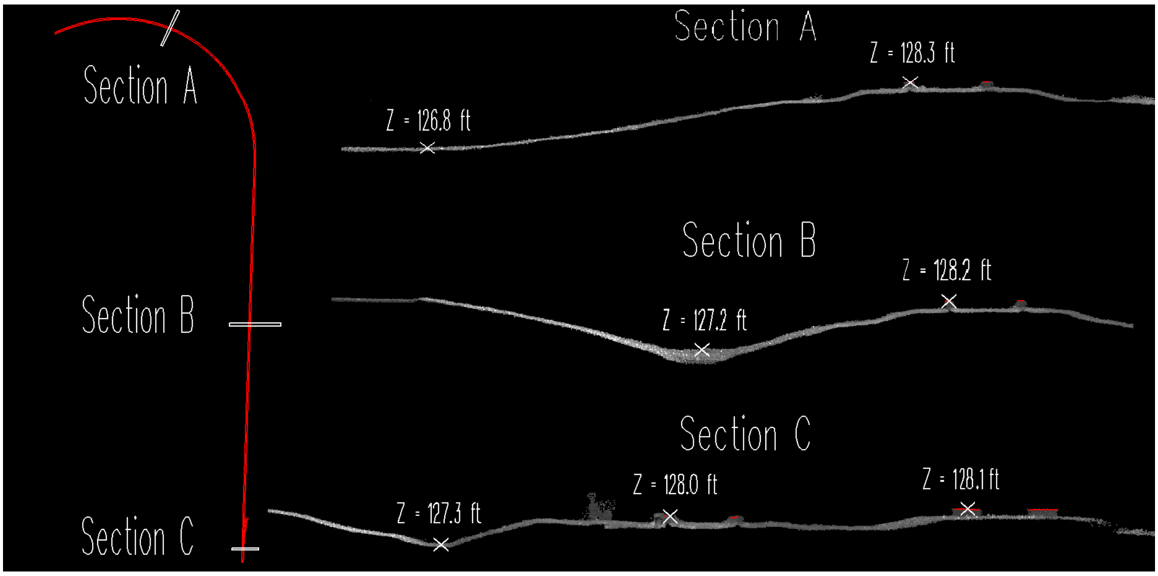

Figure 5: Cross-sections showing top rail elevation compared with lowest point along rail corridor.

Figure 5 shows elevations extracted for the top rail and low point on cross-sections of the scanned rail corridor. These cross-sections can be easily cut at whatever position and frequency the user requires.

To acquire this data in the conventional way, a surveyor would have to set up a Total Station and traverse for each cross-section. The resulting cross-section measurements apply only to those points surveyed. Other areas of interest require separate surveys. This limitation can be contrasted with the multitude of data acquired in one pass by the Lynx Mobile Mapper. The user can confirm elevation measurements at any point of interest along the scan by moving a cursor in the post-processing interface. A Lynx data set provides a permanently searchable data base after each survey.

Hydrostatic / Hydrokinetic Monitoring

The topographic maps generated from the Lynx Mobile Mapper can also be used to monitor existing drainage patterns along the track bed. Several sources—Langley et al, Beranek, Hay—stress the importance of proper drainage to the stability of the sub-grade material supporting the railway track.

In the United States, standard gauge railway track consists of individual 39-ft. long sections spaced 56.5 inches apart. These rails sit on rough timbers that are embedded in ballast that consists of sand or gravel supported by sub-grade material of a highly variable quality. The variable quality of the soil in the sub-grade material is usually site-specific, as this material is built up from the area soil surrounding the rail corridor.

The main purpose of the track is to disperse the surface stress of the train wheels to a point where the sub-grade material can support it (Hay). Hay states that reasonably firm sub-grades have a supporting capacity of about 20 psi. If the sub-grade material, upon which the rail track rests, is undermined by water, the supporting capacity of the soil can be greatly reduced from the 20 psi level.

The concentration of stress that a track must disperse is a function of the combined speed and weight of the vehicle traversing it. The sub-grade's ability to support rail traffic diminishes over time due to the cyclic nature of the dynamic load, inappropriate vehicle speeds and/or weights, or deterioration of the track or sub-grade caused by prolonged exposure to extremes in weather and climate.

The topographic maps generated by the Lynx point cloud data contain a wealth of information essential to designers. The maps can serve as the basis for analyzing current water flow patterns in the rail corridor. Such flow patterns will indicate where the sub-grade material is at risk of being undermined through erosion by flowing water, or through the capillary action of water in soil. This last consideration is especially important in environments that experience freeze-thaw cycles, and where the soil is made up primarily of a silt-clay combination, as in many parts of southern Ontario.

Rail corridor monitoring

Every railway line is unique, in that each supports a site-specific ecosystem. Various components of an ecosystem can become problematic when they impinge on the safe and efficient use of the railway corridor. Unchecked vegetation growth (e.g., massive tree roots) along the rail corridor can undermine the stability of the sub-grade material. On the other hand, some vegetation can also provide a needed mechanism to resist the effects of erosion. However, depending on their location, trees along the rail corridor can also interfere with passing trains by obstructing the free passage of rail vehicles.

In the United States, the maximum height of railway vehicles is 15 feet, 6 inches, with a maximum width of 10 feet, 9 inches (Horobin). Using the lidar data collected outside Tulsa, Oklahoma, measurements of tree heights close to the rail line could be ascertained. Figure 6 shows the height and distance of various trees measured from the top center of the closest rail along the surveyed corridor.

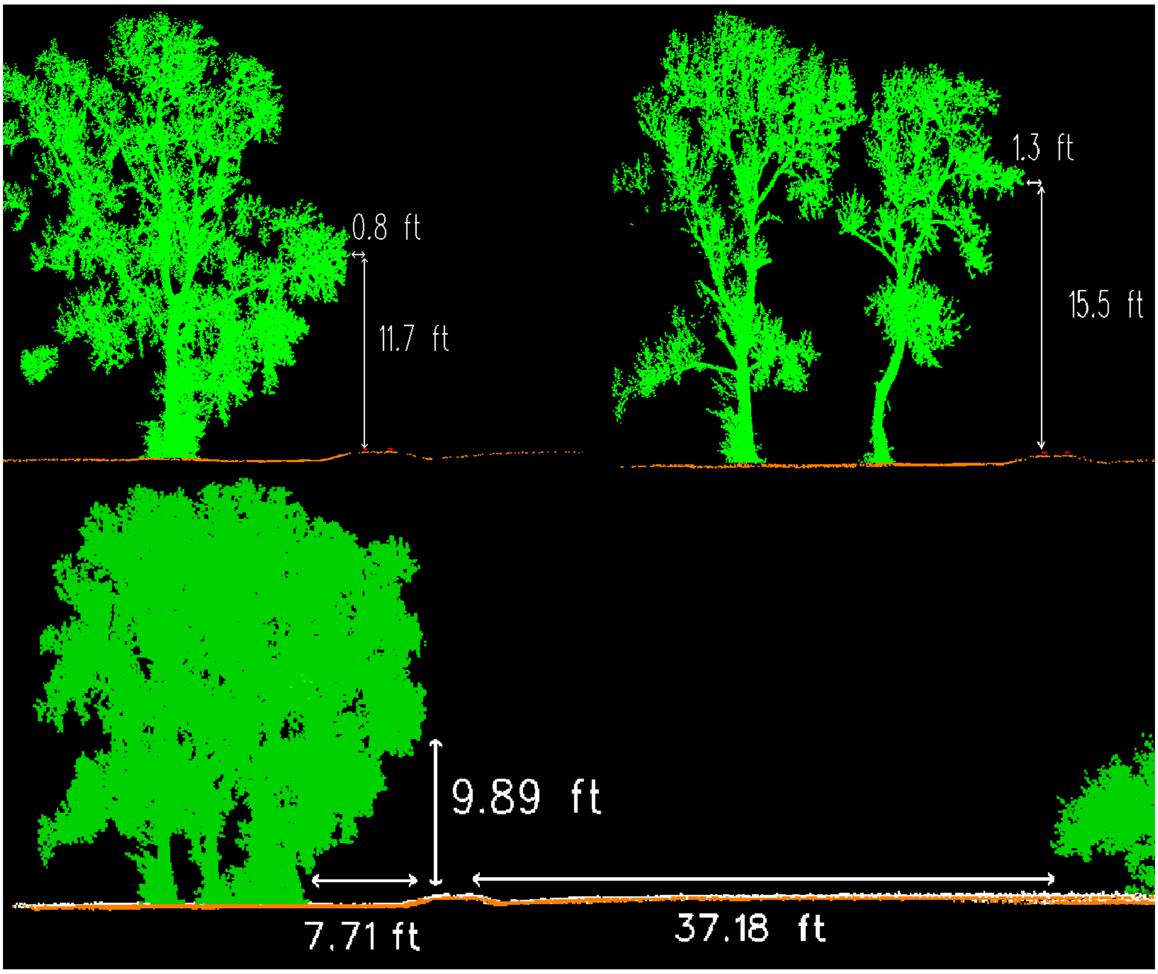

Figure 6: Various tree heights above top of rail, plus distance of trunk from top center of rail.

The measurements shown in Figure 6 indicate that there are potential problems with some of the vegetation alongside the track. Where the height of the vegetation is less than 15 feet, trimming or removal may be necessary.

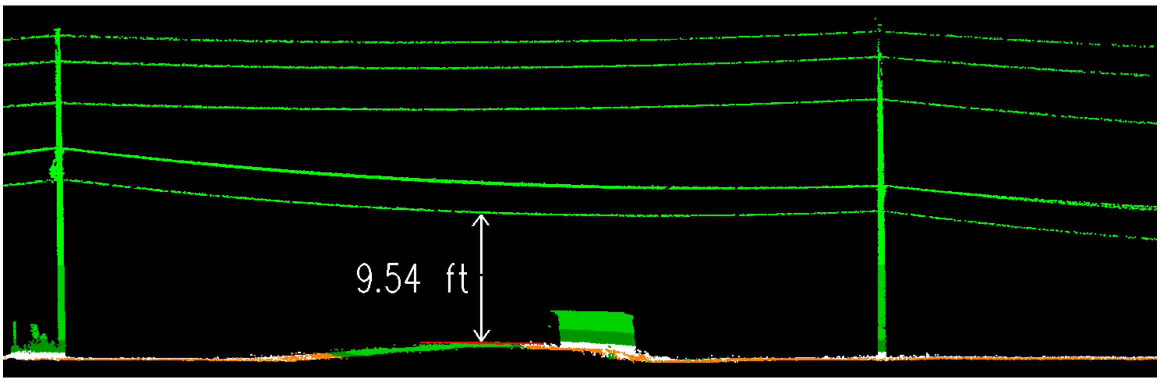

Figure 7: Height of overhead wires above top center of rail.

Along with natural obstructions, man-made features overhanging the track may also pose a risk. Figure 7 shows the measured distance from the top-center of a rail to overhanging wires above. The clearance between the tracks and the wires limits the height of rail cars that can travel along this line.

Conclusion

At the time of this project, the client had expressed a desire for an overall "proof of solution". Therefore, the data acquired here has not yet been subjected to the rigors of systematic testing. Nevertheless, it was demonstrated that terrestrial-based mobile lidar offers untapped potential for myriad uses in surveying railway infrastructure, including:

- Surveying an area of interest quickly, safely, efficiently and without the larger scale interruption necessitated by traditional survey methods
- Rail corridor design
- Rail corridor monitoring
- Hydrostatic and hydrokinetic monitoring
- Volume estimation (amount of fill needed to add for the construction of a new spur line)
- Extracting height differences repeatedly from one point cloud
- Measuring the height and proximity of trees and man-made objects surrounding the rail right-of-way.

Presently, additional projects and demonstrations at other locations are being scheduled. Considering all the recent discussion regarding investment in large-scale infrastructure projects, Optech looks forward to working with surveyors and engineers to provide them with the best tools for improving rail infrastructure quickly, efficiently, accurately and safely.

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Contacts

Lynx Sales
Optech Incorporated
300 Interchange Way
Vaughan, Ontario, Canada L4K 5Z8
Telephone: 1+ 905 660 0808 (8 a.m. to 5 p.m. local time)
E-mail: Lynx_sales@optech.ca
Website: www.optech.ca

Daina Morgan
Optech Incorporated
Product Manager, Lynx Mobie Mapper
300 Interchange Way
Vaughan, Ontario
Canada
Tel.: 1 905 660 0808 x 3744
Fax: 1 905 660 0829
E-mail: dainam@optech.ca

Using Laser Scanning for Estimating Mine Output Volumes and 3D Modelling of Geological Situation

Vladimir A. SEREDOVICH, Alexander V. SEREDOVICH, Michael D. KOZORIZ, Russian Federation

Basic indicator of mines efficiency is the volume of the extracted ore or rocks. Mine surveyors estimate the volume in the process of work, this being an urgent problem. The accuracy of work (with traditional surveying methods) amounts to 3 – 5 %. Incorrect output volume determination may result in large financial losses of enterprises. Nowadays it is a good practice to use total station and aerial photographic surveys in mining for surveying mine workings and storage yards. Aerial photographic survey is conducted several times a year in major deposits. But the current problems are solved by means of land surveys with significant errors caused by complicated forms of mine fields, which are difficult to take into account in total station surveying. Besides it takes a long time to conduct it. The way out may be found by using high-efficiency remote measuring devices i.e. terrestrial laser scanners. They are three times as fast as the traditional land surveying methods as concerns mining fields surveys. Moreover the technology facilitates and improves 3D modeling of deposits

The paper presents the experience of SSGA (Siberian State Academy of Geodesy) in surveying the manganese mine of 200 by 400 m and about 25 m depth. The survey was conducted to determine the volume of ore and substitute rocks extraction. 5 scanning stations were used and measurements were made from mine edges without lowering.

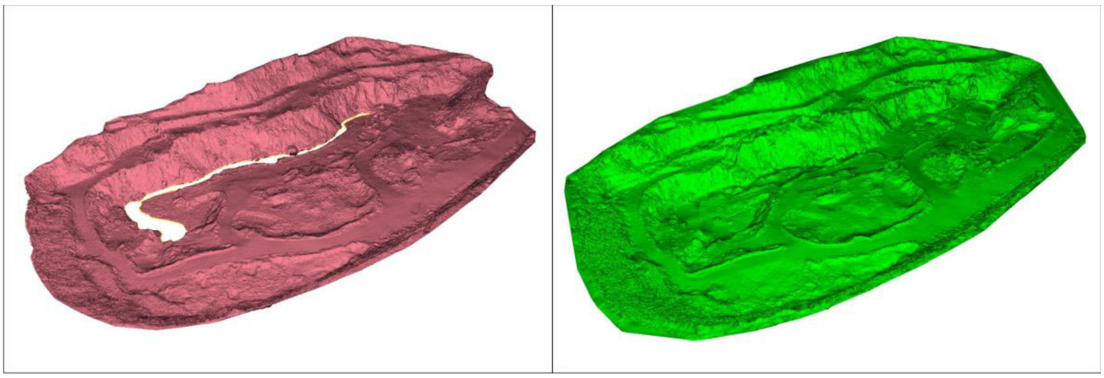

Figure 1: Mine models developed in different periods of time

On the basis of the given models the volume of the extracted rock was determined. The density of the model nodal points is 0.5 m that testifies to the high accuracy of the volume determination. It seems to be inexpedient to achieve such density and detailization of the relief description using total station surveying. The volume was determined by comparing two models using special software. The models were given to the enterprise mine survey service in AutoCAD format to be used in further work.

In the process of the given works the specialists came to an idea of developing a 3D model of the deposit geologic structure and matching it with the 3D model of the mine surface. The idea was successfully realized using digitized geologic sections and tying them to the set coordinate system according to the test boreholes and pits.

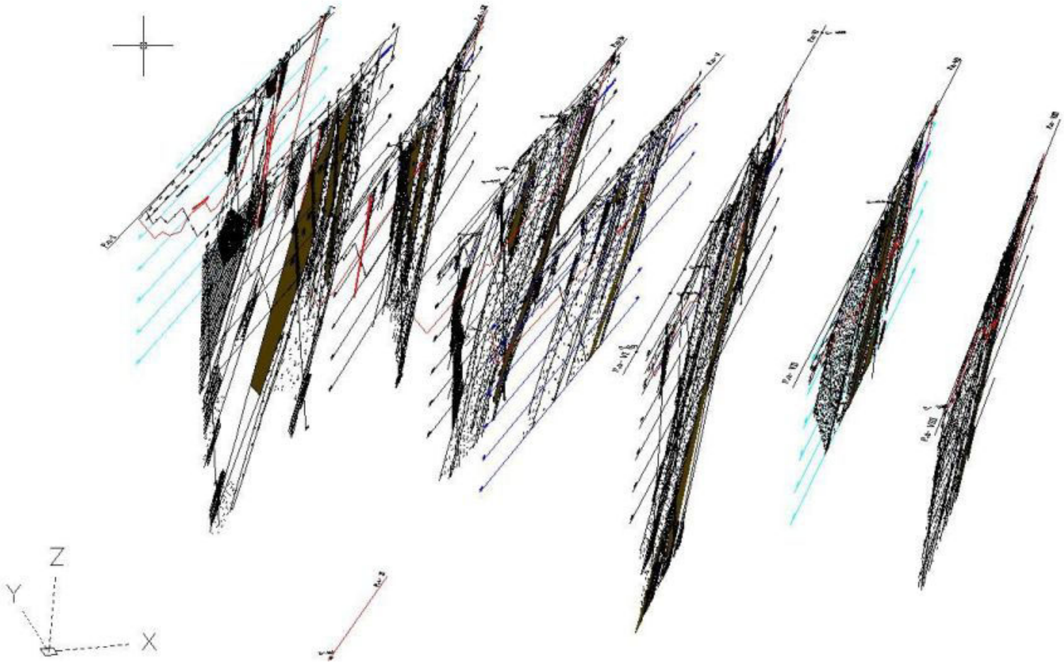

Figure 2: Geologic drawings in AutoCad format

On the basis of the sections 3D models of ore bodies were developed and later matched with the results of scanning.

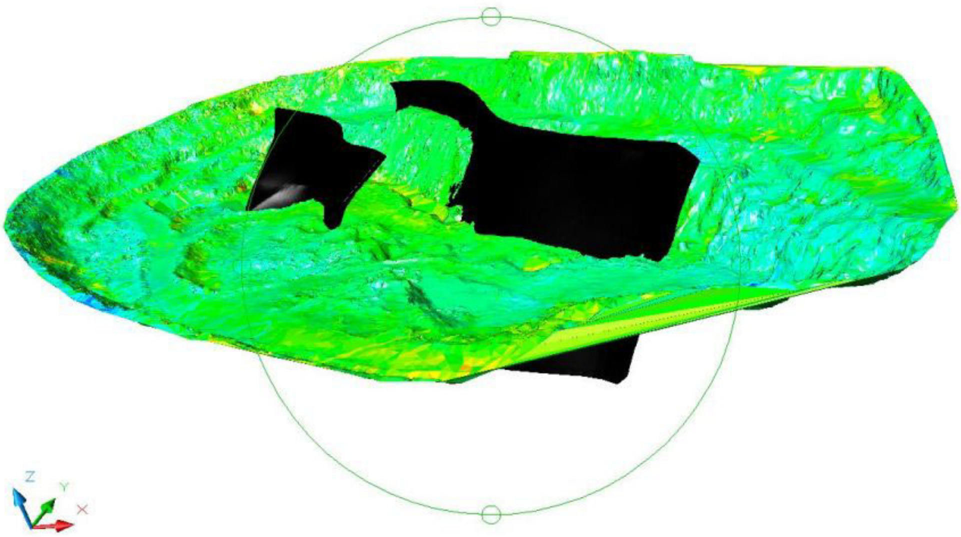

Figure 3: 3D geologic structure of the mine

The developed model may be used for efficient work planning, and the presented techniques allow keeping a record of the mine output volume.

CONTACTS

Prof. Vladimir A. Seredovich
Vice Rector for Innovative Activities
Siberian State Academy of Geodesy, SSGA
10, Plakhotnogo Ul.
Novosibirsk, 630108
Russian Federation
Tel: +7 (383) 343-39-37
Fax: +7 (383) 344-30-60
E-mail: v.seredovich@list.ru

Alexander V. Seredovich, PhD
Director of the Regional Centre for Laser Scanning
Siberian State Academy of Geodesy, SSGA
10, Plakhotnogo Ul.
Novosibirsk, 630108
Russian Federation
Tel: +7 (383) 361-00-66
Fax: +7 (383) 344-30-60
E-mail: a.v.seredovich@ssga.ru, lab.rcls@ssga.ru

Michael D. Kozoriz, PhD
General Mine Surveyor
JSC "Independent Resources Company"
Corresponding Member of International Academy of Ecology,
Man and Nature Protection Sciences
E-mail: kozoriz_md@mail .ru

Control of Highway and Railway Construction and Repairs Using Terrestrial Laser Scanning

Vladimir A. SEREDOVICH, Alexander V. SEREDOVICH, Andrey V. IVANOV
Russian Federation

In the course of the regular city highways construction and repair it is very important to control the quality of the work fulfilled by the contractors. Violation of construction techniques and economies in materials result in the rapid wear of the pavement and, thus, to the significant financial losses. The Siberian State Academy of Geodesy presents the techniques for the control of highways construction and repairs using terrestrial laser scanning. By far several kilometers of Novosibirsk streets have been surveyed by the given techniques.

For the purpose we use the car with the platform on its roof, which allows mounting a laser scanner on it. This results in the following:

1. The scanner is mounted high relative to the roadway to achieve better observability and reduce disturbances in scanning caused by the traffic.
2. The works are more efficient as the scanner may be moved from station to station by the car.

To transfer the scanning data into the unified system of coordinates the compilation survey of the site is conducted in the points to be saved for a long time. In cities the marks can be immured in buildings walls and foundations, the existing wall marks can be used as well.

As a result of the survey conducted by the specialists of SSGA the "points clouds" were produced for both the pavement and the surrounding objects (Fig. 1).

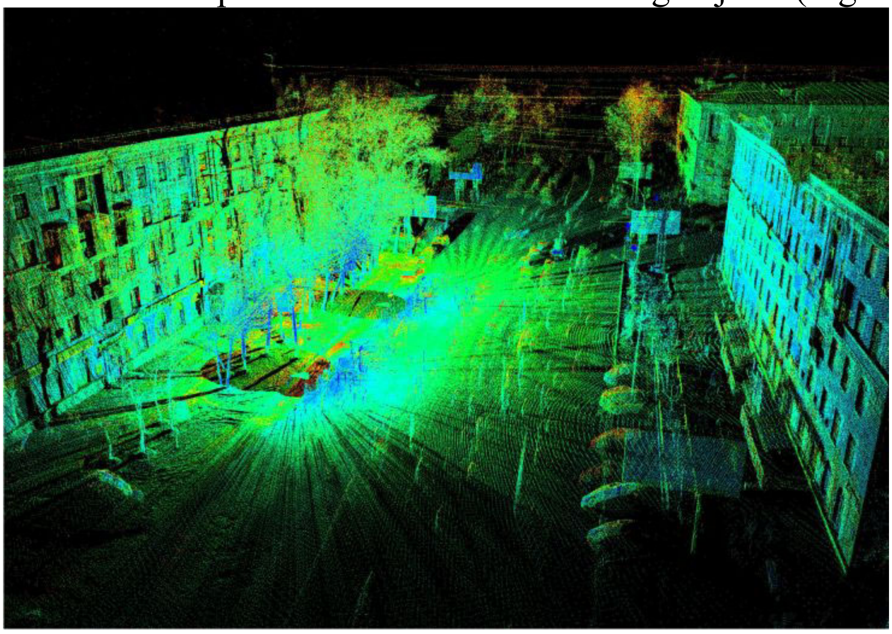

Figure 1: "The cloud of points" produced in the course of the roadway survey

The given clouds of points were then filtered to remove measurements of noise and those irrelevant to the pavement (Fig. 2).

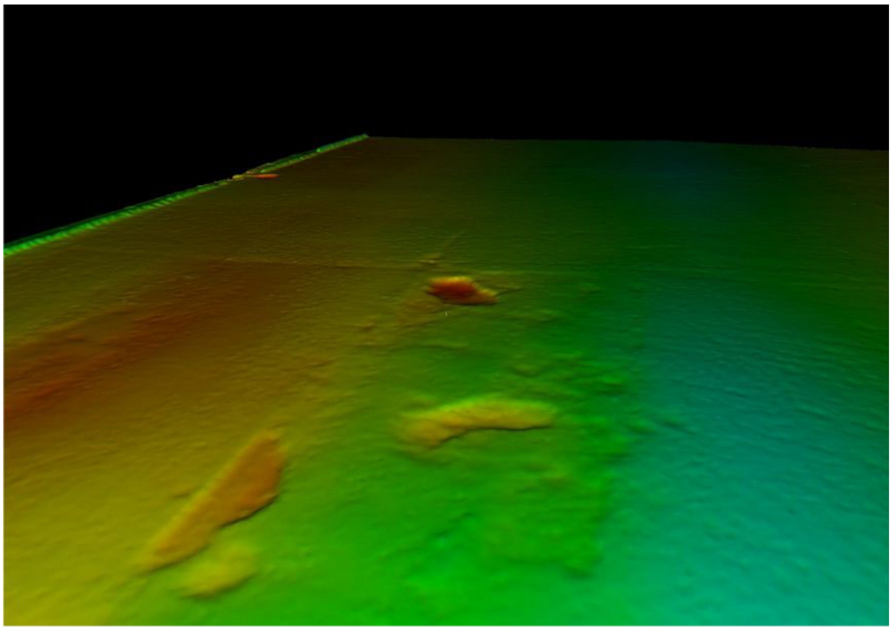

Figure 2: Model of the highway.

Filtration was made semiautomatically using special software. On the basis of the filtered "points cloud" the triangulation model of the road surface was developed. The model is used for:

1. Modelling the road surface and making sections (Fig. 3).
2. Estimating the volume of the conducted road repairs works (Fig. 4).

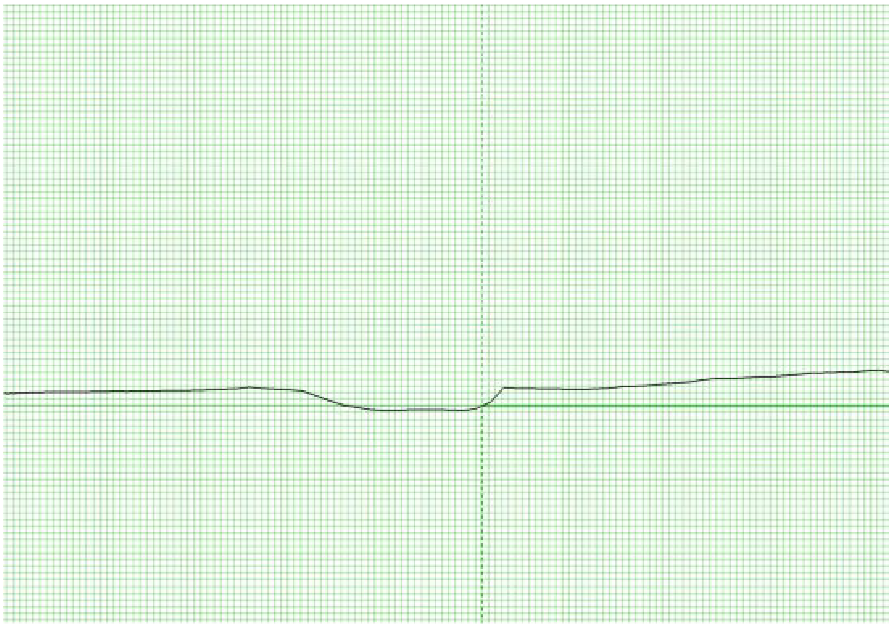

Figure 3: Road surface section

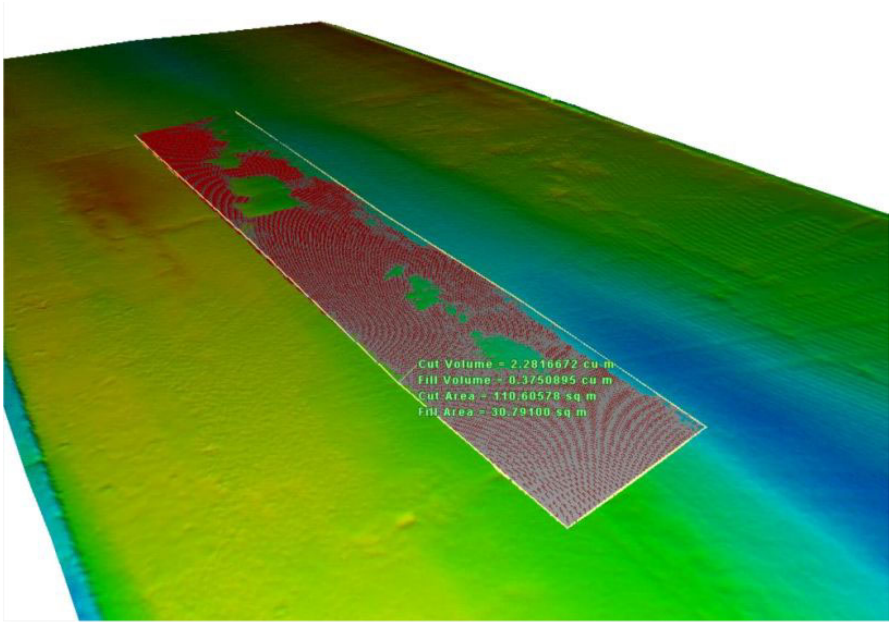

Figure 4: Estimation of the conducted road repairs volume

It should be noted that the road repairs volume may be estimated by several measurement cycles to be carried out at any stage of road building. Due to the advantages of laser scanning the presented techniques allow conducting accurate and prompt road improvement control (up to 1 – 4 km of road survey a day).

The above mentioned techniques may be applied to country roads and railways both for control and certification.

CONTACTS

Prof. Vladimir A. Seredovich
Vice Rector for Innovative Activities
Siberian State Academy of Geodesy, SSGA
10, Plakhotnogo Ul.
Novosibirsk, 630108
Russian Federation
Tel: +7 (383) 343-39-37
Fax: +7 (383) 344-30-60
E-mail: v.seredovich@list.ru

Alexander V. Seredovich, PhD
Director of the Regional Centre for Laser Scanning
Siberian State Academy of Geodesy, SSGA
10, Plakhotnogo Ul.
Novosibirsk, 630108
Russian Federation
Tel: +7 (383) 361-00-66
Fax: +7 (383) 344-30-60
E-mail: a.v.seredovich@ssga.ru, lab.rcls@ssga.ru

Andrey V. Ivanov
Regional Centre for Laser Scanning
Siberian State Academy of Geodesy, SSGA
10, Plakhotnogo Ul.
Novosibirsk, 630108
Russian Federation
Tel: +7 (383) 361-00-66
Fax: +7 (383) 344-30-60
E-mail: geoid@ngs.ru

Cartographical Support of Steady Development of Tourism on Trans-Border Territories of Russia and Mongolia

Leonid A. PLASTININ, Nadezhda V. KOTELNICOVA, Boris N. OLZOEV, Russian Federation

Key words: digital map, tourism and recreative, steady development, GIS

The steady development of locale is one of the priority tasks of the modern state, as in many respects depends directly on the socio economic and natural factors. In this connection the modern tool is indispensable, which one completely would solve the given problem. We offer as such tool – creation of an intelligence system of steady development of tourism on trans-border territories of Russia and Mongolia. The special place in solution of this problem is taken by national parks "Tunkinskiy", engaging southwest territory of Republic Buryatiya (RB) and adjacent with it – "Hubsugulskiy", posed in basin lake Hubsugul.

In 2007 in centre «SIBEK» the electronic recreative and tourist card of a national park "Tunkinskiy" to scale 1:200 000 was created. Now in centre the project of a card of Kabanskiy's and Pribaikalskiy natural and cultural heritage objects (scale 1:500 000) designed, and also form a card of Horinskiy's natural and cultural heritage objects in districts RB to scale 1:100 000 and series of educational electronic ecological cards RB to scale 1: 1 000 000 that is a landscape and ecological map, map nature usage and recreative and tourist map.

The experience of creation of electronic maps and hybrid module of offered districts will be necessary in creation of an intelligence system trance boundary of territories of Russia and Mongolia on an example of national parks "Tunkinskiy" and "Hubsugulskiy", providing steady development of tourism at an international level.
Let's consider criteria, on which one estimate steady development of locale [Vikipediya]:

- Rational maintenance of natural resources;
- Favourable directions of the investments;
- Orientation of technological development;
- Institute of change.

Rational maintenance of natural resources is meant as activity of the person on learning, reconnaissance, primary processing (enrichment) of natural resources with the purpose of their direct consumption or support by them of an industrial orb with allowance for of main ecologic and economic, social and nature protection criteria and limitations officially adopted by company.

Favourable directions of the investments are the perspective tourist projects, the resort economic programs etc. Long-term nestings of the investors can be directed on building of sanatoriums, bases of rest, hotels, camping, balneal complexes and other tourist objects. The development of the investment projects has a high social significance: the job-security program of a great many of the able-bodied population, and also will entail strengthening an infrastructure and economicses of district, that is apart important in conditions of instability and economic crisis.

At creation of a recreative and tourist zone on territory of district the forward reachings of a science and engineering, and also new geographical information technologies – digital maps with permanently enlarged and updated units of databases should be utillized. Such intelligence systems can allow the expert of any technological area to receive the staticized information on recreative and tourist resources of district.

Under institute by changes the constituent of processes of social economic development is meant expressed in development and change of social institutes [Institute of Change]. At implementation of introduced changes in an orb of tourism the different services and offices will be created, which one can be independent, and at management of district. They will be carried out a control, handle and level of development of tourism of district, and also development of the different projects and programs.

If to follow all these aspects at creation of recreative and tourist infrastructure, there is a possibility to minimize social, economic and ecological expenditures, and in a consequence steadily to develop tourism and recreation on trans-border territories.

On researched districts of geographical information mapping it is possible to develop following sorts of tourism:

– Ecological tourism and tourism in conditions of the natural environment, nature support of excursion;

– Rest at tourist centres and zones with a developed resource base and infrastructure of fissile tourism, physical culture and sports;

– Rest in wood and park zones;

– Rest in specialized tourist complexes of a family type with a developed resource base for occupations and entertainments of children;

– Winter tourism;

– Medical and improving tourism on health resorts;

– Agricultural tourism;

– Cultural – cognitive tourism.

Both districts of mapping are close on natural environments both degree of development of economics and social orb. Therefore creation of a cartographical frame of the data of territories will allow to decide the social economic tasks and to perfect foreign traffics.

Consider briefly contents of an electronic recreative and tourist map of a national park “Tunkinskiy”.

The electronic recreative and tourist map of a national park «Tunkinskiy» includes units topographic and subject contents. The topographic units represented by occupied points, road network, hydrography, contour, vegetative integument and grounds. The subject block is entered by recreative and ecological complexes, recreative and tourist objects and exogenous processes of contour derivation. At mapping the comprehensive approach will be utillized, which one allows to estimate binding and space allocation of subject objects to the precisely localized objects of topography (terrain).

In common, electronic recreative and tourist maps – complex tourist maps intended for orbs of tourism, science, derivation, nature protection activity, bionomics and managements.

The scheme of contents of electronic recreative and tourist maps is offered. In the offered scheme of a contents the methodological principles of creation of geosystems encompassing by system mapping by a landscape fundamentals (recreative and ecological complexes) and exogenous processes of contour derivation in interaction with tourist and recreational objects are considered.

The introduced principles can serve as a sample for creation of electronic maps of tourism and recreation of a national park "Hubsugulskiy", and also at more detailed mapping of characteristic recreative and tourist resources for concrete district in larger scale. Also in a recreative and tourist orb the special section "natural and cultural heritage" of mapping districts is selected, which represented historical, religious, cultural, ancient and natural objects.

In the offered scheme of a contents the methodological principles of creation of geosystems encompassing by system mapping by a landscape fundamentals (recreative and ecological complexes) and exogenous processes of contour derivation in interaction with tourist and recreational objects are considered.

In 2007 the operation on creation of a Series of electronic educational ecological maps RB to scale 1:1 000 000 started will are created as directory systems permitting to fulfill search of the indispensable data, and enables to use, having knowledge in the field of common computer science.

The names of three electronic educational ecological maps were represented above. One of them is a map nature usage RB, indicating how the person will utillize natural resources and what effect renders on the natural environment. There is a map – insertion "Characteristic of districts nature usage RB", on which one Tunkinskiy the district concerns to districts agricultural, recreational, wood trade nature usage [Map nature usage, 1998]. Allowing the given information, it is possible to speak about factors in development of tourism, about a quality of life of the population, about a degree of development of a social infrastructure.

The electronic (digital) map represents the system of interdependent subject coatings and stratums generator spatially – oriented the database. It becomes a collection of bound databases formed on a uniform conceptual and methodical basis. Such database is supported by tools a hybrid module permitting to solve the user's tasks: to produce on the basis of base maps unlimited set of derivative maps both other output illustrative and account materials of different sort and contents.

The electronic maps, created by us, represent digital general purpose working spaces, which one consist of a number of coatings and stratums, included in them. These spaces open for input of the manifold and non-simultaneous digital information about any objects nature usage and landscape and ecological processes, and, as a matter of fact, represent a regional intelligence system.

As a whole, it is possible to mark, that there are all indispensable conditions for steady development of tourism in offered districts.

In a period of 2004-2009 year the major size of the text, statistical, graphics and departmental information about districts and itself RB is accumulated, that will allow to create the directory system.

The steady development of tourism is reached at usage of the complex technological product by the way GIS. As the GIS is a combination different space and attributive of the data of territory, that enables to fulfill different inquiries, simple and composite calculations, build-up of models, bumper zones etc.

The GIS solves the tasks of handle, organization of activity, territorial planning, development of an infrastructure, therefore with the purposes of inducing development of an orb of tourism and creation of the modern competitive tourist and recreational complex state policy of Republic Buryatiya is directed on implementation of the following strategic tasks on the basis of the cluster approach:

– Development and rise of competitive strength of a tourist cluster through inducing of business – cooperation and state and private partnership;

– Creation of a modern tourist infrastructure, including transport support, comfortable hotels, industry of entertainments, and favourable business – climate for development of tourism by means of contributing to preparation of the skilled frames and implantation of information technologies;

– Rise of notoriety of the tourist product of Republic Buryatiya through promoting brands of Baikal in the global tourist markets;

– Creation of competitive tourist products on a basis most of strong tourist assets by means of installation of the long-term inter-regional and international ratios on development trance boundary of the tourist paths for the tourists traveling on North-east Asia;

– Saving and development of natural and cultural property on the basis of balanced ecological economical of technologies, development of norms marginal of recreational loads both rules of organization of tourism and rest on the Baikal natural territory.

In this connection it is possible to draw a conclusion about steady development of tourism at a level of its organization and development on the basis of creation a GIS.

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CONTACTS

Prof. Dr. Leonid A. Plastinin
Irkutsk State Technical University (ISTU)
83 Lermontova Ul.
Irkutsk, 664074
Russian Federation
E-mail: plast@istu.edu
http: www.istu.edu

Kotelnicova N.V.
Irkutsk State Technical University (ISTU)
83 Lermontova Ul.
Irkutsk, 664074
Russian Federation
E-mail: plast@istu.edu
http: www.istu.edu

Olzoev B.N.
Irkutsk State Technical University (ISTU)
83 Lermontova Ul.
Irkutsk, 664074
Russian Federation
E-mail: icob_irk@mail.ru, plast@istu.edu
http: www.istu.edu

Application of Laser Scanning in Mine Surveying

Anatoli L. OKHOTIN, Russian Federation

Key words: laser scanner, 3d model, mobile laser scanning systems, mine surveying, aerial survey, GPS-GLONASS

Laser scanners, often referred to as Lidars, are comparatively recently become be to use in mine surveying. Their application is similar to that of for surveying works, but there are also some differences.

According to the types, scanners are divided into aerial, terrestrial and underground.

Aerial scanners are intended for surveying of extended areal and linear objects. In mining the new areas of designed mining companies, existing open-cast mining sites and collieries, oil and gas pipelines, roads, and power transmission lines are related to such objects. Formerly the similar objects were mapped by aerial surveys and there was no other alternative for a long time.

Undoubtedly, laser ranging has a number of advantages over aerial surveys. The *technology of field works is simple.* After a short processing the coordinates of surveying points are got in a user's coordinate system. The quality assessment of field works including a completeness of laser reflection point clouds and orthophoto mosiacs is performed at the same aerial survey flight's day that sufficiently reduces a scrap rate, preliminary ground survey works, and eliminates the necessity for ground control points. Only a limited number of GPS-GLONASS base stations are required for laser scanning. Owing to a lidar's navigation block, the direct geo-positioning method is used to provide with coordinates of laser ranging. The rate of cartographic works is 5-10 times higher than that of traditional technologies. The accuracy of laser scanning as proved from practice meets the requirements of "Guidelines for Mine Surveying Works". In this case a survey team should strictly follow the standards for aerial surveys and calibration procedures outlined in corresponding manuals in detail.

The productivity of laser scanning is very high. It is real to survey in a day 500 km for linear object and 1,000 km for areal objects. Of vital difference of laser ranging is a *possibility of night work.* A key feature of this technology is its *feasibility to survey a* forested territory and simultaneously to generate a digital elevation model as well as *to survey a territory with a slight relief and absence of marking situation.*

As an example we may take our project realized in Yakutia. The ore field with the area of 200 sq. km was taken as an object for laser scanning survey. The gold ore deposits have been mined there for a long time. In economic recession the gold was extracted with procedural violations of mining operations. Selective mining was practiced. The mine surveying documentation was unconscientiously maintained and partially lost. At the moment of surveying the terrain had a lunar landscape with not clearly defined contours. Traditional surveying was practically unacceptable. The work was started on August 10, and on November 10 of the same year we handed over a final survey report together with accompanying digital topographical plans at scale 1: 2 000, orthophotos, digital terrain models, and 246 mine survey sheets. Our competitor participating in the same tender was ready to carry out the same volume of works for 18 months using classical aerial survey. Having got cartographic materials of good quality, the enterprise has worked out a project and extracted about 3 tones of gold for the same months.

We have done a similar work at a gold ore deposit in Balei Zabaikalsky Region. The area of 50 sq. km was covered by aerial survey only for three flying hours. The office processing was finished in three weeks.

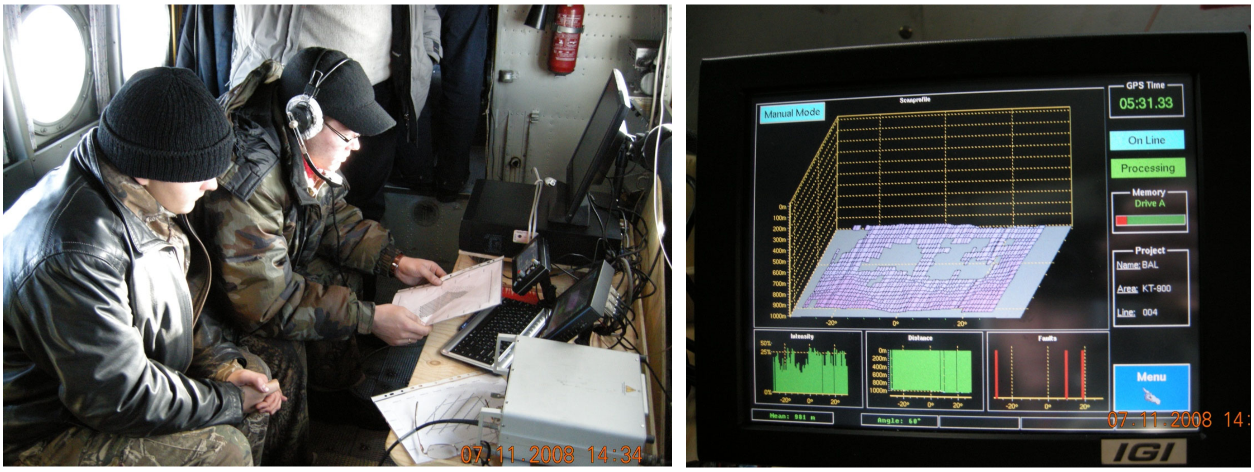

Figure 1: A survey team on board the aircraft

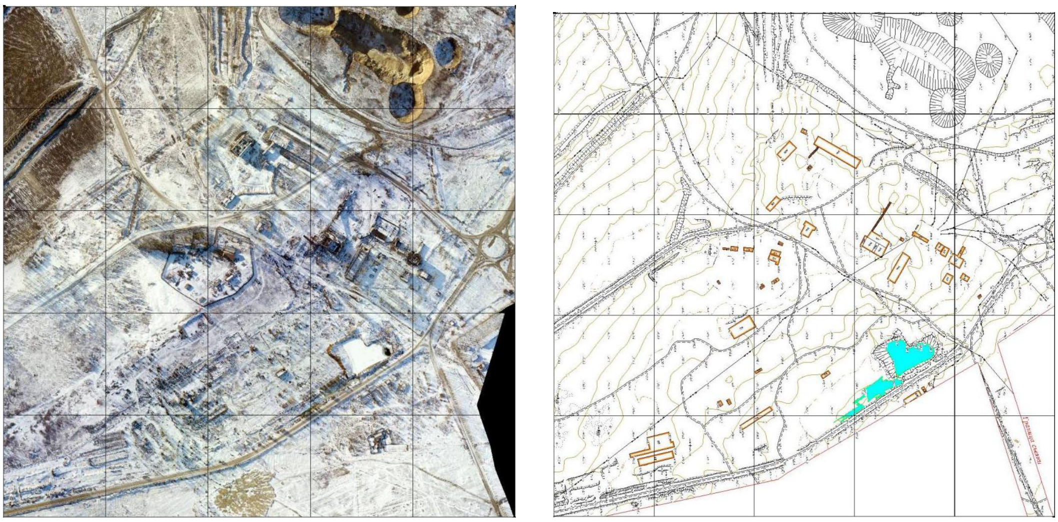

Figure 2: Orthophoto and map fragments

The economic efficiency of laser scanning is very *high*. The cost price is considerably lower than that of for aerial survey. Why are the budget expenses drawn up according to traditional price lists? There is a simple explanation: they haven't been drawn up for laser ranging yet. A profit is a good impetus to develop and implement the innovative technologies and to purchase the expensive equipment.

It should be mentioned that laser scanning has also disadvantages as well. The process is strongly depended on weather conditions. It is influenced by precipitation and high humidity, low cloud and fumulus. There are some restrictions on the flight height. The laser radiation is dangerous for human eyes. However, all disadvantages should be related to the technology merits. Thereby, it should be also remembered that many of them are inhered aerial survey.

Land laser scanning has been successfully used on open-cast mining sites and collieries. Scanner positions (scan positions) are defined while the surveying is planning. In this case the scanner is set up either on a tripod or a vehicle (mounted on a mobile platform). There is no need in instrument centering of leveling. Its geo-referencing is carried out on the targets located at a distance of 20-30 m apart of the scanner. The target positions are defined by a total station or GPS-GLONASS receiver. Laser scanner software is used for stitching of point clouds from different scan positions and creation a unified model. Terrestrial photography is performed simultaneously along with laser scanning, which serves as a sketch and allows photographic interpretation in office.

As an example we can demonstrate the scanning of a Buryatiyan opencast colliery occupied an area of 500 hectares. The team consisting of 3 persons (a teacher and 2 students) has finished field works for three working days. Office works have taken 2 weeks during which it was revealed that the team scanned and mapped 700 hectares instead of 500 hectares. In addition to traditional materials, 3D model of coal strip mine was added to DTM, a digital topographic plan and a metal-mounted board.

Once we have faced a problem to estimate load-bearing structure's geometry of a new gold beneficiation plant's in Bodaibo. The customer apprehensions were based on the fact that at building phases three different organizations were engaged in plant development. Besides, there were processing facilities on all the floors shading the building structure that complicated essentially the execution of work.

Figure 3: Organization of field works

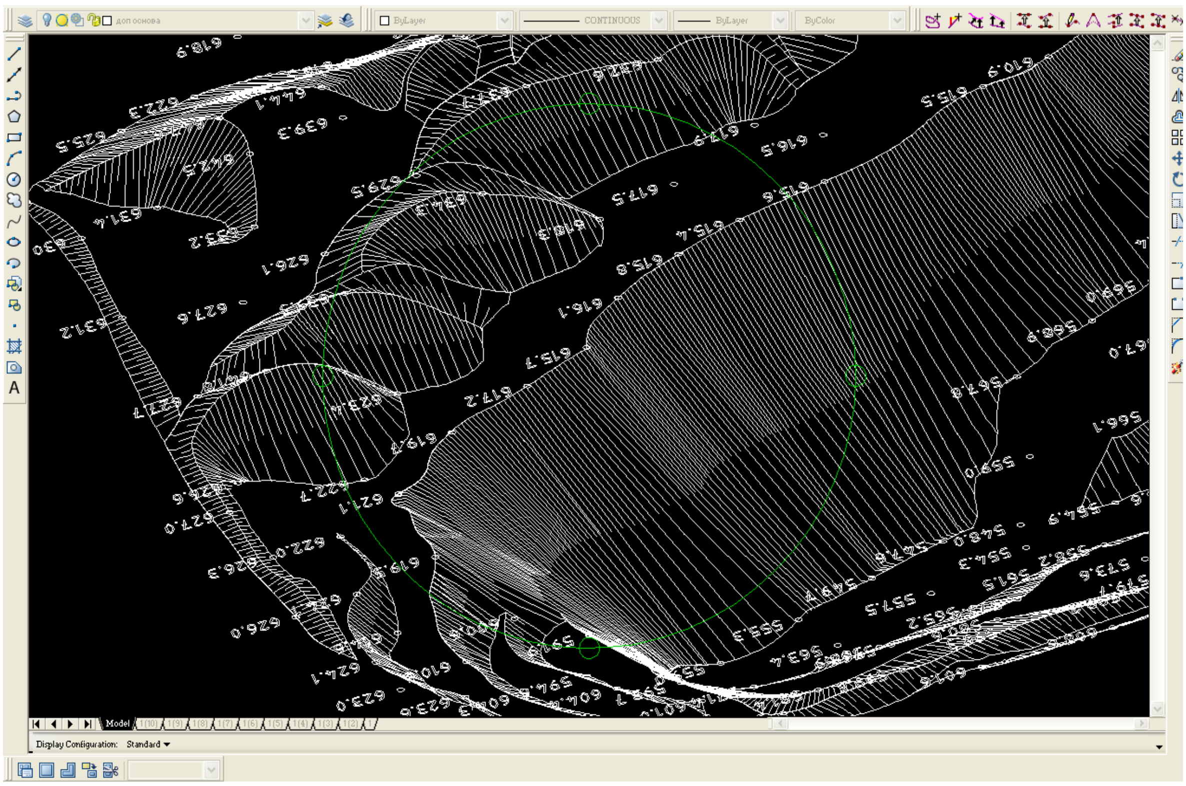

Figure 4: A topographic plan of opencast colliery compiled by scan data

Figure 5: A view of the gold beneficiation plant

Finally, the problem was solved. The scanning traverse was laid out round a building and continued through all the floors. It allowed the creation of a unified model where the columns, beams and ties were distinguished on. This model was used as a basis to plot the measurement diagrams with design deviations.

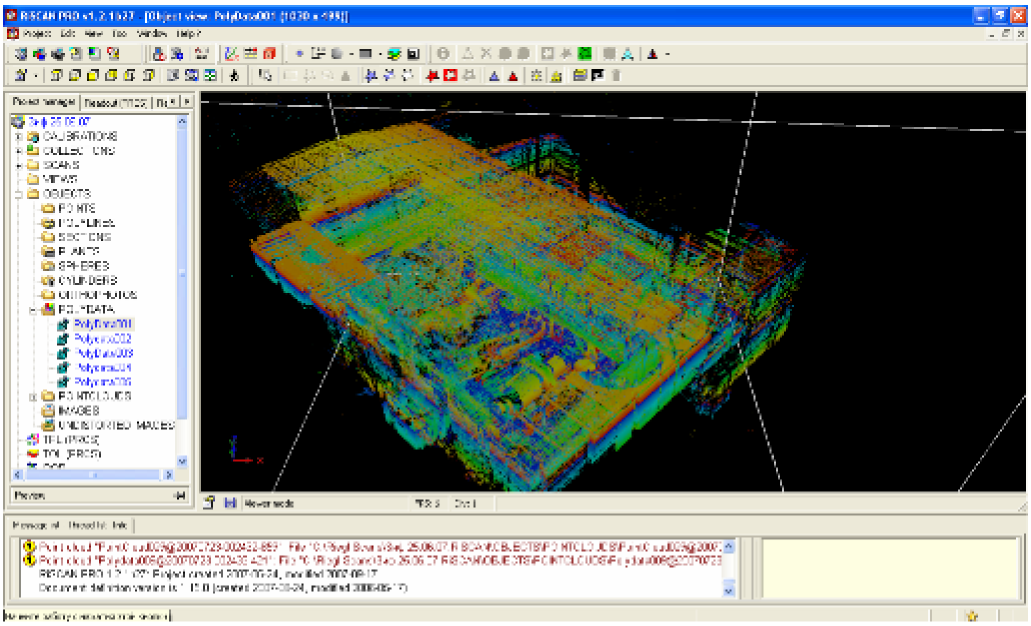

Figure 6: A stitched point cloud for the gold beneficiation plant

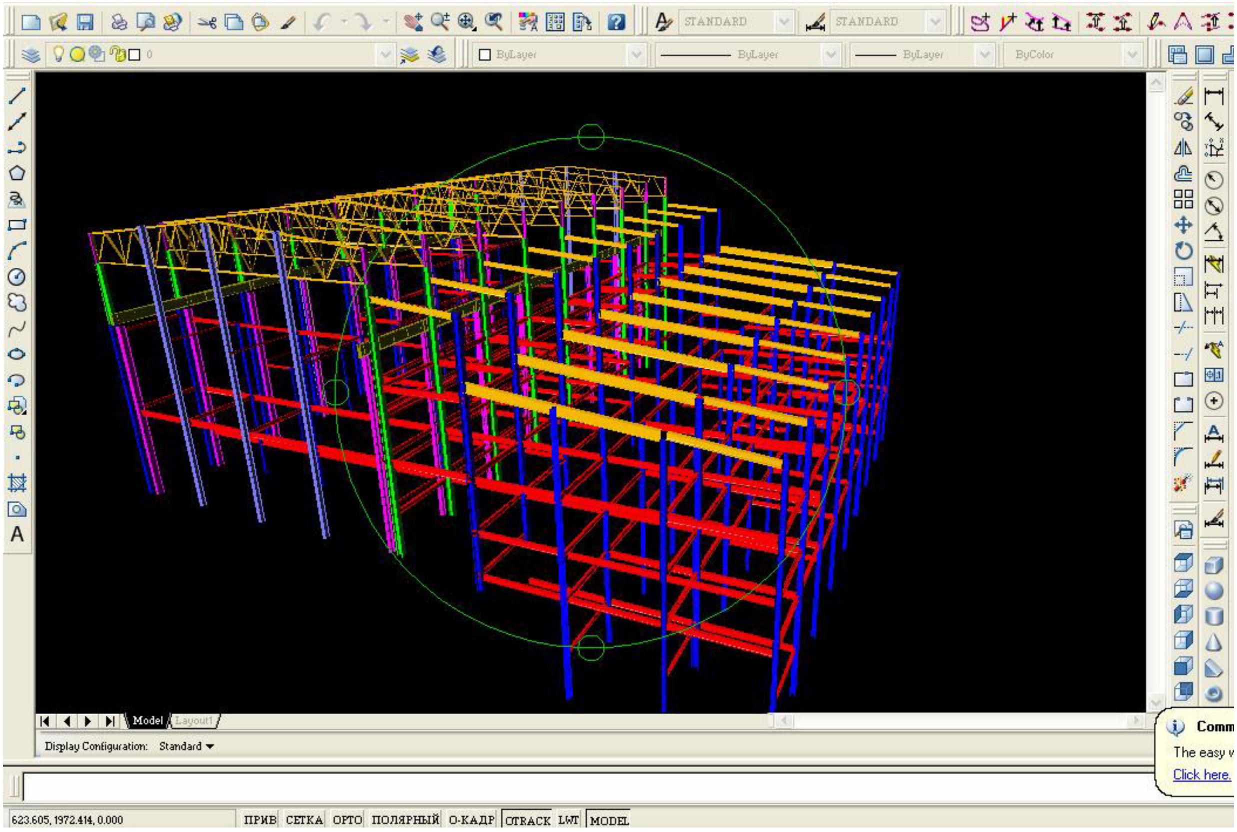

Figure 7: The distinguished load-bearing structures

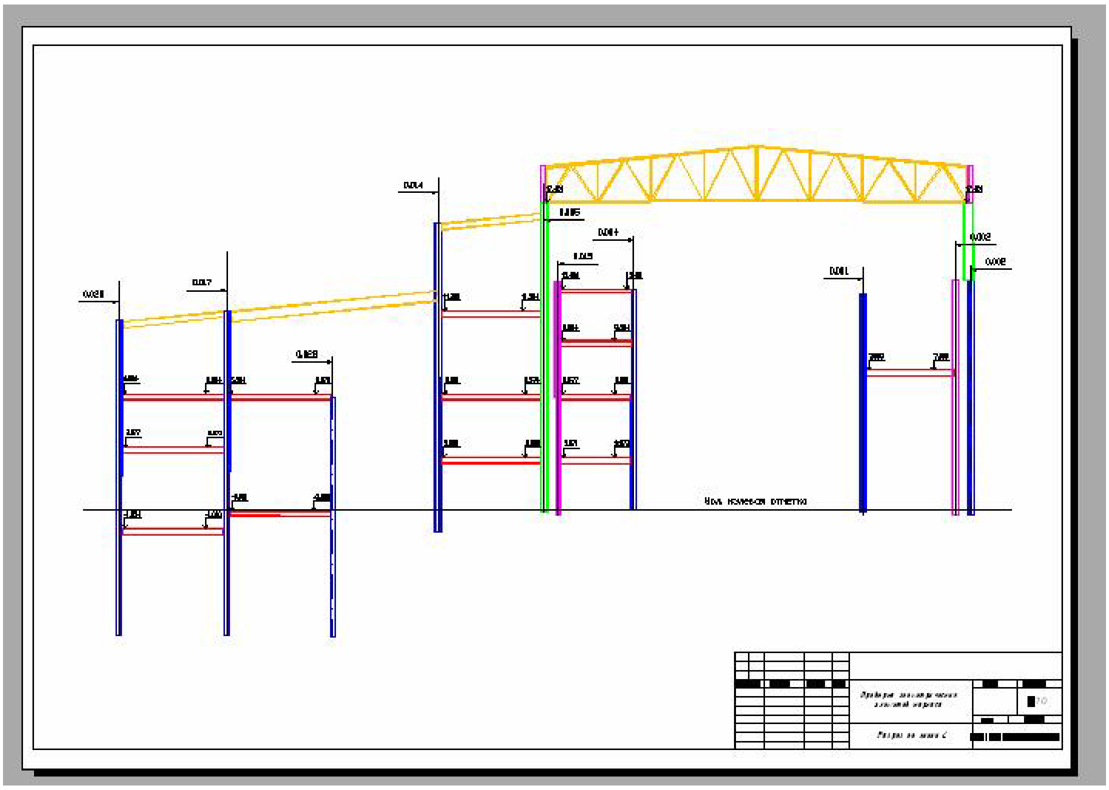

Figure 8: An approval drawing

Fortunately, all the drawings were correct enough and within specific tolerances.

We faced the same problem on the Beryozovsky hydroelectric power plant where it was necessary to estimate the structures geometry state of the highest in Russia industrial building 125 m in height.

Figure 9: A Shop at the Berezovsky hydroelectric power plant

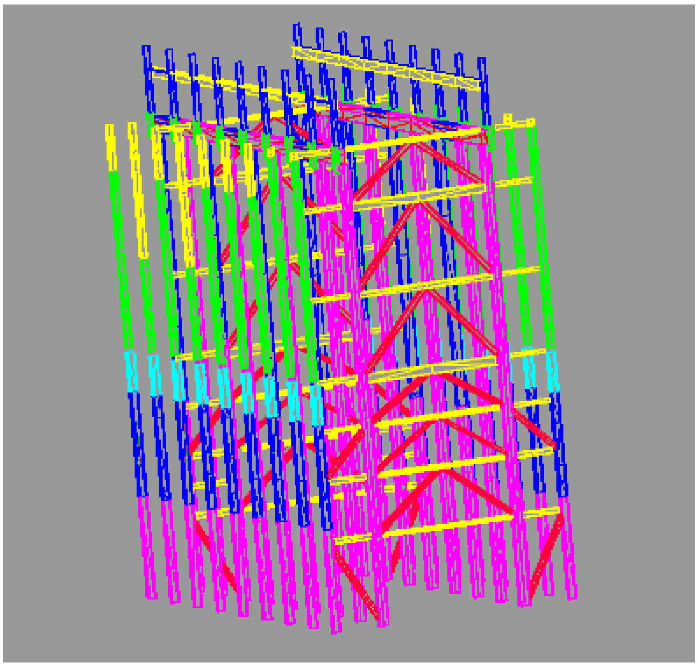

Figure 10: 3D model of load-bearing structures

The customer himself tried to solve this problem using reflectionless total stations for surveying purposes, but due to the complicated geometry of structures, their inaccessibility and danger, he has given up this idea. We used RIEGL RIEGL LMS 420i and finished the whole volume of works for 16 days.

Of great interest are mobile laser scanning systems. A scanner is set up on a moving platform (a car, a ship, a locomotive, etc.). The ready-made decisions are known in the world. They are used by such companies as IGI (Germany) and Optech StreetMapper(Canada). We have developed our own version of the system. It is planned to be tested this year.

Laser scanners can be used in underground conditions as well. The main distinguishing feature here is the necessity to scan not only what is in front but next to and above. However, it does not influence on the laser scanning survey technology and there is no need to make particular modifications in the technology. For example, we carried out the surveying of extraction chambers on the Tyretsky salt-mine.

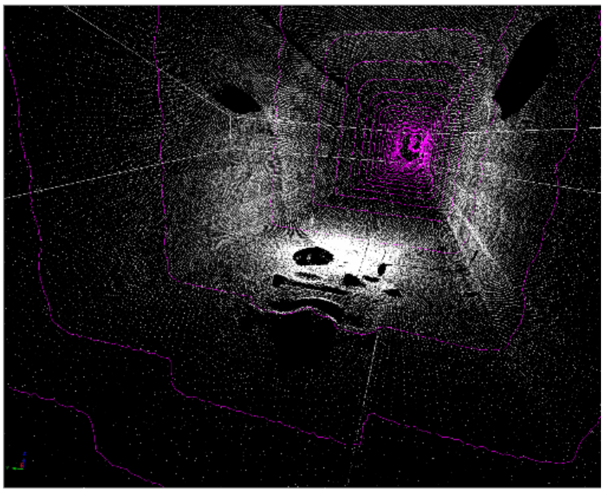

Figure 11: A point cloud of for an extraction chamber

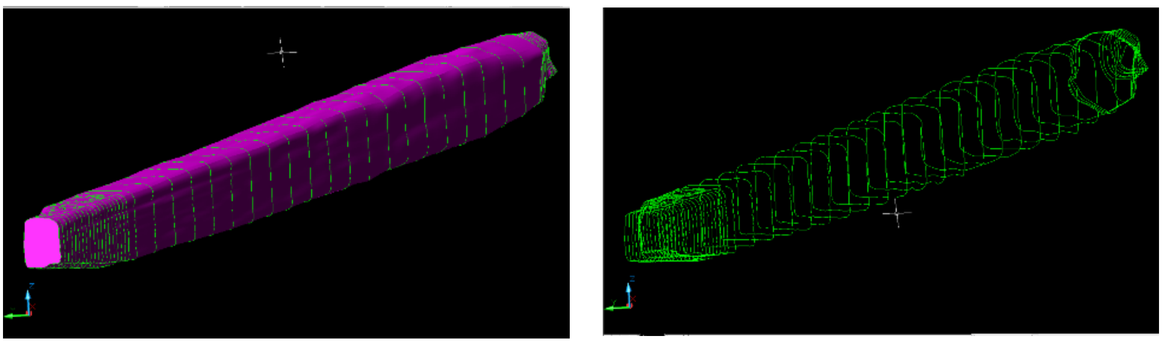

Figure 12: 3D model and vertical chamber sections

One of the key complicated problems in mine surveying is a regular vertical shaft alignment. In practice, misalignments of shaft guides are determined. A freely-hanging plumb is used as a vertical. Here should be mentioned that the alignment is complicated by the following factors: a vertical shaft depth, which is sometimes more than 1,000 m, airstream turbulence, atmospheric gas pollution, and high job hazard of working at heights in unconditioned situation. The decision can be simplified if apply an automated station for the vertical shaft alignment, but in this case it provides with strictly limited volume of information that is not sufficient for estimation of shaft conditions. From our point of view, application of laser scanning in a shaft would become the best solution of this problem. In-situ testing will be carried out in the nearest future.

Welfare and safety regulations in mining demand to carry out regular scanning of capital closed work as well as its geometry, railtrack conditions and underground utilities.

Due to their long expansion and a large volume of works, the mine surveying service has not enough time for such works. We have developed a mobile scanning complex for automation of these works. We are planning to make its presentation soon.

Among other key complicated problems in mine surveying is a scanning of dangerous and inaccessible cavities. Such cavities are a lot of in chamber mining and rise driving. At present, there are scanners able to scan the cavities at a distance. Among them we should mention Optech's Cavity Monitoring System (CMS) provides fast, reliable and efficient scanning of underground cavities. By collecting thousands of measurements per minute, the data can be used to determine stope volumes, stope dilution, backfill volumes and create detailed drawings and data formats for use in any software workflow. With the recent introduction of the wireless feature, scanner operation can be controlled from a safe zone outside the cavity to enhance operator safety.

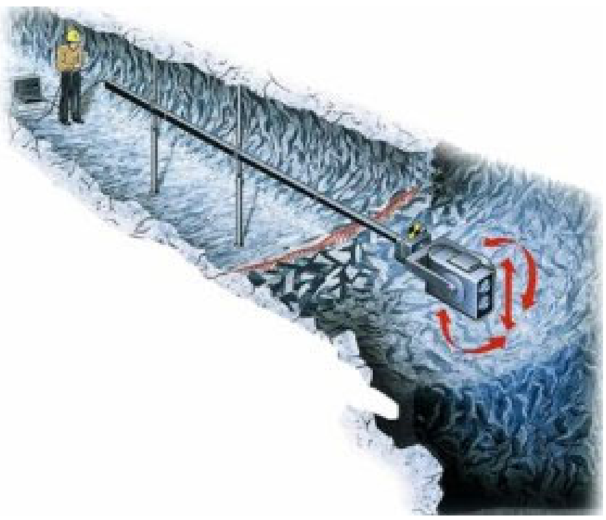

Figure 13: A schematic diagram of the scanner in operation

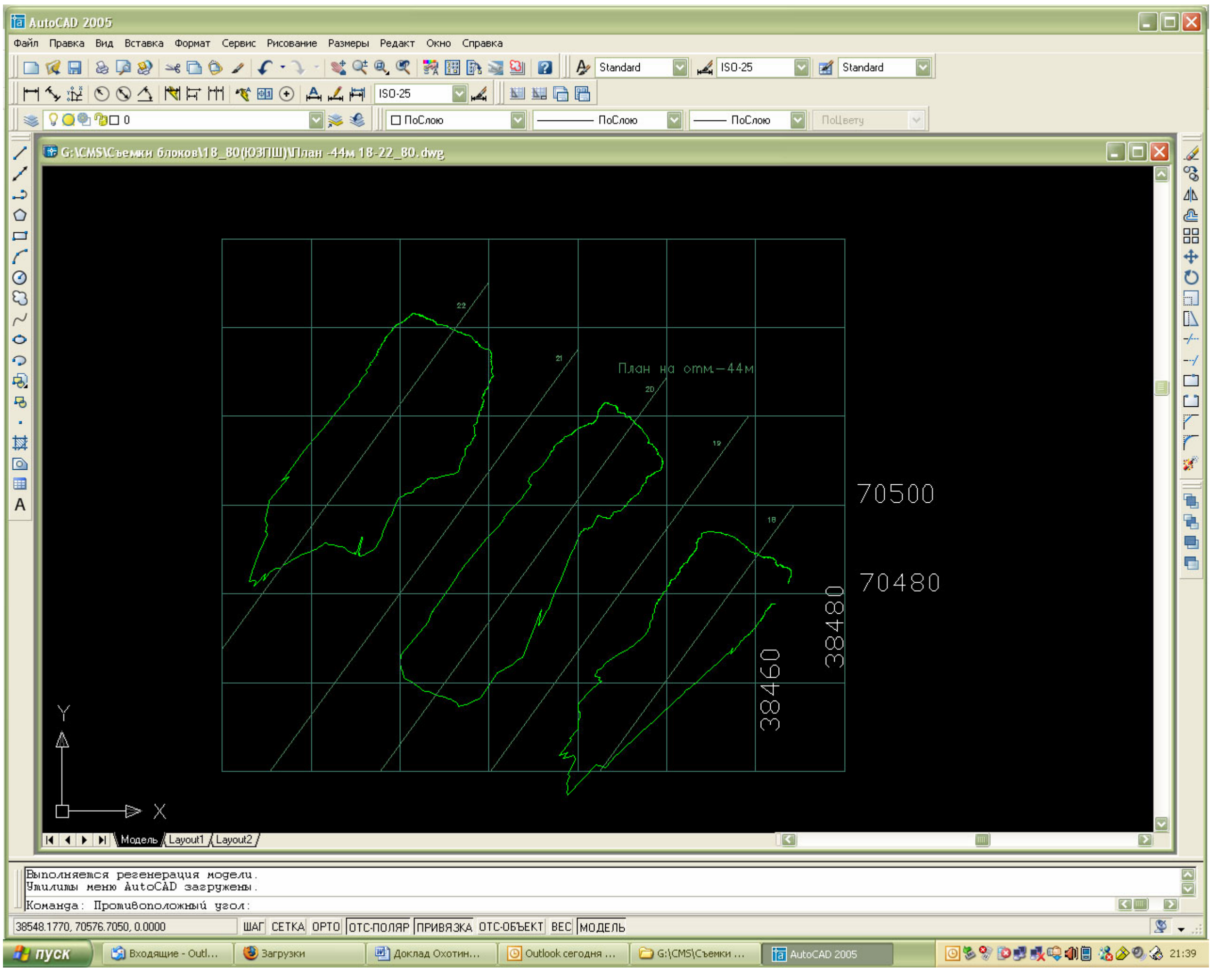

Figure 14: An example of the underground chamber's horizontal sections on a pit of the "JSC Kola Mining & Metallurgical Company"

Practical applications of laser ranging and laser scanning in mine surveying given in this paper were carried out with the participation of the author.

CONTACTS

Prof. Anatoli L. Okhotin
President of the Baikal Union of Mining Surveyors
Head of the Department of Mine Surveying
Irkutsk State Technical University
Russian Federation
Tel: +7 (3952) 52-68-48
Fax: +7 (3952) 52-68-58
E-mail: billr@iirk.ru, hunterAL@yandex.ru

New Features of Airborne Lidar Data Processing in DTM Generating, Forest Inventory and Civil Engineering Works

Eugene M. MEDVEDEV, Russian Federation

The modern aerial lidar productivity and accuracy have increased greatly recently, which makes it possible to achieve principally new results while their applauding for power line survey. This field of investigation is typical for Altex Geomatica company since 90th decade.

The new modules on power line processing are included into software package Altexis 7.1 and nowadays they are commercially available. New program modules provide the following possibilities:

- Almost 100% probability of wire detection, geopositioning and vectoring thru lidar points processing;

- Automated geopositioning of most power lines infrastructural elements: tower, insulators with 1-2 cm accuracy;

- Automated tower type recognition by point cloud, if tower frame model is available.

- Detection of tower mechanical deformations and departure from normal vertical position.

- Combining airborne and on-ground lidar survey as well as thermal survey for wire temperature measurement.

The new software features are achieved by applying of new mathematical methods, in particular Kalman filter.

Nowadays there is no doubt concerning optimization of forestry management and inventory. A good solution assumes intensive use of high productive aerial monitoring. Practical application of the monitoring solves two problems: allows finding of actual forestry assessment and estimates effectiveness of regenerative efforts.

Leading position among other modern aerial monitoring technologies belongs to aerial laser scanning. Despite it common good reputation, traditional aerial photography can not be used widely in forestry due to the fact that majority of objects of interest are obscured by canopy and so are invisible for usual cameras. The most prominent application of digital aerial photography assumes a mixture of color channels (red, green, blue and near infrared) in such a way that output image looks like a film shot that allows experts to separate trees by species and estimate health condition of an individual tree.

Aerial laser scanning at contrary basing upon direct range measurements by means of coherent beam of light that allows extracting data under canopy including land heights. Highly detailed and accurate information about forestry geometry available at any season for vast spaces allows user to use both well-known method of data processing and new ones for upcoming technologies.

Traditional usage of aerial laser scanning data assumes modeling of canopy height over a relief, which allows applying elaborated techniques of statistic methods in forestry. In this regard modern algorithm of laser data processing permits to specify the canopy model up to a separate tree starting from highest trees and finishing at underwood. Moreover, this algorithm provides additional separation of trees by species. As a result, it is possible to operate not only with forestry statistics but a separate tree model as well, that greatly increases accuracy and efficiency of aerial monitoring.

There is another novelty concerning the use of a total set of laser beam reflection during forest scanning which, in its turn, allows modelling forest layers with a high accuracy. Basing upon laser beam propagation and reflection, it is possible to expand layer model at total area to realize biomass assessment.

CONTACTS

Prof. Evgene M. Medvedev
Altex Geomatica Company
General Manager
Moscow
Russian Federation
Mobile: +7 926 726 44 71
Email: eugmed63@mail.ru

Mining and Environmental Monitoring of Closed Mines in Kuzbass

Anatoly D. TRUBCHANINOV, Olga A. YAGUNOVA, Russian Federation

Key words: technology massif, collapse, degraded surface, flooded territory, mining and environmental monitoring, gas emission

SUMMARY
Mass closing down of coal mines in Kuzbass needed to carry out the monitoring for shifting and earth's surface deformations in moulds with gap appearance; for the process of technogenic rock massif flooding and gas emissions.

According to long-term monitoring several forms, kinds and stages of coal mine fields collapse, when wholly or partially flooded, have been offered. It was revealed that toxic gas emissions and sewage water pollution had a cyclic character. The filter-capacity properties (hollow coefficient, water flows and etc.) of working mine areas were determined, as well as the time and speed of flooding.

The programme of coal mining industry restruction in Russia has been accomplished since 1993. It is tightly connected with closing of unprofitable and dangerous mines. 43 coal mines have passed through this restructure in Kuzbass.

Mass closing of unprofitable mines revealed some eco-technogenic factors in the region. These factors are connected with residual phenomena: pollution of bottom and surface water, noxious gas emissions, collapse of mine fields surface, appearing craters and cracks, and territory flooding.

The Kuzbass Industrial and Ecological Security Monitoring Center has been established in 1998. Its purpose is the assessment of geomechanical conditions and technological surroundings; monitoring for gas and water state and changes in time in Kuzbass; fulfillment of mine-ecological monitoring work.

In Kuzbass the above mentioned monitoring is carried out to determine the deformations and technological environment of closed down mines along with the following:

- the residual land shifting while the mines were flooded in the Anjersky geodynamic proof site (land shifting monitoring);
- gap appearance, obtained from advance preparation works, cleaning works and for the fixed volume of filling up works (mining fields collapse monitoring);
- the content of inert gas and carbon monoxide in special gas emission boreholes and mine workings (gas dynamic monitoring);
- the quality ground sewage water, coming out onto the surface through the immersed pumps or by self-streaming through special mine workings (hydro chemical monitoring);

- the flooding level of mines through special mine workings (ground water monitoring).

According to KCMPEB 13 coal mines are wholly flooded in Kuzbass; in 8 of them colliery water flows in the river-net by itself. In 15 mines the safety level of flooding is maintained by the immersed pumps; in other 15 partially flooded mines water comes to the ebbs of operating shafts for further flowing in the river–net.

The residual land shifting, taking place due to the flooding has been studied in a special proof ground of the liquidated “Anzherskaya” and “Sudzhenskaya” mines in the form of ground profile line of soil bench-marks. The residual ground shifting on the repeatedly exploited plots of surface, the sustainability of surface between the mines in the barrier pillars area, the residual subsidence impact on the main railroad Moscow-Vladivostok, the dwelling area have been estimated and are of a great interest. Analyzing data for the last 10-year one can determine that shifting level, occurring in ground settlings and risings do not exceed 200 mm with actual leveling error of 6.8-7.3 mm.

Besides of ecological improvement in the region (dust and methane emissions reduced to 25%; sewage water flow – to 30%) closing and flooding of mines activate such negative consequences as: getting out the settlings on the surface, coal gas exclusion, flooding of the surface, pollution of water-bearing horizon and etc.

Monitoring for the degraded mine fields of the closed mines is mainly based on the question of mine rock displacement, on gas emissions and territory flooding of different geological and mining layers.

One should distinguish forms and kinds of collapsed surface: gaps from cleaning works; gaps from preparing works, done at a little depth (before 50-70 m); from opening works; split zone adjoining to ruptured zone through which mine gas drainage is taking place; unsewered moulds, leading to season or constant flooding. According to SF VNIMI data there are 4650 collapse hazard zones in closing mines of Kuzbass; 70 % of which are conventionally hazard from opening works. Taking into consideration the information of 2006 the quantity of dwelling houses in these zones amounts 815.

Large amount of mining fields, as well as collapse hazard zones, come through splitting stage. Mainly these traces can’t be fixed visually, but however through these available gaps there is a different tense contact between ground and surface water, between fire-damp and atmosphere.

In a whole the breakdown process of exploited mining surface may be defined to the following stages: at a little depth (about 150-200m) there is an active drainage of the working areas due to hydrological regime changes of surface and ground water. At the medium and large depth (about 450m and more) the breakdown character changes: the splitting is fading or becomes local. But due to surface relief and ground covering capacity the role of the relief changing with unsewered moulds formation is raising.

According to SF VNIMI data in every closed mine in Kuzbass the forecasting collapse hazard zones accounts from 0.7 to 19% of mine allotment area, that in average is from 5 to 95 ha. Such discrepancy in area collapse depends upon many geo-mining and other factors.

High gas danger together with high surface cracking in some mines and potential gap appearance don't permit to make the most efficient use of territory for different kinds of construction. It is needed a very expensive exploration of conventionally hazard zones in gap outlet with hollow as well as the implementation of expensive liquidation methods. After recultivation of mine workings the areas of closed mines should be used for long-term pastures, haylands, green zones, gardens other type of cultural agriculture.

Special engineering and preparing work of territory is needed for country-cottage and low-storied constructions as well as mounting of security clay screens, which defend from gas emission and building closed gutters and pipes for sewage water out of construction area.

Gas emission monitoring has been conducted in 35 closed mines of Kuzbass. According to the approved programmes some air samples for methane and carbonic gas content with further analysis had been taken. The objects of test were: main mine vents with mounted gas drainage tubes; basements of social buildings and dwelling houses. By systematization and analysis of the information is revealed that mine gas concentration has a variable character and is divided due to its gas emission character: with sharp fading; with recurrent increasing of concentration and with even cycling.

The objects of hydro chemical monitoring were: mine water before and after cleaning; river water before and after sewage faulting and refining works. In 15 or 20 Kuzbass mines monthly, but in high water weekly, samples for toxic ingredients were taken. They investigated the content of suspended substances (SS), BPK, HPK, oil-products, sulphates, iron, nitrates, nitrites and others. The quality of such tests for every index consists of 230-250 pieces yearly and taken analysis of about 3300-4500. Taking into consideration the 10-year data it may be concluded that in time there is a regular cycling in most ingredients of sewage water and their unsteady character. There is a common tendency of reducing ingredient concentration to maximum allowable norms. All 43 closed mines in the region were the objects of ground water monitoring. The level of flood changing in 26 mines was inspected in time, then summarized and analyzed. The information, which fixes the dynamics of developmental flooding in those mines, is the most valuable. It helps to reveal and determine filter-capacity properties of working areas for engineering arrangements, that provide environmental and production security.

BIOGRAPHICAL NOTES

Prof. Anatoly D. Trubchaninov is a mine surveying engineer, graduated from the Tomsk Polytechnic Institute in 1959, professor of the Kuzbass State Technical University, the author of over 180 scientific publications in surveying, geodesy and higher education, a member of the Russian Academy of Natural Sciences, awarded with the Honored Worker of the Russian Ministry of Education and Energy and a holder of the orders “Miner's Fame”.

Olga A. Yagunova, Master of Science in Mining, graduated from the Kuzbass State Technical University in 1999 and specialized in surveying. Now she is a leading specialist of the Kuzbass Industrial and Ecological Security Monitoring Center and the author of 10 scientific publications.

CONTACTS

Prof. Anatoly D. Trubchaninov
Kuzbass State Technical University
Head of the Department of Mine Surveying, Cadastre and Geodesy
28, Vesennyaya str.
Kemerovo, 650026
Tel.: (384-2)58-33-23, 58-33-80
Fax: (384-2) 36-16-87
E-mail: kuzstu@kuzstu.ru, masher87@inbox.ru
http://www.kuzstu.ru

Satellite Monitoring of Mobile Objects

Evgeny V. KLEVTSOV, Valery S. PANKRATOV, Russian Federation

Key words: Satellite navigating, geoinformation systems, monitoring of mobile objects

SUMMARY

The operating navigation GIS for cities of Irkutsk, Angarsk and Shelehov, providing monitoring of moved objects, is considered. When creating maps of these cities, the partial refusal from the character map and transition to the map photographic was used. Also to user the possibility is submitted to be on a map, to come nearer to the selected object and in details him to consider.

One of the most modern innovations of technologies oriented to a broad circle of the users in many spheres of human activity is the technology of satellite systems of positioning (SSP) or navigational systems. We understand positioning processes of measurements executed with the help of satellite systems with the purpose of determination of coordinates of finding of the spectator or object in three-dimensional earth space [Serapinas, 1997].

One of the spheres of application of SSP technology is the urban transport systems. By virtue of territorial distribution they become by ideal object of automation by means GIS, as space component is the natural basis of integration of the various tasks having the attitude to transport. Let's consider some of them [Andrianov, 2007].

The standard optimization tasks of transportation (task of logistics). The simplest task is the delivery of freight from point and in point on the shortest route (or route with the least cost). For its solution it is necessary to have downlink and topology of a correct road network. The following task is the direct-sales representative. It is necessary to go round preset number of points for minimum time (or at a minimum path length). In this task the same factors, as in the task of search of the shortest route are taken into account. And, at last, classical transport task requiring such organization of routes of transportations, at which the demand of customers in transported from the suppliers (manufacturers) the product will be completely satisfied at the least total cost of transportations.

The geoinformation technologies allow not only to plan transportations, but also to inspect them: to find out deviations from the schedule of motion, to arrange to their elimination, to predict time of delivery and to inform the customers.

Some of such tasks:

- Analysis of transport load and condition of a road cloth;
- Monitoring motion;
- Assembly of statistics on performance of a subordinated road network;
- Analysis of emergencies;

- Planning and analysis of an enroute network;
- Scheduling;
- Coordination of time-tables with other types of transport.

Since 2007 the faculty of an engineering geodesy and cartography of Irkutsk state technical university (EGC ISTU) together with the company «Magic Systems» develops the project called "INFOSITY" [Plusnin, 2008]. The purpose of the project is the creation of a multi-purpose geoinformation system integrating in a large spectrum of various geotools. "INFOSITY" – charge-free geoinformation software product containing valuable three-dimensional model of cities of Irkutsk, Angarsk and Shelehov, telephone quick reference containing more of 8000 organizations and firms, geobound virtual panoramas both photos of city and organizations, and as initially built-in valuable on-line tools of monitoring of any mobile objects.

The executed activity consist of creation of a transport (automobile) navigational system for agglomeration of Irkutsk – Angarsk – Shelehov, basing on a carefully executed map of the pointed cities in a scale 1: 10 000. The cartographical activities are executed by the employees EGC ISTU. The maps composed under the data DL from satellites EROS-A and EROS-B with the spatial sanction on district 1.9 and 0.7 meters accordingly.

Standard procedures of processing Satellite snapshots and high-precision coordinate binding of the maps to the topographical basis previously were executed. Then the automated decoding of objects of space snapshots is made: structures, roads, reservoirs, sites of wood vegetation with subsequent векторизацией of objects and formation of a data base (DB). The created DB allows an information system to execute functions of the electronic quick reference – search of object to the address, name, and telephone number.

At creation of maps agglomeration of cities the approach distinguished from creation of conventional maps and the atlases was applied. The partial failure from the character map was used and in a number of cases was branched to the map photographic, a capability the user also was simulated to be «on a map», being transferred on it [Berlyant, 2006]. For this purpose the data placed in base, did not limit by a usual text – digital signature. In the basis accommodation of the additional information as virtual panoramas and virtual rounds is incorporated.

Virtual panoramas and rounds – one of most effective at present of ways of representation of the information, as they allow making the fascinating of virtual excursions and create for the user full illusion of presence. So, in a course "of travel" it is possible to approach or to remove any object, to look round on the parties, in detail to consider separate details of object, to survey a panorama from apart, to look upwards – downwards, to come nearer to a selected point or to be deleted from it, through active zones to be transferred from one panorama on another, for example, “to take a walk” on separate premises etc. And all this it is possible to do in the necessary rate and in the order, convenient particular user.

The basis of virtual round is made by (with) spherical photos (panoramas) giving a capability of the full review (view) “around of” (360x360 of degrees).

There is a capability to add anyone three-dimensional models (if necessary transferring in real time). In the current version there are the examples of accommodation of buildings, bridges, building sites, stops, and also publicity boards. (Fig. 1).

Fig. 1: A fragment of a three-dimensional map (Irkutsk)

In further it is supposed to cover more than halves of area of cities real 3D with models of buildings and facilities, the activity in the given direction conducts permanently. For increase of productivity of a system the radical optimization of a load and response of the program will be made, the search capabilities are processed. Updating a system 2 times per one year is supposed.

In a geoinformation system "INFOSITY" the on-line tools GPS/GSM of monitoring of any mobile objects is built initially – in. (Fig. 2)

There is a capability to inspect site of objects in real time, to view routes of movements for any period, and as to form the reports of movement for any period.
As a result of activity above the project "INFOSITY" maps for usage in navigational devices of corporations GARMIN, NAVIGATOR with the established program NAVITEL are also developed. The data of a map allows automatically to create a route of motion in view of an urban decoupling, to make address search and other functions dependent on the software established in device (Fig. 3)

Fig. 2: A fragment of a map with a function of monitoring of a vehicle

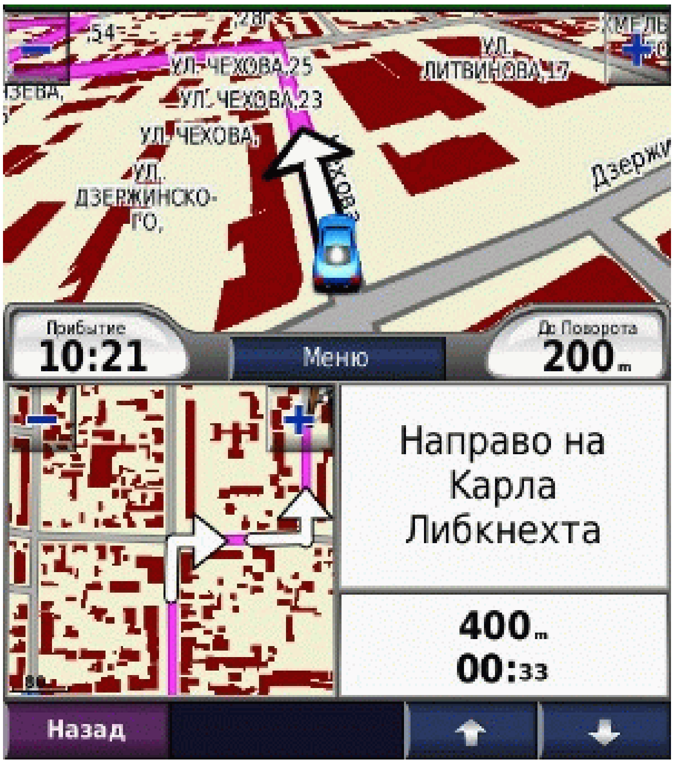

Fig. 3: A fragment of a map from the navigational device GARMIN with the route of motion

In final realization of the program all capabilities of security monitoring, control of fuel and control of activity of any aggregates and gears, removal, review and storage of photos from cameras connected to devices will be added and as social tools (capability to add the friends and to see their objects on a map in the access).

Thus, the system "INFOSITY" integrates in itself an electronic map, function of the electronic quick reference, advertising means, and means of monitoring of mobile objects.

Let's summarize. As a result of performance “INFOSITY” we receive data sets – linear objects displaying a trajectory of motion of all vehicles, connected to a system and dot objects – units displaying place of a stop of automobiles. The system records, in what instant each of machines is in the given point on a track (or on “parking”) and saves a trajectory of motion of the automobile in a DB of dispatching center.

We already spoke, that as a result of broad demand the transport information is valuable resource, and the value her consists, including, in uttermost objectivity of this information, that is determined by a way of its obtaining.

It is uneasy to see, how the available data can be used for the solution listed before the tasks. Usage of the data of our SSP in statistical and monitoring the tasks – purely system is obvious and is intended for this purpose. In the tasks of logistics in main (basic) the exact electronic maps and analytical capabilities GIS with connected optimization modules are used. For the analysis of emergencies the data of dispatching center about trajectories of motion, time and rates of the participants RTI are used. At realization of an estimation of transport load and condition of a road cloth we use the data about total of passing automobiles, their characteristics (it is possible, received from a DB of firms – owners of vehicles or State inspection of safety of road motion), characteristic of a road cloth, including normative (received from appropriate road services). The simple statistical calculations give the answer to put questions, besides, constant and, on the first sight, the unmotivated build-down of transport load on some site of a road can to testify to deterioration of a condition of cover (coating) of this site etc.

The implementation of these tasks will require some additional costs:

Organizational – tolerance to data bases of the interested departments with the subsequent granting of own results;

Scientific – selection and analysis of available developments, adapting them under the put tasks, determination of the necessary inquiries to a system and creation for them of standard templates, and also creation of new algorithms and programs;

Technological – assuring compatibility of a SSP with received or created modules and, for certain, other costs to anticipate which occurrence now it is inconvenient enough.

It is necessary also to mark, that the regular obtaining valuable space and attributive of the information enables constant actualization of digital cartographical materials and semantic data bases, capability of simulation analysis and "playing" of a plenty of versions of development of territories, and also their visual representation, ecological monitoring, creation of the cartographical and semantic basis multifunction territorial GIS.

Well and, at last, major for us a direction – training of the students. We already marked [Pankratov, 2008], as far as is more active and with large interest the students to learning process concern, when they in hands have means of the analysis and synthesis of objects of an investigated subject. Usage GIS as educational technology allows receiving in essence new results. At usage of conventional technology of training, for example, geography (maps, geographical atlas, statistical tables, and text – description) as the final purpose memorizing some volume of an educational material is considered. At the best is a mastering by the pupil of certain legitimacies in spatial phenomena, and at usage of GIS-technologies the trainee first of all takes possession of the instrument of an establishment of communications between these phenomena – simulation analysis of process of formation of these legitimacies. At a level of modern methods of knowledge (computer simulation analysis) there is a reduction of a gap between state of-the-art of a science on the one hand and contents of the educational programs and, especially, their implementation, to another [Razumovskaya, 1997].

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CONTACT

Evgeny V. Klevtsov
Valery S. Pankratov
Irkutsk State Technical University (ISTU)
83 Lermontova Ul.
Irkutsk, 664074
Russian Federation
Tel/fax: +7 (3952) 40-51-03
E-mail: v11@istu.edu

About Development of Base Conditions of Formation of Regional Innovative System in Novosibirsk Region

Gennady A. SAPOZHNIKOV, Boris I. IVLEV, Russian Federation

Mission of regional scientific technical and innovative policy of Novosibirsk Region is to create conditions for the dynamic development of the regional economy through technological renovation of enterprises, the organizations of new industries based on innovative technologies and scientific developments, transforming the area into a largest innovation center of east of the country.

The goals of scientific and technical innovative policy of areas:

- Ensuring a high level of scientific development, quality and efficiency of vocational education;
- Diversification and growth of competitiveness of the regional economy through the accelerated development of high-tech industries and social sectors.
- Improving quality of life of population.

To achieve these goals is carried out systematic work to address the following **tasks**:

- Creation of legal, economic and managerial mechanisms to promote the innovation of competitive products and services;
- Development of social sphere, providing favorable conditions of life of the Novosibirsk scientific-educational complex;
- Preparation of scientific and engineering personnel, managers for innovative business;
- Formation and implementation of major research and production clusters (projects, programs) on the basis of high technologies and breakthrough scientific achievements;
- Formation and development of modern infrastructure of innovation, including the establishment of technology parks in the research sites, universities, large enterprises;
- Development of interregional and international technical and scientific cooperation, collaboration with major domestic and foreign corporations, academic, scientific and technological centers.

1. Normative legal base, the economic mechanisms

Actively contribute to the development of innovation:

a) The laws of Novosibirsk Region:

- About scientific activity and the scientific-technical policy;
- About politic of Novosibirsk Region in sphere of development of innovative system;
- About the youth policy;
- About state regulation of the investment activity which is carried out in form of capital investments in territory of regions;

- About measures of the state support of commodity producers;
- About development of small and average business;
- About state support of agricultural production;
- About state information systems, state information resources, territorial information system of Novosibirsk Region;
- About taxes and features taxation separate categories of tax bearers
- About granting separate categories citizens of grants for acquisition or building premises in Novosibirsk Region.

b) Standard and legal acts, for example, to support young scientists include decisions of the Governor of Novosibirsk Region to hold competitions for nominal awards, scholarships and grants to young researchers, post-graduate students and students; about maintenance crediting young scientists and experts of Novosibirsk centre of science on building or acquisition of habitation, etc.

On the basis of this regulatory legal framework state support of enterprises and establishments in sphere of manufacture, science, formation and scientific service is carried out.

2. Regional innovative system

Infrastructure: • **Innovation** Technopark, business incubator, innovative centers, development agencies, and technology transfer centers, business centers, business associations, etc. • **Financial** Public support of science and education, banks, venture capital and mutual funds, private equity funds, funds for technological development, etc. • **Information** Databases, knowledge bases, technology transfer networks, data centers, offices, archives, etc. • **Legal** Laws and regulations, investment agreements and contracts	• **The system of vocational education** Higher Education, special Industrial Services, research institutes, high tech-logical enterprise • **The generation of knowledge** Research institutes, Design Office, universities, tech firms • **The generation and transfer of technology** - Research campuses, research institutes, Design Office - High-tech companies - Technology Cluster - Programs and Projects - Business plans - Consultancy framework • **Process re-manufacturing** - Technology Audit - Investments in fixed assets - Innovative enterprises - Technology Transfer

3. Small and average business in innovative sphere

In Novosibirsk Region effectively operate more than 400 small and average enterprises in scientific and technical sphere, many of which are leaders not only in Russia, but also abroad.

Innovative companies in Novosibirsk implemented exports to dozens countries around the world. Subject exports - technology and software, laser systems, devices, diagnosticums, crystals, and equipment for exploration and mining.

Cooperation of authorities and scientifically-technological complex of Novosibirsk Region with the Foundation for Assistance to Small Innovative Enterprises (FASIE) in scientific and technical sphere is carried out in three directions: Implementation Program of innovation in the field of scientific instrumentation in a unique experimental base for the modernization of basic science ("Foundation for Assistance – SB RAS"), Program funding of innovative projects at the initial stage of development ("START" - on the program was founded more than 80 new companies), the "Party Youth and Scientific Innovation Competition" (UMNIK»).

4. Innovative-investment projects and programs

Within the framework of innovation and investment programs and projects carried out by the formation of technological clusters - scientific, educational, production and business integrated structures operating in a certain area and ensure development and serial production of new technology products. Currently, the major clusters on the basis of scientific developments and technologies of Novosibirsk scientists developed in the following areas: power electronics, pharmacology and biotechnology, information technology, instrumentation. Clusters form the basis of complex innovative projects and programs focused on the transfer of high technologies and scientific developments.

5. Infrastructure innovative activity of scientific towns

In Novosibirsk Region there were formed three unique research campuses. In the world-renowned Academgorodok located nstitutes, Siberian Branch of the Russian Academy of Sciences, Russian Academy of Medical Sciences, Novosibirsk State University, in settlement Krasnoobsk - Russian Academy of Agricultural Sciences, Science-City Koltsovo – the State Research Center (SRC) of Virology and Biotechnology VECTOR (SRC VB VECTOR).

settlement Krasnoobsk

Academgorodok

worker's settlement Koltsovo

In science, technology and innovation campuses structure also includes industry research institutes, centers of technology transfer, innovation and technology centers, technology companies, subsidiaries and representative offices of universities that together form the innovation system of national scale.

The main principles (the ideas of Academician Lavrent'ev) action research is integrated townships (multidisciplinarity), scientific and applied research, advanced development of key basic science, the integration of science and education, the practical implementation of scientific achievements.

Technopark **“Novosibirsk”** created in 1996 operates as technopark distributed type, including in the structure, innovative centers in other parts of the city and region. Now in technopark territory are more than 50 small businesses created more than 500 jobs.

Except the state technoparks in Novosibirsk, are created **private technopark-like structures.** Experience of creation in Novosibirsk Region technopark-like structures allows setting the task of creating infrastructures to a new level – **creation of technoparks network** in academic campuses, large universities and industrial enterprises, the core which is the Novosibirsk Akademgorodok Technopark.

Associations of high technology firms. In Novosibirsk Region associations of firms of high technology business successfully function: “SibAkademSoft”, “SibAkademInnovation”, “Information and Technologies”, “Siberian Research-and-Production Complex Engineering of Night Vision”, “Siberian Industrial Hydraulics and Pneumatics”, management Company “Power Electronics of Siberia”. Associations established to provide an enabling environment for innovative activity, support and development of small and medium business.

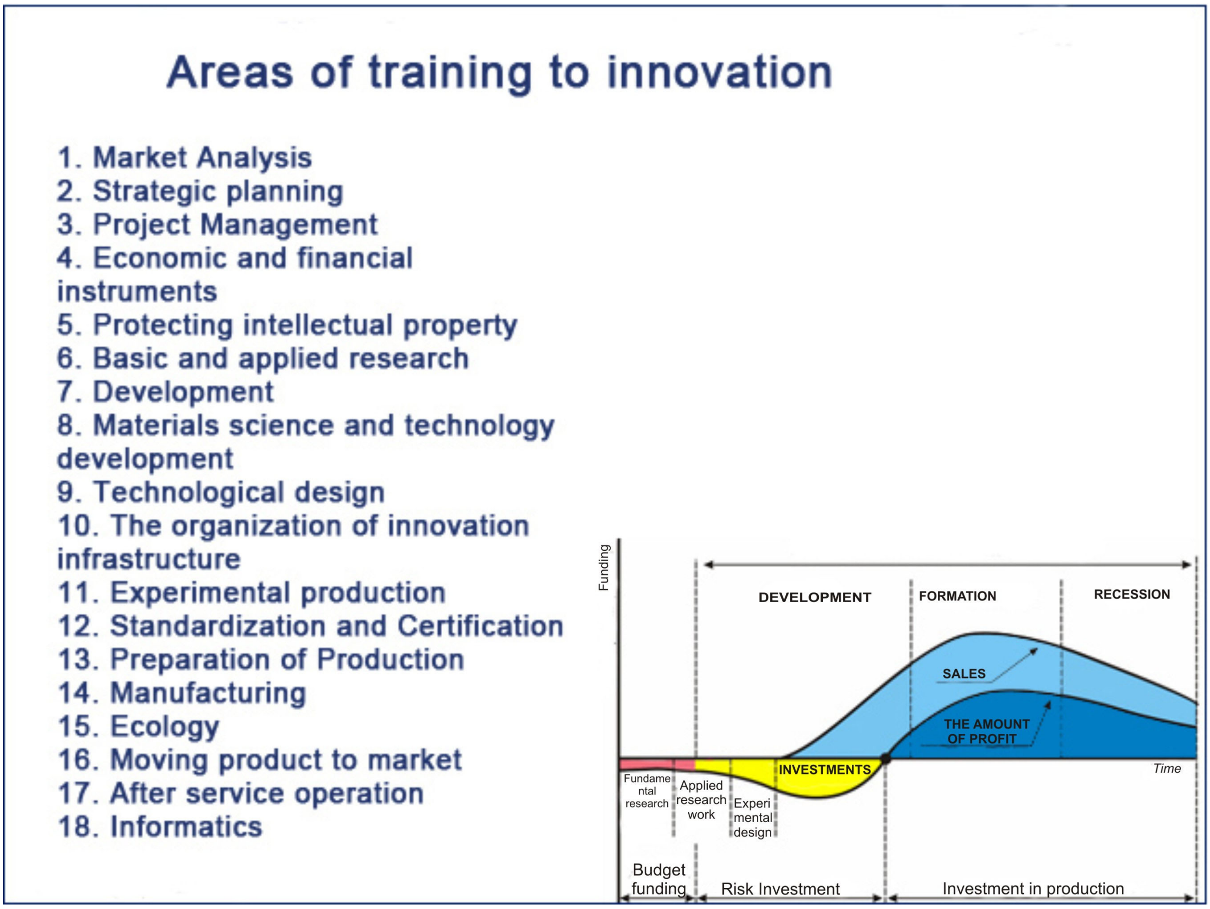
Development of financial institutions of venture business. In Novosibirsk, the annual fair of innovation and investment projects, which are important milestone in the development of infrastructure of venture funding are spent. In particular, within the framework of the exhibition “SIBPOLITEX” organized presentation of innovation and investment projects, academic and industrial research institutes, small and medium-sized enterprises in scientific and technical sphere.

Now the Administration of Novosibirsk Region together with the Ministry of Economic Development and Trade of the Russian Federation and partners creates the venture fund. It develops dynamic activities to attract investments of JSC “Agency for Investment Development of Novosibirsk Region”.

6. Improvement in the preparation and consolidation of scientific and engineering personnel and managers of innovative business

Technopark-like ideology requires qualitative changes in education due to: the development of high-tech sector of economy; training specialists able to search for innovative solutions based on fundamental knowledge, to transfer technology to effectively manage investment and innovation projects. Here is the current development of science and engineering schools and their integration with the system of continuing education, development of social partnership with employers. In Novosibirsk, are created dozens centers of collective use with unique equipment, joint scientifically-educational centers of high schools and academic institutes, chairs on basis of scientific research institute are created. The highest integration level of the Siberian Branch the Russian Academy of Sciences and Novosibirsk State University (89 joint chairs) in leading universities are operating in the region more than 20 scientific and educational centers and laboratories, 17 centers of innovation or technological fields, such as the complex problems of modern medicine «Living System» and complex of laser spectroscopy, photonics and optoelectronics at Novosibirsk State University, centers "Aircraft" and DMG (Decкel Maho Gildemeister) at the Novosibirsk State Technical University, Center for Laser Scanning in the Siberian State Academy of Geodesy, etc.

It is allocated 18 priority directions of professional training connected with the basic stages of life cycle of innovations, the requirement is analyzed in professionals for innovative infrastructure, including Academgorodok Technopark till 2015.



It is, first of all, specialties and directions of preparation connected with scientific directions, engineering and technological activity, analysis of market requirements, project management and intellectual property, industrial design, promoting new product on the market, after sales service, etc. State support of training through the regional budget (target contract training experts) was implemented in Novosibirsk Region for the past 8 years, mainly for agro-industrial complex. Further it is planned to develop an innovation system.

Development of innovative infrastructure of the higher vocational training became more active. In 2007 in 9 high schools of area, Centers of development innovative competence are created, strategically focused on training professionals to advance innovative projects on the market, development of project thinking by professionals, creating innovative business teams in university environment, with their subsequent activities in technopark-like institutions or enterprises. Four centers (Novosibirsk State University, Novosibirsk State Technical University, Siberian State University of Telecommunications and Informatics, and Siberian State Academy of Geodesy signed an agreement with the Russian Fund of Direct and Venture Investment (RVCA) on a non-profit transfer of Course to the European Private Equity & Venture Capital Association (EVCA) «Private Equity and Venture Capital».

Particular attention is paid to the selection and support of talented youth. For example, since 2004, is annually held open interuniversity Regional Olympiad (more than 6,0 thousand participants) based on the Novosibirsk State University, Novosibirsk State University of Economics and Management, Siberian State Academy of Geodesy, Novosibirsk State Academy of Architecture and Art, Siberian State Transport University, Novosibirsk State Pedagogical University, Novosibirsk State Technical University, etc., of which 50 winners are awarded certificates at the Out flow of any entrance to university in Novosibirsk Region.

As part of the national project «Education» in 2006 36 students in 2007 - 26 appointed by the President of Russia prizes, received major financial support for Novosibirsk State University (901 million rbl.) and Novosibirsk State Technical University (583 million rbl), which is aimed at equipping educational facilities, development of teaching materials, professional retraining and improvement of professional skill of teachers. Institutes of the Siberian Branch of the Russian Academy of Sciences and Medical Sciences, Novosibirsk State University and Novosibirsk State Technological University had grants under development programs of nanotechnologies.

One of the successful programs of additional professional education, establishing a dialogue between the authorities, business and education is a Presidential management training program, which is already 10 years successfully implemented in Novosibirsk Region.

7. Intellectual property protection

Involvement of intellectual property into economic turnover is a challenge. Novosibirsk Region is the undisputed leader among the regions of Siberian Federal District in the area of this innovation.

According to the Agreement of administration of the region and Federal service on intellectual property, patent and trade marks (Rospatent) annually from the regional budget "Inventions of the world" are allocated to the State Public Scientific and Technological Library of SB RAS (SPSTL SB RAS) means for a periodical subscription, seminars are regularly held on intellectual property protection. The Siberian Institute of Intellectual Property, the first beyond Ural Mountains and training experts according to additional education programs was created in Novosibirsk.

8. Information provision

At the initiative of Novosibirsk specialists, it is created and accumulated database of innovative projects and programs of Siberian Regional Center of Russian Technology Transfer Network (RTTN - www.rttn-siberia.ru). It is based on the database formats and technologies adopted in the European Innovation Relay Network. Regional data base is an integral part of the RTTN database, which contains information about more than 200 innovative projects for Novosibirsk Region's enterprises.

The Mayor's office of Novosibirsk develops the investment passport of city – (http://invest.novosibirsk.ru) centralized information resource, which will provide information about the innovation and investment projects. The structure of territorial information system of Novosibirsk Region (TIS) is developed. Formation of TIS as a unified system based on the telecommunications network, a regional center of informatization, by using a meta-database should ensure integration of information resources in the region, including innovation.

9. Inter-regional and international cooperation

In Novosibirsk, scientific complex has a time-tested system of interregional and international cooperation. It is necessary to note especially experience of the international centers of the Siberian Branch of the Russian Academy of Sciences created on the basis of institutes, taking leading world positions. It for example, Center for Synchrotron Radiation, Center Aero-physical Studies, Center for Research and Testing of Catalysts. The centers promote the process of expanding international cooperation in the new geopolitical environment, through collaborative research projects, Expeditions, demands for reception of international grants, publications, and training of young scientists, post-graduate students and students, international conferences, exhibitions, publishing, access to unique installations, marketing and other kinds of activity. On volume of export of technologies and services of technical character our area wins first place in Siberian federal district. The volume of the export agreements concluded by area makes more than 60 % of all agreements concluded in Siberian Federal district. The geography of export of technologies and services: the USA – 38 %, the Netherlands – 26 %, Switzerland, Japan, Korea – 5-7 % etc.

In order to coordinate the activities of enterprises in foreign markets, the submission of overseas interest in the area of Frankfurt am Main (Germany) works “Information and Economic Center of Novosibirsk Region”. In turn, in Novosibirsk are consulates general of Germany, Bulgaria, Uzbekistan, Vice Consulate of Republic of Kyrgyzstan, Office Embassy of Ukraine and Belarus, Republic of Korea, and Germany. The representative of the Institute of Foreign Trade of Italy launched its activities as a structural unit of Embassy of Italy. There are the Russian-Korean Center for Science and Technology, Korean Business Development Center, Russian-Indian Technology Center, etc. In Novosibirsk have opened their representative offices or research centers such firms as Beker Atlas, Kawasaki, Kodak, Motorola, Xerox Renk, Hewlett-Packard, Samsung, Siemens, Intel, Schlumberger and others.

Interregional and international cooperation actively contributes to the activities of the Exhibition Center of the Siberian Branch of the Russian Academy of Sciences ITE ”Siberian Fair”, organizing annually, the following exhibitions: Sibpoliteh; Science in Siberia; UchSib; SibSvyaz; Siberian Business Forum; Siberian Energy Congress; SibBezopasnost; SpasSib; Metals of Siberia; Geo-Siberia: Sibnedra, Mining; Sibneftegaz etc.

Personnel training for foreign economic activity (specialties: International Relation, World Economy, Regional Studies, and Custom) implemented seven universities. In many scientific, educational, and manufacturing processes are applied international quality standards GLP, GMP, GCP, 9001:2000 quality system management. Cooperation with international funds and programs (ISTC, CRDF, INTAS, INCO - Copernicus, CORDIS, etc.) are developed.

10. The list of priorities of innovation and investment programs and projects

In Novosibirsk Region practically formed and implemented in different stages the integration of innovation and investment programs and projects, taking into account the competitive advantages of Novosibirsk Region and the region. These projects meet the following main areas:

- Addressing the social humanitarian issues and human society (education, culture, morality, ethics, youth policy, social institutions, democratic freedoms, and others).
- Well-being technology (gene therapy and gene diagnostics, bioengineering and immunocorrection, nano-biotechnologies, stem cells, photodynamic therapy, human livelihoods, pharmaceuticals, bioinformatics, etc.).
- The industry of software products, information and communication systems (information technology education, modeling, automation and management, database and knowledge base, telecommunications and networks, etc.).
- Development of transport complex of Novosibirsk as a multimodal transportation hub.
- Scientifically-technological and economic maintenance of agriculture.

- Creation of methods and means for countering terrorism, preventing and reducing the risk of disaster (prevention, detection and identification, health remedies, etc.).
- Instrumentation, science equipment and automation systems (analysis, test and diagnostic for chemistry, biology, medicine, thermal imaging, sensor microelectronics, electro-optical converters, NMR-sensing, low-dose X-rays, etc.).
- Laser, plasma and electron beam technology for science, industry and medicine.
- Nuclear power.
- Catalytic technology on the basis of a new generation of catalysts.
- Scientific and technological support the creation of aerospace engineering (creation of aircraft aerogasdynamics, durability, avionics, etc.).
- New materials and nanotechnology (single crystals for electronic and jewelry industry, nanomaterials, composites, Bimetals, etc.).
- Science and technology building, including road construction (new materials based on local raw materials, methods and devices for diagnostics, technologies increase reliability and durability, architectural and technical solutions, etc.).
- Ecology, the study of subsurface exploration, transportation and processing natural resources, seismic (geological engineering and technology, mining equipment, geophysical methods of prospecting and exploration, GIS, seismic zoning, environmental zoning, etc.).

11. Issues and proposals for the development of regional innovation system

1. The reasons for the obstacles to the development of innovation:

- Not enough incentives for the development of innovation-intensive areas. Undoubtedly, the positive here is adoption of federal laws “On Status of Science-City of Russian Federation”, “On Special Economic Zones in Russian Federation”.
- The management of innovation processes, organizational structures, mechanisms and regulations in the field of science and technology requires an immediate improvement at both federal and regional levels.
- The State budgetary establishments of science and education, being the basic owners of intellectual property and participants of innovative process, do not have the right to establish small businesses by making contribution valued right to results of intellectual activities, as well as property and money received by agencies through a permitted business or income-generating activities, receive loan funds, except budgetary loans. Experience in establishment and operation of autonomous institutions in scientific, educational and innovative areas is still lacking.
- The holder of intellectual property derived from the state budget weak motivation for its commercialization.
- Weak management in the formation and management of major innovation and investment projects, programs and technology clusters.
- Low technological culture. Not infrequently companies can’t absorb high technology because of outdated technology equipment and lack of personnel with high level of competence, skills and innovative thinking.

- There is little tangible support system scheme «incubation» companies designing and producing new high-technology products (first domestic experience in recent years acquired Foundation for Assistance to Small Innovative Enterprises in science and technology - the programs: START, TEMP, UMNIK).
- Government programs aimed at reducing the risk of innovation projects and attract domestic and foreign investment in science and applications, above all - venture capital fund with state participation - have not yet been shown effective work.
- Not enough development of an enabling environment reduces the risk of innovative projects and programs to attract domestic and foreign investment in scientific applications and high-tech industries. In particular, a lack of reliable mechanisms for the protection of investors, the low activity of banks, pension funds and insurance companies in the venture business, poor infrastructure of venture investment, etc.

2. To create conditions for the development of regional innovation system it is necessary:

- To form a coherent system of measures to actively introduce technopark-like ideology of socio-economic development of Novosibirsk Region.
- Develop holistic (federal and regional) system of legal acts to stimulate innovation and investment activity in the scientific, industrial, educational, industrial and social spheres.
- Develop innovative models of systems and programs in scientific and educational complex mechanisms and management with priority on training high-level competencies and skills for the knowledge-based economy.
- Provide legal support to the status of the territories innovative development (academic campuses, technology parks in major universities and industrial enterprises) with high concentration of scientific, technological, educational, and innovative capacity.
- Take steps to overcome the technological lag of industrial enterprises.
- Develop mechanisms of the state order for scientific research and technical products and services, as well as the state protection in order to prevail over the purchase for the public use of national high-tech products.
- Develop a system of state support to small and medium business entities, including business incubation.
- Develop a system of independent assessment of the market and pledge value of intellectual property in order to ensure reliable guarantees of debt the borrower to obtain investment funds (security of property rights to intellectual property).
- Develop a system of venture investment.
- Create a unified regional information-analytical and consulting network of technology transfer.

CONTACTS

Prof. Dr. Gennady A. Sapozhnikov
Deputy Governor of Novosibirsk Region
Head of Department of Science, Innovations, Informatization, and Communication for Novosibirsk Region
18, Krasny prospekt
Novosibirsk, 630011
Russian Federation
Tel: +7 (383) 203-48-07, 223-98-26
Fax: +7 (383) 203-48-06
E-mail: felva@obladm.nso.ru
http://www.adm.nso.ru/

Boris I. Ivlev, PhD
Administration of Novosibirsk Region
Foundation for Assistance to Small Innovative Enterprises (FASIE)
for Novosibirsk Region
18, Krasny prospekt
Novosibirsk, 630011
Russian Federation
Tel: +7 (383) 218-24-20
Fax: +7 (383) 203-48-06
E-mail: felva@obladm.nso.ru
http://www.adm.nso.ru/

Basic spatial data of water ecological GIS

Irina N. ROTANOVA, Anna A. WAGNER, Russian Federation

The current state of information technologies, the development of concepts of the creation of analytical systems, the improvement of methods and tools for digital processing of cartographic information give new possibilities for the analysis of the large body of different spatial data and their use in the expert management support systems. The attention is given to the basic spatial data as a subset of information considered in the specific unified form of presentation determined by the goals and objectives of information gathering and processing.

The reference spatial data as a part of information-cartographical provision should be in line with the organizational-management and industrial-technological field. Their infrastructure is aimed at the support of management and technological processes through the development of geoinformation (GIS) and geoinformation-analytical systems.

In terms of the large body of source space-related data the necessity of the distributed access to geoinformation, the demand for analytical search tools the formation of infrastructure spatial interdisciplinary data for management decision making is timely, called-for and efficient solution of goals of information environment development. These are as follows:

- *Inventory goals* – the study of environment and its components, the use of natural resources and natural potentiality of the territory;
- *Evaluation goals* – the assessment of anthropogenic impact on the environment, the extent of unfavorable processes, the aftereffects of natural or anthropogenic eco-catastrophes, the ecological-geographical evaluation of the territory;
- *Dynamical goals* – the study of changes of environmental and natural conditions due to economic and natural factors, nature management and anthropogenic impact on the environment;
- *Predictive goals* – the forecast of the change of environmental and natural conditions caused by the anthropogenic impact or the development of natural complexes, the revealing of trends and dynamics of nature evolution as a result of human economical activity.

Of importance in the development of information and management systems is the water-oriented (water-resource and water-ecological) line that is dictated by the urgency of similar problems in many regions.

Practical application of GIS projects covers different lines and kinds of activity in the field of development of the systems for ecological monitoring on the local, regional and basin levels; territorial cadastres of natural resources; assessment of natural resources state and use including water, land, forest, biological and atmosphere ones; ecological assessment of problems caused by anthropogenic factors (eco-diagnosis); ecological expertise of territories, objects and projects; the development of GIS-technologies for sustainable development of territories as well as for the solution of hydrological, water-resource, water-management and water-related ecological problems.

In line with normative-legal documentation, the Schemes of complex use and conservation of water objects (SCUCWO) currently developed for some basins of large rivers of Russia contain information support activities, i.e. mapping and development of basin geoinformation systems, in other words, creation of infrastructure of spatial data of a basin level [1, 2].

The goal of SCUCWO development is tools' formation for expert system support. Item 12 of "Methodical guidance...» states that Schemes are based on GIS-technologies in compliance with technical and software requirements to support the digital map layers [3]. Item 22 refers mapping and GIS to fundamental (basic) activities under development of program options for conservation and restoration of water objects, steady functioning of water-economic systems as well as achievement of target indices on prevention of negative water effects [3].

This approach is of great importance for provision of uniformity and continuity of information, normative-methodical systems of the Russian Federation in the field of water objects use and conservation, systematization of materials on water objects' state, structure of water-economic and water protective activities.

The Schemes must include a set of situation, evaluation, operative and predictive maps (in electronic and paper form) constructed in scale 1:1 000 000 - 1: 100 000 and supported by inset map of larger scale, if necessary.

A set of situation maps representing factual information for a moment of their construction consists of:

- a topographic map;
- a landscape map with the mapped protected areas;
- a drainage map with boundaries of hydrographic units and water-resource regions, hydrologic and hydrochemical monitoring stations including tables with studied hydrological situation in the river basin;
- a map of water-resources regions including their major characteristics;
- a map of water objects by categories including tables that characterize water objects and their regimes;
- a map of basin infrastructure with water-management systems and waterworks facilities including the tables with their parameters and features;
- a map of ground water aquifers;

- a map of aquifers characterized by intensive ground water intake (monitoring wells, deposits of ground water, boundaries of depression whirlpools, aquifers' protection from pollution).

A set of evaluation maps representing the outcomes of the data analysis from situation maps and documentary data on water object management consists of:

- a map of watershed zoning by level of anthropogenic load on water objects;
- a map of water risks stipulated by various water impact;
- a map of the basin's territories exposed to occasional floods (at different water providing - 1%, 3%, 5%, 10%, 25% and 50%);
- a map of river basin by level of flood threat;
- a map of key types of water use;
- a map of natural and industrial pollution of surface water;
- a map of natural and industrial pollution of ground water;
- a map of water management balance (by water-resources regions);
- a map of water objects assessment due to the data obtained in the course of state hydrochemical monitoring of water objects;
- a map of environmental assessment of water objects;
- a map of protection of exploited aquifers from pollution.

A set of operative and predictive maps that forecast situations consists of:

- a map of predictive change in water content of the river basin for the period of Scheme validity (taking into account natural-climatic and anthropogenic factors);
- a map of predictive change of anthropogenic load on water objects of the river basin for the period of Scheme validity;
- maps of limits and quotas for water intake from water objects according to stages of Scheme implementation (by water-resources regions);
- maps of limits and quotas for waste water discharge into water objects according to stages of Scheme implementation (by water-resources regions);
- maps of target indices of water quality in water objects;
- maps of target indices of negative effects of water;
- maps of development of water objects and systems monitoring;
- maps of planned structural activities to be implemented on the basin's territory;
- a map for forecasting depression whirlpools development within ground water basins and aquifers characterized by intensive ground water exploitation.

Unfortunately, a large list of maps that differ in quantity and quality is not methodically supported. Moreover, the indices to be mapped are not approved. SCUCWO should be developed for one of the largest water objects in Russia- the Ob basin. Ob river takes 5th place in the world and first- in Russia by a watershed area (3 mln km^2), and the third one (after Yenisei and Lena) - by 400 km3/year runoff. A complex of research activities (RA) on " State-of-the-art study, scientific grounding of methods and support for steady operation of a hydroeconomic system in the Ob' basin" precedes SCUCWO development. The goals of RA are as follows:

- integrated assessment of water objects in the Ob'-Irtysh basin, qualitative and quantitative assessment of surface and ground water;

- elaboration of information-modeling complexes and expert support systems (ESS) for solving tasks of integrated water resources management in the Ob' basin;

- scientific grounding of methods and tools for steady water use and hydroecological safety;

- information validation for development of Ob' basin SCUCWO.

Main tasks in geoinformation-cartographic block are the following:

Cartographic assessment of water resources state-of-the-art and use in the Ob' basin:

- collection, processing and analysis of available cartographic source information containing the data on description and assessment of conditions for water resources formation as well as the ones on qualitative and quantitative analytical and evaluation indices of water object state in the Ob' basin;

- application of cartographic research method to integrated assessment of water object state in the Ob' basin;

- formulation of basic principles and standings of water-resource and water-ecological cartographic methods to be used for information support under Ob' basin SCUCWO development;

- preparation of basic digital maps and materials with the infrastructure of spatial data are to be used under development of a series of situation, evaluation and predictive maps.

Cartographic investigations of formation processes of surface and ground water's quality and quantity including their influential factors:

- landscape-cartographic field works to obtain data on the environmental assessment of water objects and their catchments;

- method preparation on water-resource and water-ecological small-, mid-, and large-scale mapping for geoinformation-cartographic support under SCUCWO development;

- cartographic evaluation of qualitative and quantitative indices of surface and ground water and their influential factors using the existing cartographic methods;

- structure development of specific databases on the basin's water objects in line with the State water register and water objects monitoring;

- elaboration of the concept, structure and information filling of a geoinformation-cartographic block of the expert support system aimed at water resources management in the Ob' basin (using model water objects);

- creation of a cartographic block with target GIS database, development of cartographic support for a pilot GIS-project.

The creation of scientifically grounded infrastructure of spatial data and information-cartographic support for steady functioning of water-economic complex in the Ob' basin due to development of:

- cartographic evaluation method of influence of diffusive sources of water pollution;

- a block of geoinformation-cartographic support for ESS information-modeling complexes aimed at specific water ecosystems management in the Ob' basin;

-integrated assessment maps of water objects subject to the peculiarities of watersheds and resource potential;

- GIS cartographic block for ESS aimed at water resources management in the Ob' basin;

- cartographic methods and construction of water-resource and water-ecological maps for model basin rivers.

To carry out research on natural conditions, revealing their peculiarities effecting on water resources formation in the Ob' basin, the territory was split into hydrographic units, i.e. river basins (a basin level), subbasins (a subbasin level), water-resource regions and sites [4]. According to water-economic zoning, the territory of the Ob'-Irtysh basin is divided into 72 water-economic sites: 36 are in the Ob' basin and 36 - in the Irtysh river basin.

The cartographic study of the basin, in particular, the landscape-cartographic provision of research was analyzed that allowed conclusion about the availability of a great quantity of landscape-typological maps for specific administrative territories. However, the coverage of the basin area is uneven. The difference in approaches to the definition of natural-territorial complexes of different rank takes place that hampers the complex assessment of the region under study. The scale to be used to construct the original and resulting maps is justified. The infrastructure of spatial data for GIS creation is discussed, and the software tools are chosen. Much consideration is given to the development of geodata bases, the unification of the original information (the creation and use of classifiers), the development of custom interface for data retrieval, analysis and visualization.

The research outcomes serve as the basis for the development of geoinformation-analytical system (GIAS) “Water and ecology of Siberia” intended for matching and integration of different cartographical materials, data base resources and metadata. GIAS is considered as the element of information filling of the system of decision making support (SDMS) for water management in the Ob basin (using the model water objects) and the development of territorial systems of Siberia.

The specific feature of GIAS is its water-ecological orientation, the creation of catalog of the distributed geoinformation resources metadata and the accessibility and the development of the system for introducing the outcomes of mathematical modeling, the addition of the data of field observations as well as the reference information. Besides, GIAS uses the technologies of remote data processing, the results of cartographical modeling, methods of interdisciplinary data integration as well as the outcomes of research based on the spatial characteristics and features. In the framework of GIAS the problems typical for GIS and specific issues including the formation of ground waters, physical and chemical characteristics of groundwater flow, the analysis of ground and surface water quality, their availability for drinking water supply, the characteristics of sources and level of water pollution, the development of rapid and efficient access and storage of information in data bases including the ones of space images, mathematical-cartographical modeling are solved.

The structurally developed GIAS is a logical model incorporating the data bases (metadata), a specialized software support and the analytical block. The analytical part of GIAS is based on the multidimensional data base including the subject-oriented information. The information is retrieved from the network data warehouse. The GIAS analytical block involves the methods, algorithms and programs oriented to the subject domains. Two subject domains conventionally called as "Water" and "Geo" are considered within the system framework.

The concept of the data warehouse (a subject-integrated, invariant data set formed for decision making support) serves as the basis for the creation of thematic data bases. In terms of multidisciplinary information the formation of the data warehouse assumes the approach that

- is oriented to the ecologically significant objects (water basins, territorial entities) and situations (assessment of state, impact and aftereffects);
- includes the object-oriented data sets containing the consistent and aggregated cartographical and factual information for the solution of theoretical and practical problems.

The objective level of GIAS involves primarily the river basins that represent the hydrographical units in a specified order hierarchy. The major model basins are of Ob and Irtysh rivers. The basins of principal rivers are differentiated into the ones of the large, medium-size and small rivers. The hydrographical units are used in the analysis of factors for the formation of water resources and the ecological state of water objects for the development of the information-modeling system.

The GIAS objects also include the RF subjects (the units of political division) and the units of hydrological zoning representing the system of hydrological sites specified with hydrographical-geographical and economic-geographical approaches to the territory zoning.

For the creation of standardized descriptions the principles of information system, formalization and unification were used under the development of the distributed information-expert systems on the GIS bases for interdisciplinary research. The description of attributive and cartographical information and the formation of metadata comply with the State standard on spatial data content SSS P 52573–2006 "Geographical information. Metadata". Using the standard, its "projection" on the subject domain GIAS "Water and ecology of Siberia" was made and the subject profile oriented to the system being developed was obtained.

The pilot program system for the metadata base formation and support was developed. The metadata base for the distributed cartographical base was created with ESRI ArcCatalog Metadata Master.

The possibility to define large blocks in such ecology-oriented maps as water-ecological, bioecological, anthropo-ecological, socio-ecological, economic-ecological, and integrated ones is assumed.

The formation of the structure of cartographical information in data base (metadata base) provides for the component-by-component approach to the use of environmental data. However, in spatial analysis the natural complexes (landscapes of different topological level) are used as territorial entities. The aspects of content-richness and information value under the different scale map modeling (scale 1:500 000, 1:1 000 000, 1:2 500 000) were worked through. The typification and generalization of landscape maps for Novosibirsk, Omsk, Kemerovo oblasts, Altai Krai and Republic of Altai were carried out, and the electronic versions of landscape maps were made.

The mathematical-cartographical modeling within GIAS is considered to mean the development and analysis of mathematical models with the data obtained from the maps as well as the construction of the new (optional) ones on their basis. In this case such chains and cycles as map-mathematical model-new mathematical model are formed. The mathematical-cartographical modeling uses the methods of the correlation, regression, and factor and cluster analysis.

The approach to the solution of the subject-oriented objectives under the lack of source information is defined within the framework of GIAS. The approach involves a number of methods among which are the use of the unified attributive and cartographical data base; the development of techniques for complex assessment using the supplementary information; cartographical modeling of the subject domain. The GIAS “Water and ecology of Siberia” is aimed at the solution of a wide range of water-resource and water-ecological issues.

The representative dataware for the development of SCUCWO, the creation of cartographical and thematic data bases, the development of pilot GIS will contribute to the formation of the infrastructure of the basic spatial data and the justified expert system for the sustainable hydrologic functioning of the Ob basin system.

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CONTACTS

Dr. Irina N. Rotanova
Deputy Director on Science
Head of the Laboratory of Ecological-Geographical Mapping
Institute for Water and Environmental Problems
Siberian Branch of the Russian Academy of Sciences (IWEP SB RAS)
1, Molodyozhnaya Ul.
Barbaul, 656038
Russian Federation
E-mail: rotanova07@inbox.ru

The Electronic Library of Subject Signs for Tourist and Recreative Maps of Pribaïkal'e

Boris N. OLZOEV, Russian Federation

Key words : digital map, cartographical signs, tourism and recreative, digital classifier

SUMMARY

The electronic library of convectional signs for recreative and tourist maps collection of graphics, semantic, metric components expressing a content of maps recreativ and tourist are of particular significance. In a technical electronic library of convectional signs publications name as the digital classifier of an electronic map. The electronic library of convectional signs has a similar construction with a legend of a customary paper map, the difference is encompass byed by composite classified and outline.

Before to elaborate electronic library of convectional signs of recreative and tourist maps, it is necessary to unify a contents and to compound mockups of legends on the initial cartographical materials. As electronic of maps recreativ and tourist mirror as topographical, and subject contents, in a basis topographical of units the methodological principles and system approach included in development of scientific bases of a contents of topographical maps [Vereshchaka, 2002] are put.

Electronic of maps recreativ and tourist is, first of all, subject maps. Therefore first of all, the subject groups of legends of the recreativ and tourist schedule will be considered. Their amount depends on district of mapping, his natural features and development of a socio economic orb. The classification of recreativ and tourist resources (cognitive concept) was earlier represented, which one is put in unification of a contents of such maps. Besides, it should be allowed the semantic principles (language concept) and modern geographical information technologies (geographical information concept) build-up of legends and application them as the shell for handle. The combination of the several concepts reduces in usage of the structural approach [Lebedev, 2003].

The contents of recreative and tourist maps has a logical sequence of allocation signs on sense, and is grouped together in subject sections, that enables to spot the philosophy of unification, thereby to form the system of legends.
The unified contents allows to understand a map, its system links between objects, to distinguish main and minor, to spot methods and receptions of cartographical interpretation of objects of a reality. This implies that than more correctly and more in detail to fulfil unification, the easier is to realize technological aspects of creation of maps.
In a basis of unification the semantic value of objects of a map is taken, which one concludes system principles of structural information organization.

The electronic maps in vector representation have possibility to show, except for the metric description of objects, their semantic properties (Fig. 1). On definition, as semantic properties name the individual characteristics of objects, their quality and quantitative parameters. The cartographical signs of design and denotations permitting visually to read a map have no semantic properties.

Outgoing from the above reduced table, it is possible to suppose about availability of types of a field (characters, whole, decimal) and text files (is attached to an electronic map).

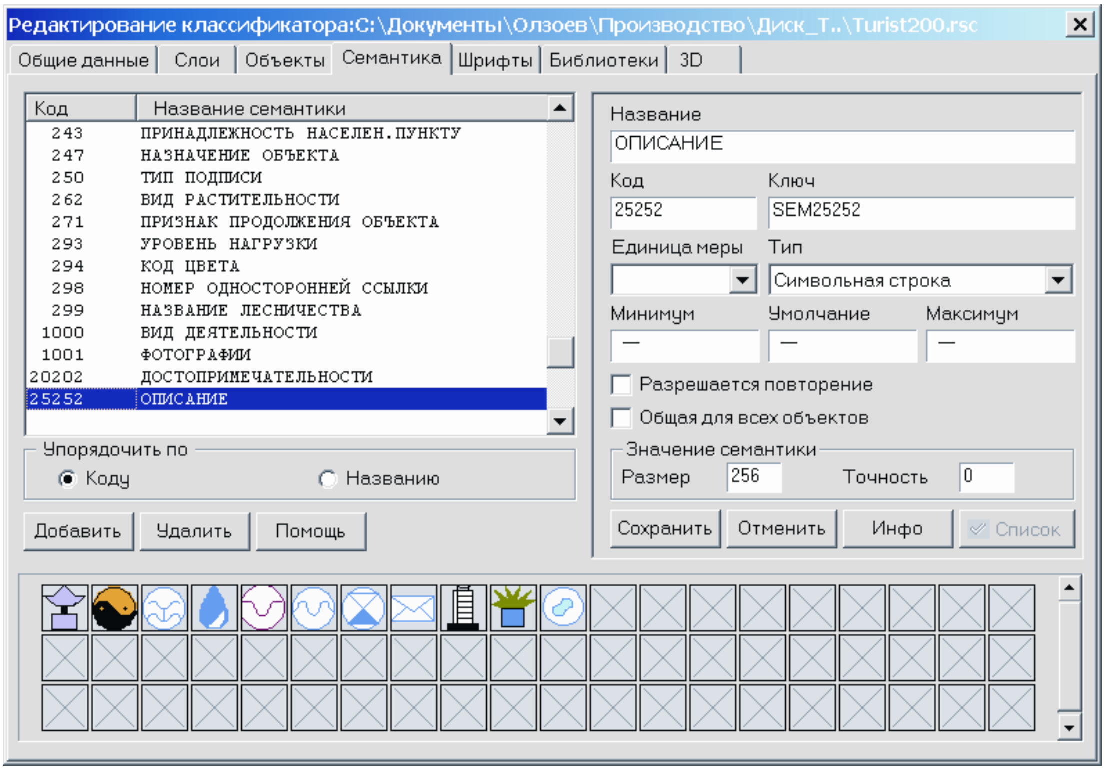

Fig. 1: Sections "Semantics" in the classifier of an electronic map

The development of the electronic library of convectional signs is one of ports of reference of creation of any map and is considered on a design stage. Therefore first of all there was a necessity to be spotted with technological principles of graphics build–up of cartographical signs and their semantic value on electronic maps recreativ and tourist.

At development of the classifier of convectional signs or electronic library of signs allow following items:

– Shared data (scale, graphic palette, electronic map type);

– Unified contents of the future map, distributed on subject groups (stratums of an electronic map);

– Objects of an electronic map – topographic and subject signs, description of their build-up with usage of structural members (point, line, polygon);

– Semantic properties of electronic map objects;

– Used fonts, description of their trajectory;

– Libraries permitting to optimize build–up of cartographical signs;

– 3D visualization of electronic map objects.

The graphics variables (form, sizes, inner pattern, colour, alignment of the sign), designed in 1960 are put at the bottom (basis) of cartographical signs designing by the French cartographer and semiologist J. Berten [Lyuty, 1988].

At computer build–up of cartographical signs the specialized cartographical complexes (hybrid module a Panorama, hybrid module MapInfo, hybrid module ArcView etc.), system of automatic design (AutoDesk, Credo etc.) and graphics editors (CorelDraw, Adobe Photoshop, QuarkExpresse etc.) will be utillized. Allowing a diversity of present programs, the choice was made on a hybrid module a Panorama, since she allows creating cartographical signs of different frame consisting of set of structural members (a point, line, polygon).

The electronic maps recreativ and tourist concern to the service charts and public health services, which one are directed on support by the information of customers on development of tourist activity, recreational significance and ecological state of territory. As the contents of maps recreativ and tourist consists from topographical and subject cartographical signs, and topographical signs are shaped of the reference digital classifier of an electronic map for topographical maps of scales 1:100 000 and 1:200 000, the major attention will be referred to development of subject cartographical signs.
In theory of cartography on space localization there are three types of cartographical signs (dot, linear, area), and also subscript (explanatory comment, own titles, subscript of the characteristics). As the creation of cartographical signs is designed in a hybrid module a Panorama, here in the program and accordingly in the digital classifier of an electronic map, two types are added: vector and templates.

The type of localization Vector is understood as conditionally – linear, having particular distance or conditionally – dot – for an alining on a direction (circle). Metric type Vector consists of two clusters: the first site indicates location, second site – direction (alignment of the sign).

The type Templates is applied at composite frame of varied signs, for example, combination of the text and ponctuel of the sign. The text can be composite, multilevel, the usually given type will be utillized seldom and is not convenient at converting in graphics formats (*.jpg, *.cdr, *.tiff etc.), because the continuous editing of signs is required.

Allowing principles of development of signs of the methodological and technological sides, it is possible to compound the scheme of a relation of objects of tourism and recreativ on a contents and type of localization (ways of the cartographical map).
The development of cartographical signs surveyed in a hybrid module a Panorama at a stage of creation of the classifier of a map.

At development of cartographical signs it is important also to allow for following specifications:

– The sign should be legible, readable, since at converting them in other environment, there are problems of a picture representation;
– To utillize the least amount of structural members;
– To apply only dot, linear, area type of localization.

In the transactions A.M. Berlyant scores, that the signs are a means fixings, formalising and systematization of knowledge [Berlyant, 2001].

In judgment V.A. Vostokova etc., the development of cartographical signs of georaphical maps founds on knowledge and rational usage semiotic of aspects, on the one hand, and deep learning of an essence of displayed appearances – with other [Vostokova, etc., 2002].

Outgoing from the above-stated scientific positions, it is possible to make following output: cartographical signs and the explanations to them shape technological knowledge grounded on substantial objects and appearances and express by particular resources of a graphics. Therefore development of different cartographical signs has the relevant value at creation of any cartographical product.

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CONTACTS

Boris N.Olzoev
Irkutsk State Technical University (ISTU)
83 Lermontova Ul.
Irkutsk, 664074
Russian Federation
E-mail: icob_irk@mail.ru, plast@istu.edu
http: www.istu.edu

Different Views on a Digital Map in the Late 20th and Early 21st Century

Stanislav Yu. KATSKO, Russian Federation

The late 20th and early 21st century is marked by the transition to the Information Age. It is characterized by highly developed information area, which includes the human activity on creation, processing, storage, collection and transfer of data, information and knowledge.

Owing to the society's computerization developed several models of spatial data are formed: digital (geoinformation) model in Geomatics, digital and electronic maps in geoinformation mapping.

The analysis of Russian authors (Berlyant A.M., Zhalkovsky E.A., Koshkaryov A.V., Tikunov V.M. and others), as well as relevant state standards for cartography and geoinformation mapping showed that a great deal of attention in these works is given to the definition of digital maps.

In [1, 2, 3] the digital map is defined as "a digital model of the Earth's surface".

Berlyant A.M. in his work [4] says that the digital map is "a digital map model created by digitizing cartographic sources, photogrammetric processing of remote sensing data, digital registration of surveying data or by any other way». He points out that the «a digital map is not a geoimage ... but only a digital geoimage model, it is the data used for geoimage creation being its analogue".

Zhalkovsky E.A. [6] gave a definition of the digital map having no recommendations that the map is a model. The digital map is: "a) the map, whose content is represented in digital form; b) presentation of map features in digital form, which allows a computer to maintain, manipulate and display the values of their attributes. The digital map is a database or a file that will become a map when creating a hard copy or image display".

Koshkaryov A.V. considers that "the digital map, as a phenomenon of digital environment, is not the direct perception of humans as well, as visualized, ceases to be digital. It is neither a map nor a cartographic image in the traditional sense, because it can not be perceived visually or in touch". [5]

In [4, 7] the authors pointed out that a digital map is the basis for production of paper, computer, and electronic maps. It is a part of a cartographic database and can serve as a basis to generate computer and electronic maps. Besides, it is one of the sources of spatial data in GIS and used as a digital map base.

In [8] the digital map is defined as "digital display of map content recorded on a magnetic tape or any other storage medium".

In addition to the definition of "digital map" should consider the classification of computer maps. According to this classification is allocated two main types of computer maps: electronic and digital.

An electronic map is visualized using computer equipment. It consists of graphic primitives in raster or vector data format, which are converted into cartographic images.

When using the electronic cartographic image, only a man is able to extract cartographic objects from graphic primitives and to compare them with terrain objects by means of the map's legend. Special software allows the user to edit map's image, thereby altering cartographic objects.

The display and perception of geoinformation by a man from electronic cartographic images are performed on the analog image basis. Cartographic image of electronic map, without regard to the map's legend is merely a set of graphic shapes or primitives do not give a person any information about objects. A trained professional perceives not the separate graphic pieces but using the legend, he is able to extract cartographic objects, to understand their properties and to create cartographic images of real objects. The information transfer is happened only in one direction that is from the image to the user.

Advanced hardware and software made it possible to realize the principle of feedback based on the separation of object's geodata, the rules for constructing an image and the cartographic image. As a result, *a digital map* was appeared, which combined geoinformation terrain model and cartographic images created on the basis of the spatial objects from the database containing geodata and cartographic objects.

Digital cartographic image is a dynamic object and there is no constant exists. It is formed as a result of the visualization of data obtained in response to a user's query to the database geodata.

When working with large volumes of geodata is not necessary to display (visualize) the entire geoinformation from the geodatabase on map. Digital cartographic images provide the representation of terrain model in a computer format, but they are intended for direct human perception. It ensures the participation of people in geoinformation processing and analyzing data, solving spatial problems, the preparation and adoption of spatial solutions. In doing so, they are no longer a direct source of geoinformation, as a means of visualizing the content of databases and/or developed spatial objects. As a result, there is a change in the role of the cartographic image, which carries out the role of the interface between man and geodatabase.

Let's consider the appointment of digital map and digital cartographic image.

A man works with a digital map image. It serves as a tool for interaction between user and database (as interface), as a means of visualization of geodata using base graphics primitives. This cartographic image is losing its past as a repository of geo-information for analysis and spatial solutions.

Digital maps, integrated with GIS, is used to implement management functions of a person in finding, processing and analyzing spatial data in virtually all industries, wherever decisions are taken in the process of working with spatially distributed data. The development of electronic networks and the emergence of a number of new technical capabilities for the visualization of computer cartographic images contribute to improving the management of spatial data.

The specificity of the perception of digital cartographic images is reflected in the different from the traditional cartography approach. It is the approach to resolving the contradictions between the demands of their visibility and readability. The solution of this issue is to use one map instead of a series of map images (layers) and a dynamic generalization of the geometry, and the semantics of digital cartographic images, allowing for greater visibility and readability on small screens.

Based on the analysis of works of different authors and formalize the essence of digital maps offer the following definition.

The digital map is a dynamic geoinformation model that integrates geoinformation terrain model and cartographic image created on the basis of the data about spatial objects from the database. It contains cartographic objects and manages by the GIS, which provide interaction the user with information from the geodatabase.

Digital cartographic image (cartographic image of a digital map) is computer image, which contained cartographic objects and created on the basis of the data of spatial objects from geoinformation terrain model. It made the conversational (interactive) mode of interaction the user with information from the geodatabase.

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CONTACTS

Stanislav Yu. Katsko, PhD
Siberian State Academy of Geodesy, SSGA
Department of Cartography and GIS
10, Plakhotnogo Ul.
Novosibirsk, 630108, Russian Federation
Tel: +7 923 244 47 29
E-mail: stanislav.katsko@gmail.com

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Mrs. Argina G. Novitskaya
responsible for editting
E-mail: argina@gmx.de, argina.novitskaya@gmail.com

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