THE SIX International Exhibition and Scientific Congress “GEO-Siberia-2010”
27-29 April 2010, Novosibirsk, Russian Federation

International Cartographic Association Working Group
“Cartography on Early Warning and Crises Management”
The International Society for Digital Earth (ISDE)
Siberian State Academy of Geodesy (SSGA)

**International Workshop on**

# “EARLY WARNING AND CRISES/DISASTER AND EMERGENCY MANAGEMENT”

28-29 April 2010
Novosibirsk, Russian Federation

# Proceedings

Novosibirsk, Russian Federation
SSGA
2010

## ABOUT ORGANIZERS

INTERNATIONAL CARTOGRAPHIC ASSOCIATION (ICA) (www.icaci.org)

**The International Cartographic Association (ICA)** is keeping a strong position in the development of cartographic science, methodology and methods of analysis, elaboration, handling, using, implementation and interpretation of spatial (geographic) and non-spatial (non-geographic) data.

**ICA is the world authoritative body for cartography, the discipline dealing with the conception, production, dissemination and study of maps.**

The ICA was founded on June 9, 1959, in Bern, Switzerland. The first General Assembly was held in Paris in 1961.

The activities of the ICA are important for promoting and advancing the theory and praxis of cartography. Throughout its 50-year history, ICA has brought together researchers, government mapping agencies, commercial cartographic publishers, software developers, educators, earth and environmental scientists, and those with a passion for maps.

The mission of the International Cartographic Association is to promote the discipline and profession of cartography in an international context.

The International Cartographic Association exists:

- To contribute to the understanding and solution of world-wide problems through the use of cartography in decision-making processes.
- To foster the international dissemination of environmental, economic, social and spatial information through mapping.
- To provide a global forum for discussion of the role and status of cartography.
- To facilitate the transfer of new cartographic technology and knowledge between nations, especially to the developing nations.
- To carry out or to promote multi-national cartographic research in order to solve scientific and applied problems.
- To enhance cartographic education in the broadest sense through publications, seminars and conferences.
- To promote the use of professional and technical standards in cartography.

The Association works with national and international governmental and commercial bodies and with other international scientific societies to achieve these aims.

ICA Working Group on Early Warning and Crisis Management

For a number of years the ICA has developed a focus on Early Warning and Crisis/Disaster/Risk management. ICA Working Group on Early Warning and Crisis Management chair, immediate past-President Milan Konečný, first elaborated on the need for cartography and GIScience to be actively involved in this area at the Second International Conference on Early Warning (EWC II) in 2003.

At the 13th ICA General Assembly, held in conjunction with the La Coruna, conference, Professor Konečný proposed that the ICA should establish a Working Group on Early Warning and Crisis Management. He is current Chair of WG.

The aims of the Working Group

– Provide leadership in the development of concepts, ontologisation and standardization of early warning for hazard, risk and vulnerability mapping and cartographic modelling.

– Promote the cartographic use of remotely sensed and other geospatial data and various analysis techniques for early warning and crisis management by organizing conferences, seminar and workshops.

– Investigate psychological condition of end user given by their personal character and situation and psychological condition of rescued persons.

– Promote capacity building and quality mapping, and cartographic modelling including modern technology for early warning and crisis management through topic related publications.

– Participate and contribute to global initiatives in early warning and crisis management for instance through the maintenance of a website.

– Promote hazard, risk and vulnerability mapping for crisis management and communication.

– Develop mechanisms and networks for exchange of information among stakeholders on crisis management and early warning.

The start of 2008 saw the beginning of a number of seminars organized by or with direct contributions from the ICA Working Group: *The Early Warning and disaster/crises management* conference was held in Borovets, Bulgaria and a *Workshop on Cartography in Early Warning and Crises Management and Round Table* at AutoCarto 8, Shepherdstown, West Virginia, USA, which addressed natural anthropogenic disasters; current global, regional and local initiatives in early warning and crises management; paradigms of action; exchange of best practices for activities in the field; avoidance of shortcuts in crises situations; sharing and standardizing of data on material reserves and potential human provisions; the interconnection between current OGC/ISO activities and crises management.

The main activity of the Working Group in 2009 was conducting a Joint Symposium with the JBGIS Gi4DM - *Cartography and Geoinformatics for Early Warning and Emergency Management* - held in January 2009 in Prague, Czech Republic. The symposium topics were organized under the themes of: frameworks and tools; technologies and infrastructures; citizens in early warning and emergency management; e-government and e –governance; and cartographic and geoinformatic applications. At the Symposium a Round Table on Spatially Enabled EW and EM was held, lead by Professor Gottfried Konecny, Germany and Professor Milan Konečný.

Later that month Professor Konečný addressed the seminar on the *Potentials in Early Warning and Emergency Management* special session at the international **GeoSiberia** conference, held at the Siberian State Academy of Geodesy, Novosibirsk and leaded by Professor D. Lisitsky. The title of the paper was “Cartographic and Geoinformatics Potentials in Early Warning and Emergency Management”. Following the success of these sessions it was decided to include meetings of the WG as part of future GeoSiberia conferences.

A number of events are in preparation for 2010. In April in Novosibirsk, Russia, a seminar will be held on *Early Warning and Crises/Disaster Management* under of leadership of Prof. M. Konecny and Prof. D. Lisitsky under auspicious of rector of SSGA *Prof. A. Karpik.* This is a joint event between the ICA, the International Society on Digital Earth-ISDE and SSGA, with the participation of colleagues from the ISPRS and FIG.

Another seminar is planned in Nessebar, Bulgaria, June 2010 – *Digital Earth Summit and 3rd Conference on Cartography and GIS* - a seminar on *Early Warning and Disaster/Crises Management: European Concepts for Crises Management and Early Warning*; and Orlando, USA, November 2010 - a workshop at *Autocarto 2010*.

In summary, the International Cartographic Association began to be active in Early Warning and Crises Management in 2003. This followed with a number of activities that have now become part of the Working Group’s activities - seminars at Borovets and Nessebar in Bulgaria, seminars in Novosibirsk, Russia and at *AutoCarto* USA. The working Group continues to address the issues of Crises Management and Early Warning in collaboration with members of the JBGIS.

**Contacts:**
Prof. Dr. **Milan KONEČNÝ.**
Past-President, International Cartographic Association (ICA)
Vice-President, International Society on Digital Earth (ISDE)
Chairman, ICA Working Group Cartography for
Early Warning and Crises Management

# INTERNATIONAL SOCIETY FOR DIGITAL EARTH (ISDE)

The **International Society for Digital Earth (ISDE)** was proposed together by the experts and scholars from more than 10 countries, such as China, Canada, USA, Japan, Russia and Czech Republic etc. Inaugurated in May 2006, the ISDE is a non-political, non-governmental and not-for-profit international organization initiated by the Chinese Academy of Sciences (CAS) with the collaboration of institutes and related scholars throughout the world. The ISDE secretariat is hosted by the Center for Earth Observation and Digital Earth, Chinese Academy of Sciences. Prof. Lu Yongxiang, the vice chairman of the Standing Committee of the National People's Congress, and the President of CAS, serves as the founding president of the ISDE.

– **ISDE Aims**

The purpose of ISDE is to promote international cooperation of the Digital Earth vision, and enable Digital Earth technologies to play key roles in, *inter alia*, economic and socially-sustainable development, to promote information technology and to reduce digital gap.

International Society for Digital Earth will play key role in different aspects of using natural resources, optimizing environment, protecting cultural heritage, improving disaster mitigation ability, global change study, natural resource conservation and improvement of living standards.

– **ISDE Executive Committee Board**

The Executive Committee Board consists of 24 scientists from 17 countries and international organizations.

– **Series Symposia on Digital Earth**

The International Symposium on Digital Earth is held every odd year and the Digital Earth summit is convened every even year. From 1999 to 2009, six international symposia on digital earth and two digital earth summits have held in seven different countries on various continents. In 2010, another Digital Earth Summit will be held in Bulgaria, and the Symposia series is also now well established, with the next one scheduled to be held in Perth, Australia in 2011.

– **International Journal of Digital Earth**

The International Society for Digital Earth (ISDE), in cooperation with Taylor & Francis Group launched its official journal *International Journal of Digital Earth (IJDE)* in March 2008. IJDE is a quarterly journal. So far, 10 issues (including a supplement) have been published.

IJDE has been indexed and abstracted in Science Citation Index Expanded.

**Contacts:**
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IJDE Editorial Office:
E-mail: ijde@ceode.ac.cn,
Website: http://www.tandf.co.uk/journals/titles/17538947.asp

## 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, and environmental monitoring. The main tendency of research activity is to implement the advanced digital technologies, terrestrial 3D laser scanning, 3D modelling, GIS and GPS technologies. Besides, the academy took an active part in implementing GLONASS/GPS project including19 reference stations established on the territory of Novosibirsk Region.

SSGA together with ITE Siberian Fair are the organizers of the international exhibition and scientific congress **"GEO-Siberia", t**he first exhibition experience beyond the Urals representing also innovative developments oriented to Siberia subsurface use. Various companies exhibit their highly specialized equipment and there is nothing like it on the Siberian market. **"GEO-Siberia"** demonstrated the growing interest to this event not only in Russia but abroad too. It has gained a merited recognition among professionals of geo-industry and become an example of collaboration of professionals and scientists from the whole world.

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THE SIX INTERNATIONAL EXHIBITION AND SCIENTIFIC CONGRESS
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– **The International Society for Digital Earth (ISDE)**
– **Siberian State Academy of Geodesy (SSGA), Russian Federation**
– **Siberian Regional EMERCOM Center**

The international workshop intends to discuss current measures for early warning and disaster and emergency management of technogenic and natural character, as well as their dynamics, liquidation and damage assessment. Key issues to be discussed include:

– Geoinformation Technologies for Early Warning and Crisis and Emergency Management. Crisis/Disaster Situations. Natural and Technogenic Risks
– **Hi-Tech Safety Technologies**
– **Security Management Systems**
– **Ecological Safety and Environment Protection**
– **3D Modelling for Industrial Safety of Hazardous Industrial Facilities**
– **Space Monitoring and Prevention of Emergency Situations**
– **Monitoring Based on Geodetic and Geologic Sensors / Methodologies**
– **Advanced Approaches to Improve Early Warning**

- **Crowdsourcing of Geographic information for Early Warning and Emergency Management**
- **Integration of Public Administraation and Volunteers Geographic Informamtion.**

## ORGANIZING COMMITTEE

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| | |
|---|---|
| Prof. Dr. **Milan Konecny** | Immediate Past President of International Cartographic Association (ICA), Chairman of ICA WG “Cartography on Early Warning and Crises Management”, Vice President of International Society for Digital Earth (ISDE), Czech Republic |
| Prof. Dr. **Dmitry V. Lisitsky** | Head of the Department of Cartography and Geoinformation, Siberian State Academy of Geodesy (SSGA), Russian Federation |

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| **Valery I. Tereshkov** | Deputy Head of the Siberian Regional EMERCOM Center, State Councellor 3d Class of the Russian Federation |
| **Ivan A. Ryzhenkov** | Deputy Assistant, FGU “Centre for Civil Defense, Emergency Situations and Fire Protection Measures for Novosibirsk Region”, Russian Federation |
| Prof. Dr. **Vladimir Tikunov** | Laboratory of Integrated Mapping and Laboratory of Sustainable Development of Territories, Faculty of Geography, M. V. Lomonosov Moscow State University, Russian Federation |
| **Alexander V. Koshkarev**, PhD | Leading Researcher, Institute of Geography of SB RAS, Russian Federation |

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| Assoc. Prof. **Yury S. Shcherbakov**, PhD | Department of Life Safety, Siberian State Academy of Geodesy (SSGA), Russian Federation |

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Novosibirsk, ITE Siberian Fair

# TECHNICAL PROGRAMME

<table>
<tr><th colspan="2">Wednesday, 28 April 2010</th><th></th></tr>
<tr><td rowspan="5">Wednesday<br>28 April 2010<br>10:30–17:00<br>Siberian Fair<br>Hall 1</td><td colspan="2">Session I</td></tr>
<tr><td>Chairs:</td><td>Prof. Dr. Milan Konecny, Immediate Past President of International Cartographic Association (ICA), Vice President of International Society for Digital Earth, Masaryk University, Czech Republic<br>Prof. Dr. Dmitry V. Lisitsky, Head of the Department of Cartography and Geoinformation, SSGA, Novosibirsk</td></tr>
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<tr><td colspan="2">Rapporteur:<br>Prof. Dr. Milan Konecny (Immediate Past President of ICA, Vice President of ISDE, Czech Republic):<br>Early Warning and Crises Management Agenda: Regional Aspects<br><br>V.N. Shumilov, A.M. Dikerman (Department for Emergencies and Mobilization Activities, Novosibirsk, Russian Federation), V.A. Seredovich (Siberian State Academy of Geodesy, Russian Federation):<br>Threat Reaction System and Emergency Services of Novosibirsk City in Natural and Man-Made Emergency Situations<br><br>Prof. Dr. Ammatzia Peled (Second Vice President of ISPRS, Israel):<br>ISPRS Test on User-defined Mapping Products for Disaster Management</td></tr>
</table>

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|---|---|
| | Em Prof. **Shunji Murai** (Institute of Industrial Science, University of Tokyo, Japan):<br>**Can We Predict Earthquakes with GPS Data?**<br><br>Em. Prof. **Gottfried Konecny** (Leibniz University of Hannover, Germany):<br>**Some Observations on the Use of Remote Sensing and GIS in Catastrophic Events**<br><br>Prof. Dr.-Ing. **Wolfgang Reinhardt** (University of Bundeswehr Munich, Institute of Geoinformation and Land Management, Germany):<br>**Early Warning for Land Slides - Approaches and Status**<br><br>**Alexander P. Karpik** (Siberian State Academyof Geodesy, Russian Federation), **Nikolai I. Stefanenko** (JSC RusHydro's Sayano-Shushenskaya HPPnamed after PS Neporozhniy, Russian Federation):<br>**The Assessment of Sayano-Shushenskaya HPP Arch-Gravity Dam After the Accident on August 17, 2009**<br><br>Dmitry V. Lisitsky, Stanislav Yu. Katsko, Alexey A. Kolesnikov, Pyotr Yu. Bugakov **(Siberian State Academy of Geodesy, Russian Federation):**<br>Geoinformation in Crises Management<br><br>**A. A. Yevsyukov, V.V. Nicheporchuk, A.A. Markov** (Institute of Computational Modelling SB RAS, Krasnoyarsk, Russian Federation):<br>**Use of On-Line Geomodeling Means for Monitoring Emergencies in the Siberian Federal Area**<br><br>**V.V. Asmus, V.A. Krovotyntsev** (SRC "Planeta", Moscow), Prof. Dr. **Valery P. Pyatkin** (Head of Digital Image Processing Laboratory, Institute of Computational Mathematics and Mathematical Geophysics of SB RAS, Russian Federation):<br>**Space Monitoring of the Arctic and Antarctic Ice Fields**<br><br>**V.A. Seredovich, A.V. Seredovich** (SSGA, Russian Federation):<br>**The Creation of Hazardous Facilities 3D Safety Data Sheet**<br><br>**V.M. Lazarev** (Tomsk State University of Architecture and Building, Russian Federation):<br>**Development of Geoecological Monitoring System for Early warning on Soil Slip Processes Activation Aimed to Provide Geoecological Safety for Urbanized Areas**<br><br>**Viktor N. Makeev, Oleg S. Sizov** (Tyumen State University, Research Institute of Ecology and Natural Resource Management, Russian Federation):<br>**Analysis of Usage Methodological Progress of Modern Sciences (Geography, Biology, and Ecology), Applied Mapping and Earth Remote Sensing Methods to Create a Regional Monitoring System**<br><br>**Sergei Serebryakov, Vladimir Gusev, Yulia Zraenko** (FGUP "Uralgeoinform", Russian Federation):<br>**Experience of Creating Geoinformation System for Emergency Management in Sverdlovsk Region** |

<table>
<tr><td></td><td colspan="2">N.A. Ustinov (INTERGRAPH SWEDEN, Moscow, Russian Federation):<br>The Intergraph Solutions for Emergency Mapping in Post-Crisis Assessment and Disaster Response Planning<br><br>Gennady A. Gienko (University of Alaska Anchorage), James P. Terry, National University of Singapore):<br>Geovisualization and Exploratory Analysis of Tropical Cyclone Tracks in the South Pacific</td></tr>
<tr><td colspan="2">Thursday, 29 April 2010</td><td></td></tr>
<tr><td rowspan="5">Thursday<br>29 April 2010<br>10:30–14:00<br>Siberian Fair<br>Hall 1</td><td colspan="2">Session 2</td></tr>
<tr><td>Chairs:</td><td>Prof. Dr. Milan Konecny, Immediate Past President of International Cartographic Association (ICA), Vice President of International Society for Digital Earth, Masaryk University, Czech Republic<br>Prof. Dr. Dmitry V. Lisitsky, Head of the Department of Cartography and Geoinformation, SSGA, Novosibirsk</td></tr>
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<tr><td colspan="2">Rapporteur:<br>G.I. Kulakov (Institute of Mining SB RAS, Russian Federation):<br>Crises and Emergency Situations Concerned with Coal and Gas Outbursts on the Kuzbass, Karaganda and Donbass Basins Mines<br><br>Vasili S. Bartosh (Institute of Automation and Electrometry SB RAS, Russian Federation):<br>Virtual Reality: New Approaches to Training Rescue Personnel<br><br>Igor N. Zlygostev, V. M. Gruznov, B.G. Titov, A.V. Savluk (Trofimuk Institute of Petroleum, Geology and Geophysics SB RAS, Russian Federation):<br>Equipment for Accident Rescue Operations on Reservoirs<br><br>Vladimir I. Medvedev, Igor O. Teslenko, Elena A. Kalinichenko (Siberian Transport University, Russian Federation):<br>New Emergency Cards for the Prevention and Liquidations of Extreme Situations with Dangerous Goods on the Railway</td></tr>
</table>

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| | Konstantin P. Koutsenogii **(Institute of Chemical Kinetics and Combustion of SB RAS),** Galina A. Ivanova **(V.N. Sukachev Institute of Forest SB RAS, Krasnoyarsk),** Lyudmila K. Trubina **(Siberian State Academy of Geodesy, Russian Federation):**<br>**Gas and Aerosol Emissions From Forest fires in Russia: Impacts on Chemical, Radiochemical and Optical Qualities of Atmosphere, Carbon Cycling, Radioecological Consequences, and Biocenosis Sustainability**<br><br>**V.N. Mikheev, Viktoria A. Otroshchenko (**Federal Consumer Rights and Human Welfare Supervision Service for Novosibirsk Region, Russian Federation), **Viktor S. Pisarev, Yaroslava G. Poshivailo, Svetlana S. Dyshlyuk** (Siberian State Academy of Geodesy, Russian Federation):<br>**GIS Technologies in the Social Health-Related Territory Monitoring System**<br><br>**Anatoli Y. Gienko (**SKTB "NAUKA" SB PAS, Krasnoyarsk), **Leonid A. Plastinin, Vladimir P. Stupin** (Irkutsk State Technical University, Russian Federation):<br>**Operative Remote Monitoring of Angarski Region in Interests of Maintenance of Rational Wildlife Management and Efficient Control**<br>**Vladimir A. Seredovich, Alexey V. Dubrovskiy** (Siberian State Academy of Geodesy, Russian Federation):<br>**The Forecast of Technogenic and Natural Threats Connected with Exploiting of the Novosibirsk Water Basin**<br><br>**Irina N. Rotanova** (Institute for Water and Environmental Problems SB RAS, Russian Federation): **Geoinformation Technologies and Mapping for Prevention and Assessment of Natural and Ecological Risks (Altai Krai as a Case Study)**<br><br>**Leonid A. Plastinin, Vladimir P. Stupin, A.V. Koptev,** (Irkutsk State Technical University, Russian Federation):<br>**Methodological and Methodical Bases of the Ecological Forecast of Influence of Angarsk Water Basins on the Environment**<br><br>**Anatoli Y. Gienko** (SKTB "Nauka" SB RAS, Russian Federation):<br>**Problems of the Operative Monitoring of Natural Environment in the Area of Influence of Cascade of Hydrotechnical Buildings on Angara**<br>**L.A. Bezrukov** (V.B. Sochava Institute of Geography SB RAS),<br>**M.V. Kornyakov, S.J. Krasnoshtanov (**Irkutsk State Technical University, Russian Federation):<br>**Technogenic and Anthropogenous Estimation of Influence and Economic Damage for Environment of the Irkutsk Region (on the Example of Boguchany Hydroelectric Power Station)**<br><br>**I.S. Koshechkin, V.V. Chernov, A.A. Yakimov** (ESF "Goszemkadastr-syomka" VISHAGI, Russian Federation):<br>**Monitoring of Negative Influence of Waters on the Waterside Area of the Bratsk Storage Pool** |

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|---|---|
| | **Yu. S. Shcherbakov** (Siberian State Academy of Geodesy, Russian Federation):<br>**Use of Geoinformational Mapping for Emergency Management**<br><br>**S. Zaichenko** (ScanEx, Moscow, Russian Federation):<br>**“WebGis” for Real-Time Emergency Monitoring**<br><br>**S.I. Mikhailov** (ScanEx R&D Center, Moscow, Russian Federation):<br>**Space Emergency Monitoring System: Approaches and Technologies**<br><br>**Vladimir P. Stupin, A.A. Karatsay, N.Yu. Lahman,** (Irkutsk State Technical University, Russian Federation):<br>**Technique of Mapping of Exogenous Geodynamics of the Zone of Influence of Water Basins of the Angara Cascade in the Light of Concept Morphosystems**<br><br>**E.R. Semakova, S.I. Klimov** (Hydrometeorological Research Institute, Uzbekistan):<br>**About Possibility of Geographical Information Systems Using for Spatial Pattern Assessment of Avalanching Frequency** |
| Thursday<br>29 April 2010<br>10:30–14:00<br>Siberian Fair<br>Hall 1 | **Poster Session** |
| | Rapporteur:<br><br>**V.M. Lazarev** (Tomsk State University of Architecture and Building, Russian Federation):<br>**Statistical Modeling Capabilities for Accuracy Estimation of Geodetic Observations in Geomonitoring System for the Early Hazard Activation Warning of Natural and Man-Made Processes**<br><br>**Irina E.Kurbatova** (Water Problems Institute RAS, Russian Federation), **Dmitry V. Gorbachyov** (Moscow State University of Geodesy and Cartography, Russian Federation):<br>**The Experience of Using Animation Cartography for Disastrous Flood Investigations**<br><br>**A.V. Koptev, Boris N. Olzoev** (Irkutsk State Technical University, Russian Federation):<br>**Statement of Research Problems of Dynamics of the Condition of the Environment in the Zone of Influence of Angarsk Water Basins on Cartographical and Space Materials**<br><br>**Nadezhda Yu. Kurepina** (Institute for Water and Environmental Problems, SB RAS, Russian Federation):<br>**Experience in Nosogeographical Mapping of Altai Krai for Natural Risks Management**<br><br>Alexey V. Dubrovskiy **(Siberian State Academy of Geodesy Russian Federation):**<br>**Geoinformational Space Research of the Megalopolis for the Prevention of People’s Life Threats** |

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| | **I.N. Rotanova, O.V. Lovtskaya, V.G. Vedukhina, Yu.M. Tsimbaley** (Institute for Water and Environmental Problems SB RAS, Russian Federation):<br>**Cartographical Mapping for Provision of Hydroecological Safety in the Ob Basin** |

## TABLE OF CONTENTS

CAN WE PREDICT EARTHQUAKES WITH GPS DATA?

**Shunji MURAI, Japan**
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**Keywords:** GPS, Earthquake prediction, Triangle networks, Daily area change

**Abstract**

Prediction of earthquakes using GPS remains an unsolved but important problem. Pre-signals in terms of changes in triangular networks of GPS Stations were examined for many large earthquakes in Japan and in other Asian regions. I discovered that the occurrence and location of an earthquake can be predicted with pre-signals found in GPS data analysis. However, more research is required to predict how many days after the pre-signals an earthquake will occur.

## 1. Introduction

The prediction of earthquake is one of science's most difficult problems. Japan is an earthquake-prone country; 162 big earthquakes with magnitude more than ML6 in Richter scale for eight years from January 2000 to the end of 2007.

Much research on earthquake prediction has therefore been carried out, but without success.

## 2. Method of prediction

A new method of GPS Network Triangles has been developed by the author around 2000 when Geographic Survey Institute (GSI), Japanese Government constructed 5m high towers with GPS antenna for monitoring movements of crust. There are about 1,200 GSI GPS stations (so called electronic control point) all over Japan of which data are opened to public through Internet. Figure 1 shows an example of GSI GPS Station and Figure 2 shows the distribution of GSI GPS Stations. Figure 3 shows 162 earthquakes with more than M6 for 2000–2007.

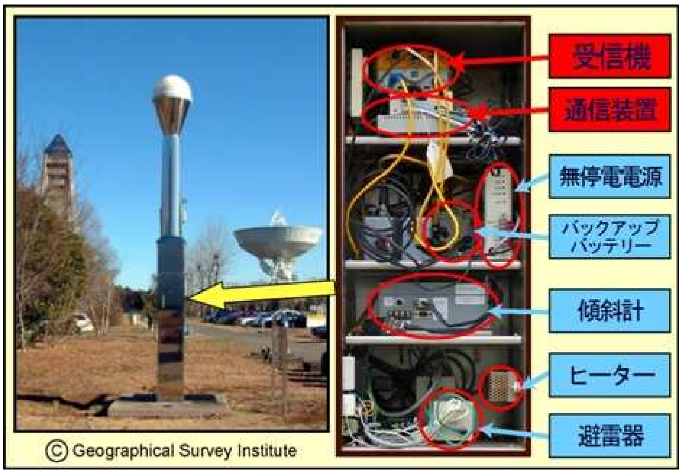


Figure 1. GSI GPS Station with 5m high tower

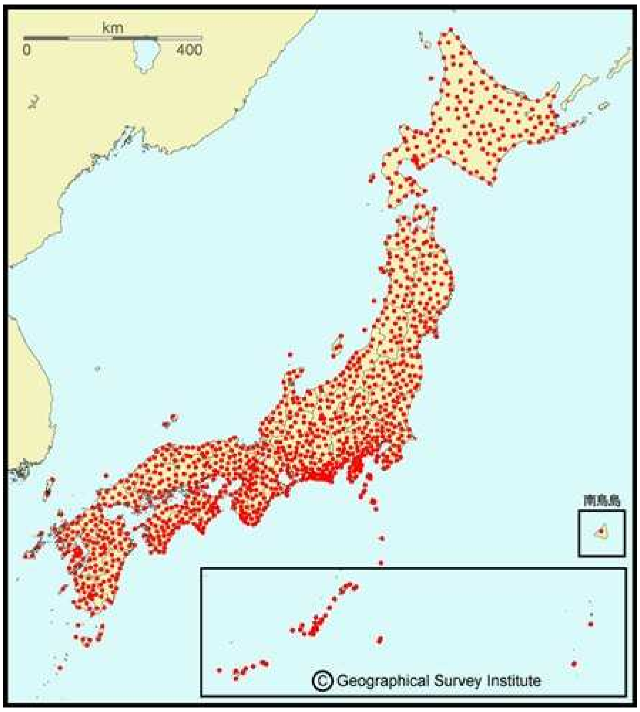


Figure 2. Distribution of GSI GPS Stations in Japan

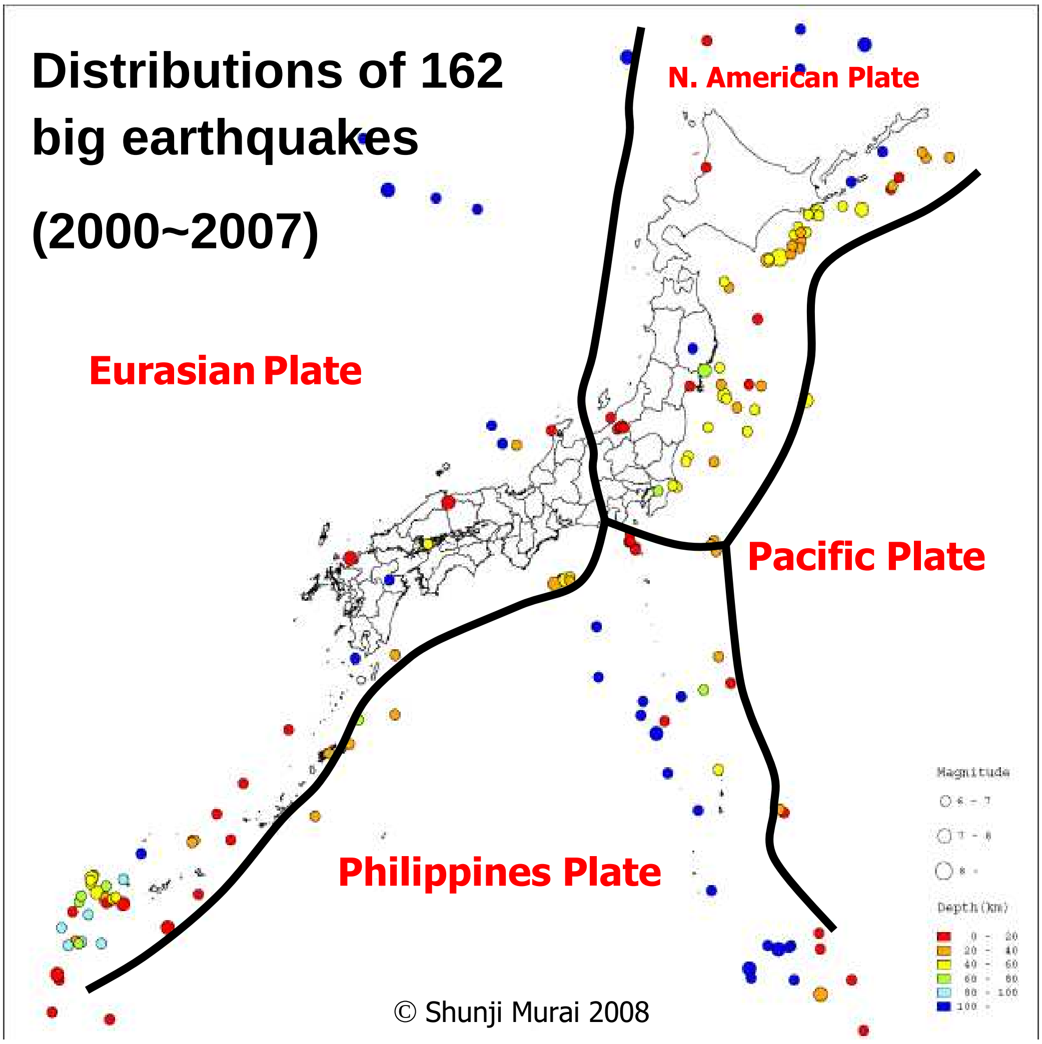


Figure 3. Distribution of big earthquakes with more than M6 2000-2007

The selection of GPS Stations for triangle network for the prediction is based on rather coarse interval (say 20-50km) because triangle crossing different plates would be more important. Triangles are formed basically with all possible combinations of those selected GPS Stations regardless of distance, but from the validation research sponsored by Tokyo Electric Power Service Company (TEPSCO), 6.590 triangles in Japan are selected and checked whether daily change of triangle area exceeds a threshold or not. All of the above mentioned 162 big earthquakes showed pre-signals 1 to 90 days in advance to each earthquake depending on type of earthquake. It proved that we can predict the occurrence and the location of earthquake but cannot predict yet the pinpoint day of the occurrence.

Concerning overseas earthquakes we don't have dense GPS stations except GPS stations provided by International GPS Service (IGS). Nevertheless our method showed pre-signals of the past big earthquakes from very coarse IGS GPS stations selected near the epicenter. Several evidences of those big earthquakes are introduced in this paper.

## 3. Validation

Those earthquakes occurred after the construction of GSI GPS Stations, have been checked whether pre-signals existed or not. The following big earthquakes with serious damages were checked more carefully as samples, though only three of them are introduced here.

Miyagi Offshore Earthquake, M7.1, 26 May 2003, North American Plate
Tokachi Offshore Earthquake, M8.0, 26 September 2003, North American Plate
Niigata-Chuetsu Earthquake, M6.8, 23 October, 2004, North American Plate
West Fukuoka Offshore Earthquake, M7.0, 20 March 2005, Eurasian Plate
Noto Peninsula Offshore Earthquake, M6.9, 25 March 2007, Eurasian Plate

Pre-signals were found in not only in small triangles near the epicenter but also very big triangles which overlay in different plates with several thousands kilometers apart.

Tokachi Offshore Earthquake was the biggest one with M8.0 during the period with no death but oil tanks broken. Figure 4 showed a typical pre-signal found a week before the occurrence in a triangle which is located near the epicenter.

Miyagi Offshore Earthquake showed several pre-signals before the earthquake; 29days before, 23 days before, 15 days before, 13 days before, 12 days before and a day before. The biggest pre-signals were found 23 days before in 1944 triangles while pre-signals were found a day before in 178 triangles as shown in Figure 5. Figures 6 show four cases of Noto Peninsula Earthquake; 24 days before, 21 days before, 17 days before and a day before where x mark shows the epicenter and red lines show triangles including the epicenter and blue lines show triangles which do not include the epicenter. It would be a surprise to realize that many of triangles were so big to range between different plates. Most of triangles were red which means they are closely related with the epicenter.

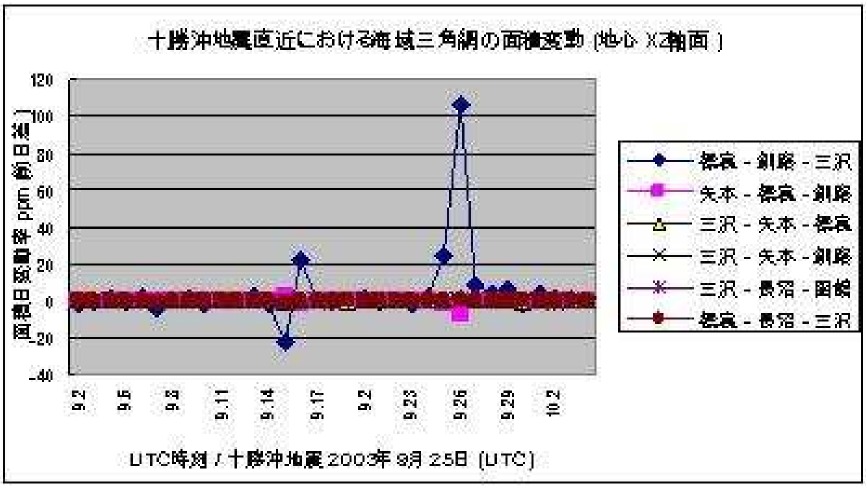


Figure 4. Pre-signal of Tokachi Earthquake

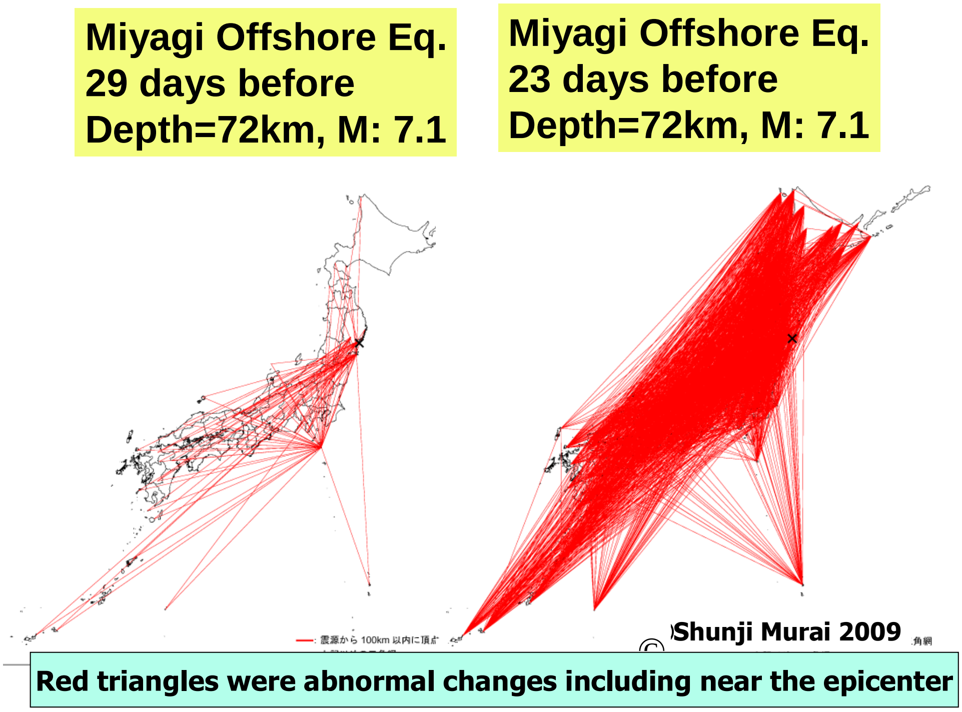


Figure 5/ Pre-signals of Miyagi Offshore Earthquake, a) 29 days before, b) 23 days before

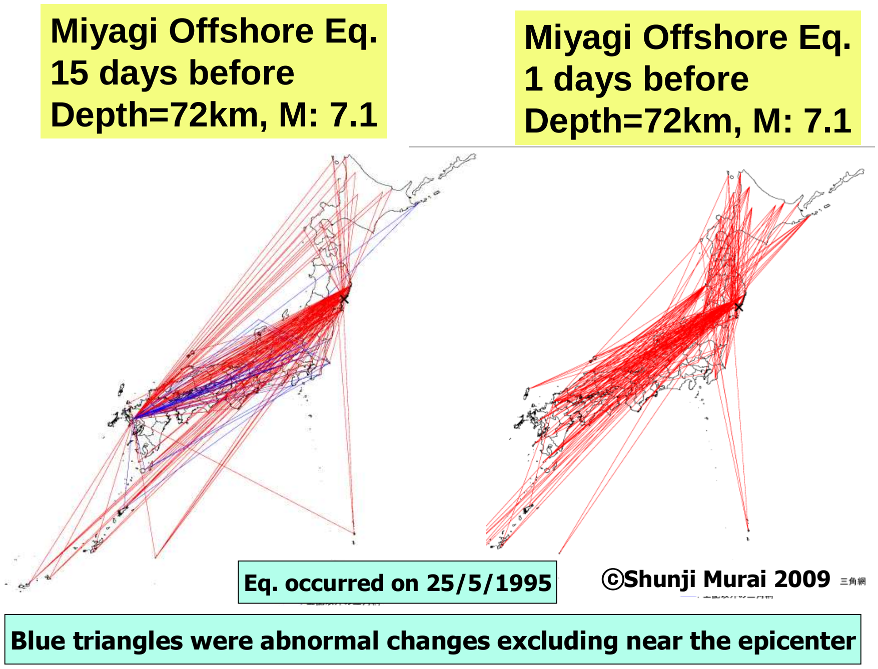


Figure 5/ Pre-signals of Miyagi Offshore Earthquake, c) 15 days before, d) 1 day before

As compared with Miyagi offshore Earthquake which is considered as the type of Inner Plate Type, Noto Peninsula Earthquake regarded as Inner Land Type showed a little different behavior as shown in Figure 6. Except a day before, pre-signals were found also in those triangles which do not include the epicenter.

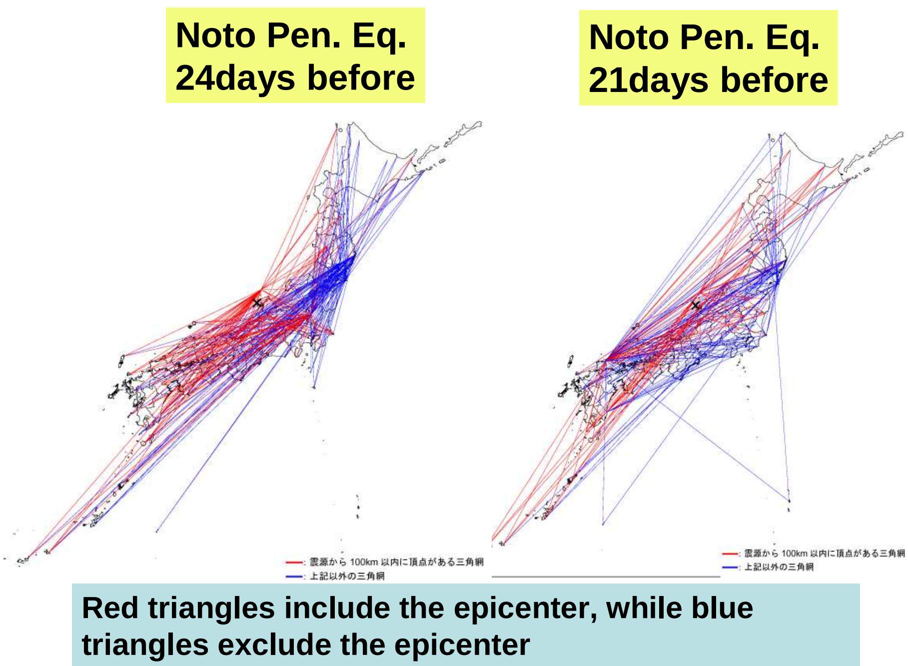


Figure 6. Pre-signals of Noto Peninsula Earthquake, a) 24 days before, b) 21 days before

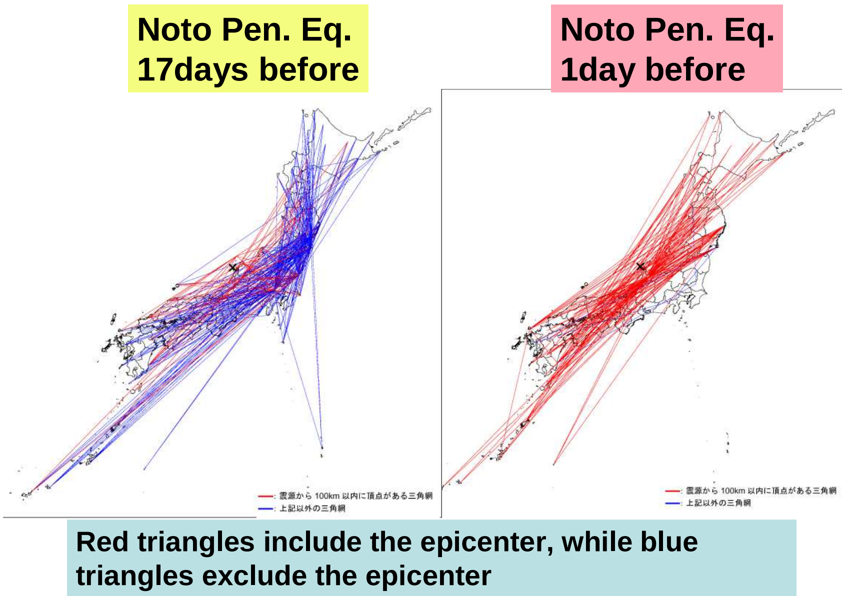


Figure 6. Pre-signals of Noto Peninsula Earthquake, c) 17 days before, d) 1 day before

## 4. Sumatra Offshore Earthquake with Asian Tsunami

Asian Tsunami triggered by Sumatra Offshore Earthquake (M9.0) occurred on 26th December 2004 lost about 300,000 victims which will be the worst record in these days. We selected 10 IGS GPS Stations surrounding the epicenter as follows.

1) Bako: Cibinong, Indonesia: E: 106.8500, S: 6.4910
2) Ban2: Bangalore, India: E: 77.5116, N: 13.0343
3) Coco: Cocos Island, Australia: E: 96.8339, S: 12.1883
4) Dgar: Diego Garcia Island: UK Territory: E: 72.3702, S: 7.2696
5) Hyde: Hyderabad, India: E: 78.5509, N: 17.4172
6) Iisc: Bangalore, India: E: 77.5704, N: 13.0211
7) Kunm: Kunming, China: E: 102.7972, N: 25.0295
8) Lhas: Lhasa, China: E: 91.1040, N:29.6573
9) Mald: Maldives: E: 73.5263, N:4.1886
10) Ntus: Singapore: E: 103.6799, N 1.3458

I checked all possible combinations of triangles which are formed by those IGS GPS Stations whether any triangle exceeds a threshold or not in the daily change ratio of triangle area in XY, XZ and YZ plane. There was a drastic daily change of -1.2 ppm in YZ plane in the triangle of ntus-kunm-lhas from the 18th December 2004, 8 days before the earthquake as shown in Figure 7. There was also big change of -0.04, 0.05 and -0.05 ppm in XZ plane in the triangle of bako-ntus-lhas on the 21st, 22nd and 23rd December 2004, 3 to 5 days before the earthquake. Though the distance between ntus (Singapore) near the epicenter and lhas (Lhasa) or kunm (Kunmin) is so far, such pre-signals are found. We realize that the earth is so complicate in the crustal movement. It would be possible to make early warning of such big earthquake.

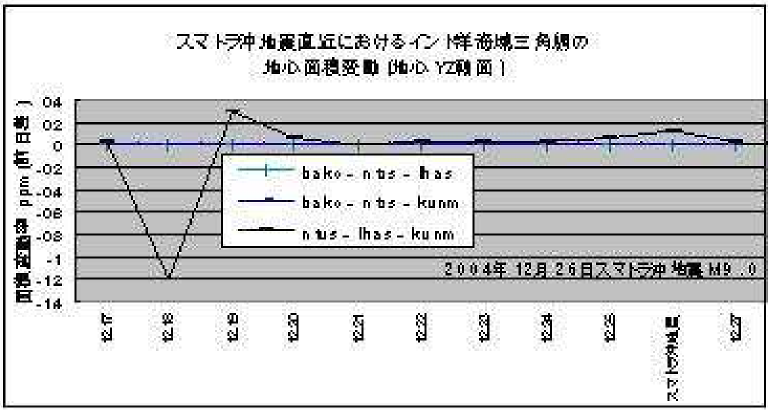


Figure 7. Pre-signals of Sumatra Earthquake in YZ Plane

### 5. Pre-signals of Wenchuan Earthquake

Wenchuan Earthquake occurred in Sichuan Province, China on the 12th May 2008 killed about 60,000 and damaged huge number of houses, roads, structures etc. There are only four IGS GPS Stations available surrounding the epicenter; Wuhan (WN), Xian (XN), Kunmin (KN) and Lhasa (LS). The epicenter and these four GPS Stations are shown in Fig. 8. and Fig. 9 shows the XZ plane in which the triangle connecting Lhasa, Xian and Wuhan showed 3 sigma abnormalities on the 6th May 2008, 6 days before the earthquake. This triangle includes the epicenter of the Wenchuan Earthquake. Though this triangle is so large with the longest side of more than 2000km, it would be valuable to know in advance around where an earthquake may happen within a critical triangle area.


Figure 8. Location of Epicenter and Four GPS Stations

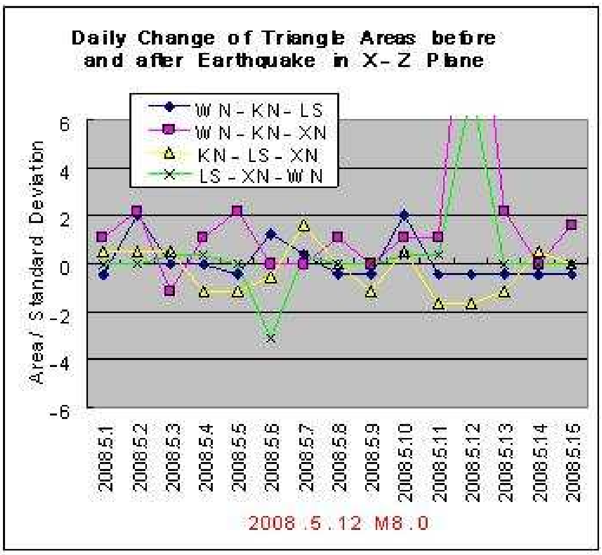


Figure 9. Pre-signals of Wenchuan Earthquake

## 6. Conclusion

The author have checked many earthquakes with more than M6 mainly in Japan with data from GSI GPS Stations plus some in Asia with limited number of IGS/SOPAC GPS Stations. I found pre-signals from GPS data before those earthquakes. Some examples are shown in this paper. It would be possible to predict the occurrence and the location of the epicenter. But it needs some more research to make better prediction about the day of the occurrence. So far, the range of the prediction will be 1 to 90 days before.


## Acknowledgement

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**Note of contributor**

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# SOME OBSERVATIONS ABOUT THE USE OF REMOTE SENSING AND GIS IN CATASTROPHIC EVENTS MITIGATION

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## 1. Introduction

Catastrophic Events are unexpected disasters threatening the environment and human beings dependant on their living space. Imaging systems from the air and from space have traditionally been able to record such events quickly, so that it became possible to offer relief from the effects of the disaster. While aerial imaging using conventional optical systems requires suitable flight conditions in cloud-free daylight conditions, optical sensors can be supplemented by thermal and microwave systems operating at night or through clouds in special cases.

Aerial sensors suffer from the inability to cover large areas on a worldwide scale. Present satellite offers a suitable possibility to image remote disaster areas quickly. Meteorological satellites at 1km resolution permit to image cloud free global scenes at half hour intervals, while 1m or 0.5m high resolution satellites need to be targeted to cover limited specific areas, permitting to cover a particular disaster site only.

Depending upon the type of disaster different image resolutions are required:

– Cyclones may already be monitored with coarse resolutions of 1 to 10km, and so are areas affected by drought.

– Floods can be monitored with 10m resolution images, while effects of earthquakes and human caused disasters require images by high resolution satellites.

## 2. International Charter “Space and Major Disaster”

The Space Agencies of Europe, France, Canada, India, the USA and of Argentina have offered their imaging capabilities to the United Nations, if a disaster is officially declared. This entails targeted image acquisition and processing of the imagery for the use in disaster mitigation. This includes the entire technical processes of sensor calibration, georeferencing, modelling, analysis archival and delivery of data during the process to transform raw data into information.

This data delivery system has proved to be very effective. In te case of the Sumatra tsunami the German Space Center DLR has provided 40 analysis products and maps of the tsunami affected areas within two weeks alone for the mitigation of post event effects.

Other German agencies, like the Geo Research Center in Potsdam has concentrated on developing an integrated system for the early warning of Tsunamis after an earthquake consisting of seismometers, tidal stations, pressure gauges, GPS buoys working in real time networks for the rapid determination of risk areas and evacuation plans. It is clear that such a system can only work within an established infrastructure to be internationally established with the mutual consent and the concerned nations.

### 3. Past Natural Disasters in Historic Times

Past historical records, shown here as incomplete examples, demonstrate that almost all continents have suffered from severe disasters:

- The Yellow River Flood 1967 in China, which killed 1 million people
- The tidal wave of 1737 in the Bay of Bengal with 300 000 dead
- The Galveston tidal wave 1899 in Galveston, Texas, which killed 60 000 people
- The Lisbon Tsunami of 1755, which resulted in the loss of 10 000 lives
- The Indian Ocean Tsunami of 2004 with a death toll of 100 000
- The Etna Volcanic Eruption of 1669, killing 100 000 people
- The Martinique volcanic eruption killing 30 000 humans.
- Even Central Europe suffered severe earthquake damages in the 15th century in the City of Basel.

### 4. Causes and Effects of Natural Hazards

A number of statistical studies have been internationally made identifying the impacts of the nature of catastrophic events with respect to:

damage:

- 32 % caused by floods
- 30 % caused by tropical storms
- 22 % caused by drought

number of persons affected:

- 33 % caused by drought
- 32 % caused by flood
- 30 % caused by tropical storms

Number of deaths:

- 26 % caused by floods
- 19 % caused by tropical storms
- 17 % by epidemics
- 13 % by earthquakes (as seen recently in Turkey, Pakistan, China and Haiti).

### 5. Studies by EMERCOM in the Russian Federation

In the Russian Federation the Ministry EMERCOM has been very effective in providing materials for disaster mitigation and in analyzing the causes of disasters within the territory of the Russian Federation:

According to these studies the causes for natural disasters in Russia are as follows:

- Floods 35 %
- Storms 19 %
- Torrents 14 %
- Earthquakes 8 %

| | |
|---|---|
| – Landslides | 5 % |
| – Snowfalls | 5 % |
| – Frosts | 3 % |
| – Avalanches | 2.5 % |
| – Droughts | 2 % |
| – Thunderstorms | 1 % |

With respect to the natural disasters, not to be ignored are the human caused technical disasters, which amount to a total of about 50 % of the damages caused.

The number of human caused disasters per year in the Russian Federation in the late 1990´s was:

| | |
|---|---|
| – Building accidents | 277 |
| – Industrial accidents | 244 |
| – Big truck accidents | 104 |
| – Life support infrastructure | 83 |
| – Explosions in populated areas | 60 |
| – Pipeline accidents | 80 |
| – Chemical accidents | 80 |
| – Air crashes | 26 |
| – Ship accidents | 20 |
| – Railway accidents | 22 |

Human induced hazards refer particularly to:

- Nuclear power plants
- Chemical hazards
- Industrial fires
- Pipelines
- Transport
- Dam breaks
- Municipal construction
- Energy and water supply
- Subsidence by water, oil or gas extraction

It is evident, that all mentioned hazards are particular for a certain region.

In this respect danger zone maps have been prepared (e.g. for seismic dangers).

With regard to seismic dangers the most advanced monitoring system using permanent GPS receivers 10 km apart and seismic stations has been established in Japan.

EMERCOM´s strategy in disaster mitigation is remarkable with respect to that of other countries:

- It makes use of the existing map material
- It enhances the existing digital map data in form of a GIS with other thematic data (e.g. population distribution, evacuation routes, building stability)

– It is like directly to the armed forces, which have a centralized decision and implementation structure, which is lacking in developing countries.

## 6. Conclusion

Emercom posseses the desired Disaster Mitigation Infrastructure:

It has:

– A central emergency decision center
– Real time satellite imagery reception facilities
– Sensor networks
– GIS information of all endangered regions based on
– Digital topographic maps
– Population distribution maps
– Evacuation routes
– Building material maps
– A fire, contamination or accident reporting system
– Computer enhanced analysis capabilities.

In the international context we must conclude:

Technology, which we all have throughout the world, is easy, but Organization is difficult in most countries with very few exceptions.

# GEOVISUALIZATION AND EXPLORATORY ANALYSIS OF TROPICAL CYCLONE TRACKS IN THE SOUTH PACIFIC

**Gennady A. GIENKO**, University of Alaska Anchorage, **James P. TERRY**, National University of Singapore

**Abstract**

The paper illustrates application of geovisualization methods and tools for spatio-temporal analysis of tropical cyclones in the South Pacific region. Results of this study will be used to outline further strategy and tactics for advanced processing of cyclone track data using numerical statistical and data mining methods.

**Introduction**

The impacts of tropical cyclones on the environments of different types of islands across the tropical South Pacific region (TSPR) are not so well understood compared to hurricanes and typhoons in other regions (e.g. the Caribbean Sea and North West Pacific). There are many factors associated with the characteristics and behaviour of cyclones, such as their relatively frequent occurrence and the weather effects they bring (intense and prolonged rainfall, storm surge, violent winds driving large erosive waves). Scientists have invested considerable effort to uncover and understand the variability of cyclone characteristics associated with El Niño events, ocean warming and climate change. One important feature is cyclogenesis position and the subsequent spatio-temporal behaviour of cyclones in tropical areas of the South Pacific. Such information is hidden in thousands of records of cyclone tracks, containing various data from satellite measurements for more than 340 cyclones since 1970 till present times.

Analysis of a large data set (1969–2009) on tropical cyclone characteristics in the TSPR, recently provided by the Regional Specialized Meteorological Service (RSMC) in Fiji, requires careful and thorough (time-consuming) checking for errors and accuracy before analysis can begin. This can be done using a combination of manual checks, mathematical tools and GIS. Once corrections have been made, investigation can commence on long-term historical trends in tropical cyclogenesis positions (i.e. locations of origins); track length; storm duration; maximum intensity produced; cyclone decay position. This work is amongst the first of its kind on the RSMC data for the TSPR, and thus provides insight into geographical patterns and changing temporal variability, possibly climate-change driven, in tropical cyclone behaviour for this region. Such research is already continuing in other cyclone-prone oceans of the world (e.g. N. Atlantic, N. Pacific), but has lagged behind in the S. Pacific owing the previous non-availability of (authenticated) data. At this stage our research is focused on developing an advanced geo-visualization methodology for exploratory analysis of spatio-temporal patterns of cyclones, which can also be used to carry out more demanding mathematical studies of storm movement.

**Data Geovisualization**

Spatial data have a complex structure involving space, time, and a number of thematic attributes, which poses significant challenges to geovisualization. The geovisualization of spatial data requires the use of maps or 3D displays where at least two display dimensions are utilised to represent the physical space, which is different from information visualization dealing with abstract data spaces. This restricts the possibilities for the representation of the temporal and thematic components of the data. In modern geovisualization software, such data are represented using both traditional cartographic techniques based on the use of colours, textures, symbols, and diagrams; and using computer-enabled techniques such as map animation and interactive 3D views. Moreover, maps are used in combination with non-geographic visualization techniques such as scatterplots or parallel coordinates. The use of multiple interactively linked views providing different perspectives into the data has become a kind of standard in geovisualization. However, a number of problems have yet to be solved, such as the scalability of geovisualization tools and their usability.

Geovisualization is set of innovative methods and tools for visualizing geospatial data, processes, analyses, and models for synthesizing and understanding geospatial phenomena. Geovisualization is one of the main tools if advanced exploratory visual analysis, widely used by geographers and environmental scientists to outline strategy and tactics for further processing using numerical statistical and data mining methods. The main objective of this research is to investigate methods and tools of geovisualization for exploratory visual analysis of spatio-temporal patterns of tropical cyclones to uncover and explore general tendencies and trends in tropical cyclone numbers, frequencies, seasonality and other future projections associated with El Niño events, ocean warming and climate change.

There are many factors associated with the characteristics and behaviour of cyclones, such as their relatively frequent occurrence and the weather effects they bring (intense and prolonged rainfall, storm surge, violent winds driving large erosive waves). As mentioned above, cyclogenesis is one of the important characteristics of tropical cyclones. Several geovisualization techniques have been used to explore different aspects of cyclogenesis in the TSPR based on cyclone track analysis from RSMC (Nadi) data base. Figure 1 (left) illustrates genesis of tropical cyclones in relation to months of a year, azimuth of the cyclone movement, and sinuosity of a trajectory. Tropical cyclones in the TSPR have clear seasonal pattern – the cyclone season starts in October and lasts till April. To explore temporal patterns of track sinuosity over a number of years, this seasonal nature of the phenomena has been taken into account and used as a focus for geovisualization (Figure 1, right).

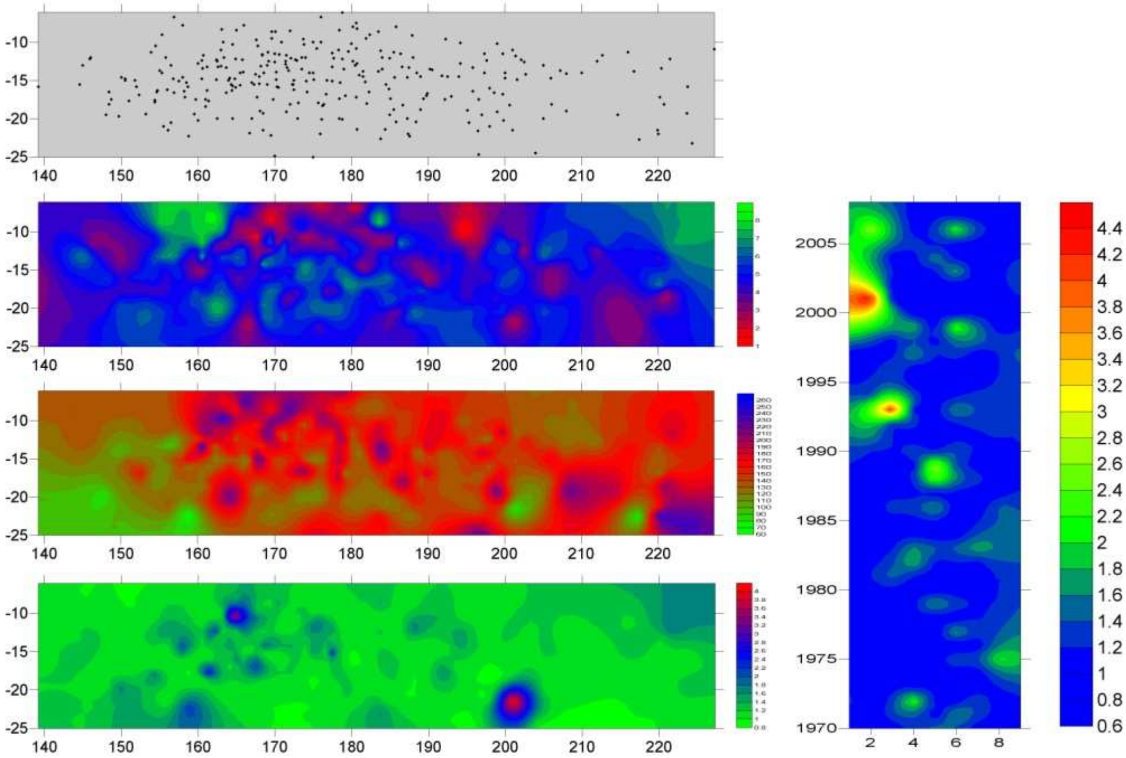


Fig. 1. Left, top to bottom: Genesis of tropical cyclones (on the top) in relation to months of a year, azimuth of the cyclone movement, and sinuosity of a trajectory (top to bottom, horizontal and vertical axes represent longitude and latitude, respectively). Right: Cyclic temporal analysis of sinuosity (horizontal and vertical axes represent months and years, respectively).

While the previous studies were aimed at analysis of the entire set of available data to uncover general spatio-temporal patterns in cyclone activity in the TSPR, in other analysis individual tracks were targeted for exploration of cyclone behavior. Figure 2 illustrates results of iterative polynomial fitting of track of TC Percy (2005). In this case an attempt was made to use polynomial coefficients as one of the characteristics of cyclone trajectories to be used for data mining using decision tree algorithms. Figure 3 serves as an illustration of 3D visualization of the same track (TC Percy, 2005) when another attribute (wind speed) was used as the third dimension. These analyses assume temporal nature of the phenomena but do not use the time component explicitly.

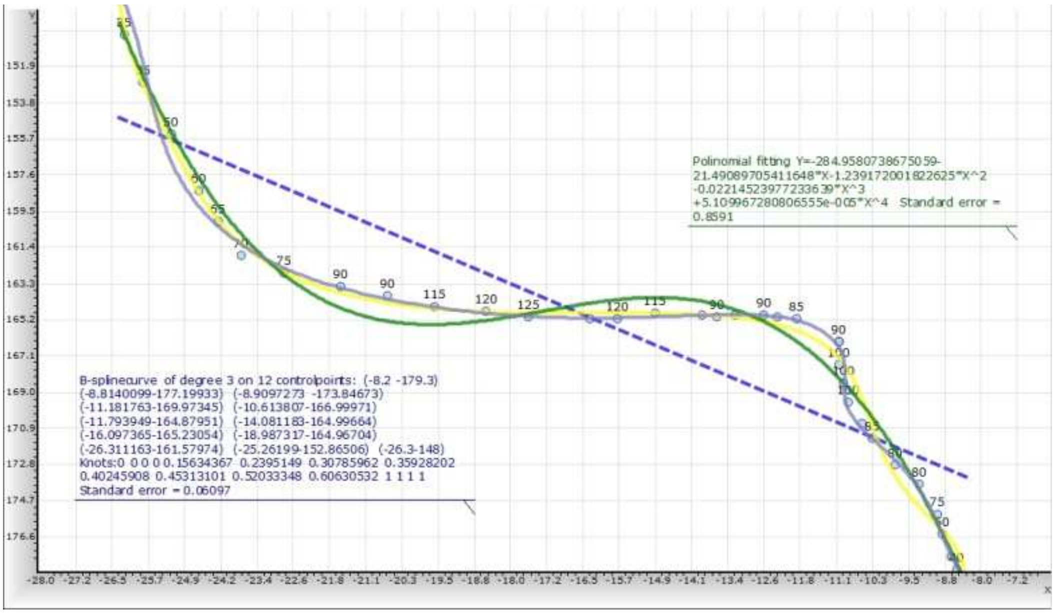


Fig. 2. Polynomial fitting of the track of tropical cyclone Percy (2005).

Fitting cyclone tracks using classical polynomial functions is not a trivial task as many cyclones have looping trajectories.

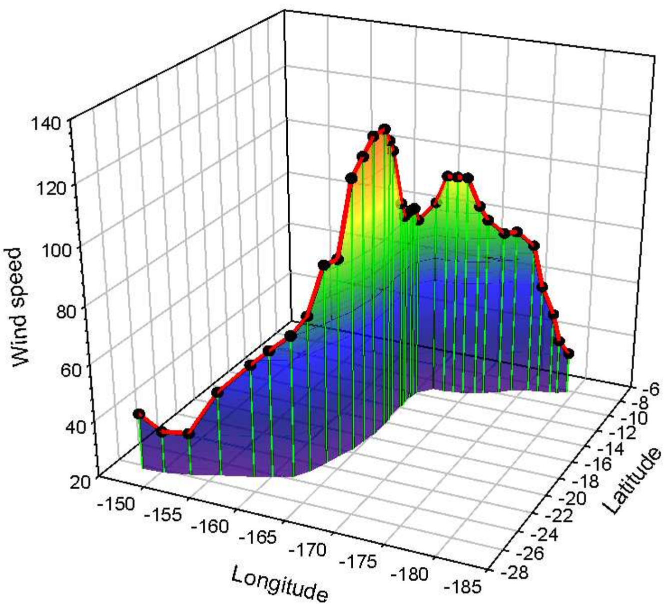


Fig. 3. 3D-visualization of cyclone Percy (2005) to explore correlation of spatial location and wind speed through all life phases of the cyclone (genesis, development, maturing and decay). Temporal behaviour can be implicitly reflected as cyclone location is recorded at certain time interval (6 or 12 hours).

**Conclusion**

The goal of this research was to explore the wide range of methods and tools of geovisualization for analysis of cyclones in the tropical South Pacific region. The first results were encouraging and allowed us to uncover and explore certain patterns and dependences in cyclone behaviour, and outline our further strategy in advanced data analysis using appropriate statistical and data mining methods.

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# GEOINFORMATION IN CRISIS MANAGEMENT

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The use of cartographic products, geoimages and geographic information systems in early warning and emergency management is considered.

One of the most important aspects of contemporary society's life activity is the warning, the adoption of measures to mitigate and eliminate the effects of various emergencies (crises).

According to the Federal Law of Russia № 68-FZ, "The emergency situation (ES) is a situation in particular area that has arisen as a result of an accident, natural catastrophes and disasters or other hazards that may cause or have caused victims, health or environment damage, significant material losses and people's life activity damages". [1]

Emergency situations are characterized by their diversity, the presence of endangered or affected people, significant economic damage and threat to natural environment, a large number of organizations and professionals involved in prevention of the emergency situation, a wide range of means used in warning and disaster management. They occur within a certain territory where the need for immediate people movement, goods, and equipment is caused. This makes the spatial aspect in crises management be the most important and causes the overriding necessity of spatial information (geoinformation).

Today geoinformation is used in any area of economy and society around the world, and spheres, forms and scales of its use are continually growing. Meeting the new society needs in the European Union, at the suggestion of the European Commission was created a system known as GMES (*Global Monitoring for Environment and Security*). This system is aimed at creating the basic and additional services for emergency management. The proper functioning of such services will depend on timely high-quality maps for situation analysis and visualization, modeling and interpretation of processes. Today GMES is working with four major types of maps: for early warning of emergencies, reference maps for the damage evaluation, as well as thematic maps [2].

In Russia, there is a need for the creation of subdivisions in the Ministry of Emergency Situations to be busy with population protection on a higher level. The disaster management, as well as early warning of their occurrence should be carried out using high-tech monitoring and disaster forecasting using space and aircraft engineering aviation technology, preventive measures, early population warning about emergencies and possible population evacuation from hazardous zones [3].

To provide all mentioned requirements are needed GI support for managerial decisions, availability of related GI used for situation analysis and visualization, modeling and interpretation of processes. Those people involved in decision making in humanitarian crises, natural or man-made disasters need the current electronic and digital maps which should be delivered in time by request. This is quite new paradigm that acts throughout the world and requires new cartographic knowledge based on innovative technologies.

Today there are a large number of different GIS in the world and Russia as well to be used in emergency management. They permit:

1. To receive and record the information on the real emergencies quickly and timely;
2. On-line tracking and visualization of forces and facilities, current situation and additional information;
3. To estimate the required forces and facilities, the disaster consequences, etc.;
4. To control the emergency tendency and measures for disaster response;
5. To forecast the emergency parameters and versions of its tendency using the tools of mathematical modeling as well as:

– To compute the motion parameters of front striking emergency factor, that is a width, a height and a speed;
– To carry out the terrain analyze in the most hazardous disaster areas;
– To determine the impact zone borders;
– To model the real emergency;
– To analyze the emergency and its consequences;
– To provide sufficient information for decision-making on population protection;
– To provide the visualization of large volumes of information for the purposes of high information sensing efficiency by decision-makers;
– To plan the course of operations, to develop any number of management decisions for choosing the optimal one and to implement the best overall operational control;
– To use the workplaces as a training complex [4, 5].

As regards the cartographic methods to be used in GIS for emergency management, we may visualize the following:

– Flood zones forecasting in by high floods and dam failures;
– Flood situations and flooding and underflooding process tendencies;
– Fire situation and its forecasting on the forested areas;
– Anthropogenic soil and water contamination;
– Phytosanitary condition of agricultural and forest vegetation;
– The condition and avalanching dynamics;
– The propagation of industrial emissions into the atmosphere and the smoke air pollution;
– Man-made soil disturbances and natural landscape destructions;
– River bed and ravine erosion-processes evolution;
– Accidental oil spills and petroleum products from oil-trunk pipelines.
– The forest fire impact assessment;
– The impact assessment of hurricanes;
– The impact assessment of chemical accidents;

– The accidental detonation assessment of fuel-air mixtures;

– The route determination for the evacuation, delivery of rescuers, medicine, food, and victims, as well as the forecast of disaster consequences influence on heat supply systems, power supply lines and pipelines;

– Creation of 3D relief model to be used for forecasting the flood areas during the high water period.

For decision of these and other problems is very important to provide the completeness of information used for decision-making in forecasting and emergency elimination, as well as to provide the maximum visibility of emergency area in order to increase the efficiency of the perception of the situation by the GIS-operator. The use of two-dimensional maps does not always provide an effective representation of necessary geoinformation. In most cases, people are much easier to grasp the whole picture in a realistic three-dimensional graphic and cartographic representation, rather than as a flat image. Therefore, the use of two-dimensional geoimages in some cases can lead to difficulties of perception, time loss and errors in making the right decisions in emergency elimination.

When a specialist forecasts the spread of the emergency damaging factor in the water bodies is very important to have a three-dimensional model of underwater currents in the reservoir in order to correctly determine the direction, speed of expansion and depth of pollution.

The significant factors affecting the emergency spread on the land is a form of relief, density and height of buildings. From them may depend on the territorial scope and speed of emergency distribution. In addition, specific relief and the height of buildings may limit free access rescuers to the emergency center and to the people for their evacuation.

Forecasting the spread of the emergency damaging factor in the airspace should be based on three-dimensional modeling of air masses in the atmosphere. It will allow correctly identify the direction, speed of expansion of the infected cloud and the overall territorial scope of the pollution.

Thus, to improve the efficiency of geoinformation and eliminate these shortcomings, it is necessary to use the realistic 3D geoimages for complex situation visualization on a site. When used 3D GI representation in GIS for emergency management, it is provided the following:

– The completeness of the visual information used for decision-making on the organization of the population protection;

– The visualization of large volumes of information to increase the efficiency of information perception by decision-makers;

– The pictorial presentation of emergency situation taken place in reality.

Another aspect of application for new geoinformation representation forms is related to the following fact. The most of crisis processes data are directly related to time intervals, so logical to display them with the effect of cartographic animation. It can be applied to the schematic displayed on the map localization of anything in the form of polygonal objects, such as flood zones, oil spills, the proliferation of harmful substances in the atmosphere, the spread of forest fires, the order of the routes, order of point objects appearance, such as fires, order the evacuation of settlements.

In this regard, come to the fore specialized geographic information systems in connect with a variety of cartographic and geoimages: static and dynamic, electronic and digital, two-dimensional and three-dimensional. Such geographic information systems make it possible to quickly create electronic and paper maps with the new emergency information. And modern means of remote sensing can provide this information around the clock and in any weather. Moreover, the modeling tools available in modern GIS software packages allow "on the fly" to forecast the development of the situation, for example, to show a progressive increase of flooding area or forest fire area.

Therefore, modern GIS technologies along with new forms of GI representation are able to participate in the processes of early warning more effectively and to reduce drastically the response time to disaster, to improve the computational accuracy and the forces and facilities efficiency. Hence, the most important task for geosciences in the years coming is the interpenetration and wide uses of geoinformation in disaster management.

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# USE OF ON-LINE GEOMODELING MEANS FOR MONITORING EMERGENCIES IN THE SIBERIAN FEDERAL AREA

**Alexander A. YEVSYKOV, Valery V. NICHEPORCHUK, Alexey A. MARKOV, Russian Federation**

## 1. Introduction

The on-line geographical modeling is an important part of informational support of the area management. The area monitoring of any scale (social-economical, environmental, that of emergencies etc.) implies the existence of a large data arrays possessing both spatial and time constituents. Besides the collection and primary treatment of monitoring indicators, the assessment of complex indicators and visualization of the results in the form of thematic maps are necessary. The results of such an analysis are the basis for planning, implementing and controlling the activities for the area management.

To solve such complex problems it is necessary to create systems based on the integration of modern information technologies such as geographical informational systems (GIS) and methods of On-Line Analytical Processing (OLAP). OLAP provides the visualization of multidimensional data, implementation of analytical operations with them, high processing speed and on-line creation of analytical reports, and GIS allows one to create dynamic maps illustrating the results of the analysis of the area monitoring indicators.

The method of cartographic visualization of the results of analyzing multidimensional data of the OLAP-system has been suggested. The algorithms of dynamic formation of cartographic layers based on the attributive information of the OLAP-system data source and spatial information of GIS topographic layers have been developed. The tool set for the dynamic formation of the cartographic layers has first been developed for geomodeling means integrated with the OLAP-systems.

## 2. Algorithm of the map attribution of multidimensional data for the formation of thematic maps

Formally, a multidimensional data cube can be presented as: $G = \langle D, F \rangle$, where $D = \{d_1, d_2, \ldots, d_m\}$ – is a multiplicity of axes – dimensions of a hypercube: each dimension represents an ordered multiplicity of values of a certain type; $F = \{f_1, f_2, \ldots, f_n\}$ – the collection of the multiplicities of values of the indicators determining its information content – the cube measures. Within the framework of the given model of the multidimensional data, the function on $m$ variables according to the number of dimensions: $f_i = f_i(d_1, d_2, \ldots, d_m)$ will be used to determine the value of the indicator.

To implement the cartographic attribution in the hypercube the geographic dimension $\hat{d}$ is determined.

To create a thematic map one fixes the values of the dimensions $d_i \subseteq D : d_i \neq \hat{d}$, $i = \overline{1,m}$ and selects from $F$ an indicator to be displayed on the map: $f^* = f^*(d^*_1, d^*_2, \ldots, \hat{d}, \ldots, d^*_m)$, where $d^*_1, d^*_2, \ldots, d^*_m$ – are the fixed values of the dimensions (marks), except for $\hat{d}$ which is not fixed and, consequently, can take any value from its definition range. The construction of the multiplicity of the values of the indicator $f^*$ is determined to be the operation of cutting over the hypercube of the data $G$ along all the fixed dimensions.

To visualize the values of the indicator $f^*$ one determines the electronic map $M = <L, S>$, where $L = \{L_1, L_2, \ldots, L_p\}$ – is a multiplicity of the cartographic layers; $S = (s_1, s_2, \ldots, s_q)$ – is the ordered multiplicity of the values of the properties of the map visualization.

The layer $L_i$ is determined to be: $L_i=<O_i, T_i, A_i(O_i, T_i), P_i>$, where $O_i = (o_i^1, o_i^2, \ldots, o_i^{f_i})$ – is the ordered multiplicity of the area objects of the given type;

$T_i = (t_i^1, t_i^2, \ldots, t_i^{g_i})$ – is the ordered multiplicity of the attributive layer properties – that of the attributive table $A_i$;

$A_i(O_i, T_i)$ – is the attributive table whose elements $a_i^{j,k}$ are determined by the values from the $T_i$ set for each object from $O_i$, here, $j = \overline{1, f_i}$ determines the table lines and $k = \overline{1, g_i}$ – the table columns (fields);

$P_i = <B_i, C_i>$ – is the legend of the layer, where $B_i = (b_i^1, b_i^2, \ldots, b_i^{v_i})$ – is the ordered multiplicity of the values of the layer properties, $C_i = (c_i^1, c_i^2, \ldots, c_i^{w_i})$ – is the ordered multiplicity of the division classes of the multiplicity of the objects $O_i$ of the layer $L_i$.

Attributing the geographical dimension $\hat{d}$ is performed to one or several cartographic layers. Let $L' \subseteq L$ – be the sub-multiplicity of the layers, which they are attributed to, with its power being $|L'| = l$. Each layer contains the attributive table $A'_i$, $i = \overline{1, l}$, with the multiplicity of identifiers of the layer objects stored in one of the table fields $t_i^{k*_i}$, $k*_i \in [1, g_i]$. If the value of the identifier is $a_i^{j,k*_i} \in \hat{d}$, $j = \overline{1, f_i}$, one can create the cartographic attribution of the value of the indicator $f^*$ to the object $o_i^j$.

On the basis of the above mentioned model an algorithm of the cartographic attribution of the multidimensional data is created. A simplified flow-diagram of the algorithm is given in Fig. 1. Following the choice of the map before the choice of the layers for the cartographic attribution there appears a possibility of the dynamic formation of the cartographic layers. If in a given task there is a necessity of the dynamic formation of a layer, the layer $L_d$. is added into the multiplicity of the layers $L$ of the map $M$. In such a case, it is possible to dynamically form not a single layer but several new ones.

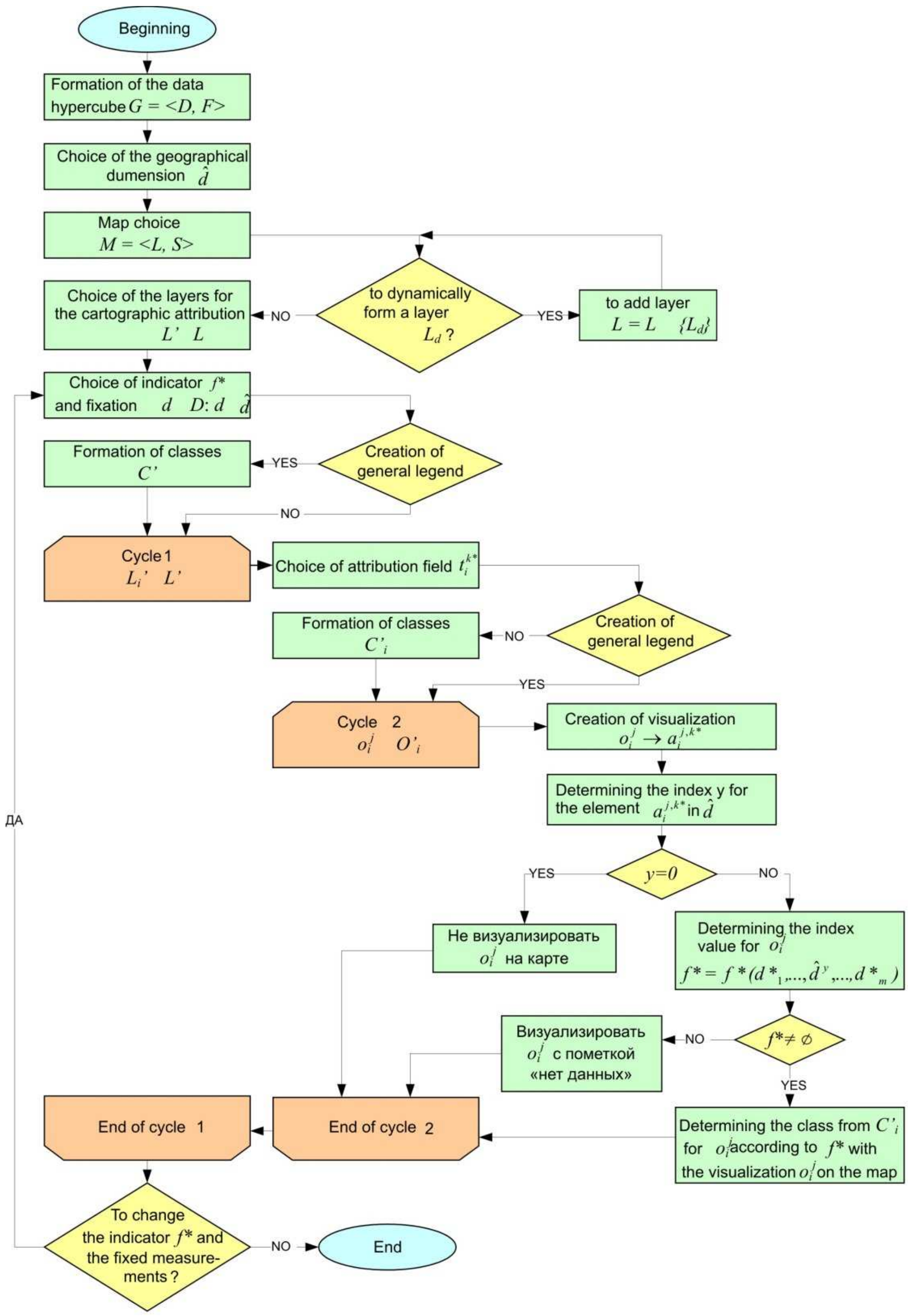


Figure 1. Algorithm of the cartographic attribution of multidimensional data

Using the given algorithm as a software unit allowed one to apply it to integrated informational systems of different purposes [1]. The system “Analytic” is implemented in the work of the Regional medical-informational centre where it is used for analyzing of medical-demographic indicators and creating complex analytical models (for funding activities, rendering services, reforming the net of medical institutions, etc.) The expert geoinformational system ESPLA-PRO is used for the analysis of the conditions connected with industrial and household fires in the Siberian Federal Area. On-line multidimensional data analysis in combination with

GIS allows specialists of the authorities of civil defense and emergency to make well-grounded decisions on fire security management of the regions with regard to their specific features, arrangement of forces and other means and many other factors [2].

## 3. Software implementation of the system OLAP-GIS

Let us consider the use of on-line geomodeling means on the example of one of the recent developments of the Institute of Computational Modeling, SB RAS – the system OLAP-GIS. The system is intended for making on-line analysis of statistical monitoring databases of emergencies and the data of meteorological conditions in the Siberian Federal Area using manuals and classifiers. The results of the data analysis are presented as tables with a complex structure, various types of diagrams and cartograms.

The databases on emergencies since 1999 (more than 165000 events) serve as the information basis for the system OLAP-GIS. The database is updated on-line in the Siberian Regional Centre of the Russian Ministry of Emergencies. An event is included into the database on the basis of the criteria determined by the regulation of the Government of the Russian Federation (May, the 21st, 2007, №304) "On the classification of emergencies of natural and technogenic character" and by the order of the Ministry of Emergencies of the Russian Federation (July, the 8th, 2004, № 329) "On the criteria of emergencies".

Analytical models are constructed on the basis of the administrative-territorial division of the area and event classifier of the Ministry of Emergencies. The system allows one to analyze the data of the number of events, the dead and injured people and material damage for any desirable period. The attributive information of the cartographic layers makes it possible to attribute the analyzed data to the area; moreover, cartograms can be created with the division both according to the area entities and municipal formations.

The system contains a unit for creating new analytical models by means of which a user, having made six steps, determines the necessary indicators and measurements according to which the analysis is made and limitations in the data choice, as well as a way of attributing the obtained data to the map.

Fig. 2 shows one of the forms of a crosstab for the analyzing the number of technogenic emergencies in the cross-section entity/year and a cartogram corresponding to the table. The flexible tool set of the GIS-unit allows one to adjust the type of the legend, the dynamic layer, the number of the classes, the division type etc.

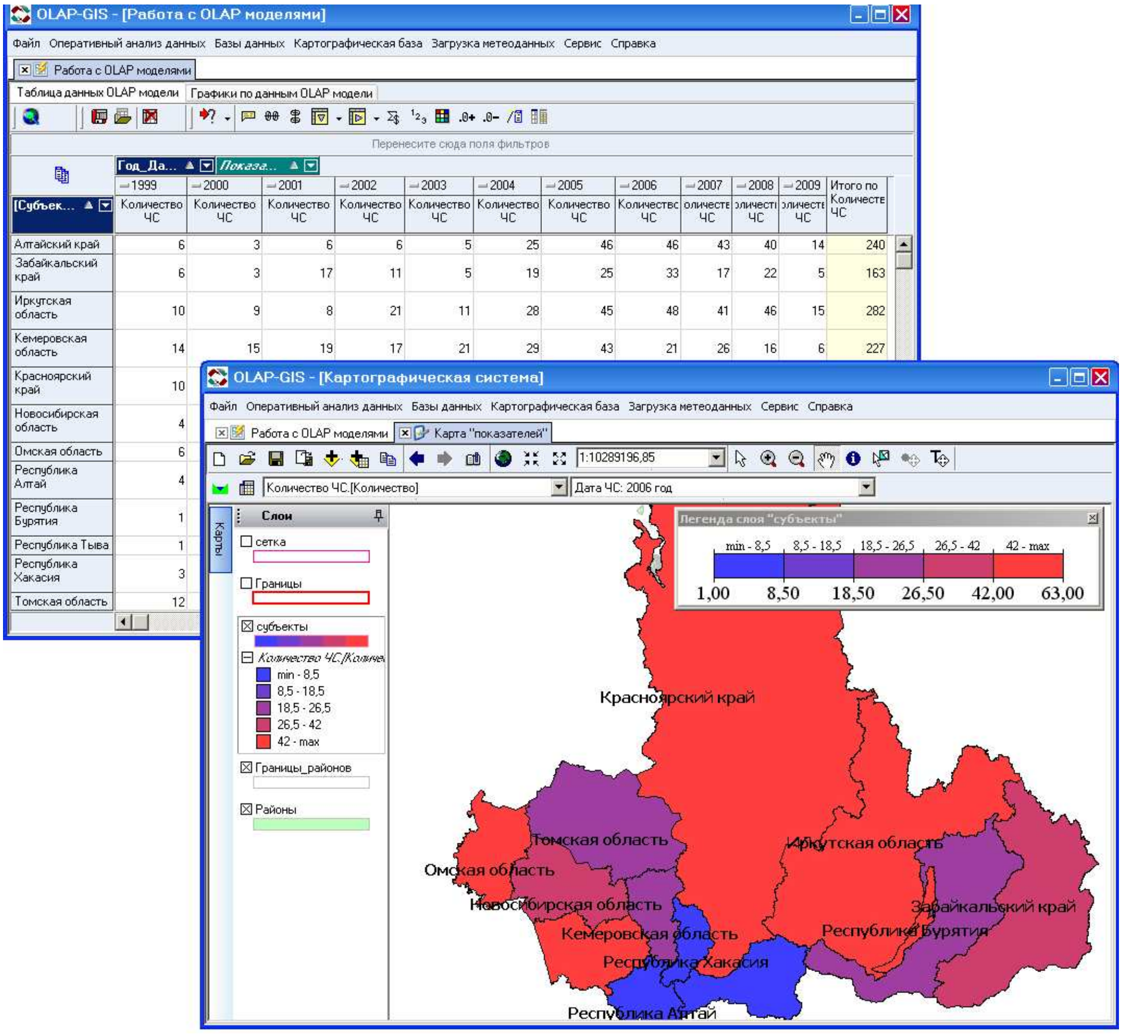


Figure 2. An example of constructing a crosstab and an analytical cartogram

## Conclusion

The system OLAP-GIS is a convenient tool set created on the integration of modern informational technologies. The principle of the unit construction and open architecture of the system allows one to easily adjust it to any entity area, dataset located in any sources. The described tool set would increase the efficiency of the area security management due to the multidimensional on-line analysis of the data presented in the form of tables and cartograms.

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# SPACE MONITORING OF THE ARCTIC AND ANTARCTIC ICE FIELDS

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**Abstract**

Russian and foreign polar-orbital satellite data of the Earth remote sensing (ERS) have been used for the space monitoring of the Arctic and Antarctic ice fields. Within this problem solution Scientific Research Center (SRC) “Planeta” and ICM and MG SB RAS have been cooperating for a long time in the field of development and use of satellite data processing methods and technologies. In the report there are the data of operating and prospective flying vehicle from our country and abroad, including space system “Arktika”, the description of developed methods and operative technologies for the space monitoring of the Arctic and Antarctic ice fields.

Space monitoring of Arctic and Antarctic ice coverage has been being developed in SRC “Planeta” for more than 25 years, since the moment of launching of the first domestic oceanographical satellite of the “Okean” line with radiolocation station of side-looking radar of X-range (the length of wave 3,2 sm). During the next years ice data have been completed with the data of visible and infrared range of domestic and foreign systems Meteor, Resurs, NOAA, EOS (TERRA, AQUA) [1]. Nowadays, as there are no Russian satellites on the orbits, monitoring of ice coverage is carried out by foreign satellites data. According Russian Federal space program` up to 2015 domestic space system of the earth observation has been planned to develop, as well as the development of operative meteorological satellites group composing two geostationary space apparatus of “Electro” line and three polar-orbital satellites of “Meteor” line (including a specialized satellite of oceanographical purpose).

Nowadays unique multipurpose satellite system (MSS) on high elliptical orbits “Arktika” destined for polar region monitoring is being carried out. Arctic region is physically difficult to access by satellites of international base meteorological group on geostationary orbits. The zone of monitoring of high quality received from geostationary orbits is limited by zenithal viewing angle of 70 degrees that corresponds to the latitude of 60 degrees. Nets of connections located on geostationary satellites can’t provide a good data receive from arctic drifting buoys and automatic hydrological weather stations.

The main problems of MSS “Arktika” – efficient receive of hydro meteorological information (rate and direction of the wind, parameters of cloudiness, precipitations, ice coverage and etc.) of arctic region to weather forecast and analysis, to provide safe flights, the north navigation, to control extreme situations and etc. Besides, this system is designed for receiving and retranslation of information from observing platforms of the ground, sea, air bases, as well as for exchange and distribution of processed hydro meteorological data all around arctic region of the Earth.

The control of Arctic and Antarctic state is carried out on the base of the data, received by the ground complex of receiving and processing of satellite information, including three regional center: SRC “Planeta” (Moscow, Obninsk, Dolgoprudnii);

regional center of receiving and processing of satellite data (RCRPSD) (Novosibirsk) and RCRPSD (Habarovsk), which provided the survey of the whole territory of the North sea way and all freezing seas of Russia [2]. In December 2007 on receiving stations of ROSGIDROMET the works of efficient receiving of information from more than 3 abroad space systems: METOP, SeaStar and FY-1 were finished.

Important trend in space monitoring support is the creation of the technology of constructing the ice conditions maps using satellite data in the visible, infrared and microwave ranges. The technology embodies a combination of automated and interactive processes. The automated mode is used for the pre-processing of the satellite images (geo-referencing, the transformation of space images into preformed map base material, the creation of overview mosaics). The interactive mode is for decoding the ice parameters (age, cohesion, form of ice, generalized characteristics, etc.) from the space images and their presentation on the map.

The SRC “Planeta” produces about 600 maps and overview mosaics of the ice conditions annually, most of which are about the Arctic region. These information products are transferred for use to the ROSGIDROMET management, Russian hydro meteorological center, in the Ministry of transport’s organizations, in the Ministry of defense, RAS, etc. Figure1 presents the mapping of ice conditions in Arctic.

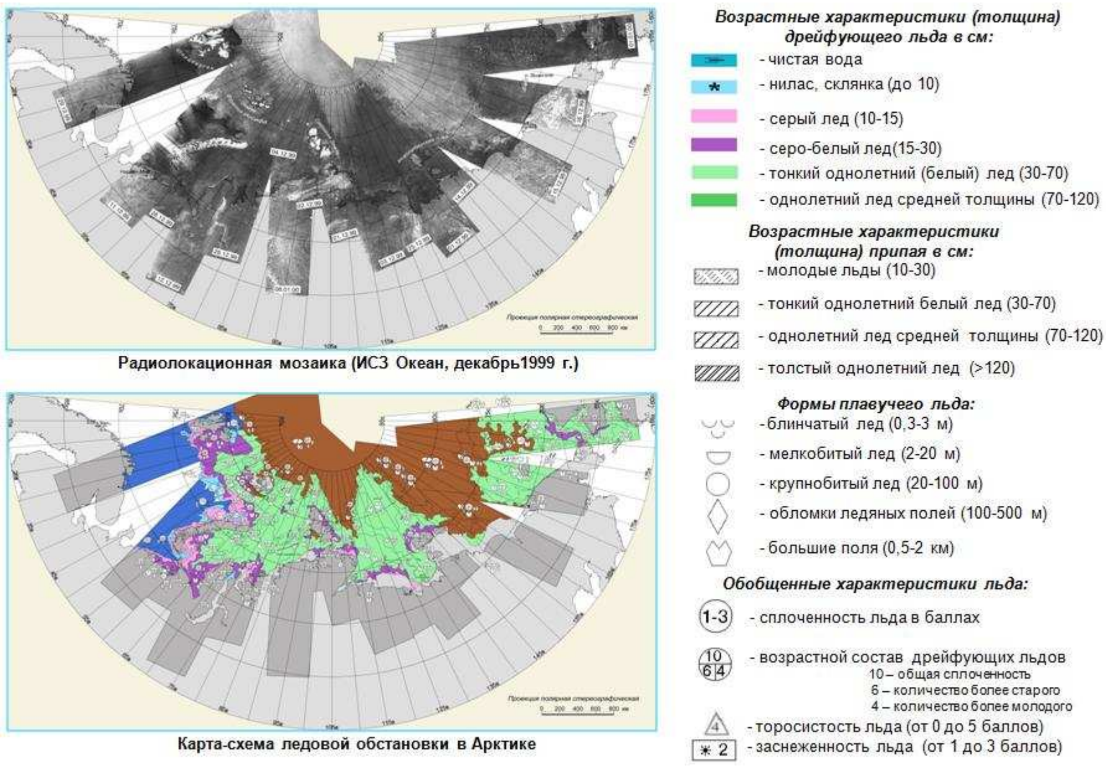


Figure 1

The SRC “Planeta” performs the long-term cooperation with the ICMMG of SB RAS in the developing of the algorithms and satellite data processing support within the solving of the Arctic and Antarctic ice cover monitoring problem [4]. In particular, one of the results of this cooperation is the creation of the technology of automated ice object recognition and classification using multispectral satellite images. The software to support this technology implements recognition, unsupervised classification (cluster analysis) and supervised classification methods [5, 6]. The cluster analysis is presented by two algorithms in the software: the K-means method and the analysis multi-dimensional histogram modes. The first approach is based on the iterative procedure of referring attribute vectors to classes by the criterion of minimal distance from the vector to the class center. Splitting of input vectors into clusters is considered optimal if the intra-class dispersion cannot be decreased by transferring any vector from one cluster to another. The second approach is based on the assumption that the source data are a sample from a multimodal distribution law, the vectors that refer to a particular mode forming a cluster. Thus, the problem reduces to the analysis of the multidimensional histograms modes. Cluster analysis allows grouping of the image elements based on their closeness in the multidimensional spectral space. The results of a cluster processing are used for the supervised classification test sites selecting. The classification system with learning (supervised classification) software consists of seven classifiers (one element-by-element and six object classifiers) based on the use of a Bayesian strategy of maximum likelihood and two object classifiers based on the minimum distance. Under the element we understand here an $N$ -dimensional attribute vector $x = (x_1, \ldots, x_N)^T$, where $N$ – is the number of the spectral channels, and the object is meant to be the square-shaped or cross-shaped contiguous vectors set. The vectors $x$ in the class $\omega_i$ are assumed to have normal distribution $N(m_i, B_i)$ with the mean $m_i$ and the covariance matrix $B_i$. The decision of the central object to belong to this or that class is made on the basis of the whole object classification results. The recognition technology became common use during the Arctic continental and sea ice classification based on the differences of the spectral properties as well as for the mapping selected classes to the real objects.

Another example of SRC “Planeta” and ICMMG of SB RAS cooperation is an experimental technique of constructing the sea ice drift fields. The technique used the method of sea ice drift fields’ recovery by place changes of some ice objects (tracers) recognized on heterogeneous in time and cartographically combined satellite images. The coordinate determination of the ice fields moving achieved by using approximation method of Delaunay triangulation. At the same time the contours of the coastline were pre-fixed on the satellite images with the ground control points in order to separate fixed land and moving ice on the ice drift maps. Fig. 2 illustrates the building of long-term ice drift map in Russian Arctic sector (satellite  QuikScat data, resolution: 35-40 kм, 14-25 February 2005).

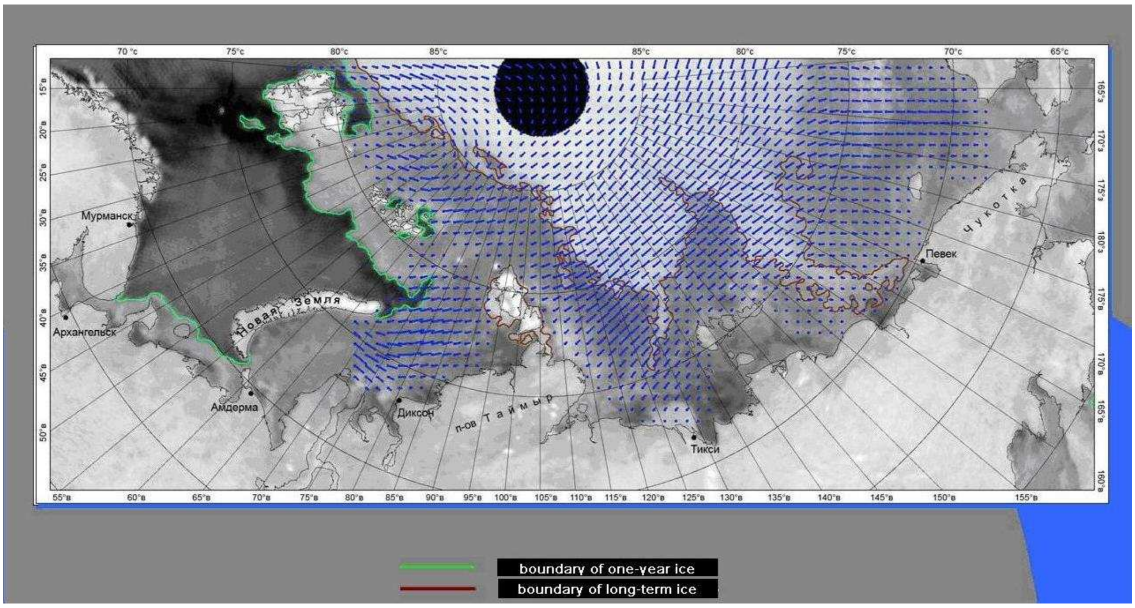


Figure 2

The SRC "Planeta" and ICMMG of SB RAS jointly carried out the adaptation of lineament analysis methods (being used for the land structures studying formerly [7]) for studying the sea ice structure in the Arctic Region. It was established, that the ordering and the movement of the drift ice fissured structures can by estimated by the distribution of the lineaments selected on the heterogeneous in time satellite images, and the lineaments over density areas selected on the satellite images of the sea ice exposed to deformations in a greater degree. These are the areas where the most number of the ice cover compressions and depressions happen.

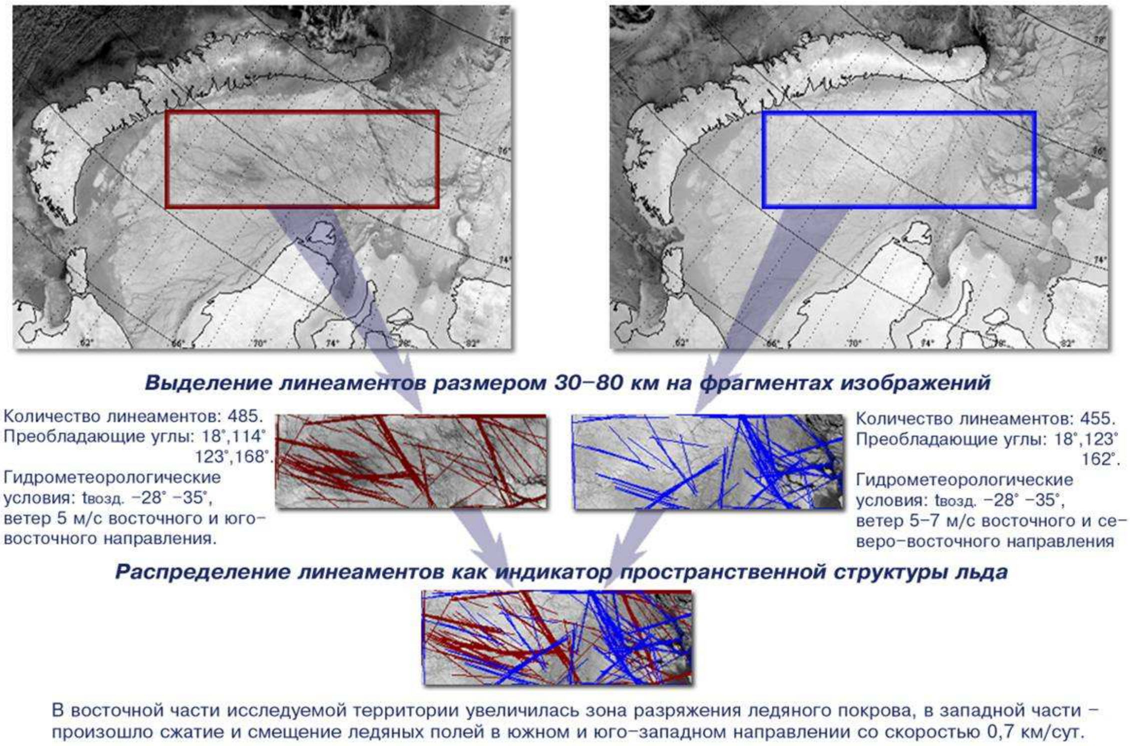


Figure 3

Fig. 3 presents the structural (lineament) analyses of image fragments of ice cover with using data of satellite NOAA, scanner AVHRR, channel: 10,5 – 11,5 micron.

The satellite observations of the large ice shelves' edges and the giant icebergs' splitting off and drifting has been continued over the 20 years. In particular, since 1986, the splitting off and drifting of three giant icebergs (A22, A23 and A24) has been being observed n the Weddell Sea. Until 1990, all three icebergs had been firmly held in the shallows at 230 km. from the edge of the Filcher's ice shelf, and then A24 had drifted along the Antarctic Peninsula and the coast of South America. A22 had been committed the same drift in 2004-2005. Iceberg A23 is still situated in the shallows. It has turned into an artificial island. The fast ice between the iceberg and the coast of Antarctica is formed in the cold season.

The satellite data processing techniques created in SD SRC "Planeta" are used not only in immediate practice but also for studying long-run characteristics' changes of ice cover using archival data. For example, in 2002–2008 the seasonal changes of the long-term Arctic ice spread boundaries and cover square had been estimated according to the data from the satellite's QuikSCAT $K_U$-ranged scattering meter (wavelength of 2.2 cm). These are the characteristics of long-term ice that are most sensitive to climate changes and can be indicators of the regional and global climate changes. The seasonal changes of the long-term ice cover square was estimated in the Russian Arctic, bounded with 10°E and 160°W. The results of the seasonal changes' analysis over six years showed some regularity. The biggest long-term ice square in the Russian Arctic is in September. During next months, it reduces irregularly. The monthly speed of the Russian Arctic long-term ice square change is about 20-70 thousands km.$^2$/month from September till December and about 110-140 thousands km.$^2$/month from January till May. In some months the long-term ice square is observed to increase (as, for example, in December 2002) due to its income from the Canadian Arctic. What stands out is the significant Russian Arctic long-term ice length reduction at the winter season of 2007-2008. The long-term ice square changes haven't been estimated during June-August because of bad separation of the long-term and first-year ice at this season.

The annual Western Arctic long-term ice square change estimating work is continued. Earlier, such estimates were based on multi-year series of radar data from the satellites "Ocean" for the period 1983 - 1999. In 2002 – 2007, these series had been enriched with the data from the satellite's QuikSCAT microwave scattering meter SeaWinds. The long-term ice border separation was carried out using automated recognition and interactive decryption techniques. The validation of the sketch maps of the long-term ice boundaries received by the satellite "Ocean" data was done using the aircraft observations' data. Standard error of determining the long-term ice boundaries had been 8-12 km. The annual long-term ice square change was estimated in the Western Arctic, bounded with 40°W and 105°W. The significant annual square variations between 180 thousands km.$^2$ and 540 thousands km.$^2$ are established to take place in the studied region. During this period the largest long-term ice square was noticed in December 1988 and 2003, the lowest – in 1985, 1999, 2005, 2006 and 2007. During the observation period from 1983 to 2007, the small negative trend (the long-term ice square decreasing by 5 %) had been taken place in the Western Arctic with account of data misses.

Since 2002 the building of the maps of the Arctic sea ice spread boundaries has been being carried out by the radar data of the American satellite QuikSCAT. The sea ice boundaries selected on the Antarctic radar images using the automated recognition and interactive decryption techniques. Analysis of satellite radar data for 2002–2007 showed that the seasonal and annual variations of the Antarctic sea ice cover square are significantly lower than in the Arctic for the same observation period (see Fig. 4.).

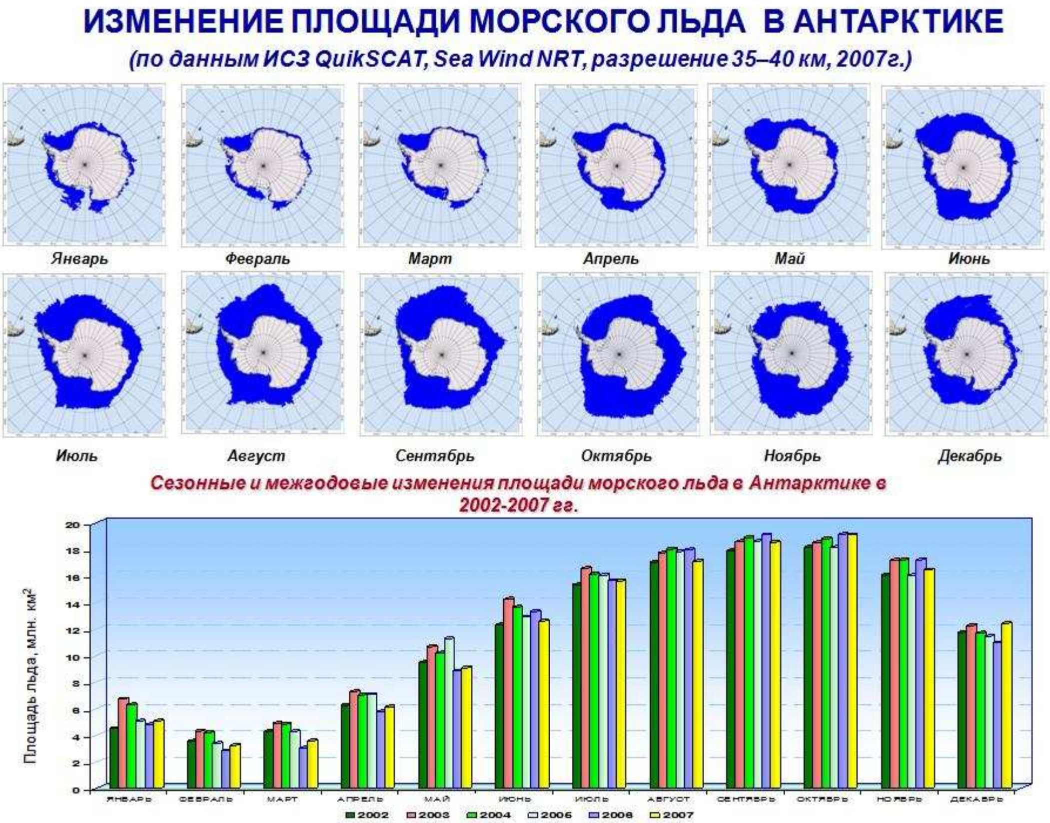


Figure 4

All kinds of information products, obtained during space monitoring of the Arctic and Antarctic, are added to the specialized digital archive as they are received. By now, the archive has accumulated series of the satellite data about various areas of the Arctic and Antarctic for more than 20-year period. This work was supported in part by Russian Foundation of Basic Research, project no. 10-07-00131.

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# THE CREATION OF HAZARDOUS FACILITIES 3D SAFETY DATA SHEETS

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Present-day safety requirements to hazardous facilities necessitate their safety data sheets. Nowadays 3D format is the best way to execute those data sheets in order to improve the quality of decisions in case of safety ensuring and emergency response. The article mentions possibilities to create and apply 3D safety data sheets.

Hazardous facilities are the enterprises using, producing, processing, storing or transporting radioactive, fire/explosion hazardous, hazardous chemical and biological substances, as well as waterworks. Each facility must have a safety data sheet with the most probable and dangerous emergency development scenario [1].

According to the requirements [1] a hazardous facility safety data sheet is developed to solve the following problems:

- Possible emergency consequences assessment for the hazardous facility;
- Possible emergency influence assessment in case of emergency at the neighboring facilities;
- Assessment of work-in-progress to prevent emergencies and of readiness to eliminate emergencies at the hazardous facility;
- Elaboration of measures to decrease risks and mitigate emergencies at the hazardous facility.

In addition hazardous facilities safety data sheets shall contain the following data:

- Hazardous substance volume;
- Estimated number of dead employees;
- Damaging factors coverage area;
- Number of dilapidated or damaged buildings, structures or process equipment within the damaging factors coverage area;
- Brief description of the most probable emergency development scenario (sequence of events).

At present possible emergency consequences coverage areas are entered the layout that amends the safety data sheet. State-of-the-art IT development allows to present the information in 3D format. It improves decision-making operational flexibility. According to the current requirements of the Siberian Regional Center for Civil Defense, Emergency Situations and Disaster Response all hazardous facilities safety data sheet must contain the following information [2]:

- Access roads;
- 3D buildings and structures models;
- Destruction areas;
- Permanent losses areas;
- Pollution areas;

– Hazardous factors coverage areas;
– Pictures;
– Floor plans;
– Communications plans;
– Process equipment layouts;
– Emergency risk areas' pictures.

Besides, 3D models shall be available for off-line processing (without special software) and be divided into separate layers: walls, floors with layouts, roof, process equipment etc.

Terrestrial laser scanning is one of the most efficient ways to acquire data necessary to accomplish 3D safety data sheets. Its main advantage is the possibility to create true 3D models of industrial facilities' territories, process equipment, and floor plans through one-cycle survey. The result of terrestrial laser scanning, i.e. 3D point model can be used to form any type of reports: plans, drawings, and 3D vector models.

SGGA specialists performed experimental research to create 3D safety data sheet based on oil and gas field facility models, and specified tasks that can be solved using 3D models:

1. 3D model navigation.
2. Determination of people evacuation ways and rescue vehicles' approach with drive ways dimensions and road carpet specification. Theoretically special analysis is possible at this stage to determine the most convenient ways (i.e. if some drive ways are damaged the ways must be re-calculated) (Fig. 1).

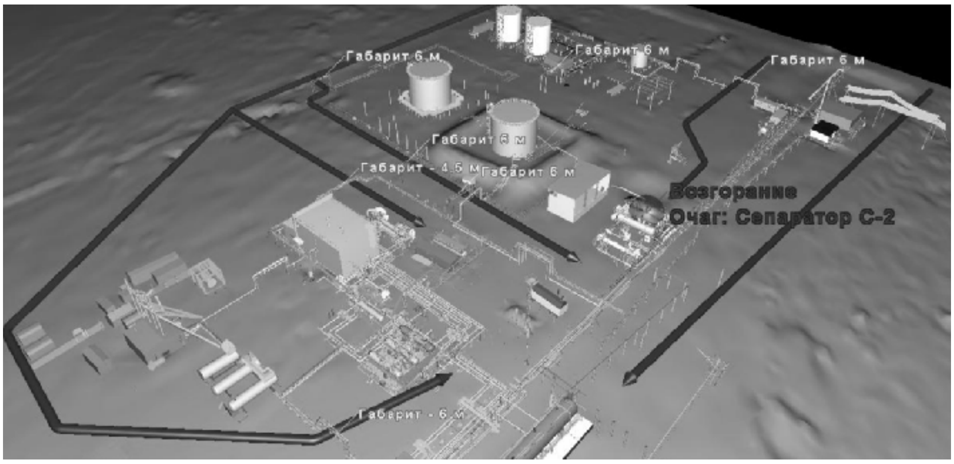


Figure 1. Rescue Vehicles Approach Visualization

3. Determination of hazardous factors coverage areas. 3D vector model provides for various damages simulation depending on the actual developments.

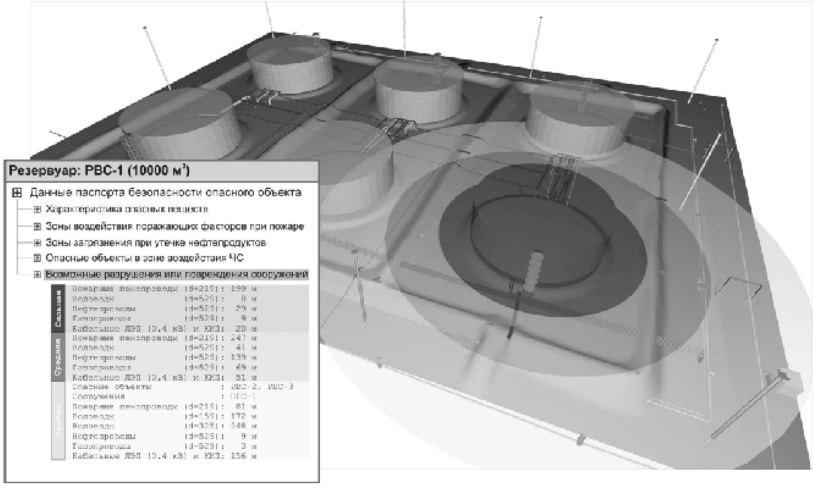

Figure 2. Hazardous Factors Coverage Areas Visualization

4. Determination of the number of damaged buildings, structures, process equipment and communications, and damage degree (Fig.3).

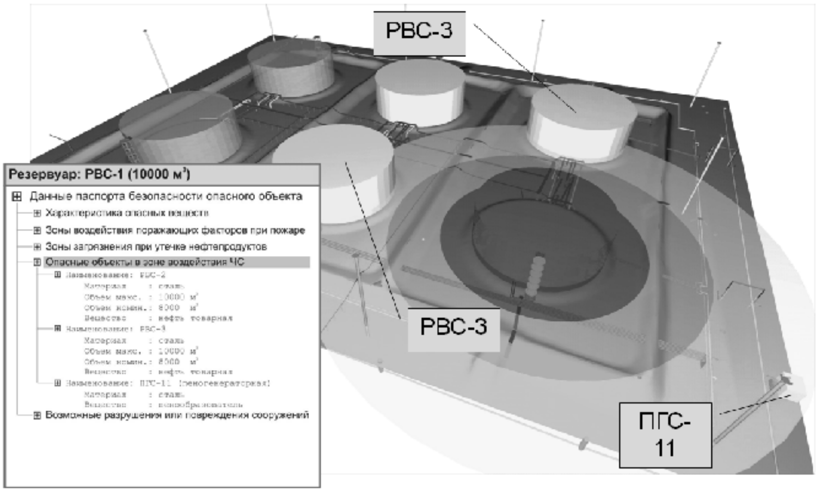

Figure 3. Possible Damages Visualization

5. Determination of rescue means, fire fighting appliances and fire cocks location (Fig.4).

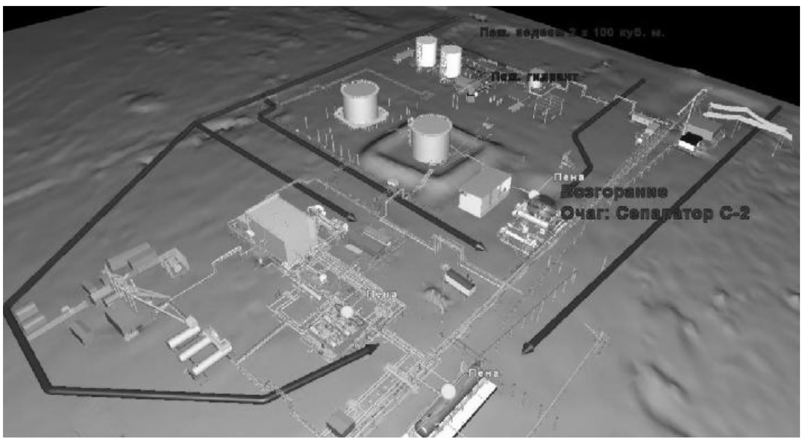

Figure 4. Fire Fighting Appliances Visualization

6. Visualization of special equipment with satellite navigation systems.
7. Viewing the detailed information on the facilities, i.e. descriptions, process flows, and pictures.

In order to create and apply hazardous facilities 3D safety data sheets successfully a general standard for 3D models is necessary to specify model presentation format, simulation and semantic data requirements. The requirements can be useful for the development of software products to form an operative working station.

3D presentation of hazardous facilities safety data sheets will improve decision-making operational flexibility and quality, and provide for remote control of people evacuation and salvage in case of emergency.

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# DEVELOPMENT OF GEOECOLOGICAL MONITORING SYSTEM FOR EARLY WARNING ON SOIL SLIP PROCESSES ACTIVATION AIMED TO PROVIDE GEOECOLOGICAL SAFETY FOR URBANIZED AREAS

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**Abstract**

The present material contains a research related to solution for development and verification of geoecological monitoring over soil slip territories and to the geodetic system providing such monitoring with usage of ad-hoc geodetic technologies and science methodologies of early warning on dangerous natural and natural-technologic processes activation.

EMERCOM of Russia reports about continuous and rapidly increasing number of natural and natural-technologic disasters through the recent years. The situation is resulted under urbanization growth and dangerous natural and natural-technologic processes spreading and activation. Disaster processes result destruction of buildings and constructions and they are really dangerous for people lives in our country and abroad. Early warning on dangerous natural and natural-technologic processes activation aiming to provide geoecological safety for urbanized areas becomes more important and natural disasters are added to Russian strategic risks list. Principles of counteracting natural disasters have been changed.

New strategy of geoecological safety for urbanized areas provision is based on three major principles – forecasting and timely warning and natural disaster management instead of elimination of consequences of natural disasters. The implementation of named principles requires good expertise in dangerous events conformities and mechanisms. One of the most important issues of current geoecology is research of urbanized areas geological environment condition and stability in case of dangerous processes activation. The most important area is research of soil slip processes resulted with natural and natural-technological reasons. Geodesic monitoring provides the basis for managing decisions making.

Modern complex geodesic monitoring is necessary for forecasting of disasters and disaster evolution and for engineering protection system development. Technological solution for verification and development of methodologies of soil slip dangerous territories geoecological monitoring becomes more important. The geodesic system of geoecological monitoring should use the latest achievements in geodesic science and technologies and requires development of the basing theory for dangerous processes evolution control and early warning and theoretical basis for merging of various methodologies and techniques of complex geoecological monitoring. Use of results of soil slip dangerous territories and natural-technological systems (NTS) researches in practice with such researches executed in urbanized territories through geodesic methodologies allows implementing of complex program of NTS geoecological monitoring for early warning on dangerous processes activation and providing engineering protection and disasters prevention. That solution is very important for cities geoecological safety, Tomsk city for example as its territory has 33 soil slip zones as City Coordinating Council in Ecology declared. Solnechny district (soil slip flank) and Lagerny garden area on Tom riverbank they are the most dangerous areas. Soil slip processes in the named areas damage city infrastructure as a result of buildings and constructions deformation and destruction. The situation required adoption of “On soil slip areas located in cities and villages of Tomsk region” law applicable for Tomsk region.

The challenge of soil slip processes geoecological monitoring in urbanized territories appeared a long time ago but it still has no final solution. The present document contains analysis of current methodologies used for soil slip processes researching and such analysis revealed necessity of complex solution for NTS condition and stability assessment that would allow timely revealing of soil slip processes activation. Classical geodesic methodologies to be used together with modern satellite geodesic technologies and magnetometrical methods of deep soil slip deformations assessment and methods of statistical modeling and mathematical forecasting to provide control over deep soil slip processes evolution and horizontal and vertical movements and deformations of buildings and constructions located on flank. Such system requires development of theoretical and technological basis for merging of various scoring and assessing methods and statistical modeling methods within geoecological monitoring complex program. The system mainly allows successfully meet all challenges in above named forecasting and early warning and dangerous processes management as the system has new characteristics and become technically sounder as results revealed with one method used could be proven with results of other methods jointly verifying trends and forecasts of dangerous processes evolution that is necessary for engineering protection and managing decisions making. The following tasks have been completed for the named goal achievement:

1. Scientific verification of geoecological monitoring geodesic methods required for successful meeting of geoecological challenges in urbanized territories in case such challenges are resulted with soil slip processes. Development of theoretical and technological basis for stationary geodesic control over soil slip masses and constructions evolutions in time and in space through joint use of classical and satellite technologies.
2. Development of technologies for mathematical forecasting of deformations of constructions while exploitation basing on analysis of constructions surface shape changes revealed with geodesic scoring.
3. Investigation of such methods. The named deformations appearance indirectly proves the presence and evolution of soil slip processes.
4. Development of statistical modeling methods and such methods use for geodesy goals achievement and assessment of stability of control points used for defining of actual movements of soil slip masses. Sharp forecasting of dangerous situations requires analysis of long period monitoring results those demonstrate dynamics of soil slip flank affecting constructions and imitating models could be the only way of issue solving in case of complex deformations of named objects. The importance of research of soil slip processes reasons and stability with ad-hoc mathematic modeling methods and GIS-technologies implemented was proven while the 32$^{nd}$ international geological congress took place in Italia as there were more than

200 reports related to soil slips and 47 of them related to statistical modeling methods (Monte-Carlo) and GIS-technologies used for soil slip danger and risk assessment. The other reports considered issues of development and testing of effective soil slip geomonitoring methods and numeric and physical modeling with soil slip mechanism and forecasted movement characteristics adjusting. Those reports proved the importance of such activities in Tomsk city territory one more time/

5. Theoretical basis and implementation of new model of three axes atmosphere ellipsoid used for considering atmosphere failures of satellite assessments within early warning on soil slip processes activation.

6. Development of methods for objects geoecological safety provision under complex geoecological monitoring over soil slip processes and analysis of HTS condition while exploitation.

Geodetic monitoring is the most important element of geoecological monitoring geodesic support as it provides time and space control points and being a basis allows revealing factors affecting NTS condition and evolution. Geodesy department of TSUAB developed complex technology for geodesic control over soil slip processes and deformations of constructions located on soil slip flank. The technology was used while implementation of complex system of geodesic support of geoecological monitoring in Tomsk city territory [1] and recommendations for city development planning and plan correcting under dangerous natural and natural-technological processes in Tomsk city were issued.

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# ANALYSIS OF USAGE METHODOLOGICAL PROGRESS OF MODERN SCIENCES (GEOGRAPHY, BIOLOGY, AND ECOLOGY), APPLIED MAPPING AND EARTH REMOTE SENSING METHODS TO CREATE A REGIONAL MONITORING SYSTEM

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**Summary**

In imitation of Khanty-Mansi Autonomous Area analyzed usage of complex methodological progress of modern sciences (geography, biology, and ecology), applied mapping and earth remote sensing methods to work out and realize of regional monitoring system.

In the article shows the role of ecological monitoring, as a tool for creating conditions for rational use of natural-resource base and environmental safety in the territory of Autonomous District.

The regional dimension of sustainable development has great importance for Russia. In this connection the development and implementation of programs on transition to sustainable development for every region, as well as the further integration of these programs in public policy for sustainable development are considered.

Adopted in 2007, the concept of ecological safety of the Khanty-Mansi Autonomous Okrug – Ugra for the period up to 2020 (hereinafter – the Concept) is a system of views on security for present and future generations a healthy environment in the territory of the Khanty-Mansi Autonomous Okrug – Ugra, conservation and development of natural complexes and objects on the territory of the Autonomous Okrug.

The implementation of the concept implies:

– Development of laws and other normative legal acts in the field of regional management and the safe management of natural resources and environment;

– Making an effective system of environmental management and ensuring environmental safety;

– Development, implementation and coordination of joint action plans and programs of federal organs of government, public authorities of the Khanty-Mansi Autonomous Okrug - Ugra, local government, people through a systematic and scientifically sound approach to environmental security.

The strategic goal of ensuring environmental safety in the Khanty-Mansi Autonomous Okrug - Ugra is rational and safe use of available natural resources potential in the interests of Russia and the population of the Autonomous Okrug, to prevent harm to the environment and the vital interests of the population.

One of the principal means of achieving this strategic goal is building a system of environmental management, which will be adequate for intensive use of natural resources and will protect the vital interests of the state, society and the individual from environmental danger, effective organization of state environmental control and industrial ecological control, making an effective system-area environmental monitoring, data collection and analysis on the state of the environment.

A dynamic and powerful development of industry in the territory of Ugra (first place in Russia in industrial output, electricity production and production) and was accompanied by a hitherto associated with a significant natural resource consumption and environmental pollution.

Area Khanty-Mansi Autonomous Okrug-Ugra is 534.8 thousand square kilometers, of which more than 160 thousand square kilometers occupied by the licensing of subsoil areas and is actively being industrial exploitation.

Assessment of the current state of the Ob-Irtysh basin within the autonomous region is a prerequisite for the development of l legislative documents and nature-conservative measures in connection with the importance of its territory, its natural hydrographic features and the intensity of industrial development.

Reconstructive natural potential of middle taiga biocenoses is unable to withstand the systematic anthropogenic impact on the environment.

The drainage network of Khanty-Mansi Autonomous Area belongs to the basin of the Kara Sea.

The Ob, the Irtysh, and 12 of their tributaries (Northern Sosva, Konda, Wah, Yugan, Kazim, Pim, Tromegan, Agan, B. Salym, Lyapin, Lyamin and Nazim) form the drainage network of the territory, as well as many smaller streams.

The length of the Irtysh River is 4248 km, it occupies the second place in Russia after the Lena basin area 1.64 million square km. The Irtysh springs from China, flows through the territory of Kazakhstan, Omsk and Tyumen regions and Khanty-Mansi Autonomous District.

The Ob river basin area occupies the first place in Russia (2.99 mln.sq.km) and the third water content after the Yenisei and the Lena. The territory of the Autonomous Okrug has a powerful water resource potential, the total number of rivers in the autonomous region – about 30 thousand.

The stream frequency is 0,25–0,4 km / sq km, water-logged of river basin - up to 70 % (basin the Konda river) lakes – up to 25 % (basin the Tromegan river).

There are 177 rivers longer than 100 km, and 10 rivers more than 500 kilometers. Of the major rivers, the four rivers have a length more than 1000 km (the Ob, the Irtysh, the Konda, and the Big Yugan).

There are about 290 thousand lakes larger in area than 1 hectare in the district. Their total area exceeds 30 thousand square km, which is 5, 7 % of the area of the district. The most of the lakes is concentrated in the Middle Ob – over 200 thousand (70% of the total number), including in basins of the Tromegan and the Agan about 90 thousand, the Vah – 36 thousand, the Lyamin- over 30 thousand, the Pym – 24 thousand. A lot of lakes are in basins of the Konda (44 thousand) and the Kazym (17.5 thousand). Relatively there are few lakes in the Berezovsky and the Soviet areas.

The swamps are occupied 38,2 % of the district. The territory of the Khanty-Mansi Autonomous District occupies the first place in the world by the presence of wetland resources within the isolated area. Swamping some areas reaches 70 % (the

Lyamin-Pimsky swampy area), here and there system of swamp entirely covered with water (the Vasyuganskoe swamp).

There are a number of hydro chemical characteristics of Ugra River water. The characteristics are following: low salinity, low transparency, and intense staining caused by the presence in the waters of lakes and rivers a large number of organic compounds, manganese and iron. The natural landscape-geochemical conditions are almost universally and measured by the excess of maximum permissible concentration of iron and manganese.

The anthropogenic load on the environment of Ugra is mainly due to the active development of oil and gas industry. This led to a complete industrial expansion, which is characterized as industrial infrastructure and population growth (over forty years, more than 1 million), urban area, higher levels of consumption and exploitation of natural resources.

From year to year within the county increased the number of anthropogenic objects. According to the Department of Environmental Protection and Ecological Safety of the Khanty-Mansi Autonomous Okrug – Ugra on 01.01.2009 is more than 82 thousand producers and 26 thousand injectors and more than 82.4 thousand km of conduit's (oil workers, infield, trunk), of which 4,2 thousand km. need to be replaced; 44 thousand kilometers of transmission facilities; 42 thousand sources of pollution of atmosphere; 561 torch for associated gas burning ; 1 382 mud pits; 1,5 million tons of waste generated per year.

Oil fields occupy an areas of tens or hundreds of square kilometers, are closely linked by various communications, organization of the economy, technological and natural flows of substances. Thus, the main hotbed of anthropogenic impact on the environment at the regional scale should be considered oil-producing areas.

Environmental monitoring is an essential component of nature conservation. Priority in the system of environmental monitoring is given control of the chemical composition of the atmosphere, hydrosphere, and soil-vegetable cover. There are several levels of organization of environmental monitoring: global, national, regional, local.

On the territory of the Khanty-Mansi Autonomous Okrug – Ugra in 7 cities on 13 posts are held regularly observations for the content of pollutants in the air.

Monthly monitoring of contaminants in surface waters are carried out on 25 posts, located at 14 water bodies. The basis of the organization and conducting of regime observations laid the basic principles such as comprehensiveness and systematic observations, the consistency of their scheduling with characteristic hydrological situations and changing weather conditions, determination of indicators of a single method.

The urgent need to have a real picture of the ecological state of the territory of Ugra has identified the need for a system of environmental monitoring at regional and local levels.

Regional Environmental monitoring is a system of tracking for the processes and phenomena within the region where these processes and events may vary in natural and anthropogenic impacts, depending on the region's economy. The project of regional monitoring network is designed GP HMAO "Scientific-Analytical Center rational subsoil use by Shpielman V.I. name”. As part of regional monitoring conducted monitoring of contaminants in surface water, sediment, and snow cover.

Observation network of surface water and bottom sediment numbers 91 and is organized on the basin principle in order to trace the migration of aquatic natural and industrial materials sequentially, from a drained basins of higher orders in the lower. The frequency testing of surface water – 2 times a year (beginning of floods, the summer low water), bottom sediment – 1 times a year (summer low water).

Observation network of atmospheric precipitation includes 32 posts (one sample per 16 713 sq. km.), the frequency of testing – 1 times per year (the third decade of March). Posts monitoring of snow cover (baseline and control) are defined taking into account the possible directions of atmospheric transport of local and regional sources of pollution.

On the territory of Ugra 69 enterprises are the owners of licensees of the right to use the subsoil for the purpose of extraction of hydrocarbon raw materials (306 licenses). Area of the distributed stock subsoil is about 28, 5 % of the district.

In accordance with governmental regulation of HMAO – Ugra № 302-P dated July 29, 2003 "On approval of requirements to identify the source of contamination of environmental components, design and management of environmental monitoring within the licensed areas of mineral resources in the territory of the Khanty-Mansi Autonomous Okrug - Ugra" from the perspective of long-term development of mineral deposits in the territory of Autonomous District, subsoil users (licensees the right to use the subsoil) are required to establish a system of regular observations of the state components of the environment within the licensed areas. Organization and management of environmental monitoring is carried out at its own expense, as part of environmental activities.

The system of regular observations of the state of the environment components (air, surface water, sediment and soil) is developed for each license area.

When designing the observation network are taken into account:

- The natural climatic and hydrological conditions and landscape features of the territory;
- Data on existing and planned sources of anthropogenic impact on the environment (pipelines, prospecting and exploratory wells, CSN, spray areas, sludge pits, roads, etc.);
- Data from previous environmental studies (including quantitative and qualitative indicators of contamination of soils and rocks of the aeration zone, surface and groundwater, air);
- Transport accessibility.

As a result of designing the optimal number and location of control points of the environment are necessary and sufficient. The list of substances and parameters studied in mandatory, defined on the basis of a list of possible contaminants resulting from the technological process in the development of deposits. The frequency of sampling of natural ingredients varies, and is determined by the characteristics of the component and ongoing internal and external natural processes. In accordance with the timetable approved by the Resolution, the subsoil users submit results of quantitative chemical analysis in a single information base.

Information software system designed to collect the results of the analytical control of the components of nature protection departmental chemical laboratories, developed Co Ltd "Institute of Geographic Information Systems" (Tyumen).

Gathering information and monitoring of departmental laboratories to establish the reliability of the data on environmental conditions within the boundaries of the licensed areas of mineral resources has branch Federal public institution “Central laboratory analysis and technical research on Ural federal Okrug "in Khanty-Mansiysk.

Centralized collection and storage of information about the content of pollutants, as well as analysis and assessment of the components of the environment within the licensed areas of mineral resources since 2004, implemented a public company “Scientific and Production Center of integrated environmental monitoring and inventory of natural resources” (public corporation “Scientific production association Monitoring” Khanty-Mansiysk).

The main condition for the successful functioning of the local environmental monitoring is to further the formation of a single observation network in the bowels of the distributed stock, based on common principles and approaches. Particular attention should be paid to the timely provision of information to land users in a standardized format.

With increasing information flow becomes more urgent to develop algorithms for comparing the data obtained at the levels of state, regional and local monitoring, integrated assessment of technological impacts on environmental components and forecasting.

Thus, in the territory of Ugra formed and operates a system of environmental monitoring at 3 levels – national, regional and local, which allows evaluating the physical-chemical component of the ongoing processes.

An effective tool for characterizing the current state and representing diverse information about the social, economic and environmental components of future sustainable development of the district in a systematic, comparable and understandable form is a comprehensive atlas of the Khanty-Mansi Autonomous Okrug - Ugra.

Atlas was created in accordance with the order of the Governor of the Khanty-Mansi Autonomous Okrug - Ugra dated 10.04. 2002 № 122 in two volumes:

Vol.1. History. Population. Economy.

Vol.2. Nature. Ecology.

The main tasks of the Atlas are:

- Provision of residents of the district, state and local governments, scientific, design, manufacturing and educational institutions, public organizations, official and scientific system of space-time information on the factors and preconditions for sustainable development of the district;
- Presentation of governments and governance at various levels, design, production and other institutions, public organizations and movements in a reliable

material for the formation of federal and regional science and technology projects, programs and initiatives related to sustainable development;

– Help to promote public and business interest in the district, and increasing its research initiatives, defining ways, means and mechanisms for sustainable development;

– The development of forecasts changes in the ecological state of the environment and human activity

– The development of government's development strategy Khanty-Mansi Autonomous Okrug – Ugra;

– Addressing issues of environment and natural resource-Ugra Khanty-Mansiysk, ensure ecological balance in the district as a whole and its regions, the organization and conduct environmental monitoring.

Atlas Material may be used for:

– The formation of information systems, including the creation and development of databases and data banks, GIS, regional and municipal levels;

– Research, teaching process in higher and secondary educational institutions;

– Establishing a scientific background, educational, popular and other maps and atlases (including electronic form) in order to ensure business practices and solve the most acute social and environmental problems of the territory.

Atlas contributes to:

– The development and use of certain parts of scientific knowledge (historical, economic, environmental, geographic, etc.), including cartography and remote sensing, are determined by natural-economic, socio-demographic and ethnic information specific region;

– Training of different skill levels, development of self, raising the cultural level of the people, educating people to the careful treatment of environment in the broadest sense;

– The dissemination of knowledge about the district, the development of domestic and external social and economic ties.

Atlas is an integral part of the Information System district.

The Atlas reflects all the major aspects of existence and development of Ugra Khanty-as a subject of Russia, its role and place in Russia, relations with other subjects of Russia. It reflects the features of the environment, resource potential, the current state of society and the economy, the level and direction of socio-economic development district. Much attention is paid to a comparative presentation of a number of indicators of the district, against the backdrop of Russia and the world, which allows an objective approach to assessing the socio-economic, environmental and other situations that prevailed in the district.

By 2010, the territory of the Tyumen region established and successfully operated two centers for remote sensing of the Earth:

1. On the basis of Ugra Research Institute of Information Technology, created with the support of the administration Khanty-Mansiysk in 2001.
2. On the basis of Tyumen State University in the Institute of Ecology and Natural Resource Management, created in the framework of the Innovation Program in 2008.

Both centers have the opportunity to implement the full cycle of works on reception, processing and analysis of remote sensing data. The quorum of the licenses supported by the Federal Space Agency for space activity obtained Research Institute of Information Technology (2005) and Institute Ecology and Natural Resource Management (2009).

It is strategically important to the direction of modernization created on the basis Research Institute of Information Technology and Institute Ecology and Natural Resource Management centers and remote sensing. This increase in the frequency location of the same territory of middle, high and ultra-high resolution with minimal material costs can only be achieved in two ways:

– Using remote sensing data with both Russian and foreign satellites
– Direct-space images directly from the natural earth resources satellites, based on the equipment of two centers consolidated into one system.

The organization of the reception system is necessary to avoid the intersection of scheduling communication sessions with the satellites and the loss of data, as well as to increase the productivity and the volume of incoming data.

Towards the modernization of satellite monitoring mechanisms should be developed technological solutions to specific industrial and environmental challenges, among which one of the most important, is to assess compliance with license conditions in the production of work for exploration and exploitation of oil and gas fields.

The main objective of the project is the introduction of satellite monitoring in the construction and operation of infrastructure of oil and gas deposits. The tasks to be solved in the course of the project include the following:

– Identification of environmental changes during the development and exploitation, as well as the discovery of traces of unauthorized human activities
– Operational (real time) in the detection of unauthorized waste disposal;
– Monitoring the progress of construction and logging operations in the territories licensed areas;
– Identification and preliminary assessment of water pollution;
– Assessment of the volume and track the dynamics of sand piles.

Receive operational data space imaging after completion of specialized treatment, also function as an update and complement the existing array of geospatial information to the District, as well as updating the departmental administration geoportal Khanty-Mansi Autonomous Okrug – Ugra.

The main consumers of research results are public entities involved in monitoring compliance with licensing agreements with mining companies, research, design, manufacturing and educational institutions and organizations.

An effective tool for remote monitoring will reduce material costs in audits with simultaneous increase in the area of the survey area, as well as to obtain high-precision operational results do not depend on subjective factors.

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# EXPERIENCE OF CREATING GEOINFORMATION SYSTEM FOR EMERGENCY MANAGEMENT IN SVERDLOVSK REGION

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**Key words**: emergency, prediction (forecast), geoinformation system, risk

**SUMMARY**

To provide the emergency monitoring and prediction, FGUP «Uralgeoinform» developed a geoinformation system for emergency management in Sverdlovsk Region. The system includes the following components: a digital cartographic base, application software for damage predictions and a database. The map is used as a terrain model in the emergency monitoring and prediction applications. The bundled software for damage estimation consists of the following units (programs):

1. Calculation of pollutant emissions from free-burning of oil and oil products
2. Estimation of damages from accidents at fire-hazardous plants
3. Estimation of damages from hurricanes
4. Estimation of damages from forest fires
5. Estimation of damages from accidental explosions of fuel-air mixtures
6. Determination of areas, contaminated with strong poisonous substances in case of accidents at chemically hazardous plants or on vehicles
7. Estimation of damages from chemical accidents - «TOXI»
8. Estimation of risks at potentially hazardous objects
9. Building of maps on the complex individual risk
10. Visualization of vehicle routs
11. Determination of flood zones

The affected areas, determined using the programs a number are reflected on the map, with their parameters being stored in the database. The database “Inventory of potentially hazardous objects” is created for storing the data on hazardous objects. The database makes it possible to accumulate the data on industrial enterprises of the region and the calculated results for emergency predictions as well. To automate the procedure, there was developed a module for calculating risks at potentially hazardous objects, and a module for calculating the complex individual risk. The module for the complex individual risk gives a possibility to calculate an indicator of the complex individual risk for a territory and make a map of the complex risk.

Since its emergence, the mankind has to deal with problems of providing security, estimating risks and preventing hazards. Every year there happen hundreds of emergency situations in our country. The Russian Federation faced 424 emergency situations in 2009 alone, which included technological (270), natural (133) and socio-biological (21) disasters. These emergencies caused death to 734 and injuries to 2428. The emergency management required 3.2 milliard roubles, almost 2 million people and 600 thousands units of technical equipment involved. (www.mchs.gov.ru)

These facts confirm the need for predicting possible emergencies.

Finding solutions for emergency prediction and risk estimation, requires processing of great amounts of diverse information. It's rather difficult for an operator to process all these data manually. Methods applied can also present difficulties: a specialist in emergency management may have no time to analyze complicated math formulas, to thoroughly substitute figures in them and make calculations. Besides, manual computation doesn't allow for getting the required on-line predictions.

For these reasons, development and introduction of automated methods for processing this information are indispensable to provide information support for emergency management applications. Monitoring and prediction of emergencies, estimation of accidents, catastrophes and natural disasters can't be carried out without the use of geoinformation technologies. Modelling tools, integrated in GIS-packages, allow an on-line forecasting of the situation's development on the basis of spatial data, as well as risk management of possible emergencies. A digital thematic map presents a convenient visualization tool for estimated and statistical data and is indispensable for decision-making processes. The major advantage of estimating risks using GIS-technologies consists in automation of the most time-consuming stages of a decision-making process and visualization of risk levels.

The territorial center of monitoring in the Sverdlovsk Regional Emergency Management Agency also has to deal with these problems. In this connection, FGUP "Uralgeoinform" developed a geoinformation system for emergency management in Sverdlovsk Region. The system is designed to accumulate data on the sources of technological and natural disasters, to provide descriptions of hazardous objects, to make calculations and analyses of damages, caused by emergencies.

The system includes the following components:

- A digital cartographic base
- Application software for damage predictions
- A database.

To make calculations and visualize the results, GIS «Emergency Management in Sverdlovsk Region» uses digital topographic maps at scale 1 : 200 000 and 1 : 10 000 – 1 : 25 000.

A 1:200 000-scale general map of the Sverdlovsk Region was made. Apart from the common topographic layers, the map has specific thematic ones: "transportation of hazardous cargo", "environmental monitoring", "seismically dangerous zones", "ground observation and control", "radiation environment", "flood zones", "seats of forest fires", "local authorities". In addition to providing an overview of the territory, the map is applied for emergency monitoring and prediction.

The cartographic base includes plans of municipal entities of the Sverdlovsk Region, which are presented at scale 1 : 10 000–1 : 25 000. The plans are intended for representing potentially hazardous objects and areas (both actual and estimated), affected by emergencies, and also for making requests of spatial data in order to estimate damages from emergencies, such as losses in man and housing, etc. The plans are also used in reporting and as hard-copies for the emergency management groups.

The bundled software for damage estimation consists of the following units (programs):

1. Calculation of pollutant emissions from free-burning of oil and oil products
2. Estimation of damages from accidents at fire-hazardous plants
3. Estimation of damages from hurricanes
4. Estimation of damages from forest fires
5. Estimation of damages from accidental explosions of fuel-air mixtures
6. Determination of areas, contaminated with strong poisonous substances in case of accidents at chemically hazardous plants or on vehicles
7. Estimation of damages from chemical accidents - «TOXI»
8. Estimation of risks at potentially hazardous objects
9. Building of maps on the complex individual risk
10. Visualization of vehicle routs
11. Determination of flood zones

Depending on emergency types, appropriate software can be chosen. The user enters initial data and indicates the location of an accident or a dangerous natural phenomenon on the map. Then the program calculates the area affected a number of the dead, injured and harmed. The estimated zones are reflected on the map, with their parameters being stored in the database. Programs for damage estimation are in compliance with the approved normative documentation.

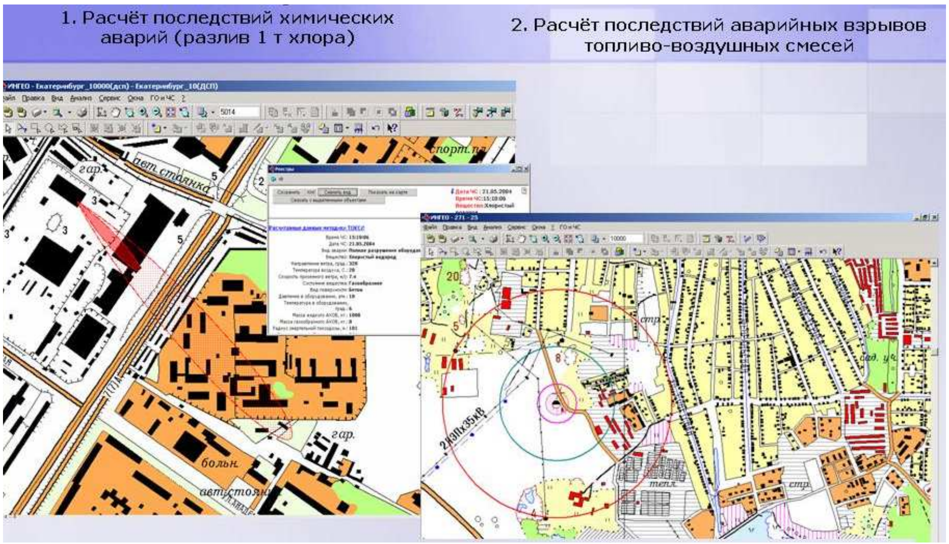


Figure 1. Modelling example: prediction of damages from technological accidents

Forecast of flood zones using digital maps is made with the help of a program, developed by «Uralgeoinform». Flood modelling consists in building an intersection between the terrain surface and the high-water surface. The source data for terrain modelling are features from the digital map, which have an «absolute height» attribute: local horizontals, elevations, stations of the public geodetic network, water edge marks, waterlines of lakes, etc. The plane, describing the high-water surface, is defined by observations from hydrological stations.

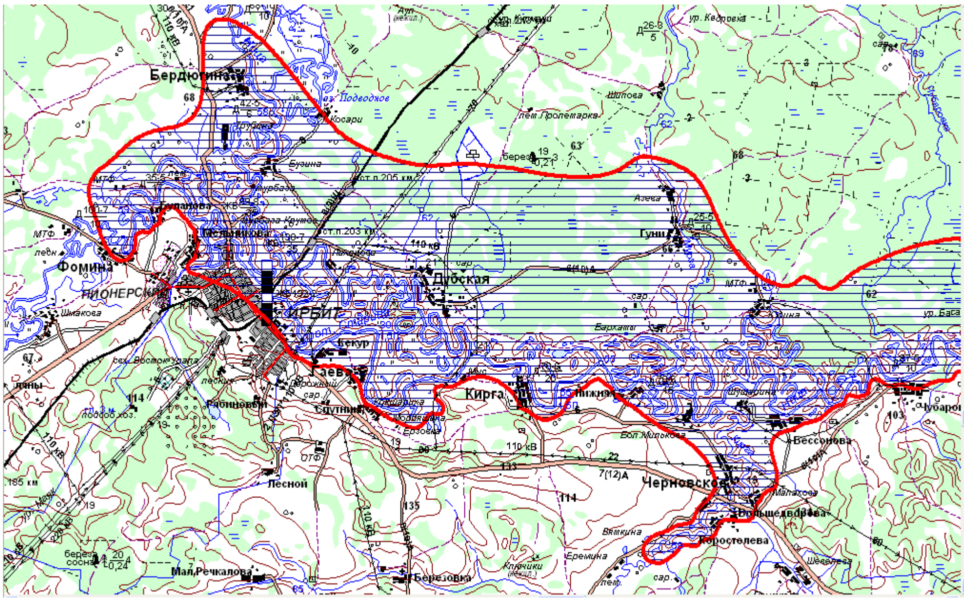


Figure 2. Flood prediction for the Nitsa-river with a 1:200000-scale map is being used

According to the information from the Sverdlovsk Regional Emergency Management Agency, accuracy of flood prediction makes up 90 %, even with maps of a medium scale, being used.

This program applies the method for calculating flood zones in case of catastrophic destructions of hydrological constructions.

The route determination program allows for building a graph using linear features (a road network, communications, etc.) from a digital map, if a start and destination point of the rout are indicated, and visualize it on a map. If one section of the route is deleted, the program will choose a new route. It can also be used in predicting damages for heating systems, power supply networks and pipelines.

The database «Inventory of potentially hazardous objects» is created for storing the data on hazardous objects. The database permits to accumulate data on industrial enterprises of the region. The Inventory presents a set of tables, designed according to the structure of a typical safety passport for a potentially hazardous object. Working with the database, a user can introduce (edit) data on organizations with potentially hazardous objects and information about these objects, to choose samples using particular parameters or a set of parameters, to export data to Word and Excel. It also permits an automated generation of safety passports for hazardous objects in the Word format. Records in the database can be linked to the objects, represented on a digital map.

The introduction, since the middle of 2005, of «safety passports» for objects and territories in the work of the territorial emergency management agencies made it necessary to develop software for automating the process of risk estimation.

Risk calculation is a key and time-consuming stage in the risk estimation process. To automate the procedure, there was developed a module for calculating risks at potentially hazardous objects, and a module for calculating the complex individual risk. Applying these modules, a user can calculate risk indicators for the territory and build diagrams for social (F/N) and material (F/G) risks.

The module for the complex individual risk makes it possible to calculate an indicator of the complex individual risk for a territory and making a map of the complex risk. This type of maps is needed for drawing up safety passports for municipal entities and subdivisions of the Federation. As there no exist guiding documents, which specify the calculation of a complex individual risk, Uralgeoinform's specialists, in collaboration with the monitoring centre of the Sverdlovsk Regional Emergency Management Agency, developed their own methods, which form a basis of the module. For the module's correct operation, it's necessary to prepare a layer, reflecting the damage effect areas with known indicators of the complex individual risk for population. As a result, the module creates a layer of isolines, representing risk levels for a territory, and calculates a numerical value of the complex individual risk indicator. (This indicator is needed for a safety passport of a territory).

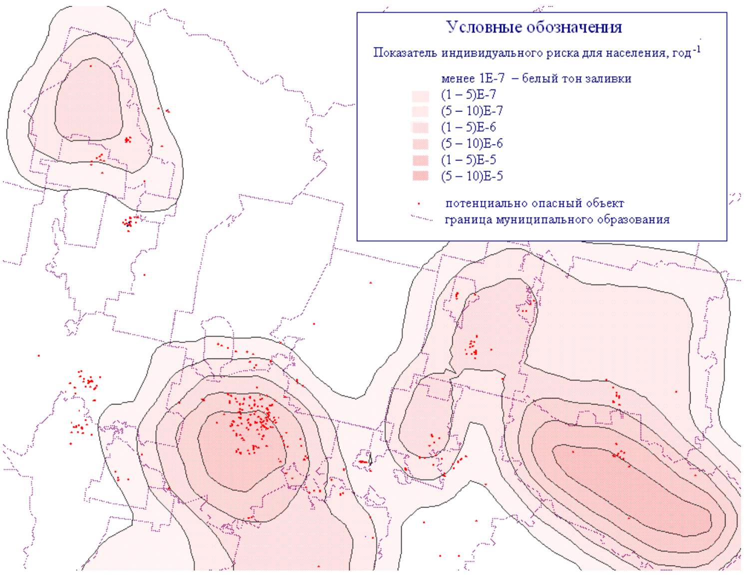


Figure 3. A fragment of a map, representing the complex individual risk indicators

GIS for Emergency Management is currently applied by specialists of the Territorial Center of Monitoring of Sverdlovsk Region in their every-day activities.

The system can be adapted to be used in any territorial centre of monitoring, which deals with problems of providing safety for population and territories, and by emergency management agencies in municipal entities. As the system is open, it can be extended to new customized applications.

Uralgeoinform's specialists are developing a technology for publishing data at the portal www.geourfo.ru, to provide an efficient interdepartmental interaction for preventing emergencies and informing the population on emergency risks.

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**BIOGRAPHICAL NOTES**

Serebryakov S.V. graduated from the Novosibirsk Institute of Engineers for Geodesy, Aerophotography and Cartography in 1984, specializes in aerial phototopography. Since 2001, he is a chief engineer at FGUP «Uralgeoinform». He is a candidate of technical sciences. His research interest is geoinformatics.

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# VIRTUAL REALITY: NEW APPROACHES TO TRAINING RESCUE PERSONNEL

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**Summary**

A new method for training rescue personnel is proposed, in which environment parameters are measured, analyzed and predicted and 3D visualization is used for presentation.

Large accidents and calamities of the recent time had significant social impact and affected the state view on the problems of emergency situations. Human fatalities, significant financial losses and social consequences of the accidents impel on looking for ways to improve training of, remodel or otherwise improve rescue services and formations.

Certainly, the best training can only be attained in real-life conditions. The traditional training aids (books, videos, tutorials etc) are not sufficient and not very efficient. The VR technology is aimed to reduce the gap between book training and real life training. It ensures higher concentration and involvement and thus provides for more ingrained skills.

In handling emergency situations, the decision making is cumulative, as it requires taking into account more data as the situation progresses. Thus, compact visual representation in VR would help the team leader make the decisions on a higher level.

The process of removal of accident results is governed by a lot of instructions and regulations and in critical situation it is difficult for the team leader to come to an optimal decision in time. Coordinated action of the leader and the team is crucial, as any mistake can result in serious consequences. A simulator trainer based on virtual reality is a versatile and flexible mean for training, teaching, working out interactions in various emergency situations that are impossible or expensive to model in real. Simulator based training improves efficiency, precision and speed of solving variety of tasks.

The Institute of Automation and Electrometry SD RAS and SoftLab-NSK accumulated a 30-year experience in building VR trainers. Our main customers are Gagarin Cosmonaut Training Centre, Russian Railways and others. We offer to develop a simulator trainer for rescue services in the following three options: “Mine”, “Factory”, “City”.

“Mine” is a 3D interconnected network of shafts, some of them with failed ventilation. Coupled with the diagnostic sensors it provides:

- Visual control of main safety-related parameters (methane, CO, smoke concentration) and automated warnings for possible emergencies;
- Real-time tracking and visual representation of people locations and state;
- On-the-fly checking of the diagnostic sensors for failures.

After the accident took place:

– Continuous control and prediction of main safety-related parameters (distribution of methane, CO, smoke, probability of caving or fires);

– Real-time tracking and visual representation of locations and state of people remaining in the mine;

– Search for optimal path of evacuation and search for optimal path for rescue personnel to reach the injured, taking into account the predictions of safety-related parameters;

– Fast familiarization of the rescue personnel with the mine topology, the routes for the mine personnel and the rescue personnel, locations of safety equipment and communication equipment and all kinds of hazards on the way;

– Fast learning and memorizing by the rescue personnel of their route with aid of visual imitation of following the route (visualizing the interior of the shaft).

“Factory” is different from the “Mine” by the topology of the structure, and is modeling and visualizing the processes taking place inside and outside the buildings of a factory plant. Also differs by a number of openings from the inside to the outside. The system provides modeling of:

– Lighting, depending on the daytime (day, night);

– Weather (fine, rain, snow), fog, smoke;

– Collapsed walls or other structures specific to the object.

Trainings for:

– Interaction between team members;

– Detection of presence and concentration of poisons/radiation on the object, front and dynamics of the chemical/radiation contamination;

– Handling the devices and probes;

– Reconnaissance from the air, by vehicle or walk;

– Laying out routes for evacuation of the injured and for delivery of the enginery;

– Removing the obstructions manually or using the enginery.

“City” is modeling and visualizing the following processes, occurring in the open space: distribution of the wreckage, contamination, prediction of the traffic flow. It can lay out routes for evacuation and for the enginery motorcades.

It is dealing with the following notions:

– Quarter, Factory, Building – Degree of destruction, Degree of functional integrity, Degree of contamination;

– Street - throughput performance, Collapse/Contamination/Accident, Traffic jams, Traffic, Routing of the traffic flow;

– Air - Wind, Direction, speed, contamination map;

– Landscape - relief, contamination map;

– Water - contamination map, map of currents.

**Visual representation methods:**

Familiar topological maps:

A topological map is a 2.5D electronic map with zoom, pan and rotation and a number of ways to visualize parameters of buildings and constructions. It serves as a mean for the experts to familiarize with the topology and organization of the object.

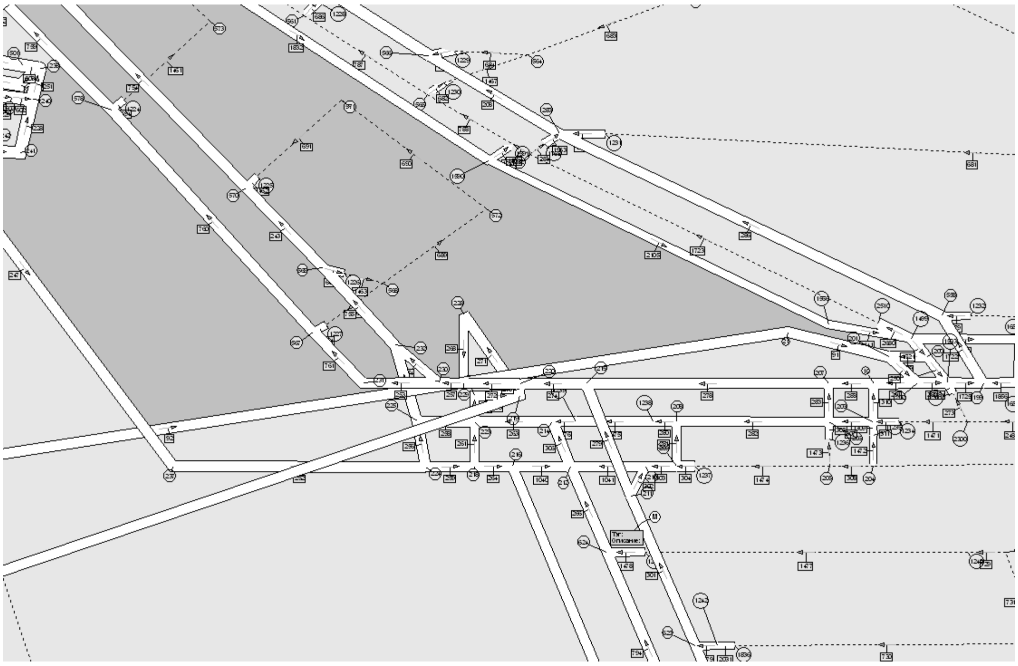

Figure 1. A mine topological map, zoomed to a selected area

3D view (outside view) of the topology:

The outside view enables surveying large areas chosen by the operator by criteria. It should provide for fast familiarizing and memorizing of the selected area topology by the rescue personnel, visualization of necessary parameters (methane, CO, smoke, contamination, temperature), of people locations and state, cave-ins, special equipment, probes, and also laying out and visualization of optimal routes for people in emergency situations. 3D representation of an area with building, with rotation, zoom and pan of the virtual camera prompts memorizing and understanding for the selected area topology, as such representation is most natural for human perception of complex 3D structures.

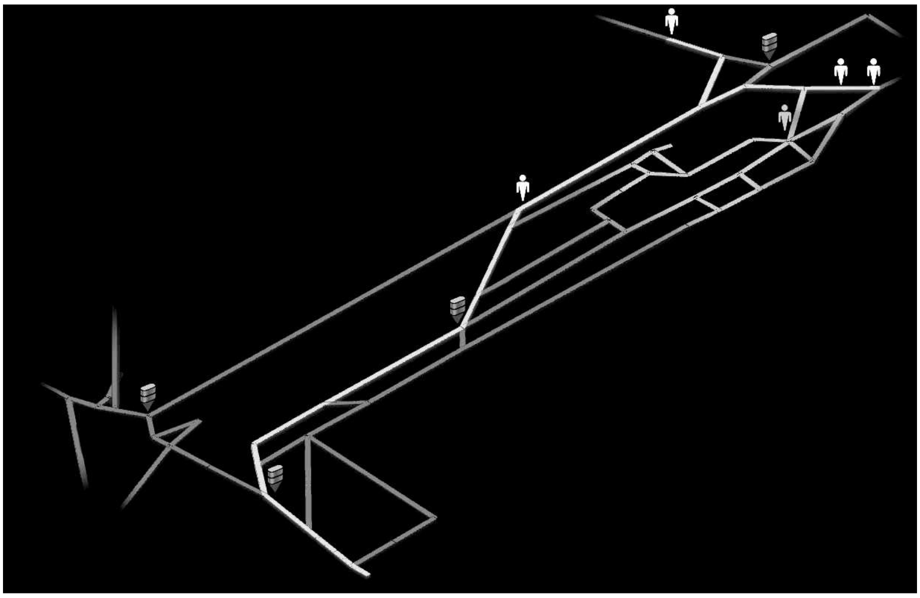

Figure 2. Outside view. Zoom of the selected area, showing a sub-area with smoke, locations and state of the people, route of evacuation and safety equipment on the route

3D view (inside view):

The inside view facilitates fast memorizing and understanding by the rescue personnel of the route inside buildings, mines, and locations of people and special equipment on the route and adjourning areas, and visualizing safety-related parameters (presence of CO, smoke or high temperature or other). The inside view is supposed to form a sense of presence inside the object for the rescue personnel. This will help them to orientate themselves even in unfamiliar areas.

Fig. 3. Inside view. Zoom of the selected area, showing sub-area with smoke, locations and state of the people, route of evacuation

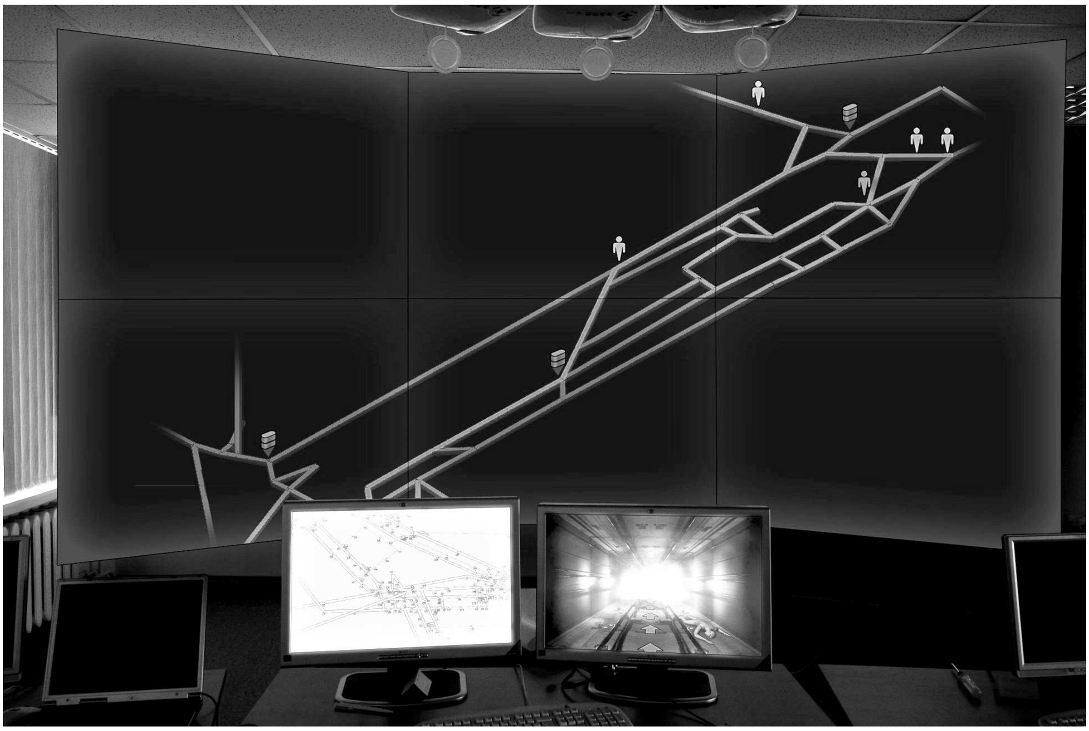

Fig 4. The control room. Foreground: two-channel operator console with the topological map and the inside view. Background: 6-channel visualization with the outside view for the rescue personnel preparing for the mission

The workplace of the operator has the following:
1) The control console
2) Multi-channel panoramic visualization system
3) Computation system
4) Automatic visual model builder system

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# EQUIPMENT FOR ACCIDENT RESCUE OPERATIONS ON RESERVOIRS

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**Summary**

In Trofimuk Institute of Petroleum Geology and Geophysics SB RAS (IPGG SB RAS) prototypes of small-sized multipurpose IG-1MS and IG-1MP engineering hydrolocators (in stationary and portable configurations) are developed and made. The devices designed for express monitoring of shallow reservoir pollution have passed the State testing and are included into the All-Russian classifier of the Products.

A modified circuit of monopulse location developed by IPGG SB RAS is used in the hydrolocators to ensure high spatial resolution.

Small-sized hydrolocators being installed on auxiliary floating crafts -boats, motor boats, ferries- are designed for topographic investigation of water obstacles.

A team of rescuers conducting accident rescue operations to avoid emergencies caused by natural disasters, technogenic and ecological catastrophes in the areas containing different reservoirs (rivers, flood zones, lakes, bogs, harbor waters, basins and etc) should determine operationally a safe way of evacuation, a ford location and its trafficability, define the places where emergency bridges can be put on as well as the nature of different natural and man-made obstructions and objects and the places of their locations in a water body or in sediments.

To solve these problems one should obtain in real time a sounding chart, a relief map (including data on mechanical characteristics and width of bottom sediments), a map of a current profile, and a map showing the location and size of different objects in reservoirs at the work area.

This information is required to evaluate ecological and economical consequences of emergency.

When conducting the works one should consider the following unfavorable characteristics of reservoirs examined:

- High muddiness due to a great amount of suspended particles of a dug-out earth, silt, peat, gas bubbles and etc.;
- Obstacles (subsurface timbers, tree stems, parts of man-made constructions) preventing float craft motion;
- Natural and man-made obstacles on a bottom;
- Spatial water inhomogenuities caused by considerable fluctuations of a current speed, temperature and density.

A set of equipment designed for the topographic investigation of reservoirs should allow one to obtain the required information (including hard map copies) under field conditions, be quickly installed on any floating craft (motorboats, floats, swimming vehicles) and be provided with an independent energy supply system from an accumulator.

Besides the equipment should be resistant to environmental load and severe operating conditions, allow submersion (without loss of function) and be low weight and small-sized, especially an antenna system.

To meet the abovementioned requirements, a set of devices a for the topographic investigation of reservoirs should include a course hydrolocator, a surveying echosounder, a device for measuring mechanical characteristics of the bottom sediments, a current meter, an embedded navigation system, a monitor display unit and a printer for maps.

To follow the safety requirements upon accident rescue operations, the course hydrolocator should ensure reliable detection of navigational obstacles with a size of 10 cm and more in a range of 20 meters at a distance of 50 meters. Angular resolution therewith should be no more than 2 degrees. The information obtained is provided to a motorman of the floating craft as video pictures with a rate of no less than 10 pictures per second.

In IPGG SB RAS prototypes of small-sized multipurpose IG-1MC and IG-1MP engineering hydrolocators (in stationary and portable configurations) are developed and made by an order of the Ministry of Defense of the Russian Federation. The devices have passed the State testing, are included into the All-Russian classifier of the Products and have been used by the Army Corps of Engineers of the Russian Federation since 2005.

A modified circuit of monopulse location developed by IPGG SB RAS is used in the hydrolocators to ensure high spatial resolution.

Small-sized engineering hydrolocators are designed for the topographic investigation of water obstacles from auxiliary floating crafts- boats, motor boats, ferries.

Upon topographic investigation the hydrolocator:

– Determines a depth of a water obstacle, measures a current speed, thickness of bottom sediments and a load bearing capacity of sediments;

– Detects and determines a location and a size of a navigational obstacle in a depth of a water barrier;

– Detects foreign objects in the bottom sediments;

– Produces automatically the maps of navigational obstacle locations and of the bottom profile in the examined section of the water barrier with a hard copy output.

When the navigational obstacles in a depth of the water barrier are detected at a nearer distance than it was preliminary determined, audible and visible alarms are produced.

The hydrolocators are provided with embedded navigation systems for topographic adjustment of the maps created. These are a GPS receiver in the IG-1MC and a system based on the integration of the vector current meter readings with due regard to the traveling direction of the carrier by the gyro-compass readings in the IG-1MP.

The current information is displayed to an operator as video pictures with a frequency of 14 pictures/ sec.

An ergonomic evaluation of a man-machine interface was performed at a stage of a hydrolocator engineering design.

The basic hydrolocator specifications are given in table 1. Fig.1 gives a general view of the IG-1MC hydrolocator. Fig. 3 gives an example of output data (a screen layout of the hydrolocator display) provided to the operator.

Table 1. Basic specifications

| Basic specifications | | |
|---|---|---|
| Name | IG-1MC hydrolocator | IG-1MP hydrolocator |
| Weight, kg: | | |
| Control unit | 12,1 | 5,4 |
| Antenna system | 8,5 | 6,6 |
| Accumulator | - | 3,2 |
| Dimensions, mm: | | |
| Control unit<br>Antenna system | 385x338x155;<br>450x300x250 | 385x340x155;<br>300x300x250 |
| Accumulator | - | 243×106×115 |
| Supply voltage, V | = 24, on-board power system or accumulator | = 12, on-board power system or accumulator |
| Power, W<br>Operating temperature range | 18<br>- 40 … + 60 $^{o}$C | 10<br>- 40 … + 60 $^{o}$C |

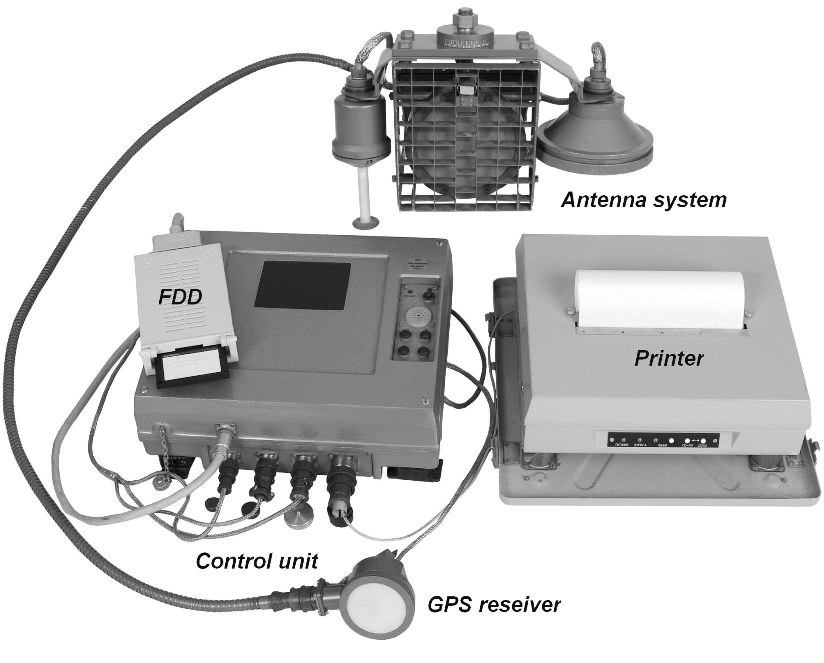


Figure 1. General view of the IG-1MC hydrolocator

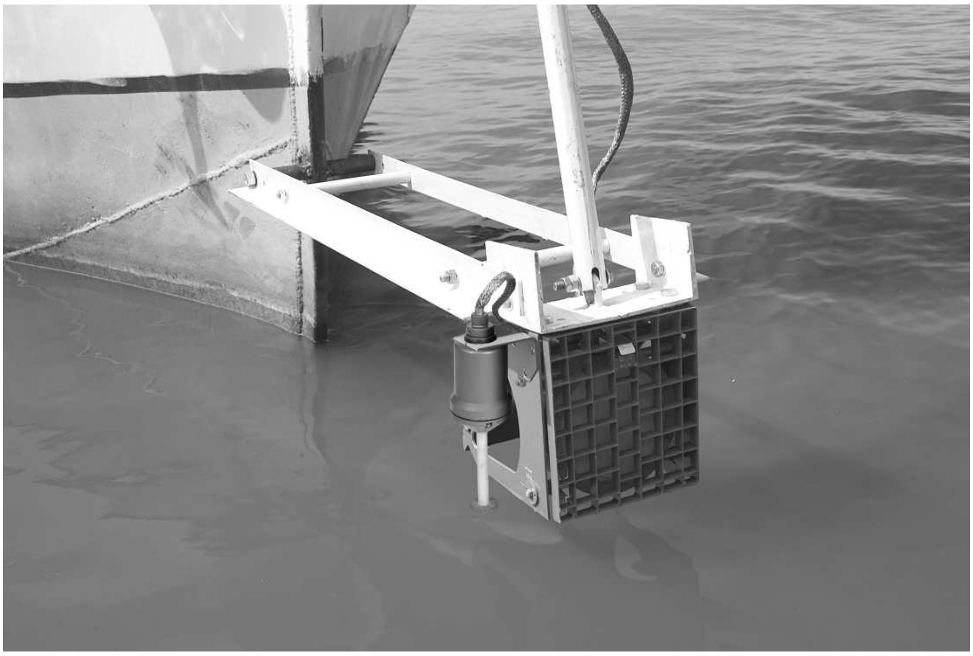

Figure 2. Installation of the antenna system on a motor boat

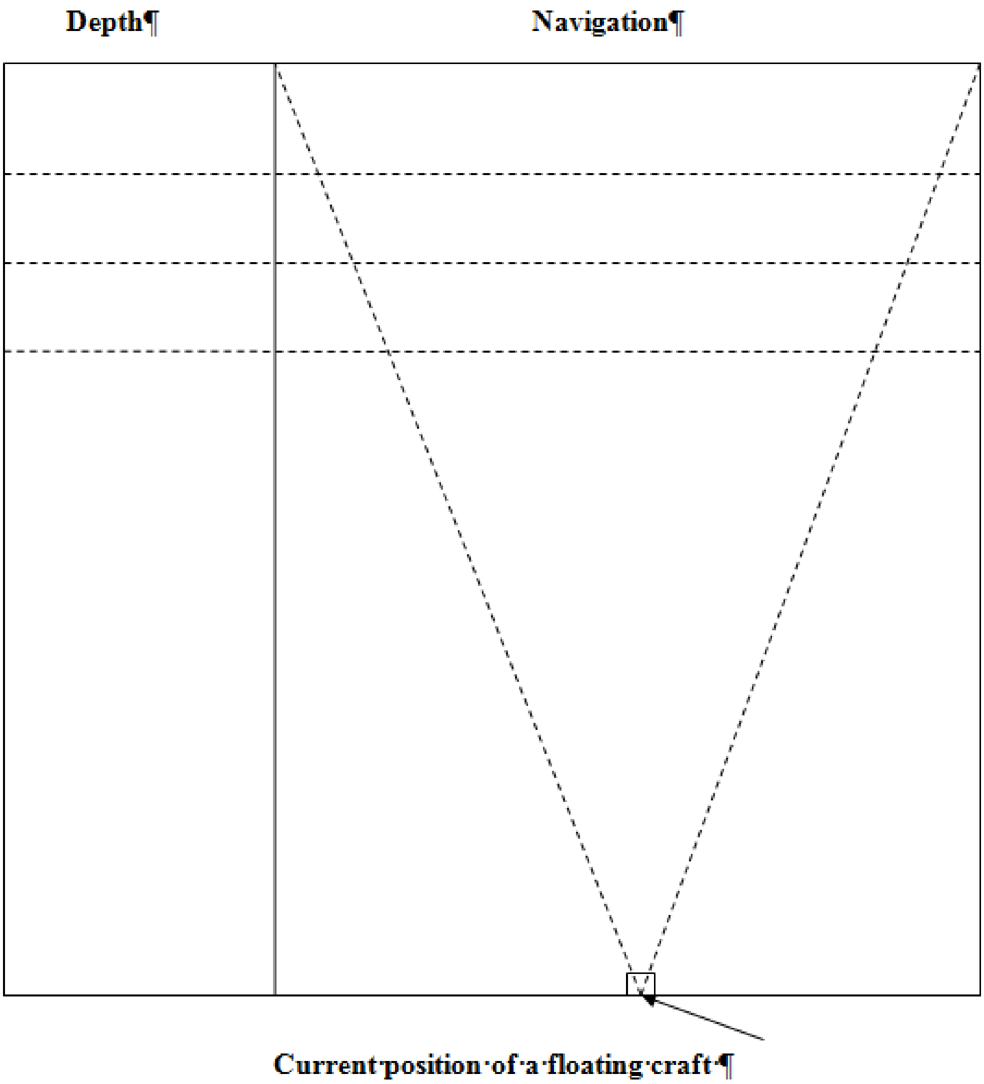


Figure 3. Video picture on the hydrolocator display upon reservoir investigation

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NEW EMERGENCY CARDS FOR THE PREVENTION AND LIQUIDATIONS OF EXTREME SITUATIONS WITH DANGEROUS GOODS ON THE RAILWAY

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**Summary**

In article there has been discussed the features of methodology of formation of emergency cards from a file of dangerous goods and factors of their updating. There are stated results of the researches executed by the development of a new package of emergency cards within the framework of work on harmonization of all major regulations on the transportation of dangerous goods. The results of this research are approved by the Council for Rail Transport and introduced on the railways of 15 states.

There are created the systems of prevention and liquidation of consequences of extreme situations caused by various sort of factors on railway and other types of transport. The transportation of dangerous goods is one of significant continuous factors. The failures of transportation lead to incidents, crashes and extreme situations. These infringements of a normal mode of transportations create a threat to a life and health of people, and also negatively influence objects of the environment.

Last year there is paid more attention to ecological safety on the railway. The ecological program of the branch directed to reduction anthropogenic pressure on /1/environment is implemented first of all by efforts of Open Joint-stock company “Russian Railways”. Detailed perfection of transportation of dangerous loads is one of tendency of the given activity. One of the main elements in developed Danger Prevention System (DPS) at transportations of dangerous goods on railway [2] is the emergency cards accepted on many types of transport and in many countries. They are intended, except for other important purposes, for the organization operative and adequate nature protecting actions at liquidation of consequences of extreme situations.

It is necessary to note, that purpose of emergency cards in modern conditions (legal, organizational and technical) still is:

– To serve as element DPS, in particular, number of an emergency card is displayed on the sign of danger drawn on all wagon, containing dangerous loads;

– To serve as the basic document regulating organizational and technical activity at the prevention and liquidation of emergencies of both workers of a railway transportation and the involved bodies, experts and the specialized formations;

– To promote unification and compression information and decisions which are necessary to liquidate the accidents; to carry out functions of “an information package”, which (or its “image” – number) is transferred by means of communications in the cases established by normative and technical documents.

The majority of railway experts the participants of Commonwealth of Independent States (CIS) saw the growth of contradictions, discrepancies between constant structure and the contents of emergency cards, on the one hand, and requirements and points of the documents connected to them, on the other hand. As a result of intensification scientific and technical discrepancy Railway Administration and their coordination executive center – Management of Council – took the decision on necessity of harmonization of all basic rules of transportation of dangerous goods, including a package of emergency cards. Such work can be carried out taking into consideration the international and national rules and rules on the advanced scientific - methodological base only. A number of experts' proposals of Open Joint-stock company "Russian Railway", Ukraine, Belarus and Latvia have been considered and realized at different stages of elaboration.

The periodicity of transition to new packages of emergency cards for the Russian railway is 13 and 12 years (1984–1997, 1997–2009). As the CIS reported the period of transition is 9 years (2000–2009), but this quantity should be recognized as surplus. By our estimation, the periodicity should be max than 5–6 years taking into account modification in the international specifications and rules, changes of state regulation, organizational and economic opportunities.

The emergency cards that were used till July, 2009 on the Russian railways, and also on railways of the countries CIS and Baltic emergency cards [3, 4] have been developed by collective of experts under A.M.Ostrovsky's management.

Creating the emergency cards the experts took into account the experience of development and introduction of the first common network document titled "Safety regulations and the order of liquidation of emergencies with dangerous goods by transportation them on railway" [5]. These regulations included 130 emergency cards as the appendix.

A new methodology [6-8] has been developed to construct a package of emergency cards on dangerous goods with classes of danger 2, 3, 4.1, 4.2, 4.3, 5.1, 5.2, 6.1, 6.2, 8 and 9. This methodology has the important scientific and practical value. A new package [9] was developed on the basis of this methodology. The general results of this approach are stated in present article. Siberian State Transport University was set the specified task by Management of the Council on a railway of states-participants of Commonwealth before in 2006. The research stage has been completed and the document was approved on May, 30 2008 at 48 Meeting of the Council. Introduction of this methodology was directed since July, 1, 2009 on railway of 15 state-participants and observers.

Necessity for a new package of emergency cards is caused by the several reasons most essential from them are:

- Appearance of new dangerous goods in the List of dangerous goods allowed to transportation [9]. This new dangerous goods are referred to serial numbers of the United Nations [3, 4];
- Appearance of new dangerous goods with new numbers of the United Nations;
- Some classification criteria are changed in the international rules owing to this matter there has changed the basic or additional kind of danger for the certain set of goods;

– Change of classification of classes 3 and 8, exception of division the given classes on three subclasses;

– Change of the classification table establishing of classification codes;

– Significant revision of structure of goods of a class 9 and criteria of reference to it.

According to its purpose the emergency card should regulate only the common principles since taking tactical and additional measures are entrusted to heads and experts and depend on developing condition (those circumstances which cannot be taken into account in generalizing document – an emergency card). Taking into account the international status of the complete set [9] and voluntariness of its usage the emergency cards should be based not only on realities of native transportation process, but also correspond to those of the majority of the countries of Commonwealth. First of all it is concerned of railway which carried out significant volumes of internal and transit transportations of dangerous goods. Owing to this the approach was modified so the instructions of cards less imperative, more variable.

For example, there is allowed the application of personal protective equipment (PPE) with the certain marks but also the samples with similar tactical and technical characteristics. Also the previous abbreviation of the name of organization (CSES – Center of Sanitary and Epidemiological Surveillance) is replaced with “bodies of sanitary-and-epidemiologic supervision”.

At a preliminary stage 2 concepts were realized: creation of new emergency cards from a full file of dangerous goods (“new sorting”) and partial change of existing emergency cards with addition new one if necessary (“updating”). Finally both approaches lead practically to similar results. By virtue of less labour-intensity the preference can be given to the "updating" including 4 basic of process:

– Entering a new dangerous goods into an existing emergency card, in other words, addition of an emergency card;

– Inclusion the known goods in an existing emergency card, i.e. moving a goods from one card in another;

– Exception a goods (as harmless) from an emergency card;

– Formation new emergency cards and inclusion new dangerous goods into them.

According to a method [6], primary operative actions $\{z_1, z_2..., z_и\}$ are caused by necessity of elimination of the danger which has arisen in connection with dangerous good G which has dangerous properties $\{x_1, x_2..., x_m\}$. Necessary actions are determined not only dangerous factors of a goods, but also others - by “characteristic" parameters of substance, including physical and chemical properties, organoleptic parameters (smell and taste), features of molecular structure and others $\{y_1, y_2..., y_h\}$. In the accepted terms emergency card (EC) – is the document establishing conformity (z) between dangerous and characteristic properties of a dangerous good and necessary measures for the prevention and liquidation of danger:

$$G(\{x_1, x_2, ..., x_\mu\}, \{—_1, —_2, ..., —_\eta\}) \xrightarrow{Z} \{z_1, z_2, ..., z_{\dot{Z}}\}, \qquad (1)$$

The emergency card represents the information in the certain symbols and in the certain structure:

$$AK = \begin{cases} y_1, y_2, \dots, y_\eta \\ x_{11}, x_{12}, \dots, x_{1\pi} \\ x_{21}, x_{22}, \dots, x_{2\tau} \\ \dots \\ x_{\mu 1}, x_{\mu 2}, \dots, x_{\mu\sigma} \\ z_{11}, z_{12}, \dots, z_{1\rho} \\ z_{21}, z_{22}, \dots, z_{2\theta} \\ \dots \\ z_{u1}, z_{u2}, \dots, z_{u\delta} \end{cases} \qquad (2)$$

Not all parameters of a dangerous goods reflected by conformity z, are submitted in АК in an obvious kind. In some cases such indication (property) is not necessary; the essential point is presence of instruction – of action. The accepted method was applied as concerned internal structure and the contents of an emergency card. Some editorial positions were changed what has been told above.

The basic modification of a method concerned formation of emergency cards as set of dangerous goods with identical danger.

As it has already been told, goods of classes 3 and 8 are not subdivided into subclasses, according to new classification. There is one more essential change that serial number of the United Nations had been determined as the third characteristic attribute (after a class – $p_1$ and a subclass – $p_2$). In expert's opinion the choice of this attribute continues a logic line: a class ($p_1$) – a subclass ($p_2$) – number of the United Nations ($p_3$) – the classification code ($p_4$) – groups of similar goods ($p_5$) – the separate dangerous goods possessing individual properties ($p_6$). This approach alters essentially the concept since number of the United Nations "comprises" diverse characteristic attributes [6]. It is possible to note thus, that actually the attribute $p_2$ now is distributed only to a class 2 (the features of its application for classes 4.1, 4.2, 4.3 will be considered in separate work).

Procedure of formation of emergency cards is represented consecutive transformation of sets of dangerous goods $N_{i,j}$ in sets of goods $N_{i,j}(x_y, x_\sigma, \dots x_\theta, y_y, y_\sigma, \dots y_\theta)$, each of which is a base set of goods for formation of an emergency card. Thus, transition from a file of goods N to emergency cards is carried out by consecutive transformations $p_1 – p_i$ with formation package emergency cards, i.e. sets of the cards which included dangerous goods of certain classes (see tab. 1):

$$N \to (p_1, p_2, p_3, \dots, p_i) \to \sum_{j=1}^{k} N_j n_j, \qquad (3)$$

Where: $p_1 \dots p_i$ – characteristic attributes;

$N_j$ – number of dangerous goods in j package emergency cards;

$n_j$ – number of emergency cards in j package;

k – the common number packages (in the given analysis 10).

As a result of sorting there have been received packages emergency cards of corresponding classes in quantities (amounts) $n_*2$, submitted in Table 1. Also quantities $n_{*}1$ and factor of increase $K = n_{*}2/n_{*}1$ are represented right there. The given factor indicates multiple of increase of the number of packages and characterizes increase of internal “heterogeneity” of qualities this or that package at increasing the number of dangerous goods in it. The general increasing the number of dangerous goods $N_{*}2/N_{*}1$ is approximately 3.

The emergency cards have been broken into 3 groups of classes depending on K quantity:

I – K = 1.0 – the number of emergency cards practically has not changed (3 package);

II – K = 1.8 + 0.1 – the number of emergency cards has grown almost twice (4 package);

III – K = 3.2 + 0.2 – number of emergency cards has tripled almost (3 package).

The quantity K characterizes an internal variety of properties packages and will be investigated in details subsequently. There is represented the summary values on both packages in Table 2.

Table 1. A grouping of classes of danger and rules of construction of packages of emergency cards/3/and/9/

| The group of classes | Classes (packages) | K | N 1 /3/ | n2 /8/ |
|---|---|---|---|---|
| I | 1 | 1.0 | 79 | 84 |
| | 5.2 | 1.0 | 1 | 1 |
| | 6.2 | 1.0 | 1 | 1 |
| II | 2 | 1.8 | 10 | 18 |
| | 3 | 1.7 | 21 | 35 |
| | 6.1 | 1.9 | 22 | 41 |
| | 9 | 1.8 | 5 | 9 |
| III | 4.1,4.2,4.3 | 3.2 | 9 | 29 |
| | 5.1 | 3.0 | 5 | 15 |
| | 8 | 3.3 | 11 | 36 |

Table 2. The comparative characteristic of packages of emergency cards

| Number of emergency cards | N1 | N2 | K |
|---|---|---|---|
| As a whole package:<br>- in view of all classes<br>- without taking into account a class 1 | 164<br>85 | 269<br>185 | 1.6<br>2.2 |
| On the average one class (without class 1) | 9.0 | 20.6 | 2.3 |

**Conclusions**

In the given work results of the researches are stated which directed on prevention of extreme situations, increase of traffic safety and ecological safety on a railway.

There is executed the development of a new package of emergency cards on dangerous goods. The package is intended for application at goods transportations in the message of the countries CIS and Baltic.

There has been discussed the features of methodology of formation of emergency cards from a file of dangerous goods and factors of their updating. The revealed laws allow analyze more deeply set of the dangerous and other characteristic properties inherent in dangerous goods of various classes.

Results can be applied by experts on prevention of extreme situations, on increase of traffic safety and ecological safety on other types of transport.

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# GIS TECHNOLOGIES IN THE SOCIAL HEALTH-RELATED TERRITORY MONITORING SYSTEM

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**Summary**

At present in Russia there is a social health-related monitoring system that aims at human health status and environmental factor supervision. GIS-technologies help to specify and analyze visually a causal connection between environmental conditions and public health.

Ecological strategy of the world's leading powers is based on the top target that is to protect population's health from environmental hostility. The problem of finding a casual connection between environmental conditions and public health is the principal one among social, medical and ecological challenges. More than 30 years of experience of the developed countries in this field proves the urgent need for instruments to control environment-health connection in the State Administration [1].

Current ecological situation in Russia is rather unfavorable. The excess amount of industrial chemical waste enters the environment and results in air, soil and water pollution. Biosphere and its human-connected elements in particular are also affected. High development and human-induced pressure taken with unfavorable social and economical situation in Russia is a real threat of ecologically-dependant diseases mass propagation that mainly concerns large and urban regions. The need for accurate and timely data about the environment and human health is growing with them being required for immediate management solutions, and preventive and diagnostic procedures development and correction [1].

The tasks to be solved by the specialists in the field of public health and human environment are rather complicated. The solution for each task shall be found with the help of optimal corresponding instruments to analyze miscellaneous data.

At present there is a state unified social health-related monitoring system to supervise human health and environmental factors.

The main functions of the social health-related monitoring are hygienic assessment, finding a casual connection between environmental conditions and public health on the basis of system approach and public health risk assessment, determination of causes and conditions for infectious and mass noninfectious diseases appearance and spreading. So social health-related monitoring provides for the sanitary and epidemiological welfare of the population [3].

In the current context of the administrative reform the organization of the social health-related monitoring system on the territory of Russia requires brand new public health and environment data production patterns. Such approach shall be supported by IT systems.

To assess IT applicability a number of criteria shall be used:

– Capability to acquire, systematize, process and analyze a body of miscellaneous information from various regions and management levels;
– Use of generally valid database (DB) tab layout;
– Information system availability for the state power and management bodies, medical and other organization;
– Flexibility for the step-by-step implementation;
– Comprehensive facilities of data export and import;
– Use of developed and generally valid platforms;
– Economic feasibility.

Geographic Information Systems (GIS) comply with the above mentioned requirements in full. They are the most science-intensive and promising management instruments both on the state and regional or local levels. GIS's performance capabilities allow combining and displaying data segments of any size on a common map.

In the course of social health-related monitoring the acquired data that are necessary for the further analysis and environmental pollution reporting are stored in a unified register of afield stations. Each station has a number of indices containing measurement data.

Through GIS the traffic load and cartographic segment are integrated into a common information area that is followed by measurement analysis in order to find out critical values and build subject diagrams and graphs.

GIS's data systematization and sequencing method is extremely easy to percept for any person: graphical object display with anchoring miscellaneous data. It is of importance that GIS allows to reproduce acquired and sequenced data in the raw state or in the form of statistics, i.e. average values, probability surfaces, index confidence limits etc.

Geo information technologies are characterized by quick result acquisition that speed up emergency decision-making in cases it is connected with the most complicated objects under investigation (population, environmental components).

In the Novosibirsk Region the social health-related monitoring system has been running since 1998. Regional data fund to acquire all information consists of several units: population health status index, atmospheric air/ portable water quality and safety, surface water/soil health and disease control, environmental objects radiation safety.

GIS-technology helped to visualize the acquired data, to perform quick search and selection of objects that are within a ROI. Water and soil sampling results were digitalized for the further processing and analysis (measurement stations' coordinates were measured by GIS-receiver with the following databases' gridding to the available map.) The map of the city of Novosibirsk (Scale 1 : 10 000) by Siberian State Academy of Geodesy was taken as a cartographic basis for the creation and display of subject layers. Relevant database of buildings on the map allows for target geocoding of data on the cases, on chemical agents concentration in the air, portable water, or soil, on water mains accidents etc.

The analysis of Novosibirsk map in ArcGIS 9.2 showed districts with maximum concentration of pollutants in the atmospheric air with the information based on the analysis of factors that influence various agents' concentration, on the analysis of water and soil quality, on the location of infectious diseases. The use of GIS-technologies helped us to specify and analyze visually a causal connection between environmental conditions and health of the population.

The development and implementation of modern IT – including GIS-based electronic mapping – changed the quality of the analysis of a causal connection within the system *environment-health*. Social health-related monitoring being the main source of data on public health and environment status change became much more important.

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# OPERATIVE REMOTE MONITORING OF ANGARSKY REGION IN INTERESTS OF MAINTENANCE OF RATIONAL WILDLIFE MANAGEMENT AND EFFICIENT CONTROL

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**Summary**

In the article experience of use of methods and materials of operative remote sounding in interests of monitoring of a zone of influence of water basins of the Angarsk cascade is resulted. Problems of these water basins connected with operation of wood and mineral resources are shined these.

Recently the opinion on necessity of “reasonable restriction” consumption level of natural resources and non-admission their thoughtless expenditure more and more affirms. Preservation of biosphere is one of conditions of steady development of the territories, described high rates of development. But, despite of state regulation of preservation of the environment and wildlife management, there are the ecological and technological risks connected with operation of natural resources, work of industrial targets and hydraulic engineering constructions. All large technogenic constructions are potentially dangerous objects and demand regular monitoring of a mode of operation and their technical condition. Failure on Sayano-Schuschenskaya hydroelectric power station has shown that threat of accidents cannot be underestimated even on the most "reliable" objects.

Angarski Region is region to which the important role in development of Eastern Siberia is allocated. From the middle of the last century on Angara scale hydropower construction that has allowed involving unique natural resources has been developed and has provided intensive development of economy of region. But it became now clear, that at realization of many programs ecological factors therefore there were the problems demanding urgent operative monitoring of an environment and updating of strategy of wildlife management have not been considered.

The cores socially-environmental problem in pool of Angara are connected with transformation of a river network, construction of water basins and hydroelectric power station, pollution of water, and also operation of wood and mineral resources. For the analysis of a situation in these directions of wildlife management 3 reference sites are chosen: area of activity Ust-Ilimsk timber industry concern, area of construction Boguchany hydroelectric power station and area of gold mining in river basin Kamenka – the right inflow of the Bottom Angara. On these sites regular supervision over change of an environment with use of geoinformation technologies are assumed.

## The problems connected with transformation of water objects

Now about 940 km of Angara (53 % of the general extent) represent water basins of Irkutsk hydroelectric power station (it is filled per 1956-1960), Bratsk hydroelectric power station (is filled per 1961–1967) and Ust-Ilimsk hydroelectric power station (is filled per 1974–1977). The Total area of these water basins makes 7546 sq. km, total volume of water weight – 230.3 cube km. The general length of a coastal line is equal 12 thousand km, from them on a share abrasion, abrasion-landslide, abrasion-landslip and other complex coast it is necessary, by our estimation, up to 50 % of length of coast.

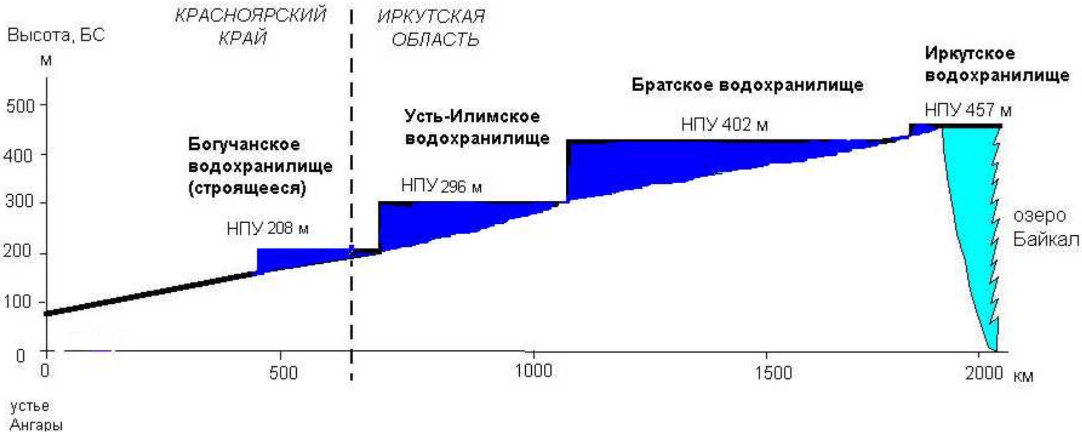


Figure 1. A longitudinal structure of Angara. Distances are given on a waterway of the river

In 455 km from a mouth of Angara construction of the next in cascade – Boguchany hydroelectric power station comes to the end. After commissioning this object under water basins there will be 74 % of length of Angara, its longitudinal structure will continue formation of the step form (Fig.1). As a result of such large-scale hydraulic engineering construction there was an infringement of a natural hydrological mode of Baikal (in connection with rising a water level a dam of Irkutsk hydroelectric power station), all Angara (in connection with a regulated drain), and also the bottom site of Yenisei. As consequence of these transformations in Angara water exchange was slowed down, ability of autopurification of water has essentially decreased.

Any river water basin represents flowing lake and in itself is not a source of pollution of water. But to Angara not enough the cleared drains the significant amount is dumped from the urbanized territories and the industrial enterprises of Irkutsk area, that extremely negatively influences a condition water ecosystems the water basins constructed on it. We shall note here, that after planned commissioning Boguchany hydrounit with mark of normal supporting level of a water basin of 208 m in a new reservoir will be accumulated drains with Ust-Ilimsk timber industrial complex (fig. 2), that will cause local secondary pollution of water. This question demands close examination and the effective decision: it is rational to lower a level of supporting of Boguchany hydroelectric power station with the purpose of preservation of a flowing site of Angara in bottom pool of Ust-Ilimsk hydroelectric power station to border with Krasnoyarsk region.

Besides, on water condition renders a great influence quality of preparation of a bed of water basins. So, on Bratsk water basin the third part of woods, on Ust-Ilim water basin – almost all wood pulp is flooded. As a result of rotting of wood and receipt of sewage quality of water in water basins below Irkutsk has worsened and on a number of chemical and biological indicators does not correspond to requirements of fish-industry and economic-drinking water use. A problem of operative space monitoring is tracing, an estimation and the forecast of changes of a condition of Angarsk water system (a problem – definition of the area of a water table in case of emergencies on dams and advancements of a wave of break, fixing of areas of possible superficial pollution of water, the control over rearrangement of coast, definition of places of a congestion of swimming wood, etc.) and coastal territories (the analysis of an anthropogenous component of changes of district).

Figure 2. Release of sewage to Angara with Ust-Ilim timber industrial complex. August, 28th, 2009

**The problems connected with operation of wood resources**

From the middle of the last century in pool of Angara intensive operation of wood resources, therefore, woods in considerable territories are exhausted is carried out. So, in the Top and Average Angarski Region half of large forests (fig. 3) is cut already down approximately. In these conditions the important problem is regulation of forestry activity for the purpose of reproduction of wood fund, maintenance rational using, and exceptions of illegal fellings.

At the comparative analysis of the data of remote sounding occurring at different times the changeablest elements of district registered on materials of space shooting are confidently allocated. In particular, all infringements of natural state of large forests concern them.

Figure 3. The taiga around bottom pool Ust-Ilim hydroelectric power station (a mesoscale space picture of Reference site 1). Stains of light tone – the cut down and burnt woods

For area of building of Boguchany hydroelectric power station (Reference site 2) we plan works on creation of maps of dynamics of an environment in scale 1 : 750 000 with use of space pictures, topographic maps and other materials of cartographical value. Cuttings down occurring at different times will be allocated for them, ashes, farmlands, a high system, electric mains and other objects. Tracing of dynamics of changes of the district connected with activity of the person in areas of new economic development of Angarski Region, is the important scientifically-practical problem which decision is possible on the basis of environment monitoring remote and cartographical methods.

**The problems connected with operation of mineral resources**

Almost all areas in which open mountain workings out are made are exposed to large-scale changes of an environment. For an estimation of a damage of such oeosystems one of pools of the small rivers of the Bottom Angarski Region where extraction gold from gravel deposit is conducted in the open way already more than century is chosen. As key range the pool of the river of Uderej, inflow of the river Kamenka running into Angara at bottom of the Yenisei range (Reference site 3) is planned.

At carrying out of mountain workings out by drag-hydraulic way on the bottoms of valleys of the rivers and streams the specific technogenic ridge-hilly relief with a high-rise partition to 5–7 m. With reorganization of a structure of the bottoms of valleys is formed change of natural hydro-geological conditions in pool that involves increase infiltration properties of thickness of friable adjournment, transformation of a hydrological mode of water currents and disbalancing of natural communications is connected. The soil-vegetative cover of the bottoms of valleys is completely destroyed. Drag ranges are dangerous pollutants of the rivers. Damage of an environment on such ranges it is accurately fixed on materials of remote shooting (Fig. 4) that allows objectively and to trace operatively occurring changes and to develop a complex of the nature protection actions directed on minimization of negative technogenic infringements of valley ecosystems.

Figure 4. Drag workings out in pool of the river of Kamenka (the Bottom Angarski Region). A mesoscale space picture of Reference site 3

In summary we will notice that the decision of tasks in view demands adaptation of techniques of space monitoring to specific conditions of Angarski Region. Operative remote monitoring supervision can provide the control over realisation of the concept of rational wildlife management in regional scale. The sustainable development of Angarski Region should be based on introduction in economy of ecologically safe technologies providing preservation of natural ecological systems and natural complexes.

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# THE FORECAST OF TECHNOGENIC AND NATURAL THREATS CONNECTED WITH EXPOLOITING OF THE NOVOSIBIRSK WATER BASIN

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The modern society is exposed to natural and technogenic risks. Annually in the Russian Federation more than 100 big emergency situations happen, which accompanied by deaths and serious economic damage. The Novosibirsk region has average index of quantity of emergency situations of natural and technogenic character. However on some possible natural and technogenic accidents the territory of the Novosibirsk region is in a risk zone. First of all possibility of emergency situations is connected with the existence on the territory of an man made hydraulic engineering construction - the Obsky water basin.

The water basin is the largest technogenic natural and territorial complex in the Novosibirsk region. The water basin hasthe name of the Ob sea, its area is 1082 sq. km that exceeds twice the territory of Novosibirsk. Water resources of the Novosibirsk water basin are used for: water supply of cities Novosibirsk and Berdsk, power, navigation, agriculture and fishing, recreation.

However, along with positive consequences of the construction of the Ob water basin its exploiting carries a number of threats of ecological and technogenic character.

Threats of natural character are:

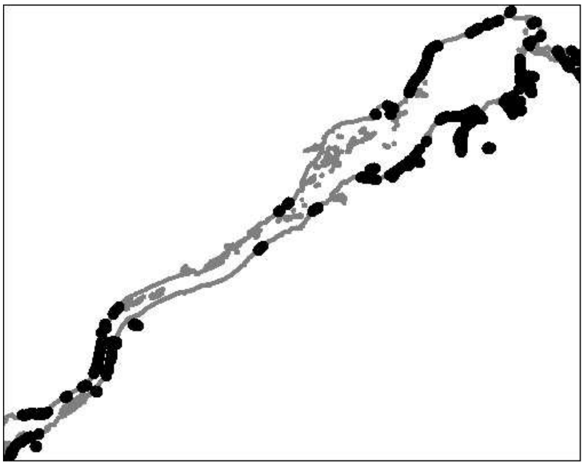
- Flooding of productive agriculture lands and valuable wood grounds;
- Progressing ravines and erosion of coasts, Fig. 1 a);
- Washing out in water of woods; extent of a coast line with progressing process of erosion is 140 km (Fig. 2);
- Water pollution by products of rotting of wood, reproduction of seaweed;
- Developing of fish parasitic diseases;
- Infecting of the population of the region by parasitic diseases and infections extending by infected fish or bathing (Fig. 1, b);

a)

б)

Figure 1. Examples of environmental problems in territory of the Novosibirsk water basin: branches and even trunks of trees on the water basin ashore casts in spring; “no bathing”

a)



б)

Figure 2. The combined raster and vector model of the Novosibirsk water basin, places of coast destruction are shown in black on the scheme

Threats of technogenic character are:

– Possibility of catastrophic flooding of territory of the left part of Novosibirsk caused by the destruction of a dam of the water basin. In Novosibirsk there can be catastrophic floodings if the pressure head front of Novosibirsk HYDROELECTRIC POWER STATION is destructed. And situations connected with flooding can happen. Using geoinformational system the mark of "Height" of flooding was calculated. The flooding area can be about 100 sq. km. In the flooding zone, only in the territory of the Leninsky district can get 12 700 industrial buildings and houses with the population about 100 thousand people. Besides, possible failure of life support objects of the city can lead to serious economic losses. In Fig. 3 the fragment of computer model of catastrophic flooding of territory of the Leninsky district is presented.

– Possibility of occurrence of the tehnogenno-induced geodynamic situations in the territory near the water basin. According to some scientists, the water basin has strengthened force of the earthquake which has happened in 2002 in Novosibirsk;

– The organization of illegal dumps, pollution of the water basin coasts by an industrial and domestic waste. Including the pollution of some territories of the Ob water basin because of using them as "wild rest" places of the population;

– Accumulation of harmful chemical substances in the bottom.

No doubt that the organization of monitoring system for operative and efficient territory control of the Ob water basin is required. The timely account and the forecast of changes of the condition of basic elements of the water basin should become an integral part of conducting any economic activities of people in this area. Thus it is necessary to organize the unique system of actions for research of the district, including as one of basic elements geoinformational monitoring of territory of the Novosibirsk water basin.

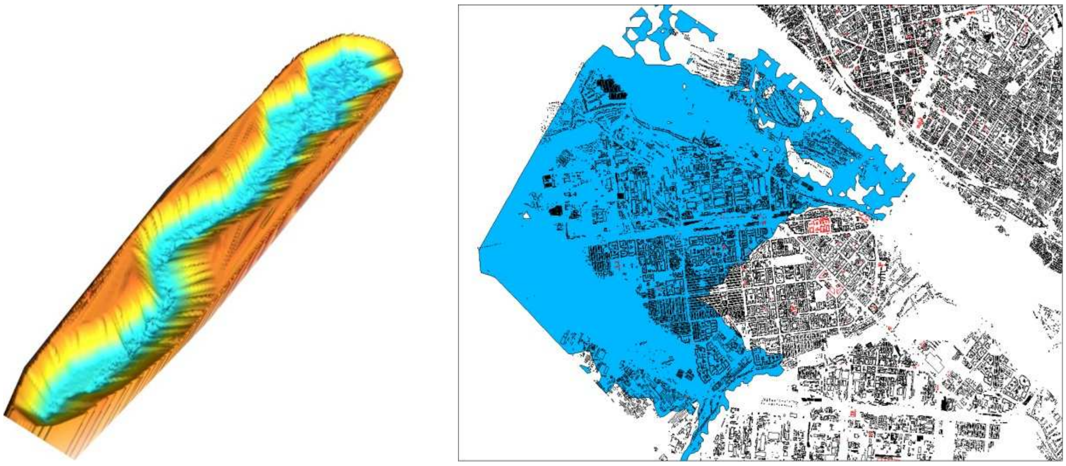


Figure 3. Computer model of catastrophic flooding of territory of the Leninsky district; three-dimensional model of the Novosibirsk water basin area

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# GEOINFORMATION TECHNOLOGIES AND MAPPING FOR PREVENTION AND ASSESSMENT OF NATURAL AND ECOLOGICAL RISKS (ALTAI KRAI AS A CASE STUDY)

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**Abstract**

The assessment of ecological risk for the territory is based on ecological-geographical and geoinformation-cartographical analyses. It makes it possible to determine the specific natural conditions and anthropogenic load as well as to assess the environment and human health. The cartographical modeling treats landscape structure of the territory as an information unit. In the course of landscape-ecological mapping of Altai Krai the matrix of conditions, factors and relationships was created. It allows the description and the analysis of relationship between the features of natural complexes and the anthropogenic load to be carried out, and the environment change causing the prerequisites for the occurrence of unfavorable ecological processes and phenomena, i.e. the ecological risk, to be revealed.

The concept of ecological risk involves at least two components that can be analyzed with geographical-cartographical tools. The first one is the natural risk that reveals itself in abrupt event change of geosystems and their components. Geoinformation-cartographical research allows the spatial analysis of geosystems using their natural and ecological features as well as the assessment of potential natural-ecological risk. Cartographical modeling is applied for the estimation of climatic, geomorphological, hydrological, hydrogeological, etc. natural risks.

The second one is the socio-technological risk of technological disasters and emergency situations resulting from the environmental pollution, and the potential and real danger for human health. The cartographical modeling of environmental incidents observed on some territories allow us to recognize the regional and local sites of different ecological risk, to study the prerequisites for its occurrence and to assess the human and environmental effect. The revealing of the source of risk, the definition of evaluation parameters and the territory typification can be carried out with the visual-interactive analysis of the subjects of mapping and with the attributive and quantitative information from databases of computer maps and geoinformation systems.

Natural risks are typical for natural systems and can change to the ecological ones as a result of economic impact on natural systems and unfavorable environmental conditions. In risk management the assessment of natural and ecological risk including the visualization of the risk territory and the spatial analysis of risk events are still topical.

Geographical maps (topographic and thematic ones) are widely used for the modeling of natural and anthropogenic processes not only as information sources or for spatial mapping of results, but for the analysis and interpretation of intermediate data obtained. For instance, the analytical maps containing the source information (measurement results) can serve as the basis for the construction of complex and

synthetic maps on the basis of cartographical and mathematical modeling. The created geoinformation systems (GIS) and databases (DB) as a part allow one to create and use the sets of different information characterizing the territory itself and the prerequisites for risk occurrence. It makes it possible to determine the specific natural conditions and anthropogenic load as well as to assess the environment and human health. The geoinformation-cartographical modeling treats landscape structure of the territory as an information unit.

Environment transformation in Altai Krai influences its state. The assessment of prerequisites and the occurrence of natural and anthropogenic risk is one of ecological characteristics.

Natural potential of Altai Krai territory is distinguished by its diversity and stability. It is determined by a set of natural factors associated with geological, climatic, orographic, hydrological and soil conditions, and biodiversity.

The analysis of components of anthropogenic impact shows that different types of nature management can initiate significant environmental change. One can recognize nature-conditioned, natural-anthropogenic and anthropogenic-industrial factors of ecological risk.

Our main concern in the assessment of ecological risk was with the revealing of aftereffects of different economic activity resulting in the transformation of natural complexes and the changes in their ecological state. The disturbance of natural-territorial structures of Altai Krai leading to the ecological risk is caused by the development of land, forest and water resources, and to a lesser extent raw material resources. The sites of ecological stress are found mainly within the urban-industrial complexes. However, other territories are changed either totally or partially. In particular, these are the agricultural lands.

The assessment of ecological risk concerned two levels, i.e. the regional (within the units of natural zoning) and the topological one (within the natural territorial complexes), and had its basis in the analysis of the following data:

– Information on natural complexes and natural conditions as the factors and prerequisites of natural risk;

– Information on anthropogenic (socio-economic) impact and environmental change as the factors and prerequisites of natural risk.

The most evident negative areal processes are the changes in soil cover structure due to land ploughing, water erosion, deflation, salinization, swamping, pasture degression and degradation of vegetation. They show the natural susceptibility of landscape complexes to negative changes and let us to evaluate them.

The importance of natural factors was defined by their predominance in geosystem and the possibility to minimize their unfavorable or limiting effect on the geosystem. The revealing of the crucial ecological factors was performed on the basis of physical-geographical characteristics of the territory.

In Altai Krai the ecologically significant factors include water soil erosion, deflation, primary and secondary salinization, and overwetting (swamping). Besides, the factors manifestation and their areal distribution were taken into account as well.

Agricultural activity and cattle breeding have the most pronounced spatial effect. In the analysis, the parameters of the change in soil cover structure (by the area of tilled land), pasture degression (number of cattle heads per unit of area and excess of pasture capacity) and the degradation of natural vegetation.

Local anthropogenic impact was considered as the source of the most concentrated effect, for instance, industrial enterprises and the zones of their influence that were much larger as compared to the zone of location.

What is more, the environment experiences the effect of infrastructure that includes transport network, power, water and heat supply, and sewage system. All these elements offer land transfer and the disturbance of natural complexes structure and functioning. The resident areas refer to the main risk factors since the natural structure here is completely disrupted. The state of water objects is estimated by total economic and human impact resulting in their contamination and exhaustion.

Aggregate prerequisites of ecological risk were obtained through the synthesis of the important information carried out by an experimental approach and with mathematical methods using the factor and component analyses. The risk was estimated by the degree of prerequisites manifestation or by the occurrence of negative factors with due regard for their territorial combinations, changes in ecologically important landscape features and according to the three-stage evaluation range, i.e. low, medium and high one.

The territories of low risk include mountain forest landscapes, channels of ancient run-off covered by pine forest, and small lakes with halophytic communities. The territories are poorly developed with a high proportion of natural landscapes. The population density is less than 1head/km$^2$. The current landscape change does not cause the disturbance of its natural features.

The medium-scale ecological risk concerns the territories where the proportion of tilled land does not exceed 30%, and the negative changes are observed only in single landscape components.

High ecological risk is found in 11 (of 23) physical-geographical regions. They are distinguished by considerable change in soil cover structure, vegetation degradation, deflation and salinization.

To improve the system of risk management the assessment was also carried out within the municipal units of Altai Krai. All in all, 25 administrative regions (of 60) were referred to the ones of high ecological risk. Medium-scale risk was registered in 27 regions, and the low one – in 8 regions.

On the whole, Altai Krai is the territory exposed to polyfactor, continuous and constant anthropogenic-industrial impact, i.e. permanent manifestation of prerequisites of natural and ecological risk. The results obtained are used for the development of strategy of socio-economic development of the region, target integrated programs on rational nature management and environment conservation, schemes for land-use planning of municipal units and the grounding for recreational development of Altai Krai.

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# METHODOLOGICAL AND METHODICAL BASES OF THE ECOLOGICAL FORECAST OF INFLUENCE OF ANGARSKY WATER BASINS ON THE ENVIRONMENT

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**Summary**

In the article the scheme of the system-complex analysis of an ecological condition of water basins, the list of the basic parameters necessary for ecological examination of influence of water basins on an environment is resulted.

**Principles and stages of the ecological forecast.** The purpose of the ecological forecast at creation of water basins and their cascades is development of adequate representation about change of an environment as a result of construction and functioning of hydraulic engineering objects [1] Complexity of the public, economic and natural phenomena generates many casual processes and forecasting is possible only in the certain degree. Accuracy of forecasting is based on results of supervision and measurements for the last period and their preliminary processing (entrance data).

Studying of experience of construction and operation of the Angarsk cascade of water basins and hydroelectric power station allows formulating the general features of forecasting of influence of water-economic construction on an environment [2].

First, it is impossible to avoid completely negative influences of formation of water basins on an environment, but it is possible to provide a minimum of negative influences.

Secondly, complex water transformations are necessary, i.e. in the project of water-economic actions should be provided not only primary consequences of construction, but also a consequence of the second, the third and the subsequent orders.

Thirdly, the complex of compensatory measures should be developed.

Fourthly, the system of preventive measures should be developed.

Features of the ecological forecast should consider the following:

– The nature develops under the laws, irrespectively our knowledge;
– Intervention of the person in an environment frequently will difficultly be coordinated with laws of the nature;
– All natural resources and objects of a planet are interconnected;
– Forecasting the nature depends on technical progress.

Main principles of forecasting in wildlife management [3]:

– A system principle which assumes indissolubility of forecasting in time and space, and also interrelation and interconditionality of methods, levels, stages, sequences;
– A principle of objectivity, scientific validity;
– A principle of concurrence, acknowledgement, adequacy, i.e. concurrence of theoretical models to practical displays;

– Alternativeness, alternativeness of decisions and expected consequences.

Forecasting of wildlife management on scope, scale of the phenomena concern to system-complex forecasts which are coordinated, incorporated by the methodological concept and expected result. System-complex can be the researches of a reservoir covering and various aspects of its condition (hydrological, chemical, biological, sanitary-and-hygienic, economic development of a reservoir and water areas, etc.).

Table 1

| Stages of researches | Functional-target orientation of researches | The primary goals of researches |
|---|---|---|
| 1 | 2 | 3 |
| I. Statement of a problem | Definition of the generalized purposes and borders of system and definition of criteria | The analysis of an environment formation |
| II. Formation of investigated system | Allocation of priorities of investigated system and its primary structurization at rough partitioning system on subsystems and elements | Studying of influence of polluting substances on quality of natural waters. The sources acting in a water basin:<br>– concentrated (dot or conditionally dot sources of pollution;<br>– the dispersed sources from a spillway, a shore and water areas |
| III. Construction and research of model, the forecast of development of system | The analysis and the forecast of development of the system, based on a finding of parameters for verification (time, a level, etc.) as a result of approbations of various variants of external influences | Synthesis and estimation (optimization) of conditions of formation of quality of water in a water basin |
| IV. Recommendations on operation of investigated system модели | The complex analysis of results of forecasting of a condition of system, check of their conformity to objects in view, development of the recommendation on perfection of model and a real condition of system | Estimation of conditions (or their optimization) formations of quality of water in a water basin |

Creation of large river artificial water basins is preceded with the basic working stages:

- Planning and development of the technical and economic documentation;
- Designing and development of the working documentation;
- Construction of water object;
- Operation of object.

According to stages carry out ecological researches (Table 1).

**Specification and materials of ecological examination.** Kinds of used and received data and materials according to stages of works are presented in Table 2.

Table 2

| Kind of materials | Stages | | | |
|---|---|---|---|---|
| | I | II | III | IV |
| 1. Data about natural resources-raw potential of territory of researches | + | - | - | + |
| 2. Data about economic-economic potential of territory | + | + | - | + |
| 3. Topographical data | + | + | + | + |
| 4. Meteorological data | - | + | + | + |
| 5. Hydrological data | + | + | + | + |
| 6. Geology-geomorphological data | + | + | - | - |
| 7. Engineering-geological data | - | + | + | + |
| 8. Hydro-geological data | - | + | + | + |
| 9. Forest-valuation data | + | + | - | + |
| 10. Hydrochemical data | - | + | + | + |
| 11. Hydrobiological data | | | | |

**Data about natural-raw and economic potential of territory of works.** These materials include all kinds of wildlife management (industrial, agricultural, forest-valuation, recreational, etc.) which are accompanied by ecological negative consequences.

At development of natural-raw potential and its water-economic complex the especial attention is recommended to give degrees of studying of development of an anthropogenous component which includes:

- Areas of new economic development where extensive forms should be minimized;
- Areas of early economic development with the developed interaction of economic activities and natural components where to danger is exposed both resources-, and reclaiming ability ecosystems;
- The urbanized territories where the basic complex of problems is connected with quality of a surrounding environment.

The analysis of the given materials allows to allocate territories:

- Disputed (an opportunity of irreversibility of negative processes);
- Crisis (threat of irreversible negative consequences);

– Catastrophic (irreversible).

Hydrometeorological and hydrochemical data. Include:

– The operative information on a hydrological and meteorological condition of a river network of pool of the future water basin;

– Regime hydrometeorological generalizations (cadastral editions);

– Short-term hydrographic and meteorological forecasts;

– Complex researches of a hydrological situation of directly contacting water-economic systems;

– Data about volume and number of the limiting and representative polluting substances dumped in a water basin.

**Topographical and Geology-geomorphological data** include:

– Topographical maps, as an exact basis for definition of the basic characteristics of the future water basin;

– Geomorphological maps for an estimation of type processing coast;

– A geological map for specification of lithology of coast;

– A hydrological map (for estimations of zones of existing and future bogs, capacities of emerging islands of peat, volumes (areas) of flooded forest stand;

– Geodetic materials for detailed elaboration of conditions of supervision over processing of coast, construction of buildings.

**Forest-valuation data** are used for carrying out of research of various ecological conditions of a water basin and contain:

– Valuation parameters of a wood pulp in a box of the future water basin after of cutting down and clearing of a wood;

– Valuation parameters of wood vegetation (quarterly) of a coastal zone of the future water basin and its large lateral inflows.

**Methods of forecasting of natural processes.** At forecasting natural processes many methods are used: analogues, extrapolation, expert estimations, and the cartographical, mathematical, existential forecast with use of geoinformation systems and others.

*The method of analogues* is used in connection with an opportunity of carry of laws fair for spatial numbers, on time numbers and on the contrary, proceeding from affinity of the spatial and time forecast; the degree of similarity of analogue and object of the forecast is defined by uniformity of compared objects. So for Angarsk water basins as analogue the water basin of Brotherly hydroelectric power station is accepted. Criterion of similarity can be a mode of levels of water basins, geological structures, valuation characteristics of zones of flooding and the zones subject to influence of wind and waves, the climate, similarity of anthropogenous loadings, etc. the Basis for successful application of this method is reliability of the data taken for analogue.

*The method of expert estimations* is based on gathering of the information of a group estimation of event. However the theoretical substantiation of accuracy and reliability of methods of group estimation does not exist. Unique criterion is experimental check on characteristic pools. The method was used at an estimation of volume of the flooded wood, deduced from information about an alloy.

*The method of extrapolation* assumes distribution of the laws which have developed in time of forecast period for the certain period in the future. At using of this method of forecasting the choice of the main predicted factors is defining. The method is used at forecasting consequences of construction of hydraulic engineering constructions and processings of coast. The method leans on materials of the supervision lead on operating water basins, having similar criteria of similarity.

Cartographical method, the most widespread complex method, is a part of each above-named method of forecasting. This method is used for the general estimation of spatial development of process.

The method of mathematical modelling is based on expedient abstraction of developments in the future. In practice of water resources management, mathematical modelling is used by a water management, water use at planning, designing, operation of water-economic systems, forecasting of water use, consequences of realization of water-economic actions and at the decision of other problems.

Today for ecological forecasting opportunities of use of modern geographical information systems (GIS) open, allowing carrying out the spatially-temporary forecast [4].

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# USE OF GEOINFORMATIONAL MAPPING FOR EMERGENCY MANAGEMENT

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In terms of modern approaches, methods, hazardous facilities security and emergencies initiation and development algorithm, it is possible to offer the following strategies for crisis state management:

– Strategy of emergency causes prevention, realized by means of automation, computerization and intelligent systems, allowing to supervise, diagnose and predict various deviations during the processes and to prevent or compensate these deviations;

– Strategy of localization and prompt suppression of arisen emergency, realized by means of special technical, organizational and technological methods, automatic localization and exception of danger and risks sources;

– Strategy of emergencies and catastrophes consequences rectification, connected with risk mitigation and damage by negative consequences of emergency situations by means of accurate mobilization of emergency response forces, fast evacuation of population to safe areas and carrying out of rescue and recovery operations and works.

By expert evaluation the application of any strategy requires the following volumes of expenses (in percentage of initial investments): the first strategy – 15–40 %; the second – 40–80 %; the third – 100–1 000 % that arises from adverse effects on ecology, biosphere and society, necessity of long recovery of affected potential.

Management strategy at the early emergency prevention should consist of two stages: working out of management strategy and its realization.

Working out of management strategy includes risk assessment and management: management information support; data analysis in terms of people health risk assessment, definition of priority sources and risk factors; forecasting of potential emergency and its consequences; working out of strategic plans (legal, economic and other measures) on minimization of risk of emergency occurrence and its consequences.

Realization of management strategy is more difficult process which includes:

1. Organization of measures to reduce emergency risk and weakening of potential emergency effects: provision of organizational and technical support of TC prevention (examination of projects, ecological, sanitary inspection, use of built-in protection systems, reservation, adaptation).

2. Preparation to crisis or emergency situation: working out and updating of operational evacuation or rescue plans; selection and preparation of specialized administrative staff; provision of organizational and technical support for notification and localization of potentially dangerous emergency.

3. Emergency counteraction (affect factors): notification of population and organizational systems about possible catastrophe; localization (restriction) of

emergency area; evacuation of personnel and population from dangerous area; rendering of first aid and life-support of injured.

4. Rectification of emergency consequences: elimination of consequences; realization of damage control.

Management process should be realized on the basis of geoinformation mapping by means of formation and realization of administrative decisions. Basic decision types that have various characteristics and demand various spatial data:

Operative decisions – of periodic nature: the same task arises periodically. Parameters (characteristics) of administrative processes used during decision-making are defined, their estimation is known with high accuracy, and interrelation between parameters and accepting decision is clear. Operative decisions are unproblematic and short-term.

Tactical decisions taken by mid-level officials, the main management parameters that form part of tactical decisions, are practically unknown, estimations and interrelation between characteristics and decisions can be undefined.

Strategic decisions provide for the basis of tactical and operative decision-making. Strategic decisions are long term, complex, unstructured and non-periodic.

Effective decision-making should consist of the work scope, separate stages, procedures and operations. Among the numerous approaches to the decision-making problem a three-stage model of decisions formation can be pointed out:

| | | |
|---|---|---|
| 1-d stage | 2-d stage | 3-d stage |
| Problem analysis, formulation of purposes, criteria of estimation | Search of possible decisions variants | Comparison of variants and final decision choice |

To realize management process at all the levels it is necessary to create the integrated database which should meet the following requirements: synchronized, complete and detailed, positionally exact and compatible with the other data, authentic, easily updated, and available. Besides, the database should be available for the following basic groups of functional subsystems of the Directorate of the Ministry of Emergency Situations:

- Emergency response subsystems;
- Daily activity support subsystems;
- Collective decision-making support subsystems;
- Administrative decisions analytical support subsystems
- Planning and management subsystems;
- Technological and information supply subsystems.

For emergency territorial administration it is necessary to carry out geo-information mapping of risk zones which includes:

- Definition of hazardous economic facilities and risk zones;
- Revealing of all possible kinds of accidents;
- Specificity of their occurrence and development;
- Calculation of potential danger areas of these accidents;

– Probability of negative potential realization;
– Construction of local risk zones for each scenario with a specified binding to the danger source;
– Construction of integral risk areas on a cartographical basis.

Version ArcGis 9 can be used as software platform, which allows solving a full range of problems in spatial data processing: from data acquisition to preparation and visualization. This version allows not only using separate possibilities of the software for emergency management, but also applying pass-through technology - integrated software with scale architecture, that can work in the unified information space at the various management levels, where common environment of data editing and updating is used. Among all ArcGis applications – desktop, built in, server and mobile GIS – desktop GIS deserves special attention, in particular ArcGis Desktop which includes three basic products – ArcView, ArcEditor, and ArcInfo, programs that have common interface and working principles, but differ in accessible functionality for all management levels.

The final management stage is the decision-making procedure which includes the following basic stages: formulation of management purposes; definition of purpose achievement criteria; modeling of decisions substantiation; search of optimal (admissible) variant of decision; decision coordination; decision implementation preparation; decision approval; management of decision implementation; decision efficiency check.

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# THE EXPERIENCE OF USING ANIMATION CARTOGRAPHY FOR DISASTROUS FLOOD INVESTIGATIONS

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**Summary**

In the present paper the experience of conventional and geoinformational dynamic cartography use for determination of storm surge spreading verges on the North Caspian coast at different sea-level stands is considered.

The main peculiarity of the contemporary Russian cartography development stage is the replacement of conventional maps with digital and electronic ones. One of the most promising trends is an interactive mapping based on the state-of-the-art software technologies that allows creating animation patters and illustrate geosystems' and their components' changes in dynamics. The patterns' application fields varies, but the most effective use is for quick and episodic processes investigation, quick results assessment and prompt decision-making at the development of adverse natural impacts.

Floods are among the most dangerous acts of nature, and people are familiar with them from the earliest times. Flood origins differ. They take place not only in river-valleys because of high water, freshets, ice clogging, but also at ocean and sea coasts during hurricanes, storm surges, and tsunami. The latest ones are unexpected with sea water level being raised at an intensive rate, and they result in significant damage. This is a global problem because lowland coasts' length amounts to one third of the World Ocean coast line; moreover, half of the World's people live within a 40km coastal zone. There is a tendency of growing damages as a result of floods generated by natural and man-made factors (some scientists believe they grew more than ten-fold for the second half of XX century). Modern society must aim at decreasing risk factors and provide for life safety of the population on the alongshore territories.

In Russia the problem of the storm serge spreading verges is urgent to some degree for all the shallow coasts of marginal and land-locked seas, large lakes and estuaries' lowlands. Flood damages can be direct (economic facilities destruction, population evacuation, harvest failure, livestock loss) and indirect ones (frequent and long-term coastal flood, water logging, fertility decrease, soil salinization, caving, difficulties in practical land use etc.) Extent of damage depends on the commercial territory use level, cost of the flooded facilities, height and speed of rising water level, flooded area, timely storm alert, flood protection waterworks.

The Caspian Sea is the most complicated area for research and forecast that is connected with storm surging on the background of substantial ancient many years' and seasonal level fluctuations. The level of the Caspian has fallen and risen several times over the last 100 years, e.g. from 26 meters in 1929 to 29 meters in 1977 with 3 meters' difference, since 1978 it has risen by 2 meters. At present the level is rather stable – 27 meters.

Shallow Northern Caspian zone is high on the world's list of surges concerning their amount and influence on the economic activity and natural coast features formation. Western shallow coast surges are caused by frequent south-east and east winds. Sea water surges are associated with north-west and west winds.

The surges continue from several hours till several days with the level rise of more than 0.5 – 3.5 meters. It results in considerable water edge movement deep into the lowlands (10–20 km, in emergency cases – up to 30–50 km.) Average surged-caused water rise rate is 4cm per hour, at the high wind speed of 25–30 m/s it can reach 20–30 cm per hour. According to hydro meteorological survey results in the period from 1936 till 2001 there took place over 40 dangerous surge floods that caused great damages to the national economy [Atlas...2005].

The liability of the northwest part of Russian Caspian coast to disastrous surges forces the scientists to develop reliable methods of storm flood forecasting and spreading verges calculation. The complexity and variability of physical and geographic conditions of the North Caspian along with the low hydro-meteorological stations network density prevented from the acquisition of desired quality data with required accuracy. A lot of factors that determine synoptic surge origin, its propagation length, and water stand duration cannot always be taken into account, measured or forecasted with adequate accuracy. At present there are surveys in this field to develop timely forecasts. They are base on mathematical simulation of hydrological and meteorological processes. Cartographic analysis is used to define spatial verges configuration after surge floods of various size.

As a part of the program of providing maps for sea coasts ecological and natural risks monitoring the conventional and geo-informational map-making in dynamics was performed to define storm surges spreading verges on the Russian coast of the North Caspian.

Geo-informational map-making must be based on integrated geographic survey and system thematic map-making experience [Berlyant, 2006] that is why we took the results of many years' surveys of the Caspian Sea level fluctuations at different times for animation patterns development. Careful and diligent preparation of source maps provided for the effective and detailed visualization.

Earlier thematic maps were taken as a source for animation with them illustrating long- and short-term (surging) sea level fluctuations.

As a master map we took digital and electronic copies of the North Caspian coast lines dynamic map over the last 100 years [Vereshchaka, Kurbatova..., 1999.] The map shows coast line positions in connection with stable, regression and transgression periods of the sea level: -26.0m – maximum average annual for the century (1900–1929); -28.0m – stable low (1942–1969); -29.0m – minimum for the century (1977); -27.8m – intermediate (1985–1987); -27.0m – contemporary.

For the sea level of -28m Abs. a conventional variant of the map *The Danger of Surging Caused Floods of the Northwest Caspian Coast* was developed. For the mapping the following materials were used: time transgressive satellite imagery and its landscape indicative interpretation, hydro-meteorological stations' survey data, field ground and aerial visual survey results. Flooded coastal zones verges were specified for the storm surges of 1.4, 1.7, 2.1 and 3.0m height which correspond to the critical, dangerous, very dangerous and catastrophic situations (at the sea level of – 28m.) Each zone was correspondingly described as alarming (flood risk once per 2 years), dangerous (once per 25 years), very dangerous (once per 50 years), and extreme (once per 100 years) [Kurbatova, Golubeva...2005.]

The map made at a scale of 1:500,000 allowed measuring flooded regions and districts that are in the risk zone of temporary flooding, finding coastal plots that are liable to active washing out, assessing the submergence verges for urban areas, industrial district, transport network, and farm lands. Marking of areas flooded with surges of various sizes gives an opportunity: firstly, to find out over ground industrial and agricultural pollution focuses within the surging areas; secondly, to mark the territories liable to the secondary sea water pollution.

The development of interactive map *Storm Surges on the West Coast of the Caspian Sea* was performed on the basis of a new professional software version for animated flash-files creation, Adobe Flash Professional. It supports quick and fruitful flash-technology work thanks to the rich interface, advanced tools to process video and animation, enhanced integration with other Adobe graphic applications. There is a function to import files from Adobe Photoshop, Adobe Illustrator, CorelDRAW and other programs. Convenient time scale helps to overlap movement effects accurately together with advanced tools to create and edit main geometric shapes, to generate user forms through integrated JavaScript API.

Flash-application helped to display images with the following layout: top – map name, left half of the screen – window with multilayer animation picture, right half – control panel, Comments window and Legend. Control panel is a number of buttons to combine various layers with an image of the coastal line of the chosen sea level and flooded coastal zones verges with the surge of the set size. For example after choosing sea level (-27 or -28 meters) in the Section *Sea Level* we receive a map of the North Caspian corresponding to the parameters. Then in the Section *Surges* we choose surge size (1.4, 1.7, 2.1 or 3.0m) button, enable it and observe smooth movement of the coastal line deep into the land up to the verge of the flooding with the surge of the set size. The higher the surge and sea level, the wider the flooded area. Some land plots with the relative elevation over the sea level higher than the surge size are marked as “safety islands”. On the coast image one can mark from 1 to 4 surge flooded area verges without blue flow in order to observe anthropogenic facilities within the reach of a storm surge. Additional scale bar can move around the image and is very convenient to define flooded zone width of a particular spot. So the researcher has an opportunity to control dynamic sequence interactively, to change figure values of long- and short-term sea level stands, and to receive animated forecasts.

Window *Comments* contains text description of surging origin, characteristics of the most catastrophic surges of the North Caspian.

Section *Legend* contains arbitrary signs depicting the main content of the map, including natural (drainage network, sea channels, estuaries, drain-less lowlands, bent bogs, marshlands, salt-marshes) and anthropogenic (settlements, traffic net, gas lines, gasoline storages, oil fields) ones.

The proposed method of animation patterns working up can be used to develop forecasting storm surging coast flood scenarios at the eventual seal level rising or falling. Here, the coastal line corresponding to the current or forecasted level mark shall be taken as a reference one.

There are the following advantages of animated cartographic patterns developed on the basis of Adobe Flash CS3 Professional software:

– Visual illustration of time transgressive dynamic changes of the North Caspian coastal line position;

– High accuracy thanks to the grid and movable measurement scale corresponding to the linear zoom that provides for such quantitative features as flooded area width of a particular spot, area of the territories flooded by surges of defined sizes, area of the "safety islands" etc;

– Detailed content preservation thanks to the conventional maps taken as a basis for the patterns.

The developed animation patterns can be used, firstly, in geographic informational systems that aim at the analysis of various aspects of territories' and population's protection against surging in case of emergency both for the North Caspian and other coasts; secondly, to coordinate task plans of the future economic development of the territories and of the storm-caused property damage decrease measures (based on the choice of the optimal protecting waterworks height, of the routes for safety population evacuation etc.).

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# EXPERIENCE IN NOSOGEOGRAPHICAL MAPPING OF ALTAI KRAI FOR NATURAL RISKS MANAGEMENT

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**Abstract**

Risk quantitative assessment of tick-borne encephalitis and Siberian tick rickettsiosis disease incidence by the example of administrative regions of Altai Krai was made for tourist-recreation territory planning. To integrate heterogeneous information (natural, anthropogenic and medical) modern software was applied, and the maps were constructed.

The rapid development of tourist-recreational activity in Altai Krai characterized by prerequisites for human natural focal diseases, i.e. tick-born infections [1–3] makes risk assessment of population infection extremely topical. The assessment is based on the use of up-to-date computer technologies and cartography.

The complex medical-geographical study of the territory in 70–80 s of XX century was followed by the construction of maps included into the "Medical-ecological Atlas of Altai Krai" [4]. The incidence of tick-borne diseases in men is still very high. From 1990 to 2005 sickness rate of tick-borne encephalitis in Altai Krai exceeded average Russian index by 1,8, while tick rickettsiosis- by 25,3.

The study and analysis of national and international experience gained in nosogeographical mapping as well as GIS application in medical-geographical research promoted the development of a method and technology for creation of evaluation nosogeographical maps in GIS-environment. It made possible to integrate medical-geographical data obtained within natural and administrative territories and to assess the situation quantitatively.[5–7].

The elaborated method allowed to make cartographical medical-geographic risk assessment of natural focal disease infection among the population of municipal units of Altai Krai. The method based on the large body of statistical data demonstrates good prospects for its further use [8-10]. Partially the research materials were applied in the development of Schemes for territorial planning of municipal units of Altai Krai (Topchikhinsky, Shipunovsky, Kur'insky regions).

Most available and projecting tourist-recreation objects of Altai Krai are situated in the piedmont and mountain territories with favorable natural conditions for manifestation of prerequisites for natural focal diseases including tick-borne encephalitis. Healing water of lakes in a steppe zone is attractive for balneological purposes but the surrounding territories are potentially dangerous for Siberian tick rickettsiosis infection.

The medical-geographical system (MGS) "Tick-borne zoonoses of Altai Krai", as a complex of interrelated information resources, was created to assess risk of zoonosis infection in Altai Krai population using GIS technologies and the developed method. MGS became the basis for a larger information structure, i.e. data base on interdisciplinary research by the Institute for Water and Environmental Problems, SB RAS.

MGS contain data on Altai Krai population health by regions and tick-born infection threat; it provides the search for territorial prerequisites of infection risk occurrence. Structurally the information is combined into two large blocks:

– Spatial data (cartographical one that provides accuracy and details of information positioning, formation of digital map structure and attributive data on cartographic layers);

– Thematic information that is layer-by layer agreed temporally and spatially; includes data on mathematical statistics, initial indices of health state; attributive natural -landscape information, information on the previous study of a territory, the revealed risk factors, etc.

It should be noted that cartographical block has its internal structure. Its content is formed according to geoinformation criteria that provide system structuring, ranking, operative processing and analysis of spatial data.

The tools and approaches to the processing and management of space-coordinated and kept as thematic layers data allows the effective use and multifunctional transformation of available information, and the creation of integral nosogeographical maps of the region.

The application of MGIS made it possible to assess the potential risk of natural focal diseases everywhere over 60 administrative regions of Altai Krai. The potential risk of infection was estimated with landscape approach and indices of its anthropogenic change influencing the spread of infection carriers. Besides, to calculate the estimated figures the information on the average annual human morbidity in each region, and the frequency of epidemic events in 1990–2005 were used. In addition, the data on specific sites of human infection were taken into consideration. As a result, the evaluation maps “Risk of tick-borne encephalitis infection among the population of Altai Krai” and “Risk of Siberian tick-borne rickettsiosis infection among the population of Altai Krai” (1 : 1 000 000 scale) provided with the description of the algorithm of nosogeosystems analysis on regional and topological levels were created.

The nosogeographical assessment of Altai Krai using the geoinformation-cartographical approach is in excellent agreement with the data of medical-geographical investigations carried out within this territory before. The maps are used for medical-geographical forecast of tourist-recreation development of regions and the planning of health services control.

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# GEOINFORMATIONAL SPACE RESEARCH OF THE MEGALOPOLIS FOR THE PREVENTION OF PEOPLE'S LIFE THREATS

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Can we precisely foresee where and when the emergency situation on the urban territories takes place? Is it possible to be prepared in advance and to take measures for preventing threats for people's life? As a rule, the megalopolis territory is formed of several technogenic natural and territorial complexes (TNTC). TNTC is necessary to consider as a combination of associated natural and man-made objects which are formed as a result of building and exploiting of engineering and other constructions, complexes and facilities interacting with the environment. TNTC are complicated self- organized systems with natural constituents, containing the interconnected elements of various hierarchy levels [1]. A characteristic feature of the TNTC city is the openness of borders and convention in their definition and establishment on the territory. It is caused by the fact that various technogenic influences on the environment, particularly on the geologic and physical environment, have a synergetic (co-operative) character and can create the general ecological trouble not only for TNTC localization borders, but also in adjoining natural and territorial formations. In developed industrial and agricultural areas, it is better not to reveal TNTC borders in their contour understanding, but the boundary zones of TNTC influence.

Difficult spatial structures and their relations, existing on a city territory, are sources of potential threats for the people life and health. Thus, the most dangerous are the threats which development can be an incitement for occurrence of some emergency situations. For example, "….now the Ministry of Emergency Situations has prepared population evacuation plans for possible repeated failure on the Sayano-Shushenskaya hydroelectric power station. Therefore, the huge tsunami of 30 metres height is possible which may cause not only the total distraction of 12 settlements, but also overflows of the Krasnoyarsk water basin. It may cause the situation of Krasnoyarsk territory flooding". [2]

From the example, it is evident that only the possibility of emergency situation can be expected in advance. Thus it's important to make the analysis of possible risk. For large dangerous industrial objects there are declarations of industrial safety in which on the risk analysis basis of the degree of danger of occurrence of failures is defined.

The basic threats on Novosibirsk city territory are:

- Traffic fatalities (1);
- The technogenic accidents connected with exploitation and failure of industrial objects and the equipment first of all of power objects (2);
- Catastrophic flooding threat (3);
- Earthquake threat (4), catastrophic earthquake of 7 points under the Richter scale (5);
- Acts of terrorism threat (6);

- Threat of electromagnetic radiation (7);
- Threat of ecological accident (8);
- Threat of natural anomalies (9);
- Epidemic threat (10).

To perform the analysis of emergency situation threats, it is necessary to possess huge volume of the information and knowledge. Only highly skilled experts can estimate and forecast the probability of threat. Thus the important factor will be the use by the expert as one of tools of the geoinformational system analysis (GIS). The data in GIS should be actual and represent all spatial objects, processes, phenomena, and their relations as well.

While performing the geoinformational analysis of possible threats it is necessary to develop:

- A system of risks identification;
- A measuring system, monitoring of potentially dangerous objects, processes and phenomena;
- The monitoring and control system of emergency situations.

To develop the risk identification system on the GIS basis it is preferable to apply the matrix analysis method. As far as in the risk analysis a special attention should be paid to the assessment of possible consequences, it is important to take into account the following facts [2]:

- People's life;
- Damages to movables and property;
- The influence on environment condition;
- Trust loss to the government from outside the population.

All possible threats are necessary to classify according to following groups:

- Improbable;
- Few propable;
- Probable;
- Rather probable
- Highly probable.

To refer the threat to a certain class by one of the basic criteria we use the statistical data about the frequency of happened emergency situations in considered territory. Also the experience describing similar events in other territories is valuable also. For Novosibirsk city the ranging of threats on danger class is presented in Table 1:

Table 1. Ranging of threats on Novosibirsk city territory by the class of danger

| | Threat | Danger class | Registered cases for last 3 years (published in open sources) |
|---|---|---|---|
| 1 | Traffic fatalities (1) | highly propable | More than 100 fatalities in a day |
| 2 | The technogenic accidents connected with exploitation and failure of industrial objects and the equipment first of all of power objects (2); | rather probable | More than 5 accidents in a year [1] |
| 3 | Catastrophic flooding threat (3); | few probable | Less than 1 case in a year in the neighbor regions |
| 4 | Catastrophic earthquake (5) | improbable | Not fixed |
| 5 | Threat earthquakes (4) | probable | More than 3 small pushes in a year [3] |
| 6 | Acts of terrorism threat (6) | probable | No more than 1 case in a year |
| 7 | Threat of natural anomalies (9) | rather probable | More than 5 cases in a year [4] |
| 8 | Threat of electromagnetic radiation (7) | improbable | Less than 1 case in a year in the neighbor regions[5] |
| 9 | Epidemic threat (10) | probable | More than 3 cases in a year |
| 10 | Threat of ecological accident (8) | improbable | A case in a year [5] |

In Table 2 influence of consequences of an emergency situation on the basic social and economic indexes of the city is presented in the matrix form.

Table 2. The Matrix of influence of consequences of an emergency situation on the basic social and economic indexes of the city

| Probability / class estimated factors | People's life | Damage to movables and propriety | Influence on the environment | Trust loss to the government |
|---|---|---|---|---|
| The improbable | 5 | 5 | 5 | Probably |
| The few probable | 3 | 3 | 3 | К3 |
| The probable | 4<br>6<br>**7**<br>**8**<br>**10** | 4<br>6<br>**7**<br>Probably<br>**-** | 4<br>6<br>**7**<br>**8**<br>**-** | 4<br>6<br>**7**<br>**8**<br>Probably |
| Rather probable | 2<br>**9** | 2<br>**9** | 2<br>**9** | 2<br>**9** |
| Highly probable | 1 | 1 | Probably | 1 |

From Table 3 analysis follows that first of all on the Novosibirsk city territory it is possible the emergency situations to occur connected with exploitation and failure of industrial objects and the equipment, traffic fatalities, and also natural anomalies. In chart 3 these threats are allocated in the separate block. Thus the look-ahead number of victims will not exceed 100 persons. The small pollution of the environment on a local part of territory is possible. Lost of trust to the government from outside the population will not occur. However it is necessary to remember about the possibility of occurrence of improbable emergency situations which can get global catastrophic character.

The second and most important element of the geoinformational analysis is the system of measurement, monitoring of potentially dangerous objects, processes and the phenomena. All data received on potentially-dangerous objects, should be transferred in GIS environment. As a rule, organizing the geoinformational monitoring, modern GIS allow to update the data dynamically.

Table 3. The estimation Matrix of the damage size from an emergency situation

| size Class of consequences / estimated factors | People's life | Damage to movables and propriety | Influence on the environment | Trust loss to the government |
|---|---|---|---|---|
| No | No victims | Neglect | There is no distribution, self-restoration<br>10 | neglect |
| Insignificant | More than1 Victim | Insignificant damage<br>4<br>10 | Small distribution, the complete liquidation of consequences is possible<br>1<br>4<br>9 | small<br>3<br>5<br>1<br>4<br>9 |
| Considerable | more than 10 victims.<br>1<br>4<br>6<br>9 | Considerable damage<br>1<br>6<br>9 | The big distribution, partial liquidation<br>2<br>6 | big<br>2<br>6<br>10<br>8 |
| Serious | more than 100 victims<br>2 | The big economic consequences<br>2 | Distribution on a city territory, the complete liquidation is not possible | The question of confidence to the government<br>7 |
| Global | from 100 to 1000 and more victims<br>10<br>3<br>5<br>7<br>8 | Economic consequences at the Subject of the Russian Federation level<br>3<br>5<br>7<br>8 | National accident<br>3<br>5<br>7<br>8 | Lost of control from outside the government |

In Fig. 1 the example of geoinformational analysis of territory on some threats are presented.

The earthquake threat in Novosibirsk city is probable. According to seismologists in a year on the city territory it is fixed from 3 to 10 insignificant pushes between Academgorodok and Berdsk border. In the immediate proximity from this zone there is the Novosibirsk HPS and a water basin dam. At catastrophic flooding of Novosibirsk city territory the territory of the Leninsky district can suffer most of all. The thermal power station-2 and the thermal power station-3 concerning the third class of danger get to the flooding zone. There is the threat not only of failure of life-support object, but also ecological pollution threat from washout ash disposal area of the thermal power station. Besides, there is a threat of industrial equipment explosion on the thermal power station. The done geoinformational analysis of catastrophic flooding threat leads to the following conclusion. Occurrence of threats belonging to the class highly probable and probable can provoke occurrence of emergency situations belonging to the class of improbable and few probable. According to Table 3 this class, threats are characterized as global technogenic accidents.

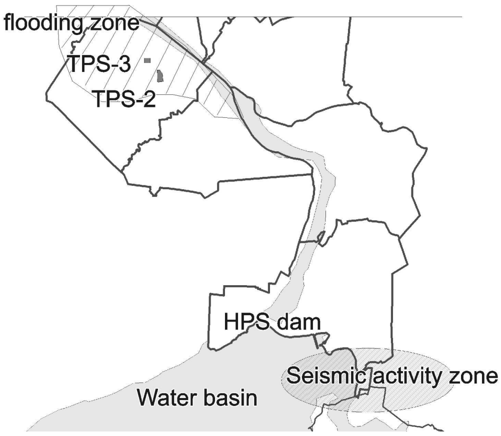


Figure 1. Result of the geoinformation analysis of potential threats

Thus, the main in measurement and monitoring system of potentially dangerous objects, processes and the phenomena is not only the control organization of potentially-dangerous objects, but also complex studying of all interrelations between natural and technogenic objects. In Fig. 2 the geoinformational analysis of threats in territory of the Leninsky district of Novosibirsk is given.

The actual information on spatial structures in the emergency situation should become the basis of control system of occurrence of emergency situations. Thus informing of the population on possible occurrence of the emergency situation, and also on possible character of destructions and dynamics of events is especially important. One of the primary goals of the control system is the organisation of people’s evacuation. Accurate execution of instructions both in advance planned and checked up plan of evacuation will allow avoiding victims among the population. An example of the irresponsible and criminal relation to the city population during the emergency situation is the greatest technogenic catastrophe - the Chernobyl atomic power station. The first estimation of the threat class of this accident done by experts was improbable.

The basic conclusions under geoinformational analysis of Novosibirsk city territory are:

– Works on the analysis and prevention of risks should be planned on the actual, authentic digital cartographical basis (geoinformational space);

– Spatially-coordinated objects, processes and the phenomena together with statistical databases and results of territory monitoring should complete the automated knowledge base;

– Created informational resource on threats distribution in studied territory should become popular and open the maintenance and possible consequences of threats.

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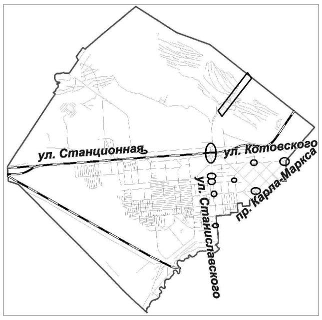
<td>
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<tr>
<td>a) The Analysis of Traffic fatalities</td>
<td>b) Placement of the industrial enterprises 3 – 5 danger classes</td>
<td>c) Flooding Model at break of a water basin dam</td>
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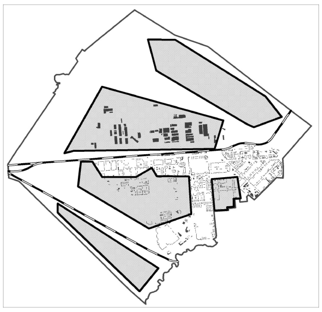
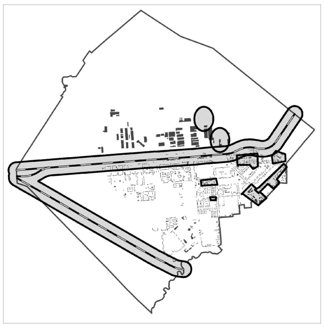
<td></td>
<td></td>
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<td>d) Buildings destructed mostly at the earthquake over 5 points</td>
<td>e) Threats of terrorism acts</td>
<td>f) Electro-magnetic threats from large transferring radio engineering objects</td>
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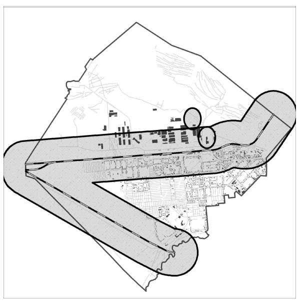
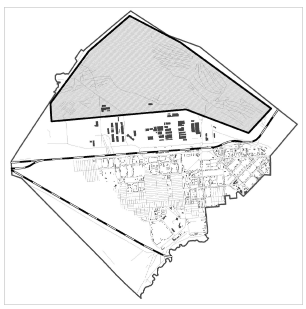
<td></td>
<td></td>
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<tr>
<td>g) Places of epidemic threat</td>
<td>h) Potentially dangerous territories of possible ecological catastrophe</td>
<td>i) Territories mostly occurred to natural anomalies threat</td>
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</table>

Figure 2. The Geoinformational analysis of threats on the Leninsky district territory of Novosibirsk city

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# CARTOGRAPHICAL MAPPING FOR PROVISION OF HYDROECOLOGICAL SAFETY IN THE OB BASIN

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**Abstract**

The problems of water management have become more pressing and call for the science-based complex solution. It is favored by the complexity of water use processes and the changing conditions for the formation of water resources (including the ones associated with climate change). The activity of 15% of Russia territory as well as the industrial and agricultural development of 14 subjects of the Russian Federation are closely related to the Ob basin functioning. The cartographical analysis of the factors of hydroecological safety allows the assessment of the runoff formation, water quality and quantity, the character and urgency of water-related issues, the current systems of water use and their management in different natural-climatic and economic conditions. Besides, it provides a conceptual model of water management in the Ob basin.

Geoinformation mapping based on the achievements and integrated studying geographical objects by different Earth sciences using mathematical methods and information technologies makes it possible to solve complicated problems (e.g. spatial analysis and hydroecological safety). Though the approaches to do such investigations are just being formed, the experience gained shows good future prospects for their development and application. Cartographical research based on geoinformation technologies and mathematical-cartographic modeling is irreplaceable under development, realization and control over water use and water protection.

Cartographical analysis of environmental factors and impacts allow us to assess runoff formation peculiarities, quality and quantity of water resources, character and manifestation of water-economic and water-ecological problems as well as to elaborate decision support systems (DSS) for water use management and hydroecological safety provision. This task assigned for the Ob' basin is under solution at the moment.

The research stage completed in 2009 involved the development of a conceptual-information model of water resources formation in the Ob' basin.

Using the hydrographic-geographical approach, hydrographic units of a basin and subbasin level were considered as the ones for studying and making spatial analysis. Physical-geographical factors effecting the regime and river runoff characteristics were split in 3 groups:

- climatic;
- Underlying surface;
- Anthropogenic.

In addition, factors directly forming a river runoff in the Ob' basin were defined. To estimate surface and ground water resources quantitatively, the structure of data bases was created. Data bases filling and initial data processing were performed.

Digital cartographic map for thematic mapping and a set of reference maps were constructed.

The analysis of a previous landscape study of the Ob' basin territory was made. At present, a digital landscape map (1:2 500 000) based on the previously created map is under construction [1]. For model hydrographic units of basin and subbasin levels, mid-scale landscape maps (1:100 000–1:200 000) were created. The outcomes obtained serve as the basis for a conceptual model of surface runoff formation in the Ob' basin.

The extreme hydrological and hydro-ecological events were revealed and analyzed.

To study hydrological, hydrochemical and hydrobiological features of different-type water objects, 16 model water objects in various natural zones of the basin were defined.

Cartographical analysis of hydrographic units' position in natural zones of the Ob' basin was made. According to the analysis, there is one hydrographic unit in tundra and forest-tundra zones, while in taiga – 10, in forest steppe – 7, in steppe – 4.

The construction of digital thematic water-resource and water-ecological maps to cover the territory under study called for:

– Preparation of a digital cartographic base for thematic mapping;

– Collecting and processing of initial data on qualitative and quantitative characteristics of natural water as well as data on natural-anthropogenic conditions for natural water formation;

– Creation of electronic data bases;

– Construction of basic address maps;

– Creation of specific inventory and evaluation water-resources and water-ecological thematic maps [2, 3].

The method for mid-scale water-resources and water-ecological mapping was elaborated with its following approbation at the construction of a map fragment of the Upper Ob' basin (within Altai Krai) and a model basin of Alei river [2, 4].

A set of maps (basic "address", surface water quality, surface water self-purification, anthropogenic loads on water objects and their catchments, a complex zoning of water objects and their watersheds by anthropogenic load and surface water pollution) were created.

*Basic "address" maps* involve a digital cartographic base of thematic mapping with attributive geodata base.

*Surface water quality maps* contain target indices on surface water pollution.

*Maps of surface water self-purification conditions* represent the conditions for surface water self-purification due to pollutants transformation and dilution.

*Maps of anthropogenic loads on water objects and their catchments* involve inventory and evaluation layers. The inventory one represents absolute values of initial indices, while evaluation- zoning of mapped objects by indices of anthropogenic loads.

*Integrated map of zoning water objects and their watersheds by anthropogenic load and surface water pollution* summarizes the content of specific evaluation maps. To define the level of surface water pollution, 1) the integrated spatial analysis of maps representing surface water quality at state environmental monitoring stations (SEMS) and 2) the information layer representing anthropogenic load on water objects and their catchments were used. Such an evaluation of anthropogenic load and surface water pollution is feasible for any catchment site.

The evaluation system and geoinformation cartographical representation of ecologically safe water use based on the areal estimate of underground water stock (in the context of the landscape-basin approach), data analysis by their permissible and factual (based on statistical accountability) withdrawal and annual water consumption monitoring was approbated by the example of Alei river basin due to the use of GIS resources.

The created maps made it possible to present and systemize the large body of interrelated information on different indices, to analyze the provision of water objects with the observation data on water quality, to evaluate water objects state, to define territories distinguished by urgent ecological problems, to assess realistic potential for solving water-ecological problems and hydroecological safety achievement.

The evaluation of anthropogenic load on rivers of the Upper Ob' basin shows that the most unfavorable hydroecological water objects here are rivers Kuchuk, Kulunda and Burla. The most hazardous industrial and agricultural wastewaters prevail in Burla and Kuchuk as a result of low water discharge that doesn't provide sufficient dilution of sewage.

Ecologically unfavorable Peschanaya, Kamenka, Alambai river basins are also subject to high anthropogenic load. The studied spatial peculiarities of anthropogenic load transformation prove it. It may be caused by pollutants entering with surface run-off as well as rather high specific loads from some pollution sources (settlements, livestock farming, fertilizers and pesticides introduction).

Rivers Biya, Barnaulka, Alei, Chumysh are characterized by moderate loads and non-critical hydroecological situation. For river Biya, the prevalence of industrial runoff and significant water draining are counterbalanced by large volumes of water discharge.

In fact, moderate anthropogenic load and moderately unfavorable hydroecological situation in the Upper Ob' basin (at the highest volumes of water disposal and industrial wastewater in Altai Krai) is stipulated by good self-purification potential.

The works on evaluation and cartographical modeling of hydroecological safety are to be continued in 2010.

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