



UNITED NATIONS  
Office for Outer Space Affairs

Committee on the Peaceful Uses of Outer Space  
Sixtieth session (7 to 16 June 2017), Vienna

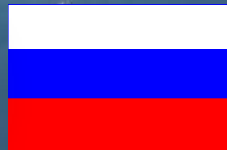
# Belarusian Space Related Projects in the Framework of Joint Space Programme “Monitoring-SG”



РОСКОСМОС

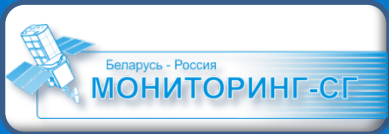


НИИ КОСМИЧЕСКИХ СИСТЕМ



State Space Corporation «ROSCOSMOS»

National Academy of Sciences of Belarus



## Joint Programme “MONITORING-SG» 2013 - 2017



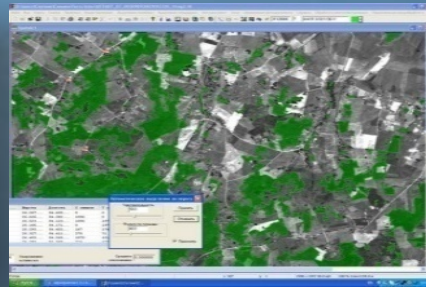
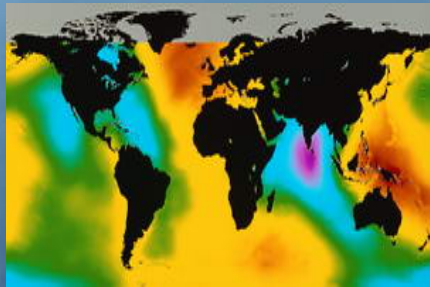
“The Development of Space and Ground Facilities To Support Russian and Belarus Earth End-users With Remote Sensing Information”

### State Customers:

- State Space Corporation «ROSCOSMOS»
- National Academy of Sciences of Belarus

### Developers :

- Khrunichev State Research and Production Space Center;
- United Institute of informatics Problems of The National Academy of Sciences of Belarus



Duration: 2013 – 2017

Number of Russian co-developers: 35

Number of Joint research Projects: 22

### The purpose of the Programme is

the creation of tools, technologies and software systems in order to improve the reliability, availability and survivability low-mass and small-sized space facilities for remote sensing

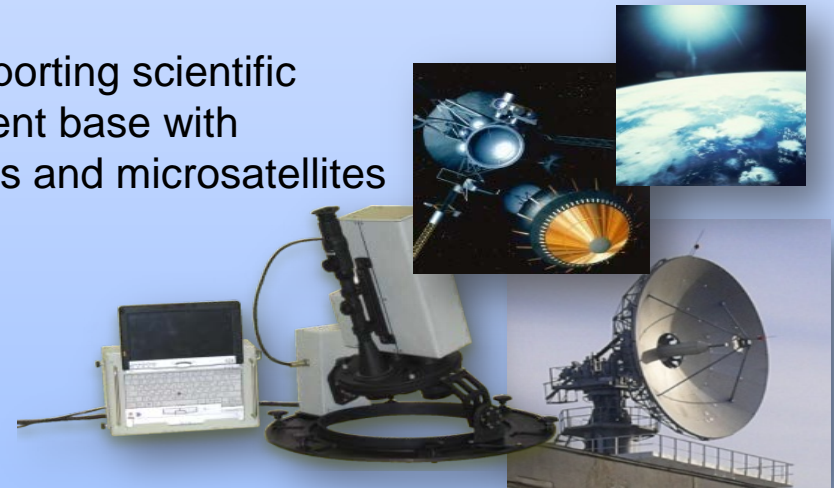


1) Create hardware and software simulating complexes for laboratory testing of new special space means, scientific equipment in order to improve the reliability, availability and survivability of space vehicles to be created.

2) Creating experimental equipment for monitoring and diagnostics of onboard systems and units to conduct field experiments to simulate the reliability, availability and survivability of new models and special space means, scientific equipment under conditions of outer space

3) Creating a perspective board special and supporting scientific equipment, new materials and perspective element base with improved characteristics for use in small satellites and microsatellites

4) Development of technologies and means for processing of space information received from a promising surveillance equipment, including, hyperspectral optical-electronic complex and others.





# Information System for Online Publication Monitoring of Space-related Information and Informational Support to Ensure the Reliability and Survivability of Spacecraft

## Purpose:

search for information on space topics on the Internet, the local network and the user's computer with the adaptation of its information needs, and with the possibility of operational summarizing of search results in a multilingual environment

The screenshot shows a search results page with a list of documents. The first result is titled '14 ИИ НАН Беларусь / ПРОГРАММА КОСМОС-НТ Беларусь-Россия / ГЛАВНАЯ НОВОСТИ НАПРАВЛЕНИЯ ИСПОЛНИТЕЛИ КОД РЕАЛИЗАЦИИ КОНТАКТЫ КОСМОС-СТ СОЗДАНИЕ КАРТА САЙТА Вы здесь: Направление // Направление 1 // Договор 14 ИИ НАН Беларусь // Паспорт проекта'. The document content includes project goals and objectives.

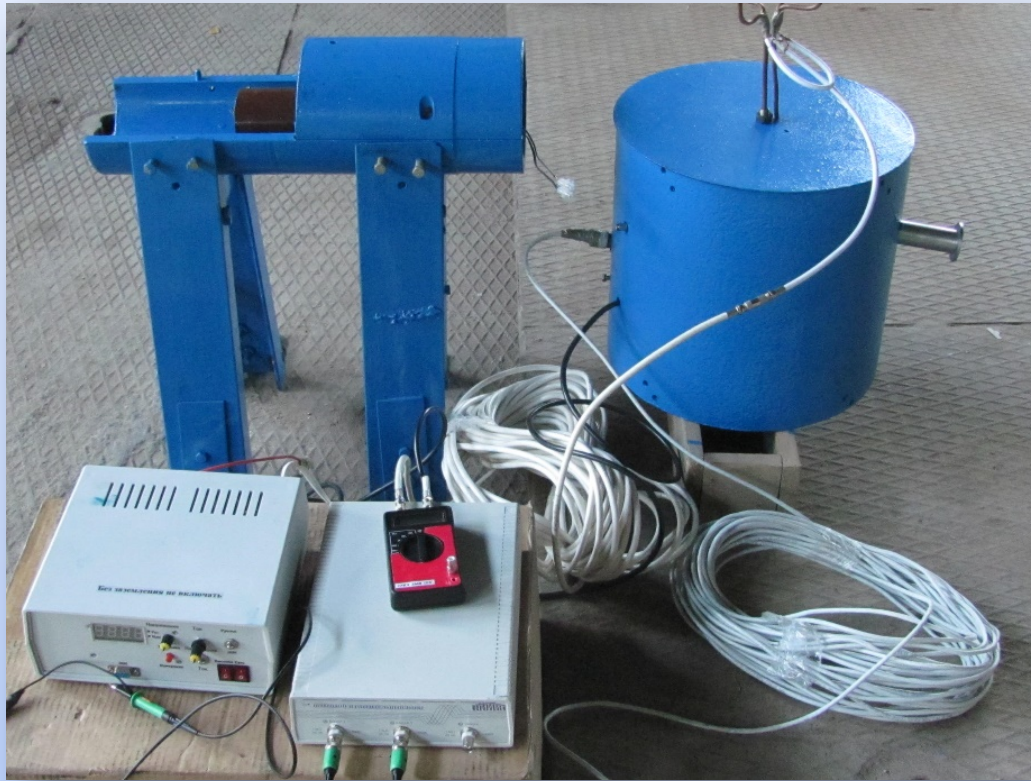
The screenshot shows a detailed view of a document titled 'Мастер-класс ШИШЕВИТСКИЕ СРЕДСТВА ИНФОРМАЦИОННОГО ПОИСКА В ИНТЕРНЕТЕ'. Below the document text, there is a table summarizing the document's content.

Информационные слова	Параметр	Значение
нет	1 Формы Генерации (слова)	6
бад	2 Предложенный	5
темуруе	3 Слов в реферате	538
реlevanceитни	4 Информационные слова в документе	542
информат	5 Знаков (с пробелами)	4197
ранжирование	6 Знаков (без пробелов)	3620

## System Functionality:

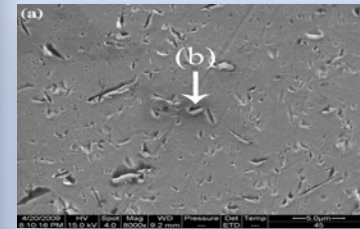
- Search the text of documents as a result of the indexing of various information sources;
- Referencing documents in Russian, Belarusian, English and German;
- Creation and editing of various types of essays;
- The creation of a list of keywords and building their chart information content;
- Updating the database for information support of the work to ensure the reliability and survivability of spacecraft during its operation;
- Updated database of scientific and technical achievements in the field of space research

# Experimental System for Simulation and Recording of High-frequency Pulsed Electromagnetic Radiation, Simulating the Conditions of Interaction of High-speed Flows of Space Dust Micro-particles With the Spacecraft in Near-Earth Space Environment

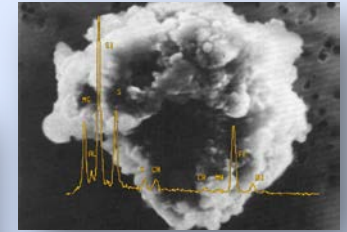


Experimental system for simulation and recording of high-frequency pulsed electromagnetic radiation

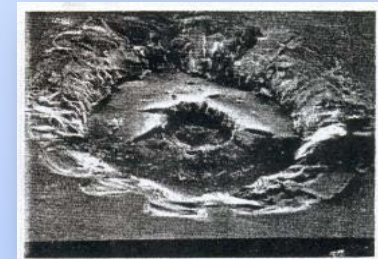
## SOLAR PANELS AFTER THE IMPACT OF COSMIC DUST



Micro X-ray spectral analysis of the micro-particles of cosmic dust

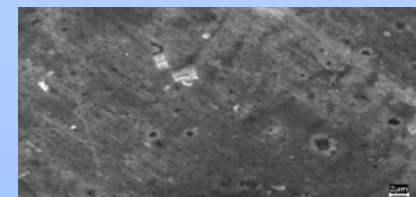
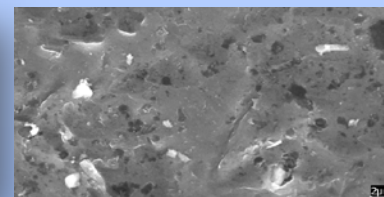
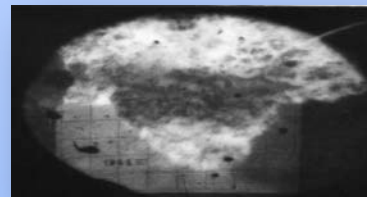


The surface of the Hubble Space Telescope solar battery



Micro crater 1,8 mm

## Micro craters on a model of an aluminum sample after exposure by micro-particles <100 microns, LABORATORY TESTS



# Experimental System for Simulation and Recording of High-frequency Pulsed Electromagnetic Radiation, Simulating the Conditions of Interaction of High-speed Flows of Space Dust Micro-particles With the Spacecraft in Near-Earth Space Environment

## Specifications

**Purpose:** the extension of the technical capabilities of the experimental study in testing and laboratory examination of pulsed high-frequency electromagnetic radiation in the interaction of high-speed flows of cosmic dust micro-particles with spacecraft.

### Structure:

- micro-particle accelerator, which simulates the processes of high-speed collision of micro-particles with spacecraft;
- devices for registration and measurement of electromagnetic radiation of high-frequency pulse.
- Experimental samples of integrated protected circuits, which are exposed to high-frequency pulsed electromagnetic radiation;
- methods for registration and measurement of electromagnetic radiation of high-frequency pulse;

### Purpose indicators:

- Micro-particles flow velocity of 0.3 - 2.5 km/s;
- Micro-particles flux density 4 - 8 g/cm<sup>3</sup>;
- A background pressure of 2 - 8 GPa;
- Duration of exposure at micro-particles flow impact 5 - 400 ms;
- Range of measured frequency 100 - 3500 MHz;
- Frequency error of  $\pm 10\%$ ;
- Minimal time for signal frequency measurement 8 ms;
- The electric field strength at the time of interaction  $\sim (4-7) \cdot 10^9$  V / m;
- The energy density of the electric field  $3 \cdot 10^5 - 5 \cdot 10^7$  J / m<sup>3</sup>;
- The minimum flux density of power 3 mW / cm<sup>2</sup>.
- Protection of IC should reduce the impact of high-frequency pulse electromagnetic radiation by 30%.

*Executor. Research Institute of Powder Metallurgy of the National Academy of Sciences of Belarus*



# Experimental Software and Hardware for Laboratory Testing of Controlling Complexes, Functional Modules and Units of On-board and Supporting Equipment for Remote Sensing Nano- and Pico- Satellites



Spacecraft simulator



Ground control complex for the simulator of the spacecraft

## Purpose:

To test controlling of ultra-small space vehicles, conducting experiments to support the reliability, operability and survivability of space on-board equipment and target pay-load, on-board software, equipment of controlling complex, training and retraining of aerospace specialists.

## Structure:

- A complex for remote controlling of a spacecraft for operation as a radio receiving and radio transmitting station with the functions of forming the transmitted and recorded information for command, telemetry and information services;
- The simulator of the spacecraft for laboratory testing of software and hardware, onboard systems of the spacecraft, scientific pay-load equipment, radio communication with the spacecraft, the training of operators;
- Software and information system for testing of on-board systems and scientific pay-load equipment for analyzing the state of on-board systems, telemetry, command-and-software, ballistic support, data exchange and includes software for analysis and control of the spacecraft simulator

## Indicators:

- Data (information) transmission rate by command radio-line at frequencies of 140 -145 MHz, not less than - 9 kbit / s;
- Data (information) transmission rate by telemetry radio line at frequencies 435 - 445 MHz, not less than - 22 kbps;
- Data (information) transmission rate for the target pay-load of 1.7 GHz; 2.4 GHz; 8.2 GHz, at least - 128 kbit / s;
- Consumed power of the spacecraft simulator, no more than - 10 W;



The full-scale model of the advanced hardware-software control and communication complex of the nanosatellite

*Executor: Belarus State University*

# Methods and Experimental Equipment for Thermoelectric and Magnetodynamic Control of Technological Coatings With Space Purposes



Magnetic thickness gauge  
MTDP-1

**Purpose:** tool control of the thickness of nickel and chromium-nickel coatings in the technological process of production of rocket engines

## Structure:

- Thermoelectric thickness gauge for measuring the thickness of nickel coatings, regardless of the magnetic properties of steel substrates;
- magnetodynamic thickness gauge MTNP-1 to measure thickness of nickel coatings;
- Magnetodynamic thickness gauge MTDP-1 to measure thickness of two-layer chromium-nickel coatings.

## Requirements to thermoelectric thickness gauge :

- measurement range - (0 - 100)  $\mu\text{m}$ ;
- resolving power when measuring thermoEMF - not worse than 0.1  $\mu\text{V}$ .
- the main permissible error in measuring the thickness of coatings - within  $\pm (2 \mu\text{m} + 5\%$  of the measured thickness);
- the temperature difference between the hot electrode and the product - in the range from 29.5 to 30.5  $^{\circ}\text{C}$ .
- availability of memory for storing up to 100 calibration dependencies, incl. when the thickness gauge is turned off.

## Requirements to magnetodynamic thickness gauge MTNP-1 :

- measuring range is (0 - 700)  $\mu\text{m}$ ;
- basic permissible error is within  $\pm (1.5 \mu\text{m} + 3 \cdot \%$  of the measured thickness);
- method of demagnetization - a pulse bipolar during measuring the thickness of nickel coatings;
- supply voltage of the system must not be more than 9 V;

## Requirements to magnetodynamic thickness gauge MTDP-1 :

- the range of measurements of chromium coatings on nickel coatings at a thickness of nickel coatings from 200 to 700  $\mu\text{m}$  - (0 - 150)  $\mu\text{m}$ ;
- the range of measurement of nickel coatings under chrome with a thickness of chrome coatings is not more than 150  $\mu\text{m}$  - (0 - 700)  $\mu\text{m}$
- basic permissible error:
  - A) when measuring the thickness of chromium coatings on nickel - within  $\pm 5 \mu\text{m} + 5\%$  of the measured thickness;
  - B) when measuring the thickness of nickel coatings under chrome - within  $\pm (1.5 \mu\text{m} + 10 \cdot \%$  of the measured thickness).



# Experimental Complex for Calibration of Target Equipment and Validation of Earth Remote Sensing Data for Space Remote Sensing Systems



Test-objects at training ground «Western Berezina»



Test-objects at training ground “Pleschinitzy”

*Executors:*

*A. N. Sevchenko Institute of Applied Physical Problems,  
Enterprise “GeoInformation Systems”*



Equipment for determining the optical parameters of the atmosphere at test ranges

*Executor: Institute of Physics NAS Belarus*

# Experimental complex for calibration of target equipment and validation of Earth remote sensing data for space remote sensing systems

## Basic Technical Specification

**Purpose:** calibration and functional maintenance during the operation of the target equipment (payload) of space remote sensing systems, including a new Belarusian Satellite

### Structure:

- instruments for determining the photometric parameters of test objects;
- equipment for determining the optical parameters of the atmosphere - a prototype of the lidar "Cosmos-NT";
- equipment for remote measurements and detailed shooting of test ranges and objects, reference points on training grounds;
- test objects for validation of the parameters for the resolution of target information;
- a device for measuring meteorological parameters;
- GPS-receiver GeoXT \$;
- software complex for processing, cataloging, storing, displaying, searching and issuing input and output data of calibration results and validation

### The functions performed together with the set of ground measurements:

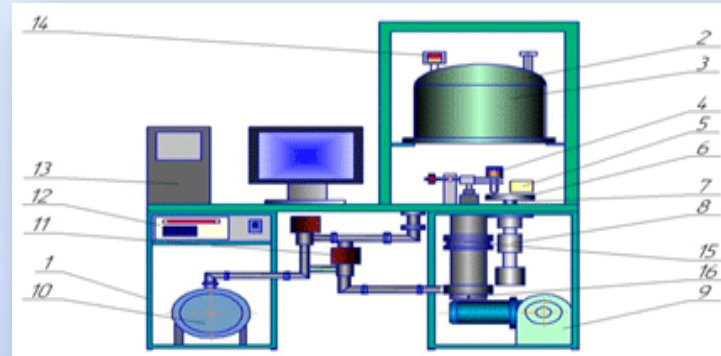
- determination of photometric parameters of the payload;
- determination of geometric characteristics of the payload;
- verification of the linear resolution of the payload on the ground.

### Requirements for the intended use:

- calibration and validation of panchromatic Space Remote Sensing Systems in the spectral range - 500 - 900 nm;
- calibration and validation of panchromatic Space Remote Sensing Systems of high and ultrahigh spatial resolution from 0,3 m to 10 m;
- calibration and validation of multi-zonal Space Remote Sensing Systems in the spectral range - 460 - 950 nm to 30 spectral channels;
- calibration and validation of multi-zonal Space Remote Sensing Systems with spatial resolution from 2 m to 10 m;
- radiometric calibration of multi-zonal Space Remote Sensing Systems with accuracy, not less than 8

# Novel Tribotechnical Materials with Improved Characteristics for Use in Outer Space and Equipment for Studying the Friction and Wear Processes of Tribotechnical Materials, Thin Films And Modified Surfaces Under Conditions Simulating Outer Space

## INSTALLATION FOR STUDYING FRICTION PROCESSES IN VACUUM



1. The table
2. The valve of admission of atmospheric air
3. Vacuum chamber
4. The loading mechanism of the indenter
5. The device for vacuum heating of the indenter
6. The mechanism for rotating of the test sample
7. The mechanism for lifting of indenter
8. The mechanism for determining the torque
9. Mechanism for lifting the vacuum chamber
10. Oil-free spiral pump Anest Iwata
11. Electromagnetic valve
12. Controller of the Turbomolecular Pump
13. Personal computer
14. The wide-band module Micro-Ion Plus
15. Shutter Vacuum GVB-SS-CF100M
16. Shimadzu turbomolecular pump



The cage of the experimental sample for the installation to study the processes of friction with a vacuum chamber and the mechanism for input of rotation

Technological equipment for the synthesis and sintering of samples with cylindrical shape.

Samples are made from composite super-hard materials based on CBN for the manufacture of rolling bodies for bearing units for space technology

### Executors:

*Research Institute of Powder Metallurgy of NAS Belarus,  
Joint Institute Of Mechanical Engineering of NAS Belarus*



# Novel Tribotechnical Materials with Improved Characteristics for Use in Outer Space and Equipment for Studying the Friction and Wear Processes of Tribotechnical Materials, Thin Films And Modified Surfaces Under Conditions Simulating Outer Space

**Purpose:** to study the friction and wear processes of thin films and modified surfaces under various operating conditions (dry friction, presence of liquid lubricant, presence of abrasive, in vacuum).

## Purpose indicators:

### a) of tribotechnical materials :

- structure – cubic boron nitride (CBN);
- hardness, GPa 30 – 32;
- ultimate compression strength, GPa 2,5 – 3,2;
- fracture strength, MPa m<sup>2</sup> , 7 – 9;

### b) of experimental installation:

#### test circuit «disc-finger»

- load range on the ball, kernel – 1 – 50 N;
- rotation frequency of testing sample – 2 – 1000 rpm;
- radius of wear ring of the sample – 10 – 50 mm;
- higher temperature of the sample – up to +130 °C;
- negative temperature of the sample – up -120 °C;
- high vacuum – 10<sup>-4</sup> Pa;
- testing environment:
  - vacuum, air,
  - drip lubrication,
  - abrasive,
  - Higher temperatures.

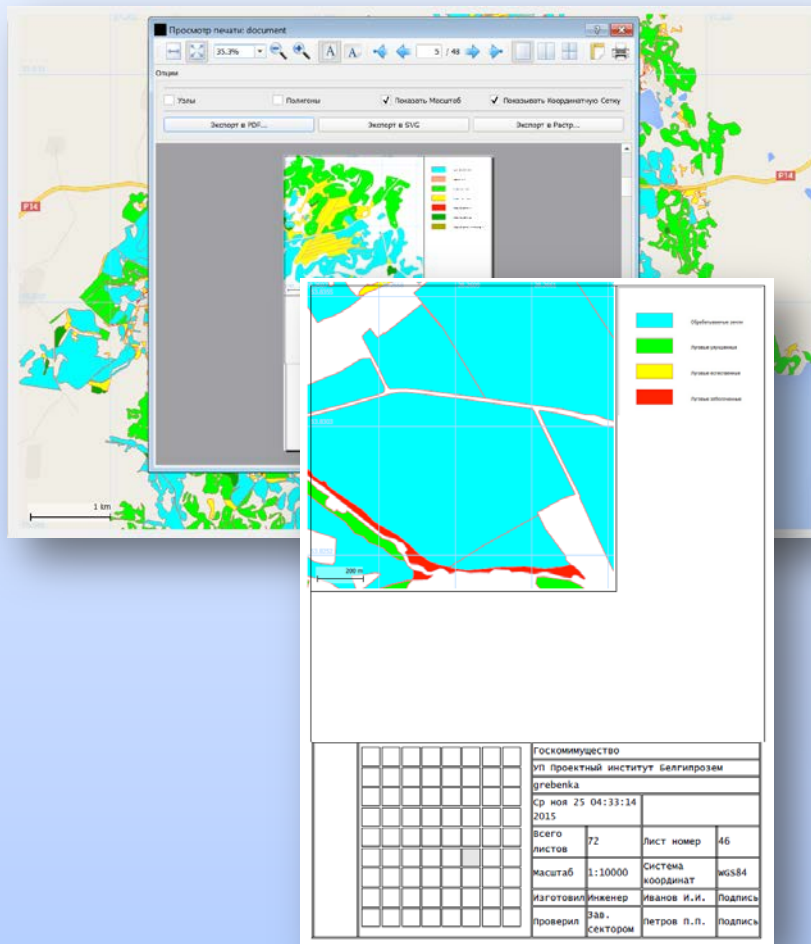
### counter body:

- Ball from steel SHH15 – Ø 3,97 mm;
- Kernel, made from hard alloy – VK8 – Ø 4 mm;
- Kernel made from steel SHH 15 – Ø 2 mm;

#### test circuit «shaft - sleeve»

- diameter of the shaft – 10 mm;
- Height of the half-sleeve – 10 mm;
- thickness of half-sleeve – 10 mm;
- rotation frequency of the shaft – 2 – 1000 rpm;
- Maximum specific pressure when half-steeves are holding-down to shaft – up to 30 kg/sm<sup>2</sup> ;

# Experimental Software System for Operation Monitoring of Operative Remote Monitoring of the State of Agricultural Crops Using Data From Prospective Hyperspectral and Existing Aerospace Equipment



Generating of subject digital map and print preview

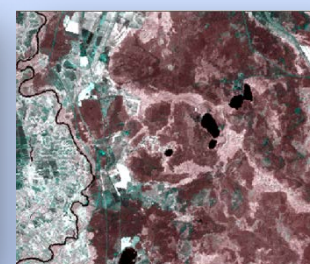
## Purpose:

- Development of technology for Remote Sensing data application for operational remote monitoring of agricultural land condition;
- Improvement of methods and algorithms for processing Remote Sensing data to increase the degree of automation of the processes of allocation and classification of agricultural lands

## INTERPRETATION OF LANDS



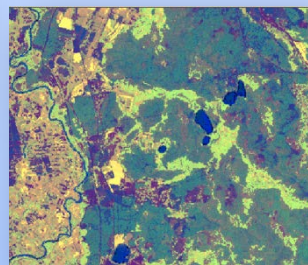
Initial image with pseudo-colors



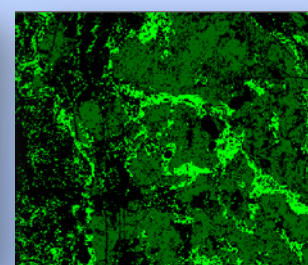
Selection of most informative channels



RGB - IHS transformation



Clusterization (segmentation) of HIS-image



Subject Information Extraction

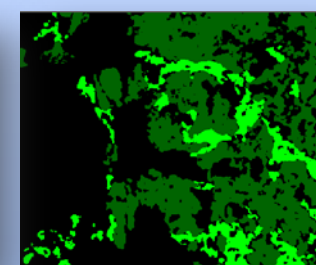


Image Generalisation



# Experimental Software System for Operation Monitoring of Operative Remote Monitoring of the State of Agricultural Crops Using Data From Prospective Hyperspectral and Existing Aerospace Equipment

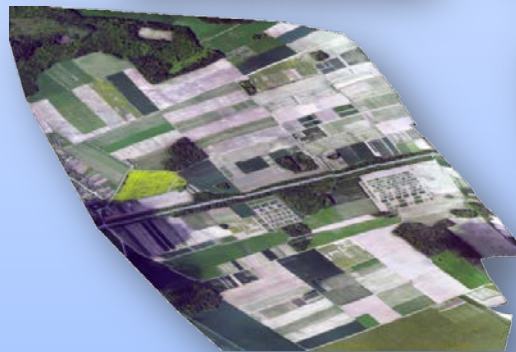
## Structure:

- Subsystem for assessment of agricultural crops damage
- Subsystem for monitoring of phytosanitary condition of agricultural crops
- Subsystem for crop yield forecasting;
- Subsystem for mapping of agricultural crops

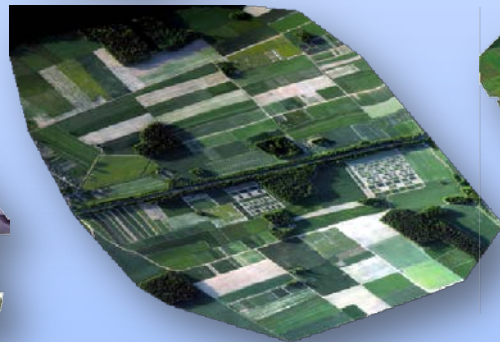


PREPARATION OF INITIAL DATA FOR THE SUBSYSTEM OF THE CROP YIELDS FORECASTING

## MAKING A MOSAIC OF AERIAL SURVEY RESULTS



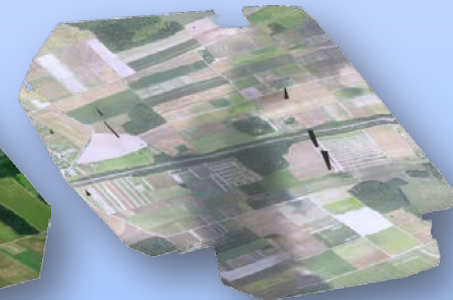
2015-05-26



2015-06-08



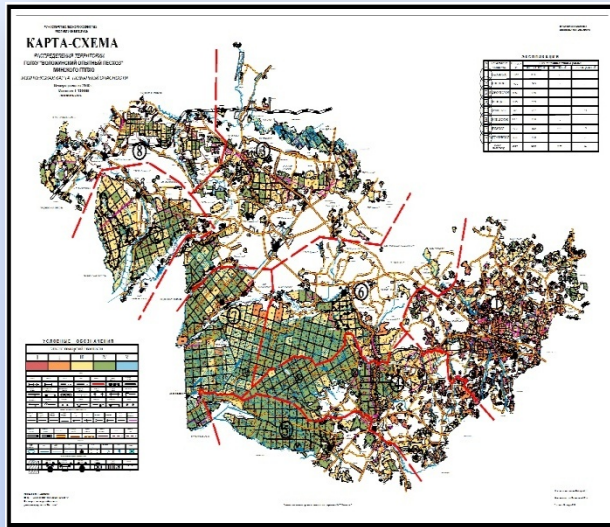
2015-06-24



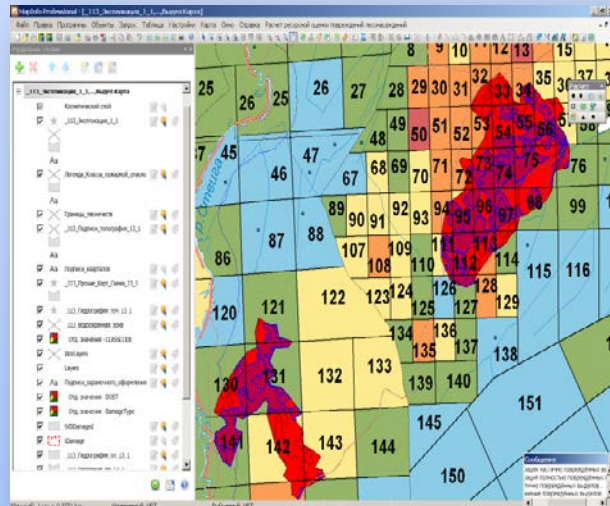
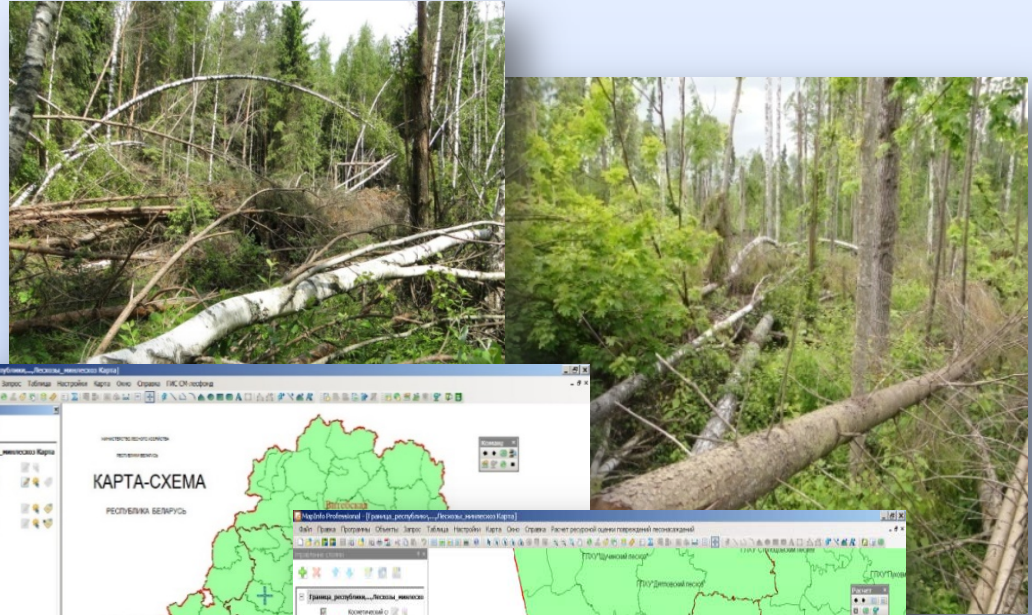
2015-07-31



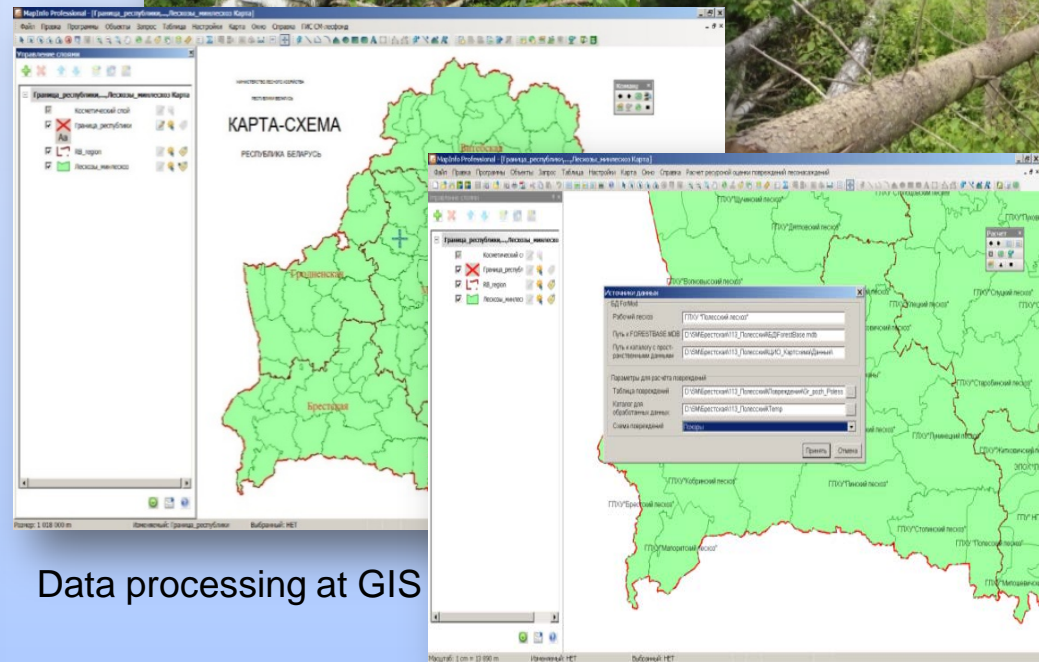
# Geo-Information System for Integrated Monitoring of Forest Resources, Forest Exploitation and Fire Hazard Assessment Based on Forest Regulation, Radar and Multispectral High-resolution Space Imagery



Fire hazard mapping



Drawing of boundaries of damages of forest resources

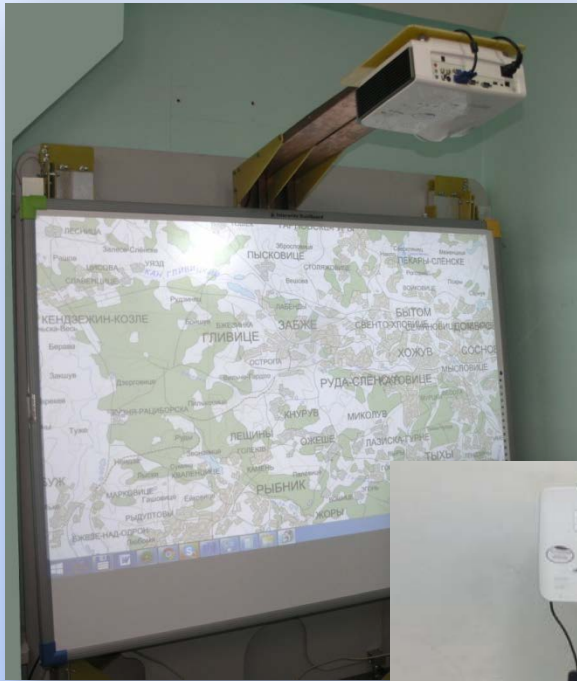


Data processing at GIS

**Executors:**  
**"Belgoses", Belarusian State Technological University**

# The Prototypes of Interactive Input Systems for Visualization and Updating of Graphical Information for Ground Monitoring Based on Predefined Given Remote Sensing and Digital Cartographic Data

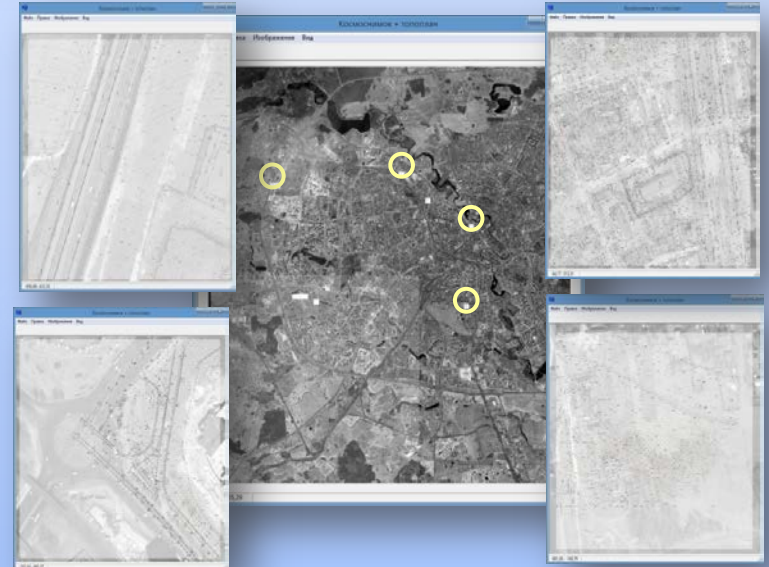
Stationary Case



Portable Case



Topo plan in the coordinate system of the satellite



Placing of topo plan at the space image



# Experimental Integrated System of Coordinated Satellite and Terrestrial Remote Observations of Hazardous Emissions Into the Atmosphere and Control of Large-scale Pollution Transfer

Hardware complex for integrated lidar and radiometric measurements

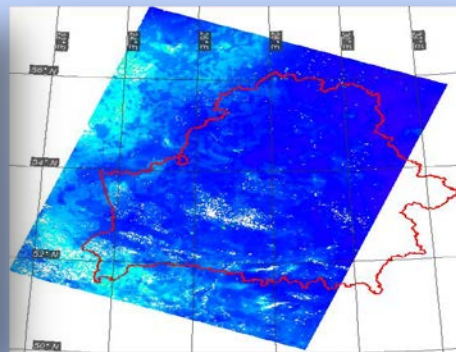
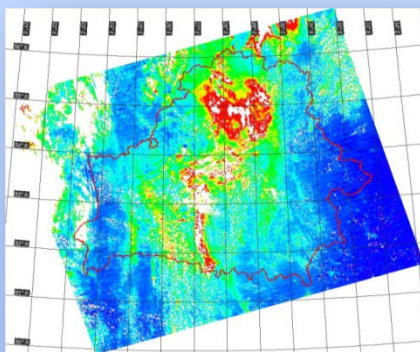


a) multiwave polarization Raman lidar MSTL-2

b) model of multiwave lidar "COSMOS-NT";

c) Solar multi-wavelength scanning radiometer CE-318N-EB9

Distribution of aerosol optical thickness of the atmosphere on the territory of Belarus. It has been transferred to **National Environmental Monitoring System**

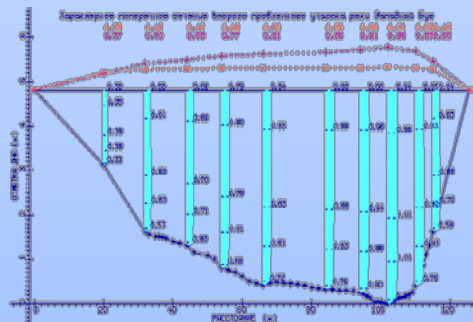




# Experimental Technology and Software For Bed-movement Monitoring and Hydrological Regime of Rivers Using Remote Sensing Data



Scheme of the location of the problem area No. 2 of the Western Bug River, taking into account the recommended strengthening of the right bank



Calculated local longitudinal averaged water flow velocities, averages on verticals and allowed (non-smashing) water flow velocities in cross sections of two problem areas of the Western Bug River. Water discharge is close to the channel-forming regime



Strengthening of the shore with a stone outline on the layer by rubble on the geotextile canvas, or with flexible concrete mats using concrete composite slabs with flexible connections.

**Executor:**

**Central Research Institute for Complex Use of Water Resources**



UNITED NATIONS  
Office for Outer Space Affairs

Committee on the Peaceful Uses of Outer Space  
Sixtieth session (7 to 16 June 2017), Vienna

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