RUSSIAN SPACE SYSTEMS

Present and Future of Russian Space Device Engineering

Alexey Romanov

Deputy General Director for Research & Development

SkolTech, 9 February, 2016

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AT THE INDUSTRY ORIGIN

The enterprise has been founded in 1946. Now it is one of the six enterprises participating in establishment of domestic rocketry

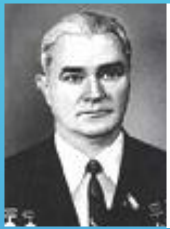
The first council of the chief designers of missiles and space systems

Korolyov Sergey Pavlovich

Chairman

Barmin Vladimir Pavlovich

Chief designer of refueling and start equipment

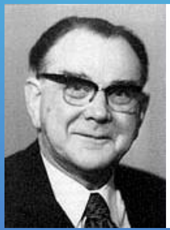


Glushko Valentin Petrovich

Chief designer of missile engines

Pilugin Nikolay Alekseevich

Chief designer of autonomous control systems



Ryazansky Michail Sergeevich

Chief designer of radio systems for control the missiles, ranges, space radiotechnical means and space systems

Kuznezov Victor Ivanovich

Chief designer of gyroscope systems

HISTORICAL HERITAGE

Systems for radio control of long-range missiles

Automated complexes for control of the satellites in near, middle and deep space

Search & rescue space system COSPAS-SARSAT

Satellite communications and relay systems S/C control systems and scientific equipment for space exploration («Moon», «Venus», «Mars»)

On-board control and telemetry radio complexes for manned and transportation vehicles «Vostok», «Soyuz», «Progress», «Buran», orbital space stations «Salyut», «Mir», ISS, cosmodromes «Baikonur», «Svobodny», «Plesetsk», Sea Launch Project and Mission Control Centers

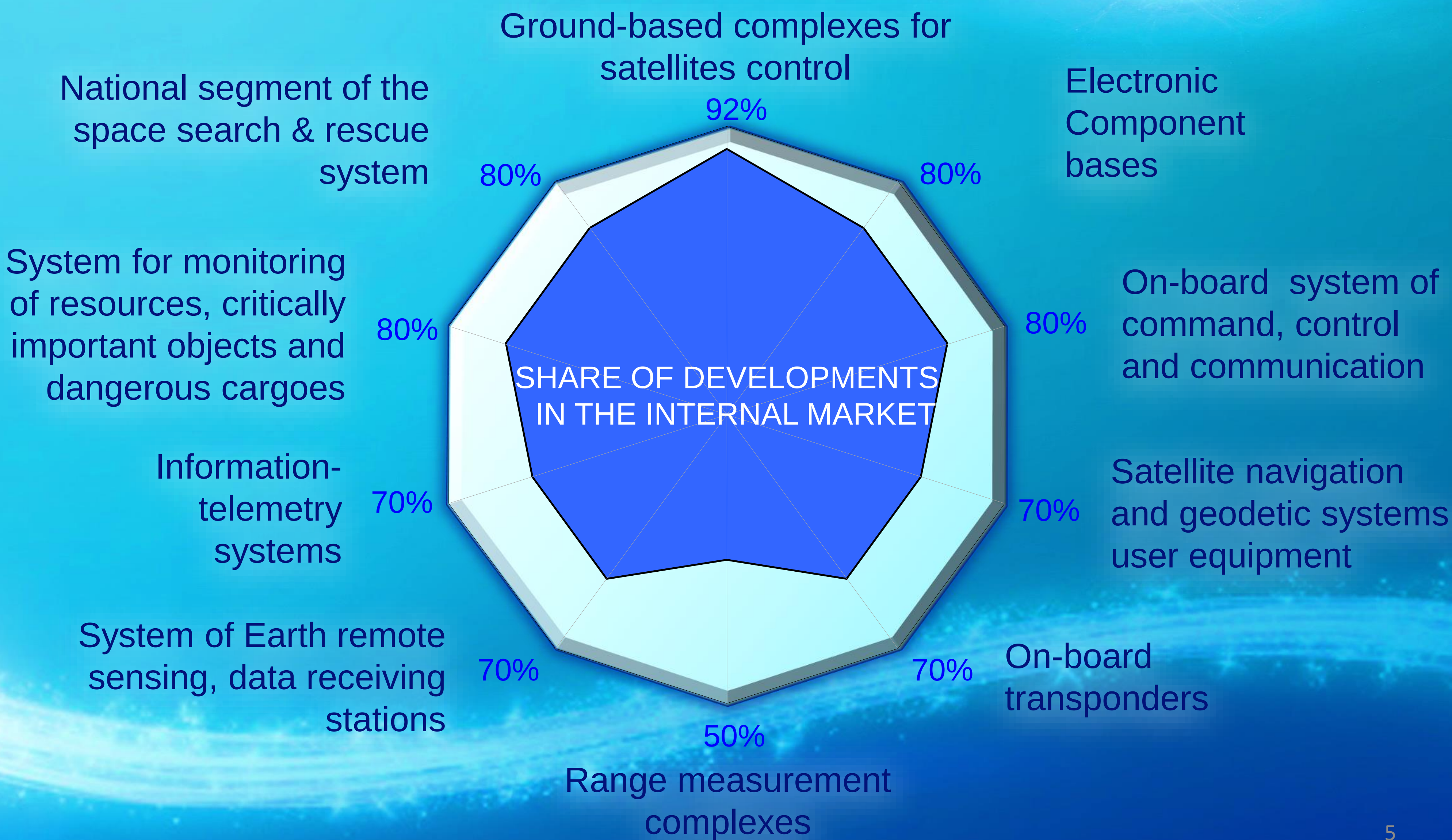
Radio systems for global positioning «Sphera» and «Tsyklon»

Radio technical complex for Global Navigation Satellite System GLONASS

Radio telemetry complexes for all Earth remote sensing Satellites («Resurs», «Meteor», «Ocean»)

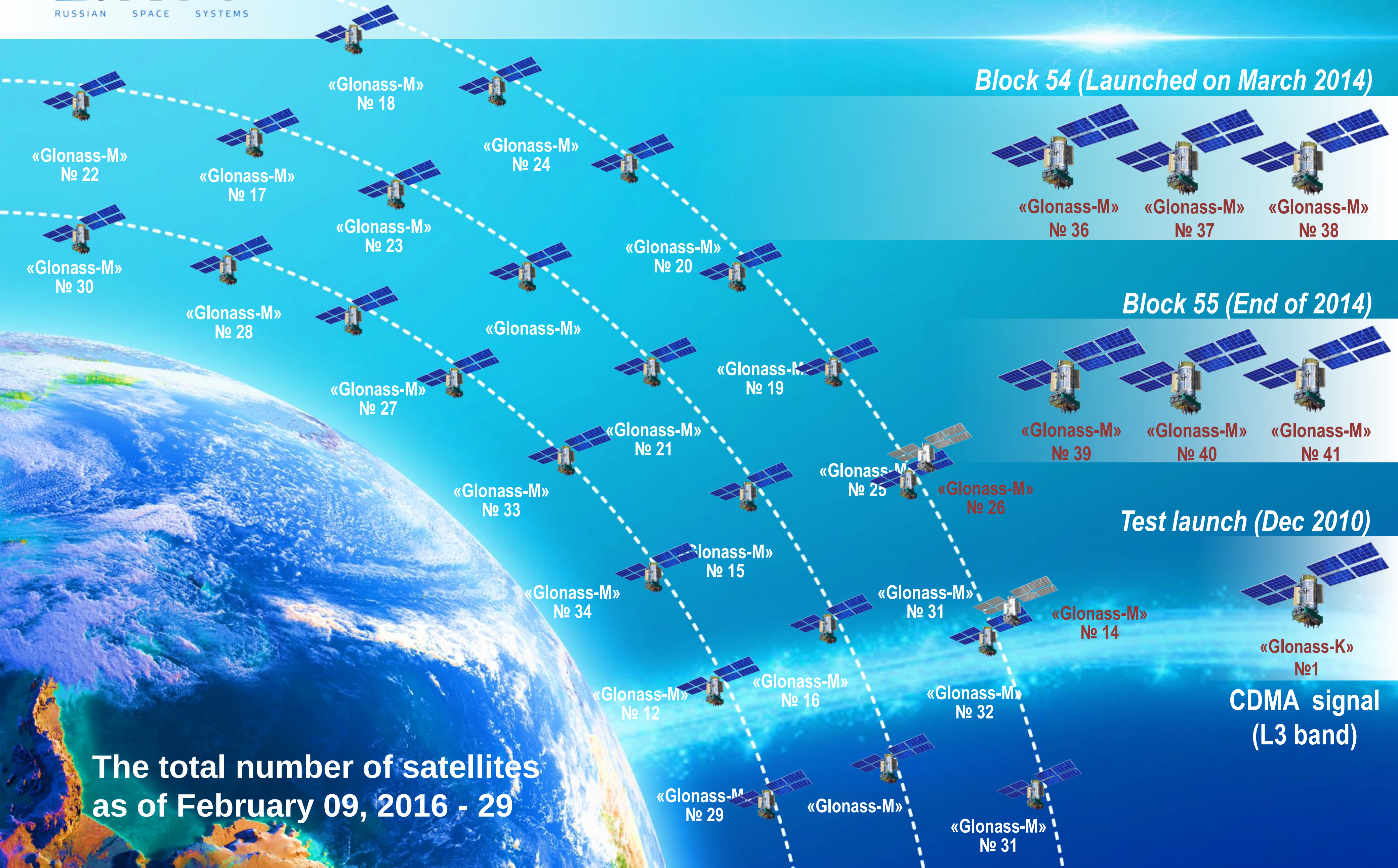
Ship-based TT&C systems

PRINCIPAL ACTIVITY DIRECTIONS OF THE JSC RSS AS A HEAD ORGANIZATION IN THE BRANCH



- GLONASS system status and future prospects
- Advantages of combined use of GLONASS and GPS signals
- Examples of specific monitoring projects based on GNSS data in Russia

CURRENT GLONASS CONSTELLATION STATUS



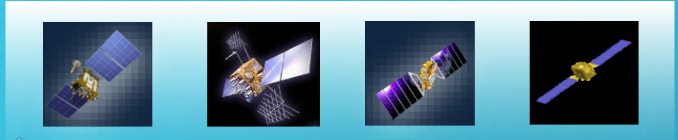
GLONASS AUGMENTATIONS

BROADCASTING FACILITY

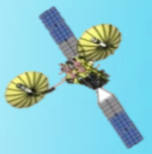
Objectives:

- All types of high accuracy service
- Integrity for critical safety applications

GNSS CONSTELLATION



GEO



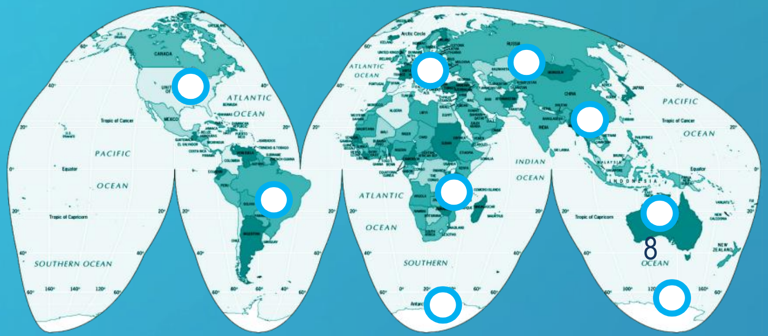
Internet

L1/L3 GLONASS

L1/L5 SBAS

NTRIP

GLOBAL MONITORING NETWORK



DATA PROCESSING FACILITY

- Master Center
- Back-Up Center

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GLONASS SYSTEM USAGE

Transport

Traffic and transportation control

ERA-GLONASS and public safety

Road accident emergency response system

Construction

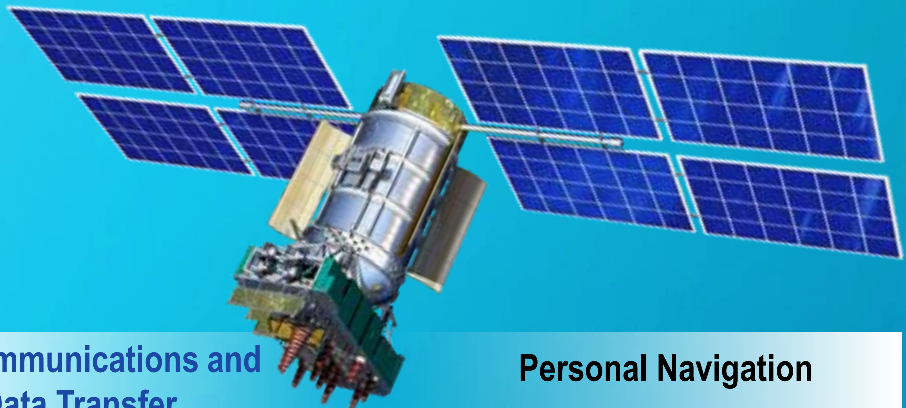
High-rise buildings, bridges, roads construction

Oil and Gas Transportation

Flowrate control

Agriculture

High-accuracy tillage, Fertilization optimization, yield control



Geodesy, Cartography and Land Regulation

Land surveying, cadastral works, land mapping

Power Production

Power networks synchronization

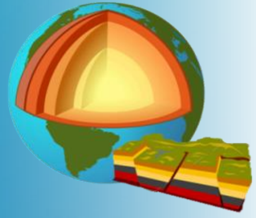
Telecommunications and Data Transfer

Data flows synchronization, capacity growth

Personal Navigation

Positioning, routing

Geosciences



Earth modelling, geodynamics research, earthquakes registration

MULTI-GNSS USER EQUIPMENT IS USED (GENERALLY GLONASS/GPS)

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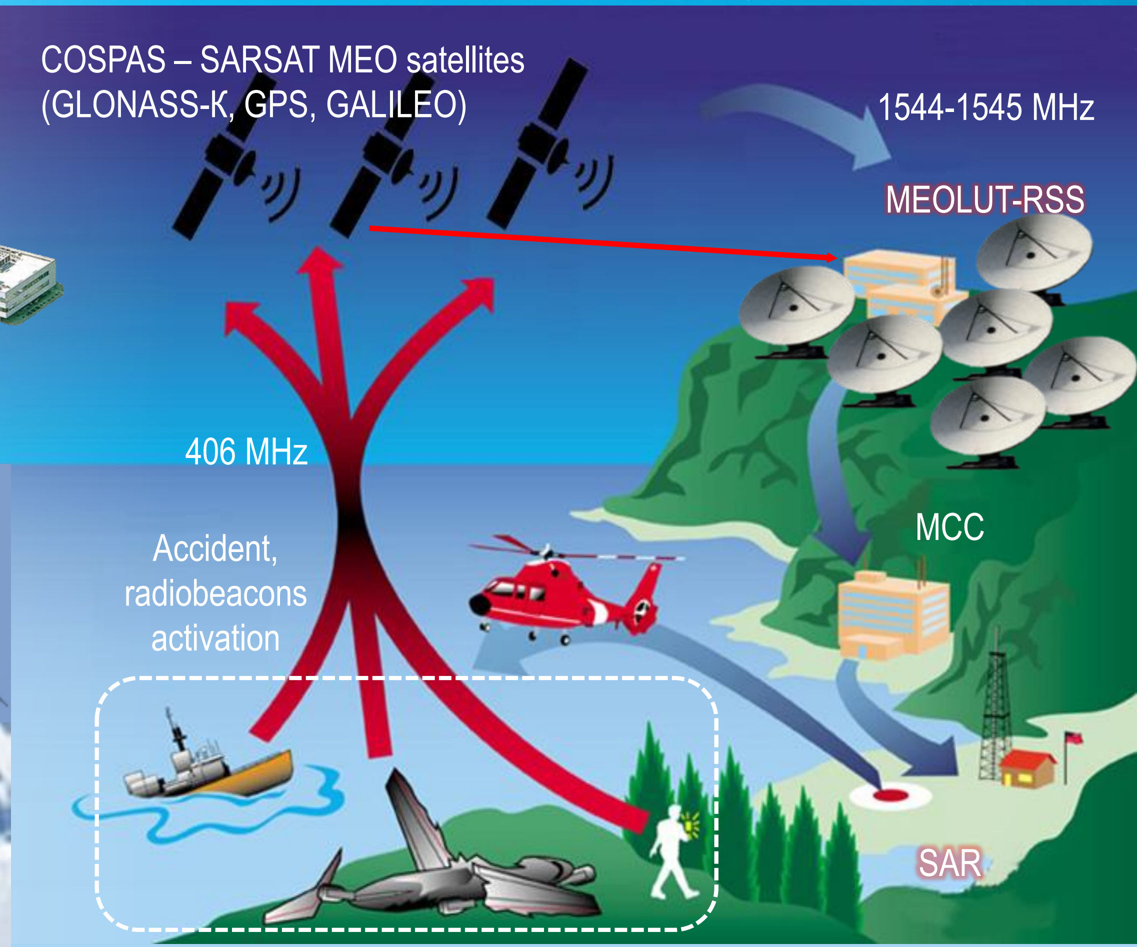
EXAMPLES OF SPECIFIC GNSS PROJECTS IN RUSSIA

- Global vessel monitoring system based on satellite AIS technology
- Space vessel monitoring system for fisheries
- Projects in vehicle tracking
- ERA GLONASS project: saving lives

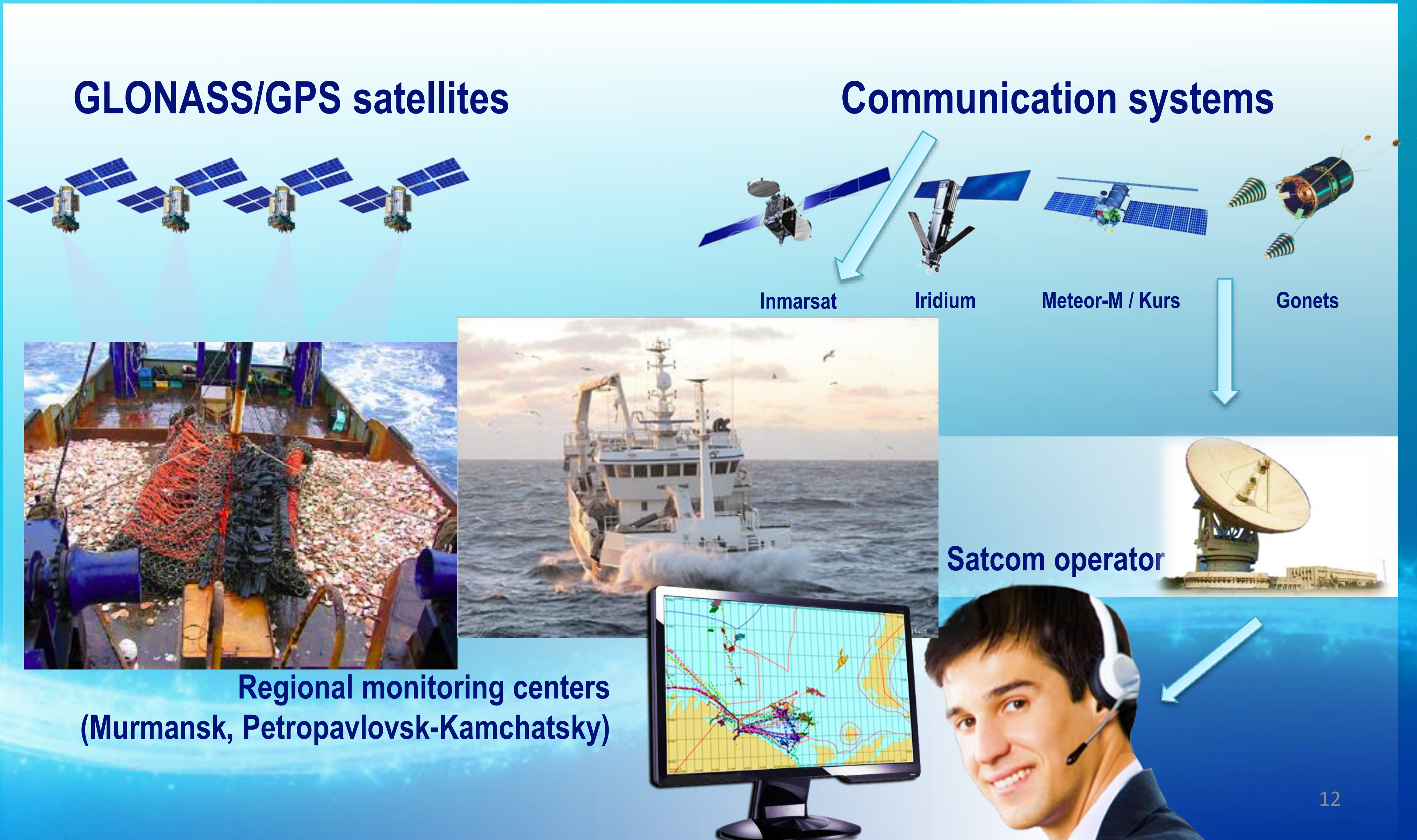
GLOBAL VESSEL MONITORING SYSTEM BASED ON SATELLITE AIS TECHNOLOGY

Space search and rescue system for personal buoys consumers



MEOLUT – MEO local user terminal
MCC – mission control center
SAR - Search and rescue services

SPACE VESSEL MONITORING SYSTEM FOR FISHERIES



MAJOR PROJECTS ON GLONASS/GPS VEHICLE TRACKING

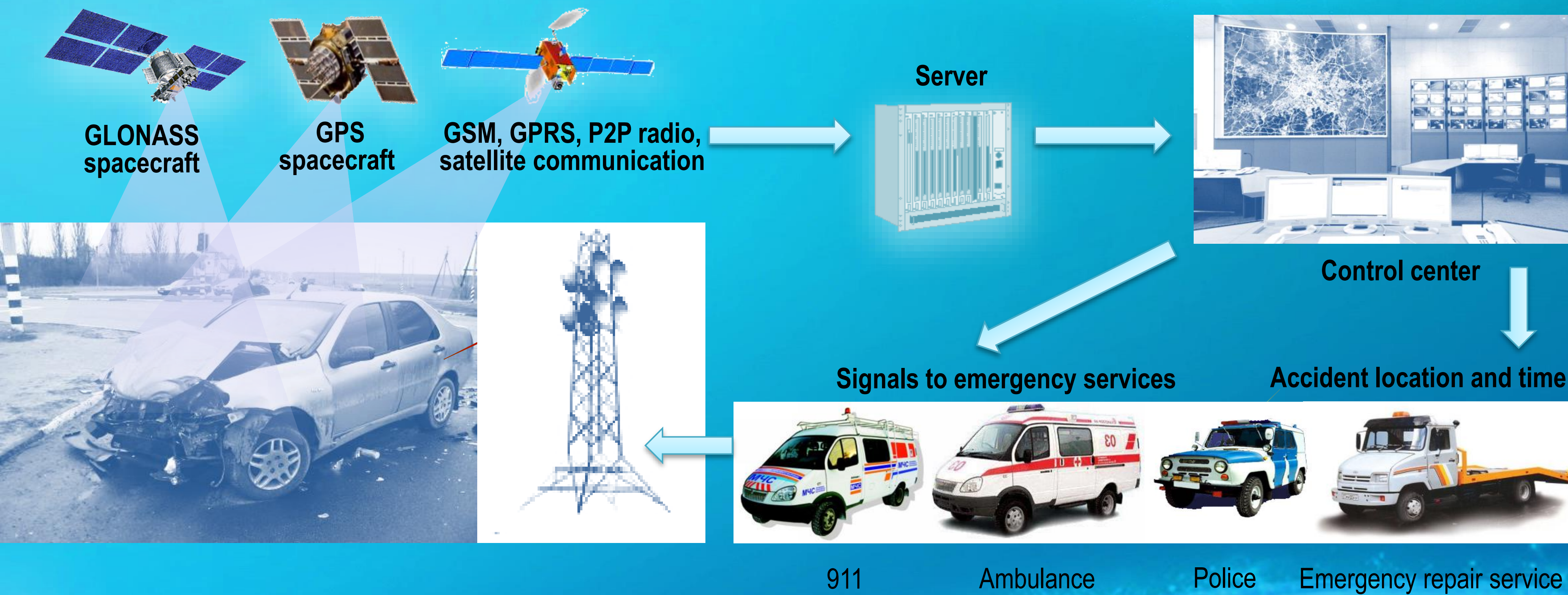
Buses
MUE «Sochiavtotrans»; MUE «Lazarevskoe»

Police cars management system

JSC «GMK «Norilsky nikel»

GLONASS/GPS in-car navigation

ERA GLONASS PROJECT: SAVING LIVES



Telematics module

Functions of ERA GLONASS:

- Communication of accident location coordinates with control center
- Vehicle movement parameters control
- Theft prevention
- Navigation
- Loudspeaker communication

SUMMARY

- GLONASS/GPS technology applications are actively implemented in Russia.
- Combined use of signals from multiple GNSS is important
- GLONASS performance is improving

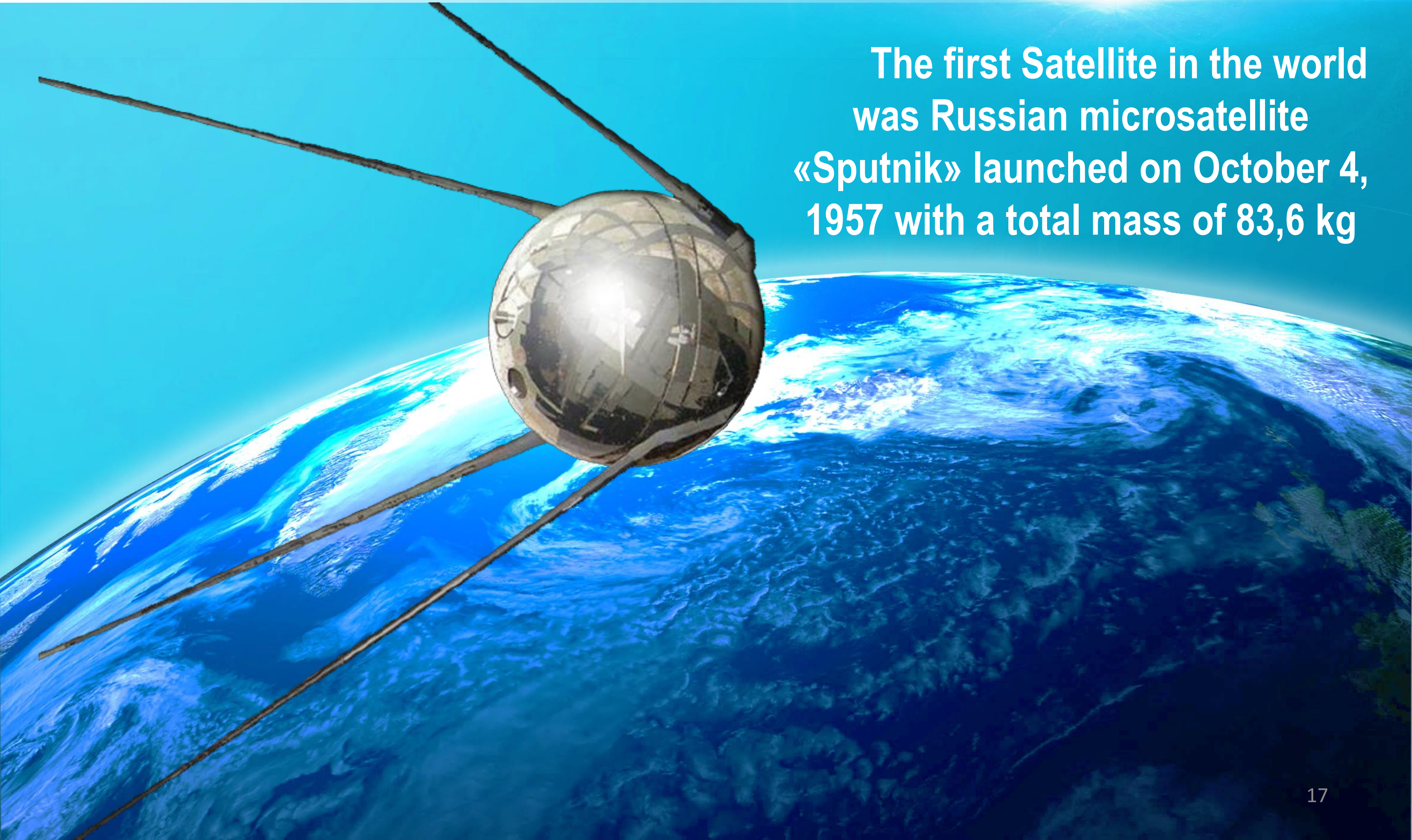
  - Introduction of CDMA signals on a new GLONASS-K spacecraft
  - Further development of SDCM network
  - 100% of global availability will be guaranteed by the end of 2010

- Several monitoring projects based on satellite GNSS and AIS technologies are currently under development

RSS — RUSSIAN SPACE SYSTEMS

RSS PROGRAM ON DEVELOPMENT OF SMALL SATELLITES FOR DIFFERENT APPLICATIONS

1. The 10th anniversary of TNS–0 launch: lessons learned
2. TNS–0 #2: status of «Radiomet» project and ISS experiment
3. Ionoshperic Radiotomography Nanosats cluster
4. «CosmoAIS»: space qualification of payload onboard «Resours-P» #2 satellite
5. Conclusions



The first Satellite in the world was Russian microsatellite «Sputnik» launched on October 4, 1957 with a total mass of 83,6 kg

BASIC PRECONDITIONS FOR PROGRAM DEVELOPMENT

- Enhance of research and commercial activity
- Acceleration of onboard equipment miniaturization
- Using of perspective technologies of small satellites control and data transfer
- Integration to the world community of future space systems designers
- Teaching graduated and post graduated students inside RSS corporation

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BASIC TECHNOLOGIES OF SPACE DEVICES MINIATURIZATION

General concepts of satellite development	- refusal from "service platform and payload are separate" and application of "satellite as flying device" concept; - net and interactive methods of super-small satellite development
Attitude control systems	-application of passive/active geomagnetic attitude control systems - MEMS usage in electromechanical attitude control systems
Command &Telemetry Systems	- united transponders for command and telemetry data - high-rate telemetry through ERS-data downlinks - satellite communication systems and Internet technologies application for flight control
Observation data downlink	- progress in data packing - application of L- and S- range downlinks
Electronic & optoelectronic instruments	- application of COTS-components (photo- & video cameras, controllers, sensors, etc.)
Thruster units for orbit correction	-application of high-effective, low energy microthrusters (plasma electro-reactive, cold-gas thrusters, etc.) - new concepts of orbit correction (solar sail, etc.)

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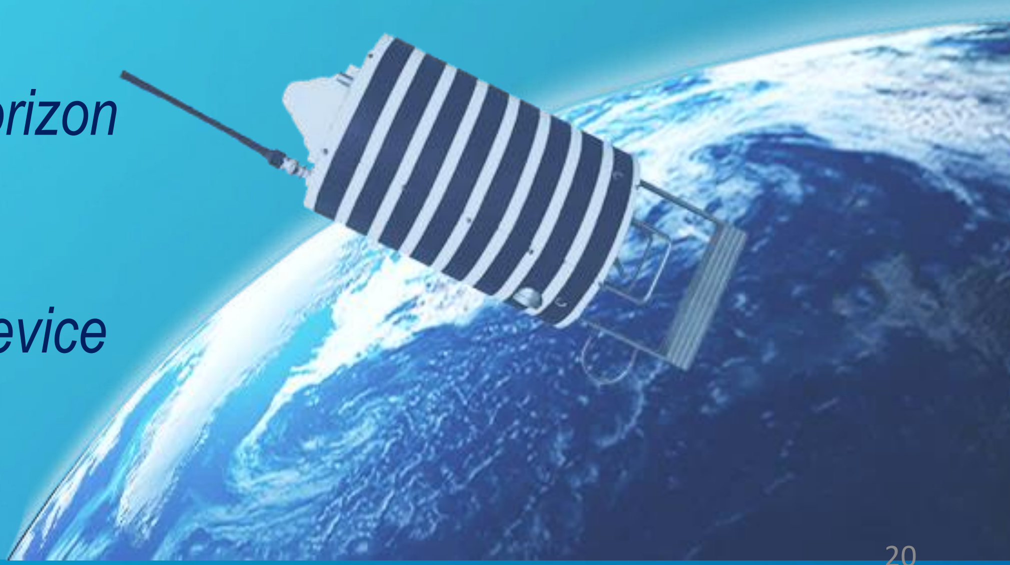
TECHNOLOGICAL NANOSATELLITE TNS-0 #1: GOALS AND TASKS

The main goal was space validation of:

- Satellite control via *Globalstar communication satellites, mobile phone and Internet*
- Satellite tracking with the help of *COSPAS-SARSAT trasmitters*
- Onboard integrated information system *IBIS-0*
- Passive magnetic *attitude control*
- Experimental sensors of *SUN and horizon*
- New type of Li battery
- Using of concept *Satellite as flying device*
- Nanosatellite *Launch from ISS*



SATELLITE DEVELOPMENT LIMITATIONS AS DRIVERS FOR TNS-0 #1 MASS AND COST MINIMIZATION

- **COST OF DESIGN AND LAUNCH MUST BE MINIMAL**
- **PROJECT DURATION: 1-2 YARS**

CONSEQUENCES

- **S/C MASS – NOT MORE THAN 10 Kg**
- **OPERATIONAL FUNCTIONALITY IS MINIMAL**
- **TIGHT SCHEDULE OF DEVELOPMENT**

- Maximum usage of COTS components;
- Wide usage of global telecommunication networks and TT&C standards for S/C control and data transfer links;
- New nontraditional structures and materials for S/C construction;
- Development of simple S/C attitude control systems based on geomagnetic field orientation;
- Multifunction integration and onboard data processing of commands and telemetry information.

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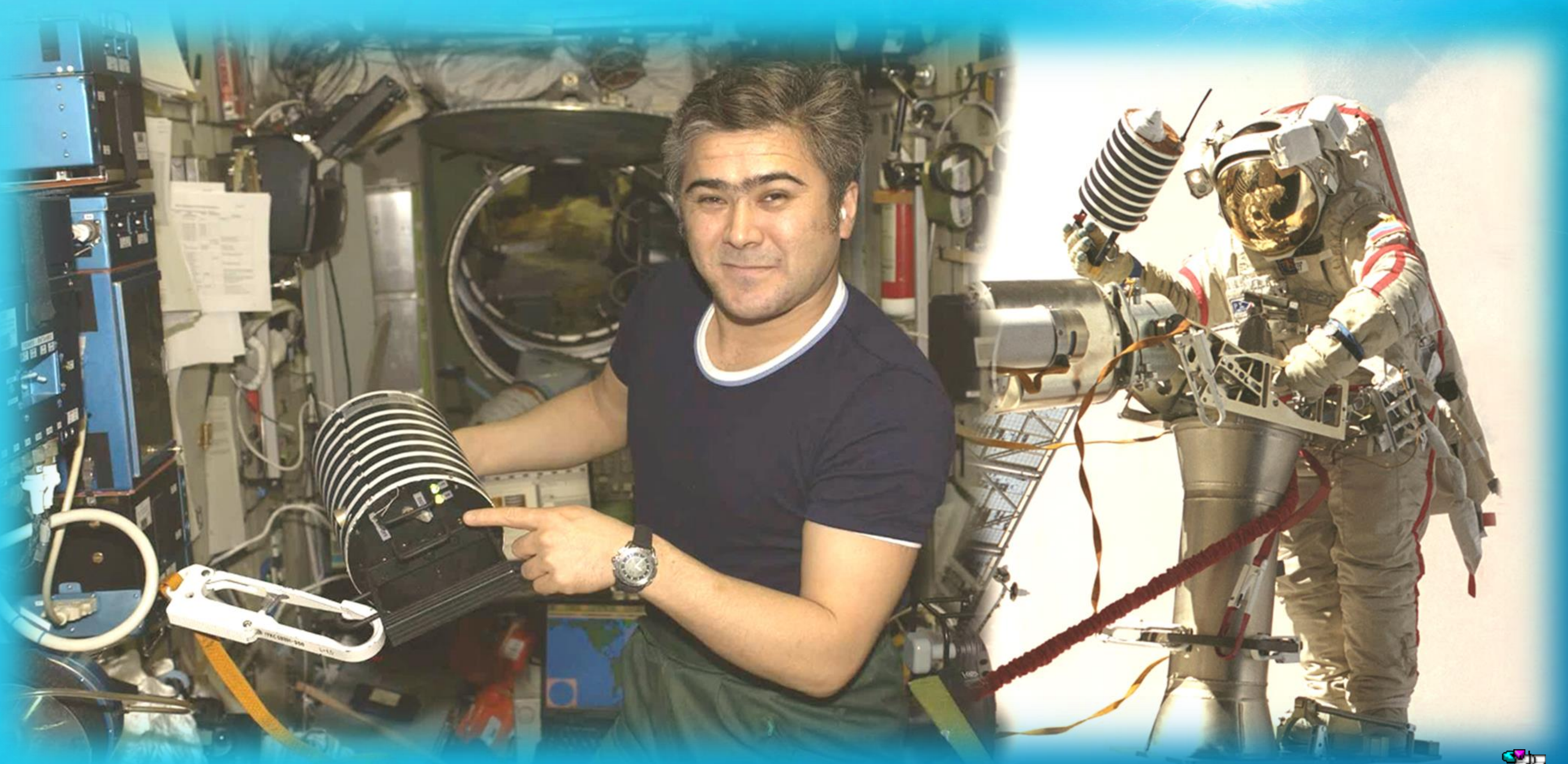
LAUNCH OF TNS-0 #1 FROM ISS ON MARCH 28, 2005



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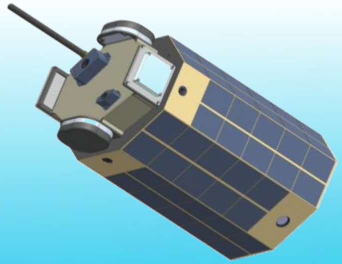
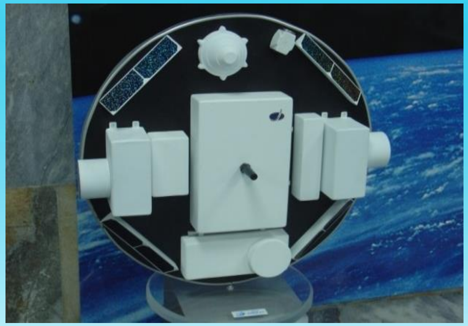
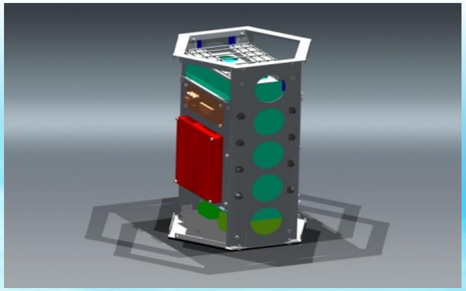
The TNS-0 #1 was manually launched by the Russian astronaut S. Sharipov at 11:30:15 UWT on March 28, 2005 from ISS during outdoor activity in open space

FIRST GENERATION NANOSATELLITES





TNS - 1
Perspective Middle Resolution RS Technology



TNS - 0 #2

S/C control via global telecommunication networks

TNS - 0 #3

Space qualification of AIS payload

TNS - 0 #4

Atmospheric parameters study above anomaly light storm areas.
Research of structure of ionospheric currents systems

Satellite for educational purposes GRESat
Comparable analysis of different types of small S/C control. Testing of active magnetic system for 3-axes attitude control

TNS - 2 #1

Testing of nanosat’s micro engines

TNS - 2 #2

Radio occultation monitoring of atmospheric and ionospheric parameters

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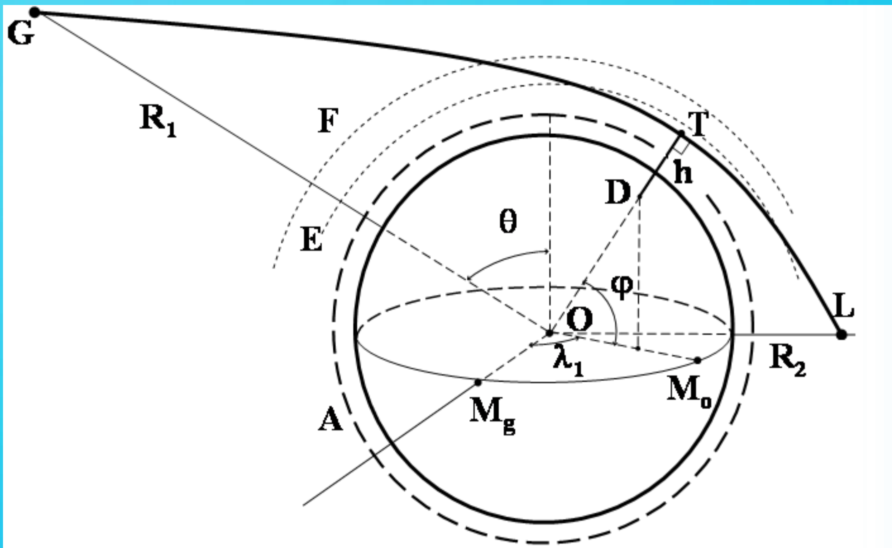
TECHNOLOGICAL NANOSATELLITE TNS-0 #2 – NEXT GENERATION OF SATELLITE CONTROL TECHNOLOGY DEMONSTRATORS

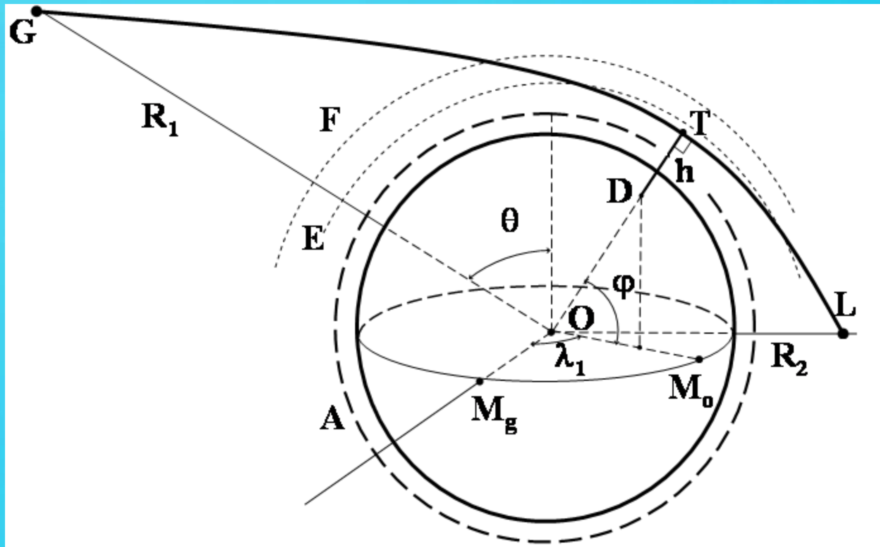
Attitude control system	passive, magnetic
Power supply	solar batteries, 9 W
Power consumption	3-5 W (average), up to 18 W (peak)
Basic command and telemetry data link	via «Globalstar» modem «Qualcomm 1620», 1,6/2,5 GHz, 7400 bps
Reserve command & telemetry data link	via UHF-modem «ROGER KD 9600», 435 MHz, 2400 bps
Lifetime in orbit	2 – 3 years
Temperature control system	passive
Total mass	5,1 kg
Mass of additional payload	up to 2 kg

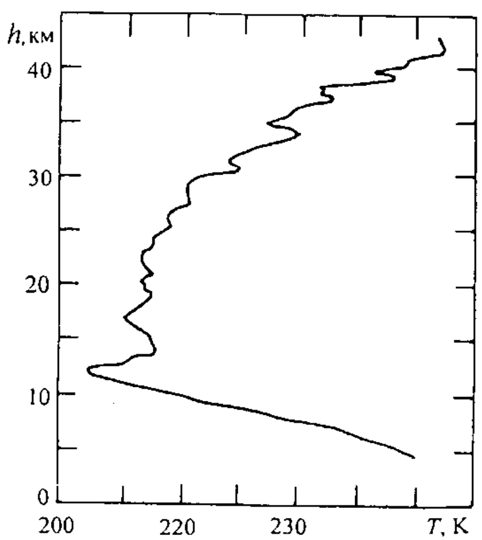
PRINCIPLE OF RADIO OCCULTATION MONITORING OF THE ATMOSPHERE AND IONOSPHERE

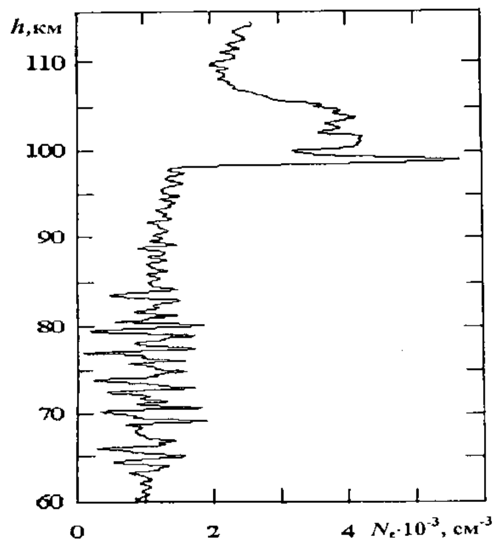


The emitting device *(G)* is located onboard GPS or GLONASS satellite. A receiver is installed onboard a low-orbit satellite *L* of radio occultation space constellation. The altitude *h* of the investigated area is determined by geographical location of point *T* – perigee of radio ray *GTL*, where the distance *TD* from the Earth's surface is minimal.

The coordinates of the investigated area are determined by latitude φ and longitude λ of point *D* on the Earth's surface. Longitude λ is measured from Greenwich meridian *Mg*. Designations *F, E, A* correspond to ionosphere layers *F, E* and atmosphere *A*. *R1* and *R2* – are the orbital radii of GPS satellite G and low-orbit satellite *L* of radio-occultation monitoring space system.







In addition to traditional meteosatellites, space systems of radio occultation monitoring can implement the following objectives everyday and globally:

- monitoring of high-resolution vertical gradients of temperature and geopotential for improving weather forecast and investigation of climate changes;

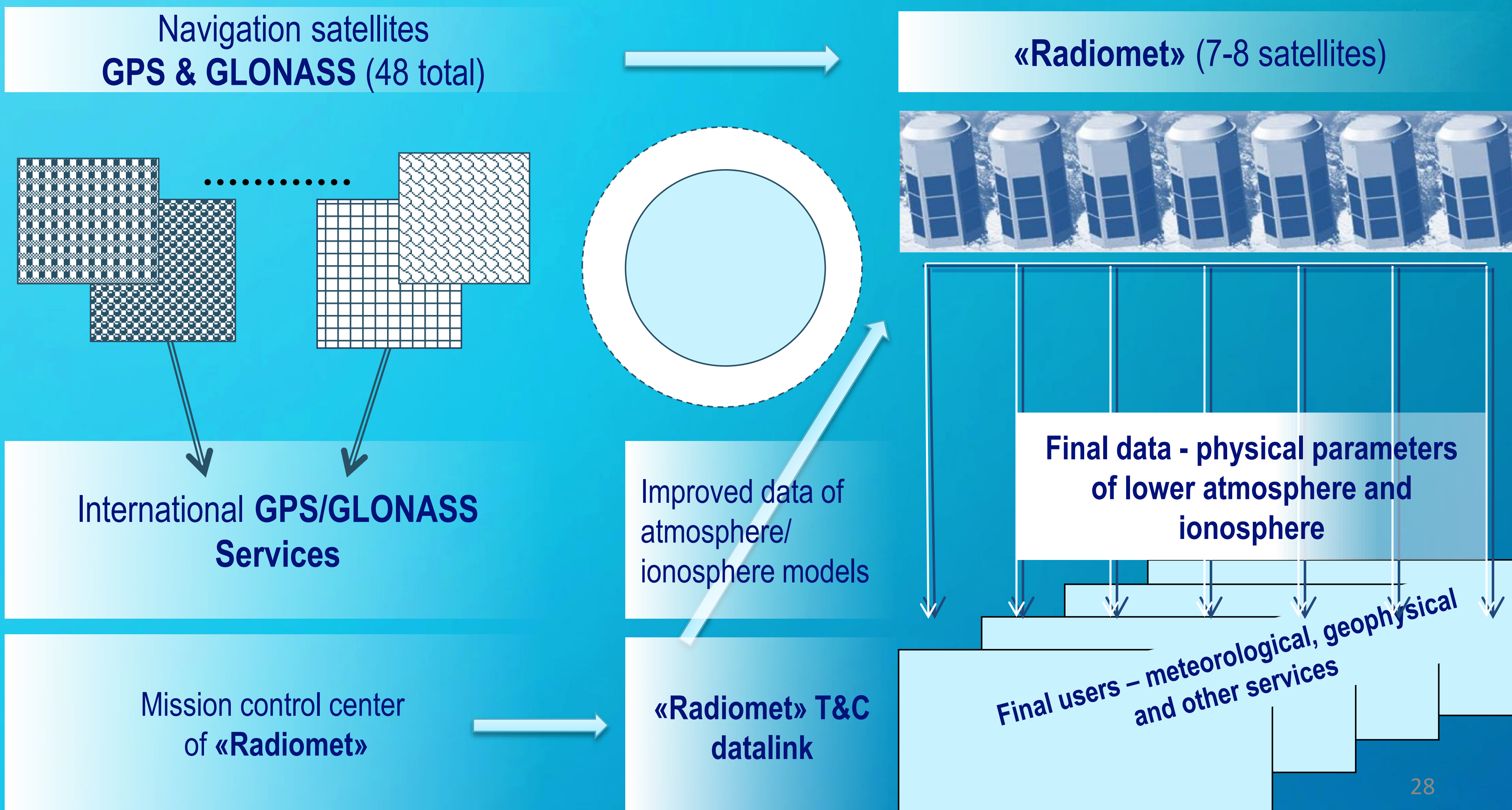
- monitoring of vertical gradients of humidity in atmosphere for investigation of water circulation global processes and climatology;

- investigation of internal stratosphere waves and their role in energy exchange;

- monitoring of electron density for investigation the influence on ionosphere status from Solar activity, technogenic impact and other factors, etc.

RADIO OCCULTATION SPACE SYSTEM «RADIOMET»

Space system «Radiomet» for GLONASS/GPS navigation signal radio occultation monitoring of lower atmosphere and ionosphere based on super-small satellites

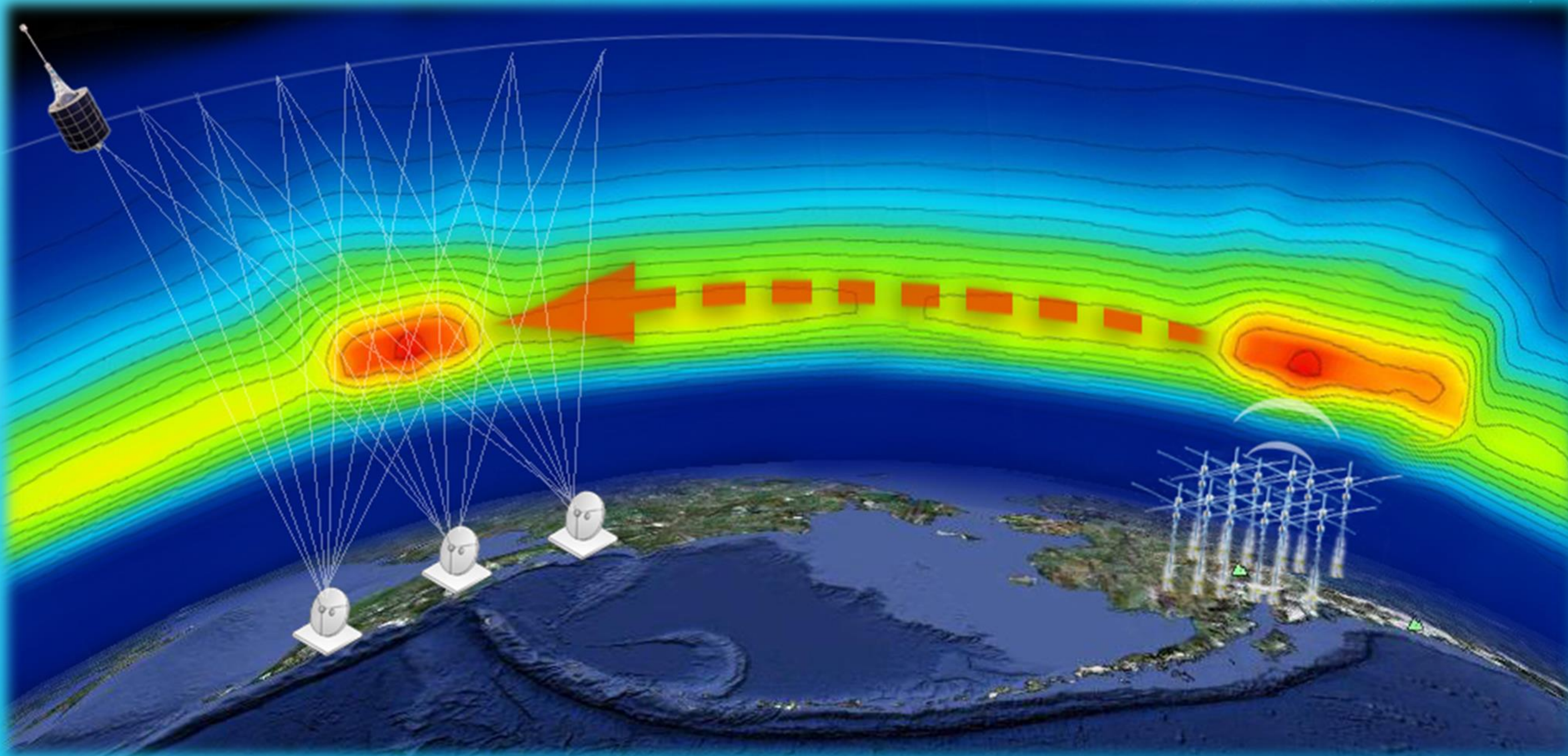


RADIO OCCULTATION SPACE SYSTEM «RADIOMET»

BASIC FEATURES

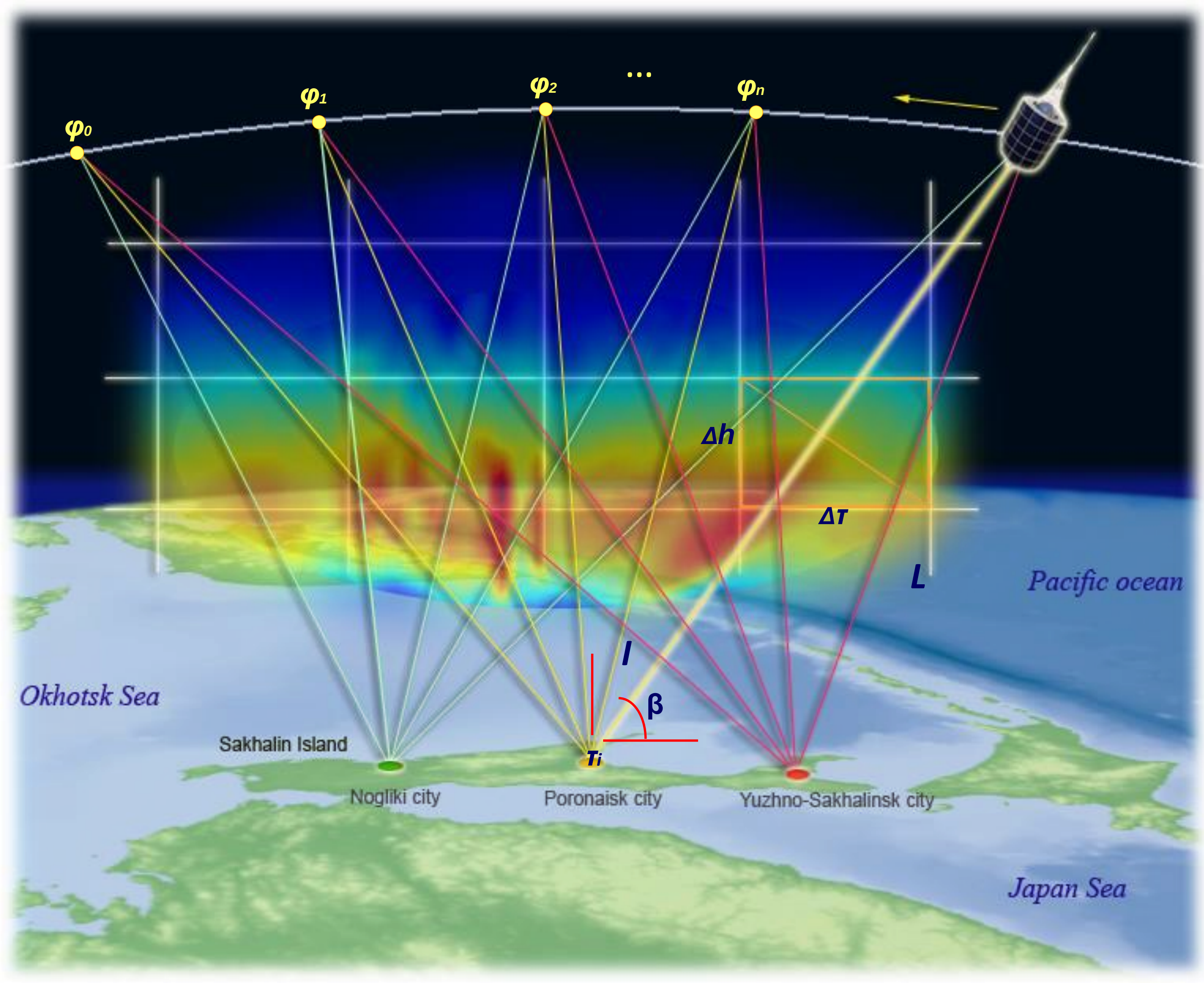
- Multy-system receivers. Low-orbit «Radiomet» satellites to be equipped with multi-system receivers in order to register signals from both GPS and GLONASS (also from Galileo – in future). That should increase up to 2…3 times the number of everyday observations of atmosphere and ionosphere.
- Optimization of orbits. Periodicity of observations to be increased for any area of the Earth (including near-equatorial and polar zones) due to optimization of the constellation orbit parameters (polar-orbit satellites to be added).
- Real-time on-board data processing. Delay of data delivery to final users to be crucially minimized (up to real-time). GPS/GLONASS signals will be thematically processed on board of «Radiomet» satellites. New radio holographic methods of navigation signal processing (developed by IRE RAS) will be applied. Final data of vertical gradients of the electron density, humidity, pressure, temperature etc. can be transmitted from satellites to users' local stations.
- Miniaturization of satellites. «Radiomet» system incorporates super-small (less than 20 kg by mass) satellites based of nano- and microtechnologies. That would ensure significant cost savings of the satellite development and launch.

MONITORING OF ARTIFICIAL IMPACTS ON EARTH IONOSPHERE



Artificial impact of shortwave RF radiation on the Earth ionosphere is a source of local heating of the ionosphere at different heights, which tends to the local areas of increase total electron concentration affecting onto proper operation of navigation and telecommunication satellite systems

IONOSPHERE ELECTRON CONCENTRATION HEIGHT DISTRIBUTION TOMOGRAPHY RECONSTRUCTION METHOD



Basic equations

Problem statement

$$\varphi = I = \lambda r_e \int N(h,\tau)dh$$

$$I(\beta,\tau_i) = \int_0^{h_0} \frac{F(h,\tau)(R+h)}{\sqrt{R^2 \sin^2\beta + 2Rh + h^2}}$$

Inverse problem solution

Linear system formation

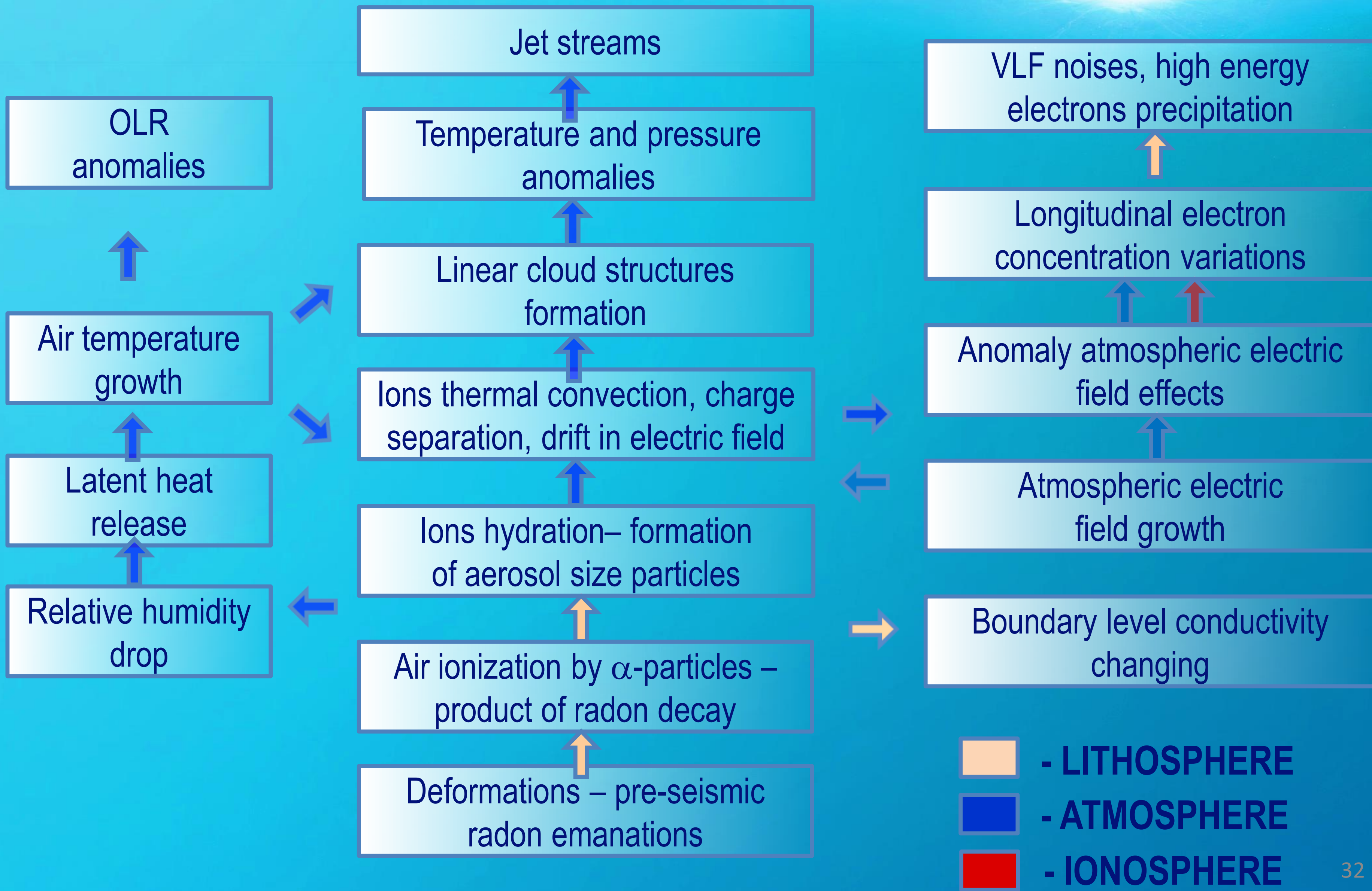
$$A_{JM} F_M = D_J,$$

$$D_J = \frac{\Delta I_J}{\Delta\beta} \qquad A_{JM} = \frac{\Delta L_M}{\Delta\beta}$$

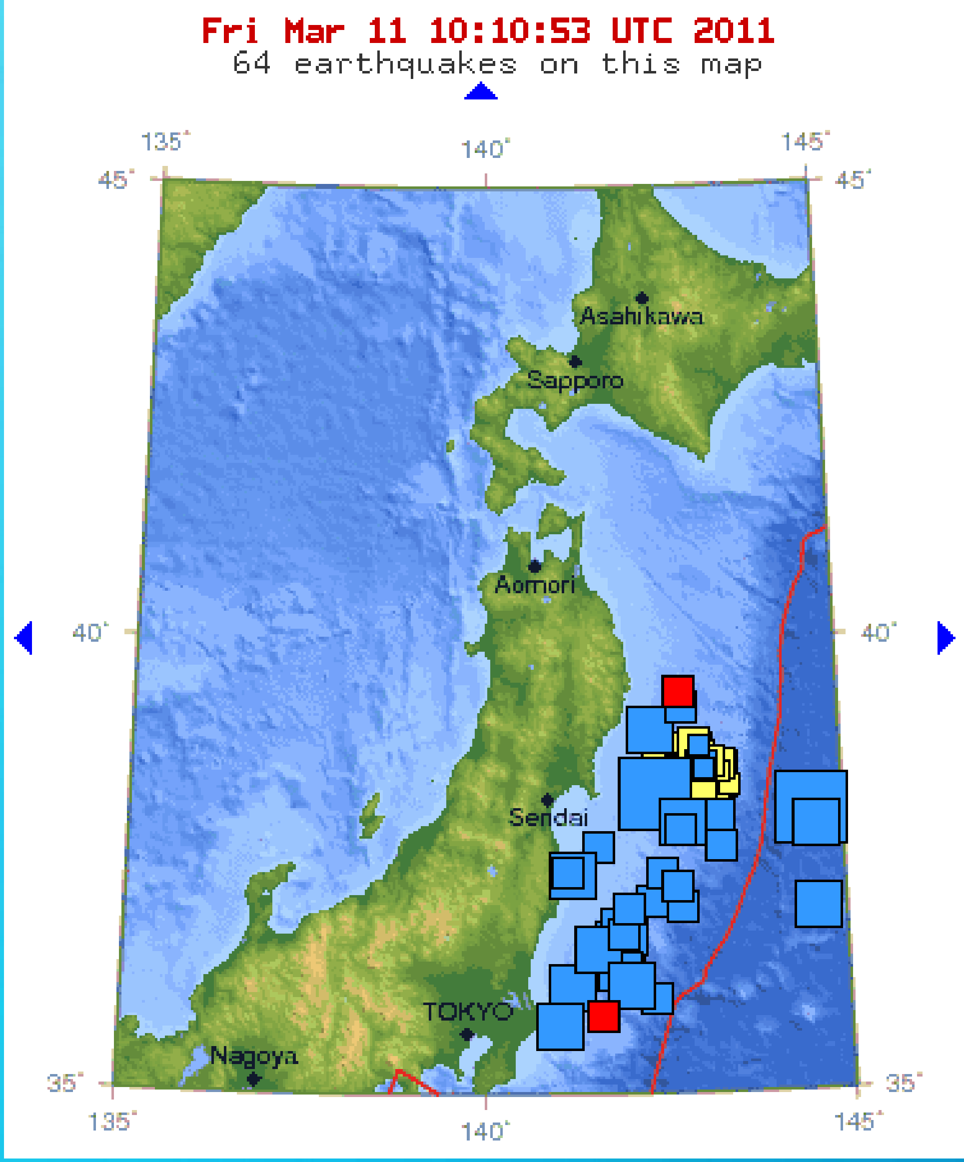
ART algorithm for system solving

$$f^{k+1} = f^k + \frac{d_i - < a^i, f^k >}{< a^i, a^i >} a^i$$

LITHOSPHERE-ATMOSPHERE-IONOSPHERE COUPLING MODEL (PULINETZ AND OUZUNOV (2010))



MAP OF JAPAN MARCH-2011 EARTHQUAKES EPICENTERS



The first strong earthquake happened on 09.03.2011 at 2:45 am

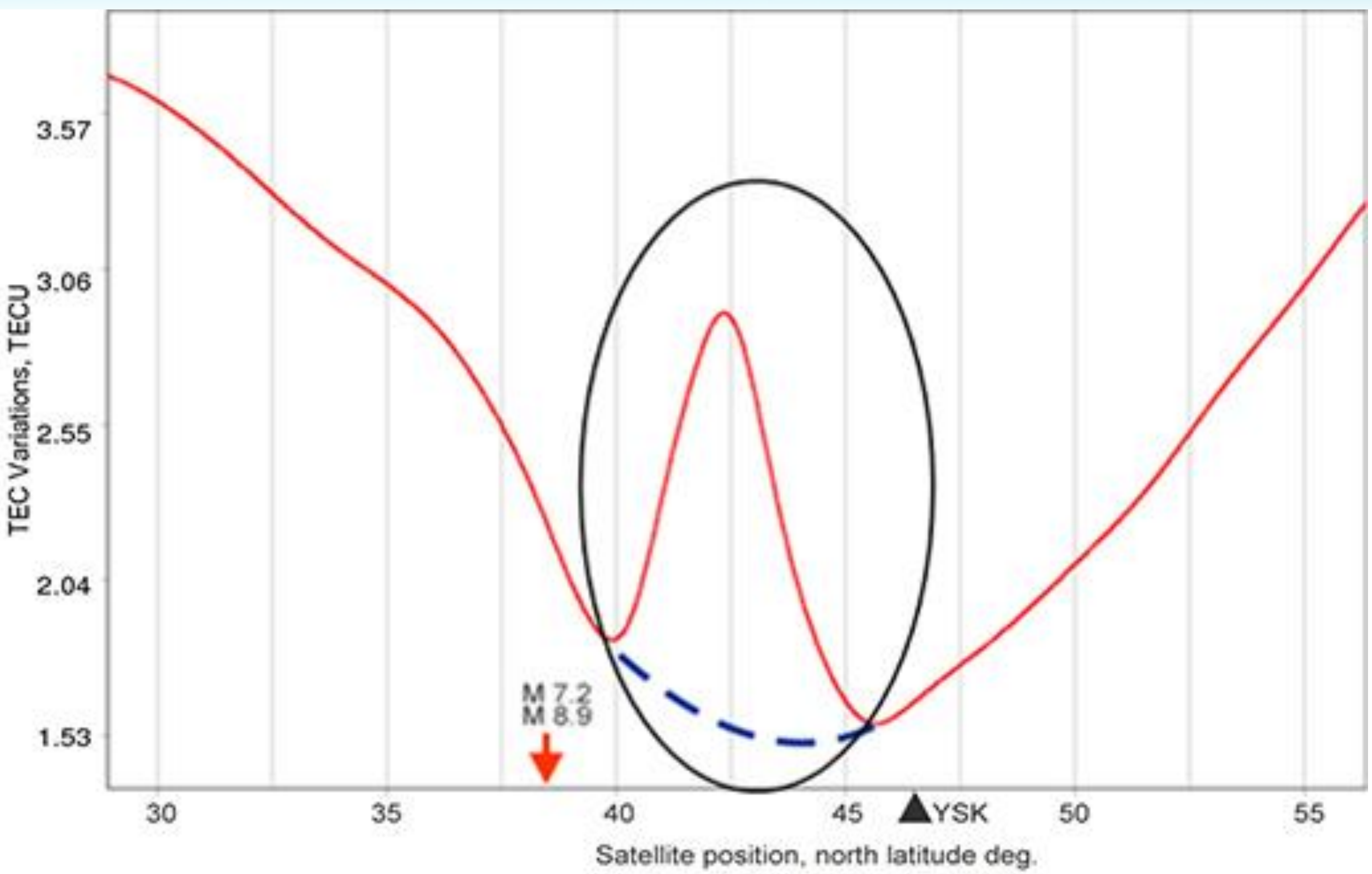
M 7.2, N 38.424, E 142.836

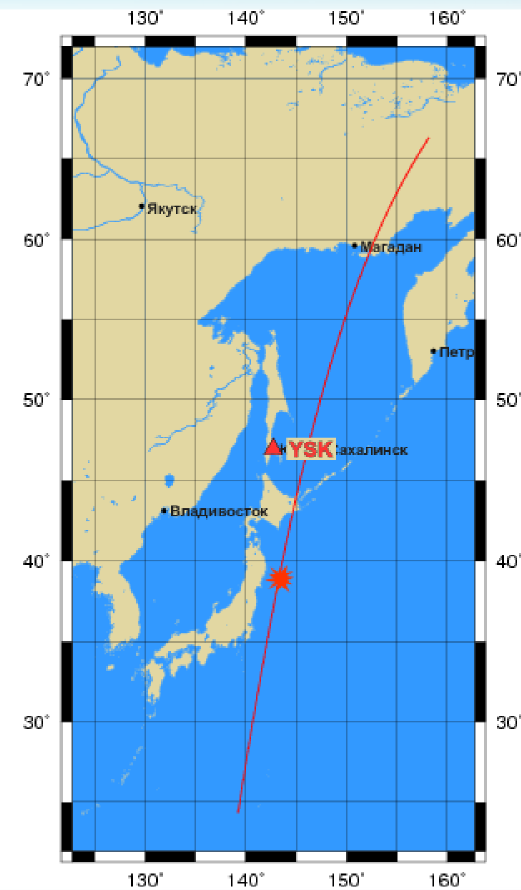
Strongest earthquake happened on 11.03.2011 at 5:46 am

M 8.9, N 38.322, E 142.369

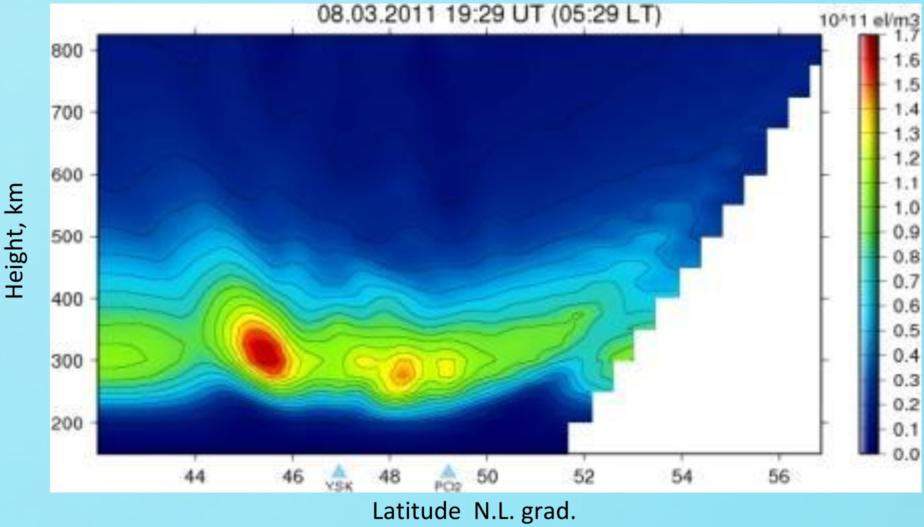
RELATIVE STEC DISTRIBUTION ANOMALY REGISTERED 7 HOURS PRIOR SET OF MARCH 2011 JAPANESE ARTHQUAKES

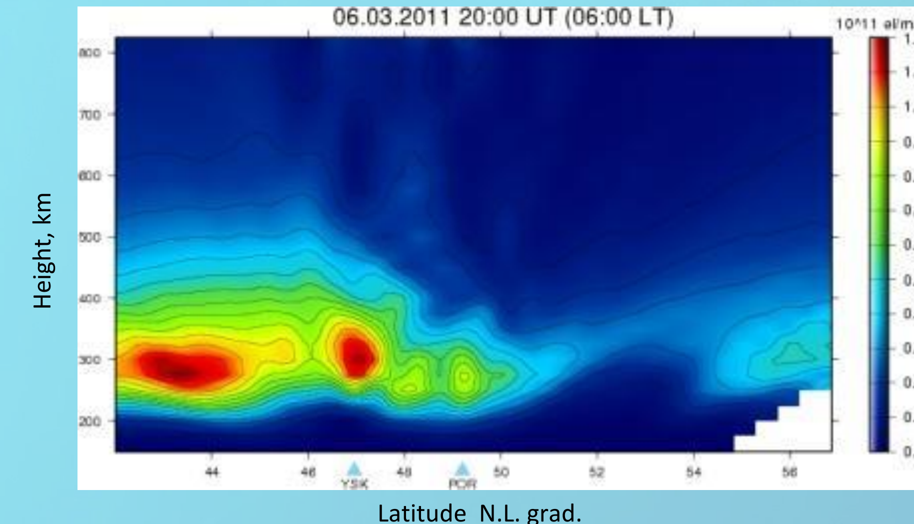
Relative STEC data from Yuzhno-Sakhalinsk ionoshere receiver

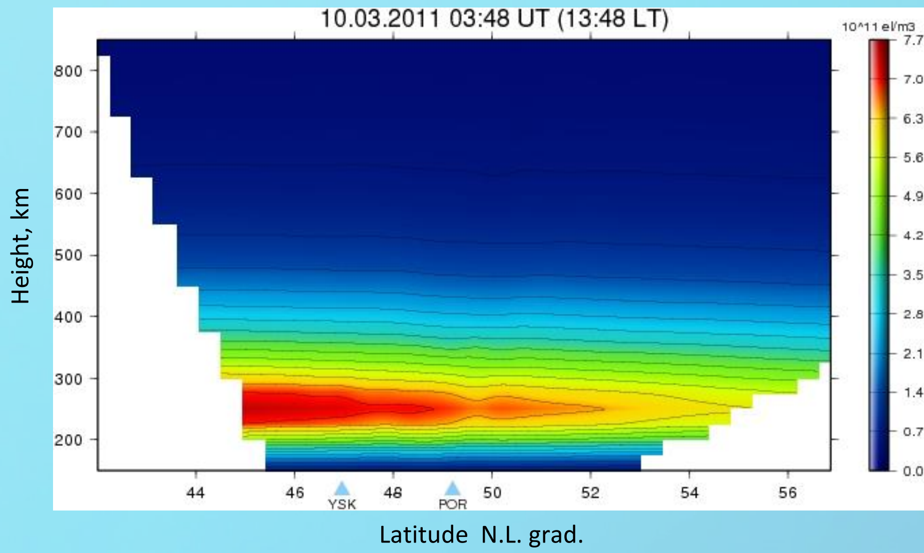


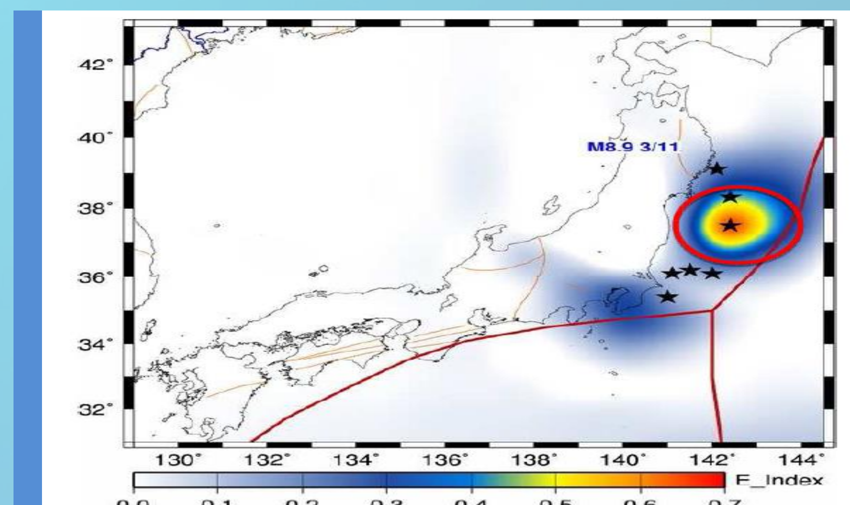


IONOSPHERE ELECTRON CONCENTRATION FIELDS VARIATIONS on 6th, 8th and 10th of MARCH, 2011









THE PLANNED SCHEME OF TOMOGRAPHY CHAINS DEPLOYMENT IN RUSSIA

It was planned to deploy about 50 tomography stations in Russia till 2015

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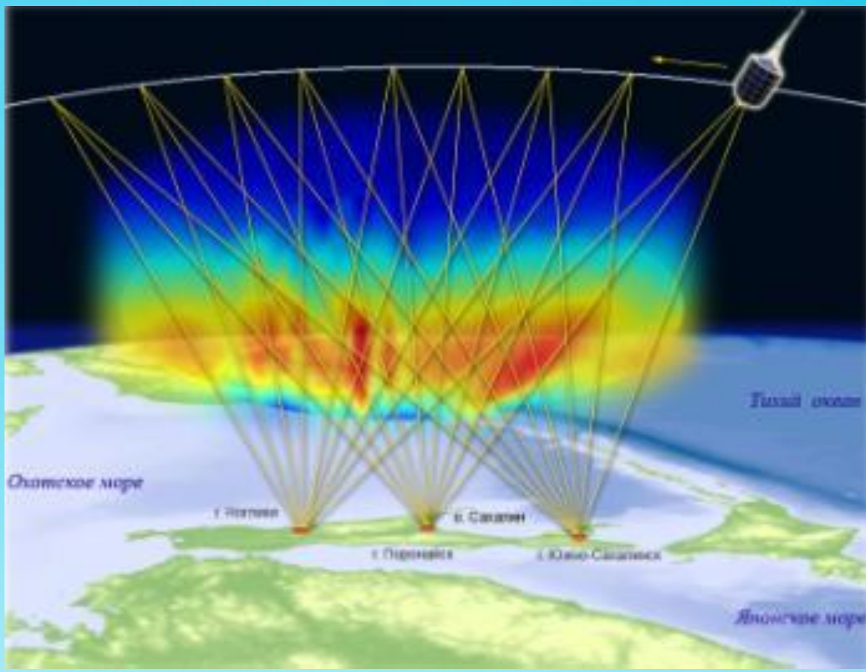
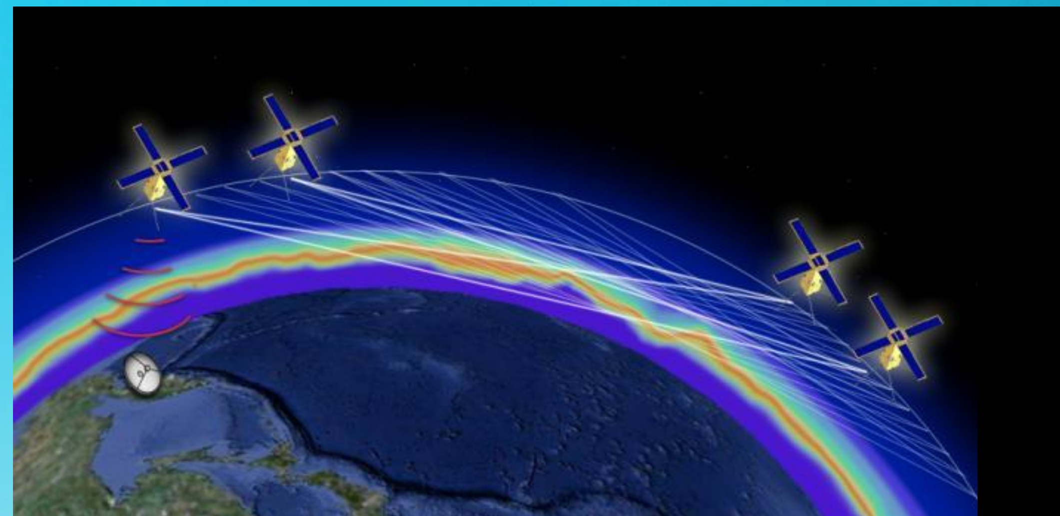
GLOBAL IONOSPHERE MONITORING VIA CLUSTER OF NANOSATELLITES

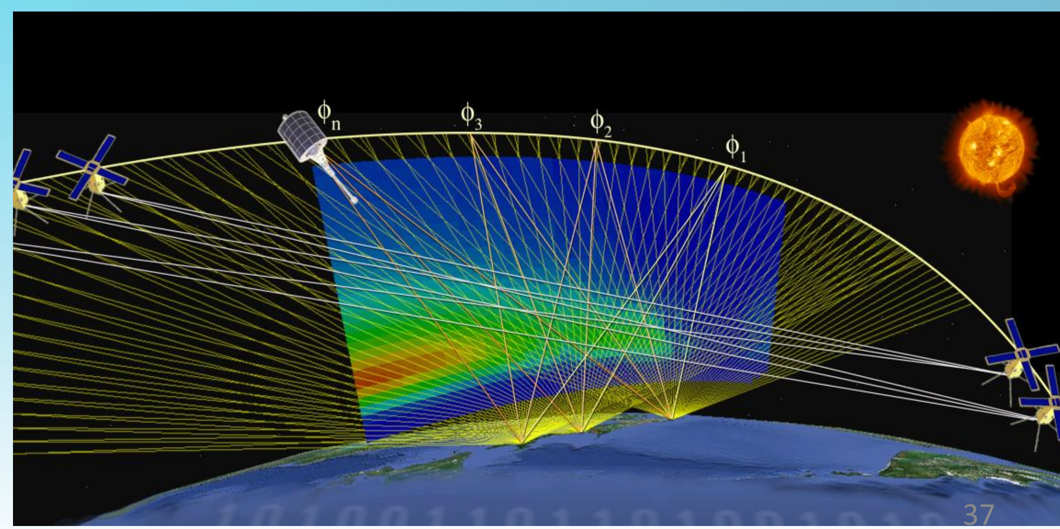
Perspective ionosphere monitoring system on the basis of nanosatellites cluster





Traditional ionosphere tomography scheme with ground stations provides only local monitoring

Signal receiving segment transfer into space makes it possible to realize the global ionosphere monitoring and to almost completely refuse from ground radiotomography receiving stations



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«CosmoAIS» PROJECT

1. «CosmoAIS» project description
2. Onboard and ground equipment
3. First results of AIS receiver testing onboard «Resource-P» #2 satellite
4. Satellite AIS data validation
5. Some future plans
6. Conclusions

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THE WORLD OCEAN AS AN ILLEGAL ACTIVITY AREA

Piracy

Transnational crime

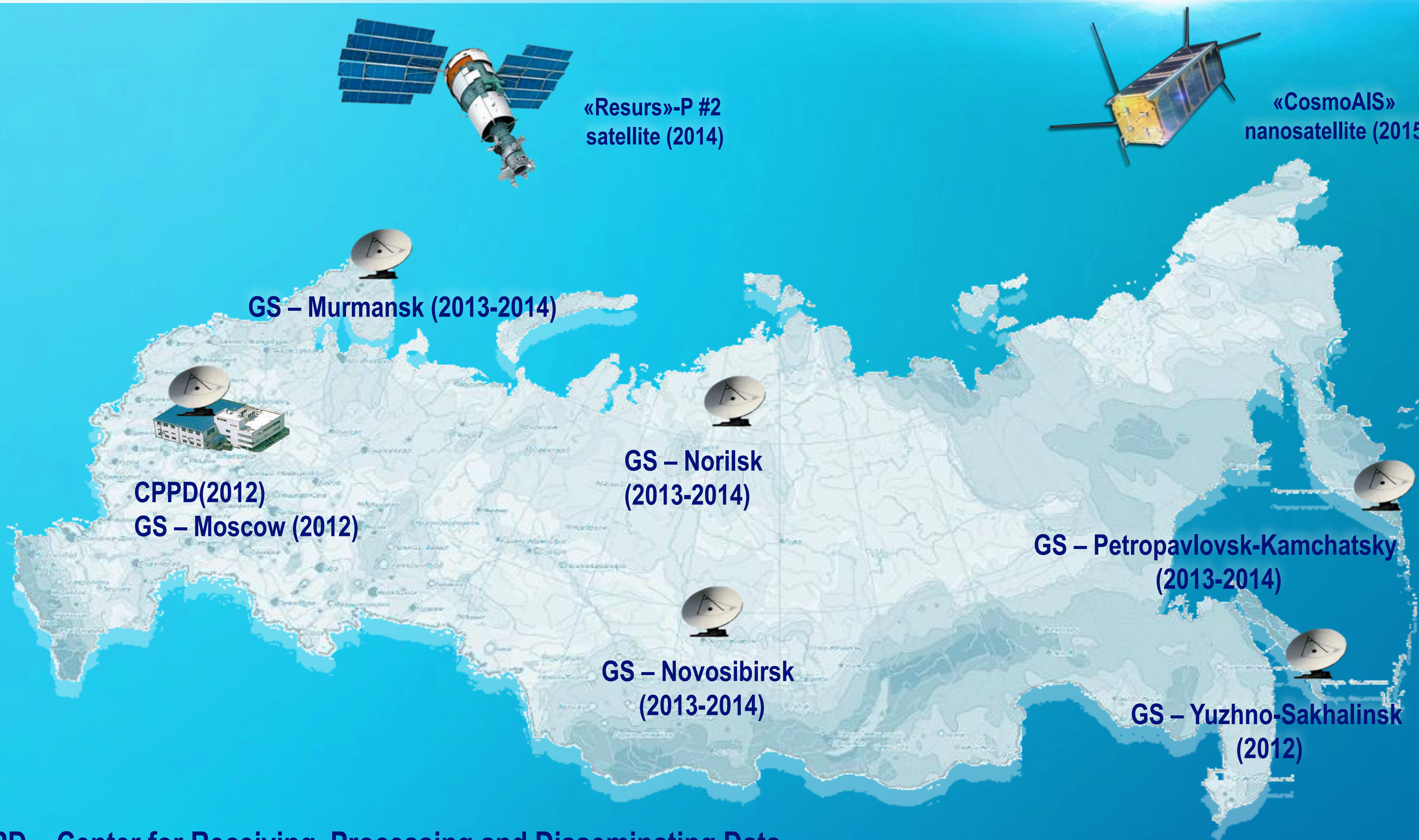
Terrorism

Illegal weapon transportation

Drug trafficking

Undocumented immigration

BASIC ELEMENTS OF SHIP MONITORING SYSTEM BASED ON SPACE AIS DATA

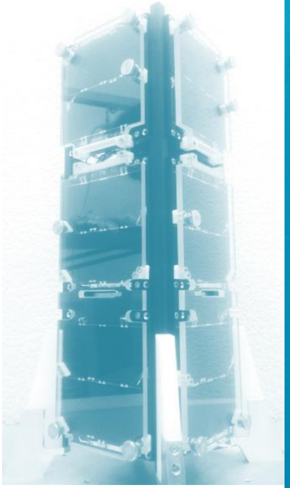


CRPD – Center for Receiving, Processing and Disseminating Data
GS – Ground Station for Receiving and Processing Data

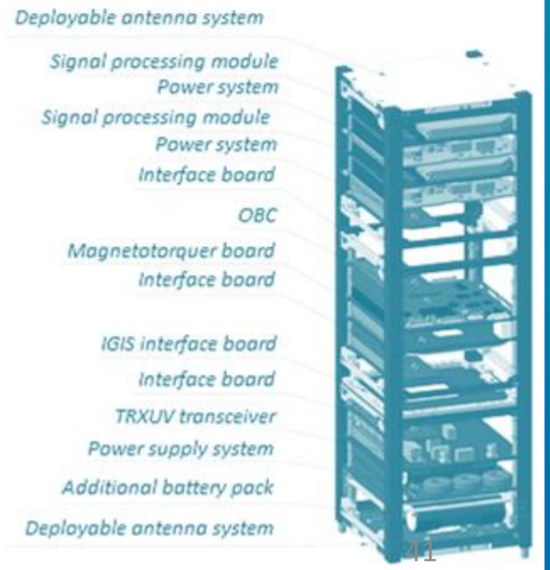
«CosmoAIS» NANOSATELLITE

Mass	**2.5 kg**
Dimensions	
- With undeployed antennas	**103 x 103 x 349 mm**
- With deployed antennas	**1114 x 1114 x 349 mm**
Lifespan	**1 year**
Orbit	**600-1000 km**
Attitude determination and control system	
Attitude along the Earth's magnetic axis	
Stabilization accuracy	**10°**
Power supply (max.)	**6,9 W**
Payload	
AIS onboard receiver gets AIS signals in frequency range from 156,775 to 162,025 MHz, with transmetted power from 1 to 12,5 W, with GMSK modulation at a transmition speed of 9600 bps	
Data transmission rate	
- Ground-space command transmition in UHF range, modulation	**1200 bps, BPSK**
- Space-ground data transmition in VHF range, modulation	**9600 bps, AFSK**
Working frequency	
- Ground-space command transmition in UHF range	**436,700 MHz**
- Space-ground data transmition in VHF range	**145,930 MHz**

Image of the "CosmoAIS" nanosatellite



Structure of the «CosmoAIS» nanosatellite



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DEMONSTRATION MODEL OF CRPD AIS

DESCRIPTION

The Center for Receiving, Processing and Disseminating data (CRPD AIS) is a complex of both telecommunications and server equipment.

CRPD is the central node of the ground infrastructure, its main functional core, which solves the issues of consolidation and integrated analytical processing of AIS data, received from regional GS, as well as presentation of the post-processing results to authorized end-users.

CHARACTERISTICS

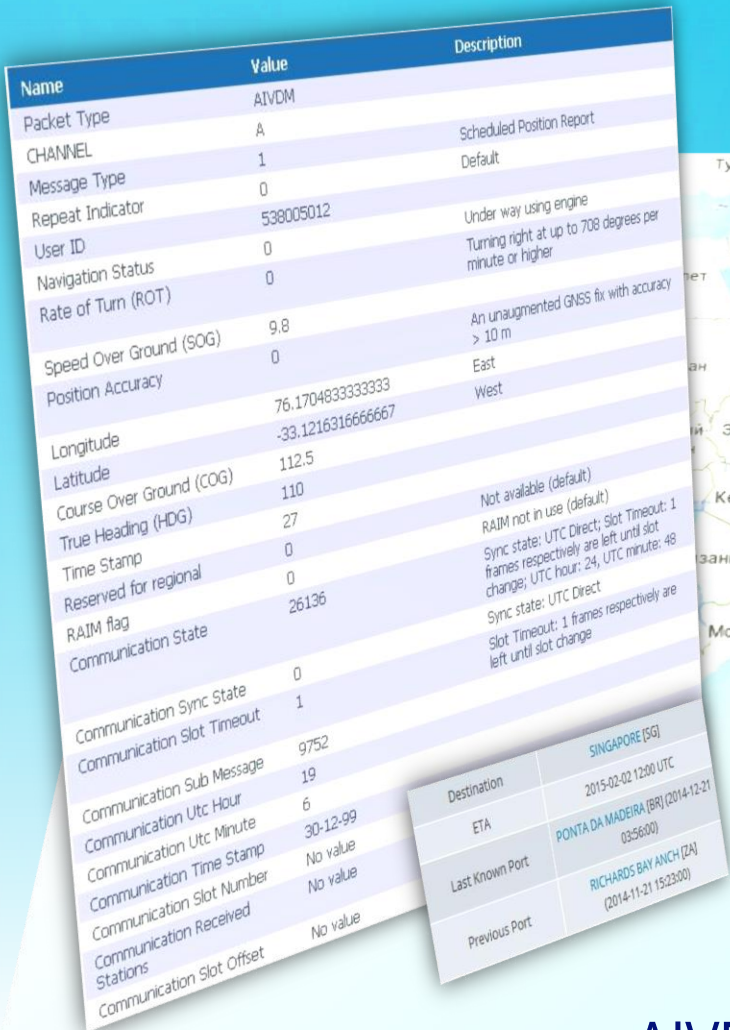
1. CRPD AIS availability factor – no less than 0.9999.
2. Lifespan – no less than 50 000 h.
3. Provides connection of more than 30 thousand users simultaneuosly (possible to scale up to 100 000).
4. Power voltage – 220 V.
5. Power consumption – no more than 10 kW.

LOCATION OF REGIONAL DATA RECEPTION CENTERS AND AIS SPACE SEGMENT'S RADIO COVERAGE ZONES

GS AIS locations # 1-6 and coverage zones for LEO satellites (angle > 10°)

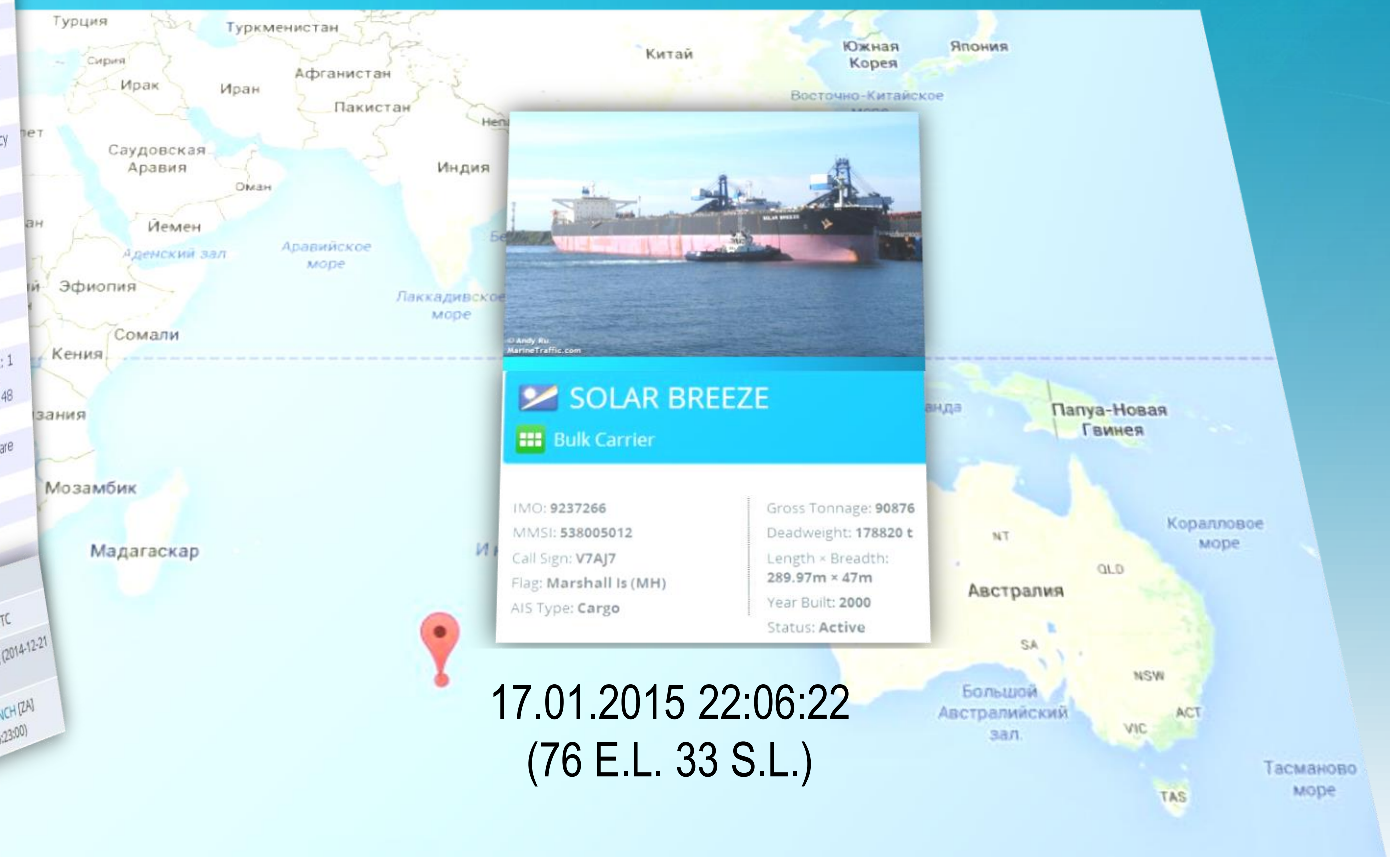
RUSSIAN SPACE SYSTEMS

FIRST DECODED AIS MESSAGE FROM AIS RECEIVER, BASED ON BOARD OF «RESURS-P» #2 SATELLITE



Name	Value	Description
Packet Type	AIVDM	
CHANNEL	A	
Message Type	1	Scheduled Position Report
Repeat Indicator	0	Default
User ID	538005012	
Navigation Status	0	Under way using engine
Rate of Turn (ROT)	0	Turning right at up to 708 degrees per minute or higher
Speed Over Ground (SOG)	9.8	
Position Accuracy	0	An unaugmented GNSS fix with accuracy > 10 m
Longitude	76.1704833333333	East
Latitude	-33.1216316666667	West
Course Over Ground (COG)	112.5	
True Heading (HDG)	110	
Time Stamp	27	
Reserved for regional	0	Not available (default)
RAIM flag	0	RAIM not in use (default)
Communication State	26136	Sync state: UTC Direct; Slot Timeout: 1 frames respectively are left until slot change; UTC hour: 24, UTC minute: 48
Communication Sync State	0	Sync state: UTC Direct
Communication Slot Timeout	1	Slot Timeout: 1 frames respectively are left until slot change
Communication Sub Message	9752	
Communication Utc Hour	19	
Communication Utc Minute	6	
Communication Time Stamp	30-12-99	
Communication Slot Number	No value	
Communication Received Stations	No value	
Communication Slot Offset	No value	

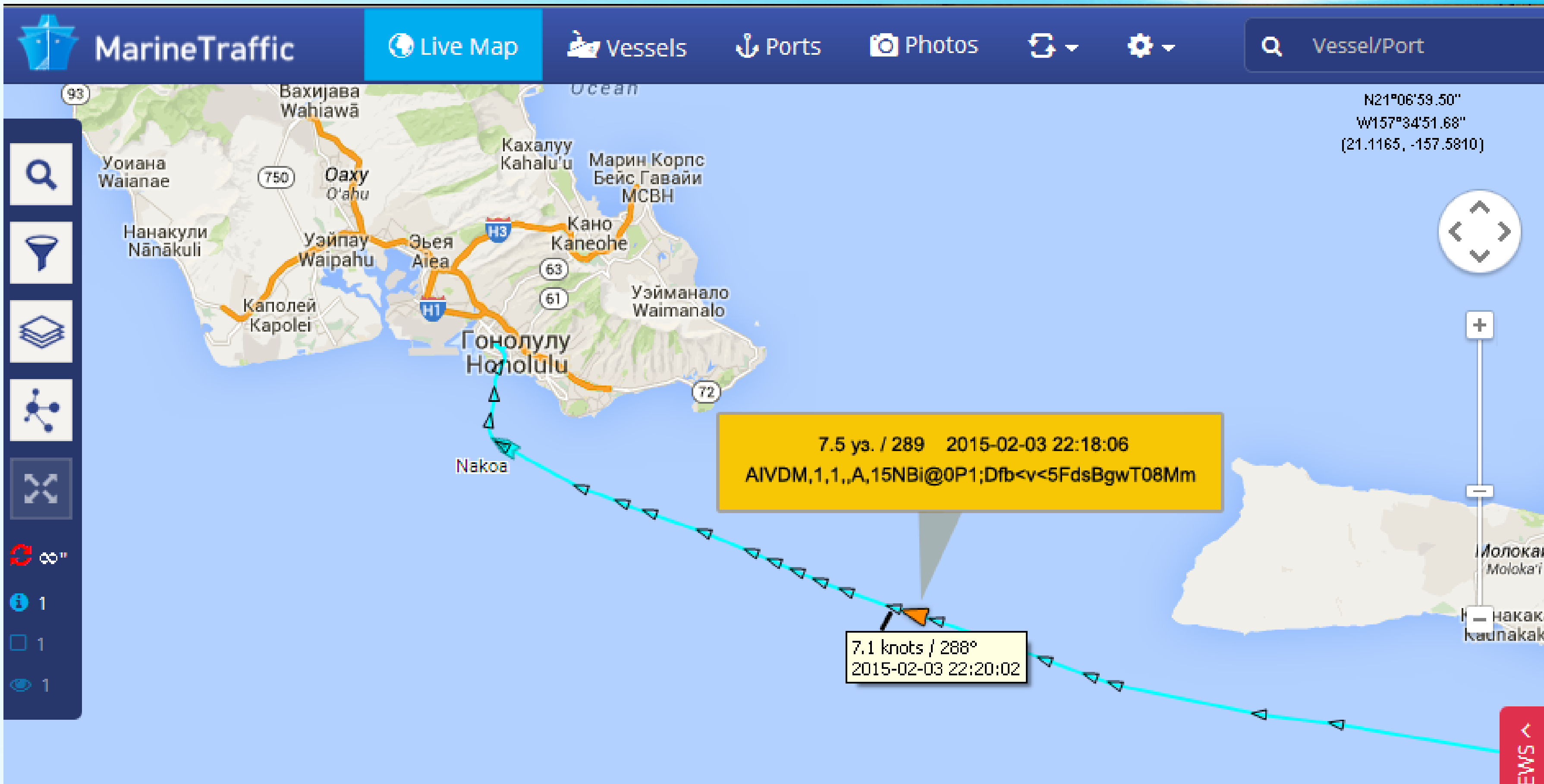
Destination	SINGAPORE [SG]
ETA	2015-02-02 12:00 UTC
Last Known Port	PONTA DA MADEIRA [BR] (2014-12-21 03:56:00)
Previous Port	RICHARDS BAY ANCH [ZA] (2014-11-21 15:23:00)



17.01.2015 22:06:22
(76 E.L. 33 S.L.)

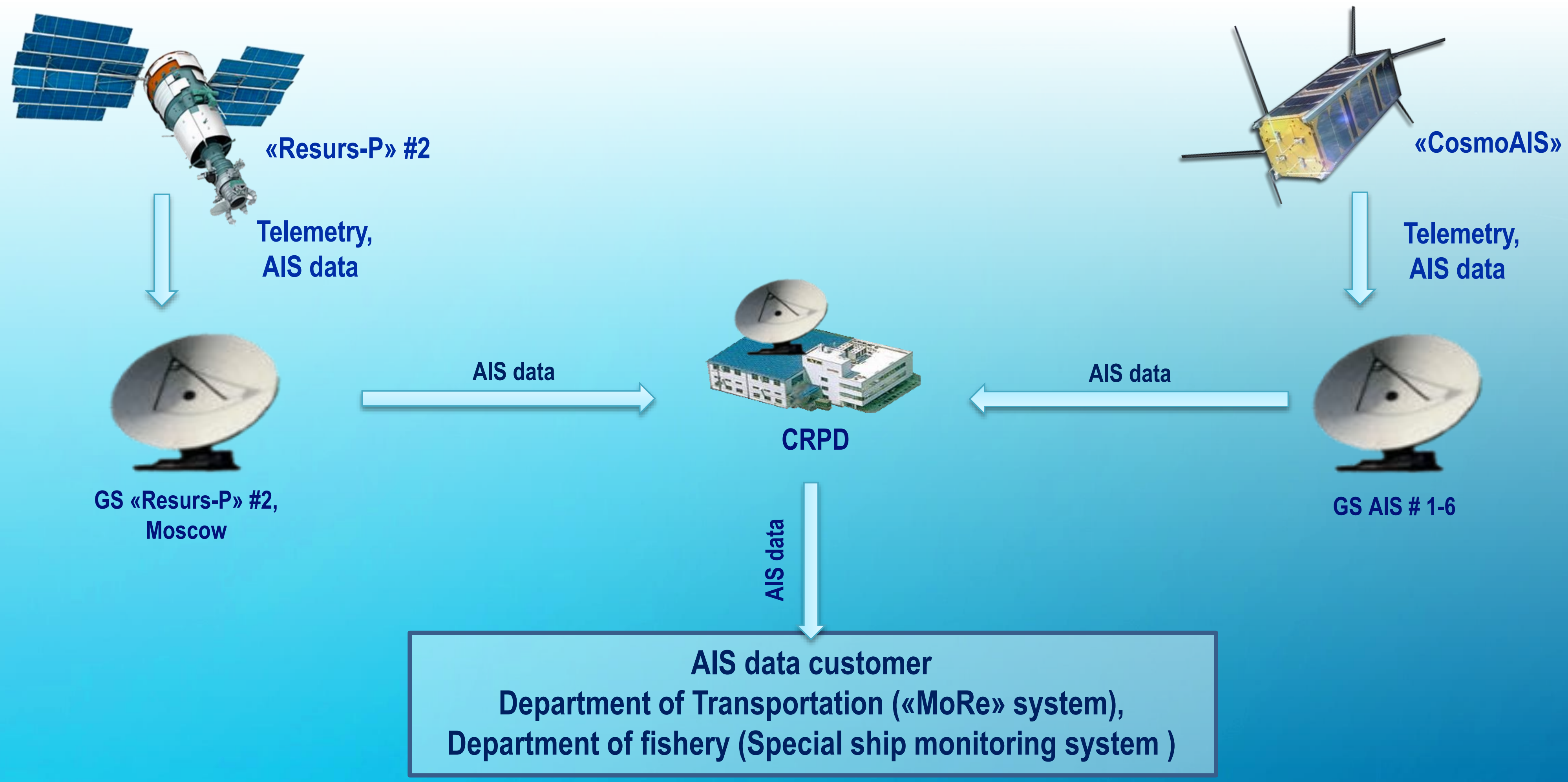
!AIVDM,1,1,,A,1815>5001R5LcTUe33;4ICLn06HH,0*

VESSEL DATA COMPARISON RECEIVED BY AIS RECEIVER AND *marinetraffic.com* SERVICE ON 03.02.2015



	Time, UTC	Latitude	Longitude	Direction	Speed
Marinetraffic	22:06	21.1088	-157.5537	291	7.0
AIS receiver	22:18	21.1177	-157.5792	289	7.5
Marinetraffic	22:20	21.1178	-157.5821	288	7.1

DATA FLOW FOR THE DEMONSTRATION PROJECT OF SPACE AIS DATA USAGE FOR THE DEPARTMENT OF TRANSPORTATION



CRPD – Center for Receiving, Processing and Disseminating Data

GS – Ground Station for Receiving and Processing Data

RESULTS OF AIS RECEIVER WORKING SESSIONS DURING 01.03.2015 – 30.07.2015

RSS
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Total number of AIS receiver working sessions during flight tests from 01.03.2015 to 30.07.2015: 377

Total number of decoded messages: 33052

Number of detected ships: 4451

Messages Type	Quantity
Messages Type 1	27547
Messages Type 2	67
Messages Type 3	3514
Messages Type 5	470
Messages Type 18 (class B)	30
Total number of messages	33052
Total number of ships	4451
Number of working sessions	377

PERSPECTIVE SATELLITE LAUNCH FOR AIS RECEIVER IN 2016-2025

2018	2019	2020	2021	2022	2023	2024
«Resurs-P» №4	«Resurs-P» №5					
	«Resurs-PM» №1	«Resurs-PM» №2	«Kanopus-VM» №1	«Kanopus-VM» №2		
«Obzor-O» №1	«Obzor-O» №2	«Obzor-P» №2		«Obzor-LP» №1		«Obzor-LP» №2
2	3	2	1	2		1

In the preliminary variant of the federal space program for 2016-2025 years, AIS receivers are planning to be placed on board of 11 satellites

NEW APPROACHES TO FORMING OF FSP-2025

I. PROJECT MANAGEMENT:

Joining in the frame of a united project all necessary research and development works and additional funding, which tend to solving common tasks

II. CREATION AND FLIGHT TESTING OF NEW KEY TECHNOLOGIES, DEVICES AND SYSTEMS INSIDE PARTICULAR DESIGN:

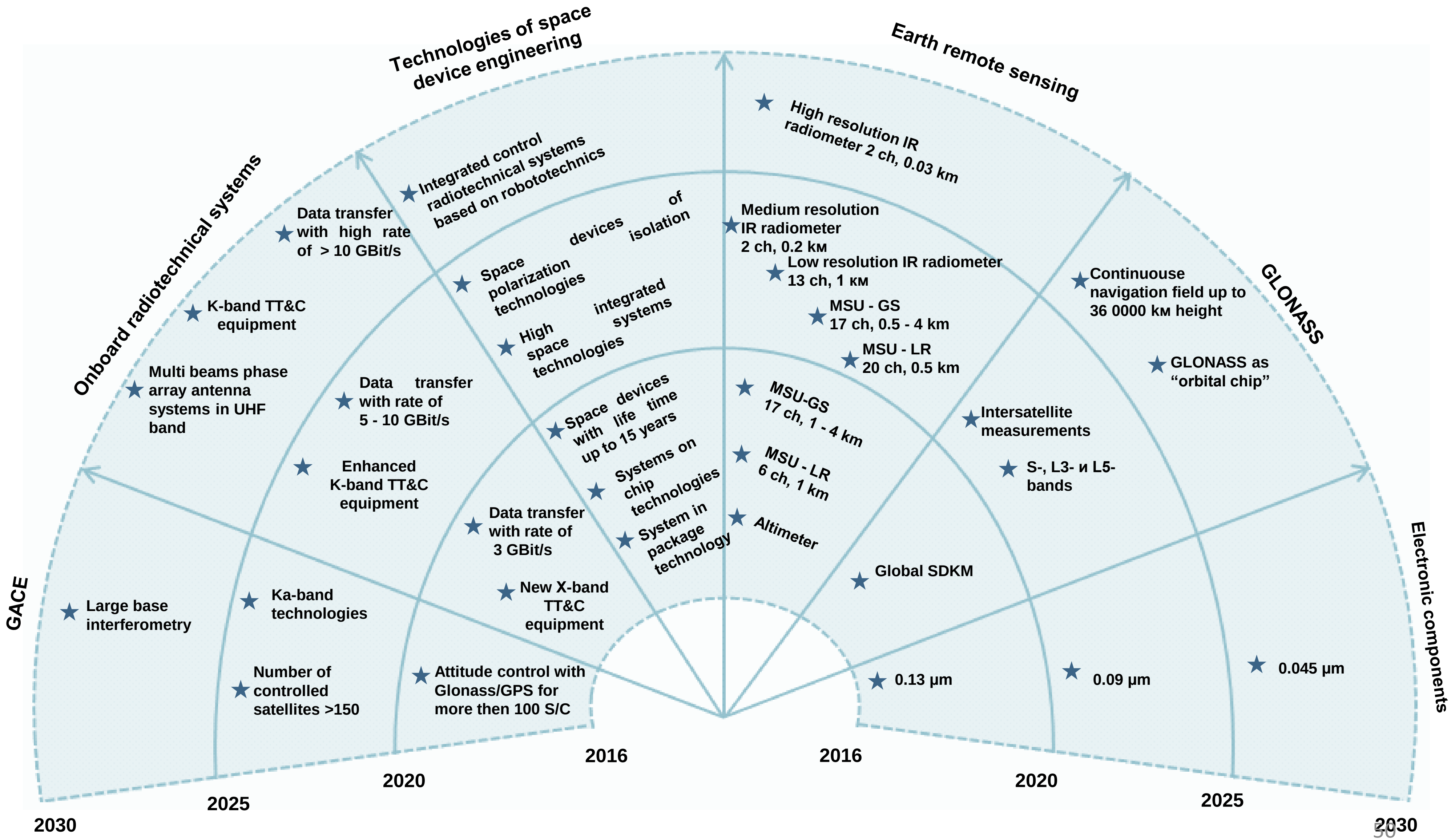
Make an initiation of new design on space complexes development only if new key technologies, devices and systems clarified their realization and effectiveness

III. NEW SERVICES:

Scientific and technological support for all phases of space equipment design life cycle, program management, deployment and execution of public orders, quality monitoring during space systems building, development analytical support of FSP-2025

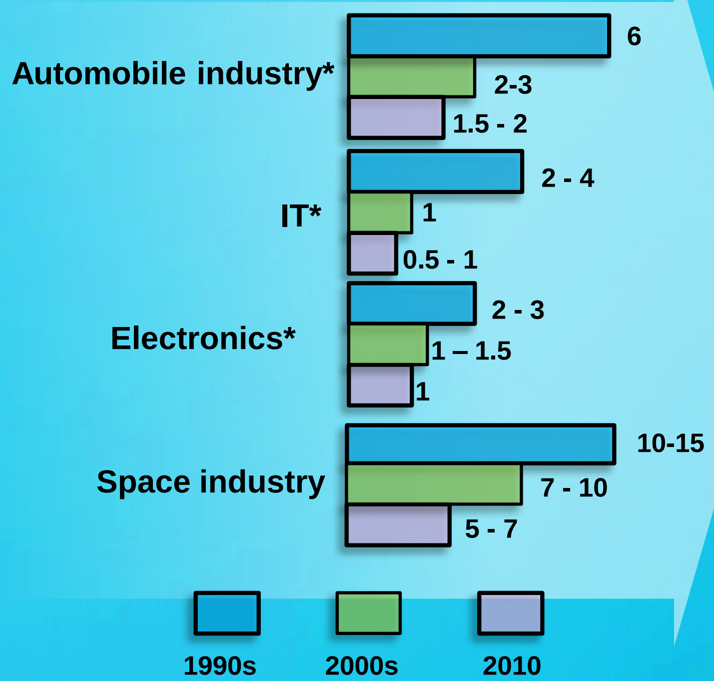
IV. PLANNING SCHEDULE OF PROJECT REALIZATION REDUCED TO 5-7 YEARS

RADAR OF SPACE TECHNOLOGIES TRENDS IN SPACE DEVICE ENGINEERING

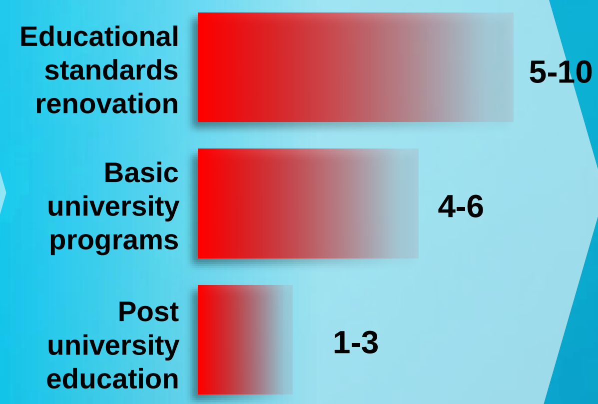


LIFE TIME REDUCTION OF INNOVATION PRODUCTS

Average time to new product appearance, years



Stuff education stages, years



Global leaders decisions
Cisco Systems, HP, Alcatel-Lucent, IBM, Huawei, Microsoft, Oracle and others

Remote education academical programs

New technologies specialized courses

During educational standards reformation industrial technologies changes ***several*** *times*

The dynamics of life cycle of innovation product do not agree with current duration of educational process. It demands seeking of new educational approaches, including the usage of «continuous education» concept

**- IDC analytical reports – 2011*

REFERENCE UNIVERSITIES

ПОДГОТОВКА

ДОПОЛНИТЕЛЬНОЕ ОБРАЗОВАНИЕ И ПЕРЕПОДГОТОВКА

ПОДГОТОВКА СПЕЦИАЛИСТОВ ВЫСШЕЙ КВАЛИФИКАЦИИ

МАИ	МЭИ	МФТИ	МГТУ имени Н.Э.Баумана	МИИГАиК	РУДН	Другие ВУЗы
«РАДИОЭЛЕКТРОННЫЕ СИСТЕМЫ И КОМПЛЕКСЫ»	«РАДИОТЕХНИКА»	«СИСТЕМНЫЙ АНАЛИЗ И УПРАВЛЕНИЕ»	«ИНФОРМАЦИОННЫЕ СИСТЕМЫ И ТЕХНОЛОГИИ»	«ГЕОИНФОРМАТИКА»	«ЭКОНОМИКА И УПРАВЛЕНИЕ»	

ЗАКАЗЧИК

ОРГАНИЗАЦИИ РАКЕТНО-КОСМИЧЕСКОГО ПРИБОРОСТРОЕНИЯ

THE NEEDS IN SCIENTIFIC AND ENGINEERING STUFF AT JSC "RUSSIAN SPACE SYSTEMS" DURING 2016-2018

Space information systems: Communications, Navigation and Remote sensing (150)

Systems of information processing, control and security (200)

Computation systems and complexes, including software preparation (200)

Machine building and production technologies in radio electronics (100)

Radio electronics systems and complexes (500)

Radio physics and remote sensing. Thematic information processing (250)

Information and measurements technique and telemetry (100)

Enterprises of the «Russian corporation of rocket and space device engineering and information systems» (JSC «Russian Space Systems»)

CONCLUSIONS

1. In conclusion, it is necessary to point out that, as a result of the «CosmoAIS» project, a sea vessel monitoring technology based on registering AIS signals was created.
2. Several key elements of the proposed technology were developed: the on-board AIS signal receiver; the «CosmoAIS» nanosatellite; ground stations; a Center for Receiving, Processing and Disseminating data; and special AIS decoding software.
3. At the moment flight tests are taking place on board the satellite «Resurs-P» #2; they should lead to further improvement of AIS data decoding algorithms. It is supposed that, with the help of the experience gained during testing, AIS data adaptive processing algorithms capable of working effectively on board a satellite will be developed.
4. In the near future the technologies developed within the framework of the «CosmoAIS» project are expected to be used for designing a specialized satellite for registering AIS/AIS-SART/ADS-B and COSPAS-SARSAT signals.

RUSSIAN SPACE SYSTEMS

Thank you for your attention!

Alexey Romanov, Deputy General Director,
Doctor of Technical Science, professor
Tel: +7 (495) 673-99-20; Fax:+7 (495) 509-12-00
E-mail: romanov@spacecorp.ru