



ROSCOSMOS

**RUSSIAN STATE CORPORATION FOR SPACE ACTIVITIES
«ROSCOSMOS»**

**State of the art and plans
for the development of
Russian space system for
Earth remote sensing**

**VALERY ZAICHKO
Russian Federation**

India, Agra, 13-17 November 2016



RUSSIAN STATE CORPORATION FOR SPACE ACTIVITIES «ROSCOSMOS»

- ❑ Now in the Russian Federation by the authorized body on outer space activities is a State Corporation «Roscosmos»**
- ❑ Earth remote sensing is one of the most important directions of Roscosmos's activities**
- ❑ The main document defining the development, and how to create space funding is the Federal Space Program of Russia**
- ❑ In the current Russian Federal Space Program for 2016-2025 identified key issues for the creation and development of tools and technologies of remote sensing**

KEY DIRECTIONS OF ROSCOSMOS ACTIVITY TO DEVELOP RUSSIAN SPACE SYSTEM FOR EARTH REMOTE SENSING

- Enlarging and improvement of Russian orbital group of satellites for Earth Remote Sensing (ERS)
- Development of ERS ground infrastructure, including complexes for acquisition and processing of space data and data distribution system
- Creation of scientific and technical background for the development of prospective ERS onboard equipment
- Improvement of legislation, rules and regulations in the field of Earth Remote Sensing Data
- Coordination with Government bodies, leading public and commercial organizations in the field of Earth Remote Sensing
- Enhancement of international cooperation



RUSSIAN REMOTE SENSING ORBITAL CONSTELLATION IN 2016:

- ❑ 3 "Resurs-P" № 1, № 2 and № 3 with high resolution (better than 1 meter) optical sensor, wide capture multispectral optical sensors (with high – 12 meters and medium – 60 meters resolution) and hyperspectral optical sensor (with 30 meters resolution)

- ❑ 1 "Kanopus-V" with panchromatic optical system (with 2.5 meters resolution) and a multispectral optical system (with 12 meters resolution/

- ❑ 2 Hydro-meteorological satellite "Meteor-M" № 1 and № 2 (with 50-70 meters resolution and 1000 kilometers swath width). It's also used for global monitoring of the Russia territory for 2 or 3 days

- ❑ 2 Hydro-meteorological geostationary space complex "Elektro-L" № 1 and № 2 with the every 30 minutes global observation of the Earth

Среднеорбитальная КС гидрометеорологического назначения

«Метеор-М» №1 (2009),
за гарантийным сроком
активного существования,
работа с ограничениями

«Метеор-М» №2 (2014)

Разрешение: 1 км
Полоса захвата: 2800 км

КС природоресурсного назначения

«Ресурс-П» №1 (2013)

«Ресурс-П» №2 (2014)

«Ресурс-П» №3 (2016)

Разрешение: лучше 1 м
Полоса захвата: 38 км

Высокоорбитальная КС гидрометеорологического назначения

«Электро-Л» №1 (2011),
на исследовании
генерального
конструктора

«Электро-Л» №2 (2015)

Разрешение: 1 км
Количество каналов: 10
Периодичность: 15 – 30 мин

«Канопус-В» №1 (2012)

Разрешение: 2,5 м
Полоса захвата: 23 км

БКА
(использование ресурса)

КС мониторинга чрезвычайных ситуаций

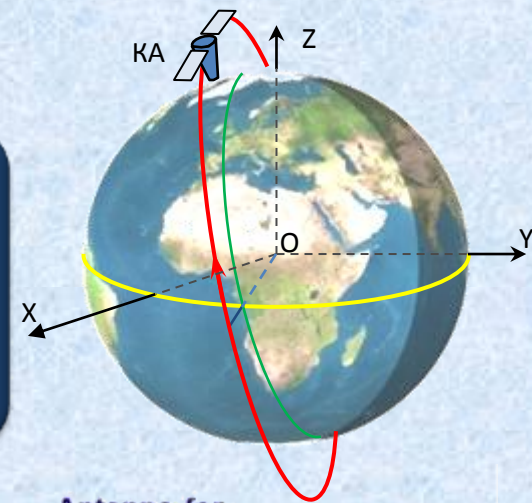
RUSSIAN REMOTE SENSING ORBITAL CONSTELLATION

Spacecraft	Resurs-DK	Meteor-M №1, 2			Elektro-L	Kanopus-V		Resurs-P № 1, 2			
Characters											
Launch date	15.06.2006	18.09.2009			20.01.2011	22.07.2012		25.06.2013, 26.12.2014			
Life time	3 years	5...7 years			10 years	5...7 years		5 years			
Swath width, km	28.3/ 16	KMSS			the visible part of the Earth	PSS	MSS	OEA	GSA	SMSA-VR	SMSA-SR
		MSU-100	MSS U-50	MSU-MR							
		900	900	2800							
Spatial resolution, m: • panchromatic band • multispectral band	1 / up to 3	-	-	-	in the visible range – 1000	2.5	-	better than 1	-	12	60
	2 - 3 / 3 - 5	60	120	1000	in IR range – 4000	-	12	3 - 4	30	23	120
Number of sensors	3 / 1	3	3	6	10	1	4	7	up to 256	6	6
Revisit time, day	up to 6	2			30 min.	4		3 - 4			

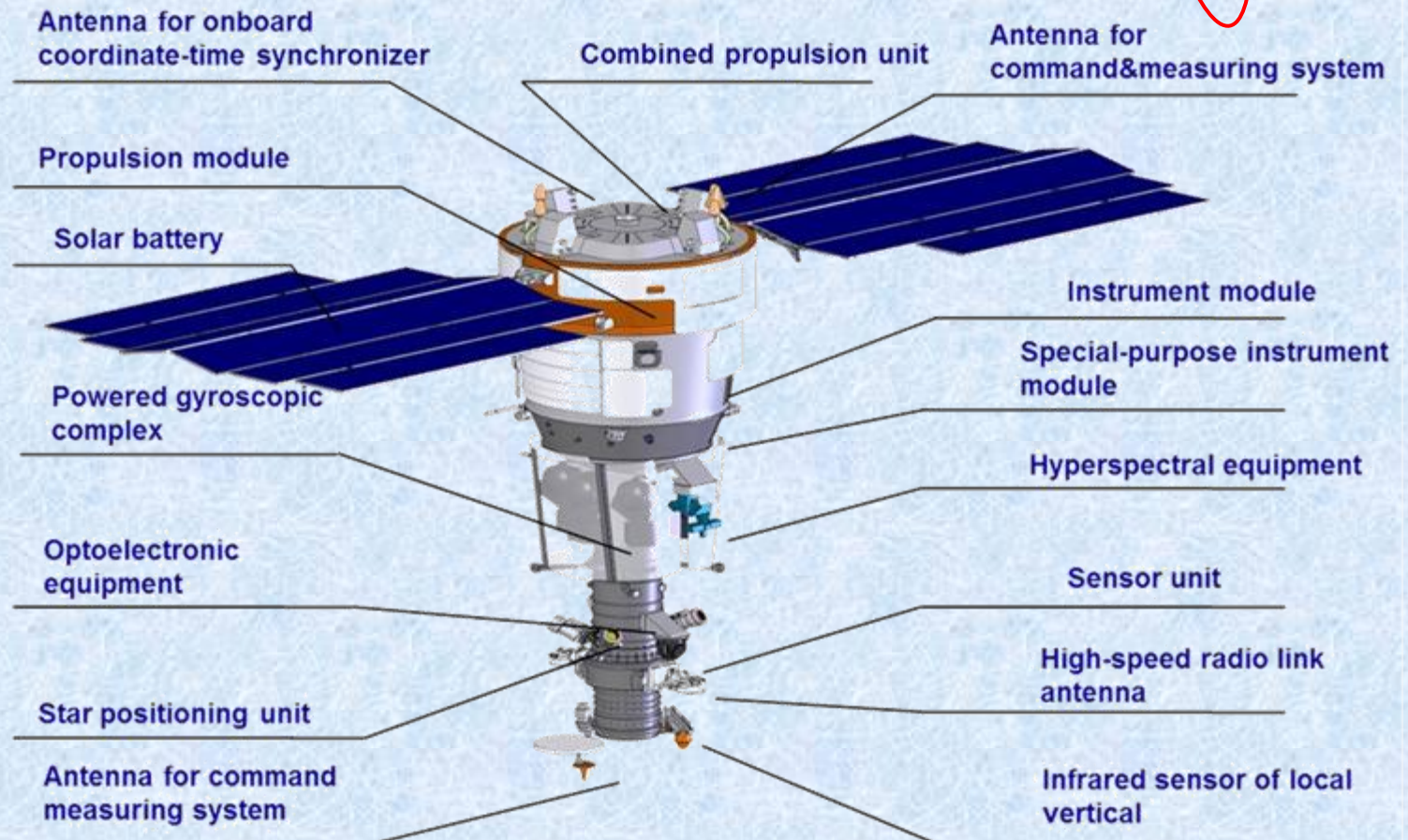
Russian orbital group provides all types and modes of imagery in the optical range

“RESURS-P”

Mission purpose: the RESURS-P satellite is designed to observe the Earth’s surface and to radio link the data acquired to ground complexes of data receiving, processing and dissemination for addressing a wide range of tasks to the benefit of various consumers as well as to use for developing an international cooperation of Russia in the environmental control and other actual problems relevant to the Earth remote sensing



General View





“RESURS-P” DATA

High Resolution – 1 m



Федеральное космическое агентство



Информация принята и обработана Оператором КС ДЗЗ
(НЦ ОМЗ ОАО “Российские космические системы”)

Italy, Rome, Vatican
August 6, 2013
Panchromatic Image







“RESURS-P” DATA

Medium Resolution – 120 m



Федеральное космическое агентство

РОСКОСМОС



Информация принята и обработана Оператором КС ДЗЗ
(НЦ ОМЗ ОАО “Российские космические системы”)

Italy, Sicily
August 14, 2013
Multispectral Image

“RESURS-P” DATA

Pansharpened Image



Федеральное космическое агентство



Russia Federation, Zhukovsky
International Aviation and Space Salon
(MAKS) - 2013
August 20, 2013



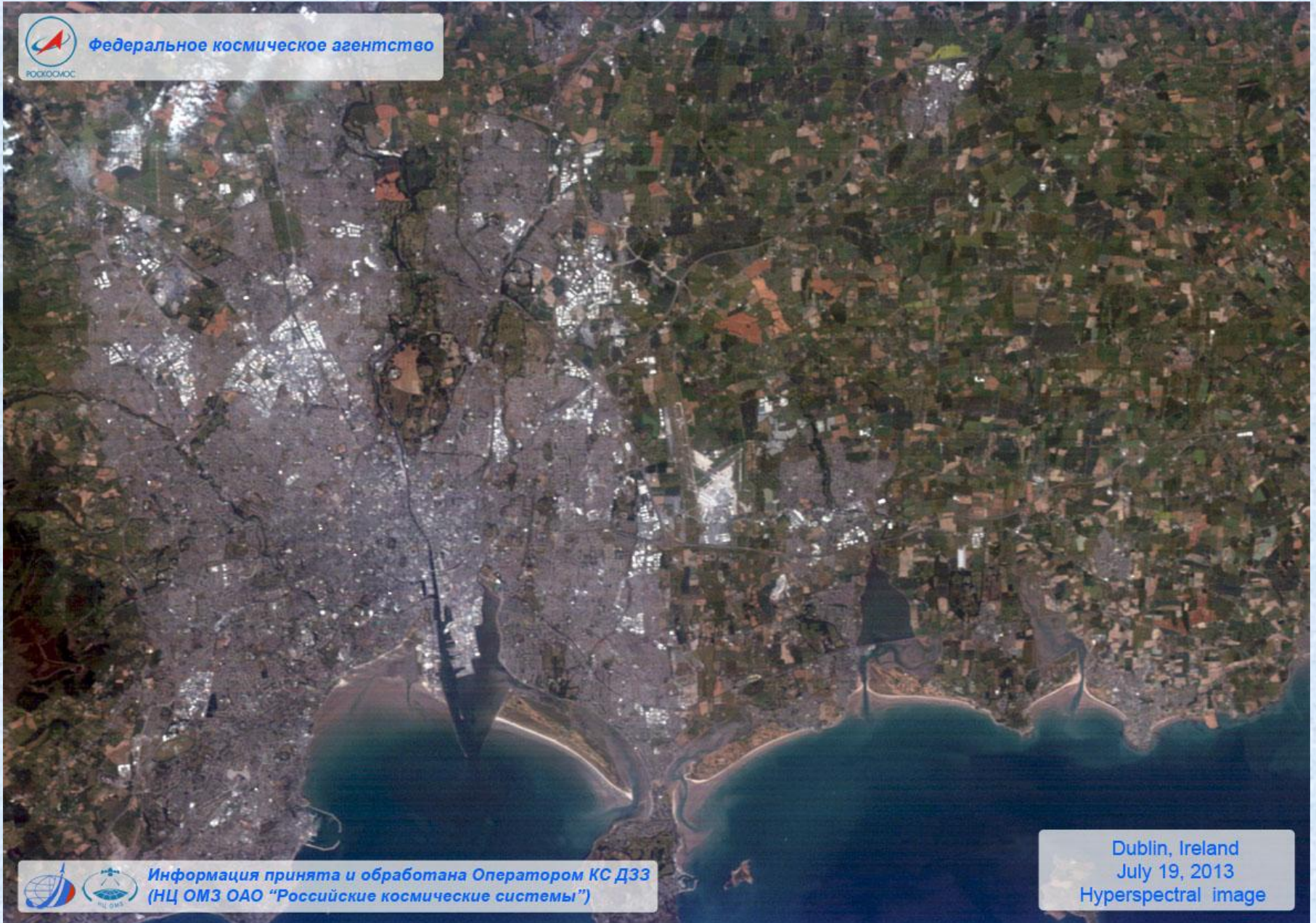
Информация принята и обработана Оператором КС ДЗЗ
(НЦ ОМЗ ОАО “Российские космические системы”)

“RESURS-P” DATA

Hyperspectral Image



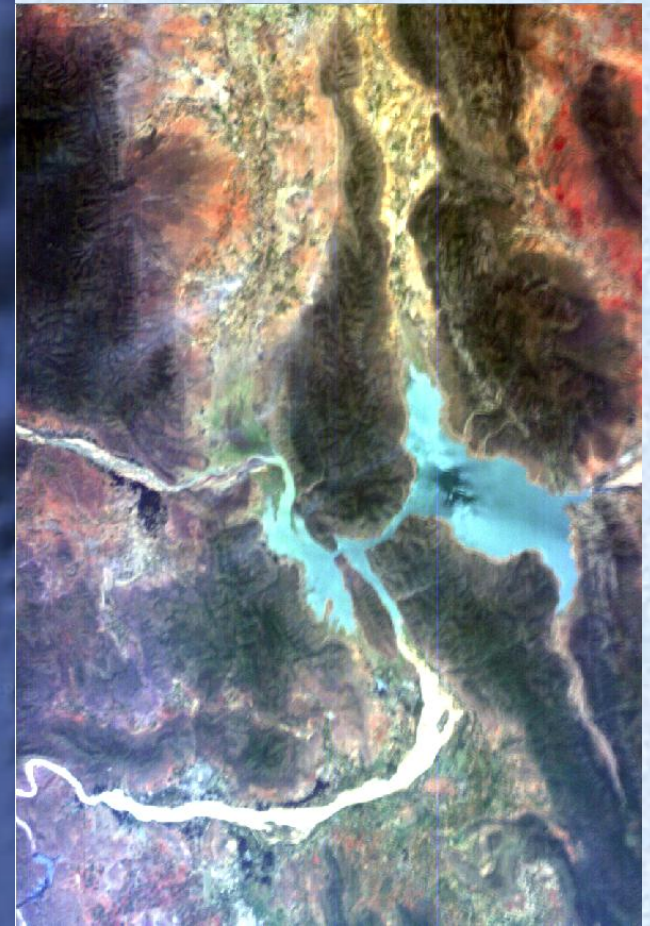
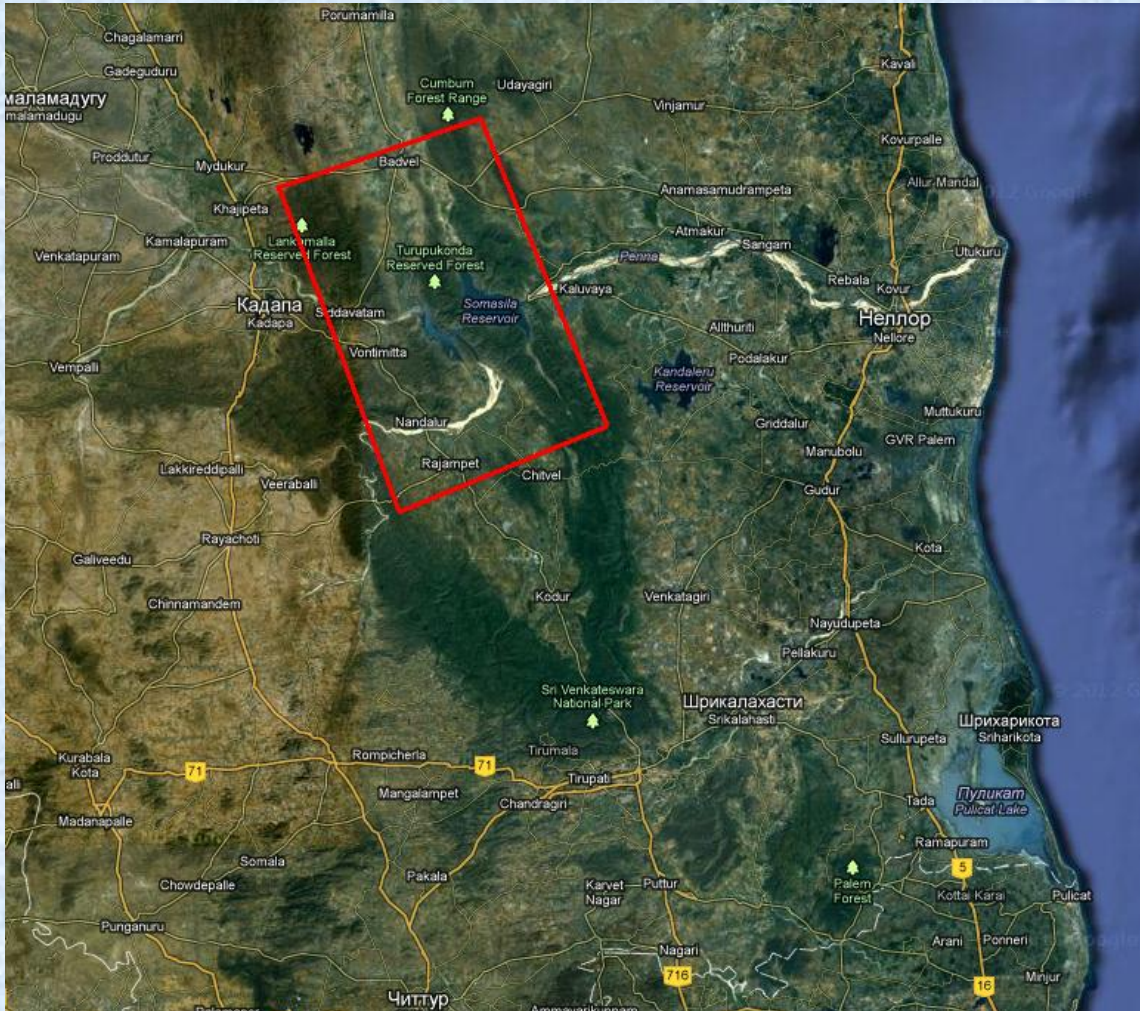
Федеральное космическое агентство



Информация принята и обработана Оператором КС ДЗЗ
(НЦ ОМЗ ОАО “Российские космические системы”)

Dublin, Ireland
July 19, 2013
Hyperspectral image

EXPERIMENTAL THEMATIC PROCESSING OF HYPERSPECTRAL IMAGES USING THE MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY SOFTWARE



Natural colors RGB-
composite

The reservoir Somasila (river Penna), Eastern India

“KANOPUS-V”



Mission purpose: panchromatic and multi-spectral imaging of the Earth

Applications Areas:

✓ creation and update of maps (scale 1 : 25 000 and smaller);

✓ environmental ecological monitoring;

✓ natural and man-caused emergency situations monitoring;

✓ respond to agriculture and forestry challenges;

✓ socio-economic infrastructure monitoring

Main Characteristics

Launch data	July, 22 2012	
Designed by	Joint Stock Company “Research and Production Corporation Space Monitoring Systems, Information & Control and Electromechanical Complexes” named after A.G. Iosifian”	
Orbit	Circular sun-synchronous	
	Inclination	97.436 deg
	Height average	510 km
Sensor	PSS (Panchromatic Optical System)	
Spectral bands	Panchromatic:	0.54 - 0.86 μm
Spatial resolution	2,5 m	
Swath width	23 km	
Sensor	MSS (Multispectral Optical System)	
Spectral bands	Blue:	0.46 - 0.51 μm
	Green:	0.51 - 0.60 μm
	Red:	0.63 - 0.69 μm
	Near Infrared:	0.75 - 0.84 μm
Spatial resolution	12 m	
Swath width	20 km	

“KANOPUS-V” DATA



Федеральное космическое агентство



Информация принята и обработана Оператором КС ДЗЗ
(НЦ ОМЗ ОАО “Российские космические системы”)

Italy, Vesuvius
August 2, 2013
Pansharpned Image

“KANOPUS-V” DATA



Федеральное космическое агентство

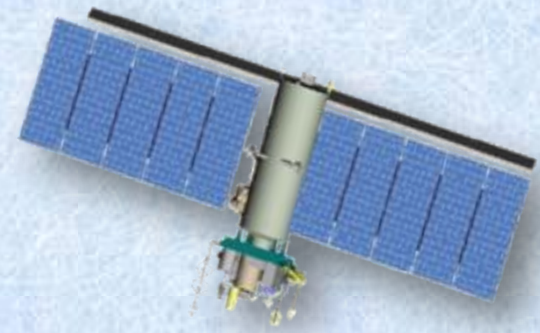


Italy, Genoa
August 1, 2013
Pansharpned Image



Информация принята и обработана Оператором КС ДЗЗ
(НЦ ОМЗ ОАО “Российские космические системы”)

“METEOR-M” / KMSS



Mission objective: hydrometeorological supervision, research of natural resources of the Earth and ecological monitoring

Main Characteristics

Launch date	17 September 2009		
Designed by	Joint Stock Company “Research and Production Corporation Space Monitoring Systems, Information & Control and Electromechanical Complexes” named after A.G. Iosifian”		
Orbit	Circular sun-synchronous	Inclination	98.85 deg
		Height average	835 km
Sensor	KMSS (Multispectral Medium resolution System) MSU-100 MSU-50		
Spectral bands, μm	MSU-100	MSU-50	
	Green: 0.535 - 0.575	Blue:	0.370 - 0.450
	Red: 0.630 - 0.680	Green:	0.450 - 0.510
	Near Infrared: 0.760 - 0.900	Red:	0.580 - 0.690
Spatial resolution	60 m	120 m	
Swath angle	39 deg		
Swath width	900 km		
Radiometric resolution	10 bits per pixel		
Temporal resolution (at 60 deg latitude)	3 days		
Scientific instruments	MTVZA-GYa, GGAk-M, BIS, BRK SSPD		

Solved problems:

✓ reception of the initial hydrometeorological data on a global scale for weather forecasting;

✓ control of the dangerous weather phenomena and the prevention of their approach;

✓ climate forcing control and the Earth global changing monitoring;

✓ radiation and heligeophysical conditions control in near-Earth space in interests of flights’ safety, steady radio communication, men health

“METEOR-M” №1 / KMSS DATA

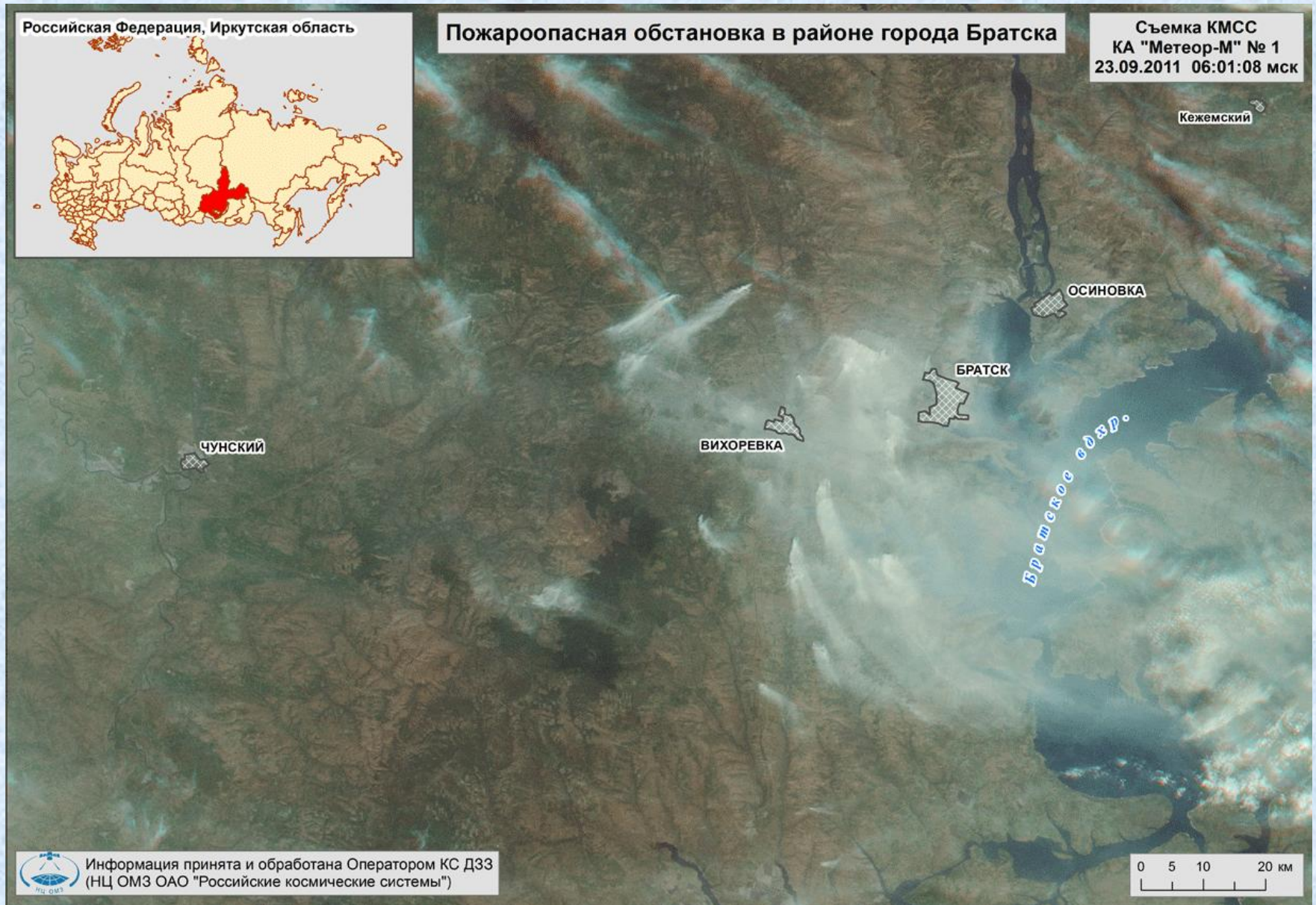
Fires monitoring, Russia Federation, Irkutskaya oblast, 2011

Российская Федерация, Иркутская область



Пожароопасная обстановка в районе города Братска

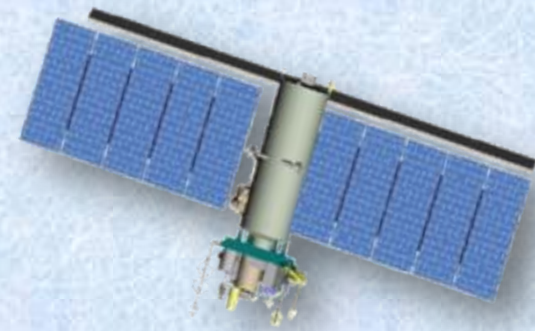
Съемка КМСС
КА "Метеор-М" № 1
23.09.2011 06:01:08 мск



Информация принята и обработана Оператором КС ДЗЗ
(НЦ ОМЗ ОАО "Российские космические системы")

0 5 10 20 км

“METEOR-M” / MSU-MR



Main Characteristics

Mission objective: hydrometeorological supervision, research of natural resources of the Earth and ecological monitoring

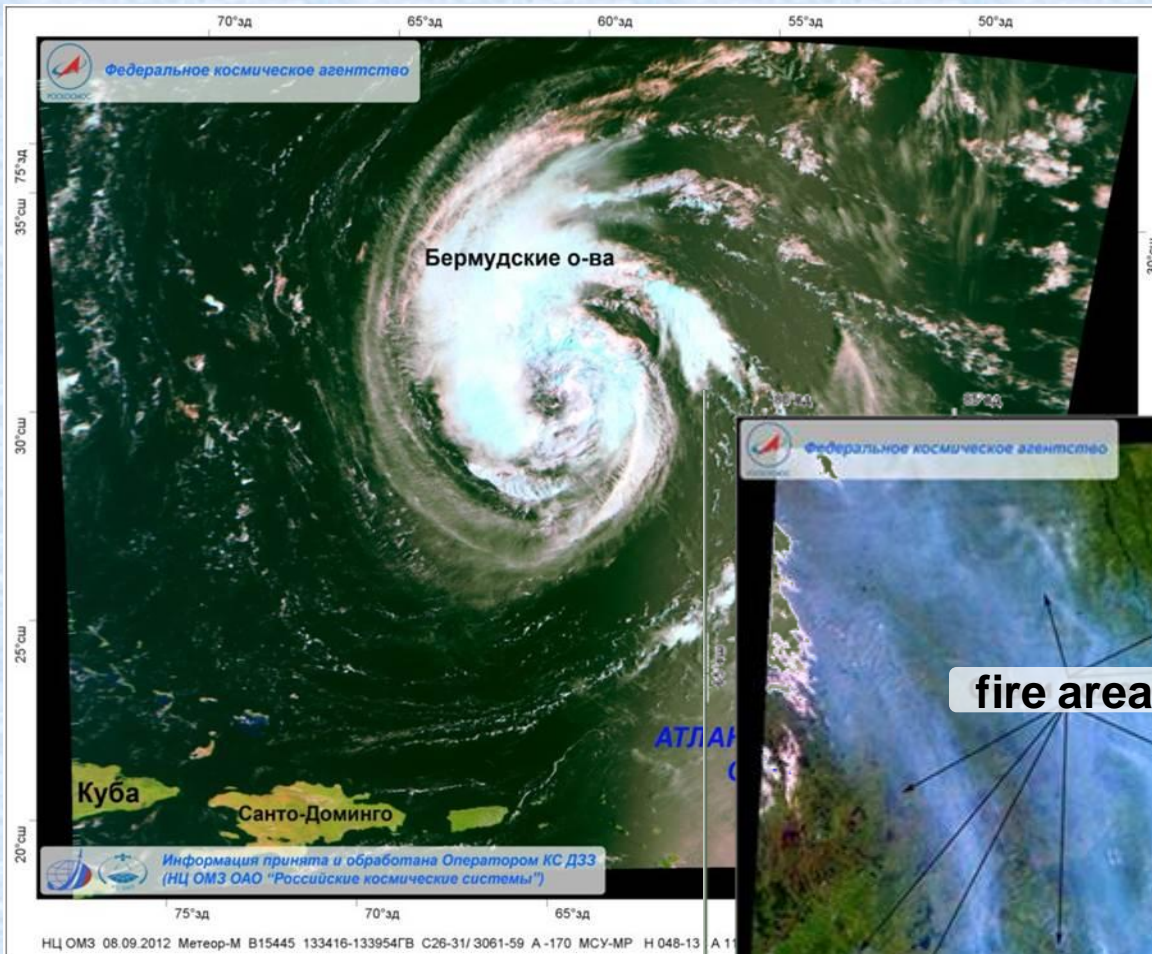
Solved problems:

- ✓ reception of the initial hydrometeorological data on a global scale for weather forecasting;
- ✓ control of the dangerous weather phenomena and the prevention of their approach;
- ✓ climate forcing control and the Earth global changing monitoring;
- ✓ radiation and heligeophysical conditions control in near-Earth space in interests of flights' safety, steady radio communication, men health

Launch date	17 September 2009	
Designed by	Joint Stock Company 'Research and Production Corporation Space Monitoring Systems, Information & Control and Electromechanical Complexes' named after A.G. Iosifian'	
Orbit	Circular sun-synchronous	
	Inclination	98.85 deg
	Height average	835 km
Sensor	MSU-MR (Multispectral Low Resolution Optical Instrument)	
Spectral bands	Red:	0.50 - 0.70 μm
	Near Infrared:	0.70 - 1.10 μm
	Short-wavelength Infrared:	1.60 - 1.80 μm
	Mid-wavelength Infrared:	3.50 - 4.10 μm
	Thermal Infrared:	10.50 - 11.50 μm
	Thermal Infrared:	11.50 - 12.50 μm
Spatial resolution	1 000 m	
Swath width	2 800 km	
Radiometric resolution	10 bits per pixel	
Temporal resolution	1 day	
Scientific instruments	MTVZA-GYa, GGAK-M, BIS, BRK SSPD	

“METEOR-M” №1 / MSU-MR DATA

**Atlantic Ocean,
Bermuda**
September 6, 2013



**Russia Federation,
Yakutiya**
July 22, 2013

“ELEKTRO-L” № 1, 2



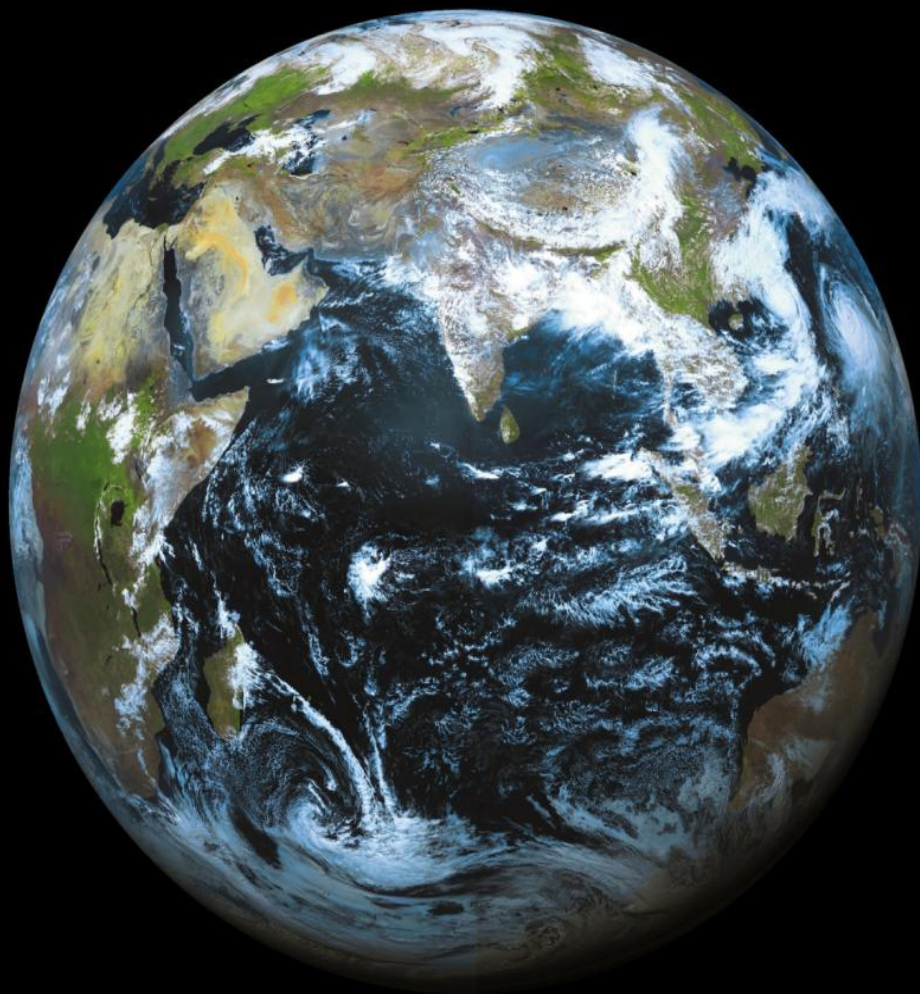
Mission purpose: ELEKTRO-L geostationary hydrometeorological spacecraft is designed for operational imaging of cloud cover and the Earth’s underlying surface, heliogeophysical measurements, hydrometeorological and housekeeping data collection and relaying

Main Characteristics

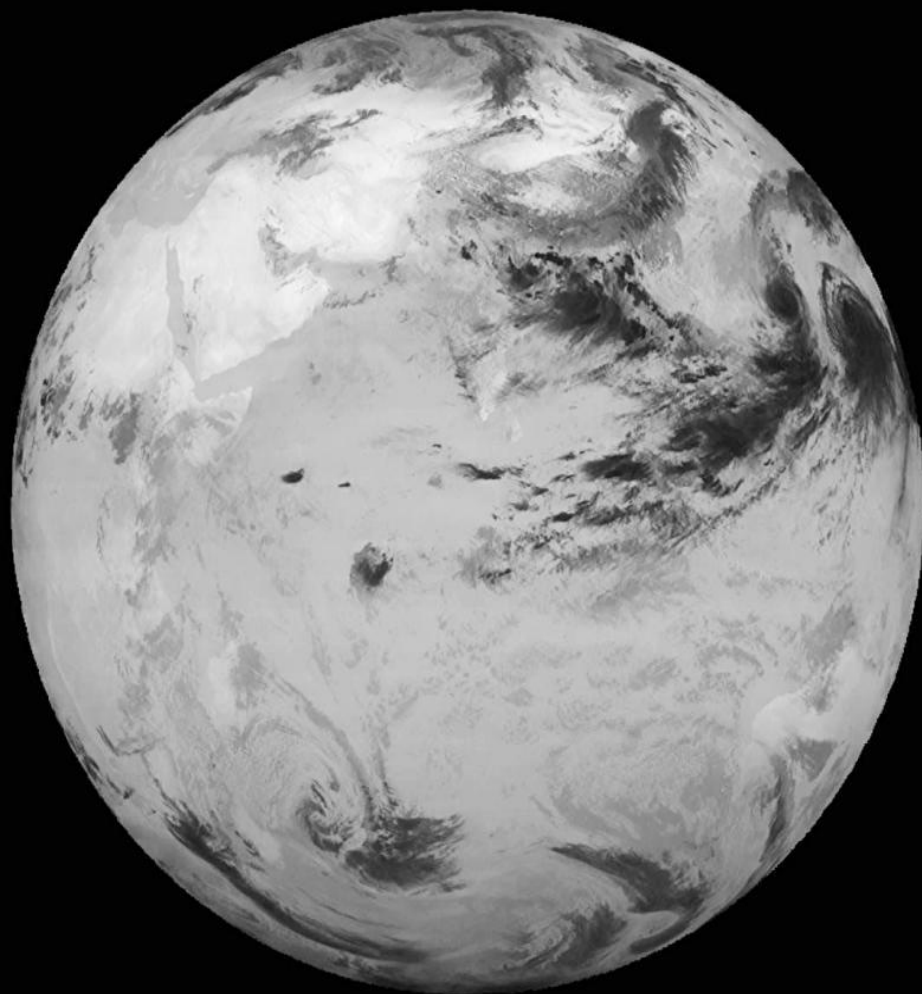
Application Areas:

- ✓ operative (15-30 min) reception of cloud and Earth underlying surface images;
- ✓ weather analysis and forecast in regional and Global scale;
- ✓ aircraft safety flight requirements analysis and forecast;
- ✓ sea and ocean conditions analysis and forecast;
- ✓ climate and global changes monitoring;
- ✓ environmental ecological monitoring

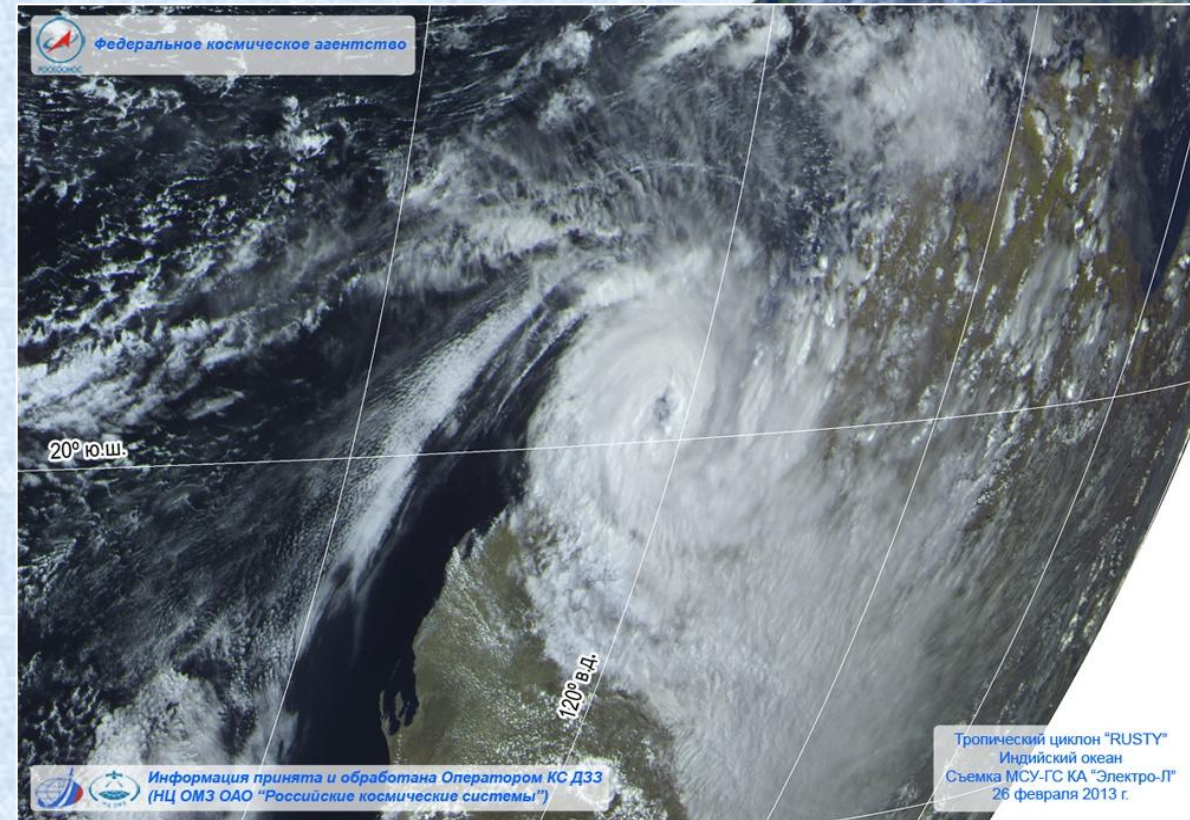
Launch date	20 January 2011	
Designed by	Lavochkin Research and Production Association	
Orbit	Geostationary sun-synchronous	
	Standing point	76 ged E
	Inclination	not more than 0.5 deg
	Height	36 000 km
Sensor	MSU-GS (Geostationary Multiband Scanning Instrument)	
Spectral bands	Visible:	0.46 - 0.70 μm
	Mid-wavelength Infrared:	6.0 - 7.0 μm
	Thermal Infrared:	10.5 - 12.5 μm
Spatial resolution	Visible band	1 000 m
	Infrared bands	4 000 m
Temporal resolution	30 min	
	in case of emergency situations - 15 min	
Swath width	All visible part of globe	
Around the Earth orbital period	24 hours	
Geophysical scientific instrument	GGAK-E	



Видимый диапазон (RGB)



Инфракрасный канал (10,2-11,2 нм)

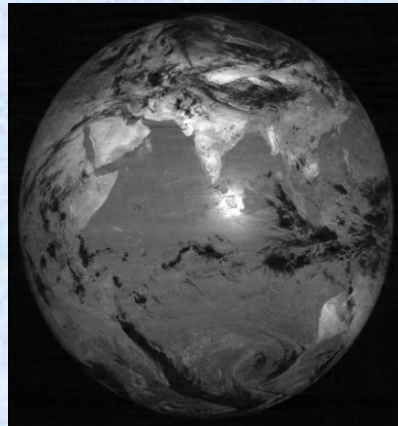


Indian Ocean,
“Rusty” cyclone
February 26, 2013

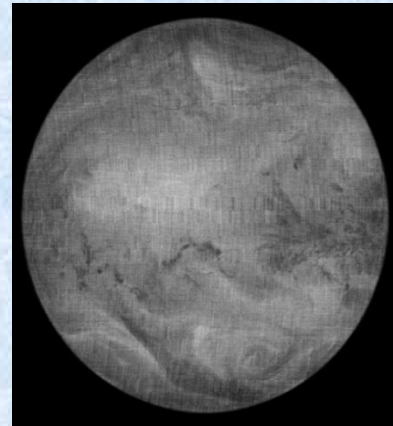
THE AMOUNT OF "ELEKTRO-L" DATA PRODUCED IN THE SHOOTING SESSION FOR 5 MINUTES



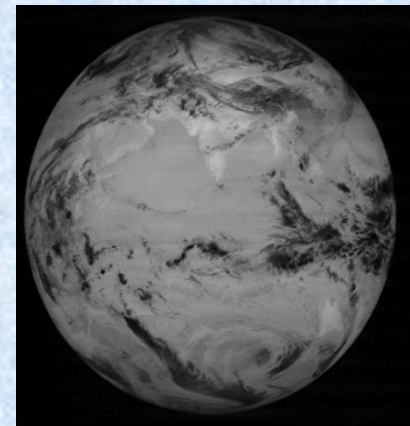
$\Delta\lambda = 0,65 - 0.9 \text{ mm}$



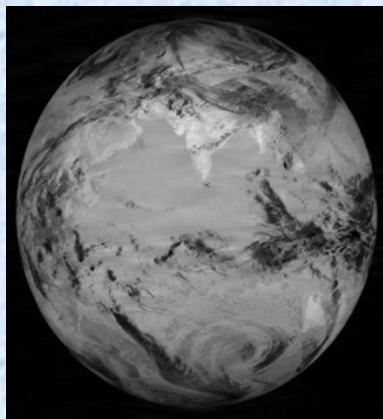
$\Delta\lambda = 3.5 - 4.0 \text{ mm}$



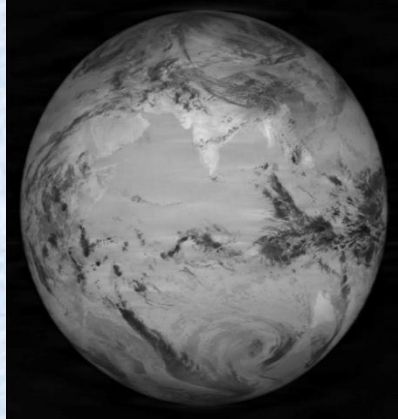
$\Delta\lambda = 5.7 - 7.0 \text{ mm}$



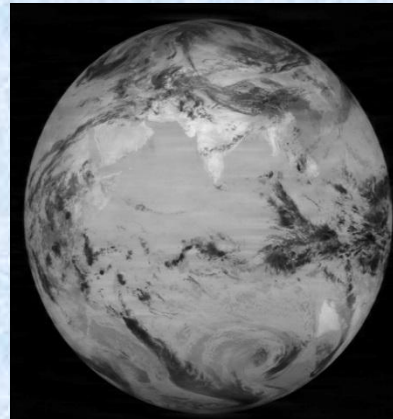
$\Delta\lambda = 7.5 - 8.5 \text{ mm}$



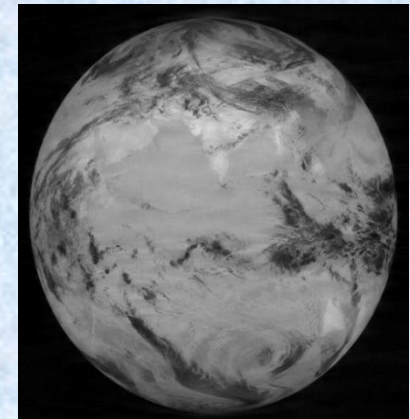
$\Delta\lambda = 8.2 - 9.2 \text{ mm}$



$\Delta\lambda = 9.2 - 10.2 \text{ mm}$



$\Delta\lambda = 10.2 - 11.2 \text{ mm}$



$\Delta\lambda = 11.2 - 12.5 \text{ mm}$



IN 2017 RUSSIAN FEDERATION WILL BE LAUNCH 2 REMOTE SENSING SATELITES:

- ❑ “Kanopus-V“-IK with panchromatic optical system (with 2.5 meters resolution) and a multispectral optical system (with 12 meters resolution) and infrared camera
- ❑ Hydro-meteorological satellite "Meteor-M" № 2-1 (with 50-70 meters resolution and 1000 kilometers swath width). It's also used for global monitoring of the Russia territory for 2 or 3 days



The development of “Resurs-P” space system, consisting of 3 satellites - the key specific feature of remote sensing data receiving.

The launch of “Resurs-P” № 3 is scheduled for March 12, 2016.

This will allow to increase the capabilities for obtaining high-resolution data up to 500.000 km² per day and to ensure high frequency of image acquisition (up to once per day).



POCKOCMOC

Thus, by the end of 2017 Russian remote sensing orbital constellation will consist of 10 satellites:

- ❑ 3 "Resurs-P" satellites with 0,8 metre resolution, a hyperspectral optical sensor (25 metres) and wide capture multispectral optical sensors (12/25 metres);
- ❑ 2 "Kanopus-V" satellites with a panchromatic optical system with 2.5 metres resolution and a multispectral optical system with 12 metres resolution, including one satellite with an infrared camera;
- ❑ 3 hydro-meteorological satellites "Meteor-M" (the final stage of flight tests) with a multispectral optical system with 50-70 metres resolution and 1000 kilometres swath width.
- ❑ 2 hydro-meteorological geostationary space complex "Elektro-L" with an optical system for the Earth global observation every 30 minutes.

RUSSIAN EARTH OBSERVATION MISSIONS 2006–2016



Multispectral sensors developed by JSC "Russian Space Systems"

Global and Regional Scale Data
VNIR, IR, Microwave
 (1) Meteorology
 (2) Natural Resources Studies
 (3) Disasters
 (4) Geophysics

> 80 mil. sq. km
 Medium-Res Images

Global Scale Data
Geostationary Orbit
VNIR, IR
 (1) Meteorology
 (2) Disasters
 (3) Geophysics

ELECTRO-L1

Global Scale Data
Geostationary Orbit
VNIR, IR
 (1) Meteorology
 (2) Disasters
 (3) Geophysics

ELECTRO-L2

Global and Regional Scale Data
VNIR, IR, Microwave, SAR (X-Band)
 (1) Meteorology
 (2) Natural Resources Studies
 (3) Disasters
 (4) Geophysics

METEOR-M2

METEOR-M2-1

2006

2007

2008

2009

2010

2011

2012

2013

2014

2015-2016



RESURS-DK

Local Scale Data
VNIR
 (1) Natural Resources Studies
 (2) Cartography
 (3) Geophysics

No OPERATION!

> 25 mil. sq. km
 Hi-Res Images

Visible / IR Data

SAR Data

Local and Regional Scale Data
VNIR
 (1) Natural Resources Studies
 (2) Cartography

> 40 mil. sq. km
 Hi-Res images

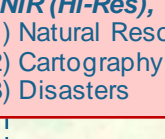


KANOPUS-V

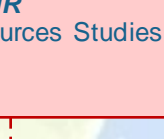
> 15 mil. sq. km
 Hi-Res images

Local and Regional Scale Data
VNIR (Hi-Res), IR, Hyperspectral
 (1) Natural Resources Studies
 (2) Cartography
 (3) Disasters

Local and Regional Scale Data
VNIR (Hi-Res), IR
 (1) Natural Resources Studies
 (2) Cartography
 (3) Disasters



RESURS-P1



RESURS-P2



KANOPUS-V-IK



RESURS-P3

Background: METEOR-M1 / MSU-MR mosaic (2012)



**By the end of 2025 Russian remote
sensing orbital
constellation will consist of 28-30
satellites**



РОСКОСМОС

ПЛАНИРУЕМАЯ ОГ КА КС ДЗЗ НА КОНЕЦ 2025 ГОДА

Среднеорбитальная КС гидрометеорологического назначения

«Метеор-МП» №1 (2024) ЛО

Разрешение: 0,5 км
Полоса захвата: 2950 км

КС природоресурсного назначения

«Ресурс-ПМ» №1 (2020) ЛО

«Ресурс-ПМ» №2 (2021)

«Ресурс-ПМ» №3 (2023)

«Ресурс-ПМ» №4 (2024)

Разрешение: 0,3 — 0,4 м
Полоса захвата: более 15 км

Внебюджет

КА оптико-электронного наблюдения:

«Смотр-В» (2020)

КА радиолокационного наблюдения:

«Смотр-Р1» (2021)

КА радиолокационного наблюдения:

«Смотр-Р2» (2022)

«Метеор-М» №2-3 (2020)

«Метеор-М» №2-4 (2021)

«Метеор-М» №3 (2021)
(океанографический)

«Метеор-М» №2-5 (2022)

Разрешение: 1 км
Полоса захвата: 2800 км

«Ионосфера-М» №1, №2 (2020)

«Ионосфера-М» №3, №4 (2022)

«Зонд-М» (2024)

Высокоорбитальная КС гидрометеорологического назначения

«Электро-Л» №2 (2015)

«Электро-Л» №3 (2017)

«Электро-Л» №4 (2019)

«Электро-Л» №5 (2024)

Разрешение: 1 км
Количество каналов: 10
Периодичность: 15 — 30 мин

«Электро-М» №1-1 (2025) ЛО

Разрешение: 0,5 км
Количество каналов: 18
Периодичность: 5 — 10 мин

Высокоэллиптическая КС гидрометеорологического назначения

«Арктика-М» №2 (2019)

«Арктика-М» №3 (2020)

«Арктика-М» №4 (2024)

«Арктика-М» №5 (2025)

Разрешение: 1 км
Количество каналов: 10
Периодичность: 15 — 30 мин

«Обзор-О» №1 (2023) ЛО

«Обзор-О» №2 (2025)

КА обзорного оптико-электронного наблюдения:

Разрешение: 5 м
Полоса захвата: 150 км

«Обзор-Р» №1 (2021) ЛО

«Обзор-Р» №2 (2023)

«Обзор-Р» №3 (2024)

КА радиолокационного наблюдения:

Разрешение: 1 м
Полоса захвата: 20 км

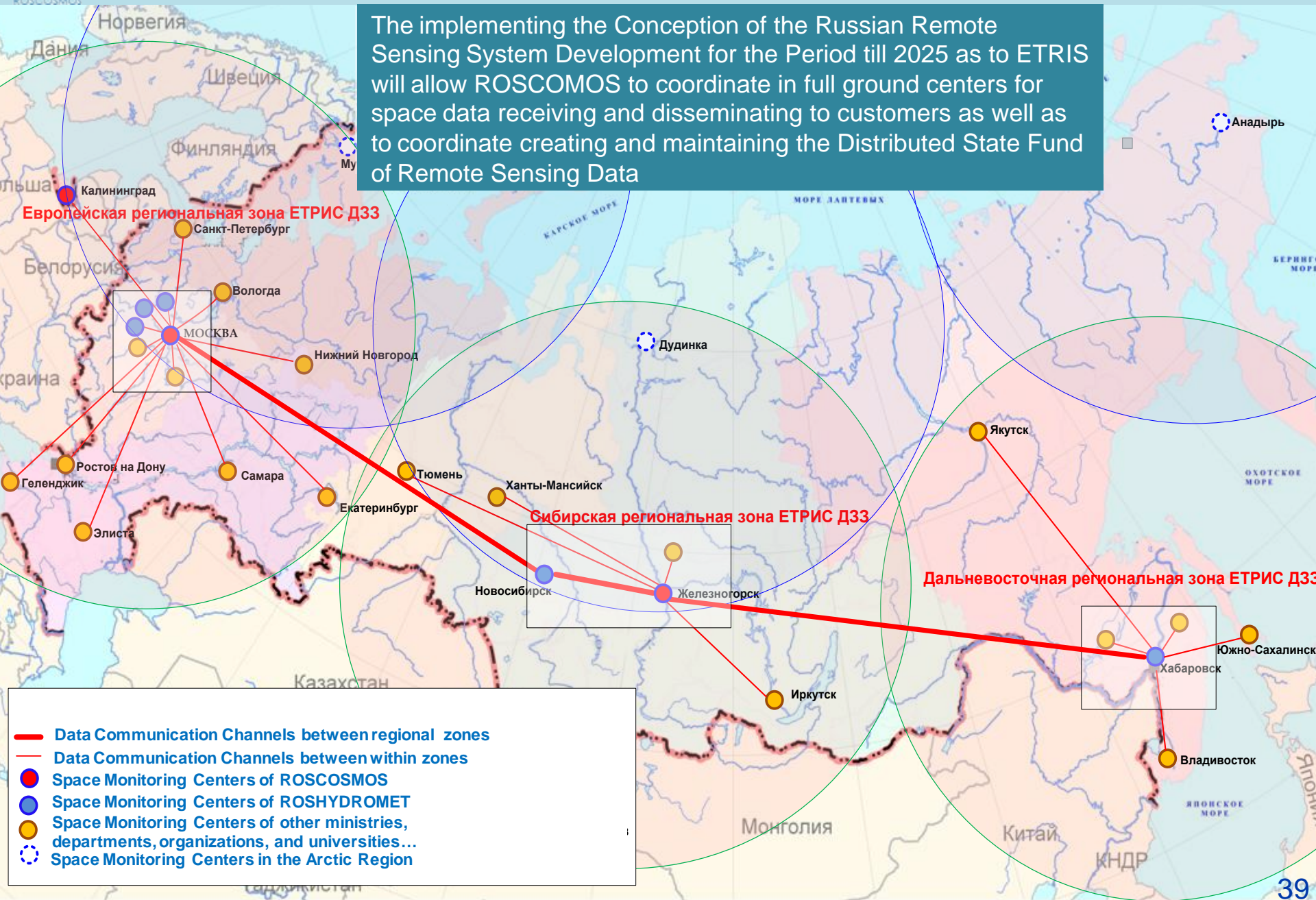
КС Мониторинга чрезвычайных ситуаций

Remote sensing orbital constellation operates via ground-based infrastructure required for data receiving, processing, storage and dissemination in order to provide customers with space information

ETRIS DZZ constitute the basis of remote sensing centers and points to obtain space information posted throughout the territory of the Russian Federation.

In 2016-2017, planned to develop three large reception center in the north of the country in the areas of Murmansk, Anadyr and Dydinka that will provide complete coverage of the territory of the Russian input areas

The implementing the Conception of the Russian Remote Sensing System Development for the Period till 2025 as to ETRIS will allow ROSCOMOS to coordinate in full ground centers for space data receiving and disseminating to customers as well as to coordinate creating and maintaining the Distributed State Fund of Remote Sensing Data



INFORMATION SERVICES. ROSCOSMOS'S GEOPORTAL

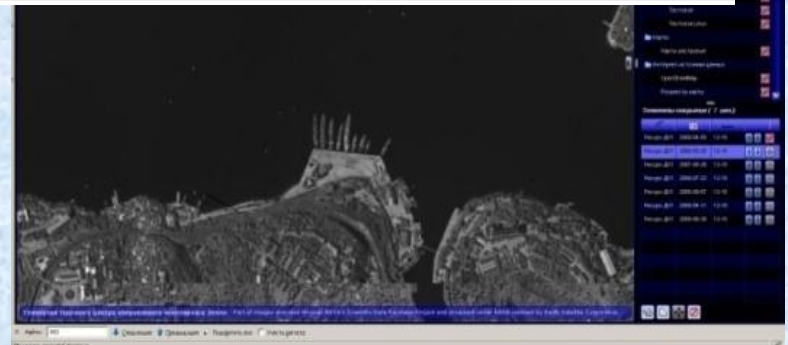
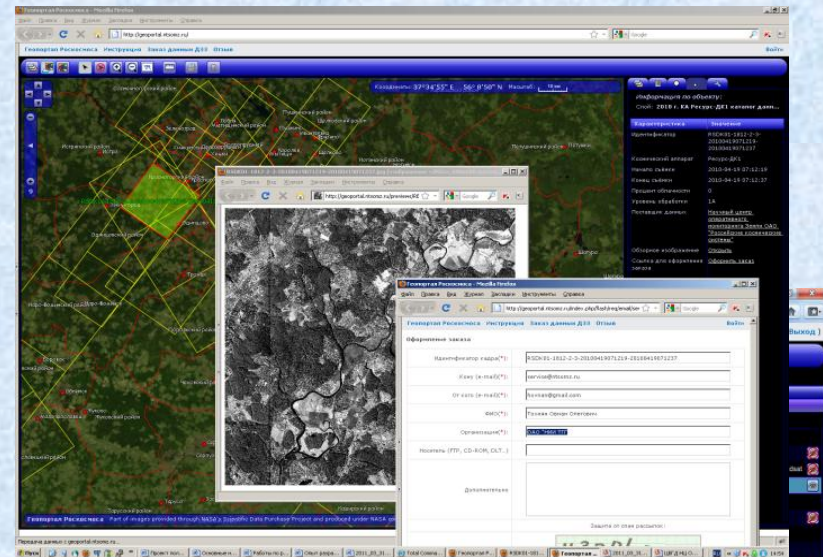


The main page of Geoportal

Roscosmos Geoportal provides operative access, data search, satellites characteristics, remote sensing data and products of its processing ordering, as well as the ability to monitor ground-based sites and facilities in time.

Every day more than 1000 visitors access the Geoportal via Internet.

A strong consumer segment is established

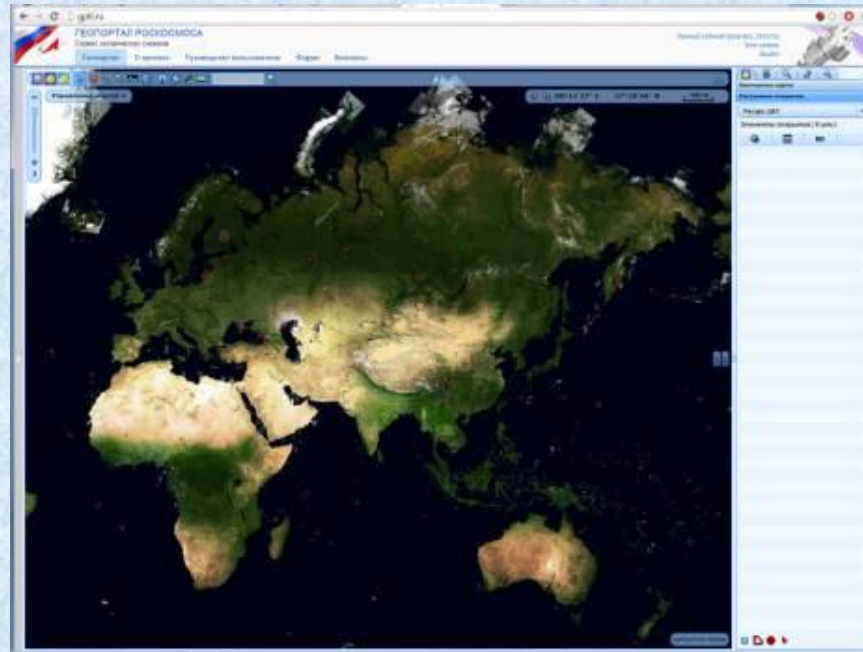


INFORMATION SERVICES. ROSCOSMOS'S GEOPORTAL

Free Access

- Metadata catalogue
- General catalogue of remote sensing data
- Continuous earth surface coating with space imagery data
- Provision of space information and thematic products on customers demands

ROSCOSMOS'S GEOPORTAL



Authorized access

- All features of free access to Geoportal
- Access to thematic data segments and special thematic products
- Very-high resolution data access

Internet



www.gptl.ru



Internet

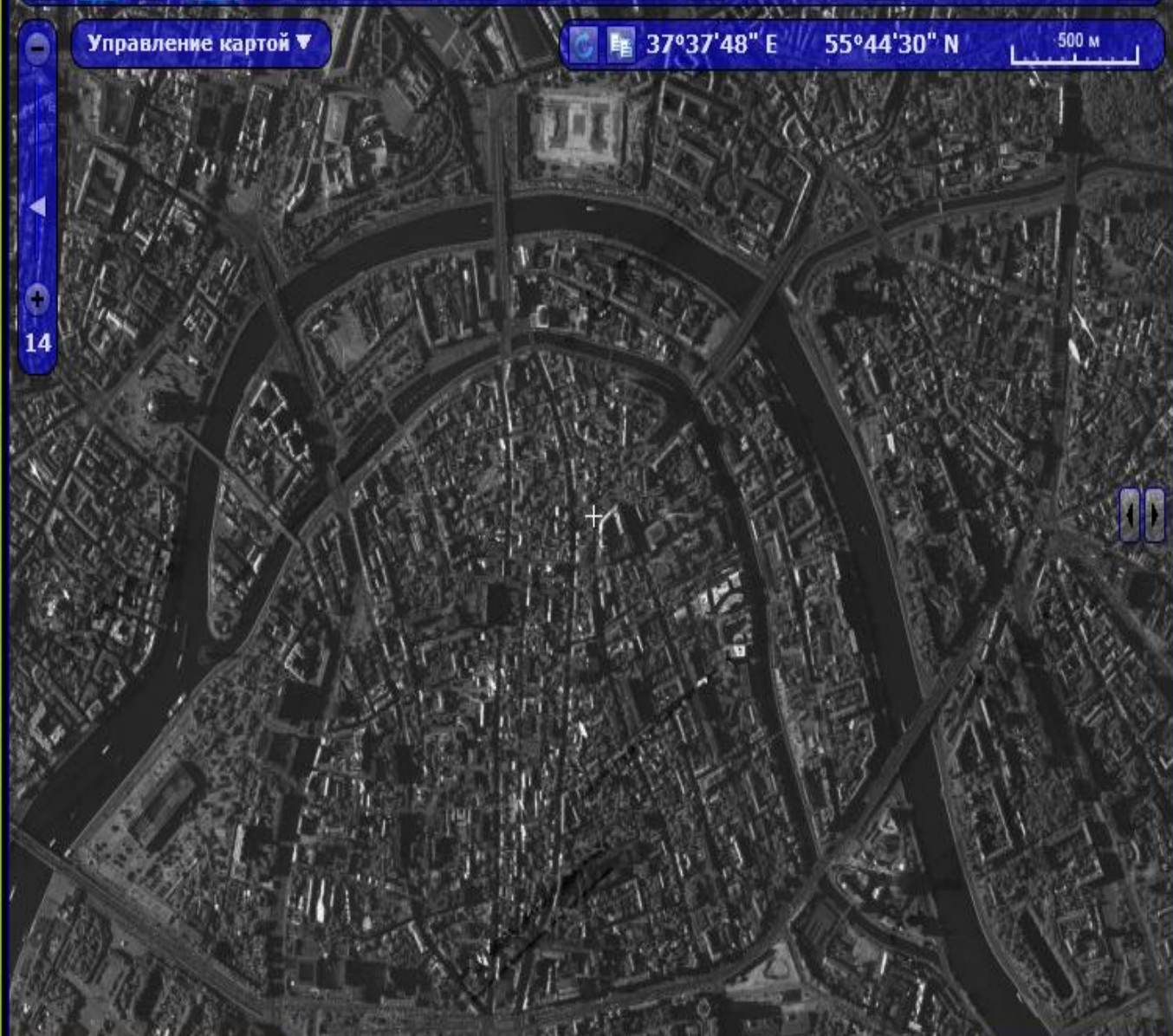
Launched in December 2010, Roscosmos Geoportal provides online access to information from Russian ERS satellites to a wide range of users and additional opportunities for authorized users

москва lego

Управление картой ▾

37°37'48" E 55°44'30" N 500 м

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 +
 14



Векторные карты

Непрерывные покрытия

Непрерывные покрытия:

Ресурс-ДК1 ▾

Элементы покрытия (10 шт.):

Ресурс-ДК1	2009-09-09	12-16	
Ресурс-ДК1	2006-09-18	12-16	
Ресурс-ДК1	2010-07-14	12-16	
Ресурс-ДК1	2009-04-15	12-16	
Ресурс-ДК1	2007-06-03	12-16	
Ресурс-ДК1	2007-06-23	12-16	
Ресурс-ДК1	2007-08-15	12-16	
Ресурс-ДК1	2007-08-20	12-16	
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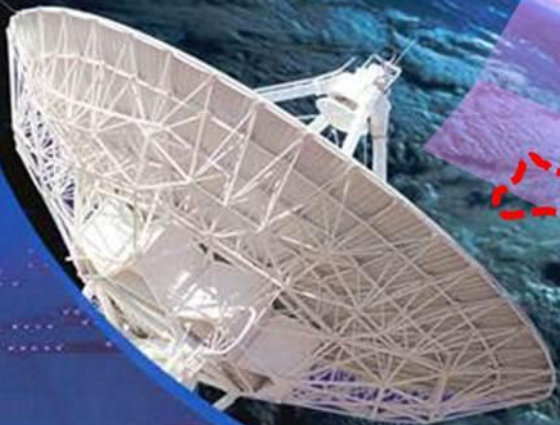


ROSCOSMOS

India, Agra, 12-15 November 2016



Thank you for your attention!



Russian Federation