



Joint-stock company «Space rocket center «Progress»

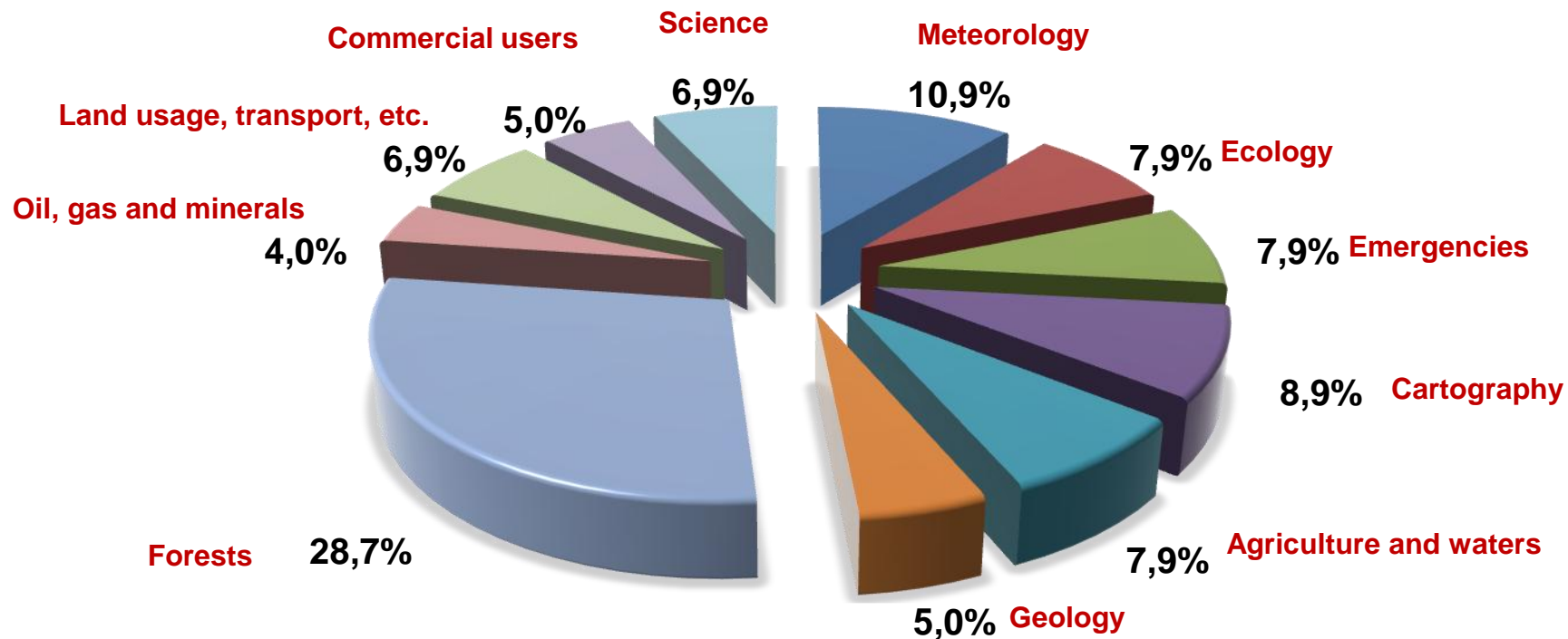


Remote sensing system Resurs-P

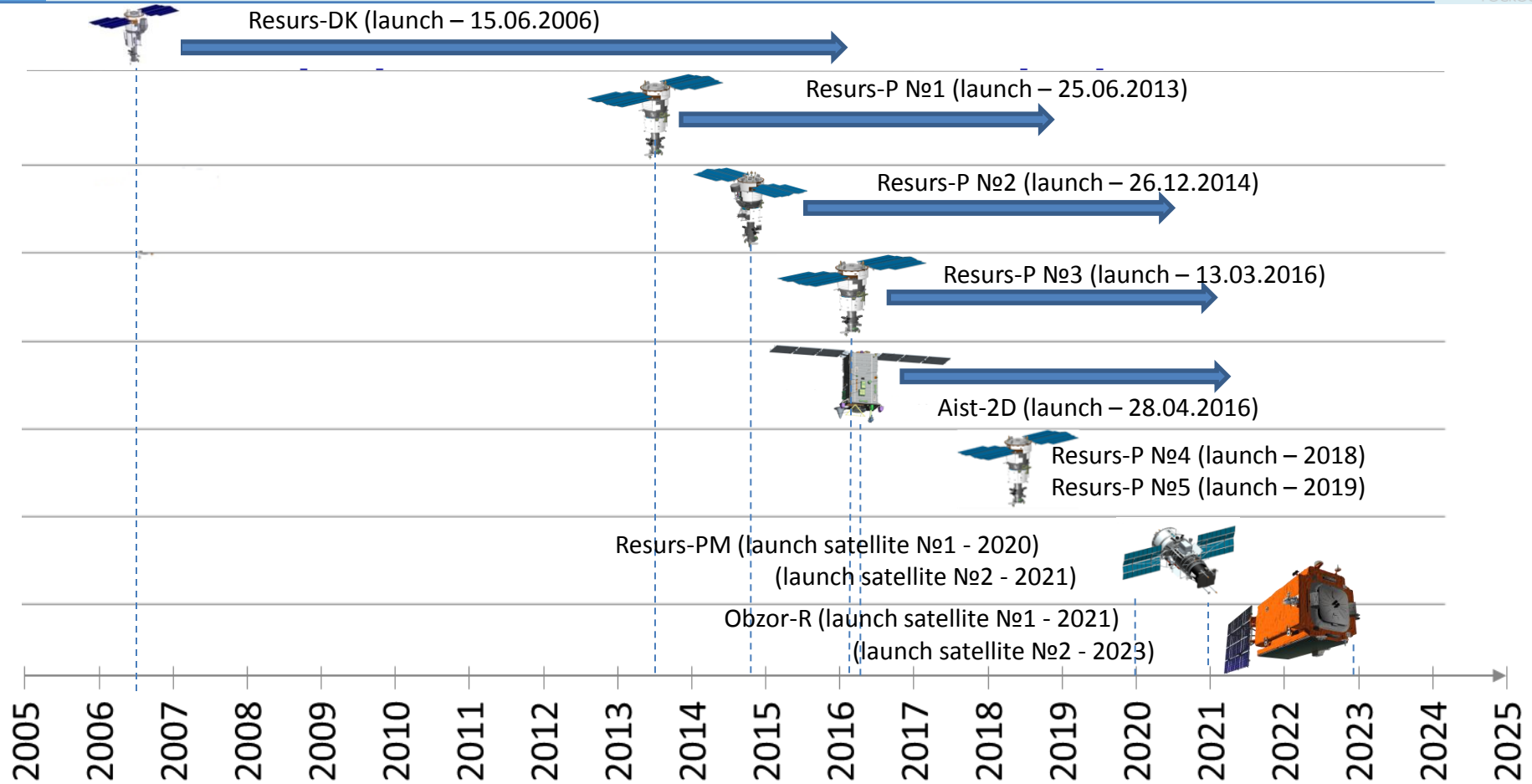
Alexander N. Kirilin, Ravil N. Akhmetov,
Nikolay R. Stratilatov, Alexander I. Baklanov

Speaker: Maxim V. Klyushnikov

October 2017



Existing and promising remote sensing systems from JSC "RSC "Progress"



Remote sensing system Resurs-P has three satellites and intended for high-resolution, wide-swath and hyperspectral sensing. This system is developed by order and specification of Roscosmos for socio-economic development of Russian Federation and international cooperation.

Resurs-P satellites can take images in panchromatic, multispectral and hyperspectral bands, and transmit they to ground stations. Images from these satellites are used in Ministry of nature, Ministry of Emergency, Ministry of Agriculture, Russian Meteorology Agency, Cartography agency (Rosreestr) and other customers.

Ecology

- Pollution control;
- National parks monitoring;
- Disasters (floods, earthquakes, fires) monitoring.

Agriculture

- Soil quality analysis;
- Forests and fields monitoring;
- Search of drug-containing plants, control of it's destruction;
- Harvest forecast;
- Forest mapping;
- Wood mass evaluation.

Oil, gas and mining

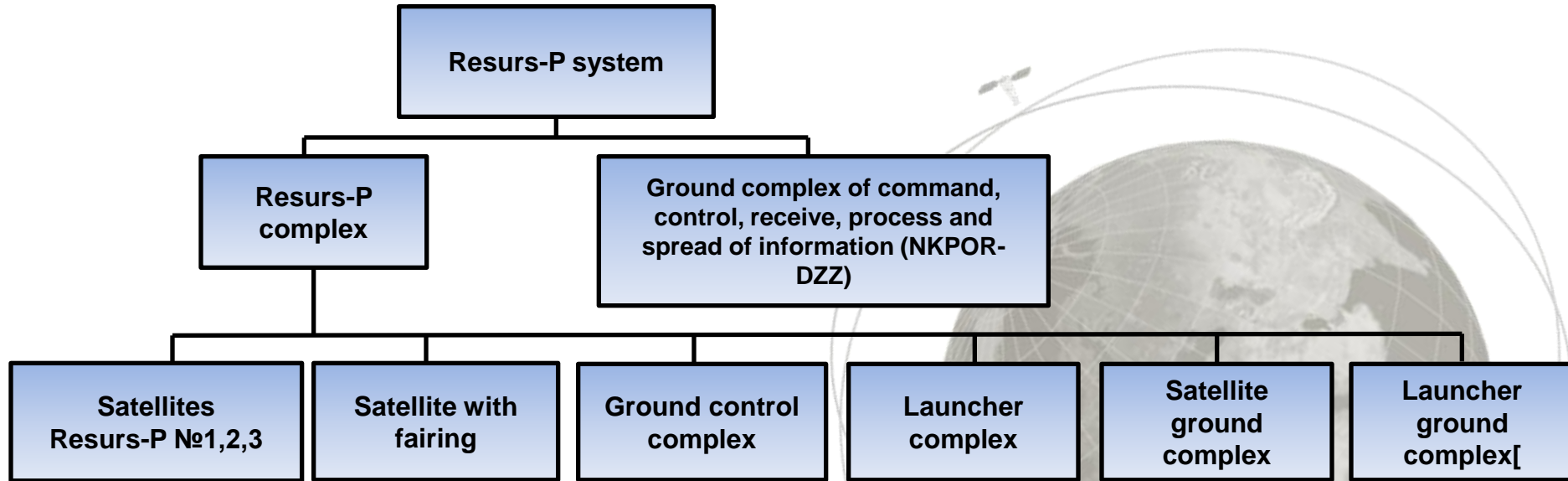
- Search locations of minerals ;
- Mineral identification;
- Lithography mapping.

Meteorology

- Long-term forecast;
- Gas analysis.

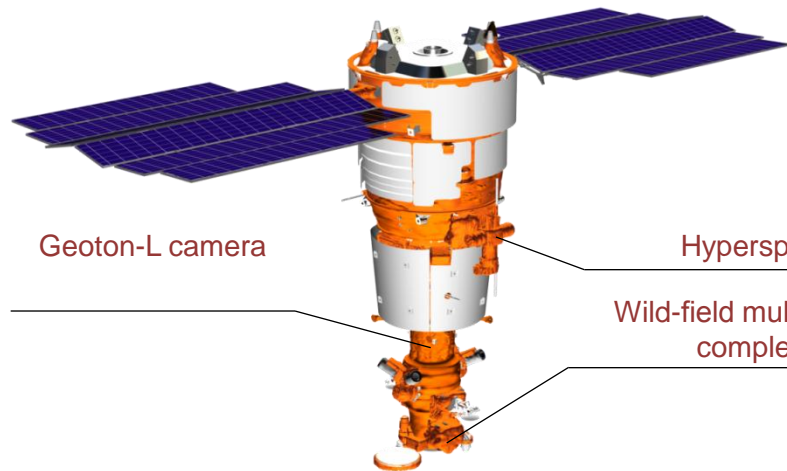
Others

- Archeology;
- Rescue operations;
- Mapping;
- Making DEM;
- Etc...

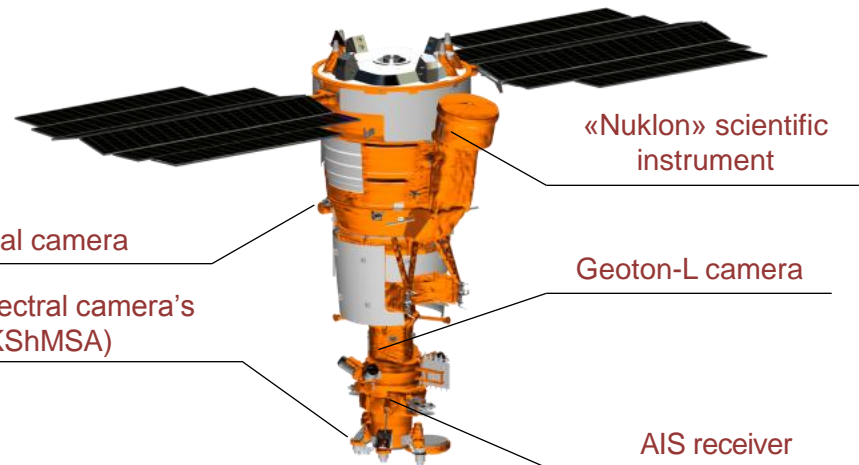


* Satellite Resurs-P №3 is the same as Resurs-P №1.

Resurs-P №1 & №3



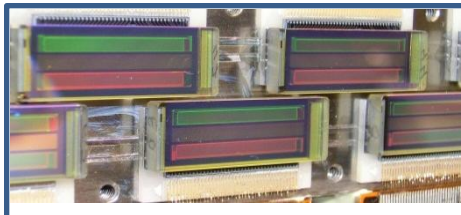
Resurs-P №2



	Resurs-P №1	Resurs-P №2	Resurs-P №3
Launch date	25 Jun 2013	26 Dec 2014	13 Mar 2016
Status	Operational 1 Oct 2013r.	Operational 1 Jun 2015r.	Operational 1 Sep 2016

«Geoton-L» camera with «Sangur-1U» focal plane assembly

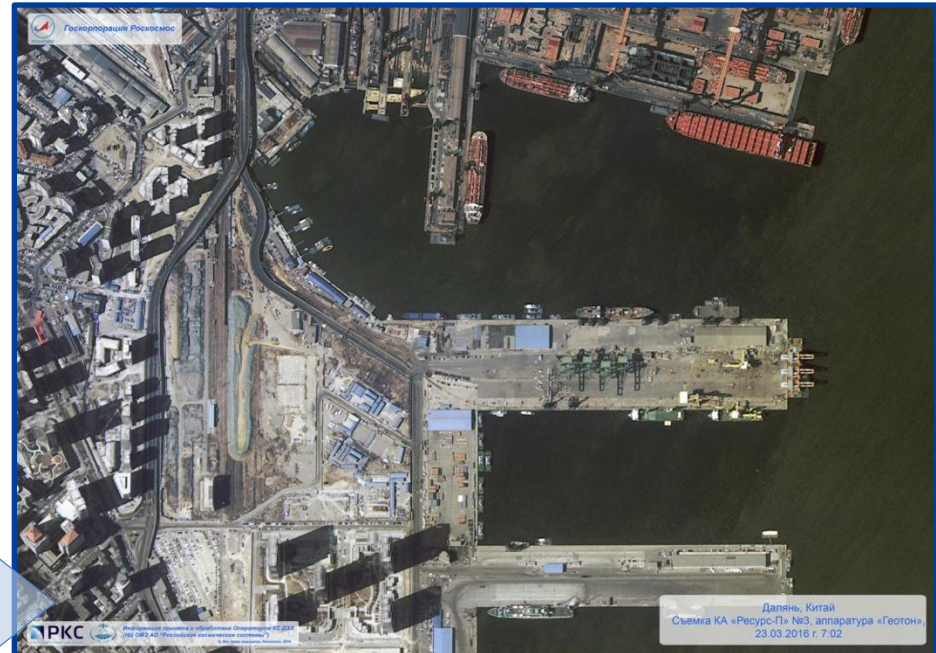
Main characteristics



High resolution Spatial resolution at nadir, m: - Panchromatic channel - Narrow-band channels	0,7-1,0 3,0-4,0
Swath width at nadir, km Review width, km	38,6 950
Spectral bands, μm - Panchromatic - Narrow bands	0,58÷0,80; 0,45÷0,52; 0,52÷0,60; 0,61÷0,68; 0,67÷0,70; 0,70÷0,73; 0,72÷0,80; 0,80÷0,90
Number of spectral bands	8
Location accuracy at nadir, m: - without refined attitude data - with refined attitude data	10-15 5
Acquisition capability of Geoton-L, km^2 / day	80 000



Russia, Moscow
Resurs-P №2; panchromatic channel

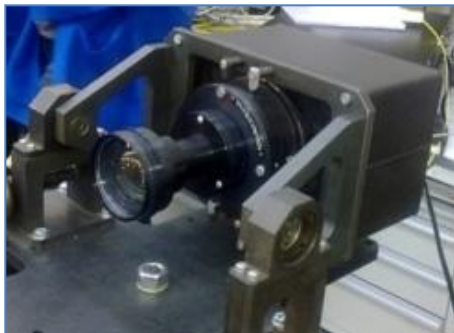
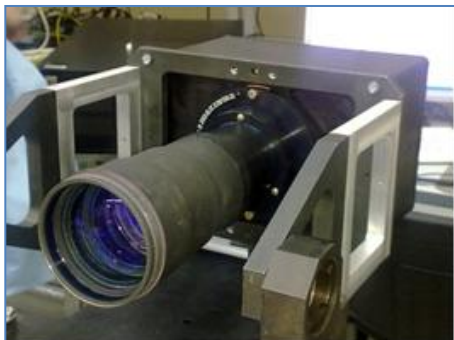


China, Daylan
Resurs-P №3; RGB image

Далань, Китай
Съемка КА «Ресурс-П» №3, аппаратура «Геотон»,
23.03.2016 г. 7:02

Wild-field multispectral camera's complex developed in RPE "OPTECS" – branch of JSC "RSC "Progress" (Zelenograd). Complex comprises two cameras – high resolution camera and medium resolution camera. Cameras can work separately as well as simultaneously.

Main characteristics



Characteristic	High-resolution camera		Medium-resolution camera	
	PAN	MS	PAN	MS
Swath width , km	97,2		441,6	
Resolution(GSD),m	11,9	23,8	59,4	118,8
Spectral bands, um	0,43÷0,70	0,43÷0,51 0,51÷0,58 0,60÷0,70 0,70÷0,90 0,80÷0,90	0,43÷0,70	0,43÷0,51 0,51÷0,58 0,60÷0,70 0,70÷0,90 0,80÷0,90
Focal length, mm	200		40	
Pixel size, um	5×5	10×10	5×5	10×10
Number pixels in line	8160	4080	8160	4080
ADC,bpp	12			



China, Luishun
Resurs-P №1 (high-resolution camera)

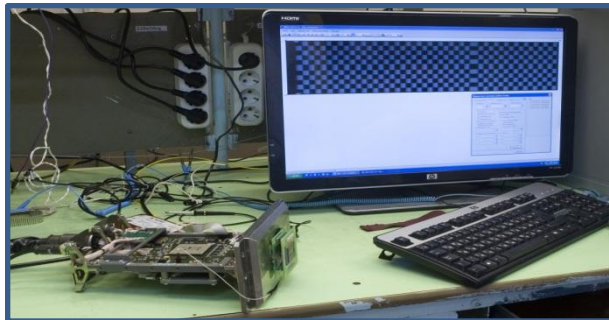
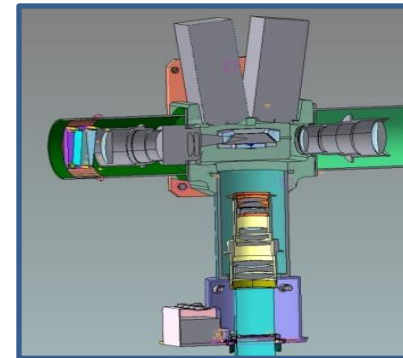


Italy, Sicily island
Resurs-P №1 (medium-resolution camera)

Hyperspectral camera is developed JSC «Zverev's Krasnogorsky zavod» in cooperation with RPE "OPTECS".

Main characteristics

Number of spectral bands	96 - 216
Spectral resolution, μm	5 - 10
Swath width, km	30
Spatial resolution, m	25 - 30
Maximum SNR	200+
ADC, bpp	14





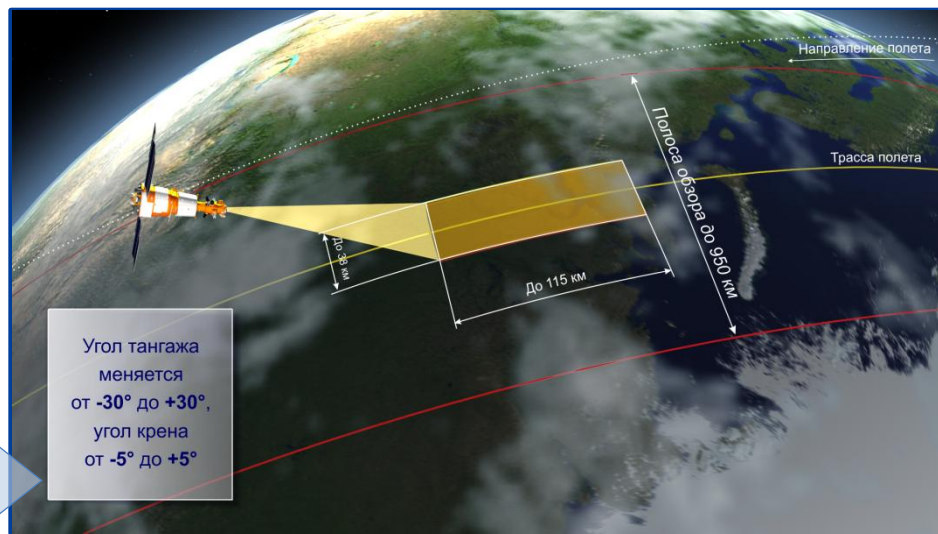
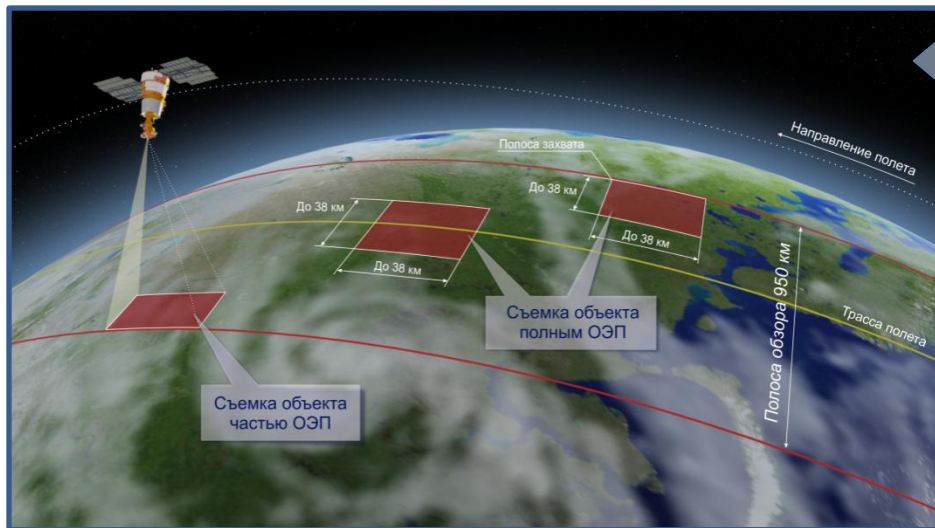
China, Shanghai
Resurs-P №1

UAE, Abu Dhabi
Resurs-P №1



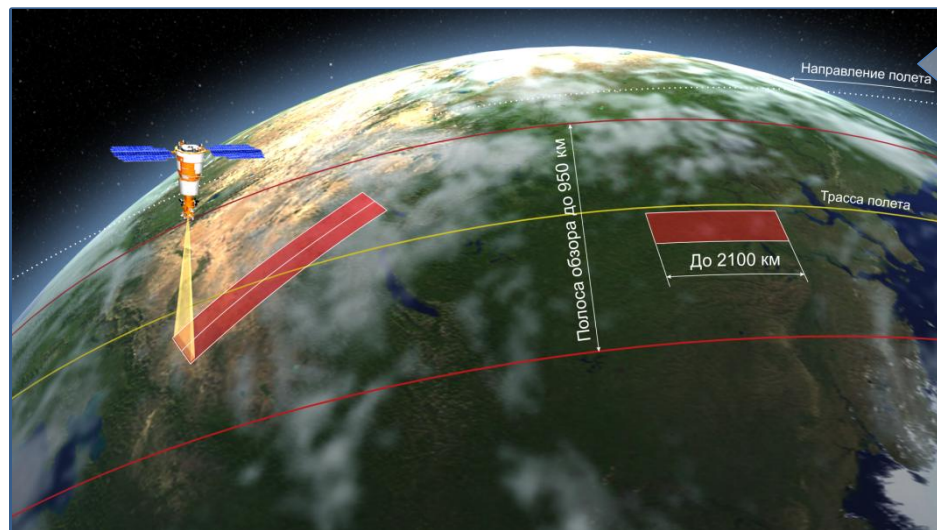
- Spot mode **28 x 28 km**;
- Long strip mode **from 2 to 300 s** length, width fixed orientation or variation azimuth;
- Stereo area mode, up to **115 km** length
- Large area mode, up to **133 km × 317 km**;
- Various combinations of high-resolution capturing, KShMSA capturing and hyperspectral capturing in all combinations;
- Using from 1 to 6 subzones (across scan) of Geoton-L camera;
- Simultaneous acquisition and data transmission to one of 20 ground stations;
- Transmission of previously recorded data to one of 20 ground stations.

Spot mode

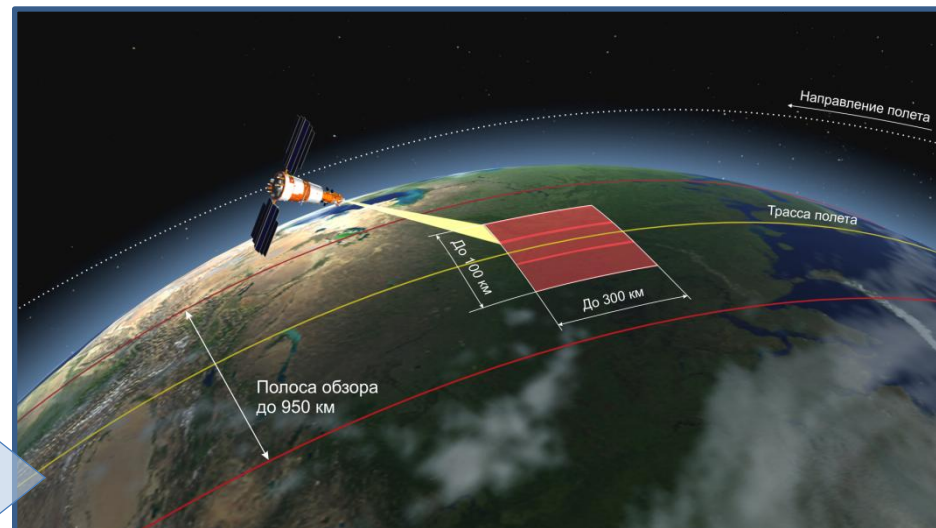


Stereo mode

Long strip mode



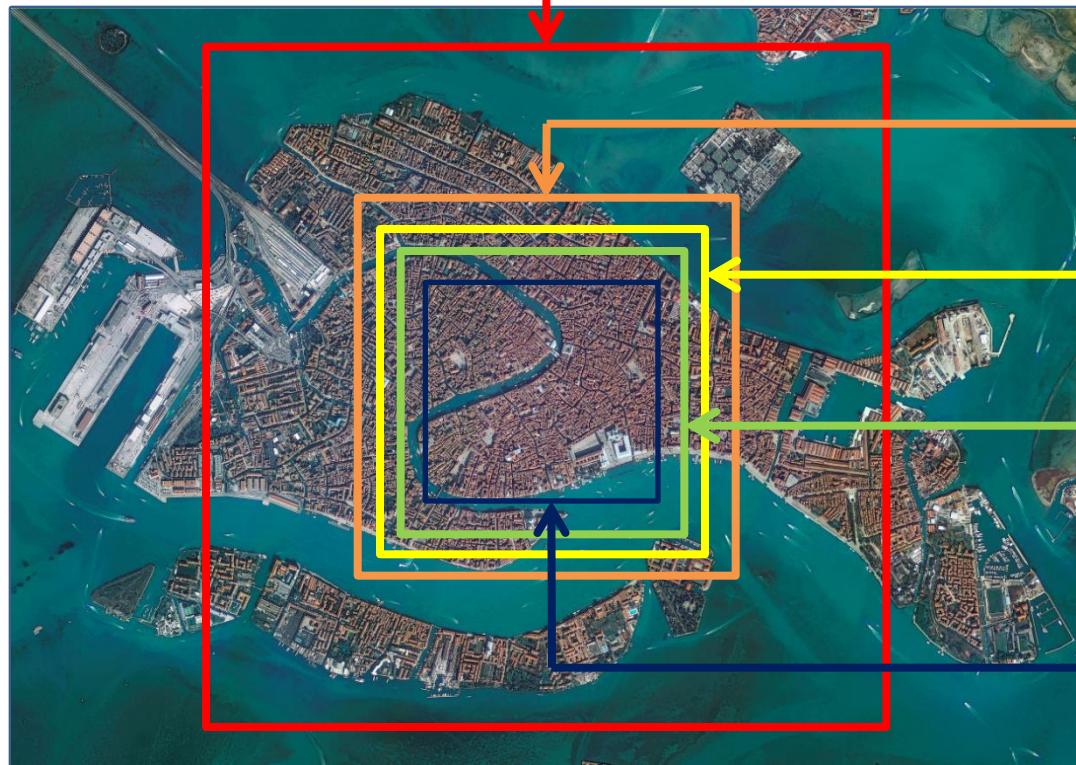
Large area mode



Comparison Resurs-P with foreign satellites

		Pesurs-P (Russia)	Ikonos-2 (USA)	GeoEye-1 (Usa)	Pleiades-1A, 1B (France)	Kompsat-3 (Korea)	World-View-3 (USA)
Launch year		№1 – 2013 №2 – 2014 №3 - 2016	1999	2008	1A – 2011 1B – 2012	2012	2014
Resolution, м	PAN	0,7*	0,8*	0,41	0,7*	0,7	0,31
	MS	2,1*	3,2*	1,65	2,8*	2,8	1,24
Swath width	km	38,6	11	15	20	16,8	13,2
	Pixels (PAN)	54300	13500	35600	30000	-	42200
Number MS-bands		7	4	4	4	4	16
Hyperspectral camera		Yes	No	No	No	No	CAVIS
Wide-angle camera		Yes	No	No	No	No	No
Location accuracy (without refined attitude data), STD		<15	10	2-6	<10	-	4

Comparison Resurs-P swath width with foreign satellites



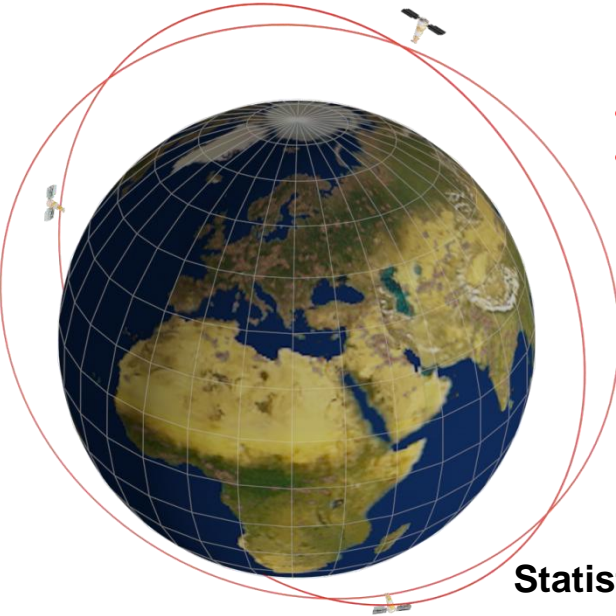
Resurs-P (Russia)
38,6 x 38,6 km
R=0,7-1 m

Pleiades-1A, 1B (France)
20 x 20 km
R=0,7 m

Kompsat-3 (Korea)
16,8 x 16,8 km
R=0,7 m

GeoEye-1 (km)
15 x 15 km
R=0,41 m

World-View-3 (USA)
13,2 x 13,2 km
R=0,31 m



- For 3 satellite's constellation:
- Efficiency of information delivery → **from 30 min to real-time;**
 - Acquisition capability :

- 1 ground station - 250 000 km²;
- 2 ground stations - 500 000 km²;
- 3 ground stations - 750 000 km².

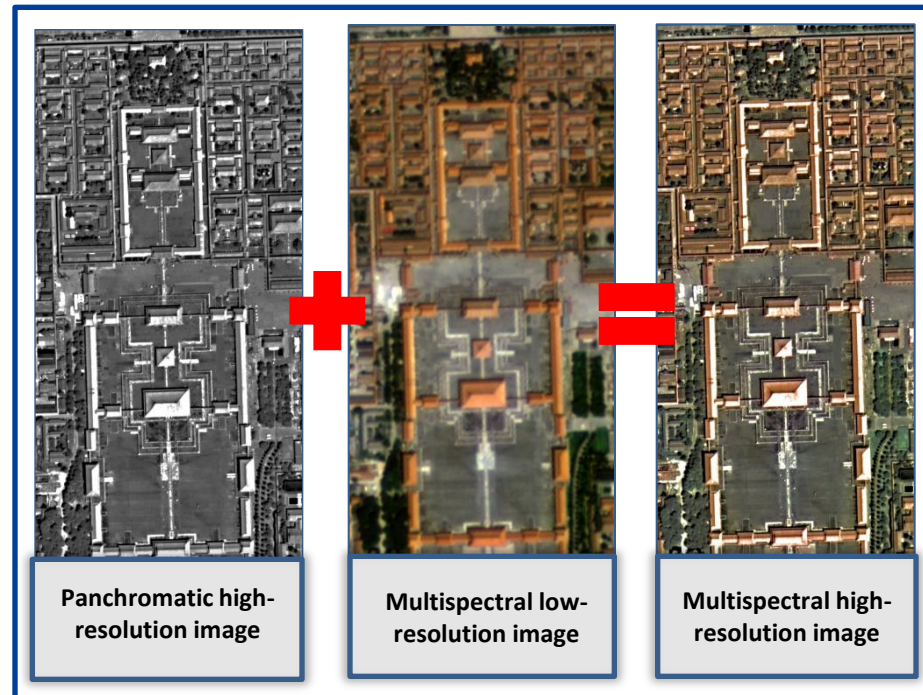
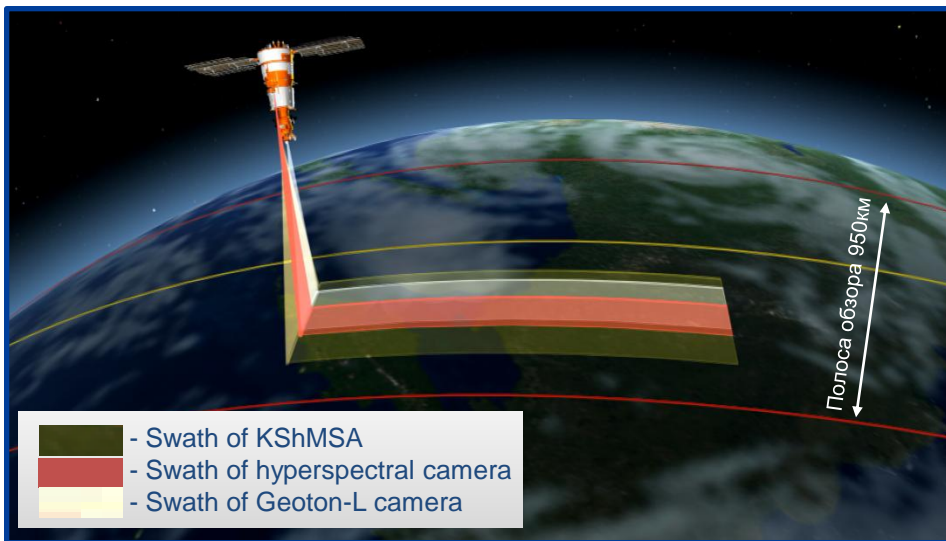
System with 3 satellites allow daily revisit any point of Russian Federation.

Statistical data of Resurs-P №1, №2 and №3:

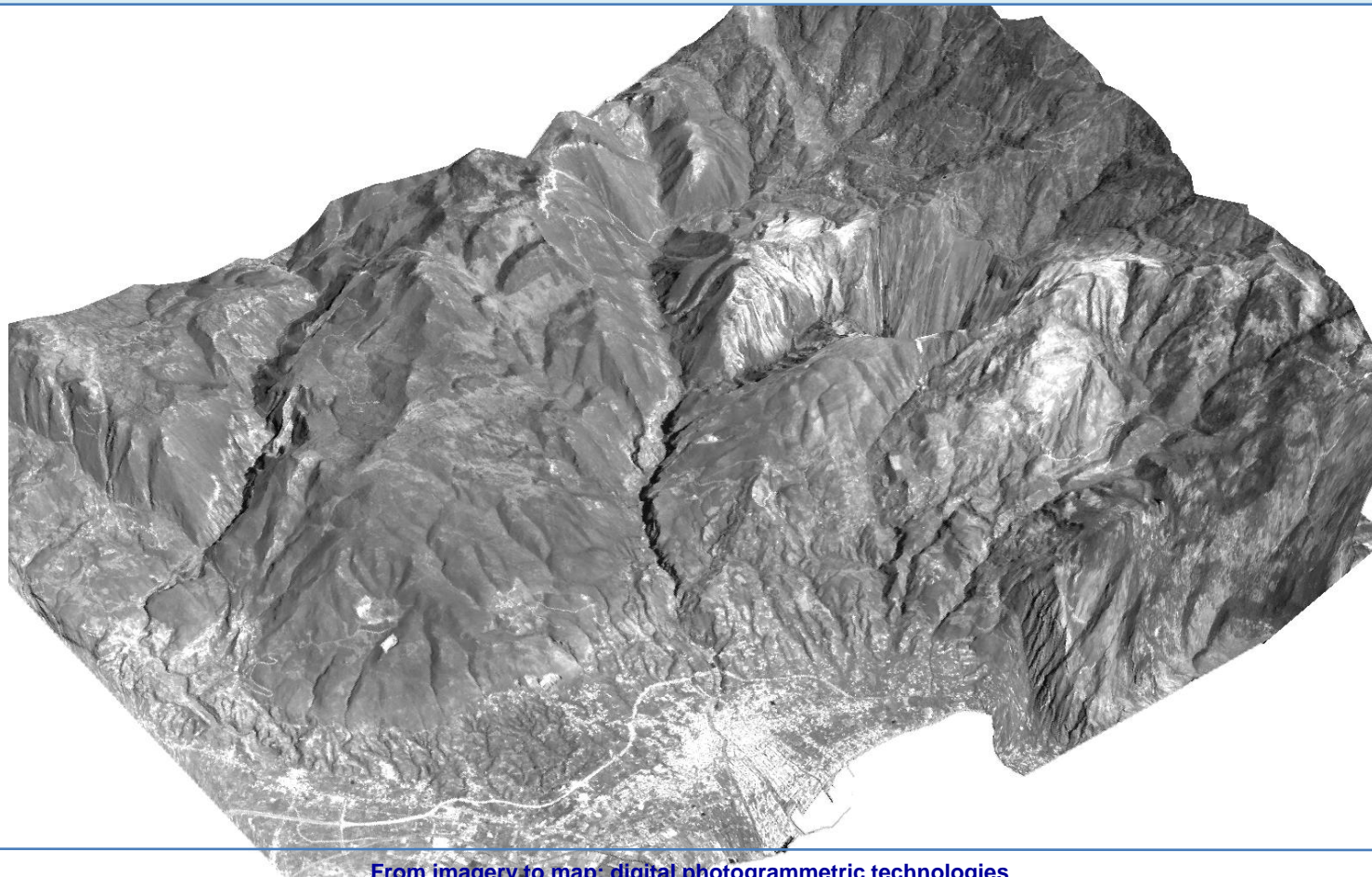
	Camera	Resurs-P №1	Resurs-P №2	Resurs-P №3
Acquired area, mln. sq.km. total/RU (02.09.2016r.)	Geoton-L	115,07 / 47,19	64,22 / 21,96	18,97 / 8,78
	KShMSA h.r.	211,24 / 149,14	149,74 / 116,25	136,82 / 100,88
	KShMSA m.r.	332,28 / 113,33	233,61 / 139,06	413,80 / 305,66
	Hyperspectral	6,05 / 3,71	3,58 / 2,38	1,25 / 0,40

Simultaneous acquisition of different instruments

Pansharp imagery



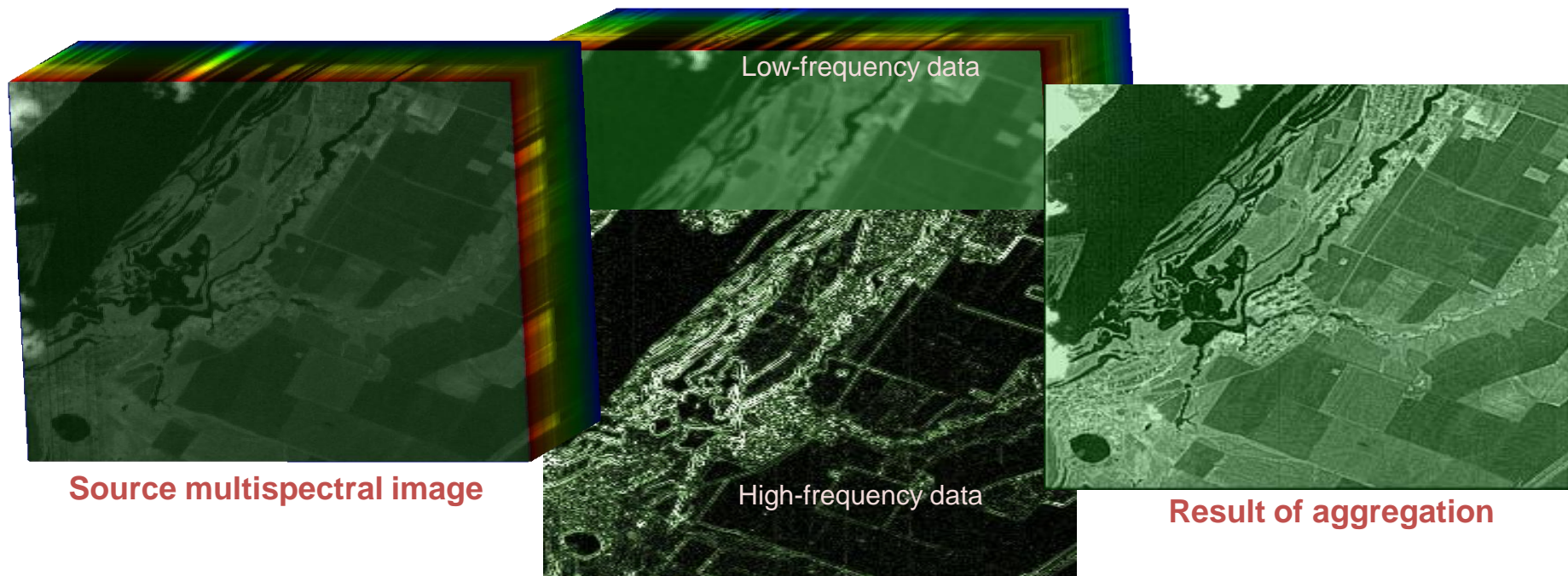
DEM based on stereo mode image



Thematic processing tools

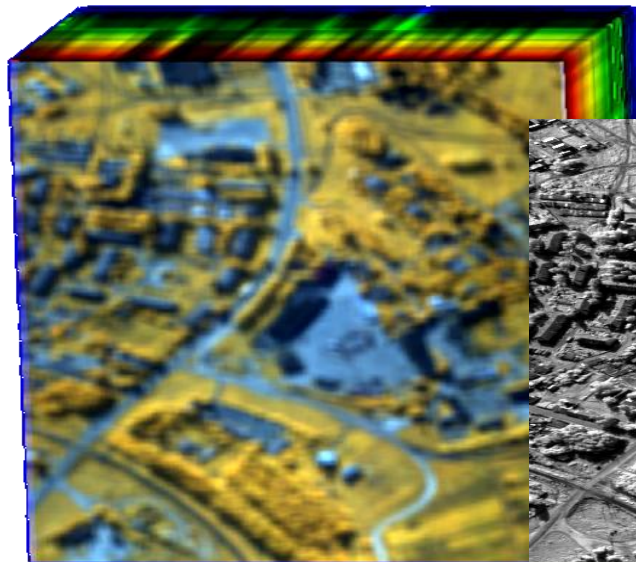
Aggregation of information

Aggregation multispectral data with high-resolution data



Thematic processing tools

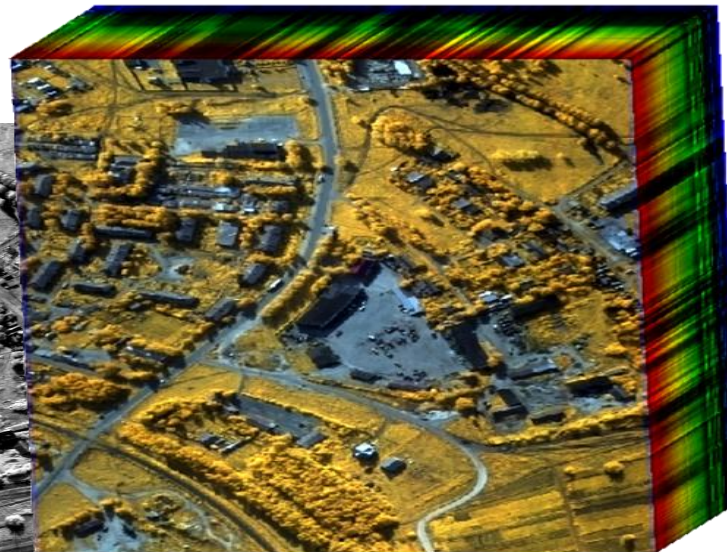
Aggregation hyperspectral data with high-resolution data



Hyperspectral image



Panchromatic image

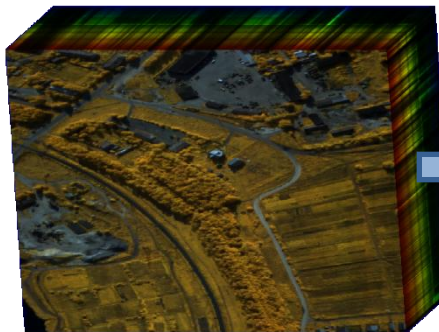


Result of aggregation

Thematic processing tools

Object identification via spectral data

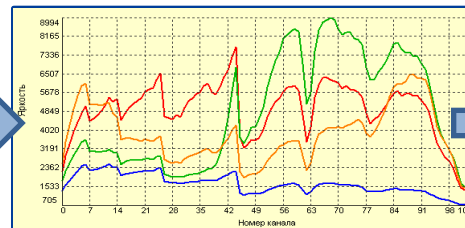
Hyperspectral image



Segmented image

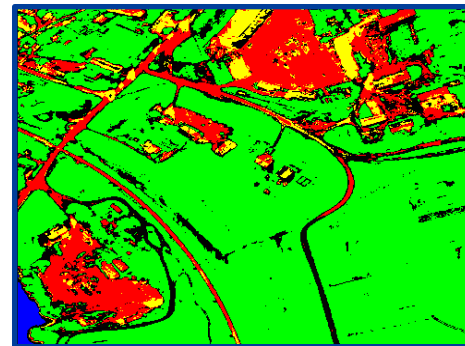


Spectral data on from image



Database

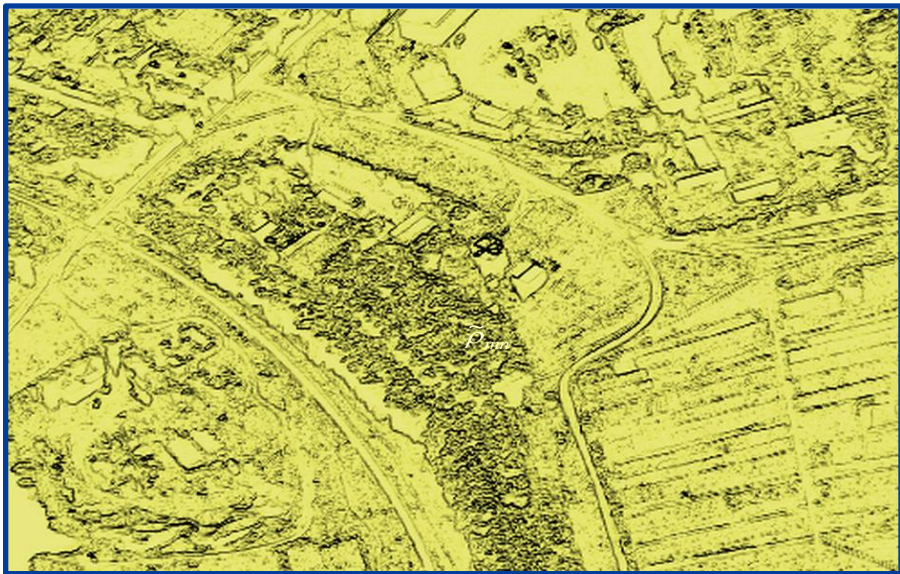
СОПОСТАВЛЕНИЕ
СПЕКТРАЛЬНЫХ
ХАРАКТЕРИСТИК



- - grass
- - roads
- - water
- - buildings

- Phase 1.** Segmentation image via spectral difference
- Phase 2.** Calculation spectral data for all segments
- Phase 3.** Comparison spectral data with database (spectral angle method)
- Phase 4.** Object identification

Segmentation image via spectral difference



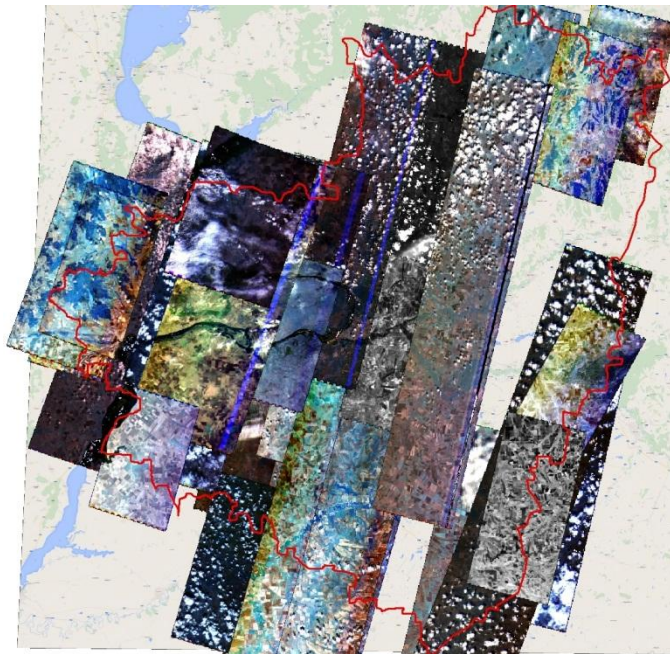
Segmented image via signal difference of neighboring elements



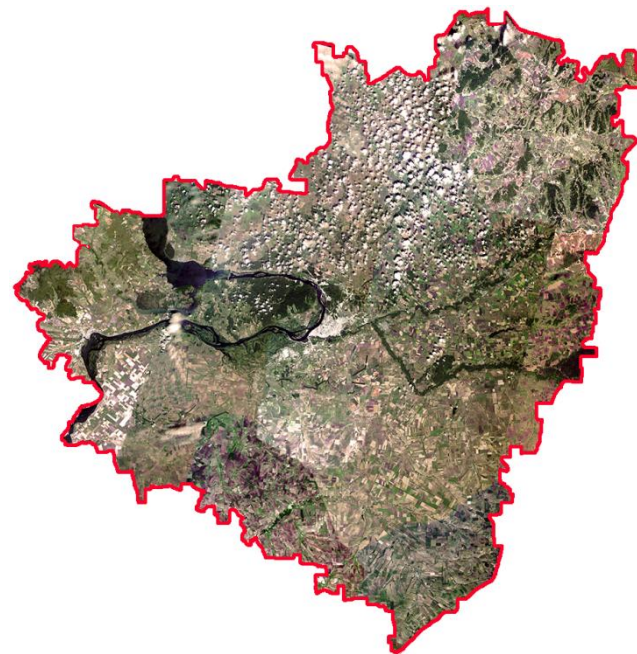
Segmented image via spectral difference of neighboring elements

Customer	Tasks	Required data
Ministry of agriculture and food	<ul style="list-style-type: none"> • Mapping of agriculture fields. 	KShMSA (high-resolution)
Ministry of property	Mapping of city's, town's and district's borders	Geoton-L
Dept. of IT and communications	Refresh thematic layers of regional GIS	Geoton-L
Ministry of forests, protection of the environment and nature management	<ul style="list-style-type: none"> • Search the illegal mining; • Search the illegal garbage dumps; • Forest's monitoring; • Water's monitoring. 	Geoton-L
Ministry of the interior	Search the illegal buildings and illegal agriculture activities	Geoton-L

Coverage of Samara region in 2015



Samara region's coverage of Resurs-P (Geoton-L) images is 80%.
Total square of imagery is 100000 km².



Samara region's coverage of Resurs-P (KShMSA high-resolution) images is 96%.
Total square of imagery is 250000 km².

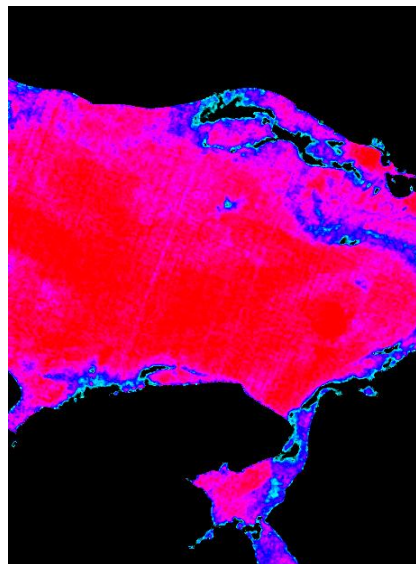


Kyibyshev's reservoir

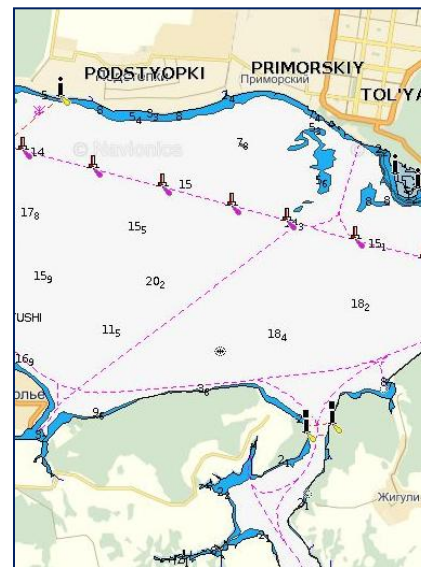
Bathymetry map of water object



Resurs-P image,
Sep. 2015



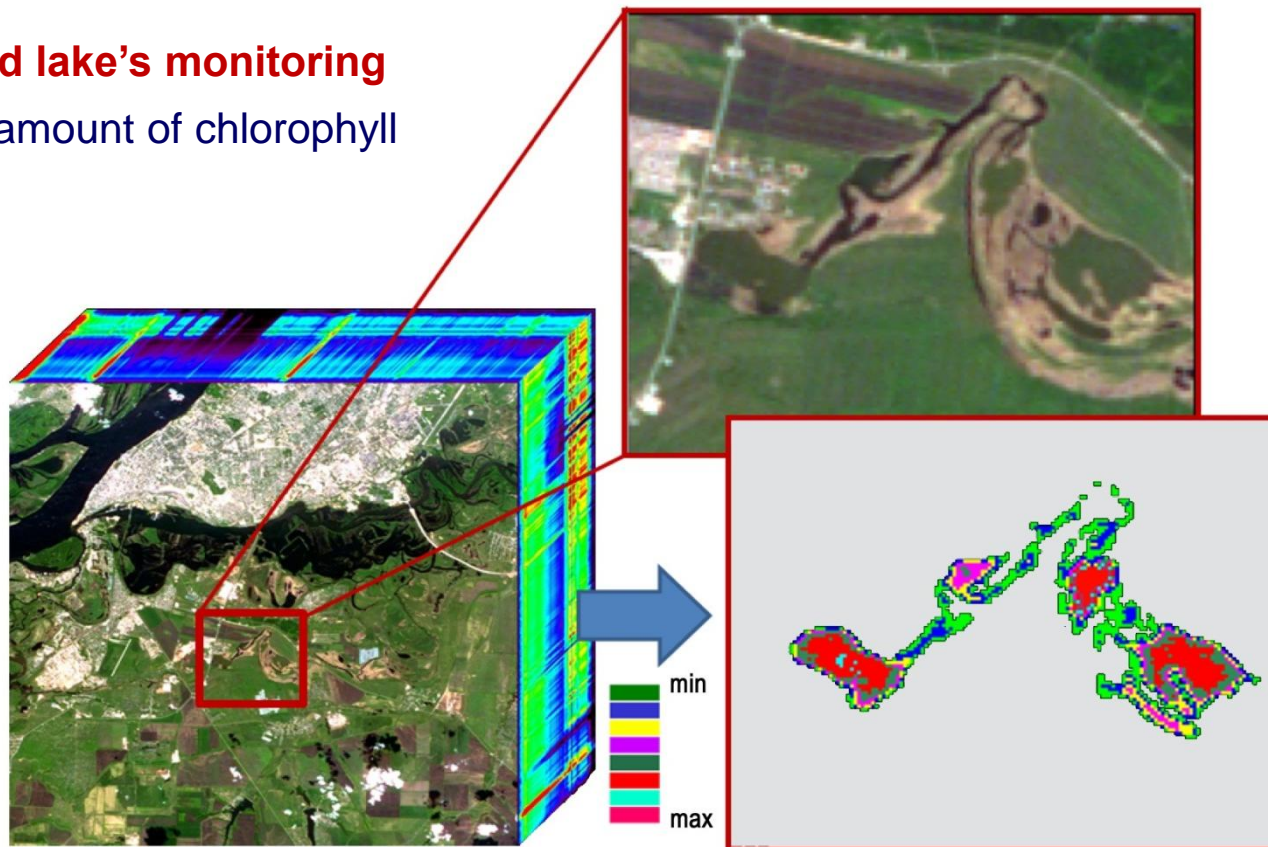
0 5 10 15 20
Bathymetry map , m



Refined attitude data

River's and lake's monitoring

Estimation amount of chlorophyll



Yaitskoe and Peschanoe lakes



Gypsum quarry in Samara region

Mining monitoring

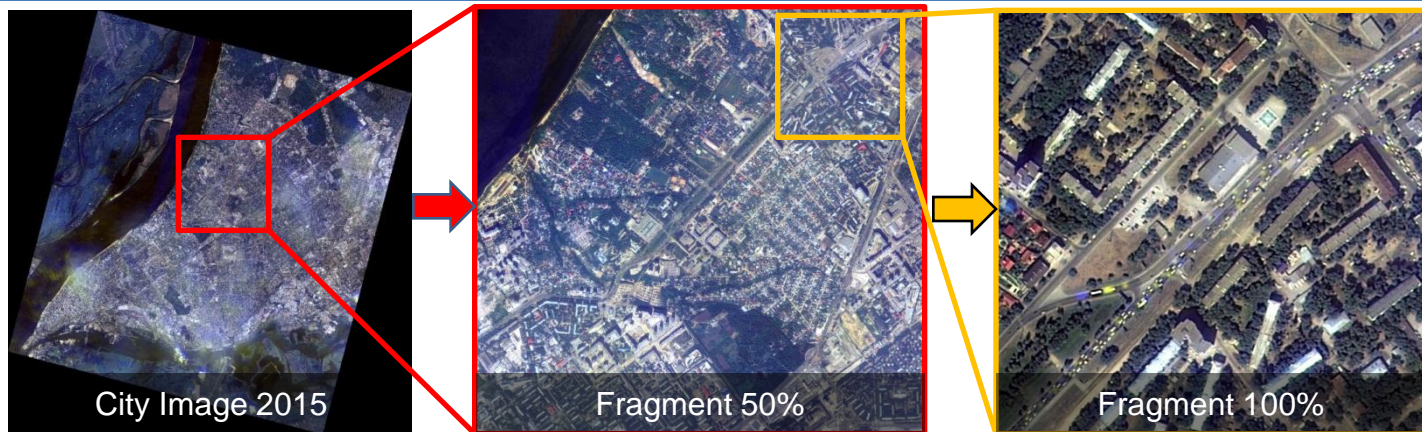


Garbage dump, Samara region

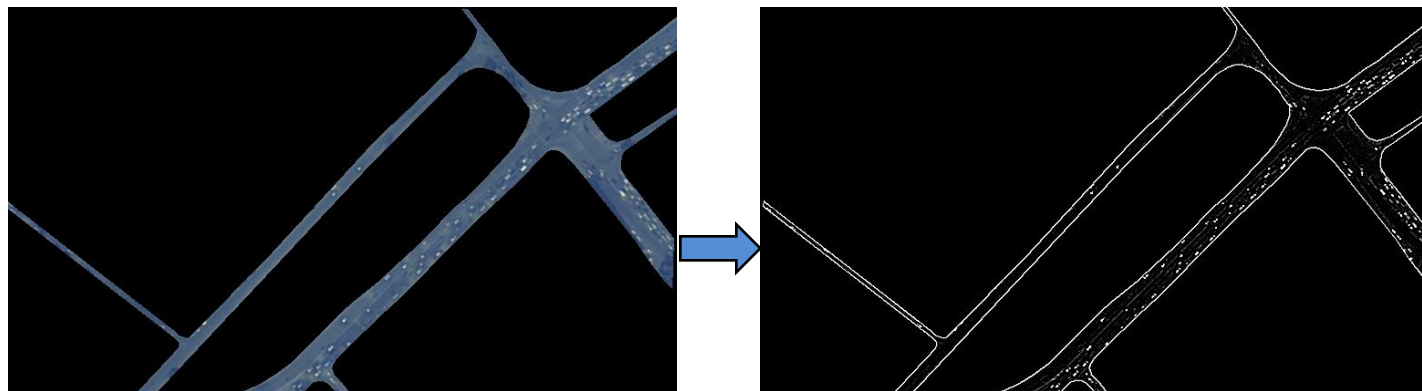
Garbage dumps monitoring

 Square 1,097 he (22.05.2014)

 Square 1,241 he (23.06.2015)



Traffic monitoring



Roadmap mask
(Novo-Sadovaya str., Samara)

Vehicle's selected

Road construction monitoring



2014



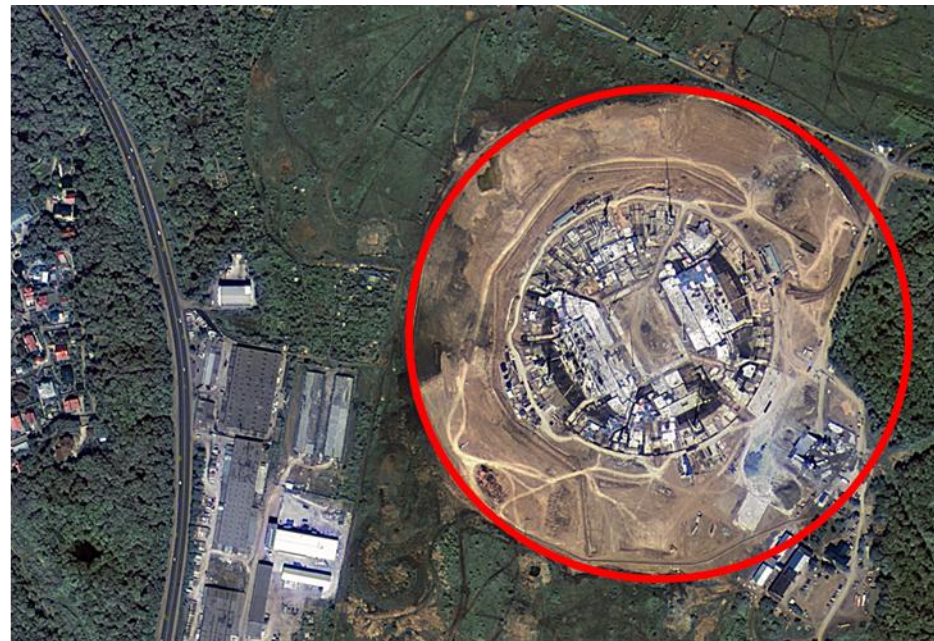
2015

Car interchange construction in Chernoreche town, Samara region

Monitoring of stadium construction for World Championship 2018



2014

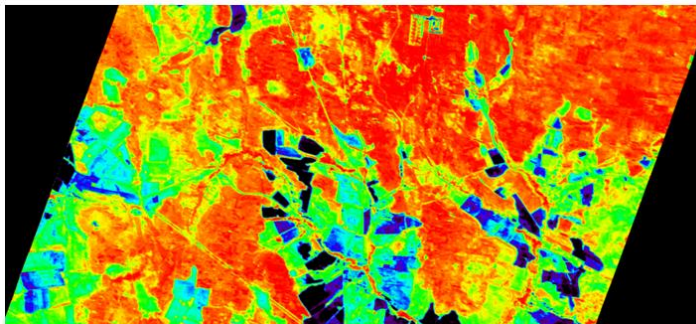


2015

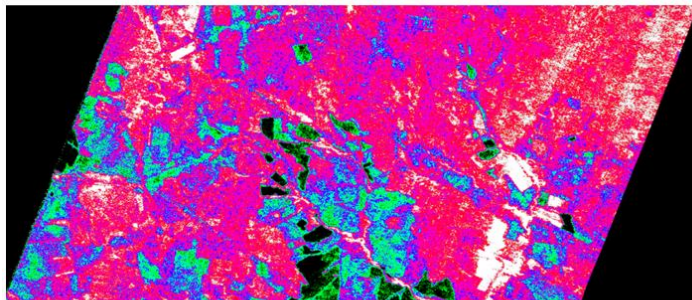
Forest's and agriculture's fields monitoring



Hyperspectral image,
Syzran's forest 12.07.2015

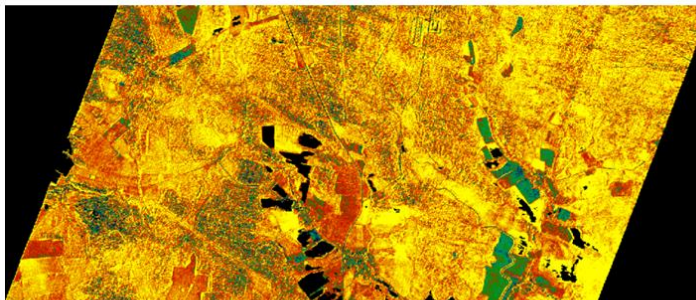


-1 -0.5 0 0.5 1
NDVI



0.6 0.7 0.8 0.9 1 1.1 1.2

Water supply index



0 0.5 0.1 0.15 0.2

Reflection index of Anthocyanin

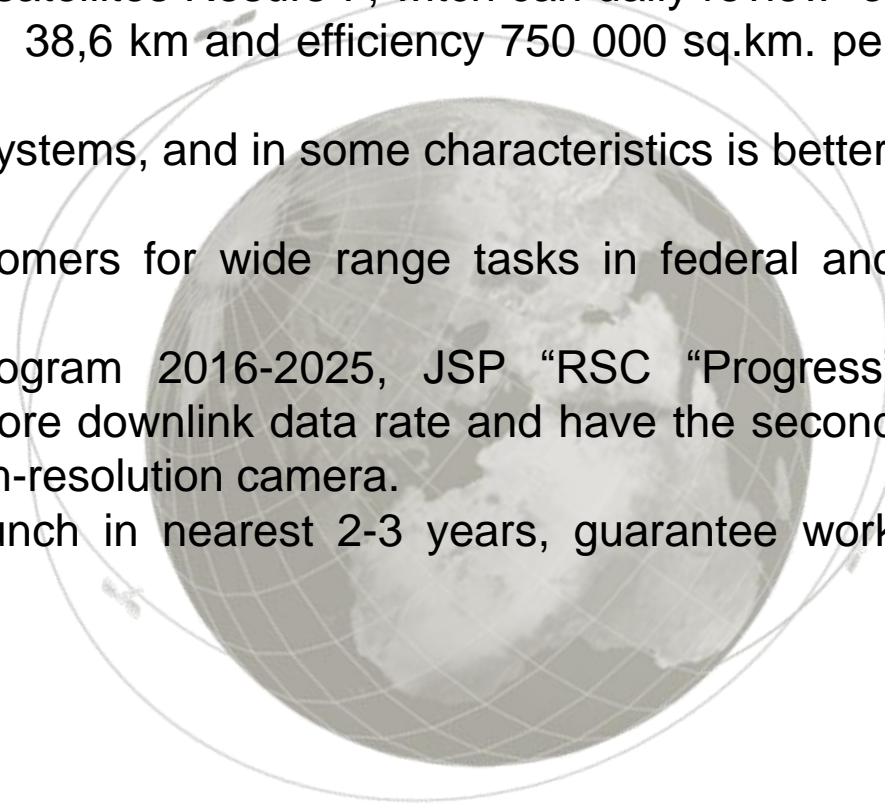
In 2016 was created the constellation of 3 satellites Resurs-P, which can daily review of earth surface with resolution 0,7-1,0 m in swath 38,6 km and efficiency 750 000 sq.km. per day.

Quality of information is similar of foreign systems, and in some characteristics is better, then competitors.

Resurs-P images are used Russian customers for wide range tasks in federal and regional needs.

Currently, according Federal Space Program 2016-2025, JSP "RSC "Progress" modernizes Resurs-P. Next satellites will have more downlink data rate and have the second high-resolution KShMSA camera instead medium-resolution camera.

Resurs-P №4 and №5, scheduled to launch in nearest 2-3 years, guarantee work remote sensing system till 2023 year.





Thank you for attention

JSC «RSC «Progress»

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