

Resurs-P Earth Remote Sensing constellation

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The Resurs-P constellation was created by the PROGRESS Space-Rocket Centre JSC (RKTs-Progress) on order of the ROSCOSMOS State Corporation under the Federal Space Program based on the existing experience and groundwork in improvement of target characteristics in the following ways: increase in number of narrow spectral bands, provision of hyperspectral, wide-angle, area and stereo imaging, provision of image gridding with an accuracy of no worse than 15m, increase of mission life from 3 up to 5 years.

The Resurs-P constellation is built for highly detailed, wide-angle and hyperspectral detailed optoelectronic Earth observation and meant to provide information for solution of the following tasks:

- Creation and upgrading topographic and other maps;
- Monitoring of emergency regions, areas of natural disasters, accidents anthropogenic disasters, assessment of damages, planning of recovery work;
- Monitoring of farming lands;
- Inventory of natural resources and monitoring of anthropogenic activities to provide rational activity in different branches of the economy;
- Monitoring of conservation areas;
- Search of oil, natural gas, ore and other mineral deposits;
- Monitoring of development of land, obtaining of data to assess land from the point of view of suitability for social and economic activity;
- Environmental monitoring;
- Assessment of ice conditions;
- Environmental assessment.

Obtained information can be also used for development of international cooperation of the Russian Federation in the field of Earth observation and solution of other pressing problems of the Earth remote sensing (ERS).

For the purpose of maximum satisfaction of national economy needs and according to the

Federal Space Program, RKTs-Progress built and launched the Resurs-P #1 spacecraft (Fig. 1) on 25th of June, 2013 from the Baikonur cosmodrome. The flight test program was fully implemented in three first months after the launch and the spacecraft was accepted to service as of October 1, 2013 by Poscosmos's Order #192 of October 4, 2013.

Resurs-P #2 was launched (Fig. 2) on December 26, 2014. Upon completion of flight tests it was accepted to service as of June 1, 2015 by Poscosmos's Order #99 of June 1, 2015. Main performance characteristics of Resurs-P #2 are the same as those of Resurs-P #1. For the purpose of extending the capabilities of Resurs-P #1, Resurs-P #2 have the following scientific equipment added on:

- the NUKLON research hardware;
- the onboard radio system of automatic ship identification.

After valid tests, the Resurs-P constellation comprising two spacecraft (#1 and #2) was accepted to service on November 10, 2015.

On March 13, 2016 the Resurs-P Earth remote sensing spacecraft #3 (Fig. 1) was put into orbit. At present the work is underway to commission Resurs-P #3 and to perform flight testing of the three-spacecraft constellation. The Resurs-P spacecraft #3 is already providing consumers with high-quality imagery on requests.

Spacecraft of the Resurs-P family feature qualitatively new capabilities including new target equipment. One of the main principles of forming the appearance of the Resurs-P family was use of technical solutions developed during creation of the Resurs-DK1 spacecraft. The capabilities of the latter were not only preserved but also improved regarding the swath width and panchromatic and spectral resolution. The swath width of highly detailed imaging is 38.6 km, and the coverage is up to 950 km. Besides, the consumer properties, accuracy of image gridding and dynamic behavior of spacecraft were improved too.



Fig. 1. General View of Resurs-P #1 and #3

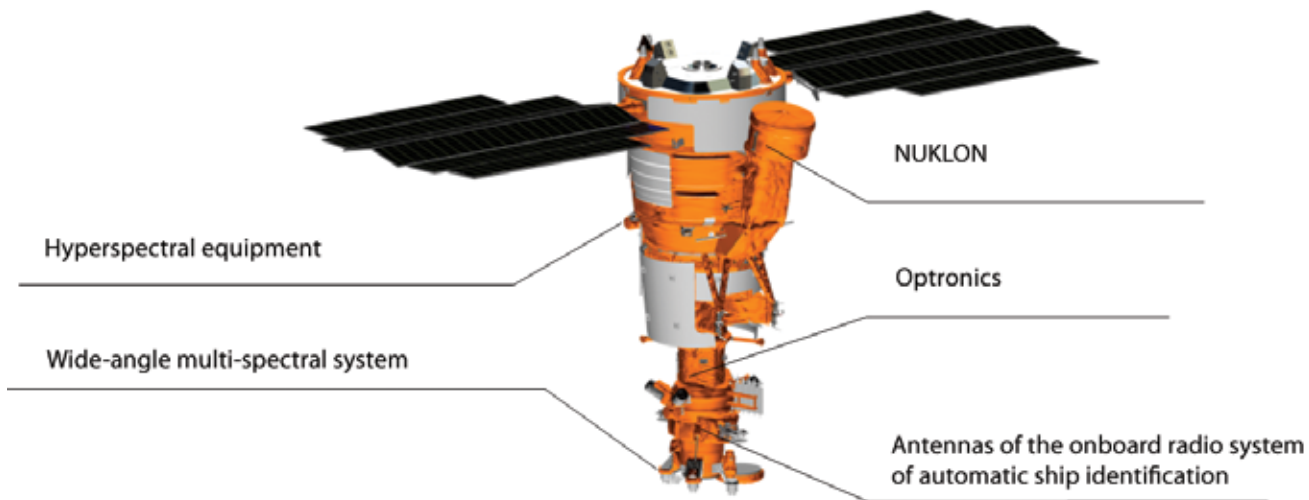


Fig. 2. General View of Resurs-P #2

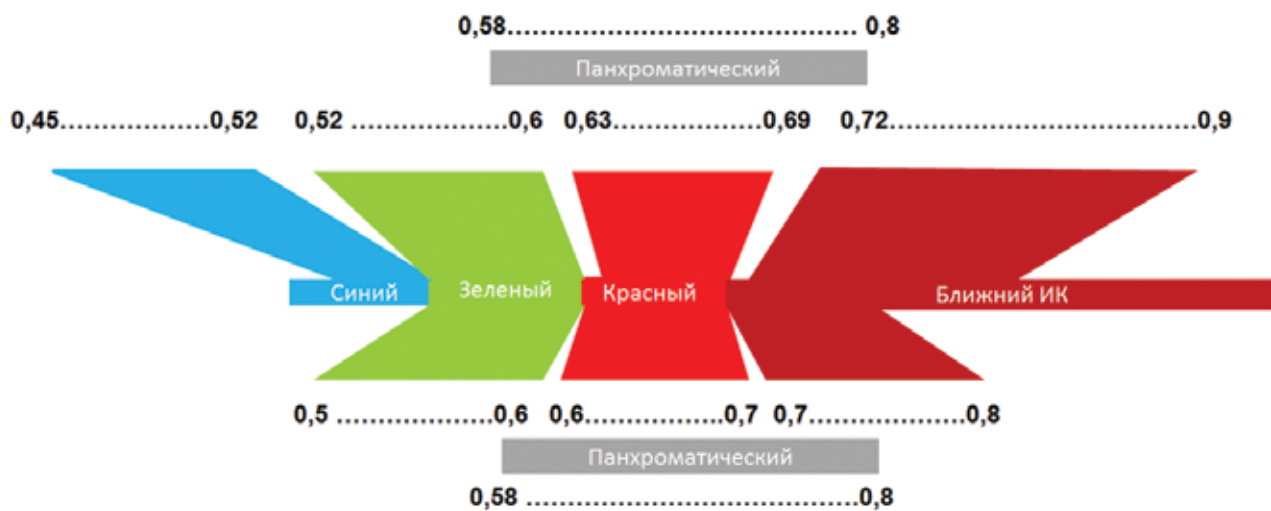


Fig. 3. Comparison of spectral ranges of Resurs-P and Resurs-DK1

Created within the framework of spacecraft constellation development, Resurs-P #1, #2, and #3 are unique for their class since, as opposed to single-purpose satellites designed to solve one task, Resurs-Ps are multi-purpose spacecraft, which is achieved due to several types of imaging equipment installed on them.

Resurs-Ps have the Geoton-L1 optronics that allow obtaining highly detailed imagery with panchromatic resolution of no worse than 1 m and resolution of no worse than 3-4 m in narrow spectral bands. The target equipment of the Resurs-P family's spacecraft also comprises a hyperspectral imaging equipment (GSA), developed by PAO Krasnogorsky Zavod im. Zvereva plant, and a wide-angle multi-spectral system (KShMSA), developed by RKTs-Progress's branch NPP OPTEKS.

GSA's swath is 30 km, the number of spectral bands is 130, resolution is about 30 m. KShMSA allows wide-angle observation with 12-m resolution across a swath of no less than 100 km

and with 60-m resolution across a swath of no less than 450 km.

Processed highly detailed Earth image data obtained by the Resurs-P constellation are widely used for solving different Earth observation tasks in the interests of different customers.

Resurs-Ps' image data have shown they are in considerable demand for fire fighting and flood monitoring in the territory of Russia and particularly in Siberia and the Far East. Emergency regions are monitored both by KShMSA and Geoton-L1 daily. Imagery obtained by the Resurs-P constellation also has shown its great demand in the international arena.

Yielding to no foreign analogues in respect of their consumer properties, the space-based imagery features a price, which is attractive for nongovernmental consumers, and profitable conditions of commercial delivery.

The pictures below show example image data obtained by spacecraft of the Resurs-P family.



Fig. 4. Image taken by the Geoton-L1 optronics of Resurs-P #1



Fig. 5. Image taken by the ShMSA-VR wide-angle multi-spectral high-resolution equipment of Resurs-P #2

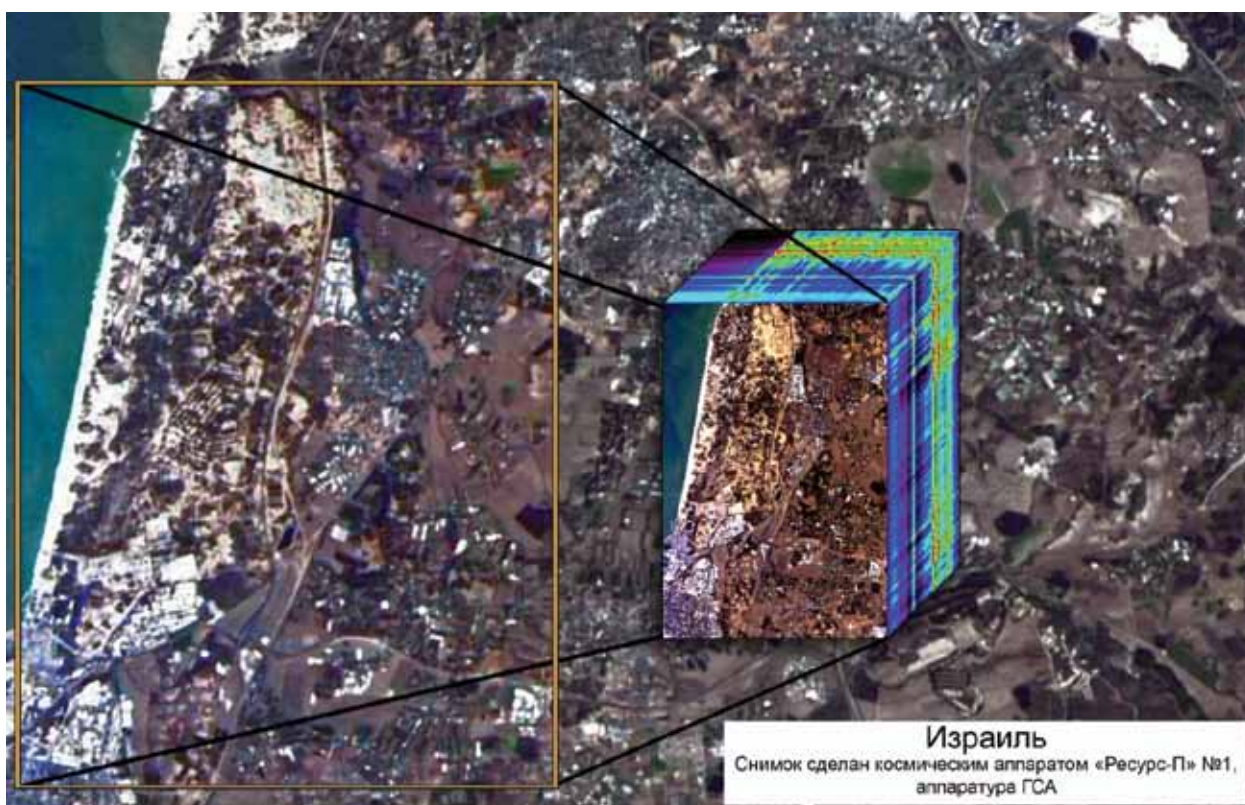


Fig. 6. Image taken by the hyperspectral equipment of Resurs-P # 1



Fig. 7. Image taken by the Geoton-L1 optronics of Resurs-P #3

Not yielding to foreign satellites in the respect of performance or target data properties, spacecraft of the Resurs-P family take their place in the world's cluster of Earth observation satellites. The Resurs-P efficiency in solving of a wide range

of social and economic tasks is provided by its capacity to comprehensively observe the Earth surface.

Table 1 summarizes technical characteristics of the Resurs-P spacecraft and foreign analogues.

Table 1. Comparison of Resurs-P to foreign satellites.

Parameter	Pecypc-II (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, m - PC-channel - MS-channel	0.7* 2.1*	0.8* 3.2*				
Swath - km - pixel	38.6 ~54,300	11 -				
Number of spectral channels (MS-channel)	7	4	4	4	4	16
Hyperspectral equipment	Yes	No	No	No	No	No
Wide-angle equipment	Yes	No	No	No	No	No
Geolocational accuracy (without reference points), RMS error	<15	10	2-6	<10	-	4

Comparative analysis of characteristics given in Table 1 reveals that the satellites – though being products from different periods of space engineering – are of the same class of Earth observation systems by their all characteristics, which determine consumer properties of image data obtained by them. The Geoton-L1 highly detailed imaging equipment installed on Resurs-P provides observation data with linear resolution on a level with the best foreign systems, insignificantly yielding to American observation systems only, and outperforms most foreign analogues in swath and number of spectral bands by 1.5-2.

The Resurs-P constellation, as opposed to foreign analogues, has hyperspectral observation equipment that provides imaging of the earth surface in over 100 separate spectral channels. The said equipment allows brand new observation data suitable for solving new ERS tasks. To sum it up we can say that high degree of image detailing, wide imaging swath, gridding accuracy and availability of hyperspectral equipment, put the Resurs-P ERS constellation on the same level with cutting-edge space-based observation systems. At present, commercial satellite constellations with similar resolution and performance are owned by the USA (GeoEye, WorldView), and France (Pleiades). Other countries own single satellites of highly detailed observation.

Beside three spacecraft, the key elements of the Resurs-P system are a ground control complex and

ground complex of ERS data planning, receiving, processing and distribution.

Taking advantage of the high degree of Resurs-Ps' operational autonomy, the ground control complex allows simultaneous control of the three spacecraft with the help of minimum operators, automates all tasks to control the flight of the spacecraft simultaneously operating in orbits through their entire mission life including cases of possible emergencies in any of.

The ground complex of Resurs-Ps' ERS data planning, receiving, processing and distribution provides prompt acquisition of imagery up to real time, generation of geo information products.

The spacecraft of the Resurs-P family have been successfully operating for several years providing ERS data of high quality to both Russian and foreign consumers, which are tens of federal and regional executive bodies representing different branches of the economy (agriculture, forestry, water industry, power industry, cartography and so on). At the middle of 2016 Resurs-P's Geoton-L1 highly detailed equipment imaged over 150 mln. km². It should be noted that domestic government consumers are provided with Resurs-P's Earth remote sensing data free of charge.

At present under the 2016-2025 Federal Space Program, the work is underway to build Resurs-P #4 and #5, which are planned for launch within the next 2-3 years.