Space Rocket Centre 'Progress', JSC

EXPERIMENTAL AND TECHNOLOGICAL SMALL SPACECRAFT 'AIST-2D': FIRST RESULTS OF ON-ORBIT OPERATION

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14 – 17 November, 2016
Agra, India

16th International Scientific and Technical Conference
'From Imagery to map: digital photogrammetric technologies'

Introduction

Experimental and technological (ET) small spacecraft (SSC) ‘Aist-2D’ was launched on 28 April, 2016 from spaceport ‘Vostochniy’ via rocket ‘Soyuz-2’ stage 1a with upper stage ‘Volga’ in cooperation with spacecraft ‘Lomonosov’ (designer – Corporation VNIIEM, JSC) and self-unit module of scientific and technical hardware ‘Contact-Nanosputnik’ (designer – Samara University).

RSC ‘Progress’, JSC is designer and operator of the SSC ‘Aist-2D’, providing management, reception and processing of receiving information.

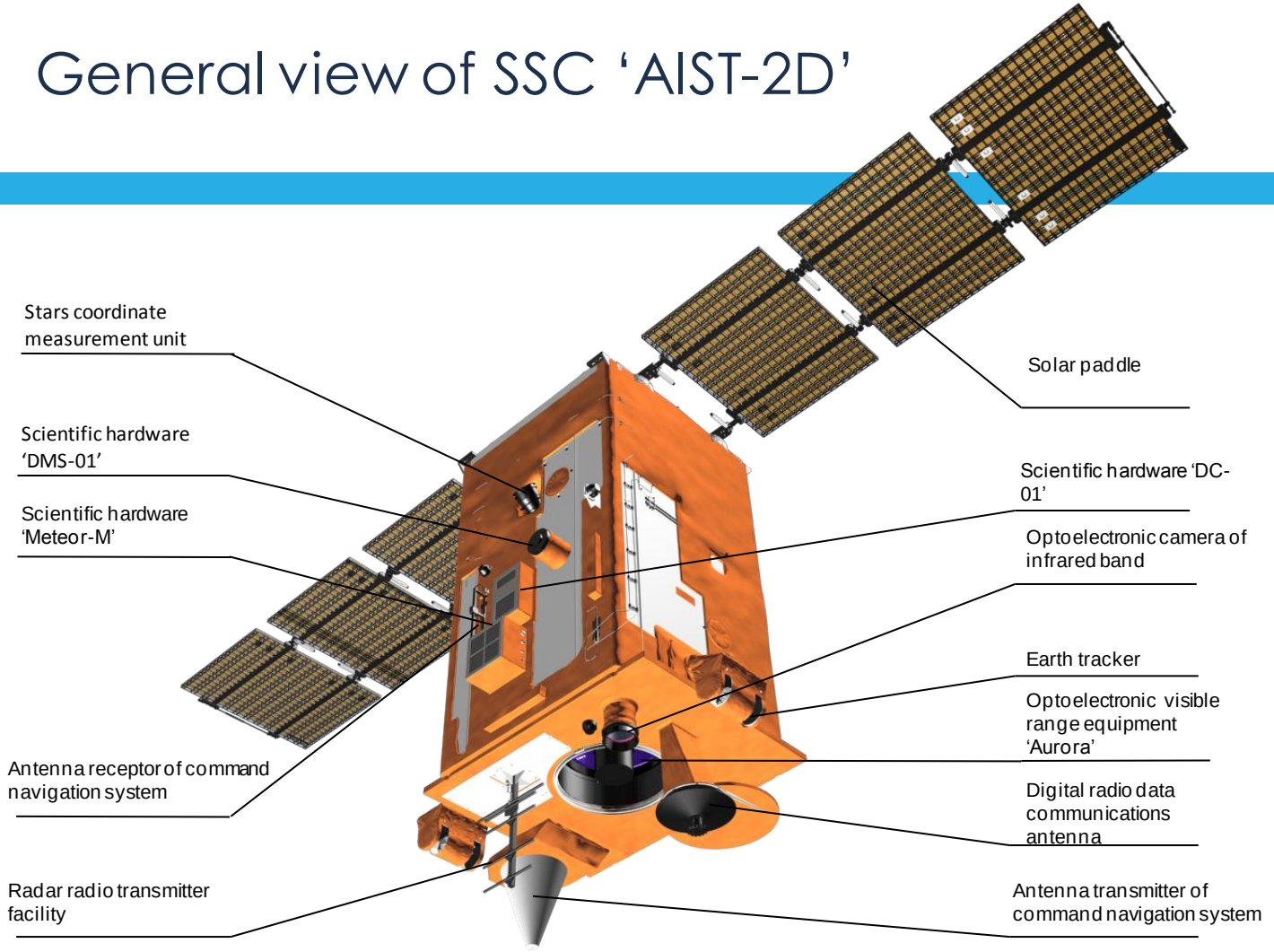
Purpose and issues to solve

Space complex ‘Aist-2’ with SSC ‘Aist-2D’ is intended to develop and demonstrate new technical solutions, also to develop and certificate the target-oriented equipment, scientific hardware, supporting systems and their software in order to be applied in perspective development SRC ‘Progress’, JSC .

Issues to solve:

- Construction and on-board equipment development for remote sensing SSC;
- Software and technical facilities development;
- Development of the target-oriented equipment, ground management facilities, information reception and processing facilities, as well as methods of the information processing;
- Development of remote sensing and data processing methods in thermal IR band;
- Exploitation of scientific and experimental equipment complex developed by Samara University, serving interests of rocket-space industry;
- Development of remote training methods for space-rocket branch specialists educating.

General view of SSC ‘AIST-2D’



Key performance features of SSC ‘Aist-2D’ (target survey equipment)

Item	Value
Operational orbit parameters: - type of orbit - altitude, km	 SSO 490
Linear ground resolution at a height of 490 km, m - in panchromatic mode (0,58 - 0,80 µm) - in multispectral mode (0,45 - 0,52 µm; 0,52 - 0,60; 0,63 - 0,69 µm) - In infrared survey mode (8 - 14 µm)	 at a level of 2,5 at a level of 6 at a level of 122
Capture range for visible range sensor, km	39,6
Capture range for IR-band sensor, km	47
Rate of target data transmission to downlink point, Mbit/s	150
Daily average electricity consumption of on-board equipment, W	300
Active life, years	3
SSC mass, kg	530
Survey and research equipment, kg	150

Target survey equipment of SSC ‘Aist-2D’

Wide coverage optic-electronic equipment of spectrum visible range (OEE-VR)

Purpose and special features

OEE-VR consists of optic-mechanical unit (OEE ‘Aurora’) and optic-electronic conversion elements.

OEE-VR provides acquisition of information on earth surface in panchromatic range (0,58-0,8 µm) and narrow range (0,45-0,52; 0,52-0,6; 0,63-0,69 µm) with linear ground resolution at a height of 2,5 m in panchromatic mode, and 6 m at a height of 490 km in multispectral mode. OEE ‘Aurora’ is developed on the base of axially symmetric catadioptric lens with maximum field angle and minimum mass-dimensional properties.

Optic mechanical unit
general view

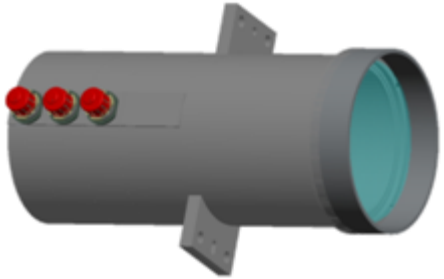
Optic mechanical unit contains:

- catadioptric lens which is composed of: case with sun and heat shield, main reflector, sub reflector with mechanism of compulsory adjustment. lens corrector;
- focal node.

Target survey equipment of SSC ‘Aist-2D’

Target optic-electronic equipment complex (TOEEC)

Purpose and special features

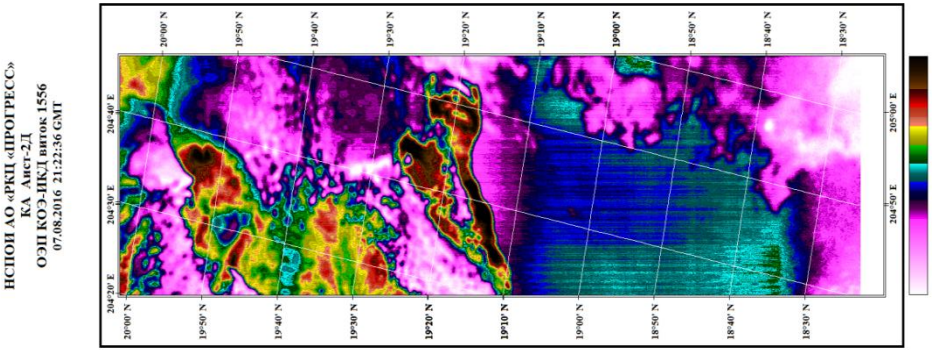


Optic-electronic equipment complex consists of:

- Optic-electronic conversion elements for panchromatic and multispectral range (OEC-1, OEC-2);
- Power supply equipment for OEC-1 and OEC-2;
- Optic-electronic complex IR-band (OEC-IR);
- On-board memory (OBM);
- On-board equipment set for digital data transmission radio line (DDRL).

Thermal IR-band equipment includes microbolometrical photoelectric receivers without refrigeration requirements. It allows to install them on board of SSC.

Through operating OEC-IRB it is intended to develop certain technologies, such as small fireplaces detection.



Research equipment of SSC ‘Aist-2D’

№	Purpose of research equipment
1	*Spectrometral weight cell ‘DMS-01’* is designed for experimental investigation about how space environment factors influence on quality of scientific and technological experiments by analyzing own outer atmosphere of SSC
2	*Particles detector ‘DCH-01’* is designed for: - experimental investigation of the degradation of spacecraft superficial elements samples (optical glass, thermal control coating, solar batteries) under hypervelocity particles stream. It is considered that study samples are influenced by other factors of space environment: photon beams, ultraviolet and own outer atmosphere of SSC (RE ‘DCH-01’); - investigation of the influence of space environment factors on electronic components (memory chips, microcontrollers etc.); - investigation of the influence of atomic oxygen on nanomaterials and coatings;
3	Equipment ‘*Meteor-M*’ is designed for measuring micrometeorites and space garbage parameters in the near-Earth space.

Research equipment SSC of ‘Aist-2D ‘

№	Purpose of research equipment
4	*Microaccelerations compensator ‘KMU-1’* is designed for status control and compensation of on-board microaccelerations in low frequency sub spectrum from 0 to 0.01 Hz. It also helps to develop the procedure of SSC angular motion management by the equipment’s electromagnet set, in order to ensure board research and target equipment functioning.
5	*Research and technology equipment* is designed for technological experimentation in order to ensure access to isolated parts of research equipment that require efficient support and management.
6	*Integrated experimental equipment* (IEE) is designed for realization of flight experiment with advanced optical fiber sensors, as well as experimental study of photoelectrical conversion elements produced using nanopatterning technology.

Supporting systems of SSC ‘ Aist-2D ‘

Item	Designer
Board equipment of control system	
Board monitoring and control system:	
BSCO DOKA-B278	NIILAKT DOSSAF
AFC BSCO	RSC ‘Progress’, JSC
Motion control system:	
Executive and sensitive elements complex	NPP ‘Antares’
Controlling flywheel engines complex	Research institute of control units, JSC
Optical solar sensor	Institute of space researches of Russian Sciences Academy
Electromagnet	Institute of space systems of Samara University
Earth tracker	NPP KP ‘KVANT’, JSC
Star sensor	Institute of space researches of Russian Sciences Academy
Electric power supply system:	
Solar cell battery	‘Saturn’, JSC
Battery 8x2LI-40	‘Saturn’, JSC
Automation, control, operation and regulation unit	RSC ‘Progress’, JSC
Thermal control system:	
Membranous electric heater	RSC ‘Progress’, JSC
Operation controller SPTR	NIILAKT DOSSAF
Operation thermal sensor	
Loop heat pipe	RSC ‘Progress’, JSC
Top node OEE ‘Aurora’	RSC ‘Progress’, JSC

Ground operation, information reception and processing facilities (GOIRPF)

SSC «Aist-2D» is operated by ground operation, information reception and processing facilities situated on JSC SRC «Progress» base:

Ground operation complex (GOC) provides SSC operation during target issues solving and in case of emergency in all lifecycle stages.

Radiotechnical facilities complex for information reception (RFCIR) provides reception, registration and temporary storage of target information.

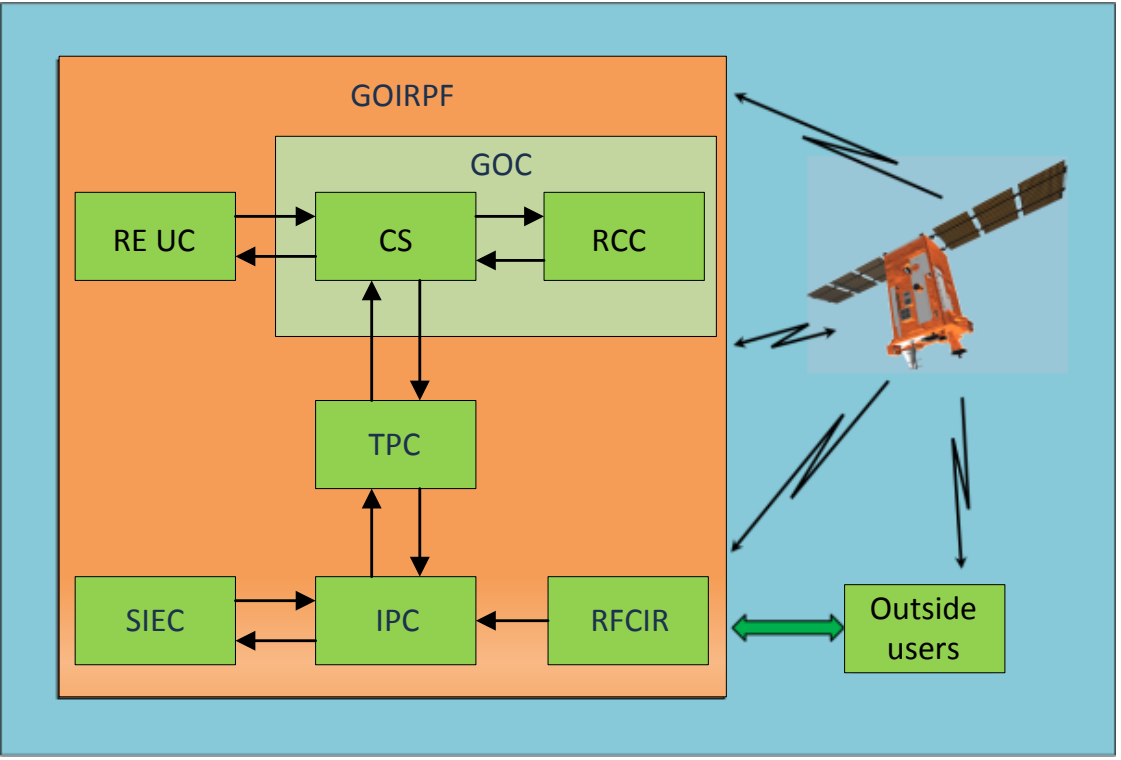
Target planning complex (TPC) provides target equipment operation planning, operation programs of target equipment and initial data organization for SSC operation programming, target equipment operation program feasibility evaluation in terms of maintaining SSC power balance.

Information processing complex (IPC) is designed for target board information processing.

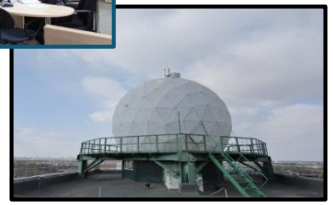
Storage and information exchange complex (SIEC) is designed for long-term storage of all incoming information, as well as information exchange organization.

Research equipment user center (RE UC) is designed for automatic processing of incoming scientific information received from GOC, as well as providing information for equipment operation and function during orbital flight.

Ground operation, information reception and processing facilities



RFCIR



IPC, SIEC

GOC

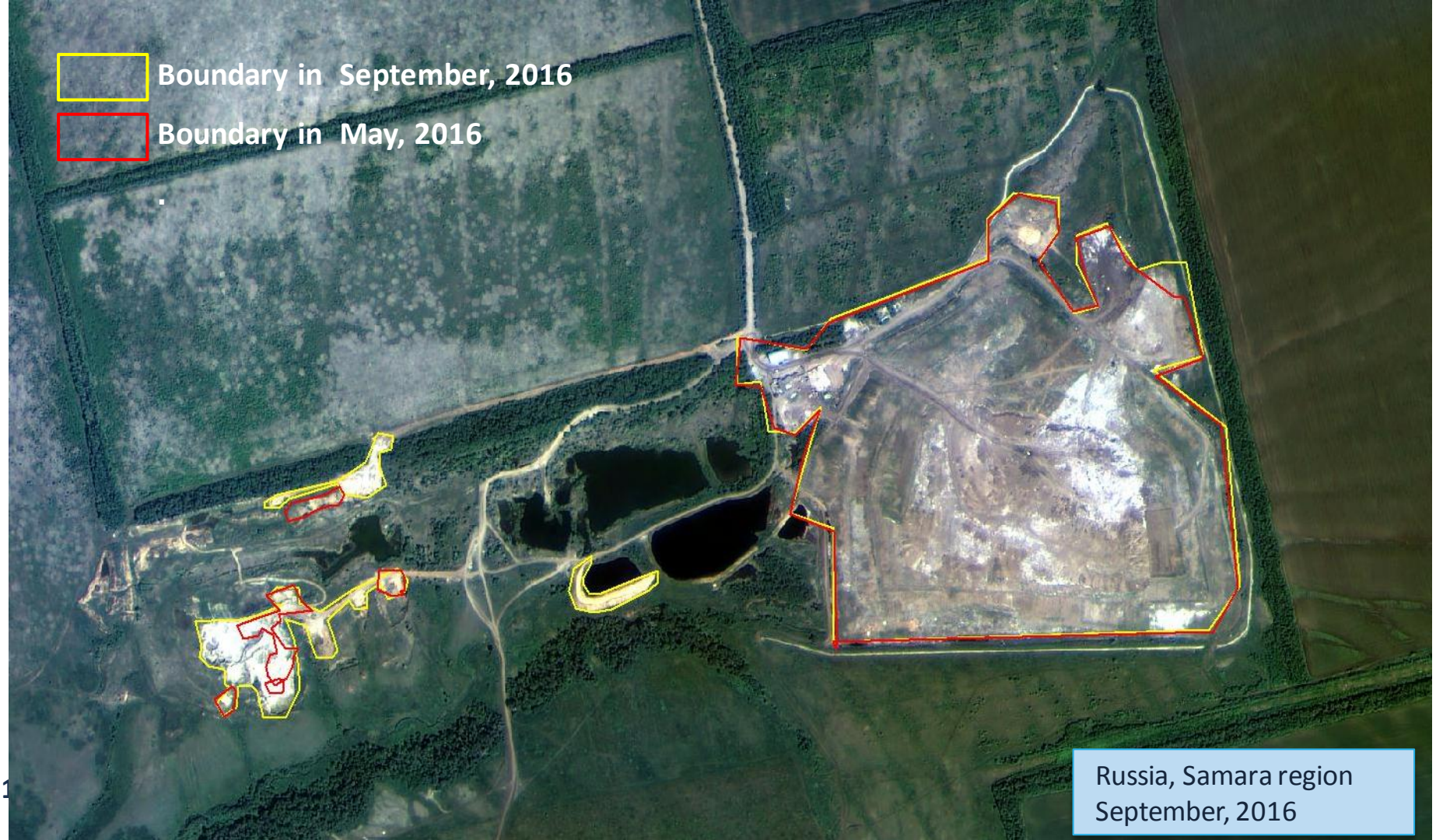
Potential spheres of SSC ‘Aist-2D’ remotely sensed information thematic use

Sphere	Issue
Agriculture	Delimitation of agriculture fields and agriculture seeding
	Agriculture seeding conditions definition based on color specification
Natural resource management and forestry	Control of illegal common minerals extraction places
	Control of illegal solid domestic waste dumping areas
	Control of unauthorized economical activity (such as nature conservation and water protection areas)
	Control of deforestation because of negative effects (windfalls, burnt, cutting trees)
	Density of canopy evaluation
Water resources	River network mapping
	Suspended sediments areas detection, coastal accumulation mode analysis
	Flood flows detection in high water period
Transport infrastructure	Roads network configuration definition, network change detection
	Evaluation of transport network load by vehicles
	Evaluation of traffic network sites construction progress
Mapping	Development and maintenance of topographical maps, scale 1:50000 и 1:25000
Regional infrastructure of spatial data	Maintenance of regional digital base material in order to provide effective operation of regional geographical information systems and services

Examples of SSC ‘Aist-2D’ remotely sensed information thematic use

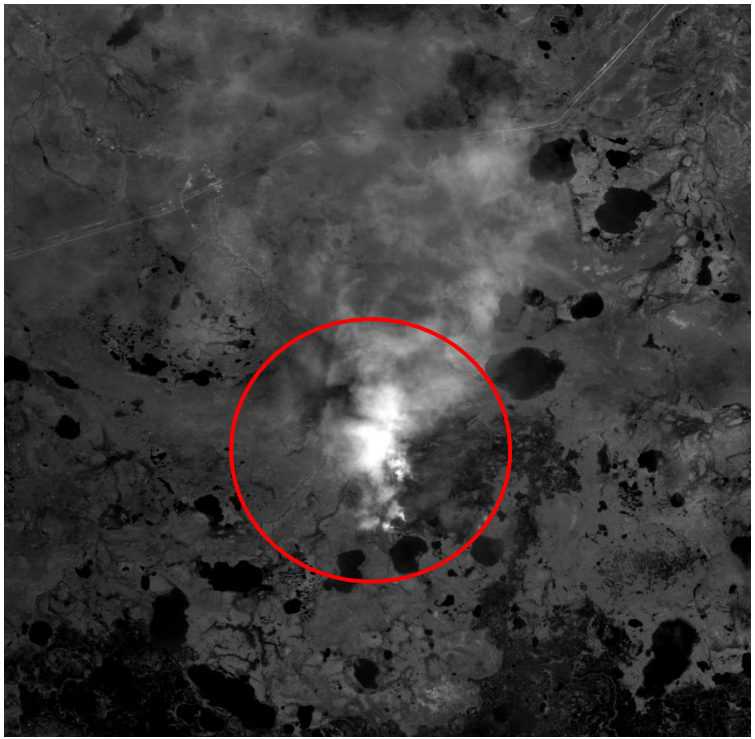
Illegal mineral resources mining detection (Samara region)

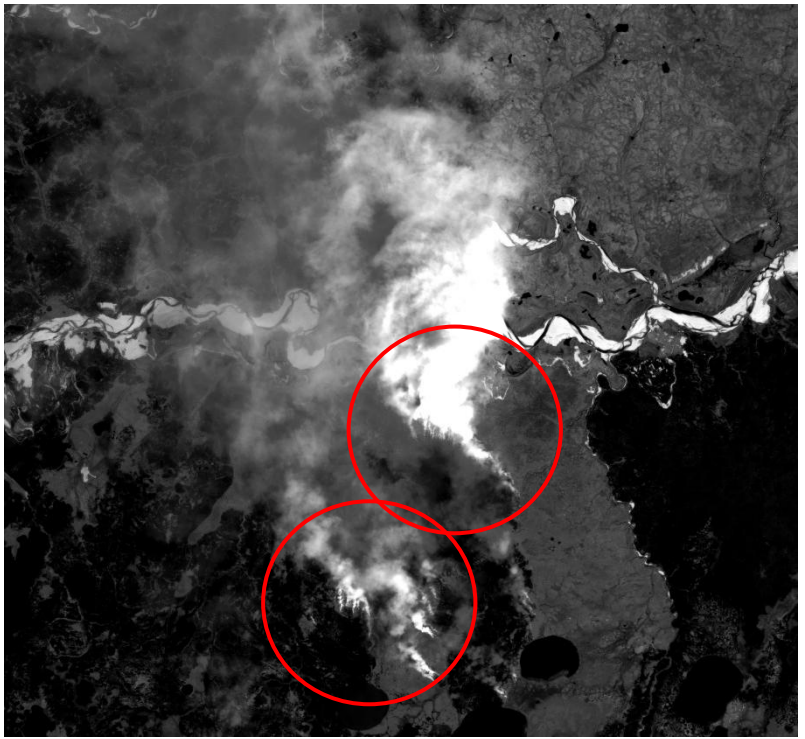
Illegal solid domestic waste detection (Samara region)


Boundary in September, 2016
Boundary in May, 2016
Russia, Samara region
September, 2016


Boundary in September, 2016
Boundary in May, 2016
Russia, Samara region
September, 2016

Examples of SSC ‘Aist-2D’ remotely sensed information thematic use





Обнаружение очагов лесных пожаров в ЯНАО

Australia, Sydney
7 October, 2016


Georgia, Caucasus
15 October, 2016

UAE, Dubai
2 October, 2016

Qatar, Doha
15 October, 2016

Russia, Sochi
30 September, 2016

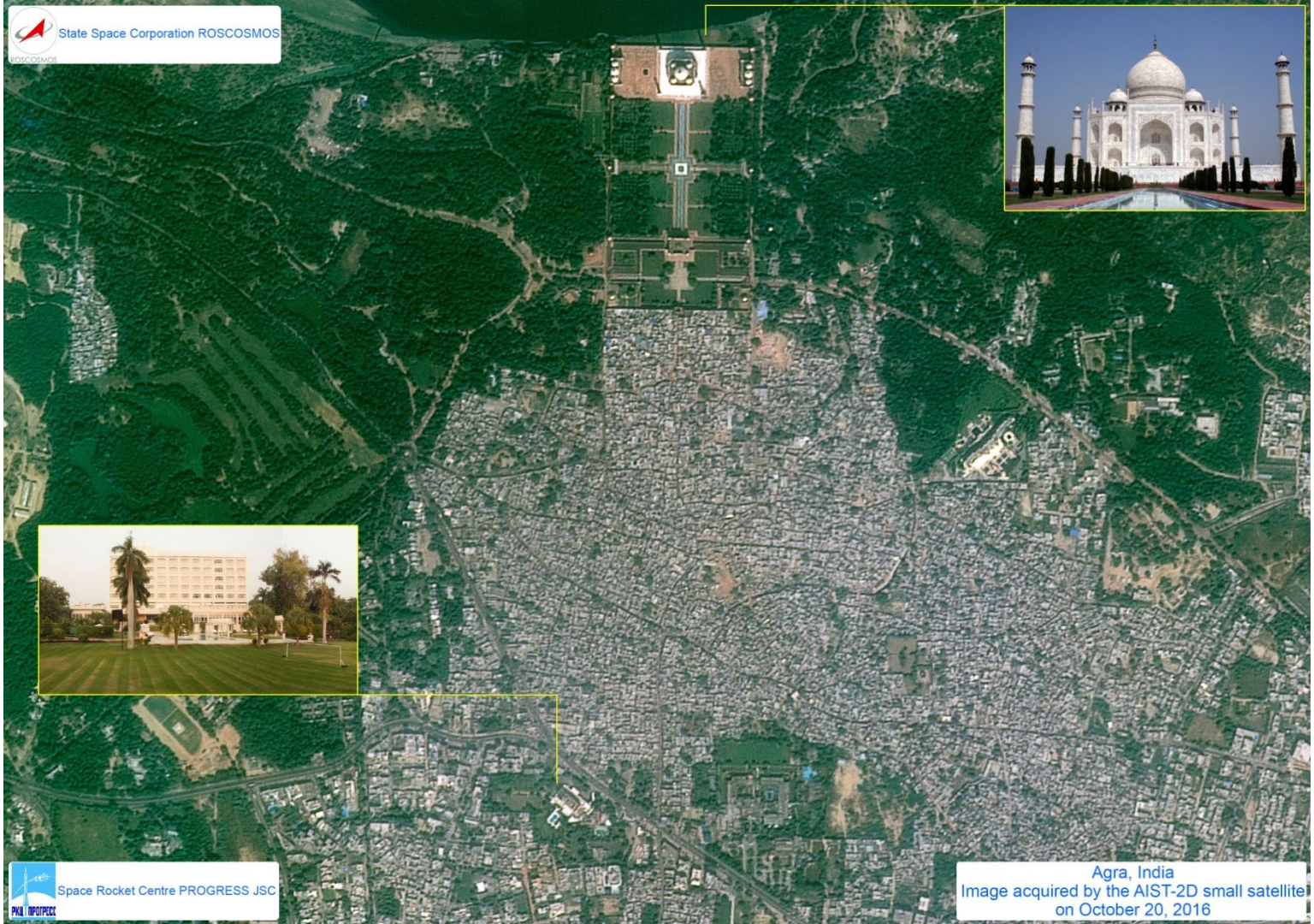

USA, Niagara Falls
4 October, 2016

Croatia, Galishniak
17 October, 2016


USA, Ferry-Pass
17 October, 2016

France, Paris
9 October, 2016


Germany, Buhel
16 October, 2016


State Space Corporation ROSCOSMOS
Space Rocket Centre PROGRESS JSC
Agra, India
Image acquired by the AIST-2D small satellite
on October 20, 2016

Current state and further development of the project

Meantime SSC flight tests are held, arrangements are processed and made in order to define performance limits of the product (board equipment power, controllability, transferred downlink information volume etc.), as well as considerations for creating modern small spacecraft of Earth remote sensing (SSC ERS) are developed based on this platform.

During SSC 'Aist-2D' flight tests the capabilities of high quality ERS information reception were confirmed.

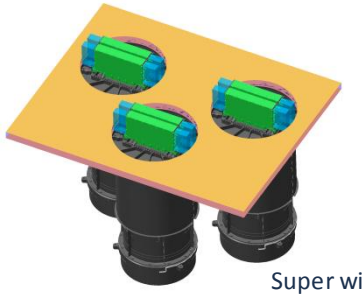
Satellite images accuracy and possibilities of specify purpose use for solving a range of practical tasks are being developed and tested. Visibility range is now possible to broaden by means of turning SSC in roll (±45˚).

Meantime together with interested organizations possibilities of using ERS information for specify purpose are developed. It is planned to use it for the benefit of such consumers as Russian Emergency Ministry, Ministry of Agriculture, Federal Agency for State Registration, Cadastre, and Cartography, regional executive authorities and commercial organizations.

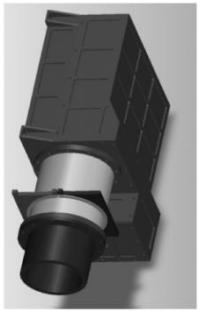
Unified low mass dimension space platform

Index name	Item value
Platform mass, kg	350
Working load, kg	250
Generated working load energy SES, daily average/peak, W	400/750
Target information transfer rate, Mbit/s	300
Target active shelf life, years	5
Maximum rate of angular redirection (SSC), °/s	1,2

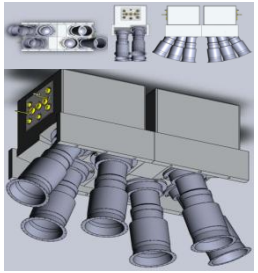
Research or experimental equipment with medium and high standards of placement parameters



Super wide coverage optical equipment of detailed supervision

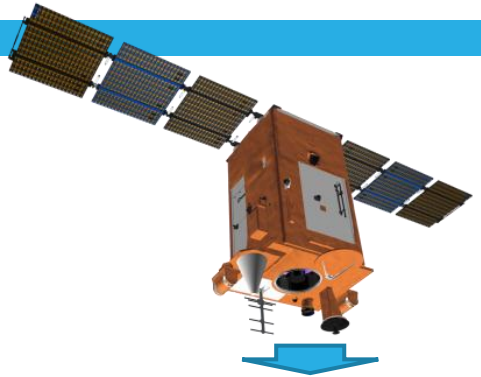


Hyper spectral equipment with innovative characteristics

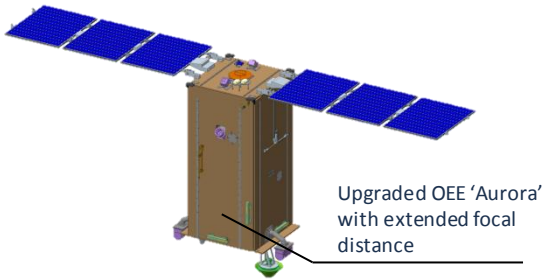


Perspective wide coverage multispectral optical equipment

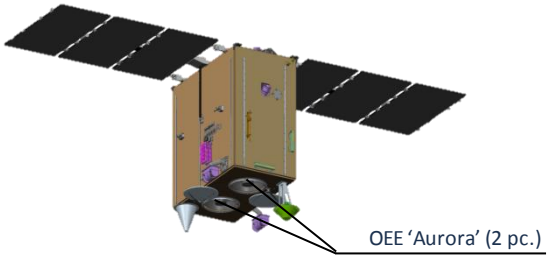
Configurations of advanced SSC based on SSC ‘Aist-2D’



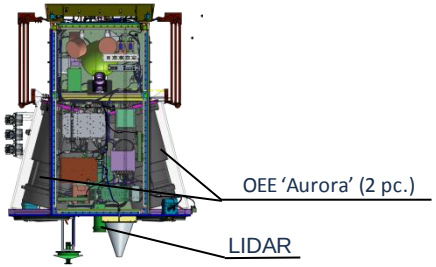
SSC «Aist-2D»: realized spatial resolution – 2.1 m in panchromatic mode, capture range 40 km



SSC ERS with high resolution:
Resolution (pixel size) from altitude H=500 km, m
- In panchromatic mode – 1 m;
- Swath width - 35 km



SSC ERS with extended swath width :
Resolution (pixel projection) from altitude H=500 km, m
- In panchromatic mode – 1, 5 m (possibility of considerable detailed performance – 1 m);
- Swath width - 80 km



SSC ERS of cartography purpose providing possibility of stereo imagery with high accuracy of coordinate altitude measuring of the surface

THANKS FOR YOUR ATTENTION !

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