САМАРСКИЙ УНИВЕРСИТЕТ
SAMARA UNIVERSITY

EXPERIENCE OF PARTICIPATION IN INTERNATIONAL SCIENTIFIC AND EDUCATIONAL SPACE PROJECTS BY THE EXAMPLE OF QB50 PROJECT

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Problems arising in the implementation of international projects in the space field

Differences in the technology of space projects management

Differences in the technology (stages) of spacecraft design

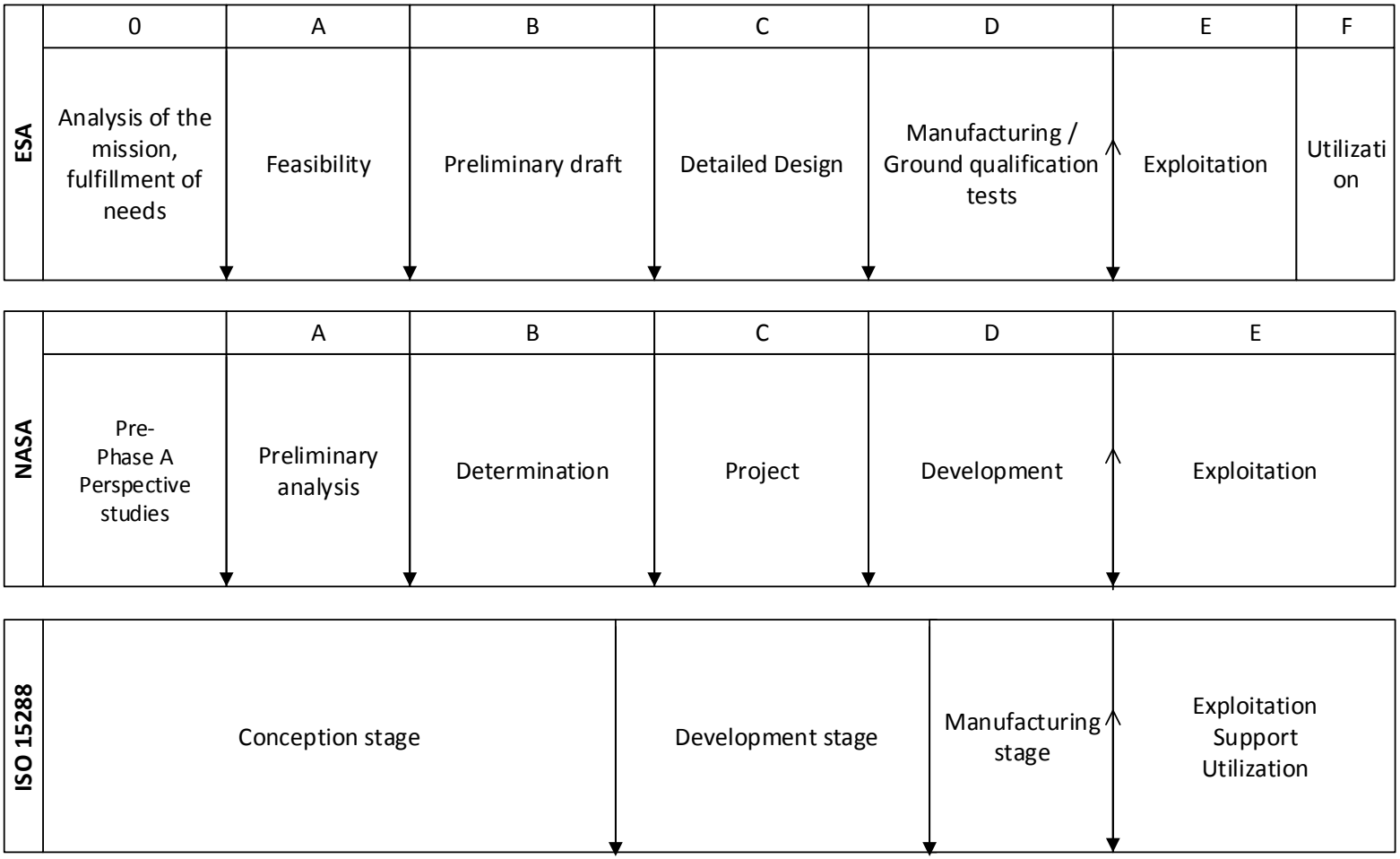
Differences in the legislation of countries in the field of space activities:

- certification of space technology,
- ensuring launch safety,
- permission to use the frequency band,
- permission to export abroad (export license).

The differences in requirements for Piggy-Back payloads during launch by various means:

- requirements for interfaces (mechanical and electrical),
- requirements for safety launching and orbiting,
- requirements for the order and conditions of testing,
- requirements for the order of power-on and the state (mode) during integration and the launching of a spacecraft in a Piggy-Back type.

An example of difference in the technology of space projects management in different countries



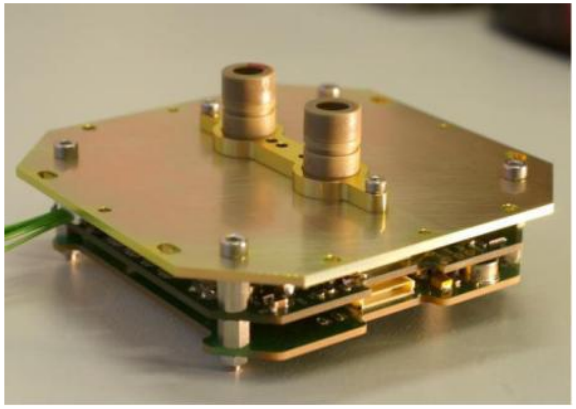
Developed standards governing the development of nanosatellites

- **ISO 27852:2010(E);**
- **CubeSat Design Specification Rev. 13 (CalPoly);**
- 6U CubeSat Design Specification PROVISIONAL (CalPoly);
- Payload Specification for 3U, 6U, 12U and 27U (Planetary Systems Corporation);
- 12U CubeSat Specification (Tyvak Nano-Satellite Systems);
- 6U CubeSat Specification (Tyvak Nano-Satellite Systems);
- NanoRacks CubeSat Deployer Interface Control Document Revision 0.36 (NanoRacks);
- GOST R 56515-2015 Automatic spacecrafts and onboard support spacecraft systems. General requirements for protection and resistance to electrophysical space factors and static electricity

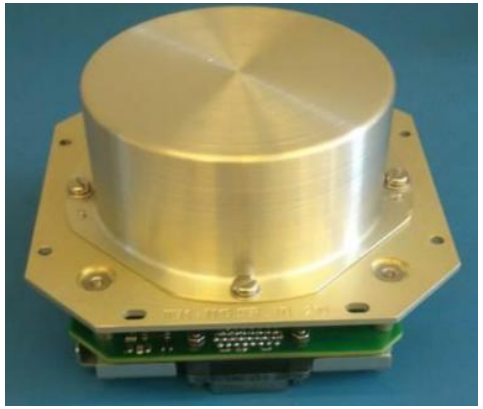
An example of an international project QB-50

Organization and curator of the project:
Von Karman Institute for Fluid Dynamics, Belgium

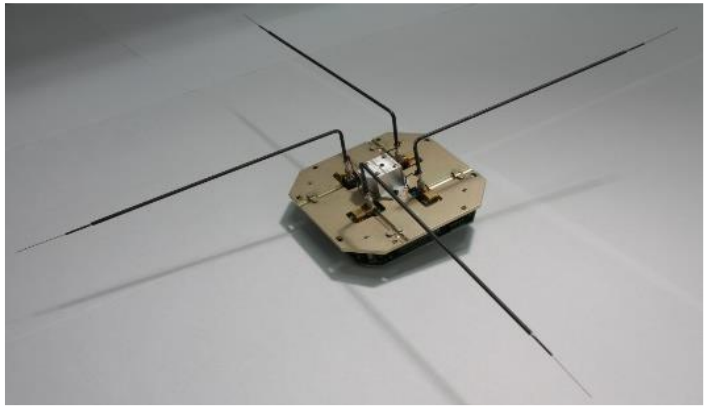
The international project QB50 is aimed at studying the lower layers of the Earth's thermosphere (90-320 km) by using a group of nanosatellites of the CubeSat standard of 2U and 3U formats, each of which is equipped with one of three types of measuring equipment: ion-neutral mass spectrometer, Langmuir probe, time resolved sensor of behavior of an atomic oxygen for conducting atmospheric studies in the lower layers of the thermosphere.



FIPEX



INMS

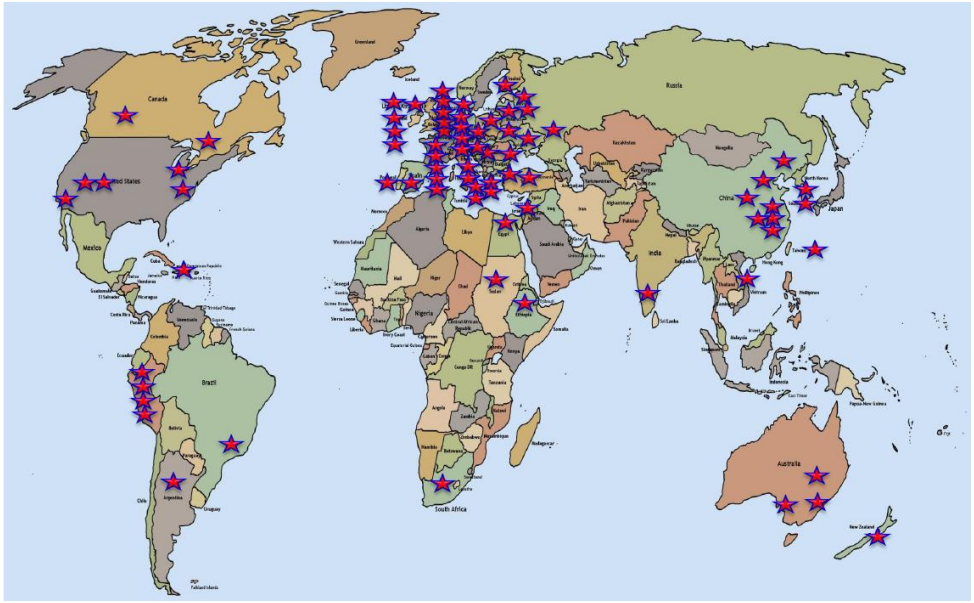


MNLP

QB50 project participants

The initial number of participants CubeSat 2U / 3U:

Austria (2), Australia (3), South Africa (1), Belgium (3), Brazil (1), Canada (2), China (7), Colombia (1), Czech Republic (1) Spain (1), Finland (1), France (5), Greece (2), United Kingdom (3), Israel (1), India (1), Italy (1), Korea (2), Lithuania (1), The Netherlands (2), Portugal (1), Romania (2), **Russia (1)**, Turkey (2), Taiwan (1), Ukraine (1), USA (4).



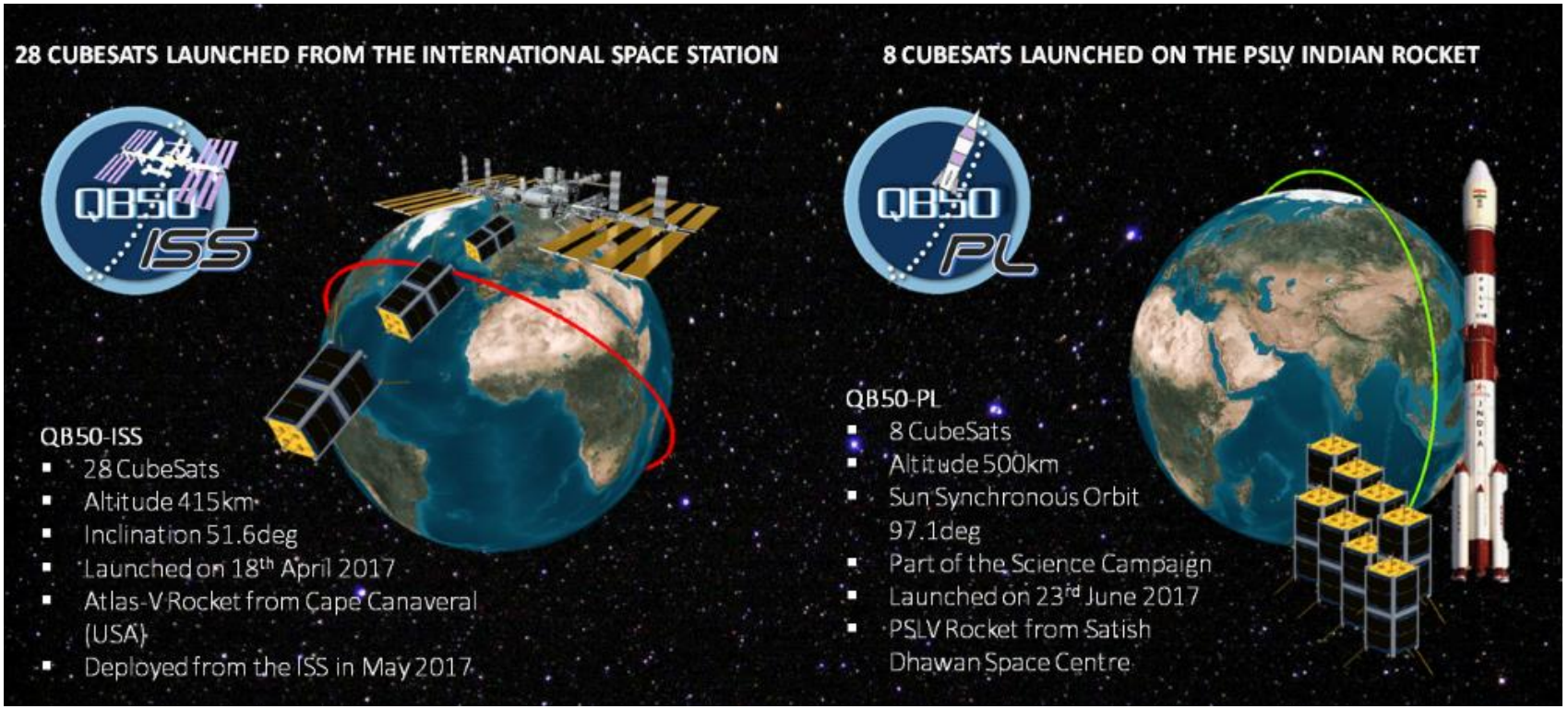
Deployment of the space segment QB50

Space Segment:

- 28 nanosatellites for atmospheric research;
- 8 nanosatellites to in-orbit technology demonstrate.

Ground Segment:

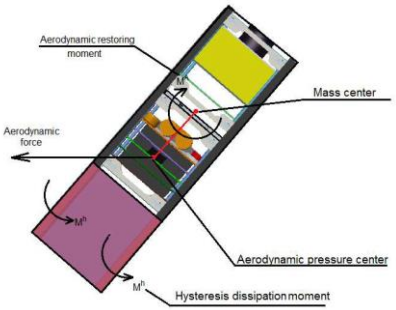
- A network of 50 ground stations of participants and their partners.



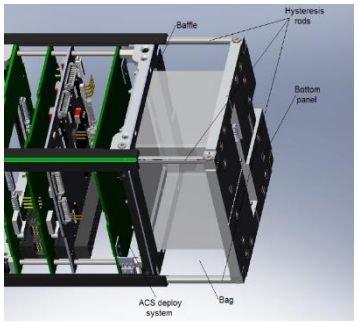
QB-50 Stages

- **Preliminary Design Review.**
- **Critical Design Review.**
- **Assembly Integration and Testing Readiness Review.**
- **NanoRacks CubeSat Safety Data Template QB50.**
- **Flight Readiness Review.**
- **Obtaining a set of permits.**
- **Transporting a nanosatellite to a launch services provider.**

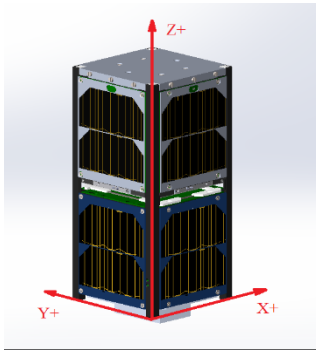
Proposal/PDR stage



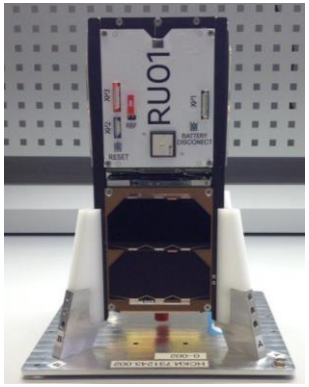
CDR stage



AITRR stage



SDT/FRR stage



Preliminary Design Review (PDR)

Purpose

The purpose of the PDR is principally to review 3 questions:

1 Are the top level performance requirements for the subsystem complete and adequate?

2 Have the correct design solutions been selected for study and development? Are there important alternate solutions that are not being studied.

3 If a major procurement is required for the subsystem, is the procurement plan correct?

Documents submitted for the implementation of the phase:

1 PDR Cubesat Summary Report;

2 Cubesat Compliancy Table.

Requirements and specifications:

- *CubeSat Design Specification Rev. 12;*
- *System Requirements and Recommendations (Interface Control Documents) issue 3.*

Critical Design Review (CDR)

Purpose

The purpose of the CDR is principally to review 4 questions:

1 Are the detailed requirements for the subsystem complete and adequate?

2 Will the design selected for implementation on the test array meet the requirements?

3 Are interfaces to other subsystems defined adequately and completely?

4 Has adequate attention been given to the produceability and maintainability of the subsystem?

Documents submitted for the implementation of the phase:

1 Cubesat Critical Design Overview;
2 Cubesat Risk Analysis and Mitigation Plan;
3 Cubesat Assembly Integartion and Test Plan;
4 Cubesat Management Plan;
5 Cubesat Overview Spreadsheet;
6 Cubesat System Requirements Compliancy Table;
7 Payload Requirements Compliancy Table;
8 Request for Waiver.

Requirements and specifications:

- CubeSat Design Specification Rev. 12;
- System Requirements and Recommendations issue 6;
- FIPEX Interface Control Document issue 2.3.

Assembly Integration and Testing Readiness Review (AITRR)

Documents submitted for the implementation of the phase:

1 Cubesat verification Plan;
(The purpose of this document is to provide a detailed verification and testing plan for the QB50 CubeSats in accordance with the QB50 System Requirements.)

2 Cubesat user manual;
(The purpose of this document is to provide a detailed user manual describing, in particular, the handling, integration and charging procedures for the QB50 CubeSats.)

3 Non-Conformance Report;
4 CubeSat Overview Spreadsheet
5 System Requirements Compliancy Table
6 Payload Requirements Compliancy Table
7 Request for Waiver

Requirements and specifications:

- CubeSat Design Specification Rev. 12;
- System Requirements and Recommendations issue 6;
- FIPEX Interface Control Document issue 2.4.

Formation of new requirements for a nanosatellite due to changes in the launch company

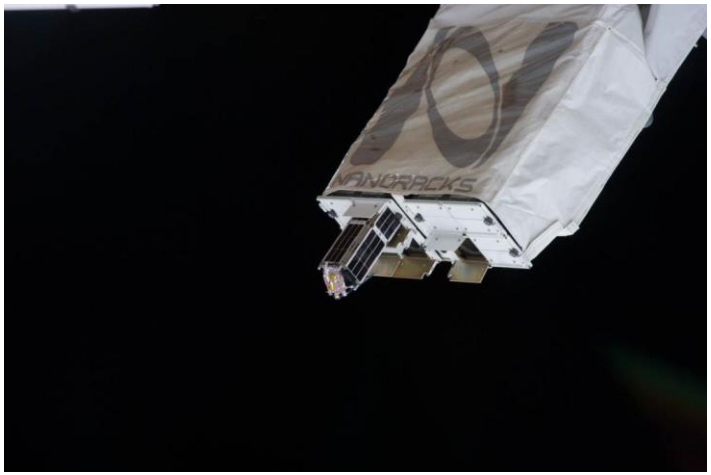
<u>Changes in the requirements for the orientation and stabilization system</u>

- Changing the work of algorithms.
- Changing energy budget.
- Changing the work schedule.

<u>Change of provider launch services</u>

- Change the deployment adapter.
- Change the requirements for interfaces

Quadpack (ISISpace)



NRCSD (NanoRacks)

NanoRacks CubeSat Safety Data Template QB50

Purpose

This document is a generic NanoRacks (SDT) security data template for CubeSats, developed for QB50 commands.

Documents submitted for the implementation of the phase:

1 NanoRacks CubeSat SDT Template;
2 NanoRacks BOM.

Requirements and specifications:
- NR-SRD-139 Flight Acceptance Test Requirements for Li-ion Cells and Batt.

QB50 ID	Satellite Name	Lead Institute	Country	Launch	Deployment date/time (UTC)	Size	QB50 sensor
AU01	SUSat	University of Adelaide	Australia	ISS via Atlas-V	25/05/17, 11:55	2U	INMS
AU02	UNSW-EC0	University of New South Wales	Australia	ISS via Atlas-V	25/05/17, 5:25	2U	INMS
AU03	i-INSPIRE II	University of Sydney	Australia	ISS via Atlas-V	26/05/17, 04:00	2U	mNLP
AZ01	ZA-AEROSAT	Stellenbosch University	South Africa	ISS via Atlas-V	18/05/17, 01:00	2U	FIPEX
AZ02	nSIGHT	SCS-SPACE	South Africa	ISS via Atlas-V	25/05/17, 08:45	2U	FIPEX
CA03	ExAlta-1	U of Alberta	Canada	ISS via Atlas-V	26/05/17, 08:55	3U	mNLP
BE02	LilacSat-1	Harbin Institute of Technology (HIT)	Belgium	ISS via Atlas-V	25/05/17, 08:45	2U	INMS
BE03	NJUST-1	Nanjing University of Science and Technology	Belgium	ISS via Atlas-V	25/05/17, 5:25	2U	FIPEX
BE04	Ao Xiang-1	NPU	Belgium	ISS via Atlas-V	26/05/17, 12:15	2U	INMS
DE02	SOMP2	TU Dresden	Germany	ISS via Atlas-V	16/05/17, 08:25	2U	FIPEX
ES01	QBITO	E-USOC, ETSIA, Universidad Politécnica de Madrid (UPM)	Spain	ISS via Atlas-V	25/05/17, 11:55	2U	INMS
FI01	Aalto-2	Aalto University	Finland	ISS via Atlas-V	25/05/17, 11:55	2U	mNLP
FR01	X-CubeSat	Ecole Polytechnique	France	ISS via Atlas-V	17/05/17, 01:45	2U	FIPEX
FR05	SpaceCube	École des Mines Paristech	France	ISS via Atlas-V	18/05/17, 08:25	2U	FIPEX
GR01	DUTHSat	Democritus University of Thrace	Greece	ISS via Atlas-V	25/05/17, 08:45	2U	mNLP
GR02	UPSat	University of Patras and Libre Space Foundation	Greece	ISS via Atlas-V	18/05/17, 08:25	2U	mNLP
IL01	Hoopoe	Herzliya Science Center	Israel	ISS via Atlas-V	18/05/17, 08:25	2U	mNLP
KR01	LINK	KAIST	South Korea	ISS via Atlas-V	18/05/17, 01:00	2U	INMS
KR02	SNUSAT-1	Seoul National University	Korea	ISS via Atlas-V	26/05/17, 04:00	2U	FIPEX
KR03	SNUSAT-1b	Seoul National University	Korea	ISS via Atlas-V	25/05/17, 23:40	2U	FIPEX
SE01	qbee	Open Cosmos Ltd. & LuleaUniversity of Technology	Sweeden	ISS via Atlas-V	17/05/17, 01:45	2U	FIPEX
TR01	BEEAGLESAT	Istanbul Technical University	Turkey	ISS via Atlas-V	26/05/17, 12:15	2U	mNLP
TR02	HAVELSAT	Havelsan	Turkey	ISS via Atlas-V	16/05/17, 08:25	2U	mNLP
TW01	PHOENIX	NCKU	Chinese Taipei	ISS via Atlas-V	17/05/17, 01:45	2U	INMS
UA01	PolyITAN-2-SAU	National Technical University of Ukraine & Shenyang Aerospace University	Ukraine	ISS via Atlas-V	26/05/17, 04:00	2U	FIPEX
US01	Challenger	University of Colorado	USA	ISS via Atlas-V	25/05/17, 5:25	2U	INMS
US02	Atlantis	University of Michigan	USA	ISS via Atlas-V	26/05/17, 12:15	2U	FIPEX
US04	Columbia	University of Michigan	USA	ISS via Atlas-V	16/05/17, 08:25	2U	FIPEX
AT03	PEGASUS	FHWN	Austria	PSLV	26/06/17, 03:59	2U	mNLP
BE06	NUDTSat	National University of Defense Technology	Belgium	PSLV	26/06/17, 03:59	2U	INMS
CZ02	VZLUSAT1	VZLU	Czech Republic	PSLV	26/06/17, 03:59	2U	FIPEX
DE04	DragSail-CubeSat	FH Aachen, University of Applied Sciences	Germany	PSLV	26/06/17, 03:59	3U	N/A
GB03	UCLsat	UCL	Belgium (made in UK)	PSLV	26/06/17, 03:59	2U	INMS
GB06	InflateSail	University of Surrey	Belgium (made in UK)	PSLV	26/06/17, 03:59	3U	N/A
IT02	URSA MAIOR	Sapienza University of Rome	Italy	PSLV	26/06/17, 03:59	3U	mNLP
LT01	LituanicaSAT-2	Vilnius University	Lituania	PSLV	26/06/17, 03:59	3U	FIPEX

Flight Readiness Review (FRR)

Documents submitted for the implementation of the phase:

1 **Summary test report;**
(The purpose of this document is to present the results obtained during the test campaign. In this report, only the main results and conclusions are fixed. They are confirmed by the detailed test report specified in the reference documents.)

2 **Cubesat user manual;**
(The purpose of this document is to provide a detailed user manual describing, in particular, the handling, integration and charging procedures for the QB50 CubeSats.)

3 **Detailed report;**
(The purpose of this document is to detail the test campaign in detail. It should reflect convincing evidence (data, photographs, procedures in standby mode) that the tests were conducted in accordance with the requirements and approved test plan. The results should be carefully documented and analyzed.)

4 **CubeSat Overview Spreadsheet;**

5 **System Requirements Compliancy Table;**

6 **Payload Requirements Compliancy Table.**

Requirements and specifications:

- *CubeSat Design Specification Rev. 12;*
- *System Requirements and Recommendations issue 7;*
- *FIPEX Interface Control Document issue 2.5.*

Sending a nanosatellite to the provider of launch services

Preparing for shipment

- Sending an application to the state technical and export control service.
- Preparing and sending a package of accompanying documents.
- Obtaining an export license.
- Preparation of documents for customs authorities / search for a logistics company.

Delay in shipment and getting out of the jurisdiction of the project organizer

- Preparation and sending of an application and a package of accompanying documents to the national radio frequency regulator.
- Receiving permission from the national regulator for radio frequencies.
- Appeal to the space agency to obtain launch services in the framework of the launch program for small space vehicles (student satellites).

PROGRAM OF LAUNCHING SMALL SATELLITES (STUDENT SATELLITES)

The state corporation "ROSKOSMOS" together with OAO "Glavkosmos" (part of the State Corporation) are implementing a program for the free launch of high-school Russian small spacecraft (ICA) using Russian launch vehicles within the framework of the Federal Space Program (FCN) 2016-2025. To determine the current directions for the development of the ICA, the procedure for adapting and launching them, ROSKOSMOS has created a commission (Order No.XM-128-rsp of May 17, 2017).

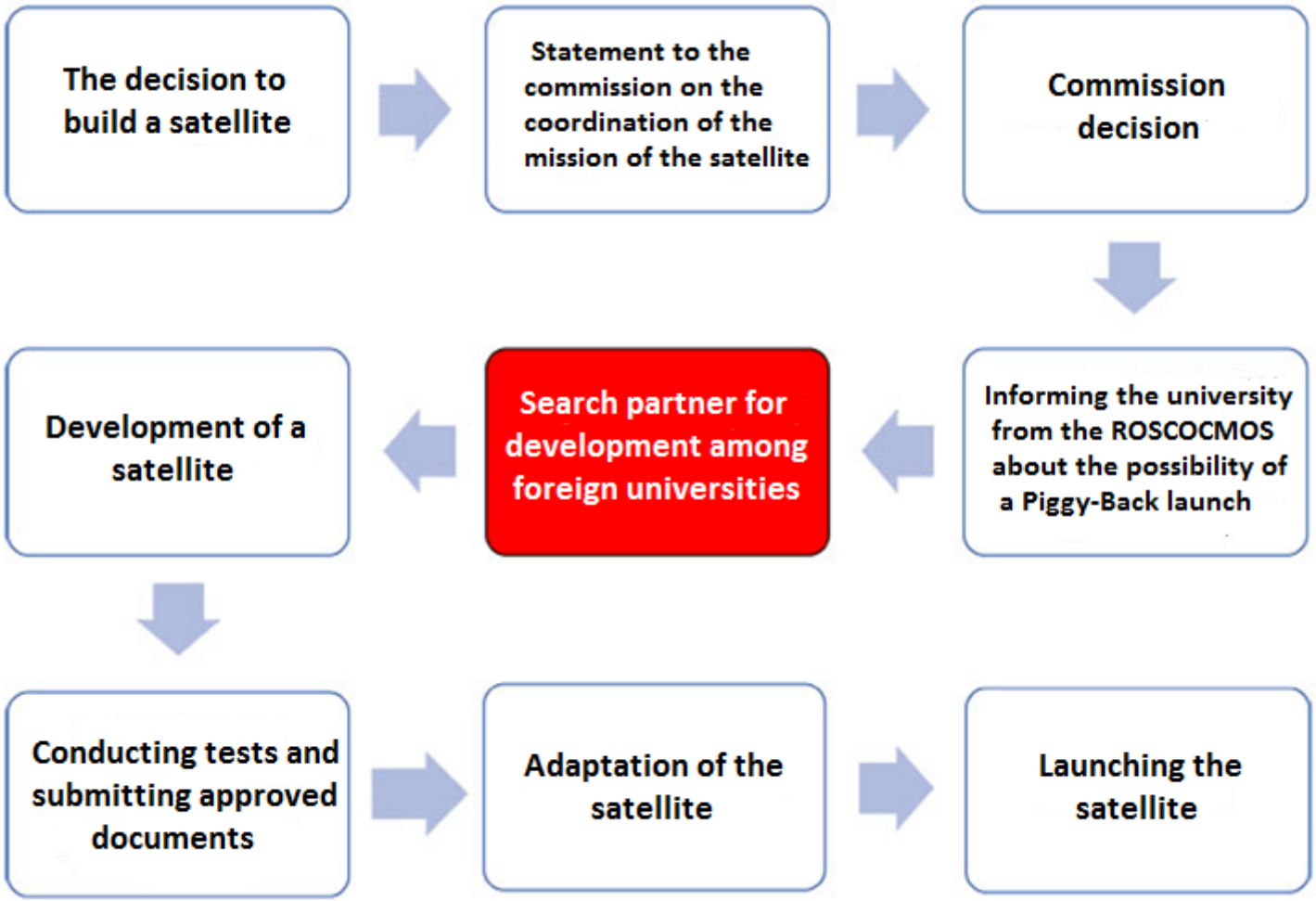
Objectives of the program

- Involving young scientists and specialists in the organizations of the rocket and space industry.
- Disclosure of the creative potential of students.
- Qualitative practical training of future developers for the rocket and space industry.
- Involvement of material resources for the development of small student space vehicles.
- Promotion of Russia's leadership and popularization of Russian cosmonautics abroad.

Participants of the program

https://www.roscosmos.ru/23836/

Algorithm of actions



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List of necessary documents

1.Statement to the commission on the coordination of the mission of the spacecraft.
2.The protocol of the commission with the decision on the coordination of the mission of the spacecraft.
3.A letter to the State Corporation "ROSKOSMOS" about the possibility of the associated launch of a small spacecraft (initiation of development).
4.Document requirements for the spacecraft interfaces (SC source data).
5.Report on testing of spacecraft (based on information on mechanical loading of spacecraft in the launch vehicle launching area).
6.Certificate of Satellite Assignment.
7.A letter to the State Corporation "ROSKOSMOS" with information about the final user of the spacecraft.
8.Certificate of obligation to register a satellite in an authorized national organization.
9.Certificate of general view of the satellite.
10.Certificate of registration of satellite frequencies.
11.Certificate of non-military use of the satellite.
12.Certificate of general safety of the satellite.
13.Certificate of ecological safety of the satellite.
14.Certificate of readiness for launch.

https://www.roscosmos.ru/23836/

The draft list of prospective subjects of the State Corporation "ROSKOSMOS" for the development and creation of small spacecraft

1.Remote sensing earth remote sensing satellite with a wide-coverage multispectral equipment providing a 5 m resolution on the terrain in panchromatic and 10 m in multispectral mode with a capture band of at least 120 km.
2.Earth remote sensing satellite in the infrared range.
3.Earth remote sensing satellite with radar target equipment.
4.Satellite with the system of automatic vessel identification - tracking of sea vessels (AIS).
5.Satellite providing automatic dependent surveillance - broadcasting for air traffic (ADS-B).
6.Space debris monitoring satellite and creation of systems for recording small spacecraft from a working orbit with subsequent flooding.
7.Earth space weather monitoring satellite (ionospheric measurements).
8.Fundamental scientific space research.
9.Satellite on the development of new technological and circuit solutions of service systems and target equipment.

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CONCLUSION

Attention needs to be paid:

- formation of requirements based on the situations associated with the launch, separation and operation;

- test campaign;

- creation of conditions for equalizing the competences of project participants.

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Thank you
For attention

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