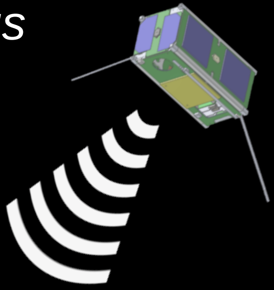
Integration of the Belarusian Space Research potential into International Nano/Pico Satellite Programs

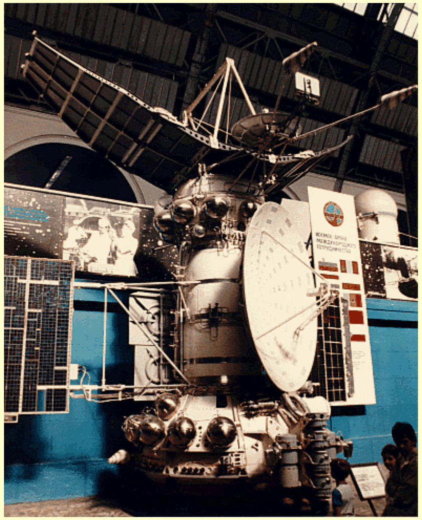
Vladimir A. SAETCHNIKOV

Radio Physics and Computer technologies Department, Aerospace Educational Center, Belarusian State University, Minsk, Belarus

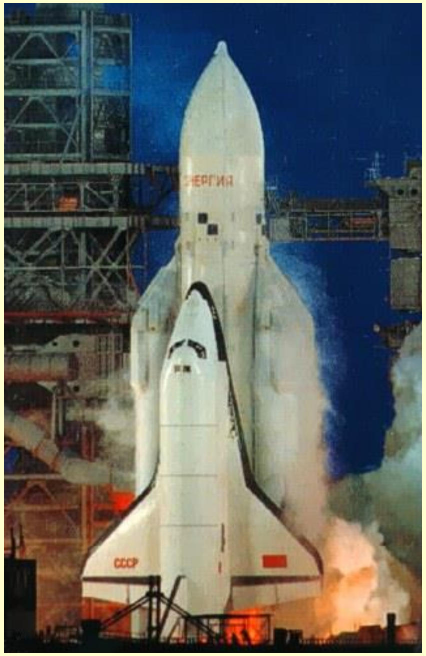


Participation of BSU in USSR, Russia and international space programs

Mir project (USSR)



Venera project (USSR)



Buran-Energia project (USSR)

International Space Station

Photo spectral system «ФСС»

June 2010 until today

ЮРЧИХИН
Федор Николаевич

СКВОРЦОВ
Александр Александрович

Outer space sensor module “БВД”

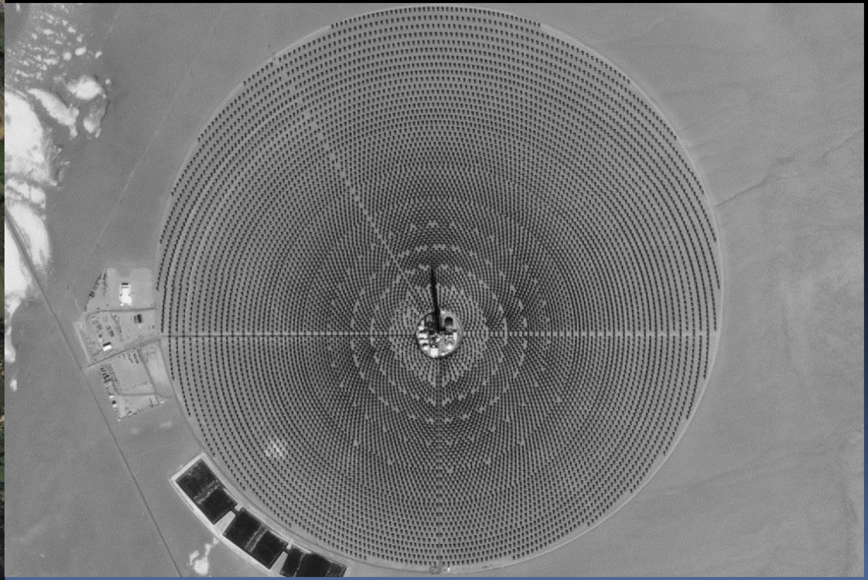
СКРИПОЧКА
Олег
Иванович

КОНДРАТЬЕВ
Дмитрий
Юрьевич

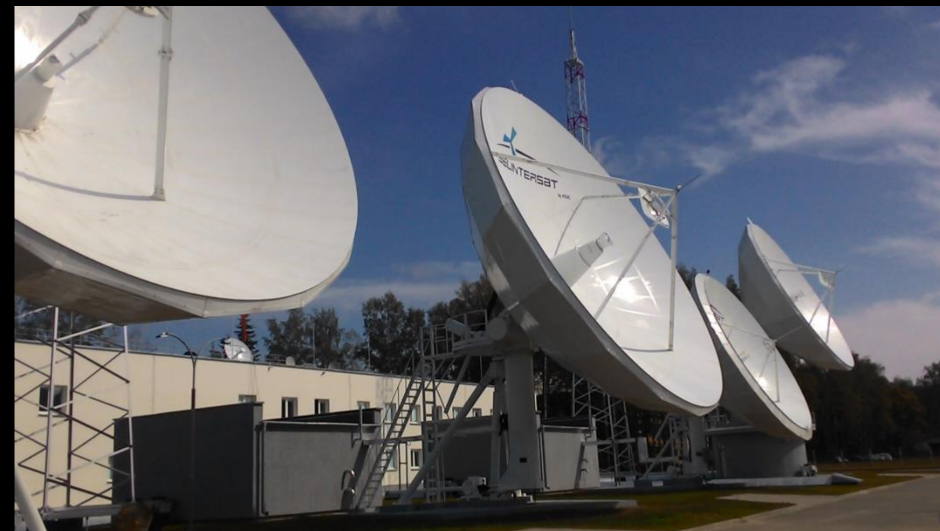
October 2010 until today

Belarusian spacecraft of remote sensing. July, 22 2012

Belarusian spacecraft of remote sensing. July, 22 2012
2/10 m resolution



Belarusian telecommunication satellite, January, 15, 2016



BSU Aerospace Educational Center

BSU AEROSPACE EDUCATIONAL CENTER

REMOTE SENSING

- Development Ground station equipments
- Development new methods and software
- Receiving and processing of remote sensing data

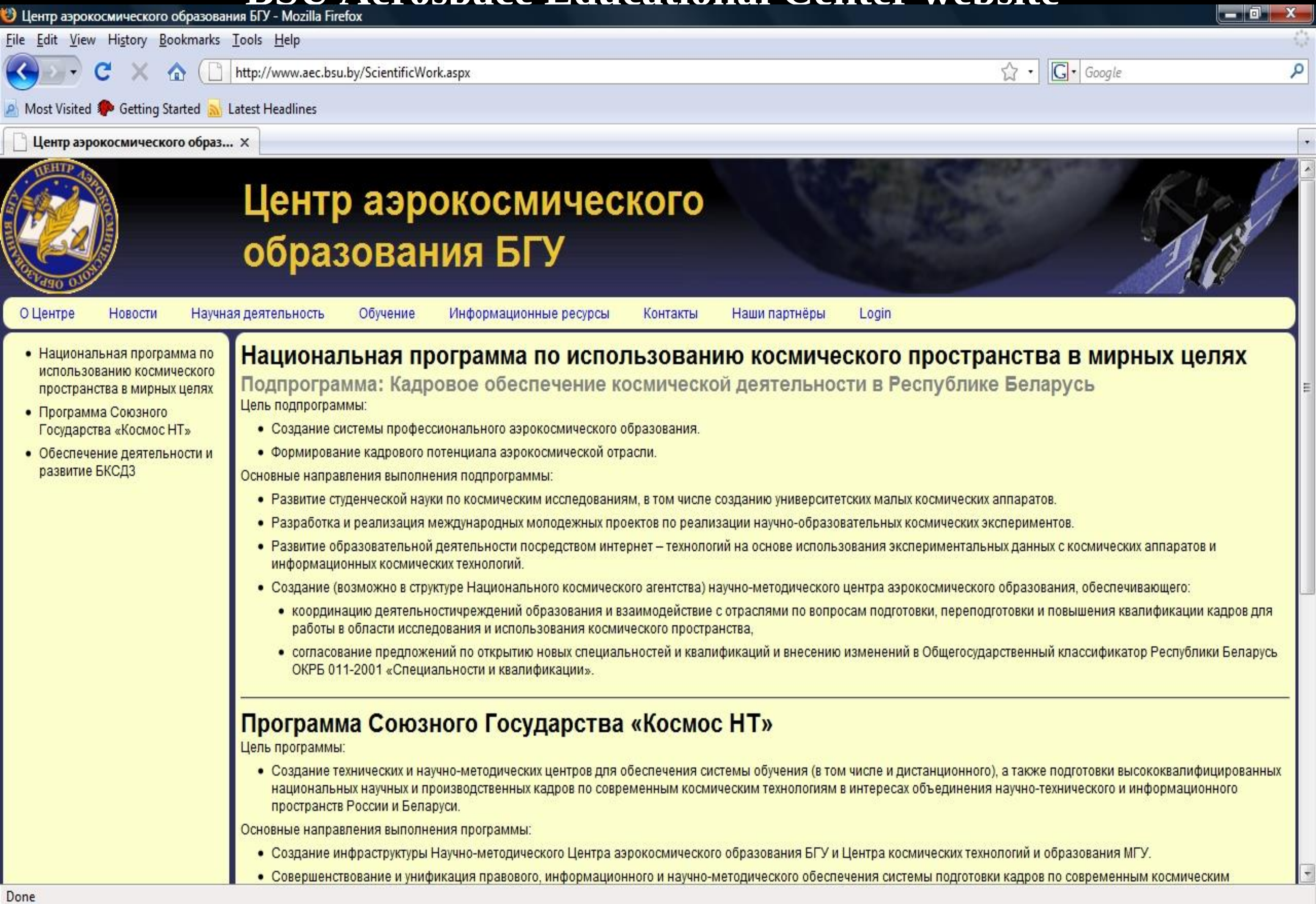
EDUCATION

- Educational and methodical support for the Universities
- Development Aerospace courses
- Aerospace training courses

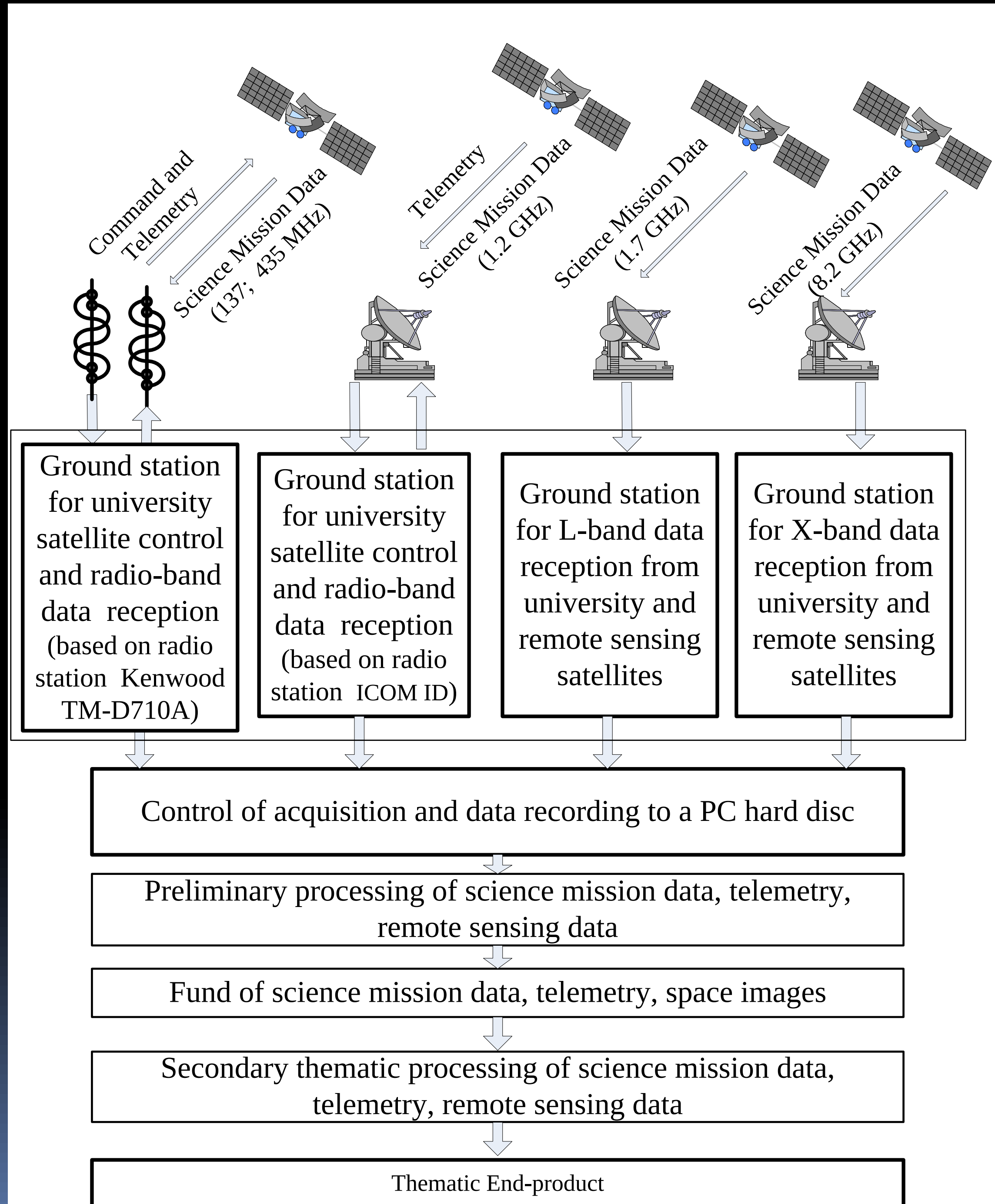
UNIVERSITY MICROSATELLITE

- Development and launching microsatellie
- Development new scientific experiments
- Development new scientific equipments
- Experimental data and telemetry processing and analyzing

BSU Aerospace Educational Center website

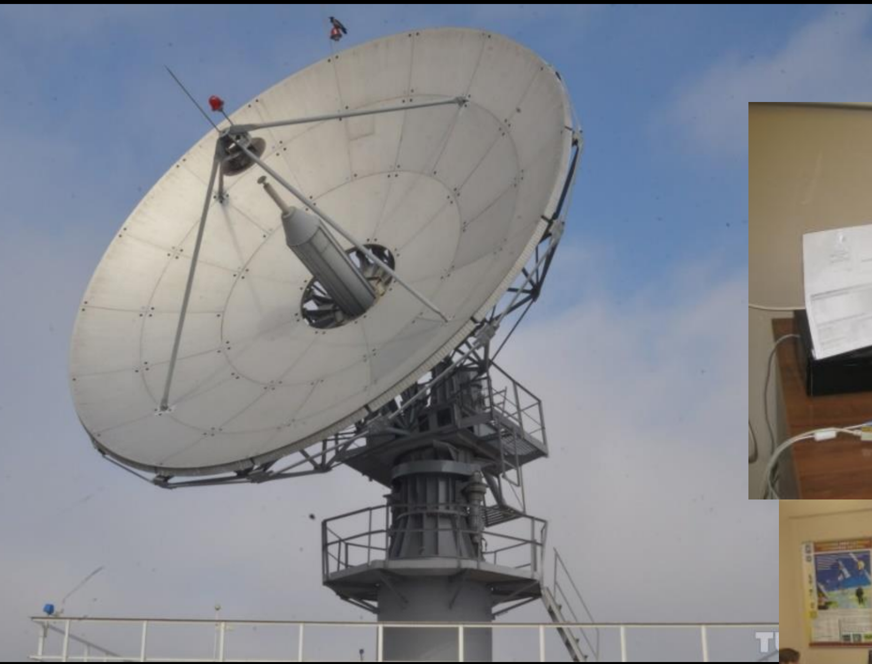


Ground station

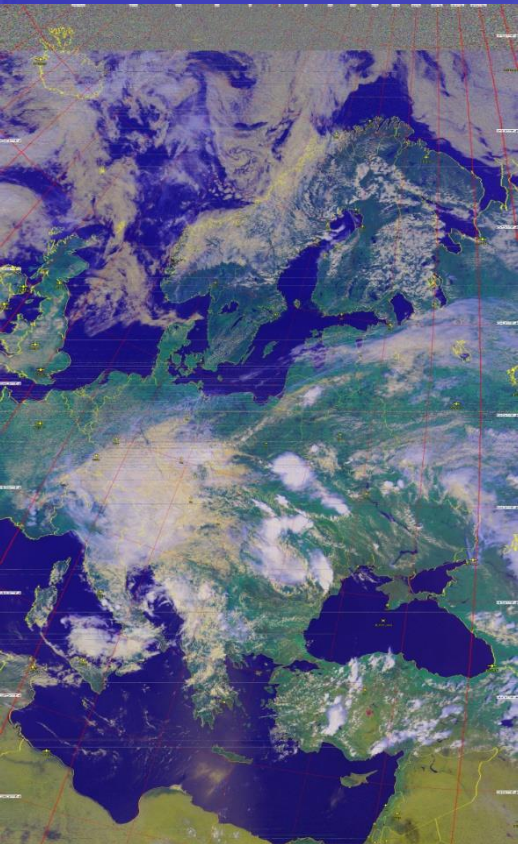


University ground station, VHF/UHF/L BAND

University ground station, S/X band



Receiving and processing of spacecraft payload information



Ввод исходных данных
(карты, снимки)

↓

Регистрация растрового изображения
(геопривязка)

↓

Векторизация и ввод атрибутивных данных

↓

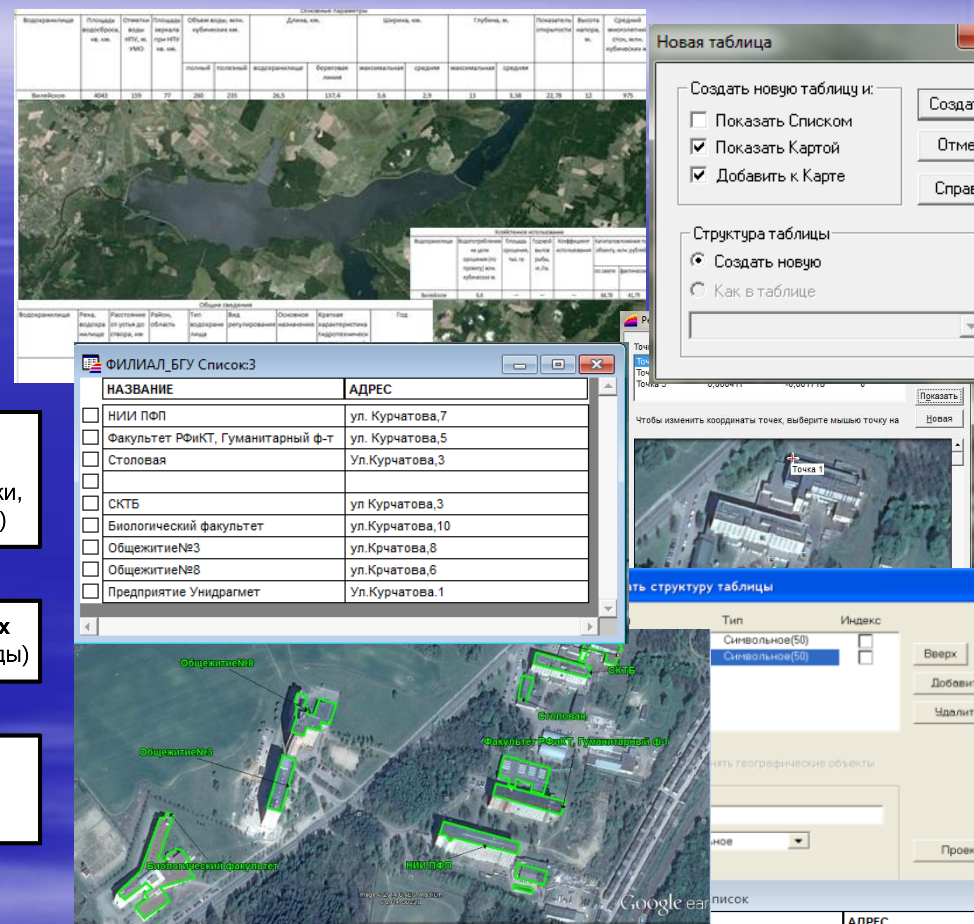
Отображение и работа с атрибутивными данными
(просмотр табличных данных, выборки, SQL-запросы, построение графиков)

↓

Анализ пространственных данных
(создание тематической карты, легенды)

↓

Вывод информации
(новый отчет, экспорт окна, вывод на печать)



Stages of creation of electronic map in MapInfo

Fragments of work with maps, pictures and databases

Receiving images of Europe from NOAA 19 (AVHRR)

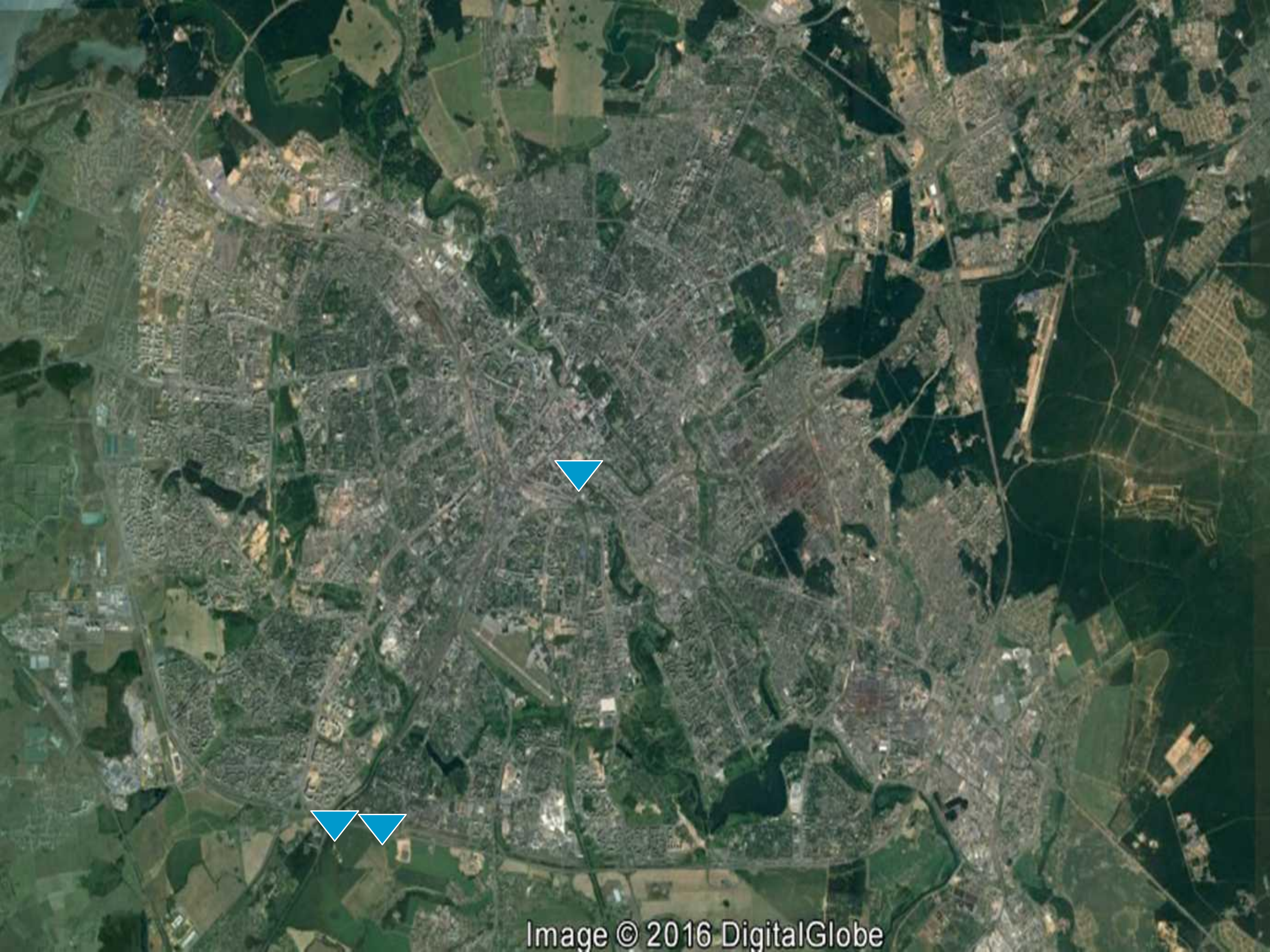
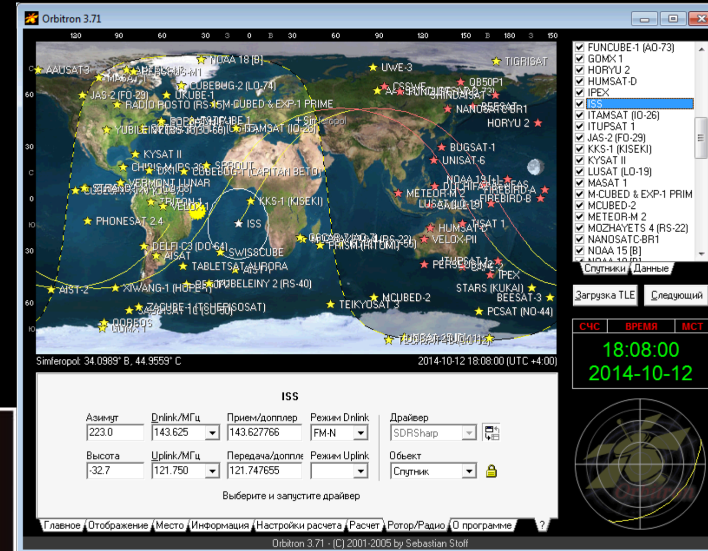


Image © 2016 DigitalGlobe

University mission control center

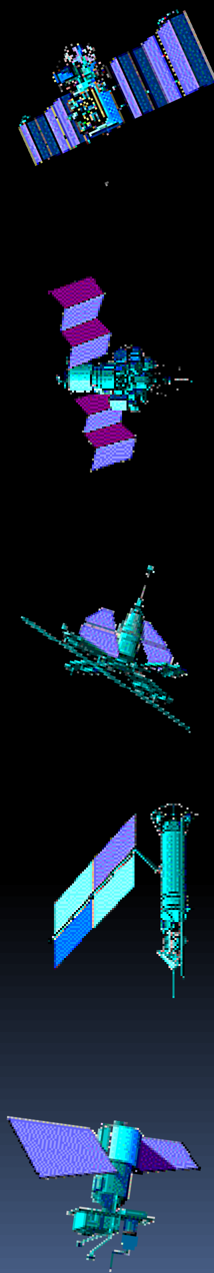
University mission control center

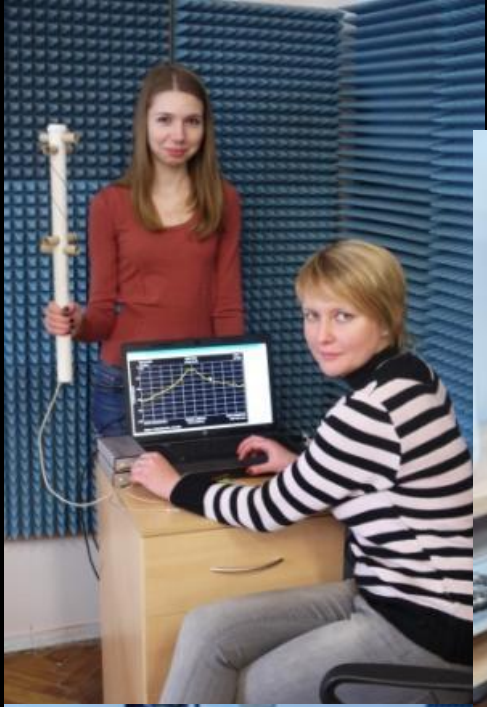


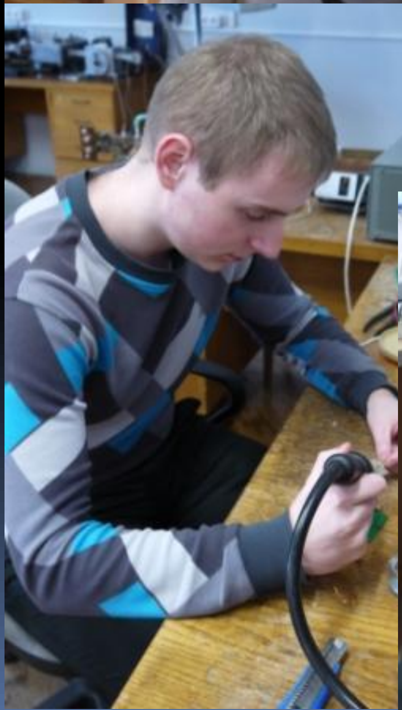
June, 5 2013 direct radio communication with ISS

Books for aerospace education

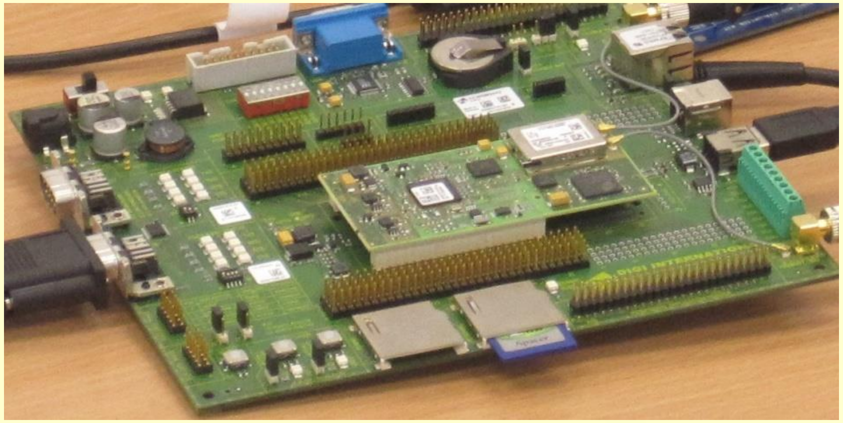
The students participating in development

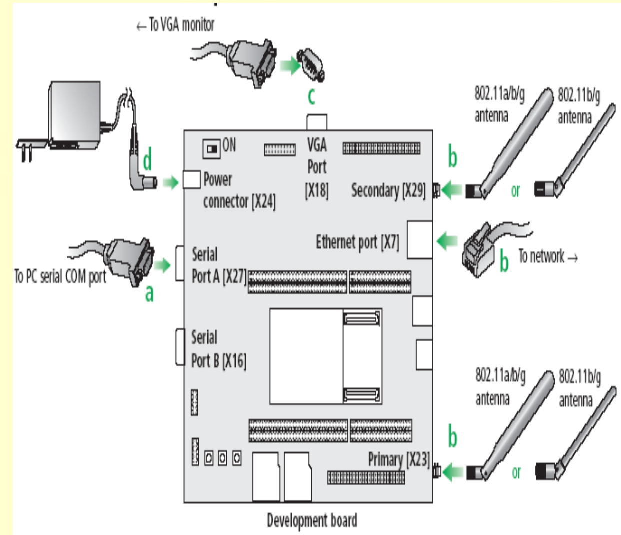




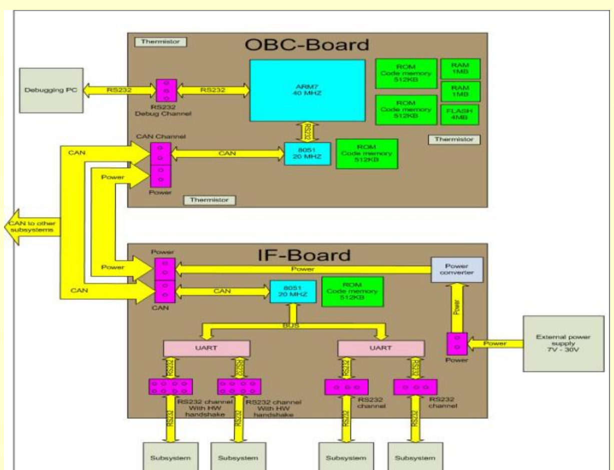


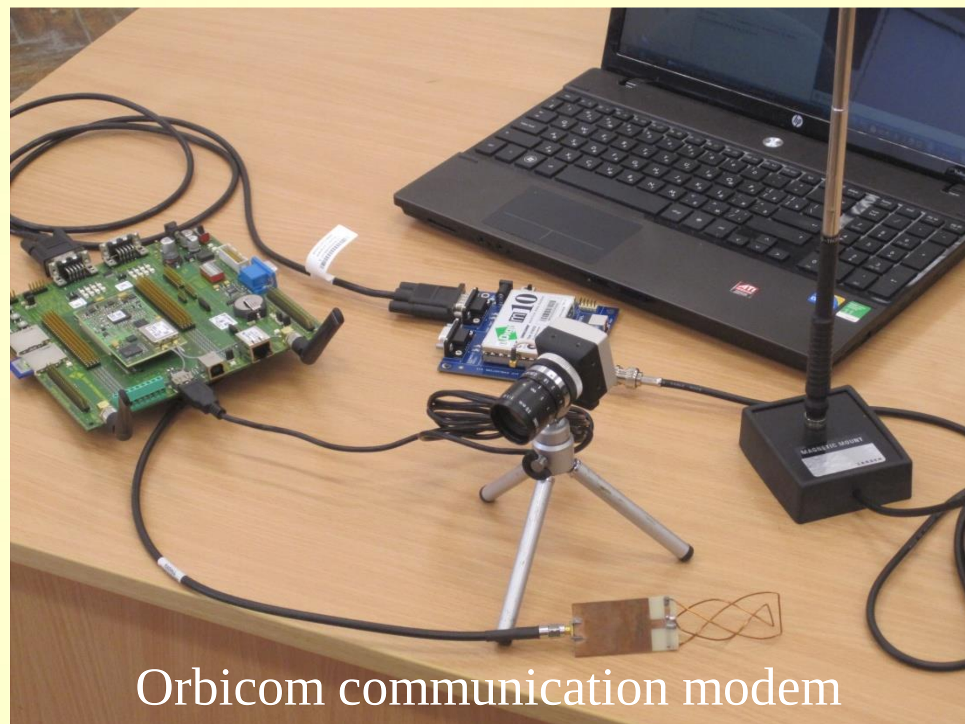
The space vehicle simulator





- ARM920T 400/533 MHz
- 16 Kb cash
- tire speed 133 МГц;
- NAND flash till 1Gb
- DDR SDRAM 256 Mb
- expected 4 Krad




Orbicom communication modem

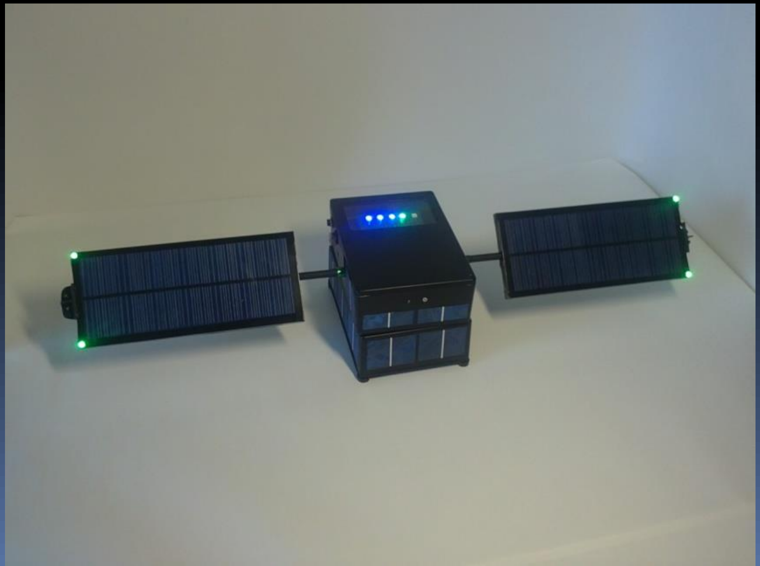
Training imitator: small spacecraft – ground station

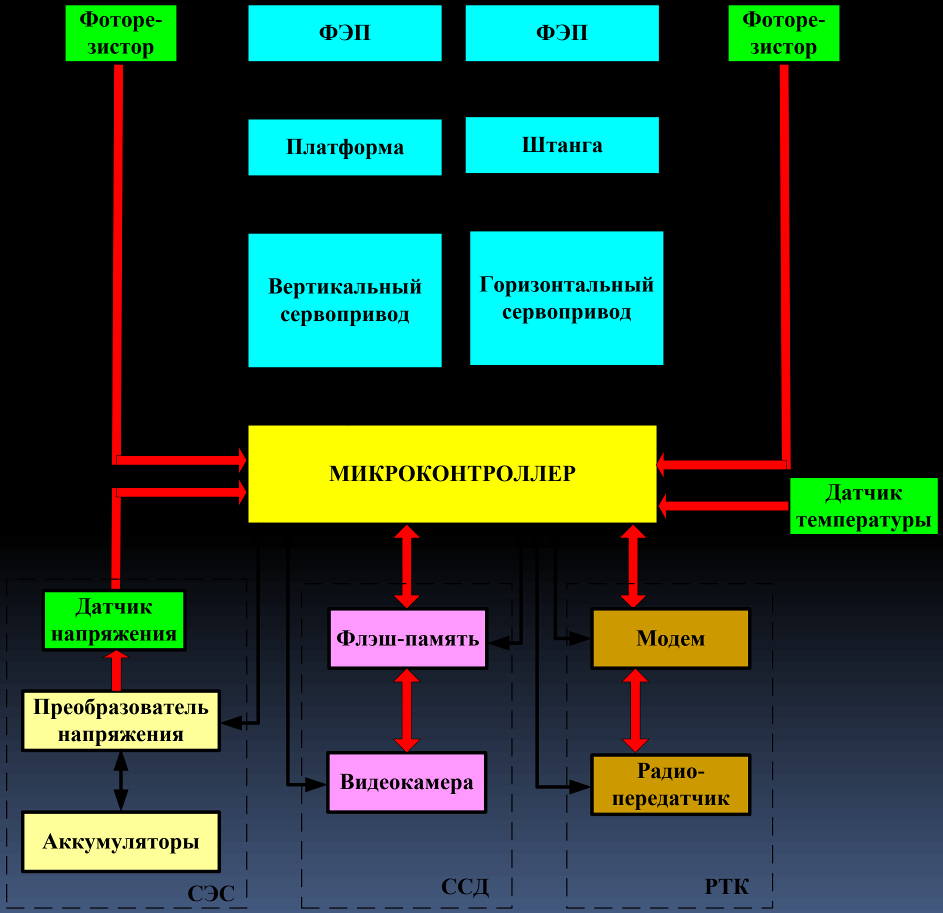
: Small spacecraft

Ground station

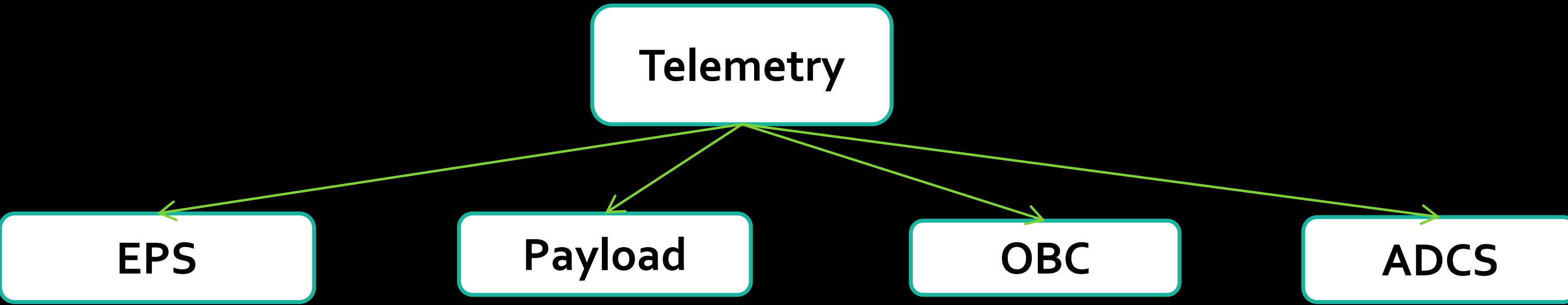
Students coursework. Model of nanosatellite

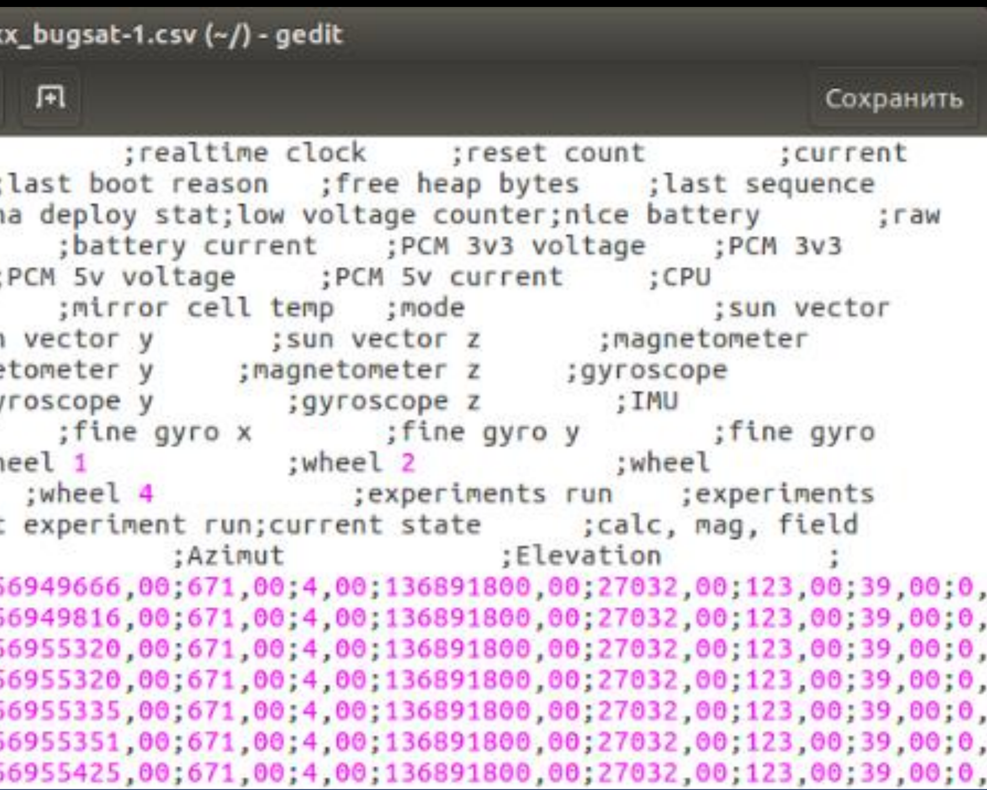
As part of the course project students 4 courses of specialization "Satellite information systems and technologies" developed a training model nano-satellite. This training model is used to simulate the reliability and efficiency of the systems on board and individual modules.





Student work: database of telemetry and payload information from small spasecrafts




x_bugsat-1.csv (~/) - gedit
Сохранить

```
;realtime clock ;reset count ;current
;last boot reason ;free heap bytes ;last sequence
na deploy stat;low voltage counter;nice battery ;raw
;battery current ;PCM 3v3 voltage ;PCM 3v3
;PCM 5v voltage ;PCM 5v current ;CPU
;mirror cell temp ;mode ;sun vector
n vector y ;sun vector z ;magnetometer
etometer y ;magnetometer z ;gyroscope
yroscope y ;gyroscope z ;IMU
;fine gyro x ;fine gyro y ;fine gyro
heel 1 ;wheel 2 ;wheel
;wheel 4 ;experiments run ;experiments
t experiment run;current state ;calc, mag, field
;Azimut ;Elevation ;
56949666,00;671,00;4,00;136891800,00;27032,00;123,00;39,00;0,
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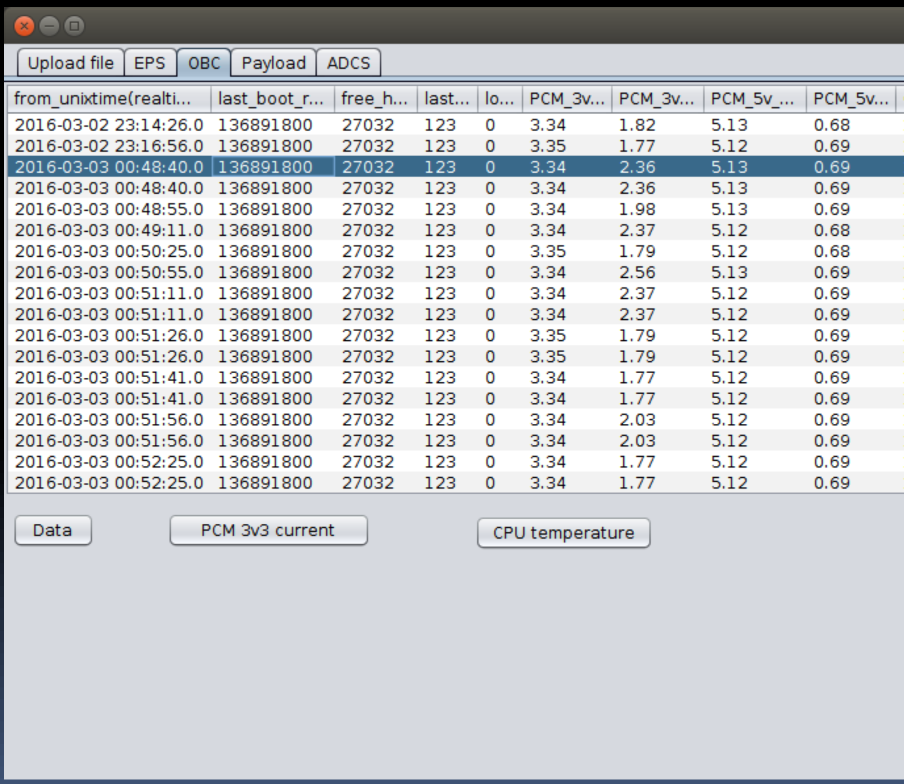
Upload file | EPS | OBC | Payload | ADCS

from_unixtime(realti...	last_boot_r...	free_h...	last...	lo...	PCM_3v...	PCM_3v...	PCM_5v_...	PCM_5v...
2016-03-02 23:14:26.0	136891800	27032	123	0	3.34	1.82	5.13	0.68
2016-03-02 23:16:56.0	136891800	27032	123	0	3.35	1.77	5.12	0.69
2016-03-03 00:48:40.0	136891800	27032	123	0	3.34	2.36	5.13	0.69
2016-03-03 00:48:40.0	136891800	27032	123	0	3.34	2.36	5.13	0.69
2016-03-03 00:48:55.0	136891800	27032	123	0	3.34	1.98	5.13	0.69
2016-03-03 00:49:11.0	136891800	27032	123	0	3.34	2.37	5.12	0.68
2016-03-03 00:50:25.0	136891800	27032	123	0	3.35	1.79	5.12	0.68
2016-03-03 00:50:55.0	136891800	27032	123	0	3.34	2.56	5.13	0.69
2016-03-03 00:51:11.0	136891800	27032	123	0	3.34	2.37	5.12	0.69
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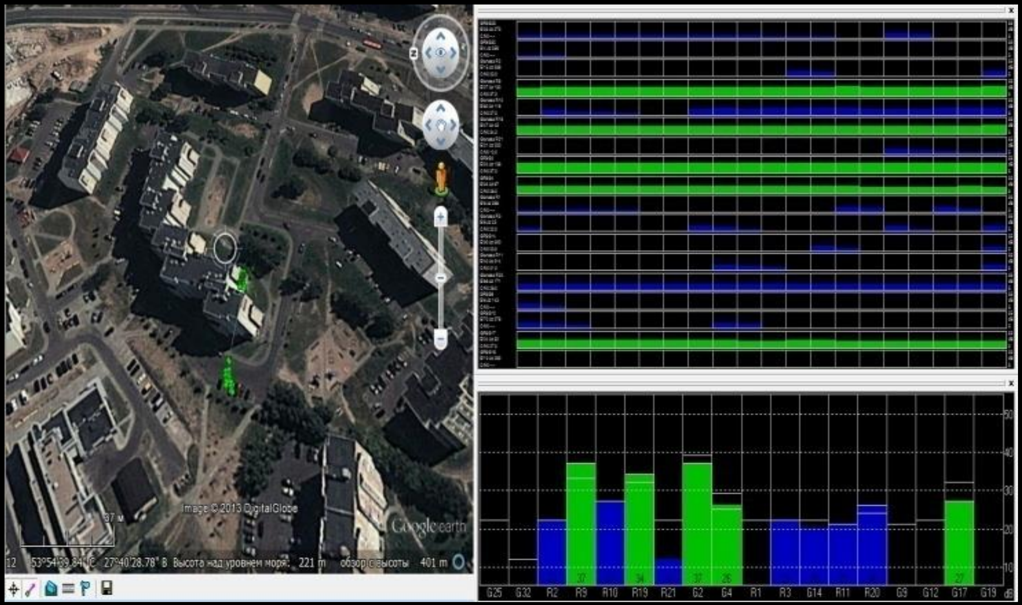
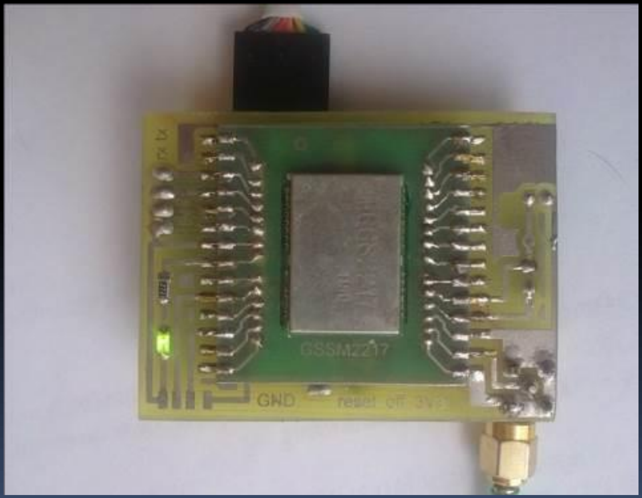
2016-03-03 00:51:26.0	136891800	27032	123	0	3.35	1.79	5.12	0.69
2016-03-03 00:51:26.0	136891800	27032	123	0	3.35	1.79	5.12	0.69
2016-03-03 00:51:41.0	136891800	27032	123	0	3.34	1.77	5.12	0.69
2016-03-03 00:51:41.0	136891800	27032	123	0	3.34	1.77	5.12	0.69
2016-03-03 00:51:56.0	136891800	27032	123	0	3.34	2.03	5.12	0.69
2016-03-03 00:51:56.0	136891800	27032	123	0	3.34	2.03	5.12	0.69
2016-03-03 00:52:25.0	136891800	27032	123	0	3.34	1.77	5.12	0.69
2016-03-03 00:52:25.0	136891800	27032	123	0	3.34	1.77	5.12	0.69

Data | PCM 3v3 current | CPU temperature

Magister thesis "UAV onboard navigation module with data logging"

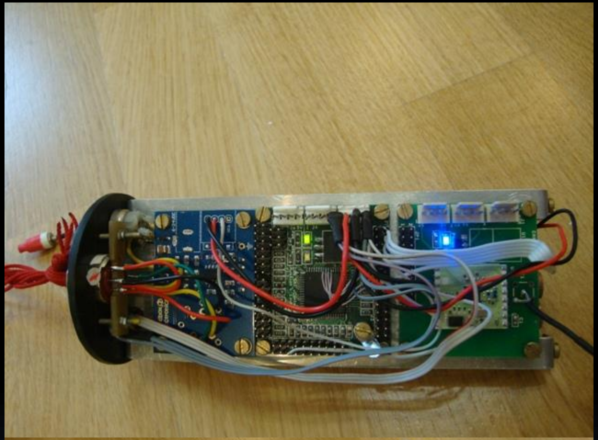




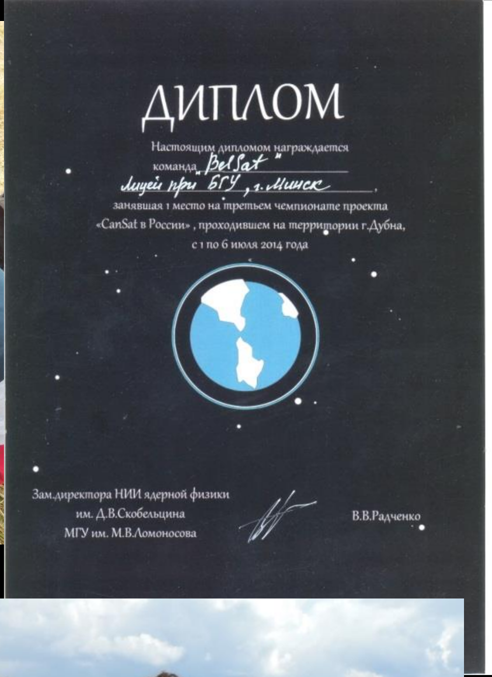
Pico satellite «BelSat»

•May, 4 2012 the BGU lyceum team, under the leadership of students of faculty of radio physics and computer technologies started an educational picosatellite of own development "BelSat" on height of 2 km near the city of Kaluga (Grabtsevo's airfield) within the first CanSat championship in Russia. Through 213 seconds the satellite successfully landed on a parachute of own development. Descent all the time from the satellite the telemetry from various sensors, and also from the GPS receiver came to reception station which also is own development.

•To the BelSat team the 2nd place among 17 teams was awarded, and also the cup on the nomination "For Development of the Best Scientific Task" is handed over.



Team “BelSat Mark 3 – the winner in the majors”, 2014



ДИПЛОМ

Настоящим дипломом награждается
команда „BelSat“
Лицей при БГУ, г. Минск,
занявшая 1 место на третьем чемпионате проекта
«CanSat в России», проходившем на территории г.Дубна,
с 1 по 6 июля 2014 года

Зам.директора НИИ ядерной физики
им. Д.В.Скобельцина
МГУ им. М.В.Ломоносова

В.В.Радченко

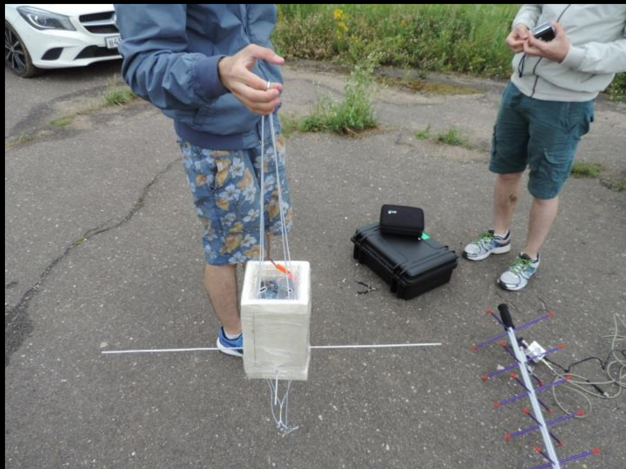
Flight models of picosatellites CanSat v.1 (a), v.2 (b)
and nanosatellites CanSat v.3 (c), v.4 (d)

a

b

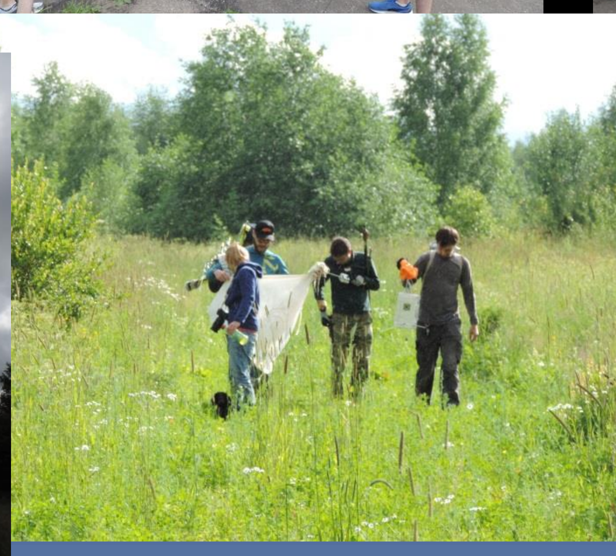
c

d




Out

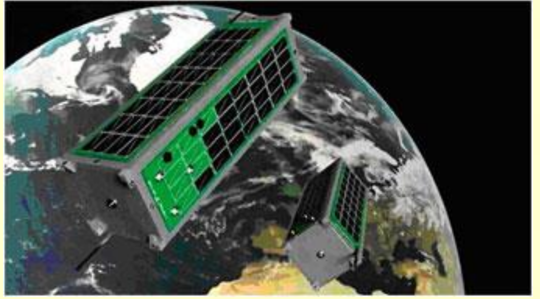



5.11.2012 in BGU competition was declared

On competition of the best project of space experiment 15 works were given also it is offered to the 23rd name of the university nanosatellite

Open competition "Send your idea to the space"



Nomination - best project of space experiment

The 1st place – "Phase transitions under zero gravity and space radiation", the author the Krot Yury, the graduate student of the physics faculty.

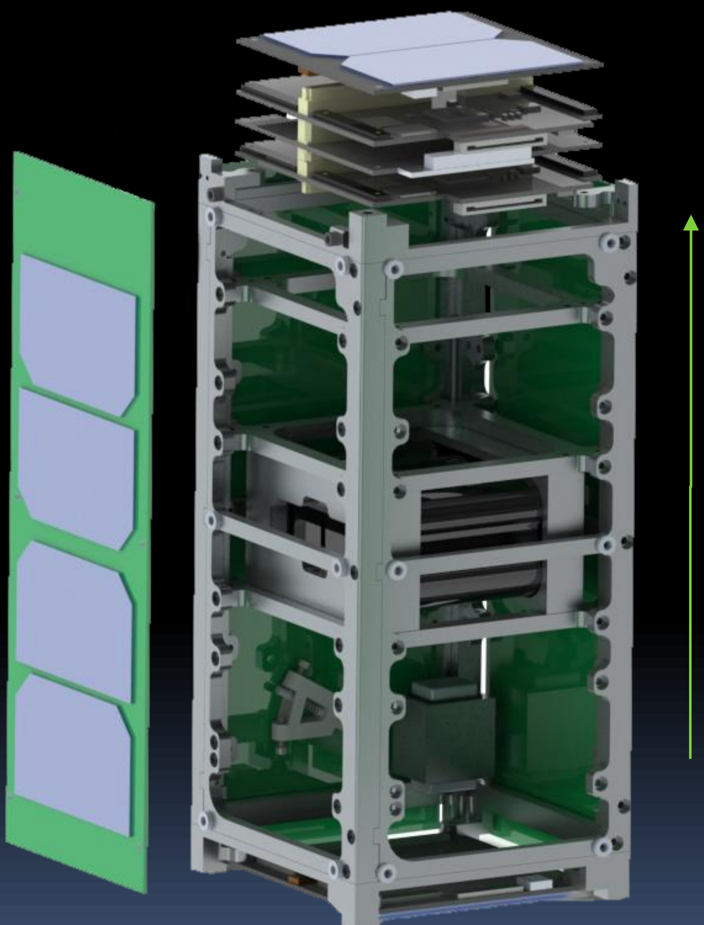
The 2nd place – “Electromagnetic field pollution from a radio emission", author - Martinov Anton, the student of the 4th course of the faculty of radio physics and computer technologies.

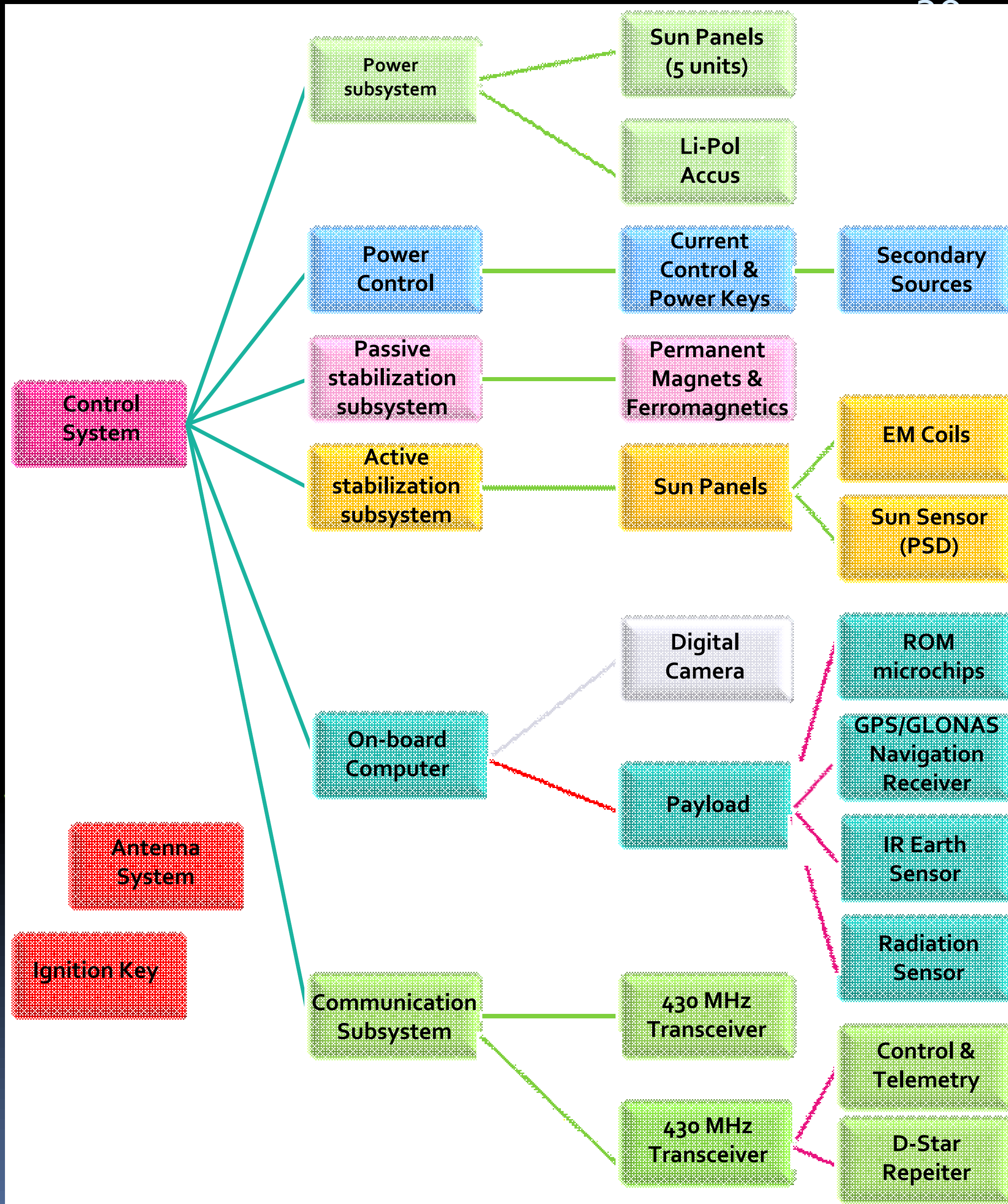
The 3rd place – "An ionospheric harbinger" (research of ionospheric indignations during preparation of seismic events), author Reznikov Yury, the student of the 5th course of the faculty of radio physics and computer technologies.

Nomination – the best NAME for the university nanosatellite

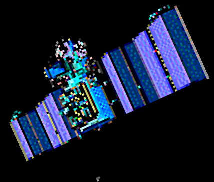
BEKASS the author the Peter Lopuh, the head of the department of the general physical geography and hydrometeorology of geographical faculty.

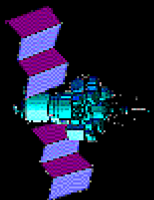
Block diagram
CubeBEL-1

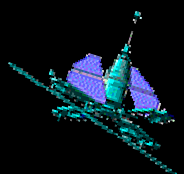


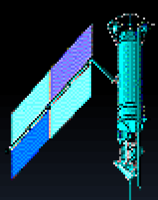


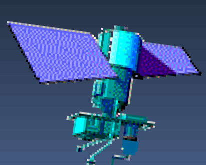
Primary satellite team, mission discussion

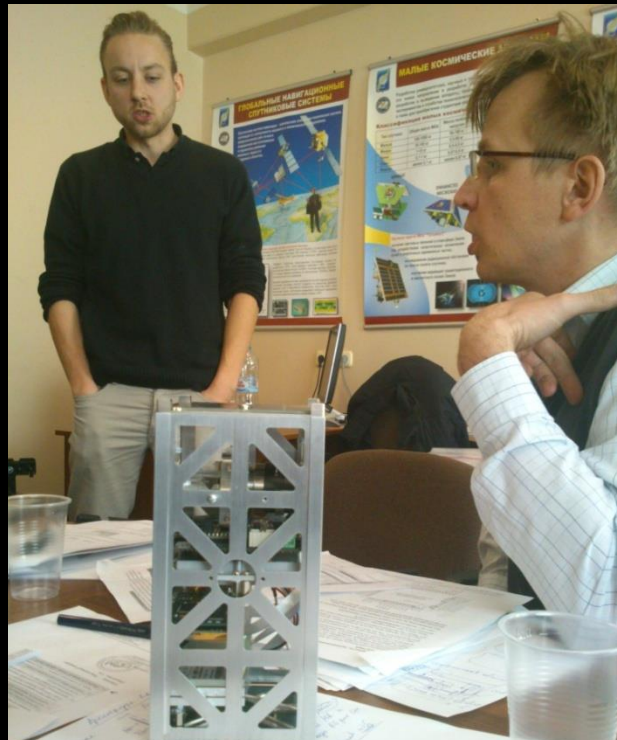




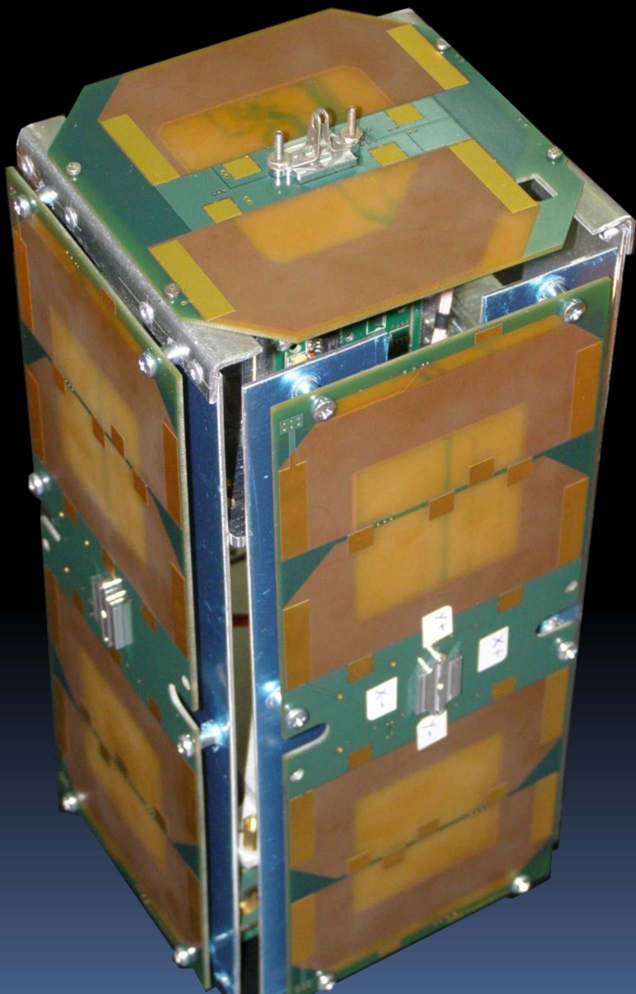


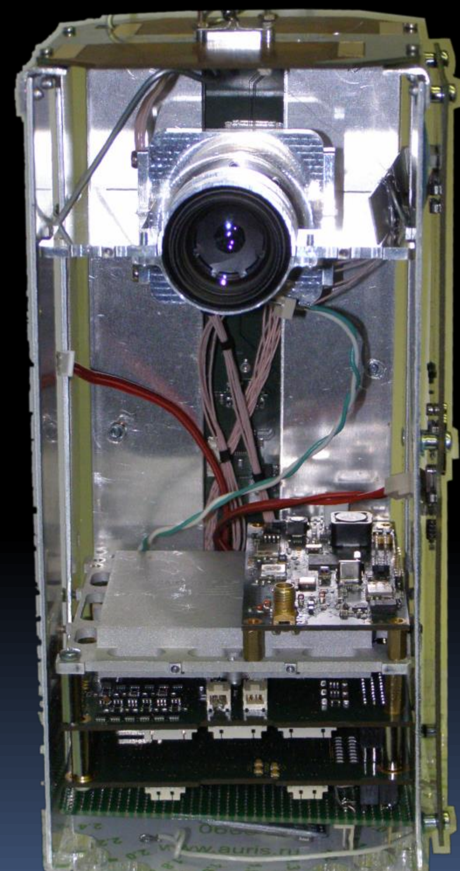


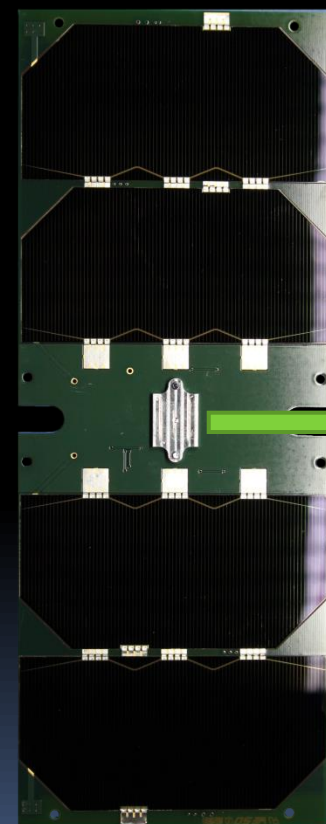


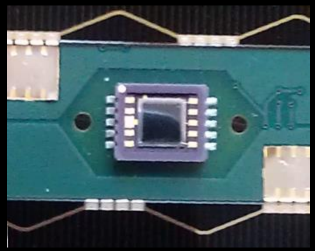


Engineer Model

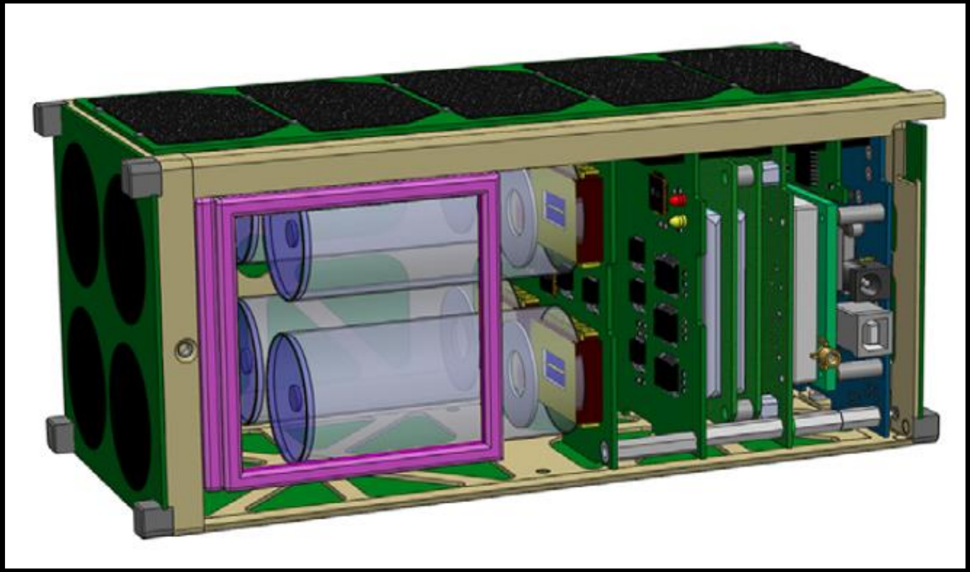






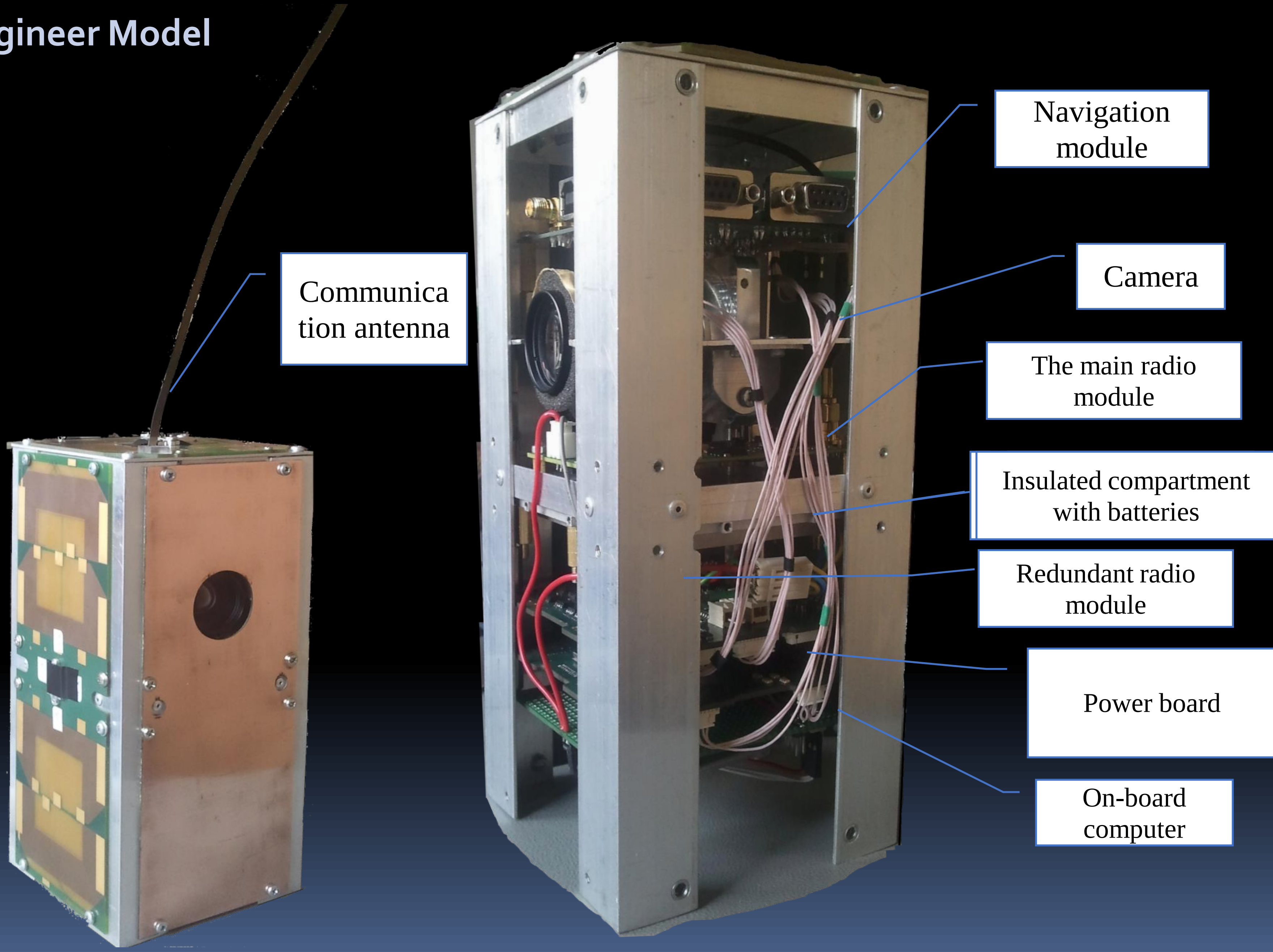


Engineer Model

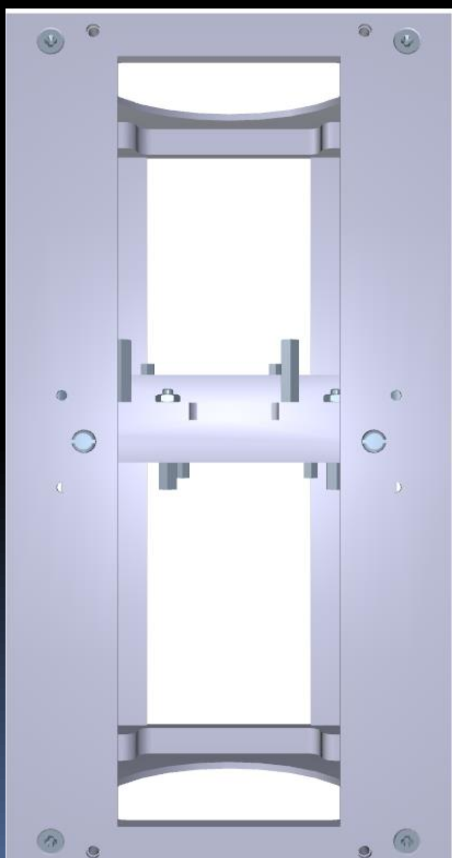


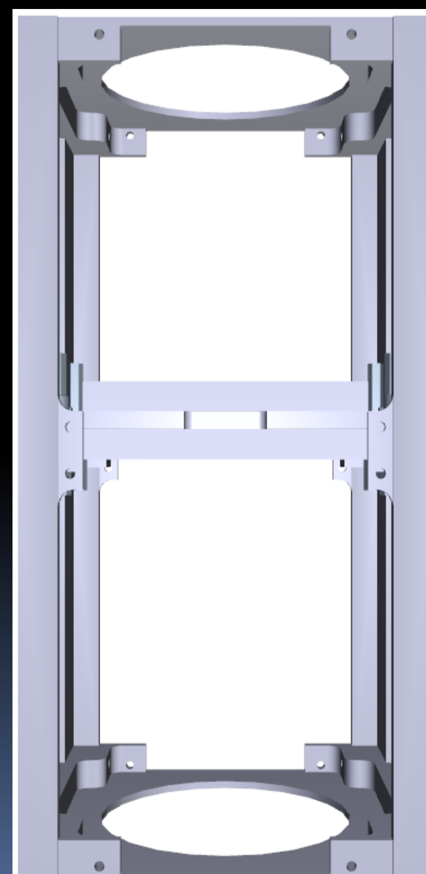
- Test the functionality of subsystems within the BC board
- Calibrated inertial sensor
- Developed GUI application for managing the satellite model, telemetry and control display

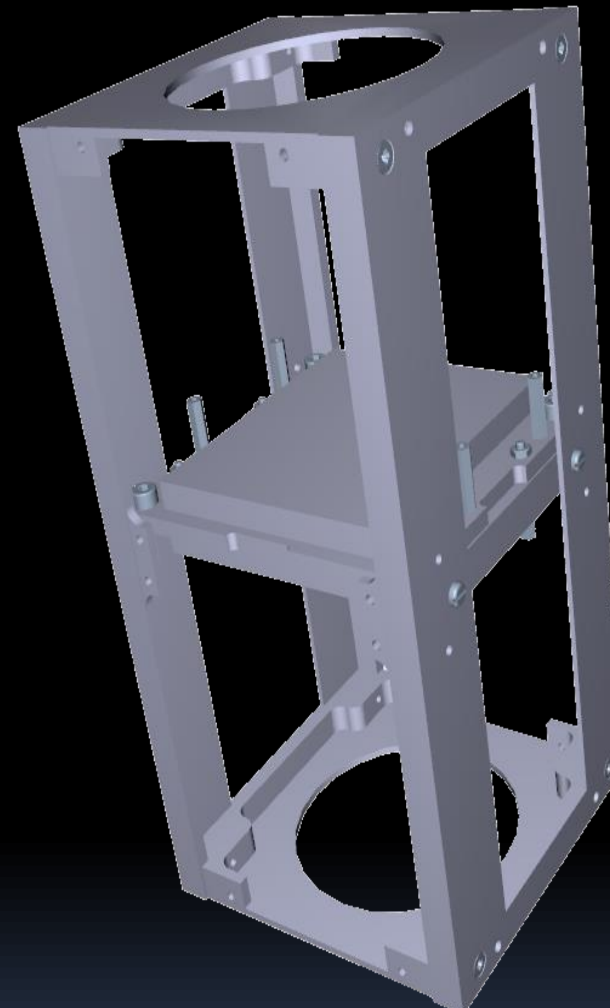
Engineer Model



Constraction parametric model

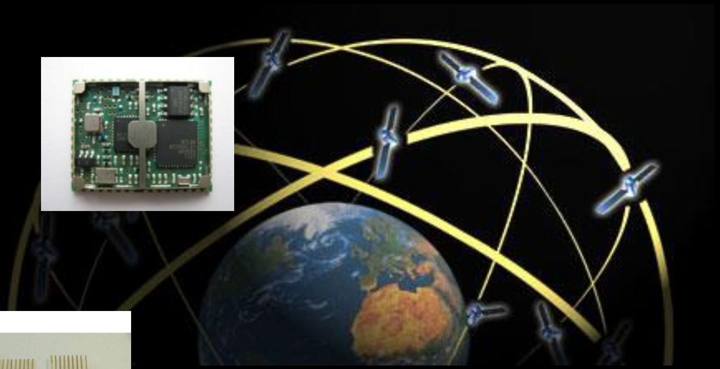


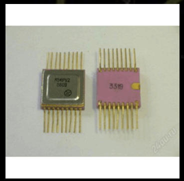


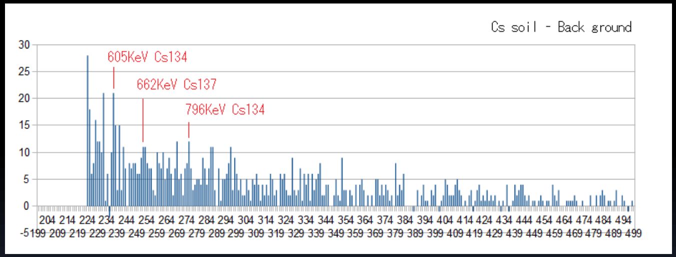


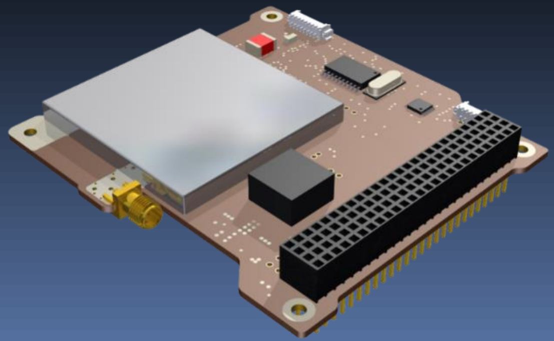
Payloads

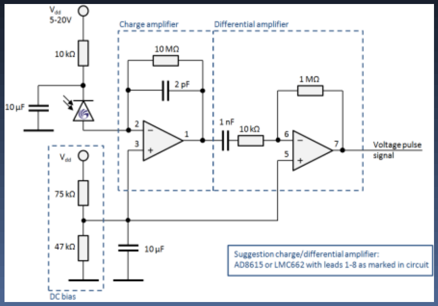
- 2 frequency GPS/GLONAS navigation receiver: NAV-01 (GLONASHA), NT-Lab Company (Minsk). Three types of messages: RANGEB, GPSEPHEMB, GLOEPHEMERISB NOVATEL OEMv4.
- Gamma ray Geiger-Mueller Indicator: JSC «Polimaster" (Minsk) (from 0.06 to 1.33 MeV).
- Radiation resistance of special use ROM 1635RT2U, 512K (64Kx8). JSC "Belmikrosititemy", (Minsk).
- Infrared sensor - calibrated temperature measurement in the direction on the Earth (MLX90614 MELEXIS). (-40 ... + 125C), +/- 0.1C.
- Solid-pin-diode (PS100-7-CER-PIN 100mm^2) + scintillation screen + metal screen + integrating circuit + ADC + Soft = gamma-ray spectrometer.
- 640x480 Digital camera.

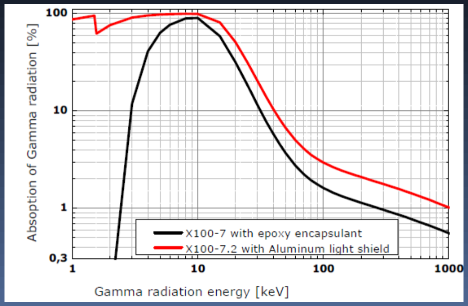




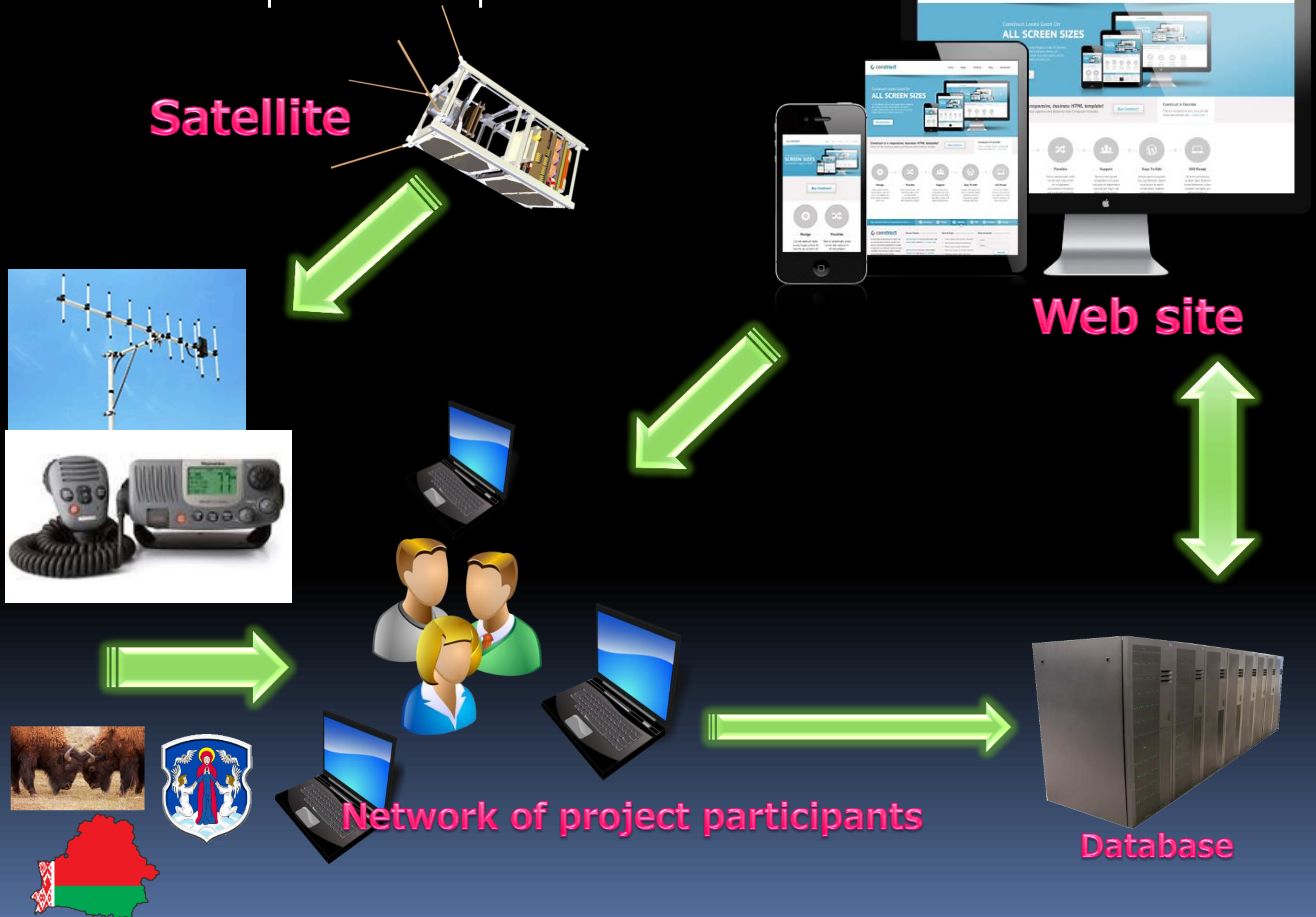








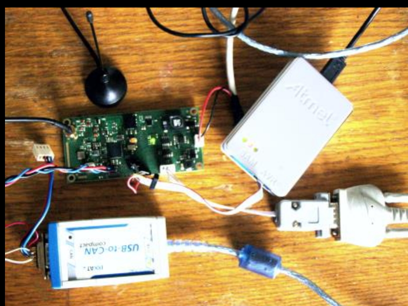
Destributed network based on WEB portal for amateur radio operators and partners

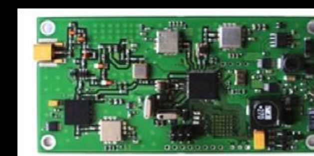
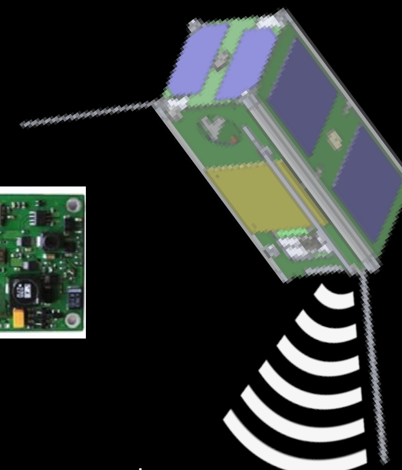
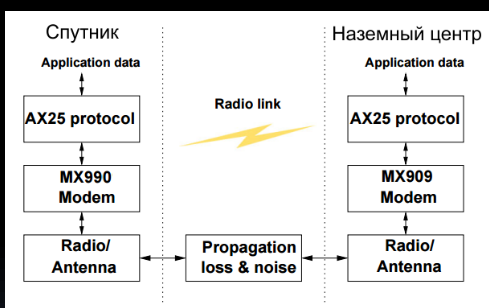


Engineering kit onboard and ground communications equipment (For debugging software, the radio test, alignment of antennas)

Equipment

433,625 MHz radio modem, power amplifier c temperature control,
DVB-T receiver (SDR RTL2832U + R820T), spectrum analyzer ANRITSU MS2691A, antenna)



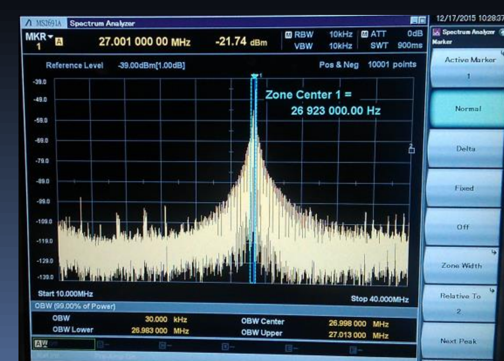
Transmitter: up to 1.5W, Senses. reception: -112dbm

UP-Link ↑ 9600 baud, GMSK, Mobitex, encryption of data, remote commands

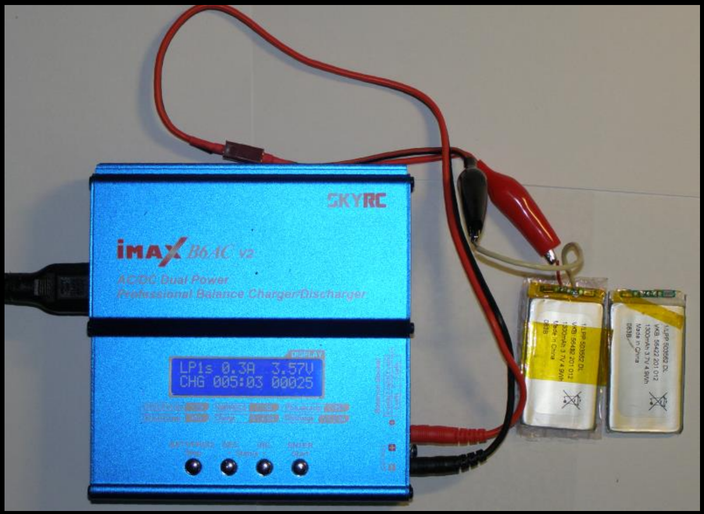
The packet length from 4 to 4608 bytes + 7 bytes header + CRC + FEC

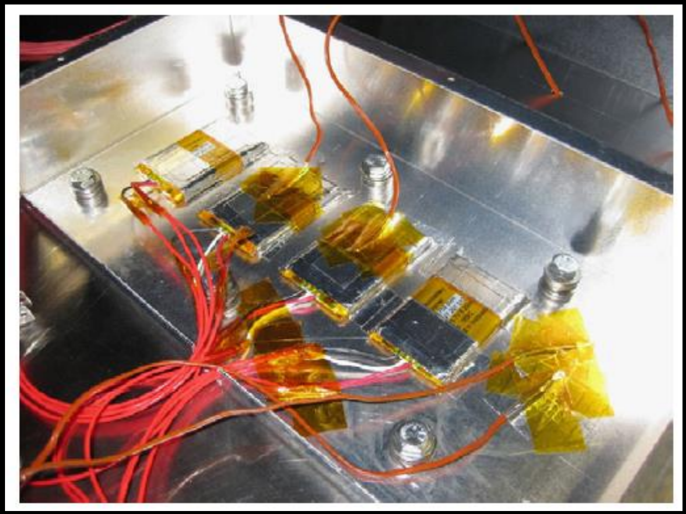
Down-Link ↓ 9600 baud, GMSK, Mobitex, AX.25 / kiss, Encryption



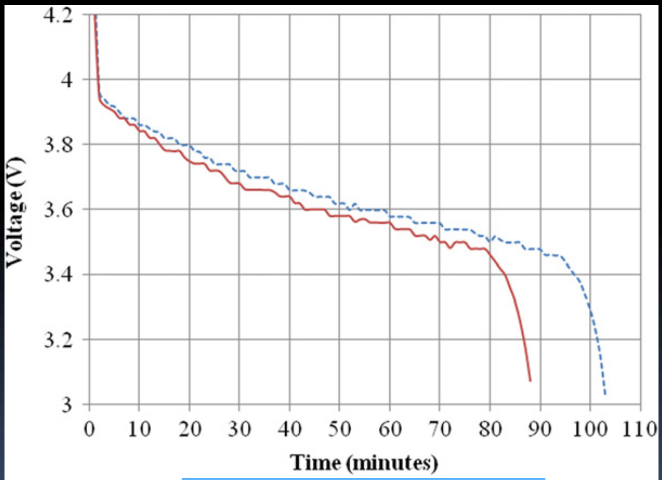


Stand for testing and balancing batteries

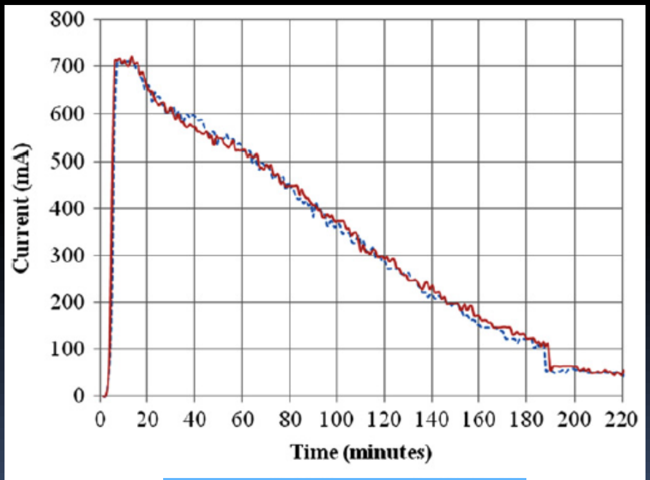




LiPolymer
4 x elements 1300 мAh



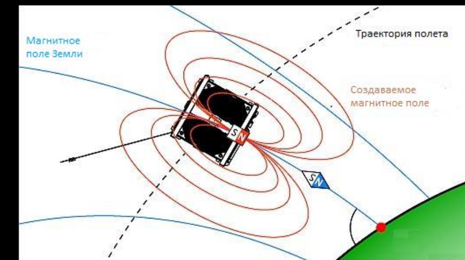
Цикл заряда



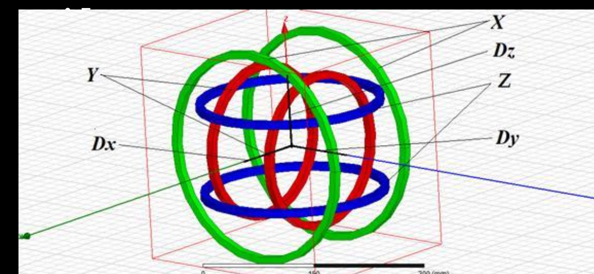
Цикл разряда

Stand for testing the MEMS sensors and testing of the satellite stabilization algorithms (orientation axis of rotation and the rotation speed control)

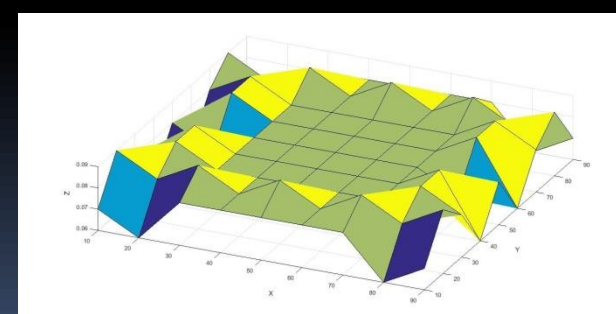
Magnetic induction field of the Earth ≈50mkTl,
Coils reproduce magnetic field up to 300mkTl



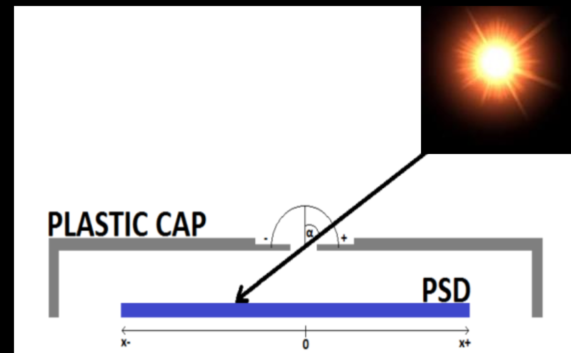
Three pairs of Helmholtz

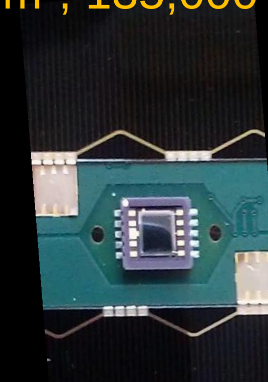


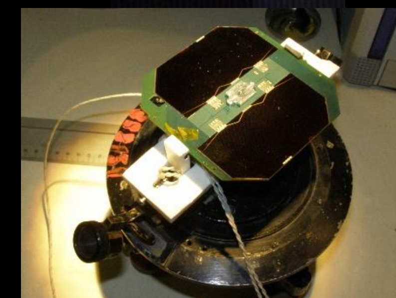
The distribution of the magnetic induction B in the central section

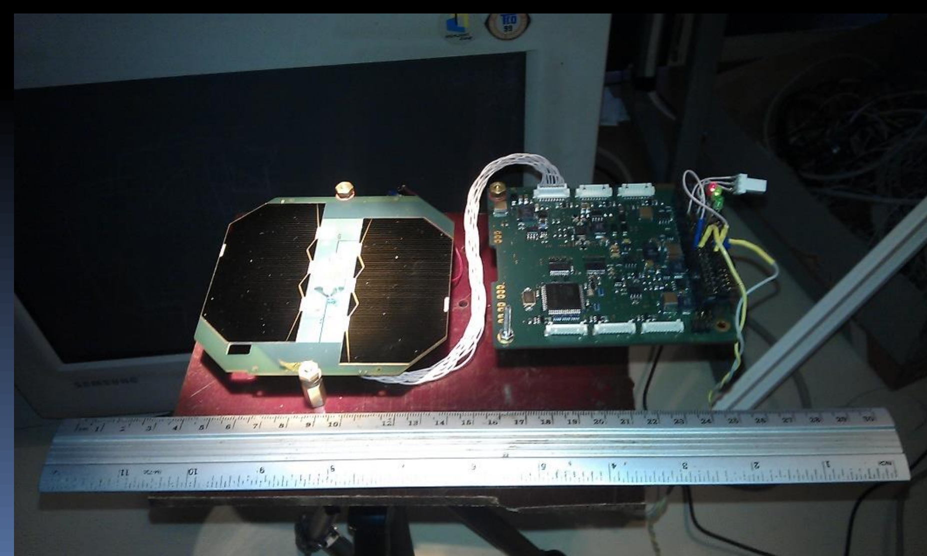


Stand for calibration direction on the sun sensor
Stand with two degrees of freedom, the sun simulator of 1367 W / m², 135,000 lux)

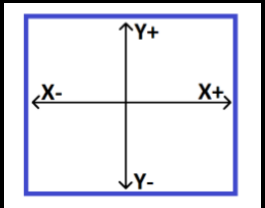


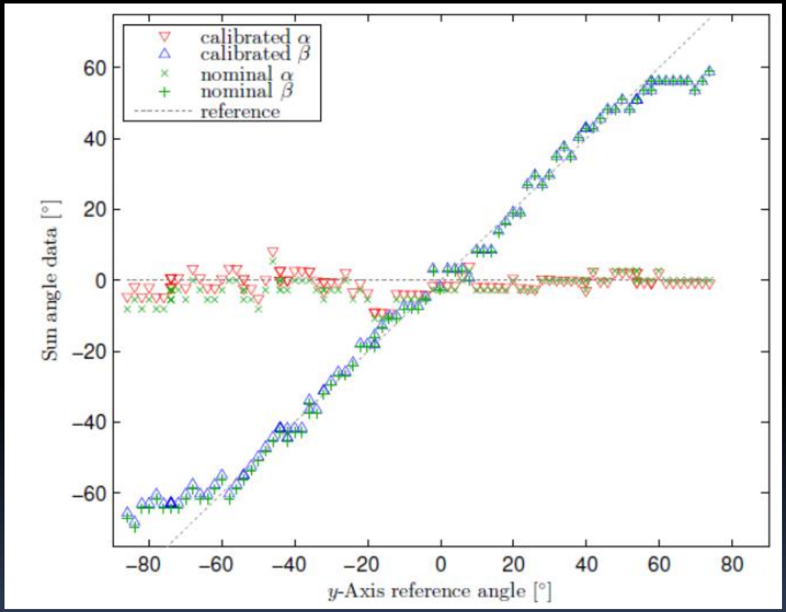


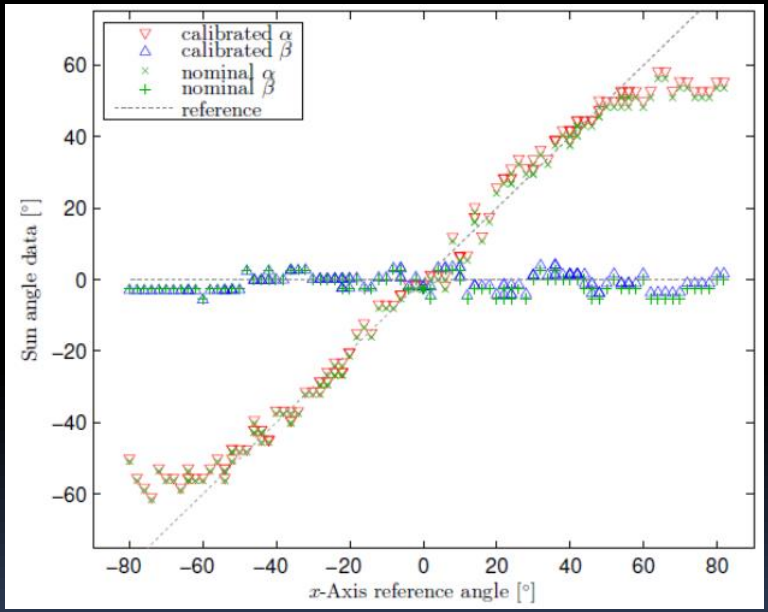




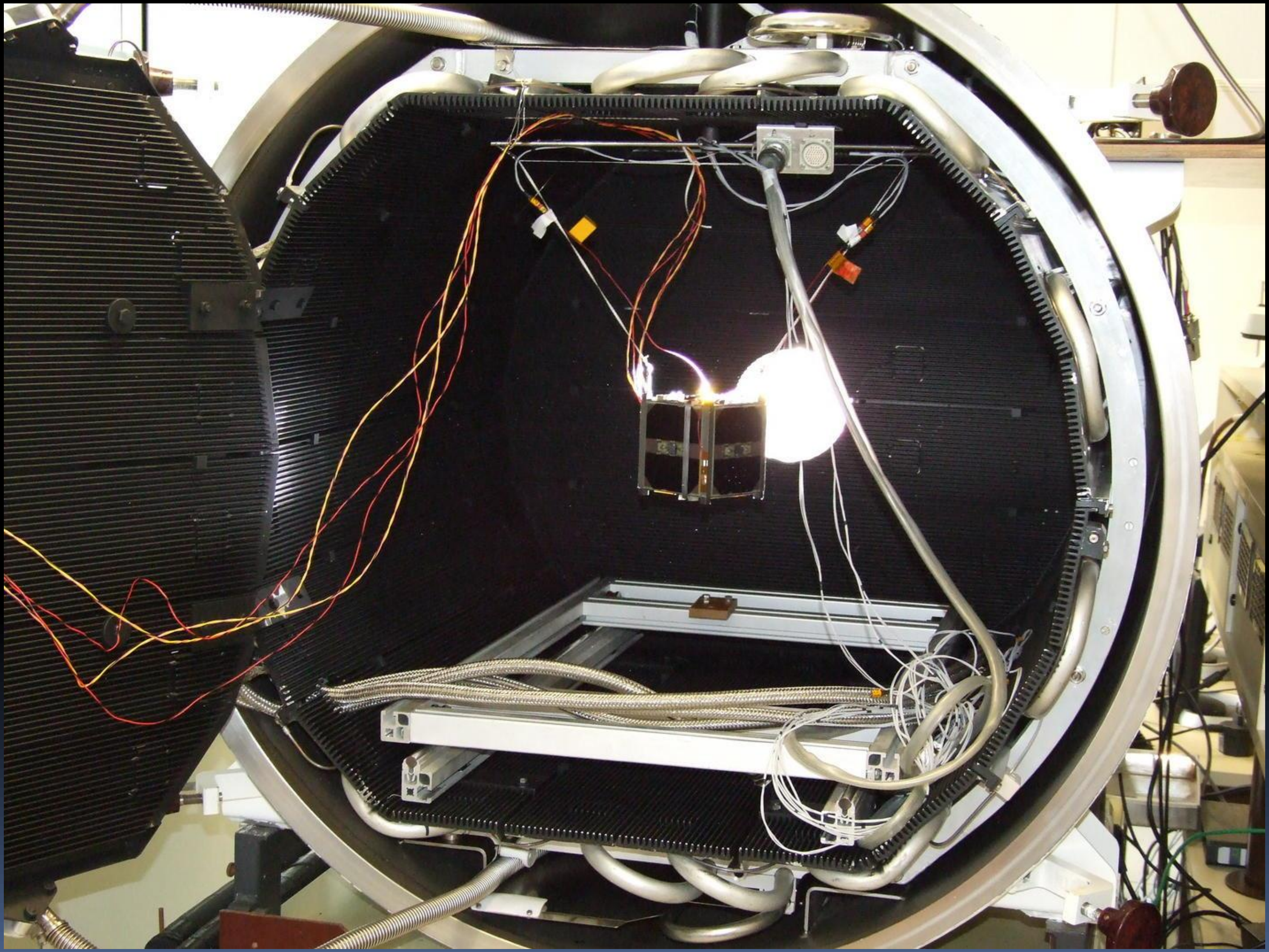
The result of calibration 2-axis heading sensor in the sun
(Linear range biaxially +/- 60 degrees





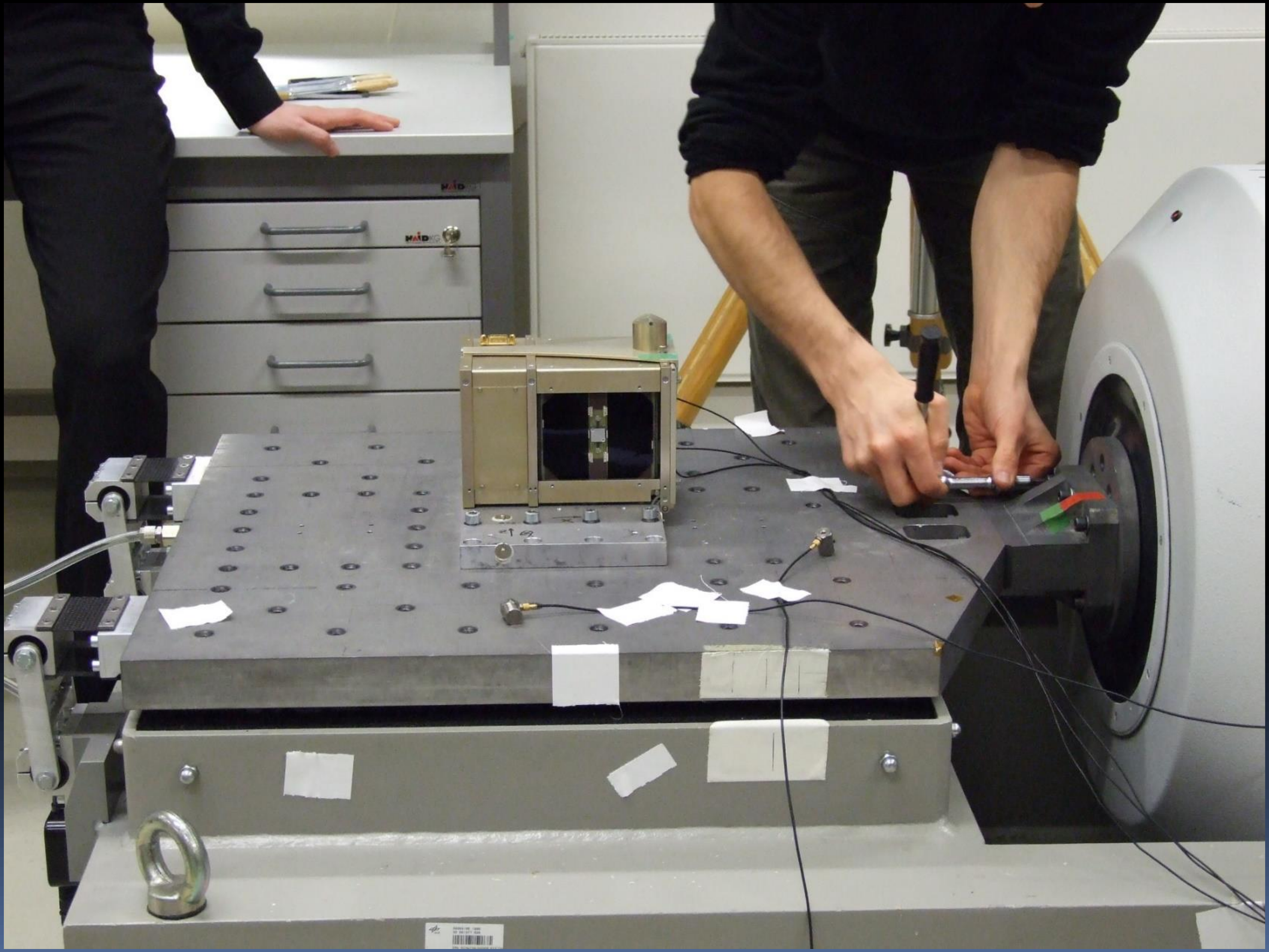


- **Thermo test (-30 ° C .. + 90 ° C)**

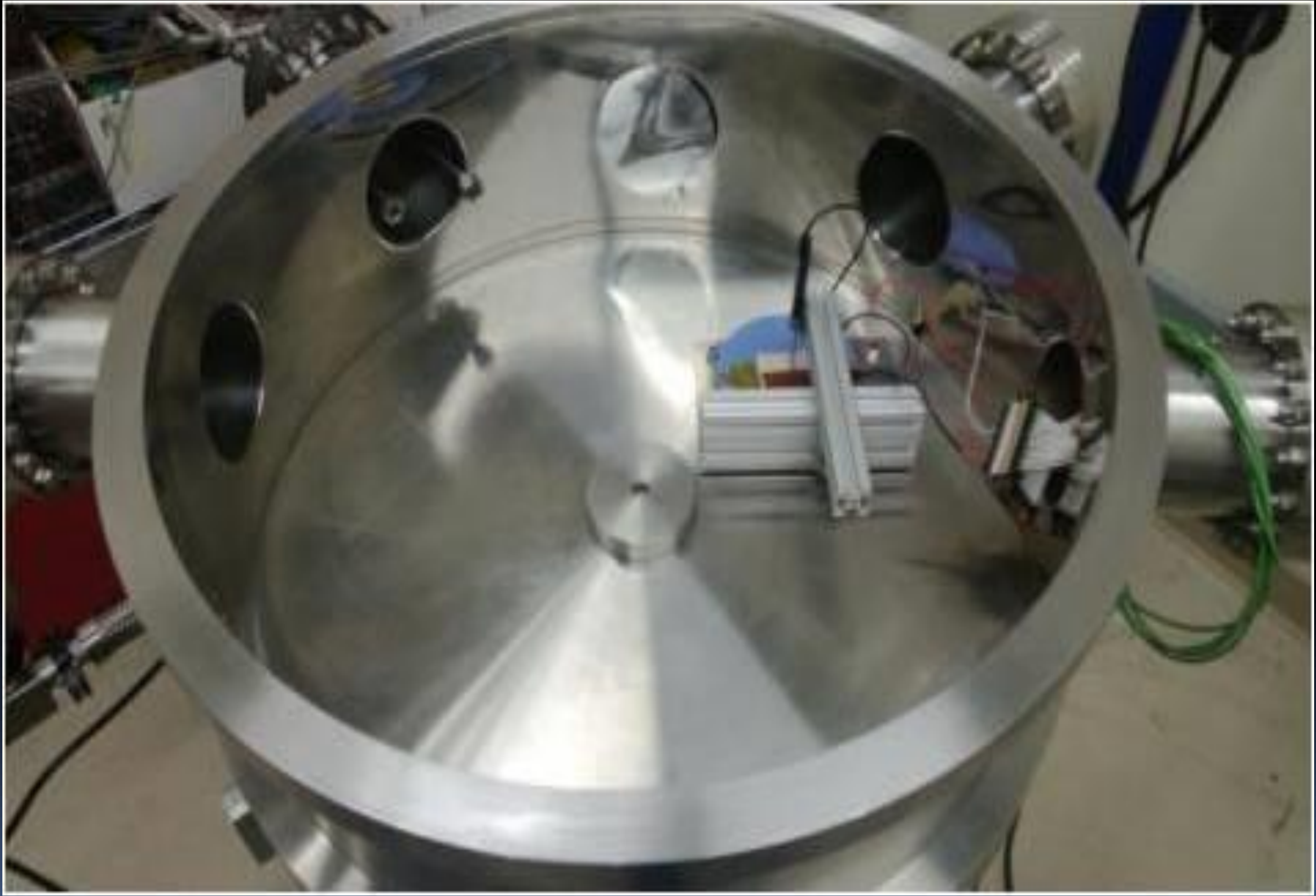


- **Vibration tests (depending on the rocket)**

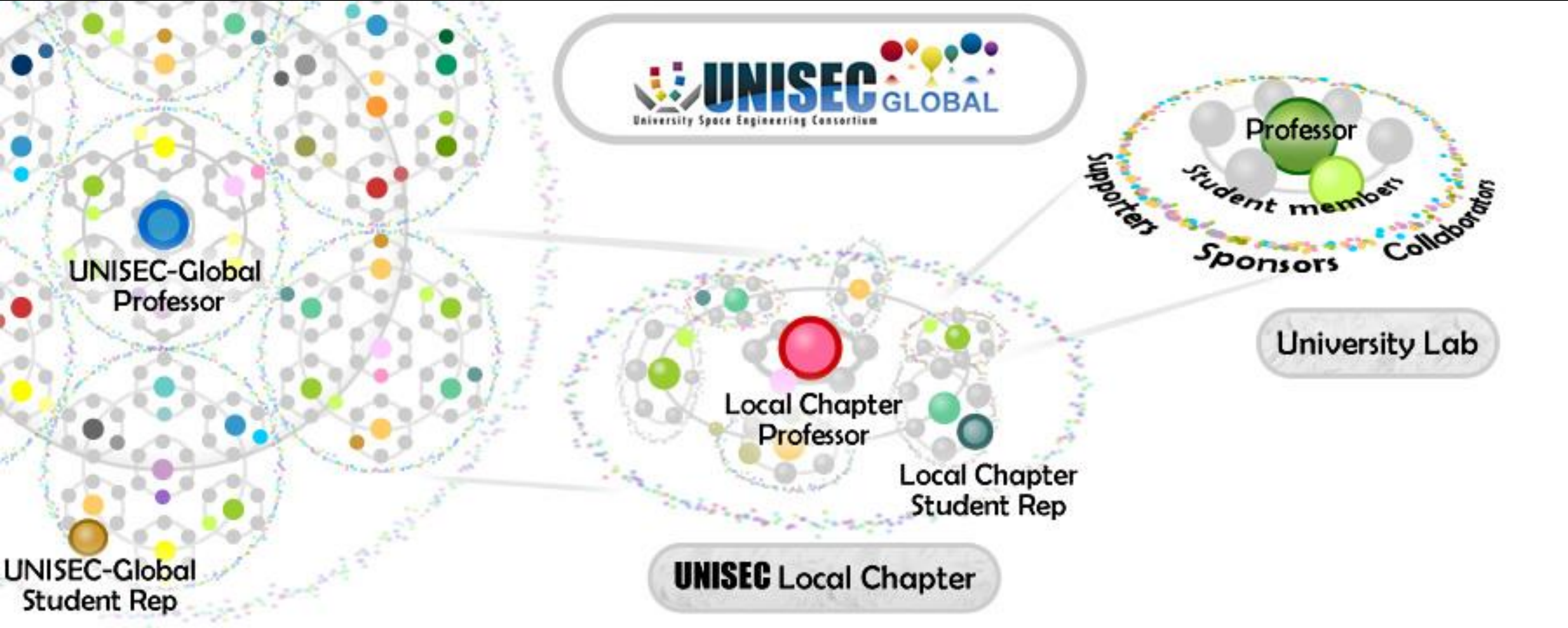
the longitudinal axis Overload - 7.5 g, transverse overloading - 0.8 g, integrated speaker load - 140 dB



- **Tests in a vacuum chamber**
- **Temperature: 60 ° C & Fine vacuum: 0.02mbar**

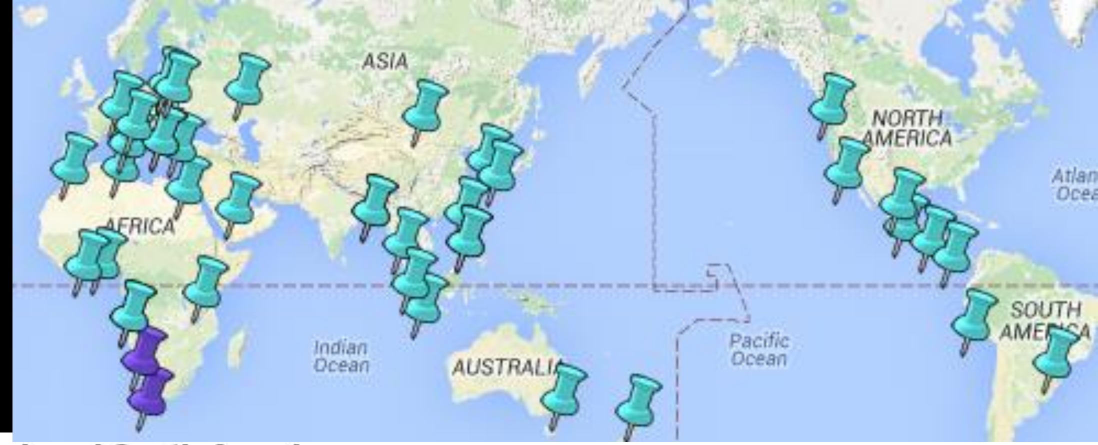


Our aim is to create a world where university students can participate in practical space projects in more than 100 countries by the end of 2020. The fractal structure (figure below) of University Space Engineeirng Consortiums (UNISECs) worldwide support engineering education at multiple levels - from university labs to nation-wide groups.



Points of Contact (POC)

UNISEC-Global Office
c/o UNISEC
Central Yayoi 2F, 2-3-2, Yayoi, Bunkyo, Tokyo 113-0032, Japan
Tel: +81-3-5800-6645
Fax: +81-3-3868-2208
Email: meeting(at)unisec-global.org (please replace (at) with @.)



May 23, 2016

New Point of Contact

Please welcome Vladimir Saetchnikov (Belarusian State University, Belarus)

List of the Points of Contact

North, Central, and South Americas

João Dallamuta
Associação Aeroespacial Brasileira, Brazil

Larry Reeves
Canadian Satellite Design Challenge Management Society, Canada

Jordi Puig-Suari
Cal Poly, USA

Mario Gómez Jenkins
Costa Rican Inst. of Tech., Costa Rica

Willy Ricardo Cabañas Villagrán
Central American Association for Aeronautics and Space, Chapter Guatemala

Blanca Rebollar
Mexican Space Agency, Mexico

Barbara Bermudez Reyes
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Hector Bedon
National University of Engineering, Peru

Europe

Vladimir Saetchnikov
Belarusian State Univ, Belarus

Plamen I. Dankov
Sofia University, Bulgaria

Vesselin Vassilev
CASTRA, Bulgaria

Klaus Schilling
University of Würzburg, Germany

Vidmantas Tomkus
Lithuanian Space Association

Fabio Santoni
University of Rome la Sapienza, Italy

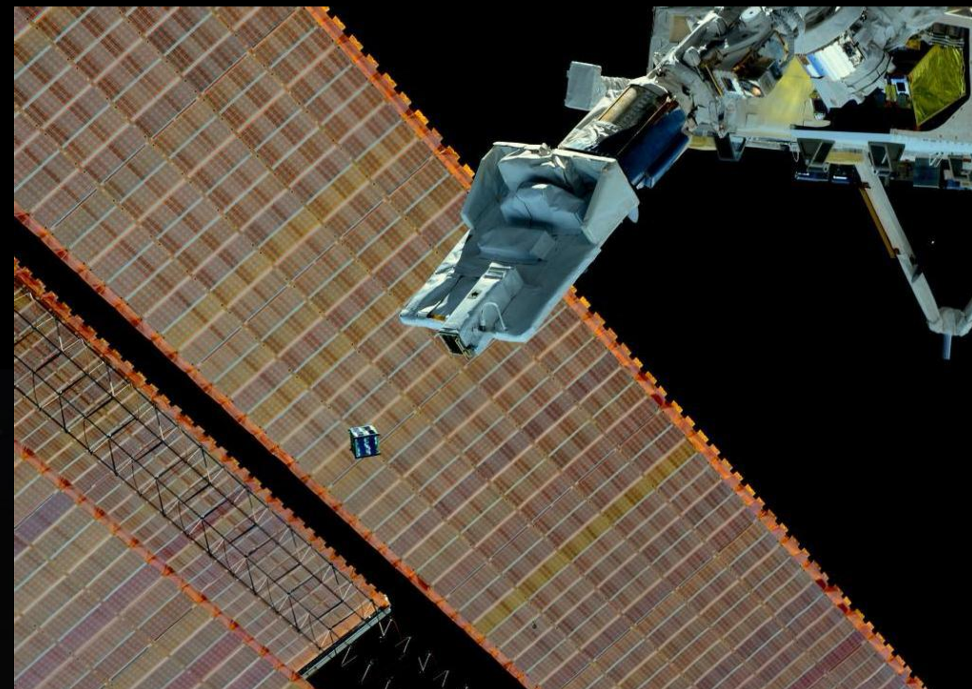
Igor V. Belokonov
Samara State Aerospace University, Russia

Saso Blazic
the University of Ljubljana, Slovenia

UNISEC GLOBAL
University Space Engineering Consortium

UNITED NATIONS
Office for Outer Space Affairs

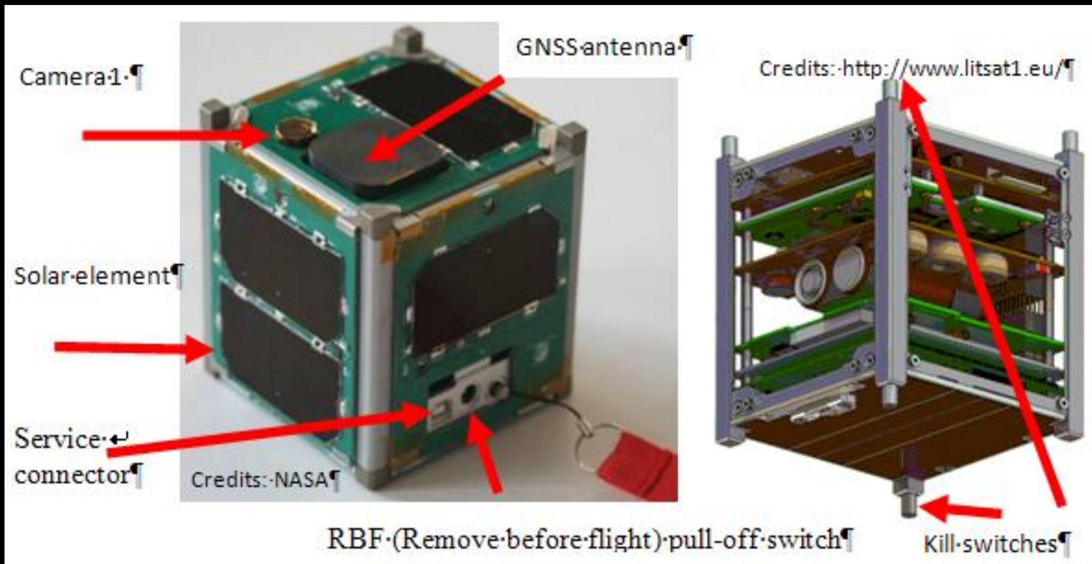
The United Nations/Japan Cooperation Programme on CubeSat Deployment from the International Space Station (ISS) Japanese Experiment Module (Kibo) "KiboCUBE"

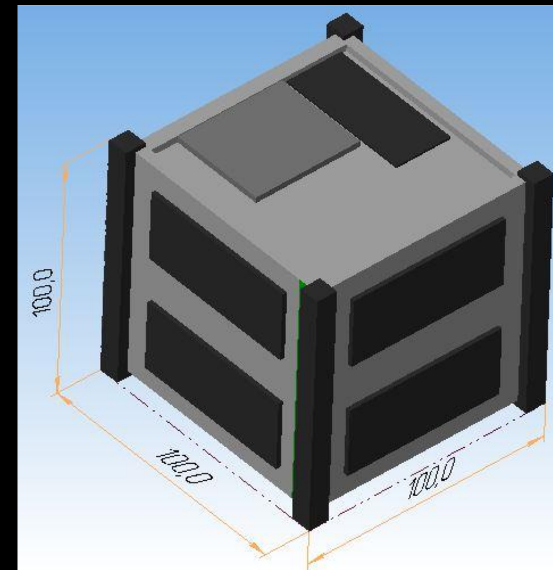


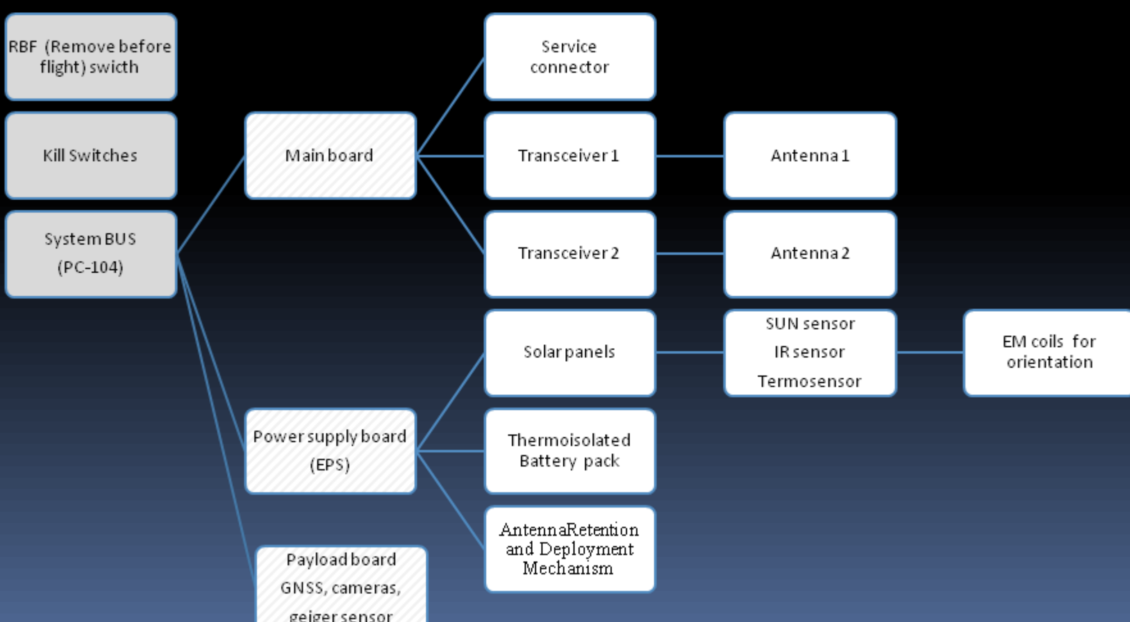
The United Nations Office for Outer Space Affairs (UNOOSA) and the Japan Aerospace Exploration Agency (JAXA) are pleased to announce the *United Nations/Japan Cooperation Programme on CubeSat Deployment from the International Space Station (ISS) Japanese Experiment Module (Kibo) "KiboCUBE".*

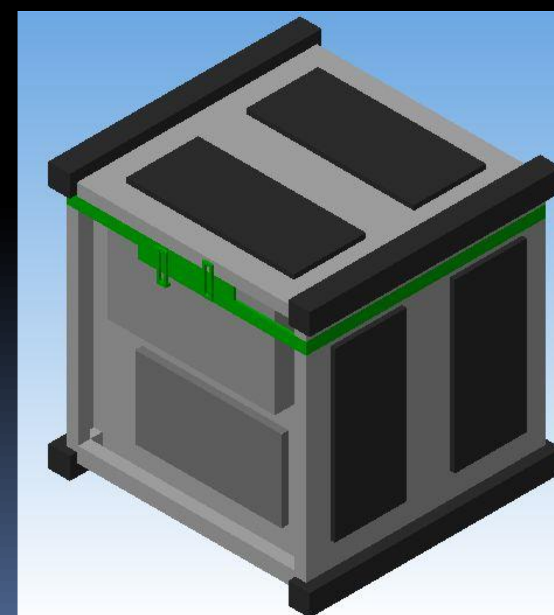
After receipt, UNOOSA and JAXA will proceed to evaluate each application. At UNOOSA's or JAXA's sole discretion, additional information may be requested from applicants, if necessary, to assist in the evaluation of the application. Selected applicants will then be notified with the results of the selection process. All awards are final, are made at the sole discretion of UNOOSA and JAXA, and not subject to challenge or review.

The United Nations/Japan Cooperation Programme on CubeSat Deployment from the International Space Station (ISS) Japanese Experiment Module (Kibo) "KiboCUBE"









Belarusian State University, Belarus

CubeSat Deorbit Device based on combination of gravity gradient tape, aerodynamic drag, electrodynamic tether and ion engine

V. Saetchnikov, S. Semenovich, A. Spiridonov, V. Chorny, S. Leshkevich
saetchnikov@bsu.by

Deorbit Device Competition

Model

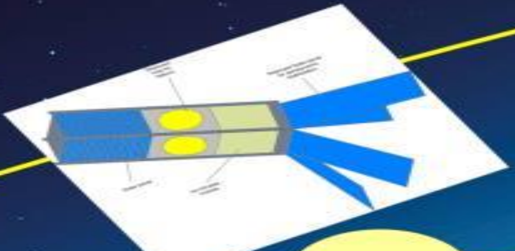
$$\vec{f}_A = -\frac{1}{2}\frac{C_D A}{m}\rho V^2 \frac{\vec{V}}{|\vec{V}|}$$

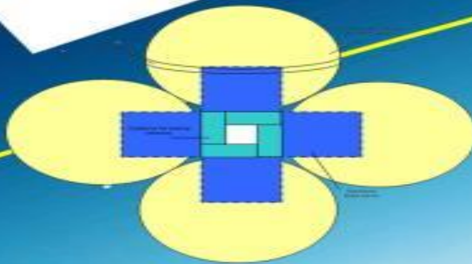
$$\vec{f}_{Rad} = -\frac{p_{SR} c_R A_{exp}}{m}\frac{\vec{R}_{Sun\_Sat}}{|\vec{R}_{Sun\_Sat}|}$$

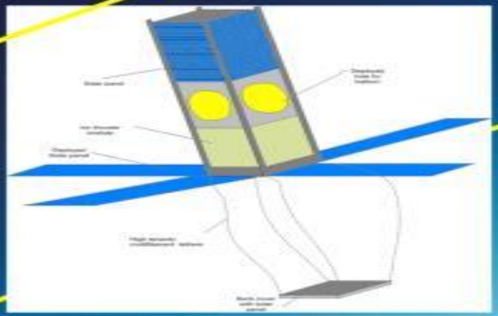
$$\vec{f}_{J2} = \frac{3J_2 \mu R_E^2}{2r_4}\begin{pmatrix} 3\sin^2 i \sin^2 u - 1 \\ -\sin^2 i \sin 2u \\ -\sin 2i \sin 2u \end{pmatrix}$$

$$\vec{f}_{Mag} = I\frac{\vec{L}\times\vec{B}}{m}$$

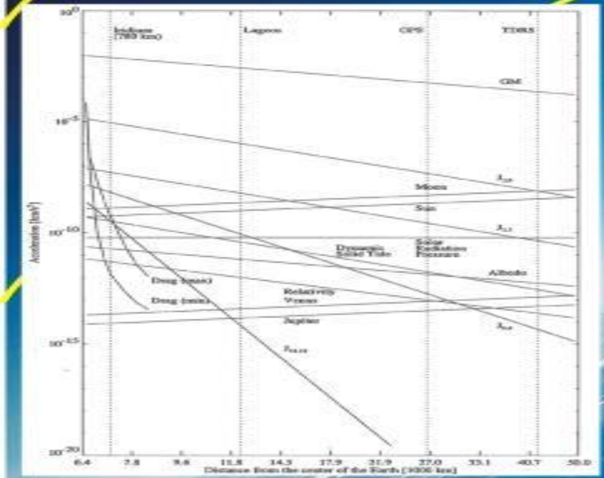
A proposed method of CubeSat de-orbiting is to use four inflatable double-layer thin-film balloons, drag tether with end mass in form of a panel and ion engine.







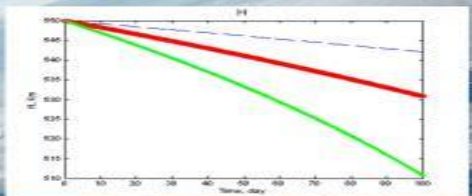
The balloons increase the body's area to mass ratio and shortening orbital lifetime. In addition balloons have a metal coating on its surface and there is an excess charge. The balloons are electromagnetic tether and use of magnetic effect to increase the rate of de-orbiting.
Benzoic acid with additives is used to inflate balloons.



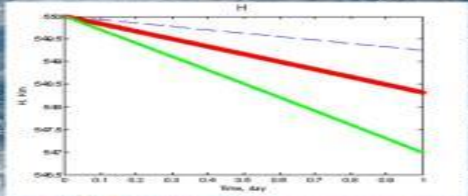
Comparisons of the disturbing accelerations for the main sources of perturbation

The end mass in form of a panel connected to the spacecraft's is drag tether. The tether is kept in position by gravity gradient forces and is on the Earth-facing side of the spacecraft. Its make use of drag to slow the spacecraft down, decreasing its orbital energy, and lowering its altitude.

And the last but not the least is a system – ion thruster module. Balloon with 0.2 kg of gas namely ammonia or hydrazine can be accelerated using the ion engine to 10 - 100km / s will have impulse and 2·10³. Impulse of the satellite is about [illegible]. This is enough to de-orbit. Obviously, this will need [illegible] joule of electric power. So if you afford to spend 1W, the process will take six months. Naturally, for such a system engine impulse orientation in apogee and perigee will be very significant. Stabilization and orientation system (passive/active electromagnetic) of such a satellite will be paid much attention because it is obviously ion thruster system requires manageable orientation of the satellite during in orbit.



Rough estimation deorbiting under R = 0.1 (blue), 0.15 (red), 0.2 (green) m.



Improved (smaller step) estimation deorbiting under R = 0.1 (blue), 0.15 (red), 0.2 (green) m

Thank you for attention!