



# **NANOSATELLITE DEVELOPMENT, CHALLENGES AND EXPERIENCE of TECHNICAL UNIVERSITY of MOLDOVA**

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Chisinau, Rep. Moldova**

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## **About TUM Space technologies Center activities, founded in 2012...**

**The core mission of the TUM Space Technology Centre is to promote modern space technologies to the younger generation and involve them in various educational projects, including the development and launching of nano-microsatellites.**

# Activities at the National Centre for Space Technologies (NCST) of TUM (1)



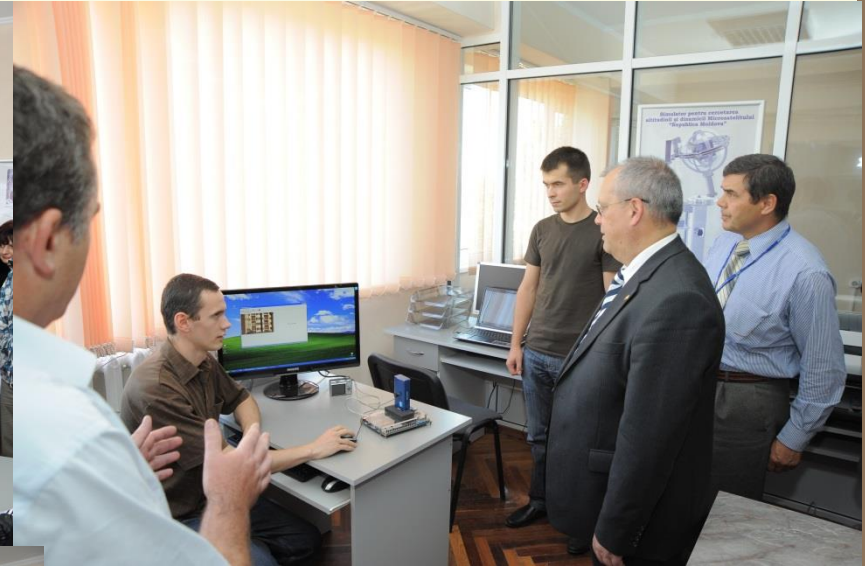


# Activities at the National Centre for Space Technologies (NCST) of TUM (2)





# Activities at the National Centre for Space Technologies (NCST) of TUM (3)





**Astronauts Frank Lee Culbertson (USA), Dumitru Prunariu (Romania) and Vladimir Dejurov (Russia), who piloted ISS, visited NCST.**

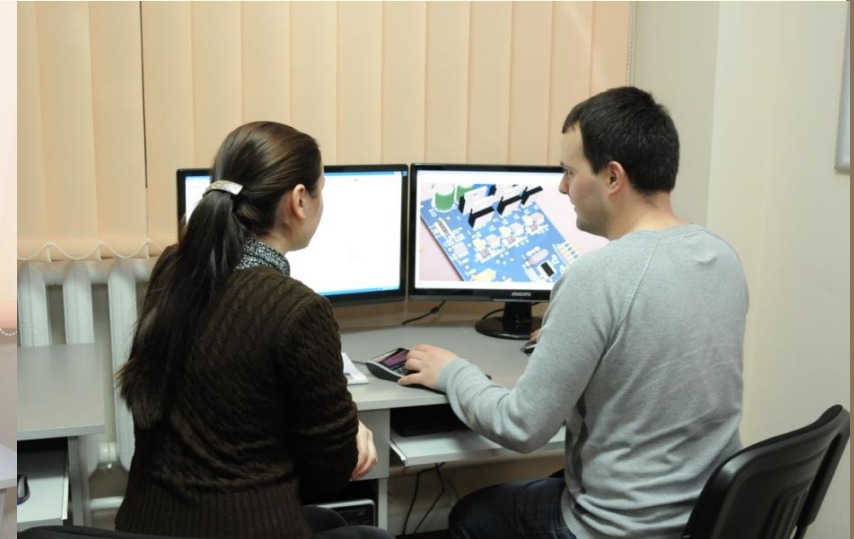
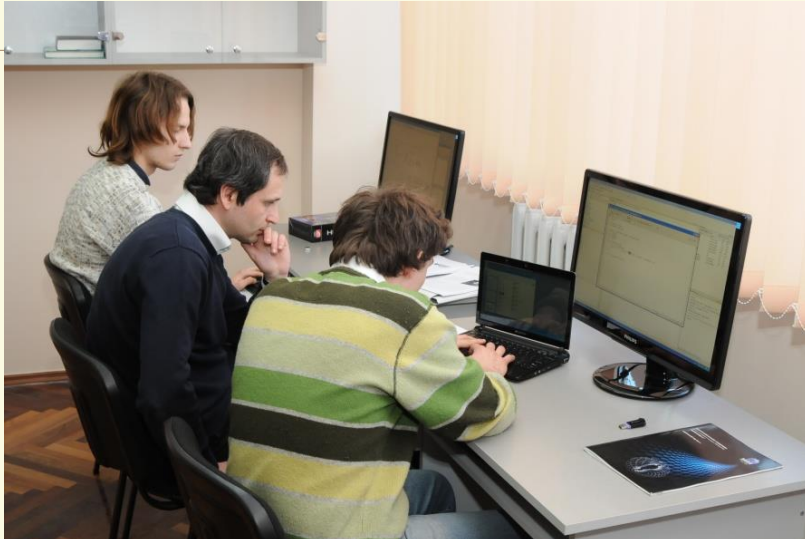




# Microsatellite development projects

**TUM Space Technologies Center has developed several educational projects on nano-microsatellite development with financial support from the Academy of Sciences and the Research/Development Agency of Rep. Moldova.**

# Design and development of microsatellite systems

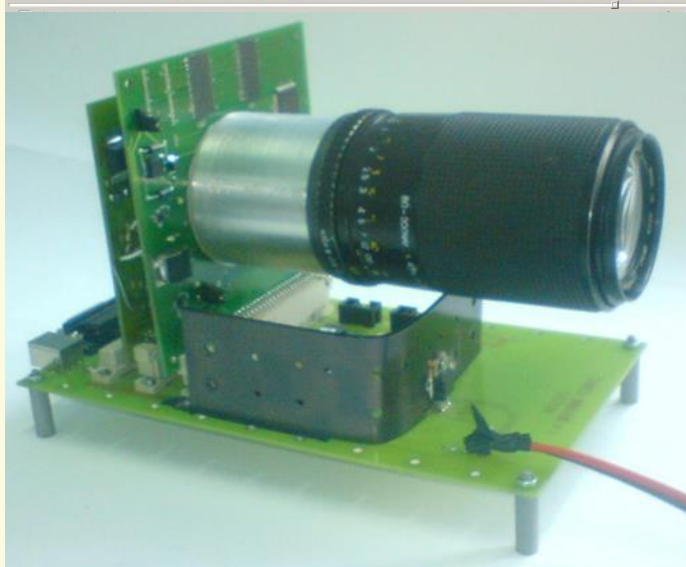




# Earth remote sensing and image capturing



The remote sensing is a critical factor in Earth surface exploration and collection of scientific data. On a national level, it finds itself in such fields as: agriculture, forestry applications, hydrological applications, floods and others.



# SATUM/RM Image Capturer testing by capturing the Moon image



## Parameters:

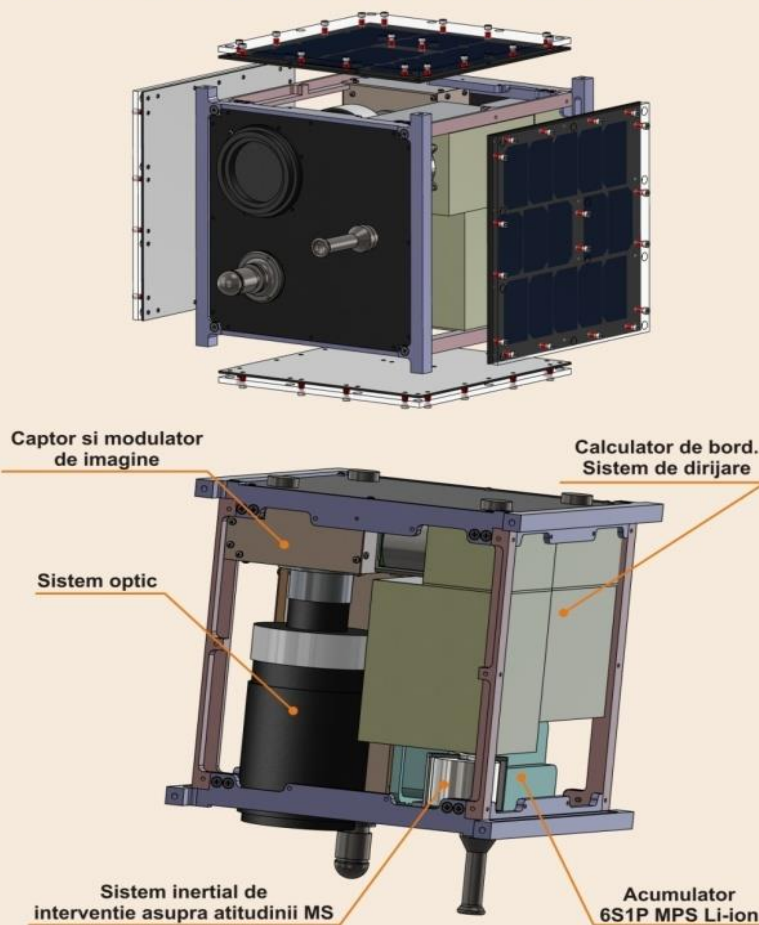
- Image vol.: 5 Mpix
- Resolution:  
2592 x 1944 pix
- Focal distance:  
500 mm
- Distance to Moon: ~  
400 000 km



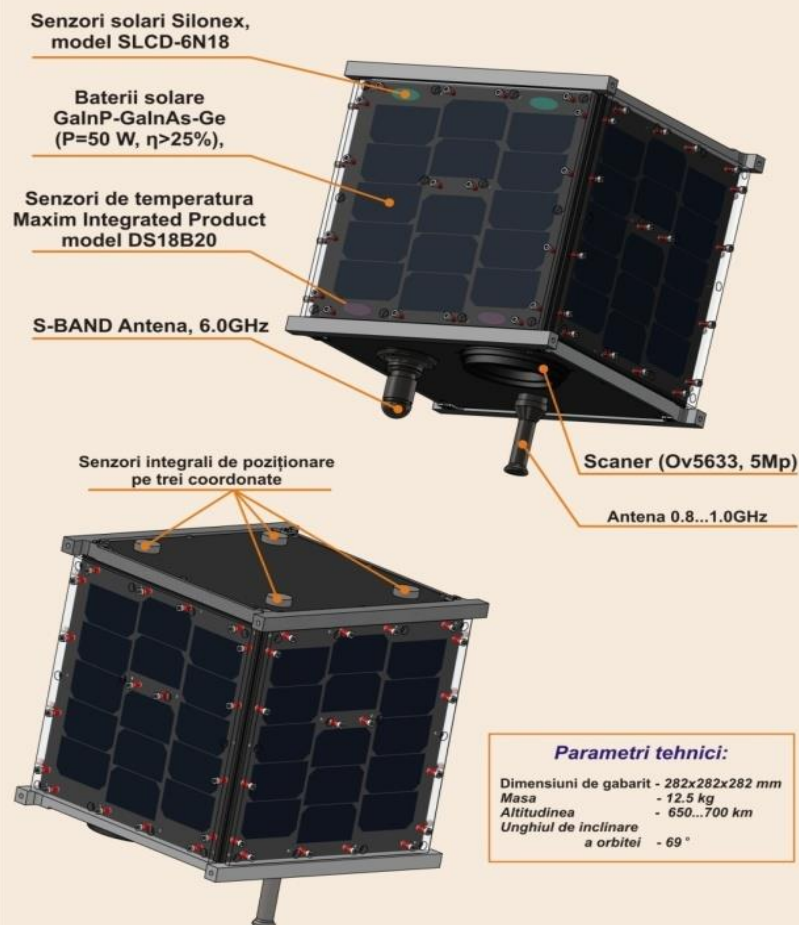
## SATUM/RM microsatellite

This is the first microsatellite prototype, a 25 cm cube, built in 2010-2014 with our own forces. The exception are the PV panels, which were designed by us, but manufactured by the company "Clyde Space". This satellite has not been launched.

### Microsatelit "REPUBLICA MOLDOVA"



### Microsatelit "REPUBLICA MOLDOVA"



# Orbital flight simulation and testing of satellite attitude control





# Microsatellite's infrastructure development projects

On the basis of those educational projects of nano-microsatellites development with financial support from the Academy of Sciences and the Research/Development Agency of Rep. Moldova, a grant from the EU, including TUM co-financing, the TUM Space Technology Centre has developed an infrastructure for research/development of satellite systems. .

# NCST's base ground station in construction

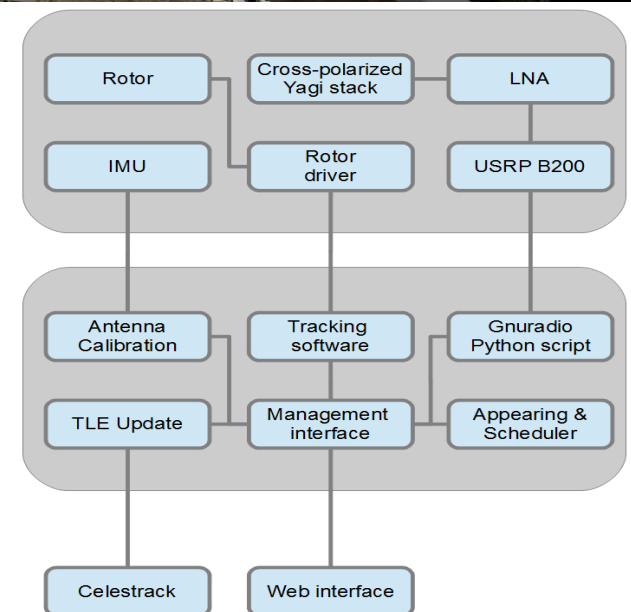








# NCST's satellite telemetry ground station



# NCST telemetry station in Brânza (Cahul)

Southern telemetry station (from Cahul) serves as NCST support point, which ensures satellite communication across with the station on the TUM campus by remote control, being in a very favorable electromagnetic area.



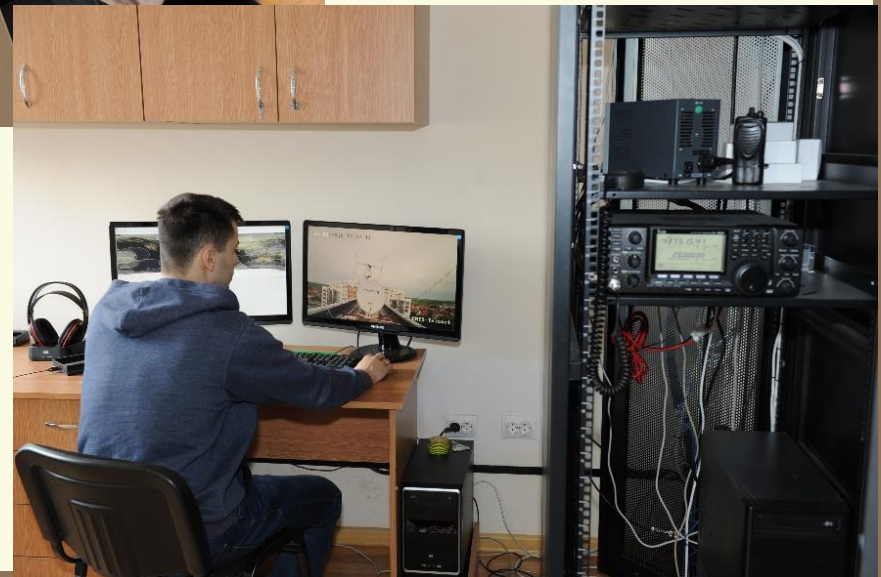


# NCST Satellite Tracking and Communication Centre

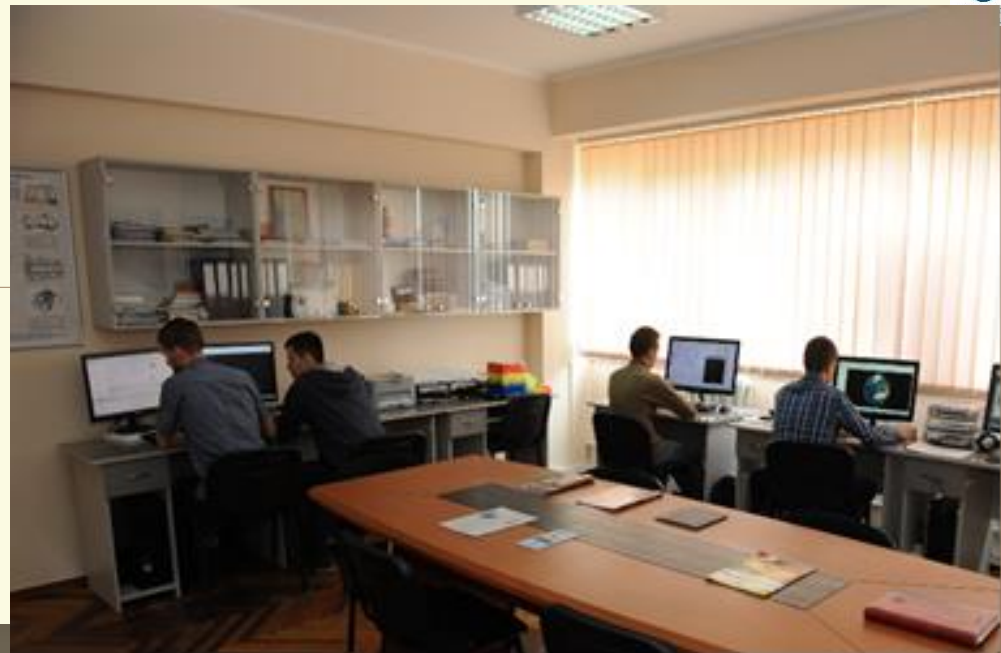


Satellite Tracking and Communication centre provides remote control of the TUM Space Technology Centre ground stations.

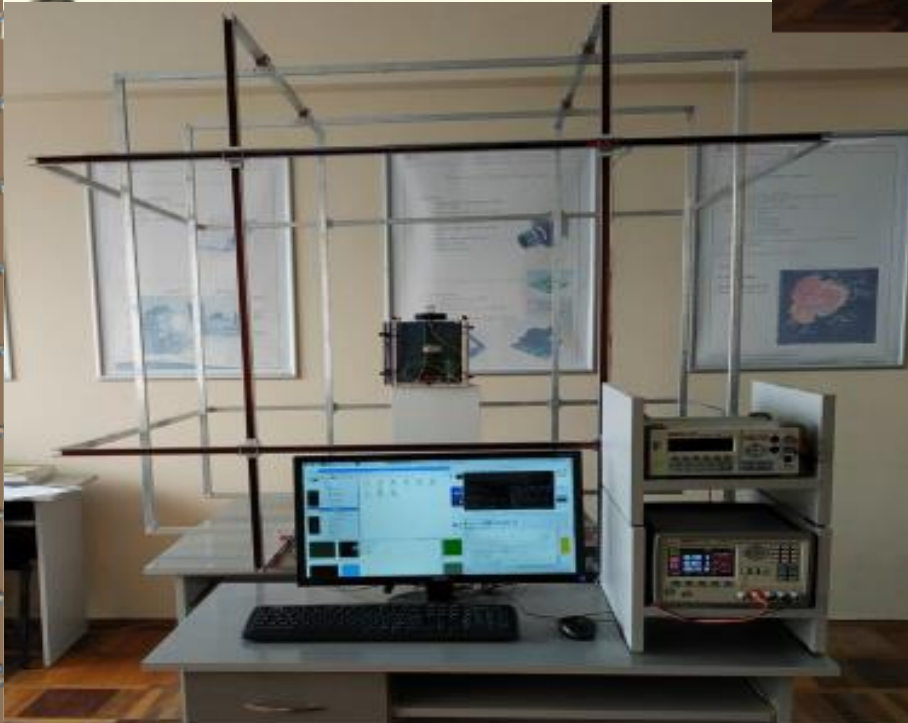
Telemetry communication station (SCT) (Chisinau) equipped with radio reception/transmission equipment, antenna cluster, computer + control server.



Laboratory "On-Board Nano/Microsatellite Subsystems" (SBNMS), equipped with workstations for simulation, design of satellite systems/subsystems.

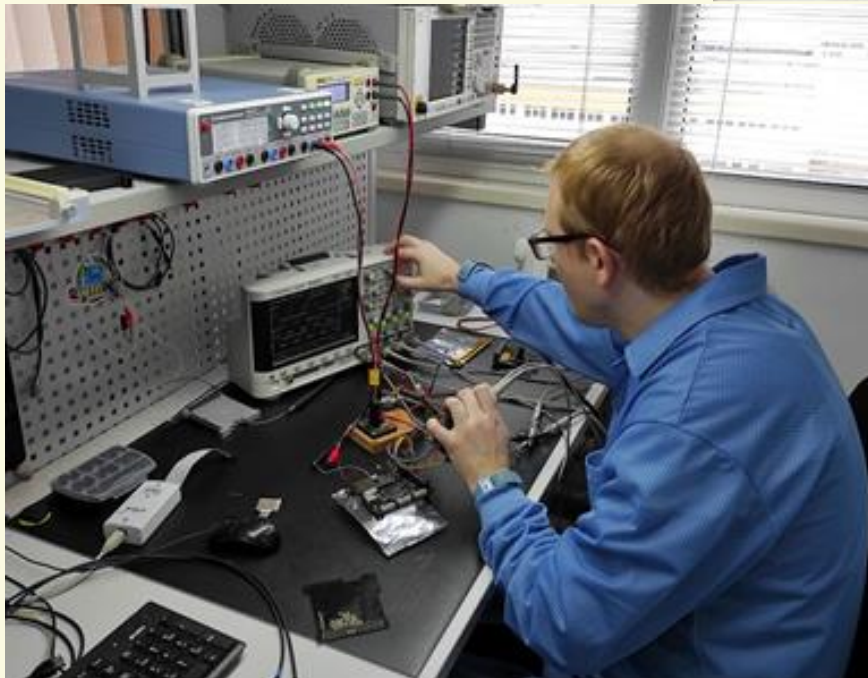
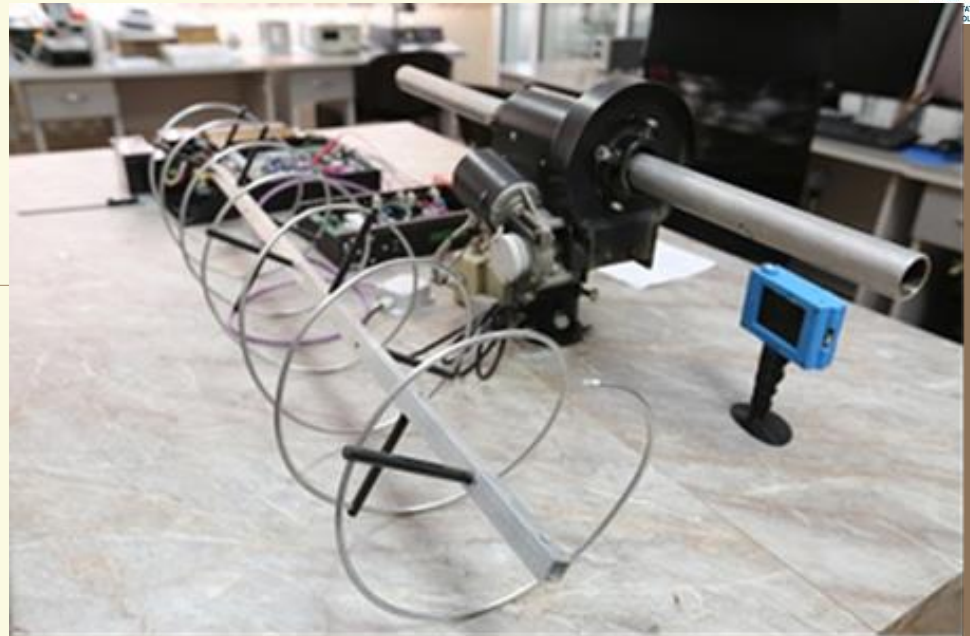


The microsatellite on-board subsystems assembly and experimentation laboratory is equipped with a platform for studying the attitude of microsatellites in a magnetic field similar to orbital conditions, developed and manufactured with our own forces.



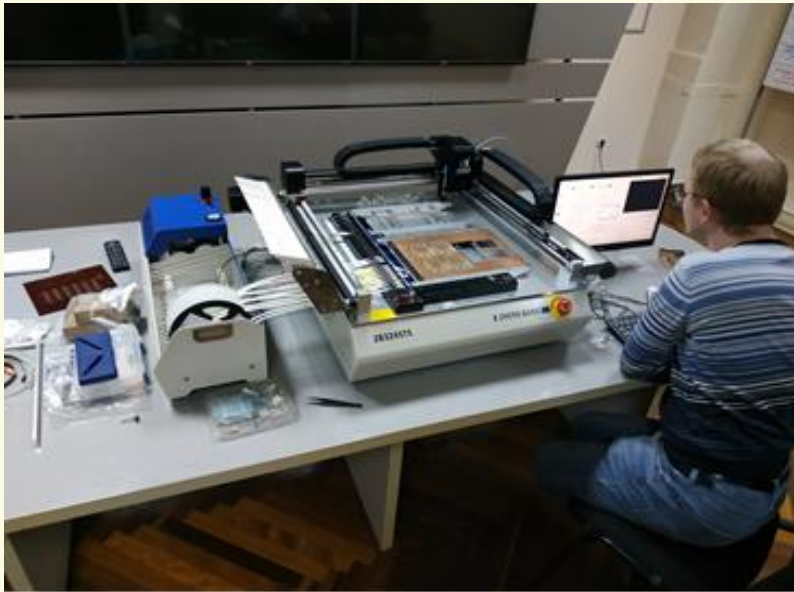
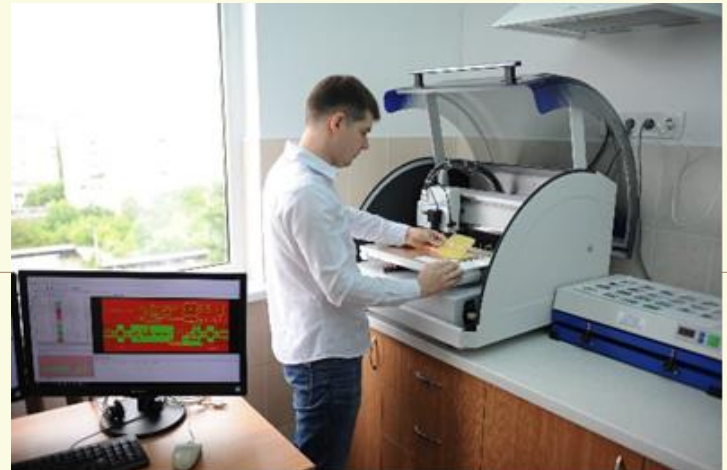


Laboratory for mechanical assembly and experimentation of on-board nano/microsatellite and ground station subsystems, equipped with experimental test stand for antenna orientation control of telemetry satellite communication stations.



"Clean room" for assembly and experimentation of microsatellite on-board subsystems, which is equipped with a double ventilation system and with a stand for assembly and computerized experimentation of microsatellite subsystems in near to clean room conditions.

Satellite module design and manufacturing platform equipped with LPKF - 103 PCB prototyping station for electronic modules.



Satellite module manufacturing platform equipped with Zheng Bang ZB3245TS automatic PCB SMT mounting placement machine and ZBRF-630 convection oven with integrated conveyor belt.



# Testing satellite communications in real conditions

The TUM team carried out a series of real satellite communication experiments to verify ground stations. One experiment was carried out with satellite modules (communication, low resolution image sensor and OBC) launched with a high altitude helium balloon up to 29,800 m and over a duration of 3 hours and 15 min more than 300 images and telemetry were received every 5 minutes.

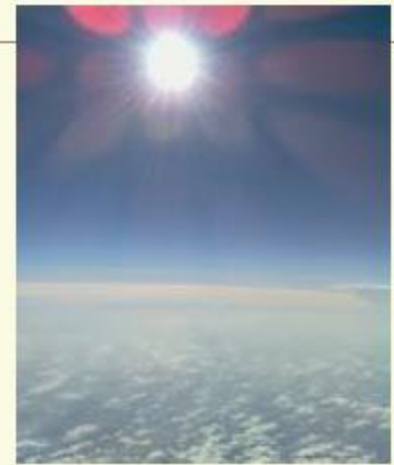
Other experiments involve receiving and decoding images from weather satellites and the ISS.

# "Microsatellite" - ground station communication: reception of telemetry data and captured images

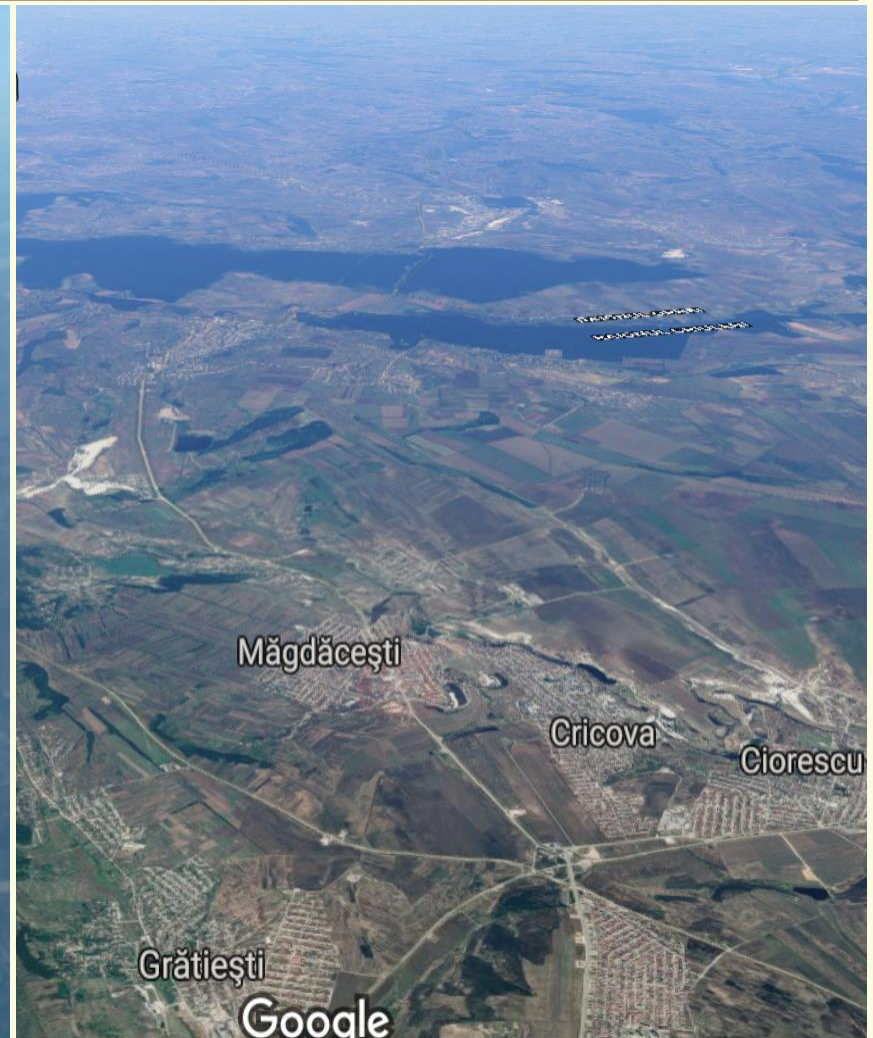
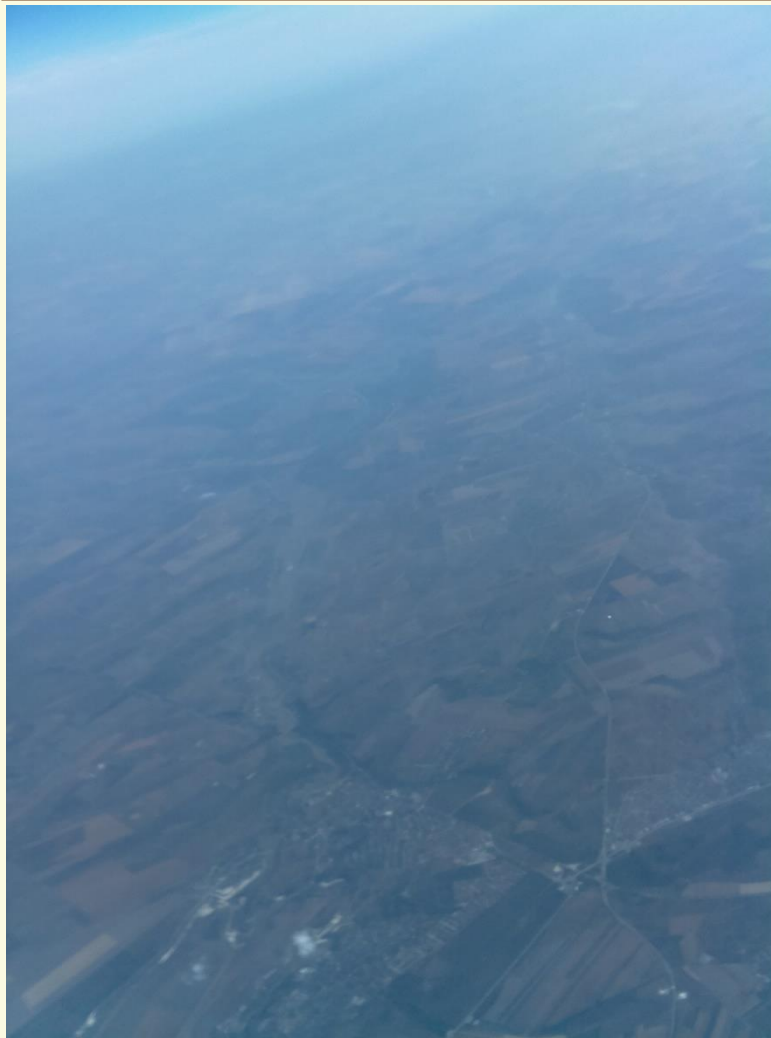




# Earth images captured by the "microsatellite" from stratospheric altitude

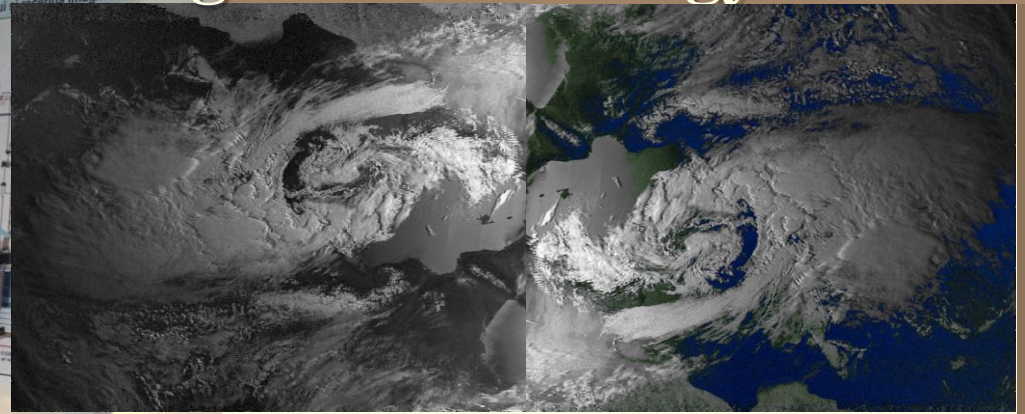


# A comparison of images captured by the "microsatellite" module with Google maps

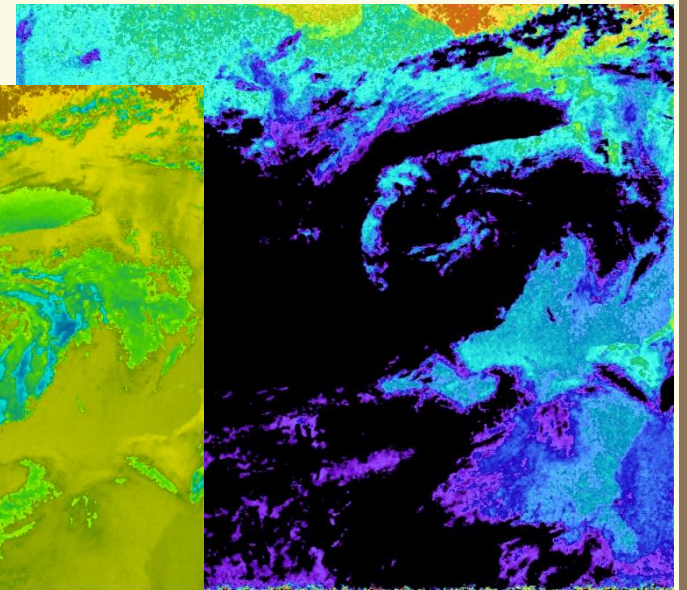
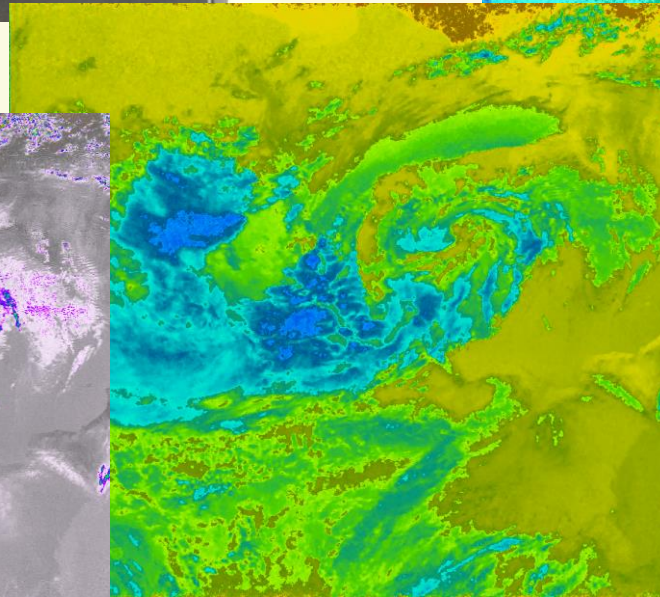
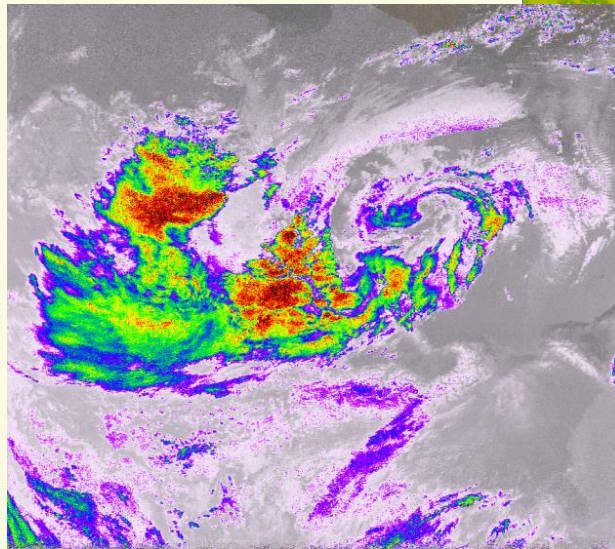




# Verification of weather image reception from NOAA satellites using SDR technology



Contrast image received from NOAA18 satellite



Thermal image received from NOAA18 satellite



# Participation in the ISS SSTV image reception experiment

Onboard the ISS on October 9 and 10, 2019, SSTV images were transmitted as part of the Inter-MAI-75 experiment.

SSTV images were transmitted at 145.800 MHz using the Kenwood TM-D710 transceiver. They used the PD-120 SSTV format.

## Timetable:

- Wednesday, October 9, 2019 from ~ 09:50 ~ 16:00 UTC
- Thursday, October 10, 2019 from ~ 08: 45 ~ 16:25 UTC

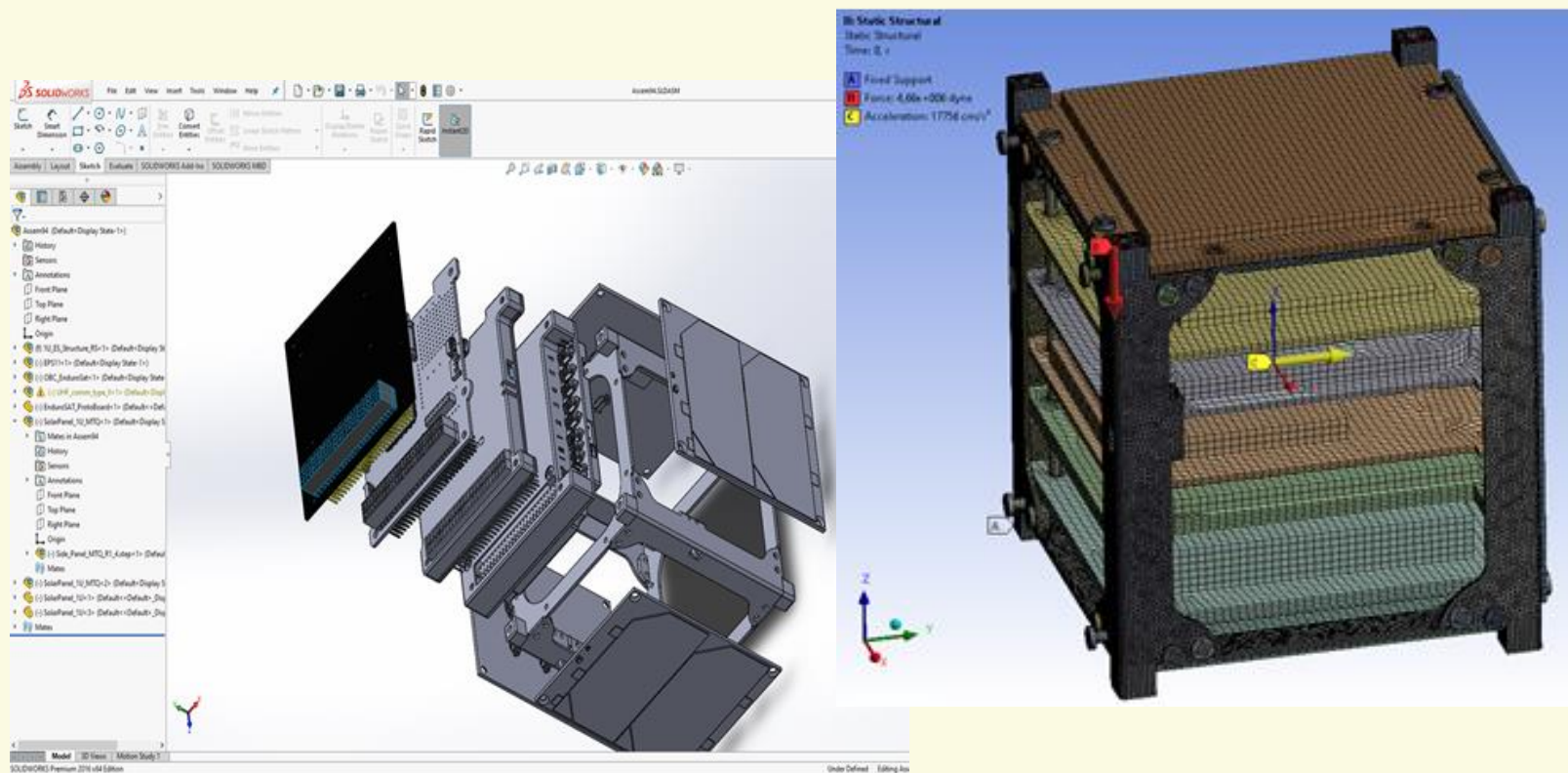




# Carrying out nanosatellite development and launch projects

# 3D model of the TUMnanoSAT nanosatellite

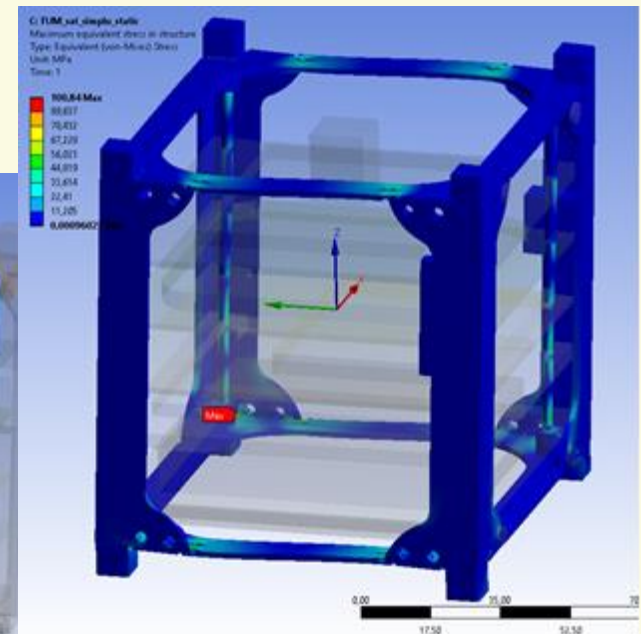
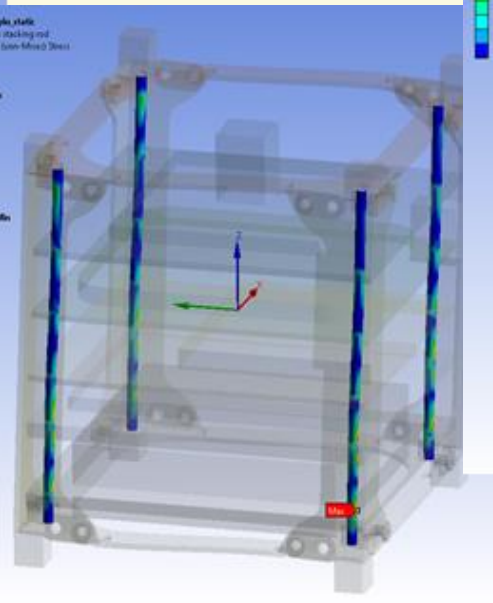
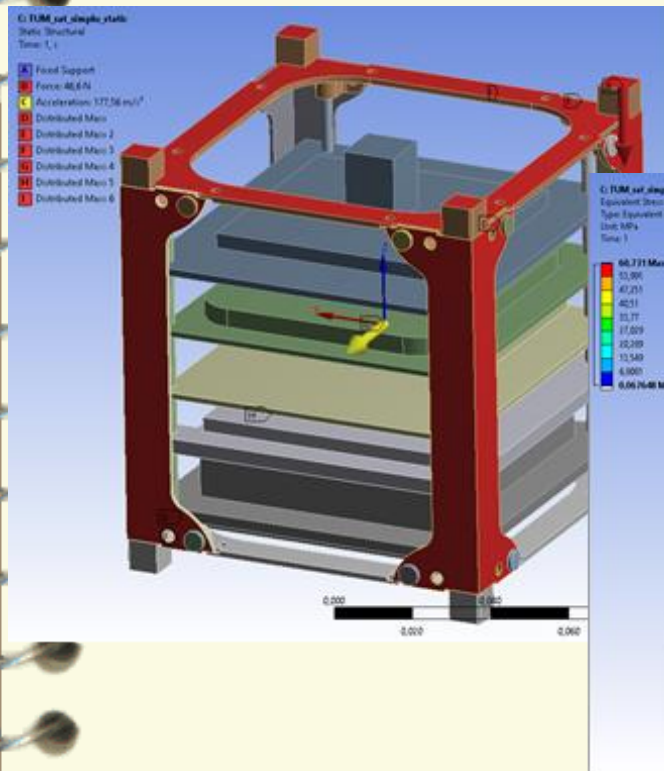
The 3D model of the TUMnanoSAT nanosatellite was created, which generates the assembly documentation and the finite component model for the structural analysis of TUMnanoSAT.





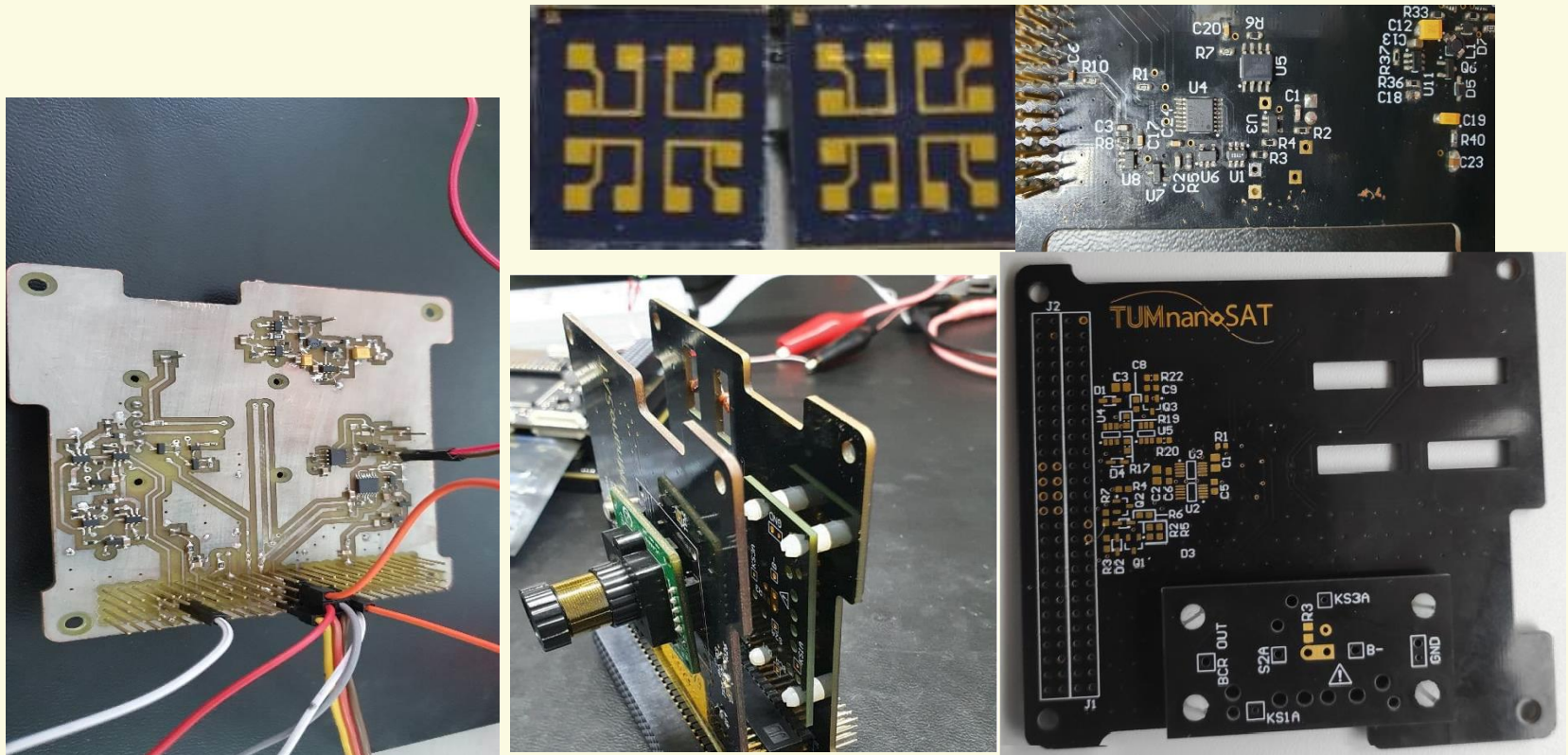
# Structural analysis of the TUMnanoSAT nanosatellite

All necessary experiments have been carried out and the TUMnanoSAT structure failure hazard report has been created in terms of the risk of failure specific to nanosatellite structures.



# The payload modules of the TUMnanoSAT

The payload modules were designed, prototyped and tested in a special way: with satellite orientation sensor, image capture camera and space radiation nanosensors for the realization of nanosatellite missions.

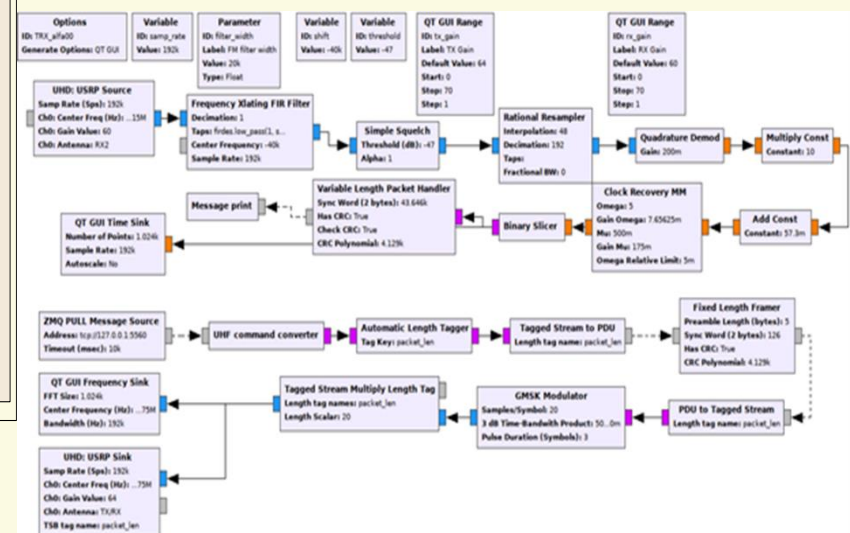
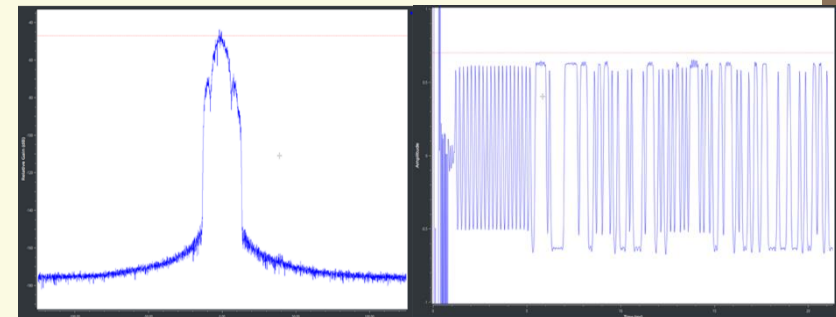
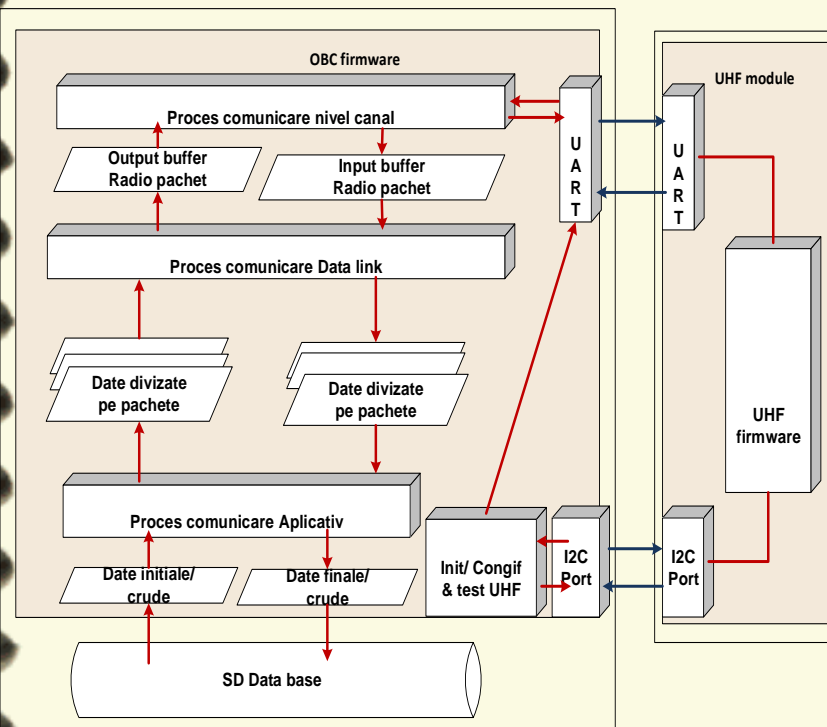




# Space segment (satellite) communication

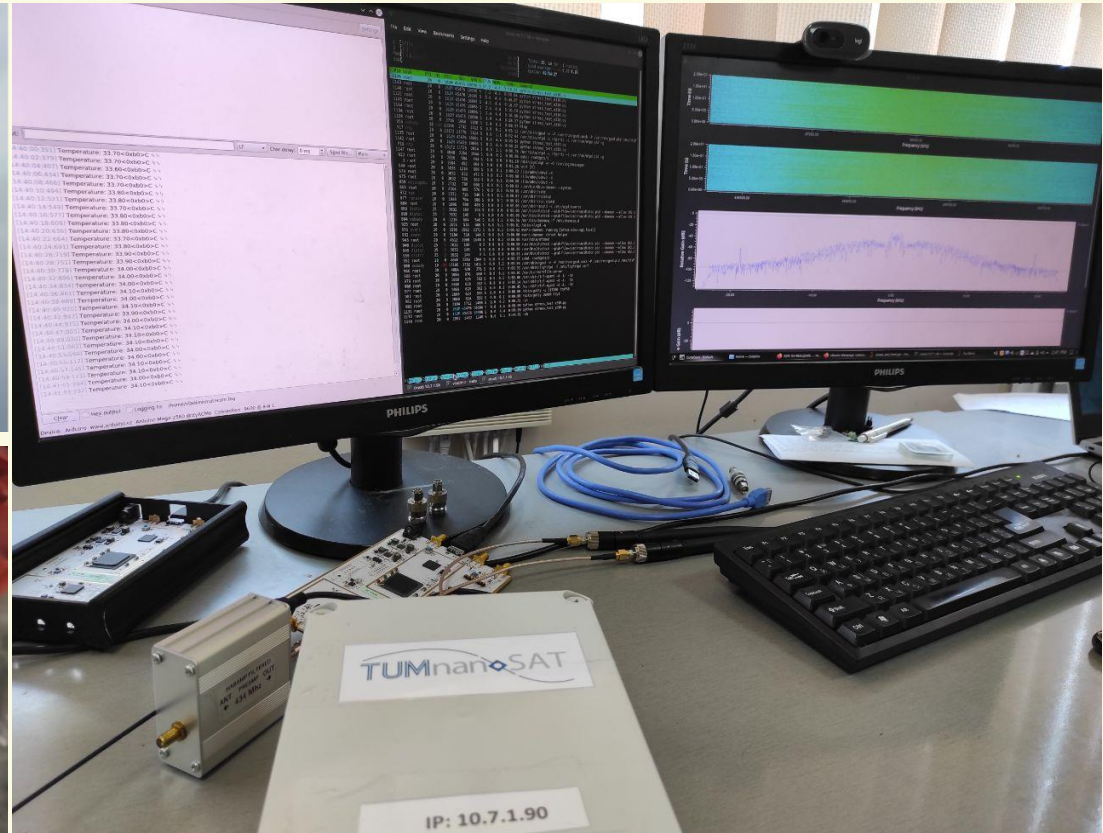
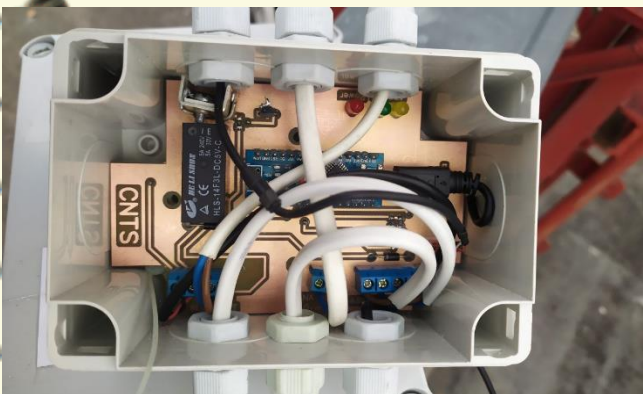
Procedures and algorithms for efficient and reliable communication of nanosatellites with ground stations under conditions of ion- and tropospheric disturbances were developed.

Procedures for packing/unpacking large messages (images, archives, etc.) were developed, which offers the possibility to increase communication efficiency.



# Ground segment (ground stations) communication

Algorithms for communication with nanosatellites, the transmission part of the telecommands, have been developed and implemented.





# TUMnanoSAT proposal for "KiboCUBE" deployment program



## TUMnanoSAT

proposal for CubeSat Mission Application for the Fourth Round in the framework of United Nations/Japan Cooperation Programme on CubeSat Deployment from the International Space Station (ISS) Japanese Experiment Module "KiboCUBE"

Chisinau, 2019

UNOOSA & JAXA nominated the TUM team's nanosatellite launch project proposal to the Round 4 competition.

TUM participated in 2019 with a nanosatellite project proposal for the UNOOSA & JAXA competition in the 4th round.



UNITED NATIONS  
Office for Outer Space Affairs

18 April 2019

Dear Mr. Bostan,

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

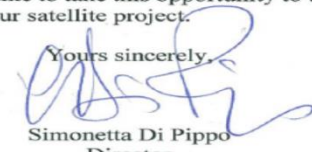
On behalf of the United Nations Office for Outer Space Affairs (UNOOSA) and the Japan Aerospace Exploration Agency (JAXA), we are pleased to inform you that the proposal ("TUMnanoSAT") that you have submitted in response to the Announcement of Opportunity of the United Nations/Japan Cooperation Programme on CubeSat Deployment from the International Space Station (ISS) Japanese Experiment Module (Kibo) "KiboCUBE" has been reviewed and considered favourably by UNOOSA and JAXA.

Your team will be offered the opportunity to deploy your CubeSat from the International Space Station (ISS) Japanese Experiment Module (Kibo).

Please note that the notification made herewith is of confidential nature at this stage. You are strongly advised to refrain from any announcements, notifications and release of any news about this communication until further notice from UNOOSA and JAXA.

On behalf of UNOOSA and JAXA, I would like to take this opportunity to thank you for your application. I wish you success in realizing your satellite project.

Yours sincerely,



Simonetta Di Pippo  
Director  
Office for Outer Space Affairs

# UNOOSA/JAXA/TUM kickoff meeting

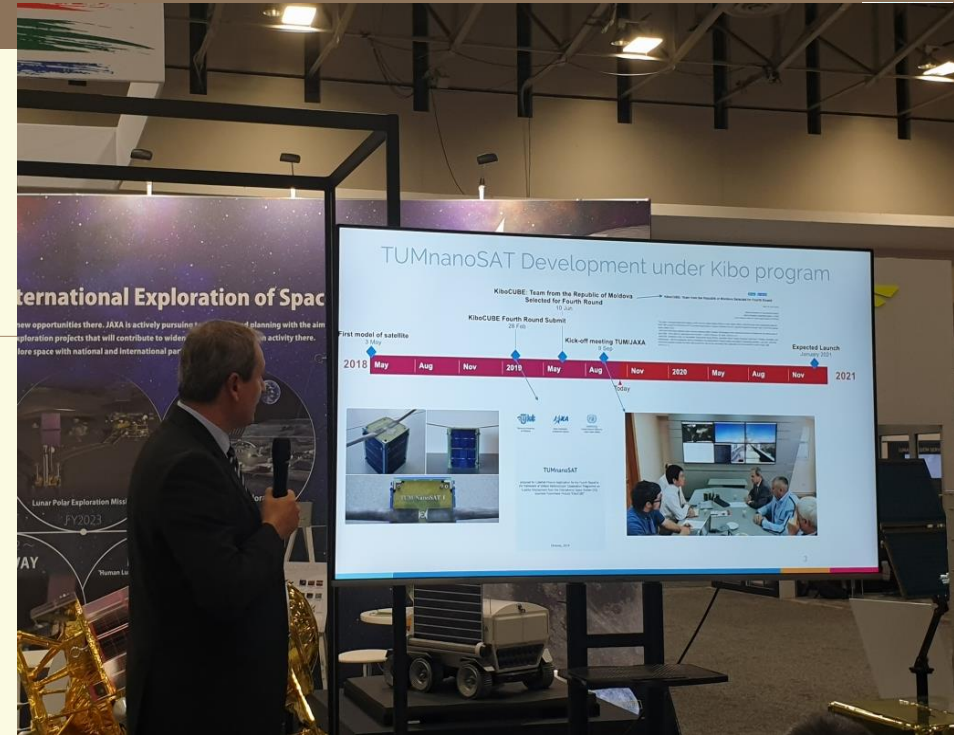
organized by Technical University of Moldova in collaboration with the United Nations Office for Outer Space (UNOOSA) and the Japanese Aerospace Exploration Agency (JAXA)





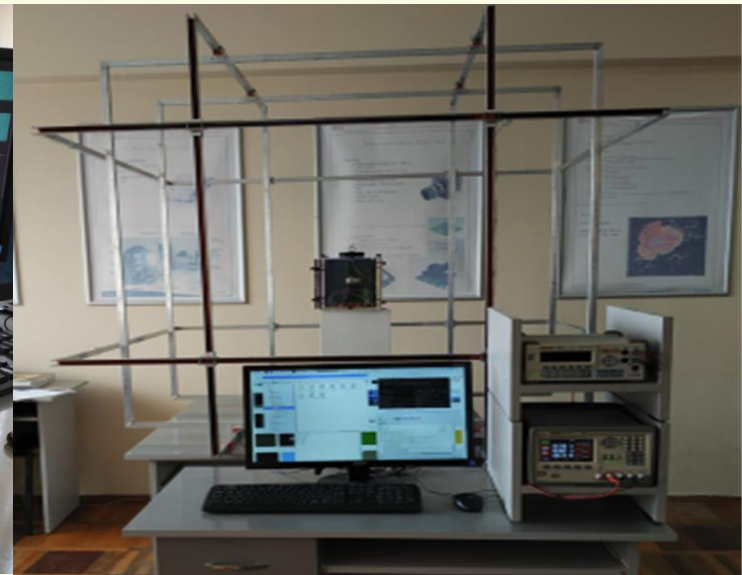
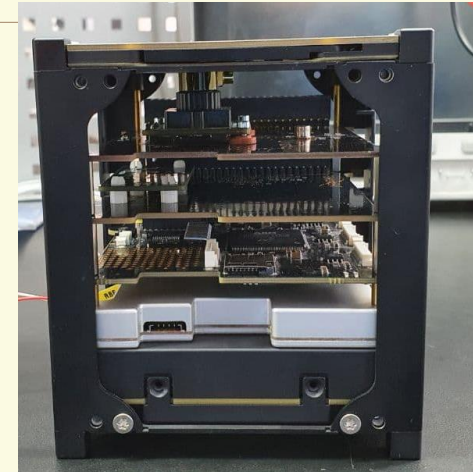
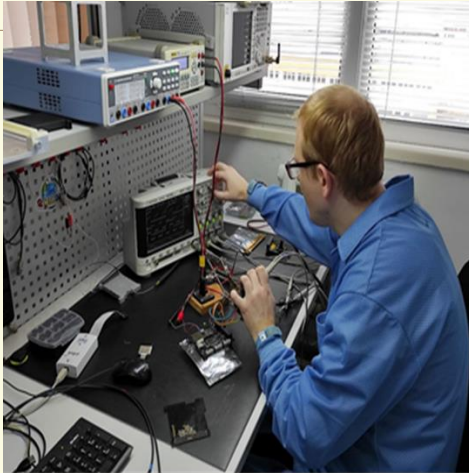
# IAC-2019 & KiboCube program

TUM's Rector Viorel BOSTAN and Valentin ILCO, NCTS researcher, present at the launch of the KiboCUBE programme, round 4 at the 70th International Astronautical Congress (IAC-2019).



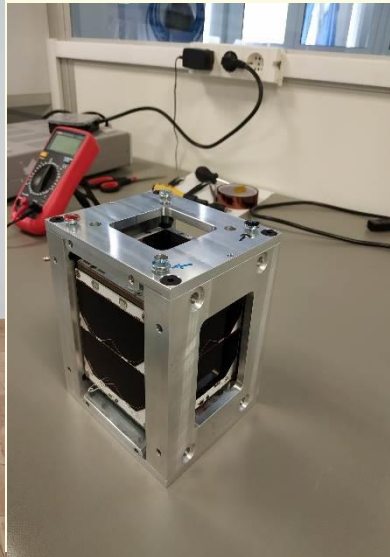


# Development, assembling and verification of the nanosatellite TUMnanoSAT for KiboCUBE.





# Final testing and verification of the TUMnanoSAT nanosatellite at the ISS (ROSA)



# TUMnanoSAT -1U launch with Falcon 9, SpaceX and deployment from the Kibo Module of the ISS

1. Last TUMnanoSAT inspection and integration into launch capsule at JAXA's Tsukuba center, March 4, 2022.
2. Launch of TUMnanoSAT on July 12 by Falcon 9, SpaceX from Cape Canaveral Space Force Station, Florida, USA to the International Space Station.
3. Deployment of TUMnanoSAT into LEO orbit from the International Space Station on 12 August 2022.

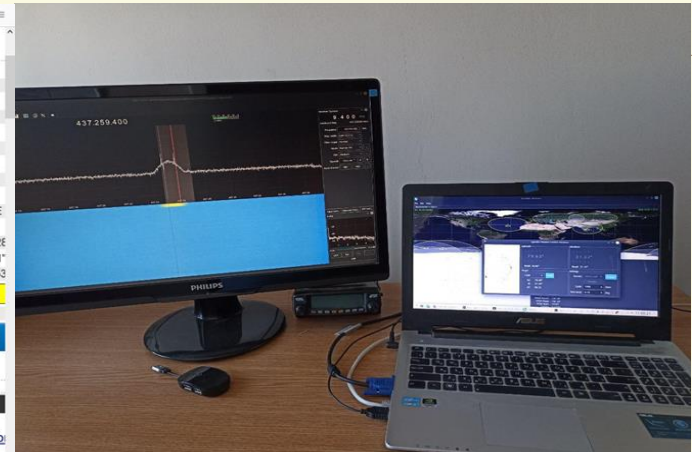
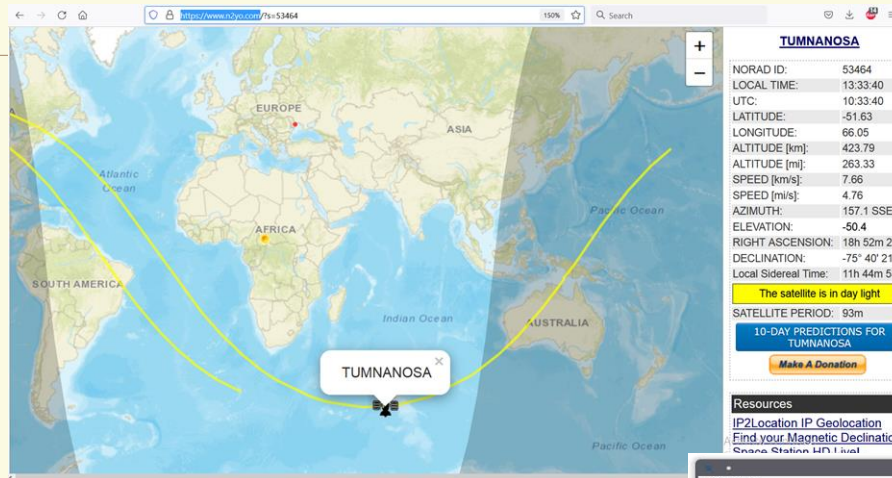
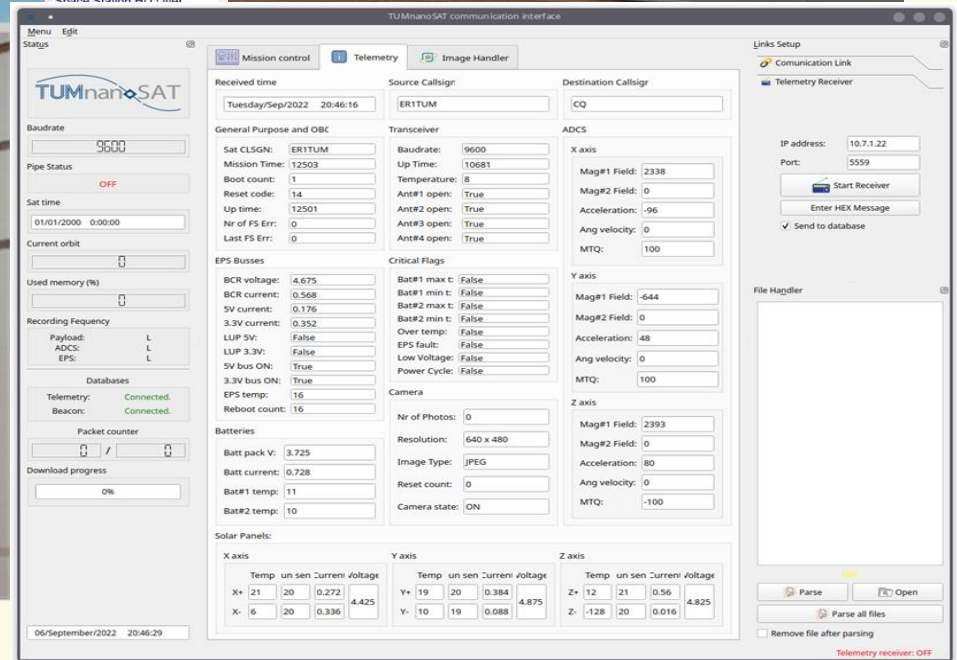




# Certificate of deployment of TUMnanoSAT in LEO orbit from the International Space Station on 12 August 2022.



# Reception of "TUMnanoSAT" telemetry data with the communication platform from the NCTS telemetry ground station

**TUMnanoSAT communication interface**

Menu Edit Status

**Mission control** **Telemetry** **Image Handler**

Received time: Tuesday/Sep/2022 20:46:16

Source Callsign: ER1TUM Destination Callsign: CQ

General Purpose and OBC

Sat CLSGN: ER1TUM  
 Mission Time: 12503  
 Boot count: 1  
 Reset code: 14  
 Up time: 12501  
 Nr of FS Err: 0  
 Last FS Err: 0

Transceiver

Baudrate: 9600  
 Up Time: 10681  
 Temperature: 8  
 Ant#1 open: True  
 Ant#2 open: True  
 Ant#3 open: True  
 Ant#4 open: True

ADCS

X axis  
 Mag#1 Field: 2338  
 Mag#2 Field: 0  
 Acceleration: -96  
 Ang velocity: 0  
 MTQ: 100

Y axis  
 Mag#1 Field: -644  
 Mag#2 Field: 0  
 Acceleration: 48  
 Ang velocity: 0  
 MTQ: 100

Z axis  
 Mag#1 Field: 2393  
 Mag#2 Field: 0  
 Acceleration: 80  
 Ang velocity: 0  
 MTQ: -100

EPS Busses

BCR voltage: 4.675  
 BCR current: 0.568  
 5V current: 0.176  
 3.3V current: 0.352  
 LUP 5V: False  
 LUP 3.3V: False  
 5V bus ON: True  
 3.3V bus ON: True  
 EPS temp: 16  
 Reboot count: 16

Critical Flags

Bat#1 max t: False  
 Bat#1 min t: False  
 Bat#2 max t: False  
 Bat#2 min t: False  
 Over temp: False  
 EPS fault: False  
 Low Voltage: False  
 Power Cycle: False

Camera

Nr of Photos: 0  
 Resolution: 640 x 480  
 Image Type: JPEG  
 Reset count: 0  
 Camera state: ON

Batteries

Batt pack V: 3.725  
 Batt current: 0.728  
 Bat#1 temp: 11  
 Bat#2 temp: 10

Solar Panels:

X axis  
 Temp un sen Current voltage  
 X+ 21 20 0.272 4.425  
 X- 6 20 0.336 4.425

Y axis  
 Temp un sen Current voltage  
 Y+ 19 20 0.384 4.875  
 Y- 10 19 0.088 4.875

Z axis  
 Temp un sen Current voltage  
 Z+ 12 21 0.56 4.825  
 Z- -128 20 0.016 4.825

Links Setup

Communication Link

Telemetry Receiver

IP address: 10.7.1.22  
 Port: 5559  
 Start Receiver  
 Enter HEX Message  
 Send to database

File Handler

Parse Open  
 Parse all files  
 Remove file after parsing  
 Telemetry receiver: OFF

06/September/2022 20:46:29



# International cooperation

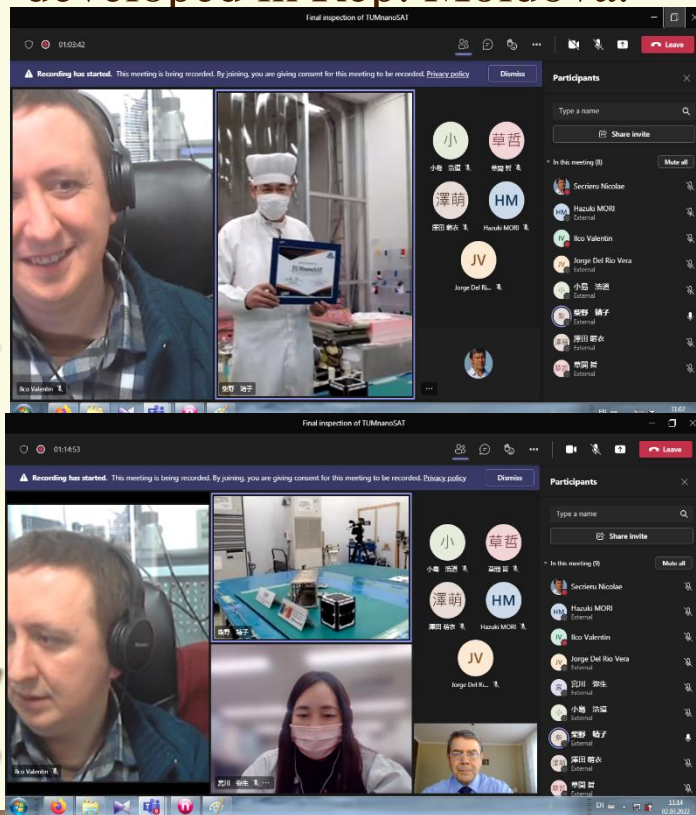
# Team SATUM at the UNOOSA Basic Space Technology Initiative - 2010 Symposium



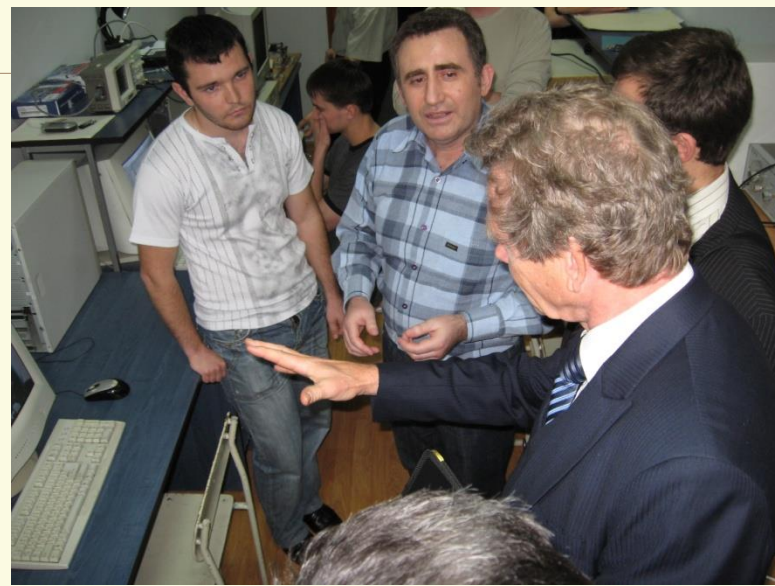


# Cooperation with the Japan Aerospace Agency (JAXA)

The Space Technology Centre cooperated with JAXA in the Kibo\_CUBE programme to launch CubeSat from the Japanese Experiment Module (Kibo) of the International Space Station (ISS). The collaboration culminated with the launch of the first TUMnanoSAT nanosatellite developed in Rep. Moldova.



# Our partner from Siegen University are present at the seminars and conferences ICTEI 2010-:-2018





# TUM- ROSA and RISE cooperation

## „Bilateral cooperation program Romania - Moldova,, (2010 –current time) (1)

Under this program we conducted various consultations on design issues microsatellites, developing of image capture systems and guidance, stabilization and attitude control of satellites, as well as terrestrial infrastructure.



# TUM- ROSA and RISE cooperation

„Bilateral cooperation program Romania - Moldova,,  
(2010 –current time) (2)

The collaboration agreement provides for the assembly and testing of satellite components on various Space Science Institute facilities.

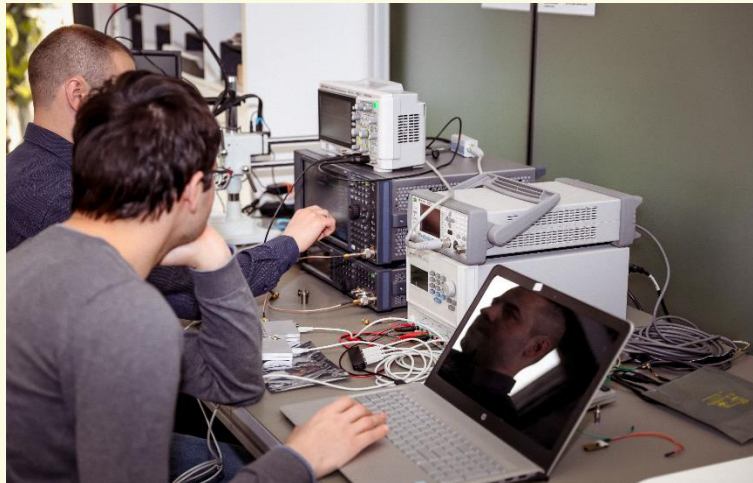


Silvana Radu - cercetator științific în cadrul Centrului Român de Competență în Tehnologii pentru Nanosateliți - camera albă





# EnduroSat and Solar Space Companies, Sofia, Bulgaria



- Founded on January 2015
- Launch of advanced communication and power modules;
- EnduroSat is one of the fastest growing space companies in Europe, providing solutions for the Global space market.



## MEMORANDUM OF UNDERSTANDING between

EnduroSat AD Post code: 1606 , 16  
“Tundzha” str., Sofia, Bulgaria  
hereinafter referred to as

“EnduroSat AD” and  
Technical University of Moldova  
168 Ștefan cel Mare și Sfânt Chișinău,  
Republic of Moldova  
hereinafter referred to as „TUM”

# BSUN Workshop on *“Interuniversity Cooperative Activities on Satellite Data Proccession and Space Technologies”*

Technical University of Moldova, Chisinau, October 19-20th 2017



**“Interuniversity Cooperative Activities on Satellite Data Proccession and Space Technologies”, Prof. Dr. Eden MAMUT, BSUN Secretary General**



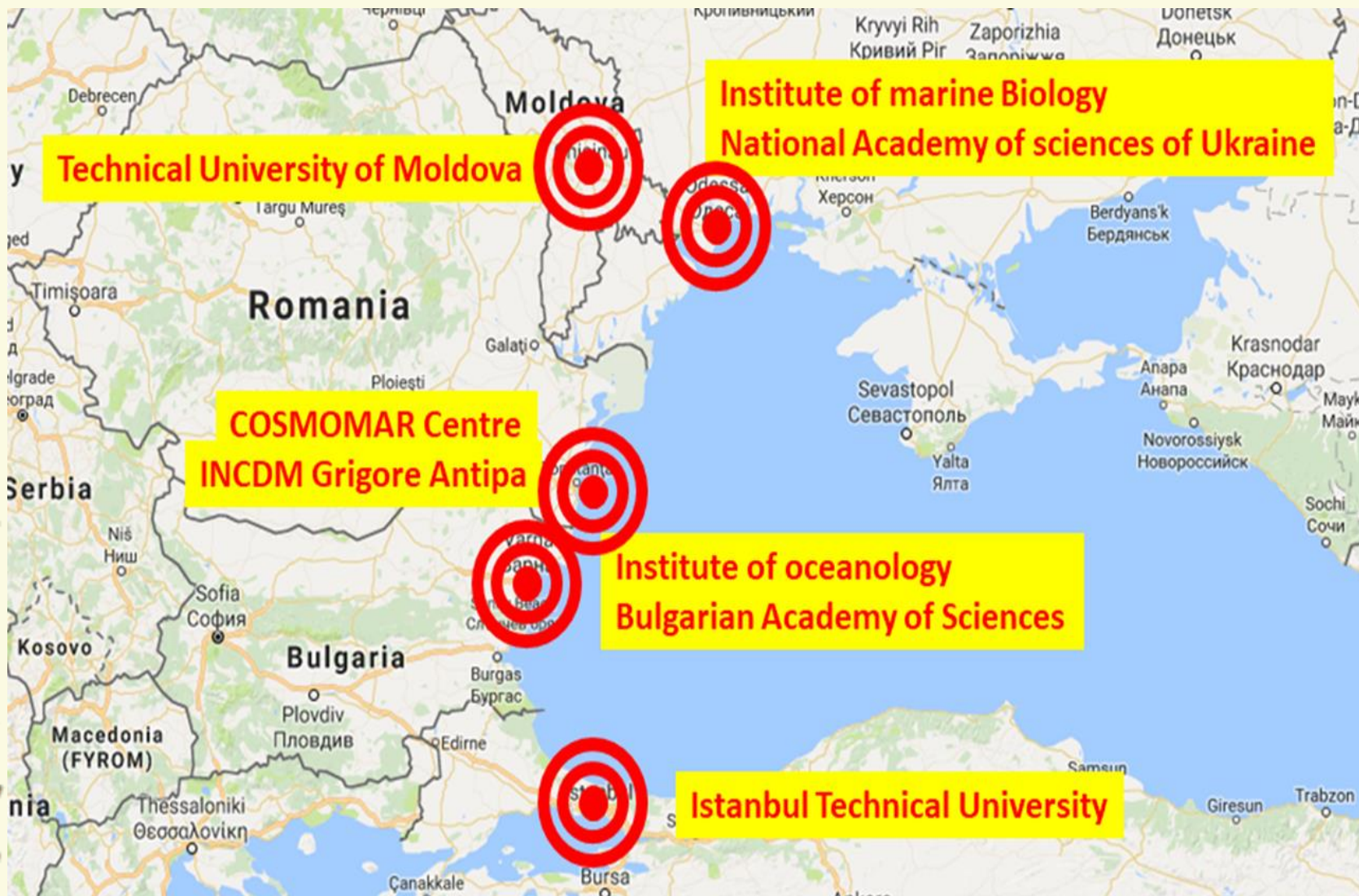
**Presentation of the satellite tracking facilities at Technical University of Moldova**

**Acad. Ion BOSTAN, Director CNTS, Technical University of Moldova**



# Black Sea Basin ENI Cross-Border Cooperation Programme 2014-2020”

<http://blacksea-cbc.net/black-sea-basin-2014-2020/calls-for-proposals>



# The team of students participating in the project at various meetings and summer school



The team TUM students to summer school with Adrian Stoica, NASA's robotics department head.

TUM student team in the SATUM laboratory

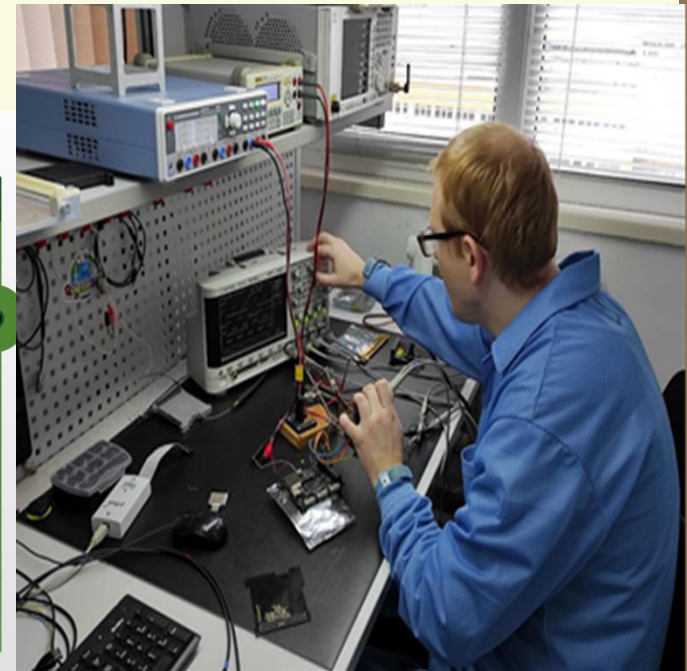
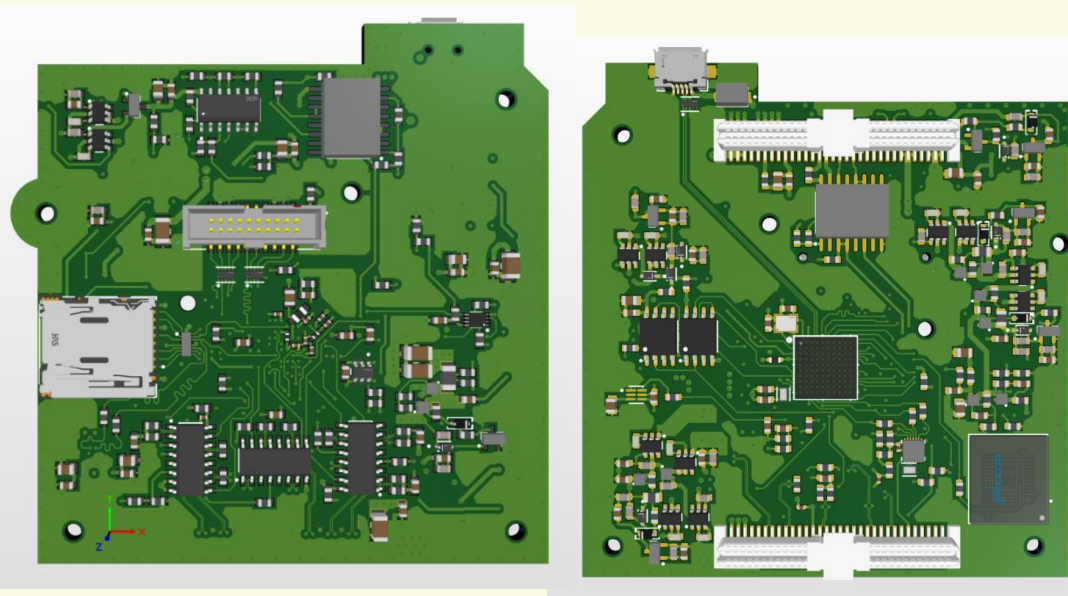




# Future ideas & projects

# New on-board computer architecture for TUMnanoSAT series nanosatellites

The PCB of the OBC-2 for the TUMnanoSAT series nanosatellites with complex missions was designed and module samples were assembled and the upgraded platform (software and hardware) for the development of the nanosatellite on-board computer software for the efficient creation of various missions was developed.





## The assembly and functional testing of the TUMnanoSAT-2U prototype

The assembly and functional testing of the nanosatellite prototype with new TUMnanoSAT - 2U missions was carried out. The test procedures confirm that the nanosatellite can advance to the launch stage, but still requires some modifications to the satellite. The reference documents for the TUMnanoSAT-2U nanosatellite test procedures were based on the procedures recommended by JAXA as the most rigorous.



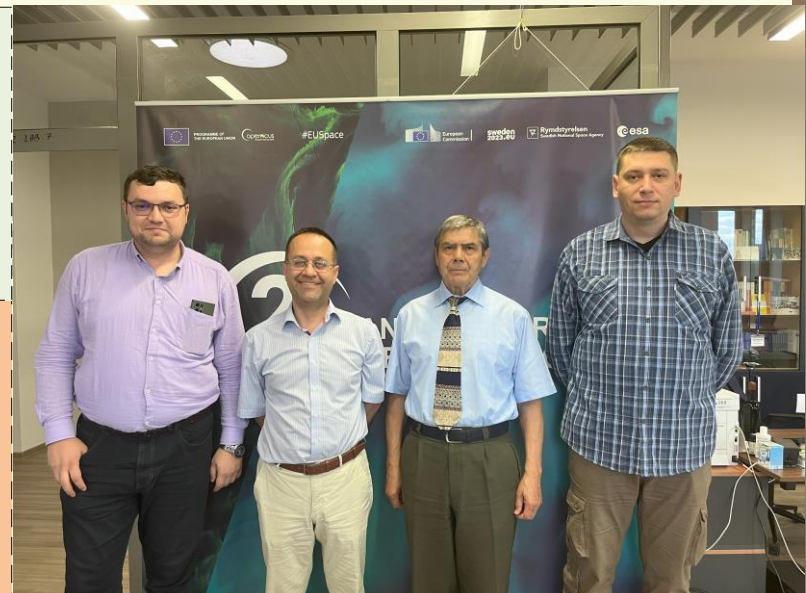
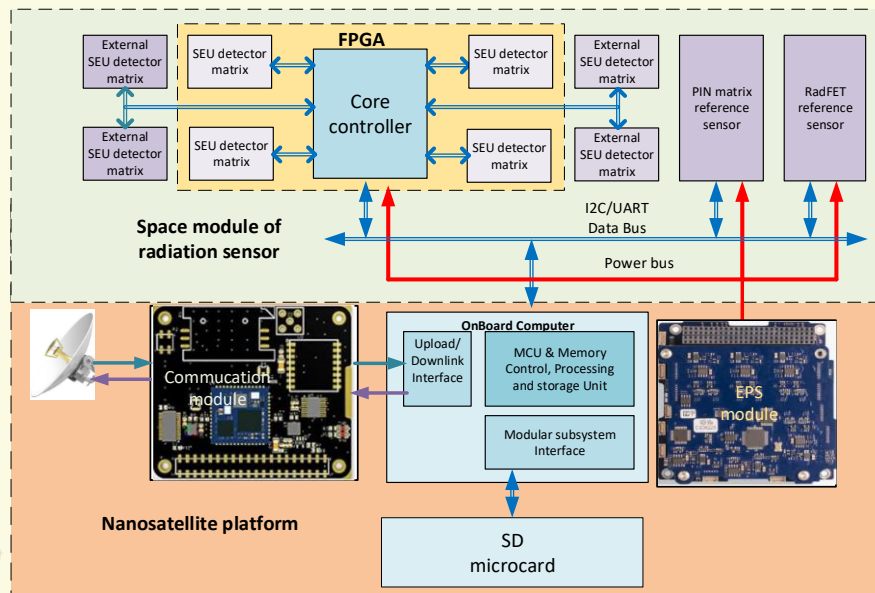
# Diploma of Merit and Silver Medal from the Geneva International Exhibition of Inventors





# TUM – Transilvania University bilateral project

The project "Artificial Intelligence-enabled Hardware Cosmic Radiation Sensor for Space Applications - AICoRS" - is dedicated to the study of cosmic radiation and its effects on electronics, as well as how to measure them to help realize the architecture of the satellite module of space radiation sensors for real-time classification and analysis of cosmic radiation-induced defect patterns and prediction of the state of electronic systems embedded in satellites.



# UNOOSA and Mohammed Bin Rashid Space Centre - Access to Space for All umbrella

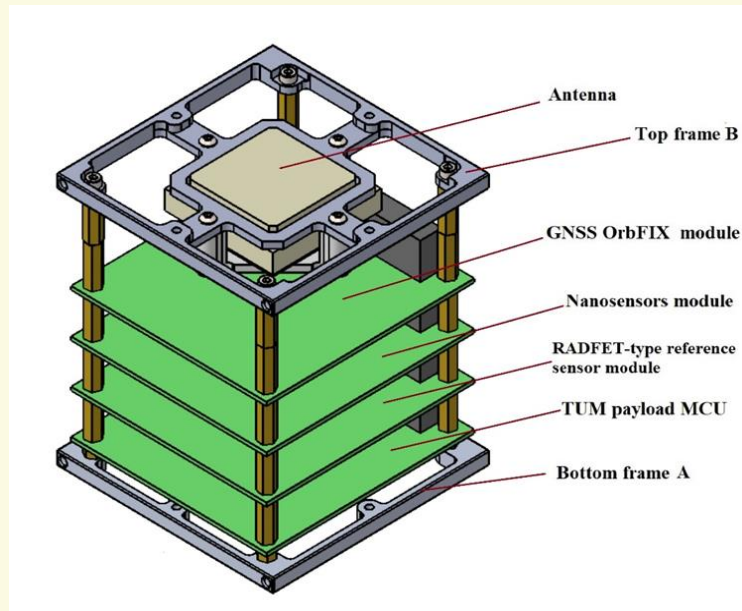
The United Nations Office for Outer Space Affairs (UNOOSA) and the Mohammed Bin Rashid Space Centre (MBRSC) of the United Arab Emirates are opening a new round of their joint Payload Hosting Initiative (PHI) programme.



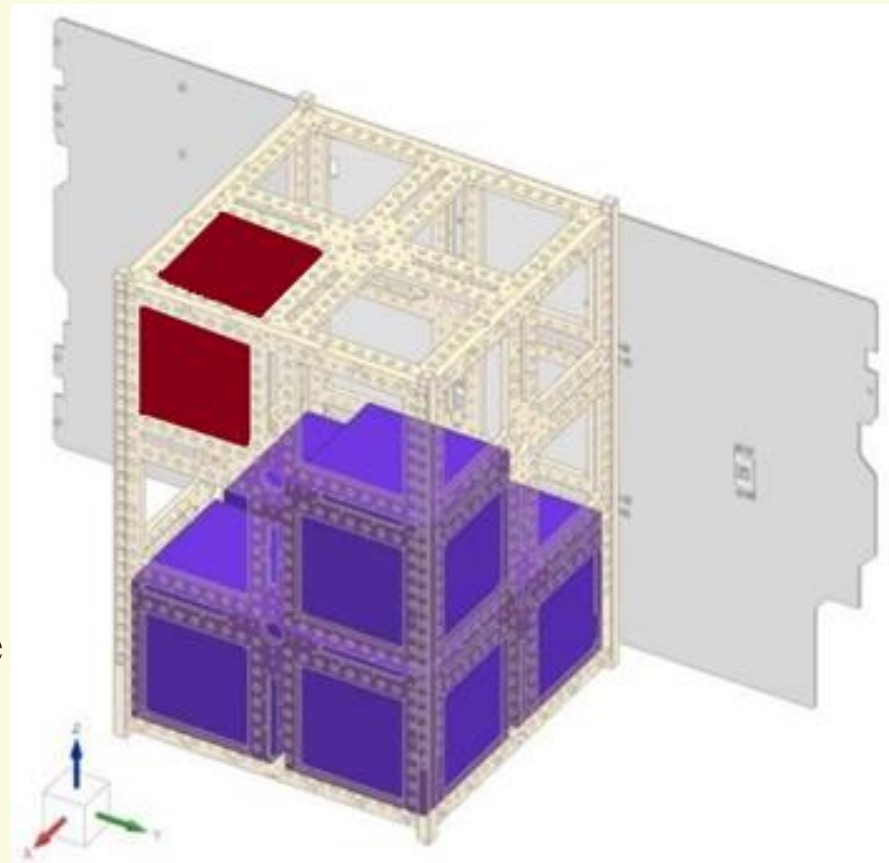
Through PHI, each applying team can submit a proposal of a payload of a maximum Three Units (3U) in size, recognizing that the maximum space for the combined awardees will be Five Units (5U) in a Twelve Unit (12U) satellite platform provided by MBRSC.



# The 2nd Announcement of Opportunity United Nations Access to Space and Mohammed Bin Rashid Space Centre for All initiative United Nations for Cooperation Programme on Payload Hosting Initiative



”TUM’s Payload Hosting Initiative - 2024” of National Space Technologies Center of the Technical University of Moldova



# JAXA and UNISEC J-CUBE Program

The Japan Aerospace Exploration Agency (“JAXA”) and the University Space Engineering Consortium (“UNISEC”) have announced CubeSat deployment opportunity from the International Space Station (ISS) -

Japanese Experiment Module (Kibo) (JEM Small Satellite Orbital Deployer (J-SSOD)) for domestic universities/college called J-CUBE, based on the MOU about “Comprehensive collaboration agreement on CubeSat release from ISS-Kibo for academic research and capacity building”



The graphic is a promotional poster for the J-CUBE program. It features a photograph of the International Space Station (ISS) in the upper left. Below the photo is a yellow triangle with a dashed line and the text "Your Future CubeSats". To the right of the photo is a blue starburst shape with the text "J-CUBE". Below the starburst is the text "A new collaboration between JAXA and UNISEC to help emerging space nations get their first CubeSats deployed into Low-Earth Orbit via the ISS." The JAXA logo is in the center, and the UNISEC logo is to its right. At the bottom right, it says "This 9-page document by G. Maeda, 16 April 2022".

**Introducing**

**J-CUBE**

A new collaboration between JAXA and UNISEC to help emerging space nations get their first CubeSats deployed into Low-Earth Orbit via the ISS.

**JAXA**

**UNISEC**  
University Space Engineering Consortium

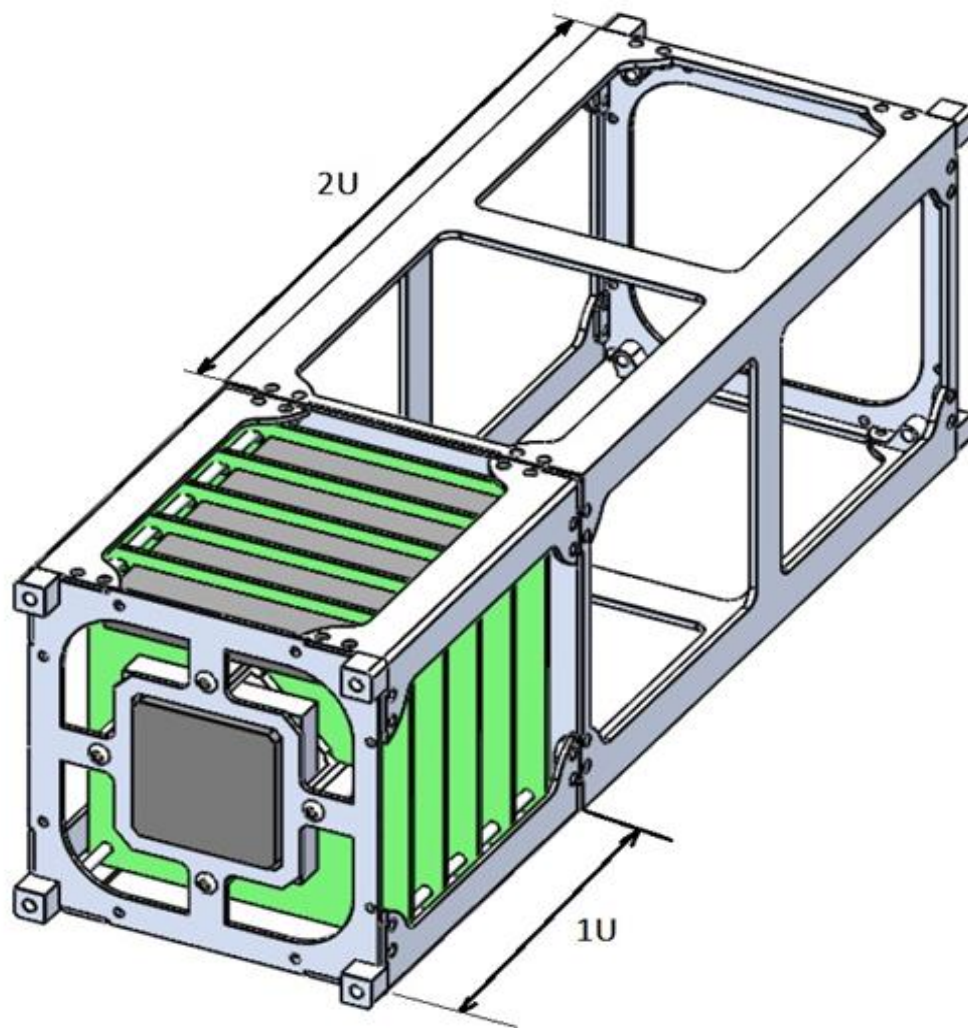
*This 9-page document by  
G. Maeda, 16 April 2022*



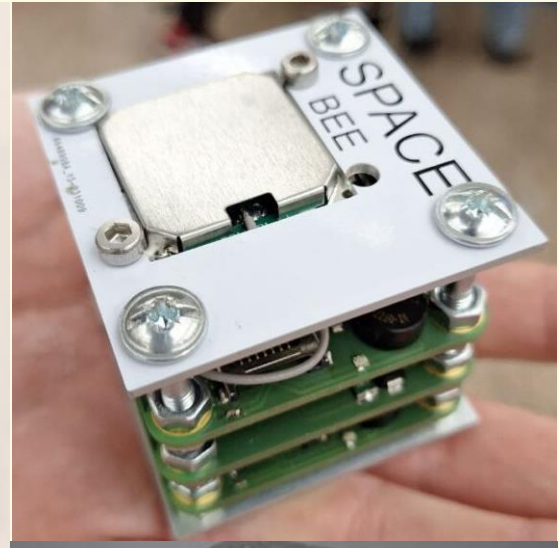
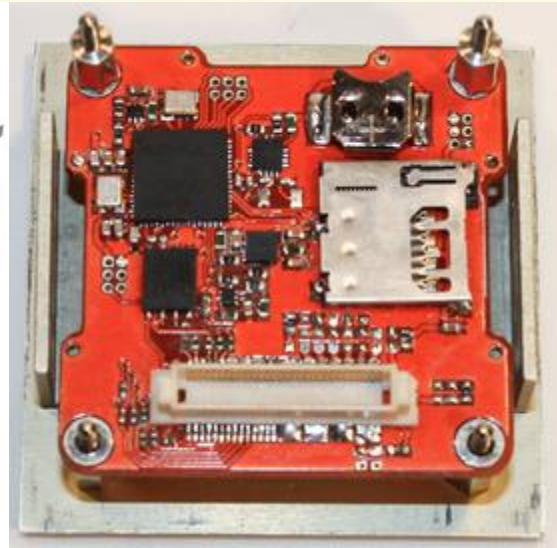
# JAXA & UNISEC J-CUBE prorgamm for International Collaborative Partner

Project proposal  
"TUM's Payload J-  
CUBE - 2024"

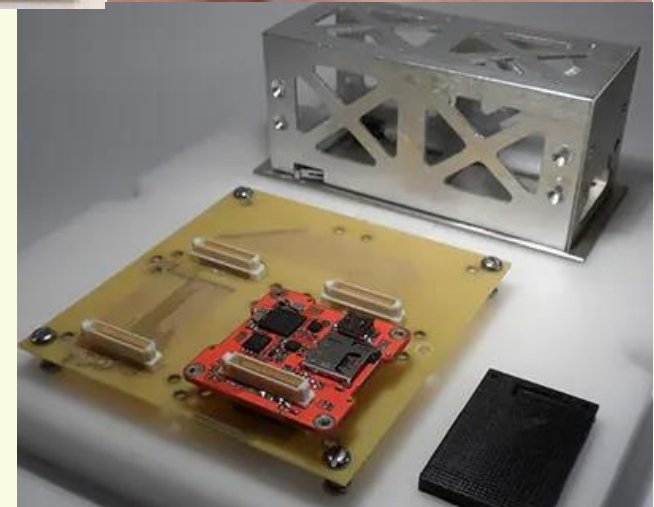
of the National Space  
Technologies Center  
of the Technical  
University of Moldova



# TUM PocketQube hub for students to build their own satellites



**PocketQube** is a type of miniaturized satellite for space research that usually has a size of cube with 5 cm sides (one eighth the volume of a **CubeSat**), has a mass of no more than 250 grams, and typically uses commercial off-the-shelf components for its electronics.





**Thanks for your  
attention!**

