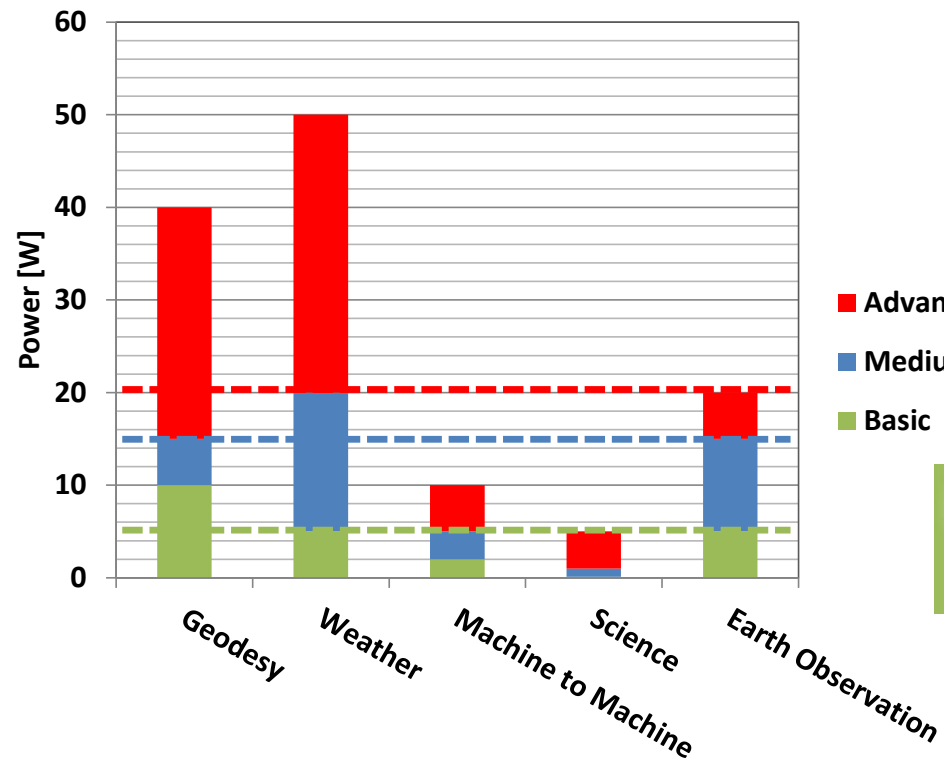


Possible uses of nanosatellites for various mission applications

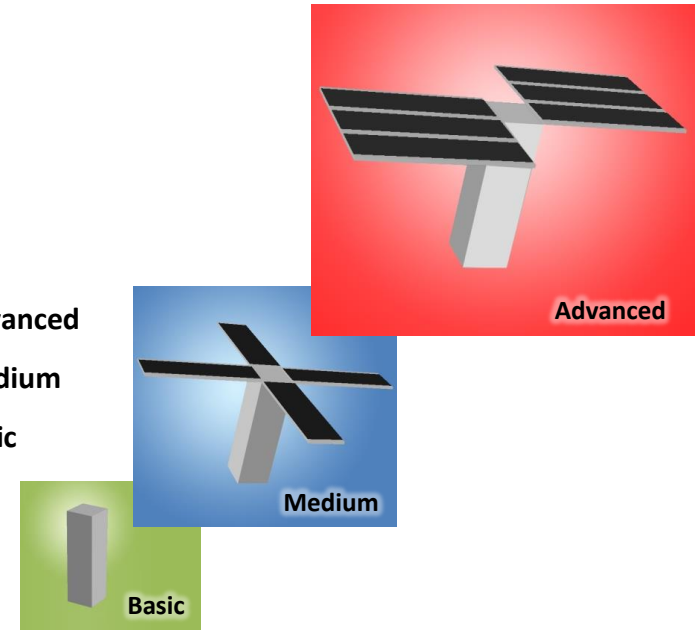


Mr. Gábor Marosy
Budapest University of Technology and Economics

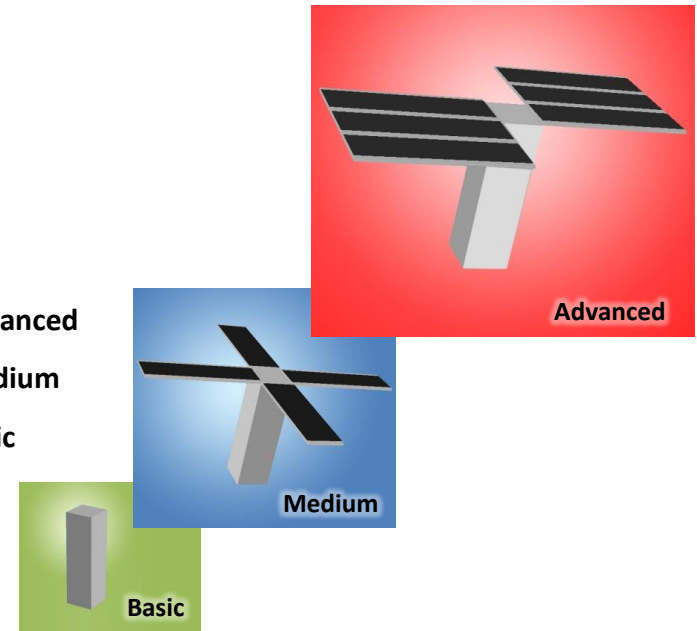
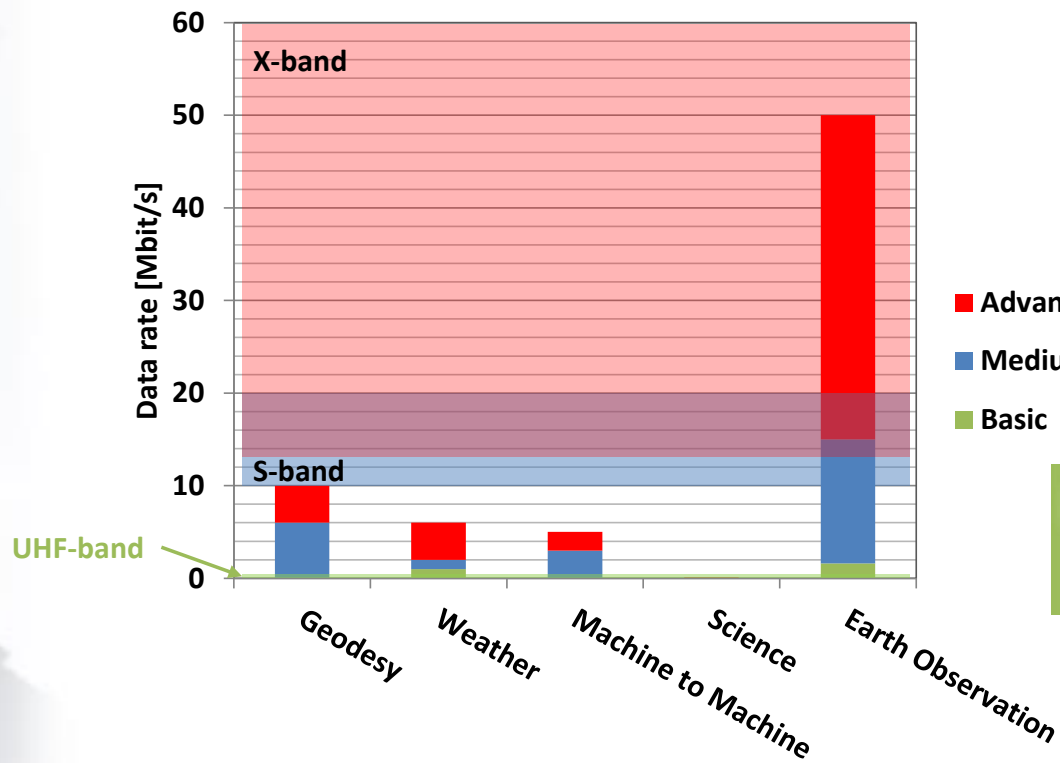
CubeSat Capabilities – Power



■ Advanced
■ Medium
■ Basic

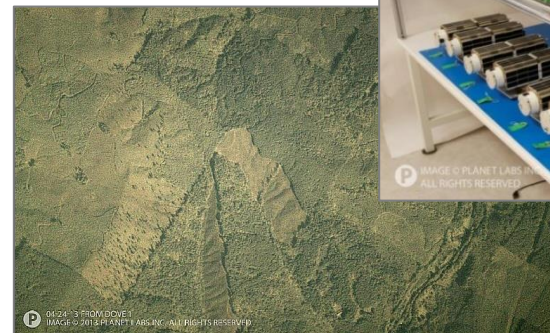
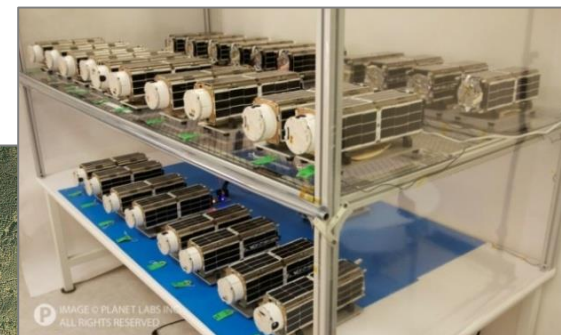


CubeSat Capabilities – Data rate



Remote Sensing Applications

- Gaining information without direct physical contact
- Every segment is fully covered by professional service providers
- Imaging requires sophisticated optical instrument / system
- **Importance of remote sensing**
 - Homogenous data-collection about extensive areas
 - Good spatial and time resolution, fast access to new data
 - Relatively small investment, processes can be fully automated
- **CubeSat based remote sensing versus large satellites**
 - Development time: CS advantage
 - Launch costs: CS advantage
 - Response & revisit time: CS advantage
 - Optical performance: CS is constrained
- **CubeSat capabilities**
 - $P < 20W$
 - $m < \text{a few kg}$
 - $V < \text{a few dm}^3$



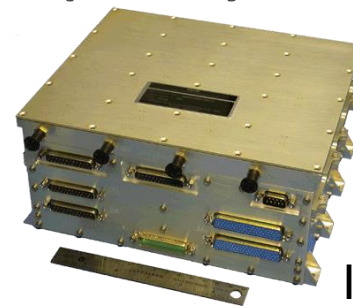
DOVE and Flock missions in the USA

Weather Applications

- Some professional payloads could be adopted to CubeSats

Instrument / Application area	Mass [kg]	Power [W]	Data rate [bps]
Limb-scanning sounder	8	15	3 M
Special scanning or non-scanning MW radiometer	15	20	?
MW sounding radiometer with cross-track scanning	14	26	320
Solar irradiance monitors	6-15	10-15	600-16 k
GNSS radio-occultation sounders	3-6	10-50	0.5-40 k

- **Dedicated CubeSat missions for weather observation (3U & 6U)**
 - ³Cat-2, CHARM, MicroMAS, PolarCube, [SIMBA](#)
 - Typical payloads: scatterometer, MW radiometer (183 GHz), cavity radiometer
- **There are payloads developed especially for use on-board a CubeSat**
 - Light Detection And Ranging, Radar Altimeter
 - Typical requirements: 1-6kg, 1-40W, 100k – 6Mbps



IGOR



TIM

Geodesy Applications

Typical application areas which might benefit from CubeSat technologies:

- Geoid measurement
- Tectonic plate motion
- Earth rotation measurements
- Oceanography
- Tides

Geodesy CubeSats

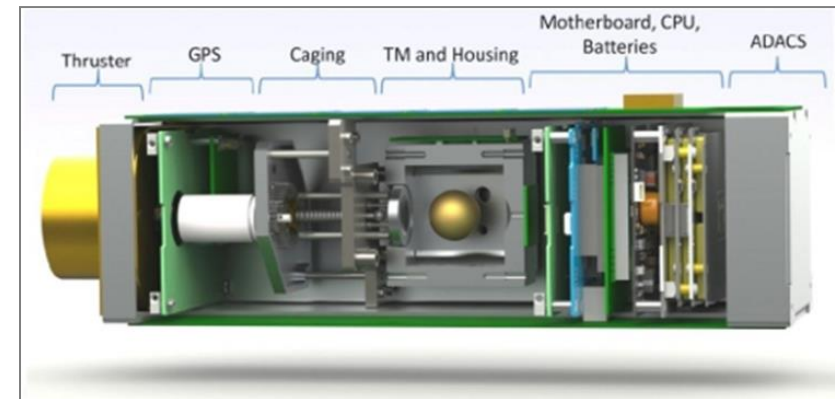
- DORIS (~1 kg, ~1U, ~10 W)
- GPS (0.1 kg, 96 x 90 x 11 mm, 1.3 W)
- Altimeter (3.1 kg, 95 x 95 x 320 mm, 10 W)
- Satellite-Satellite Tracking (1-1.5U)
- Drag-free (2U, 6.5-9.3 W)



DORIS Generations



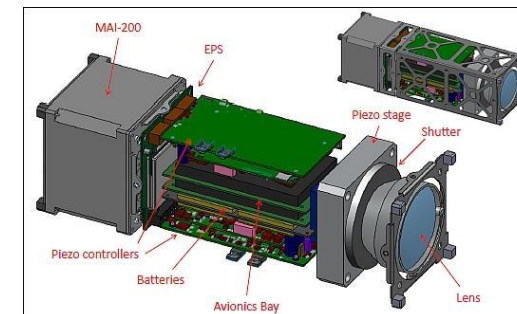
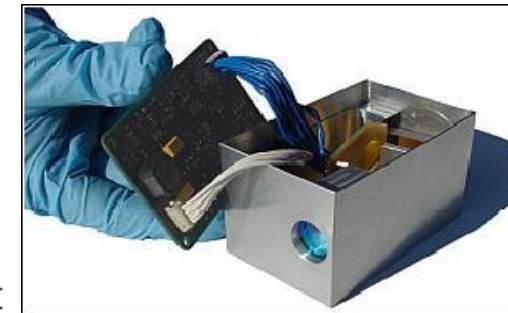
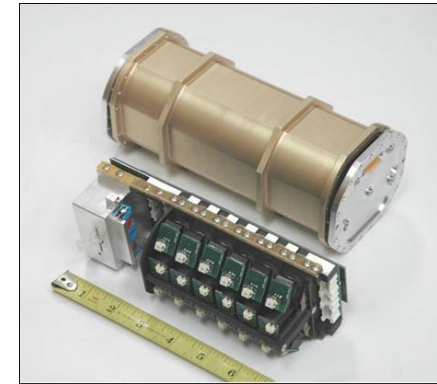
LRR: Laser Retro-Reflector (CHAMP)



Drag-free CubeSat (Stanford University)

Science and Technology Satellites

- Lower resolution, lower sensitivity (size, mass, power constraints)
- Higher spatial and time resolution and coverage (small sat constellations)
- **Astronomy**
 - Astronomical observations on different wavelength
 - Long term observations, detecting and tracking changes
- **Examination of the Earth's vicinity**
 - Space weather: magnetic field, gravity field, ionosphere, plasmas, radiation, micro-meteorites, chemical investigation of the upper atmosphere
- **Materials technology research**
 - Material sciences, semiconductors, electronics, single event effects
 - How the space environment effects the lifetime and reliability of different devices, components
- **Biological research**
 - Biological samples in space environment
 - Observing biological processes in microgravity



Telecommunication Applications

- **Typical application areas which might benefit from CubeSat technologies:**
 - Telemetry & Telecommand
 - TAG tracking (bird, animal, buoy, ...)
 - AIS (ship tracking)

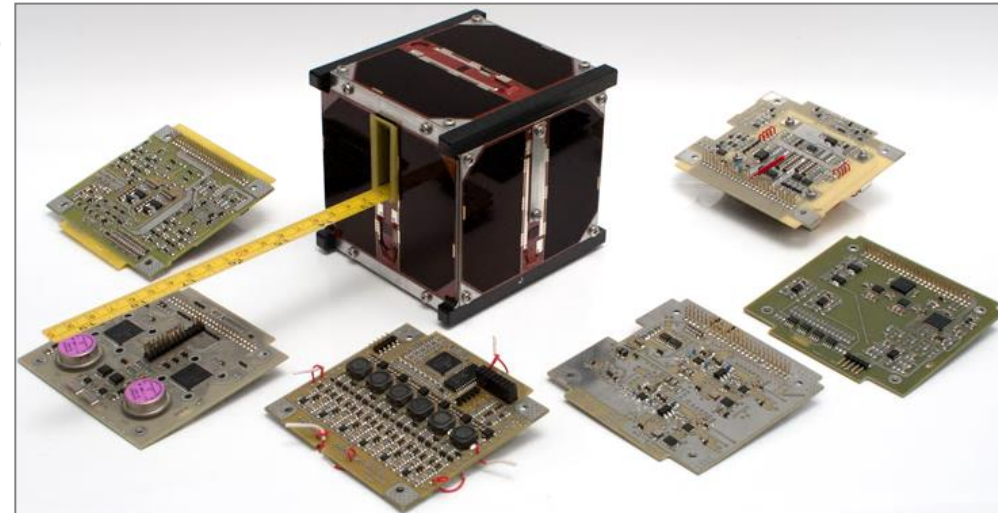


ISIS Triton 1 satellite with an on-board AIS receiver

Masat-1 Introduction

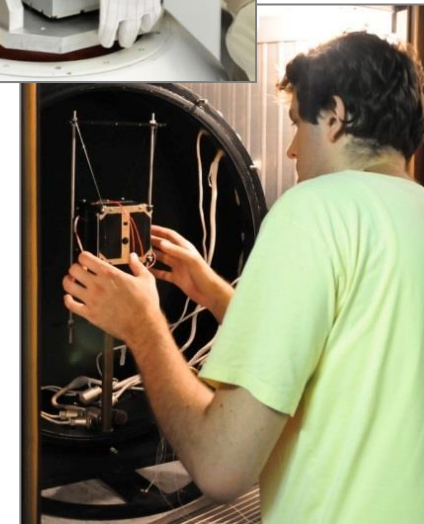
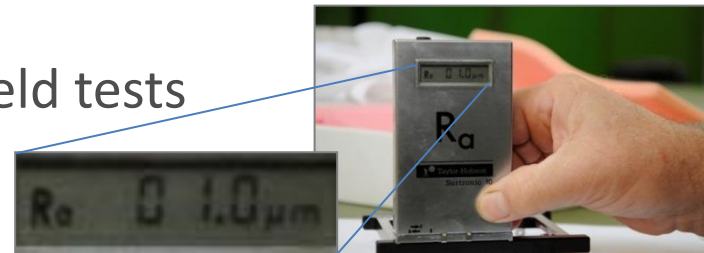
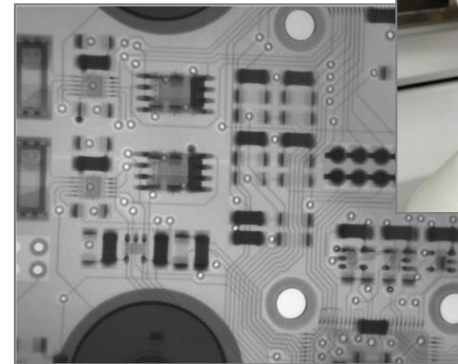
1U CubeSat

- 1st satellite of Hungary
- Built at the Budapest University of Technology and Economics
- Student initiative, 10 intensively involved, altogether 20 persons
- More than 60.000 work hours
- Fully custom built, redundant main subsystems
- 2.500 electrical and mechanical components
- Up to 250 photos from space
- Up to 5.000.000 received tm packets
- Up to 220 radio amateur tracking Masat-1

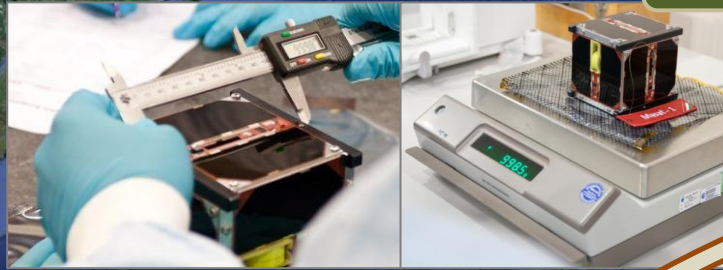
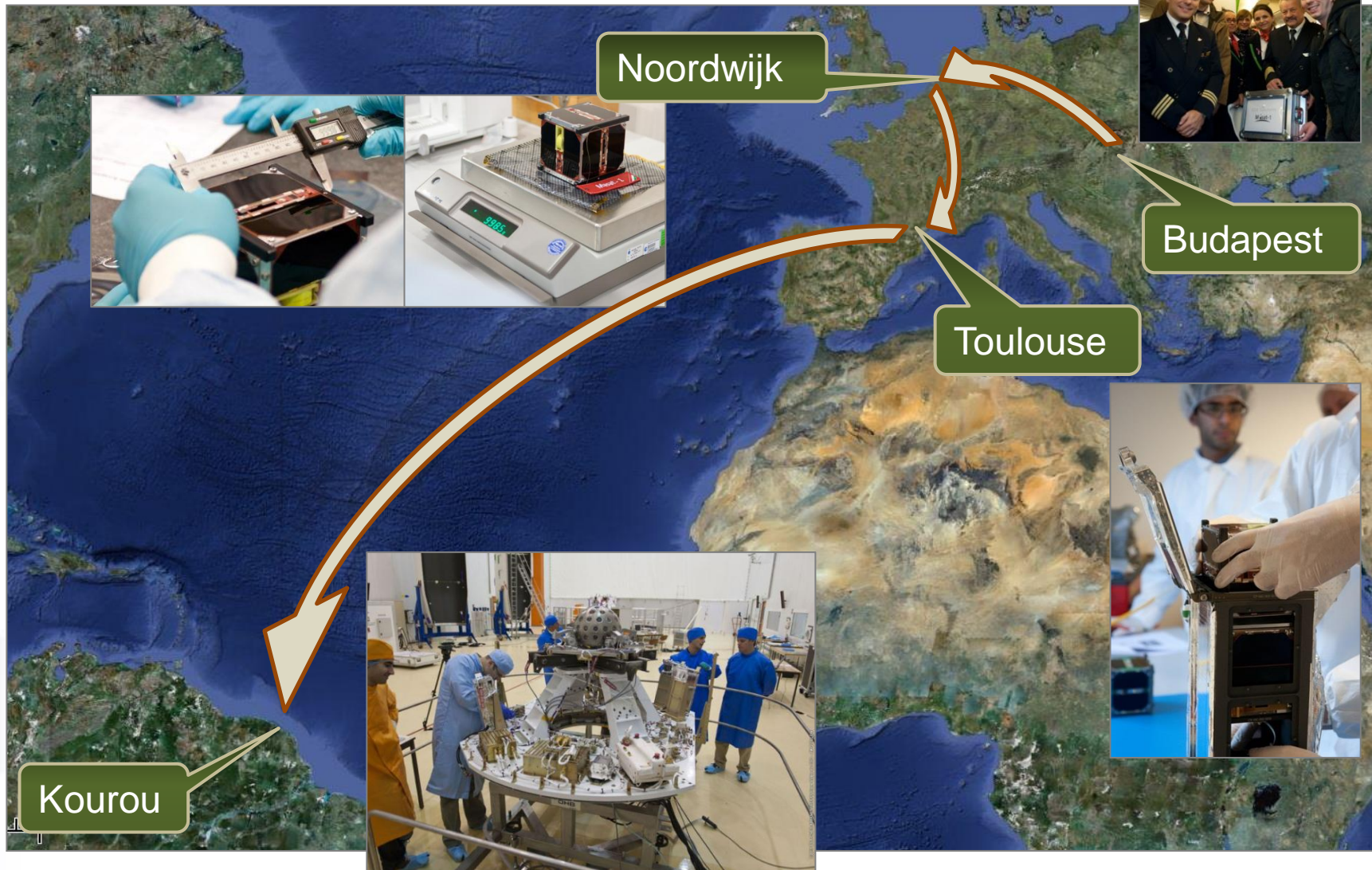


Qualification tests passed

- Calculated, simulated, and measured every critical function
- First satellite: safety factors, on-board tune and check capabilities to compare tests with flight results
- Testing is very important (1:1 development/test time)
- Flight Model tests:
 - Functional (assembly)
 - Thermo-vacuum
 - Vibration
 - X-ray
 - Sensor calibration
 - Communication field tests



Road of Masat-1 to launch pad



Cooperation with ESA

THEN:

- Launch campaign
- Documentation
- Acceptance tests
- P-POD integration
- Integration to Vega adapter
- Launch
- Lessons Learned meeting and Operation reports

NOW:

- Development of CubeSat technologies
- Robust Fault Tolerant On-Board Computer with Redundancy
- Telemetry-Telecommand Transceiver with CCSDS compatibility
- 3U CubeSat Structure for high density electrical components



Main administrative milestones

Before start

- NMHH, ITU, IARU
- Export license

After start

- OSCAR-72
- 2012-006E-> Masat-1
- UN registration
- HSO – Satellite register

United Nations



Secretariat

ST/SG/SER.E/648

Distr.: General
20 April 2012

Original: English

Committee on the Peaceful Uses
of Outer Space

Information furnished in conformity with the Convention on Registration of Objects Launched into Outer Space

**Note verbale dated 12 April 2012 from the Permanent Mission of
Hungary to the United Nations (Vienna) addressed to the
Secretary-General**

The Permanent Mission of Hungary to the United Nations (Vienna) presents its compliments to the Secretary-General of the United Nations and, in accordance with article IV of the Convention on Registration of Objects Launched into Outer Space (General Assembly resolution 3235 (XXIX), annex), has the honour to transmit information concerning Hungarian space object Masat-1 (international designator 2012-006E) (see annex).

International cooperation with HAMs

Ground Station Client - 2012. 02. 02.

File Ground Station Satellites Team Tools

Masat-1 Control Window

Settings Packets Telemetry - OBC Telemetry - EPS Telemetry - COM Telemetry - ADCS Telemetry - TCS

On-Board Time	OBC - Data Acquisition	OBC - Error Counters	OBC - Reset Flags
Time Code: Calendar Segmented	Acquiring Data: No	TC Integrity Error Cntr.: 0	Power On Reset: True
On-board time: 2012-02-02 02:08:25 CET	OBC - Battery Status	TIME Get/Set Error Cntr.: 0	Brown Out Reset: True
Timer Cntr.: 745	Battery Status (OBC): OK	SPI FLASH/RTC Error Cntr.: 0	Watchdog Timeout Reset: False
Osc. Status: Running	Battery Voltage (OBC): 3.63 [V]	SPI COM Error Cntr.: 0	Software Reset: False
Reporting on: Reporting on.	Vbus Unreg. (OBC): 3.63 [V]	I2C1 Error Cntr.: 0	External Reset: True
BEACON - Message	Battery Temp. (OBC): +28 [°C]	I2C2 Error Cntr.: 0	Illegal Opcode Reset: False
Beacon: MASAT	Heater PWM: 0 [%]	UART AP Error Cntr.: 374	Trap Conflict Reset: False
	Heater Enabled: Disabled	UART CAM Error Cntr.: 0	
OBC - General Information	OBC - Overcurrent Status	FILE SF/DR Error Cntr.: 0	
OBC Timer Cntr.: 747	ADCS Overcurrent State: OK	ADCS Connection Lost: No	
Boot Attempts Cntr.: 6	ADCS Overcurrent Cntr.: 0	ADCS Connection Lost [sec]: 0 [sec.]	
Current Op. Mode: LP Normal	COM Overcurrent State: OK	HK1 Connection Lost: No	
Next Op. Mode: LP Normal	COM1 Overcurrent Cntr.: 0	HK1 Connection Lost [sec]: 0 [sec.]	
Op. Mode Locked: Open	COM2 Overcurrent Cntr.: 0	HK2 Connection Lost: No	
Program Memory Chk.: 0xDDE	HK Overcurrent State: OK	HK2 Connection Lost [sec]: 0 [sec.]	
Debug Mode: Normal	HK Overcurrent Cntr.: 0	HK3 Connection Lost: No	
		HK3 Connection Lost [sec]: 0 [sec.]	
OBC - Transmitter	OBC - Power States	OBC - Temperatures	
TCTM Buffer Ovfl. Cntr.: 0	Active OBC: OBC-1	OBC uC. Temp.: +29 [°C]	
LP/HP Cntr.: 1	Active COM: COM-1	OBC Board Temp.: +27 [°C]	
LP/HP Setting: 4-th cy	ADCS Power State: On	Battery Temp. (OBC): +28 [°C]	
Antenna Sense: SWR-O B-O (1.7)	COM Power State: On	OBC - A/D Converter	
Antenna Deployer: Disabled	HK Power State: On	OBC Vref / 2: 0.00 [V]	
Closed Ant. Start: False	CAM Power State: Off		



Masat

AKTUÁLIS ADATOK GALÉRIA

Akkumulátor hőmérséklet
12 °C

Akkumulátor feszültség
3.93 V

A műhold üzenete
HappyBirthdayMasat-1

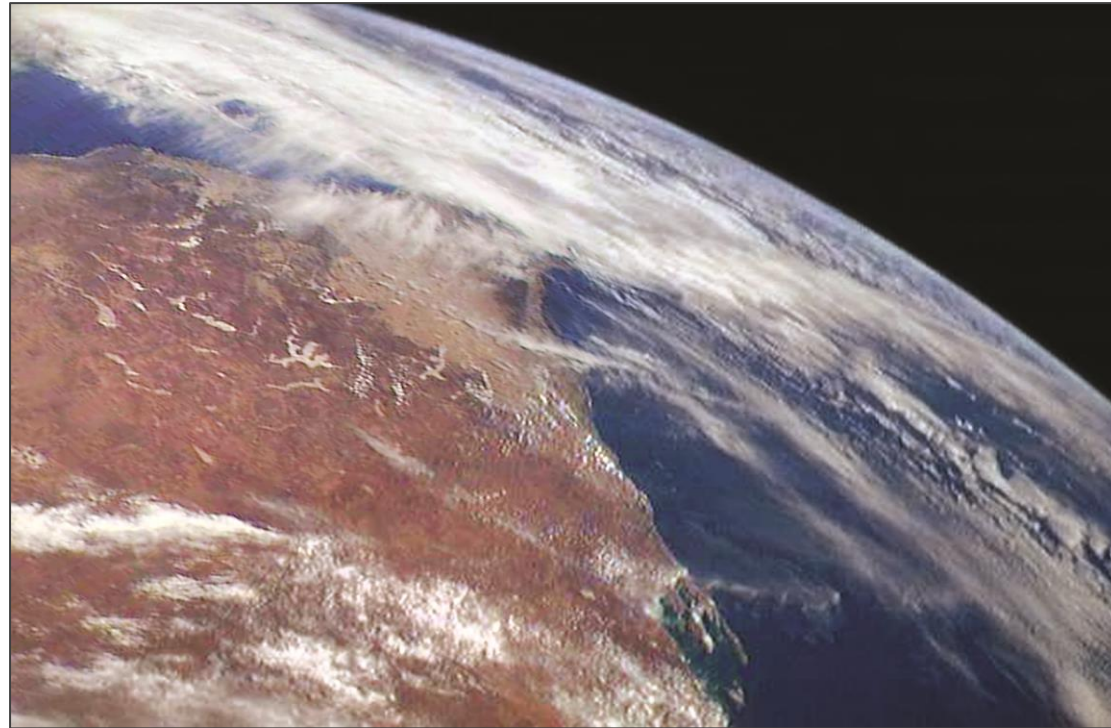
Összes csomag
11942474

Hőmérsékleti adatok
X+: -13 °C X-: 0 °C
Y+: -12 °C Y-: -12 °C
Z+: -13 °C Z-: -11 °C

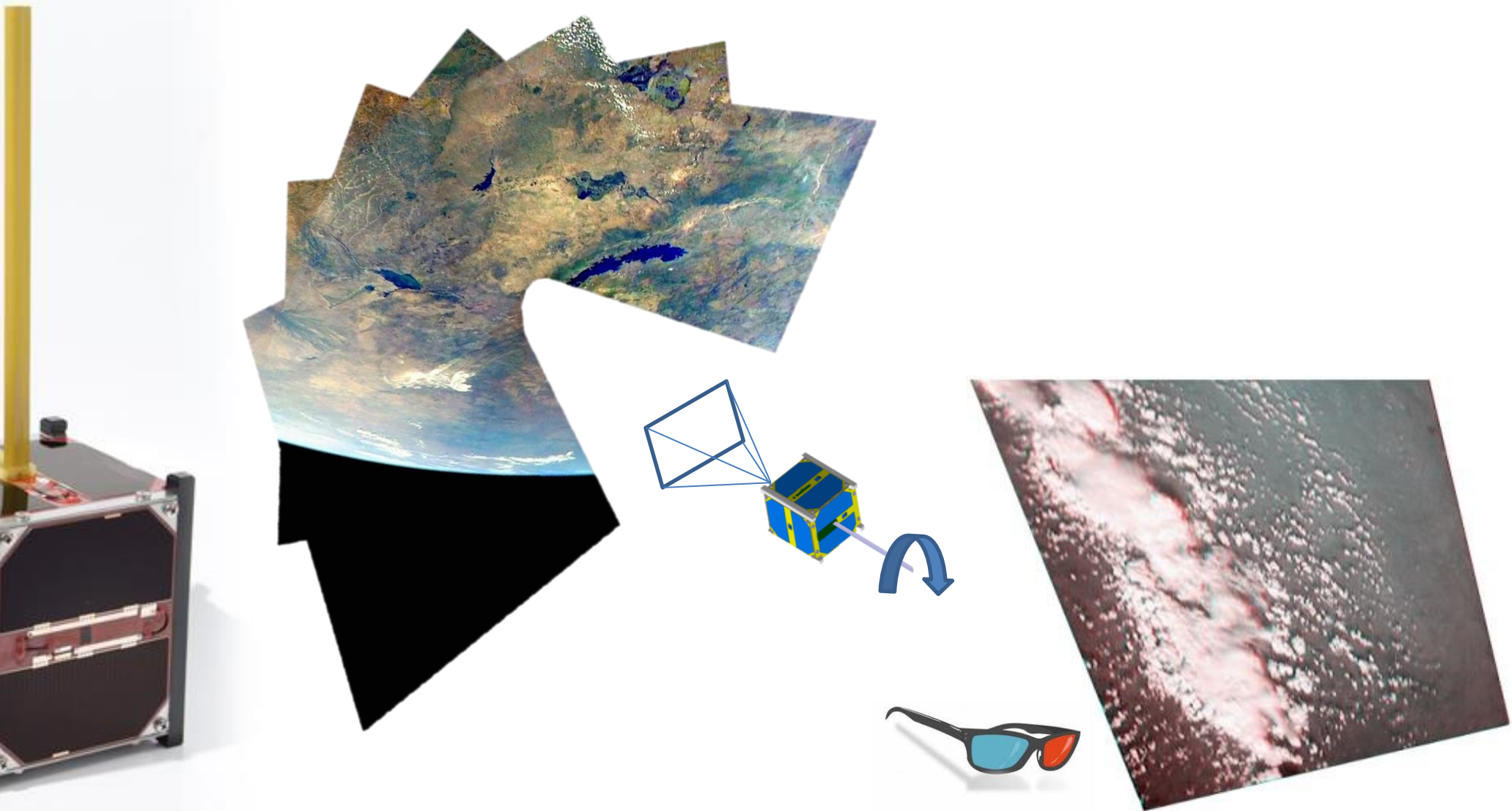
366n 2ó 1p 3mp
a Föld körül



Photos taken by Masat-1



Mosaic and 3D picture



Conclusion and strategic plan

- **Education**
 - Give student hands on experience in the field of space electronics
 - Provide new and amazing space related opportunity for students
 - Continuously updated educational portfolio
 - To train high qualified engineers for the space industry
- **Space industry**
 - Upgrade the results to market-capable devices, services
 - To include and strengthen the SME sector
 - Provide long term engineering support for the industry
 - Participation in international projects
- **Space research**
 - Provide a satellite bus for future scientific missions
 - Provide opportunity for Hungarian research centers

