Space Technology

Introduction

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and Electromagnetic Theory

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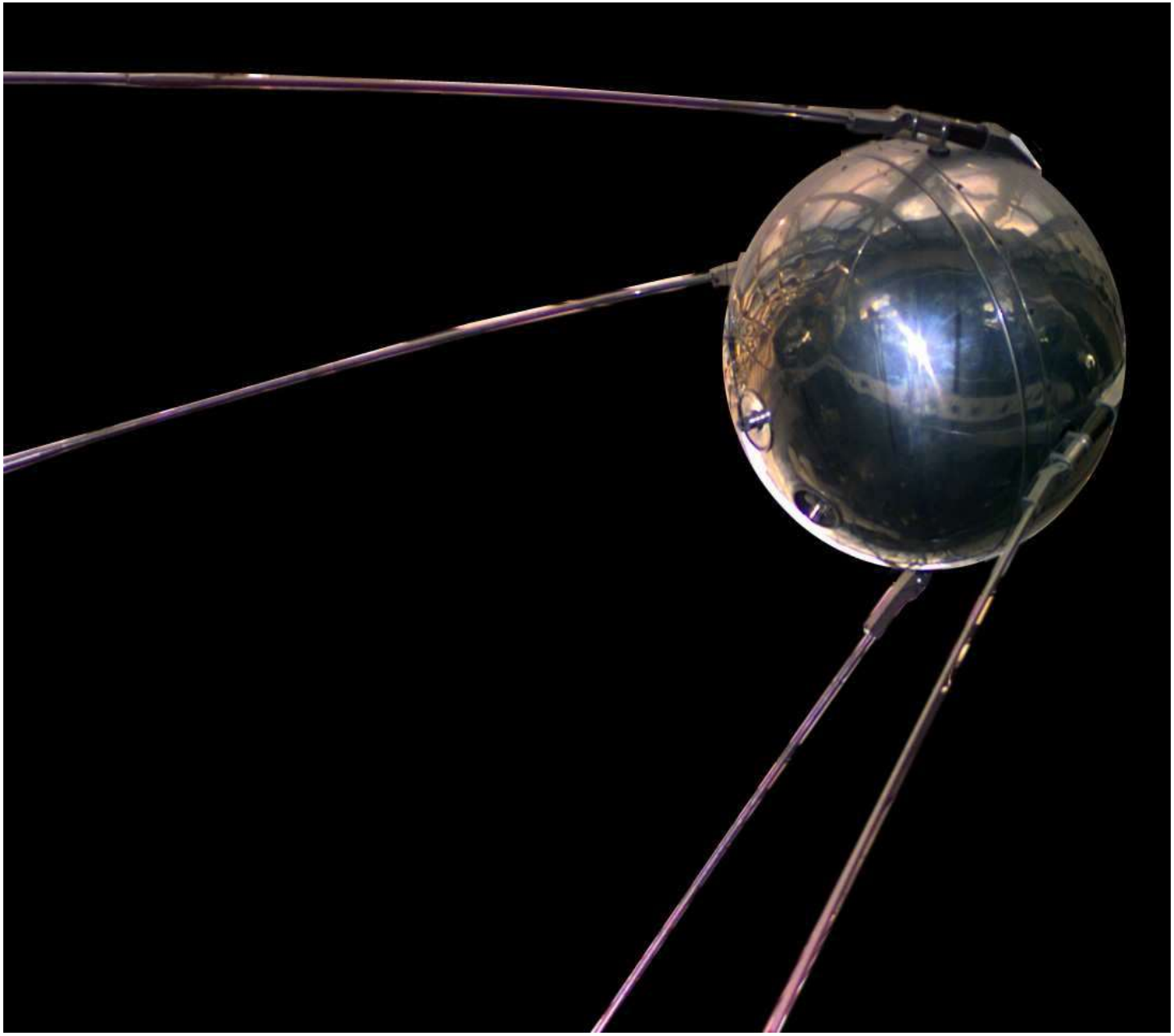
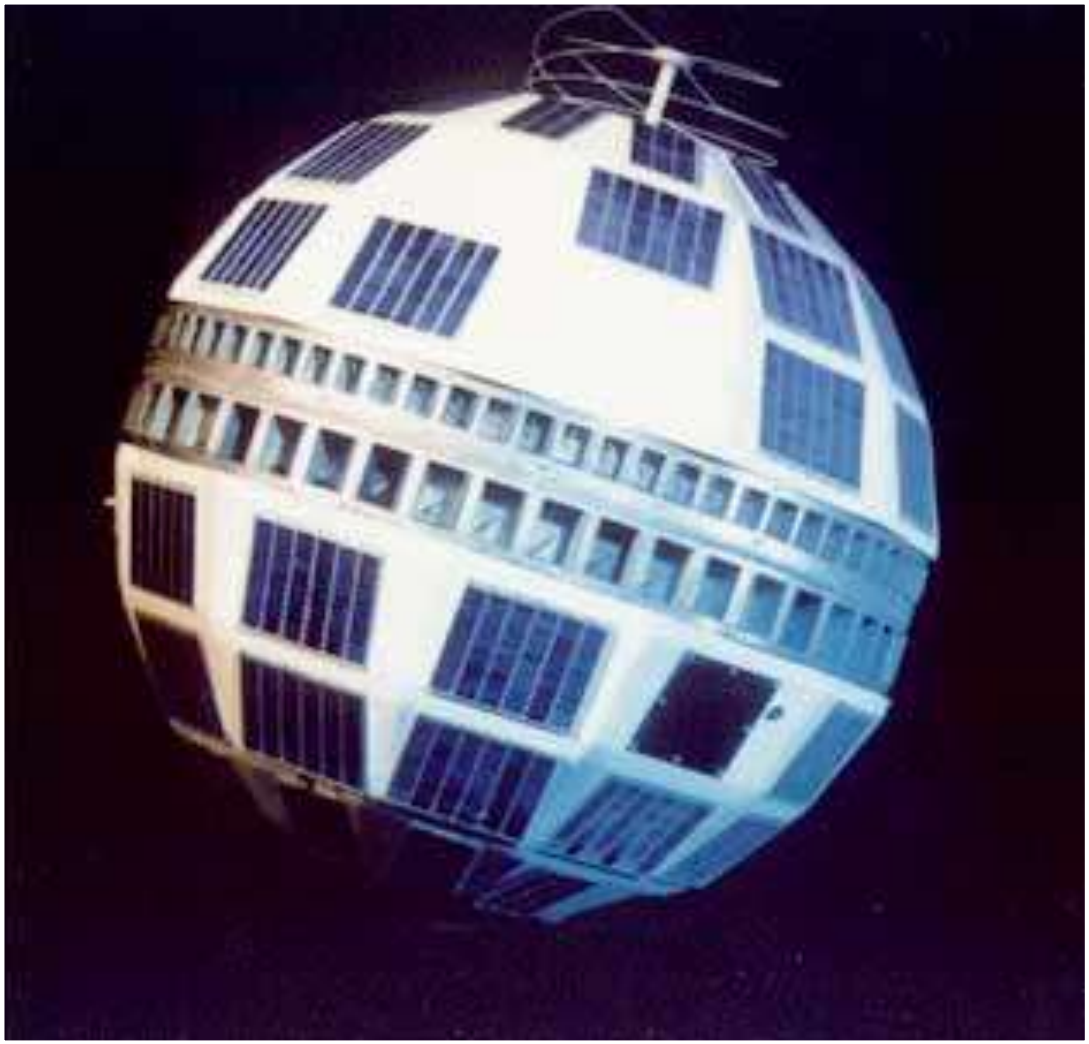
Sputnik-1 (1957) 21 days, 1440 orbits

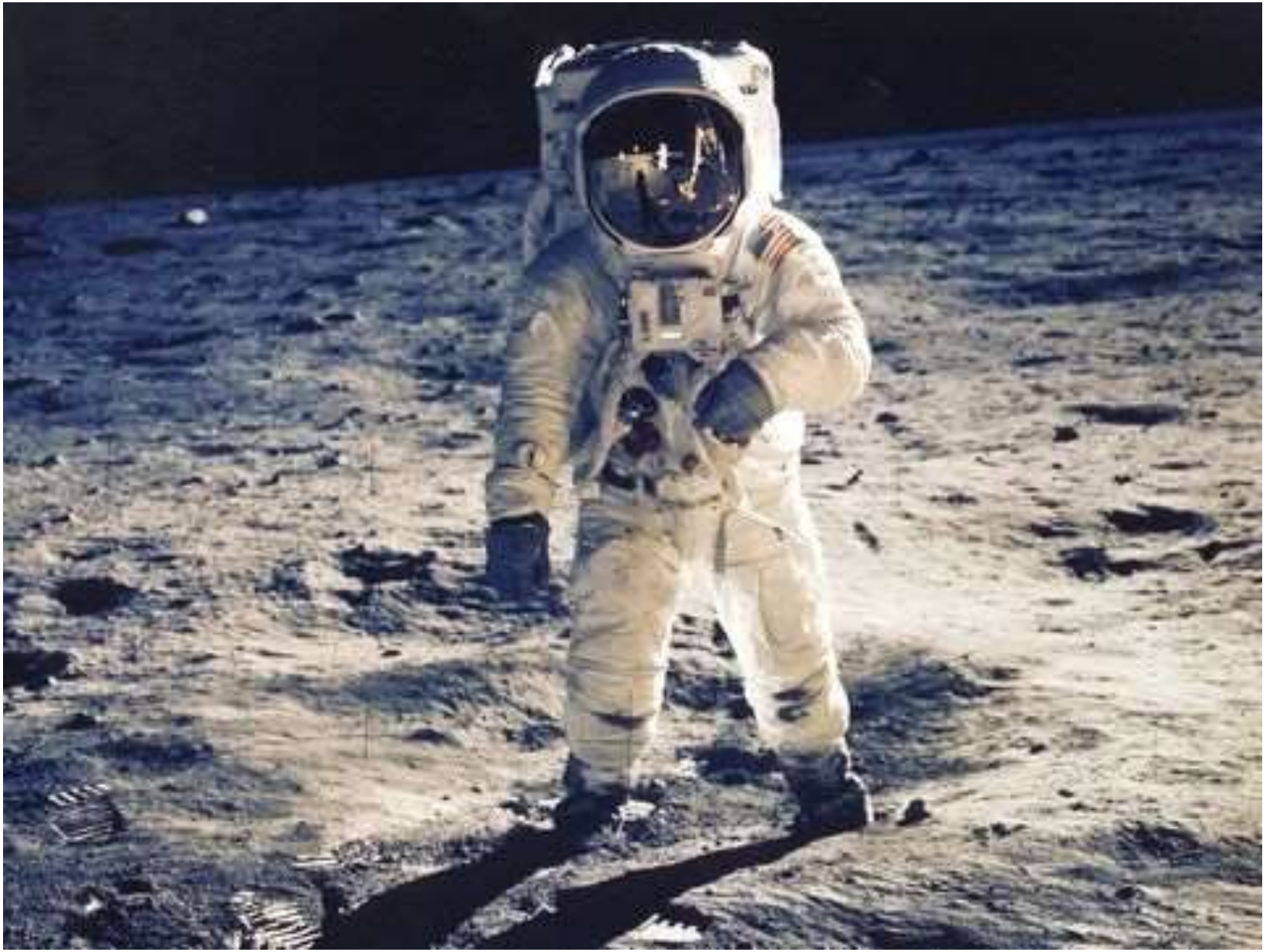


Vostok-1 (1961)

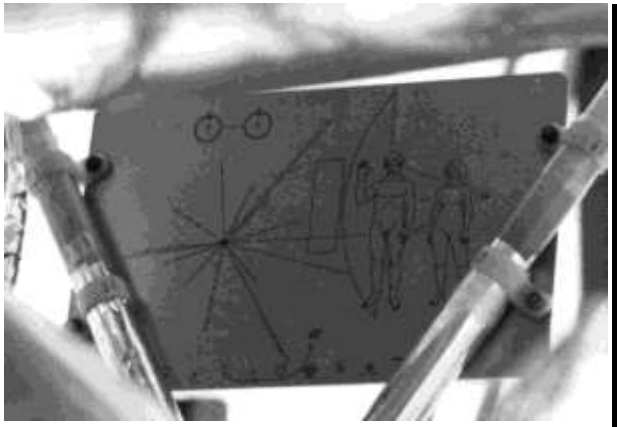
Telstar-1 (1962)

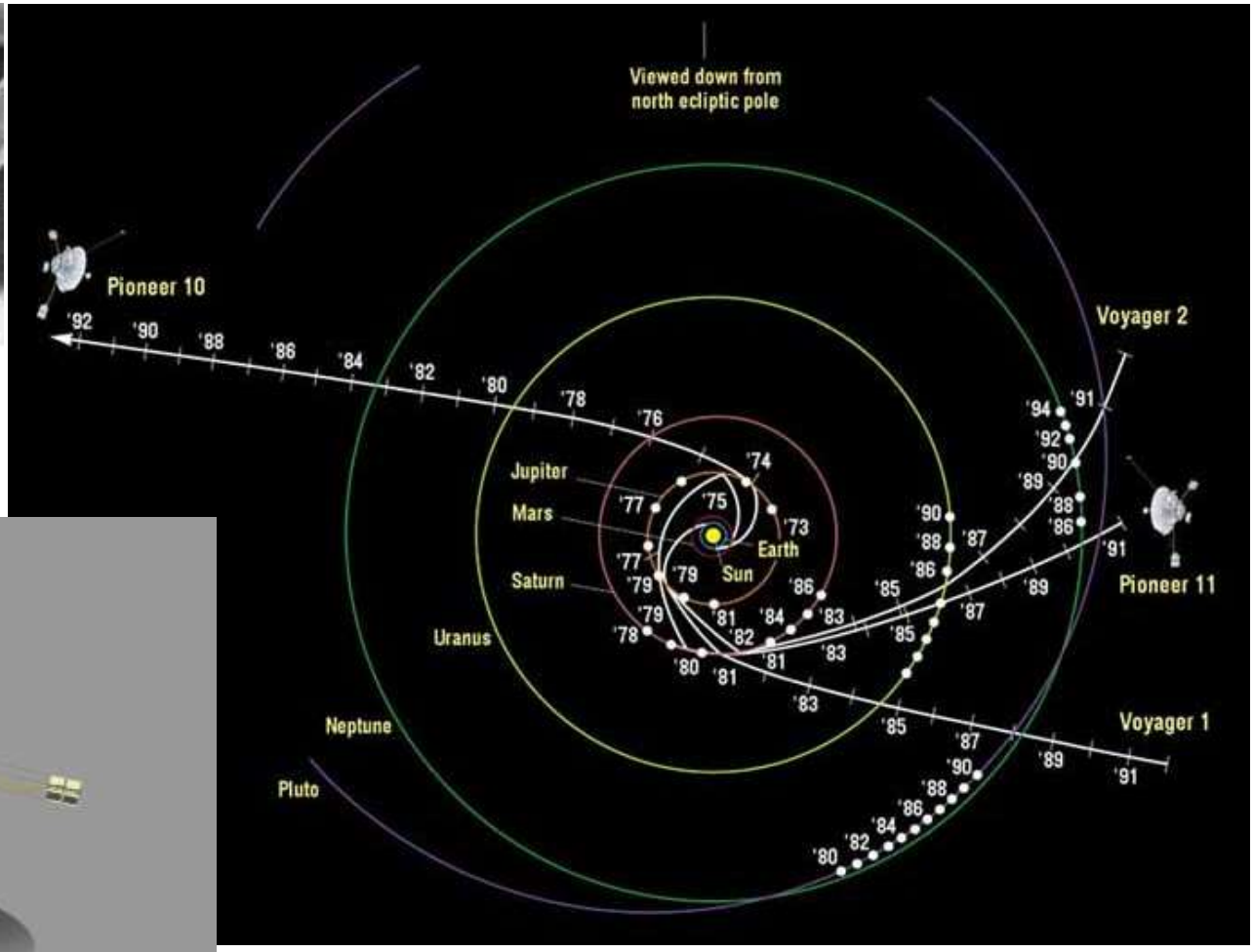


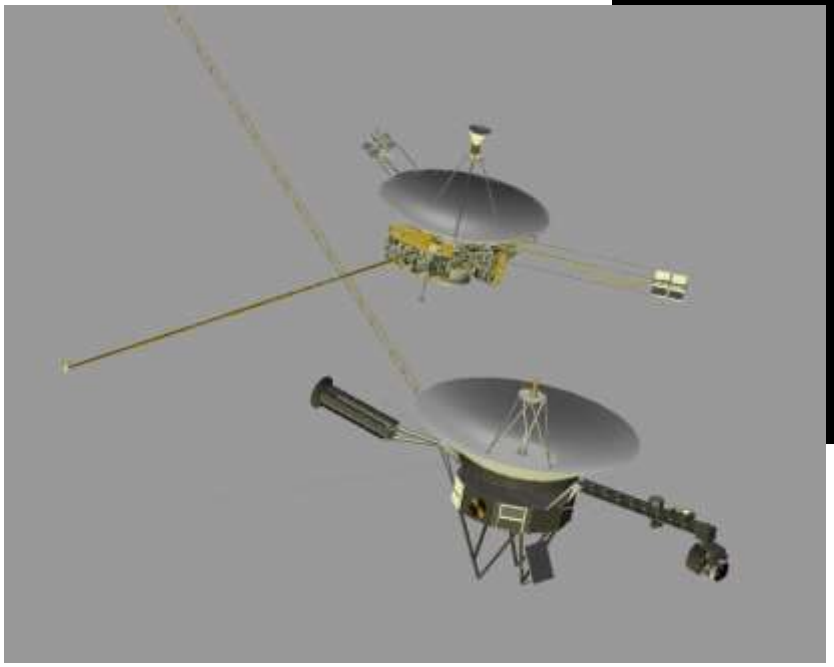
Apollo-11 (1969 20th July)



Pioneer 10/11, Voyager 1/2 (1970th)







GPS (1973-)

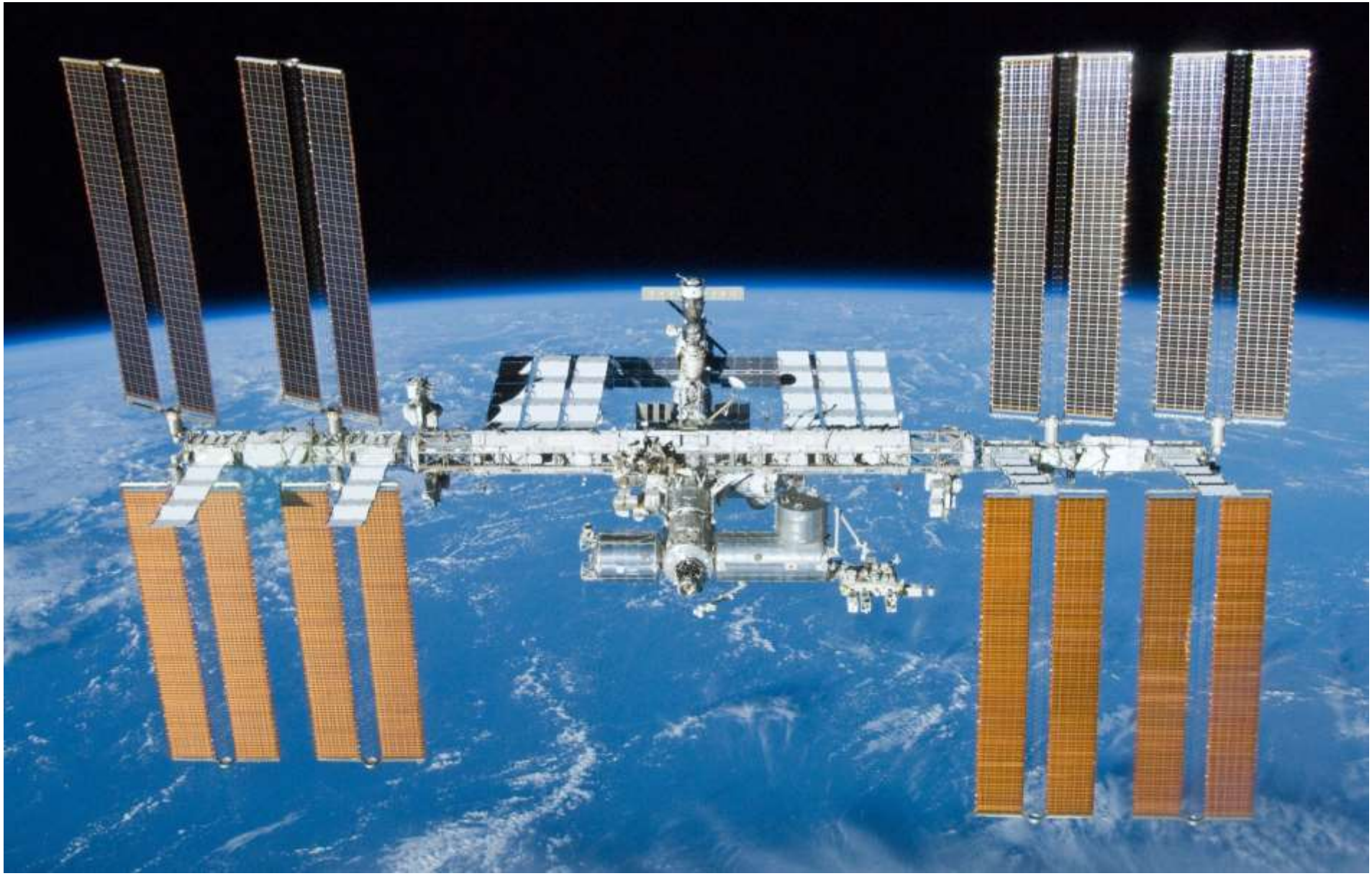

GARMIN
Pozíció
3
N 47°37.234'
E019°03.592'
Edge 605
lap
start/stop

Meteorology (1977-)

Columbia Space Shuttle (1981, 12th April)

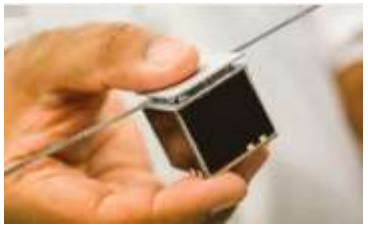
Mars Pathfinder (1996)

ISS (1998-)

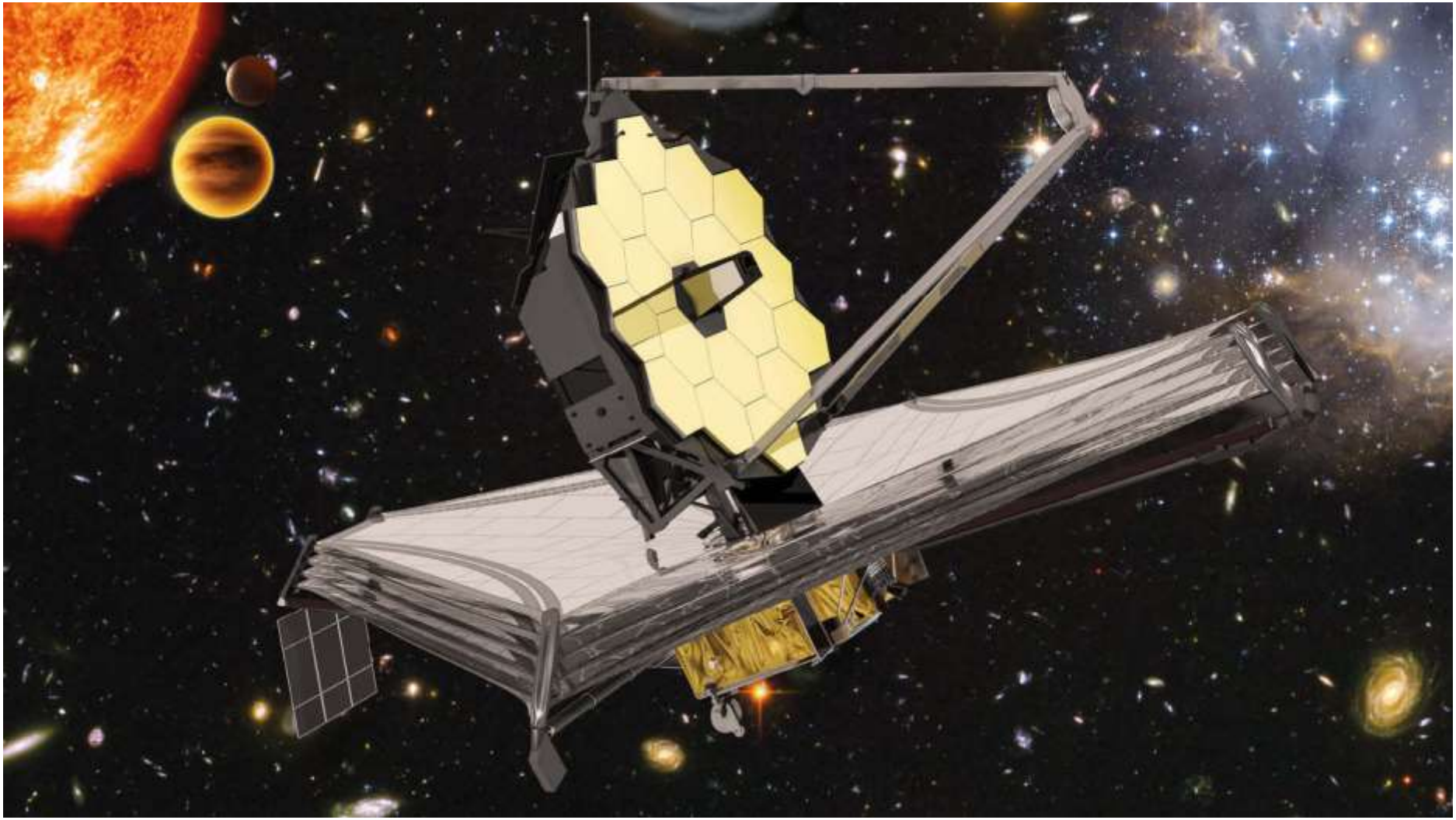


Space technology/research/industry/commerce …

- Science
  - Astronomy
  - Planetary missions
  - Material sciences
  - Medicine and biology
  - Physics, chemistry
  - Robotics
  - …
- Commercial applications
  - Earth observation
  - Communication, broadcasting
  - Navigation
  - …
- Technology transfer: space → Earth
- Military

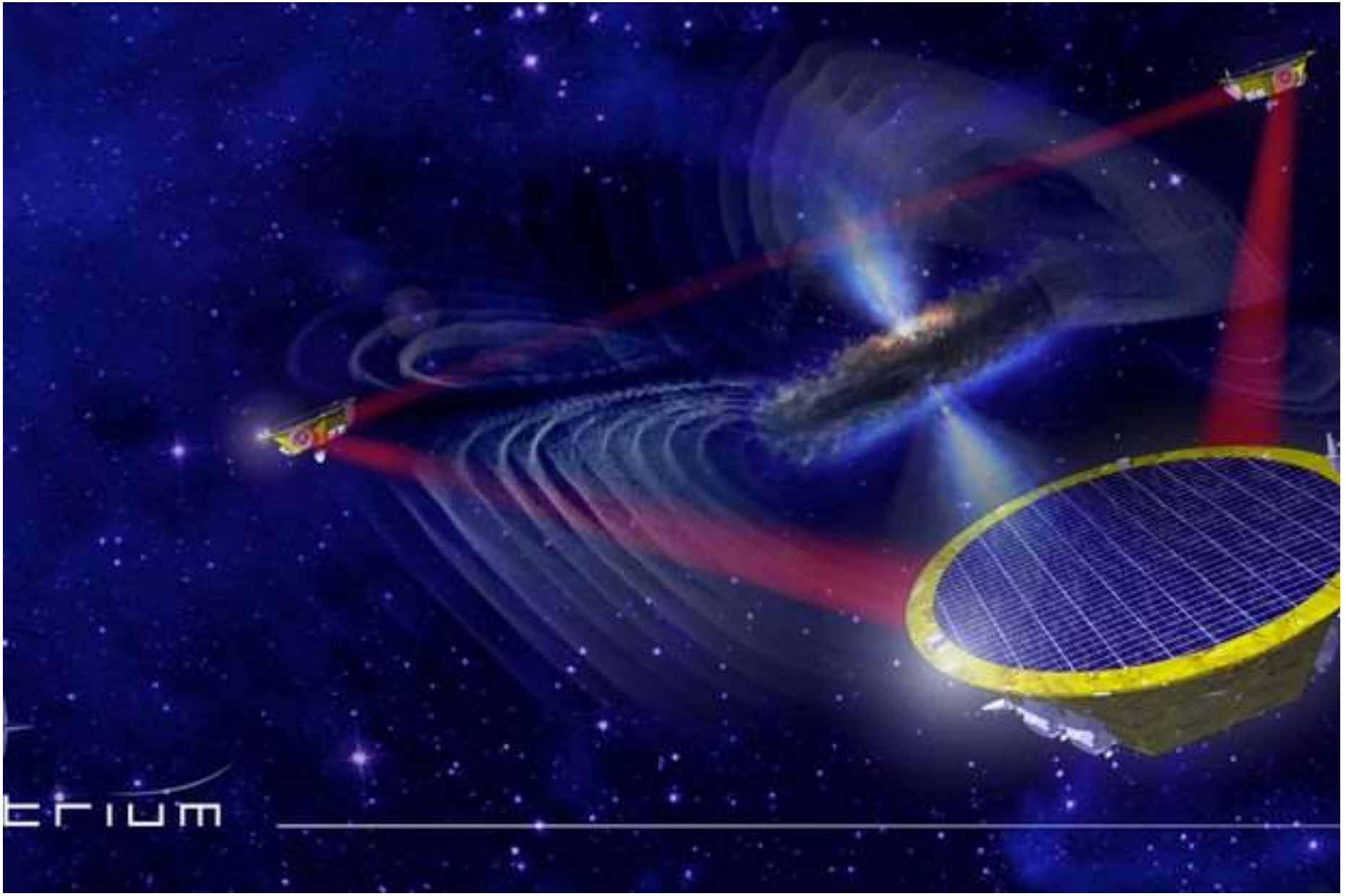


Future missions 1: ESA James Webb Telescope (JWST) 2021



Future missions 2: Human Mars mission (after 2030 ??)

Future missions 3: Laser Interferometer Space Antenna (LISA) 2034



About the subject

- Lecturer: Dr. László Csurgai-Horváth, associate professor
- How can you find me: building V1/room205, csurgai@hvt.bme.hu

- Weekly schedule: 2 lectures / 1 practice
- Requirements: midterm test on 11th week + written exam

- Website: http://eik.bme.hu/~csurgai/SpaceTechnology/index.htm

About the department

Budapesti Műszaki és Gazdaságtudományi Egyetem
Szélessávú Hírközlés és Villamosságtan Tanszék
MŰEGYETEM 1782

Department of Broadband Infocommunications and Electromagnetic Theory

www.hvt.bme.hu

- 20 successful launches since 1976
- INTERCOSMOS, ESA, NASA, AMSAT cooperation
  - Power systems
  - Radiocommunication
  - Onboard computer
  - Measurement data collection
- Rosetta (cometary research): 2004-2014
- BEXUS (biodosimetry): 2012
- MASAT-1 CubeSat: 2012-15
- REXUS (ionosphere research): 2013
- ESEO (plasma diagnostics): 2008-2018
- Alphasat (propagation and communication): 2014-
- SMOG picosatellite family: 2019-

About missions we participated so far

Kosmos-3M

Ariane-5

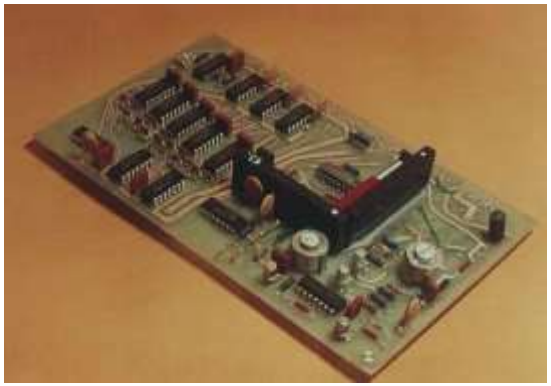
Mission	Launch/period	Equipment
INTERCOSMOS-15	1976. 06. 19.	Telemetry System, Power Subsystem (PSS), A/D Converter
INTERCOSMOS-17	1977. 09. 24.	Telemetry System, PSS
INTERCOSMOS-18	1978. 10. 24.	PSS
INTERCOSMOS-19	1979. 02. 27.	Onboard Data Collection System (ODCS) PSS
INTERCOSMOS-20	1979. 11. 01.	ODCS, PSS
Phase III / A	1980. 05. 23.	PSS
INTERCOSMOS-21	1981. 02. 04.	ODCS, PSS
Phase III / B AO-10	1983. 03. 02.	PSS
VEGA-1 & 2	1984. 12. 15.	ODCS, TV-PS, PLAZMAG-PS, TÜNDE-PS
Phase III / C AO-13	1988. 06. 15.	PSS
INTERCOSMOS-24 ACTIVE	1989. 09. 28.	ODCS, SAS Experiment, SAS–TX
INTERCOSMOS-25 APEX	1991. 12. 18.	ODCS
INTERBOL-1 TAIL	1995. 08. 02.	ODCS
MIR-PRIRODA	1996. 04. 23.	MOS-Obzor spectrometer PS
STS-91	1998. 06. 02.	Alpha Magnetic Spectrometer PS
Phase III / D “AO-40”	2000. 11. 16.	PSS, RF-MONITOR
ROSETTA	2004. 03.02. (2004-16)	Roland-PSS
MASAT-1	2012. 13.02. (2012-15)	RF/PSS/Ground station
“BioDos” Balloon exp.	2012. 25.09.	Experiment + Data collection system
“Daemon” Balloon exp.	2013. 10. 08.	Experiment + Data collection system
“Gekko” Rocket experiment	2013. 06. 06.	Experiment + Data collection system
Alphasat TDP5 experiment	2013. 07. 25. (2014-)	Beacon receiver
ESEO	2015, TBD	PDU, LMP experiment
Alphasat COMEX	2013. 07. 25. (2015-)	Q-band DVB-S2 satellite receiver
Esa technology transfer	2016-17	5G propagation tester
SMOG-1/SMOG-P/ATL	2019-	RF spectrum monitoring

Intercosmos
AMSAT
NASA
ESA
HSO

The history 1: BME

- 1959-1969: short wave radio station, meteorological rocket development, satellite receiver station
- 1967: Hungary joined to Interkosmos (a Soviet space program)
- 1970: establishment of the Space Research Group

BE7 for IK19/20

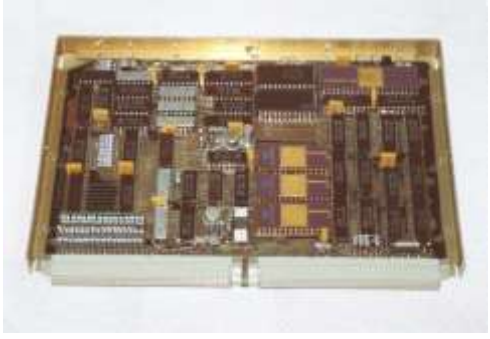


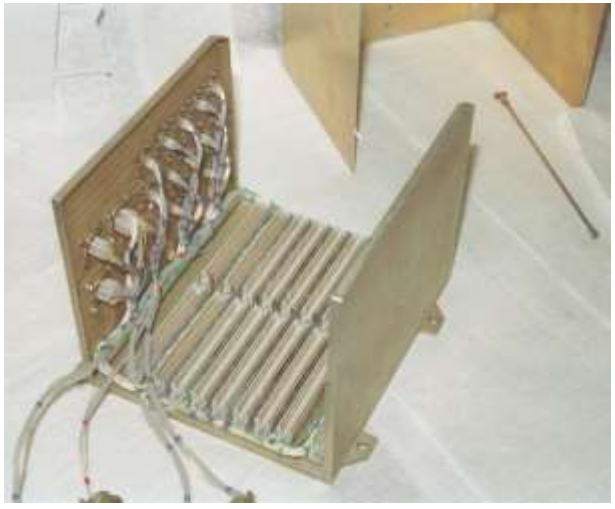
A/D for IK15, 1976

The history 2: electronics

- The 60th:
  - Vacuum tubes
  - Discrete components
  - no PCBs
- The 70th:
  - Silicon semiconductors
  - TTL digital circuits
  - 2-sided PCBs
- The 80th:
  - MSI/LSI integrated circuits
  - Microprocessors (NSC-800)
  - CMOS technology

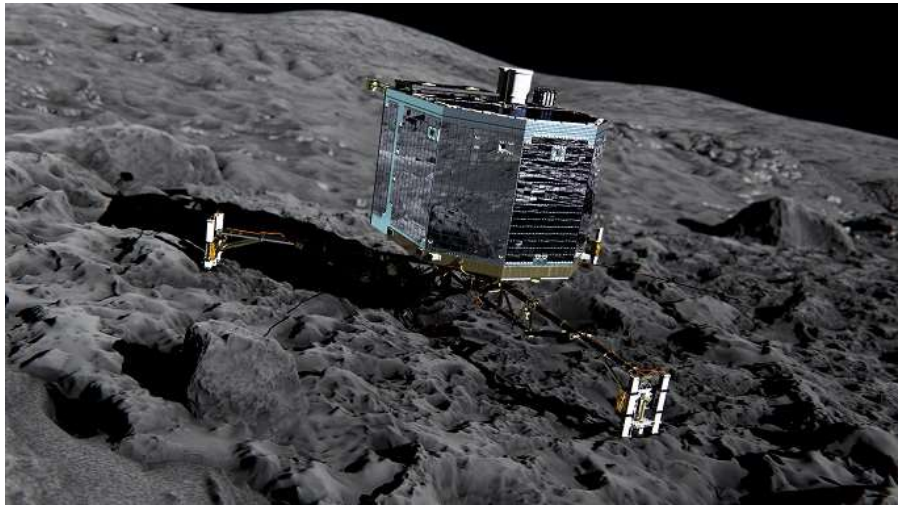
ODCS – Onboard Data Collection System

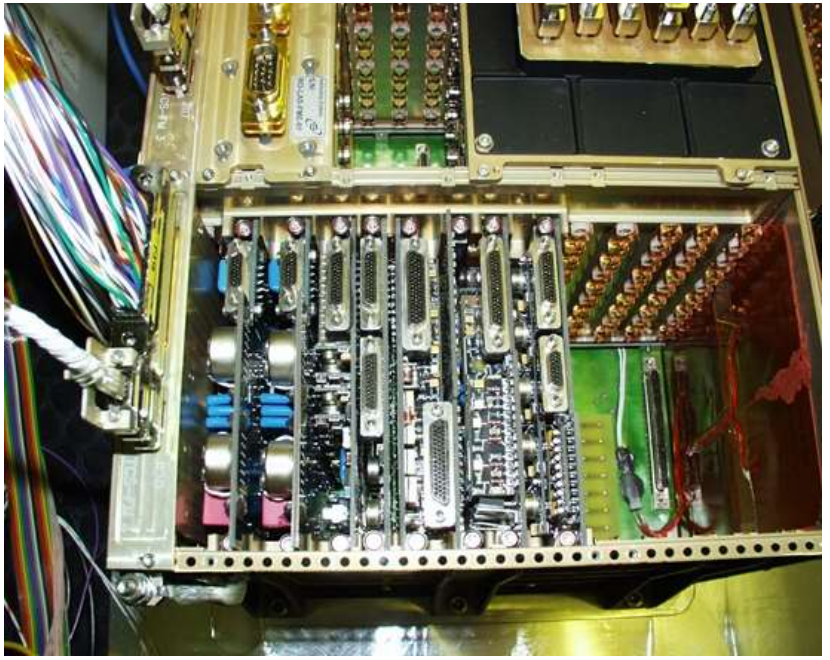




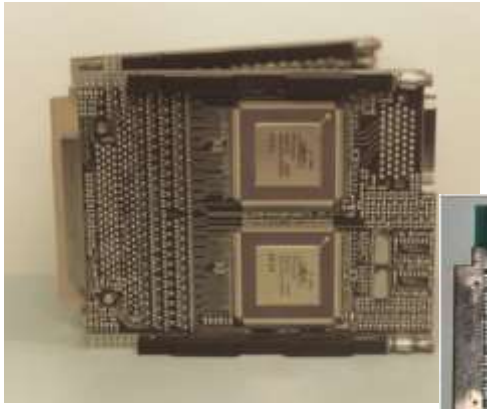
Cosmodrome Plesetsk

The history 3: one of ESA's cornerstone missions





- Rosetta Lander project (1996-2015)
  - The Lander's Power Subsystem
  - 10 boards
    - power control
    - power management
    - wakeup
    - battery/solar power management
    - A/D, housekeeping data



- HC technology, FPGA, radhard components

The history 4: the ESA story

- 1998: Hungary joined to ESA PRODEX (PROgramme de Développement d'EXpériences scientifiques) programme
- 2003: Hungary joined to ESA PECS (Plan for European Cooperating States)
- 2015: Hungary became full ESA member

Today

- Power distribution system development for ESA ESEO satellite
  - European Student Earth Orbiter,
  a micro-satellite to Low Earth Orbit (2008-18)

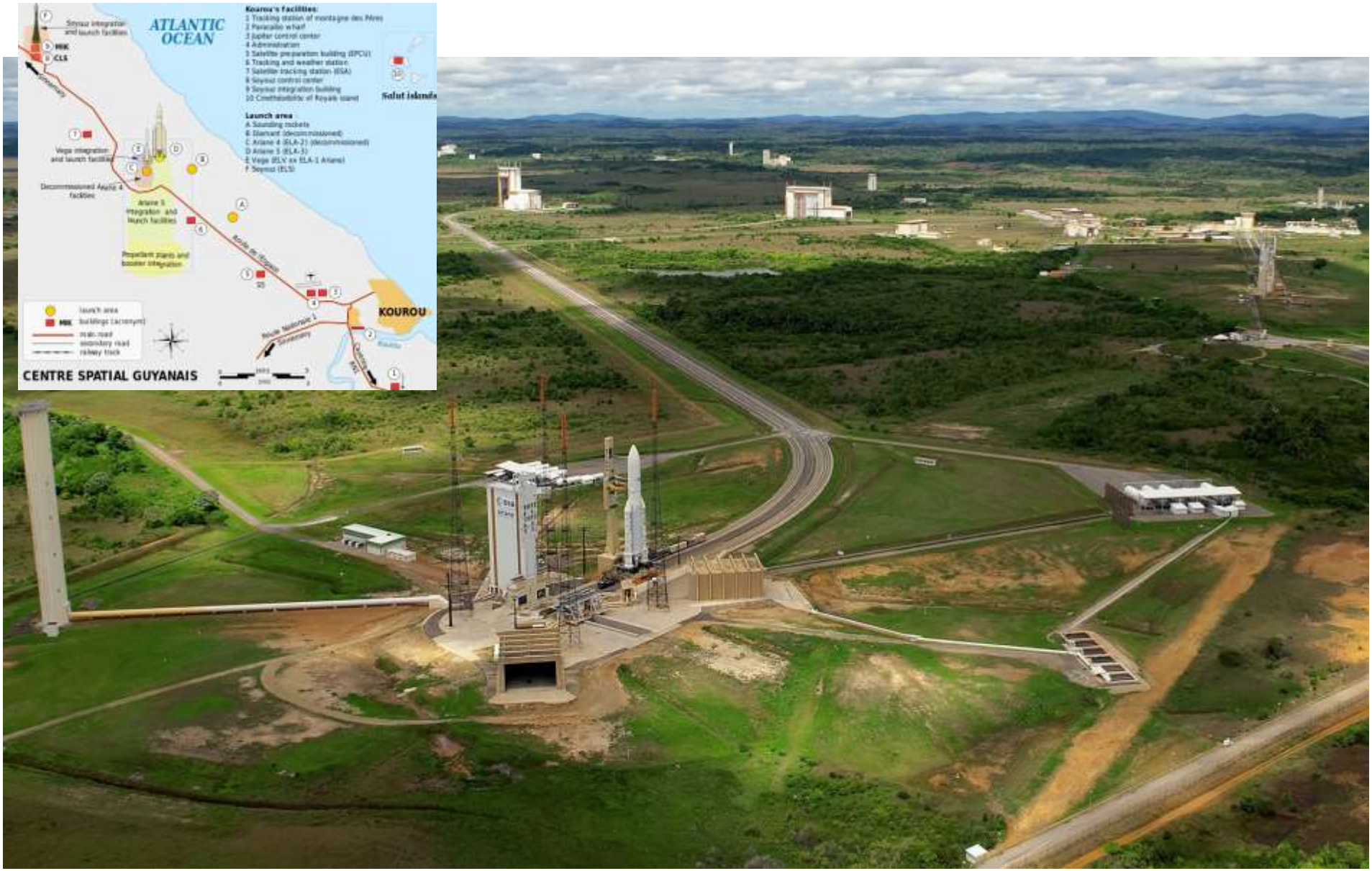
- Participation in ESA student programmes
  - REXUS Rocket Experiments for University Students
  - BEXUS Balloon Experiments for University Students
    - bio-dosimetry, ionosphere-monitoring
  - The Bremen drop tower: Drop your thesis!

- The ESA Alphasat propagation and communication experiment (2014-)

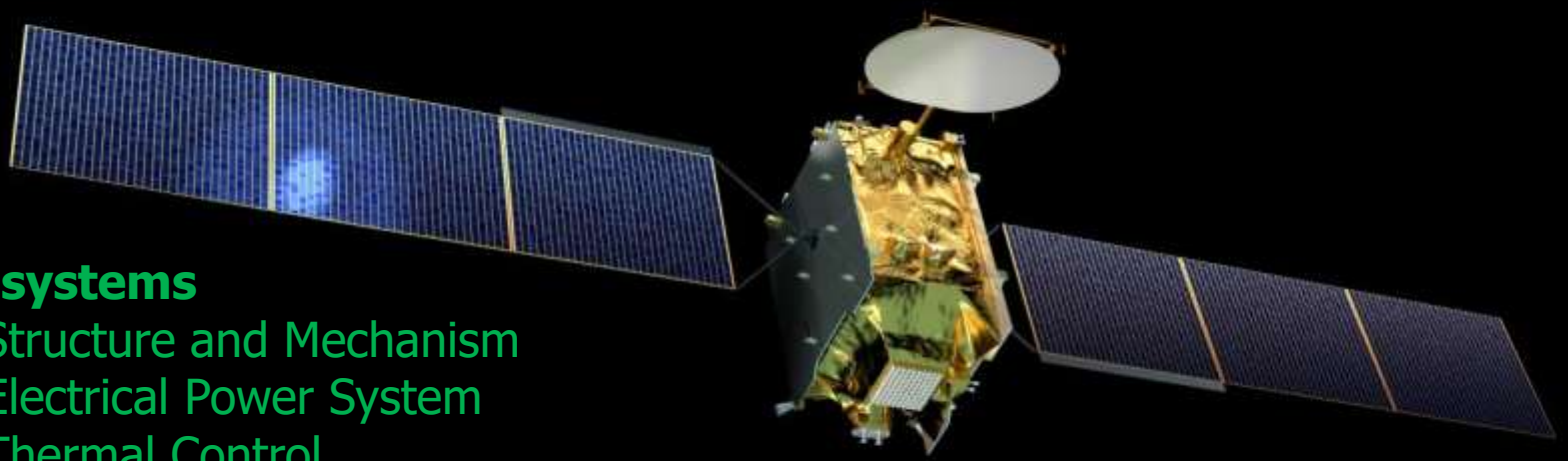
- MASAT-1 : The first Hungarian cubesat (2012-15)

- SMOG family : PocketQube Class Satellite (2019-)

Guiana Space Centre



Spacecraft subsystems and payloads



Payloads

- Technology demonstrations
- Scientific experiments
- Commercial devices

Subsystems

- Structure and Mechanism
- Electrical Power System
- Thermal Control
- Propulsion
- Attitude Control
- Data Management (onboard computer)
- Communication
- (Software)

The curriculum of subject Space Technology

Weekly 2 lectures / 1 practice

Introduction
The space environment
Orbits
Propulsion
Structure and mechanisms
Power
Thermal control
Attitude control
Communication 1.
Communication 2.
Digital systems 1.
Digital systems 2.
FPGA
Rosetta
GPS
Reliability

Orbits
Antenna and link budget calculations
Propagation statistics and modelling
Digital design
FPGA design example
Onboard communication
PC104/demo
Cubesat/Microsat design
Alphasat propagation/communication experiment

Midterm test
Visiting the Alphasat receiver stations

Sources:

- Gary D. Gordon, Walter L. Morgan:
  Principles of Communications Satellites
  Wiley, ISBN: 978-0-471-55796-8
- Wilfried Ley, Klaus Wittmann and Willi Hallmann (ed):
  Handbook of Space Technology
  Wiley, ISBN: 978-0-470-69739-9