

# The achievements of AKUP and the capabilities of TÜBİTAK UZAY

TÜBİTAK UZAY

Space Technologies Research  
Institute

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14 December 2023



COMMERCIAL IN CONFIDENCE

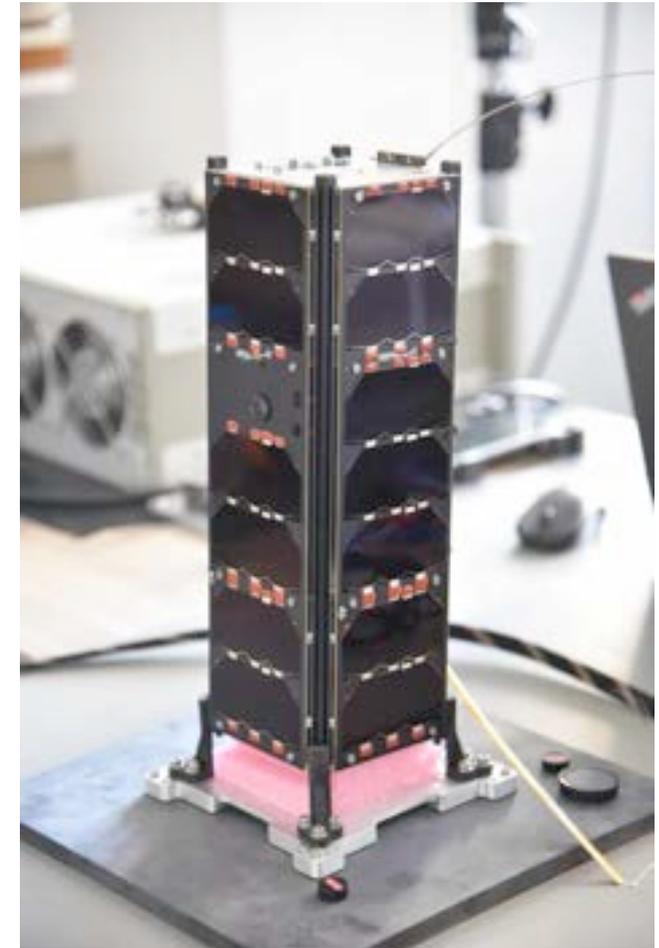
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## ➤ OBJECTIVES

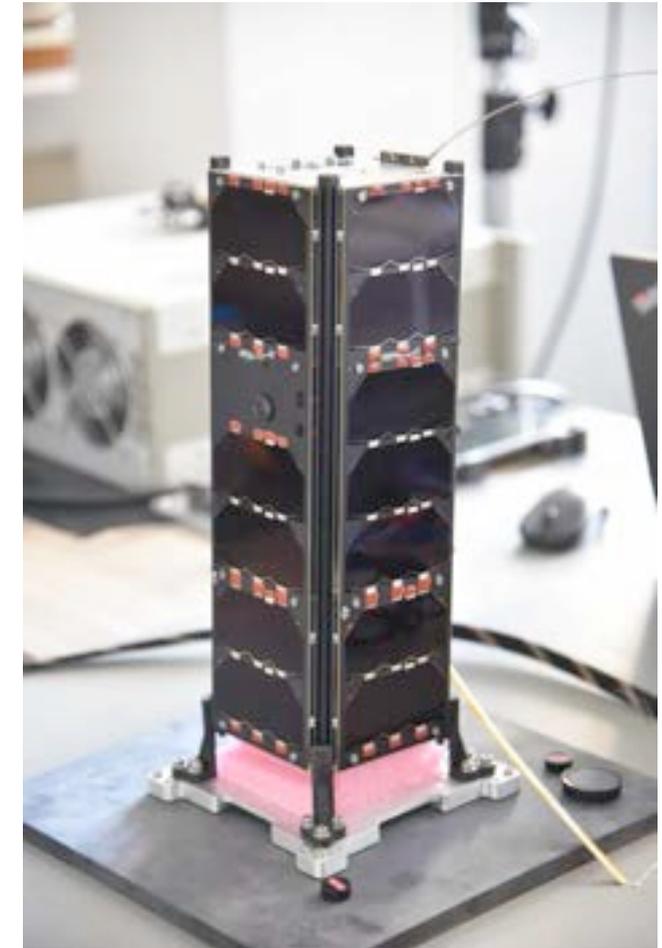
❖ Building capability to develop (Cube) satellites

- ✓ TÜBİTAK Uzay's first CubeSat is an APSCO Project
- ✓ Now, TÜBİTAK Uzay has experience and heritage in the CubeSat area



## ❖ Building payload / subsystem integrated on the satellite(s)

Equipment/Capability	Related Turkish Organization
CubeSat S-band Patch Antenna	TÜBİTAK UZAY
CubeSat Dosimeter Payload	TÜBİTAK UZAY
CubeSat Software Development	TÜBİTAK UZAY
CubeSat Solar Panels	TÜBİTAK MAM
CubeSat OBC	Gümüş Havacılık ve Uzay
CubeSat EPS Board	Gümüş Havacılık ve Uzay
CubeSat Battery Board	Gümüş Havacılık ve Uzay
CubeSat Sensor and Mechanical Control Interface Board	Gümüş Havacılık ve Uzay
3U CubeSat Structure	Gümüş Havacılık ve Uzay



## ➤ OBJECTIVES

❖ Build their own capability to operate satellites and/or process image/data

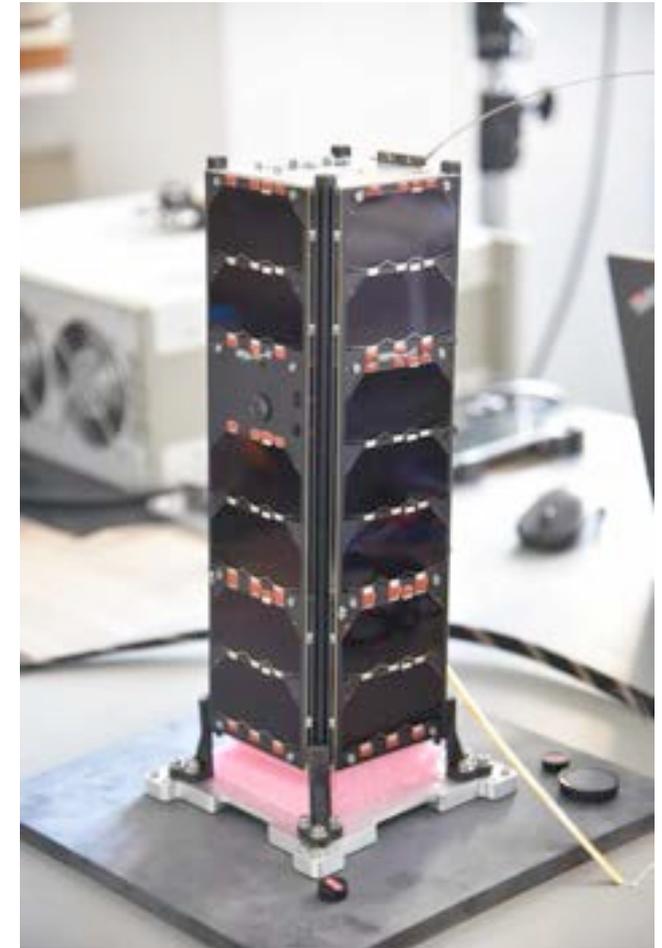
- ✓ TÜBİTAK Uzay re-built a VHF/UHF ground station
- ✓ TÜBİTAK Uzay operates CubeSat from its ground stations
- ✓ TÜBİTAK Uzay downloads data from the CubeSat



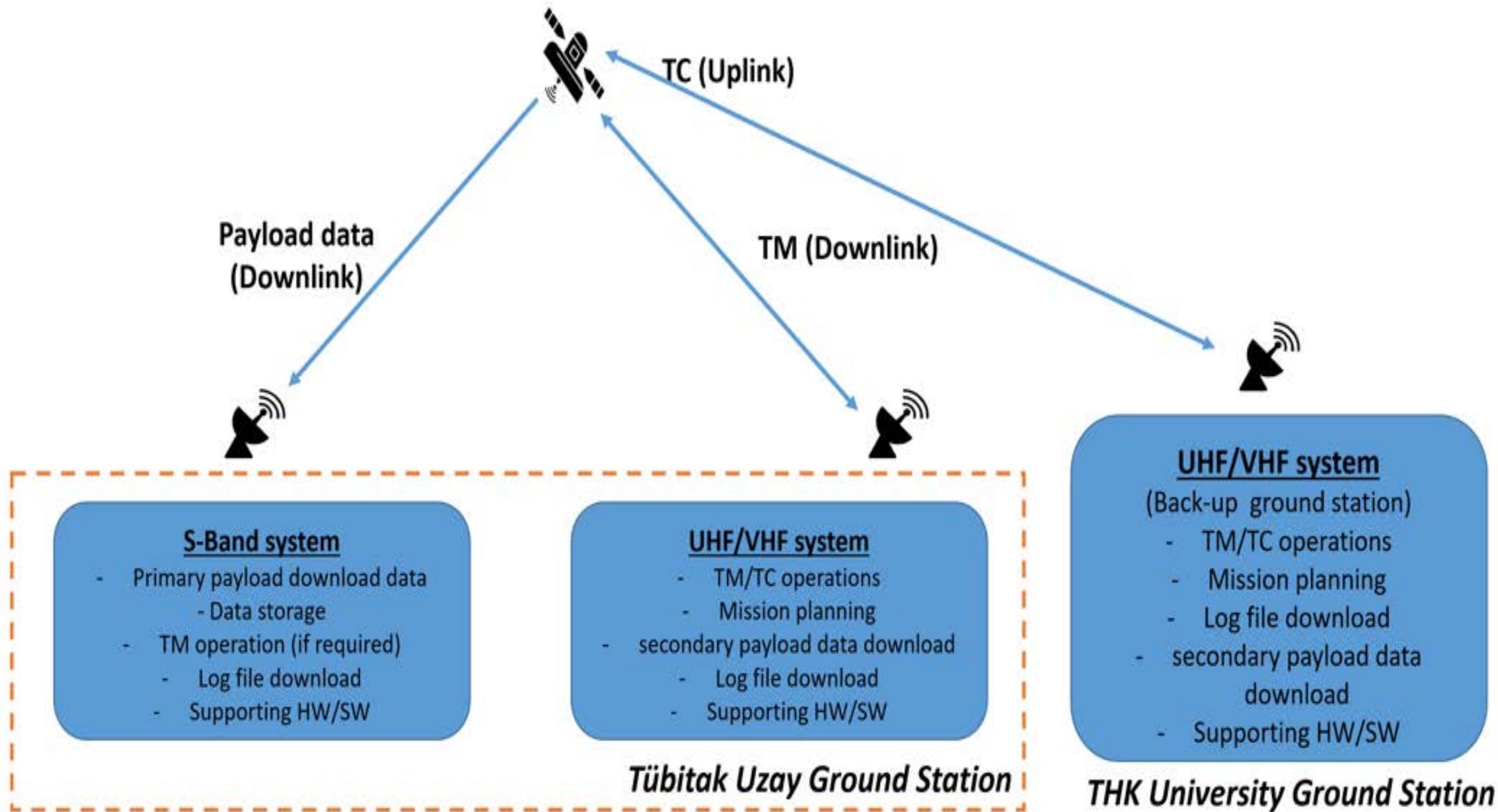
## ➤ OBJECTIVES

❖ Shall involve universities, institutes, and companies from multiple countries to accomplish the cooperation and engineering training, and to enable participant parties to gain hands-on practice in:

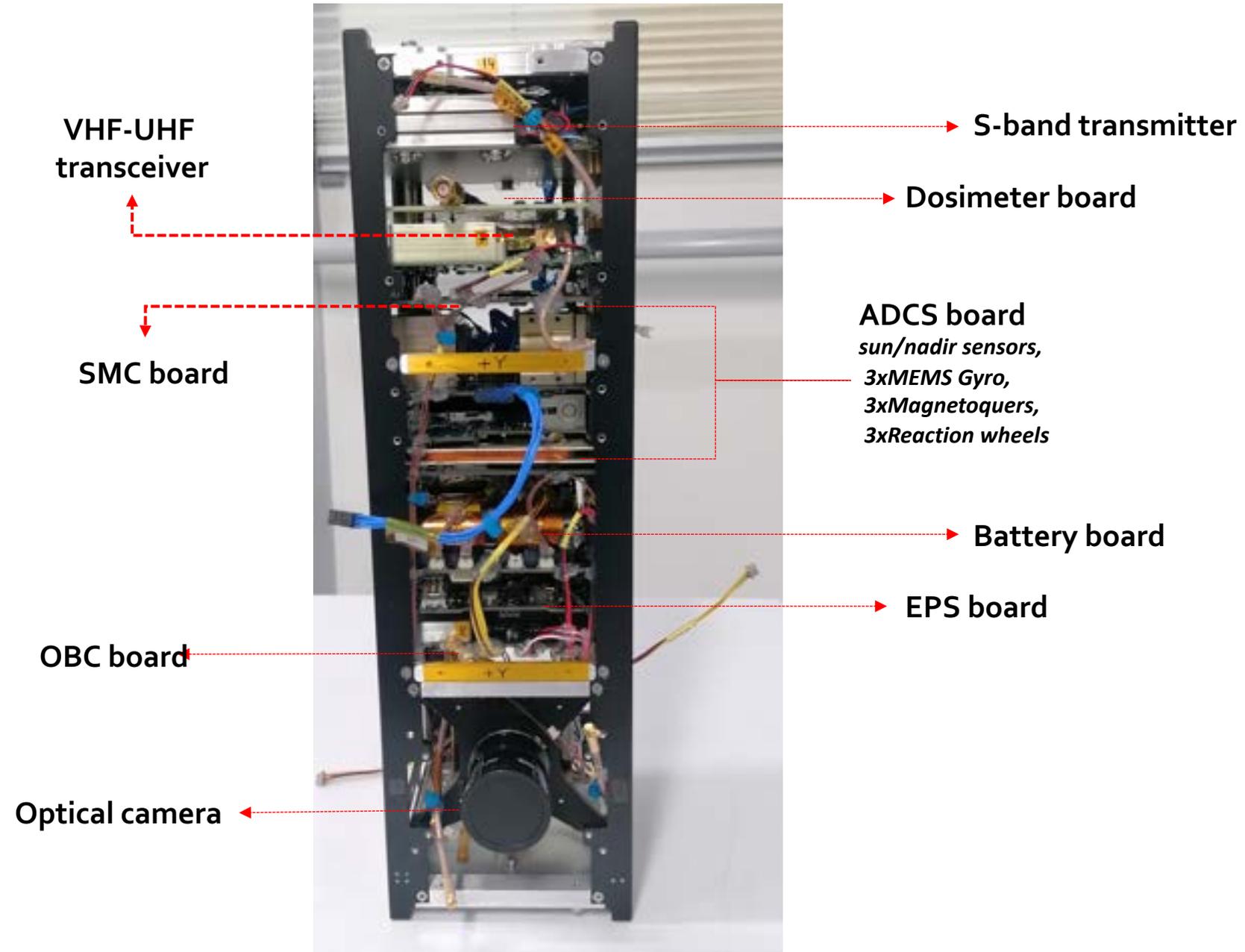
- ✓ Satellite system design and system engineering
- ✓ Satellite payload and sub-system design and development
- ✓ Satellite assembly, integration, and testing (AIT)
- ✓ Satellite launch and operation
- ✓ Satellite payload data processing and application



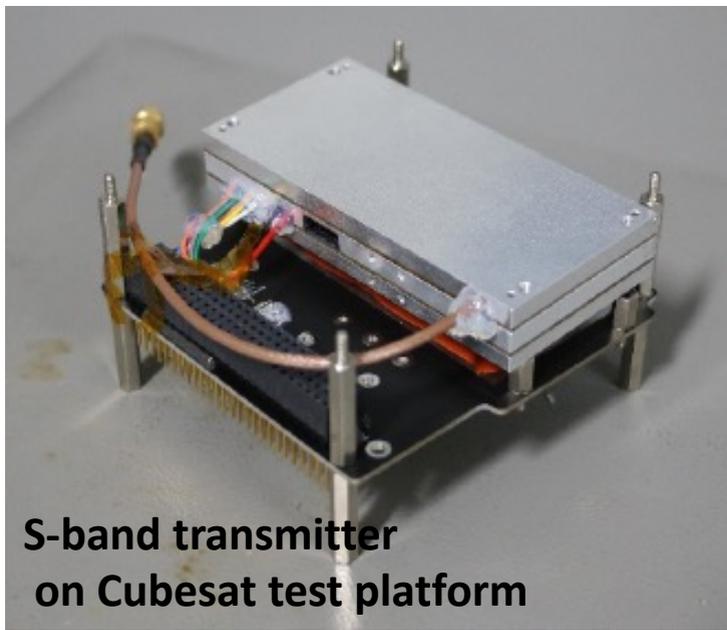
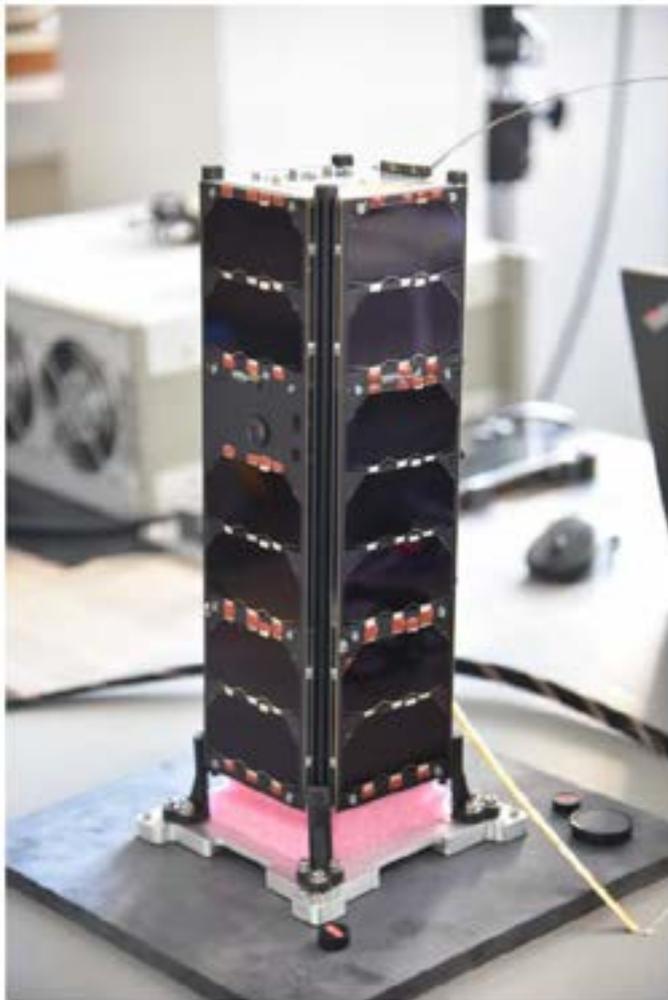
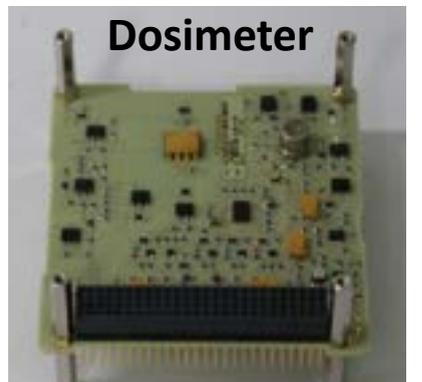
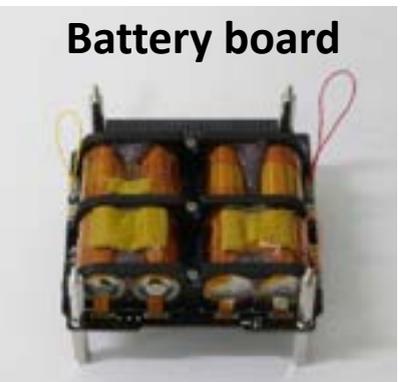
# ➤ OPERATIONAL CONCEPT



# ➤ AKUP Cubesat – The inside View



# ➤ Board design to integration



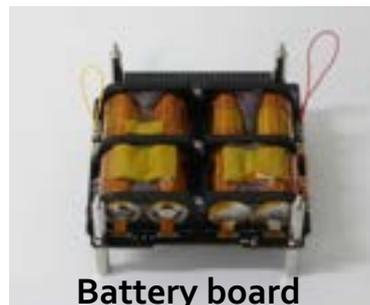
# ➤ Board design to integration

## Electrical and functional tests of all equipment and subsystems

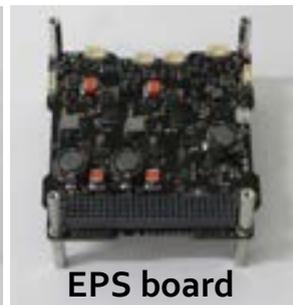
- A PC104 compatible test platform used for stand alone
- Power check
- Communication
- Physical check
- RF check
- Operational modes



OBC board



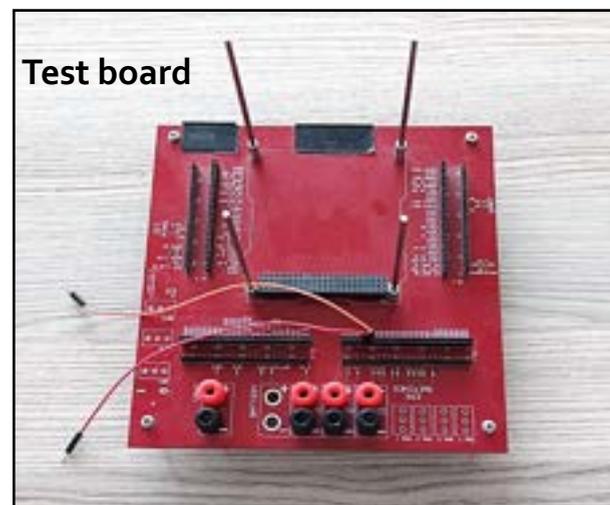
Battery board



EPS board



Dosimeter



Test board



ADCS equipment



S-band Transmitter



VHF/UHF Transceiver



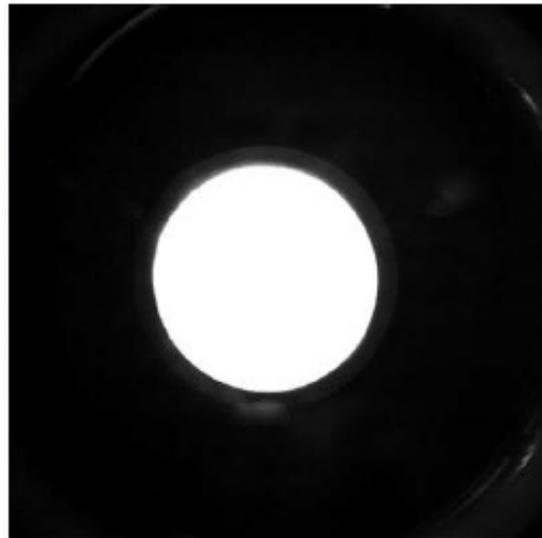
SMC Board



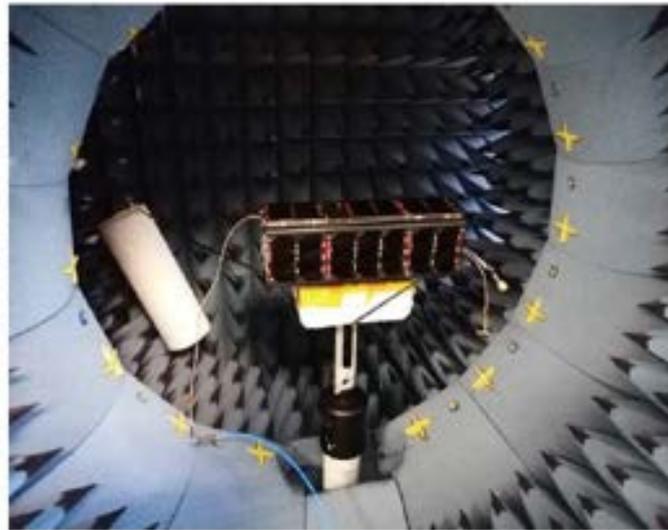
Camera

# ➤ SOME OF THE PERFORMANCE TESTS IN FLIGHT CONFIGURATION

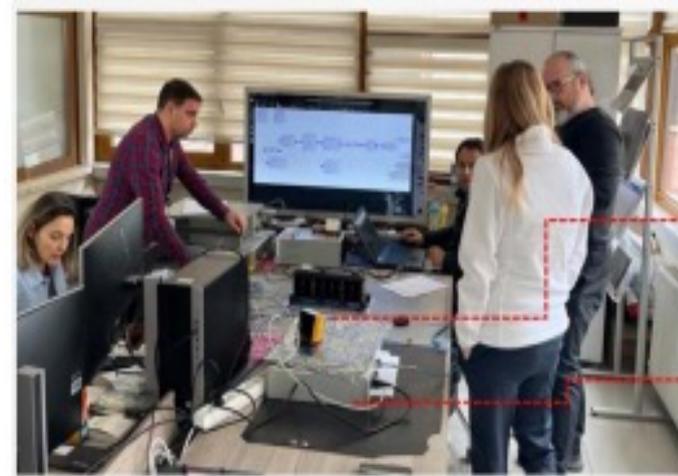
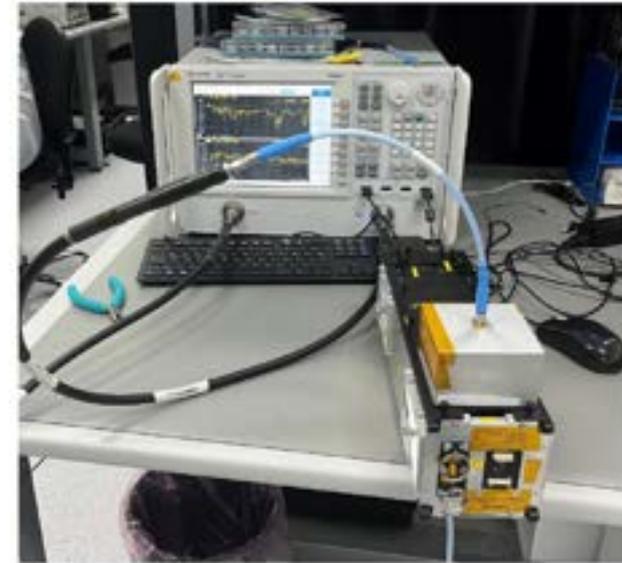
Nadir / Sun sensor calibration



Antenna tests

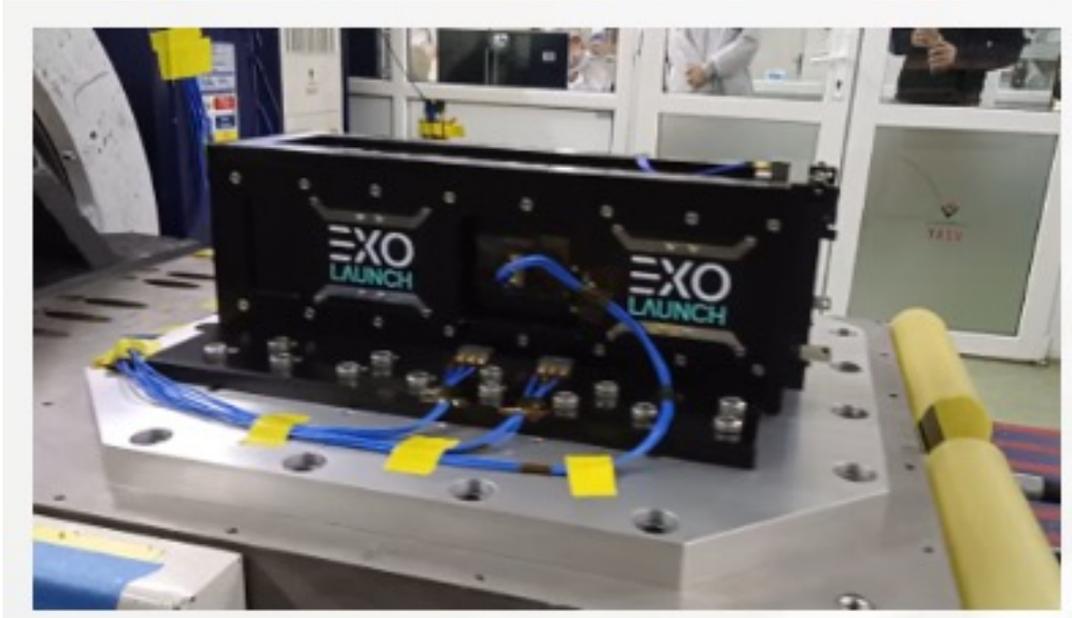


Communication tests



# ➤ QUALIFICATION TESTS

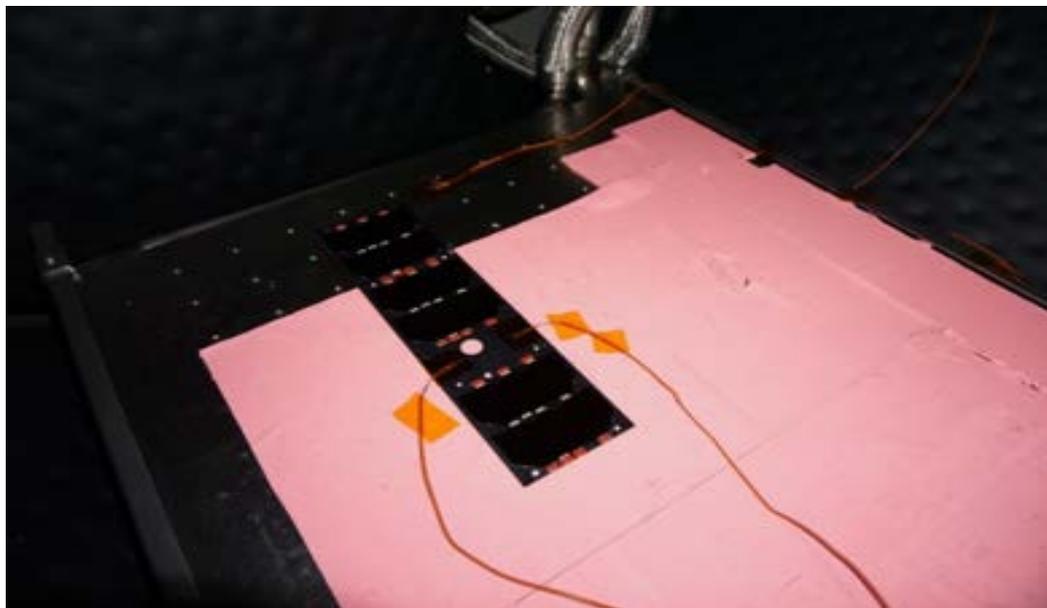
**AKUP in vibration tests**



**AKUP in Thermal oven**



**Solar panel in TVAC**



**Solar panel tests**



## ➤ OPERATIONAL PHASE GOALS

- First contact
- Maintaining stable communication
- Attitude determination and control
- Subsystem Validations
- Payload tests
- At least 3 months of operation



# ➤ FIRST SIGNAL

After getting the first signal we had received information from

- OBC,
- EPS,
- SMC,
- Battery,
- VHF/UHF transceiver,
- ADCS
- Solar panels.

They were all evaluated as healthy in the first glance.

The remaining equipments; camera, dosimeter and S-band transmitter validated after maintaining stable communication between primary ground station (TÜBİTAK UZAY) and the CubeSat.

UHF/VHF spectrum

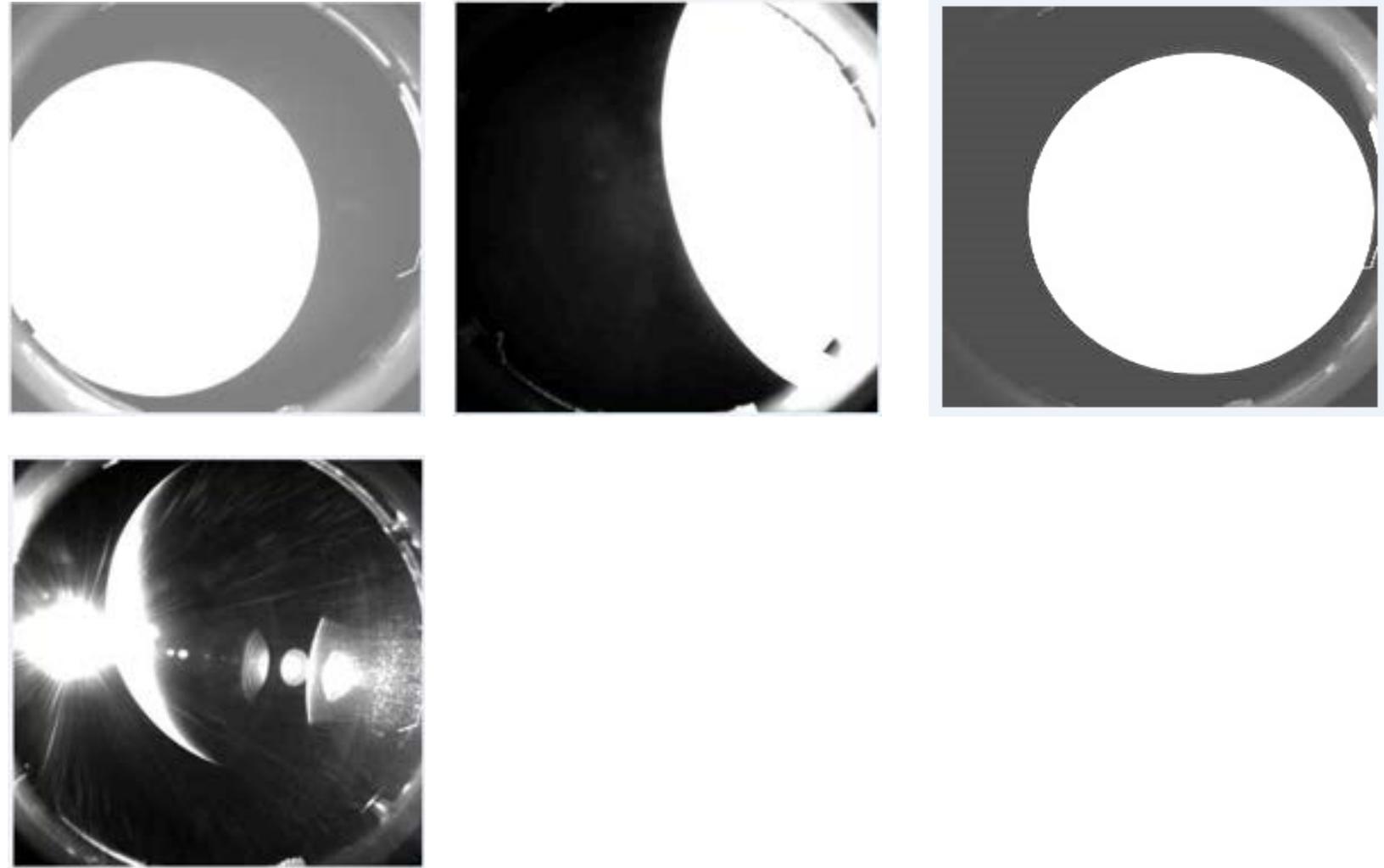


S-band spectrum



# ➤ ADCS COMISSIONING

There is an optical nadir sensor in the nadir panel of the SSS-2B. The logs of the lens measurements were downloaded and analysed.



## ➤ Post-operation assessments

Step	Status	Feedback
First Contact	Completed	Ground station improvements
Communication	Completed	UHF communication drawbacks
Attitude Control	Completed	Gyro power cut
Subsystem Validations	Completed	Monitoring circuits failure
Payload Tests	Completed	Camera settings failed
3 Months of Operation	Completed	Lessons Learnt

### Lessons

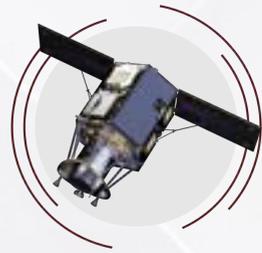
- VHF/UHF range and monopole antenna use
- Better understanding of communication coverage and awareness of obstacles
- Spare equipment
- Software update in orbit
- meticulous planning
- rigorous testing
- the significance of teamwork
- Interdisciplinary collaboration

### Gains

- Accessibility to sources
- Indigenous gains
- Technology demonstration
- Equipment qualification
- Understanding radiation environment
- Knowing the RF environment thanks to operational use of the satellite
- First nano-satellite of Tübitak UZAY

# WHO ARE WE? WHAT WE DO?

**TUBITAK UZAY:** The leading research Institute of Türkiye in space technologies.



**SATELLITE  
TECHNOLOGIES**



**OPTICAL  
SYSTEMS**



**HUMAN  
SPACEFLIGHT**



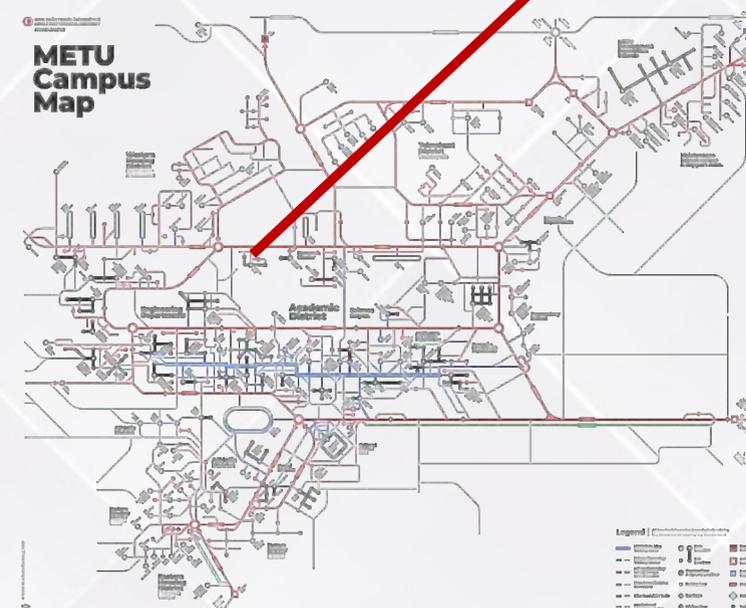
**IMAGE  
PROCESSING &  
REMOTE  
SENSING**



**GROUND  
STATIONS**

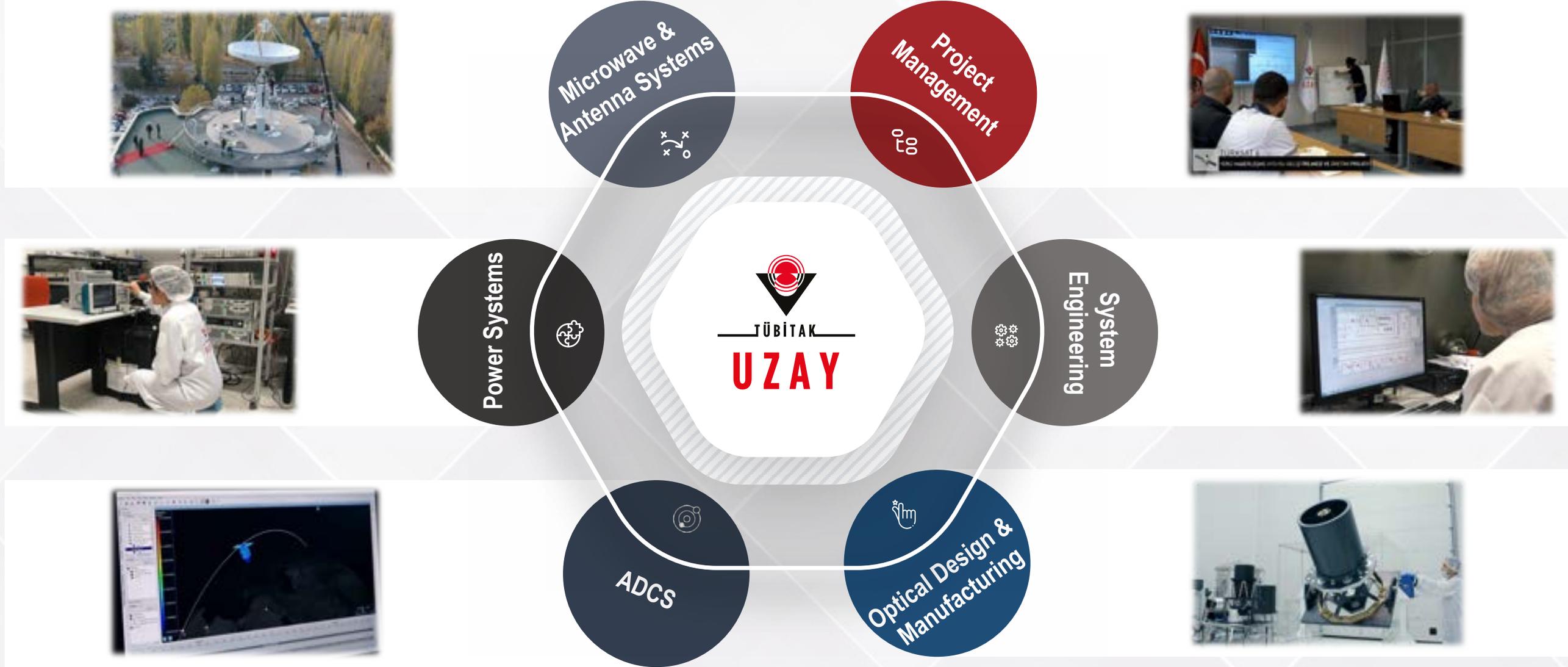


**DEEP SPACE  
TECHNOLOGIES**

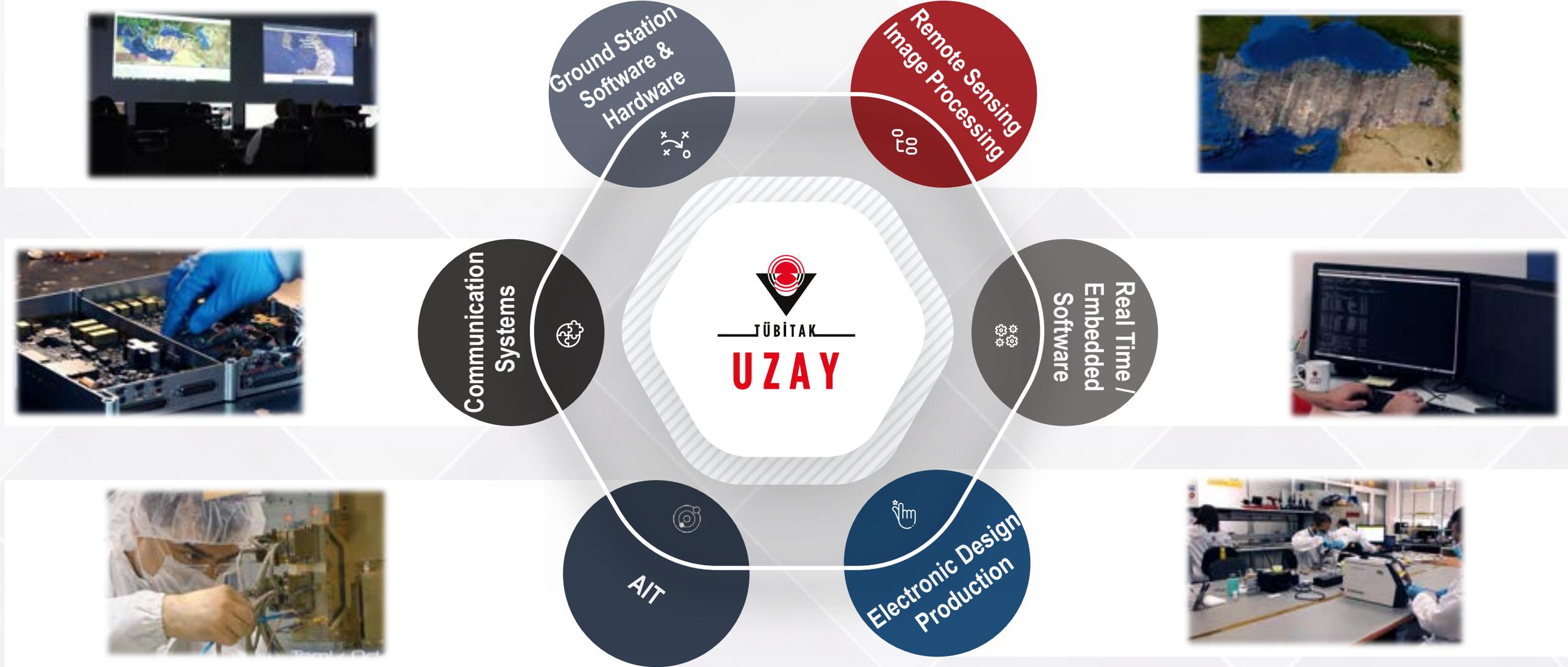


**MIDDLE EAST TECHNICAL  
UNIVERSITY  
ANKARA CAMPUS**

# ➤ CAPABILITIES

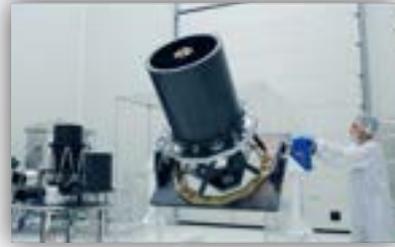


# ➤ CAPABILITIES





**PRODUCTION**



**Camera**



**Electronics**

**ASSEMBLY & INTEGRATION**



**Clean Room**



**Electric Propulsion**

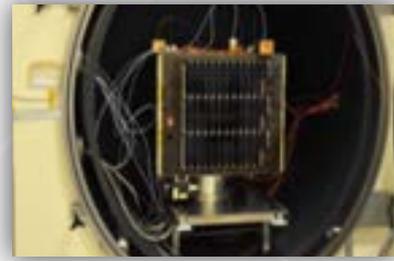


**Ground Support Equipment**

**TEST**



**Vibration Test**



**Thermal Vacuum Test**



**Propulsion Test**

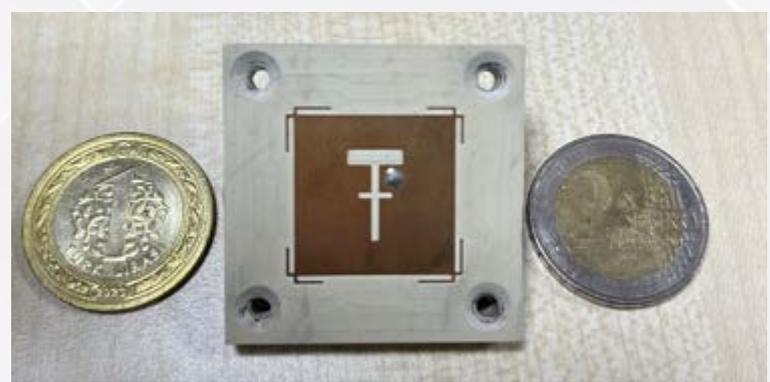
**OPERATION**



**Ground Station**

# HERITAGED ANTENNAS

Helix Antennas	Patch antennas	Horn antennas	X-dipol antennas	GPS/GNSS Antennas	Redundancy rings/power divider/combiners	LNA board
RASAT, GK2, İMECE	RASAT, GK2, İMECE , AKUP	İMECE	İMECE	İMECE	İMECE	İMECE
Iso-flux pattern, S-band, 6-7 dBi, CP	Iso-flux pattern, S-band, 6-7 dBi, CP	Directive pattern, X-band, 18 dBi, CP, 2-axes mechanism	Iso-flux pattern, X-band, 6-7 dBi, CP	GPS/GNSS band, 7-8 dBi, CP	½, 1/4, 2/4 dividers,	GPS band, 18.5 dB gain, NF 1.7 dB



**Akup S-band Antenna**

## ➤ ON-GOING MAJOR PROJECTS



### TABM - Turkish Astronaut & Science Mission

Türkiye's First Human Space Flight Mission to:

- Conduct microgravity research in
  - Material Sciences
  - Physical Sciences
  - Life Sciences
- Perform education and outreach objectives



### AYAP-1 – Lunar Research Project

- Demonstrate operational capability around the Moon
- First contact with Moon's surface
- Deep space heritage for indigenous space systems
- Raising awareness in space science and technologies

THANK YOU

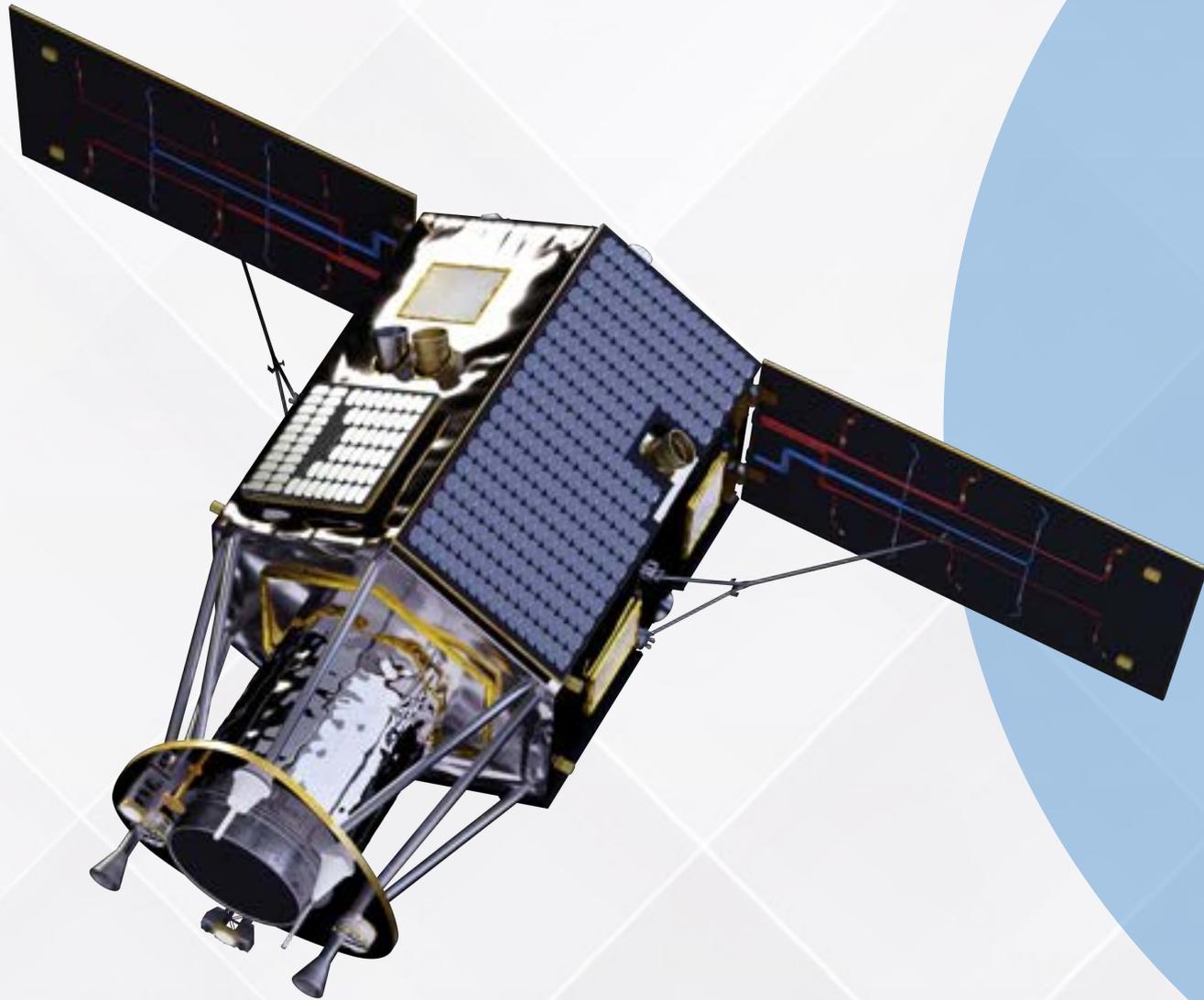


TÜBİTAK

UZAY

[uzay.tubitak.gov.tr](http://uzay.tubitak.gov.tr)

Extra slides

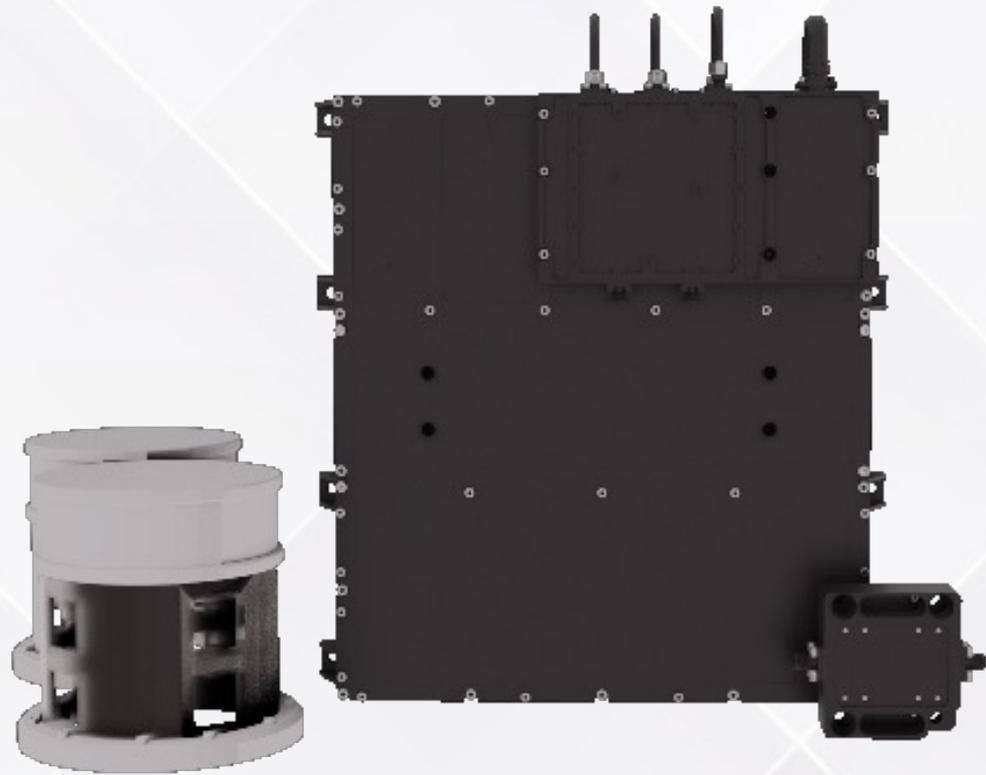


- Space Segment
  - System level design, integration & test
  - Equipment level design, manufacturing & test
  - Embedded Software
- Ground Segment
  - Hardware (Antenna, Modem, RF components, etc.)
  - Mission Planning & Control Software
  - Image Processing Software

## ► İMECE EO PAYLOAD



- GSD: Pan < 1 m, MS < 4 m
- MTF > %14
- SNR > 85
- Swath Width = 13.76 km
- Mass < 80 kg



- Positioning Accuracy  $< 10$  m
- Velocity Accuracy  $< 0.15$  m/s
- Signals Received:
  - GPS L1, L2, L5
  - Galileo E1, E5a
- Data Interface -> MIL-STD-1553

## ➤ İMECE REACTION WHEEL

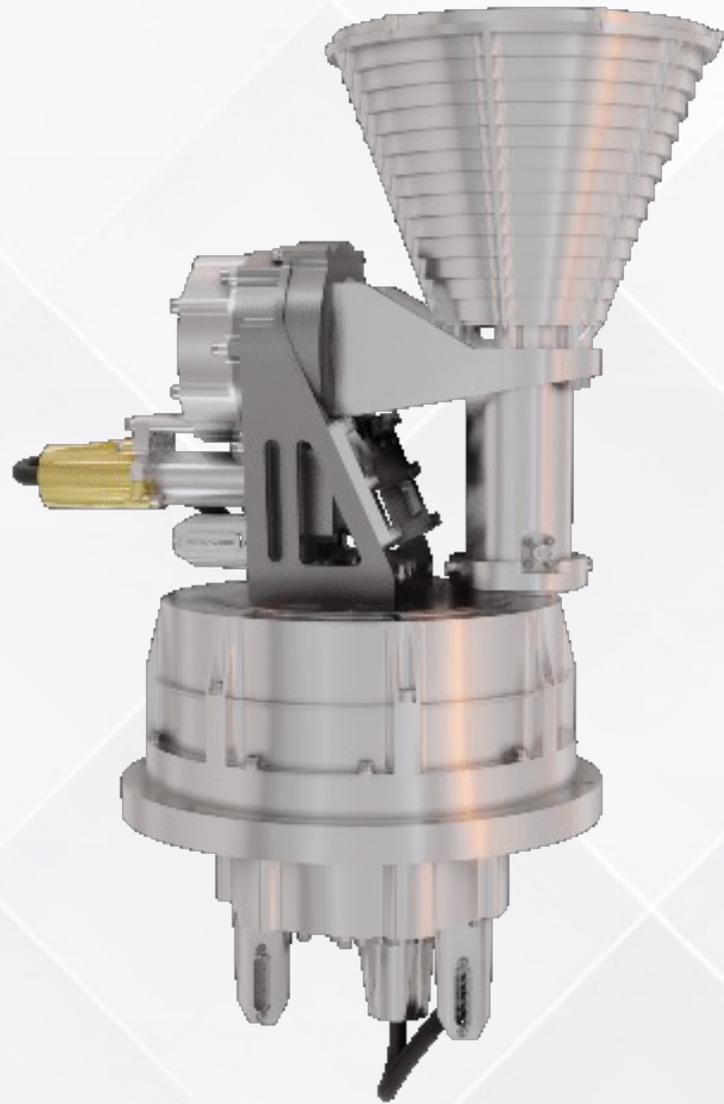


- Maximum Torque  $> 250$  mNm
- Momentum Capacity  $> 15$  Nms
- Data Interface -> CAN-SU
- Torque capability in both directions



- 3 optical heads configuration
- Data Interface: CAN-SU
- Data Update Rate  $< 10$  Hz
- Attitude Data Accuracy  $< 100$  arcsec

## ➤ İMECE X BAND ANTENNA



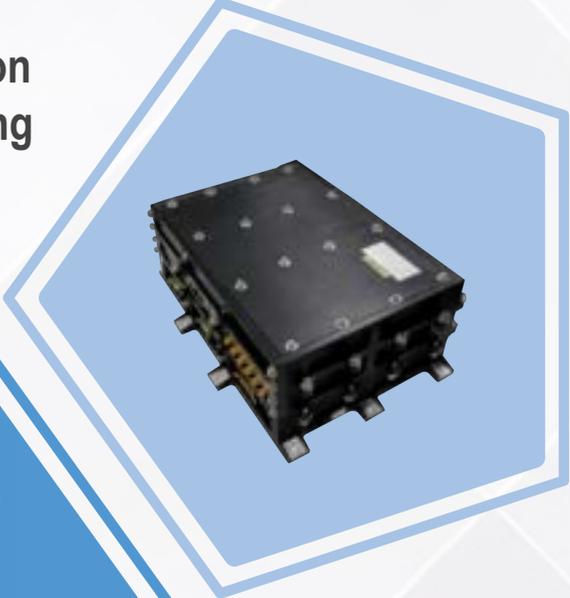
- Angle of Rotation at Elevation:  $\pm 70$  deg
- Angle of Rotation at Azimuth:  $\pm 270$  deg
- Dual Channel
- Data Rate = 320 Mbps



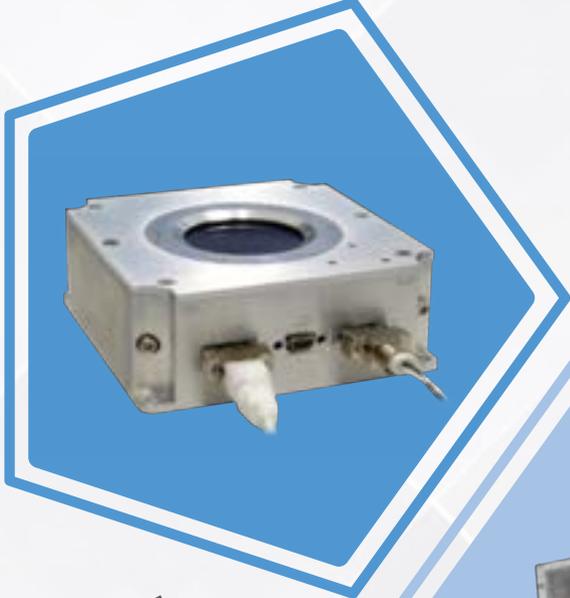
- Power Control & Distribution
- Most Power Point Tracking Algorithm
- Configurable Design
- Voltage = 28 V
- Hot Redundancy

# IMECE IN-HOUSE DEVELOPED EQUIPMENT

Data Compression  
Record Formatting  
Equipment



Sun  
Sensor



S Band  
Receiver-  
Transmitter



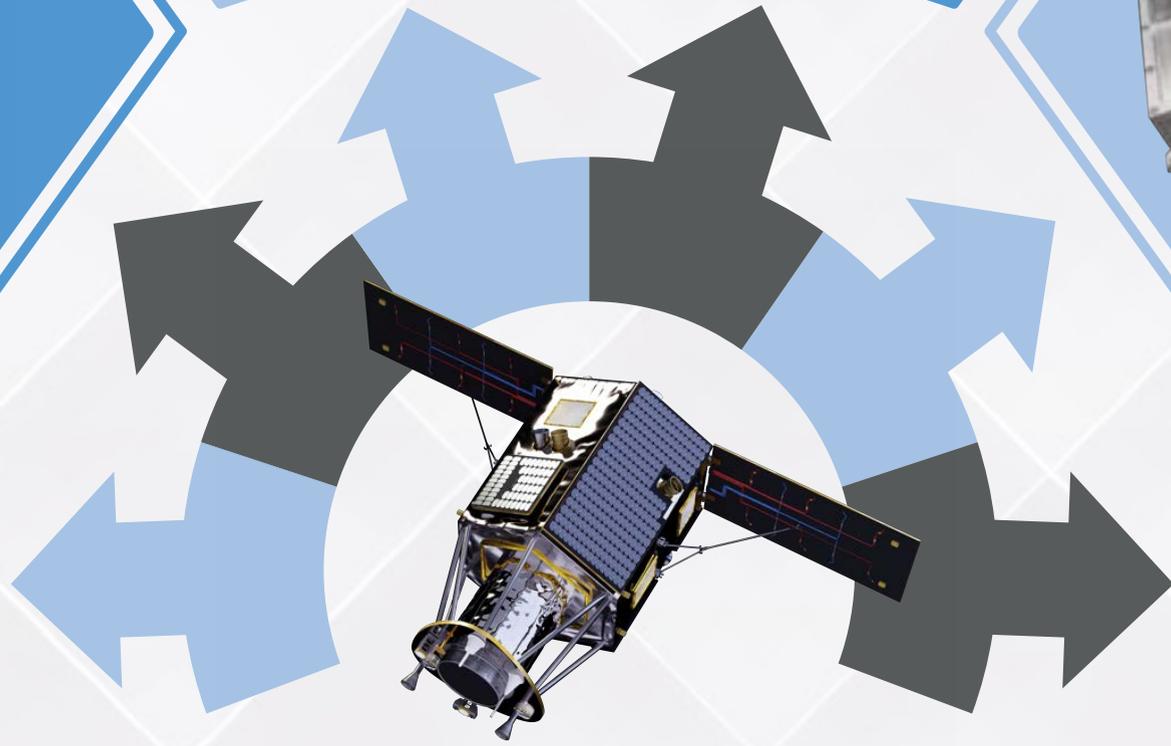
Electric  
Propulsion  
Subsystem



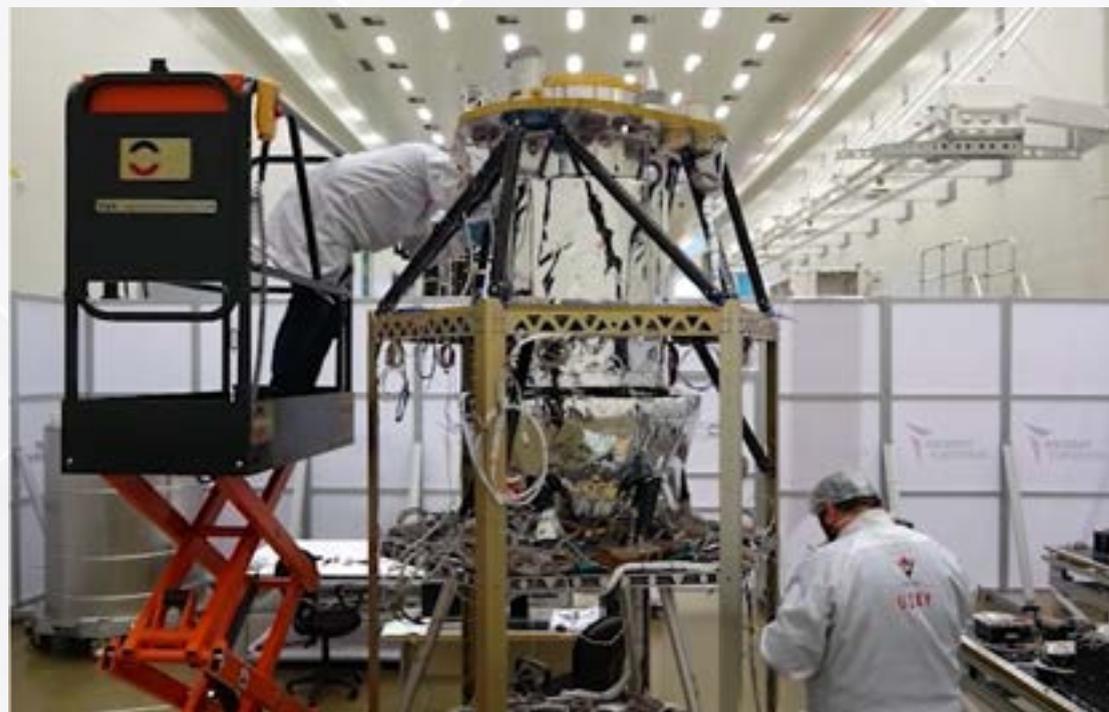
X Band  
Transmitter



S Band  
Antenna



# ▶ İMECE SATELLITE DEVELOPMENT



# ▶ İMECE SATELLITE LAUNCH CAMPAIGN

