



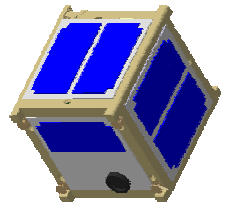
# Design and Development of the İ.T.Ü. pSAT I Engineering Prototype

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Prof. Gokhan Inalhan, Prof. Rustem Aslan

Istanbul Technical University,  
Faculty of Aeronautics and Astronautics

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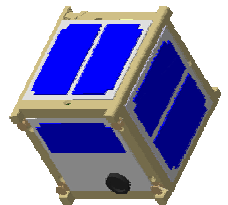


● ● ● | The picture we promised last year!

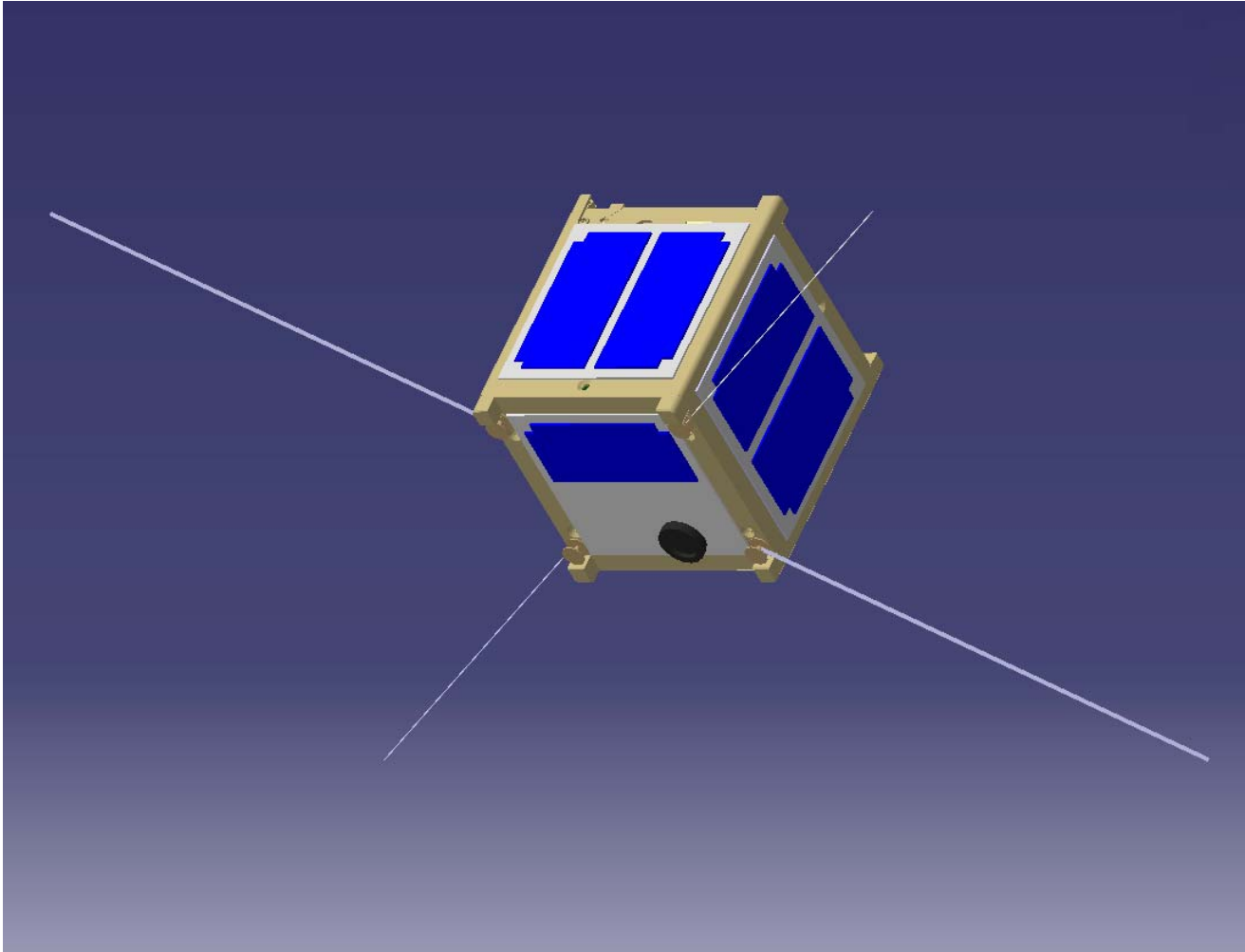


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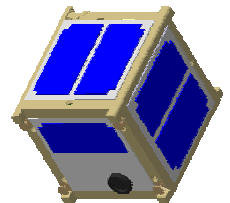
# İTÜ-pSAT I



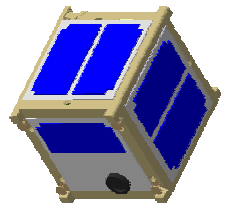
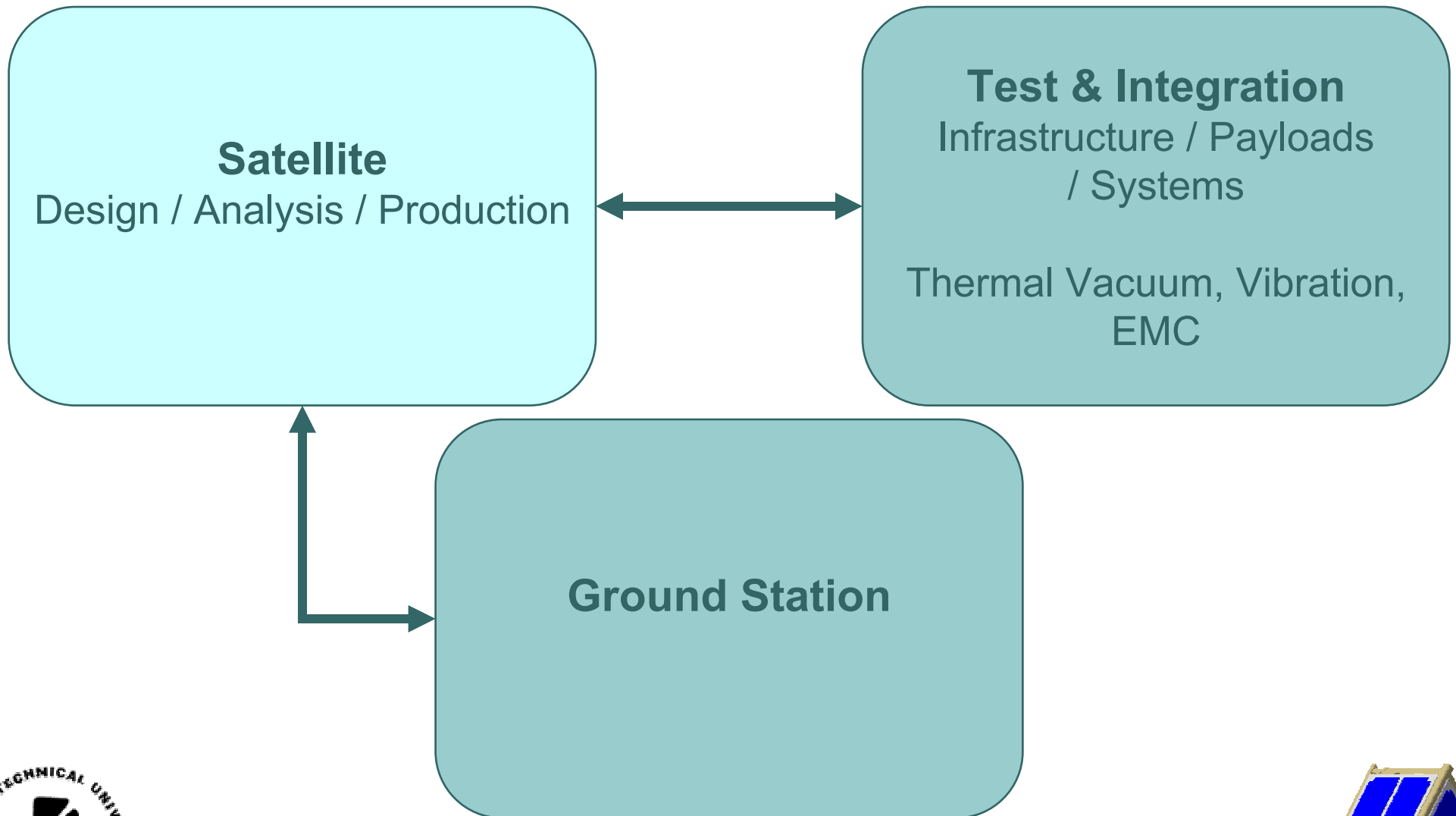
**pSAT I is getting ready for its 2008 launch...**

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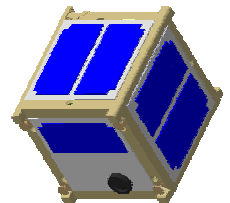
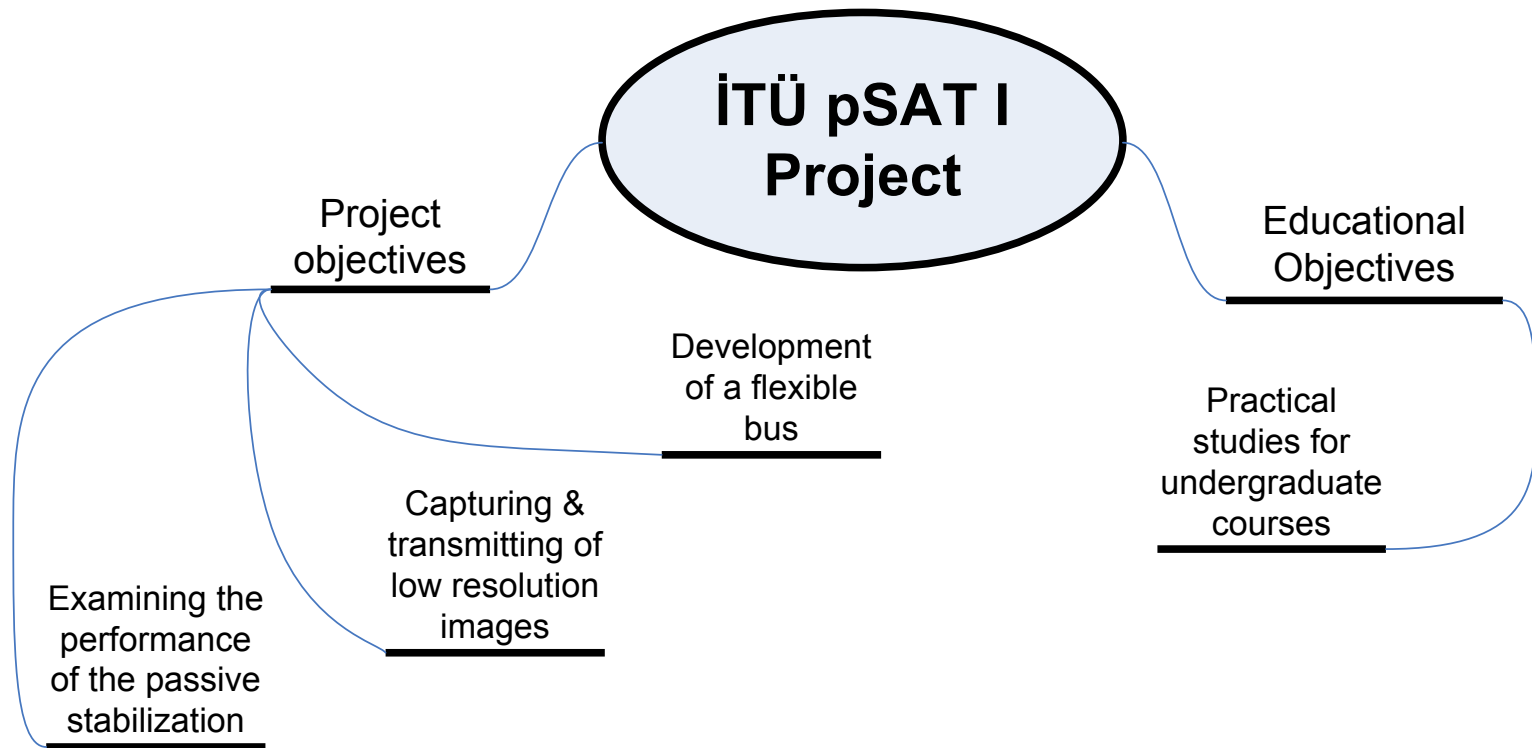
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# Basic Realm



# Mission



# Subsystems

CMOS Camera

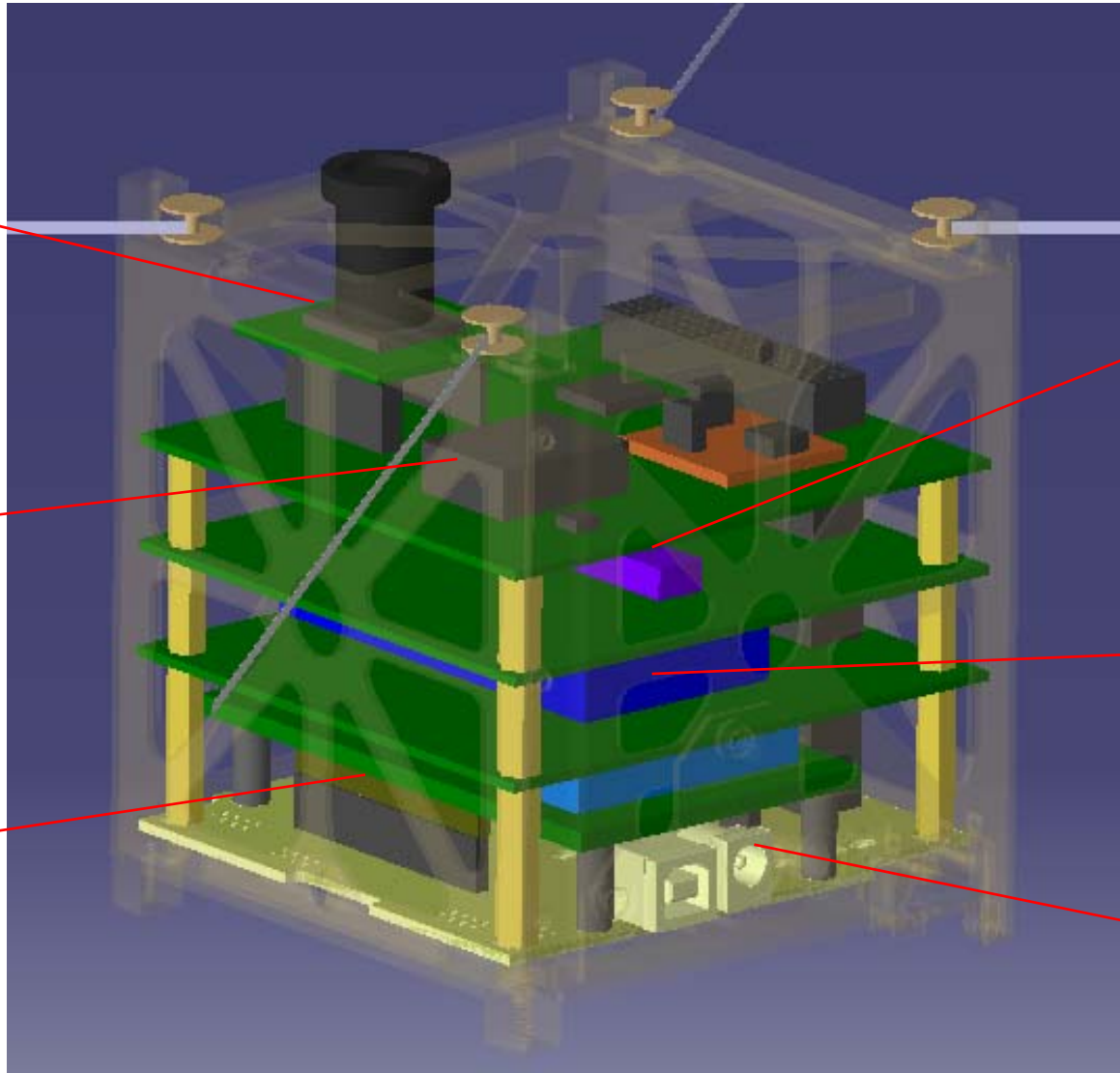
Sensor Board

Transceiver

Passive  
Magnetic  
Stabilization

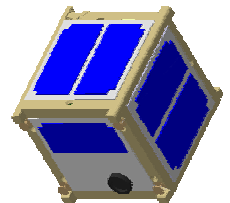
Power Board

On Board  
Computer



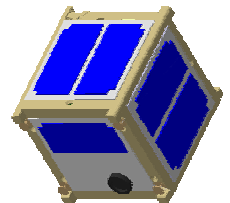
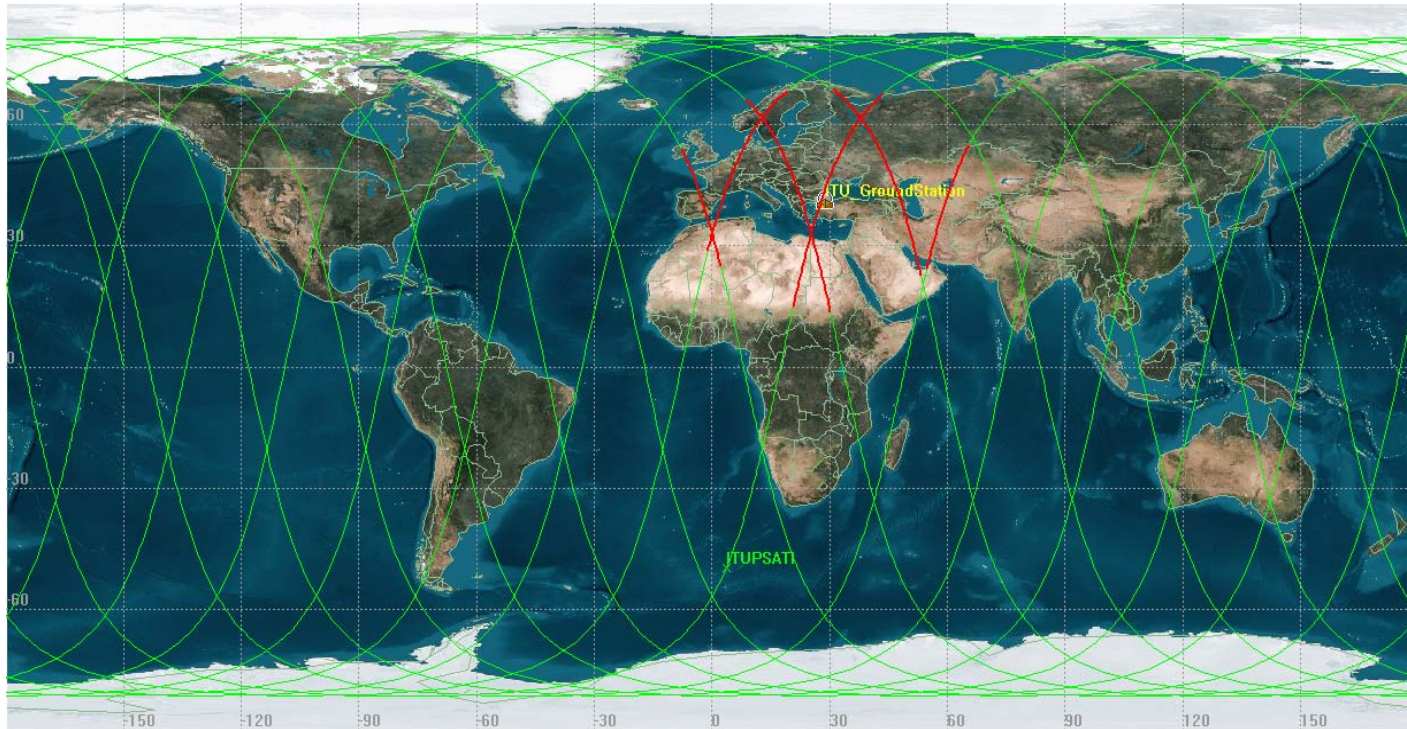
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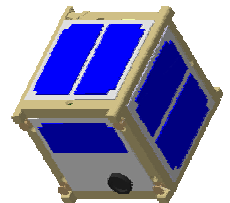
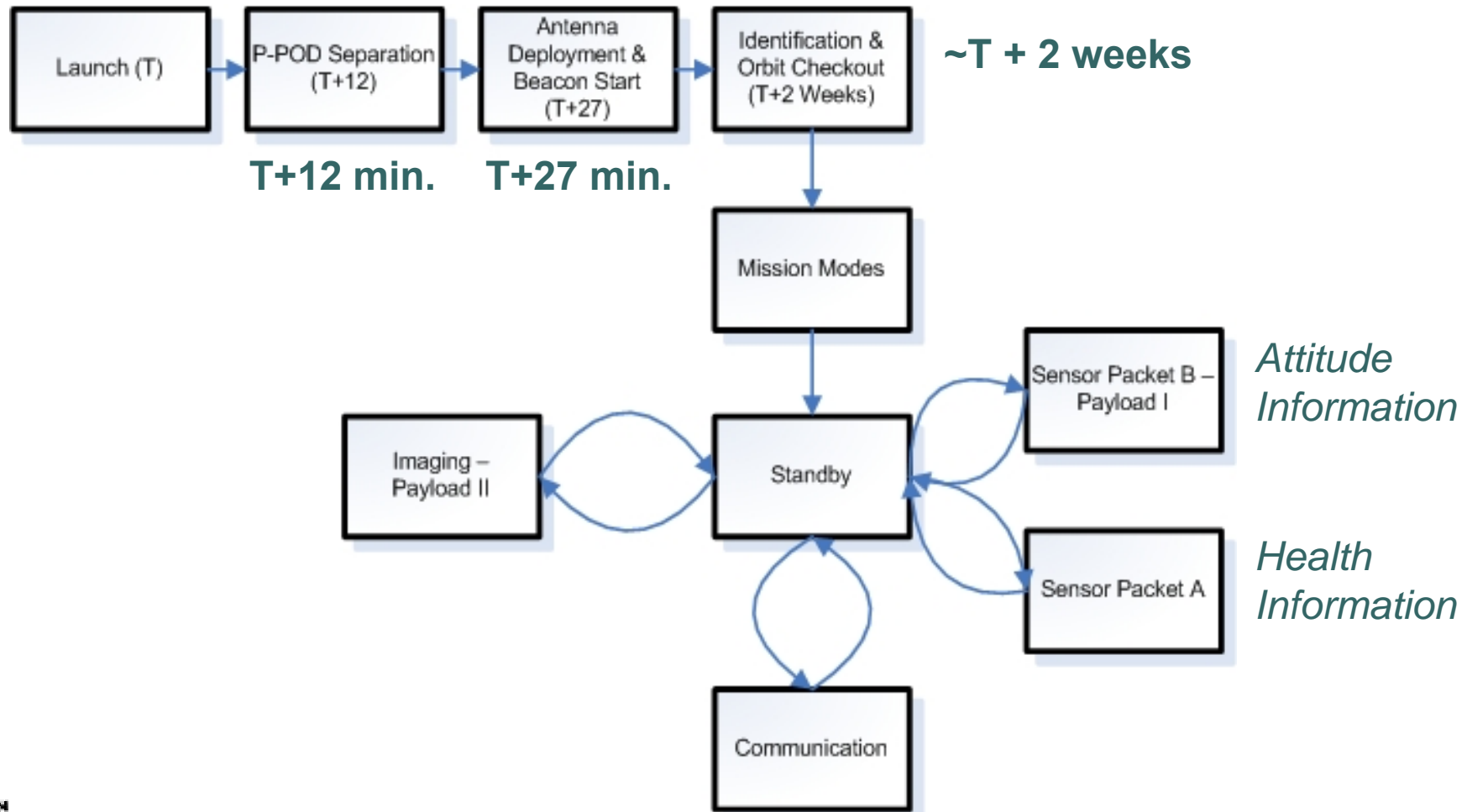


# Launch & Orbit

- DNEPR 2008
  - 600-700 km circular polar orbit
  - Allows a comm window of ~50 min/day



# Operational Modes

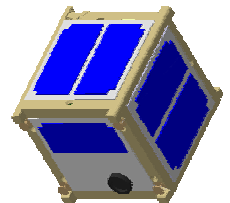




# Mission Modes

Active Payload

	Beacon	On-Board Computer	Power Board	Radio-Modem	Payload 1	Payload 2
Standby	On	On	On	Off	Off	Off
Communication	On	On	On	On	Off	Off
Sensor Packet SPA	On	On	On	Off	On	Off
Sensor Packet SPB	On	On	On	Off	On	Off
Taking a photograph	On	On	On	Off	Off	On



# Subsystems

CMOS Camera

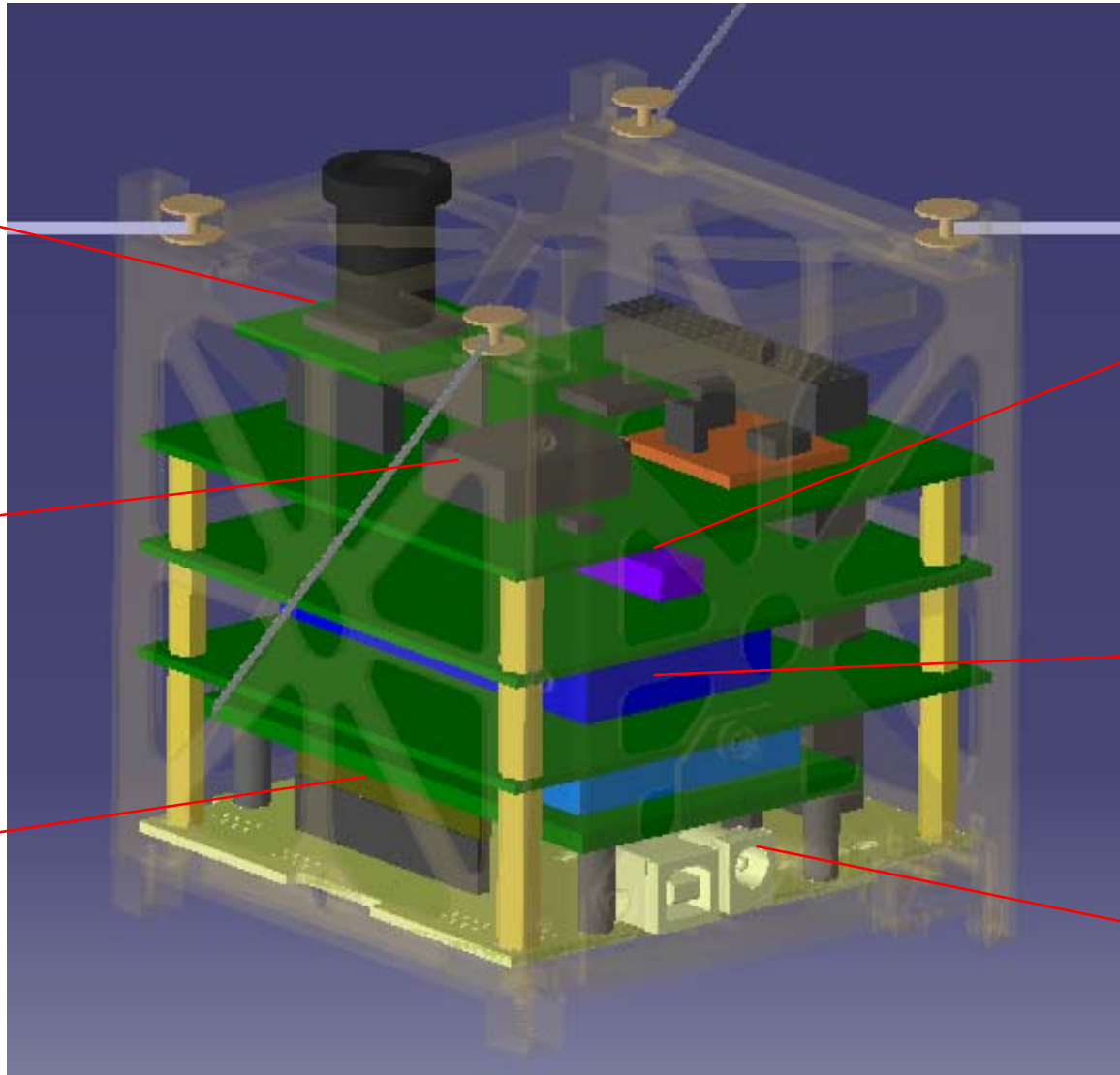
Sensor Board

Transceiver

Passive  
Magnetic  
Stabilization

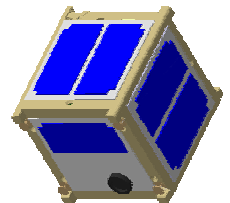
Power Board

On Board  
Computer



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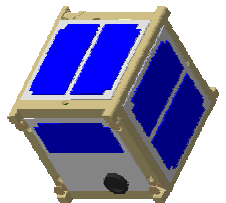
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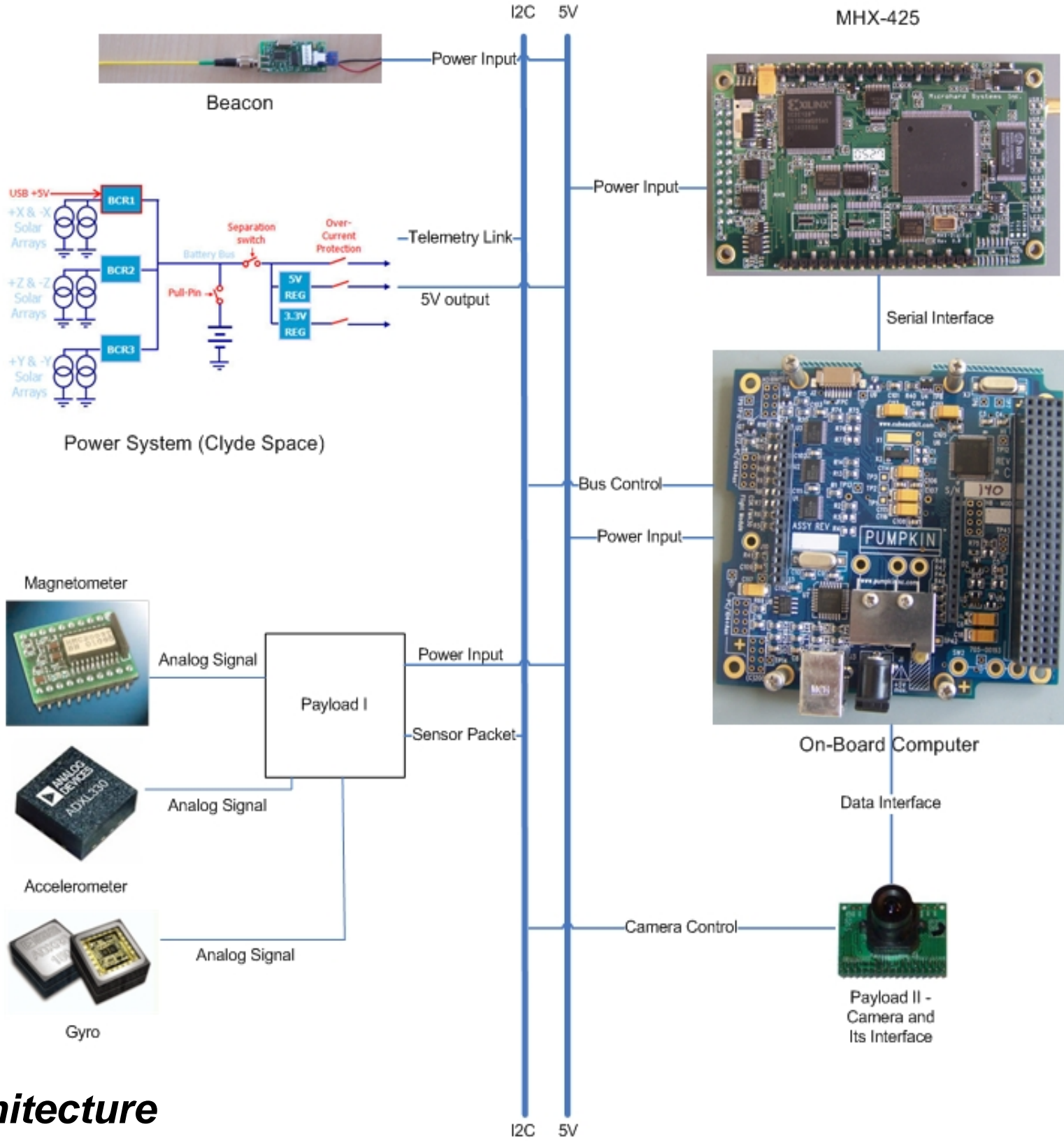




# Bus – *approach philosophy*

- Simple design structured around COTS equipment
- Low risk
- *Concurrent in-house development within SSDTL*
  - Ever-growing involvement of undergraduate and graduate students





**pSAT I Architecture**

# Systems Engineering

- Mass Budget
  - Left some headroom for surprises
- Power Budget
- Link Budget

	Current (A)	Power (W)
Standby	0,055	0,275
Communication	1,155	5,775
Sensor Packet SPA	0,105	0,525
Sensor Packet SPB	0,105	0,525
Imaging	0,175	0,875
Peak	1,155	5,775

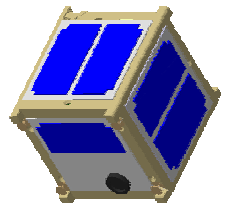
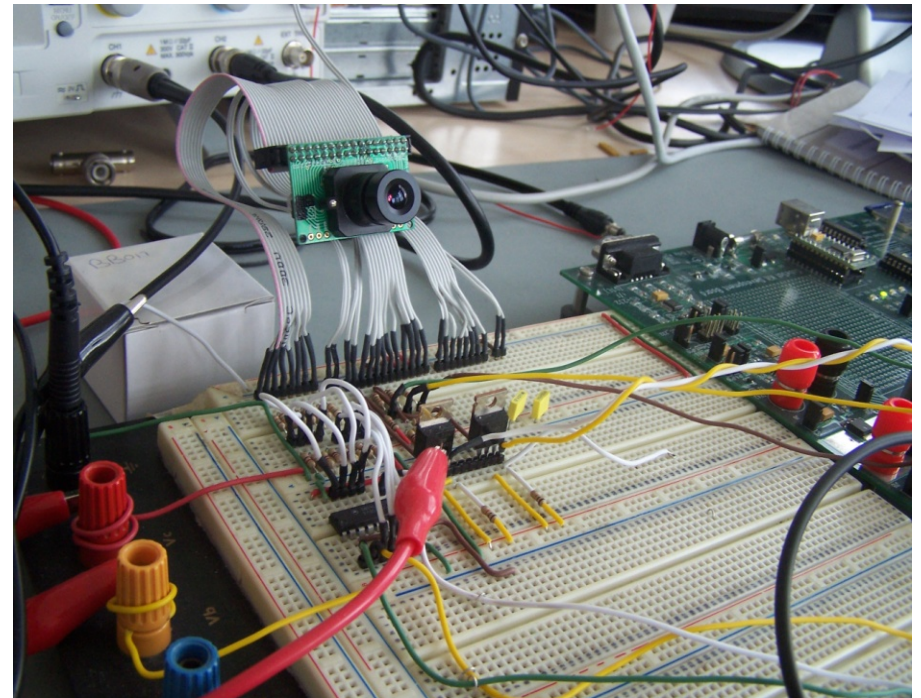
Subsystem	Component	Brief Explanation	Mass(g)
<b>Structure</b>			
	Base structure		165
	Cables		5
	Fasteners		15
<b>Payload</b>			
	Payload #1	Sensor Board	80
	Payload #2	Camera	40
<b>Attitude Control</b>			
	Magnet		50
<b>On-board Computer</b>			
	Board		55
	SD - Card		10
<b>Communication</b>			
	Transceiver		80
	Antenna		20
<b>Power</b>			
	Solar Panels	25g x 6	150
	Power System Board	Battery + circuit board	150
<b>Total Mass</b>			820

Downlink Budget	
Spacecraft Transmitter Power Output:	1.0 Watt / 30 dBm
Spacecraft Total Transmission Line Losses:	1.9 dB
Spacecraft Antenna Gain:	2.2 dBi
Spacecraft Antenna Pointing Loss:	0.3 dB
S/C-to-Ground Antenna Polarization Loss:	0.2 dB
Path Loss:	143.3 dB
Atmospheric Loss:	1.1 dB
Ionospheric Loss:	0.4 dB
Ground Station Antenna Pointing Loss:	0.7 dB
Ground Station Antenna Gain:	18.95 dBi
Ground Station Total Transmission Line Losses:	5.1 dB
<b>Link Margin</b>	<b>13.15 dB</b>

Uplink Budget	
Ground Station Transmitter Power Output:	75 Watt / 49 dBm
Ground Stn. Total Transmission Line Losses:	5.1 dB
Antenna Gain:	18.95 dBi
Ground Station Antenna Pointing Loss:	1.2 dB
Gnd-to-S/C Antenna Polarization Losses:	0.2 dB
Path Loss:	143.3 dB
Atmospheric Losses:	1.1 dB
Ionospheric Losses:	0.4 dB
Spacecraft Antenna Pointing Loss:	0.3 dB
Spacecraft Antenna Gain:	2.2 dBi
Spacecraft Total Transmission Line Losses:	2.0 dB
<b>Link Margin</b>	<b>31.55 dB</b>

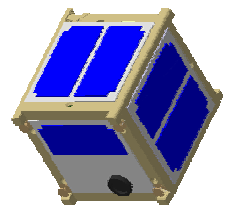
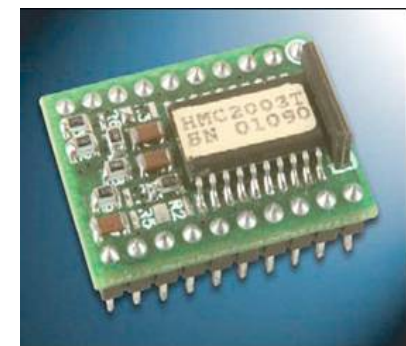
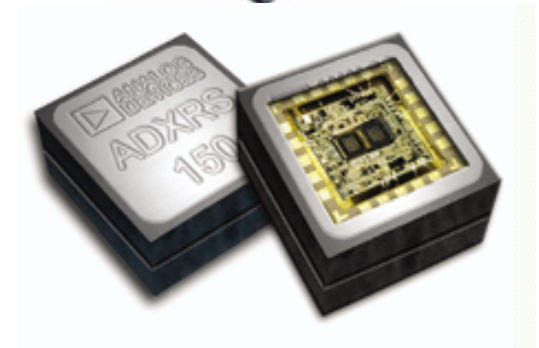
# Payload II – Imaging Experiment

- CMOS camera and interface board continental scale image capturing
- Camera C3188A (OV7620 chip)
  - Low resolution (VGA)
  - 5V
- Needs an interface circuit for MSP430!
- Might switch to a MCU at the same voltage level

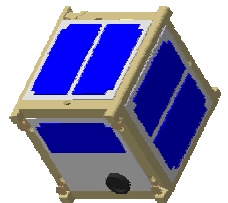
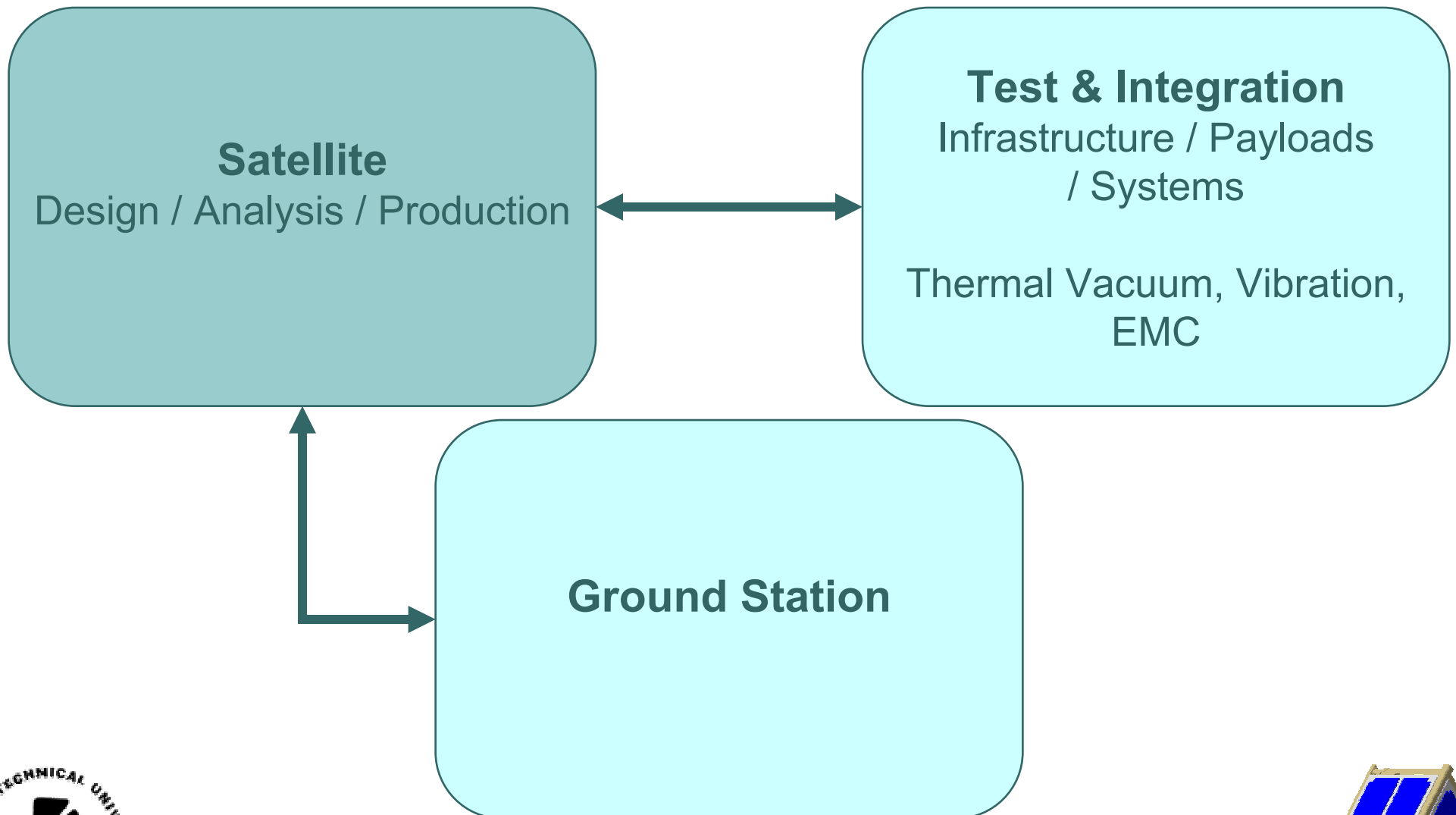


# Payload I – Passive Attitude Control Experiment

- Passive magnet and sensing board
  - Reports on I<sup>2</sup>C after ADC (Sensor Packet B)
- Sensors
  - Accelerometer – ADXL330
  - Gyros – ADXRS300
  - Magnetometer – HMC2003
- Passive AlNiCo magnet



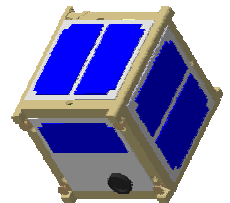
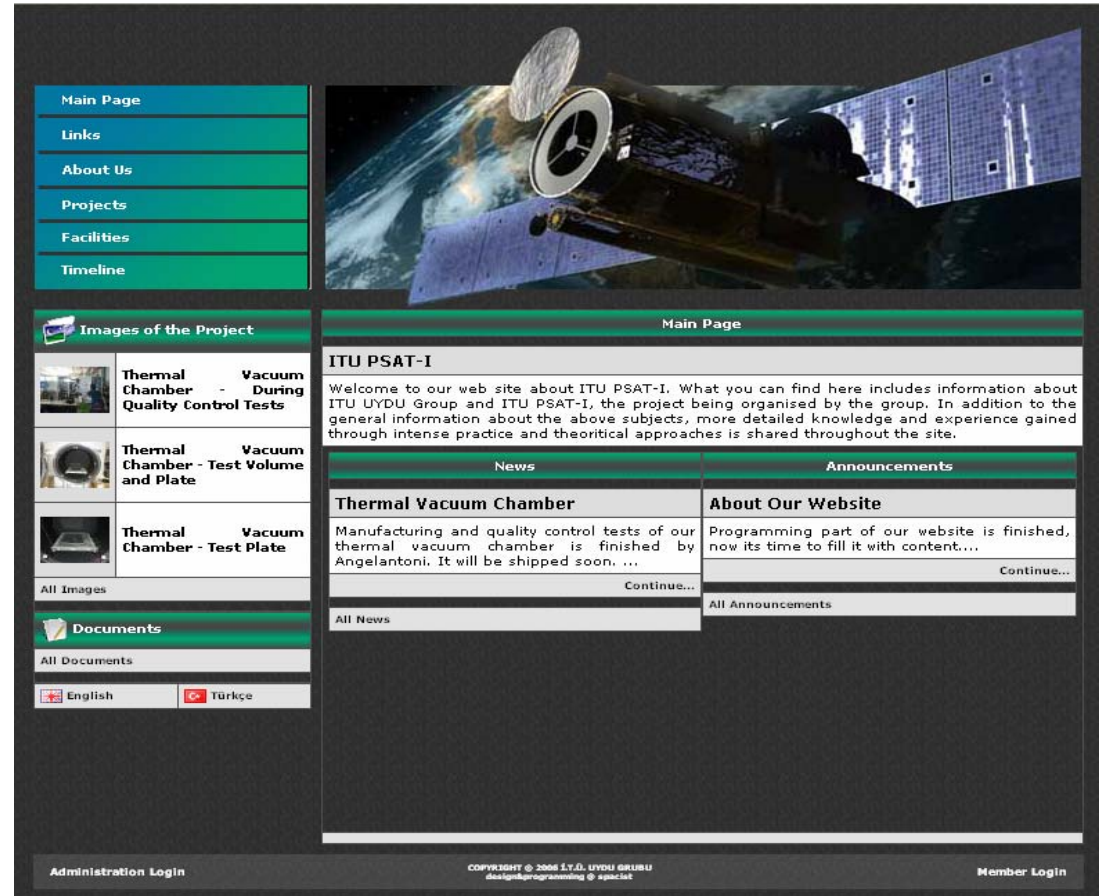
# Basic Realm





# Space Systems Development and Test Laboratory

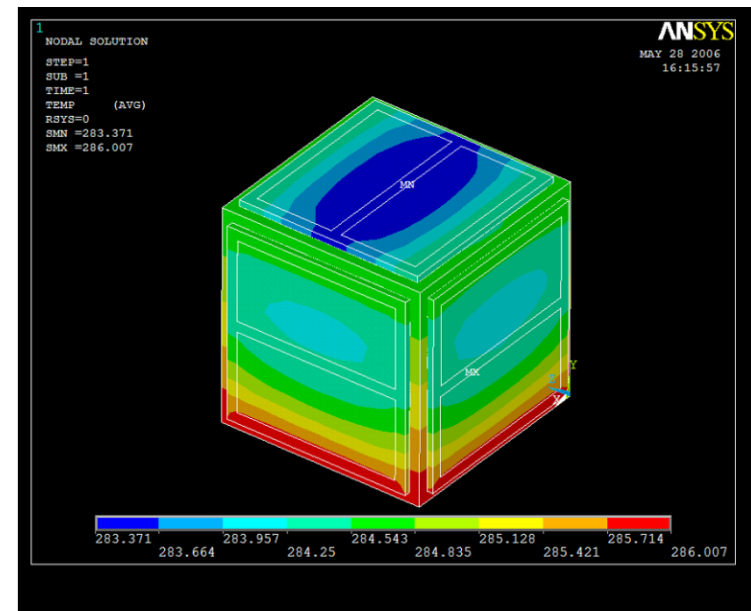
- Thermal/Vac Chamber
  - 350 litre,  $10^{-6}$  torr
  - $-60^{\circ}\text{C} - 90^{\circ}\text{C}$  at  $1^{\circ}\text{C} / \text{min}$  steps
- Class 1000 Clean Room,
  - $25\text{ m}^2$
- Access to university resources
  - Shake Table
  - EMI/EMC
- Ground Station



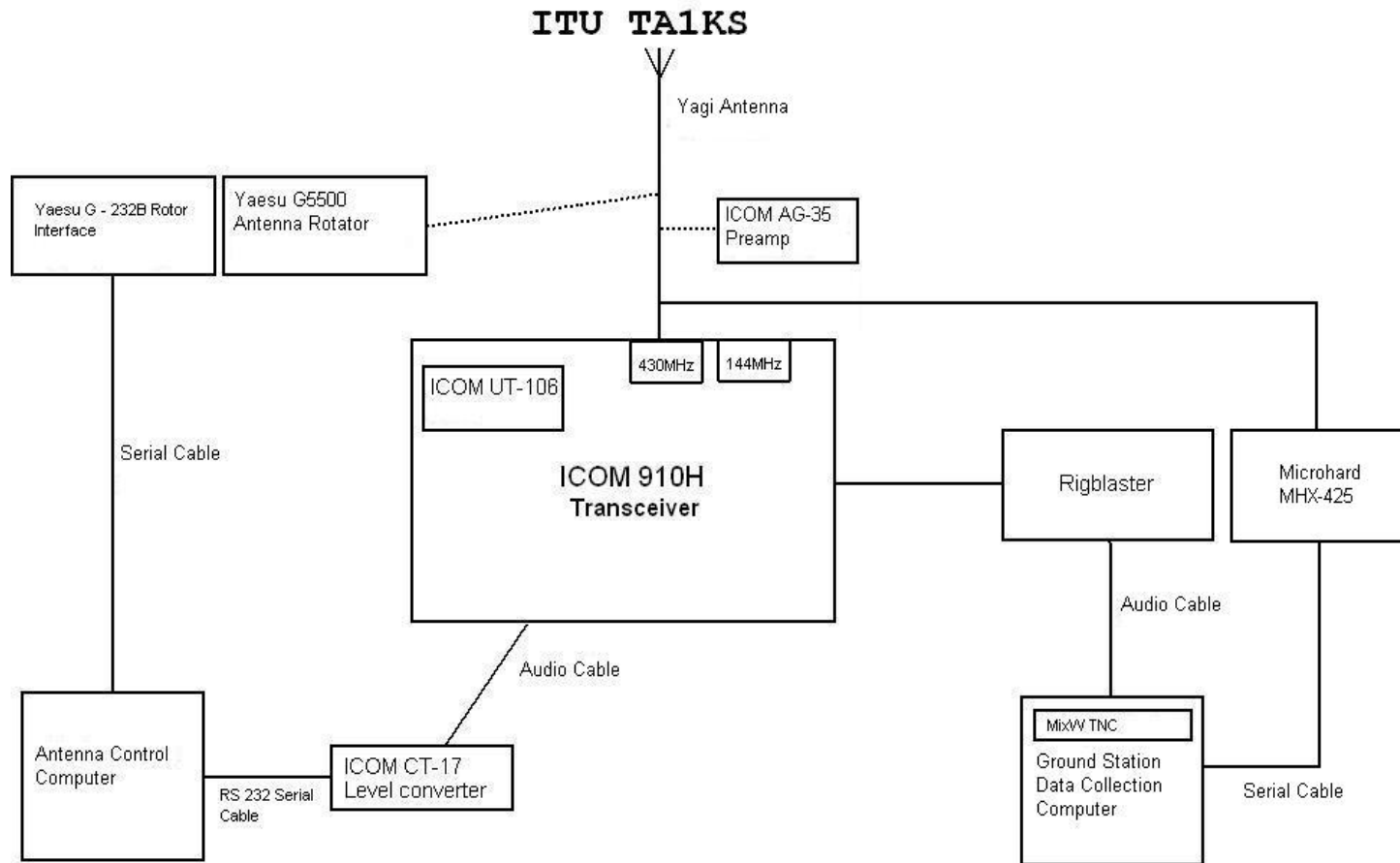
# Facilities



- Access to researchers, students and small business initiatives **from all around the world**
  - **Assemble** and **Test** science payloads, and nano-to-micro satellites.



# Ground Station – ITU TA1KS ☺

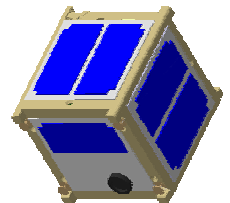


- Will operate as a part of GSN
- Typical amateur radio setup
- Dual transceiver

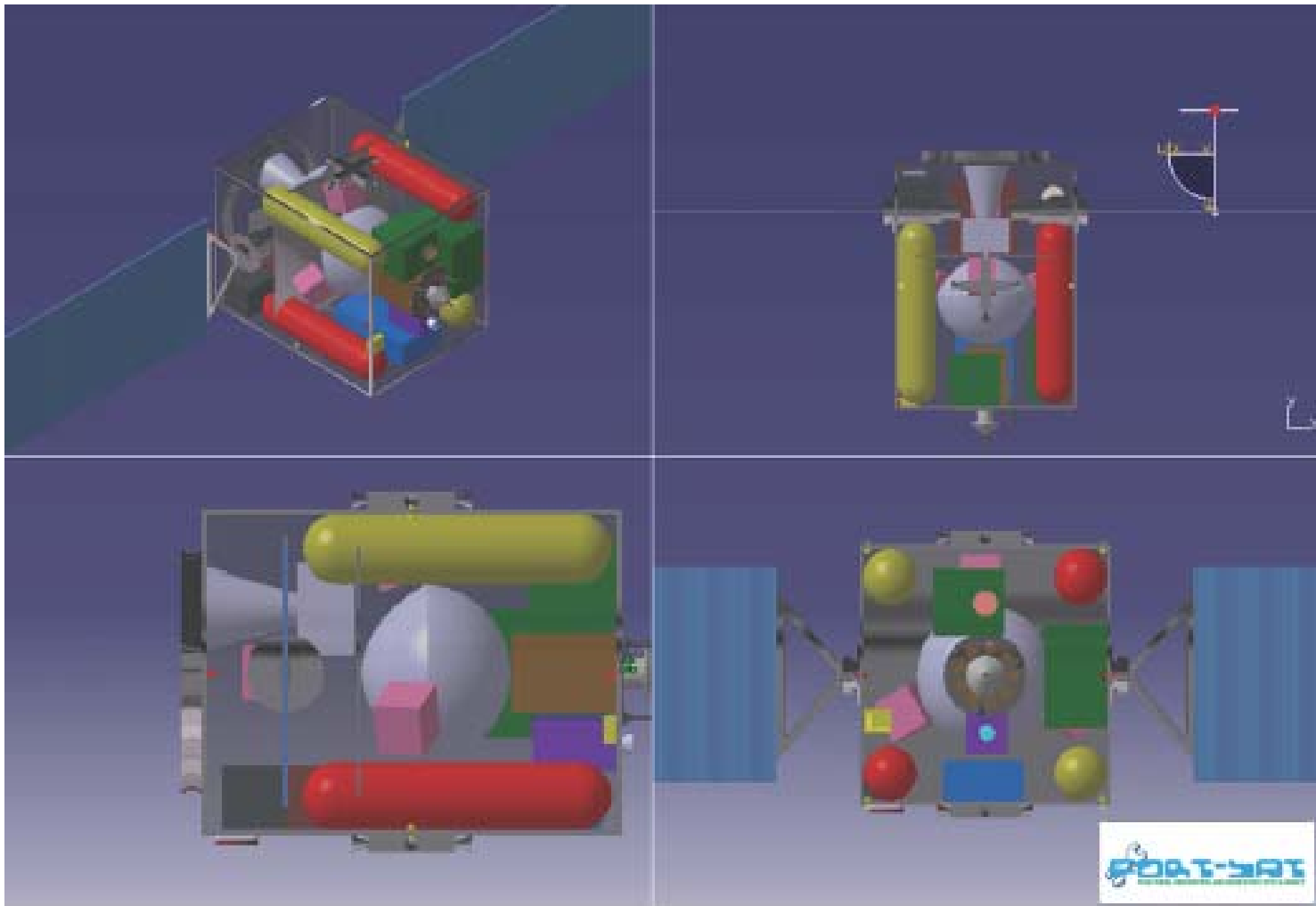
*Will be up and running by the summer of 2007*

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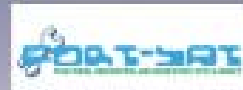
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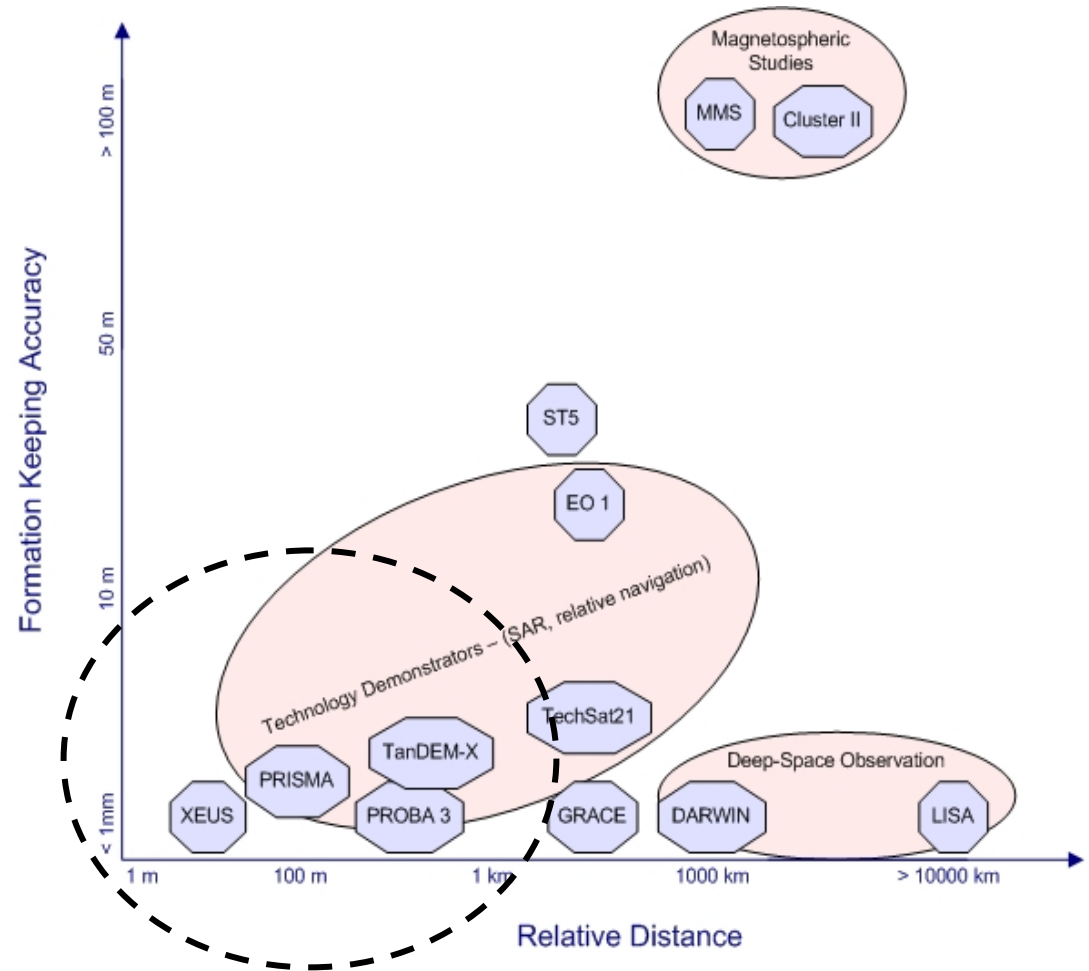
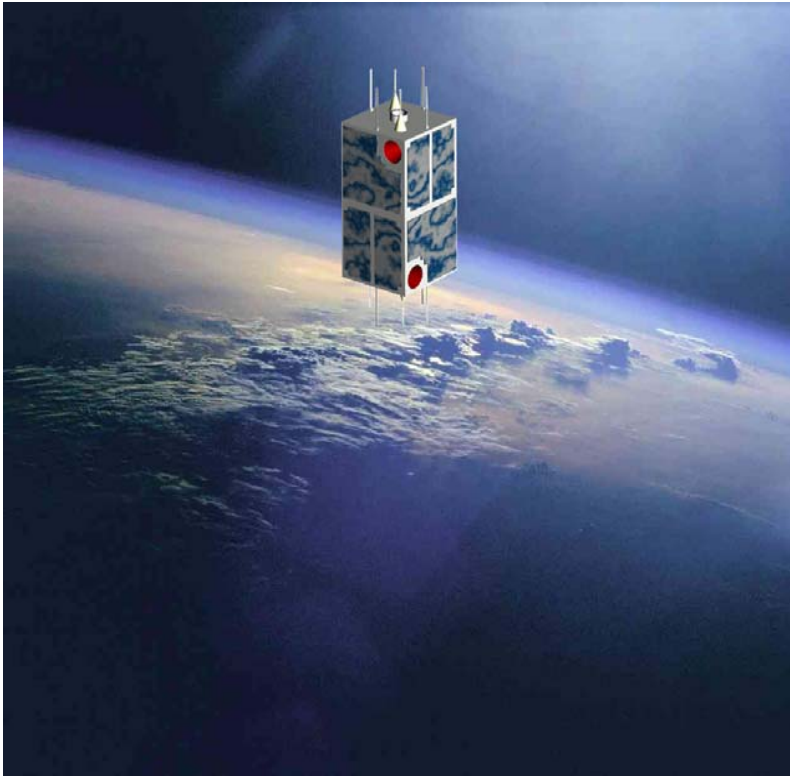
# Spacecraft Systems Design Course – The winner is ...



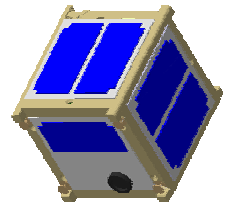
- |   |   |   |  |
|---|---|---|--|
| <span style="color: red;">●</span> Fuel Tank        | <span style="color: blue;">●</span> Li-Po Battery Package | <span style="color: green;">●</span> LASER          | <span style="color: brown;">●</span> IAU                               |
| <span style="color: olive;">●</span> Oxidizer Tank  | <span style="color: black;">●</span> LPT                  | <span style="color: yellow;">●</span> Sun Sensor    | <span style="color: tan;">●</span> IMU                                 |
| <span style="color: pink;">●</span> Momentum Wheels | <span style="color: purple;">●</span> Camera MC 4020      | <span style="color: brown;">●</span> Docking System | <span style="color: lightblue;">●</span> Cold Gas Tank and Star Sensor |



# ITU-nSAT Concept



Need for cheap on-orbit demonstration against key technologies.



# Nano-satellite Formation Experiment

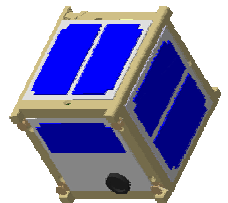
- A true research platform for key control, micro-propulsion and imaging technologies :



20x20x20cm per unit; Total 12-14kg

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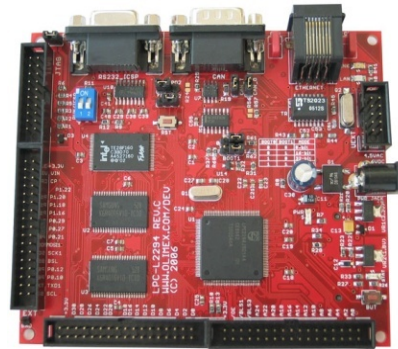
<http://usl.itu.edu.tr>



# Concepts developing...

- Space Qualifying New Processors

- LPC2294 – Arm
- MPC 555 – Motorola PPC



LPC2294



MPC555

- Transition to CAN Bus

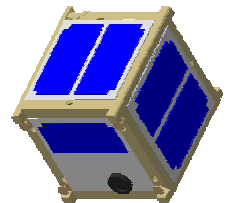
- PIC based sensor interface boards
- Other sensors



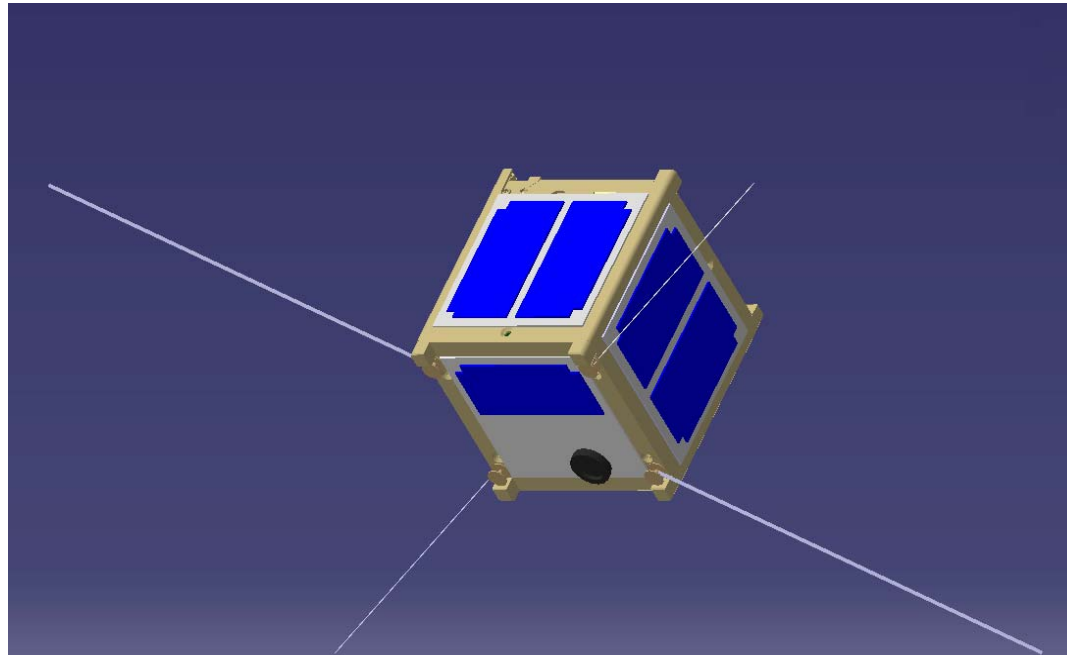
CAN Interface



Smart Sensor Nodes



İTÜ pSAT I is on schedule for its 2008 launch...



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See “it” at Recent Advances in Space Technologies 2007  
June 14<sup>th</sup> -17<sup>th</sup> at Istanbul.





# Thank You!

## Any Questions?

