5th Annual CubeSat Developers' Workshop

9 - 11 April 2008
Cal Poly
San Luis Obispo, California

From UNISAT to UNICubeSAT

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Scuola di Ingegneria Aerospaziale
"SAPIENZA", Università di Roma

Satellite S. Marco 1

(Scout, Wallops Island)

December 15, 1964

S. Marco Equatorial Range

Launches from San Marco Equatorial range		
Date	Satellite	Payload
April 26, 1967	San Marco 2	Thermosphere analysis
December 12, 1970	Small Astronomy Satellite (SAS) 1, Uhuru	X rays sources
April 24, 1971	San Marco 3	Thermosphere analysis
November 15, 1971	Small Scientific Satellite (SSS) 1	Van Allen belts electrical and magnetic fields
November 15 1972	SAS 2	Gamma rays sources
February 18, 1974	San Marco 4	Thermosphere analysis
October 15, 1974	UK-5	X rays sources
May 8, 1975	SAS 3	
March 25, 1988	San Marco 5	Thermosphere analysis

A short history of UNISAT program

1990 -Theoretical studies on building low-cost microsatellites at university

A few people trusted it was possible that students could design realize microsatellites using commercial off-the-shelf components

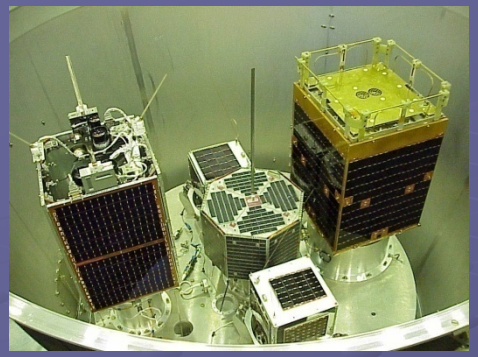
1995 – First grant to UNISAT program received from Italian Ministry of University

Building of ground station (SPIV)
researchers of University of Rome at Stanford University

1997 – Design and realization of UNISAT start

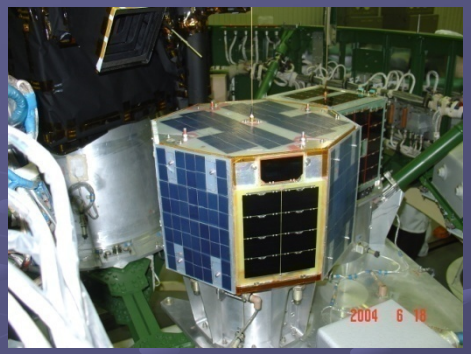
2000 – Launch of UNISAT

UNISAT microsatellites

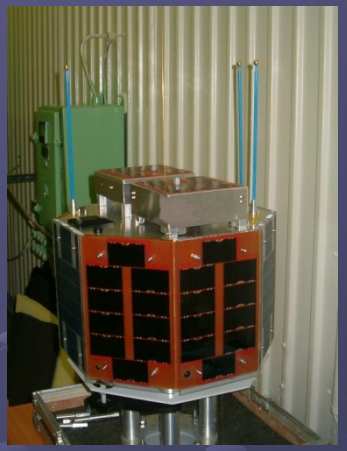


Unisat
26 Sept. 2000

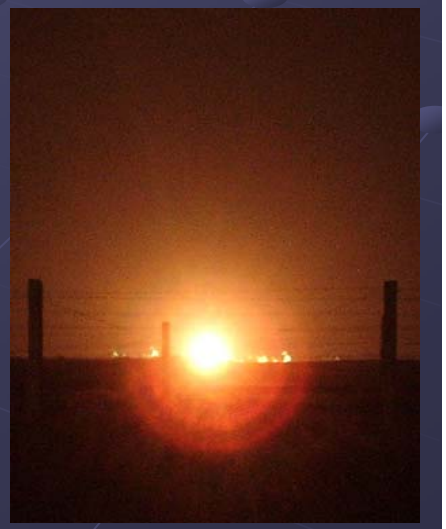
Unisat-2
20 Dec. 2002



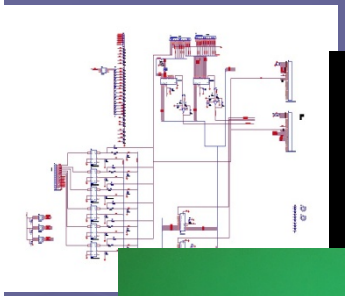
Unisat-3
29 Jun. 2004

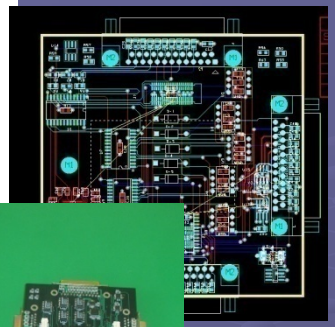


Unisat-4
26 Jul. 2006

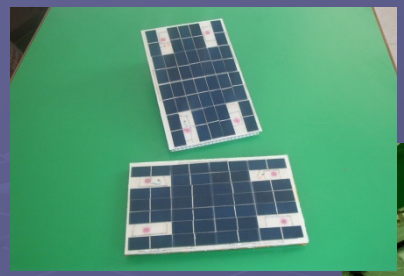


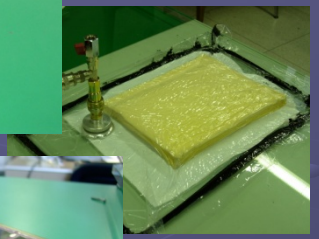
Design and realization of electronic boards



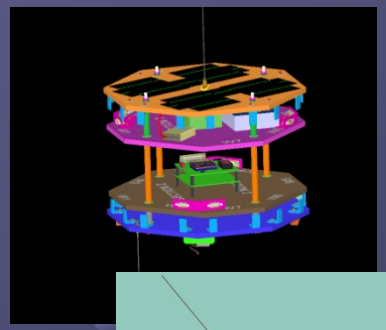


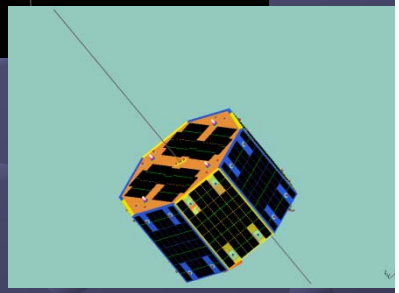
Solar arrays manufacturing



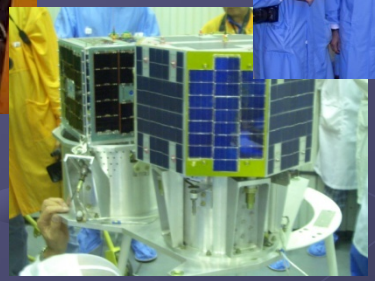


Structure design and manufacturing

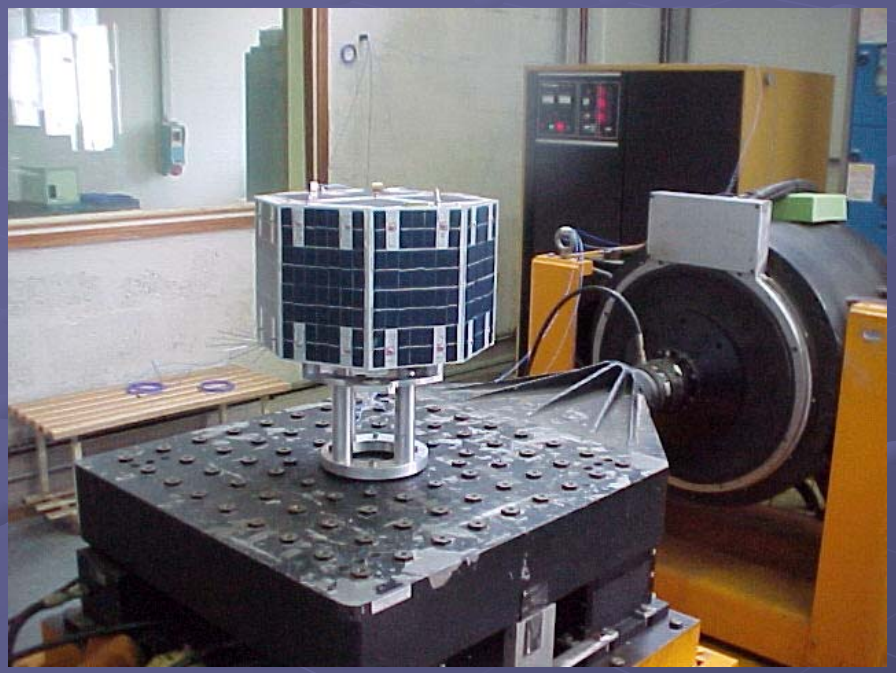




Ground tests, integration, launch and operation in orbit



Test campaign



Integration at the Baikonour Cosmodrome

Launch UNISAT 3

Launch site

Launch groups

GAUSS Activities

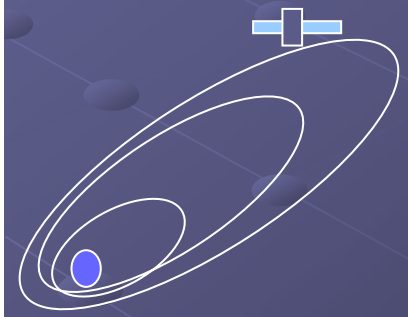
Publications

- Papers
- Thesis
- *Quaderni di Astrodinamica*

Space Education through "hands-on" experience *since 1990*

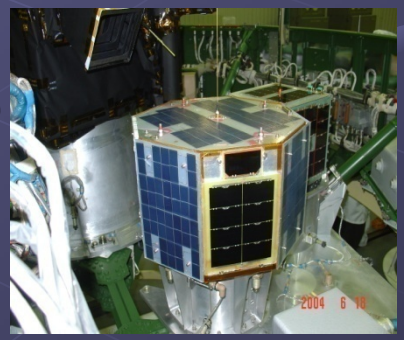
Astrodynamics laboratory

Mission Analysis

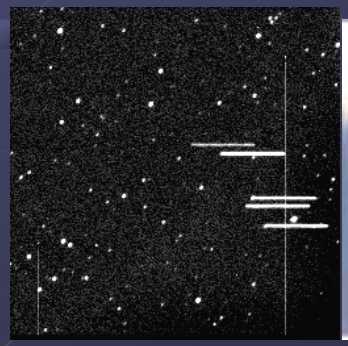


SPIV Ground Station

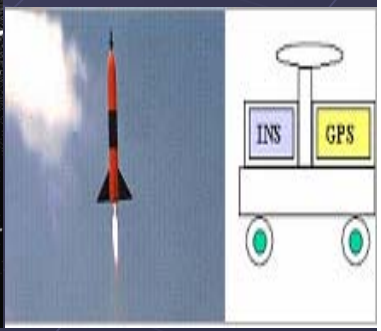
Microsatellites UNISAT



Space debris

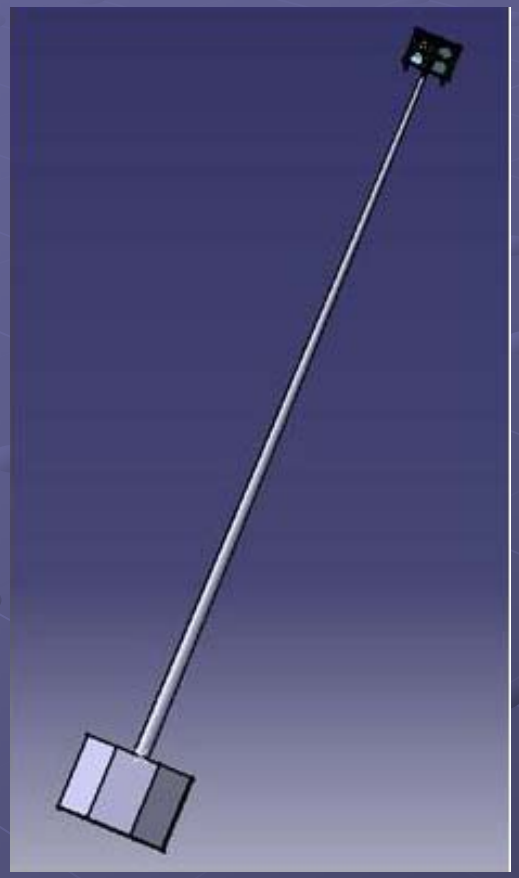


Guidance, Navigation and Control

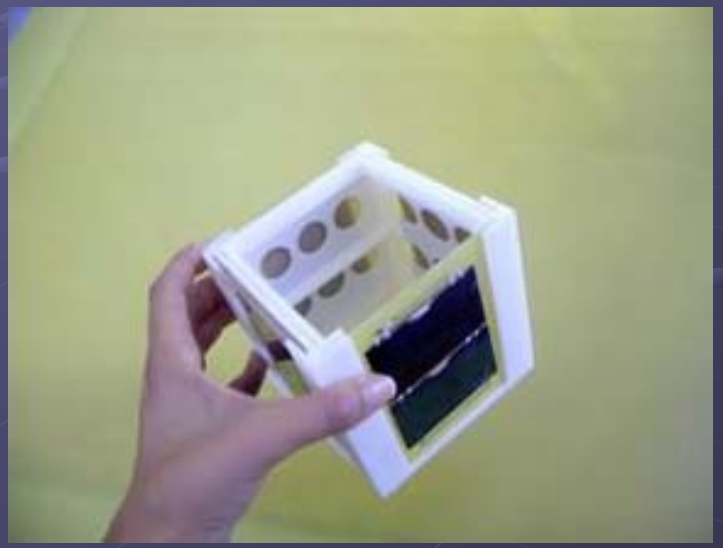


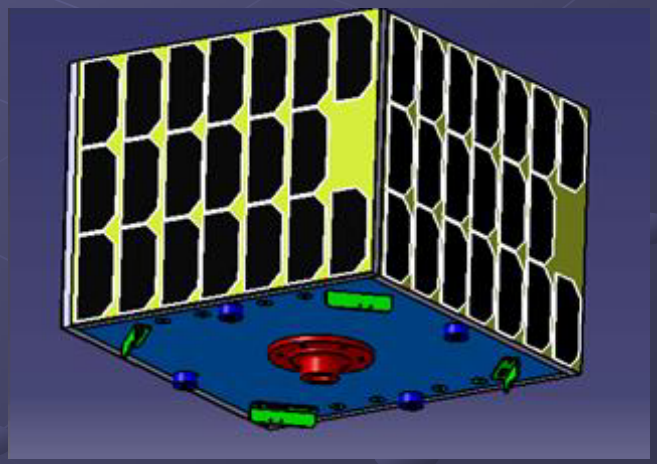
Today Activities

Unisat - 5



UNICubeSAT



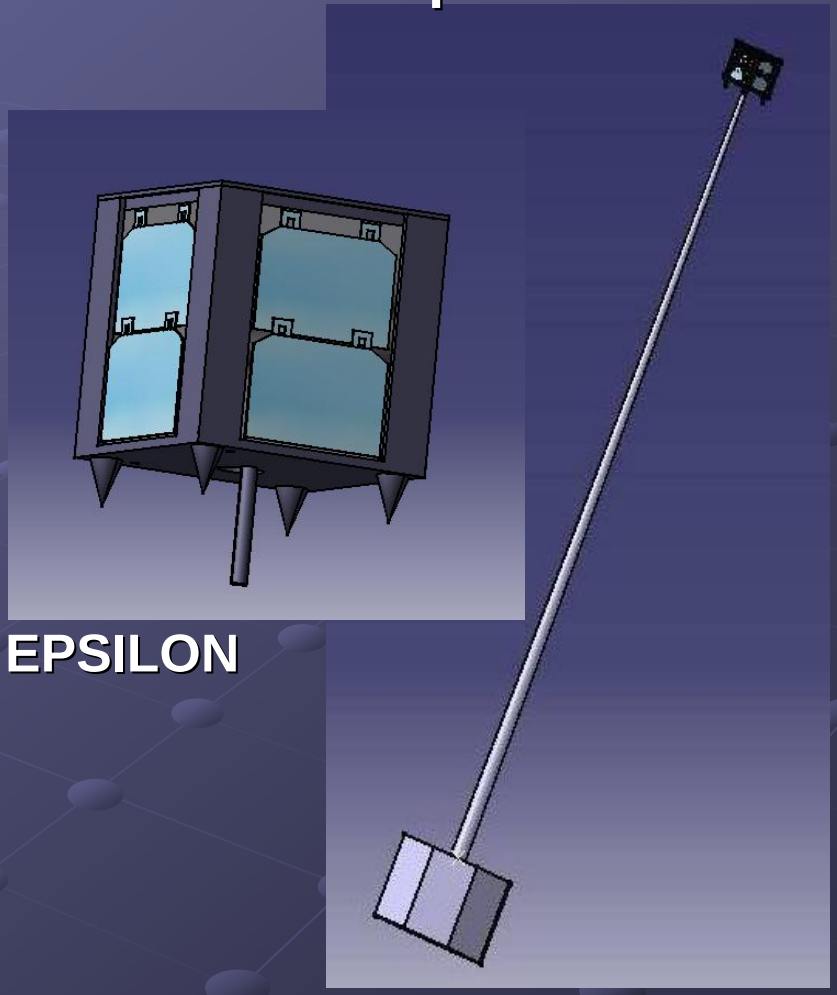


Edusat

Epsilon (Narcissus)

Students payload NARCISSUS - the satellite that pictures itself

- Take pictures of UNISAT from a camera located on the TIP MASS of a gravity gradient boom (EPSILON)
- EPSILON structure has been already designed, built and tested
- 1W average power
- 1 kg weight
- 10x10x10cm 1 liter volume
- PIC micro
- Wireless connection to UNISAT



EPSILON

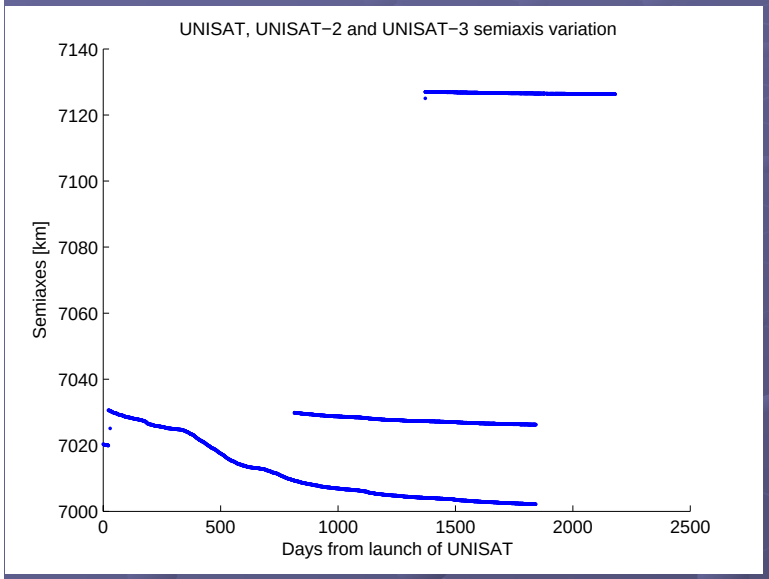
NARCISSUS

UNICubeSAT Experiments

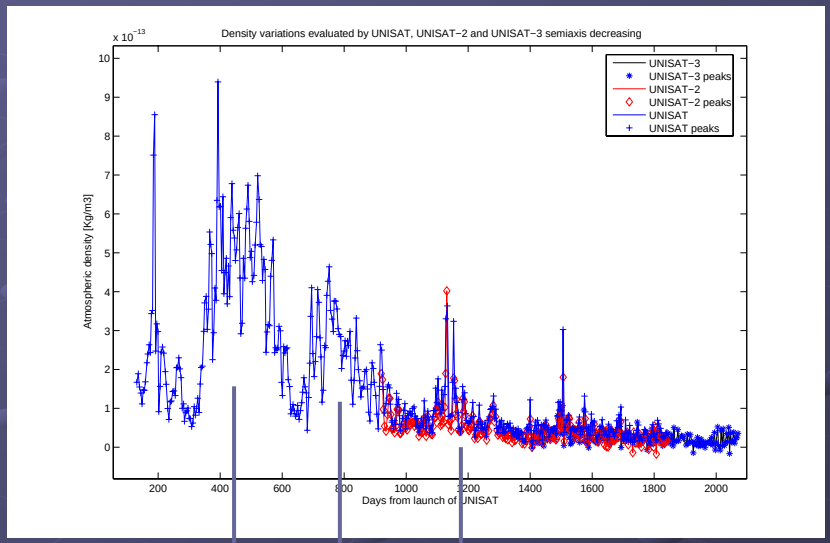
The VEGA MAIDEN flight Cubesat orbit (350x1200km) has unique characteristics for:

- **Atmospheric density measurement (low altitude perigee)**
- **Radiation environment measurements (High altitude apogee)**

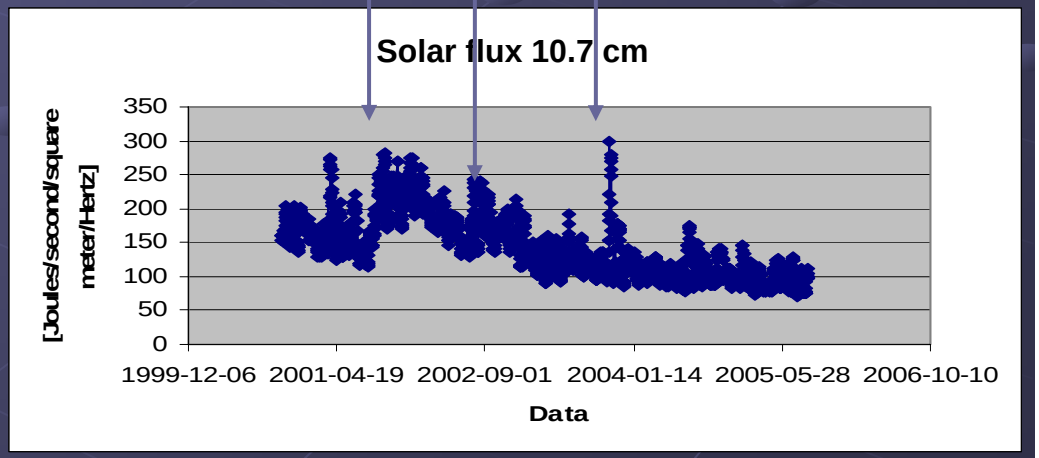
Atmospheric density evaluation from UNISAT, UNISAT-2 and UNISAT-3 global semiaxis data



$$\frac{\dot{a}}{a^2} = -\frac{\rho v^3 S C_D}{m\mu}$$

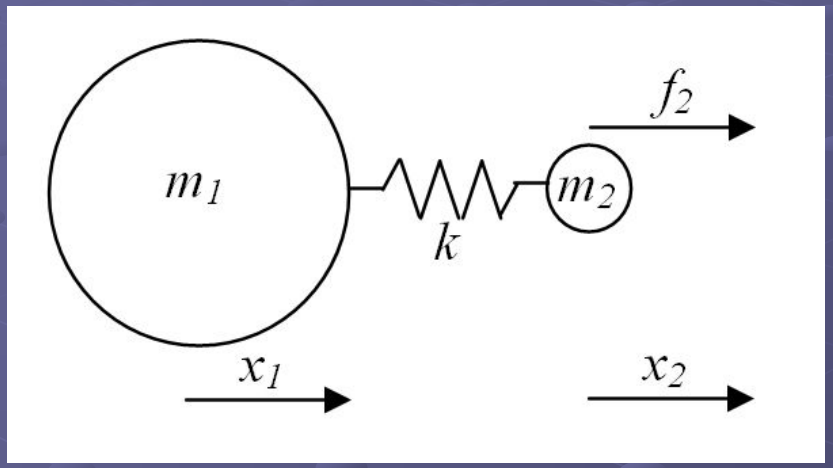


U.S. Dept. of Commerce, NOAA, Space Environment Center



Thermosphere analysis (atmospheric density) from local measurements and orbital velocity data

- **The Broglio Theory**



$$m_1\ddot{x}_1 = -k(x_1 - x_2) + m_1 g$$
$$m_2\ddot{x}_2 = k(x_1 - x_2) + m_2 g + f_2$$

$$x = (x_1 - x_2)$$
$$k\left(\frac{1}{m_1} + \frac{1}{m_2}\right)x = \frac{f_2}{m_2} \quad \Rightarrow \quad x = \frac{m_1}{m_1 + m_2}\frac{f_2}{k}$$

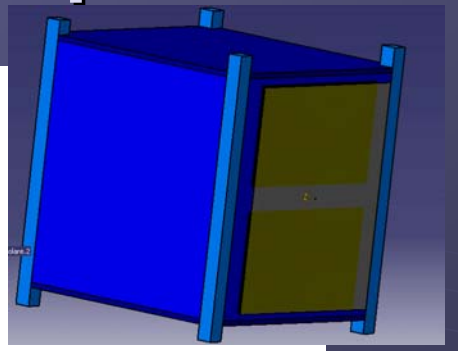
$$m_1 >> m_2 \Rightarrow x \simeq \frac{f_2}{k}$$

Broglio Drag Balance (dynamometer concept)

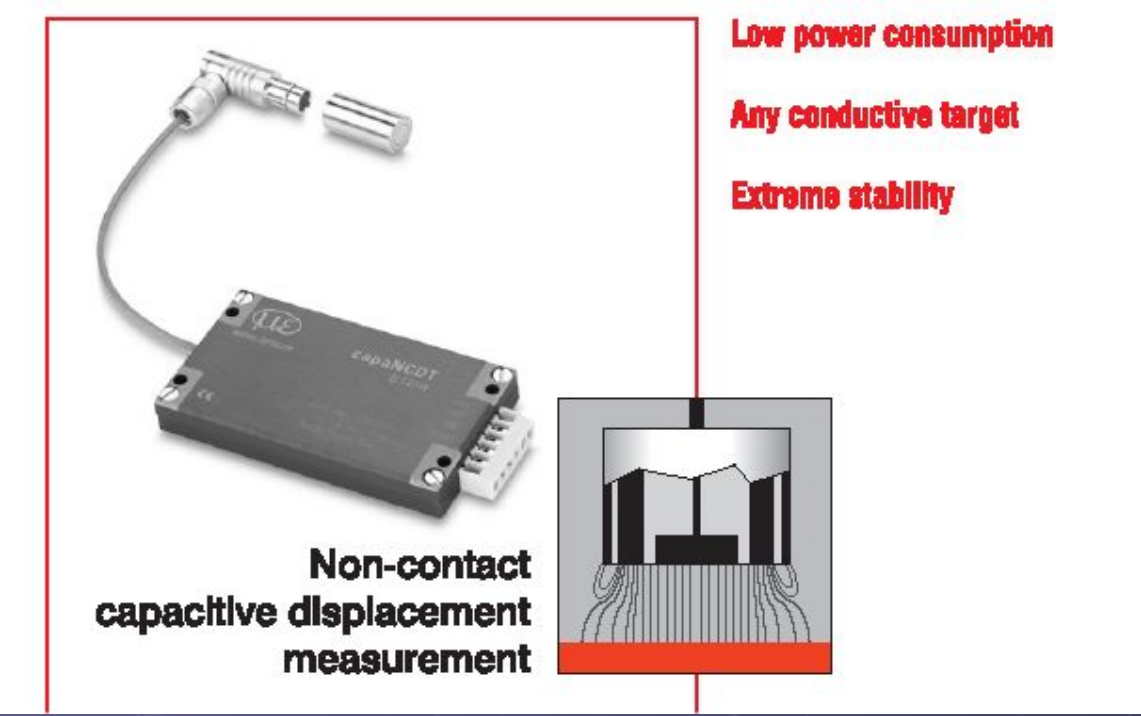
$$m_1 << m_2 \Rightarrow x \simeq \frac{m1}{m_2}\frac{f_2}{k}$$

Traditional accelerometer concept

UniCubesat implementation of the Broglio Drag Balance concept

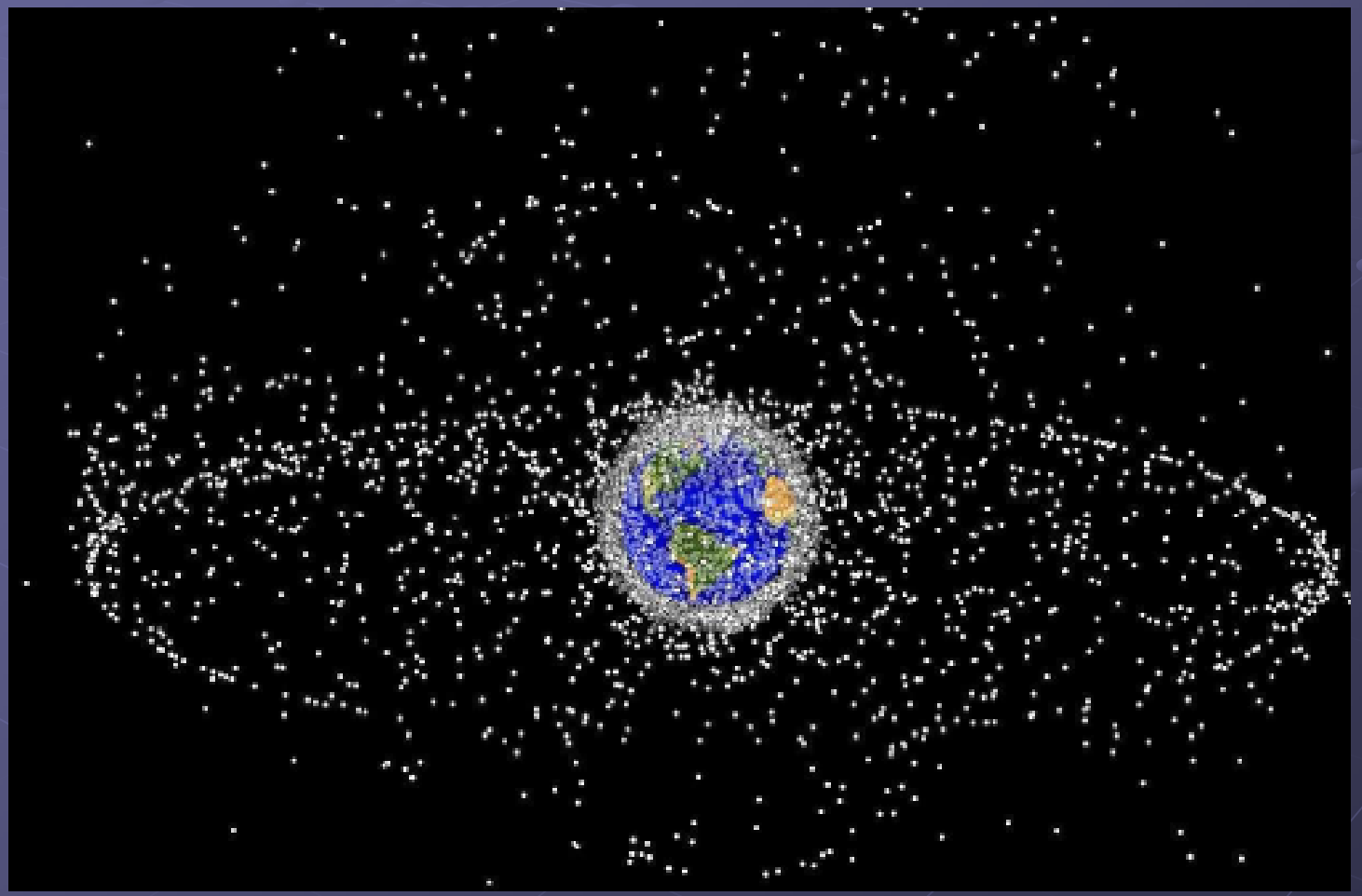


Displacement sensor (preliminary selection)



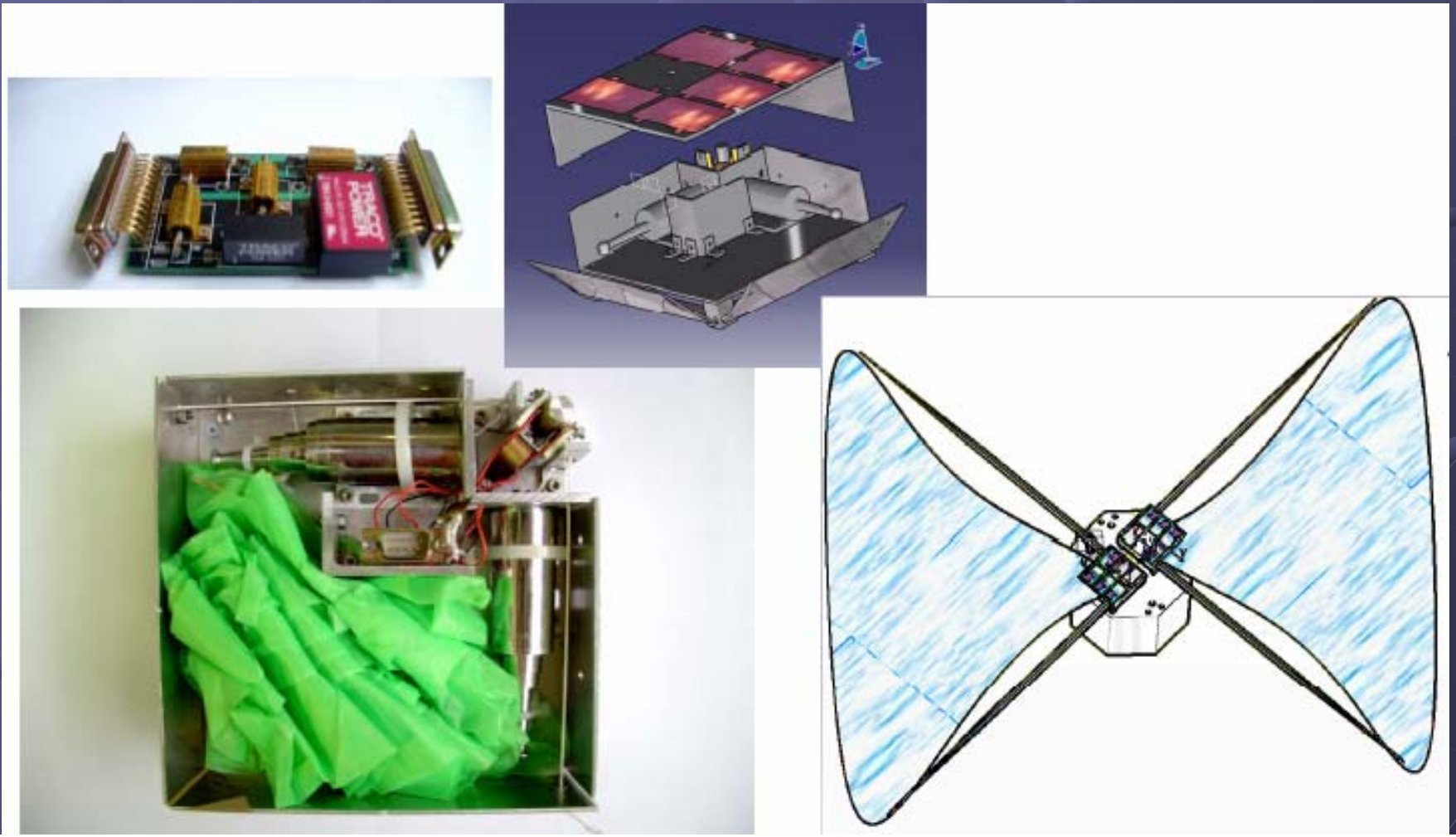
Model	S601-0.2	S600-0.5	S600-1	CS2	CS3	CS5	CS10
Measuring range	0.2 mm	0.5 mm	1 mm	2 mm	3 mm	5 mm	10 mm
Resolution (static)	≤ 0.01% FSO						
Linearity	≤ 1% FSO						

Space Debris Project



SIRDARIA

Spacecraft Integrated Re-entry Device Aero-Resistant, Increasing Area



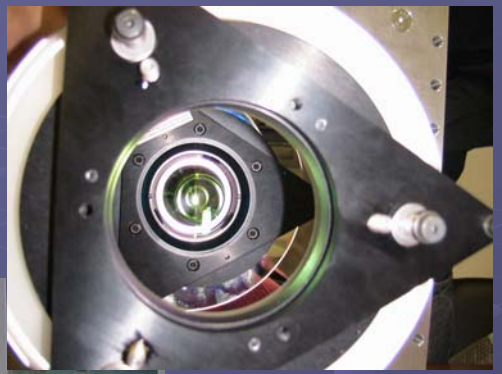
Infrastructures:

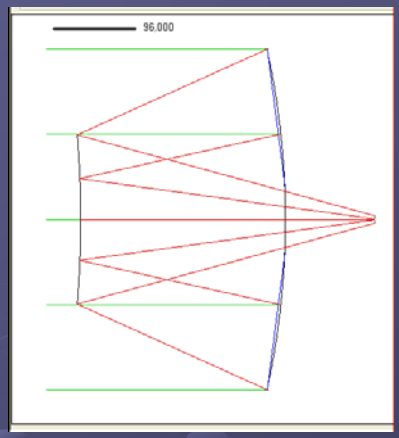
Dome

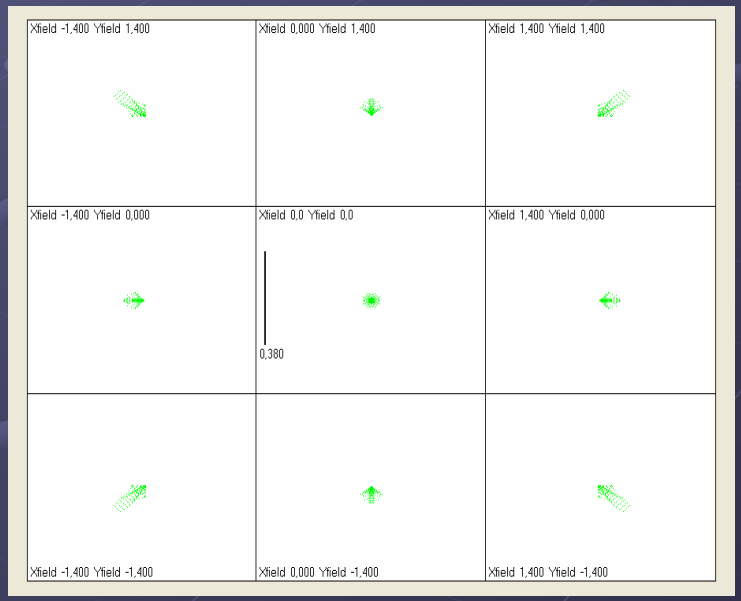
- lightness (max 8 kg)
- easy to transport
- fast to assemble (2 hours)
- modularity
- completely automated
- remotely controlled

OPTICS/1

CASSEGRAIN MODIFIED,
400 mm, f/1.8.

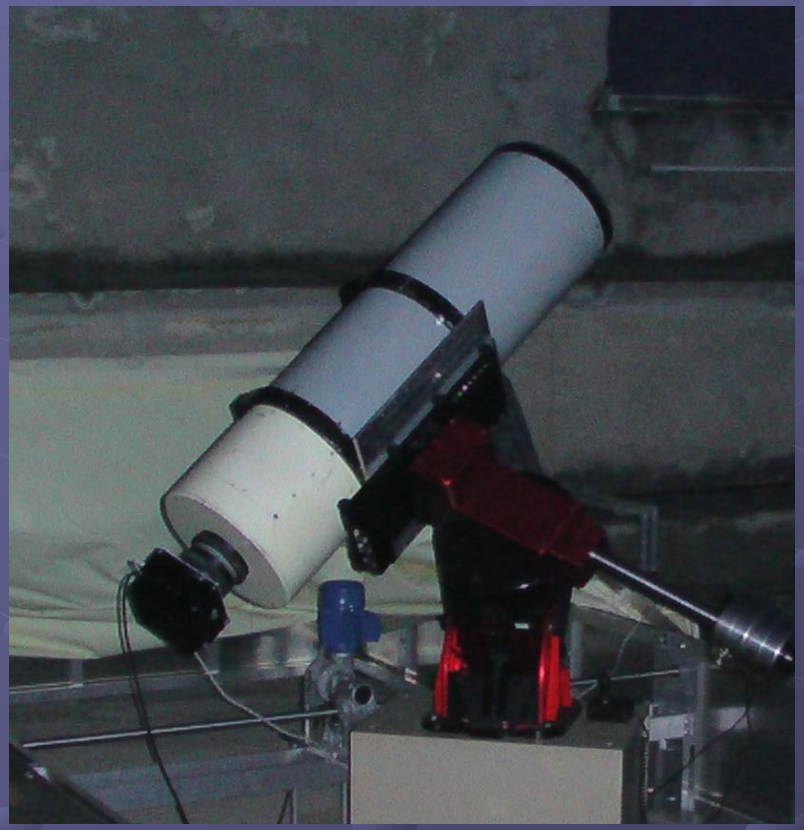


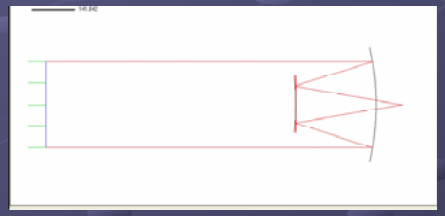




OPTICS/2

BAKER-SCHMIDT
300 mm, f/2.8





Space debris optical observation and orbital determination