

An Overview of the Brazilian Space Program

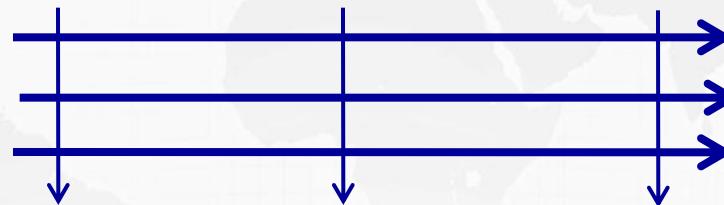
Thyrso Villela



Goals

To maximize returns
to society in terms of

To execute
programs
aiming at

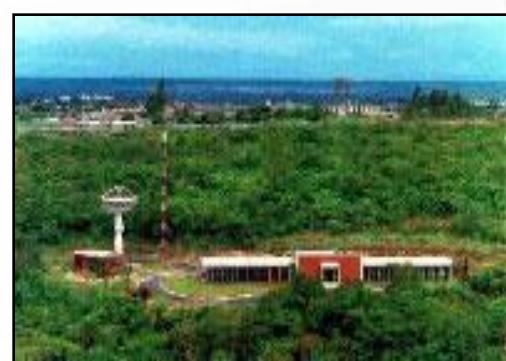


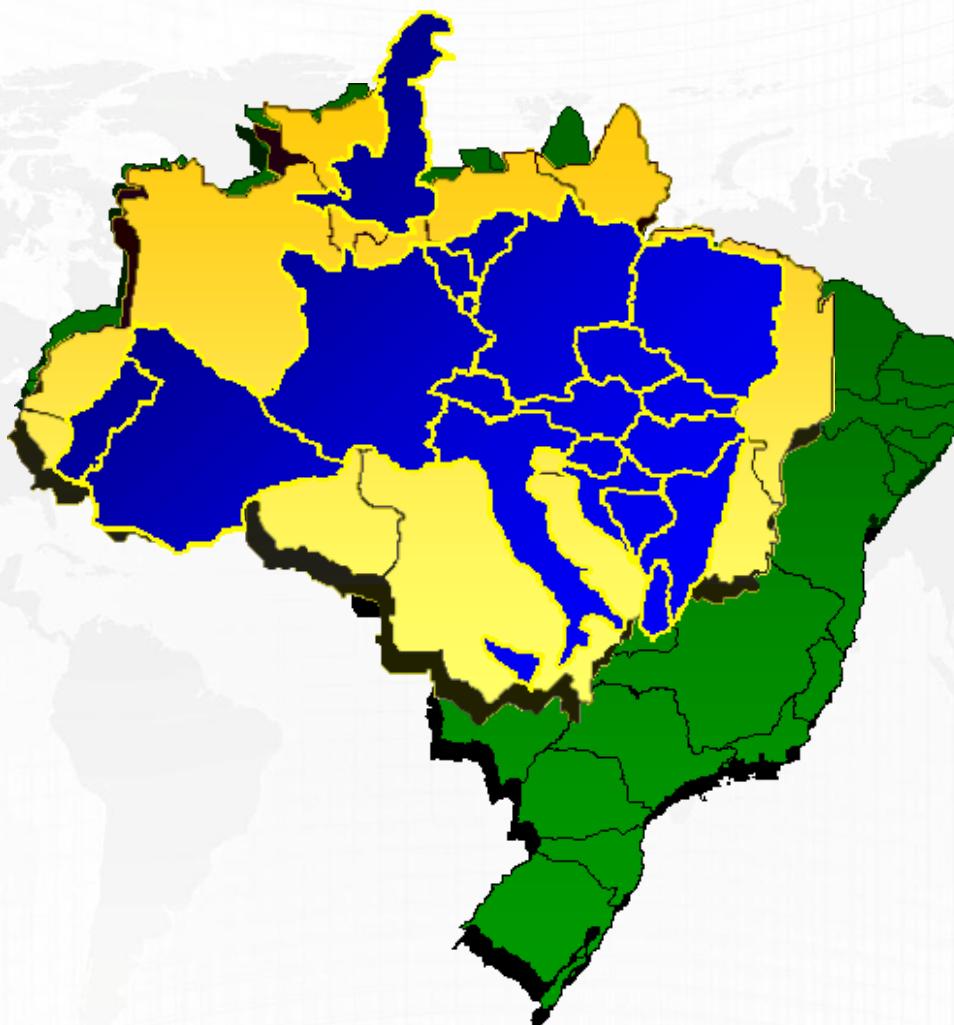
To promote
excellence in C&T
and innovation in
the Space Area

Products
and
Services

Industrial
Policy

Diffusion of
Knowledge





Earth observataion from space is mandatory!

Area: 8.5 million km²...





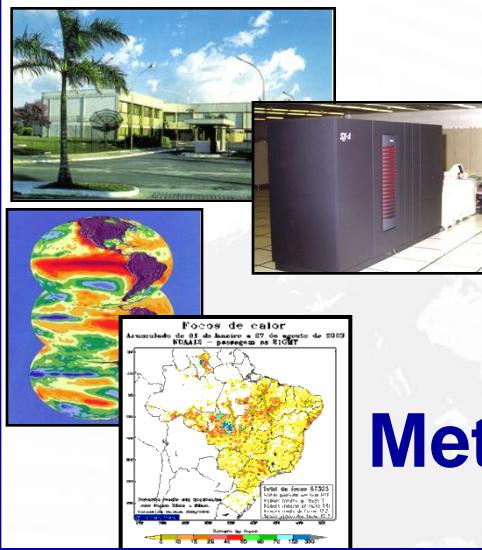
Borders...

Land: 15800 km

Maritime coast: 7400 km

~190 million people...



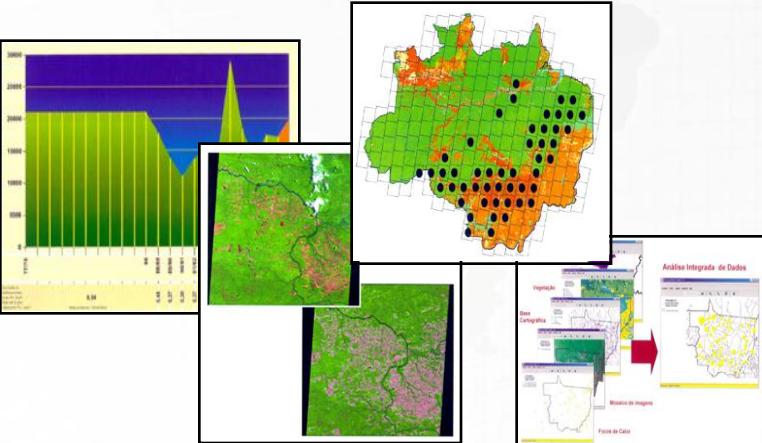


Meteorology

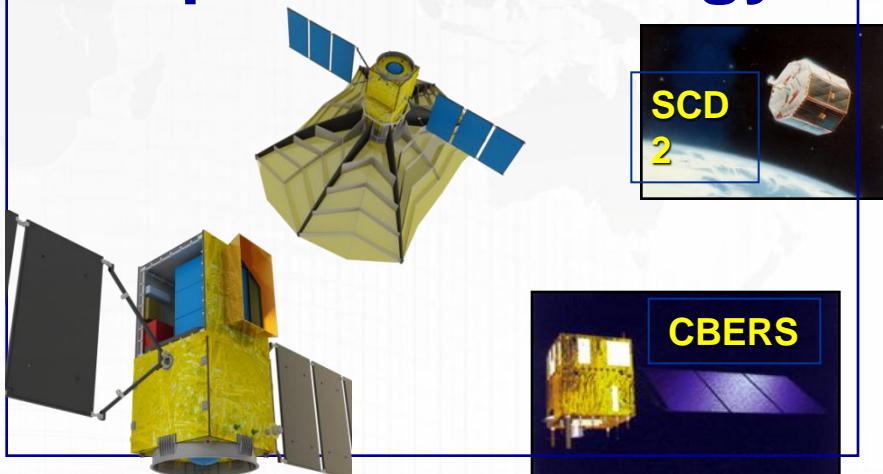


Space Sciences

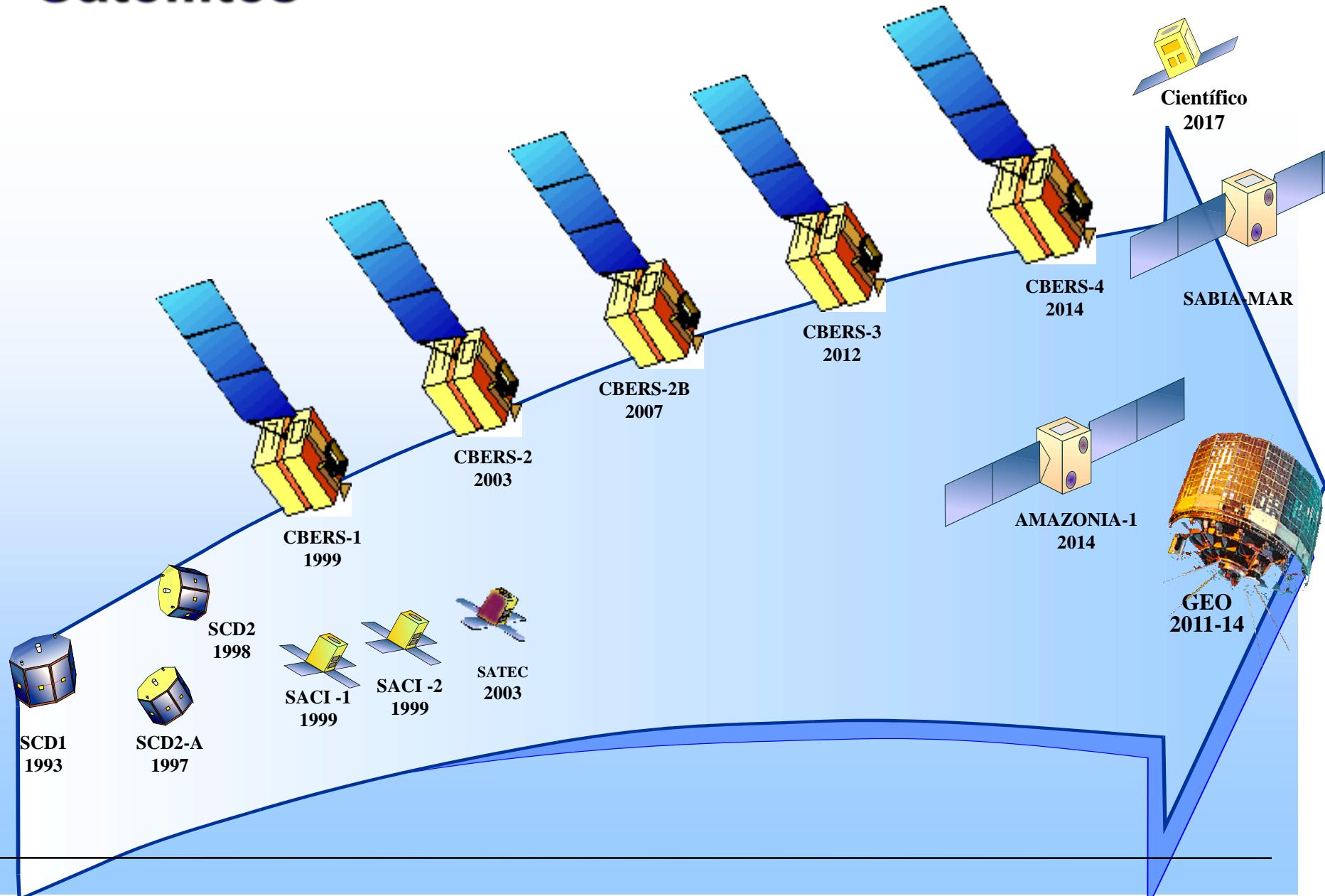
Earth Observation



Space Technology



Satellites



Heritage

MECB Program beginning: 1979

SCD-1: launched in 1993

SCD-2: launched in 1998



CBERS Program beginning: 1988

CBERS-1: launched in 1999

CBERS-2: launched in 2003

CBERS-2B: launched in 2007



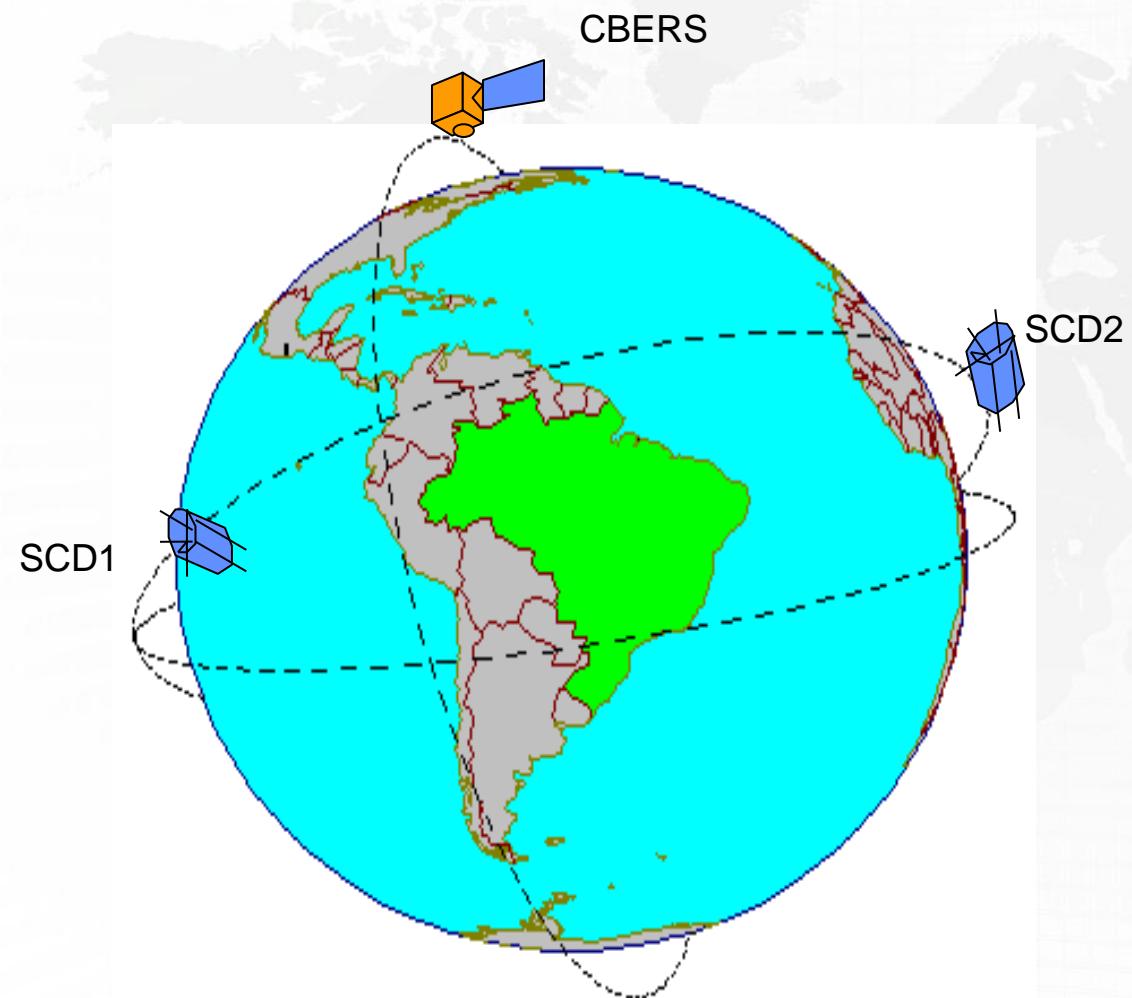
Data Collecting Satellites



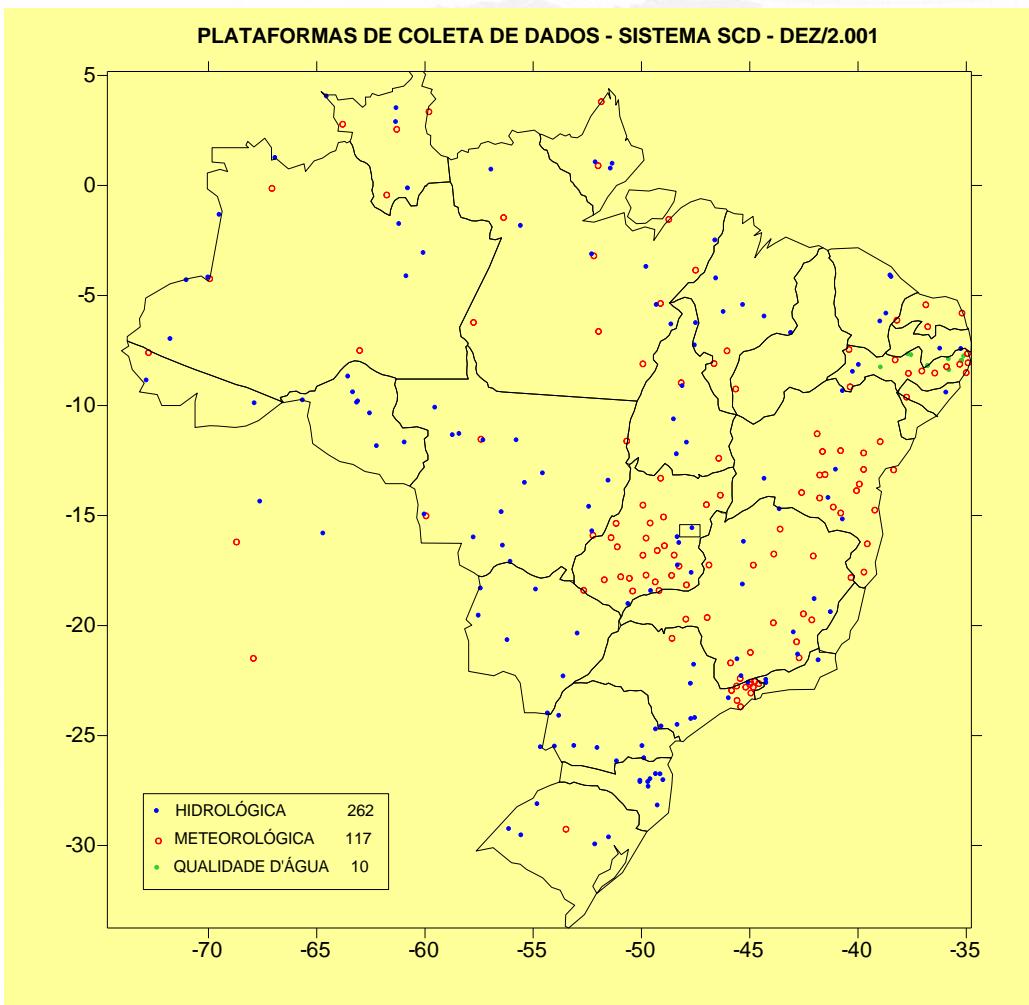
SCD1: 1993
SCD2: 1998

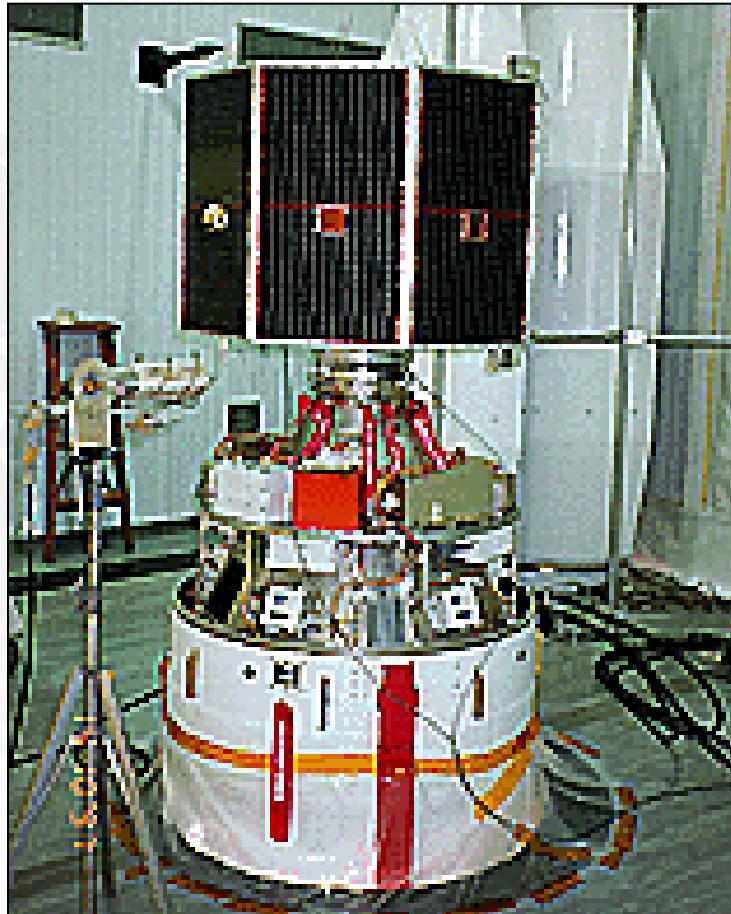


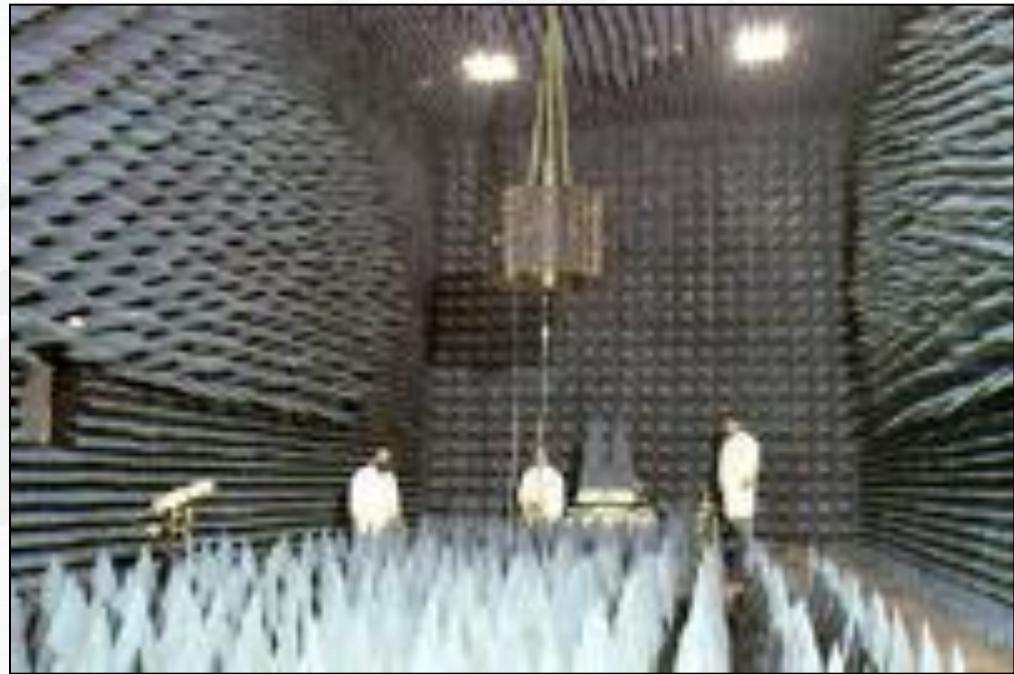
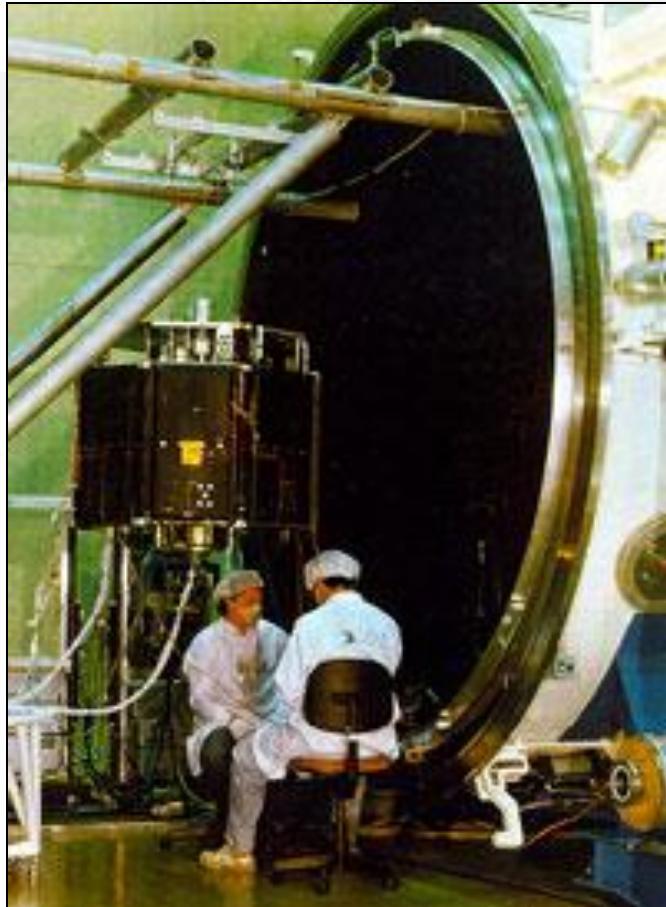
Data Collecting Mission



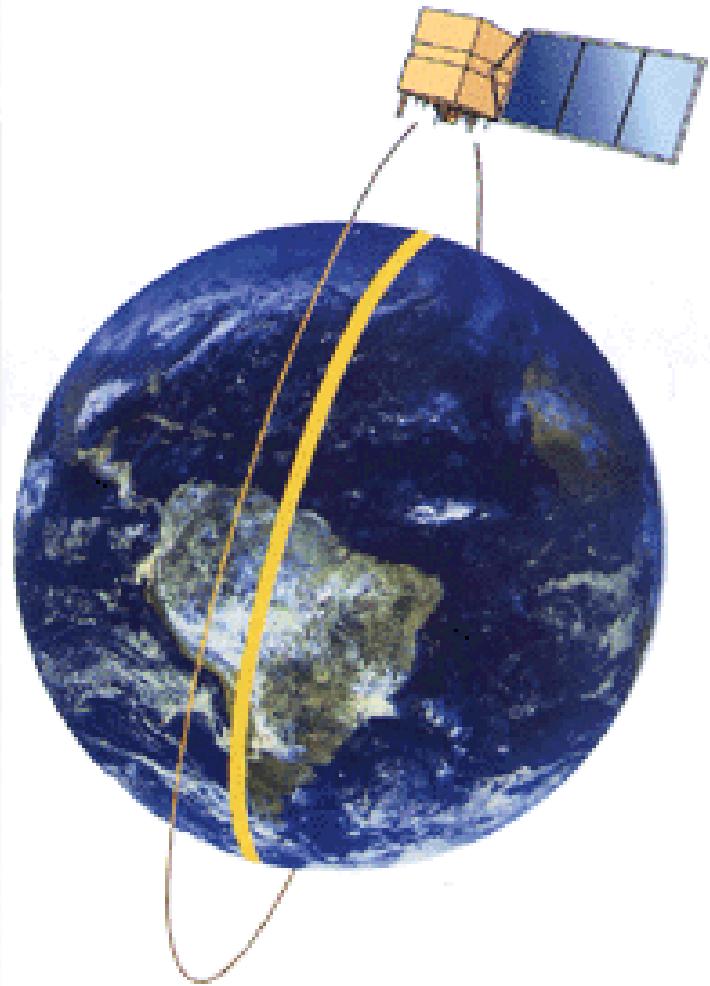
SCD







China – Brazil Earth Resource Satellites CBERS





CBERS 1
October, 1999

CBERS 2
October, 2003

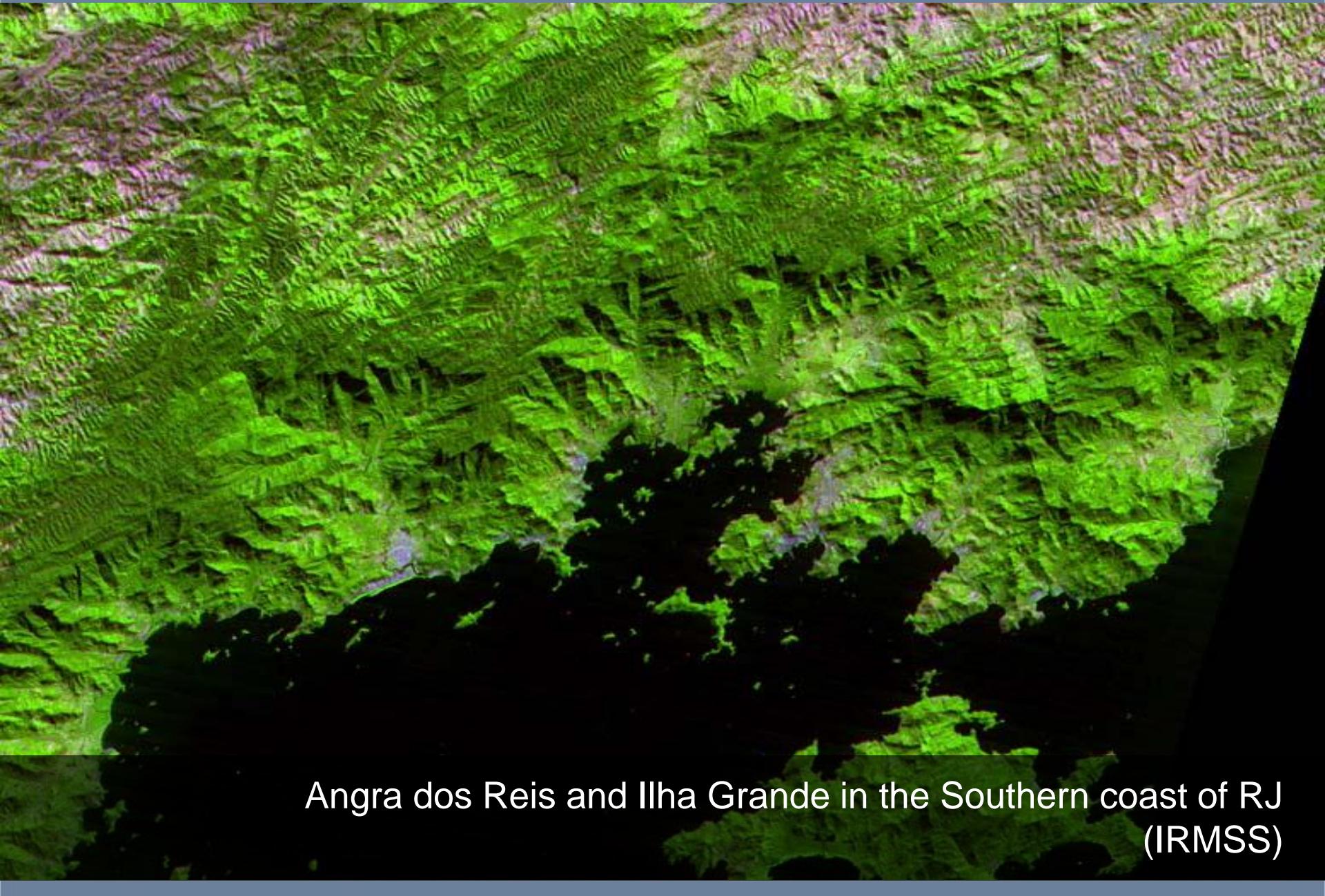
CBERS-2B
September, 2007



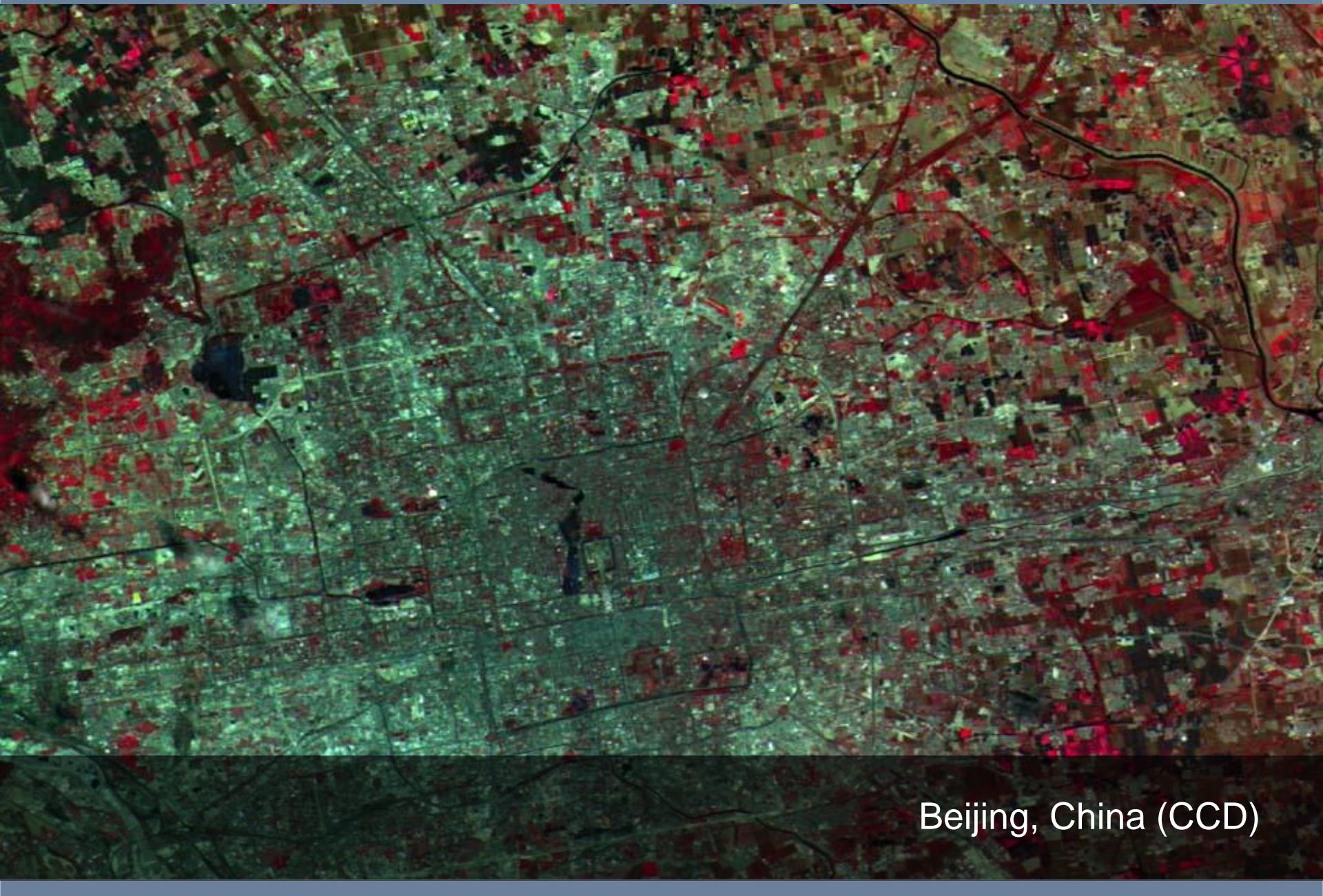
CBERS-1 and 2 characteristics



| | | |
|------------------------|----------------|---|
| Total mass | 1540 kg | 80 kg hydrazine |
| Mechanical structure | 1.8x2.0x2.2 m | aluminum and carbon fiber |
| Electrical power | 1100 W | 14 m ² silicon solar panel two 30 Ah NiCd batteries |
| Propulsion system | hydrazine | 16 thrusters (1 N) 2 thrusters (20 N) |
| Pointing accuracy | 0.2 degree | reaction wheels, magneto-torquers, gyros and sensors |
| On-board data handling | distributed | 10 micro-processors |
| Telemetry and command | UHF and S-band | ESA standard for S-Band |
| Reliability | 0.6 | After 2 year lifetime |



Angra dos Reis and Ilha Grande in the Southern coast of RJ
(IRMSS)



Beijing, China (CCD)

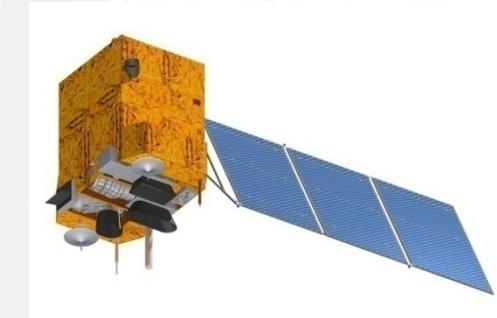


Northern China (CCD)



CBERS 3 and 4 Main Characteristics

| | |
|------------------|------------------|
| Mass | 1980 kg |
| Dimensions: | |
| Body | 1.8 x 2.3 x 3.2m |
| Solar Array | 2.6 x 6.4m |
| Electrical Power | 2300 W |
| Payload Bit Rate | 303 Mbits/sec |
| Lifetime | 3 years |



CBERS-3 and 4 Payloads

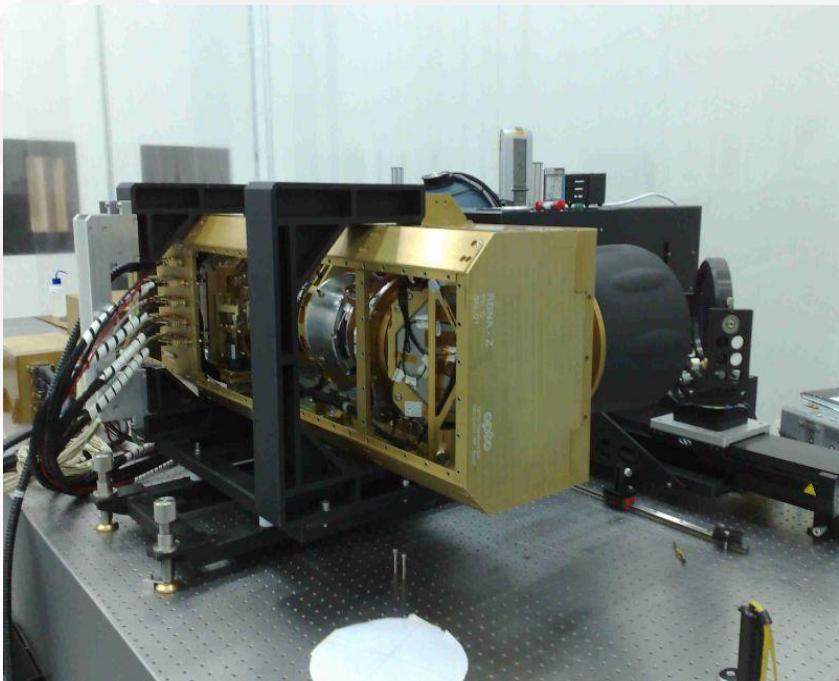
| Payload | Geometric Resolution | Spectral Bands | Swath Width | Revisit |
|-------------------|---------------------------|---------------------|-------------------------------|---------|
| PAN Camera | 5 m 10 m | PAN G, R, NIR | 60 km, lateral view 32° | 52 days |
| MUX Camera | 20 m | B, G, R, NIR | 120 km | 26 days |
| IRS Camera | 40 m 80 m | PAN, SW, MIR TIR | 120 km | 26 days |
| WFI Camera | 73 m | B, G, R, NIR | 866 km | 5 days |
| DCS | Data Collecting Subsystem | | | |
| SEM | Space Environment Monitor | | | |

China-Brazil Subsystem Work Share

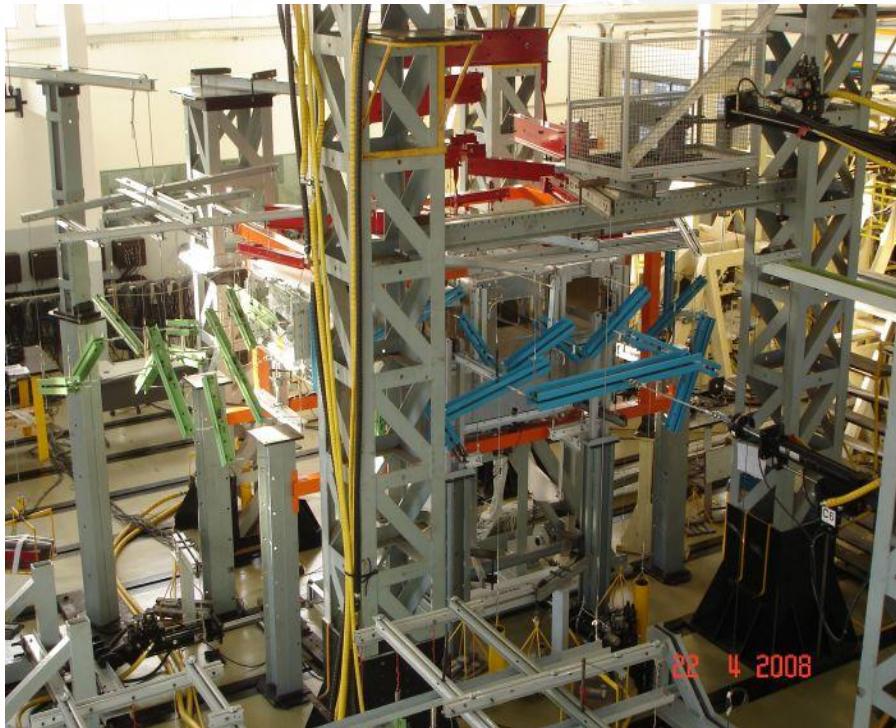
| China | Brazil |
|--------------------------------|--------------------------------------|
| TCS - Thermal Control | Structure |
| AOCS - Attitude Control * | EPSS - Electrical Power Supply |
| OBDH - Onboard Data Handling * | TTCS – Service Telecommunications |
| SCS - System Circuitry | MUX camera (20m) |
| PAN camera (5m) | WFI-2 camera (73m) |
| IRS camera (40m) | DDR – Data Recorder |
| SEM – Space Environment | DCS – Data Collecting |
| PIT – Data Transmitter | MWT – Data Transmitter |

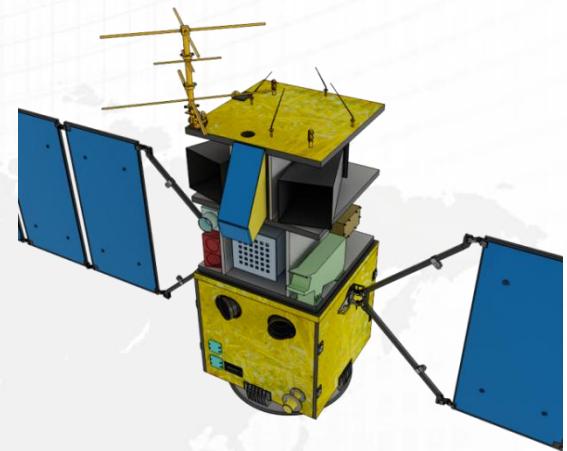
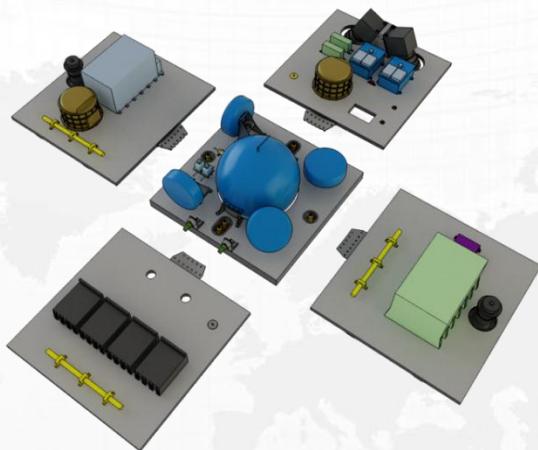
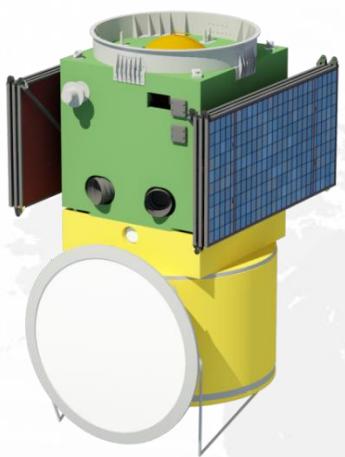
* AOCC, CTU and RTU are part of the Brazilian share

WFI/MUX

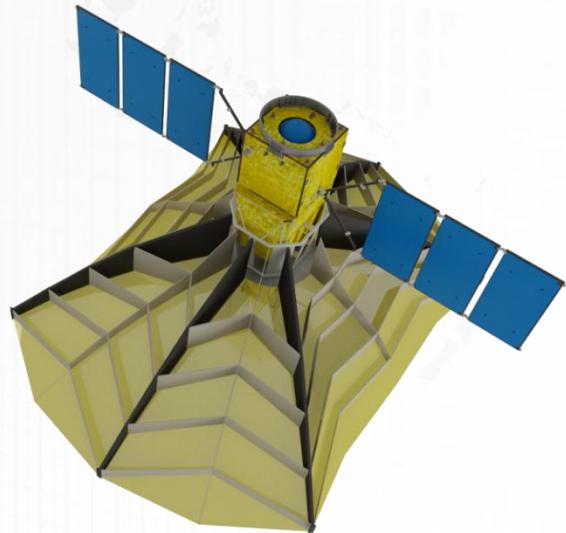
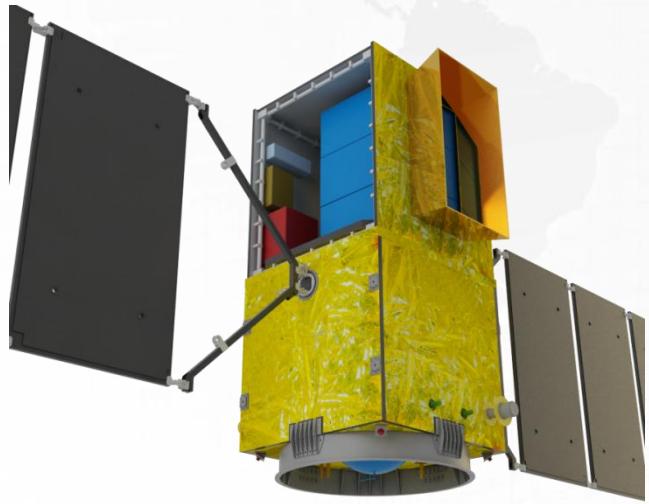


Structural Model – Static Tests

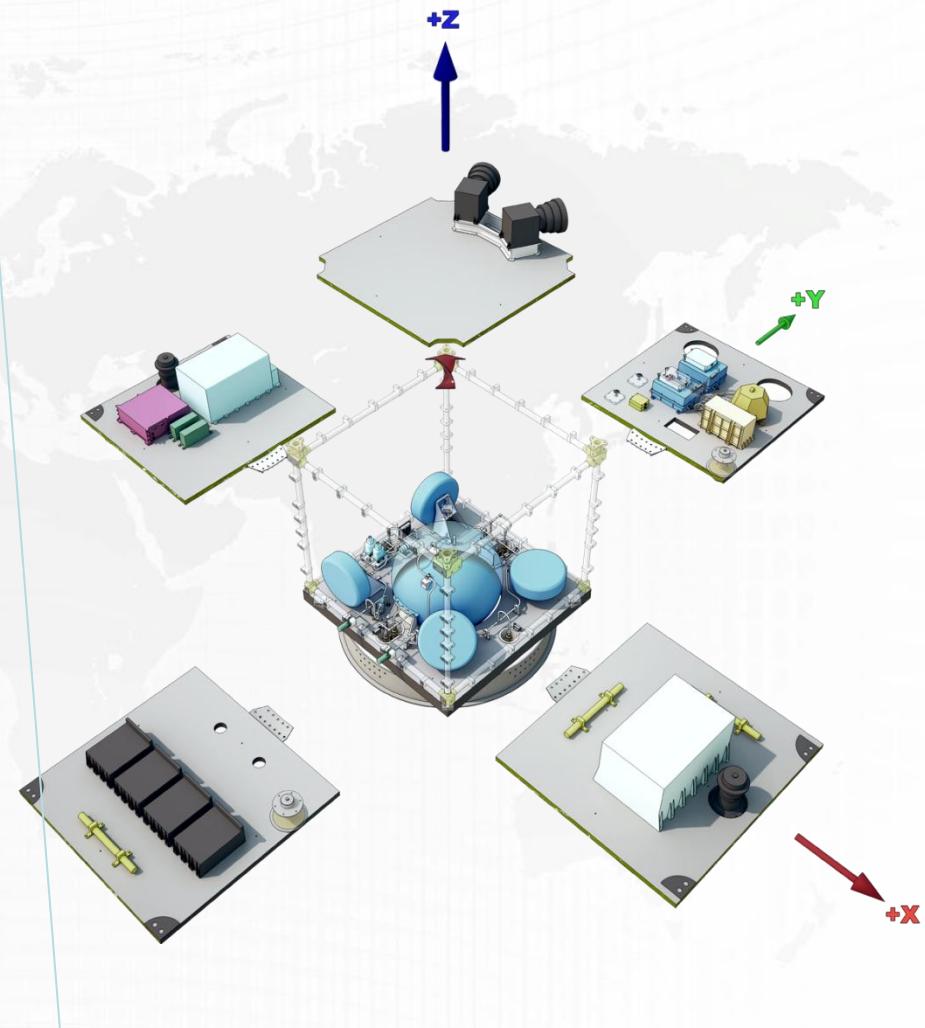
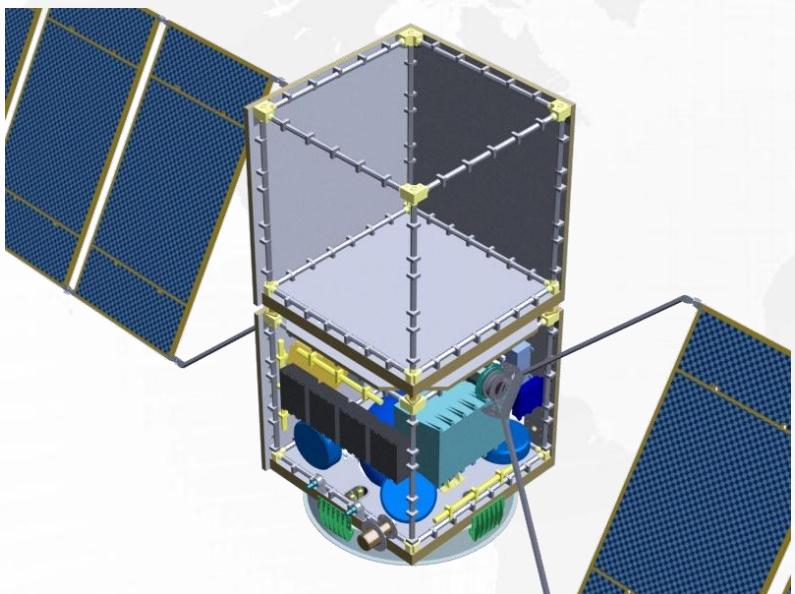




The Multi-Mission Platform (PMM) & Applications



PMM pictorial view

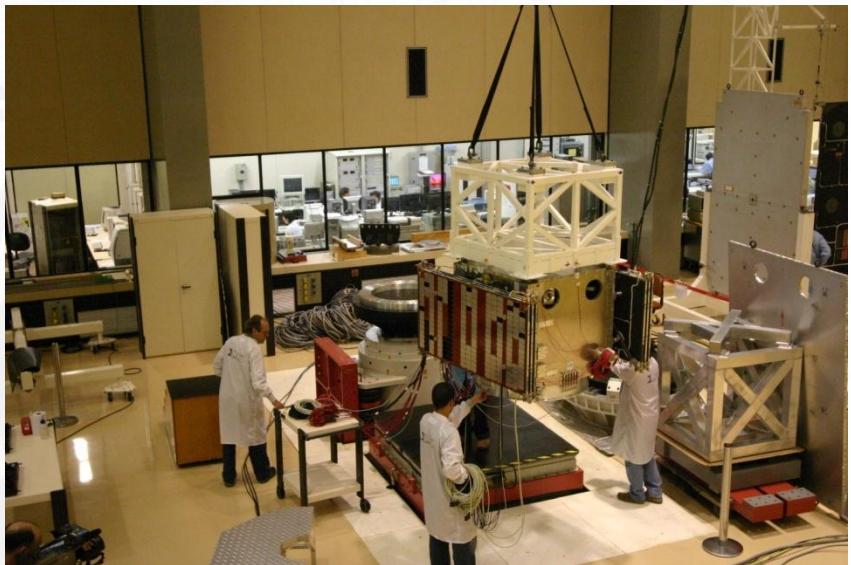
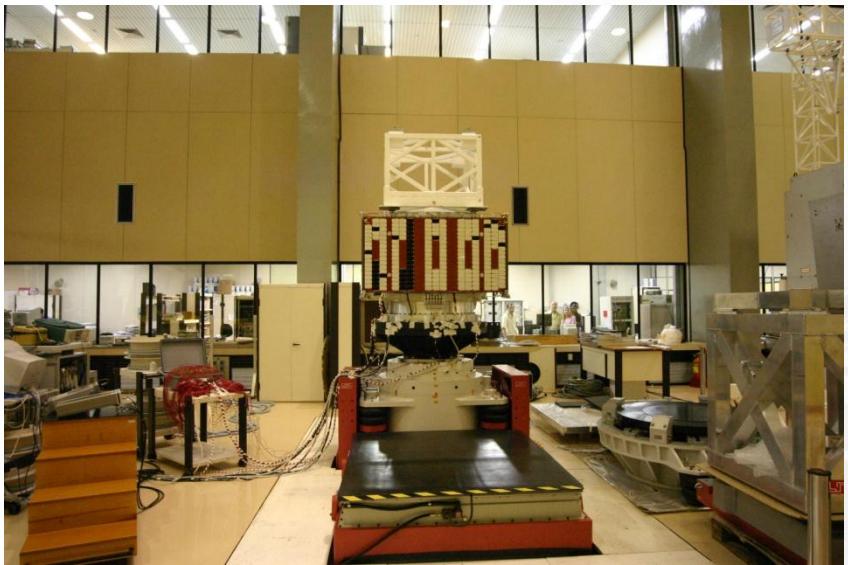


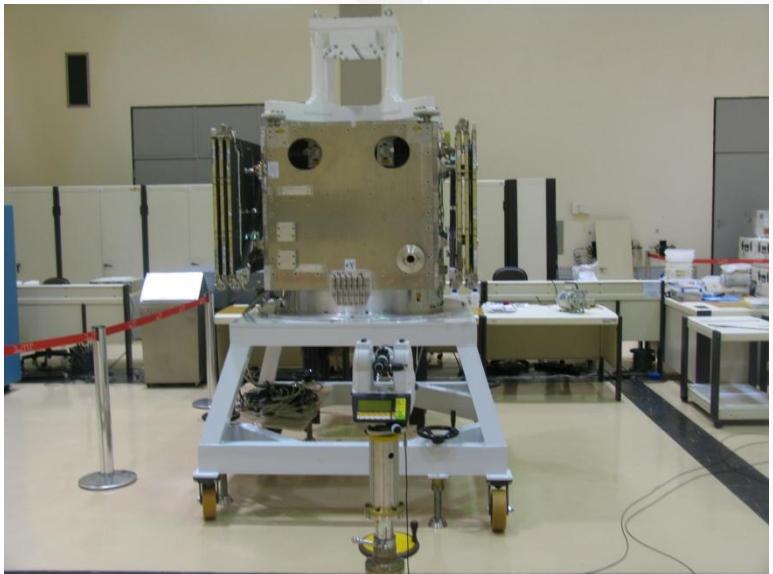
ACDH:

- **Pointing:** $< 0.05^\circ \text{ (} 3\sigma \text{)}$
- **Stability (*Drift*):** $< 0.001^\circ/\text{s}$
- **Attitude determination:** $< 0.005^\circ \text{ (} 3\sigma \text{)}$
- **Jitter** $< 0.0001^\circ$
- **Agility:** $30^\circ \text{ in } 180 \text{ s}$

Payload:

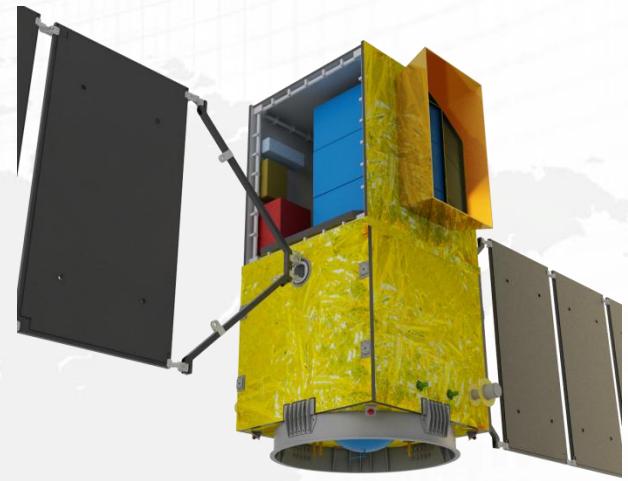
- **Mass:** up to 280 kg
- **Volume:** ~1x1x1m
- **Power:** 225 W average
900 W peak
- **Orbit:** near-equatorial & polar
600 to 1200 km altitude





Amazônia 1

- First satellite with PMM
- Optical payload
- PMM flight demonstration
- Amazon monitoring / deforestation

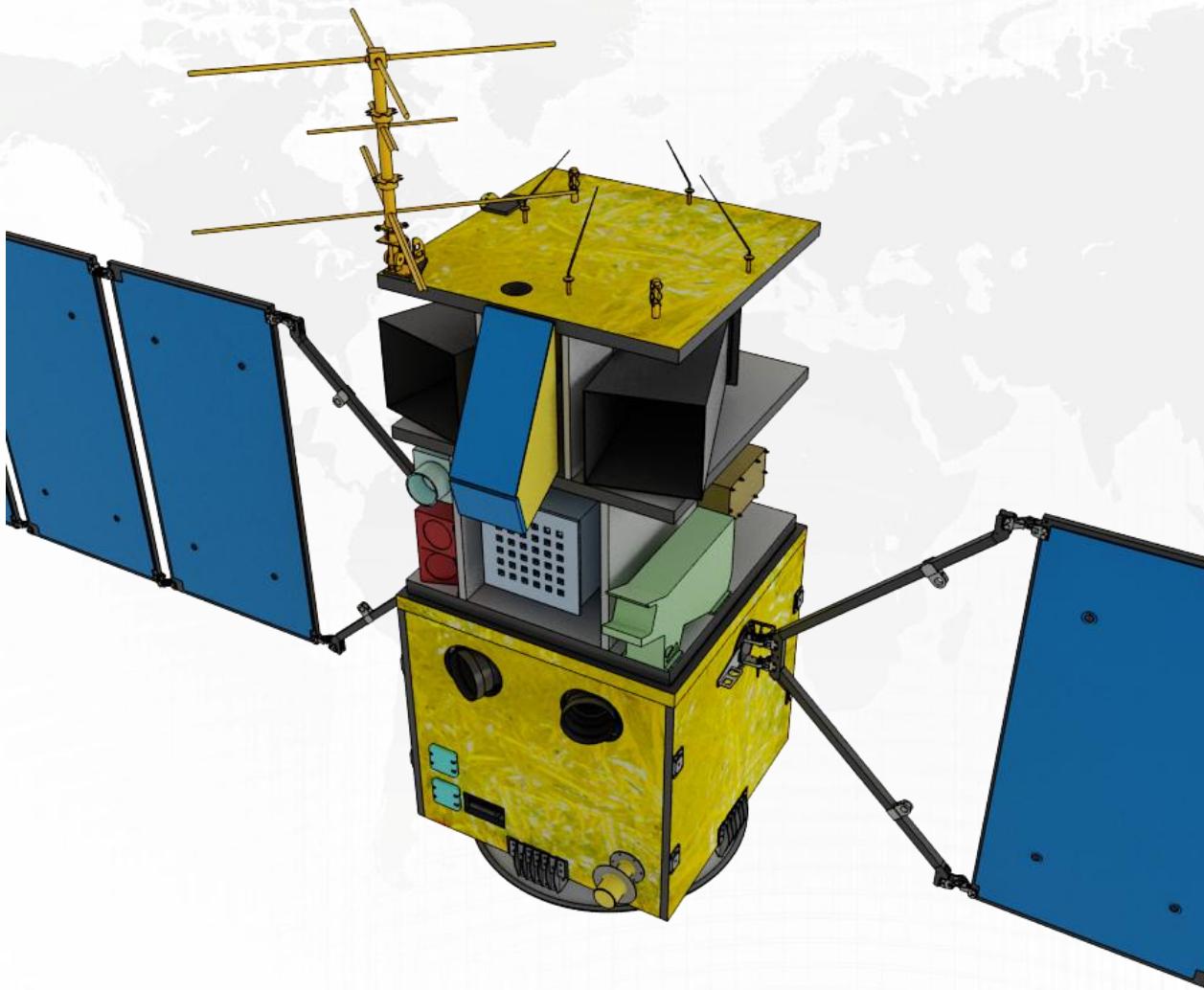


| AWFI | |
|----------------------------|--|
| Spectral Bands (μm) | 0.45-0.52 B 0.52-0.59 G 0.63-0.69 R 0.77-0.89 NIR |
| Resolution (m) | 40 |
| Swath width (km) | 700 |
| Revisit (days) | 5 |

Global coverage every two days together with CBERS-3

Scientific satellite

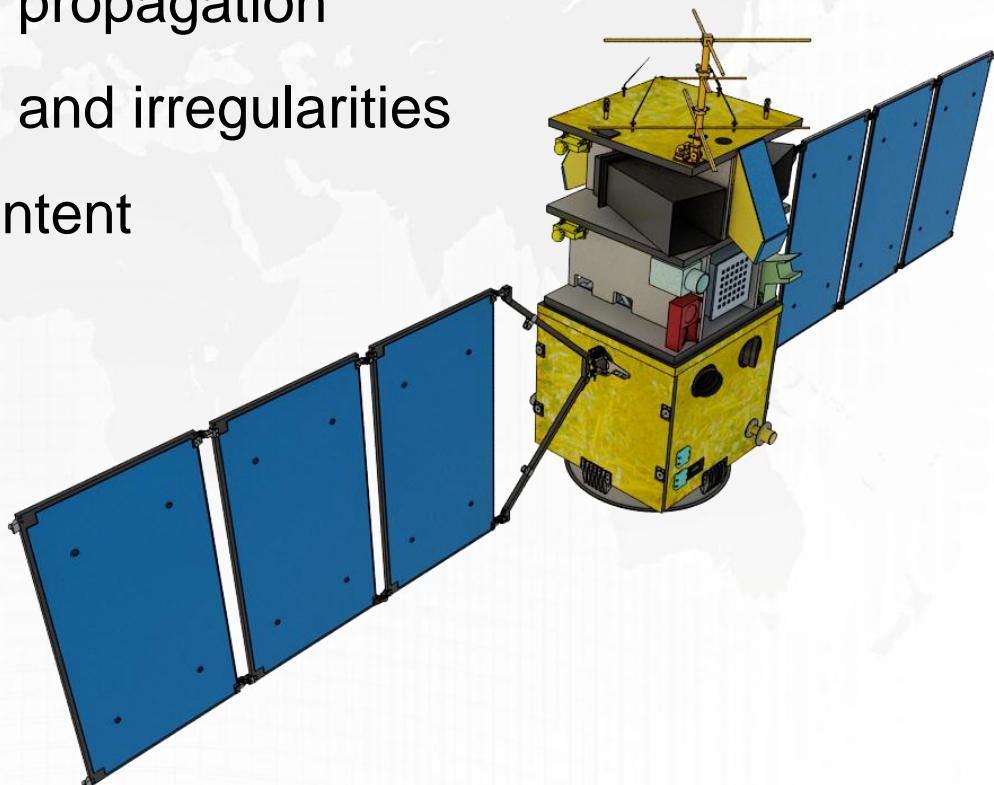
- Equars
- Mirax



Equars - *Equatorial Atmosphere Research Satellite*

- ✓ Temperature variation on the stratosphere and mesosphere
- ✓ Interplanetary gravity waves propagation
- ✓ Ionospheric plasma bubbles and irregularities
- ✓ Troposphere water vapor content

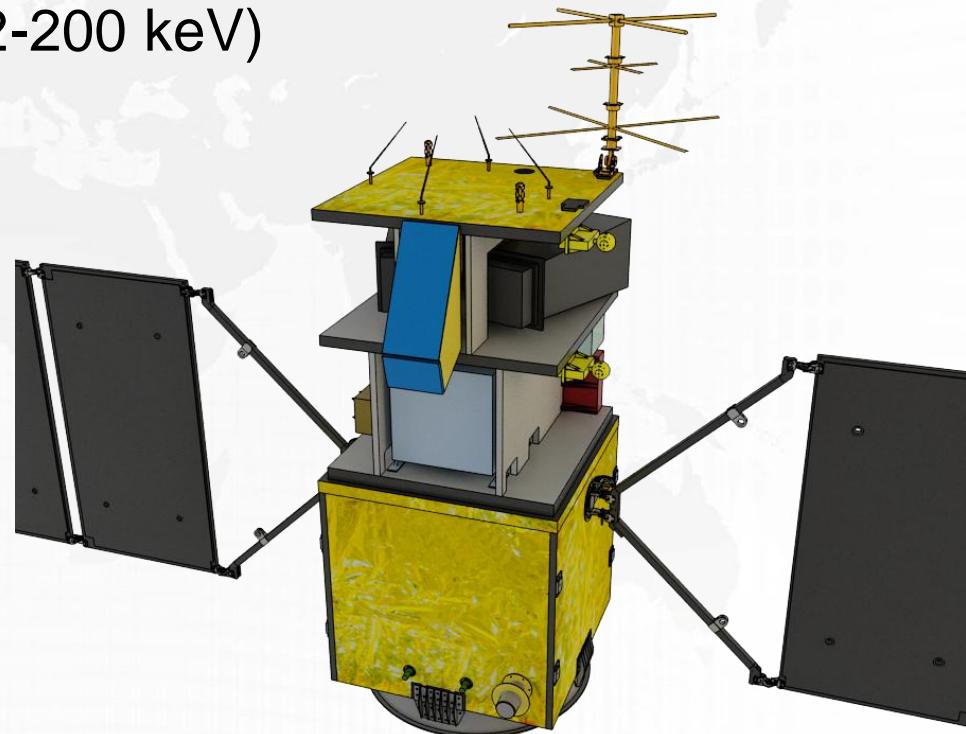
Geocentric pointing



Mirax – *Monitor e Imageador de Raios X*

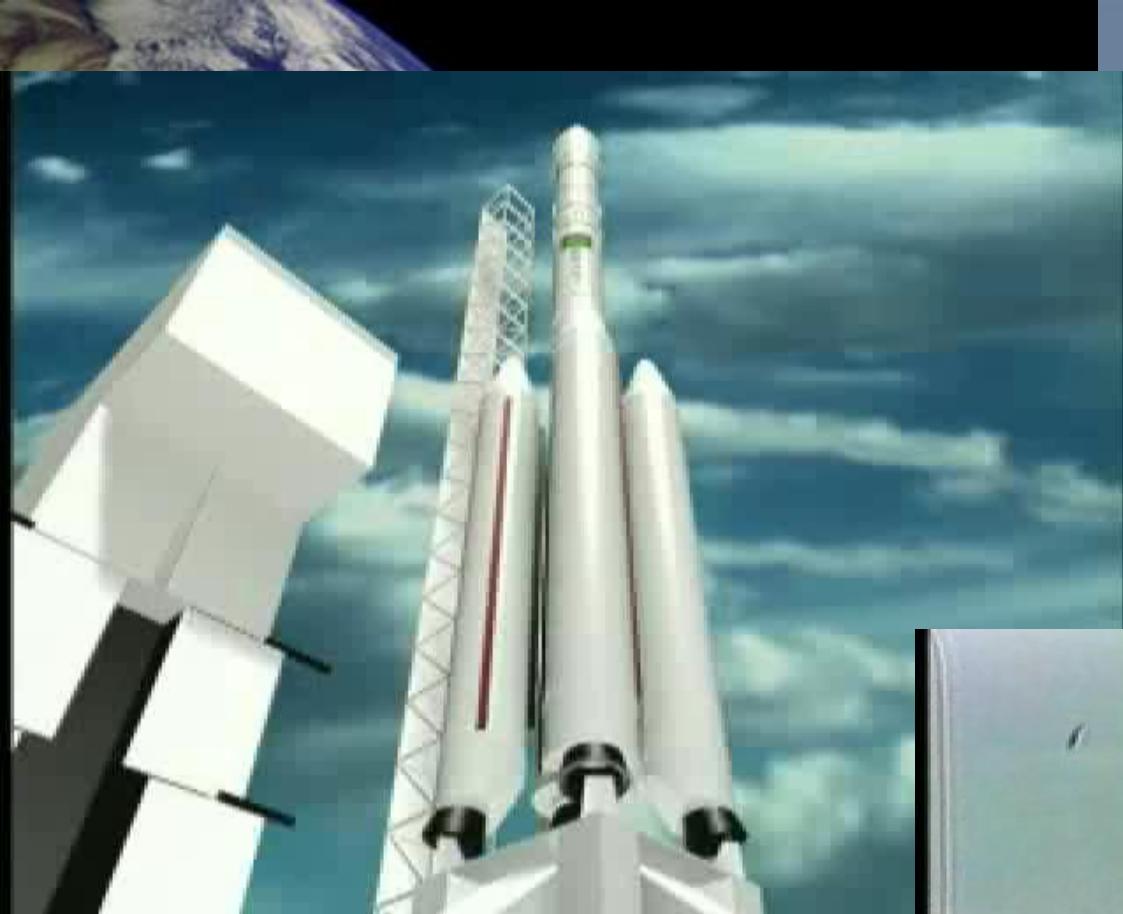
- ✓ Observation of X-ray sources of the Galactic Center
- ✓ Spectroscopy in a wide band (2-200 keV)

Inertial pointing / Galactic Center



Launchers

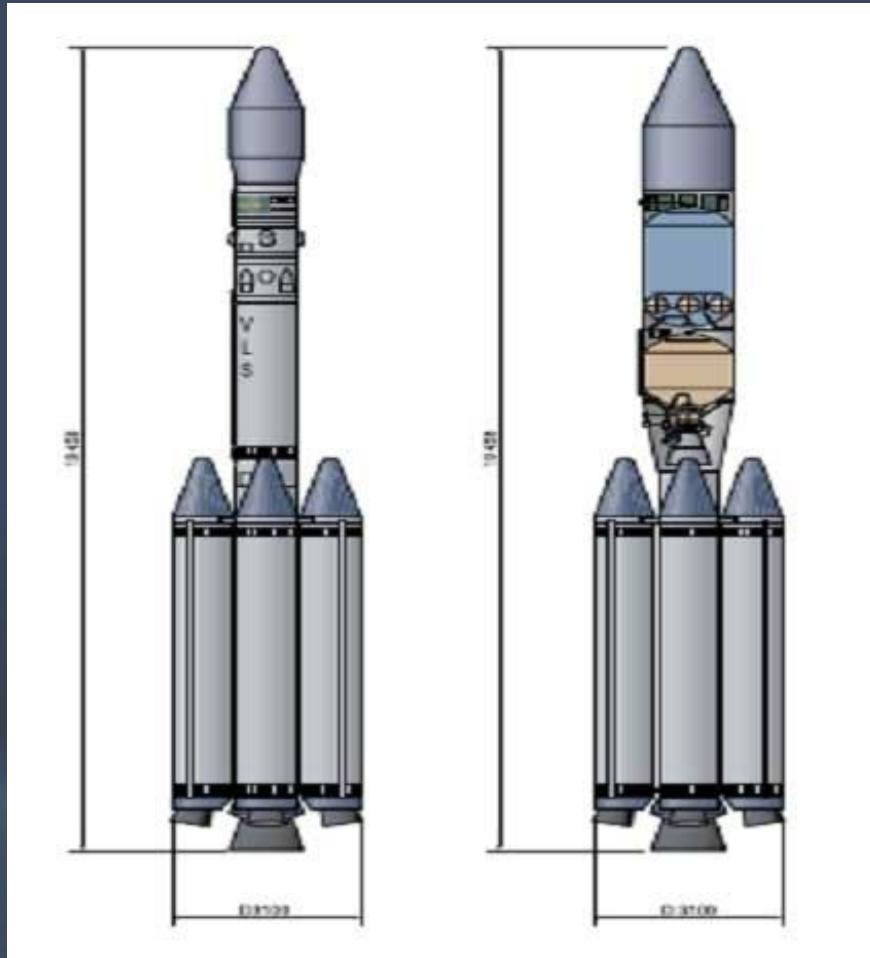
Sounding rockets



Sounding Rockets



Launchers

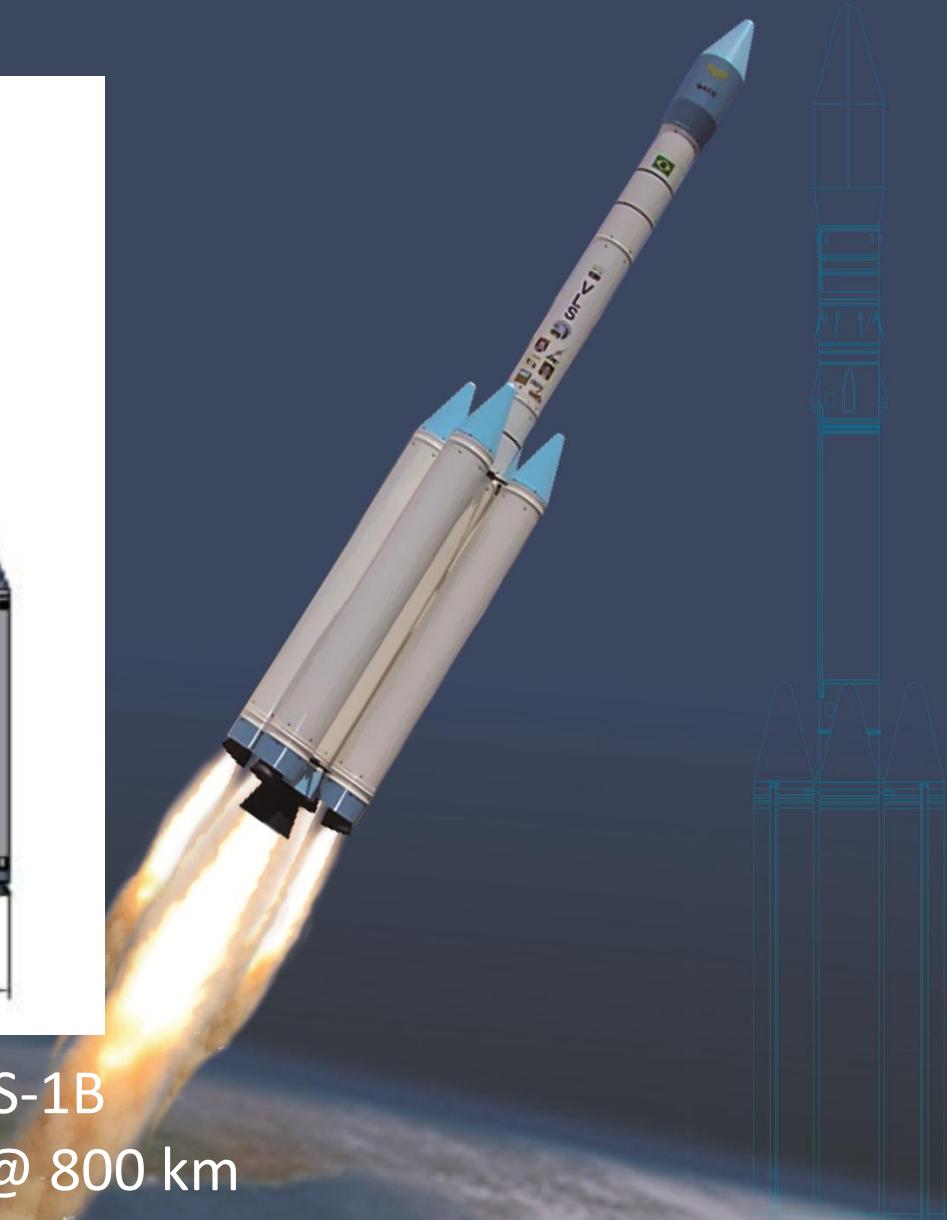


VLS-1

200 kg @ 600 km

VLS-1B

600 kg @ 800 km



Facilities

Support for Satellite
Development and Operations

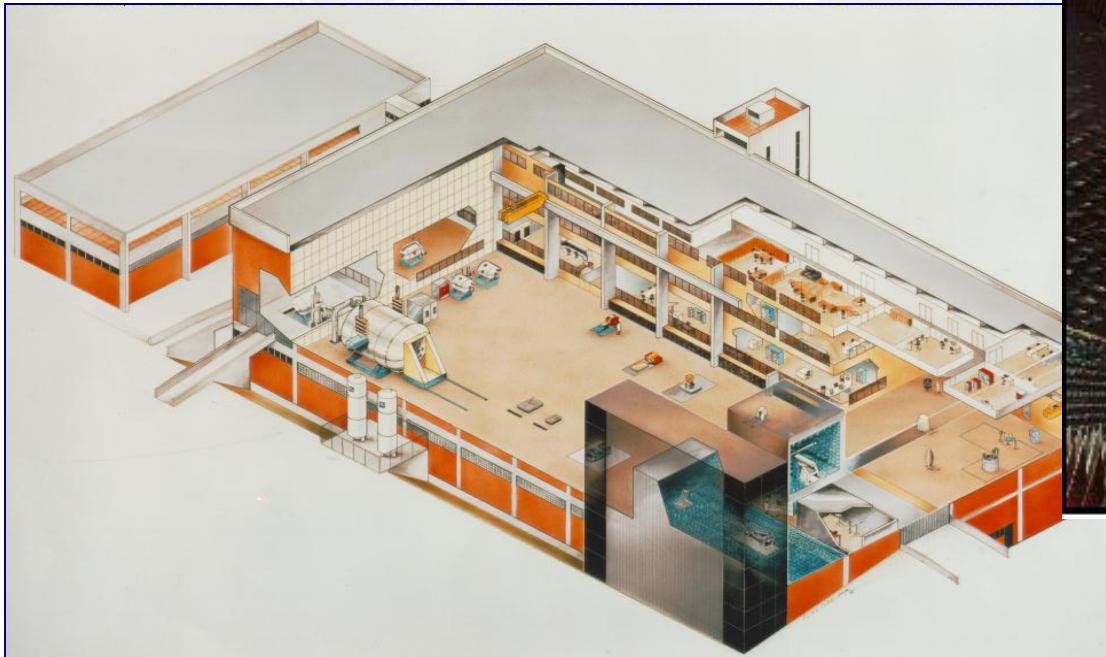
Ground Control Center



Facilities

Support for Satellite
Development and Operations

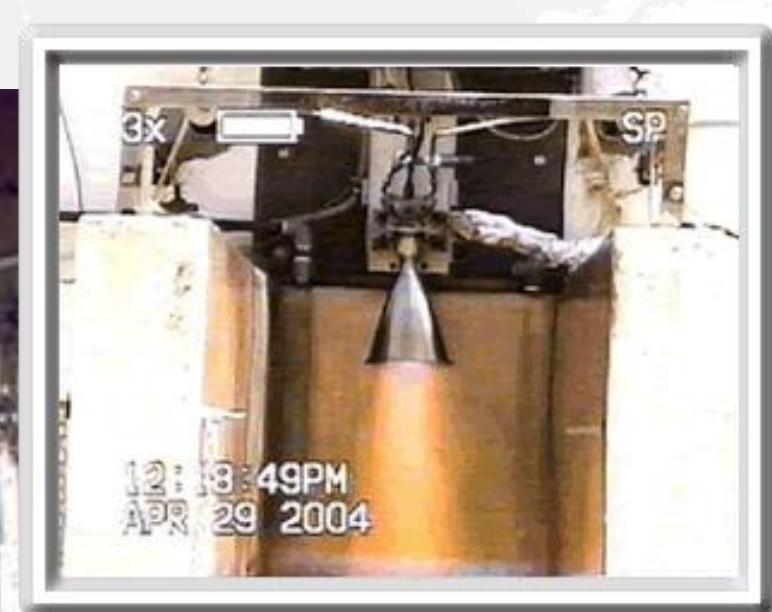
Integration and Test Lab - LIT



Facilities

Support to Satellite
Development and Operations

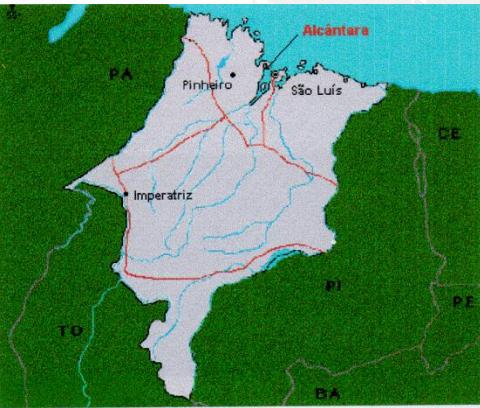
Propulsion and Combustion Lab



Facilities

Support for Launch Vehicles
Development and Operations

Alcantara Launch Complex



Alcantara Launch Center



ACS

Alcantara Cyclone Space

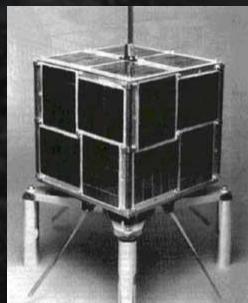
Brazil-Ukraine company

CYCLONE-4



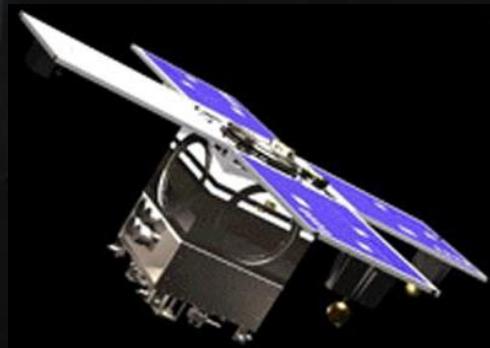
Earlier initiatives for low-cost and technological satellites in Brazil

Dove (Digital Orbiting Voice Encoder) – AMSAT-Br



Dove-OSCAR 17
22/01/90

SACI's (Satélites de Aplicações Científicas) - INPE



http://space.skyrocket.de/doc_sdat/saci-2.htm

SACI-1 15/10/99



http://space.skyrocket.de/doc_sdat/saci-2.htm

SACI-2 11/12/99

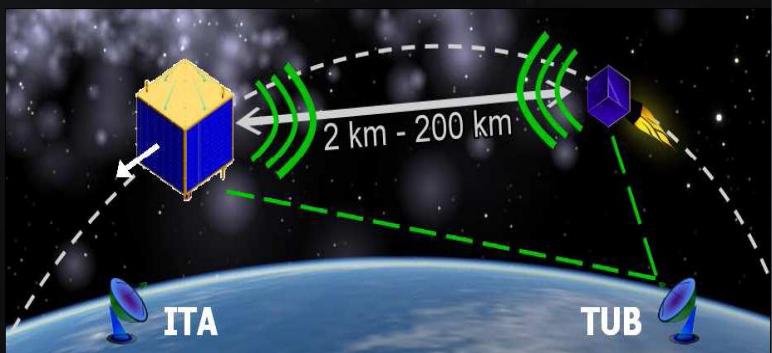
Itasat 1



Payloads:

- Digital data collection transceiver (CRN/INPE-UFRN)
- In orbit test of aluminum-acetone heat pipe (INPE-SJC)
- MEMS gyro experiment for attitude determination (UEL)

Formation Flying Experiment:
a leader-follower formation
with Itasat 1 and a TU Berlin
satellite



From :Timm, C.: Diplomarbeit, TU Berlin, 2011

We will have in-house options



VLS



Cyclone - 4



VLM