Small Missions at ESA

Giorgio Saccoccia

Luca Maresi, Frederic Teston, Andrea Santovincenzo

ESA and Small Satellites

Small satellites have been developed at ESA mainly as part of its In-Orbit Demonstration (IOD) approach.
Innovative key technologies have found opportunities for flight demonstration thanks to missions developed by Programme Directorates (mainly Science) and the Technical Directorate.
Funding by technology programmes (mandatory and optional) have been used in support of the development of the satellites and the key technologies to be tested.

In addition, ESA considers small satellites developed by Universities an excellent educational instrument for the formation of the future professionals in the space domain.

SMART-1

SMART-1 Demonstration: Electric Propulsion

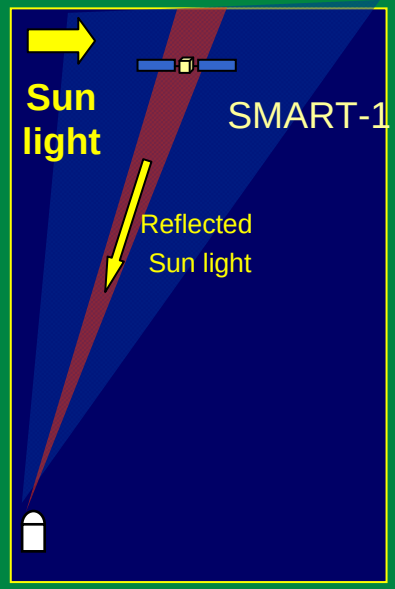
Power Processing Unit

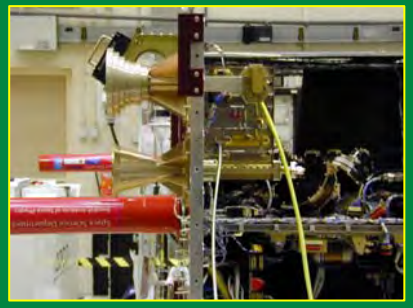
Flow Control Unit

Xenon Tank

PPS-1350
HET

SMART-1 Innovative Technologies

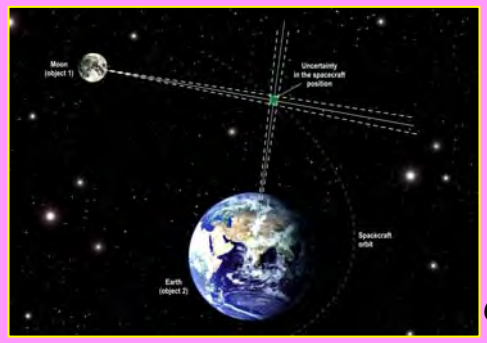




KA-band antenna

Laser Link

Communication



OBAN

Autonomy

Triple junction solar cells

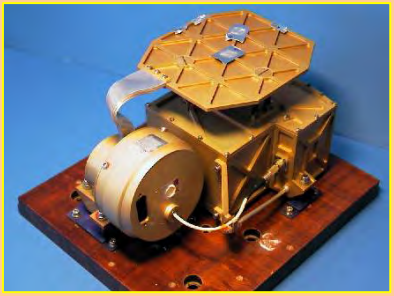
On-board computer

Lithium ion batteries

Platform Technologies

Multicolor microcamera

X-Ray Spectrometer



Infrared Spectrometer

Miniaturisation

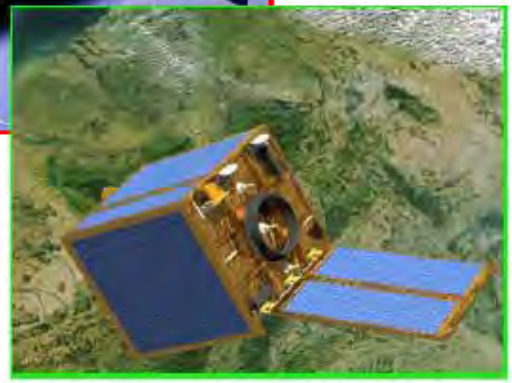
Small Techno Demo Missions: PROBA

Small Satellite Projects

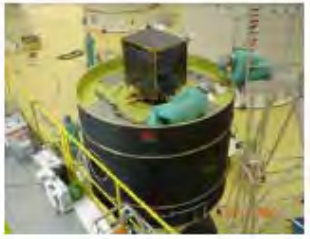
PROBA 1
Development: 1998-2001
Mission: 2001 – still fully operational

PROBA 2
Development: 2004-2008
Mission: Nov 2009 - …

PROBA 3 – in preparation
Development: foreseen 2009-2013
Mission: foreseen 2014 - …



PROBA V
Development: 2009-2011
Mission: 2012 - …



Sloshat- Flevo
Mission: Feb 2005

PROBA 1

Small technology demonstrator satellite for autonomous operations and Earth observation (launched in 2001)

Technology Demonstration / innovations:

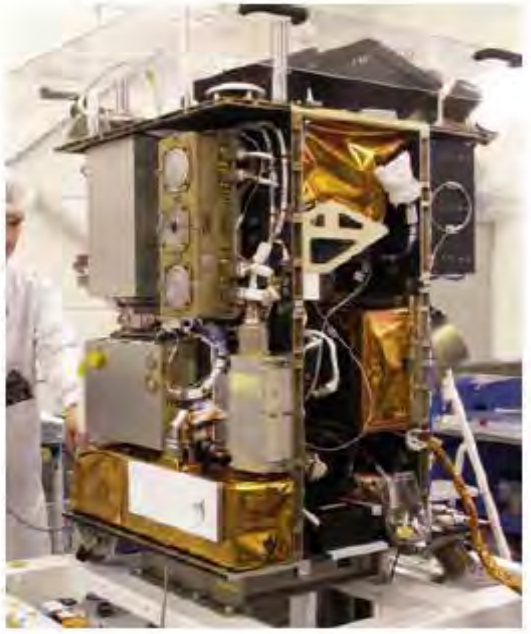
- Autonomous on board flight dynamics (position, attitude and maneuver determination)
- Avionics technology (ERC32, DSP, 3D modules)
- Low cost autonomous star tracker for attitude and rate
- Gyro-less maneuvering satellite
- Software methodology (auto coding and SVF)
- Battery technology (Li-ion)
- New instruments and sensor test (HRC, MRM, PASS, SIPs)
- Common ground infrastructure (EGSE and mission control centre)
- Ground segment automation
- Compact High Resolution Imaging Spectrometer (CHRIS)

PROBA 2

Small technology demonstrator satellite for autonomous operations and Sun monitoring (launched in 2009)

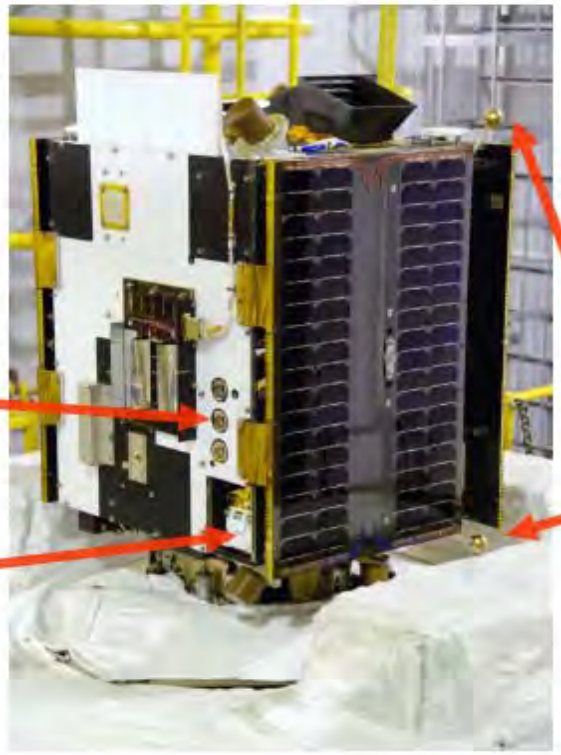
Platform:

- lithium-ion battery,
- advanced data and power management system based on LEON
- combined carbon-fibre and aluminium structural panels,
- new miniature reaction wheels
- Miniaturised star tracker
- COTS based GPS receivers
- digital Sun-sensor
- dual-frequency GPS receiver
- fibre-sensor system for temperatures and pressures
- APS based star-tracker (BepiColombo)
- New 3 axis magnetometers
- very high precision flux-gate magnetometer
- Solar panel with a solar flux concentrator
- solid-state nitrogen gas generator
- exploration micro-camera (X-CAM)
- new GNC algorithms



Instruments

PROBA 2 flies a new generation of miniaturised science instruments:



•LYman-alpha Radiometer (LYRA)

•Sun Watching using Active Pixel sensor (SWAP)

•Thermal Plasma Measurement Unit (TPMU)

•Dual Segmented Langmuir Probe (DSLP)

PROBA 3

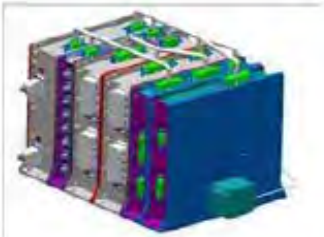
Formation Flying technology demonstration mission

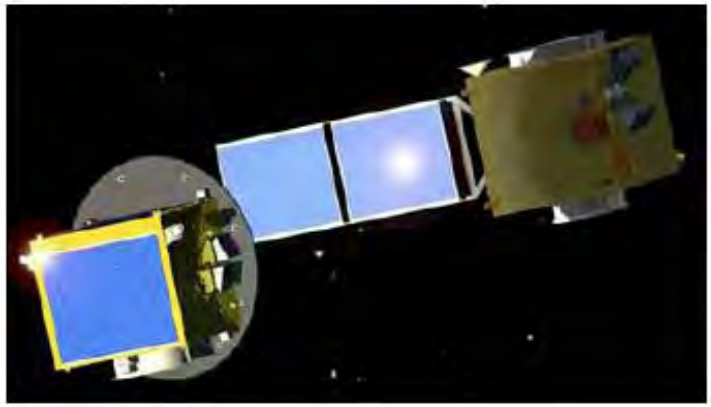
Technology Demonstration:

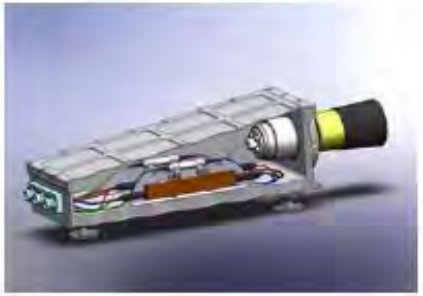
- GNC
- RF metrology
- Optical metrology
- Propulsion
- System
- Operations

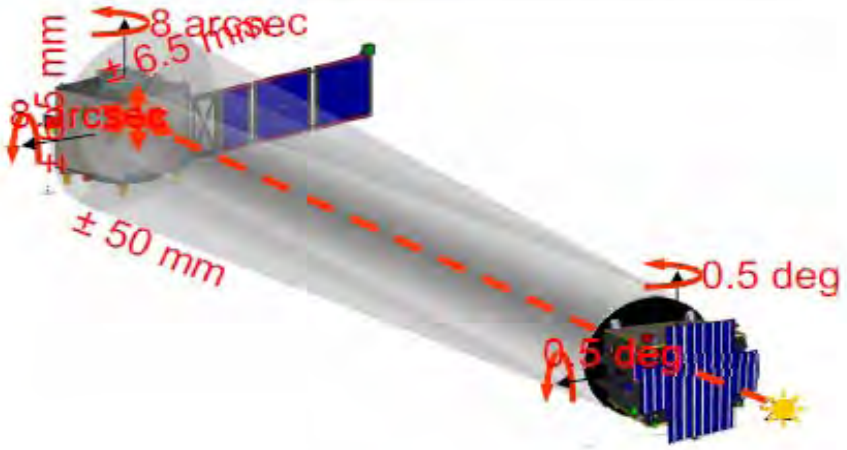
Payload

- Giant coronagraph









PROBA V

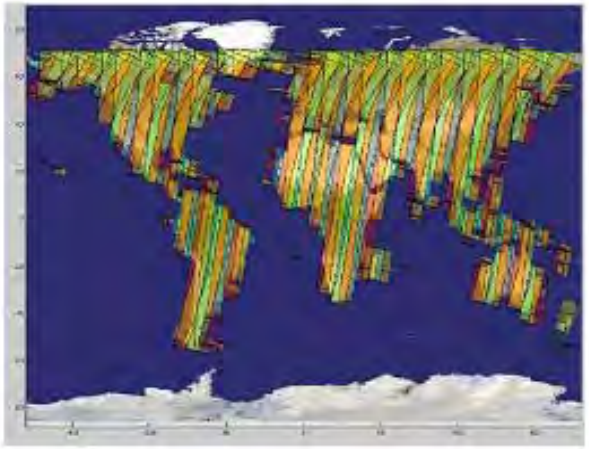
Gap Filler for Vegetation Mission

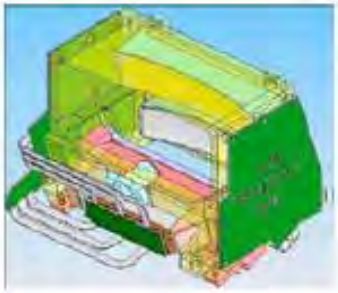
Technology Demonstration:

- SWIR detector
- GaN X band transmitter
- Wide angle TMA

Payload

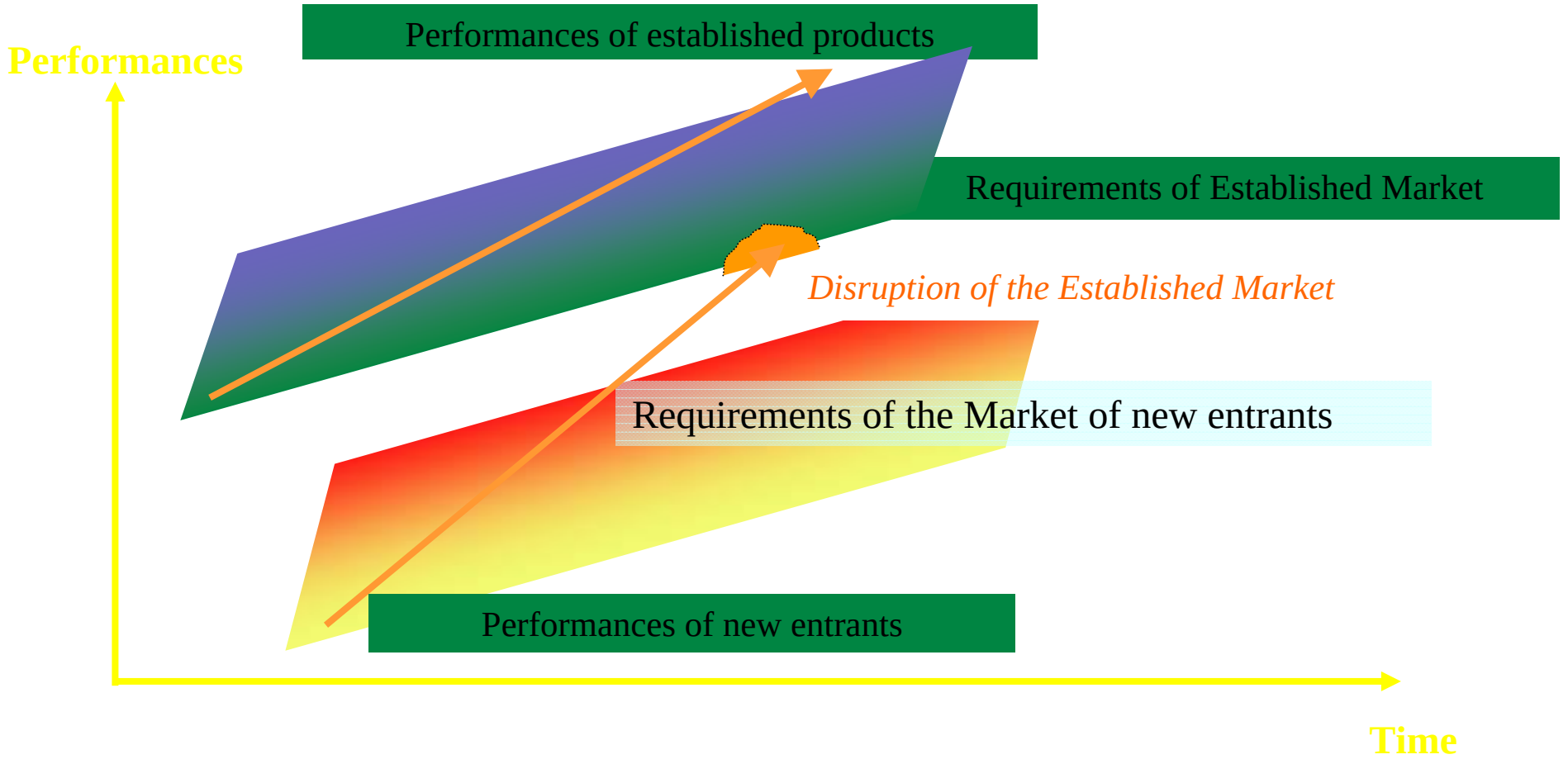
- Mutli-spectral imager



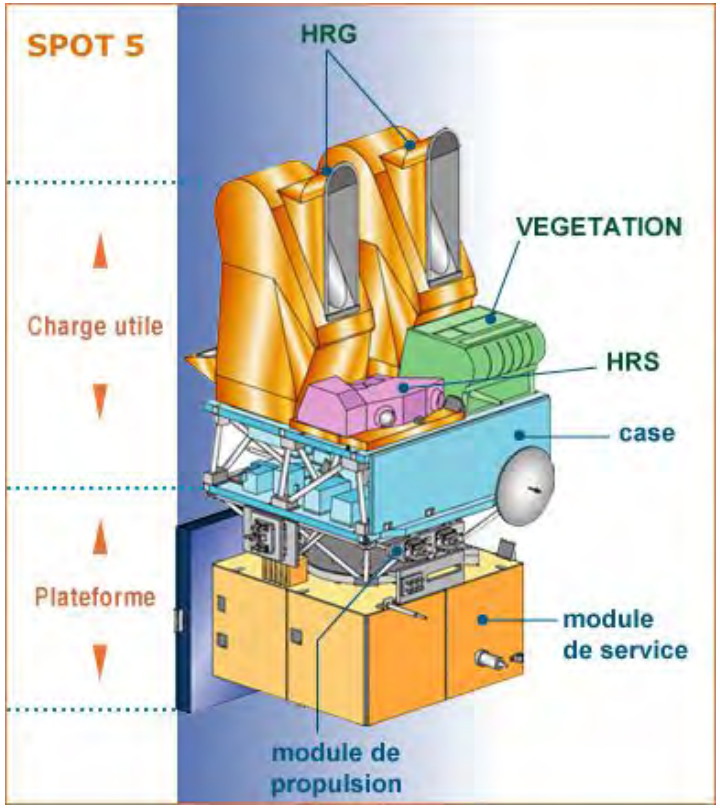


Innovation or Disruption?

Disruptive Technologies



Disruptive Approach



Mass of Spot-5: 3 tons

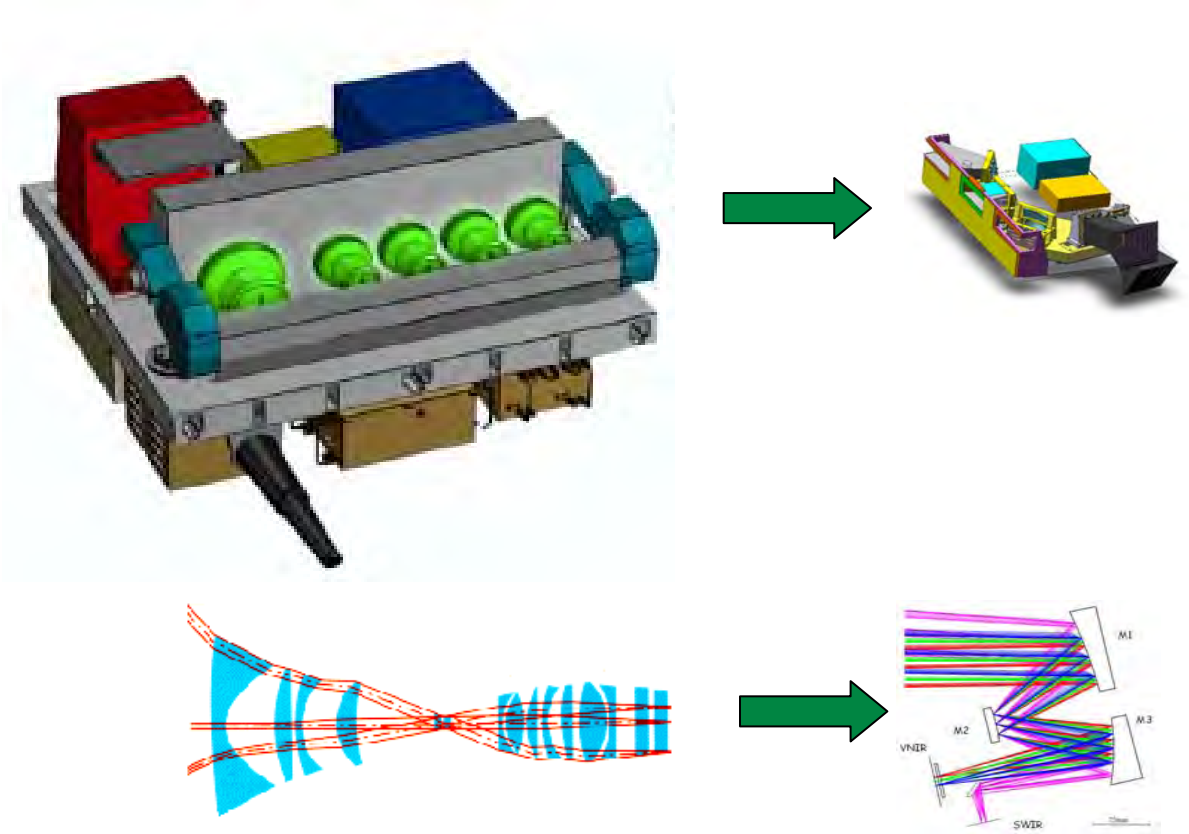
Mass of Végétation: 138 Kg

Disruptive Approach

Proba-V Dimensions
800mm x 800mm x 1000m

Disruptive Approach

From Refractive to Reflective



Disruptive Approach

The Results

Technologies (1)

Star tracker

Testing on small satellite of (more and more) miniaturized versions of spacecraft units, e.g. star tracker.

Star tracker on PROBA 1:

-Mass:1.5 kg

-Power:7.6 W

-Performances:5 arcsec and up to 1 deg/s

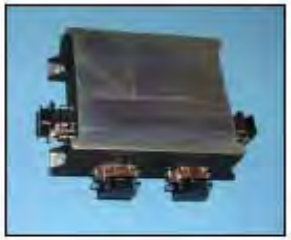
Star tracker on PROBA 2:

-Mass: 740 g

-Power: 3.7 W

-Performances: 5 arcsec and up to 10 deg/s

This star tracker has flown on several main stream missions, but PROBA has also provided the test bed to improve it !



Technologies (2)

GPS

Testing on small satellite of COTS and high end GPS receivers:

COTS GPS on PROBA 1:

-Mass:1.5 kg

COTS GPS on PROBA 2:

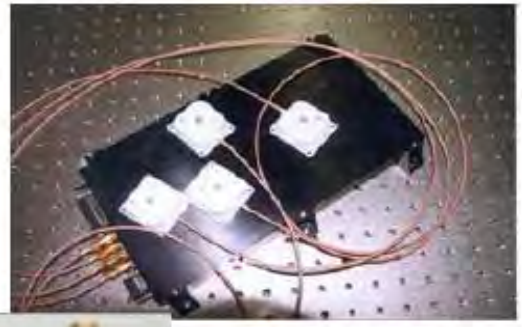
-One board 50x70 mm

-Power: < 1 W

-Performances: < 1.1 m

High end GPS on PROBA 2:

First receiver tracking L1 & L2CS



Technologies (3)

Battery

Li-Ion cells

PROBA 1 based on industrial cells

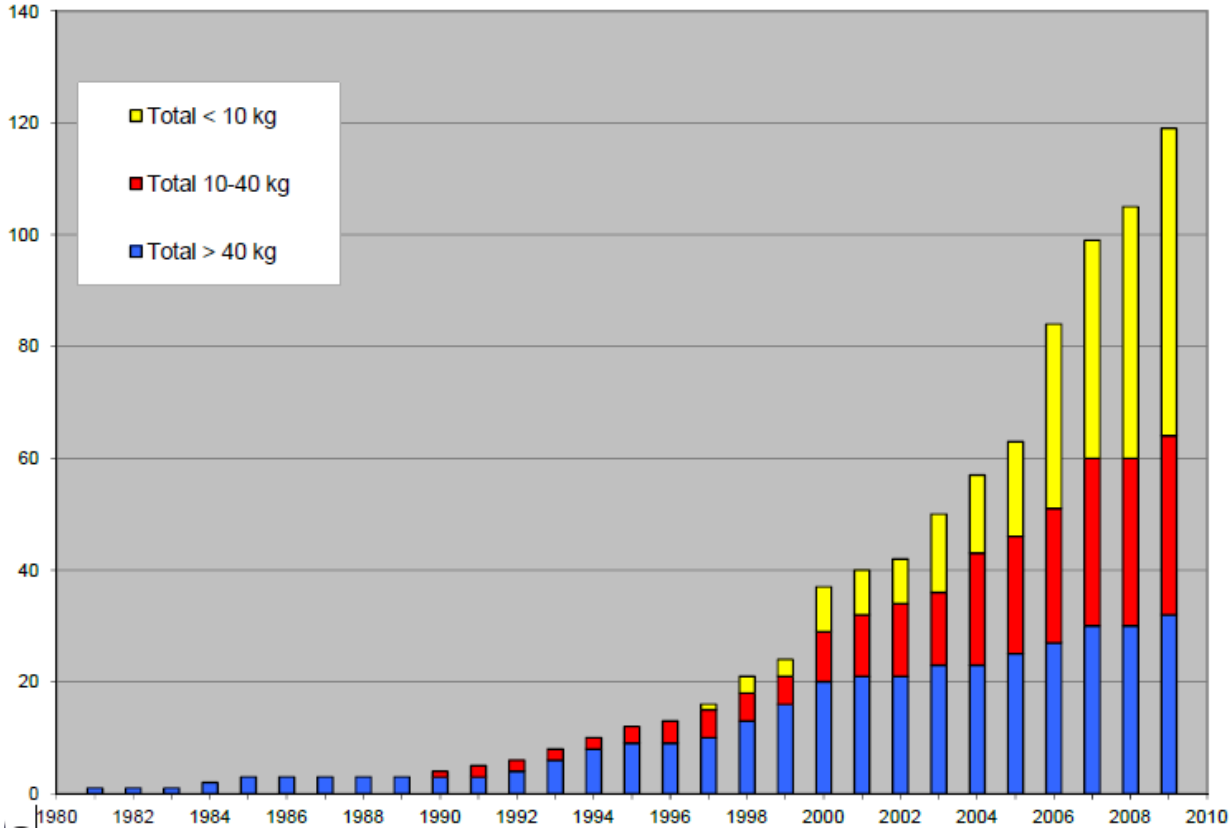
First Li-ion battery on LEO

Longest in orbit life time (since 2001)

PROBA 2 based on military cells

Students and Satellites

Small Satellites – Trend of University Class Satellites



Credit: M. Swartwout

St. Luis University

AIAA/USU Conference

13 August 2009

Conclusions

1. *From Big to Small:* Technology Innovation allows to built more compact instruments, still with the necessary performances. This is the result of Technology Evolution

2. *From Small to Big:* the effort to squeeze in a cubesat or in any small satellites instruments and functionality, but with degraded performance may be of interest for future application in bigger systems.

3. *Bigger is Better, Smaller is Nicer:* The mass isn't the only parameter that define the class of a satellites. Dependability (as for Navigation Systems) availability (as for Meteorological satellites) are the qualifiers of satellites.

ESA is constantly monitoring technology evolution (technology push) and its novel application to small satellites with less demanding reliability requirements and technology innovation stemming from challenging scientific satellites to be used on new small missions (market pull).

The next 4S Symposium

Call for Papers:	7 May 2011
Abstract Submission:	7 January 2012
Notification to Authors:	7 February 2012
Conference Dates:	4 - 8 June 2012

CubeSat Workshop in parallel 5-7 June

Further information to be published soon at www.esa.int

Portoroz, Slovenia

4-8 June 2012