May 25th, 10:45 AM

Full Electric Mission to Moon (SMART-1) and Technologies: Electric propulsion, rendez-vous, formation flying

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OHB SWEDEN

SATELLITE SYSTEMS

Full Electric Mission to Moon (SMART-1) and Technologies: Electric propulsion, rendez-vous, formation flying

Presentation to the 44th Space Congress

OHB Sweden – A small innovative space company in a small country

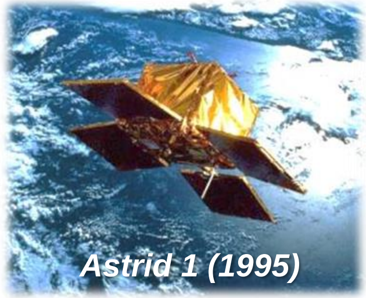
From pioneering small satellite builder in Swedish Space Corporation...

EARLY SATELLITES

Small scientific satellites in 1980th and 90th


Viking (1986)


Freja (1992)


Astrid 1 (1995)


Astrid 2 (1998)

HIGH-PRECISION

Precise 3-axis attitude control for astronomy and Earth observation Still operated by OHB Sweden.


Odin (2001)

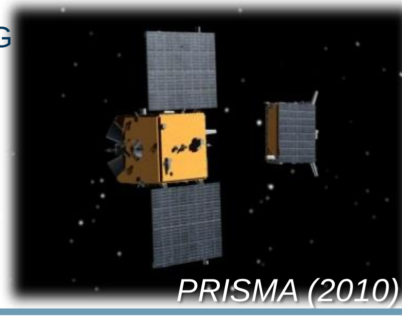
INTERPLANETARY

First ESA Lunar mission.
Low-thrust transfer to lunar orbit

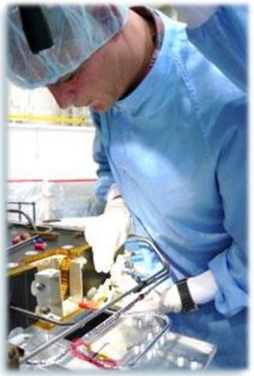

SMART-1 (2003)

FORMATION-FLYING

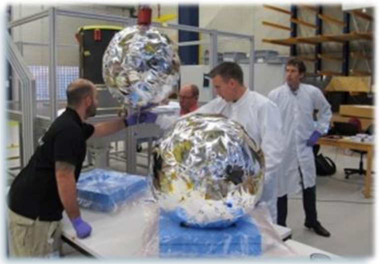
Demonstration of Formation-Flying & Rendezvous using GPS, Vision-Based, and RF-navigation.

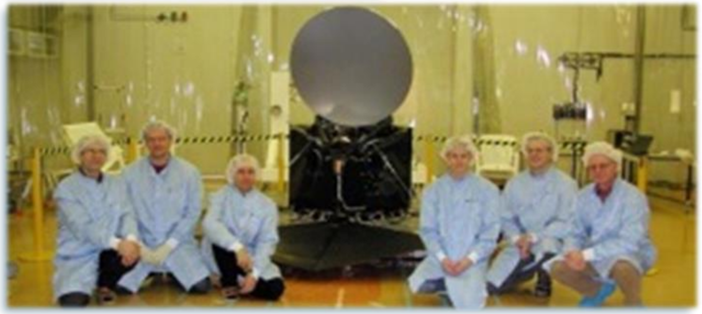

PRISMA (2010)

... to Technology specialists in the OHB group

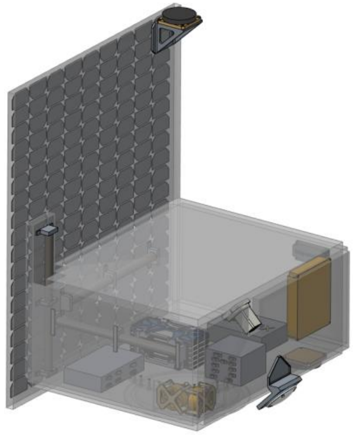


- A small, flexible, innovative team with high technical know-how focussing on new developments
- Total company staff 70 people
- Specialized in Propulsion and AOCS
- Still small satellite capability through new **Innosat** platform:
  - Innovative low cost microsatellite 40 kg
  - First launch planned 2017 with climate research mission

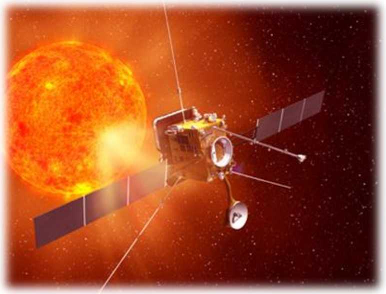




Orion PQM



Innosat



Solar Orbiter

SATELLITE SYSTEMS

Electric Propulsion and SMART-1

Electric propulsion: From lunar mission SMART-1 to future telecom

2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018/19

Launch "Landing"

SMART-1

- From GTO to Lunar orbit
- Testing of EP and satellite technology for interplanetary missions
- High radiation environment through radiation belts

Development AIT Launch

SGEO

- Chemical propulsion from GTO to GEO
- EP for station keeping in operations (15 years)

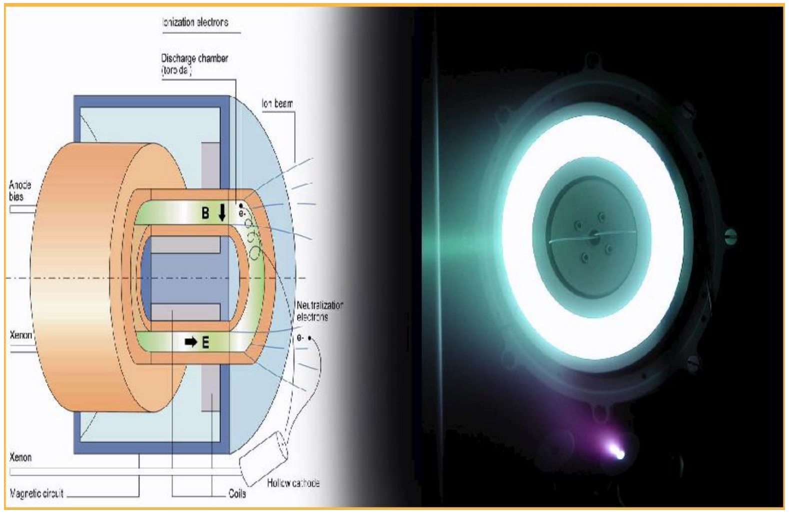
Development AIT Launch

ELECTRA

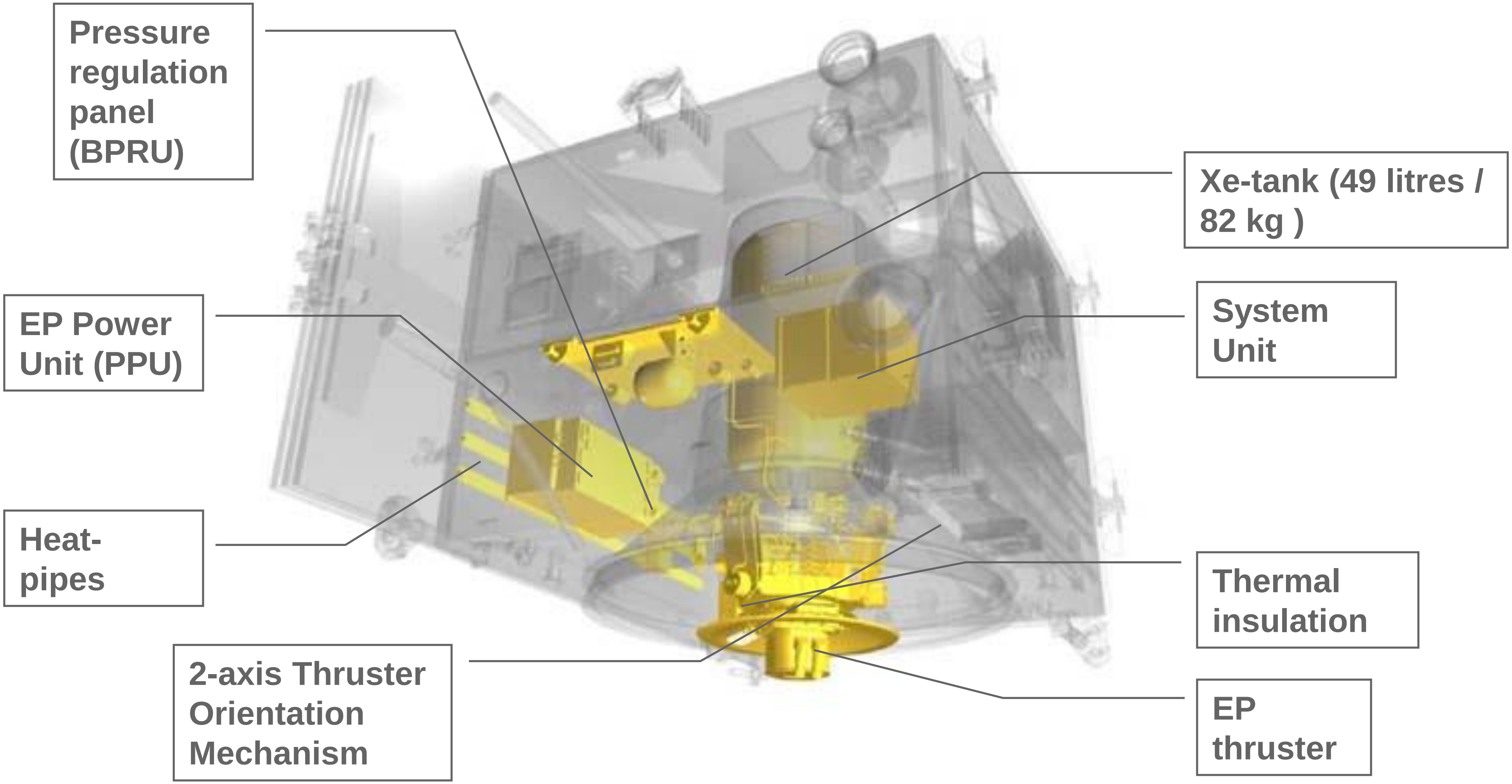
- Full EP (transfer + GEO)
- Cost efficient EPPS & AOCS architecture

SMART-1: First to the moon – from Europe...

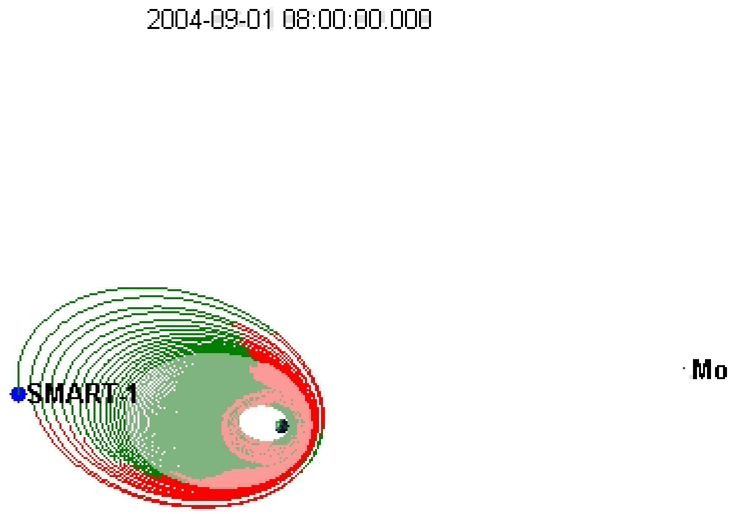
- ESA Technology mission to demonstrate use of low thrust for future interplanetary space journeys
- Developed and built in short time by Swedish Space Corporation (today OHB Sweden) using Small Satellite methods
- European Hall Effect Thruster fuelled by Xenon gas
- 15 months orbit transfer with 70 mN (7 gram) thrust
- <80 kg Xenon for full earth-lunar transfer



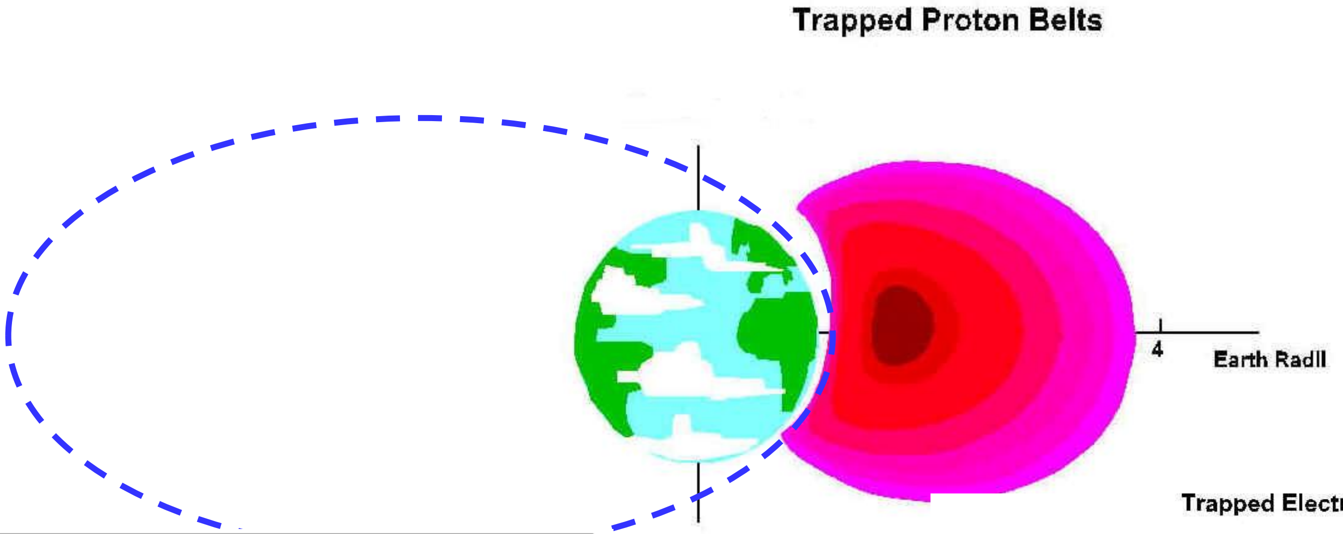
SMART-1: Accommodation of the EP system

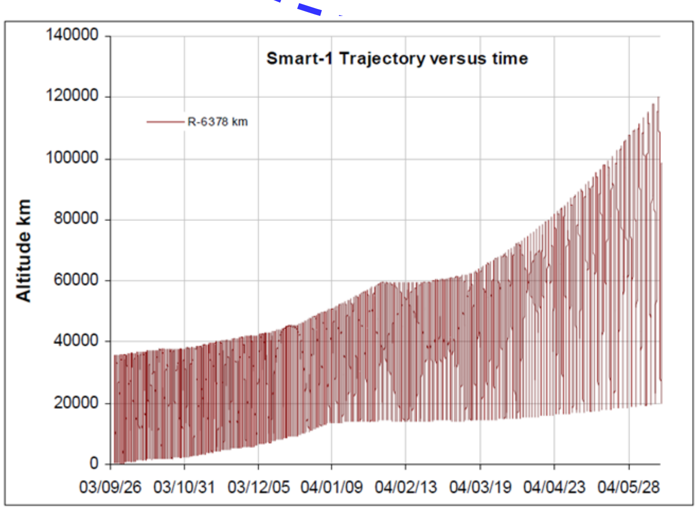


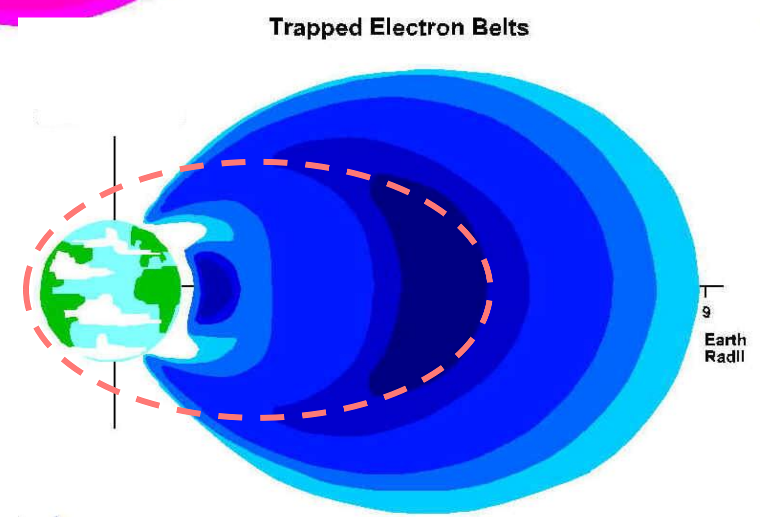
Spiralling out to the moon over 15 months



SMART-1: A tough journey through the radiation belts

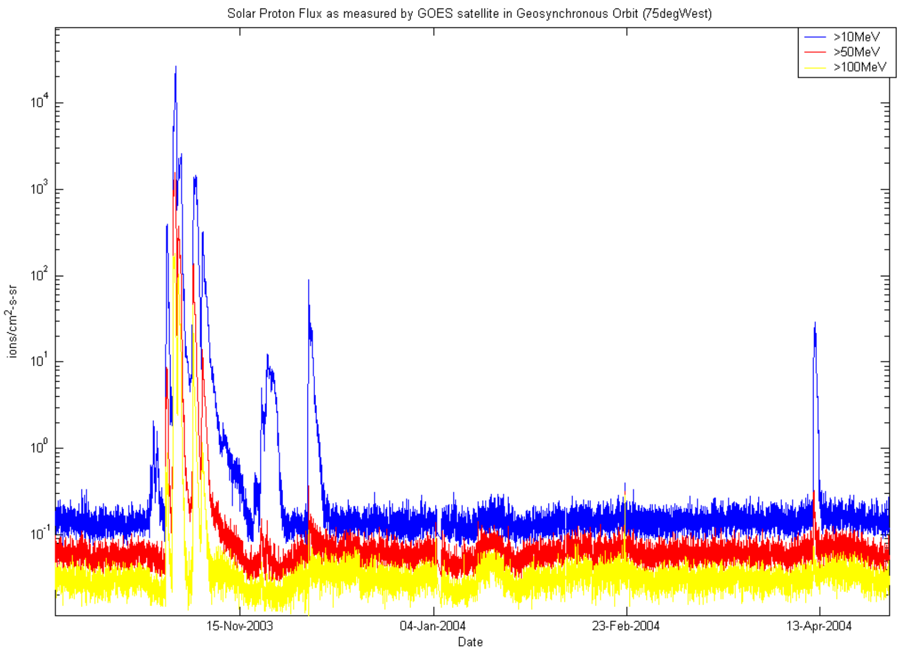


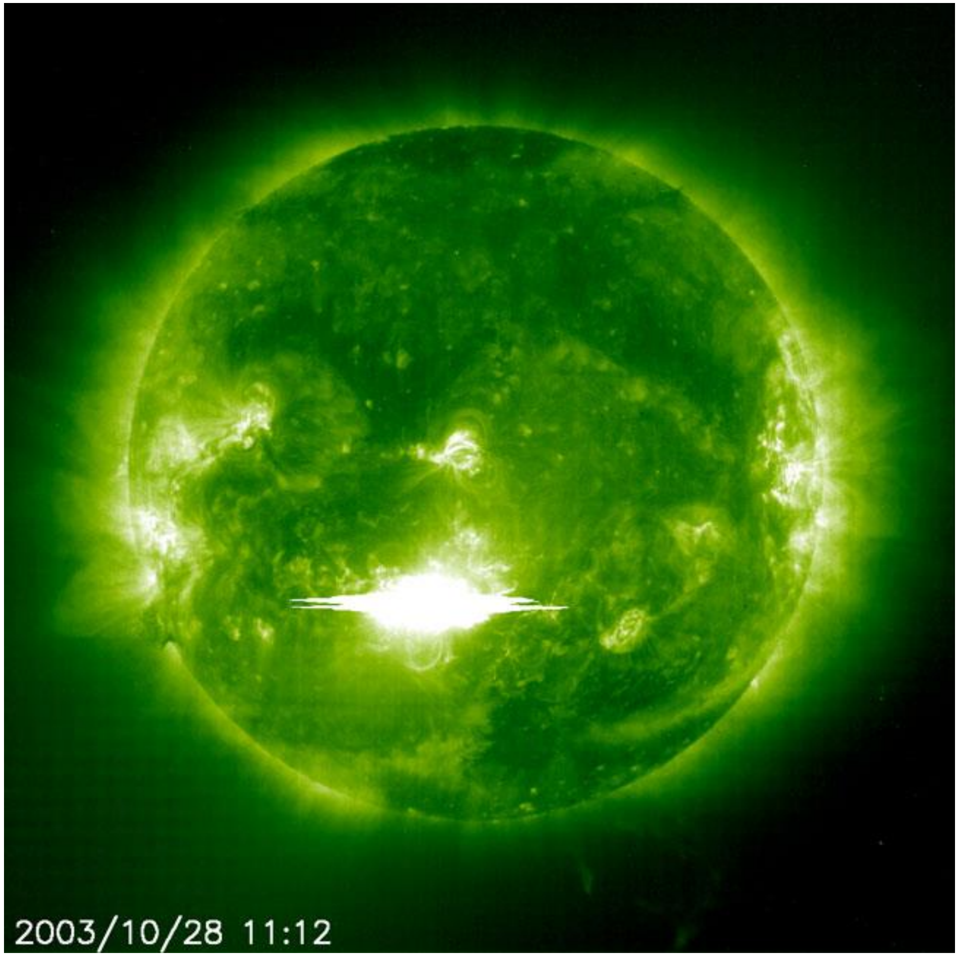




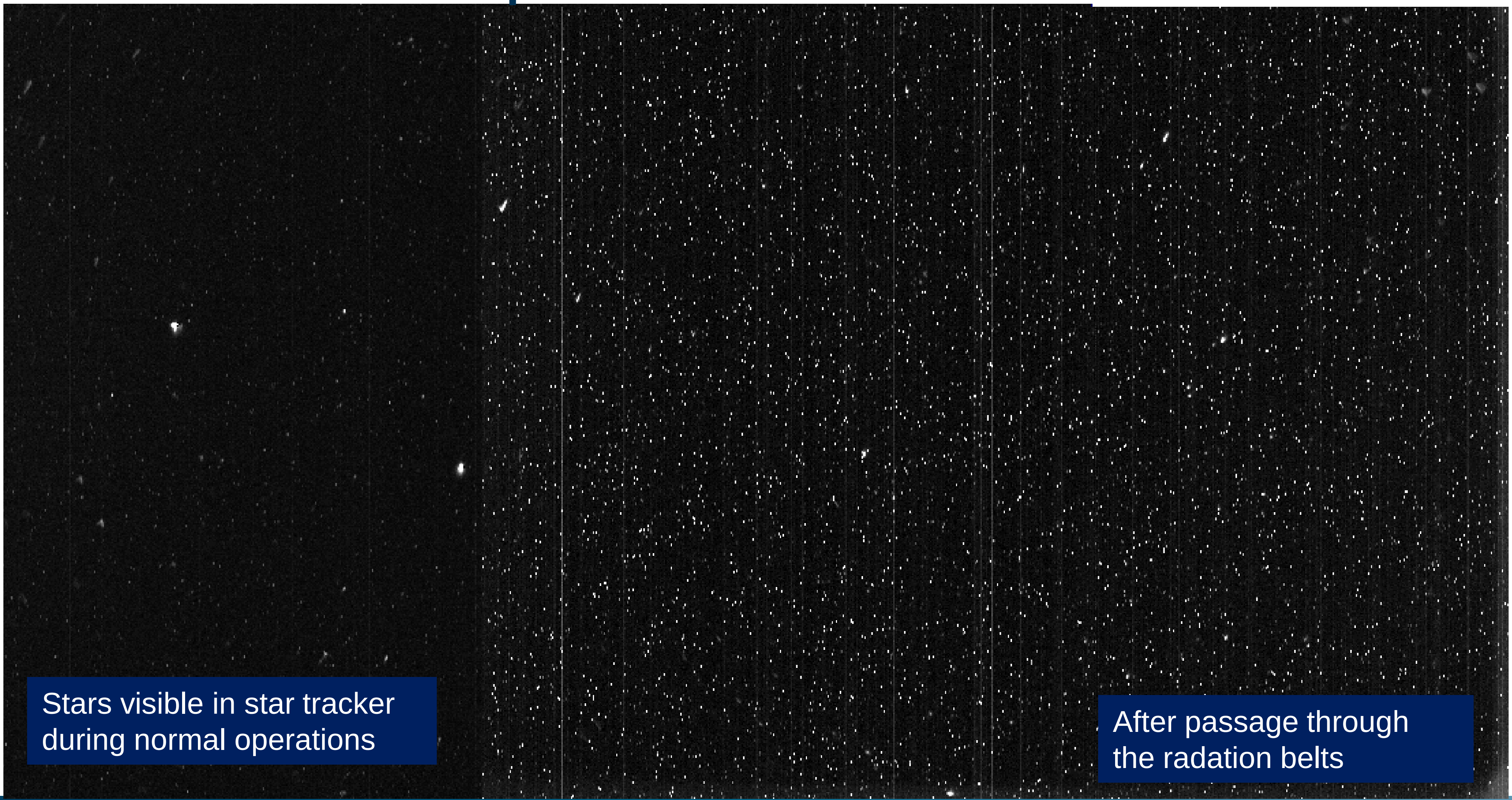
Worst possible weather conditions!

- Massive solar storms Oct/Nov 2003
- Immense increase (x10^5) of solar protons





Star tracker hot spots



SMART-1 flight experience:
200 µm coverslides, 8% loss of S/A power before reaching hp=10,000 km

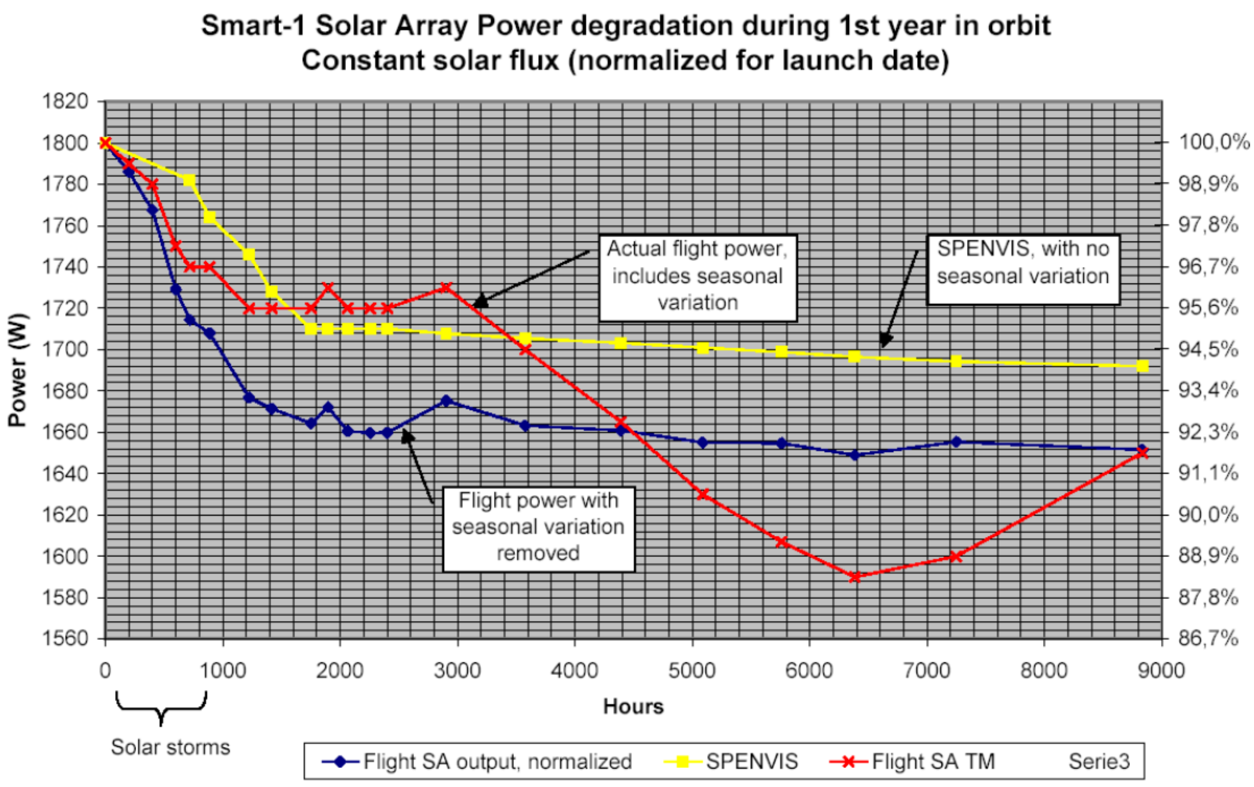
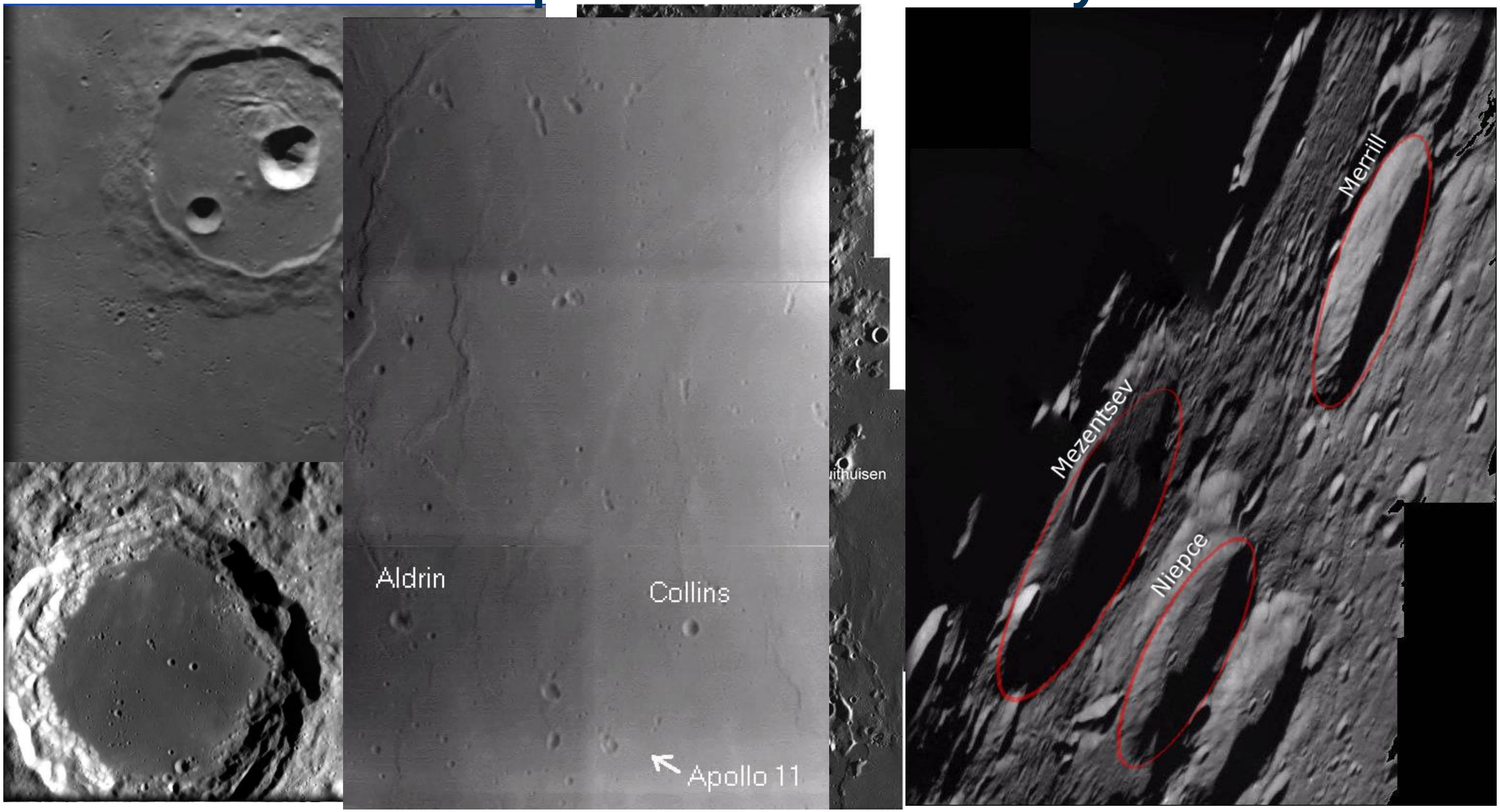
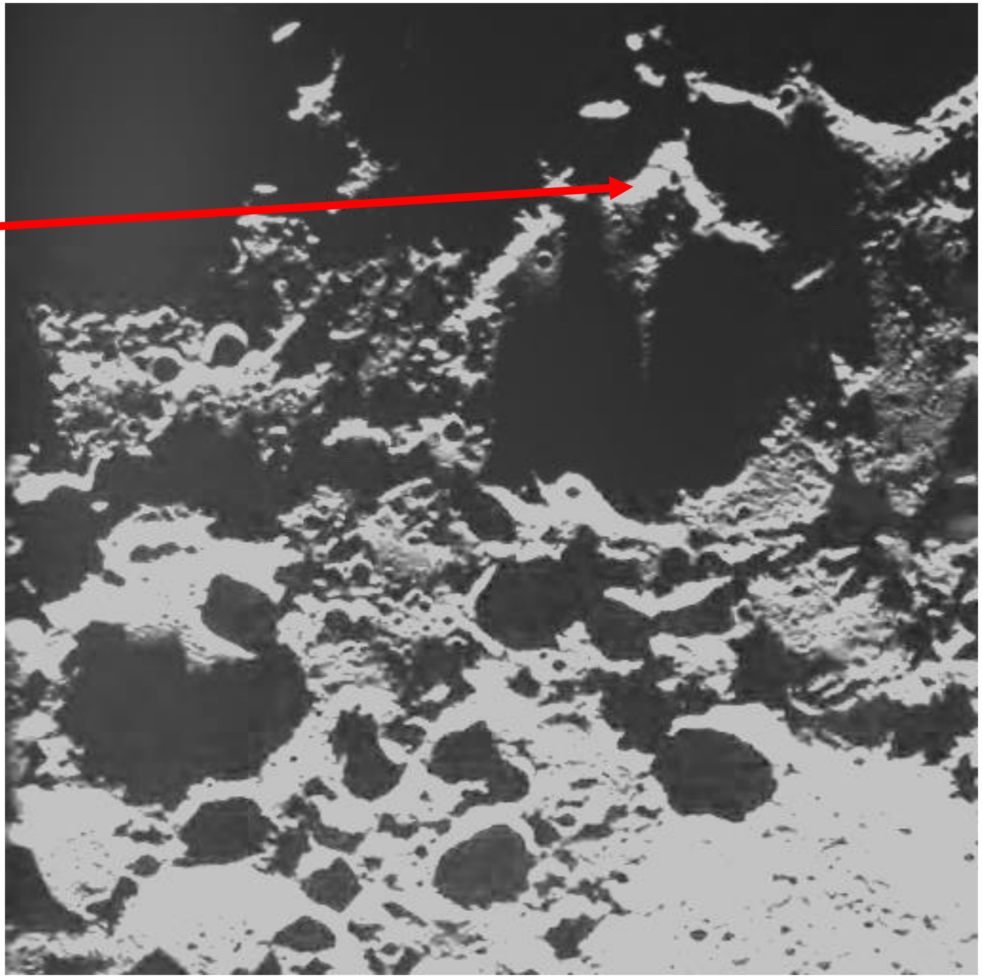


Figure 2-3 *SMART-1 Solar array output power (W) during the first year of the mission*

Around 50 000 moon pictures were taken by SMART-1



Search for ”Peak of eternal sunlight ”

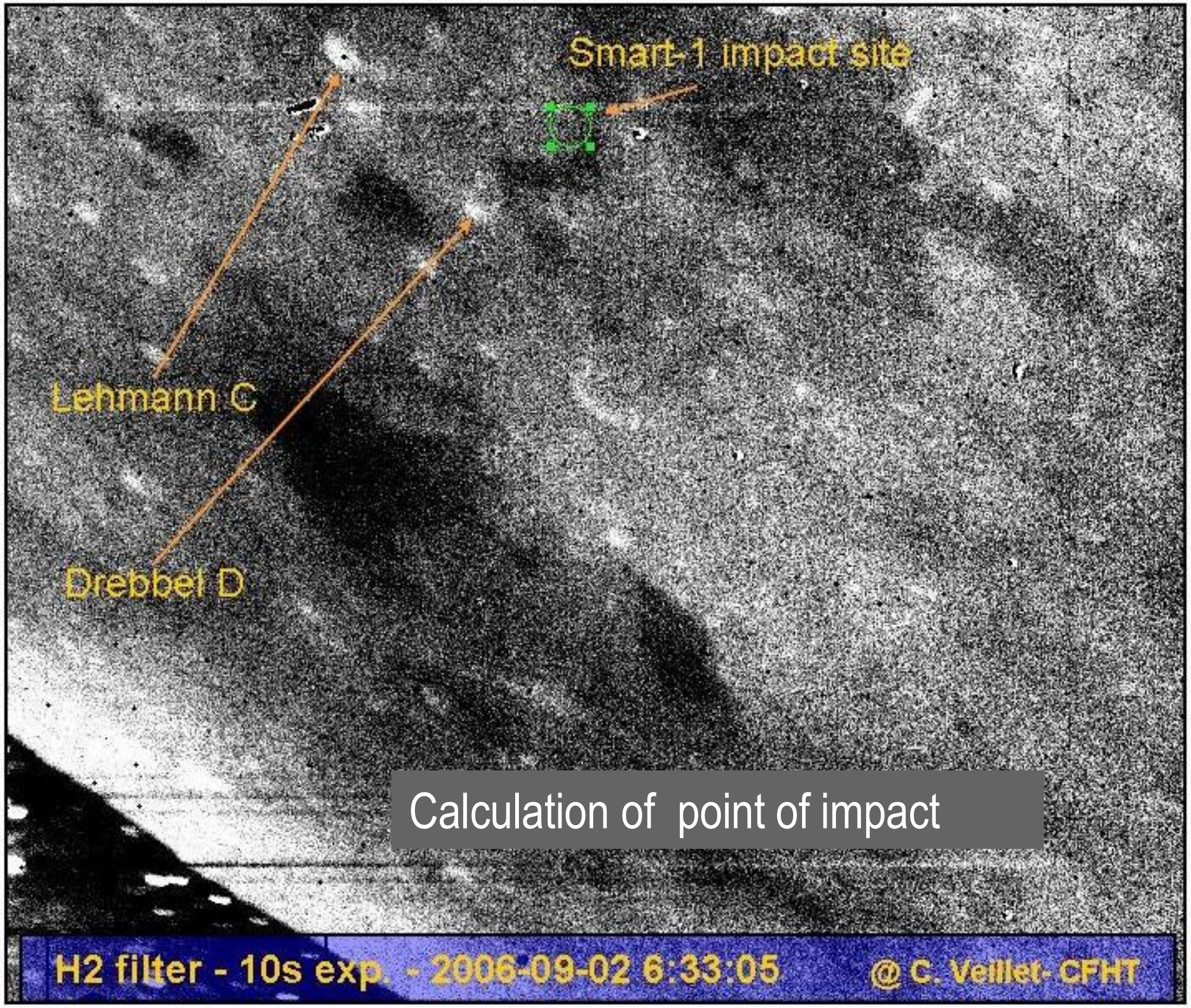


Jan 2005

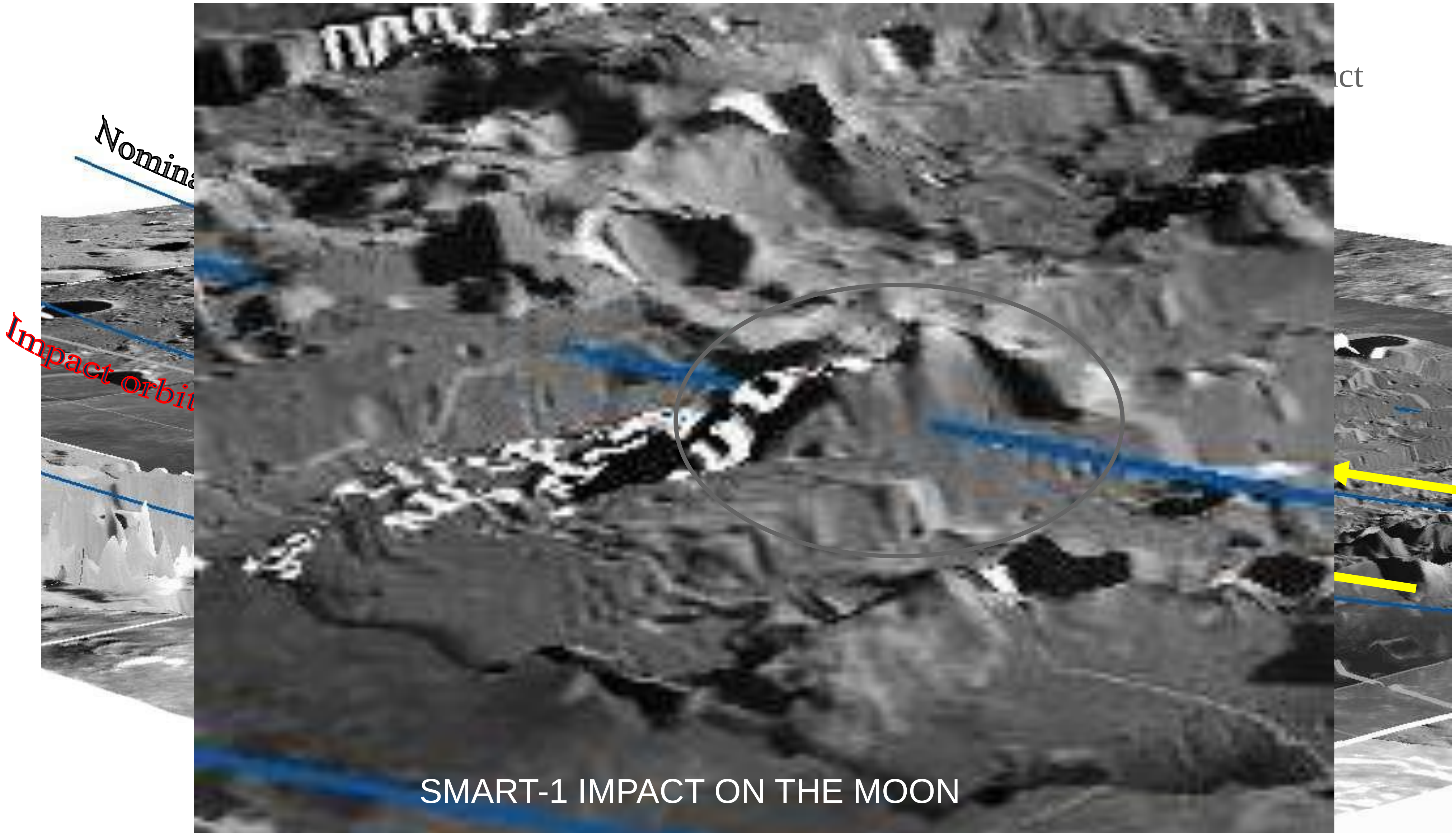
Lunar North Pole from 5000 km

Deemed to end...

Decending orbit due to earth and sun influence



Calculation of point of impact

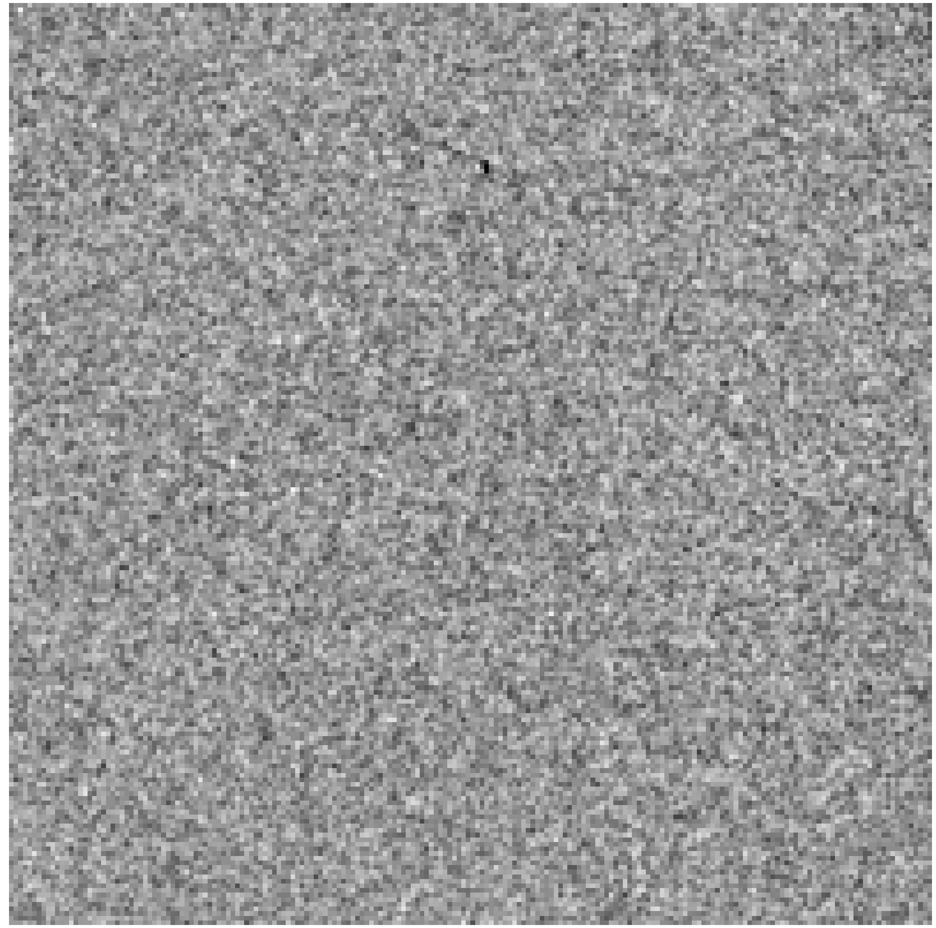


SMART-1 IMPACT ON THE MOON

Courtesy of Mark R Rosiek USGS Astrogeology Team, Planetary Geomatics Group and
Dr Anthony C.Cook, School of Computer Science and IT,University of Nottingham,

Impact on the moon

Sep 03, 2006, 05.42.22 UT
Canada-France-Hawaii Telescope
(CFHT) 3.6m telescope, Mauna Kea

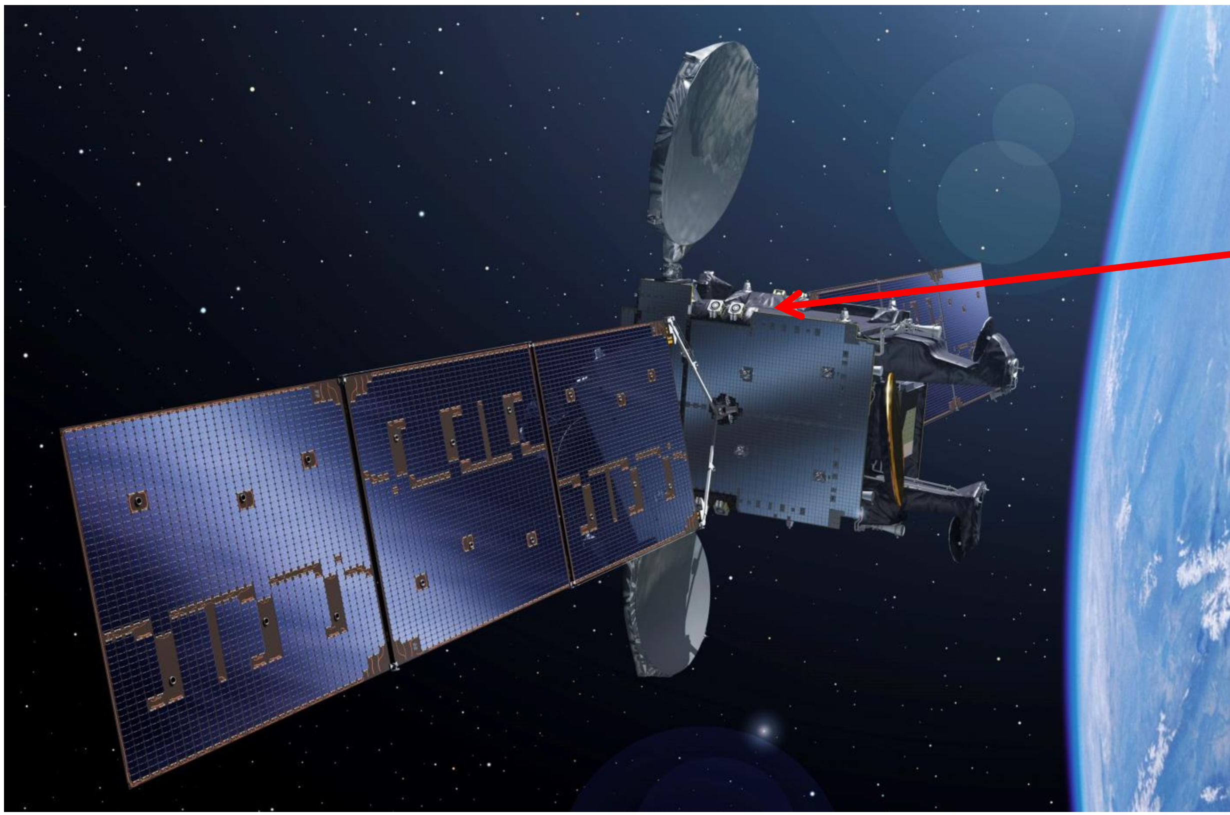


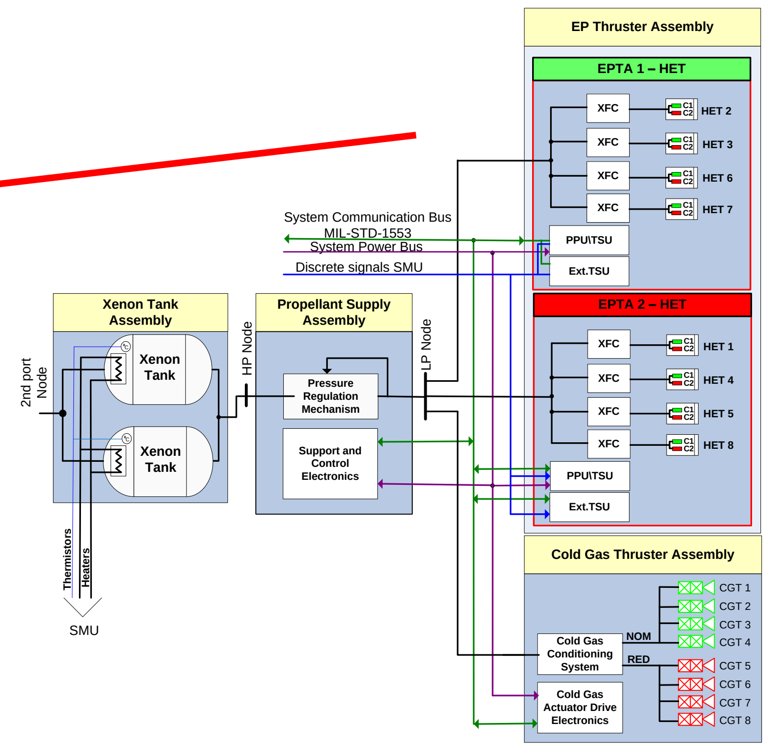
DUST CLOUD OF 20 X 80 KM

Small GEO

Europe’s first geostationary”All-EP”satellite

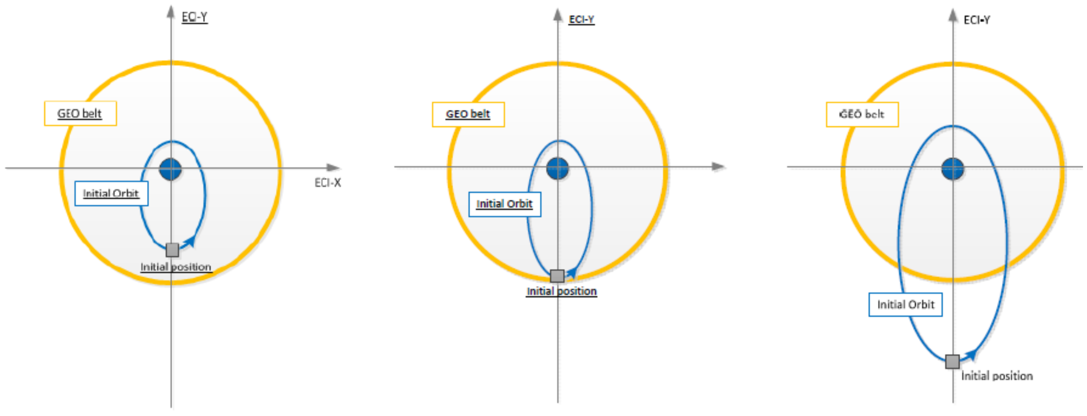
Hall Effect Thrusters for east-west and north-south station keeping





Electra: Europe's Full EP satellite

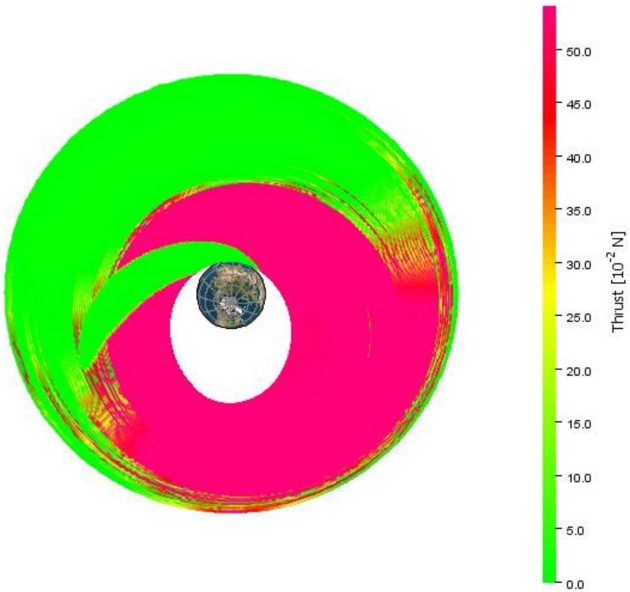
- Public private partnership with ESA, satellite operation SES and OHB group
- Combines EP transfer knowledge from SMART-1 with station keeping knowledge from SGEO
- Orbit transfer in 80- 200 days depending on launch scenario

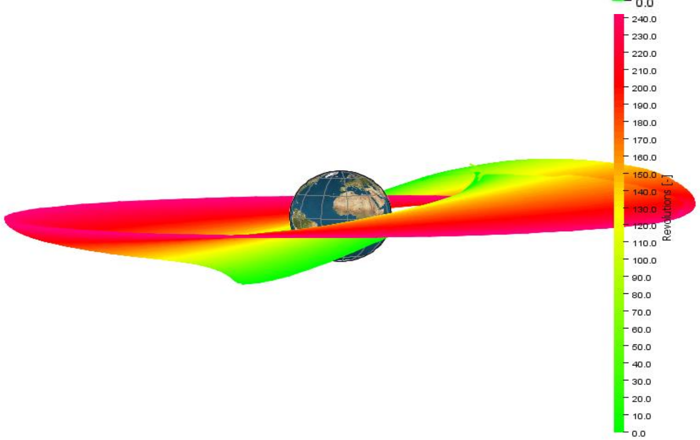


SGTO to GEO

GTO to GEO

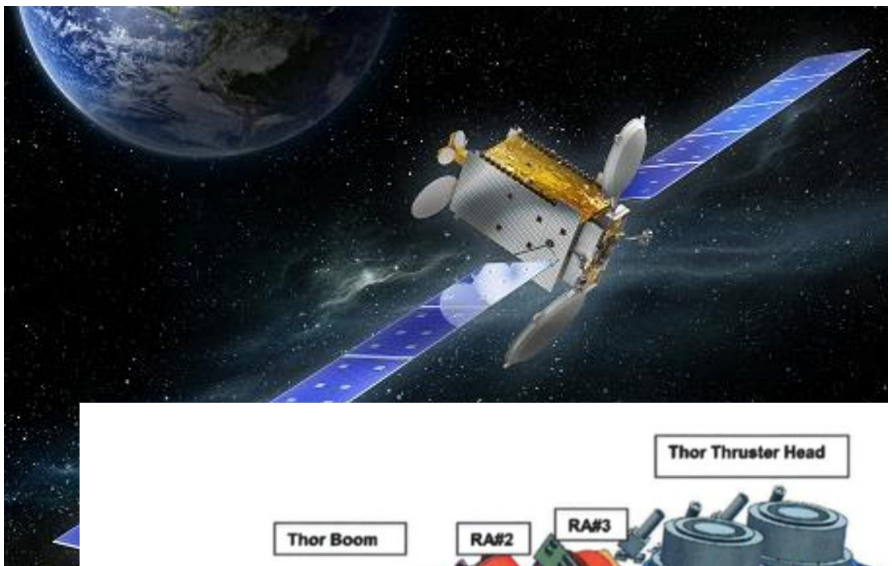
SSTO to GEO

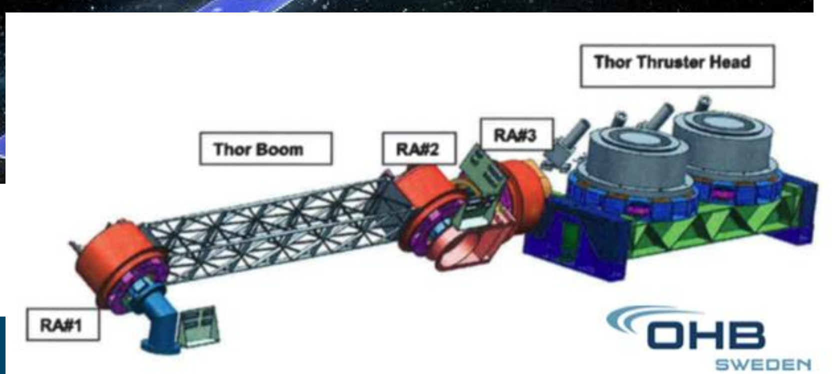


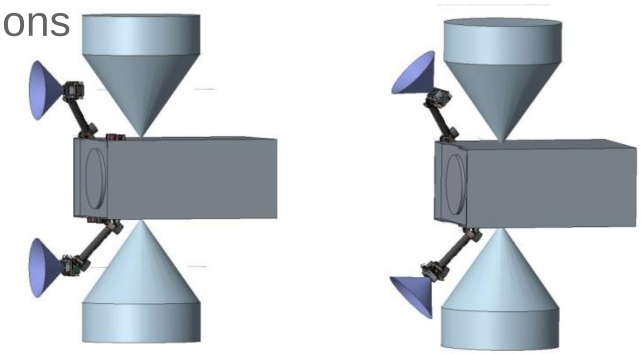


Electra: An innovative Electric propulsion system

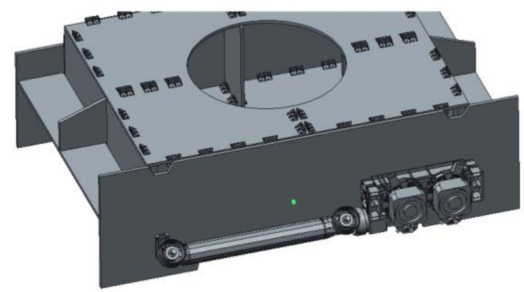
- Newly developed 4.5 kW/270 mN HET thruster for both orbit transfer and station keeping
- Xenon storage capacity up to 800 kg in new developed tank
- Optimized thruster configuration with four thrusters for all EP operations
- Newly developed robotic THOR boom for thruster reorientation
- High flexibility in COG position allows big variation in payload size







Electra EP thrusters arrangement showing OR mode (left) and SK mode (right).



SATELLITE SYSTEMS

PRISMA – A test bench for future scientific and exploration missions

PRISMA Mission Background: Why?

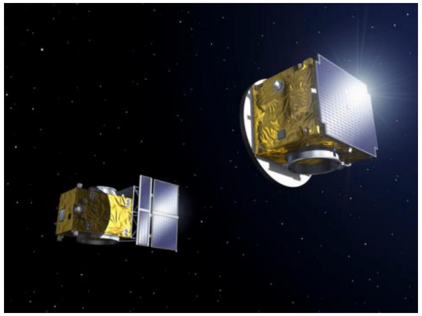
Needs of future exploration missions

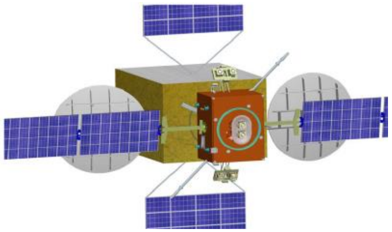
Autonomous Formation Flying

Large apertures and antennas for science missions, stereoscopic or phased imaging.

Autonomous Rendezvous

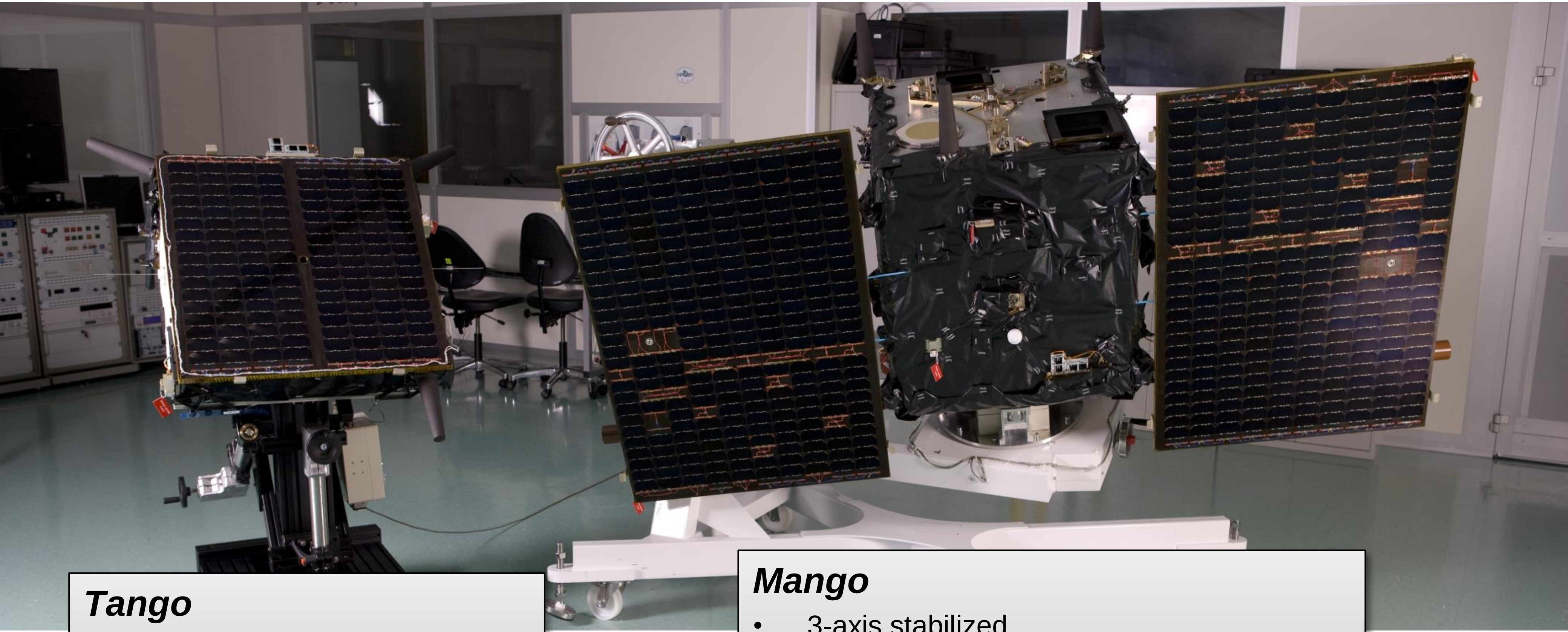
In Orbit Inspection, Servicing, or debris removal.





PRISMA MISSION IDEA:

”Demonstrate maneuvering techniques and sensor technology for Autonomous Formation Flying and Rendezvous”



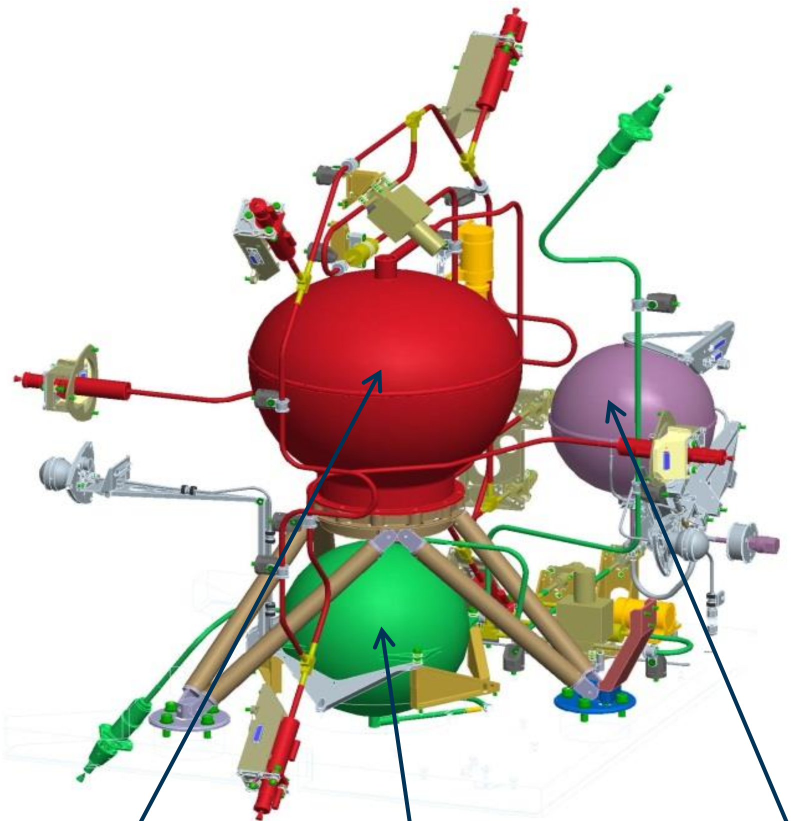
Tango

- 3-axis stabilized
- Solar Magnetic control
- 40 kg launch mass
- FFRF, GPS, Inter-satellite link

Mango

- 3-axis stabilized
- Attitude Independent Orbit Control
- 145 kg launch mass
- FFRF, GPS, VBS, DVS, Inter-satellite link
- 3 propulsion systems, >200 m/s Delta-V

Three (!) Propulsion systems on Mango

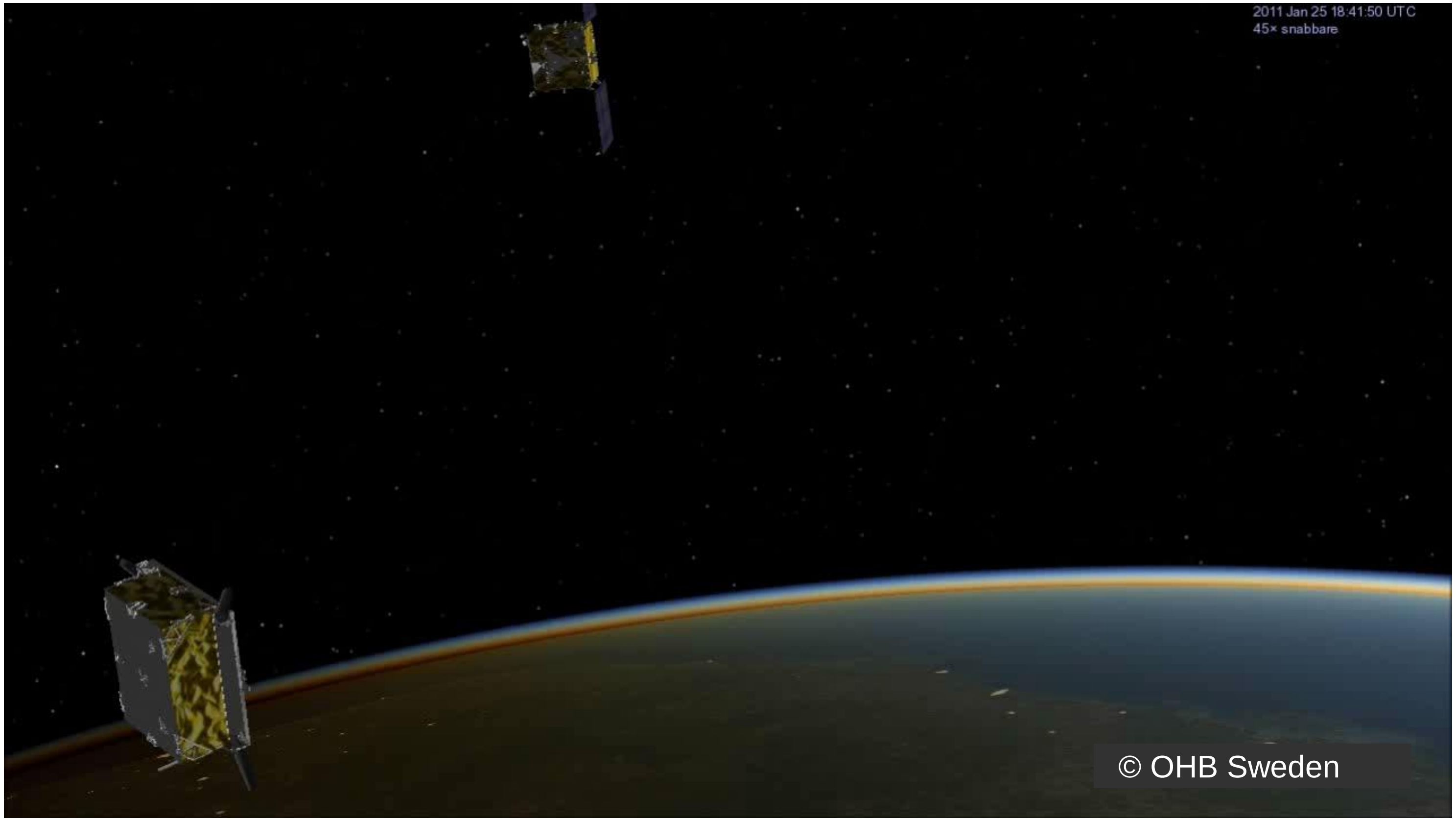


Hydrazine
Six 1N thrusters

Green propellant
Two 1N thrusters

MEMS Micropropulsion
Two thrusters pods

PRISMA Rendezvous Reconstruction and Video from Orbit



Formation keeping demonstration

Formation pointing to the Moon for 5 hours (5 cm positioning accuracy)


OHB
SWEDEN
Thank you!