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SPACE SYSTEMS

The success of the PRISMA mission and the rendezvous between the PRISMA Mango and Picard satellites

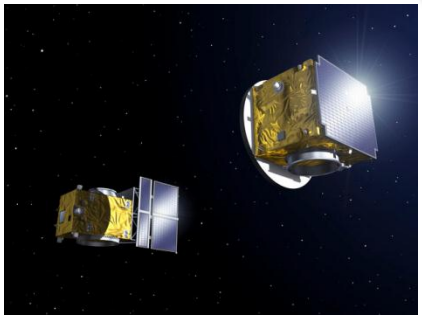
What are the needs of future space missions?

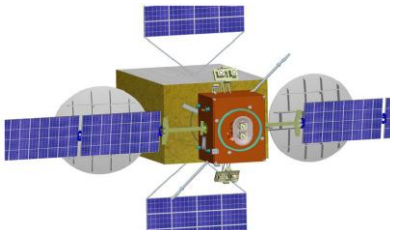
Autonomous Formation Flying

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

Autonomous Rendezvous

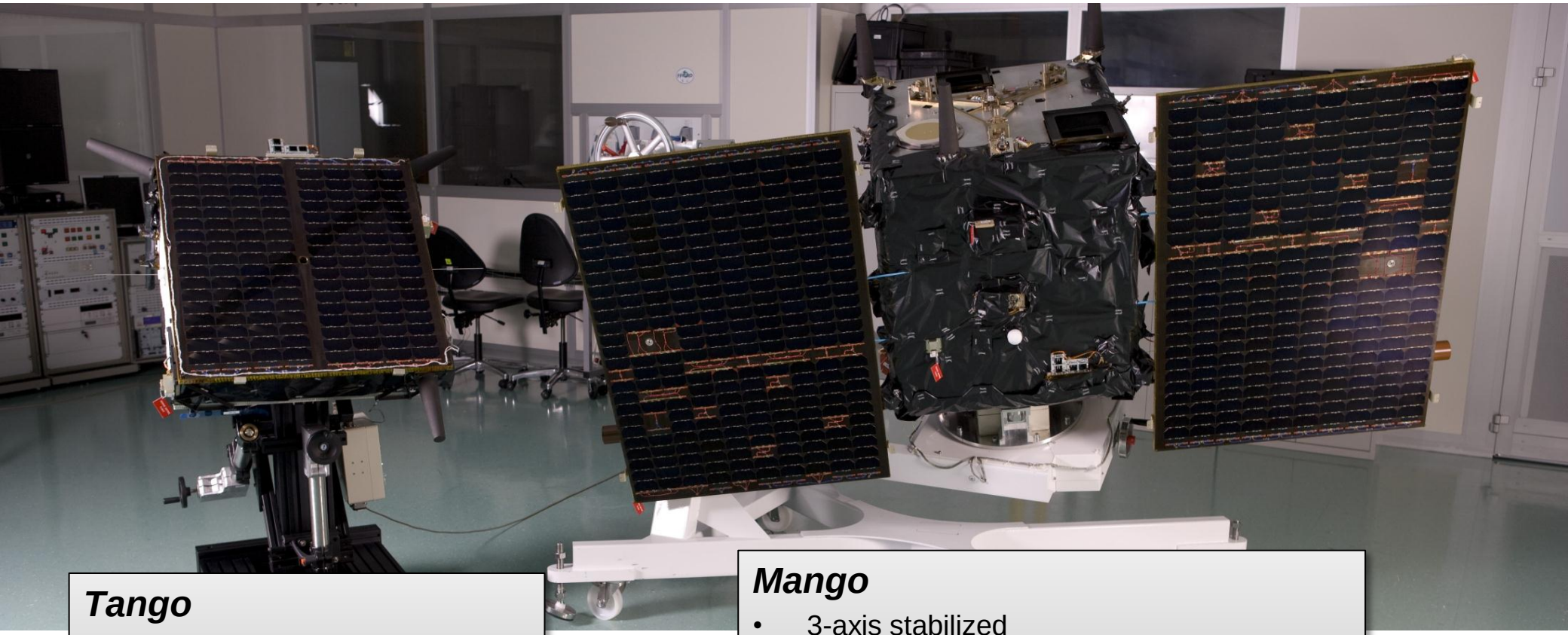
In Orbit Inspection, Servicing, or debris removal.





MISSION IDEA:

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



Tango

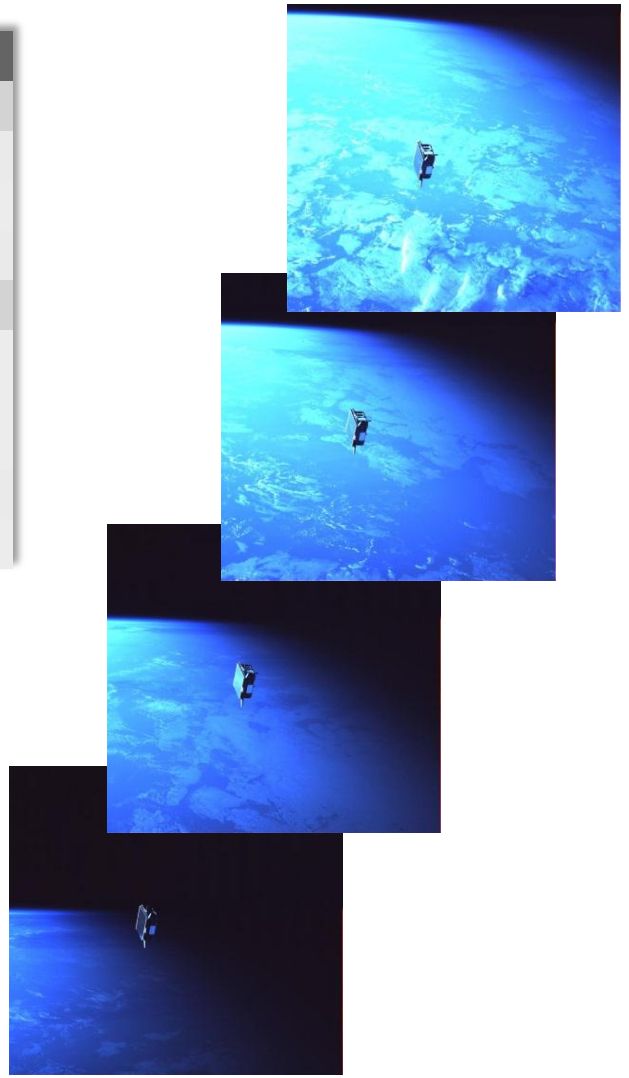
- 3-axis stabilized
- Solar Magnetic control
- 40 kg launch mass
- FFRF, GPS, Inter-satellite link

Mango

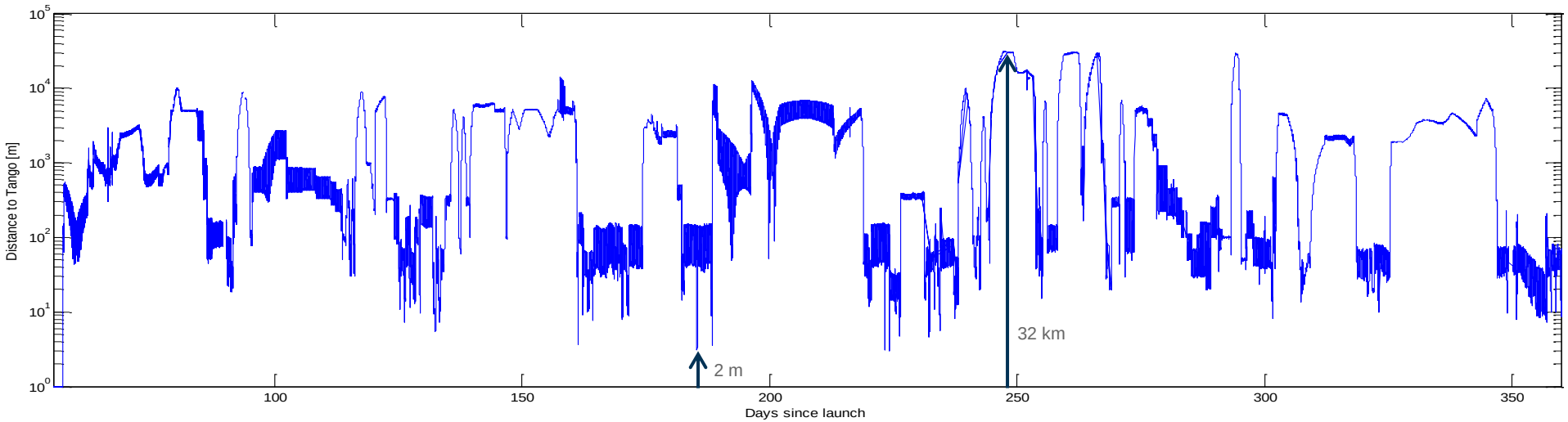
- 3-axis stabilized
- Attitude Independent Orbit Control
- 145 kg launch mass
- FFRF, GPS, VBS, DVS, Inter-satellite link
- 3 propulsion systems, >200 m/s Delta-V

GNC Experiment Demonstrations	
Passive formation flying	
Autonomous formation flying (AFF)	OHB Sweden
Autonomous formation control (AFC)	DLR
RF-based formation flying	CNES
Forced motion	
Proximity Operations (PROX)	OHB Sweden
Final Approach and Recede (FARM)	OHB Sweden
Forced RF-based motion	CNES
Collision avoidance	OHB Sweden / CNES
Autonomous Rendezvous (ARV)	OHB Sweden

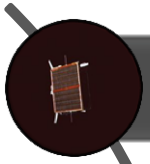
Hardware Flight Demonstrations	
HPGP Motor Tests	ECAPS
Microthruster Motor Tests	Nanospace
Relative GPS receivers	DLR
Vision Based Sensor (VBS)	DTU
RF Sensor Tests	CNES
LEON-3 on-board processor	OHB Sweden
PRIMA MEMS mass analyzer	IRF
Digital Video System	Techno Systems



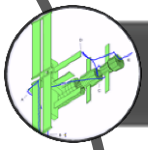
Inter-satellite distances



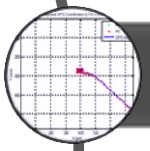
Mission results summary



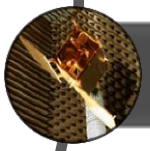
AFF (Autonomous Formation Flying mode) - used for closed loop cooperative satellite formation flying and dedicated AFF experiments. Also used for routine operational formation flight between 30km to 10m relative distances.



PROX/GPS – First flight demonstration of close proximity GPS based forced motion relative orbit control over the range of 50m to as low as 2m relative distances.



ARV – First flight demonstration of autonomous line-of-sight only based target search, orbit determination, orbit align and approach from 30km to 50m relative distances.

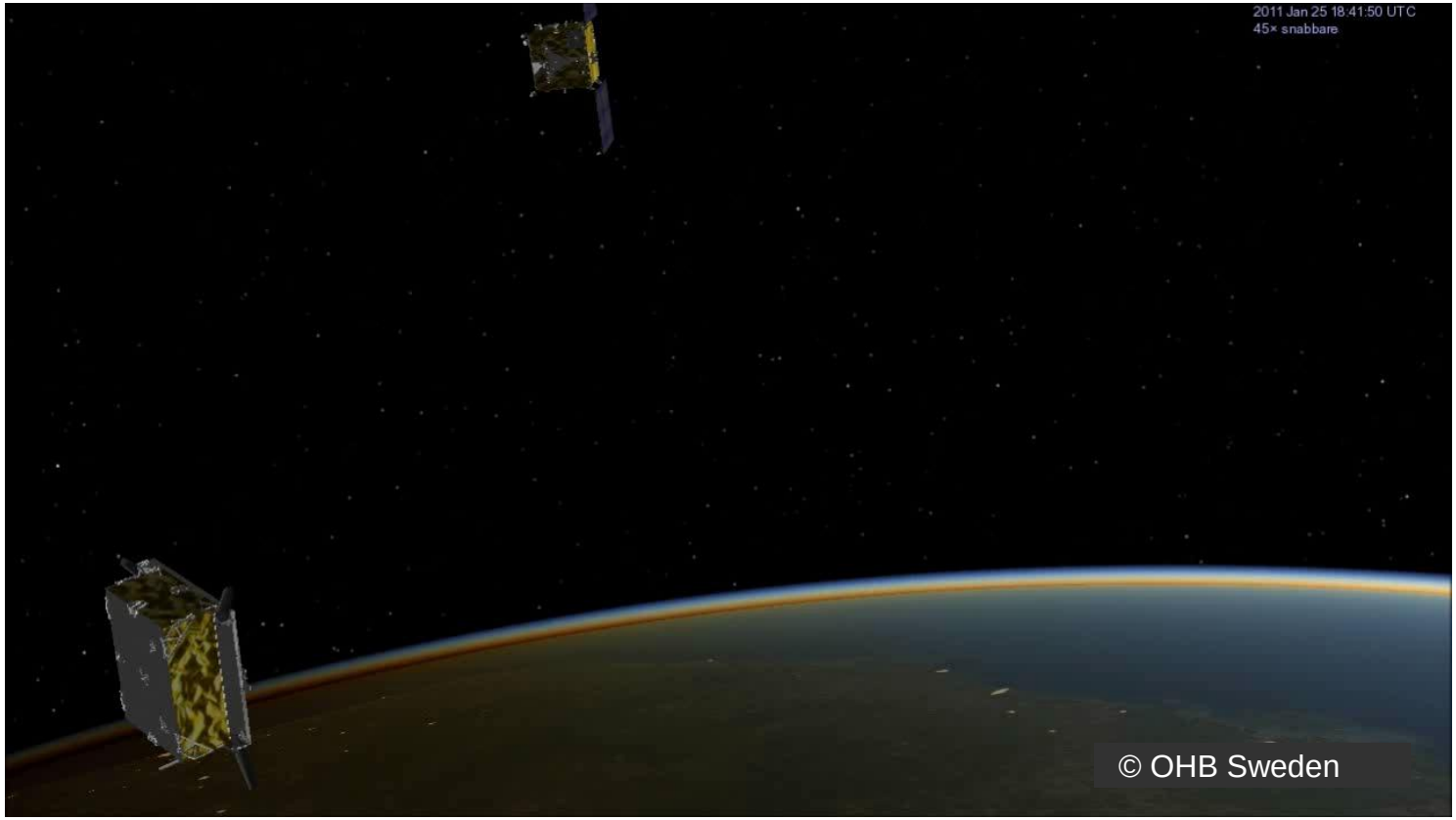


CNES – First flight demonstration of autonomous formation flight using a radio electric relative sensor.

DLR – First comprehensive demonstration of GPS based autonomous formation flight (<5cm relative accuracy) and extraction of relative Precision Orbit Determination (<0.5cm relative accuracy).

PROX/VBS – The first closed loop proximity operations based on visual sensor had been performed to within 2m relative CoG distance (~1m physical separation)

PRISMA Rendezvous Reconstruction and Video from Orbit

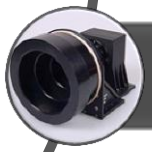


Mission results summary

ECAPS – First flight and space demonstration of the High Performance Green Propellant (HPGP) 1N thruster system, still ongoing…

Nanospace – First flight of the MEMS cold gas micropropulsion system. Electrical validation of all MEMS components was possible.

PRIMA – First flight demonstration of MEMS shutter based low energy (<100eV) ion mass analyzer.



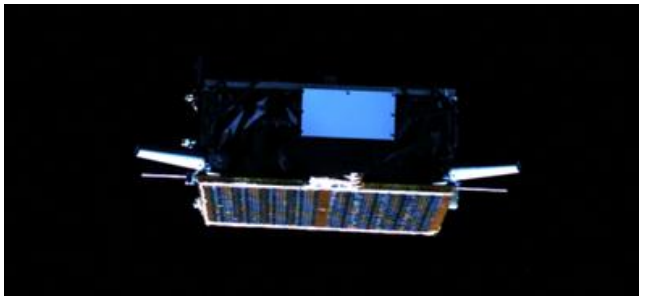
DVS – First flight of Techno Systems digital video camera system.

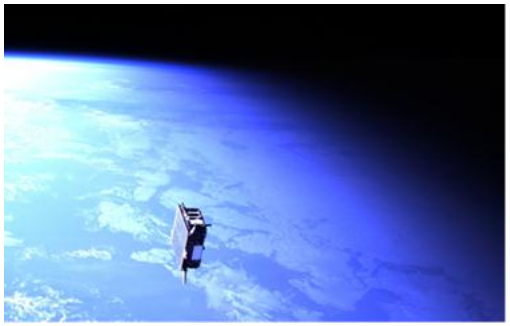
SW & DHS – 100% fault free operation of autocoded Model Based Software (MBSW), running on a LEON-3 processor, first full spacecraft flight operation of the RAMSES ground control system.

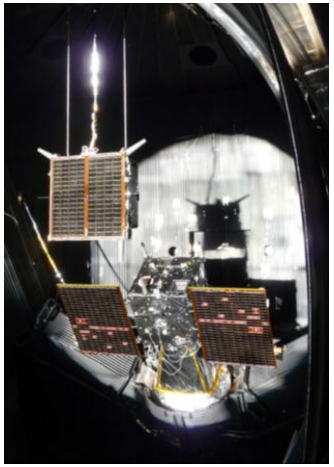
- After the PRISMA Nominal mission, experiment capability was offered to interested partners and other organisations.
- Then the idea came up at OHB Sweden to use PRISMA for a final exciting experiment!

PRISMA - IRIDES

- **Primary goal: To perform rendezvous with and inspection of a non-cooperative satellite!**
- IRIDES = Iterative Reduction of Inspection Distance with Embedded Safety
- Unique opportunity to develop, validate and test technologies within a low project budget in preparation of future exploration, debris mitigation and servicing missions (refueling, replacement or addition of modules,…).

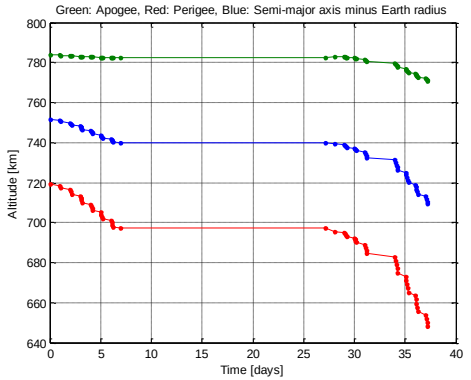


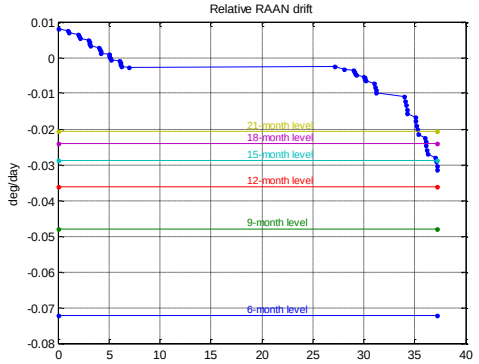


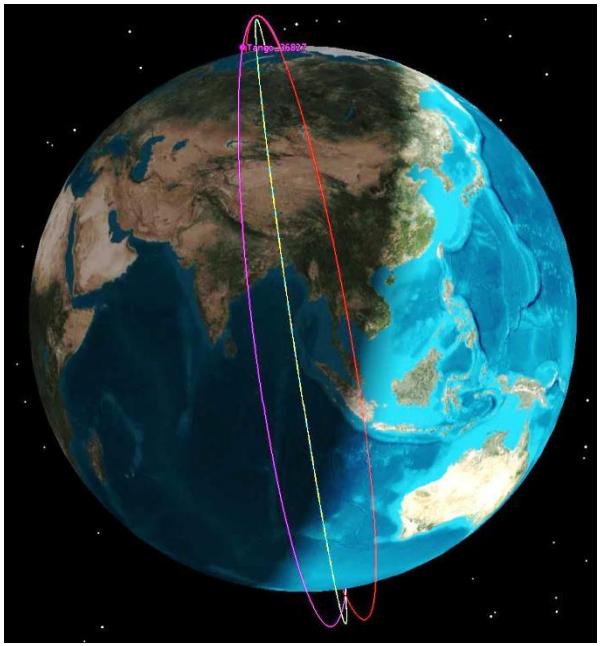


IRIDES Phases (1)

- Tango (target S/C) decommissioning, completed
- Transfer Start, executed in a series of delta-V manoeuvers from May 13 to June 20, 2013. The total amount of delta-V was 32 m/s. Completed.
- Transfer Orbit, on-going, completed this summer
- Transfer Stop and Orbit Aligning





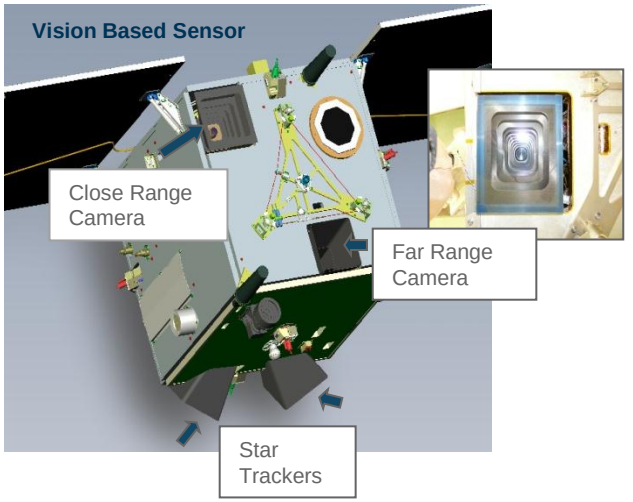


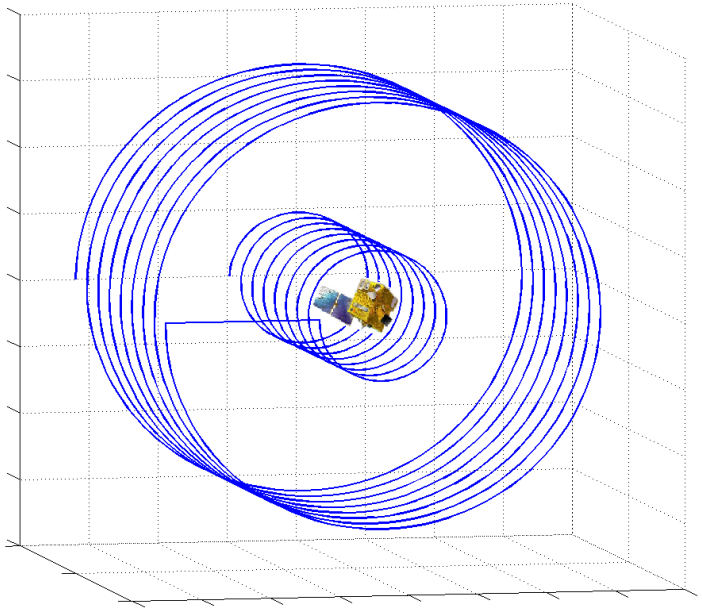
IRIDES: Phases (2)

- Inspection Campaign:
  - Vision Based Sensor will be the primary instrument for relative navigation
  - Performance is expected to be better than 10 m along-track and 1 m in cross-track and radial
  - Iterative strategy
  - A distance of 10 m allows for images of the rendezvous object where a pixel would represent 4x4 mm with the Vision Based Sensor and 3x3 mm with the Digital Video System

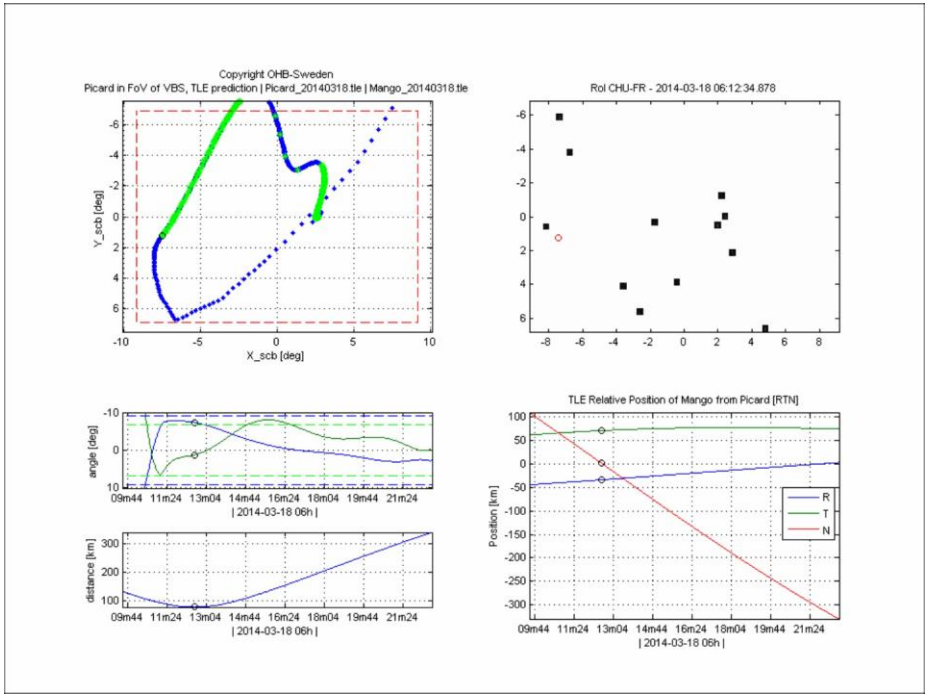
- Generation of an object model with accurate dimensions, pose and tumbling behaviour. Used as input for active debris removal missions, or other purposes.

- Deorbit – Propellant Depletion





First glimpse of Picard!



Thank you!

Visit www.ohb-sweden.se for more information or contact bengt.larsson@ohb-sweden.se