BepiColombo
ESA's 5th Cornerstone Mission

ベピ・コロンボ

BepiColombo
Mission to Mercury

October 2010

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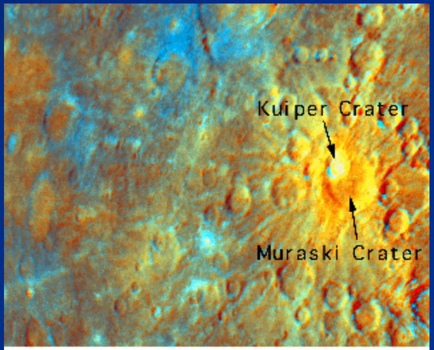
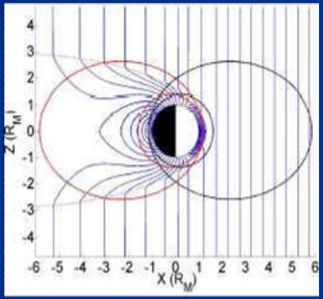
http://www.esa.int/science/bepicolombo

BepiColombo Scientific Objectives

- *Origin and evolution of a planet close to the parent star*
- *Mercury as a planet: form, interior, structure, geology, composition and craters*
- *Mercury's vestigial atmosphere (exosphere): composition and dynamics*
- *Mercury's magnetized envelope (magnetosphere): structure and dynamics*
- *Origin of Mercury's magnetic field*
- *Test of Einstein's theory of general relativity*

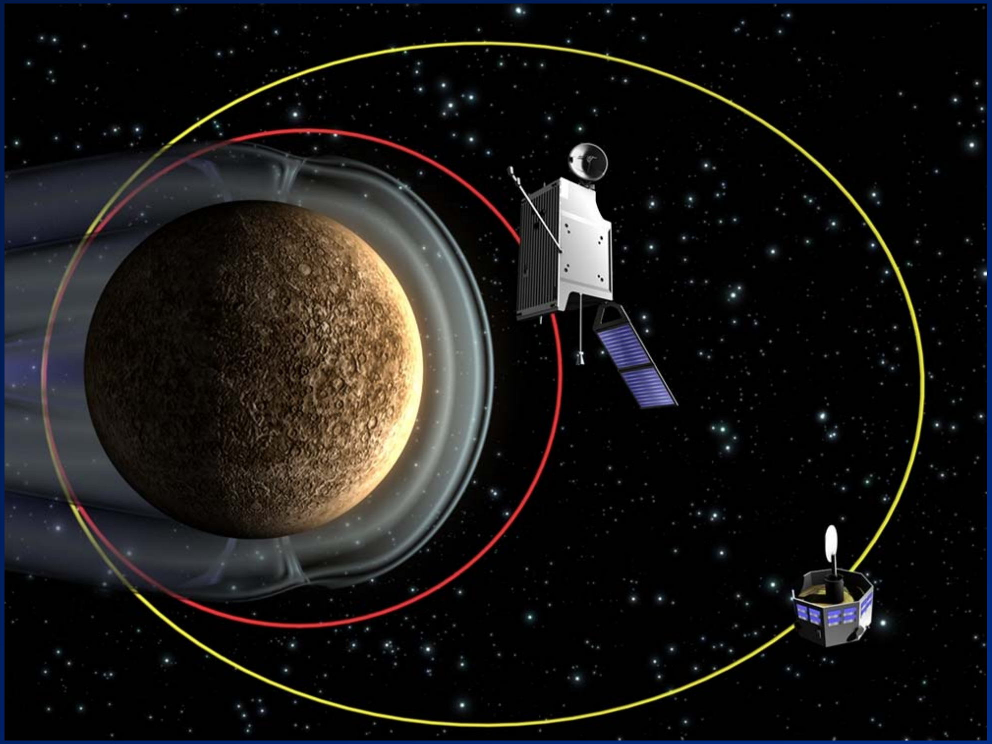


(Courtesy of Mark Robinson and Paul Lucey.)



BepiColombo

named after the late Prof. Giuseppe *"Bepi"* Colombo



- First dual spacecraft mission to Mercury
- Provides global high resolution coverage

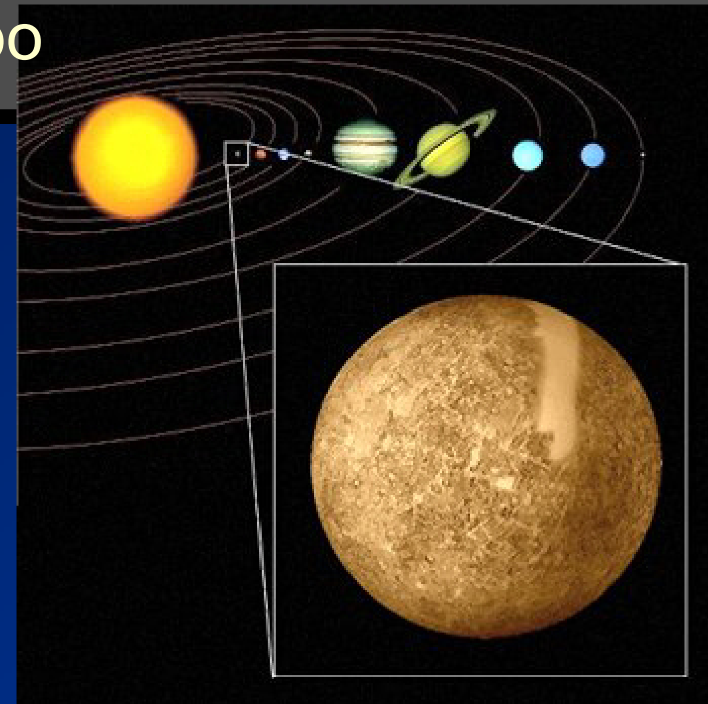
Mercury Planetary Orbiter (MPO)

- focus on surface and interior science
- built under ESA responsibility
- orbit: polar 400x1,508 km, 2.3 hours period
- data return:1,550 Gbit/year

Mercury Magnetospheric Orbiter (MMO)

- focus on the planetary environment
- built under JAXA responsibility
- orbit: polar 400x12,000 km, 9.2 hours period
- data return: ~1/20 of MPO

Designing BepiColombo



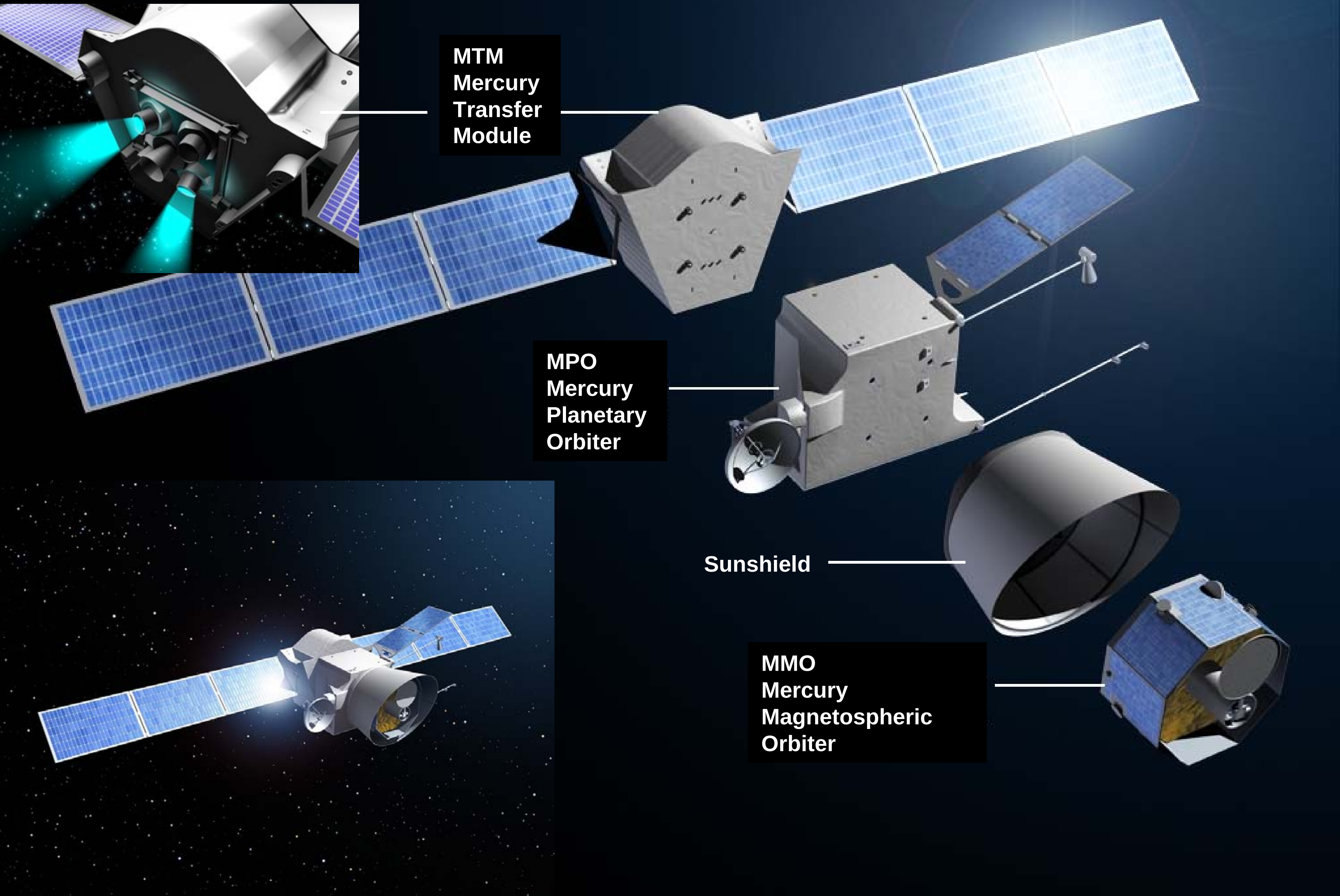
Mercury is the innermost planet in the solar system at a third of Earth's distance to the Sun:

- Spacecraft need to survive a very hot environment with surface temperatures up to 470°C
- Large amount of energy needed to brake against the Sun's gravity

Mission requires:

- A single launch Ariane 5 from Kourou
- Clever mission design using gravity assists and solar electric propulsion
- A transfer module, housing the propulsion systems, to thrust the 2 orbiters to Mercury
- Nadir pointing and high data-rate, implying most spacecraft sides and antennas in full Sun

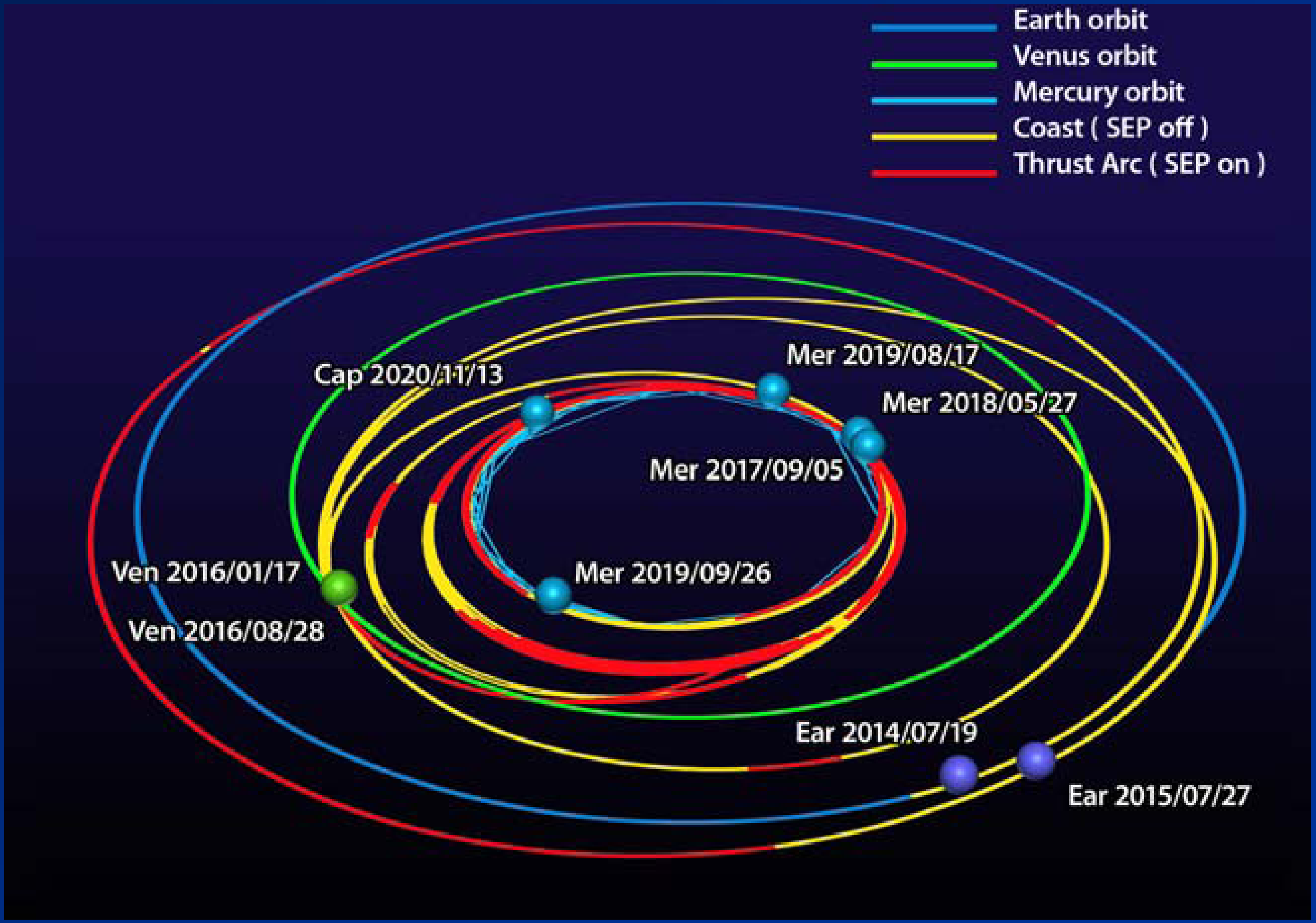
BepiColombo Cruise Configuration



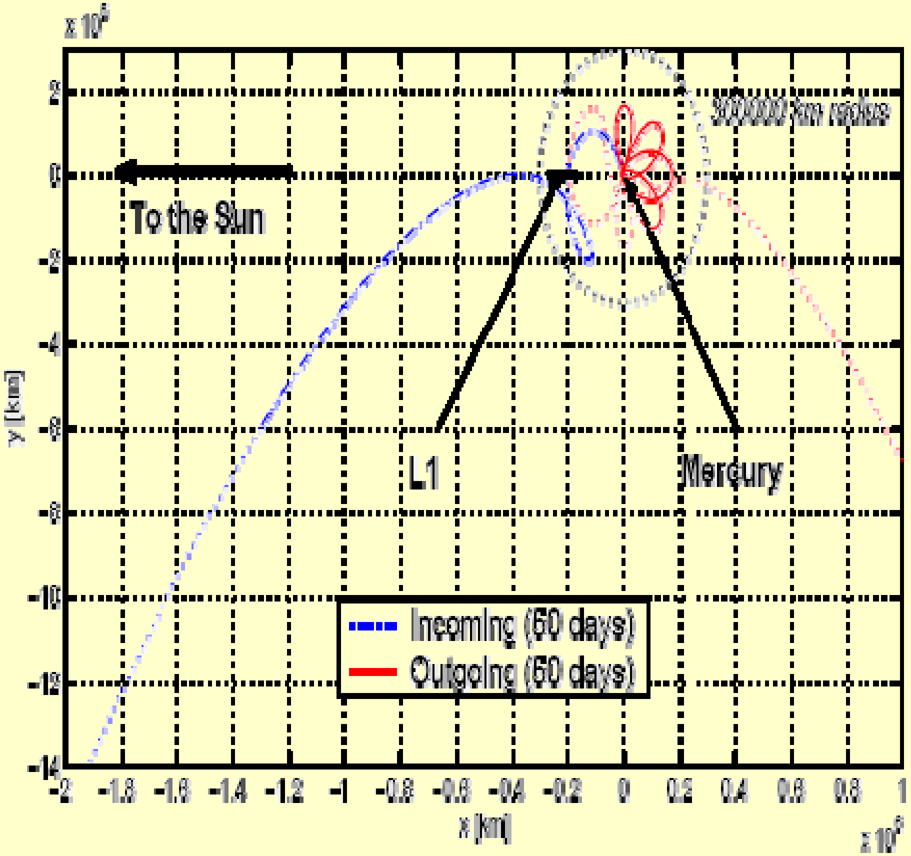
esa SCIENCE

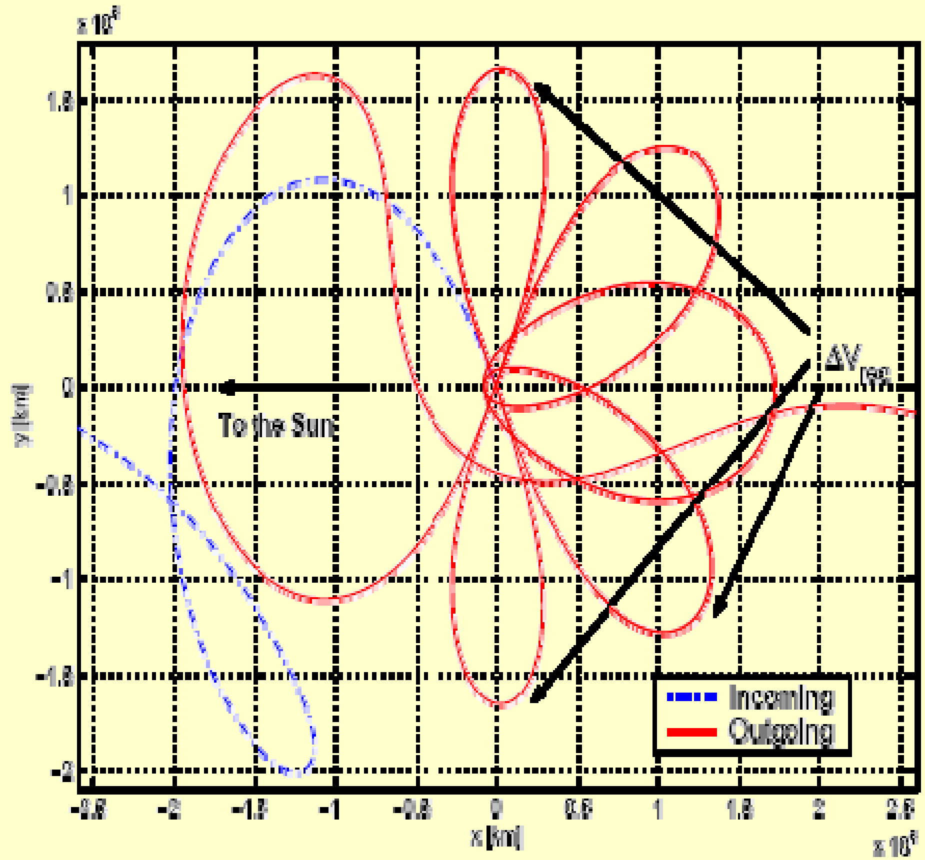
Journey to Mercury

- Launch: July 2014 by Ariane 5 from Kourou
- 6.3 year cruise to Mercury by electric propulsion
- Earth, 2 Venus, 4 Mercury flybys/gravity assists
- Arrival at Mercury: November 2020



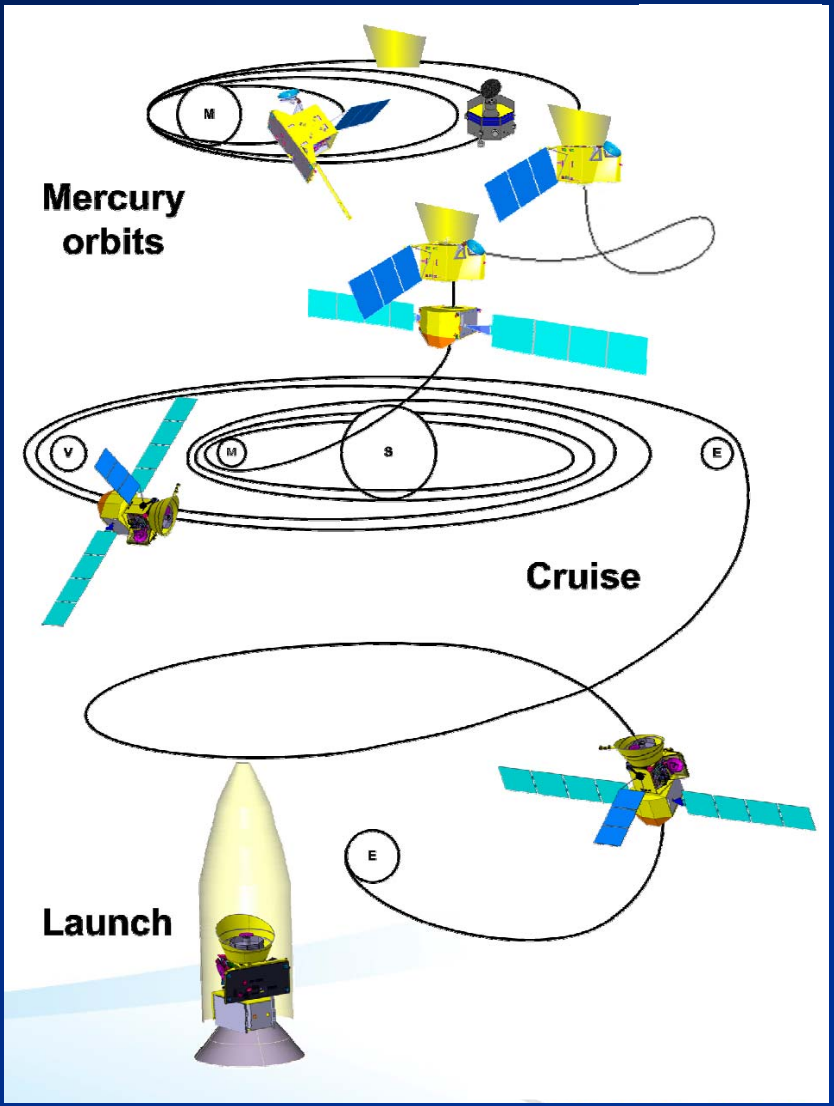
Mercury Arrival – Gravitational Capture



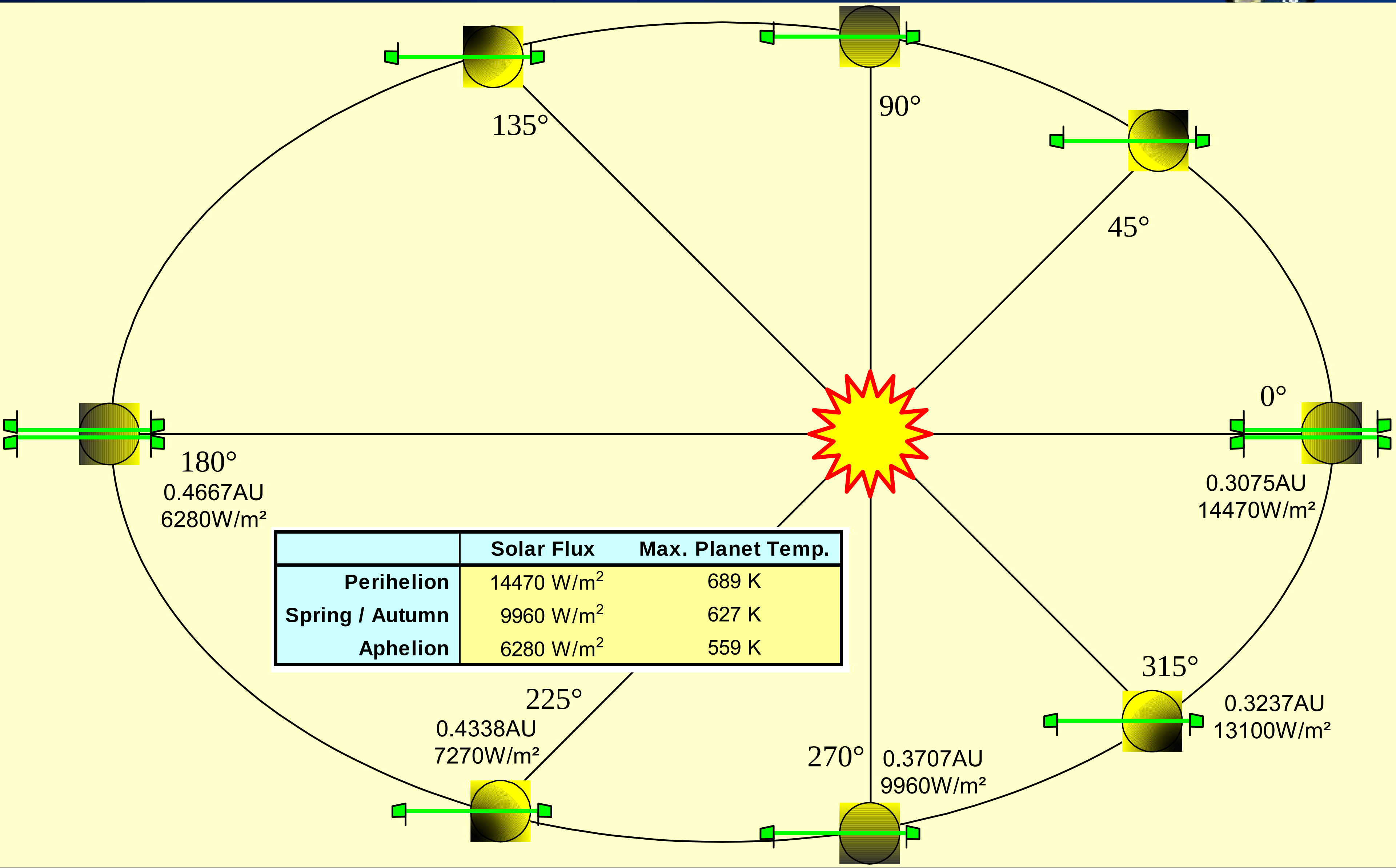


Journey to Mercury

- Gravity capture into Mercury orbit / Mercury orbit adjustment by chemical propulsion
- Injection of the MPO and MMO into their respective orbits by chemical propulsion
- Science operations: 1 year nominal plus 1 year extended



MPO Orbit



	Solar Flux	Max. Planet Temp.
Perihelion	14470 W/m^2	689 K
Spring / Autumn	9960 W/m^2	627 K
Aphelion	6280 W/m^2	559 K

Spacecraft Configuration

Launch mass: 4,100 kg

- MPO P/L: 80 kg
- MPO dry: 1,147 kg
- MMO: 275 kg
- MTM: 1,155 kg
- Xenon fuel: 560 kg
- MTM Chemical fuel: 150 kg
- MPO Chemical fuel: 657 kg

Delta-V

- 5,760 m/s electrical
- 1,065 m/s chemical

MTM Propulsion:

- 4 x 145 mN ion engines, Isp = 4300 s
  290 mN max
- 24 x 10 N biprop thrusters

Dimensions:

- Overall height: 6.3 m
- Span: 30.4 m

Electrical power:

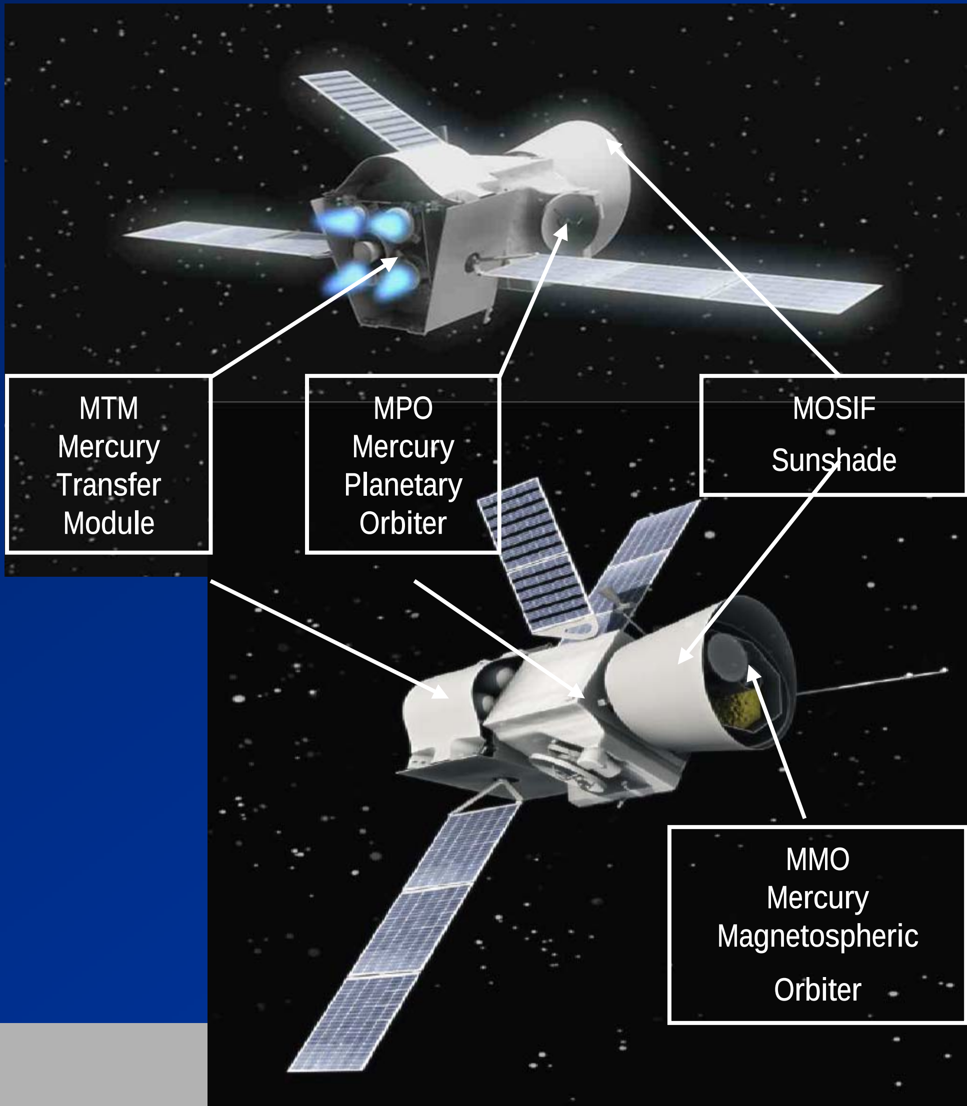
- MTM: 13,200 W @ 0,3 AU, 40.9 m^2
- MPO: 2,000 W @ 0.3 AU, 8.2 m^2 array

Data:

- 1,550 Gbit/year
- X / Ka – bands
- Cebreros DS-2 35m Ground Station
- 384 Gbit memory

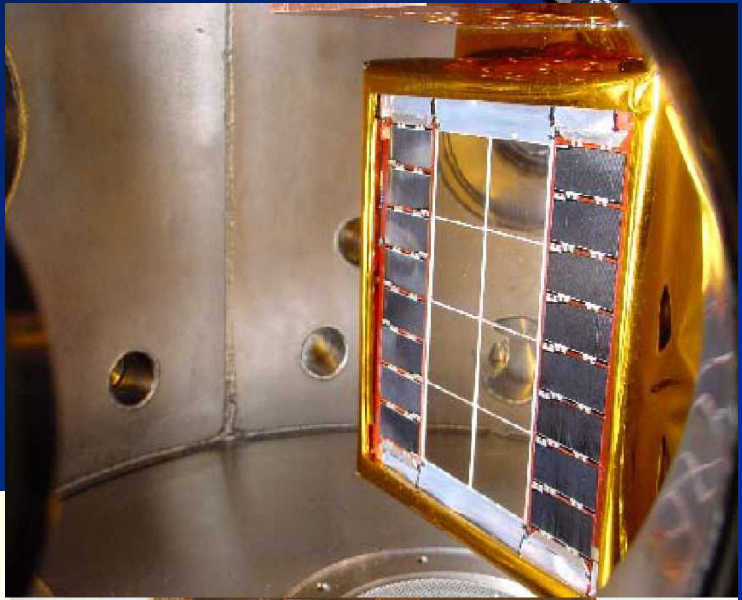
MPO Propulsion:

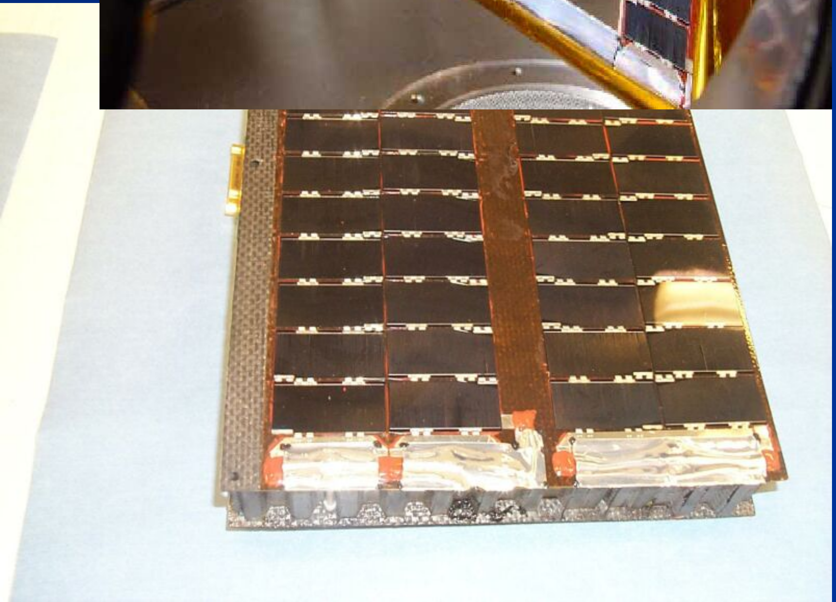
- 8 x 5 N monoprop thrusters
- 8 x 22 N dual-mode thrusters



Solar Arrays

- Solar cells:
  - GaAs triple-junction
  - Qualification at maximum temperatures of 200° C and (limited time) 230° C
- Solar array tilted to maximum 85° away from Sun at 0.3 AU
- Optical Solar Reflectors:
  - ~30% on MPO solar array for low Mercury orbit
  - None on cruise arrays (MTM), which see no planetary heat flux
- Substrate:
  - High-temperature CFRP

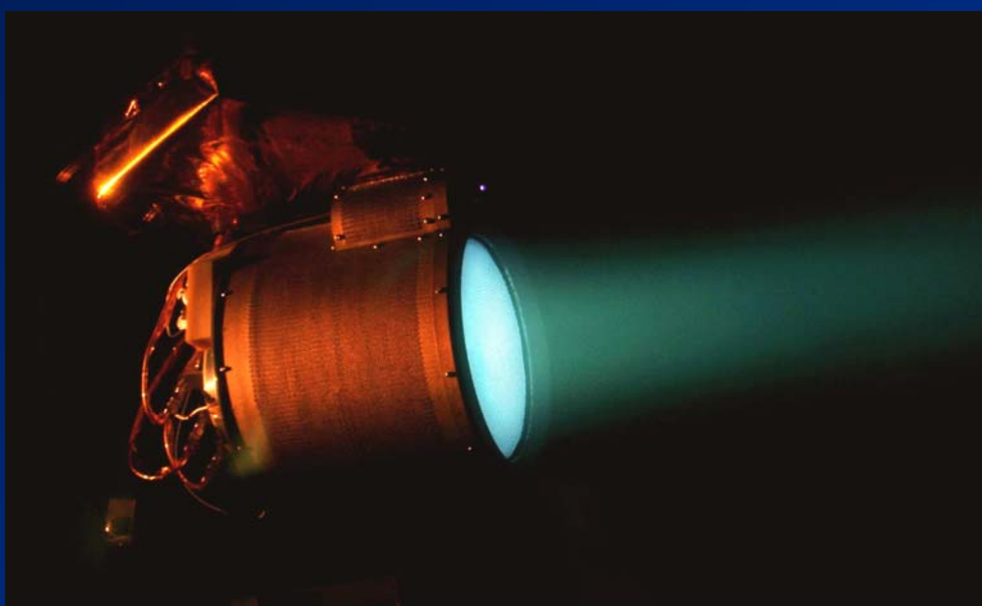




Electric Propulsion Engines

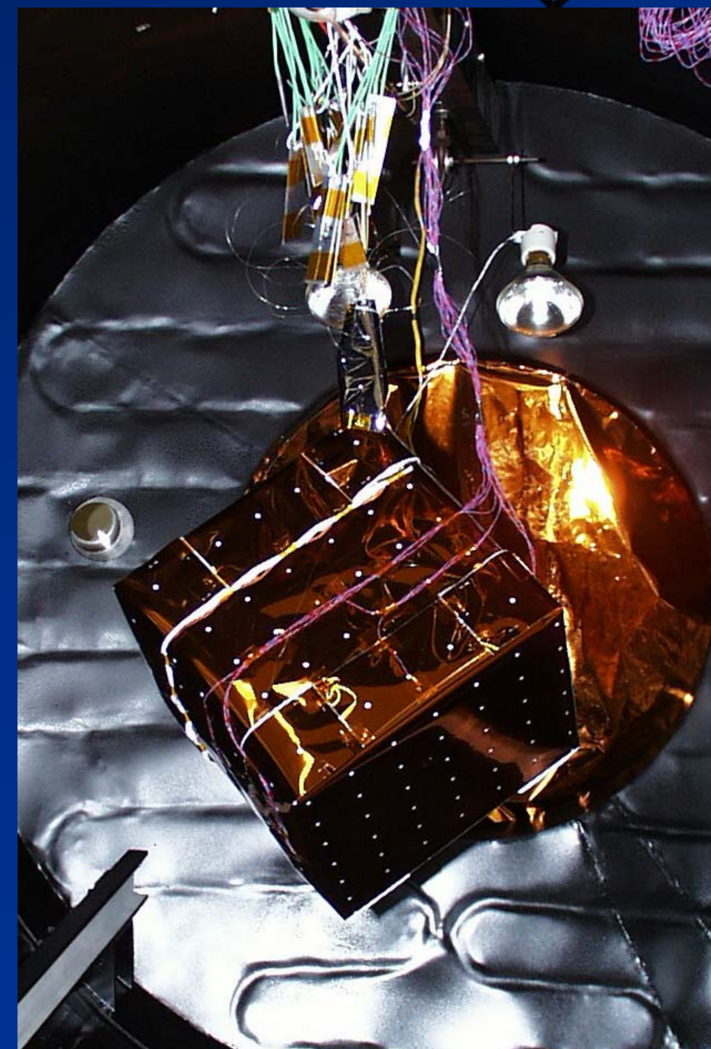
» QinetiQ T6

- Thrusters have successfullty provided thrust for 5,500 hr (versus a qualification duration of 25,000 hr)
- Simultaneous firing of 2 engines has been demonstrated without interference



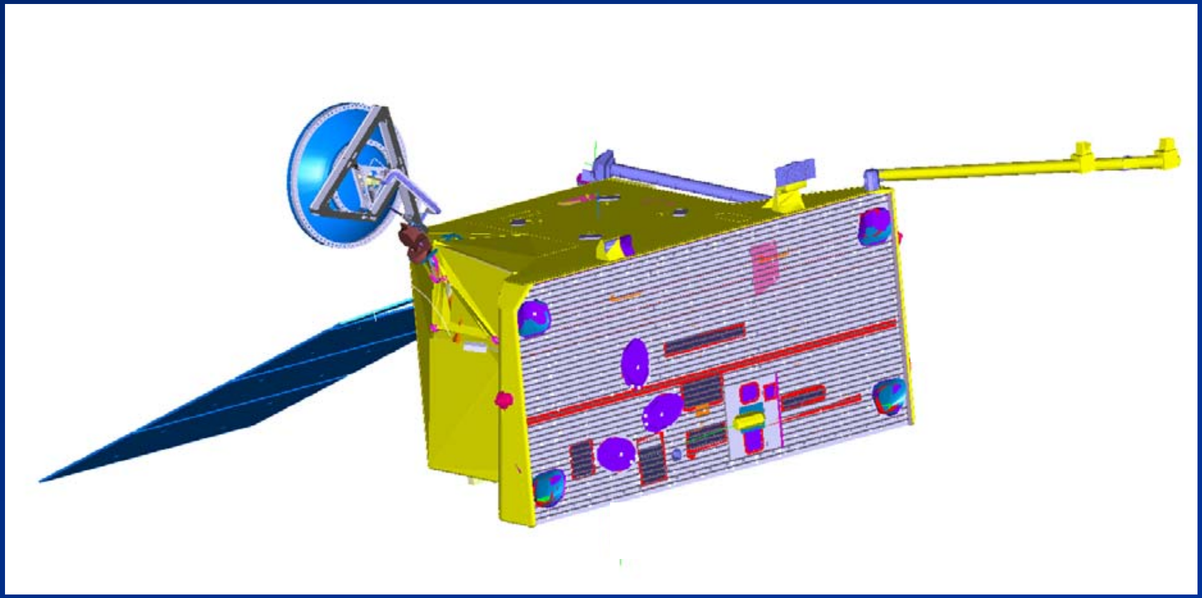
High Temperature Multi-Layer Insulation

- Sunshield: ceramic fabrics (Nextel) to limit temperature of reflective screens
- Reflective screen layers (20x): polyimide (Upilex) to 350° C maximum, some outer metal foils (mass impact)
- Spacers: tissueglass (mass impact)
- EOL degradation of α/ε (synergistic effect of long-term UV and hi-T exposure)
- Insulation performance of as-built MLI at hi-T

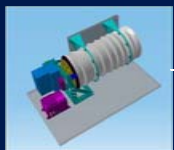


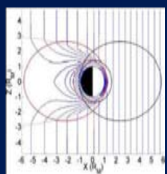
MPO Configuration at Mercury

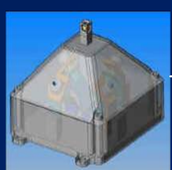
- MPO design exhibits:
  - Overall design optimized for operation in low Mercury orbit.
  - Surfaces facing the Sun may exceed temperatures of 400°C
  - Radiator designed specifically for Mercury IR environment.
  - High temperature HGA, MGA, Solar Array, and MLI.
  - Continuously rotating single-sided Solar Array
  - Boom-mounted MGA able to look around MPO body.
  - Twice a year: flip-over to keep radiator away from sun.

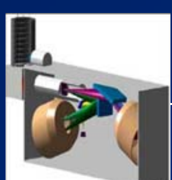


MPO Payload

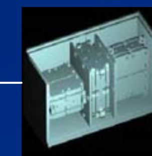


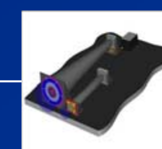


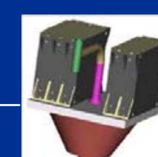


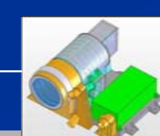


BELA	Laser Altimeter	N. Thomas / T. Spohn
ISA	Italian Spring Accelerometer	V. Iafolla
MERMAG	Magnetometer	K.H. Glassmeier
MERTIS	Thermal IR Spectrometer	H. Hiesinger
MGNS	Gamma Ray/Neutron Spect.	I. Mitrofanov
MIXS	X-ray Spectrometer	G. Fraser
SIXS	Solar Monitor	J. Huovelin
MORE	Radio Science Ka-band Transponder	L. Iess
PHEBUS	UV Spectrometer	E. Chassefière
SERENA	Neutral Particle Analyser/ Ion Spectrometers	S. Orsini
SIMBIO-SYS	High Res.+ Stereo Cameras visual and NIR Spectrometer	E. Flamini

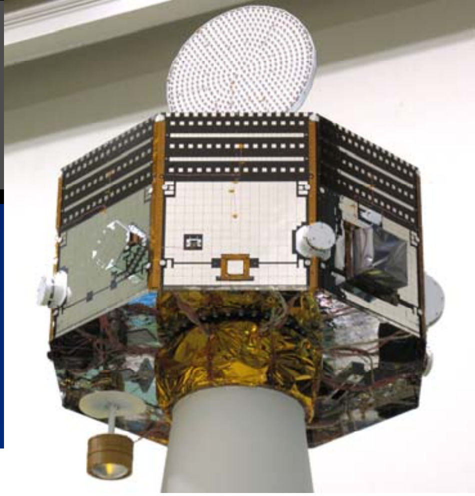






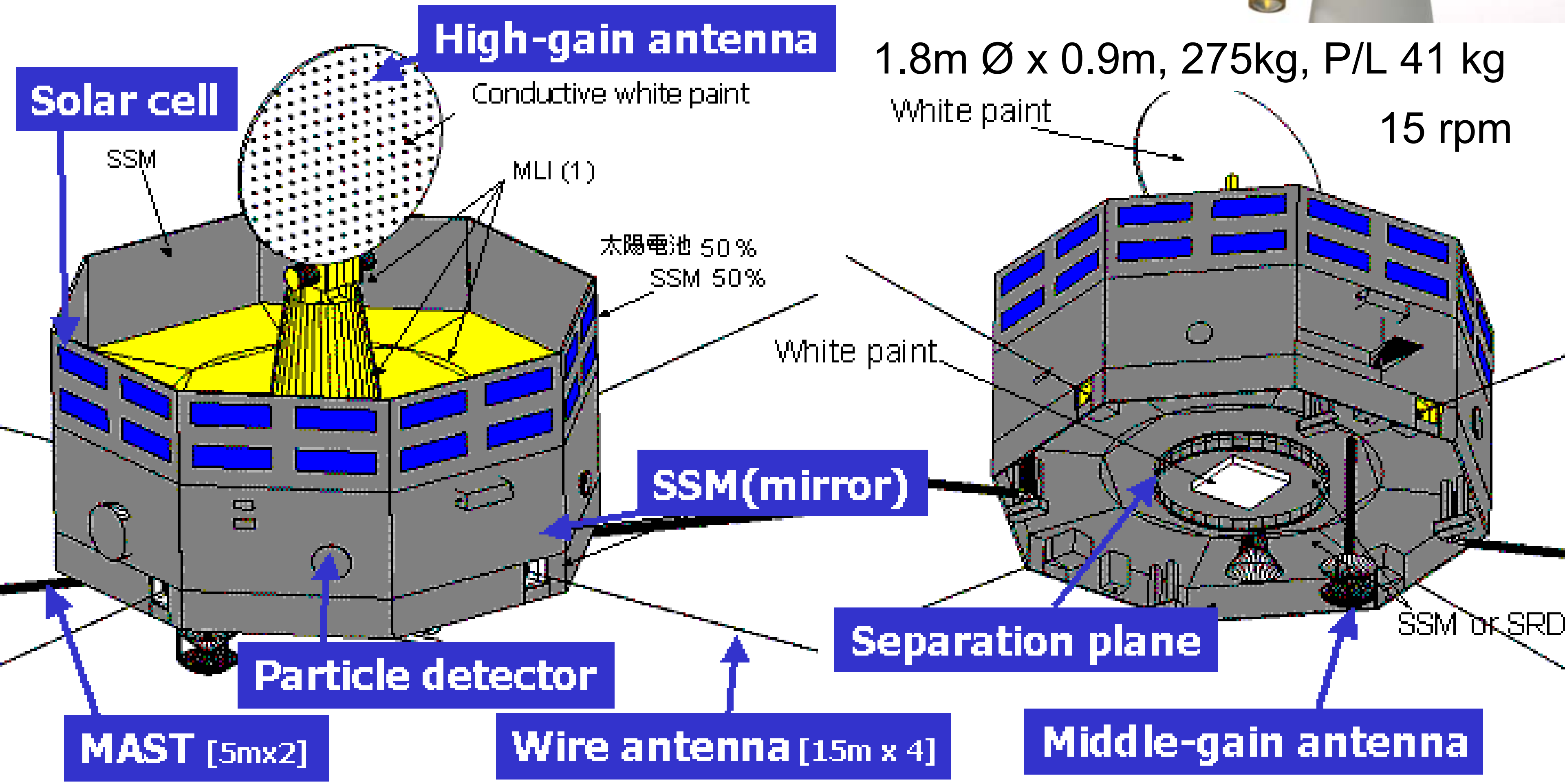


The Mercury Magnetospheric Orbiter



1.8m Ø x 0.9m, 275kg, P/L 41 kg

15 rpm



Summary

- First European mission to Mercury
- First mission with 2 spacecraft to the planet
- First mission to be captured by the planet's gravity before orbit insertion
- Posing enormous but exciting challenges for its implementation:
  - first Mercury orbiter with full-time nadir pointing capability
  - technology and materials to survive the high-temp environment
  - highly efficient solar-electric propulsion