

# Marco Polo: The European contribution

David Agnolon  
ESA-ESTEC

Directorate of Science & Robotic Exploration  
Solar System and Robotic Exploration Missions  
Section

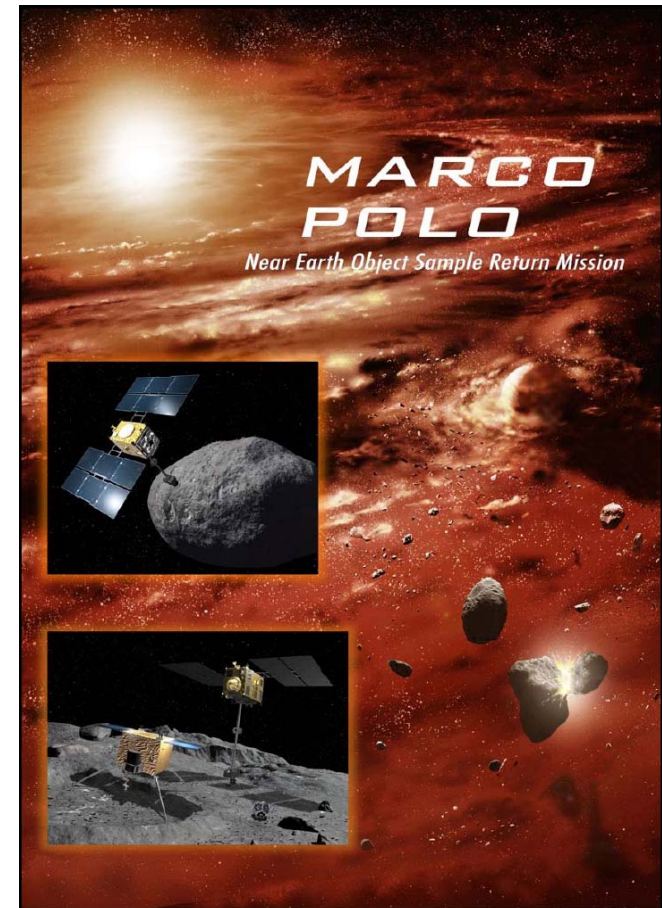
Email: david.agnolon@esa.int



*European Science Study Team, Marco Polo JAXA study team, Marco Polo ESA study team,  
Astrium Ltd, OHB, Thales Alenia Space-I*

# Outline

- ❑ Marco Polo in Cosmic-Vision
- ❑ Assessment phase
- ❑ Marco Polo scenarios, design options and technical challenges
- ❑ Enabling technologies
- ❑ Conclusion



CV-proposal  
Marco Polo



# Marco Polo in Cosmic-Vision

- ❑ Selected in 2007 as an M-class mission (ESA Cost at Completion (CaC) < 450 M€) to go into assessment phase in the Cosmic-Vision Scientific programme
- ❑ Assessment phase (~ Ph. 0/A) ongoing. Started in ~ Nov. 07. Will be completed in ~ Dec. 09
- ❑ TBD number of M-class missions/missions of opportunity will be recommended to enter definition phase (~ Ph. A/B1) by SSWG/AWG/SSAC for SPC approval (Feb. 2010)
- ❑ Selection on the grounds of (mainly):
  - Science value, compliance of the design with science requirements
  - CaC (all cost but nationally-provided science instruments) < 450 M€
  - Technical feasibility (space (inc. payload) and ground segment) within the given timeframe (launch in 2017-2018) → TRL 5-6 by end 2011
- ❑ Final missions to be adopted end 2011 for implementation phase (Phase B2/C/D) for launch in 2017/2018





# Marco Polo assessment phase

- ❑ Science: Marco Polo Science Study team → Science requirements
- ❑ Payload: ~ 18 instrument studies (following Declaration of Interest) → Payload definition
- ❑ Mission/System design: ESA study team → Mission requirements
  - Space segment:
    - ✓ ESA internal pre-assessment (CDF)
    - ✓ 3 competitive European industry system studies
  - Ground segment: ESAC and ESOC → Science/Mission operations
- ❑ Technology activities: ESA technology programmes (TRP, CTP, GSTP, etc.)
- ❑ JAXA teams interface across all European activities above
- ❑ Various collaboration scenarios looked at
- ❑ **Outcomes/Products of the assessment phase:**
  - Marco Polo Yellow Book (Science/Mission summary),
  - Spacecraft, instruments and ground segment technical/programmatics reports
  - Associated ESA technical and programmatics feasibility review reports



# Marco Polo scenarios

## ❑ ESA-defined scenario:

- Selected at Mission Architecture Review in Jan. 08, design-to-cost
- Recommendations from industry/ESA, agreed by European SST

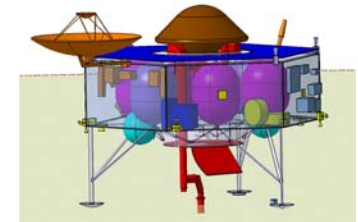
## ❑ JAXA-led scenario (under discussion, launch date TBD):

- JAXA {
- ✓ Main spacecraft (ion engines), Hayabusa capability + ~ 15 kg (TBC), shared by instruments, lander, enhanced sampling, etc.
  - ✓ Main mission/science operations

- ESA {
- ✓ Re-entry capsule, also investigated in European system studies
  - ✓ Support to mission operations (e.g. ground stations)

## ❑ Synergies:

- Primitive-class asteroid 1999 JU3, selected out of ~ 5000 NEOs as:
  - ✓ One of most easily accessible primitive NEOs in given timeframe
  - ✓ “Mild” environment, physical properties (do not drive design)
- Re-entry capsule:
  - ✓ Similar re-entry conditions
  - ✓ Maximization of common interfaces
- Soyuz-Fregat 2-1b launch vehicle (feasibility TBC for JAXA-led)

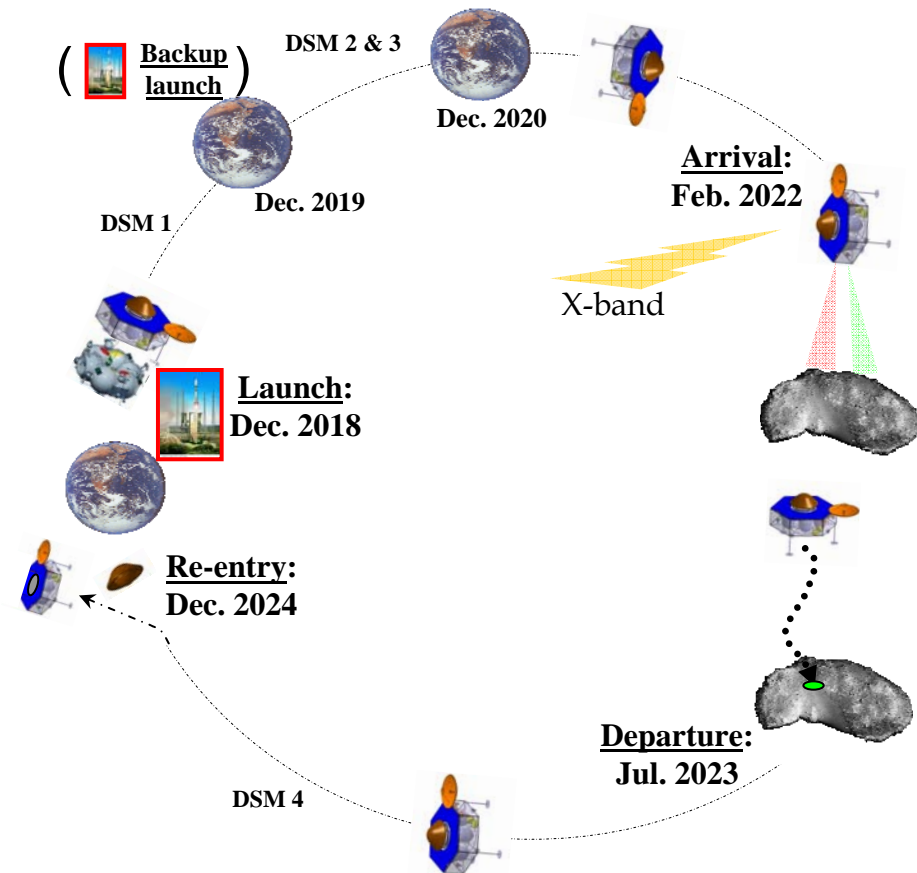


*Courtesy of JAXA*



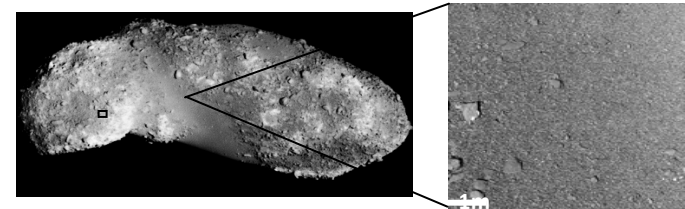
# ESA-defined scenario

- ❑ Launch from Kourou, direct escape:  
 $V_{inf} \sim 3.15-3.3 \text{ km.s}^{-1}$ ,  $Dec = 0^\circ$
- ❑ 6 year mission, incl. 17 months at asteroid
- ❑ Single spacecraft (chemical prop.) + capsule
- ❑ ROM budgets:
  - $\sim 1440 \text{ kg}$  launch mass capability (incl. margins, excl. adapter)
  - Power  $\sim 500 \text{ W}$
  - Instrument total mass:  $\sim 24 \text{ kg}$
- ❑  $\Delta V$  (incl. margins):
  - Total in/out transfer  $< \sim 1500 \text{ m.s}^{-1}$
  - Near-asteroid phase  $< \sim 50-100 \text{ m.s}^{-1}$
- ❑ Re-entry velocity  $\sim 11.9 \text{ km.s}^{-1}$



# ESA-defined scenario

- ❑ Characterization before sampling:
  - Get the global/local context information
  - Select safe and scientifically rewarding sites
- ❑ Descent/sampling:
  - Rehearsals, 3 sampling attempts
  - Dedicated landing/touchdown system to ensure safe attitude during sampling operations
  - Capability to cope with hazards up to 50 cm scale
  - Safe sampling area → high landing accuracy is a major asset (~ 3-5 m)
  - Fast “volumetric/mechanical” sampling and transfer technique (few seconds to minutes)
    - ✓ Suitable and reliable to collect “up to tens of g” given the considered soil properties
    - ✓ Verification technique as a “must”, backup method investigated
    - ✓ Lowest development risk in Europe to achieve TRL 5 by 2011
- ❑ High-speed Earth re-entry:
  - Capsule design builds on Hayabusa architecture



Courtesy of JAXA



Courtesy of JAXA

# European industry system studies



Astrium Ltd - Astrium GmbH/SAS/ST, Deimos, DLR, Selex Galileo

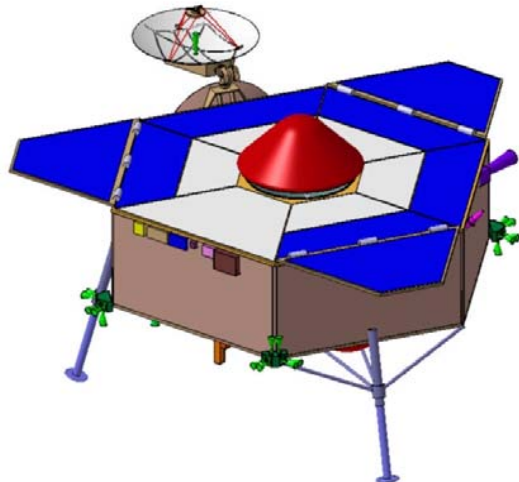


OHB - Aerosekur, GMV, Qinetiq, SENER

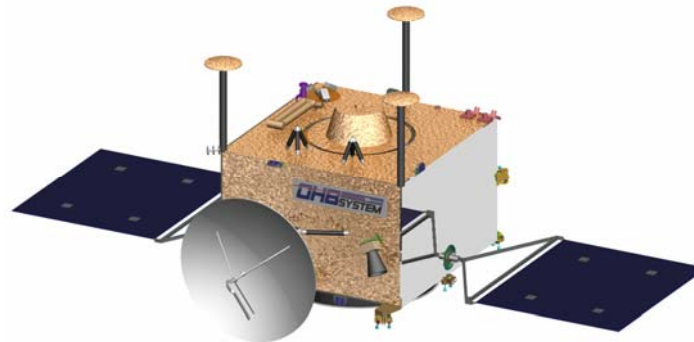


TAS-I - NGC, Selex Galileo, TAS-F

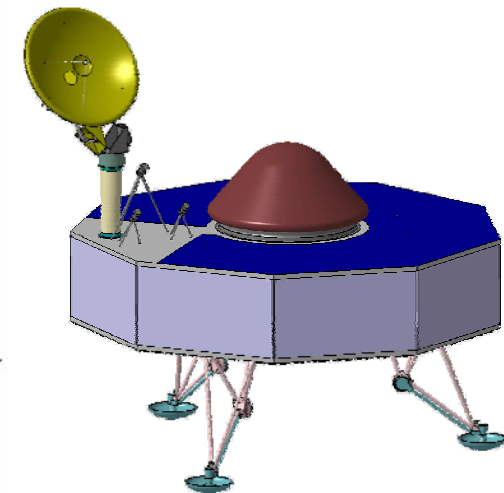
- Design iterations and consolidation coming up in next two months
- Mass margins comfortably sit within ESA requirements at this stage



*Courtesy of Astrium Ltd*



*Courtesy of OHB*



*Courtesy of Thales Alenia Space*





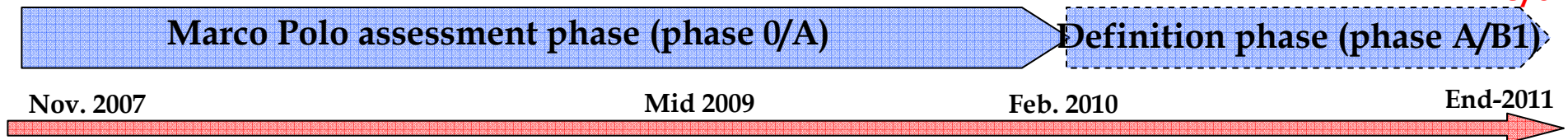
# Enabling technologies

High precision descent/touchdown autonomous GNC	- Ongoing MSR/Moon NEXT-related activities, TRP - Orbiting GNC/operations covered by Rosetta
Low-gravity/high clearance landing/touchdown system	Philae, Ongoing MSR/Moon NEXT-related activities
“Volumetric” sampling tool, “deterministic” sample transfer and containment chain	Philae, CNSR, Beagle 2, Ongoing ExoMars/MSR-related activities, GSTP, Nationally-funded
“High heat flux” ablative TPS material (TBD low or high density ?)	ARD, Generic Aurora-related activities, Ongoing TRP
Upgrade of re-entry testing facilities (high heat flux), new shock tube (radiations)	Generic Human Spaceflight, Aurora-related activities, Ongoing TRP
Parachute (Suitable techno still under investigation)	Huygens, ExoMars, ARD

- Follow-up CTP-funded activities ready to start upon mission selection
- Implementation of the actual development pending on ESA contribution
- P/L: most instruments require development to reach TRL 5 by 2011, but no breakthrough technology required

~ TRL 4

TRL 5/6



# Summary and way forward

- ❑ **Marco Polo assessment activities ongoing nominally**
- ❑ **Studies show promising feasibility results at spacecraft, instrument and ground segment levels**
- ❑ **To limit development risk and cost to ultimately fulfil M-class constraints:**
  - Build wherever possible on available technologies or ongoing activities
  - Robust technology maturation development must and will be undertaken
- ❑ **Forthcoming key events:**
  - Industry studies technical (resp. programmatic) completion in ~ Jul. 09 (resp. Sep.)
  - Final version of the Yellow Book by ~ Oct. 09
  - ESA technical/programmatic review in Oct. 09, independent science review (TBC)  
→ Advisory Structures
  - Public presentation of the study results on Dec. 1, 09
  - Overall review by Advisory Structures in Dec./Jan. 09
  - Final selection by SPC in Feb. 10



# Backup slides



