MarcoPolo-R
Near Earth Asteroid Sample Return Mission

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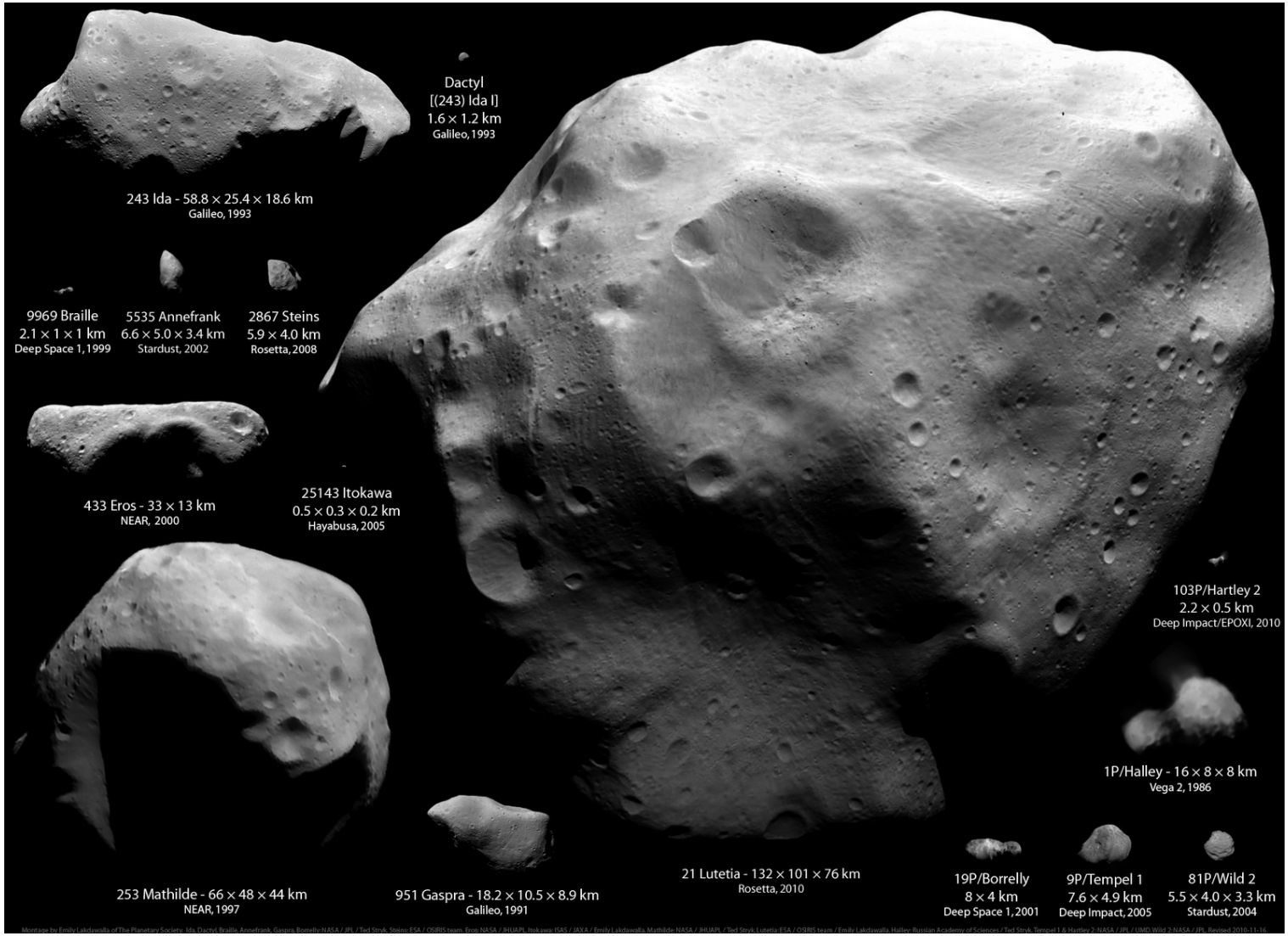
Ref: M.A. Barucci, et al, submitted to Experimental Astronomy

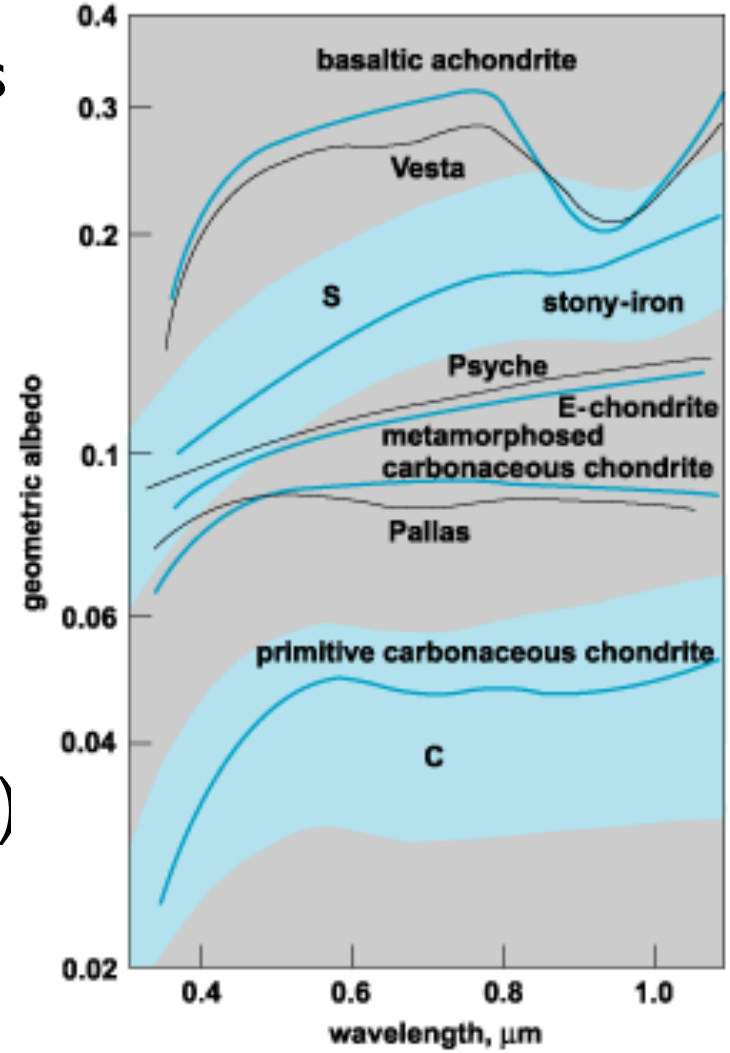
Small Bodies



Credit: Emily Lakdawalla, Planetary Society

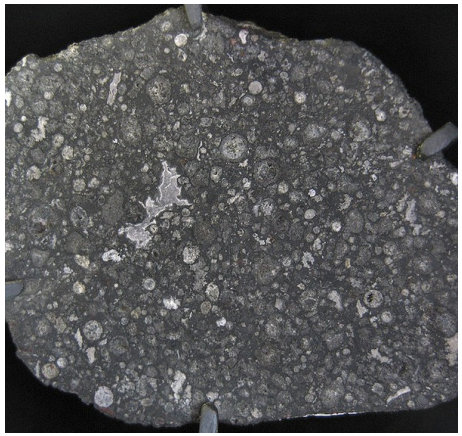
Asteroid Types

- C-group dark carbonaceous objects (75%)
  - Related to carbonaceous chondrites (0.1%)
- S-type silicaceous "stony" objects (17%)
  - Related to stony meteorites (10%)
- M-type metallic objects (8%)
  - Related to iron meteorites (86%)

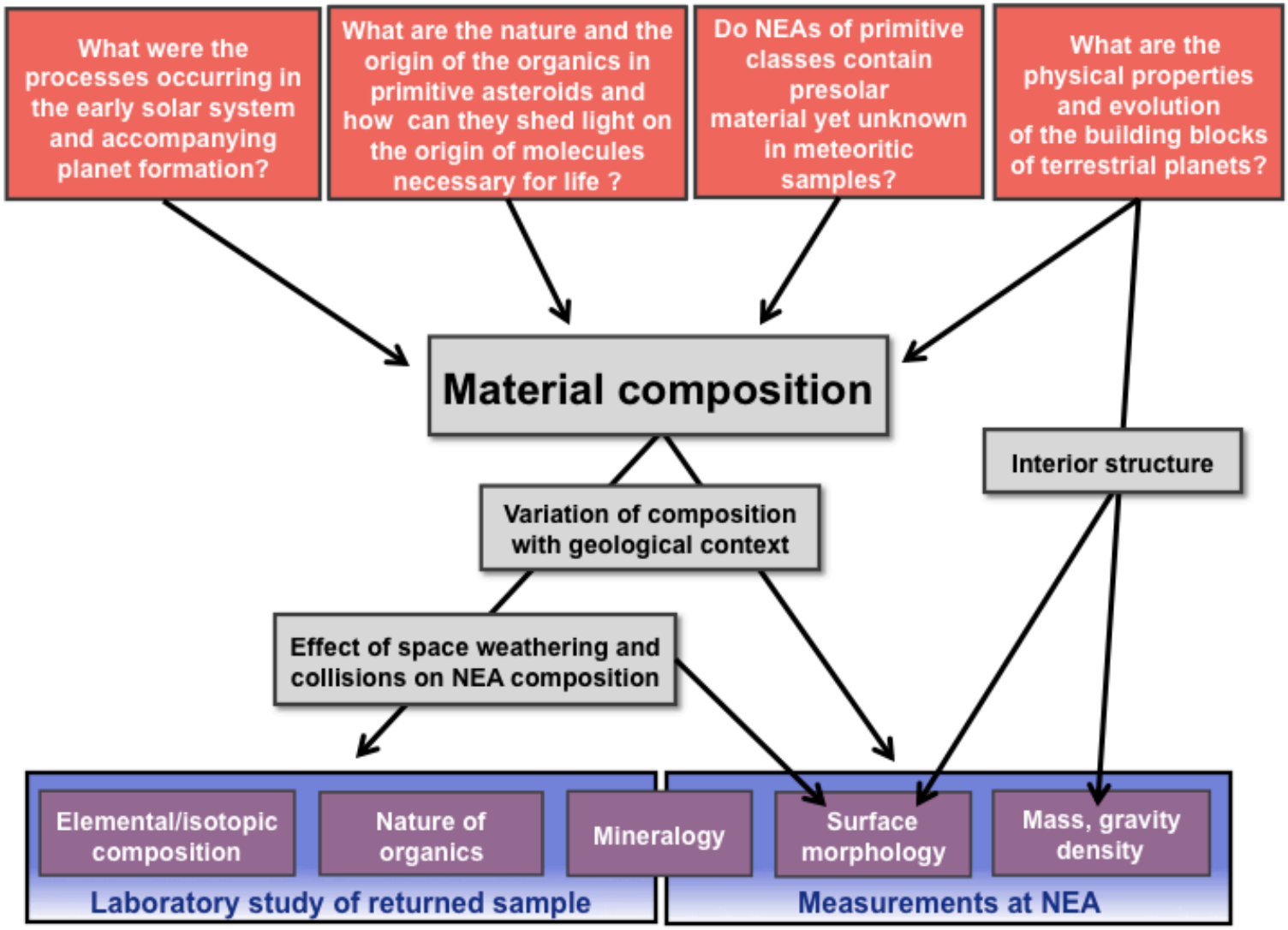


Primitive Asteroids

- The C-group is of special interest because of their dominance, their organic content, and their potential for primitive material
  - Material that is largely unaltered from the time of the formation of the planets
  - *These objects may have been the source of Earth's organic inventory — the elements that life requires*
- Primitive (less altered) material would be more friable and not survive entry as a meteorite
- Hayabusa returned particles of a highly processed S-type asteroid

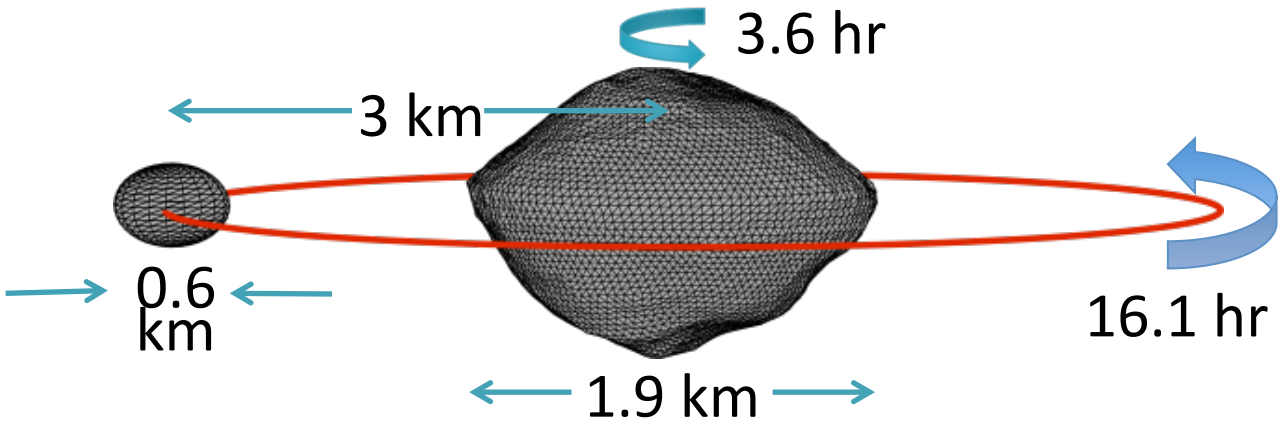


MarcoPolo-R Science Objectives



1996 FG3 C-type Binary

- The MarcoPolo-R target is 1996 FG3
- Orbit 0.69 to 1.42 AU, Apollo class PHA



- A binary offers unique science: binary formation, regolith motion, YORP effects
- Binaries are 15% of the population

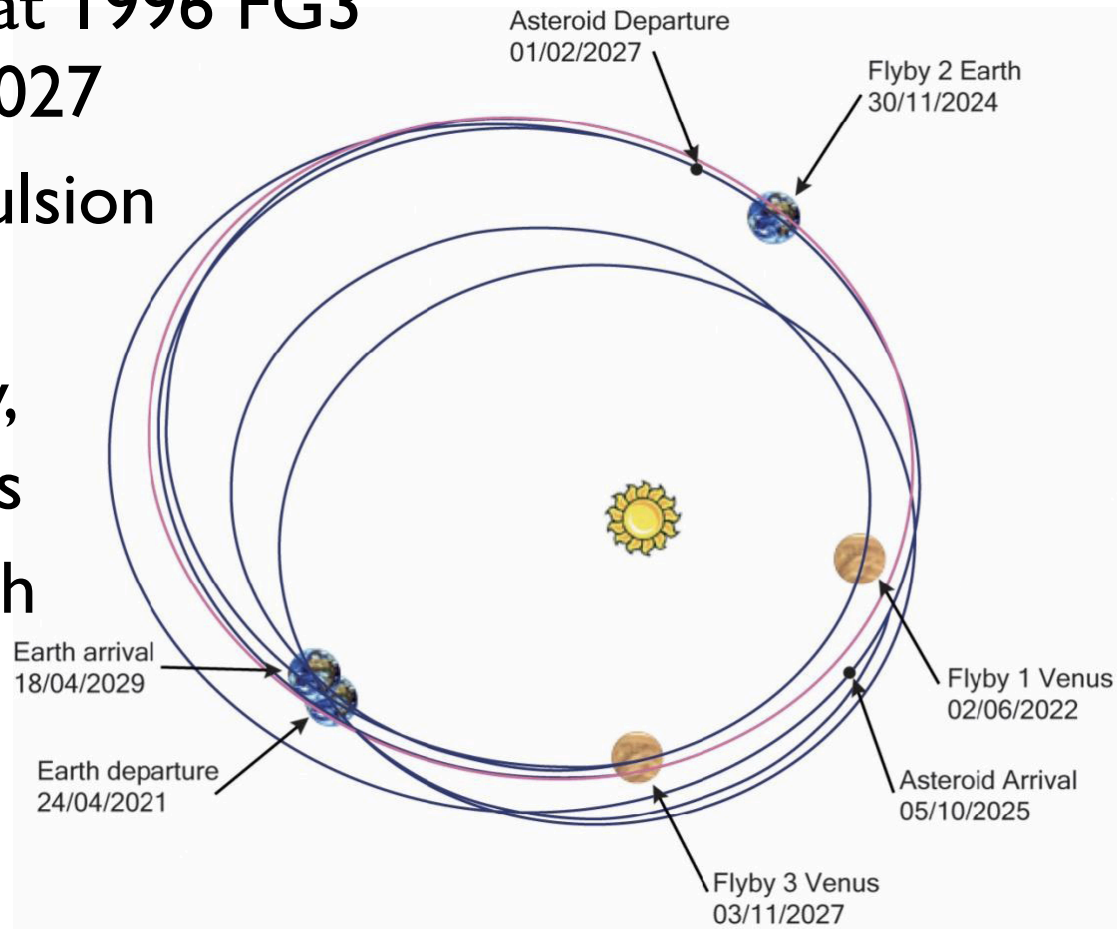
Potentially Hazardous Asteroids

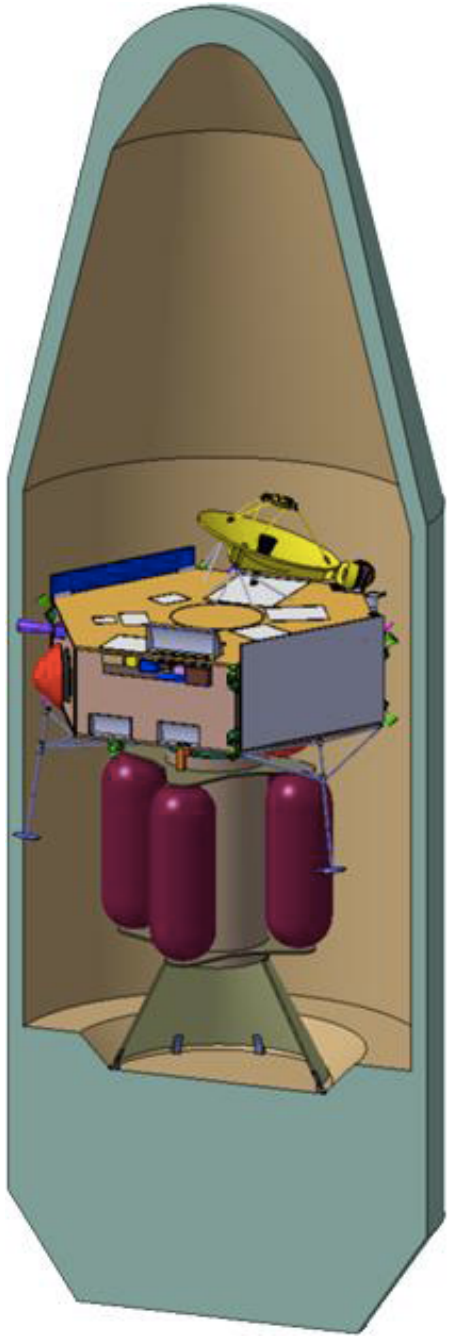
- The continually replenished population of near-Earth asteroids is a threat to life on Earth
- It is a cheap insurance policy to find, track, and *understand* these objects
  - Knowledge of physical properties needed to develop deflection methods
  - Yarkovsky, YORP effects

→ Clearwater Lakes in Canada (26 and 36 km in size), formed by a binary asteroid impact

MarcoPolo-R Mission

- Launch April 2021, 8-year round trip
- 16-month stay at 1996 FG3 Apr 2025-Jan 2027
- Chemical propulsion 2.8 km/s total
- One Earth flyby, two Venus flybys
- April 2029 Earth entry at 13.6 km/s to UTTR



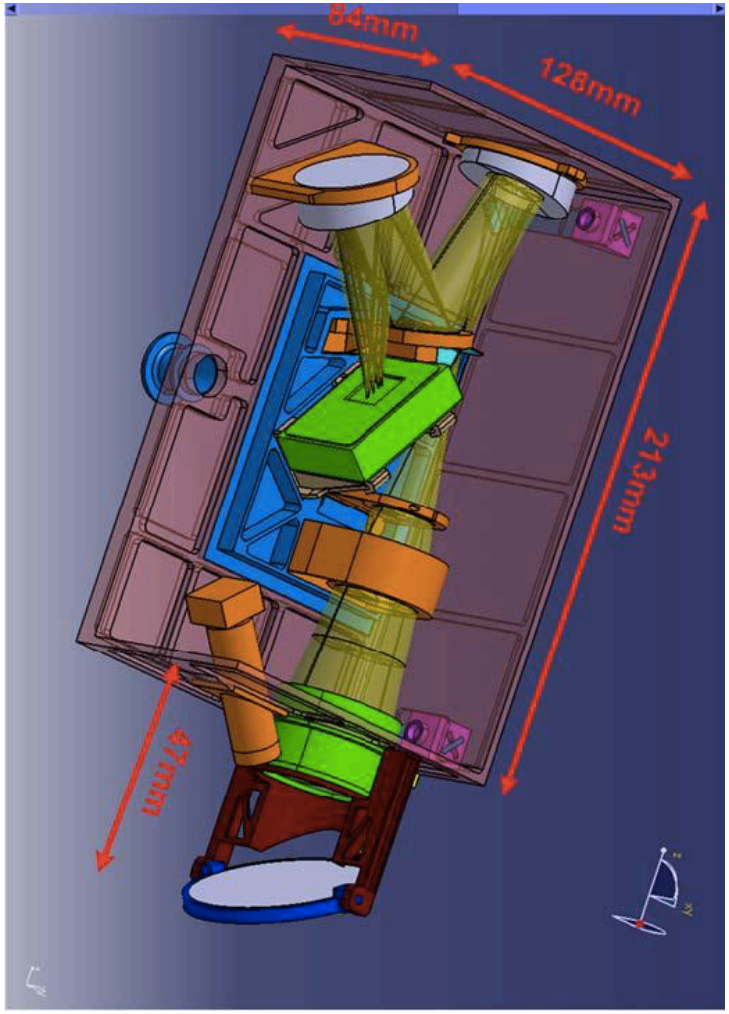


MarcoPolo-R Launch

- Soyuz/Fregat launched from Kourou
- Brings stack to GTO
- Separate propulsion stage takes vehicle from GTO to escape for first Venus flyby
  - Found to be lower mass, better mass margins than direct injection

MarcoPolo-R In Situ Payload

- Wide Angle Camera
- Narrow Angle Camera
- Close-up Camera
- ➔ Visible Near-IR Spectrometer
- Mid-IR Spectrometer
- Radio Science
- Neutral Particle Analyser
- Optional detached lander
  - Camera
  - LIBS
  - Thermal probe
  - RADAR
  - Seismic sensor

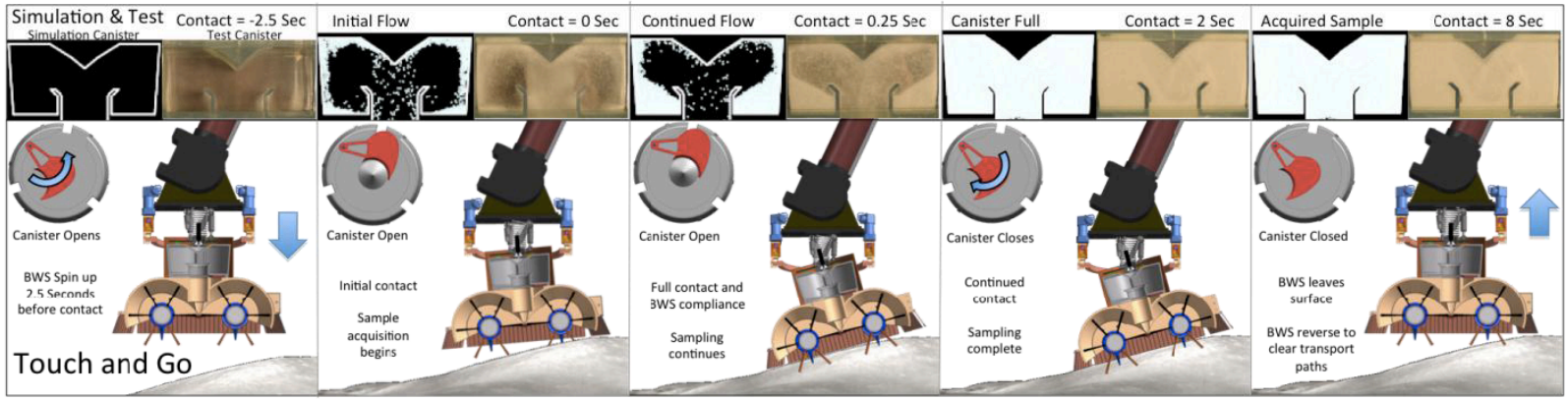


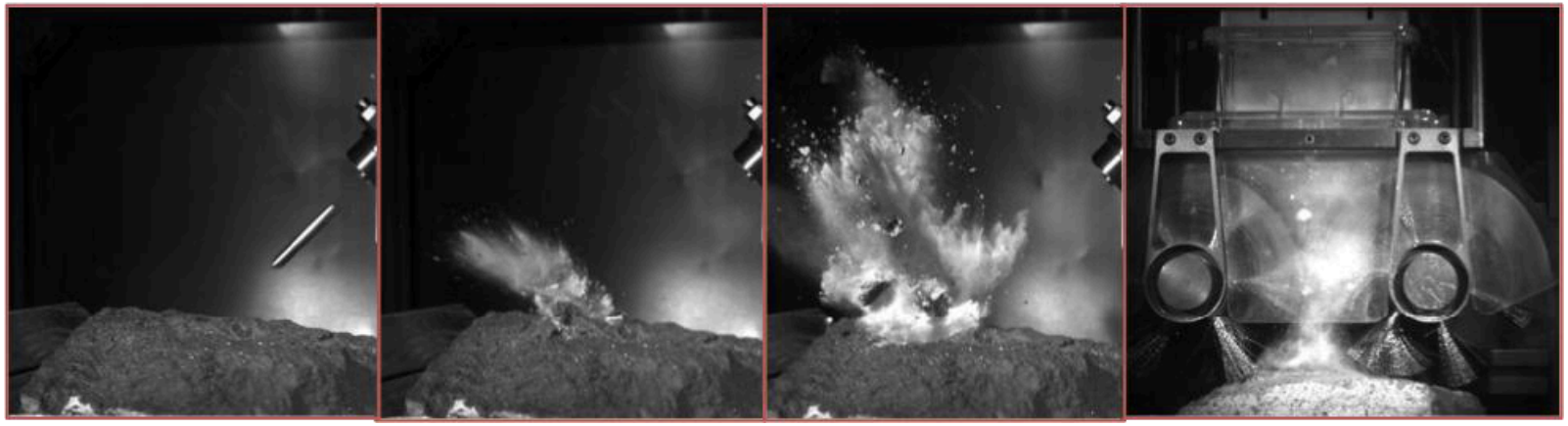
MarcoPolo-R NASA Contribution

- Cost to ESA reduced to a Medium-class mission by collaboration with NASA
- Consortium led by Andy Cheng (APL) including JPL, LaRC, ARC, and MIT
- NASA would contribute:
  - Science team members (APL, JPL, MIT)
  - Brush Wheel Sampler and Robotic Arm (JPL)
  - Earth Re-entry Capsule (LaRC/ARC)
  - Sample transfer and containment (JPL)

Brush Wheel Sampler

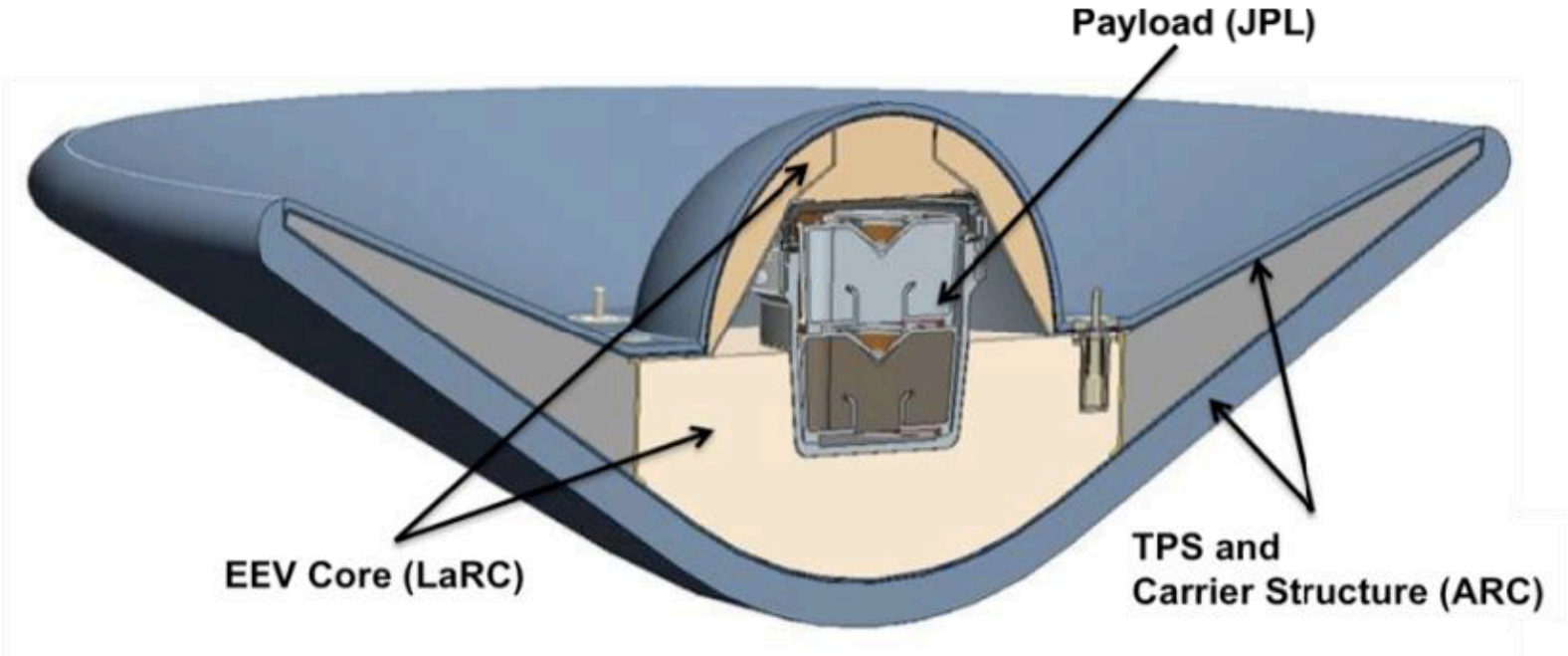
- Rotating brush wheels sweep sample into container
- Pyrotechnic projectiles break rock if necessary





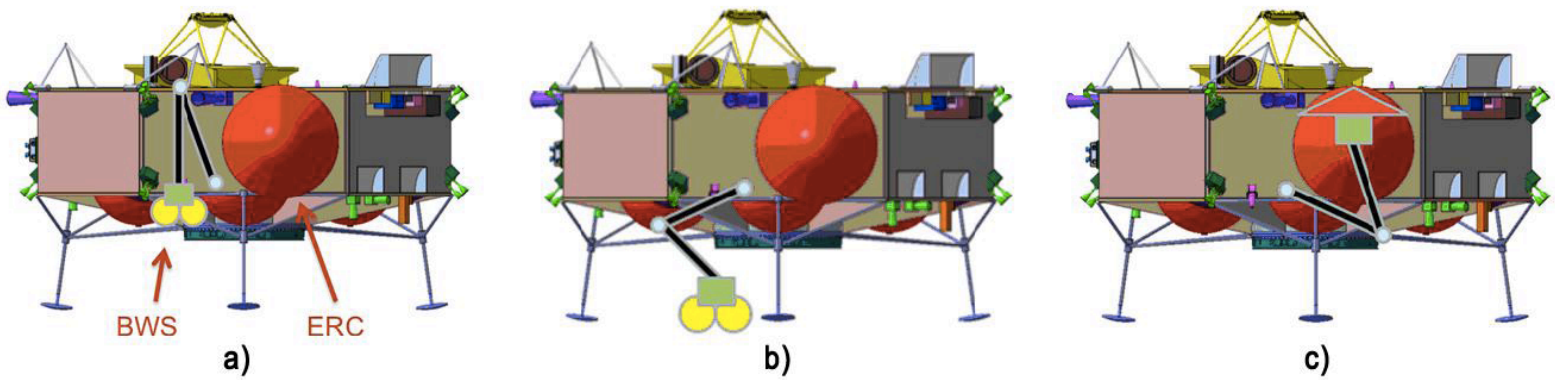
Earth Re-entry Capsule

- Based on Multi-Mission Earth Entry Vehicle
  - Parachuteless design developed for Mars Sample Return
  - 0.9 m monolithic PICA (Stardust), impact foam 1500 G
  - See Rob Maddock poster

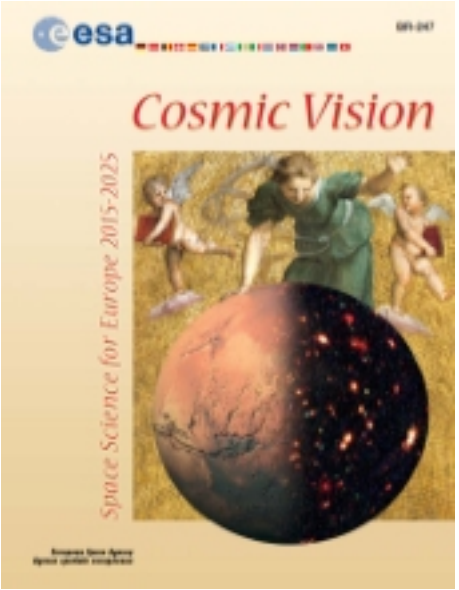


MarcoPolo-R Sampling

- In this configuration (Astrium) the spacecraft lands on legs for a few seconds
- The BWS collects up to 2 kg of sample in less than 2 seconds
- The sample container is put in the ERC



MarcoPolo-R Status



- European-led M-class mission with NASA contribution
- One of four candidates selected in Feb 2011 for ESA M3 Cosmic Vision 2 assessment study (out of 47 proposals)
  - Exoplanet Characterisation Study
  - Large Observatory for X-Ray Timing
  - Space-Time Explorer and Quantum Equivalence Principle Space Test
- One mission will be selected by ESA as M3
- NASA OSIRIS-REx selected two weeks ago