Marco Polo science requirements

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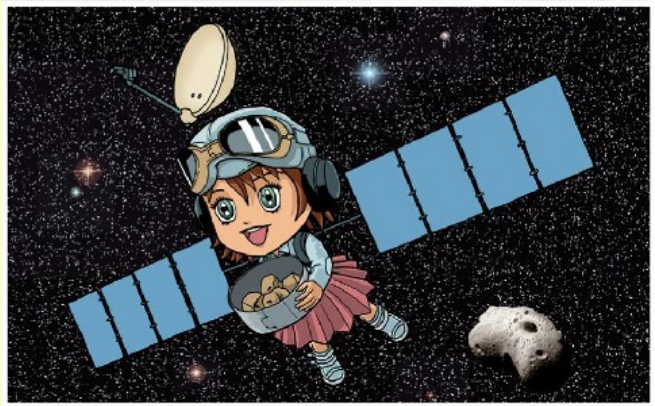
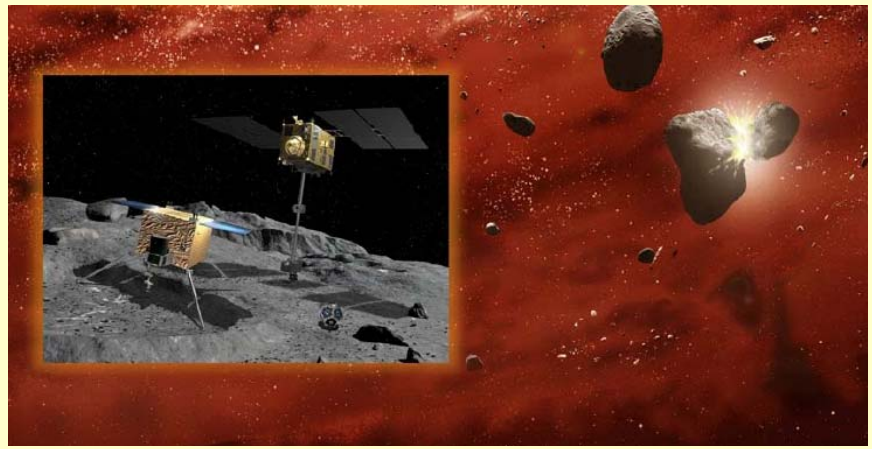
M.A. Barucci, H. Boehnhardt, J.R. Brucato, E. Dotto, I.A. Franchi, S.F. Green, J.-L. Josset, P. Michel, K. Muinonen, J. Oberst and compiled by D. Koschny



Paris, 17 May 2009

Marco Polo

- Studied in the context of Cosmic Vision
- Assessment Study Report (= Yellow Book) due end September 2009
- Will assume an 'ESA-defined' mission
  - ☞ Launch ~2018
  - ☞ open for collaboration – e.g. Earth Reentry Capsule for JAXA-led mission
- ESA Missions
  - ☞ Payload is funded by member states
  - ☞ Rest comes from ESA – s/c, launcher, operations



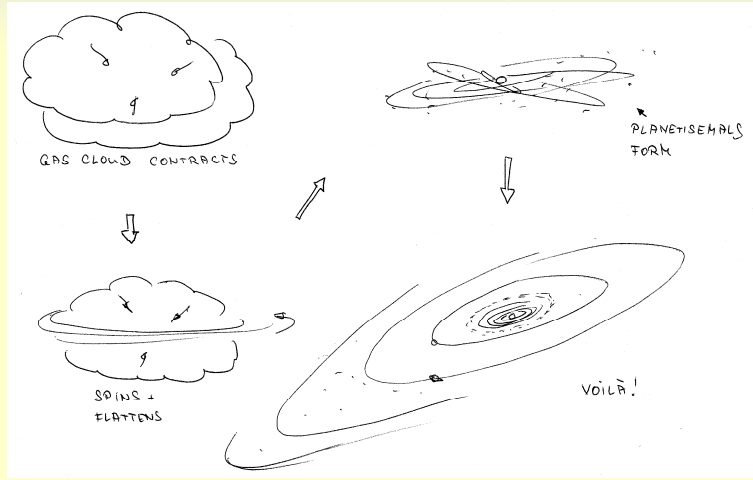
Science goals

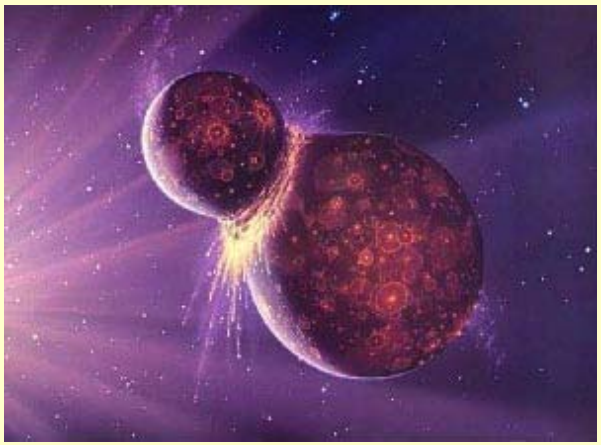
Marco Polo = Sample return from a primitive Near-Earth Object (NEO)

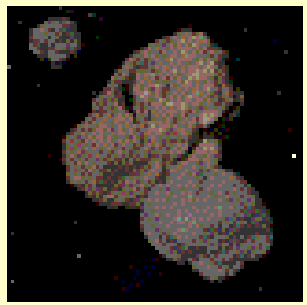
(1) Orgin of the solar system and the planets

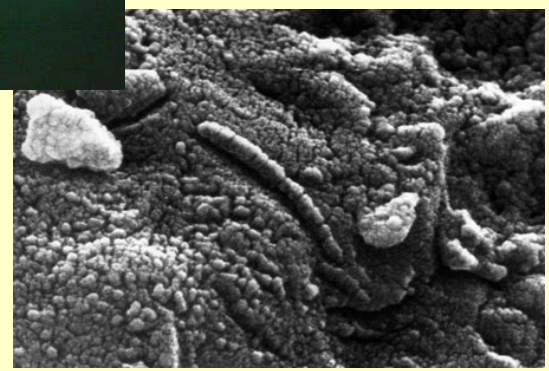
(2) Formation and evolution of NEOs

(3) Astrobiology









Introduction

Requirements hierarchy

- 'Shall' = without fulfilling this requirement, the mission does not make sense
- 'Should' = it would be extremely beneficial to fulfil this requirement
- Separate section on 'Additional science'

Main science requirement

To return a sample from a Near-Earth Object belonging to a primitive class to the Earth.

Mission objectives

- To enable the safe operation and manoeuvring of the spacecraft in close proximity to the NEO and safe collection of the sample(s).
- To place the samples in their global and local context.
- To provide complementary science results not achievable from the samples themselves.

Structuring the measurements

	Spatial resolution for imaging in the visual	Spatial resolution for VIS/IR spectrometer	Mission scenario
Global characterisation	Order of decimeter	Order of meters	Far orbit or hovering
Local characterisation	Order of mm	Order of decimeter	Go down close to the potential sampling sites
Context measurements	hundred micrometers	-	Close-up imaging during sampling – before and after sample retrieval

Target and sampling requirements

Target selection

- “Primitive” object => C or D type
- Rotation period >2.5 hours – Current baseline is 1999JU3.
- Characterisation from ground shall be possible => >340 m diameter

Requirements for sampling mechanism (not the sample)

- Allowing tens of grams - Still under discussion.

Science versus sample mass

< 50 mg: noble gas measurements, other bulk elemental and isotopic measurements

50 mg: for spectroscopy such as IR, X-ray, Mossbauer (50 mg per technique and therefore per laboratory)

1 g: a polished section (or thin lame) can be done. On one section most of the mineralogy, elemental and isotopic compositions determined. One should then target 5 g, i.e. 5 to 10 sections for 5 to 10 laboratories.

2 g: age measurements with 10 radiochronometers available in geochemistry

(4 g if duplication in 2 laboratories, 6 g in 3 laboratories etc …)

'Pebbles' needed (particles with size >0.5 mm) to have material without cosmic ray effects available

=> You always get good science results, even with small sample masses.

Refer to Ian's presentation!

Target and sample requirements

Target selection

- "Primitive" object => C or D type
- Rotation period >2.5 hours – Current baseline is 1999JU3.
- Characterisation from ground shall be possible => >340 m diameter

Requirements for sampling mechanism (not the sample)

- Allowing tens of grams - Still under discussion.
- 1 sample (with up to 3 attempts)
- We want a mix of larger (mm to cm-sized pebbles) and 'dust' – the pebbles to have material protected from cosmic rays, the dust for diversity
- Verification device shall be foreseen (imager? Breakwires?)
- Contamination requirements are given – seems ok
- Temperature: below 40 deg C, for short time periods 80 deg C

Global characterisation req'ts

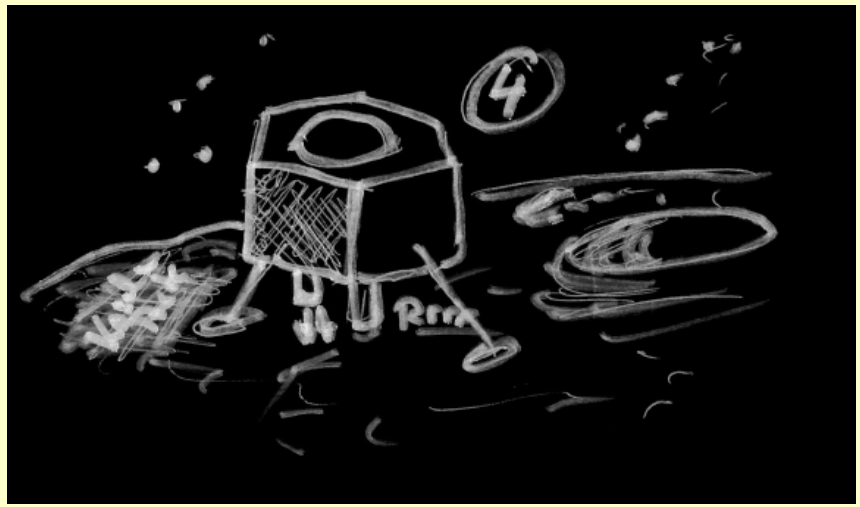
- Produce surface map:
  - ☞ In visible: at least 3 different colors, decimeter resolution – to get topography, craters, boulders…
  - ☞ Vis-Near-IR: λ/Δλ in the order of 200 and a spatial resolution of the order of meters - mineralogy
  - ☞ Mid-IR: λ/Δλ in the order of 200, 10 m or better spatial resolution – temperature, thermal inertia
- Produce shape model with accuracy of typically 1 m
- Mass determination accurate to 1 % - Itokawa was 3 % but it could be much better
- Derive surface temperature to at least 5 K (goal 1 K) accuracy, thermal inertia better than 10 %
- "Should"- Map atomic/molecular particle flux, speed, direction in the range 0.01 – 1 keV, 25 % resolution, 5 x 5 deg angular resolution.

Local characterisation req'ts

- Characterise up to 5 dedicated potential sampling sites
- Map the area of the landing inaccuracy
  - ☞Visible: at least 3 colors, order of millimeter resolution
  - ☞Vis-Near-IR: λ/Δλ in the order of 200, order of decimeters
  - ☞Mid-IR: λ/Δλ in the order of 200, order of decimeters
  - ☞"Should"- Atomic/ molecular particles – as before

Sample context requirements

- Determine regolith size distribution of the actual sampling site before and after sampling down to 100 um – needs Close-Up Camera
- Determine organisation of the regolith structure – needs Close-Up Camera
- "Should"- Measure bulk rock-forming elemental composition with 0.01 amu resolution



Other requirements

- Calibrate color response of the instruments
- Verify that sample was obtained
- Deceleration load smaller 800 g
- Instrument operations during planetary flybys (if any)
- Determine J2 term of gravitational field with tbd accuracy
- Perform near-surface investigations of several areas
- More to come… And see the Lander science requirements

Conclusions

- Marco Polo requirements are documented in Science Requirements Document
- Sample mass is a matter of ongoing discussion
- European studies indicate that requirements can be met
- Biggest uncertainty is of course the asteroid surface itself!