

Selected in Feb. 2011 for assessment study phase Next selection step: February 2014

Cosmic Vision ESA – M3

Science Study Team (SST):

M.A. Barucci (F) Chair

P. Michel (F) Co-Chair

J. Brucato (I)

H.Böhnhardt (D)

E. Dotto (I)

P. Ehrenfreund (NL)

I. Franchi (UK)

S. Green (UK)

L.Lara (E)

B. Marty (F)

Detlef Koschny(ESA - Study Scientist)

David Agnolon (ESA- Study Manager)

Jens Romstedt (ESA - Study Payload Manager)



MarcoPolo-R will rendezvous with the primitive NEA 2008 EV5 (A POTENTIALLY HAZARDOUS ASTEROID):

- scientifically characterize it at multiple scales, and
- return a sample to Earth (order of 100 grams) unaffected by the atmospheric entry process or terrestrial contamination.

http://sci.esa.int/marcopolo-r http://www.oca.eu/MarcoPolo-R/

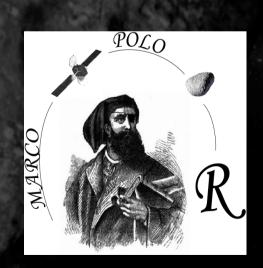
European Community Supporters:

694 scientists (July 10, 2013) (25 countries) +

USA, Japan, Brazil etc

MarcoPolo-R is on Faceboook:









Cosmic Vision

Science for Europe 2015-2025



Cosmic Vision 2015-2025

1) What are the conditions for life and planetary formation?

2) How does the Solar System work?





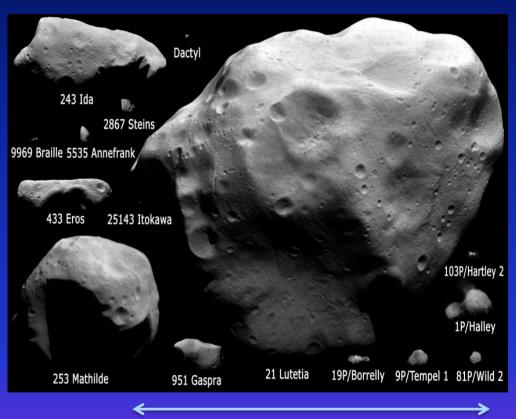
Mitigation

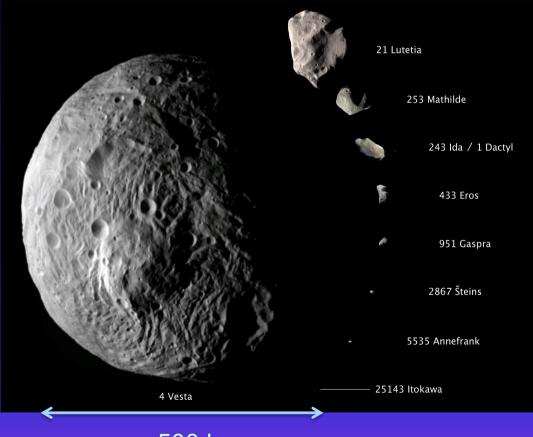


feropous Speco Agono, Agono spatinio ovropiones

Asteroids: a great variety of physical properties and compositions







~100 km ~500 km

No detailed image yet of a primitive asteroid (Mathilde's images are from fly-by)

There are different populations of primitive bodies, several missions are needed to

achieve a complete understanding

Understanding primitive materials: an international objective

- MarcoPolo-R: selected for the assessment study phase of M3-class missions of the Programme Cosmic Vision 2015-2025 of ESA in Feb. 2011
- On-going selected projects:

Hayabusa 2: phase B at JAXA, launch in



OSIRIS-Rex: selected in NASA New Frontiers,

OSIRIS-REX

launch in 2016

Supported by > 680 European scientists

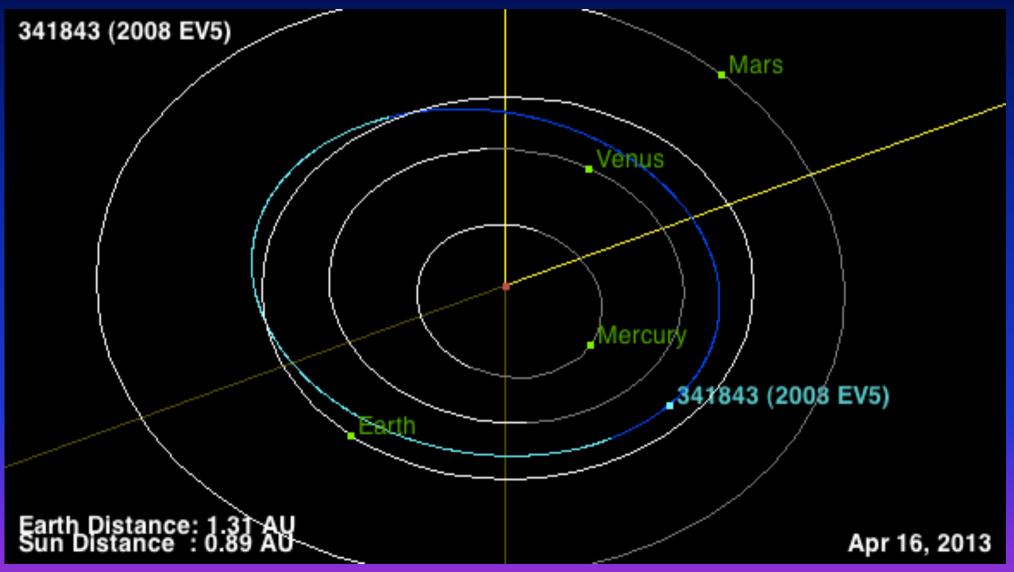
Common objectives:

Origin and evolution of the Solar System, origin of life, Hazard.

To understand the diversity and to have a comprehensive knowledge primitive materials requires several missions:

H2 + OSIRIS-REx + MP-R >> 3

Our baseline target: the fascinating PHA (34843) 2008 EV5



Well studied object by radar, spectra, thermal IR

Unique Science Value of 2008 EV5

Spectral type: belongs to the C complex

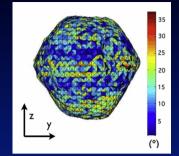
The spectrum is essentially featureless except for a shallow 0.48-µm spin-forbidden Fe3+ absorption band.

Overall blue slope, typical of many CI chondrites

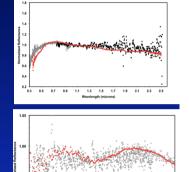
Parent body may have accreted in a volatile rich region

- Size and shape from radar: 400 +/- 50 meters oblate spheroid (Busch et al. Icarus 212, 2011)
- Rotation: retrograde, about 3.725 ± 0.001 h
- Albedo: > 0.1 (possibly 0.12)

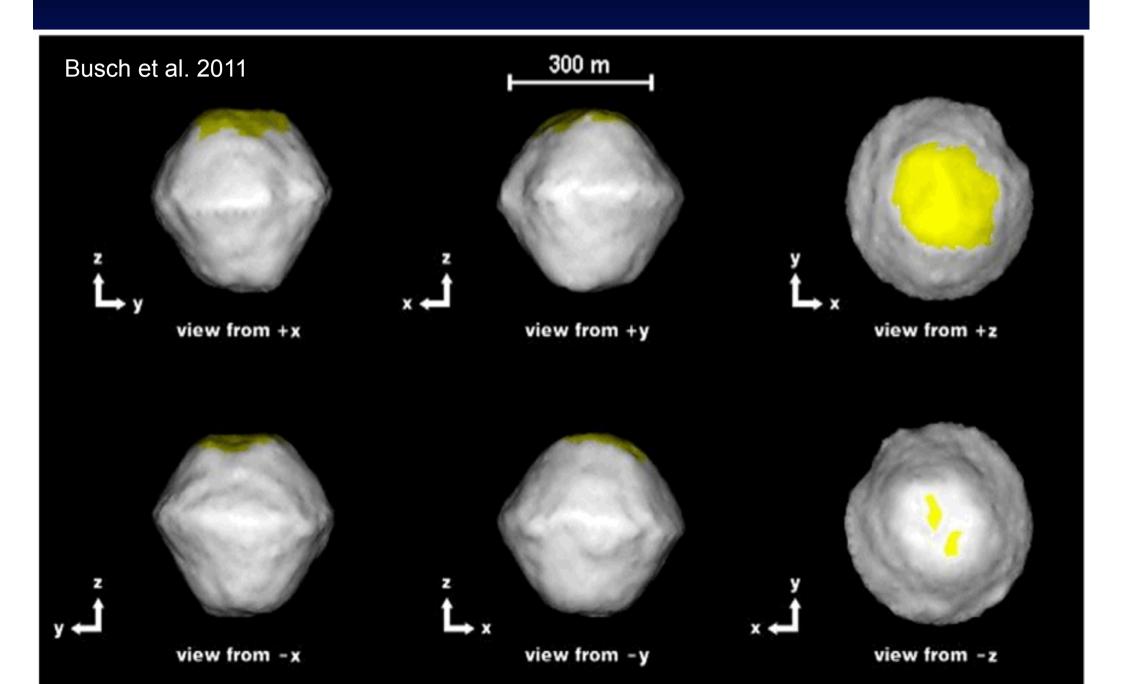
MP-R will allow collecting a unique sample from a body belonging to a distinct population of moderate-albedo primitive bodies!!





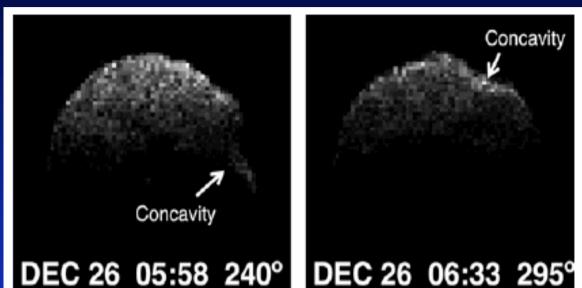


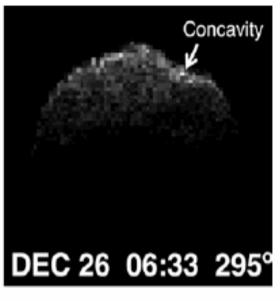
Principal axis views of 2008 EV5 shape mode



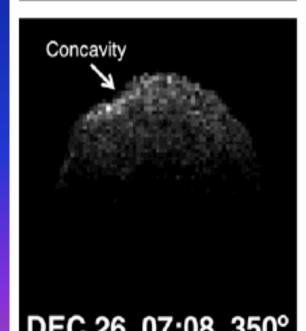
Arecibo delay-Doppler images of 2008 EV5 from 2008 December 23-27

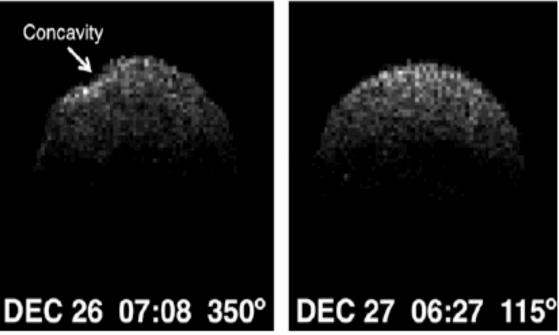






D = 400 + / -50 mConcavity of 150 m (Busch et al. 2011)





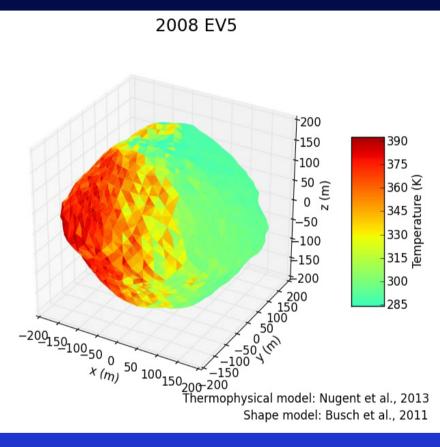
Few or no large blocks evident in the 7.5 m-resolution Arecibo images

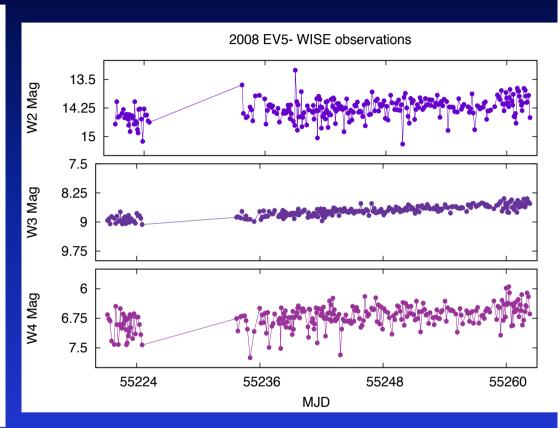


2008 EV5

A. Mainzer's courtesy







Full radar shape model, thermal inertia of 350 J s^{-1/2} m⁻² K⁻¹:

1-dimensional thermal conduction
Subsolar hotspot symmetric
Pole temperature comparable to nightside

Observations in 3 bands 2008 EV5 observed between Jan 25, 2010 and March 7th, 2010

200

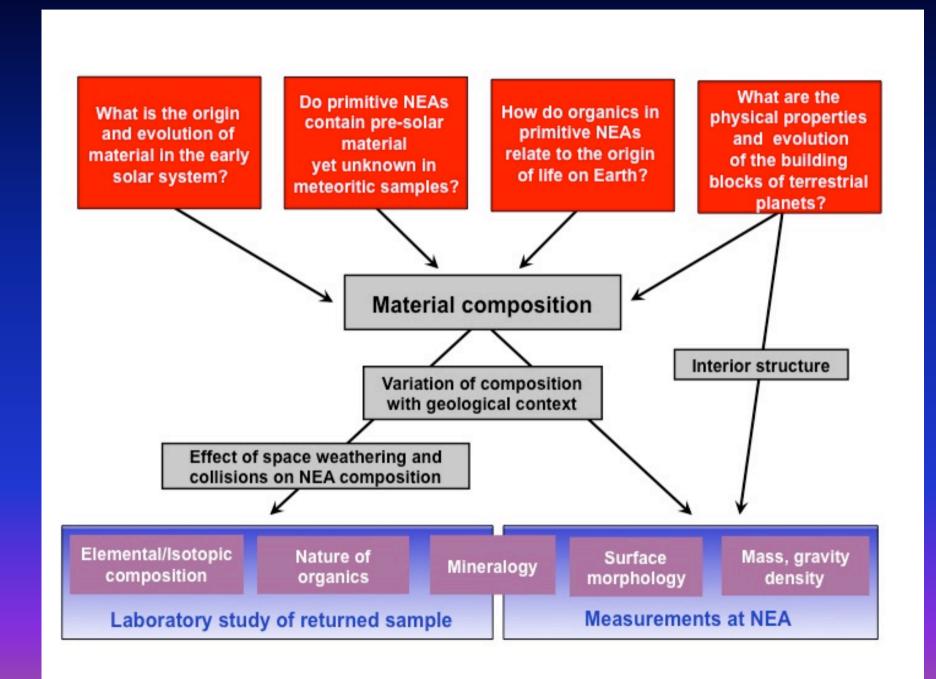


2008 EV5 Technical advantages



- We already have some very useful information on 2008 EV5 for the design of the mission based on radar observations:
 - Top shape
 - Model of gravitational slopes (can help determine where loose material should be more abundant)
 - Geopential maps
 - Surface roughness (lack of large blocks, rough at decimeter-centimeter scale)

Scientific Questions



MarcoPolo-R payload summary

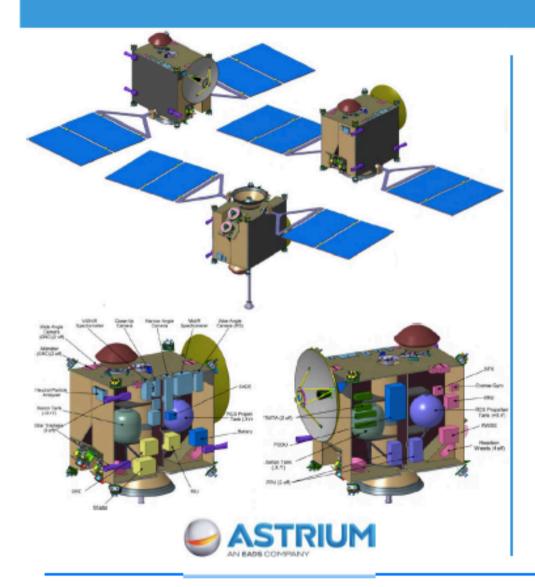


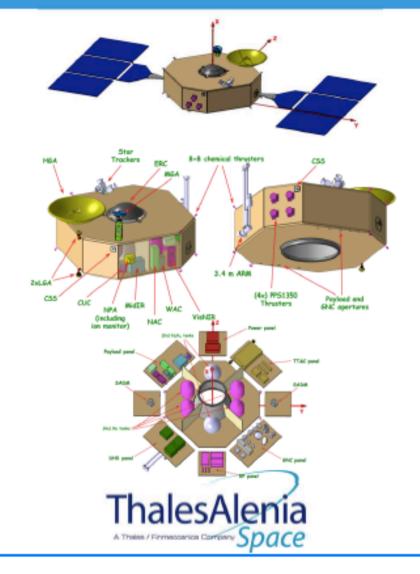


Name	Туре	Mass	PI (Lead & partners)
MaNAC	Narrow Angle Camera	10.6 kg	G. Cremonese (Osservatorio Astronomico Padova, Italy)
CUC	Close-up Camera	0.8 kg	JLuc Josset (Space Exploration Institute, Switzerland)
MaRIS	Visible near Infrared imaging Spectrometer	6.2 kg	A. Barucci (LESIA, France)
THERMAP	Mid-infrared spectro imager	4.4 kg	O. Groussin (LAM, France)
RSE	Radio Science Experiment	none	T. Andert (Universität der Bundeswehr, Germany)
VESPA/ VISTA2	Thermogravimetric analysis (one sensor out of a larger instrument package)	1.0 kg (tbd)	tbd
		23.0 kg	

Mission design: The spacecraft Main features





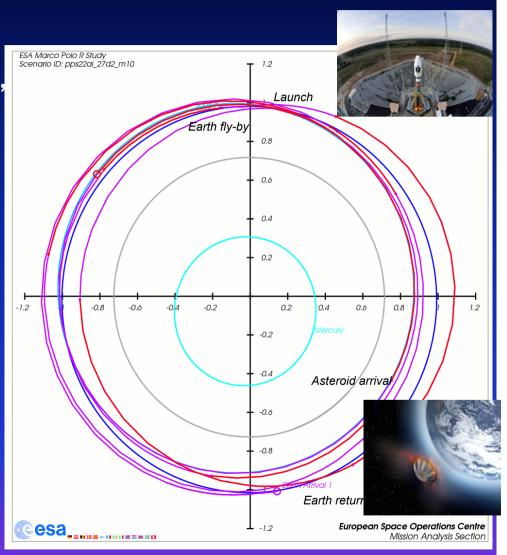




Mission analysis and operations



- □ 3 (+) launch opportunities:
 - December 2022 and 2023: 4.5 years,
 - December 2024: 6.5 years (backup),
 - (June 2021: 4 years)
 - (> 2025: 7 years, TBC)
- □ Earth fly-by
- 6-month science (proximity)
- ☐ Return to Earth in June 2027
- □ Electric propulsion transfer, total "electric" delta-V < 4 km.s⁻¹



Transfer to and from 2008 EV5, Credit: ESOC

MarcoPolo-R - 2008 EV5



Compared to the mission to 1996FG3, a 2008EV5 mission features:

- ➤ Shorter mission duration (approx. 4.5 vs. 7 years)
- ➤ Reduce required mission delta-V ([3-4] km/s vs. [5-6] km/s)
- Shorter distance between Earth and spacecraft (higher data rate and simpler communication system)
- ➤ Have a "constant" distance from the sun (good for thermal design)
- Have a lower sample capsule reentry speed (smaller ERC)





Sample mechanism European industrial studies

(AVS & Selex Galileo)

Sampling system

- Top-level requirements:
 - ✓ Get > 100 g sample in 3-5 seconds,
 - ✓ Compatible with soil properties,
 - ✓ Keep it "clean".
- Ongoing parallel sampling tool development/tests:
 - ✓ Brush-wheel at AVS, Spain
 - ✓ Grab bucket at Selex Galileo, Italy
 - ✓ Both will be breadboarded and tested in 1-g
 - √ 0-g parabolic flight testing in 2014

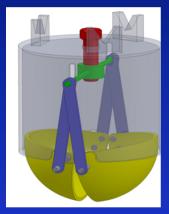


Brush-wheel sampler concept, Credit: AVS



Bucket sampler early breadboarding, Credit: Selex Galileo





Bucket sampler concept, Credit: Selex Galileo



Novespace

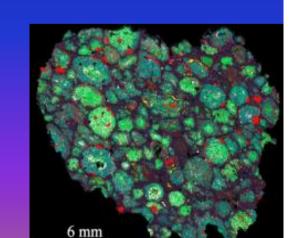
Laboratory investigation of returned samples



High spatial resolution and analytical precision are needed:



- ➤ High precision analyses including trace element abundances to ppb levels and isotopic ratios approaching ppm levels of precision
- ➤ High spatial resolution a few microns or less
- ➤ Requires large, complex instruments e.g. high mass resolution instruments (large magnets, high voltage), bright sources (e.g. Synchrotron) and usually requires multi-approach studies



Develop an European Storage & Curation Facility

for analyses, storage and delivery of samples



Curation
Facility
at JAXA
(Sagamihara)

Large European Community waiting for sample

Schedule for class M3 mission



Advisory structure

500 M€

Selection in February 2014 (among 5 missions)

2011

ESA-internal studies in Concurrent Design Facility

2012

Industrial studies (2 competing for each mission)

2013

Phase A

2014

Submission of the Yellow Book on mid-Nov. 2013

Public presentation at UNESCO on Jan. 29, 2014

Final selection in February 2014

Phase B1 by March 2014 for selected mission

Implementation phase in industry

Launch 2022 - 2024



A new ERA of Sample Return

























Apollo & Luna Launch

Return 1969

ucricsis	
2001	
2004	

Stardust 1999

2006

Hayabusa 2003 2010

Phobos-Grunt 2010

2014

Hayabusa2 2014

2020

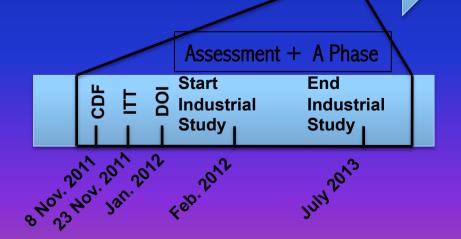
Osiris-Rex 2016 2023

MarcoPolo-R 2022

2027

MarcoPolo-R (ESA)

- Different population of primitive object
- Different sampling mechanism



MarcoPolo-R addresses a wide range of objectives



Stars

Stellar nucleosynthesis
Nature of stellar condensate grains

The Interstellar Medium IS grains, mantles & organics



The proto-solar nebula

Accretion disk environment, processes and timescales



Planetary formation

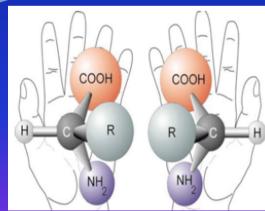
Inner Solar System Disk & planetesimal properties at the time of planet formation



Asteroids

Accretion history, alteration processes, impact events, regolith





The Earth
Impact hazard
Evolution of life on Earth

MP-R mission will

- ✓ allow Europe to contribute in a timely manner to the international sample return effort
- ✓ provide a unique window into the distant past
- ✓ allow scientists to unravel mysteries surrounding the birth and evolution of the solar system
- ✓ involve a large community, in a wide range of disciplines

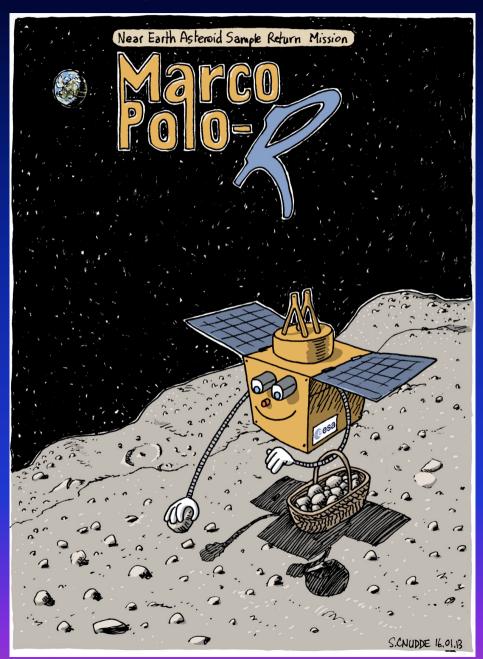
 Planetology Astrobiology

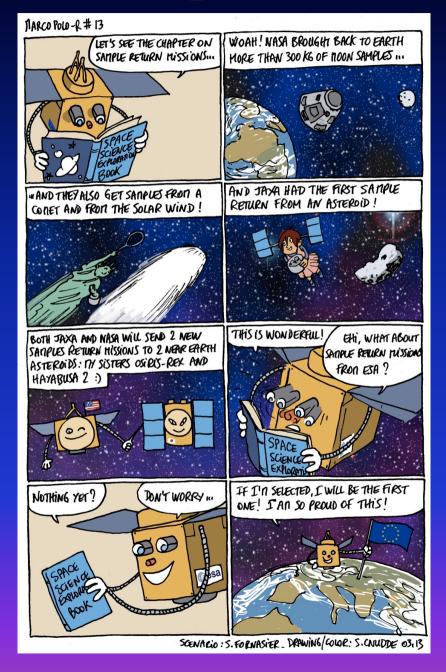
 Nucleosynthesis Cosmochemistry
- ✓ retain samples for future advances
 through a Curation and Distribution Facility
- ✓ demonstrate key capabilities for any other sample return mission
- ✓ support for mitigation strategies
- ✓ generate tremendous public interest



An easy case for outreach

http://www.oca.eu/MarcoPolo-R/Cartoon/MarcoPolo-R_Cartoon.html





Translation in French, German, Italian, Spanish, Portuguese, Greek....



We need

- more than one sample return mission
- an European NEA return mission

and even if 2+1=3

HY2 + O-Rex + MP-R >> 3

(Shogo Tachibana, Hayabysa-2 Sampler Science PI, Paris, 17.12.2012)