Selected in Feb. 2011 for assessment study phase
Final selection: Dec. 2013

Cosmic Vision ESA – M3

Science Study Team (SST):

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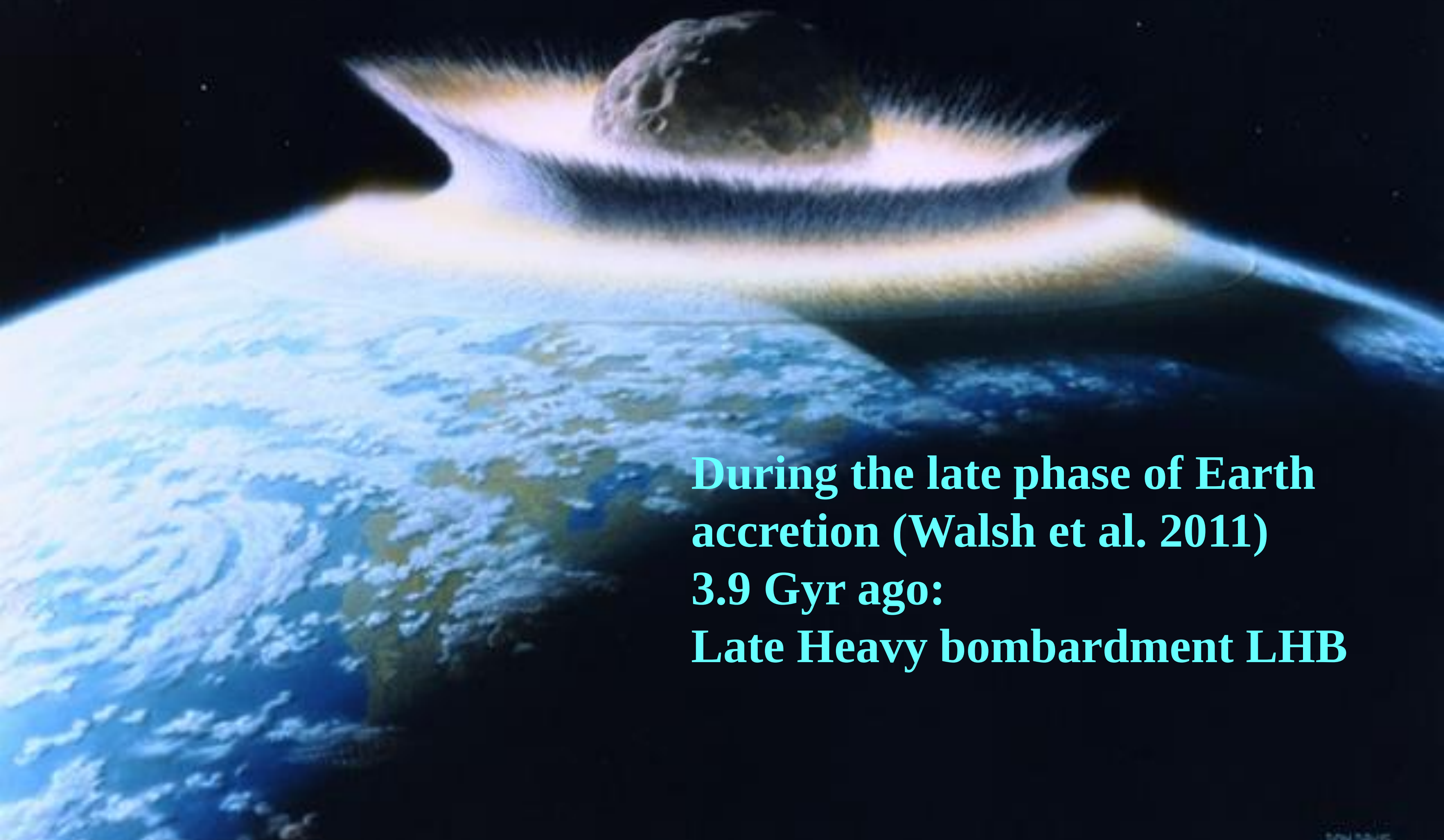
Tracing the origins …

Small bodies of the Solar System are believed to be the remnants - either fragments or “survivors”- of the swarm of planetesimals from which the planets were formed.

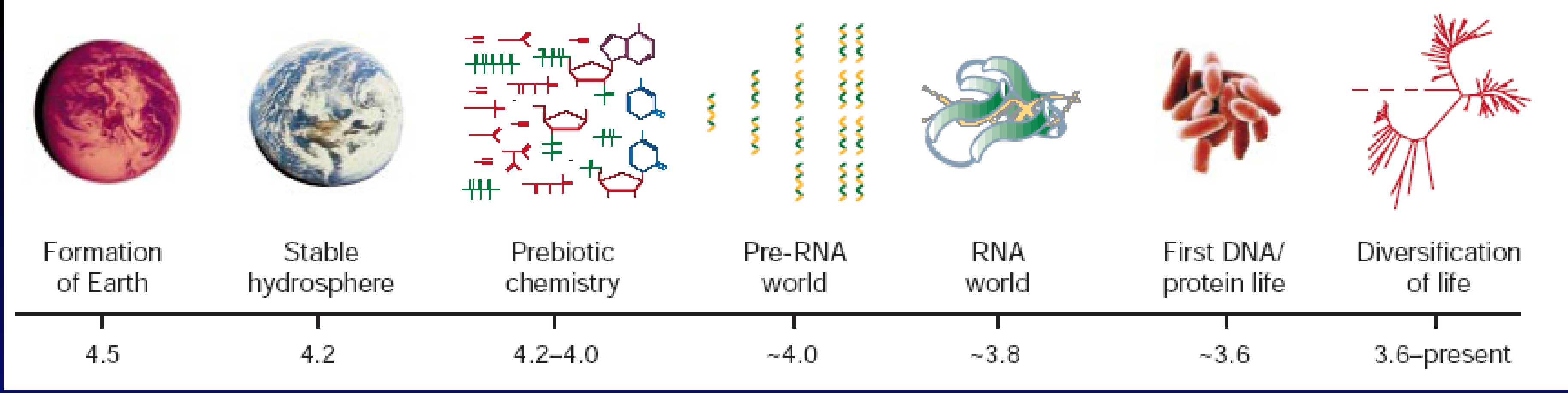
In contrast to the planets, which have experienced major alteration during their history, most asteroids and (dormant) comets, due to their small sizes, are believed to have retained a record of the original composition of our solar system’s proto-planetary disk.

Abundant within the inner solar system, small bodies have played a fundamental role as impactors of Earth during the so called Late Heavy Bombardment.

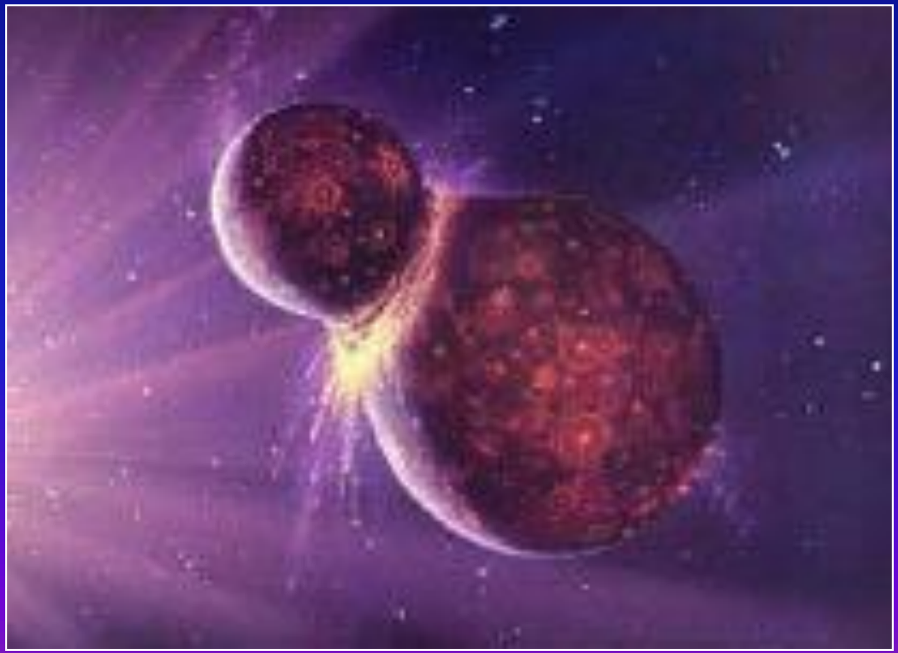
Impacts had both beneficial and destructive effects on the evolution of planetary biospheres



During the late phase of Earth accretion (Walsh et al. 2011)
3.9 Gyr ago:
Late Heavy bombardment LHB



Current exobiological scenarios for the origin of life invoke the exogenous delivery of organic matter to the early Earth



The planets of the inner solar system experienced an intense influx of organic-rich material for several hundred million years after they formed.

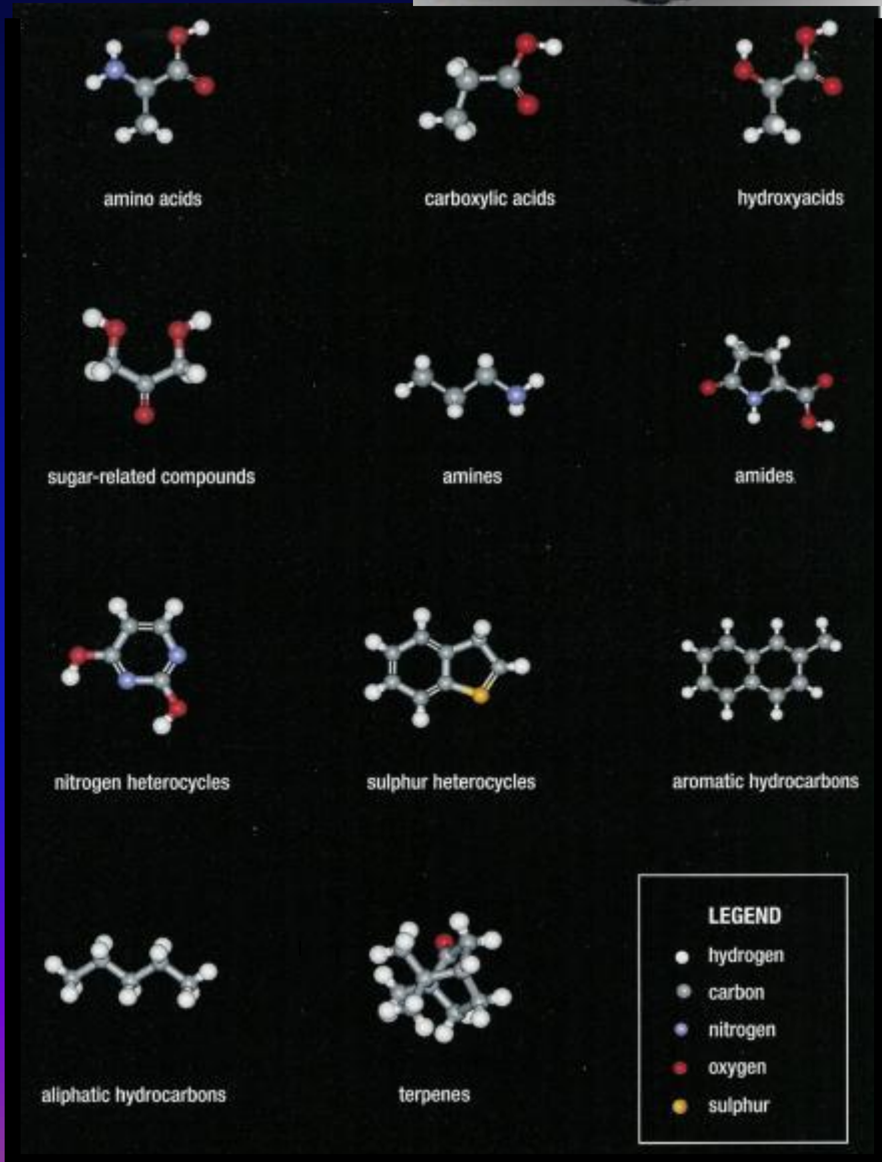
The earliest evidence for life on Earth coincides with the decline of this bombardment.

Many biologically important molecules are present in the organic materials.

Organic compounds in Murchison

Compound Class	Concentration(ppm)
CO_2	106
CO	0.06
CH_4	0.14
NH_3	19
Aliphatic hydrocarbons	12-35
Aromatic hydrocarbons	15-28
Amino Acids	60
Monocarboxylic acids	332
Dicarboxylic acids	26
α-hydroxycarboxylic acids	14
Polyols (sugar-related)	~24
Basic N-heterocycles	0.05-0.5
Purines	1.2
Pyrimidines	0.06
Amines	8
Urea	25
Benzothiophenes	0.3
Alcohols	11
Aldehydes	11
Ketones	16

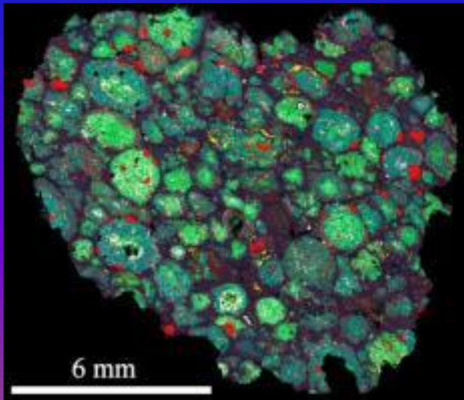
Sephton 2002



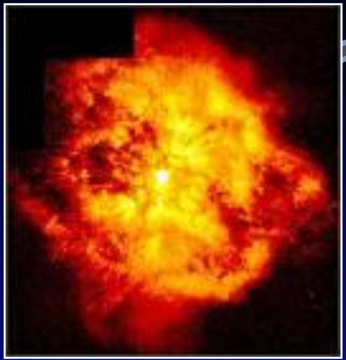
Laboratory investigation of returned samples

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**



MarcoPolo-R addresses a wide range of objectives

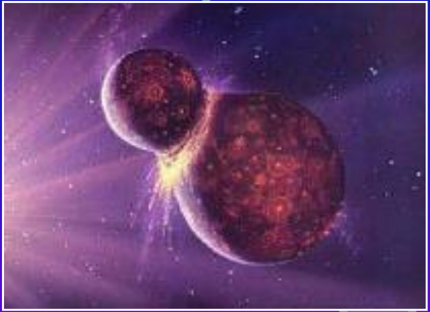


Stars
Stellar nucleosynthesis
Nature of stellar condensate grains

The Interstellar Medium
IS grains, mantles & organics

The proto-solar nebula
Accretion disk environment, processes and timescales

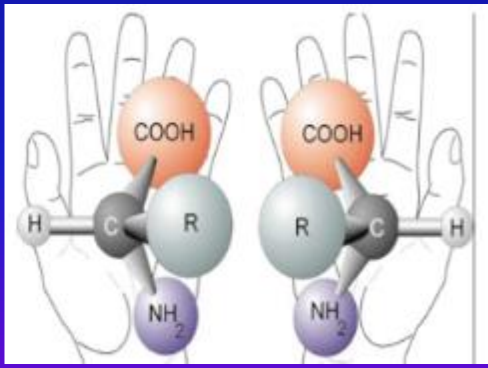
Planetary formation
Inner Solar System Disk & planetesimal properties at the time of planet formation



Asteroids
Accretion history,
alteration processes,
impact events,
regolith

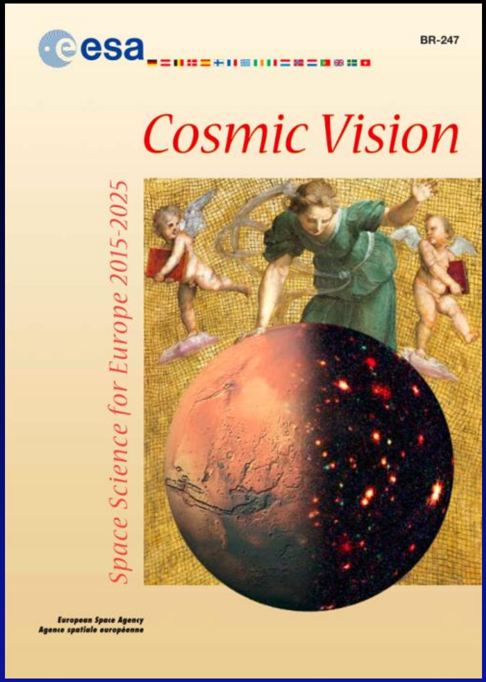
The Earth
Impact hazard
Evolution of life on Earth

Life
Nature of organics in NEOs



Scientific Objectives

- What are the conditions for planet formation and the emergence of life?
- How does the Solar System work?



MarcoPolo-R will address:

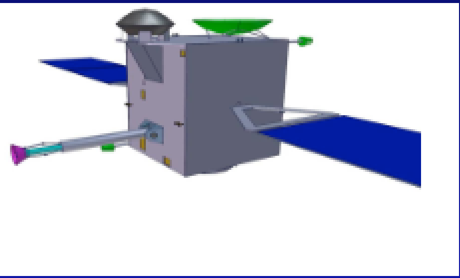
1. **The processes occurring in the early solar system and accompanying planet formation;**
2. **The physical properties and evolution of the building blocks of terrestrial planets;**
3. **Whether primitive NEA contain presolar grains yet unknown;**
4. **The nature and the origin of the organics in primitive asteroids and how they shed light on the origin of molecules necessary for life.**

Baseline mission

Official Baseline Target: 2008 EV5 (4 years mission)
Launch window: 2022/2024/Soyuz
Back-up target: 1996 FG3, 3-6 months stay time

Single primary spacecraft, carrying:

- **Earth Re-rentry Capsule (ERC)**
- **Sample acquisition and transfer system (SAS)**



Touch and go sampling mechanisms (non-exhaustive list):

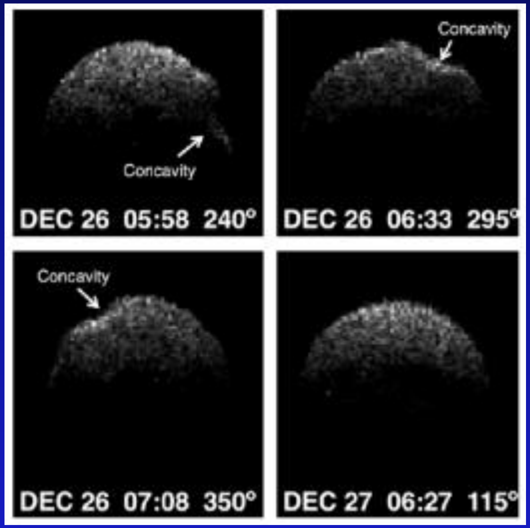
- **Brush or cutting wheels**
- **Corers**
- **Gaseous transport devices**

Sample device should collect a minimum of 100 g sample
(2 ESA dedicated study starting in July 2012 +1 by NASA)

Official Baseline Target: 2008 EV5

Potential hazardous asteroid

- Spectral type: belongs to the C complex (Reddy et al. 2012)
- Size and shape from radar:
  - 400 +/- 50 meters oblate spheroid
  - (concavity 150m, Busch et al. 2011)
- Rot Period = 3.725±0.001h (retrograde)
- Pole -- Ecliptic: 180˚ , -84˚ ± 10˚
- Albedo: 0.12±0.04 (Bush et al. 2011)



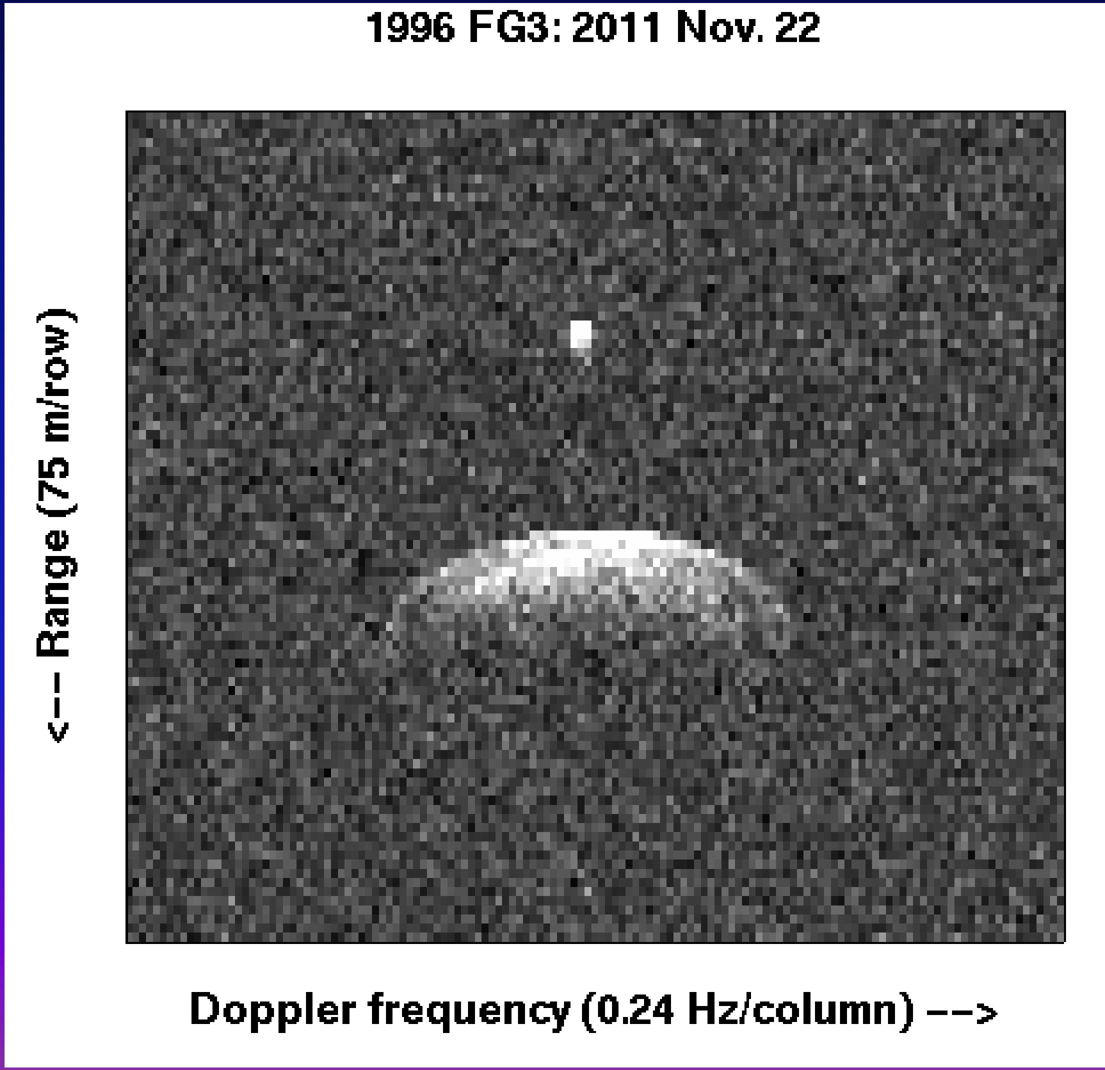
Spectra have a weak 0.48-μm feature and an overall blue slope consistent with CI (Orgueil-probably origin from comets)

Advantage: allows a very short mission duration (sample return in 4 years)

Marco Polo R – 2008 EV5

- After a first assessment, the precise mission analysis is currently on-going at ESA-ESOC and should be shortly available (figures below not yet finalized)
  - Primary launch opportunities:
    - ✓ Launch in December 2022, 4.5-year duration, arrival at the asteroid ~ January 2025, return to Earth in June 2027
    - ✓ Launch in December 2023, 4.5 year duration, arrival at the asteroid ~ December 2025, return to Earth in June 2028
  - Backup opportunity:
    - ✓ Launch in December 2024, 6.5 year duration, arrival at the asteroid ~ November 2027

Back-up: (175706) 1996FG3
Evidence for an equatorial ridge



Albedo $p_v = 0.029+0.026-0.012$

Diameter 1.9 +0.55-0.42 km

Secondary Diameter ~ 0.5 km

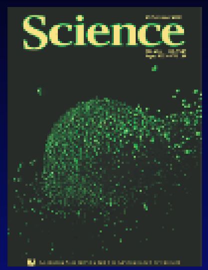
Binary system:

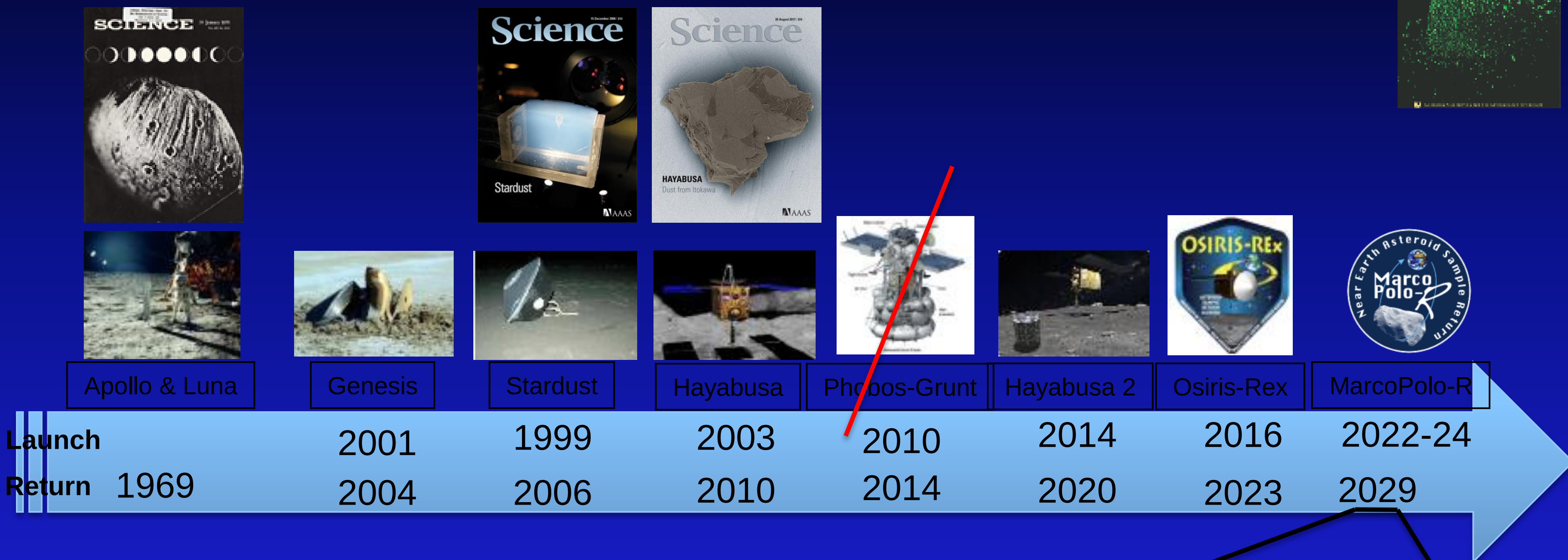
Primary
P = 3.5942 +-0.0001 h
Secondary
P = 16.14 h

Pole direction
λ = 242 +-96, β = -84 +14 -5 deg

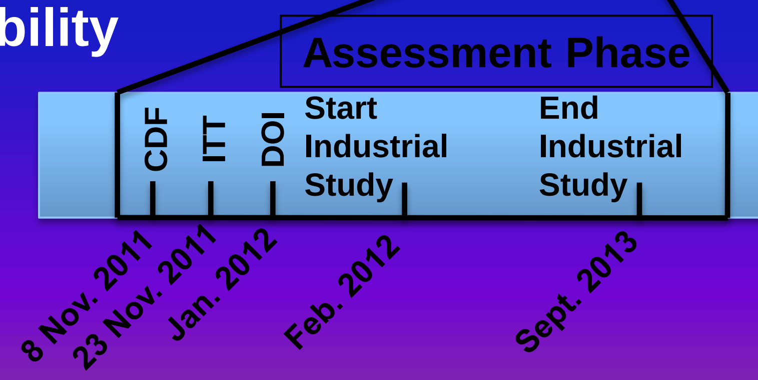
L. Benner, JPL Courtesy

Programmatic International Framework





EUROPE needs to demostrate SR capability



MarcoPolo-R (ESA)

- **peculiar C-type**
- **different sampling**

Schedule

- **Class M3 Mission: up to ca. 470 MEuros**

Advisory structure

Selection of 4 missions

2011 — ESA-internal studies in Concurrent Design Facility

2012 — Industrial studies (2 competing for each mission)

2013 — ~~Final presentation; selection of two missions for definition study~~

2013 - 2015 — ~~Detailed definition study; selection of one mission~~

2015 - 2020 — ~~Implementation phase in industry, launch 2020 - 2022~~

End phase A Dec. 2013

Phase B1 kick-off Jan 2014 for the selected mission

Launch 2024

MarcoPolo-R

Baseline Payload

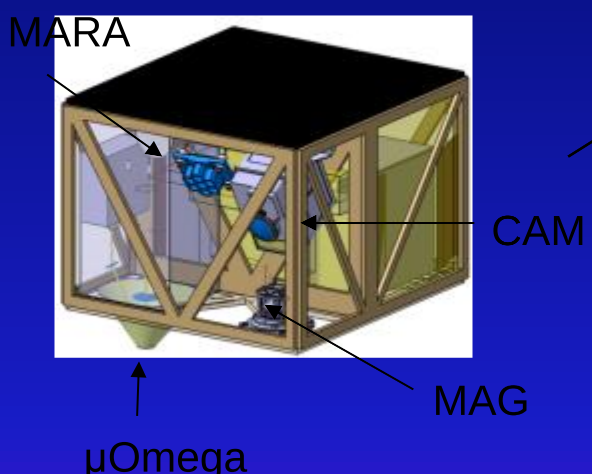
	Spatial resolution		
	VIS imaging	VIS/IR spectrometer	Mid-IR instrument
Global characterisation	Order of dm	Order of m	Order of 10 m
Local characterisation	Order of mm	Order of dm	Order of dm
Context measurements	Hundred µm	-	-

	Wide Angle Camera (WAC)	**Narrow Angle Camera (NAC)**	**Close-Up Camera (CUC)**	**Visible Near Infrared spectro. (VisNIR)**	**Mid-Infrared spectro. (MidIR)**	**Radio Science Experiment (RSE)**	**Neutral Particle Analyser (NPA)**
Mass [kg]	2.0	8.92	0.82	3.6	3.0	Contained in the resources of the radio subsystem	2.2
Volume [mm]	237x172x115	520x380x197 250x170x120	364x78x68	270x110x90 150x180x82	160x220x370	Contained in the resources of the radio subsystem	200x200x100
Power [W] average	11.5	13.5	12.5	18	2		11
Data volume single measur.	67 Mbit	67 Mbit	67 Mbit	0.45 Mbit	360 Mbit	Data recorded in the ground station in real time	0.72 kbit
Heritage	Rosetta, ExoMars, ISS, Bepi Colombo	Rosetta, ExoMars, ISS, Bepi Colombo	Rosetta, ExoMars, ISS, Micro-rover (ESA)	Mars/Venus Express, Rosetta	SMT, TechDemSat		Bepi Colombo

Optional payloads: lander with payloads, laser altimeter, seismic experiment

MarcoPolo-R   Proposed Lander Packages

On the basis of MASCOT (a ~10kg lander for the Hayabusa 2 mission), landers with various instrument complements are studied as optional payload for MP-R



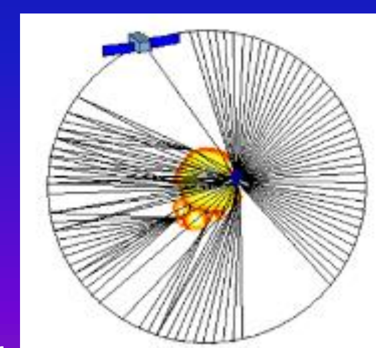
MASCOT

MAPOSSI
- LIBS
- APX
-Thermal Mapper
- Mößbauer Spectrometer,
- IR-spectrometer (MicrOmega)
- Camera
- optional elements

FANTINA
- Radar Tomographer
- Camera
- optional elements

LIBS for ExoMars
© DLR

MicrOmega
for MASCOT
© IAS



Concept of
Radar Tomogapher
Image: IPAG

ESA - Technology

In total, **ESA is investing close to 4.5M€**

in activities directly relating to MP-R and other technologies developed in other programmes which are indirectly related to MP-R

in addition to all national activities such as the “instrument” studies initiated in the frame of the Declaration of Interest (~ 20 nationally-funded studies are ongoing).

NASA financed (Aug.14, 2012) 300 000 $ to study the Sample mechanism for MP-R

We need

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

MP-R mission will

✓ 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**

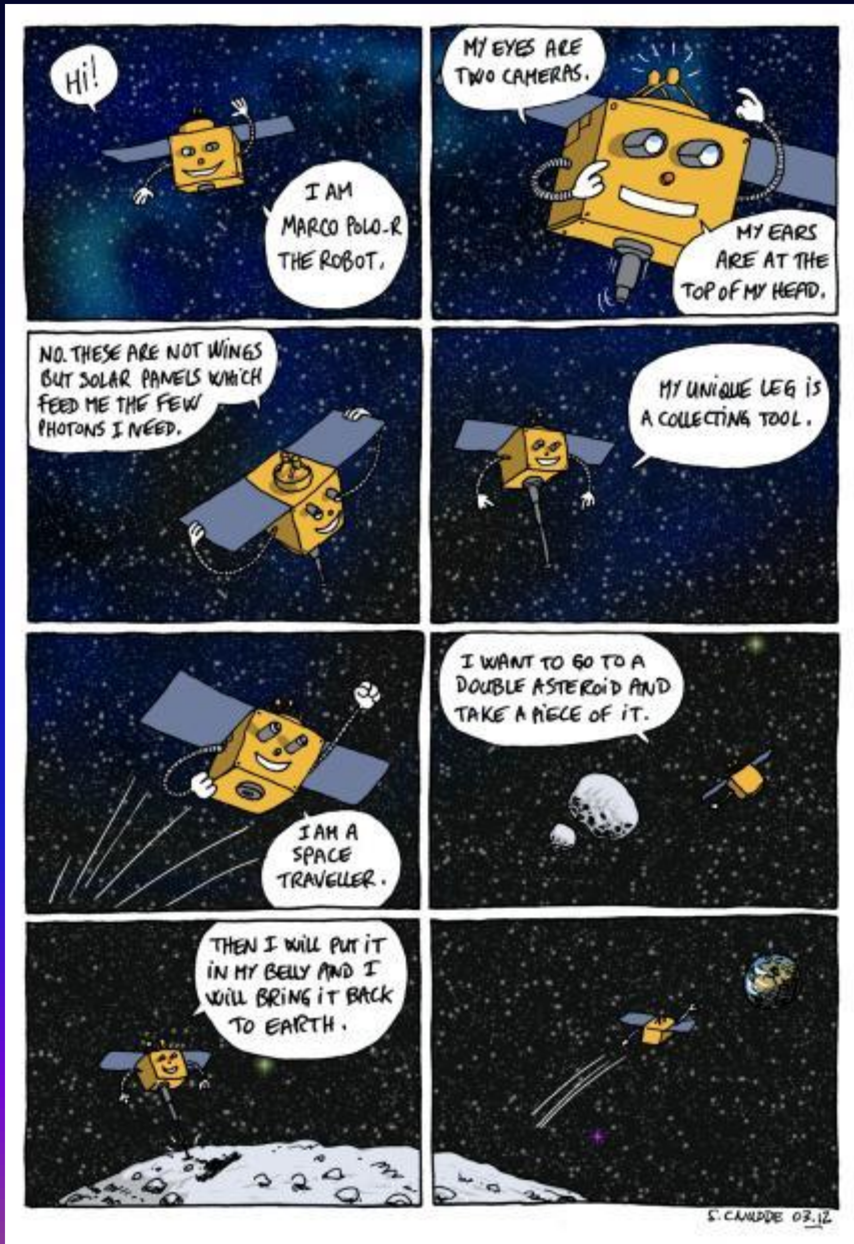
✓ retain samples for future advances through a Curation and Distribution Facility

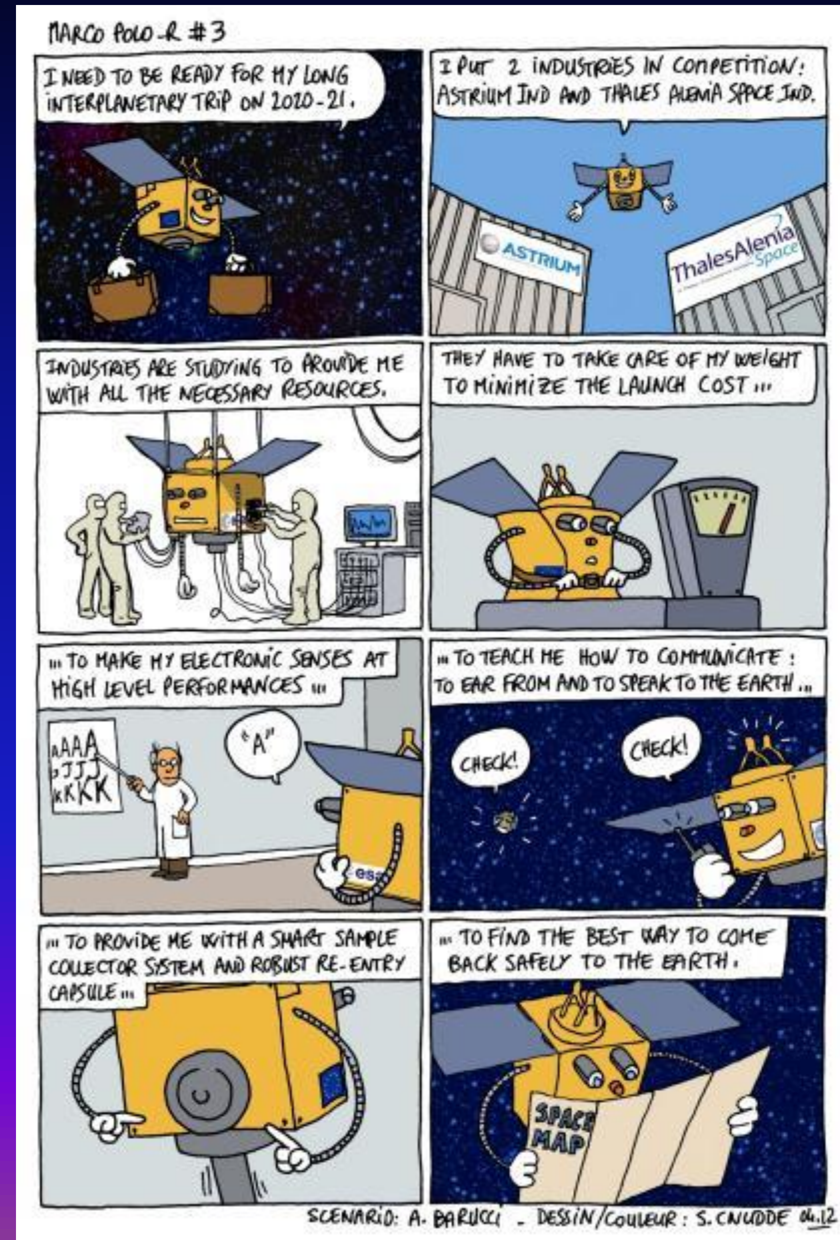
✓ demonstrate key capabilities for any sample return mission

✓ generate tremendous public interest

David Hardy

An easy case for outreach





MarcoPolo-R Mission

http://www.oca.eu/MarcoPolo-R/

European Community Supporters:

More than 600 scientists (October 2012),

25 countries

(more than 120 in Italy)

International collaboration is open

MarcoPolo-R is on Faceboook:

http://www.facebook.com/pages/MarcoPolo-R-Space-Mission/40232049502