SAMOSA

Study of Active Mainbelt Object through Sample Acquisition

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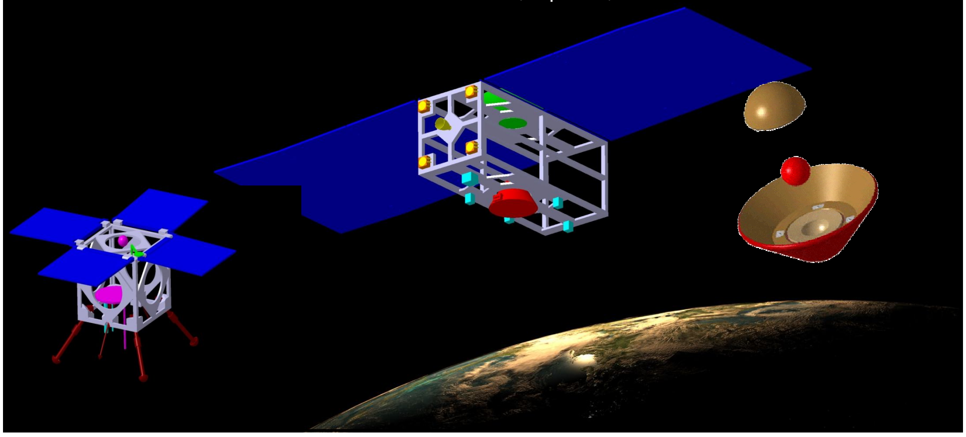


Introduction

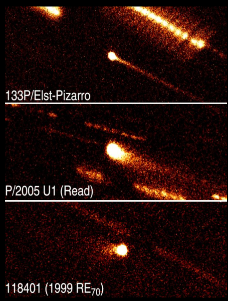
What is SAMOSA?
- Sample return mission to a main belt comet (MBC)
- Return a sample of ~50g
- In-situ investigation and remote sensing

Why?
- MBC are fragments of a former planet
- MBC contain volatiles
- They may give us information about
  - -Planet formation
  - -Planet and solar system evolution
  - -Origin of life

Why a sample return?

What are MBC's?

What are Main-Belt Comets (1)?

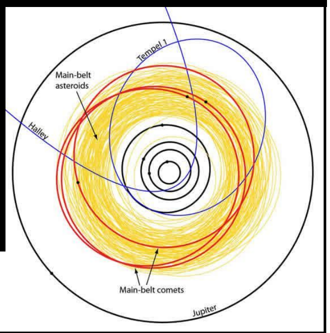


- In 2006, a population of objects was discovered in the Main Belt showing cometary activity
→ Main-Belt Comets (MBC)

- Currently three such objects are known:
  133P/ Elst-Pizarro
  176P/ LINEAR
  P/2005 U1 Read

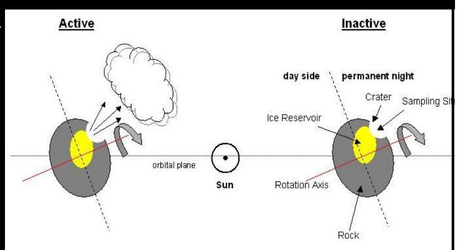
- For EP the activity is definitely driven by sub-limation of volatiles on the surface:

- Activity was observed at the same orbital position in 3 consecutive apparitions (1996, 2002, 2008), inactivity at other parts



What are Main-Belt Comets (2)?

- Water is not stable at the surface in the Main Belt over longer time
  → It must have been stored below the surface since the some 10^9 a
  → An impact must have exposed it to sunlight recently
  → The crater surface is young (<10^3 a?)
  → There is no regolith in the crater area



- The MBC are members of the Themis Family of asteroids:
  - Dynamically it fits
  - They have the BVRI colours of C-type asteroids, but not of comet nuclei and TNOs
  - It is dynamically unlikely to insert a comet
  - There are indications that water ice is present on the surface of 24 Themis, too

→ The MBC were parts of the former Themis Family parent body

What to do?

What to do at the MBC?

- Aquire a sample of volatile and non-volatile material from one MBC → go in the crater
- Get a sample that includes sub-surface material (>1cm) → drilling
- Determine the morphology and mineralogy of the MBC → global mapping
- Return some tens of grams of the sample to Earth → re-entry
- Determine the physical microstructure in situ → microscopic investigation

What to do on the way to the laboratory?

- Keep the sample below 0°C at all times → avoid aqueous alteration
- Monitor the temperature continuously → trace the sample environment
- Ensure high level of cleaness to minimize contermination with terrestrial material
  → avoid analysis of terrestrial organics
- Ensure high density of the sample container → avoid loss of volatiles in space

...AND WHY?

Sample Analysis

Why return a sample?

Planet Formation → Dating → Isotopic composition
Planet Formation → Cooling rate → Elemental composition on microscale
Origins of Life → Organic composition → high precision & sensitivity
Planet Formation, Protoplanetary disk → Microscopic mineral composition
→ high spatial resolution
Origins of Life → Isotopic ratios in minor volatile species → high accuracy and sensitivity

This implies:

- Complex sample preparation
- Sample decisions
- Analysis adaptability
- Instrumentation

Mission Target & Objectives

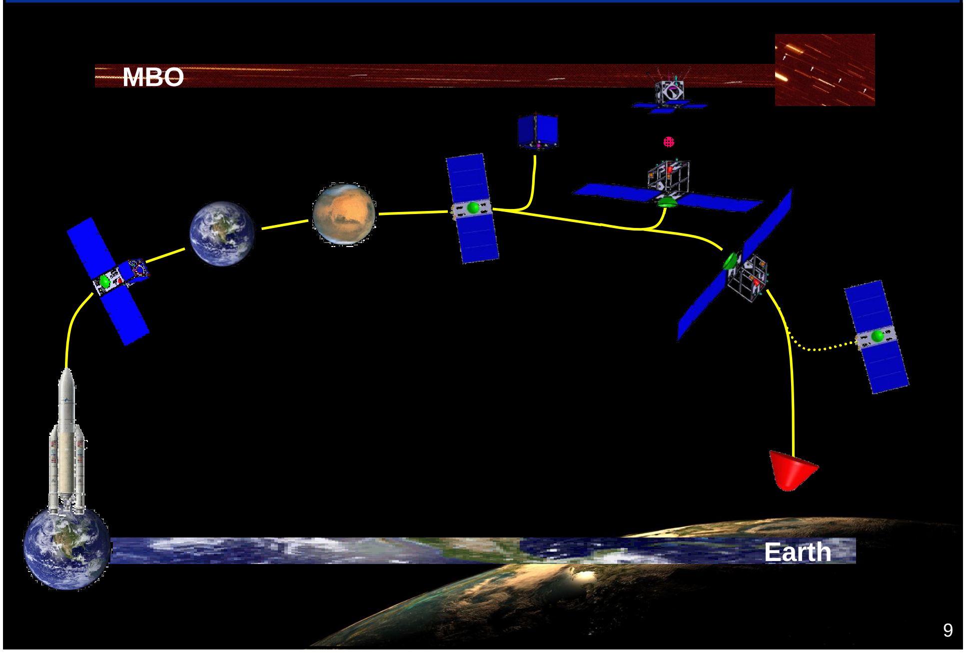
- Target: 133P/Elst-Pizarro
  - ✓ Main Belt Comet and member of Themis Family
  - ✓ has activities driven by sublimation of volatiles
  - ✓ located around a 3.2 AU, with low inclinations and relatively high eccentricities
- Objectives:
  - ✓ Find a link between meteorite collection on earth and astronomical objects
  - ✓ Constrain conditions in the pre-planetary disk
  - ✓ Search for the origins of emergence life
  - ✓ Search for information about stellar evolution and planet formation
- How to achive these objectives?
- Need to return a sample back to earth

Payload Requirements

<u>What to do at the MBC?</u>

- Aquire a sample of volatile and non-volatile material from one MBC
- Get a sample that includes sub-surface material (>1cm)
  - → Drilling – Core Extraction Device (Lander)
- Determine the morphological and mineralogic context on the MBC
  - → Optical Cameras (HR, WA, stereo) (Orbiter)
  - → Laser Altimeter + Radio Science (Orbiter)
  - → Visible-Near-IR spectrometer (Orbiter)
  - → Mid-IR spectrometer (Oribter)
  - → Alpha Particle X-ray Spectrometer (Lander)
- Return some tens of grams of the sample to Earth
  - → Re-entry capsule
- Determine the physical microstructure in situ
  - → Microscopic Imager (Lander)

Mission Profile



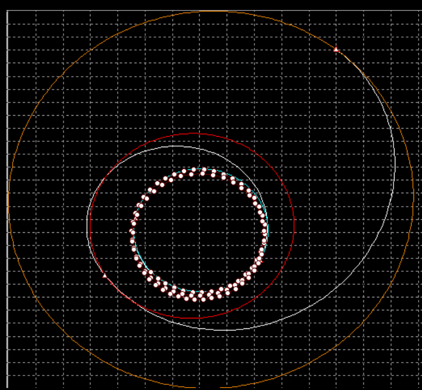
Transfer

Outbound leg

<u>Launcher AR5 ECB (Kourou)</u>

Launch	09 March 2020
Arrival date	15 October 2025
Transfer time	2056 days (~5.7y)

- main transfer with SEP
- 2 Gravity assist: ***Earth & Mars***
- Final target arrival burn with chemical propulsion system



<u>Transfer Parameter</u>

Δv Launcher	2236.0 m/s
Δv SEP	5311.3 m/s
Δv Chem Propulsion	1656.6 m/s

Approach and Sampling

Approach

- Orbit of 1 km around the target for remote sensing measurements
- Selection of suitable landing site
- Deployment of lander at an altitude of 500 m
- Descent time: ~ 40 min
- AOCS with monopropellant hydrazine

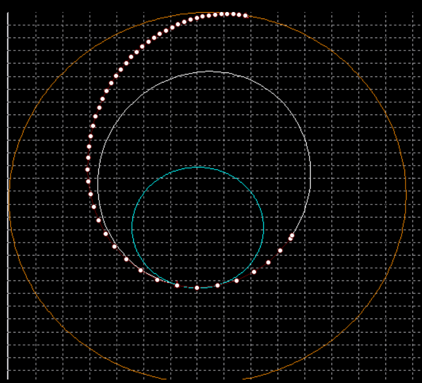
Sampling

- Anchoring lander by harpoons to prevent rebound during sampling
- Storage of max. 150g sample in container
- Deployment of container with a spring loaded separation device
- Orbiter will capture canister at altitude 50m
- Storage of canister in re-entry capsule
- Landers remains on surface for in-situ measurements

Transfer

Return leg

Launch target	01 April 2026
Arrival date	02 June 2030
Transfer time	1523 days (~4.2y)

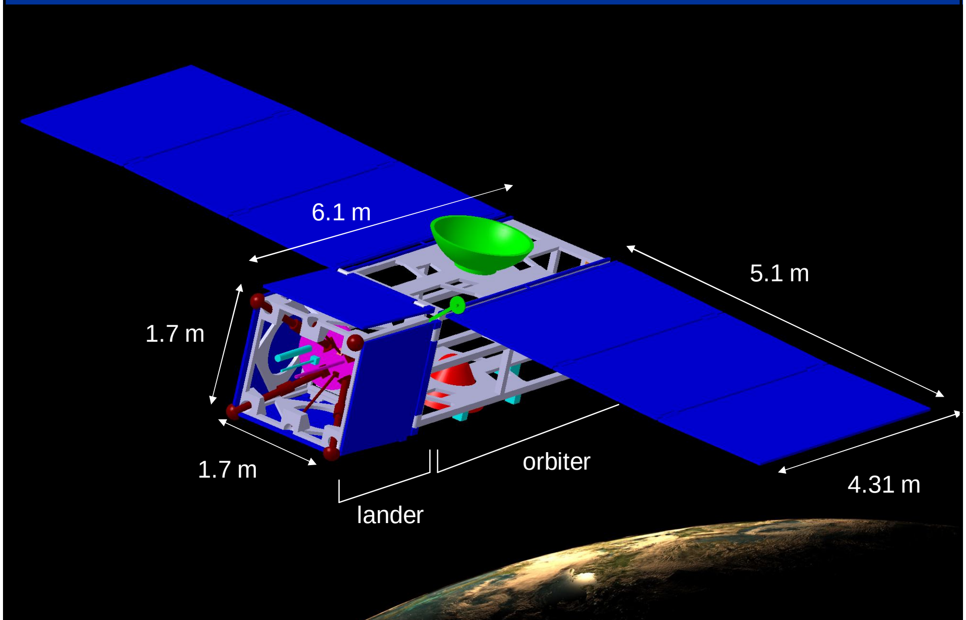


- Time of stay: 6 months
- Use of SEP for transfer
- Additional revolution at Earth to lower entry velocity (12.6 km/s)
- Deployment of ECR, collision avoidance maneuver
- Entry with 12.6 km/s at FPA 13°

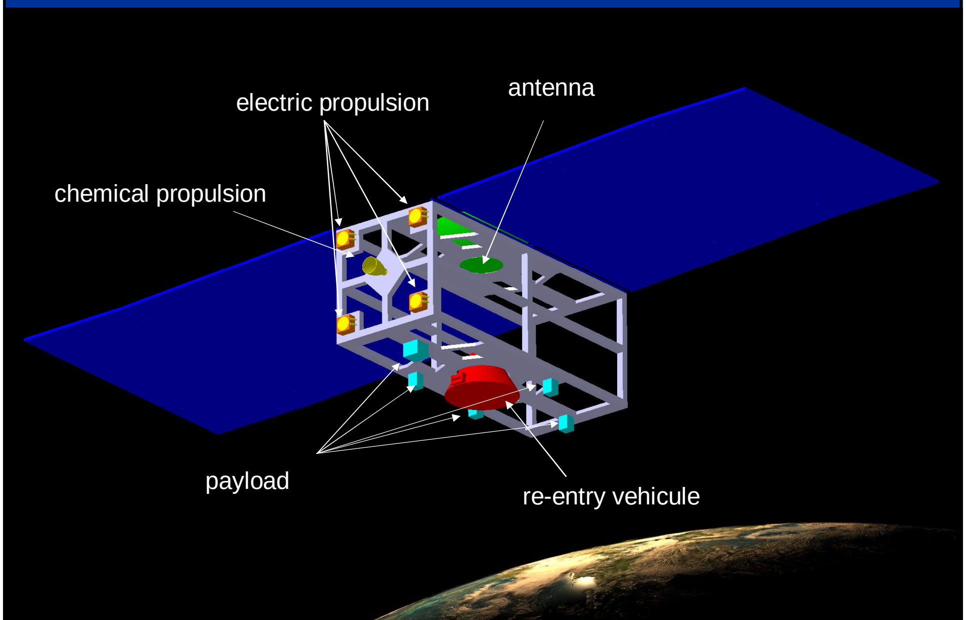
Transfer Parameter

Δv SEP	3360.6 m/s

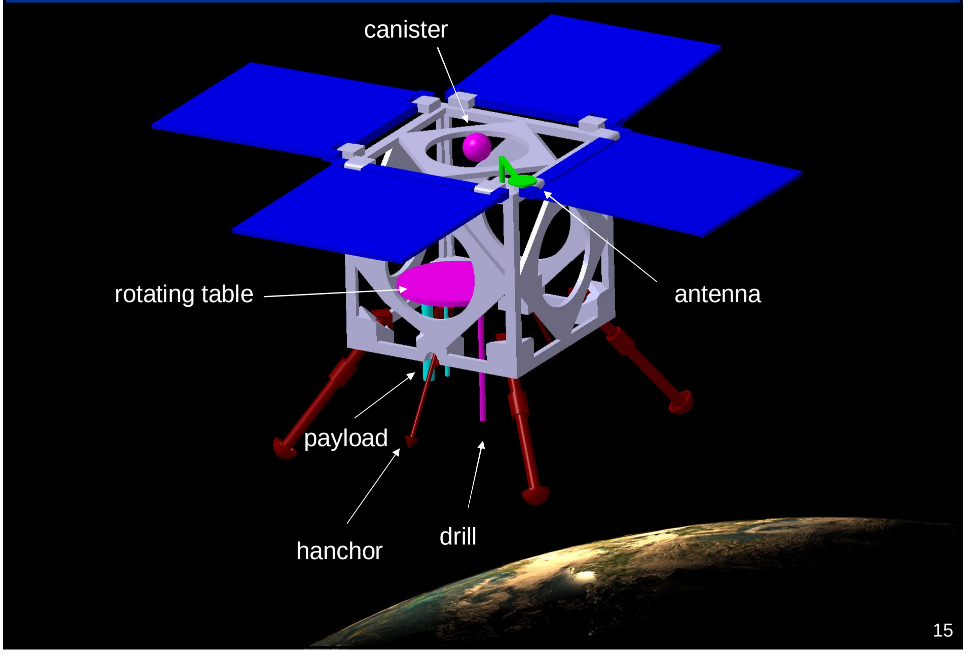
Spacecraft



Orbiter



Lander



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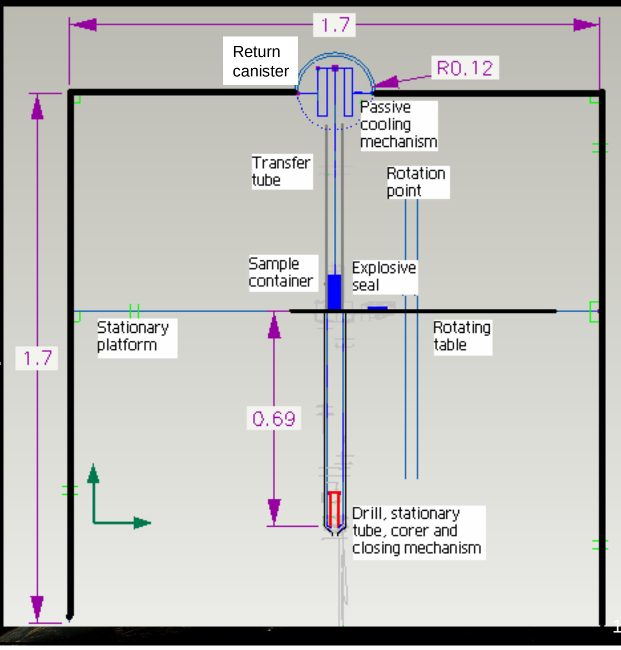
Sampling and Storage

- The rotation shaft and transfer tube are fixed on the stationary platform.
- The rotating table enabling optimal sampling site to be located upon arrival.



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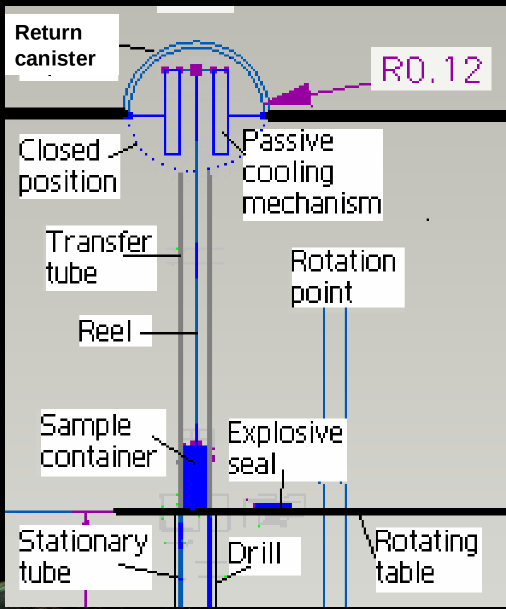
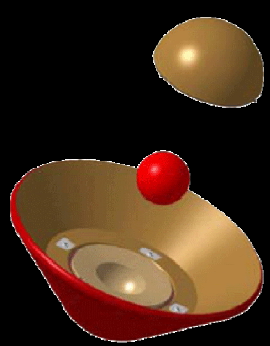
Sample transfer mechanism

- The corer is secured in the sample container and the table is rotated to apply the explosive seal
- The sample container is then transferred into the passive cooling mechanism through the sample transfer tube via a reel mechanism
- The return canister is rotated and sealed and ready for deployment to the return capsule



Re-entry capsule

- Mass estimate: 54 kg
- Entry speed:12.6 km/s
- No parachute but high energy absorption material to reduce g-loads
- Landing ellipse diameter ~20 km
- Quick recovery and transport to curation facility
- Beacon for localization



Picture from study overview of the near earth asteroid sample return

Mass budget

Lander Mass Budget

Subsystem	Mass [kg]	Mass incl. 20% Margin [kg]
AOCS	21.89	26.27
OBDH	3.0	3.6
Comm. (UHF)	5.0	6.0
Payloads	2.16	2.59
Sampling System	16.2	19.44
EPS	82.5	99.0
Thermal	8.0	9.6
Structure	37.2	44.64
Mechanism	13.92	16.7
Harness	12.72	15.26
Total dry mass	**202.59**	243
Propellant (Hydrazine)*		6
Total wet mass		249.1

Return Module Mass Budget

Subsystem	Mass [kg]	Mass incl. 20% Margin [kg]
AOCS	65.49	78.59
OBDH	19.0	22.8
Comm. (UHF)	58.4	70.08
Payloads	12.36	14.83
EPS	246.0	295.2
Thermal	6.96	8.35
Propulsion (SEP)	209.9	251.8
Propulsion (Chem.)	364.5	437.4
Structure	246.0	295.2
Mechanism	31.9	38.3
Harness	49.2	59.0
Return Capsule	54.2	65.1
Total dry mass	**1363.9**	1636.7
Propellant (SEP)		243.2
Propellant (Chem.)		78.9
Total wet mass		1958.3

Orbiter Mass Budget (Total)

System	Mass [kg] incl. Margin
Lander Module wet mass	249.1
Return Modul wet mass	1958.3
Total dry mass	2207.4
Propellant (SEP)	616.8
Propellant (Chem.)	1548.5
Total wet mass	4372.7

* The hydrazine is used in the lander AOCS system

Power budget

Orbiter Power budget

Subs.	Power (W)
Electrical Propulsion	10000
AOCS	129
OBDH	10
Comm.	70
Payloads	35.3
Sampling mech.	10
EPS	5
Thermal	100
Power without margin	10359.3
Margin (%)	20
Total	12431.16

Lander Power Budget

Subs.	power in light (W)	power in night (W)
AOCS	0	0
OBDH	5	5
Comm	5	5
Payloads	7	7
Sampling Mech.	0	0
Thermal	0	20
EPS	0	0
Power required	**17**	**37**
Margin (%)	20	20
Total*	**20.4**	**44.4**

* The power required by AOCS and sampling mechanism are provided by the batteries and considered as pulse loads

Conclusions

- SAMOSA will provide unique information on planet formation and the origin of life
- SAMOSA is a feasible mission using existing techniques
- SAMOSA is a mission which will be completed within 10 years that will provide fundamental answers and will raise new questions

Credits

We thank Oliver and Peter, roving tutors for excellent support and Johannes Ortner and his team for an intensly exiting time!