# Smallsat-aided Mission for the 2029 Apophis Rendezvous: ATENA

Upcoming and Innovative Mission Concepts For Small Satellite Missions

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# Agenda

- Outline of Argotec Deep Space Mission
- ATENA Mission Consortium
- Implementation Roadmap
- Mission General Overview and Science Objectives
- Payload Suite
- Mission and Proximity ConOps
- Rapid Trajectory to Apophis
- Platform Overview
- Advanced Features
- Next Steps

**ATENA –**
**A**dvanced
**T**echnology
**E**xploration of
**N**EA
**A**pophis

# Flight Heritage

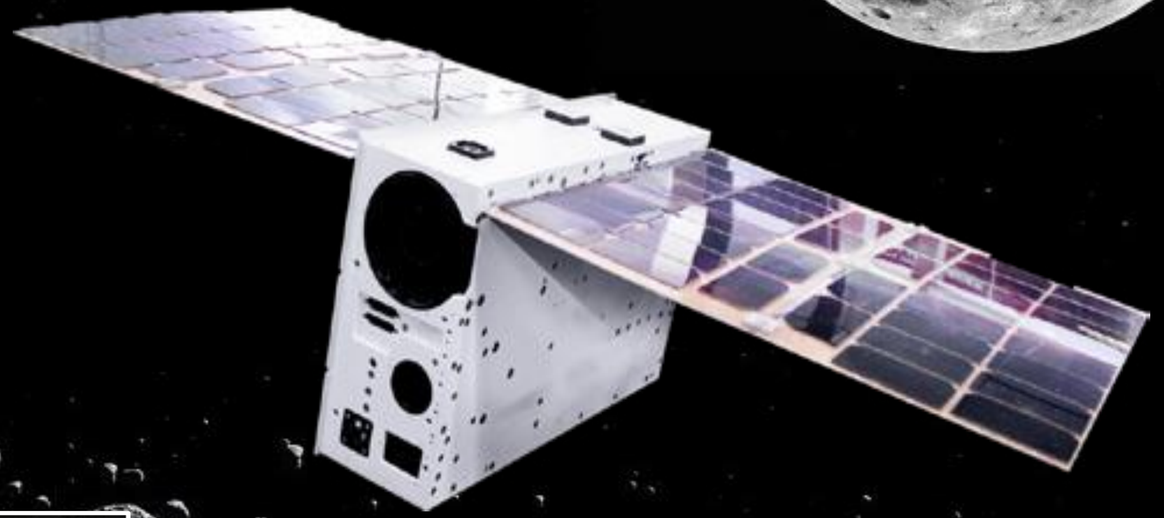
## LICIACube

Argotec flew onboard the DART mission in the framework of the first planetary defense mission.

LICIACube witnessed the consequences of the impact of the NASA's probe against the Dimorphos and took pictures of the asteroid, the plume and the impact region.
More than 600 photos were taken during the flyby and downloaded to Earth.

AIAA
**Mission of the Year 2023**







## ArgoMoon

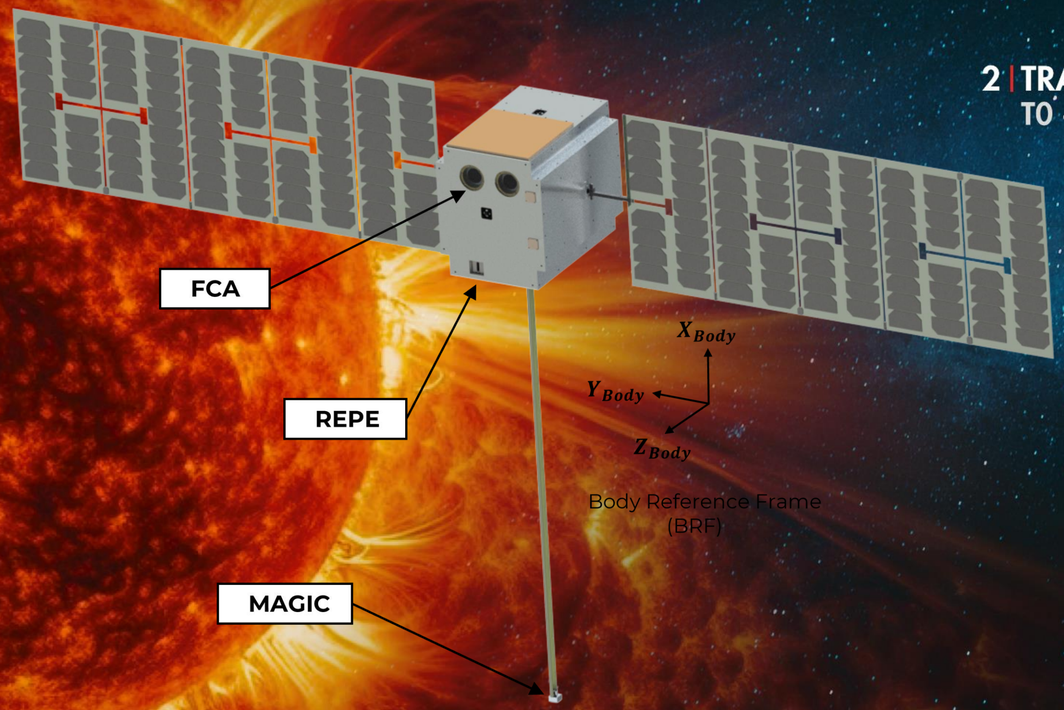
Argotec took part in the ARTEMIS 1 program whose goal is the return of man on the lunar surface.

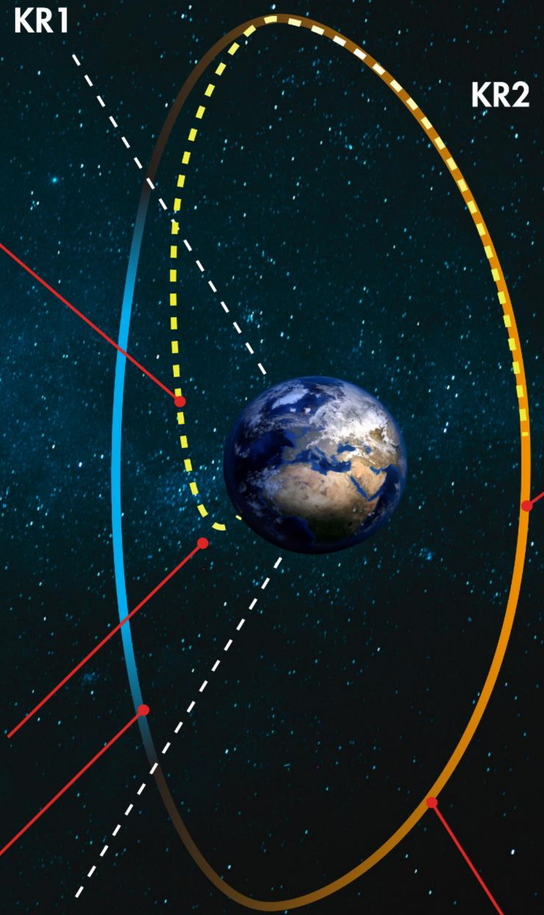
The main mission goals of ArgoMoon were:

- Validate new key nanosatellite technologies in deep space
- Demonstrate high hardware reliability and operability
- Provide Historically Significant Photography of Artemis-1Mission
- Provide high-resolution images of Moon and Earth

# HENON

**HEliospheric pioNeer for sOlar and interplanetary threats defeNce**




**2 | TRANSFER TO DRO**
T0 + 5d

**3 | P/L COMMISSIONING**
T0 + 1.05y

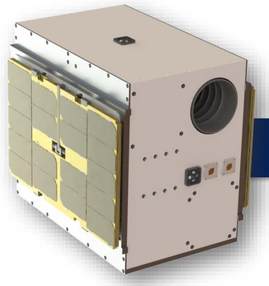
**1 | LEOP**
T0

**4.2 | NOMINAL OPERATIONS - KR1**
Near Real-Time Alert Service

**4.1 | NOMINAL OPERATIONS - KR2**
Scientific Measurements
Data Download

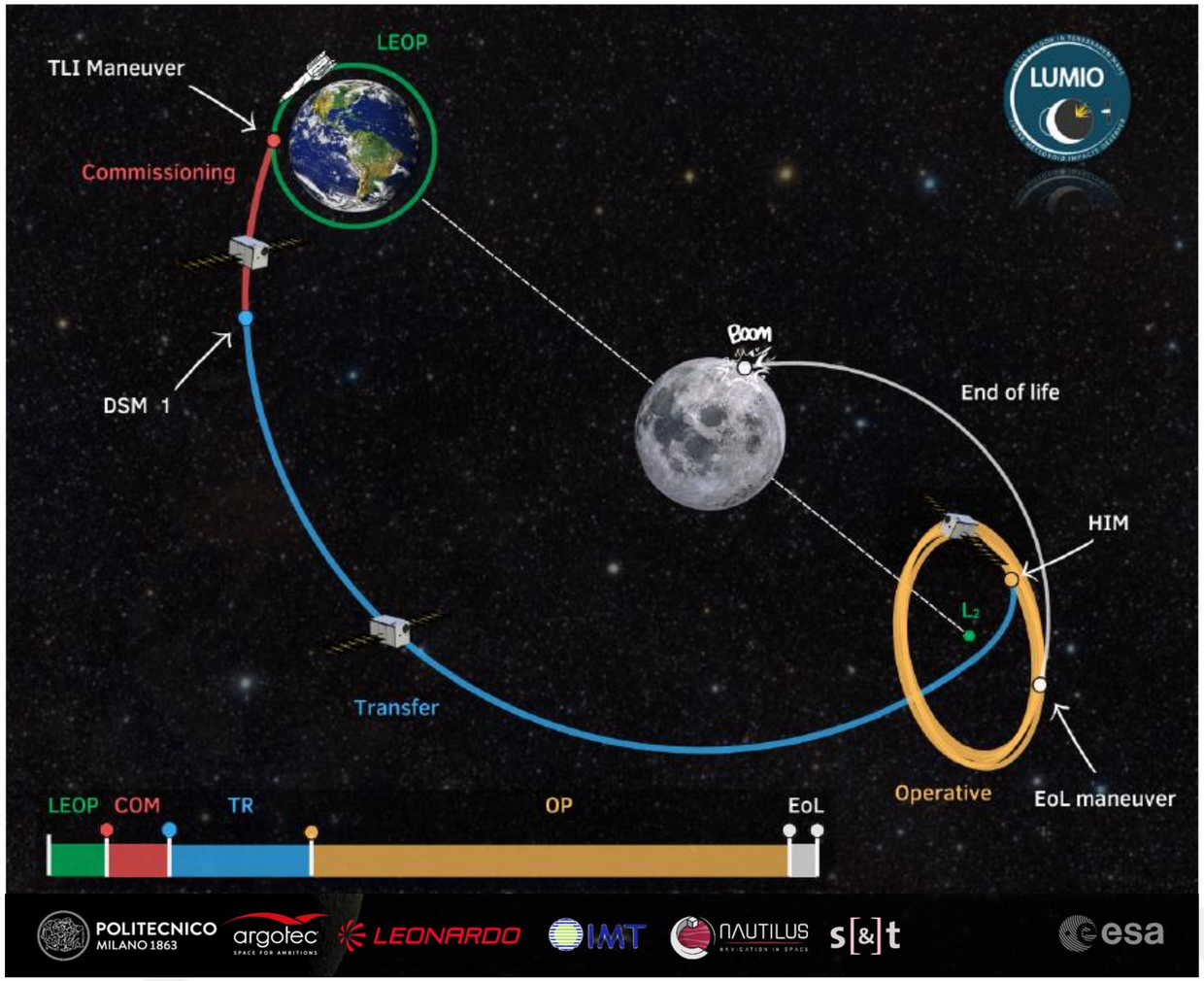
# LUMIO

Lunar CubeSat for Meteoroid Impacts Detection



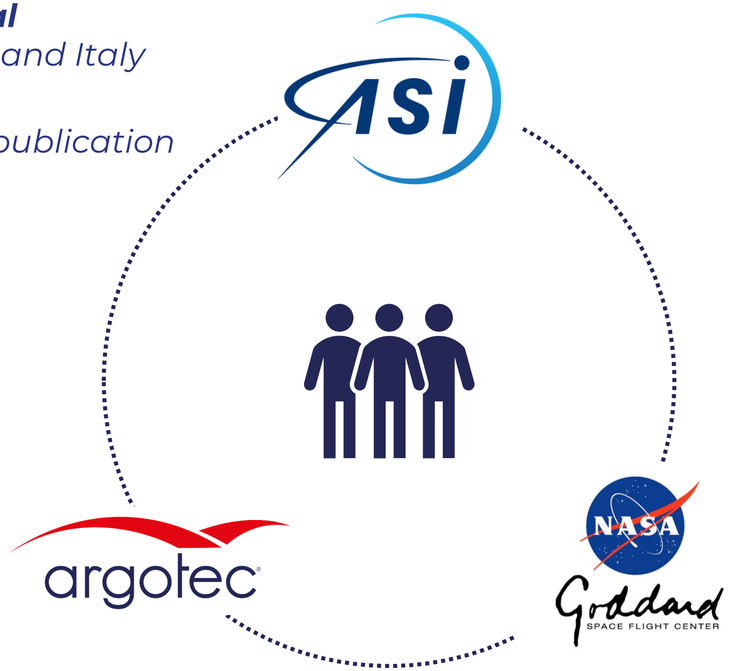
## Key Mission Features

- Autonomous transfer through a weak stability boundary trajectory up 1.5 million km from Earth
- Meteoroid flash detection capabilities
- Autonomous optical orbit determination
- BUS avionics RAD hard by design
- Operational lifetime of 1.5 years in deep space
- End of life: disposal on the lunar surface
- Compact 12U form factor



# ATENA Mission Consortium

- ***Scientific Investigation***
- ***Coordination*** *of Scientific partners*
- ***Manage the international cooperation*** *between US and Italy*
- ***Data management*** *and publication*

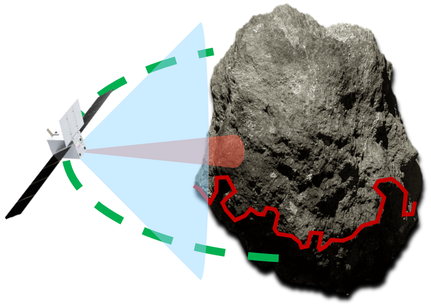



- ***ConOps*** *and* ***Mission Design***
- *Spacecraft* ***Development & AIT***
- ***BIRCHES to Platform Integration***
- ***UST-Lite to Platform Integration***
- ***Satellite to Launcher Integration***
- ***Operations*** *preparation and execution (LEOP, Transfer, Science, Disposal)*

- ***Scientific Investigation***
- ***Trajectory*** *and Mission Design*
- ***BIRCHES Production*** *and Acceptance*
- *Spacecraft* ***Navigation***
- ***Interface and Joint Operations with APEx***
- ***DSN Support***

# ATENA Implementation Roadmap

## Timeline



***Phases A/B***
Q1 2024 to Q1 2025

***Phases C/D***
Q1 2025 to Q1 2027
(Payloads and Sat MAIT)

***Launch Window***
Nov 2027

***Arrival at Apophis - Rendezvous***
Feb 2029

***Earth Approach***
Feb 2029 to Mar 2029

***Pre-Encounter***
Mar 2029 to Apr 2029

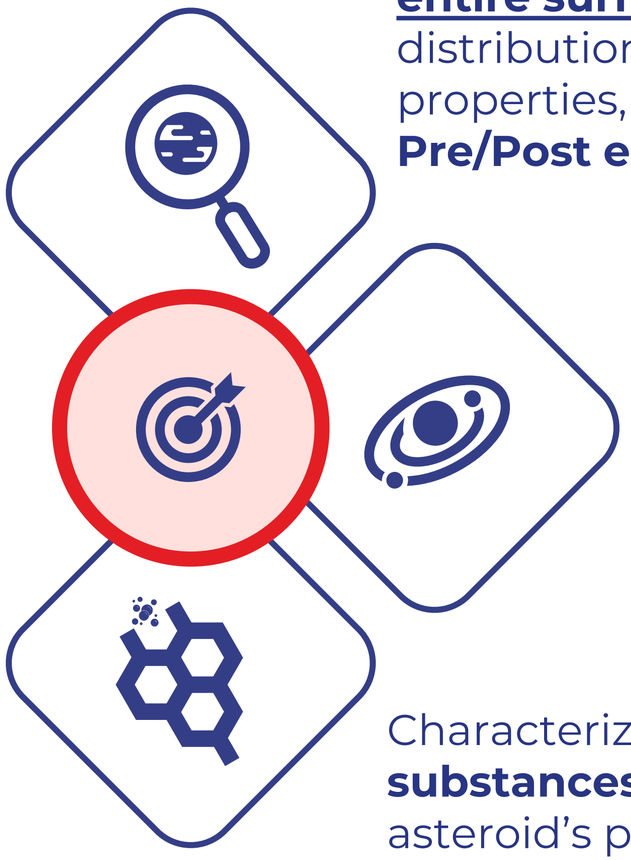
***Earth Encounter***
May 2029

***Post – Encounter Orbital Phase***
May 2029 to Jun 2029 – APEX Arrival

**Phase A** | **Phase B** | **Phase C** | **Phase D** | **Phase E**

# Mission General Overview

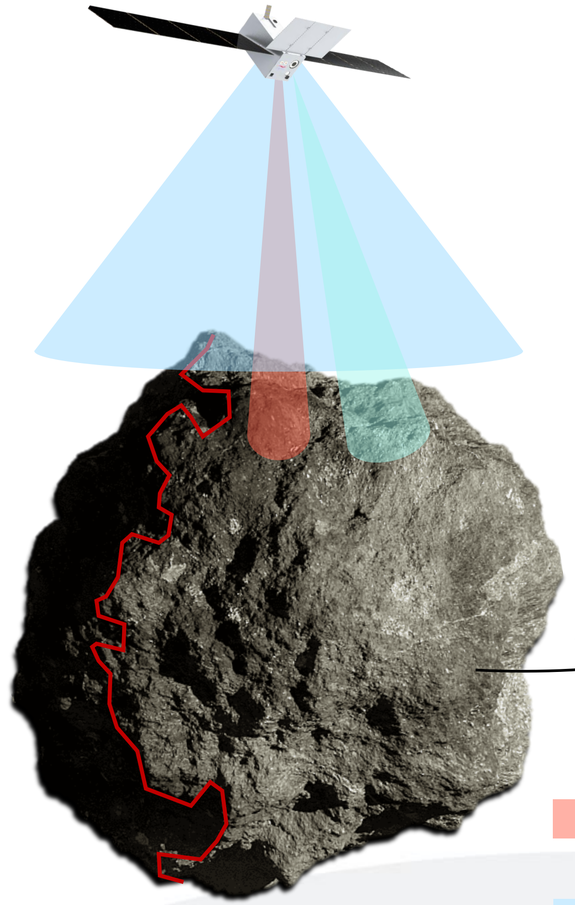
## ATENA Key Scientific Objectives



**High resolution mapping and monitoring of the <u>entire surface</u>** (topography, crater map, mass distribution, surface features, albedo, color, thermal properties, rotation state…).
**Pre/Post encounter** optical and spectral acquisition.

Determination of **Apophis' orbital dynamic properties**.
Improve the **Planetary Defence Program.**

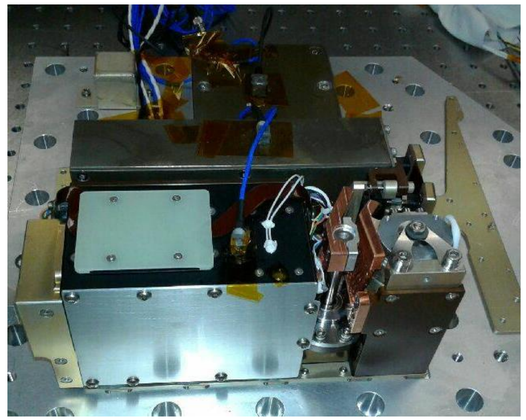
Characterization of **water and other volatiles substances** present on Apophis. Analyses of the asteroid's plume.



# ATENA Payload Suite

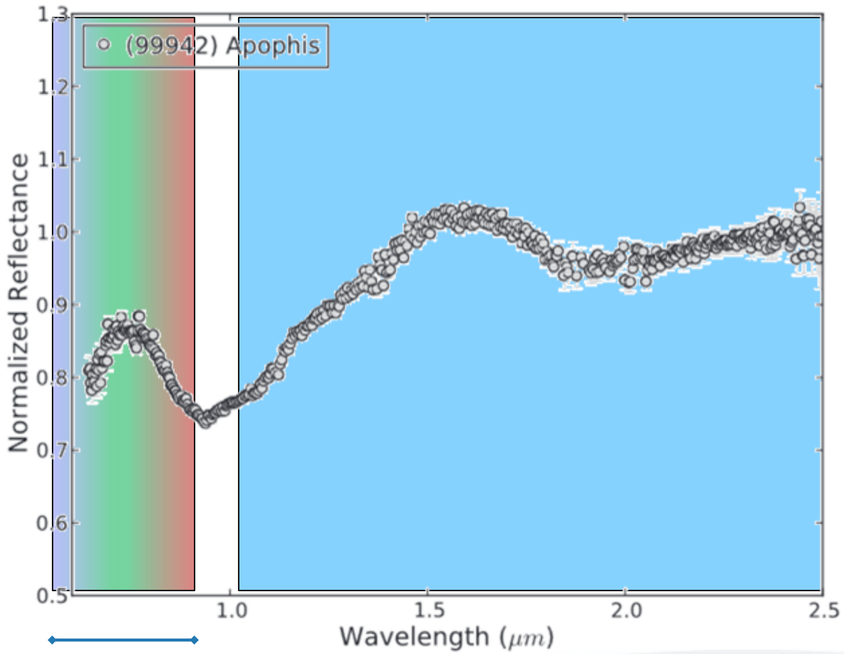
VIS Cameras & NIR Spectrometer

## Infrared Spectrometer – BIRCHES



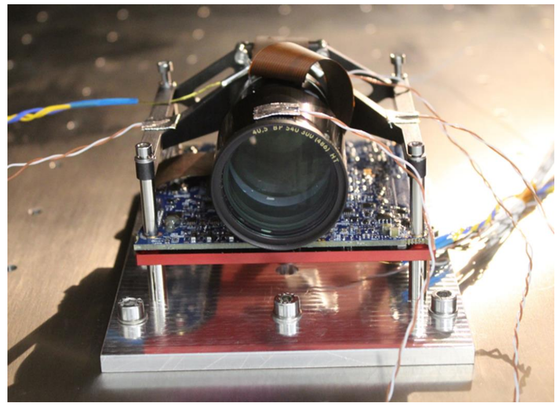
- **Heritage** from New Horizons's LEISA and OSIRIS-Rex's OVIRS.
- **Maps** the surface composition from 1-4.2 μm
- NIR measurements associated with volatiles in **3 μm region**
- **< 10 nm spectral resolution**
- **GSD=30 m** @ 1km

**BIRCHES spectral coverage**
1.0 to 4.2 μm

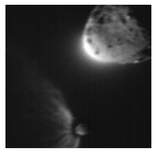



**LUKE imaging**
0.4 to 0.9 μm 3-color Bayer filter

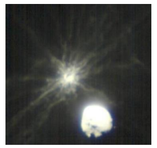
## Visual Cameras – LUKE & LEIA



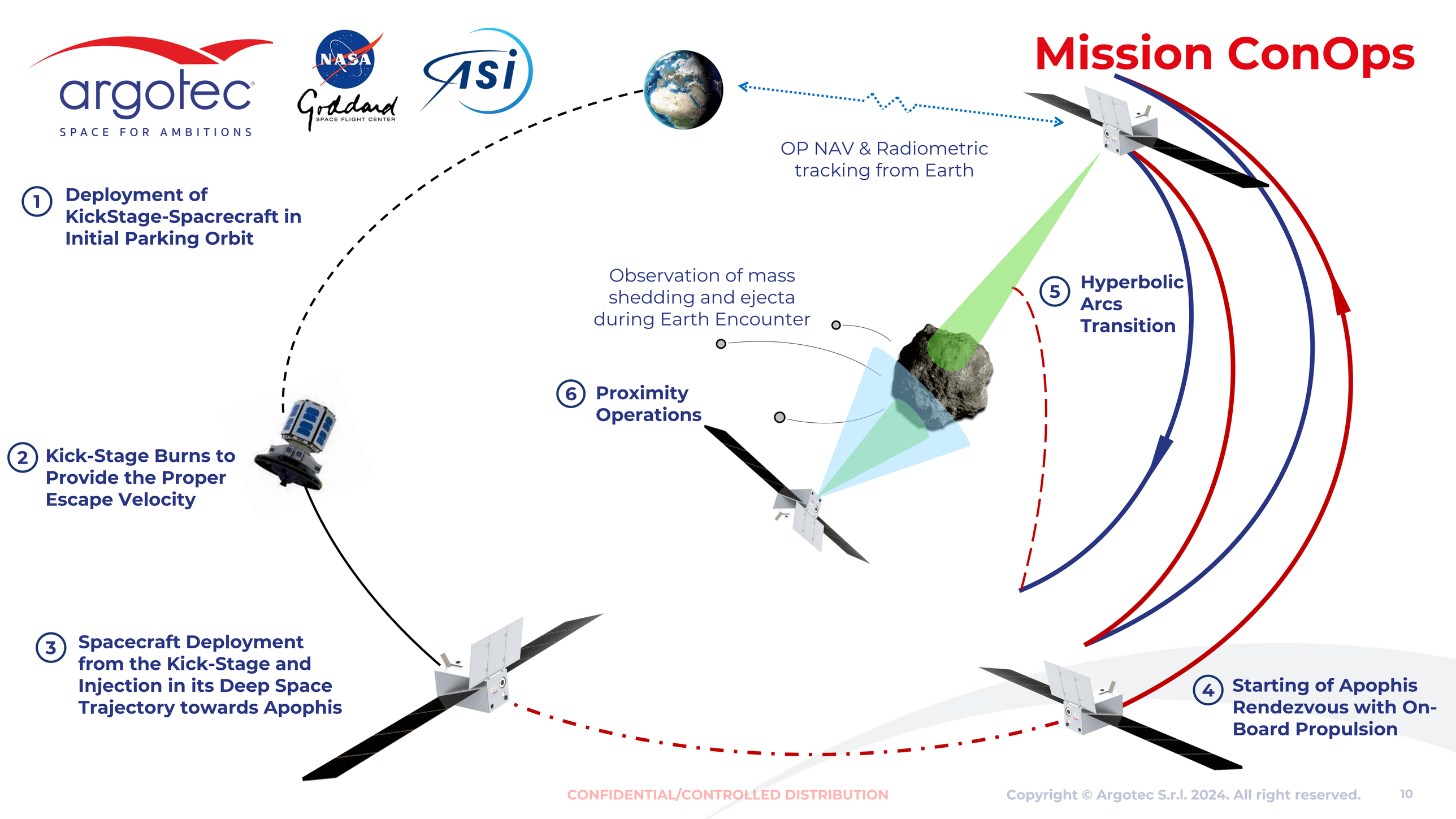
- **Heritage** from **LICIACube**
- **LEIA:**
  Narrow field, 4.2 MP
  2048 x 2048 pixels
  2.5 cm/px @ 1 km



- **LUKE:**
  Wide field, 2.2 MP
  2048 x 1088 pixels
  7.8 cm/px @ 1 km
  RGB Acquisition

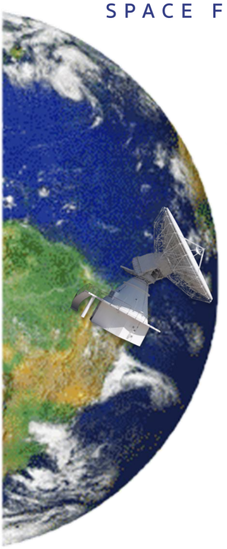


# Mission ConOps



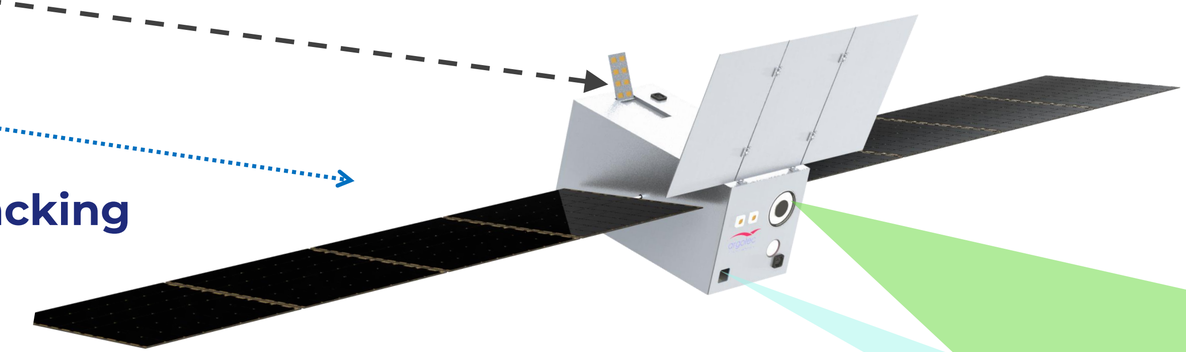
# Proximity Ops

## Typical Proximity ConOPS Scenario



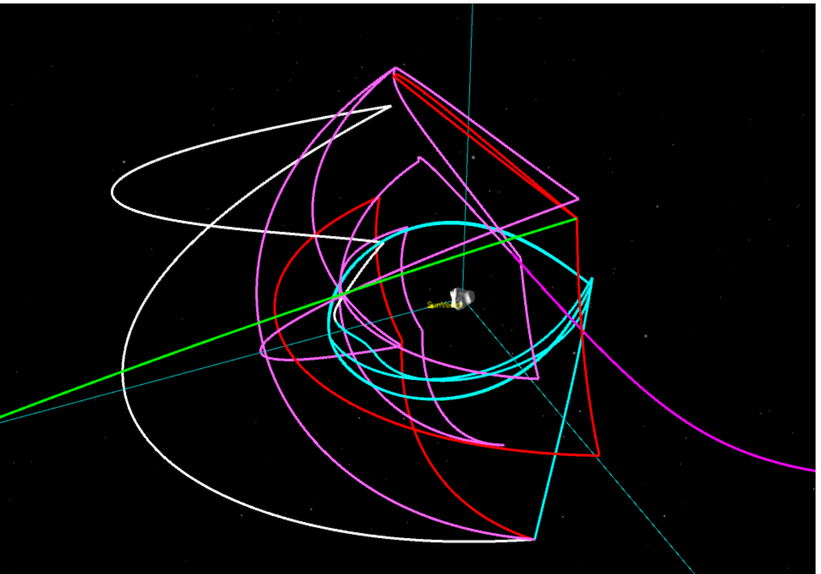
Scientific and NAV Photos

Radiometric Tracking



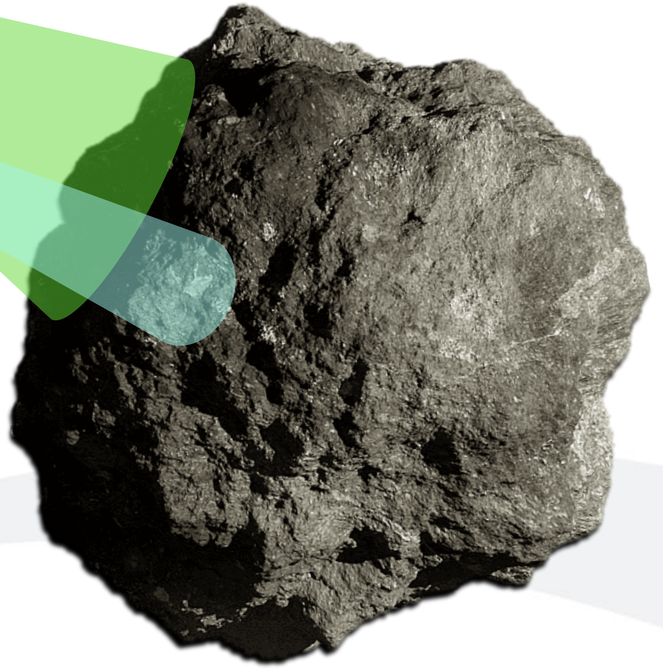
**VISIBLE Acquisitions**
(LEIA and LUKE)

**NIR Measurements**
(BIRCHES)



**Proximity OPS Phases [2-15 km]:**

1. Approach w/particle search
2. Preliminary Survey
3. Low-Phase Trajectories
4. Earth flyby: Safe Observations
5. Post Earth Flyby Survey
6. End of Life



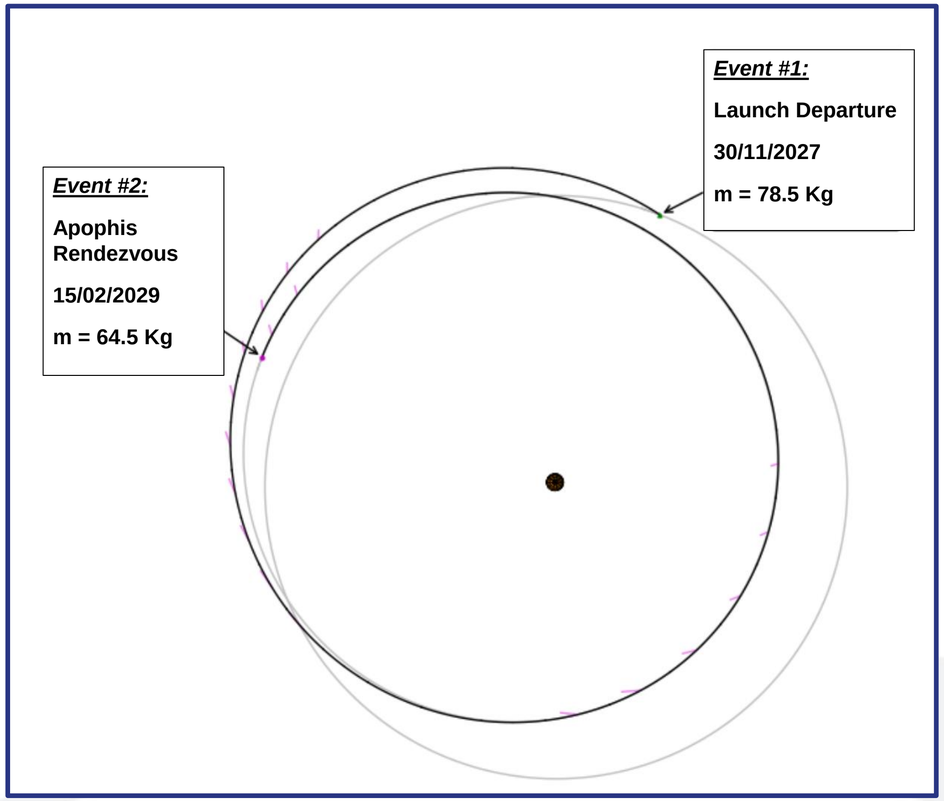
# Rapid Trajectory to Apophis

## Enabling Early Pre-Encounter Comprehensive Mapping

For the transfer several cases in terms of Thruster Technologies (Hall vs Ion Effect Propulsion Systems) are evaluated. The trajectory can include possible Lunar and/or Earth gravity Assist to reduce the requested C3.

### Main Assumptions and Constraints

- Arrival date NLT 16 Feb. 2029
- Modeled $I_{SP}$ and T thruster curves according Solar distance
- 10% margin on propellant
- Apophis model used (density, shape, rotation)
- Max Propellant mass < 15 Kg




| Case | Departure | Trajectory | Thruster | C3 (km2/s2) | LD | AD |
|---|---|---|---|---|---|---|
| #2 | Direct Launch or KS | Direct | Option A Hall Effect | 38,1 | 30-nov-27 | 15-feb-29 |

# ATENA Platform Overview

## Key Features and Subsystems

**< 80 Kg**

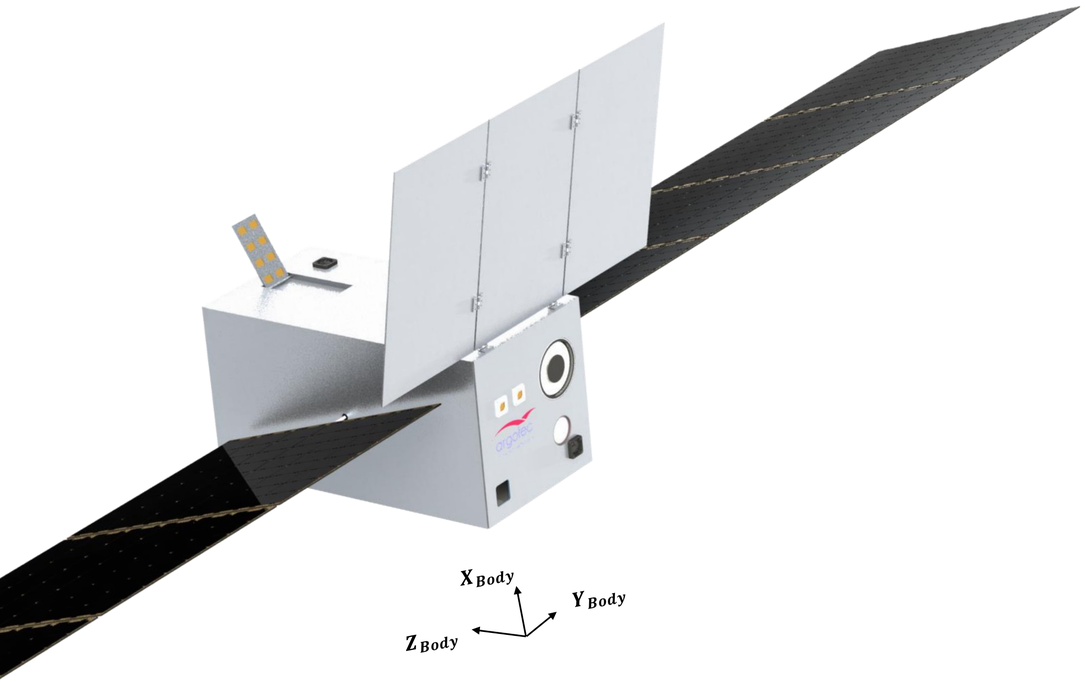
**Custom**

**Electric Propulsion**
< 2 km/s
**Cold Gas RCS**
> 20 m/s

**< 0.1 deg**

**> 350 W BOL**

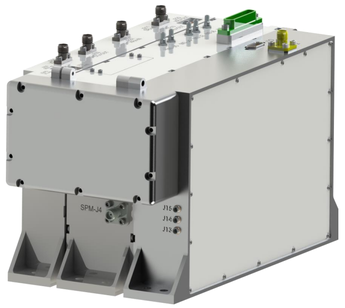
**X-Band**
512 kbps @ 0.15 AU
32 kbps @ 0.45 AU




| S/S | Remarks | TRL |
|---|---|---|
| **Payload Suite** | • BIRCHES<br>• LEIA<br>• LUKE | 9 |
| **TMTC Subsystem** | • X-Band Transponder<br>• HGA deployable Reflectarray<br>• 4x LGA patch for omnidirectional TT&C | 8 in 2026 |
| **Propulsion Subsystem** | • Hall-Effect Thruster<br>• Thruster Pointing Mechanism (gimbal)<br>• Cold Gas RCS<br>• Xenon Propellant Tanks | 9 in LEO* |
| **Power Subsystem** | • 2-wing Deployable SA<br>• SADA Mechanism<br>• 2x ELEKTRA Battery<br>• 2x VOLTAplus PCDU | 8/9 |
| **ADCS** | • 2x Star Trackers<br>• 4x Sun Sensors<br>• 4x Reaction Wheels<br>• IMU | 9 |
| **OBC&DH** | • Rad-hard FERMI OBC&DH system<br>• OBSW based on Argotec heritage | 9 |

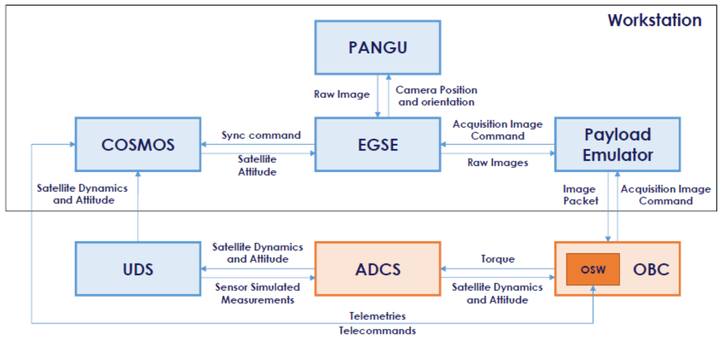
# ATENA Advanced Features

## • Key Technologies

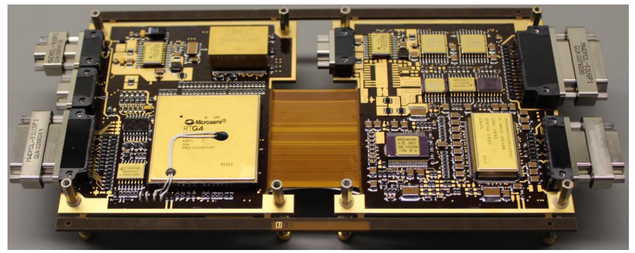


Jet Propulsion Laboratory
California Institute of Technology

**ARG-JPL Deep Space Transponder**, useful also perform **Radio-Science** experiments.



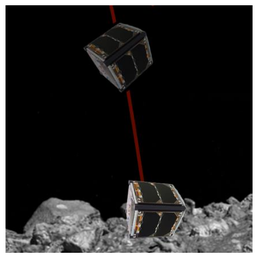

**Prox OPS** and **Optical NAV** based on **LICIACube** heritage



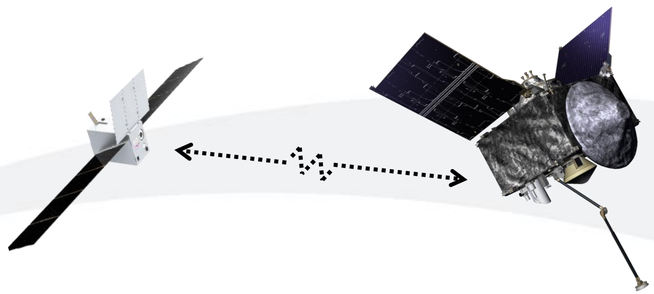
**Rad-hard design** qualified for deep-space mission and Advanced **FDIR** implemented on-board

## • Possible Additional Features

Possibility to embark **additional payload** (up to 1.5U)

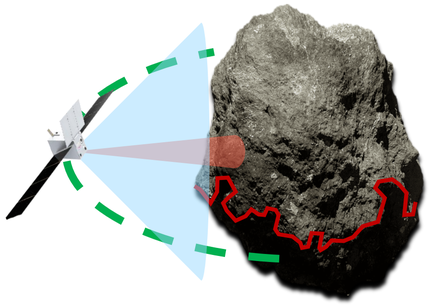


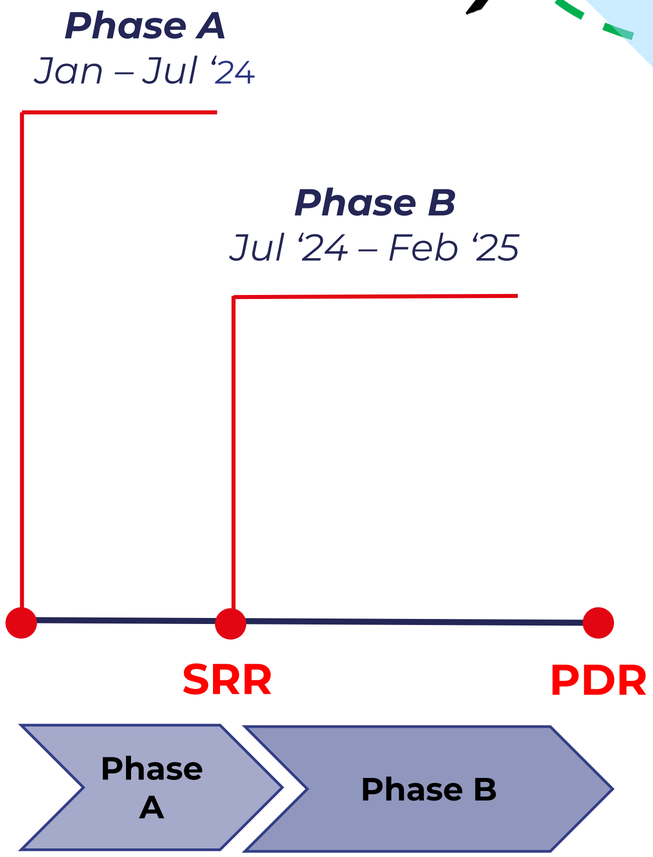
**Inter-satellite Link** with OSIRIS-APEX



# Next Steps

Way-Forward and Current Activities






## Towards the SRR

- Review of Scientific Target and Mission Objectives
- Mission and System Requirements Definition
- Detailed ConOps Consolidation
- Mission Environment Characterization
- System Levels Preliminary Analyses
- Space, Ground and Launch Baseline Consolidation
- System Development and AIT Plan Definition

- Strengthening of International Collaboration and ATENA Consortium – **Open for Proposal and Discussion**

ATENA creates a lower cost option in a budget challenged environment, while still providing full scientific coverage

ATENA's advantages spring from previous mission studies and hardware builds, reducing the risk of a short schedule

The ASI, ARGOTEC and NASA GSFC partnership combines proven flight project expertise, lowering cost to both NASA and ASI

# Thank you

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