Milo Space Science Institute
Arizona State University

ASU's Milo Space Science Institute: Increasing the World's Access to Space

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About the Milo Space Science Institute at ASU

ASU Milo Space Science Institute
Arizona State University

The Milo Institute, formed in 2018, is a non-profit membership-based organization that is part of Arizona State University's Enterprise Partners infrastructure. Milo's main goal is to make impactful space science and exploration accessible to space agencies, universities, and other organizations around the world that want to build capacity, increase infrastructure, and engage in missions to participate more deeply in the growing global space economy.

Build Capacity

Bundle space infrastructure as a service

Create access to space science missions

Milo's Origin Story...

- More opportunities
- Increase access
- Leverage expertise

- "Mini-ESA" analogy

Support for ASU's Charter and Design Aspirations

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ASU is a comprehensive public research university, measured not by whom it excludes, but **by whom it includes and how they succeed**; advancing **research and discovery of public value**; and assuming fundamental responsibility for the economic, social, cultural and **overall health of the communities it serves**.

Milo supports the ASU Charter in key areas:

Leverage Our Place
ASU embraces its culture, socioeconomic and physical setting.

Enable Student Success
ASU is committed to the success of each unique student.

Transform Society
ASU catalyzes social change by being connected to social needs.

Fuse Intellectual Disciplines
ASU creates knowledge by transcending academic disciplines.

Value Entrepreneurship
ASU uses its knowledge and encourages innovation.

Be Socially Embedded
ASU connects with communities through mutually beneficial partnerships.

Conduct Use-Inspired Research
ASU research has purpose and impact.

Engage Globally
ASU engages with people and issues locally, nationally and internationally.

Practice Principled Innovation
ASU places character and values at the center of decisions and actions.

Milo Capacity Building

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International implementation of a workforce development program pioneered at ASU by Sheri Klug Boonstra, with leadership from SESE Prof. Phil Christensen

Milo ***Mission Academy*** is based on the L'SPACE Program, implemented for NASA's Lucy mission by ASU. L'SPACE has achieved:

- 9,500+ participants with a 90%+ completion rate
- 915+ colleges and universities and 278 Community/Technical colleges
- 41% of students are female and 54% are students of color

Milo ***Space Works*** is designed for individuals who have shown promise as leaders in their country, training participants on the lifecycle of an instrument

- Hands-on application of knowledge to obtain scientific results
- Work in multi-disciplinary teams to create a unique instrument
- Guided by requirements and risk assessments

Contracts for these programs have been executed in Australia, Ecuador, and Puerto Rico. Contracts pending in S. Korea, Saudi Arabia, and Morocco

A NASA Space Act Agreement is in process to aid in the delivery of the Mission Academy to signatories of the Artemis Accords

Photo credit: ASU

Milo Space Infrastructure based on ASU experience

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Photo credit: ASU

The ***Milo Space Payload Challenge*** provides participants with:

- Guidelines and processes to accelerate development of prototypes
- Preparation of important milestones and a Tech Maturation Plan
- Participation in a Demo Day event held in Los Angeles or Washington DC

A key element to the Space Payload Challenge is **access to ASU's space-related facilities and personnel expertise,** including the nascent **Exploration Lab.** Access is **provided as a service** to support some or all of Milo members' design, review, test, calibration, and operations payload and/or mission needs. Complete instruments can also be purchased directly from the ASU Exploration Lab.

A proposal is in process with NASA's Science Mission Directorate (SMD) for potential deployment of Milo's Space Payload Challenge in Rwanda, Ecuador, and Uruguay. A separate proposal is in process independently in Saudi Arabia.

Milo Space Science Missions

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Image credits: (top) Lockheed Martin; (bottom) NASA/JPL

Milo provides guidance and at least initial leadership for Space Science Missions, including the early participation of the **Milo Science Council** in the development of scientific requirements and the traceability from science to instruments to mission requirements.

Two Example Missions in Development:

Luna Ride leverages the NASA Lunar Terrain Vehicle (LTV) program's **infrastructure as a service** model

- Milo will help the commercial LTV team close their business model by providing integrated lunar surface payloads from Milo members at a substantially lower cost than "doing it on their own".
- Cost per payload is based on the volume and amount of tasking of the infrastructure required.

Apophis Pathfinder is a university-led mission to perform a flyby of the Potentially Hazardous Asteroid (99942) Apophis ~1 year prior to it's extremely close Earth encounter in 2029. Milo's international science team will feed-forward important information for other larger-scale Apophis encounter missions

(99942) Apophis: A Potentially Hazardous Asteroid

- Estimated to be ≈340 meters wide, the Potentially Hazardous Near-Earth Asteroid (99942) Apophis will come within ≈ 32,000 km of Earth's surface on April 13, 2029
- Apophis will be visible from the ground in the Eastern Hemisphere
- This is the closest any celestial object of that size will have come to our planet in modern history
- No evidence that this object will impact Earth in next several centuries, but objects this size (and larger) have caused environmental and biologic havoc in the past, and will again sometime in Earth's future...

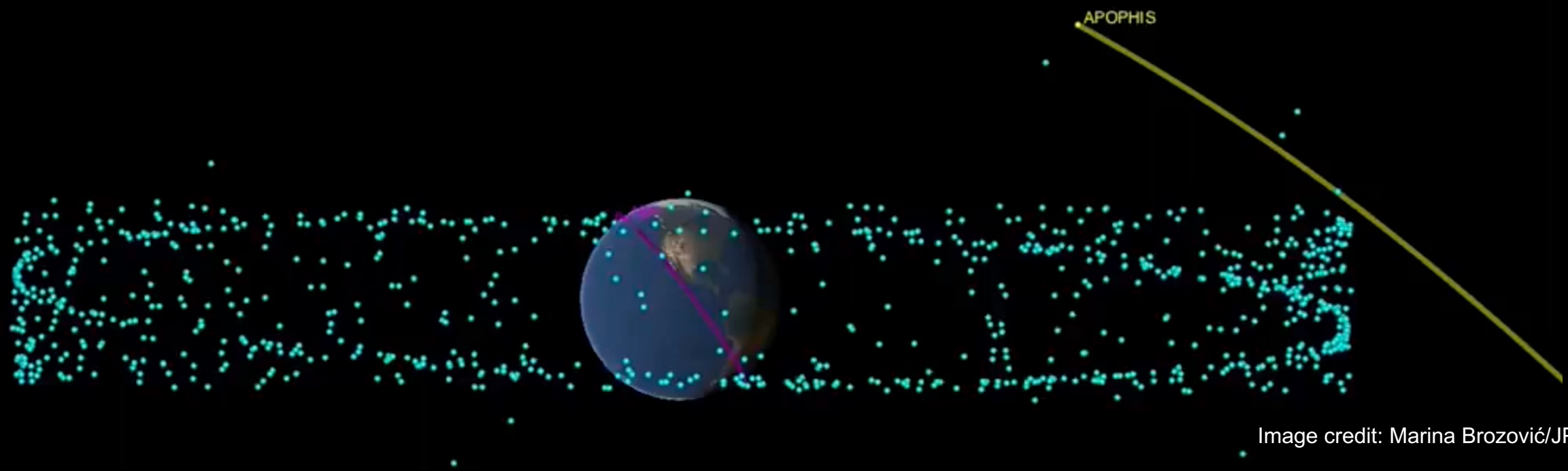


Image credit: Marina Brozović/JPL

Milo's Apophis Pathfinder Mission

Simple Payload focused on Geology, Composition, Mass Determination

- Visible RGB color imaging system with a targeted resolution of ~1 m/pix
- Near-IR point spectrometer for detection of minerals and organics (?)
- Thermal-IR imager for mapping of temperatures, regolith properties
- Might accommodate additional (small) Milo member payloads...
- Innovative dual spacecraft approach to mass determination
  - Christensen, Park, & Bell (2021) *J. Spacecraft Rockets*.

Simple Spacecraft

- Heritage bus/major systems based on deep space experience
  - MARCO (JPL)
  - JANUS (U. Colorado/Lockheed) ← Just pitched to NASA
  - Artemis-1 CubeSats like ASU's LunaH-Map, etc.

Simple Mission Design

- Rideshare launch, short cruise, approach, flyby, & departure ops

Milo's Space Diplomacy

The Milo Ambassador program promotes space diplomacy within emerging partner countries/regions. Milo Ambassadors are citizens within the country who have signed 2-year agreements, which may be renewed.

Regions: Africa, Indo Pacific, Latin America, MENA, North America, UK + Europe

Countries: Australia, Canada, Ecuador, Morocco, Paraguay, United Kingdom, United States, Zimbabwe

Metrics: 12 Agreements, 4 projects, Hundreds of engagements supporting space diplomacy outcomes

Current or expected space diplomacy outcomes:

- Scale support from State Department – the Consul General in Guayaquil is **providing 170 scholarships** for a program in Ecuador.
- Promote Milo's use of space-derived data in pursuit of diversity, equity, equality, and inclusion objectives.
- Connect emerging and aspiring space partners with ASU expertise through agreements with Milo to advance research and discovery of public value.
- Support Milo funded programs in space exploration, commerce, and workforce development to improve the socio-economic health of communities in their region.

Project Funding: $250k Ambassadors are supported by third party organizations within their region.

Milo Extends ASU's International Reach

Countries where the Milo Institute at ASU has agreements in process (preliminary or definitive).

International relationships maintained by the Milo Institute at ASU

Sustainability of the Institute

1. Mission Academies for Lunar Exploration and Climate Intelligence are now being implemented internationally.
2. We will achieve break even from workforce programs in FY24 and leverage existing relationships to secure funding for payload challenges and missions.
3. Work with NASA to extend capacity building through a Space Act Agreement to Artemis Accord signatories.

Scalability

1. Beginning in 1Q24, promoting the **Mission Academy** to signatories of the Artemis Accords.
2. Proposal in process for the University-led **Apophis Pathfinder** mission.
3. Plan in place to roll out **Luna Ride** on pace with NASA Artemis missions.
4. In 3Q24, scale up a Program Management Office working closely with ASU's Exploration Lab to facilitate payload development from participants of **Space Payload Challenge** and **Space Science Missions**.

Impact

- Large scale STEM workforce development.
- Train space leaders in the partner country.
- Promote capability development in the partner country.
- Provide access to space science and exploration.

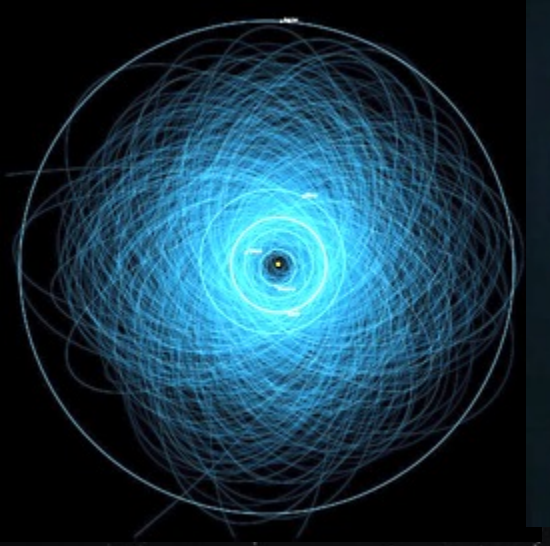
Milo Business Development Pipeline Snapshot

Capacity Building

Space Infrastructure

Space Science Missions

University	Bulgaria, Ecuador, Greece, Israel, Poland, Saudi Arabia, South Africa	United Arab Emirates	Australia, Germany, India, Norway, United States
Industry	Australia, South Korea		Canada, United Kingdom, United States
Research Org / Nonprofit	Morocco, Türkiye, United Kingdom, US (Puerto Rico), Uruguay	New Zealand	South Korea, United States
Space Agency	30+ agencies via NASA Space Act Agreement	NASA Science Mission Directorate	Italy, United Arab Emirates, United States
Other Gov. Agency	Chile, Monaco, US State Department		



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@MILOInstitute
http://miloinstitute.org

The MILO Space Science Institute

Demonstrating ASU's global leadership in innovative ways to access and explore space

Thank You!

For more information and membership details please contact,
miloinstitute@asu.edu or visit our web site, http://miloinstitute.org

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BACKUP

MILO MISSION ACADEMY

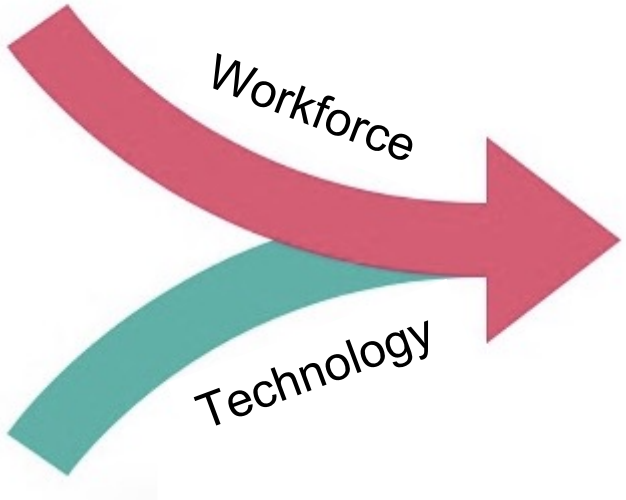
Focus: Drive payloads to missions

Mission Academy

- Mission concept design
- Space science and engineering
- Workforce development

Payload Accelerator

- Academia, industry, and government partnerships
- Advance technology
- Translation opportunities and entrepreneurship



Deep Space Science Missions

LunaRide

Apophis Pathfinder

NEOshare

Yours!

Capacity Building

12 Organizations in deal flow (preliminary or definitive agreements)

Country	Prospect Name	Stage	Product
AU, NZ	AROSE	Closed Won	Lunar Exploration
EC	Hemispheres University	Closed Won	Climate Intelligence
PR	Puerto Rico Science Trust	Closed Won	Climate Intelligence
KR	Hyundai Motor Company	FY24 Commitment	Custom
MA	ICESCO	FY24 Commitment	Climate Intelligence
SA	Prince Sultan University	FY24 Commitment	Lunar Exploration
EC	Universidad San Francisco de Quito (USFQ)	Proposal	Lunar Exploration
EC	La Escuela Superior Politécnica del Litoral, (ESPOL)	Proposal	Lunar Exploration
SA	Communication, Space and Technology (CST) Commission	Proposal	Custom
AE	UAE Space Agency	Preliminary Agreement	Multiple
IL	Ben Gurion University	Preliminary Agreement	Climate Intelligence
SI	Space Faculty, Singapore	Preliminary Agreement	Climate Intelligence

49 countries in the pipeline
(includes discovery and validation stages)

Apophis Pathfinder Opportunities for University Participation

- Increase knowledge of orbit, geology, and composition
- Understand the formation and evolutionary mechanics of S-Type asteroids
- Influence planning for the 2029 flyby for ground-based telescopes
- Combine flyby observations asteroids with ground-based observations of the systems
- Mass estimation of Apophis using the OpGrav technique[1,2]
- **Inform future Planetary Defense strategies**

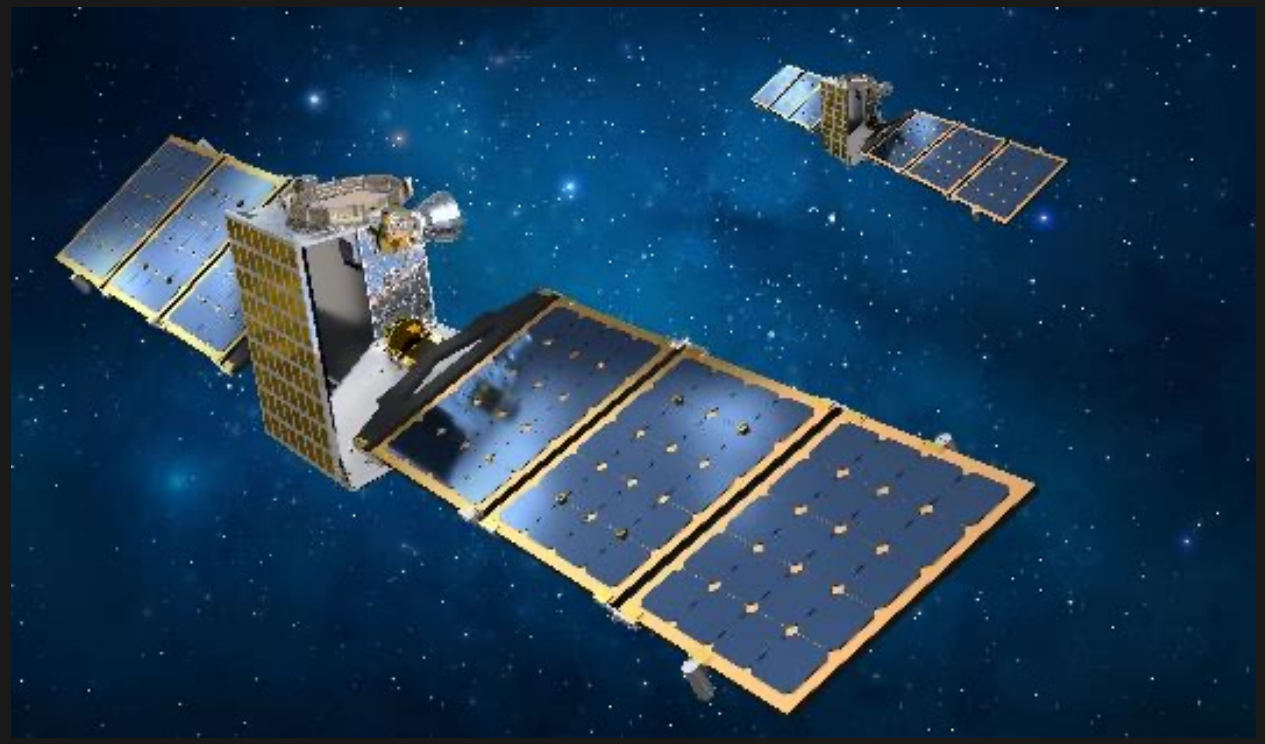


Image credit: Lockheed Martin

1. J. Bell, R. Park, et. al., Apophis T-7 Years 2022 (LPI Contrib. No. 2681)
2. Christensen, L., Park, R. S., and Bell, J. F. III, (2021), Journal of Spacecraft and Rockets.

Apophis Pathfinder Consortia structure

Item*	Tier 1	Tier 2
Access to Data	✓	✓
Scientific collaboration	✓	✓
Workforce Development	✓	✓
Train in test facilities		✓
Mission planning		✓
Mission operations		✓
Virtual mission operations center		✓
Attend the launch		✓

- *All processes are compliant with ITAR / EAR*
- *Additional information in the backup slides*

Apophis Pathfinder Consortia Status

Organization	Contribution
AE – UAE Space Agency	Tier 1, MOU executed
AU – Australian Space Agency	Tier 2
DE - German Aerospace Center (DLR)	In discussion
ES – Spanish Space Agency	In discussion
IN – ISRO (India)	In discussion
KO - KASI (Republic of Korea)	Tier 1, OpGrav subsystem (in kind), MOU executed
SA – Saudi Space Agency	In discussion
UK - Goonhilly Earth Station	Deep Space Communication (in kind), MOU in process
US – CU Boulder	Science co-lead
US – Lockheed Martin Space	Technical lead, System Integrator

Apophis Pathfinder Benefits

- First **University led mission** to a “potentially hazardous” asteroid
- Foundation for a future **rapid response for Planetary Defense**
- **Affordable** and mature mission concept
- Demonstration of an **innovative approach** to space exploration
- Promotes **international cooperation** in space science

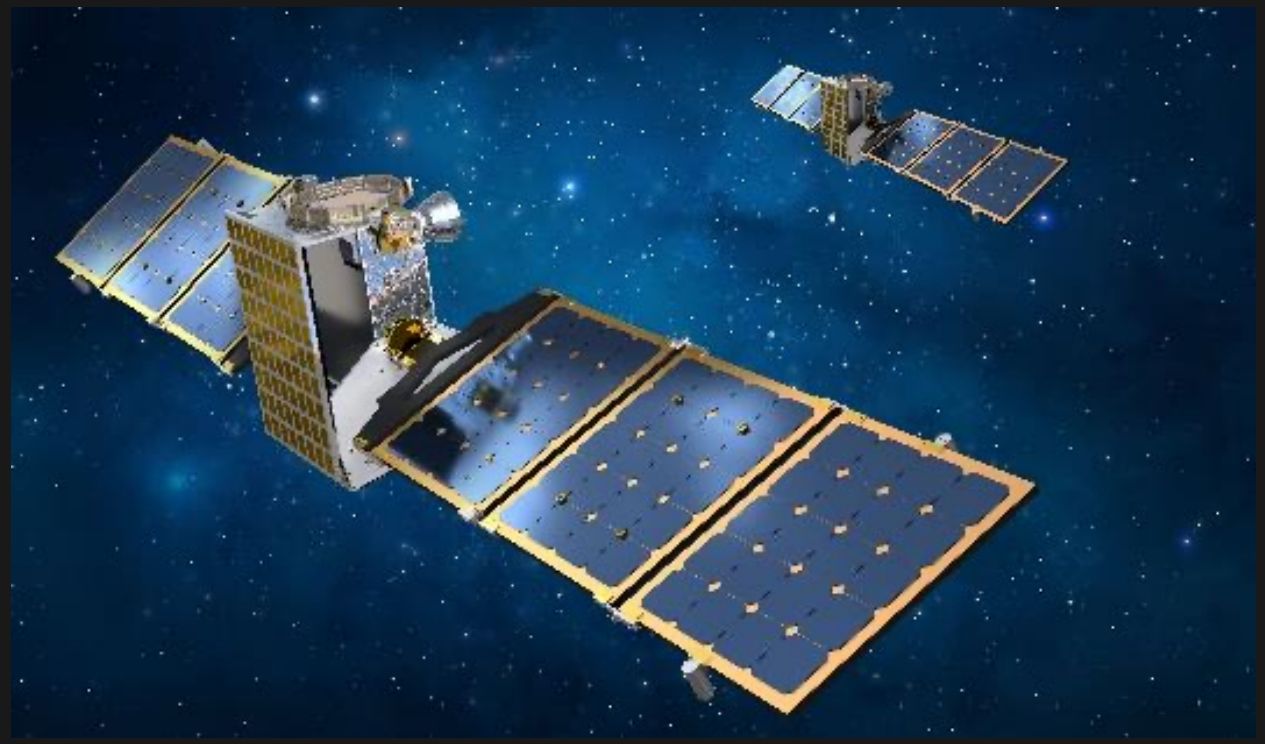
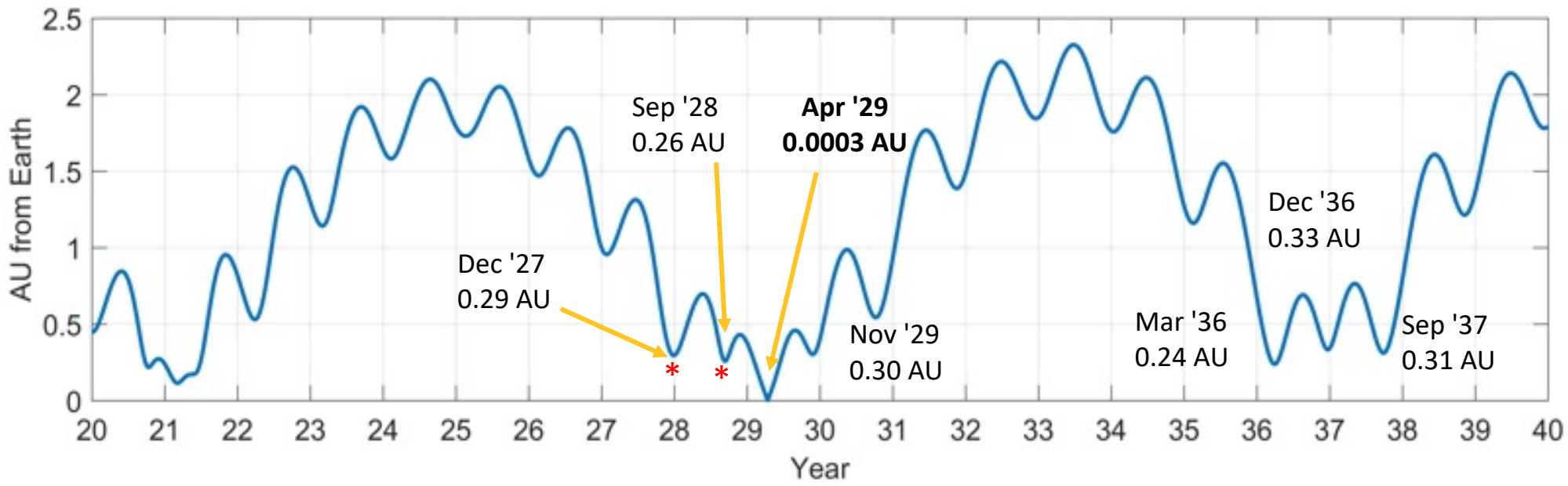


Image credit: Lockheed Martin

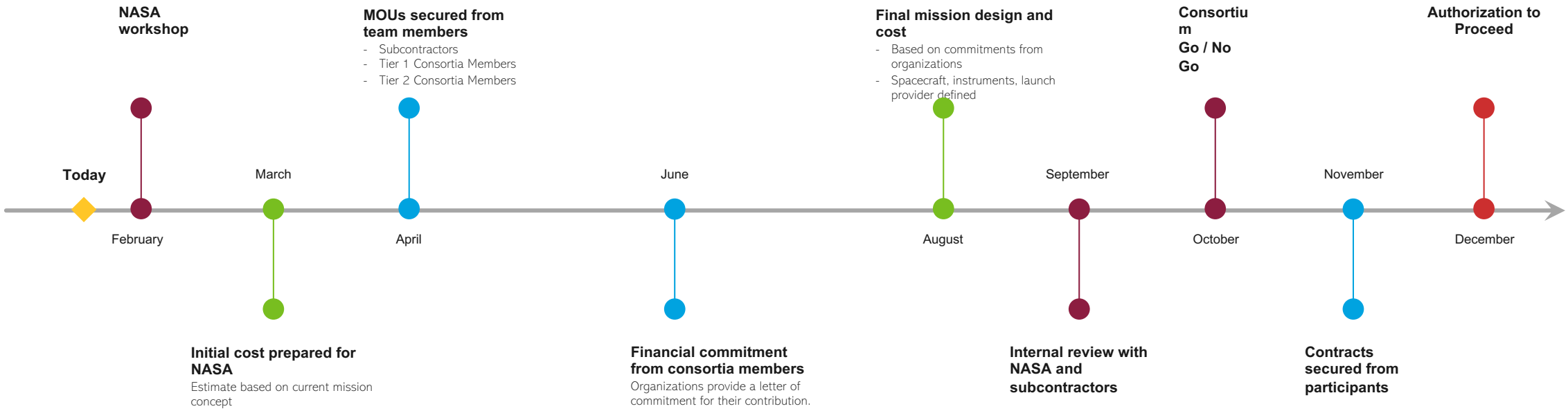
Apophis Pathfinder potential flyby dates



2024 Timeline

1. ATP end of 2024
2. Launch mid 2026
3. Mission completion by Sep 2028

Baseline



Legend

- **Engagement with NASA**
- **Consortia response**
- **Financial milestones**

Indo Pacific Region

Mission Academy

ASU's Milo Institute provides participants with a hands-on, deep-dive understanding of the space exploration life cycle. The team-based experience helps participants gain knowledge about the needs of the space sector, along with learning practices, protocols, and procedures to be operational within a space environment. The foundational workforce skills are transferable across many Earth-based sectors including energy, resources, security and defense, communications, advanced manufacturing, robotics, among others.

Partners in the region supporting the metrics.

Countries: Australia, India, New Zealand, Singapore, Thailand

Metrics: 1 Contract awarded, 4 MOUs executed, 1 Ambassador in the region

Current or expected outcomes of the partnership or initiative:

- Build capacity to participate in the growing space economy by developing the STEM workforce within the partner country and improving the socio-economic health of communities that are served.
- Make space exploration more accessible to countries around the world that want to increase their knowledge, infrastructure, and human capital that is engaged in research and discovery of public value.

Latin America Region

Mission Academy

ASU's Milo Institute provides the skills needed to leverage data from satellites to provide terrestrial observations that make them highly productive in any business environment. Participants develop a Minimum Viable Product (MVP) document for an application designed to address one or more of the challenges facing the Earth today, including monitoring water resources, soil conditions, land usage and natural resources, among others.

Partners in the region supporting the metrics.

Countries: Brazil, Ecuador, Paraguay, US (Puerto Rico)

Metrics: 2 contracts awarded, 2 MOUs executed, 2 Ambassadors in the region

Current or expected outcomes of the partnership or initiative:

- Build capacity to participate in the growing space economy by developing the STEM workforce within the partner country and improving the socio-economic health of communities that are served.
- Make space data more accessible to countries around the world that want to increase their knowledge, infrastructure, and human capital that is engaged in research and discovery of public value.

MENA Region

Space Exploration, Commerce, and Workforce Development

With Prince Sultan University (Saudi Arabia) deploy the Mission Academy for Lunar Exploration across Saudi Arabia to provide a hands-on, deep-dive understanding of the Lunar exploration life cycle. With the UAE Space Agency, enhance collaboration between ASU and UAE in the upcoming mission to asteroid belt (EMA), seek to build capacity in space commerce, host joint events at ASU in LA and DC, engage in the development of University-led space missions. With Ben Gurion University (Israel), work towards the establishment of collaboration agreements in Climate Intelligence and Disaster Response. With ICESCO (Morocco), deploy the Mission Academy for Climate Intelligence in Morocco and predominantly Muslim nations.

Partners in the region supporting the metrics.

Countries: Israel, Morocco, Saudi Arabia, United Arab Emirates

Metrics: 1 award announced, 2 MOUs executed, 1 Ambassador in the region

Current or expected outcomes of the partnership or initiative:

- Build capacity to participate in the growing space economy by developing the STEM workforce within the partner country and improving the socio-economic health of communities that are served.
- Make space exploration more accessible to countries around the world that want to increase their knowledge, infrastructure, and human capital that is engaged in research and discovery of public value.