Solicitation: Interstellar and Extreme Long Period Object Rapid Response

Problem Statement

Interstellar objects (e.g. 1I/'Oumuamua and 2I/Borisov) and near-parabolic heliocentric comets (e.g. C/2020 H4 Leonard) offer unique and valuable opportunities to gain insight into the creation of the solar system through the understanding of celestial objects that have originated and evolved distant from the Sun's influence.

With Earth-based assets (e.g. Pan-STARRS1, ESO's Very Large Telescope, Rubin Observatory's LSST) being applied to detecting these types of objects, the expectation is that more of this type of celestial objects will be detected. However, the unpredictable occurrence and high relative velocity trajectories of these objects make them challenging to study due to their range from Earth and their velocity as they approach perihelion.

NASA, ESA, and JAXA are soliciting proposals for mission concepts to better understand interstellar and extreme long period objects once they have been detected. Proposals must include comparison of pre-positioning systems in space, systems ready for launch on Earth as needed, or a mixture of pre-positioned and ready-to-fly systems. Proposals including other types of systems will be considered and must also include comparison with pre-positioning systems in space and systems ready for launch on Earth as needed.

Mission Objectives and Scoring

Each proposed system must show compliance with the primary objective and at least one of the secondary objectives.

Proposals will be scored based on how well the criteria within the objectives are met, total estimated cost, and feasibility.

Primary Objective (required): 70 points

The primary objective is for the proposed system to be able to identify (composition, size, angular momentum) a minimum of one interstellar object or near-parabolic heliocentric comet.

Note 1: the system readiness date must be no later than a date within CY 2030.

Note 2: "identify" here means the proposed system does not need to discover new objects. The system must, at a minimum, be able to characterize objects already discovered.

The proposed system must prove it has a minimum likelihood of 80% to reach and identify such object within 20 years of its readiness date.

The parameters of the targeted object are defined in section A.1. and the object identification criteria are defined in sections A.2. through A.4.

A.1. Object Parameters

- Identification Parameters:
  - Object identified inbound to the Sun at 3.0 AU from the Sun
  - One object identified per Earth year, with the detection of such object is assumed to be a uniform distribution through the year.
- Orbit parameters:
  - Eccentricity between 0.99 and 3.5, inclusive, uniform distribution
  - Perihelion between 0.3 AU and 2.0 AU, inclusive, uniform distribution
  - Inclination from 0 to 180 degrees, inclusive, uniform distribution
  - Argument of perihelion from 0 to 360 degrees, inclusive, uniform distribution
- Physical parameters:
  - Minimum geometric albedo of 0.05, though the system design must not preclude exploring objects with higher albedo
  - Mean dimension between 1.0 to 1.5 km, though the system design must not preclude exploring larger objects

In addition, the proposed mission must be able to determine the object composition, morphology, and angular momentum using instrumentation as described below. Other or additional instrumentations are welcome and will be considered if the proposal demonstrates their capabilities as per the criteria defined below.

A.2. Composition

Multispectral imagery:

- Visible with resolution of 5 meters per pixel or better of the illuminated surface
- Infrared with resolution of 10 meters per pixel or better of the visible surface

A.3. Morphology

Imagery:

- Determination of the object overall size and shape to within +/- 10 meters

A.4. Angular Momentum

Imagery:

- Determination of the spin axis to within +/- 1 degree
- Determination of the rotation rate to within +/- 0.5 hours

Secondary Objectives (at least one required): 10 points per secondary objective

The proposed system must demonstrate its capability to address at least one of the secondary objectives described in sections B.1. through B.6.

B.1. Advanced Object Definition

The proposed system must provide:

- Ultraviolet imagery of the object and potential coma
- Active measurement of object shape and range
- Active measurement of surface dielectric properties
- In-situ measurement of potential coma plasma and dust environment

B.2. Impactor Science

The proposed system must fly and operate an impactor to excavate material at the object. The system shall use:

- An impactor with a known velocity vector
- Employ same instrumentation as described in the primary objective section to enable the investigation of the excavated material

B.3. Remote Observation Platform

The proposed system must perform observation campaign of heliocentric orbiting bodies such as NEOs or other objects. The proposal must specify:

- Coverage area and area covered per unit time
- Limiting apparent magnitude of system

B.4. Heliophysics Platform

The proposed system must acquire measurements of (one or more):

- Solar plasma environment with characterization of ions and electrons
- Heliospheric magnetic field
- Heliospheric radio and plasma waves
- Solar total irradiance and/or spectral irradiance
- Coronal mass ejection location and timing

B.5. Exoplanet Platform

The proposed system must perform exoplanet photometry campaign and the proposal must specify:

- Photometry system signal to noise ratio
- Coverage area and number of star systems monitored

B.6. Data Relay

The proposed system must host a heliocentric data relay. The proposal must specify:

- Frequency band of operations
- Possible application(s) of the data relay

Proposal Constraints

Launch:

No more than two launches, with any combinations of launch vehicles and launch sites as follows:

- Any US-based launch vehicle from VAFB, KSC, or MARS launch sites
- Any Japanese-based H-II launch vehicle variant from Tanegashima launch site
- Any European-based Ariane or Vega launch vehicle variant from Guiana Space Centre launch site
- In all cases above the selected launch vehicle must have successfully flown from or have one planned flight from the launch site prior to launch of proposed system

Nuclear Fuel Use:

- Proposed missions including use of radioisotope power generation are restricted to:
    - Using the NASA/DOE MMRTG
    - VAFB and KSC launch sites
    - Launch not earlier than 2026
    - Utilize a launch vehicle with three successful or planned launches prior to first use for the proposed mission.
    - Use of radioisotope power generation will result in loss of 5 points in scoring the proposal
- Proposed missions including use of radioisotope heat units are restricted to:
    - VAFB and KSC launch sites
    - Use of radioisotope heat units will result in loss of 2 points in scoring the proposal
- Use of nuclear thermal propulsion systems is precluded

Deliverables

For the primary objective, the proposal must include the following deliverables:

- Requirements breakdown structure
- Concept of operations
- Technical report on design trades
- Documentation related to the design reviews at the various phases of the program

For the secondary objective(s), the proposal must include the following deliverables that must be independent from the deliverables of the primary objective:

- Requirements breakdown structure
- Concept of operations
- Technical report on design trades
- Documentation related to the design reviews at the various phases of the program

Timeline

Phase I: September 14, 2020 to December 20, 2020

Mission Concept Reviews will be held with the call respondents during the November 9 – December 13, 2020, timeframe to assess the proposed concepts. Selected concepts will move to Phase II.

Phase II: January 4, 2021 to March 26, 2021

Selected concepts from Phase I will undergo a System Requirements Review during the January 25 – February 12, 2021, timeframe. Then, System Definition Reviews will be held during the March 1 – March 19, 2021 timeframe to assess the proposed systems. Selected systems from the System Definition Review will move to Phase III.

Phase III: March 29, 2021 to June 18, 2021

Selected concepts from Phase II will undergo a Preliminary Design Review during the May 24 – June 11, 2021, timeframe. Upon completion of the Preliminary Design Reviews one proposed system will be invited to move forward with the manufacturing, assembly, integration, testing, launch, and operations of the proposed system.

Contact

For inquiries, contact Halley Vegoort at aerocustomer@calpoly.edu.