STERNEO

Simultaneous Stereoscopic Near-Earth Object Observations by Lagrange-Point Satellites

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Overview

We propose a method and space mission for a space-based astrometric survey for small Near-Earth Objects (NEOs) and Potentially Hazardous Asteroids (PHAs).

The "STERNEO" system (for Simultaneous Stereoscopic NEO Observations) consists of two identical spacecraft (SC) situated near the Sun–Earth Lagrange points L4 and L5. The SC perform a survey to

- detect new NEOs,
- keep track of recently discovered objects, and
- help to obtain follow-up observations to improve their orbital elements.

The simultaneous observation of an NEO by both SC, in combination with ground-based facilities, determines the NEO's spatial position and Earth–NEO distance by a geometrical method.

A second set of simultaneous observations at a different time determines the missing parameters for a complete orbital characterization.

Another aspect will be autonomous interceptors carrying an explosive charge for NEO deflection.

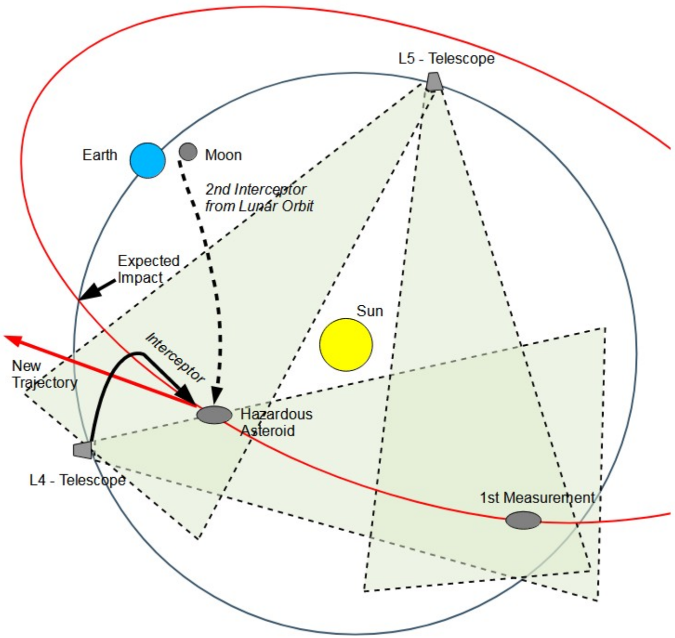

Fig. 1: Concept drawing of detection and counter-measures. (after [1])

Geometry and Observations

- **Orbit Determination via Triangulation**
  - measured quantities:
    S_1 … heliocentric position vector of SC #1
    S_2 … heliocentric position vector of SC #2
    α, β … angles from $S_{1,2}$ to NEO
- **Observational Method (cf. [2], [3])**
  - 1st pair of simultaneous observations:
    fixes heliocentric position vector **N** of NEO
  - 2nd pair of simultaneous observations:
    fixes heliocentric velocity vector **V** of NEO
    by interpolation of two different time instants
  - Orbital elements of NEO from (**N**, **V**)
  - Further observations for orbit refinement

- **Advantages**
  + SC not confined to ecliptic plane
  + SC not confined to same orbital plane
  + Space-borne observation: no atmosphere
  + Two pairs of simultaneous observations sufficient
  + SC measure angles; SC tracking from ground
- **Disadvantages**
  − Unfavourable orbital configurations:
    near-linear alignment of S_1–N–S_2
  − Velocities only interpolated

Mission Design

- **Science Goals**
  - Survey of NEOs for >10 years
  - Active follow-up observations
  - Orbit refinement
  - Provide counter-measures („interceptor“)
- **Science Objectives**
  - Wavelength: VIS/NIR 0.4 – 5 µm
  - Limit magnitude ~21 mag
- **Parameters**
  - Mirror: >1 m

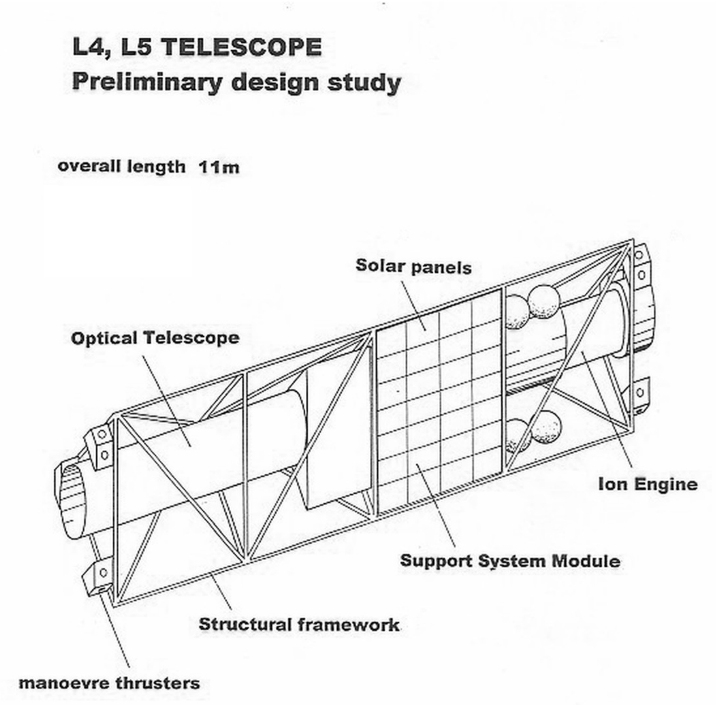

Fig. 2: Preliminary telescope design. (after [1])

Autonomous Robotic Interceptor

- **NEO Deflection Component**
  - Deploy additional SC at L4, L5 and in lunar orbit
  - Mothership as carrier for Robotic Interceptor
  - Rendezvous with NEO and initiate deflection (like AIDA mission [4])
- **Main System Components**
  - Guidance, control, communication unit with navigation telescope
  - Main engine (chemical propulsion)
  - Maneuver thrusters
  - Blasting charge (chemical or nuclear)

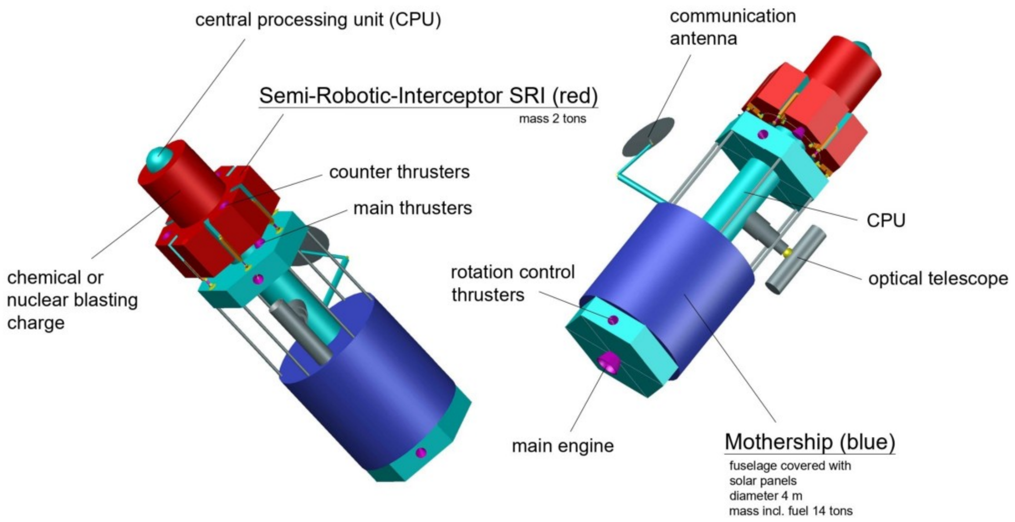

Fig. 3: Concept design of interceptor mothership and detachable explosive charge (after [1]).

Robotic Interceptor Approaching a Target Asteroid

When the Robotic Interceptor spacecraft has approached close enough to the target asteroid, the detachable explosive charge SRI is undocked, turns around by its rotation control thrusters and will land on the asteroid's surface.

Meanwhile the mothership is orbiting the asteroid and will determine the best time for blasting the explosive charge.

If the deflection maneuver fails, a second interceptor can be launched from Earth or lunar orbit to complete the planetary defence mission successfully.

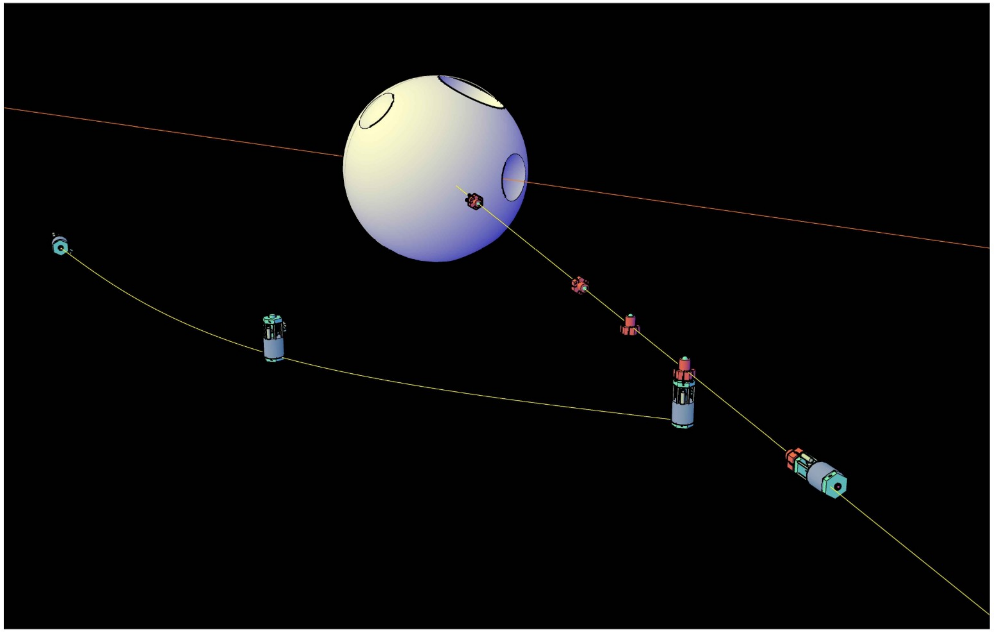

Fig. 4: Concept drawing of interceptor operating scheme (after [1]).

Summary

Advantages

- Novelty = two telescopes at Sun–Earth L4/L5 (cf. NEOSM [5], NEOSSat [6], Twinkle [7], SODA [8])
- Lagrange points: maneuvers require only low delta-v budget
- Survey of inner-Earth objects (Atens, Atiras) feasible
- Combination with ground-based facilities
- Detection, characterization and deflection capabilities
- Synergies with Autonomous Robotic Interceptor SC
- Integrated explosive charge and in-situ deflection monitoring by mothership

Drawbacks

- Complex technology & low Technology Readiness Level
- High level of autonomous operations needed
- No maintenance
- Outer-Space Treaty

References

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