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Topic: Space Mission & Campaign Design

LOW-COST MISSION ARCHITECTURES TO SMALL BODIES

Anthony Freeman[(1)], Lorraine Fesq[(2)], Steven Matousek[(3)], Ralf Zimmerman[(4)] and Marc Steckling[(5)]

[(1)]*Jet Propulsion Laboratory/California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, 818-354-1887, Anthony.Freeman@jpl.nasa.gov*
[(2)]*Jet Propulsion Laboratory/California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, 818-393-7224, Lorraine.M.Fesq@jpl.nasa.gov*
[(3)]*Jet Propulsion Laboratory/California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, 818-393-7877, Steven.E.Matousek@jpl.nasa.gov*
[(4)]*Airbus Defence and Space GmbH, Airbus-Allee 1, D–28199 Bremen, Germany, +49 421 539 4609, ralf.zimmermann@airbus.com*
[(5)]*Airbus Defence and Space GmbH, Airbus-Allee 1, D–28199 Bremen, Germany, +49 162 294 9776, marc.steckling@airbus.com*

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ABSTRACT

The 30,000+ known Near Earth Objects are some of the closest objects in our solar system. Dedicated missions such as NEAR, Hayabusa-1 and -2, OSIRIS-Rex, and DART have revealed much about their nature, with more to come from ESA’s Hera mission, and others. Dedicated space missions to individual NEOs are relatively costly, however, so we discuss ways to reduce costs to explore and possibly redirect more NEOs, as was done with DART. Here we describe a low-cost approach to NEO missions for small body science and planetary defense that makes use of existing and planned space vehicles.

Past small body missions have been re-purposed to achieve new objectives, such as the transformation of Deep Impact into the EPOXI mission to fly by a second comet, Hartley 2, and NEAR, which was not planned to land on Eros as part of its baseline mission. The lesson of reuse and repurposing is relevant to NASA’s Planetary Defense and Small Body Science objectives, as expressed in the most recent decadal survey for Planetary Science and Astrobiology. Building on this lesson, we explore current and future missions to achieve low-cost access to NEOs. For example, current robotic sample return missions such as OSIRIS-Rex and Hayabusa-2 consist of a carrier spacecraft that ejects the samples hours or even days before closest approach. This gives the carrier spacecraft ample time to apply thrusters to adjust its trajectory so that it swings by the Earth, instead of burning up in the atmosphere. Future sample return missions such as ESA’s Earth Return Orbiter for Mars Sample Return and JAXA’s Martian Moons Exploration mission (MMX) could include additional objectives following completion of their primary missions.

Artemis-1 (see Figure) is the first of a series of missions that mark a return to the Moon for NASA and its partners. Artemis launches are planned for roughly one per year, beginning in 2022. The Interim Cryogenic Propulsion Stage (ICPS) of Artemis-1 injects the Orion Capsule and European Service Module (ESM) onto a translunar trajectory. The ICPS (which has a 3.5-ton dry mass), separates from Orion/ESM, deploys 13 CubeSats, and then is disposed of in a heliocentric orbit. If the ICPS hosted 12 SmallSat spacecraft on every launch, that provides up to 12 different NEO rendezvous missions on every Artemis launch.

The ESM's propulsion system provides the thrust to return both Orion and the ESM to Earth. After separating on approach, Orion enters Earth's atmosphere and executing its landing sequence while the 4-ton ESM is 'discarded'. The ESM is quite a capable space vehicle, with an additional 360 kg of payload capacity, and solar panels that generate 11.2kW of power. It could maneuver onto a trajectory that crosses the path of a suitable NEO for a subsequent rendezvous, fly-by, or impactor mission.

By re-purposing existing mission elements and partnering with international space agencies, a comprehensive and affordable program to achieve planetary defense and small body science objectives is possible.

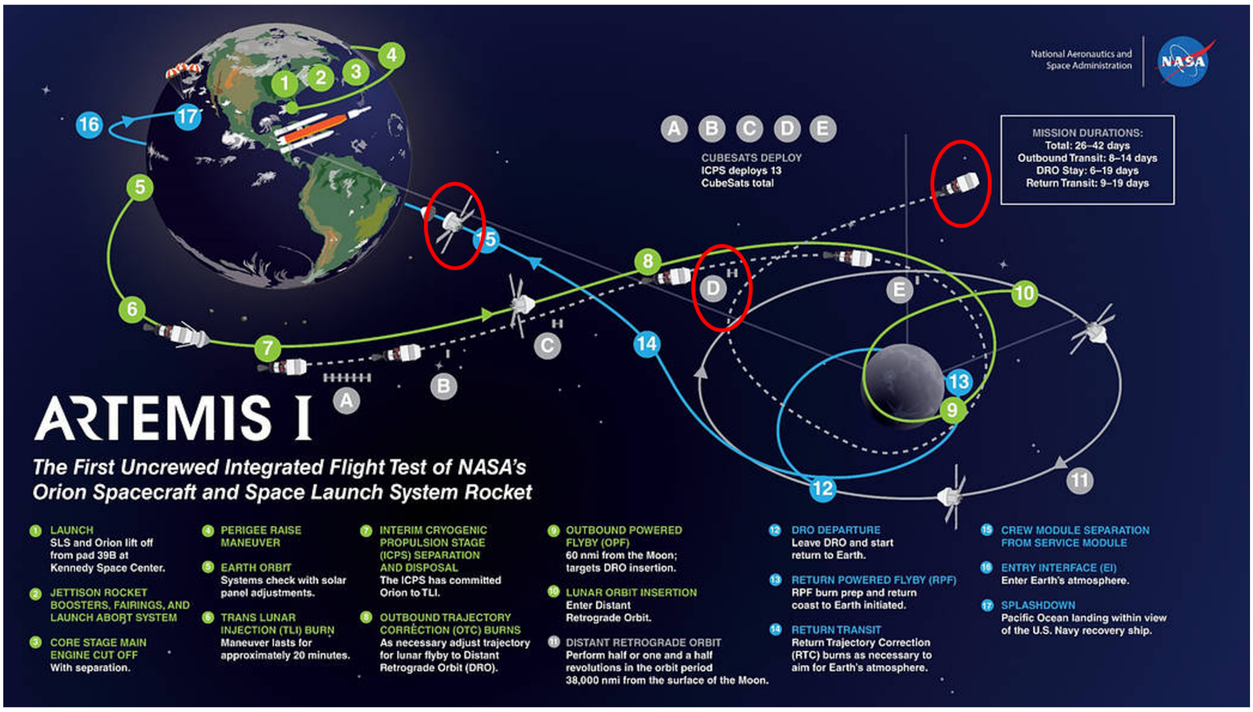

Figure: Artemis 1 mission architecture; opportunities to re-purpose mission elements are circled in red.