

ESA Interplanetary Small Spacecraft Missions: Pushing the Boundaries of Miniaturised Systems & Technologies

The European Space Agency (ESA) is enhancing its small spacecraft capabilities, enabling rapid development of missions across the inner solar system. These missions represent a significant step forward in cost-effective interplanetary and lunar exploration, promoting pioneering innovation and paving the way for further advancements.

Various ESA programmes have ambitious projects and enabling technology development activities to facilitate these objectives. Various mission profiles are under development, including lunar orbiters, NEO rendezvous, and missions to Mars. CubeSats are integral to larger missions, such as the Hera mission, currently en route to the Didymos binary asteroid system,, and the Ramses mission under development to rendezvous with asteroid Apophis before its close encounter with Earth in 2029.

Several key interplanetary and lunar SmallSat missions are in definition or development phases:

- Milani: Equipped with a hyperspectral imager, Milani will perform detailed spectral imaging of the asteroid Dimorphos to analyze its surface composition.
- Juventas: Using a low-frequency radar, Juventas will characterize the gravity field and internal structure of Dimorphos, providing insights into its subsurface composition.
- LUMIO (Lunar Meteoroid Impacts Observer): This stand-alone 12U CubeSat will observe lunar meteoroid impacts from the Earth-Moon L2 Lagrangian point, capturing flashes of light from impacts and providing data on the lunar meteoroid environment.
- HENON (HEliosphoNeer for sOlar and interplanetary threats defeNce): Manoeuvring to and operating in a distant retrograde orbit, the stand-alone HENON 12U CubeSat will showcase advanced SmallSat capabilities for autonomous deep-space missions, serving as a precursor for more complex interplanetary missions such as adverse space weather advance warning services.
- SATIS: Focused on NEO rendezvous, SATIS will demonstrate a cost-effective rapid reconnaissance capability for observing potentially hazardous asteroids.
- VMMO (Lunar Volatile and Mineralogy Mapping Orbiter): This 16U CubeSat will map the distribution of water-ice and ilmenite on the lunar surface using a multi-wavelength Chemical Lidar system.
- Small Missions for Moon Exploration: This activity includes pre-phase A studies of SmallSats and small surface missions for scientific and technological exploration of the moon.
- Low-Cost Mars Platforms: This activity identifies SmallSat and CubeSat platforms to be secondary passengers on LightShip, the new European propulsive tug under development. LightShip will transfer spacecraft to Mars, enter Mars orbit, and host MARCONI for data relay services.

ESA works closely with European industry to develop key technologies such as compact high performance deep-space transponders for reliable communication, propulsion systems optimized for SmallSat applications, and radiation-tolerant avionics. These missions and associated technological advancements underline the significant potential of SmallSats and

CubeSats to contribute to our understanding of the solar system and space weather. They serve as cost-effective, agile platforms supporting future scientific discovery, planetary defence and exploration endeavors, shaping future interplanetary SmallSat initiatives and fostering international collaboration.