2023-2032 Planetary Science and Astrobiology Decadal Survey: A Smallsat Proposal for Ocean Worlds Program.

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ABSTRACT

The overarching goal of an Ocean Worlds Program (OWP) is to identify/ characterize ocean worlds and evaluate their habitability. The confirmed ocean worlds Enceladus, Titan, and Europa have known subsurface oceans, as determined from geophysical measurements by Galileo and Cassini space missions. Lessons may be learned from near-term study missions to the Earth's moon in locating water regions. The purpose of this poster is to provide notional smallsat architectures developed for the lunar missions that will address Outer Planets Assessment Group (OPAG) concerns about implementing technologies of observational sensing/ imaging and communications.

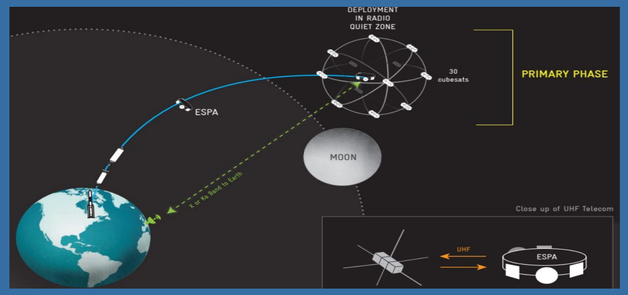
Flybys of the Earth's Moon

INTRODUCTION

The Lunar Polar Hydrogen Mapper Mission (LunaH-Map), to be launched in November, 2021, as a secondary payload on Artemis 1. LunaH-Map's primary objective is to map the abundance of hydrogen down to one meter beneath the surface of the lunar south pole. It will be inserted into a polar orbit around the Moon. LunaH-Map will provide a high resolution map of the abundance and distribution water, in south polar PSRs of the Moon .

LRO, LunaH-mapper, and Lunar Smallsat Constellation Communications with Lunar Surface Rovers CLPS and VIPER

Commercial Lunar Payload Services (CLPS) will scout for lunar resources, testing in situ resource utilization (ISRU) concepts, and focusing on scouting and creating 3D maps of a polar region for signs of water ice or lunar pits for entrances to Moon caves. *VIPER* (Volatiles Investigating Polar Exploration Rover) is tasked with prospecting for lunar resources in PSRs by mapping the distribution and concentration of water ice. Both are equipped with instruments –the Regolith and Environment Science and Oxygen and Lunar Volatile Extraction (RESOLVE) payload—to extract oxygen from the lunar regolith and process it with hydrogen to make water

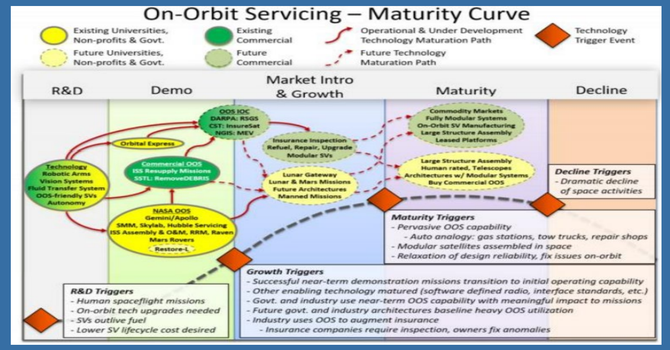


THE ROLE OF CUBESATS AND SMALLSAT CONSTELLATIONS

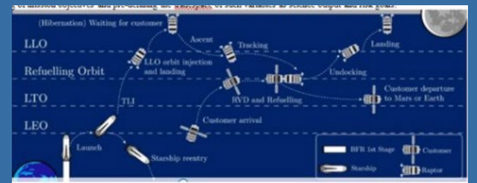
National Academies Report (2016) concluded that constellations of 10-100 cubesats have proven their ability to produce high value science.

Just as LEO smallsats remote sense observations and transmit data and images to ground control centers on Earth, a smallsat constellation will communicate with both lunar orbiters and rovers near PSRs as the industrial base develops on the Moon. Moreover, they will aggregate user data, and connect over the larger LRO's relay's links with Earth.

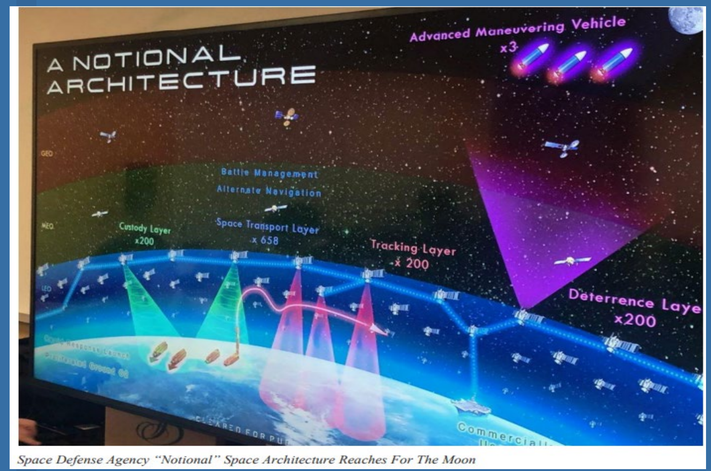
Eventually, the lunar permanently shadowed region-based ROW will expand to a lunar mining operation that extracts and processes water ice into liquid oxygen/liquid hydrogen propellant. The availability of space-sourced propellants dramatically lowers the cost of space transportation beyond low Earth orbit, enabling the development of a robust commercial economy in cislunar space.



Constellations based on different configurations of instruments and orbits provide a forward-looking, quantitative, cost-benefit analysis was not intended to deliver a particular point solution with definitive satellite constellation, instrument vendor, or data service provider. Rather, it identified options to inform budget and program decisions. Technology has been developed to "approach, grasp, manipulate, modify, repair, refuel, integrate, and build completely new platforms and spacecraft on orbit.



Space activities known as "on-orbit rendezvous and proximity operations" are being explored although the lack of clear, widely accepted technical and safety standards for on-orbit activities involving commercial satellites remains an obstacle to the expansion by commercial firms, civilian governments and their military .



Space Defense Agency "Notional" Space Architecture Reaches For The Moon

Smallsats are an emerging class of spacecraft that incorporates recent software and hardware improvements. These lower-cost satellites' display expendability, faster refresh, and simultaneous deployment in large numbers. Lunar observation, PSR investigation and potential mining for water-ice, communications, data analytics are all part of ROW best facilitated by the economical option of smallsat constellations, the infrastructure of which demands maintenance as well as national defense. Security of national hardware assets that enable lunar base development and ISRU for potential autonomous sustainment indicates a notional military architecture notional architecture