

# NASA Gateway Refueling Architecture and Concept of Operation

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## *Abstract*

The Lunar Gateway is a deep space orbiting outpost being developed by NASA in partnership with ESA and other domestic and international partners. It is a critical component of NASA's Artemis program supporting long-term human exploration of the moon and is designed to be refueled, requiring the on-orbit transfer of propellants.

The first two modules of Gateway to be launched will be the Power and Propulsion Element (PPE) and the Habitation and Logistics Outpost (HALO). The PPE contains the bipropellant chemical and electrical propulsion systems that will provide attitude control and orbit raising capability for Gateway. The reaction control system (RCS) utilizes monomethylhydrazine (MMH) and mixed oxides of nitrogen-3 (MON-3) as the fuel and oxidizer, respectively. Helium is used as a pressurant. The Advanced Electric Propulsion Systems (AEPS) and Busek hall thrusters that comprise the solar electric propulsion (SEP) system use xenon as the propellant. The ESPRIT Refueling Module, provided by ESA, will supply the propellant refueling function to Gateway's propulsion systems.

On-orbit refueling is a complex, technically challenging operation that is key to enabling sustainable crewed Lunar and Martian exploration. Numerous systems may be involved in the refueling operation. Also numerous systems are required to enable the successful ability for Gateway to refuel such as, SEP, RCS, Structure & Mechanisms (S&M), Guidance, Navigation and Control (GNC), Thermal, Software, Vehicle System Manager (VSM), Flight Ops, Extra Vehicular Robotics (EVR), Communication and Tracking (C&T), Avionics, and more. This paper will detail the design architecture, concept of operations, and challenges associated with the Gateway refueling system. The methodologies used in Gateway will be compared to those implemented in OSAM-1 and the best practices documented by AIAA and CONFERS (Consortium For Execution Of Rendezvous And Servicing Operations).