21 - Moon 2030 - A New Hope

The race for the Moon has been reignited with the announcement of the Artemis program. NASA has committed to returning to the lunar surface and establishing a permanent base as well as a space station, Lunar Gateway. This creates a strong need for crew and cargo transport services, which will enable the utilisation of the Moon's useful resources, such as helium-3, water ice, and rare-earth elements, bringing benefits back on Earth. Interfacing with the planned Lunar architecture could open up additional opportunities, such as the transport of fuel produced on the Moon to refuel ships bound for Mars.
The Human Landing System contracts awarded to SpaceX and Blue Origin have highlighted the need for innovative solutions in the field of lunar landers. Reusability and flexibility will become key design factors, with low recurring costs needed to make a lander economically viable.

Mission Objective

ARCH-E, the Autonomous Reusable Crew/Cargo Hauler for Exploration, is a novel lander concept designed to meet the demands of the new lunar economy. The project started with the mission to design a reconfigurable lunar landing vehicle in collaboration with Airbus Defence and Space UK. This vehicle will be able to carry from Earth to the lunar surface either a usable cargo mass of 5000 kg or a human crew of up to four. It will be capable of operating for a period of 10 years while accomplishing 10 round-trip missions. ARCH-E can be reconfigured between flights to optimise the vehicle for either crewed or cargo operations. A further objective is the capability to land anywhere on the Moon, to provide opportunities for harnessing the rich resources at sites such as the lunar south pole. By keeping the lunar surface pristine with non-toxic propellants and being fully reusable, ARCH-E improves on the sustainability of past designs.

System Design

ARCH-E is designed as two vehicles, an Orbital Transfer Vehicle (OTV) to provide the trans-lunar injection, and a lander which will provide ascent and descent capabilities. The OTV will be propelled by methane and liquid oxygen, with the lander using high-performance, low-emission hydrogen as its fuel. ARCH-E will be powered by solar panels and batteries, which provide it with the required electricity to cool its cryogenic fuels, orient and guide itself autonomously to the Moon, and facilitate high data rate transmissions such as 4K video back to Earth. Simulations for both the Earth-Moon trajectories and the lunar descent and ascent phases were performed to arrive at accurate ΔV estimates. In addition, a novel approach to the life support systems was conceived, packaging the components in pallets. This way, functions only needed for human crew, such as CO_2 removal, can be taken out in orbit for the cargo configuration, saving mass.
As a result, ARCH-E has taken shape as a versatile and extensible design. Capable of completely autonomous operations, all parts of the vehicle are returned to Earth orbit after each mission where it is refuelled, ready to go for another trip to the Moon.