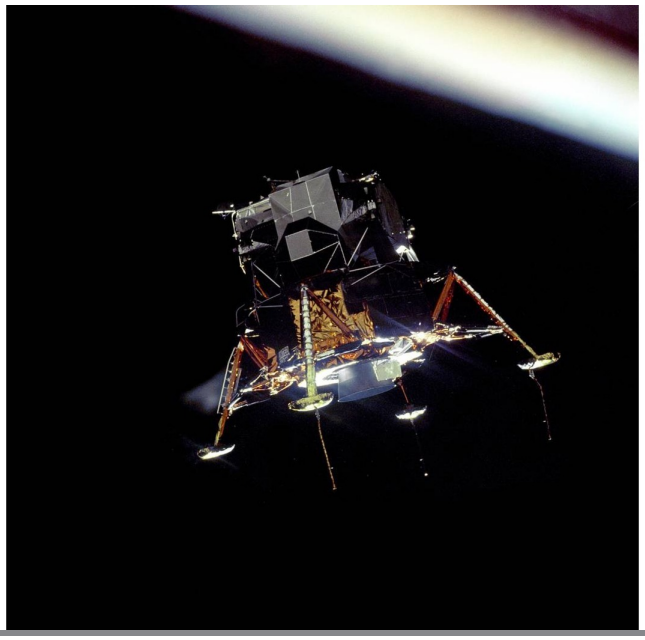


National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Aerospace

eVTOL UAS with Lunar Lander Trajectory

Rapid, repeatable, & cost-effective EDL sensor testing on Earth

Lunar landers are critical to enabling NASA's mission of sustained human presence on the Moon. These spacecraft require advanced landing technologies (e.g., sensors, algorithms, navigation loops) to enable automated and precise entry, descent, and landing (EDL) on planetary surfaces. EDL operations rely on advanced, high-accuracy sensors that enhance navigation precision and improve the control performance of the spacecraft. These sensors must undergo rigorous testing and validation on Earth before mission use.

To test EDL sensors today, organizations generally use helicopter or rocket flights to simulate lander trajectories. However, helicopters are not capable of achieving the rapid descents experienced by landers (due to vortex ring state). Rocket flights are expensive, high risk, often not repeatable, and cannot be performed in rapid succession. This limits the volume and quality of data available for EDL sensor verification and validation, making iterative testing and development slower and lower fidelity than desired.

In response to this challenge, engineers at NASA's Langley Research Center (LaRC) have developed an electric vertical takeoff and landing (eVTOL) unmanned aerial system (UAS) designed to fly trajectories with high similitude to those flown by lunar landers. The NASA invention is poised to enable rapid development and testing of EDL sensors and improve EDL sensor testing data quality at a fraction of the cost of alternative methods.

BENEFITS

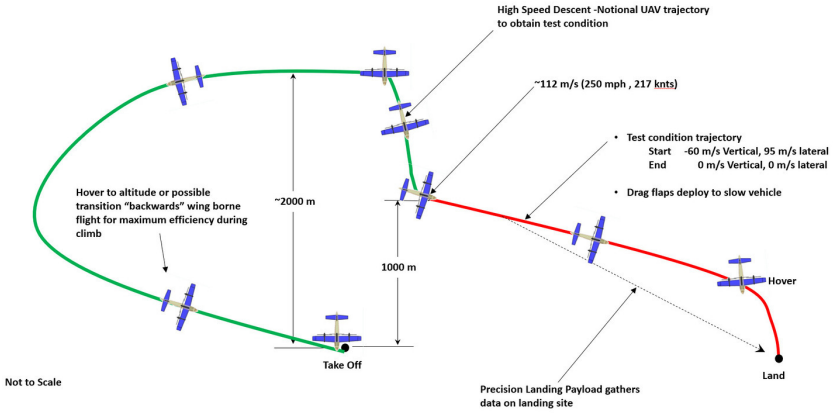
- Provides improved EDL sensor testing data: NASA's UAS was designed to closely match lunar lander trajectories and operational conditions on Earth. More representative flights tests improve the quality of testing data.
- Reduces EDL sensor flight test costs: Provides significantly cheaper testing relevant to (lower fidelity) alternatives such as helicopter and rocket testing.
- Enables increased test flight volume: This innovative UAS is designed to be all-electric and reusable, meaning it could be flown 10+ times per day. Thus, the development-test-validation feedback loop for EDL sensors can be significantly shortened, allowing for rapid iterative development.
- Capable of rapid deceleration: Due to its unique design and control system, the UAS is capable of achieving stable and controlled flight states as it passes through the vortex region of flow, unlike alternative flight vehicles such as helicopters.
- Adaptable for other propulsion technologies: While designed to be all-electric, the UAS could be manufactured for hybrid-electric or internal combustion power sources for applications requiring increased range.

THE TECHNOLOGY

This NASA-developed eVTOL UAS is a purpose-built, electric, reusable aircraft with rotor/propeller thrust only, designed to fly trajectories with high similarity to those flown by lunar landers. The vehicle has the unique capability to transition into wing borne flight to simulate the cross-range, horizontal approaches of lunar landers. During transition to wing borne flight, the initial transition favors a traditional airplane configuration with the propellers in the front and smaller surfaces in the rear, allowing the vehicle to reach high speeds. However, after achieving wing borne flight, the vehicle can transition to wing borne flight in the opposite (canard) direction. During this mode of operation, the vehicle is controllable, and the propellers can be powered or unpowered.

This NASA invention also has the capability to decelerate rapidly during the descent phase (also to simulate lunar lander trajectories). Such rapid deceleration will be required to reduce vehicle velocity in order to turn propellers back on without stalling the blades or catching the propeller vortex. The UAS also has the option of using variable pitch blades which can contribute to the overall controllability of the aircraft and reduce the likelihood of stalling the blades during the deceleration phase.

In addition to testing EDL sensors and precision landing payloads, NASA's innovative eVTOL UAS could be used in applications where fast, precise, and stealthy delivery of payloads to specific ground locations is required, including military applications. This concept of operations could entail deploying the UAS from a larger aircraft.



This graphic demonstrates the flight trajectory and operational conditions for NASA's eVTOL UAS when used for simulating lunar lander trajectories on Earth. The ability to fly forwards and backwards and achieve controlled, rapid deceleration are critical to producing high fidelity representations of lunar lander operational conditions.

APPLICATIONS

The technology has several potential applications:

- Lunar lander EDL sensor testing & validation: NASA's UAS was developed to enable trajectories with high similitude to those experienced by lunar landers (improving EDL test data quality), reduce EDL testing flight costs, and increase feasible flight tests per day given its reusable design.
- Fast, precise, and stealthy delivery of payloads to ground locations: Given its unique trajectory capabilities (e.g., ability to achieve rapid deceleration while mitigating vortex ring states), the system could be used to deliver payloads with high precision and speed to desired ground locations. For such use-cases, the VTOL UAS could be deployed from a larger aircraft, immediately entering the horizontal, cross-range portion of its trajectory.

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NASA's Technology Transfer Program pursues the widest possible applications of agency technology to benefit US citizens. Through partnerships and licensing agreements with industry, the program ensures that NASA's investments in pioneering research find secondary uses that benefit the economy, create jobs, and improve quality of life.

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National Aeronautics and Space Administration

Agency Licensing Concierge

Langley Research Center

Mail Stop 020
Hampton, VA 23681
202-358-7432
Agency-Patent-Licensing@mail.nasa.gov

www.nasa.gov

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