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TECHNICAL
REPORT

# Feasibility of Laser Power Transmission to a High-Altitude Unmanned Aerial Vehicle

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Prepared for the United States Air Force



RAND PROJECT AIR FORCE

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## Summary

Solar-powered unmanned aerial vehicles (UAVs) that have been developed and flown have demonstrated interesting capabilities for high altitude and long endurance. However, current solar-powered UAVs are extremely light and fragile and have small payloads. The concept of a UAV with photovoltaic (PV) cells powered by a laser beam has been demonstrated by the National Aeronautics and Space Administration (NASA) on a tiny scale but has not been applied to a UAV of sufficient size to be of any practical interest.

This report examines whether the laser-beam-powered UAV concept could be scaled up to a practical high-altitude UAV and identifies some of the concept's limiting factors.

The finding of the report is that the concept does have merit, at least in the narrow sense that it is technologically feasible, and it could be used to build a UAV with performance characteristics that are beyond the performance envelope of existing air vehicles, especially sustained extremely high altitude. Commercially available lasers and PV cells could provide a UAV with twice as much power as that of a similar solar-powered UAV. Moreover, the laser can be more consistently available than the sun, thus reducing the need for batteries on the UAV. Even under conservative assumptions, a laser-powered UAV could have four times the payload and 80 percent higher nighttime altitude than a solar-powered UAV of the same size and total weight. With more aggressive assumptions and state-of-the-art lasers and PV cells (demonstrated, but not necessarily commercially available off the shelf), it is possible to achieve up to 10 times the power of a similar solar-powered UAV. Beyond that power level, the concept runs into thermal limits of current state-of-the-art PV cells.

One disadvantage of the concept is that if the laser is beamed from the ground or from a ship, the UAV is closely "tethered" to the beam source and (to receive useful amounts of power) must fly in an orbit within a few tens of kilometers of it. It could, however, fly at extremely high altitudes over the beam source. Another problem with the concept is that clouds could interrupt the beam and force the UAV to descend below the cloud layer from time to time.

Both of these problems could be circumvented by placing the laser on a conventional aircraft, so that the UAV would be powered by an air-to-air transmission. In this case, the "tether" from the UAV to the power source could be much longer (hundreds of kilometers), and clouds would no longer be a likely threat. Deploying the laser source on an aircraft should be technologically feasible, although flying that aircraft, of course, imposes an additional operational burden.

This report focuses on the physical parameters of flight—altitude, range, persistence, and power—that are possible for a laser-PV aircraft that uses current technology. Whether the performance niche opened by this concept is really valuable and worth pursuing or merely a technology "stunt" waiting to happen is debatable (and could be examined in a future study). Jet

propulsion is generally a superior technology, except for missions requiring extreme endurance or extremely high altitude. Because of the effort required to support a laser-PV UAV above the cloud layer, the "extreme endurance" argument is not very compelling. However, the laser-PV concept could be worth further consideration if an important mission were identified for an air vehicle with ultra-high operating altitude and moderate persistence and payload. Some possibilities include ultra-high-altitude observation stations or communication relays and flocks of high-altitude sensor probes powered remotely from a large aircraft "mother ship."