# Developing an Aerial Transport Infrastructure for Lunar Exploration

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Thorough scientific exploration of the lunar surface will be dependent on access to remote and restricted sites. While pressurized and unpressurized rovers are planned to extend human range beyond the outpost location or sortie landing site, these systems will not be capable of reaching the bottom of a rille, the top of a mountain, or sites hundreds of kilometers away from the outpost. Using operations in Antarctica as an analogue to lunar exploration, these extreme operating locations are serviced by aerial systems: helicopters and fixed-wing aircraft. This paper explores the use of rocket propulsion to provide lunar transport infrastructure in the roles filled by aerial vehicles in Antarctica. The paper reviews the basic physics of rocket transport on an airless body, focusing on two competing approaches: ballistic hopping (thrusting at takeoff and landing while following a ballistic trajectory in between), and propulsive gliding (traveling at constant altitude and horizontal velocity while using thrust to continuously offset gravity.) The basic theory is derived, and extended to include cases including multiple hops, hopping and gliding between sites with differing altitudes, and hybrid approaches involving elements of both hopping and gliding. Once the basic theory is derived, past design concepts for lunar flying vehicles are reviewed, and Constellation outpost operations are examined to arrive at a baseline design for a lunar transport vehicle capable of reaching locations inaccessible to wheeled transports. The baseline system is used to derive an concept of operations for aerial transport at the lunar outpost, and requirements established for lunar-derived propellants, operational support, and contingency operations. In addition, a small unmanned vehicle design is developed for use in deploying instrument packages, performing autonomous sampling, and for early demonstration of aerial transport prior to the development and deployment of human systems.