National Aeronautics and Space Administration

CubeSat Laser Infrared CrosslinK

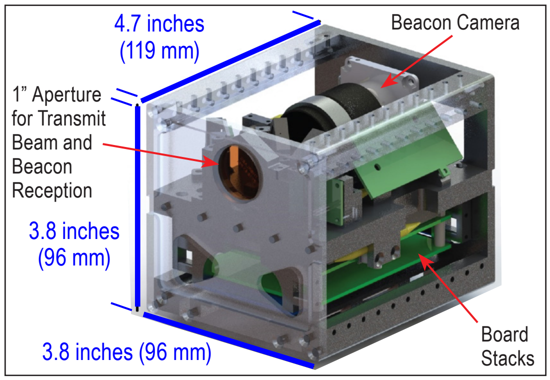
Demonstration of Flexible High-Data-Rate, Low-Cost CubeSat Optical Communications and Ranging Capability

The CubeSat Laser Infrared CrosslinK (CLICK) mission will demonstrate technology to advance the state of the art in communications between small spacecraft as well as the capability to gauge their relative distance and location. CLICK is comprised of two sequential missions.

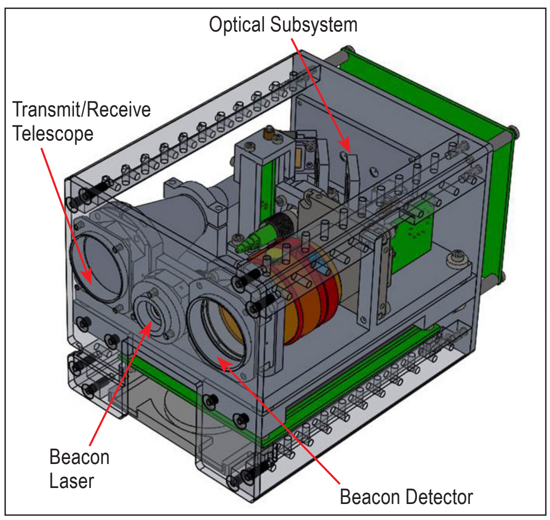
The first mission, CLICK A, is a risk reduction mission that will test out elements of the optical (laser) communications with a single 3-unit (3U) spacecraft. The key objective of this risk reduction testing is to demonstrate the fine steering mirror control system's high precision pointing performance which enables the use of a lower power laser in CLICK B/C. This will be demonstrated via communication between the spacecraft in low-Earth orbit and a portable ground station telescope. The key performance metric of CLICK A is to establish a greater than 10 megabits per second (Mbps) data downlink from the CLICK A spacecraft from an altitude of approximately 249 miles (400 kilometers), to a 12-inch (30-centimeter) telescope on the ground.

The goal of CLICK B/C, the second mission, is to demonstrate full-duplex (send and receive) optical communication crosslink between two 3U small spacecraft, in low-Earth-orbit, at distances between 15 and 360 miles (25 - 580 kilometres) apart at data rates greater than 20 Mbps. This second mission will also demonstrate precision ranging capability between the spacecraft that provides the ability to measure the distance and location of each with a range resolution to within approximately 20 inches (0.5 meters).

Miniaturized optical transceivers located on CLICK B/C spacecraft are capable of both transmitting and receiving laser communications and will form a communication crosslink between the two spacecraft with their alignment supported with a new fine pointing capability. The miniature optical transceivers are an improvement over radio frequency (RF) technology due to the power efficiency of laser communication at high



An view of the CLICK A mission's 1.2U payload. The CLICK A mission will demonstrate an optical downlink.



A view of the CLICK B/C mission's 1.3U payload. Laser crosslink and precision ranging will only be demonstrated on the CLICK B/C mission.

data rates, which lessens the impact on the small platform's already severe constraints on size, weight, and power.

Optical technology is mature for terrestrial use through fiber-optic-based systems. Transitioning optical technology to space-based platforms to create communication crosslinks between spacecraft will leverage commercially available optical components to benefit from their advantages in power efficiency and a compact form factor. The CLICK mission will use commercially available components to enable high rate crosslinks to prove the next generation of low-cost and low-complexity communication technology that is scalable to gigabits per second (Gbps) data rates. CLICK will transmit in the near-infrared wavelength at 1550 nanometers. CLICK B/C inherits various technologies from CLICK A with additional hardware such as a compact, low-power chip-scale atomic clock. The clock is used for precision range measurements, measuring the travel time of laser pulses. CLICK A and B/C both implement two-stage pointing. The first stage utilizes spacecraft body pointing for each spacecraft's 1.3 milliradian wide beam, then they each use a fine steering mirror for precision pointing 70 microradian wide beams.

The CLICK technology will provide crosslink communication for small spacecraft that could enable NASA science missions that involve constellations or swarms of small spacecraft. High rate crosslinks are needed when communication nodes within small spacecraft must rapidly exchange or route significant amounts of data to other spacecraft or to the ground. Rapid exchange of observational data can enable on¬board image processing that fuses images from multiple spacecraft to look for indicators that would trigger action or additional high-priority observations. NASA science missions involving multiple small spacecraft that form a constellation or swarm may carry one or more moderate to high-resolution imaging or scientific sensors that require high date rate processing and transmission.

The Massachusetts Institute of Technology, in partnership with the University of Florida, will design and build the three miniature optical transceiver payloads to be integrated into small spacecraft procured by NASA Ames Research Center in California's Silicon Valley. It is anticipated that the CLICK mission will require 2 years to develop and prepare for launch.

The CLICK mission is managed and funded by the Small Spacecraft Technology (SST) program within the Space Technology Mission Directorate. The SST expands U.S. capability to execute unique missions through rapid development and in space demonstration of capabilities for small spacecraft applicable to exploration, science, and the commercial space sector. The SST will enable new mission architectures through the use of small spacecraft with goals to expand their reach to new destinations and challenging new environments.

For more information about the SSTP, visit:
www.nasa.gov/directorates/spacetech/small_spacecraft/

For more information about CLICK, please contact:

Kerri Cahoy
CLICK Principal Investigator
Massachusetts Institute of Technology
kcahoy@mit.edu

John W. Conklin
CLICK Co-Investigator
Mechanical and Aerospace Engineering
University of Florida
jwconklin@ufl.edu

David Mayer
CLICK Project Manager
Small Spacecraft Technology Program
Space Technology Mission Directorate
NASA Ames Research Center
David.J.Mayer@nasa.gov

Roger C. Hunter
Small Spacecraft Technology Program Manager
Space Technology Mission Directorate
NASA Ames Research Center
Roger.C.Hunter@nasa.gov

Christopher Baker
Small Spacecraft Technology Program Executive
Space Technology Mission Directorate
NASA Headquarters
Christopher.E.Baker@nasa.gov

National Aeronautics and Space Administration

Ames Research Center
Moffett Field, CA 94035

www.nasa.gov

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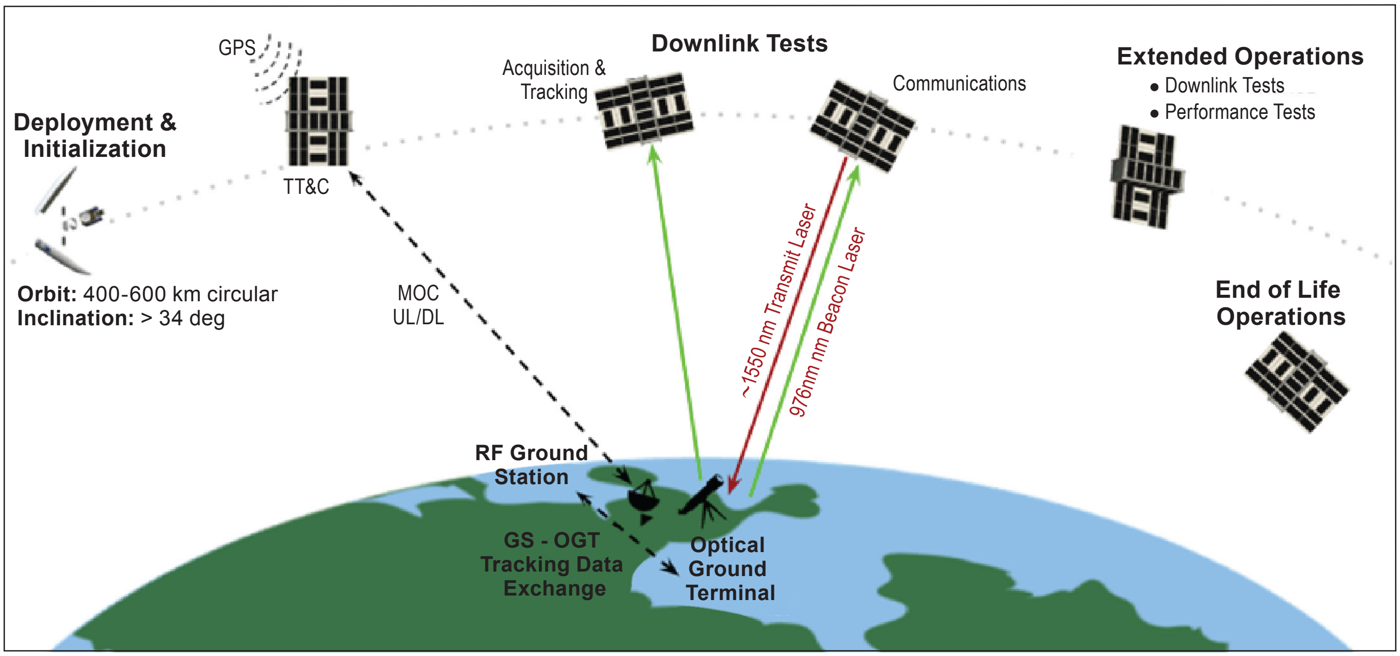
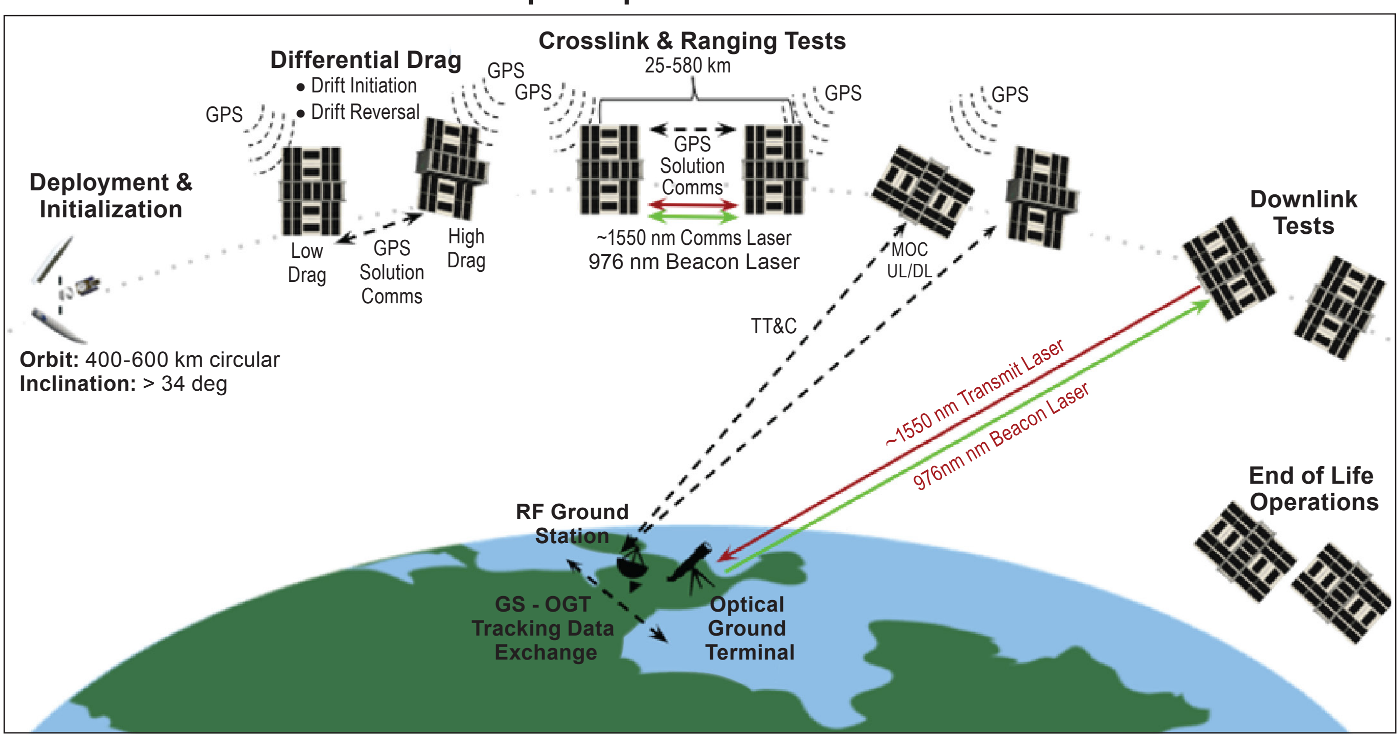
Concept of Operations for CLICK A



The concept of operations of the CLICK A mission involves four primary phases: deployment & initialization (~ 1 day); optical downlink test operations (~ 1 month); extended operations to assess performance limits (~ 5 months); end-of-life operations.

Concept of Operations for CLICK B/C



The concept of operations of the CLICK B/C mission involves the following phases: deployment & initialization (~ 1 day); controlled spacecraft separation and initial operations (~ 7 days, < 124 miles [200 km]) with optical crosslink link tests (~ 4 days); continued separation (~ 20 days, 124-435 miles [200-700 km]) with optical crosslink and downlink tests; spacecraft reduce separation (~ 25 days, 435-560 miles [700-900 km]); extended operations to assess performance limits (~ 3 months); end-of-life operations.