

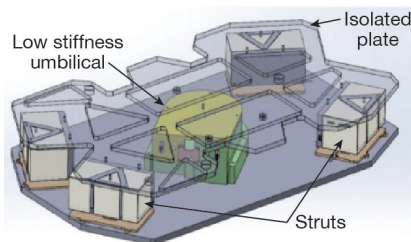
The technologies are:

- Isolation and pointing assembly (IPA) for operating in the presence of spacecraft vibrational disturbance.
- Photon-counting camera for the FLT to enable acquisition/tracking and uplink with a dim laser beacon.
- Photon-counting ground detectors that can be integrated with large aperture diameter ground collecting apertures (telescopes) for detecting the faint downlink signal from deep space.

A high peak-to-average power laser transmitter for deployment on deep-space spacecraft is also being developed to enable photon-efficient communications. The laser, along with optics and electronics, will be integrated with the flight technologies identified above into a deep-space flightworthy FLT.

Isolation Pointing Assembly (IPA)

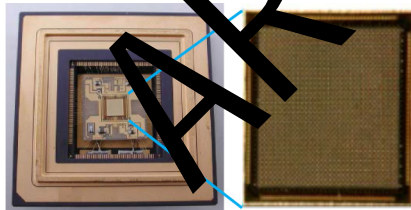
The IPA conceptual design, right, has struts with actuators and sensors that allow the isolated plate to be “levitated” so that it is mechanically decoupled from the base that is attached to the spacecraft. The optics attached to the isolated plate can be steered over limited angular range of ± 5 mrad. Electrical wires and optical fibers can be routed to the payload through the low stiffness umbilical that prevents a mechanical short of the vibration isolated payload. The IPA is required to provide at least 25 dB of isolation from vibrational disturbance injected at the base.



A solid-model rendering of the isolation pointing assembly (IPA) conceptual design.

Photon Counting Camera (PCC)

The photon counting camera (PCC) has single photon detection sensitivity with low dark noise and negligible read noise. A dim beacon with 5–15 $\mu\text{W}/\text{m}^2$ irradiance at the optical entrance aperture of the FLT will be focused on the camera and detected. The focused spot will be used for accurate centroid estimation. At least 3.75 μrad mispointing error is required for pointing the downlink laser beam. The centroid estimation error on the PCC focal spot is a component of this overall mispointing error. Above is a 32 x 32 pixel InP/InGaAs Geiger mode avalanche photo-diode array. The

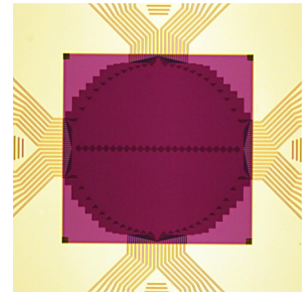


32 x 32 focal plane array to be used for the TRL-6 FLT being matured at JPL.

focal plane array is mated to a custom read-out integrated circuit developed by Lincoln Laboratory, Massachusetts Institute of Technology.

Ground Photon Counting Detectors

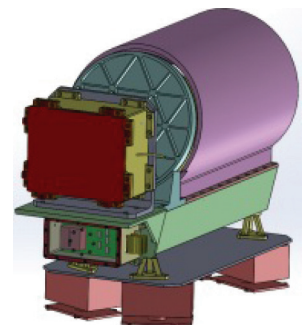
Faint deep-space downlink signal is detected using large aperture diameter (>5m) ground telescopes equipped with low noise, high detection efficiency, single photon counting detectors. Tungsten silicide (WSi) superconducting nanowires single photon detector (SNSPD) arrays are being developed to achieve this.



Optical micrograph of WSi SNSPD array with 320 micrometer effective diameter.

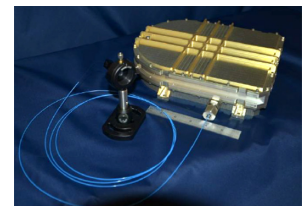
The SNSPD arrays operate at <1K and were verified during LLCD in the alternate ground station developed by JPL. For DSOC large effective diameter (~300 μm) arrays are required. An optical micrograph of such a recently fabricated detector array is shown top right.

The integrated TRL-6 FLT is shown right, and the laser optical module is shown below right. The FLT is based on a 22-cm clear aperture off-axis Gregorian optical transceiver assembly. The laser is based on a master-oscillator power amplifier architecture using optical fibers.



Integrated TRL-6 FLT solid model.

Successful technology maturation to TRL-6 will establish the readiness for deploying a DSOC FLT on an upcoming NASA mission for a Class D Technology Demonstration Opportunity (TDO). The TDO will serve as a precursor to implementing operational optical communications for NASA's future missions.



Laser optical module for high peak-to-average power.

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