

National Aeronautics and Space Administration

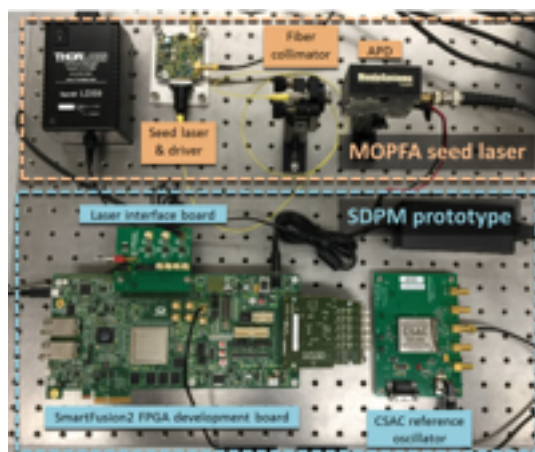


# Miniature Optical Communications Transceiver (MOCT)

## Software-defined Modulator/Receiver Reduces Power Needs

This project will advance the technology readiness of the Miniature Optical Communications Transceiver (MOCT) from TRL 3 to TRL 4. MOCT consists of a novel software-defined pulse modulator (SDPM), integrated laser system, and avalanche photodetection system, and is designed for optical communications between small spacecraft, including CubeSats, using a pulse position modulation (PPM) scheme. PPM encodes data in the timing of optical pulses with respect to a set of timing windows known as slots. The MOCT design focuses on power-efficiency making it particularly interesting for small satellites. We have demonstrated in the laboratory that this technology can generate shorter than 1 nanosecond-wide 1550 nanometer (nm) optical pulses with better than 50 picosecond (ps) timing accuracy. The timing resolution of this system is roughly a factor of four better than previously flown systems, meaning that it can transmit more bits of data with each optical pulse. Because this technology can both generate and time-stamp the arrival of short optical pulses with 50 ps precision, it simultaneously provides power efficient communications and relative ranging between small spacecraft at the centimeter (cm) level.

The pulse timing is generated by software-defined precision delays within a Field Programmable Gate Array (FPGA) using a new technique developed at the Precision Space Systems Laboratory at the University of Florida. This technique does not require a GHz slot clock or GHz processor speeds, but instead uses a 10 MHz chip-scale atomic clock, consuming only 120 mW, to continuously calibrate the timing delay chain. The modulator is paired with a novel avalanche photodetector-based



*Prototype Miniature Optical Communications Transceiver Software-defined Pulsed Modulator and Seed*

receiver with a measured 50 ps timing accuracy. When combined with a laser amplifier, transmit/receiver optics, and a precision pointing capability, this technology enables high data rates (~100 Mb/s) on power-constrained small satellite and nanosatellite platforms.

The primary objective of this project is to prepare the SDPM and photoreceiver for a subsequent flight demonstration on a pair of inter-communicating CubeSats. Together with our partners at the NASA Ames Research Center (ARC), and through a collaboration with Dr. Kerri Cahoy at the Massachusetts Institute of Technology (MIT), we envision a follow-on project to demonstrate an integrated laser communications system incorporating MOCT. The two 3-unit (3U) or 6U CubeSats will be equipped with identical laser transceivers for two-way communications between the satellites. The pair of optical transmitters and receivers will also provide simultaneous cm-level intersatellite range informa-

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tion as a side benefit. Farther in the future, we can envision using this optical communications technology to provide high precision orbit determination for nanosatellites flying beyond the GPS sphere or to enable small satellites to provide navigation solutions and data relays to human or robotic explorers operating near the Moon or Mars. This technology could also allow constellations of Earth orbiting nanosatellites to network with one another to precisely correlate astronomical or Earth observations or to coordinate spacecraft flying in formation to produce a distributed aperture telescope.

The Precision Space Systems Laboratory at the University of Florida will collaborate with the ARC to design and demonstrate an integrated cross-linking optical communications system using the novel SDPM and receiver, compatible with ARC's existing Edison Demonstration of Smallsat Networks (EDSN) based CubeSat bus. This project will also be enhanced by a collaboration with MIT, which is working on precision pointing technologies for optical communications systems.

The MOCT project is managed and funded by the Small Spacecraft Technology Program (SSTP) within the Space Technology Mission Directorate. The SSTP 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 SSTP will enable new mission architectures through the use of small spacecraft with goals to expand their reach to new destinations, and challenging new environments.

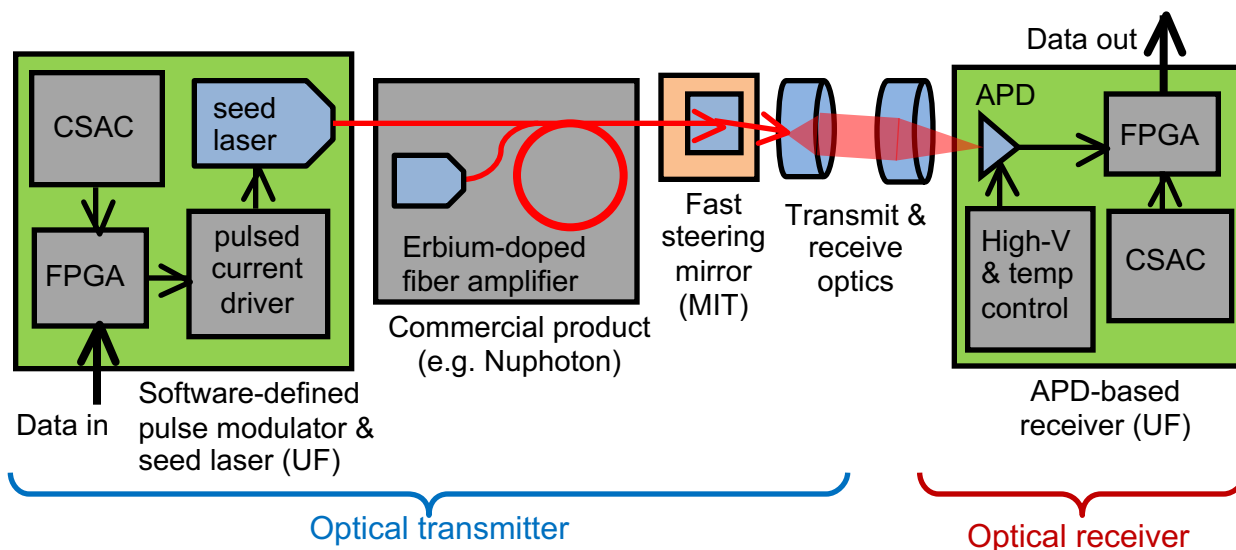
**For more information about the SSTP, visit:**  
[www.nasa.gov/directorates/spacetech/small\\_spacecraft/](http://www.nasa.gov/directorates/spacetech/small_spacecraft/)

**For more information on MOCT, contact:**

John W. Conklin,  
 MOCT PI  
 Mechanical and Aerospace Engineering  
 University of Florida  
 jwconklin@ufl.edu

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



*Block diagram of the Miniature Optical Communications Transceiver optical cross-linking system*

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**Ames Research Center**  
 Moffett Field, CA 94035

[www.nasa.gov](http://www.nasa.gov)

FS-2017-03-03-ARC

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