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The Multi-View Onboard Computational Imager (MOCI) Mission: A 3U Sized Supercomputer Floating in Space

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PROGRAM OVERVIEW

The UGA Small Satellite Research Lab (SSRL) is an undergraduate lead lab that focuses on creating and sustaining a cube satellite program at the University of Georgia. The lab began as a way to train students from UGA in STEM related fields, and quickly became a success when the lab took on two cube satellite missions. The first mission that the SSRL acquired was SPOC (SPectral Ocean Color imager). SPOC is a part of NASA's Undergraduate Student Instrument Project (USIP) which is setup to aid students in developing the skills they need in STEM fields. The primary focus of SPOC is to develop an adjustable multi-spectral imaging cube satellite that monitors coastal wetlands status, estuarine water quality including wetland biophysical characteristics and phytoplankton dynamics, and near-coastal ocean productivity. The second mission of the SSRL is the Multi-View Onboard Computation Imager (MOCI) mission. MOCI is funded by the Air Force Research Laboratory's (AFRL) ninth iteration of the University Nanosatellite Program (UNP). MOCI will demonstrate how a compact, high performance computing unit can be utilized on a space-based platform.

Figure 1: a) 3D rendering of a full assembly of MOCI. As a 3U cubesat, it is ~30 cm in length and 10x10cm wide, b) MOCI's swath over a land mass, and c) another 3D rendering of MOCI that has its UHF/UHF antennas deployed

SUBSYSTEMS

ADCS: Will feature a MAI-401 ADCS unit; this unit includes three magnetorquers, 3-axis reaction wheels, a star tracker, and a proprietary ADCS algorithm developed by Adcole-Maryland Aerospace. In addition to the MAI-401, MOCI will also have a fine sun sensors located on two of its solar panels for increased pointing accuracy. Theoretically, MOCI will have pointing accuracy of a few arcseconds degrees as long as the Star tracker is not washed out by the Earth's albedo or the Sun. If the star tracker loses pointing knowledge, then the pointing accuracy increases to ~3 degrees.

EPS: Features the GomSpace BP4 38.5 WHr Battery and P60 EPS Motherboard. These have a current limit protection of 4 A and an over voltage protection of 8.4V. Two 3U and one 1U solar panel, located on the Y+ X+ and Z+ faces, respectively, will be used to recharge the batteries.

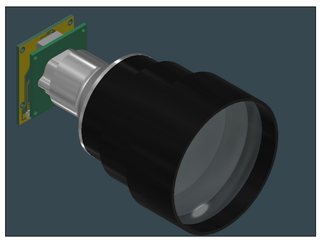
COMM: MOCI is equipped with a UHF/UHF transceiver that will handle command uplink and telemetry downlink. The UHF system will be the primary way MOCI communicates with our ground station at the University of Georgia. MOCI will also be fitted with an S-Band transmitter; this system allows for MOCI to downlink its scientific data.

PAYLOAD

The main component of the payload is a Jetson TX2 GPU from Nvidia

- Based off of Nvidia's Pascal architecture
- Programmable using CUDA
- We are currently developing structure from motion algorithms for the GPU to allow us to create DSM of mountain ranges, clouds, and possibly cities
- Will use a neural net that will enable MOCI to do feature detection
  - MOCI will initially run feature detection on algal bloom and sediment plumes
  - The neural net can be re-trained to any other object of interest such as ships or glacial ice in the arctic

Figure 4: MOCI's current lenses configuration that is being developed by Ruda-Cardinal. It will feature a GSD of 8 meters and have dimensions of roughly 56mm OD x 76mm



MISSION OBJECTIVES

The MOCI mission's primary objective is to perform SfM to create DSM's of the Earth's surface. The Multi-view Onboard Computational Imager (MOCI) mission will acquire imagery of the Earth's surface from (Low Earth Orbit) LEO and perform near real time Structure from Motion (SfM) at a landscape scale using custom algorithms and off the shelf, high performance computational units. The MOCI mission will also identify and map coastal phenomena such as sediment plumes and algal blooms while training students in STEM related fields. Efficient data compression, feature detection, feature matching, and SfM processing techniques of space-based imagery will be performed on board the spacecraft as a proof-of-concept of high performance, on board processing capabilities. 3D models produced by the MOCI satellite will take the form of Digital Surface Models (DSM) as their end product for quick data downlink.

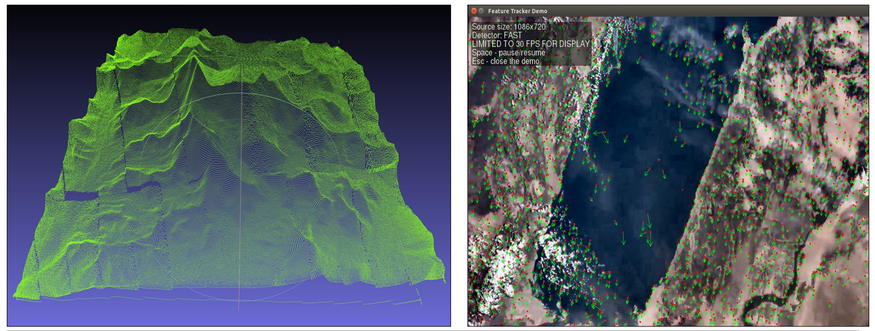


Figure 3: a) Sparse cloud recreation of a mountain used to demonstrate MOCI's SfM capabilities and b) A screen grab of demo showing MOCI's feature tracking capabilities

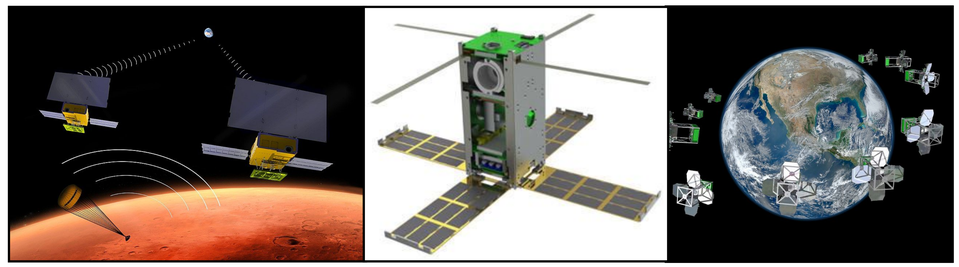
Figure 2: image of the Eastern United states which will be a target for MOCI while it identifies algal blooms and sediment plumes

POSSIBLE ASTROPHYSICAL APPLICATIONS

MOCI's main highlight is its GPU, with its GPU MOCI is a 3U supercomputer floating in space. Exchanging its optical payload and communications system, MOCI could operate to achieve a wide variety of tasks and be configured to fit any desired application. A couple possible astrophysical applications are listed below:

- A swarm of MOCI's could be used to create an affordable and easily repairable space based interferometer with a centralized MOCI that can control the cluster and serve as a central processing hub
- Use constellation of cubesats to continuously observe astrophysical objects to better detect variability
- Complement large missions by accompanying traditional satellites

Figure 5: a) Mars Cube One accompanying InSight Lander mission (credit JPL) b) CXBN-2 Cubesat, a 2u cube satellite used to measure the Cosmic X-Ray Background (credit MSU), and c) Concept network of Cubesats for interferometery. (Credit Frank Marchis)



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