Nanohmics Inc.

Recent Space Technology Highlights

www . nanohmics . com

Austin, Texas

6201 E. Oltorf St.
Austin, TX 78741
www.nanohmics.com

NANOHMICS INC.
T 512-389-9990
F 512-389-9850
info@nanohmics.com

The CHIMP:

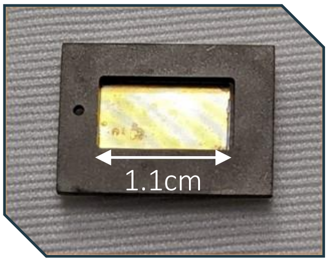
Chip-Scale Hyperspectral Imaging MISSE Payload

Principal Investigator: Chris Mann, cmann@nanohmics.com

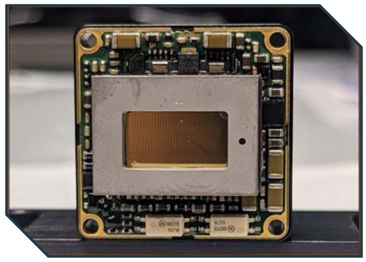
ISS NATIONAL LABORATORY

Mission Objective:

Monitor the calibration stability of the Nanohmics integral-field spectral imaging micro-optical chip in LEO

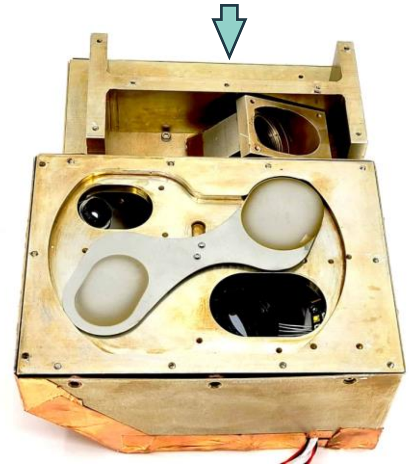


Custom spectral chip

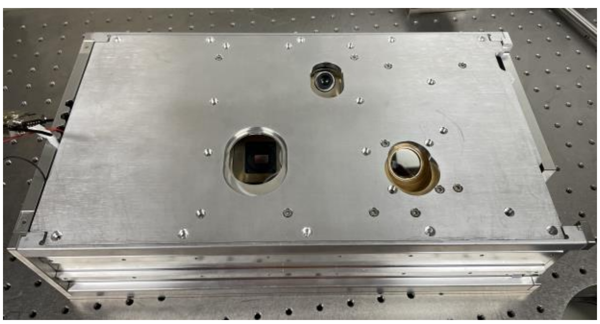


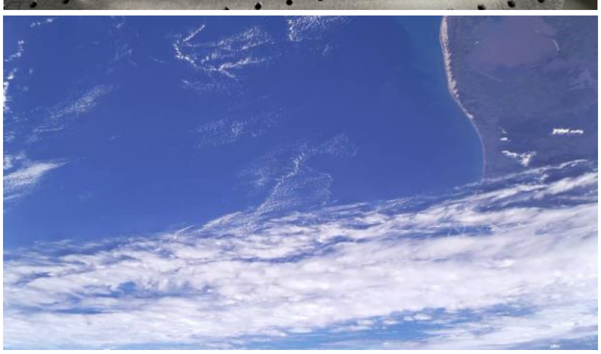
Bond to COTS camera core

Integrate with COTS optics

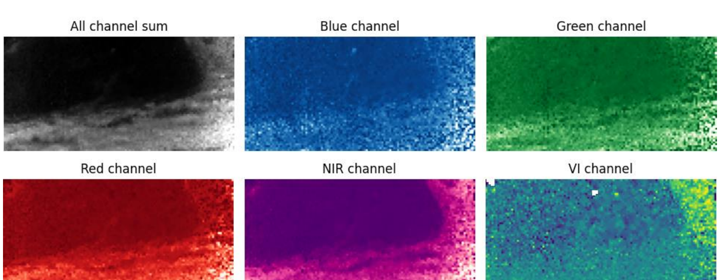


The CHIMP included a payload computer, in situ calibration test capabilities, and two cameras that could capture simultaneously





(Above) Context camera
(Below) Spectral reconstruction results



The CHIMP flew on the ISS from Aug 2021 to Aug 2022, the flight was sponsored by ISS National Lab

- Launched on CRS-23 in Aug. 29, 2021
- Out the airlock Nov. 20, 2021
- First light Jan 10, 2022
- Communications lost Jan 21, 2022
  - Solar event that caused crew to shelter coincided with loss of comm
- Splashdown Aug 20, 2022, on CRS-25
- Back to Nanohmics for post-flight inspection Sept 9, 2022

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Chip-Scale Hyperspectral Imaging MISSE Payload

Principal Investigator: Chris Mann, cmann@nanohmics.com

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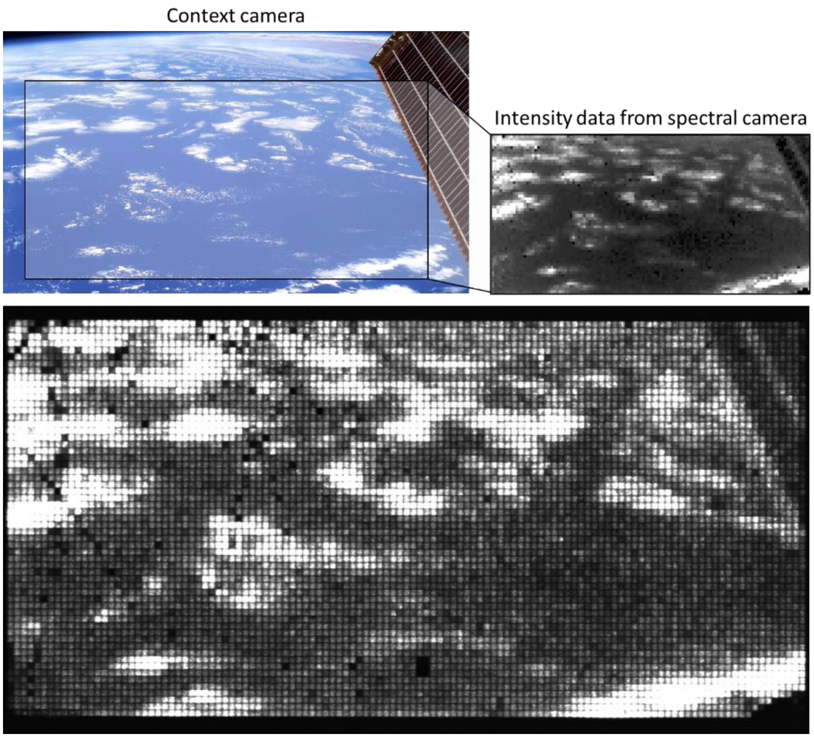
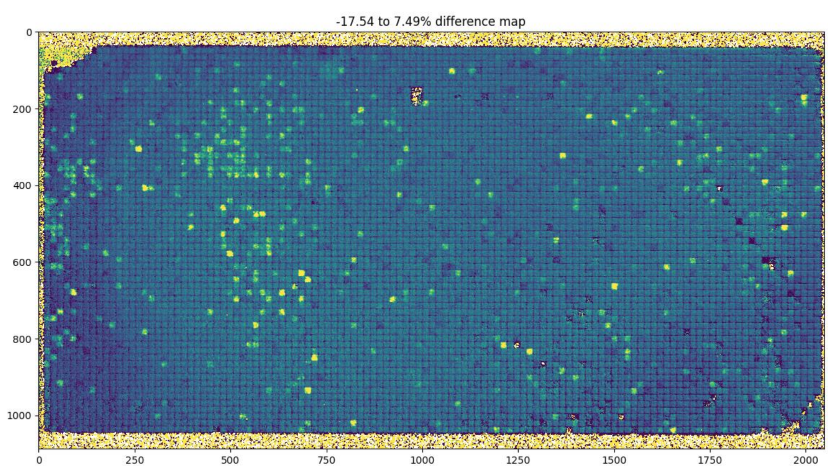




Relative pixelwise differences between pre-flight and post-flight calibration of the ISS article. The majority of superpixels maintained their ground calibration to within experimental error. Several superpixels in the chip experienced particle-bed delamination (the brightest and darkest squares), causing a net increase or decrease of throughput depending on how it failed.

Mission Hardware:

- Prototype spectral camera
- HD context camera
- Calibration LEDs
- Bistable rotary shutter with Lambertian coating on backside for in situ calibration testing
- TX2i computer and Spacely carrier board
- SSD local storage
- Sun sensor
- Power conditioning and distribution electronics
- Communication interface to MISSE experiment computer

Mission Outcome:

- All mission objectives were completed successfully

Lessons Learned:

- We identified a new failure mode of our device that we attribute to repeated thermal swings
    - We designed improvements to avoid this delamination effect in the future
    - Nvidia hardware lacks means of providing redundancy and is very challenging to troubleshoot

Compact Imaging Spectropolarimeter Based On Multifunction Meta-optic

Principal Investigator: Mark Lucente, mlucente@nanohmics.com

NASA SBIR Phase II, began May 2022

The City University of New York

Mission:

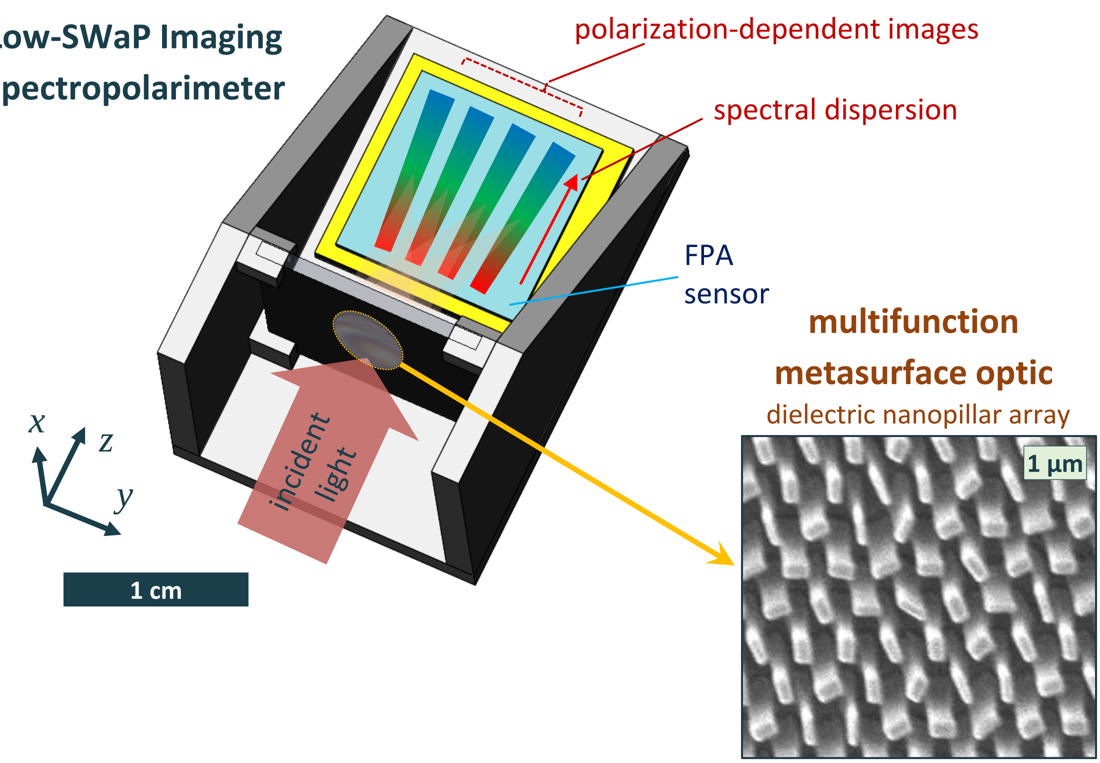
Compact, light-weight instrument for remote measurements of planets and small bodies

Solution:

By providing imaging, polarimetry, and spectroscopy in a simple low-cost package, this compact sensor is ideal for hyperspectral remote measurements of gas and dust – initially in the near-infrared (NIR) spectral band but easily extensible to cover the visible (VIS) and other spectral bands.

- Cost-effective planetary science data collection such as atmosphere/plume composition and aerosol absorption and scattering
- Hyperspectral imaging spectropolarimeter uses a single multifunction meta-optic that analyzes both the spectrum and polarization state of collected 1D images
- Operating bands demonstrated to-date include NIR and SWIR; easily scalable to other spectral bands such as visible, MWIR, LWIR
- Low-cost measurements for NASA's Science Mission Directorate (SMD)
- Light-weight, low-cost, high-performance optics based on microfabricated metasurfaces, a key component of many imaging, remote sensing, and optical communication subsystems with small size, weight and power consumption (SWaP)
- Team includes Andrea Alù and group at CUNY Advanced Science Research Center (ASRC)

Low-SWaP Imaging Spectropolarimeter



Maximizing Small Sat Real Estate

Principal Investigator: Andrew Foley, afoley@nanohmics.com

NASA SBIR Phase I T5.05-2038 Solar Sail Integrated Antenna Technology

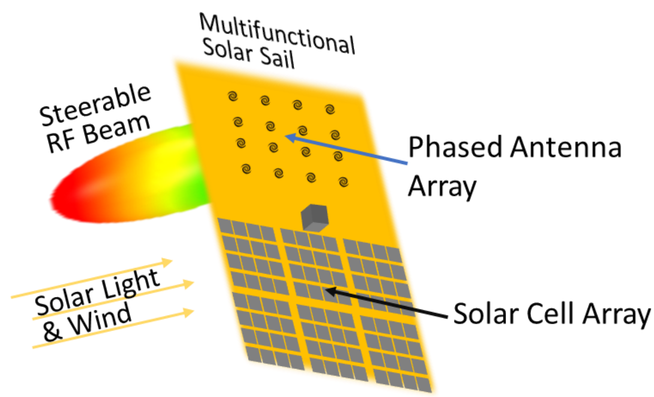
Mission:

Small-Sat scientific monitoring missions at Lagrange points

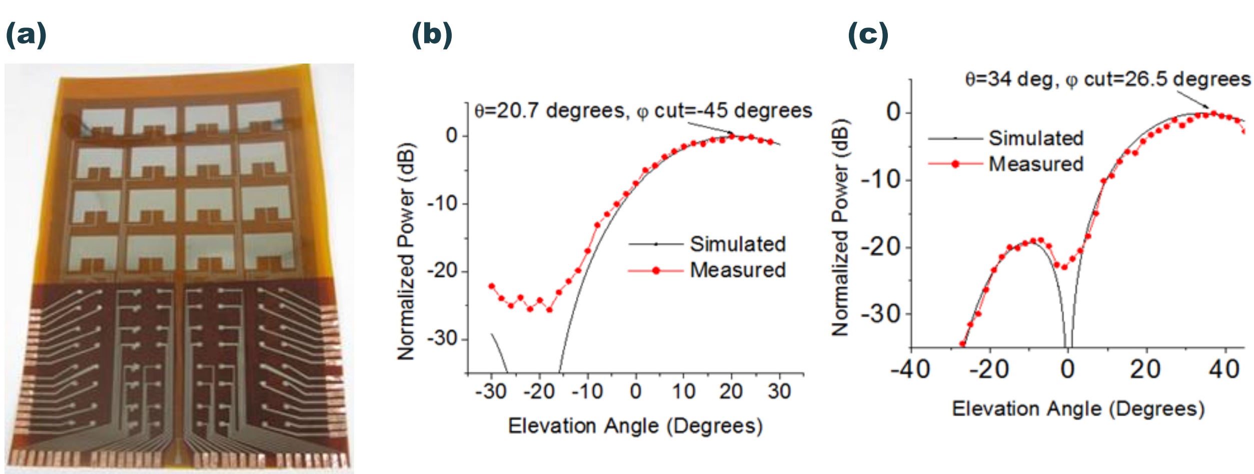
Solution:

Upcoming missions plan to use solar sails to maximize mission duration by minimizing propellant dependance. These sails will be new stowable real estate for solar cells and comms arrays. Mission and platform requirements necessitate a new combination antenna technologies features:

- Compatible with stowable substrates
- Highly-directive and electronically-steerable beams to reach distant terminals regardless of sail orientation
- Long-term material survivability under solar winds
- Forward compatible with next generation comms frequencies in long-term technology road map



A fully ink-jet printed 4x4 PAA system embedded in Kapton, far-field radiation patterns of the 2-bit 4x4 PAA system for 5GHz signal showing peak at (b) θ = 20.7°, ϕ = -45°, and (c) θ = 34°, ϕ = 26.5°.



Better Imaging Performance at a Fraction of the Cost and Lead-Time

Principal Investigator: Sebastian Liska, sliska@nanohmics.com

NASA SBIR Phase II, Contract No. 80NSSC22CA088, Adaptive Optics for Low-Cost CubeSat Optical Systems

Mission:

Smallsat scientific monitoring missions from low- and medium Earth orbits using optical imaging telescope

Solution:

Modular, low-cost Adaptive Optics (AO) system based on passive wavefront sensors, deformable mirrors, and computational imaging techniques.

Capabilities:

- Modular, low-SWaP+C approach to active correction of optical aberrations
- Ideal for correcting the aberrating effects of manufacturing imperfections and thermal transients, as well as structural changes due to launch, flight, outgassing, pose variations, and platform controls
- Less stringent tolerances ⇒ 10x cost and 4x lead-time reductions of imaging telescopes
- Suitable for mitigating optical, thermal, and mechanical requirements in advanced (e.g., off-axis and freeform) telescope designs, multi-layer / plated mirrors, and low-cost fabrication techniques (e.g., diamond-turned aluminum)
- High sensitivity and high dynamic range wavefront sensing without the need of artificial or natural guide stars
- Compatible with COTS deformable mirrors and wavefront sensors
- Customizable to different imaging bands and mission requirements, scalable framerates

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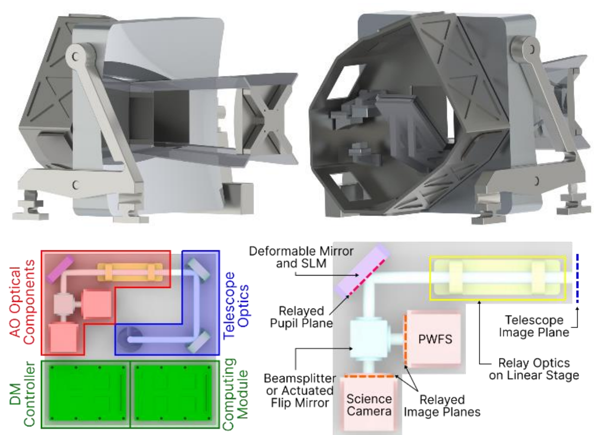
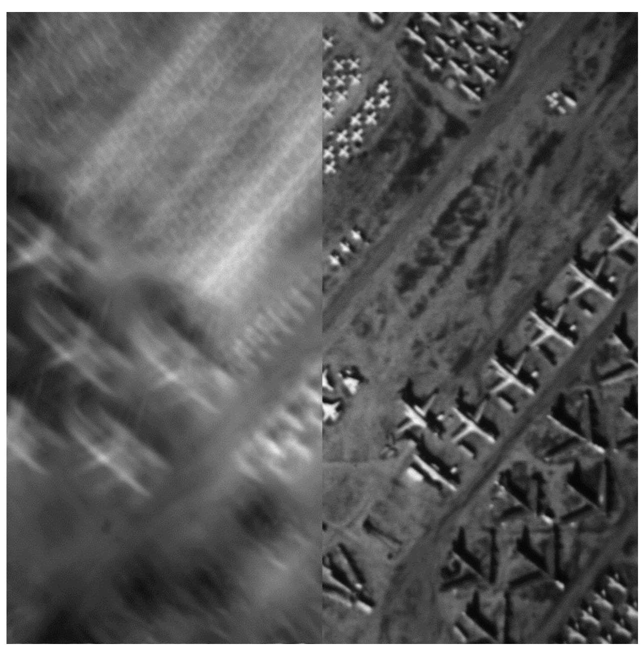


Concept CubeSat telescope with modular AO system



Aberrated, infinity-projected imagery (left) corrected by laboratory breadboard AO system (right)

Surviving Extreme Environments with Thermoelectrics

Principal Investigator: Josh Ruedin, jruedin@nanohmics.com

NASA SBIR Phase I S13.07-2597 Thermal control for energy storage in extreme environments

Mission:

Rover, survive the Lunar night

Solution:

Thermoelectric modules operating as high-efficiency heat pumps to maintain battery temperatures during the lunar night can be more efficient than resistive heaters.

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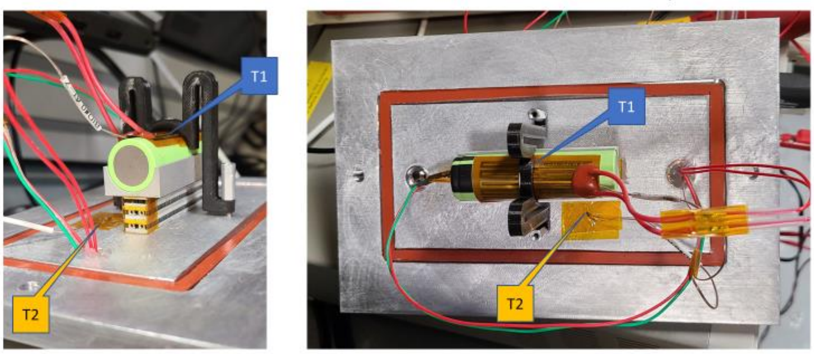
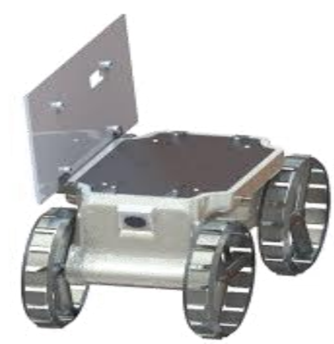
ASTROBOTIC

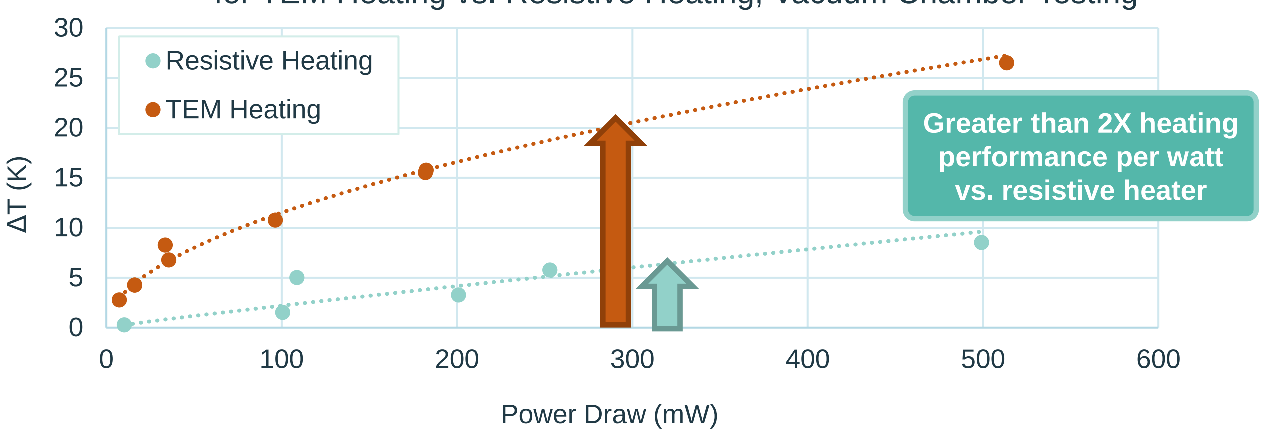
TEM mounted on emulated CubeRover radiator plate



Aluminum plate acts as CubeRover radiator – 18650 is mounted with 3d printed clamp to reduce thermal conduction. Film heater is applied to 18650. Aluminum cradle was made to have a flat surface to clamp TEM against radiator. Wire routed through vacuum sealed port. Multi-stage TEM shown here. T1 and T2 are thermocouple locations.



ΔT (Kelvin) vs. Electrical Drive Power (mW)
for TEM Heating vs. Resistive Heating, Vacuum Chamber Testing



Enabling Machine Learning on Gateway and Other Cislunar Environments

Principal Investigator: John Sarik, jsarik@nanohmics.com

NASA STTR Phase I T10.04 Space-Qualified Environmental Evaluation Drones with Wireless Intelligent Networked Data Processing (SPEEDWINDs)

Mission:

Autonomous environmental monitoring of Gateway.

Challenges:

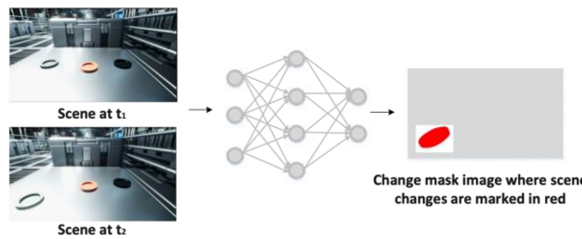
Compared to ISS, Gateway is smaller (125m^3 vs. 916m^3), operates in a harsher radiation environment, is not permanently crewed, and has lower bandwidth, higher latency communication

Solution:

Combination of inherently rad-hard hardware and high-performance COTS hardware to enable rapid development of **autonomous** and **resilient** systems.

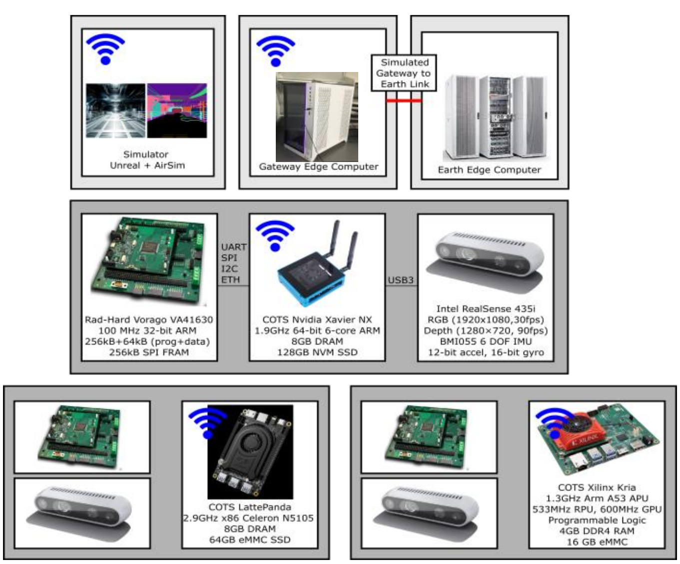
Drone navigates environment, swabs surfaces, and returns swab to processing station. Station cultures microbes then performs colony counting and identification.

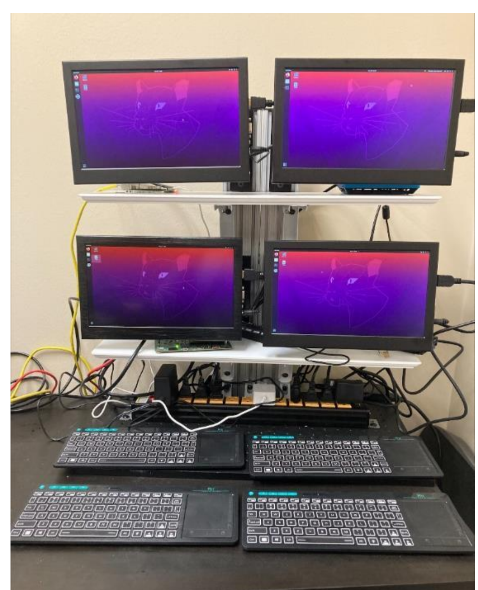
Development of machine learning techniques to overcome hardware, bandwidth, latency limitations and to compensate for sensor degradation from radiation effects.



Scene change detection for navigation

Colony counting and identification





Reconfigurable Adapter for Snapshot Multimodal Imaging

Principal Investigator: Sebastian Liska, sliska@nanohmics.com

NASA SBIR Phase I, Contract No. 80NSSC22PB104, Reconfigurable Plenoptic Objective for Snapshot Multimodal Flow Diagnostics

Mission:

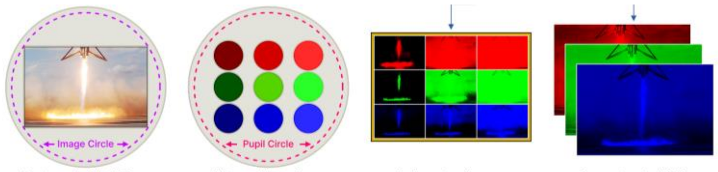
Optical measurement systems for characterizing the complicated flow physics of plumes and plume-surface interactions of landing and ascent systems.

Solution:

Reconfigurable plenoptic objective (i.e., photographic lens) that will convert a standard high-performance camera into a snapshot multimodal (e.g., multispectral, polarimetric, and/or high dynamic range) imaging system. Post-processing software to extract quantities of interest (e.g., temperature, species concentration, and dynamic flow structure) for flow diagnostics and comparisons with computational fluid dynamics models

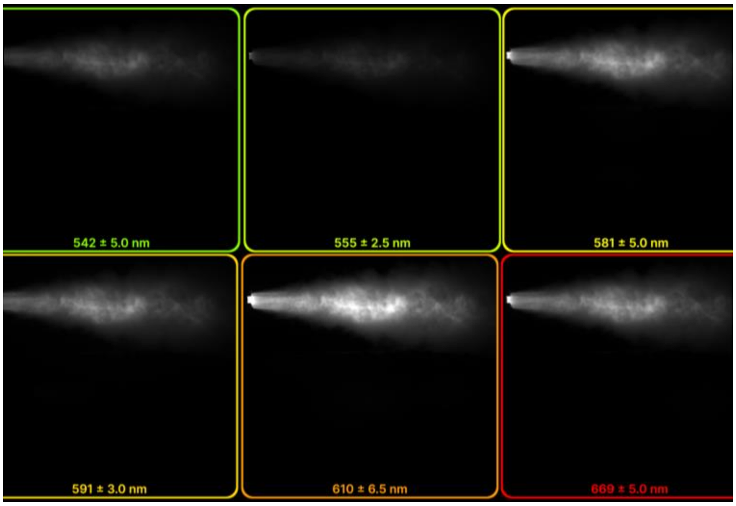
Capabilities:

- Descent-stage spectral imaging and full multispectral video
- Non-intrusive, time-resolved flow measurements
- Snapshot multispectral, polarization, and/or high dynamic range imagery
- Add-on design—no need to modify the camera package and/or image sensor
- Swappable “sensing cartridges” for different flow measurements
- Low-cost path for validating flow physics models
- No temporal multiplexing or no moving parts (e.g., no filter wheel)
- Immediately compatible with ground testing missions, but offers multiple low-risk paths for supporting space sensors and missions

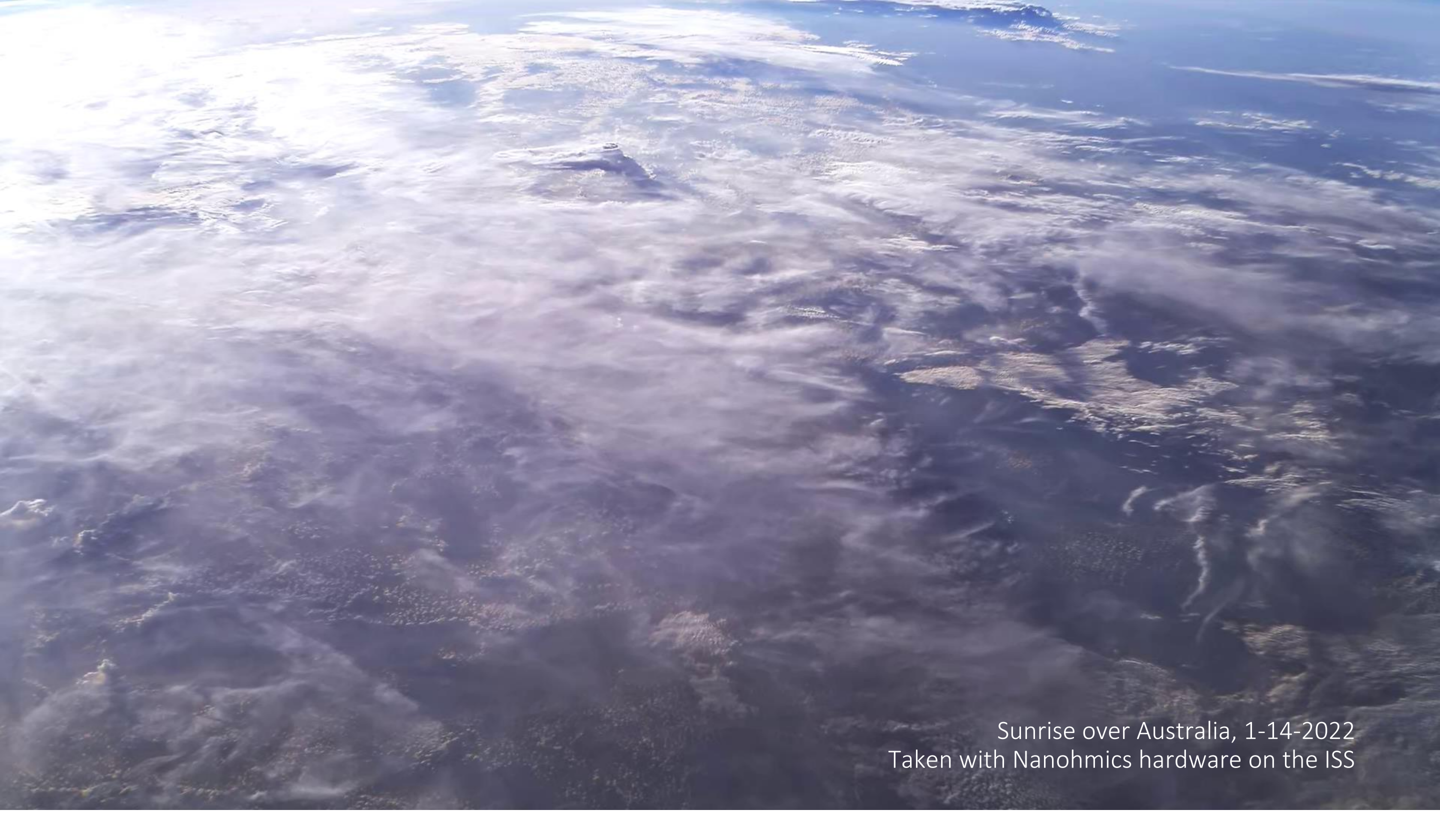


Solution architecture for plenoptic multimodal imaging system

SBIR Phase I hardware prototype



Snapshot multispectral video captured with SBIR Phase I prototype during full-scale, hot-fire rocket tests at Redstone Arsenal, AL



About Nanohmics

Nanohmics is a small business located in Austin, Texas. Our 45 staff members work with customers, collaborators and partners across a wide range of industries to design and develop smart technology solutions that improve your product, technology or system performance.

We specialize in the applied sciences of light, molecule and advanced material interactions at the heart of custom-engineered sensing technologies and measurement instrumentation. We apply a diverse approach to tackle challenging technical problems that require broad research expertise to design and build information collection and analysis capabilities tailored for detection, surveillance, electro-optic imaging, performance characterization, environment awareness, and energy conversion applications.

From concept to benchtop and subsurface to orbit, we provide custom research and engineering for hard problems.

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