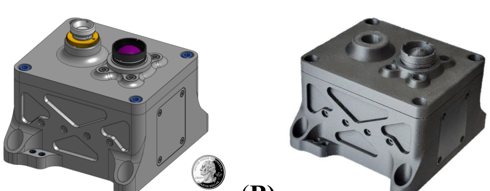
THE VISIBLE AND INFRARED OBSERVATION SYSTEM (VISIONS) OVERVIEW. Laura Lee[1], Christopher Edwards[1], Christopher Haberle[1], Michael Shafer[1], David Trilling[1], Jagoda Janiszewska[1], Aaron Klingaman[2], Wyatt Watson[1], Aaron Walcott[1], Alec Zodrow[1], Alix Ford[1], Amber Malenowsky[1], Anna Baker[1], Ari Koeppel[1], Benjamin Perkins[1], Breelyn Cocke[1], Brock Davis[1], Cheng Ye[1], Danielle Stephenson[1], Emily Mendoza[1], Henry Zuyle[1], Jaidyn Thompson[1], Julie Heynssens[1], Koby Perkins[1], Loren Larrieu[1], Oriel Humes[1], Owen Murphy[1], Paul Howell[1], Rebekah Wucinich[1], Ryan McGaughey[1], Sean Ly[1], Shawn Sargent[1], Sophia Frohna[1], Sydney Inselman[1], Thomas Carter[1], Willem Spencer[1], Dawson Purcell[1]
[1]Northern Arizona University, Flagstaff, AZ, USA, [2]Lucint Systems Inc., Portland, OR, USA.

Introduction: The VISible and Infrared ObservaitoN System (VISIONS) is Northern Arizona University's (NAU) student-led, low-cost, dual-wavelength imager for planetary science applications. VISIONS is a technology demonstration of how off-the-shelf parts can be ruggedly integrated and tested to withstand space environments under a do-no-harm philosophy. VISIONS utilizes a flexible mechanical and operational design (tailoring field of view, observation cadence, compression/data output types), allowing it to be repurposed for numerous low-cost space and planetary missions. For more demanding applications with more stringent requirements, VISIONS can accommodate space-qualified, non-COTS (commercial off-the-shelf), components. Furthermore, the VISIONS development program addresses recommendations from the Technology and State of the Profession chapters of the 2023-2032 Planetary Science and Astrobiology Decadal Survey [**1**].

The primary objective for VISIONS is to provide a technical demonstration of a visible and infrared, low-budget, camera system utilizing commercial off-the-shelf parts to be used on small-satellite platforms for deep-space/interplanetary missions. This abstract presents the scientific objectives of the instrument, the components of the instrument, student involvement, and the status of the project.



(A) (**B**)

Figure 1. *Computer-aided design (A) and 3D printed model (B) of the VISIONS instrument composed of a visible sensor and its corresponding lens (A, left), an infrared camera (A, right), and adapter and control boards all encased in aluminum housing. Quarter (middle) for size reference.*

Science Objectives: VISIONS' scientific objectives are to: **(1)** Obtain spatially resolved, calibrated surface temperature data for distinguishing distinct thermophysical units, **(2)** Differentiate surface features with variable visible color and albedo, and **(3)** Monitor the global energy budget of planetary bodies. The current design has been optimized for inner Solar System space environments such as the Moon, Mars, asteroids, etc.

Instrument Components: VISIONS is a dual-wavelength imaging system with a three-band, Bayer pattern RGB visible sensor with an infrared cutoff filter and a broadband thermal infrared VOx microbolometer. VISIONS incorporates custom-built interface electronics provided by our commercial partner, Lucint Systems, under the guidance and requirements definition of NAU. The housing structure of this instrument is designed and manufactured by the NAU VISIONS mechanical engineering student team using aluminum 7050-T74. The engineering team designed the housing for VISIONS to minimize susceptibility to vibrational loads, simplifying the structural analysis and mitigating environmental testing risk. This design will undergo thermal, structural, EMI/EMC and other environmental tests following NASA Goddard's General Environmental Verification Standard (GEVS) for spaceflight testing in spring 2023.

VISIONS has an envelope of 9.10 x 9.80 x 7.53 cm and a current best estimated mass of 764 grams. The visible imager has a field of view of 39° x 33° with a wavelength range of 400-1000 nm and the infrared imager has a field of view of 45° x 37° with a broadband thermal spectral range of 8-14 μm [**2, 3**]. VISIONS provides onboard data volume flexibility through a call and response telemetry interface, multiple image compression options (lossy and lossless), thumbnail generation (flexible size), and in-flight parameter updates (e.g. exposure, frame co-adding). The control board utilizes redundant gigabit ethernet allowing communication with a back-up flight computer. The control board handles power regulation with capability to step down up to 40V DC to the necessary 5V DC needed. The VISIONS data transfer protocol handles UDP packets for images, thumbnails, and telemetry. Thermal control of VISIONS is managed through multi-layer insulation (MLI) blanketing and conductive coupling to the spacecraft deck, which will be tested across a temperature range of -40℃ to +50℃.

Figure 2. *VISIONS control board designed and built by Lucint Systems.*

The thermal infrared sensor has spaceflight heritage in low-earth orbit (LEO) as tested by NASA (MFS-TOPS-108) [**4**]. Similar visible CMOS (complementary metal oxide semiconductor) sensors also have extensive spaceflight heritage. All other VISIONS hardware components have been carefully designed with outgassing, environmental testing, contamination prevention, and radiation mitigation in mind to further reduce risk.

Student Involvement: Beginning in January 2022, NAU's Department of Astronomy and Planetary Science (DAPS) has been offering a multidisciplinary planetary instrument design and development course. Participating students have a wide range of backgrounds including: astronomy and planetary science, mechanical engineering, electrical engineering, thermal engineering, structural engineering, physics, manufacturing, and software engineering. Depending on each student's interests, they are free to explore various instrument development roles including: science, systems engineering, thermal engineering, mechanical engineering, electrical engineering, and ground support engineering. Additionally, students are given the opportunity to gain leadership experience in each of these subteams.

Figure 3. *VISIONS students and faculty working with modeled design to step through the camera integration process in the cleanroom.*

This course consists of undergraduate and graduate students who interface with the management team. The management team is composed of DAPS faculty, Mechanical Engineering faculty, a post-doc, and a DAPS graduate student. Students are provided the opportunity to work with industry professionals to discuss spaceflight hardware and software, interface electronics, and concepts of operation.

NAU has undergone several infrastructure upgrades in order to ensure VISIONS meets the requirements from Planetary Protection provided by GEVS (General Environmental Verification Standard) [**5**]. The largest upgrade was the installation of a class 10K cleanroom with electrostatic discharge (ESD) control mats and ESD-safe equipment. Participating students are cleanroom certified in order to fabricate, install, and test the camera system.

VISIONS Status: VISIONS has successfully advanced past two critical design reviews. During the Preliminary Design Review (PDR), in May 2022, teams presented their work covering the camera's scientific research possibilities, operational specifications, data volume minimization strategies, thermal and mechanical designs, electronic components, and various environmental testing plans. The Critical Design Review (CDR), in November 2022, covered updated information on instrument design, hardware changes, software, concept of operations, and responded to the Request for Actions from PDR.

As of January 2023, the VISIONS control boards completed workmanship laboratory tests. The housing for VISIONS has been fabricated on-site at NAU's machine shop by students on the Mechanical Engineering team. In early 2023, VISIONS will undergo camera calibration, vibration testing, thermal vacuum testing, and EMI/EMC testing. At the beginning of the program, the instrument was assessed at TRL 5 given the sub-system heritage at the start of the effort. The aforementioned environmental tests to be carried out in early 2023 will verify the design for spaceflight readiness and result in a TRL of 6.

VISIONS is projected to be a fully flight-qualified instrument by March 2023.

References: [**1**] National Academies of Sciences, Engineering, and Medicine. (2022) *Origins, Worlds, and Life: A Decadal Strategy for Planetary Science and Astrobiology 2023-2032*. [**2**] The Imaging Source, LLC. (2017) *Industrial Cameras: Spectral Sensitivity.* [**3**] Teledyne FLIR LLC. (2022) *Uncooled, Longwave Infrared (LWIR) OEM Thermal Camera Module, Boson.* [**4**] NASA. (2021) *Ruggedized Infrared Camera, High Vibration and Harsh Environment Option*, Ref. #MFS-TOPS-108. [**5**] NASA Goddard Space Flight Center. (2021) *General Environmental Verification Standard (GEVS)*, Doc. #GSFC-STD-7000B.

Acknowledgements: Funding for this effort is provided by the Northern Arizona University Office of the Vice President for Research, the Technology Research Initiative Fund and NAU NASA Space Grant.