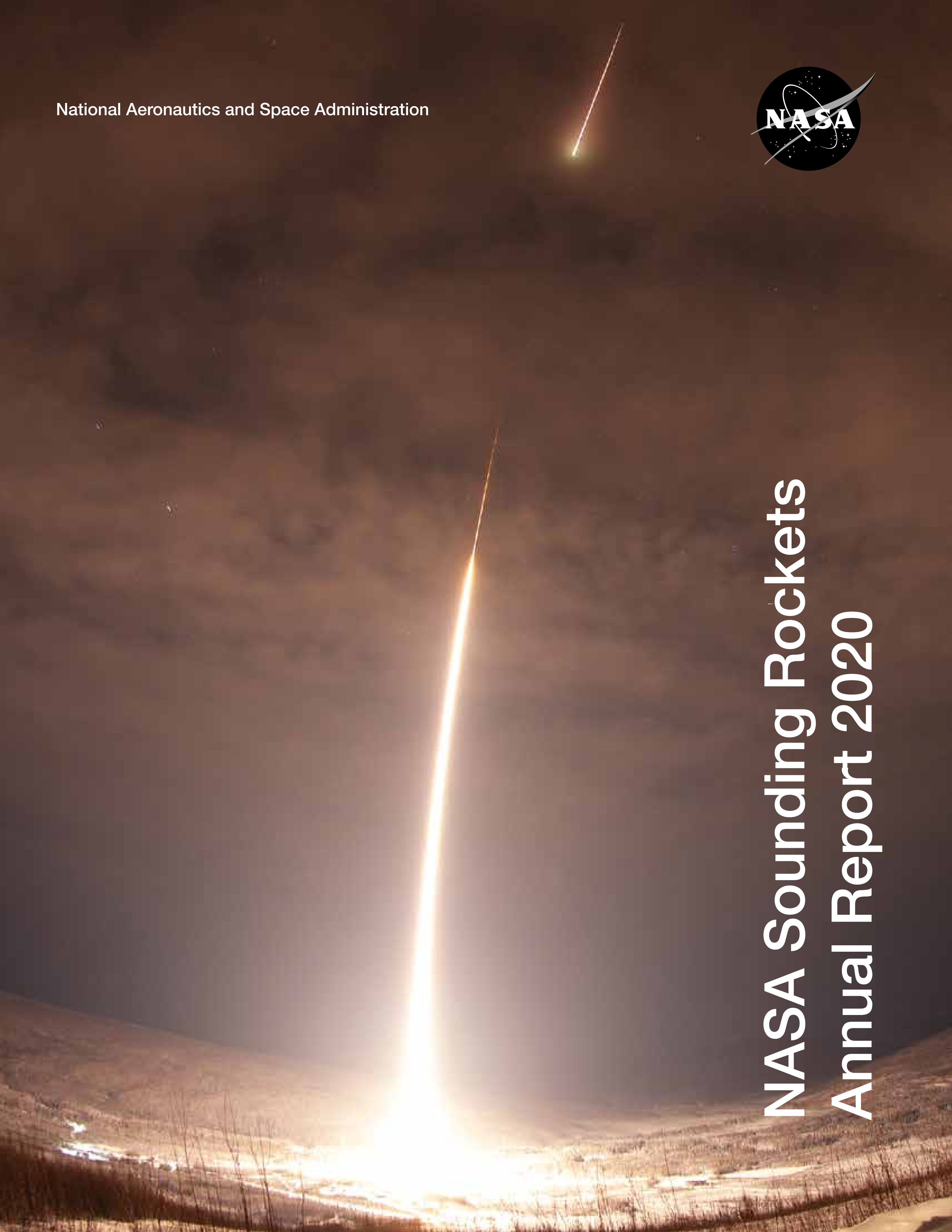
National Aeronautics and Space Administration

NASA Sounding Rockets Annual Report 2020



Message from the Chief

Giovanni Rosanova, Jr.
Chief, Sounding Rockets Program Office

I will start this year's message with expressing my gratitude to the people supporting the sounding rockets program. Through the challenging time of the CoVid-19 pandemic, the outstanding efforts by the entire team have enabled us to continue meeting several milestones. Our mission meetings have been held using virtual tools. Enhanced screening, social distancing rules, and the use of Personal Protective Equipment (PPE), have enabled us to resume limited onsite activities. In July, part of the NSROC workforce, mainly where remote work is not practical, returned to limited onsite work. We have also submitted mission restart requests for pending missions and have received approval to start integration and testing for missions on schedule for launch early in 2021. Our payload teams follow strict protocols while onsite and occupancy levels are kept to the minimum required.

The first mission for FY 2020, Determining Unknown yet Significant Traits (DUST), for Dr. Nuth, Goddard Space Flight Center, was successfully launched from White Sands Missile Range (WSMR), NM. DUST-2 launched on September 8, 2020 and capped the year with another success. The main objective of these missions was to study how individual atoms, shed by dying stars and supernovae, stick together. The DUST-2 mission could not have been executed without the outstanding support of the Wallops Aircraft Office. They transported both personnel and hardware to WSMR on the NASA C-130 aircraft, and retrieved the crew and equipment after the launch.

The Far-ultraviolet Off Rowland-circle Telescope for Imaging and Spectroscopy (FORTIS), for Dr. McCandliss, Johns Hopkins University was successfully launched from WSMR in October 2019. This, the fourth mission for FORTIS, studied the massive hot star clusters in the star-forming Galaxy M33.

Prior to the CoVid-19 shutdown we finished the Grand Challenge – CUSP Initiative launches from Ny Ålesund, Svalbard, Norway. The first mission, Investigation of Cusp Irregularities (ICI) 5, a Norwegian science payload launched on a Terrier-Improved Malemute provided by NASA, experienced a vehicle failure and science data was not recorded. The Cusp Heating Investigation (CHI) for Dr. Larsen, Clemson University, measured neutral upwelling and high-resolution electric fields over an extended region in the cusp, and was a resounding success. Additionally, the Cusp-Region Experiment (C-REX) 2 for Dr. Conde, University of Alaska, was staged and ready to go at Andoya Space Center, Norway, however, science conditions did not materialize, and after 17 launch attempts the window of opportunity closed. C-REX 2 is currently on schedule for launch in December 2020.

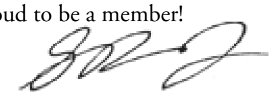
The final geospace science launch for fiscal year 2020 took place from Poker Flat Research Range, Alaska. Polar Night Nitric Oxide (PolarNOx), for Dr. Bailey, Virginia Tech, was successfully launched in January 2020. Data from PolarNOx will aid in the understanding of the abundance of NO in the polar atmosphere, and its impact on ozone.

Technology development is a core aspects of the program. This year we launched the eighth dedicated technology development flight, SubTEC-8. Key elements of this mission included a test of new deployable sub-payloads with telemetry links to the main payload. Four sub-payloads were deployed and all successfully transmitted data. The first science mission that will take advantage of the new deployable sub-payload system is Kinetic-scale Energy and momentum Transport eXperiment (KiNET-X), schedule for launch from Wallops Island, VA in 2021. Additionally, a low cost star tracker and a high data rate telemetry encoder were successfully flown on SubTEC-8. Further details on technologies flown on this mission are outlined in this report starting on page 26.

As with the rest of the world, our operations have been significantly impacted by the pandemic. We have worked closely with our Principal Investigators to reschedule science missions for future dates, mostly for FY 2021, but also for FY 2022. The student flight opportunities, RockOn, RockSat-C, and RockSat-X have been postponed and are currently scheduled for summer 2021. The annual teacher workshop, Wallops Rocketry Academy for Teachers and Students (WRATS), was also postponed. We intend to continue these activities when onsite work has resumed and large gatherings do not pose a health hazard.

It is hard to balance the words to express both the gratitude for what we have achieved despite the challenges, and the sorrow for what we have lost because of them. Many of our colleagues have faced unprecedented hardships and have still braved the world as we know it in 2020. It is my deepest wish that we look to the future with hope and optimism. I want to thank all of you for the diligence, professionalism, and endurance that you have, once again, demonstrated. There is no team better than this, and I am proud to be a member!

Wishing you the very best for 2021!



Giovanni Rosanova, Jr.

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Cover photo: PolarNOx Launches from Poker Flat Research Range, AK

Credit: Wallops Imaging Lab

Sounding Rockets Overview

The Sounding Rockets Program supports the NASA Science Mission Directorate's strategic vision and goals for Earth Science, Heliophysics and Astrophysics. The 20+ suborbital missions flown annually by the program provide researchers with unparalleled opportunities to build, test, and fly new instrument and sensor design concepts while simultaneously conducting world-class scientific research. Coupled with a hands-on approach to instrument design, integration and flight, the short mission life-cycle helps ensure that the next generation of space scientists receive the training and experience necessary to move on to NASA's larger, more complex space science missions. The cost structure and risk posture under which the program is managed stimulates innovation and technology maturation and enables rapid response to scientific events.

With the capability to fly higher than many low Earth orbiting satellites and the ability to launch on demand, sounding rockets offer, in many instances, the only means to study specific scientific phenomena of interest to many researchers. Unlike instruments onboard most orbital spacecraft or in ground-based observatories, sounding rockets can place instruments directly into regions where and when the science is occurring to enable direct, in-situ measurements. The mobile nature of the program enables researchers to conduct missions from strategic vantage points worldwide.

Telescopes and spectrometers to study Solar and Astrophysics are flown on sounding rockets to collect unique science data and to test prototype instruments for future satellite missions. The program's rapid response capability enabled scientists to study the Supernova 1987A before it faded from view. Currently, new detectors, expected to revolutionize X-ray astronomy, are under development and have been successfully tested on sounding rocket flights. An important aspect of most satellite missions is calibration of the space based sensors.

Science with Sounding Rockets

In 1957 scientists participating in the International Geophysical Year (IGY) had available to them rockets as research tools for the first time in history. They took full advantage of these new assets, and launched a total of 210 rockets from 7 different sites as part of the United States contribution to the IGY. The research ranged from atmospheric sciences to astronomy. Ionospheric soundings included direct electron density measurements and detailed mapping of the E and F regions.

IGY 1957 firmly established sounding rockets as viable tools for science and proved their utility for in-situ measurements, quick response, and temporal and geographic mobility. The utilization of sounding rockets for science has continued with undiminished importance.

Heliophysics, Astrophysics, Geospace science and Aeronautics benefit from sounding rockets. Advantages such as the quick response to scientific events, low cost, and mobile operations provide researchers with opportunities to conduct world class science.

Some of the highest resolution spectral data of the Sun are recorded with telescope payloads flying on sounding rockets. Payload recovery yields significant cost savings by ensuring that sensors, one-of-a-kind telescopes, cameras and recorders are available for reflight on future missions.

As research tools, sounding rockets are key to the study of the near Earth space environment; in fact, they are the only means of collecting in-situ data in the ionosphere. Several launch sites in the arctic region enable studies of phenomena such as magnetic re-connection, ion outflows and the effects of Joule heating. Understanding the fundamental processes that govern the Sun-Earth space environment will enhance our ability to more accurately predict the solar storms that can disrupt power grids and satellite-based information systems on Earth.

In the high energy and the ultraviolet and visible parts of the spectrum, Astrophysics uses sounding rockets to test new instruments on unique scientific missions. Sub-systems, developed by NASA, provide unprecedented pointing accuracy for stellar targeting, yielding high resolution spectra and potentially leading to new ground breaking discoveries about our own galaxy. rockets offer calibration and validation flights for many space missions, particularly solar observatories such as the Thermosphere-Ionosphere-Mesosphere-Energetics-Dynamics (TIMED) satellite, the Solar Heliospheric Observer and the future Solar Dynamics Observatory (SDO).

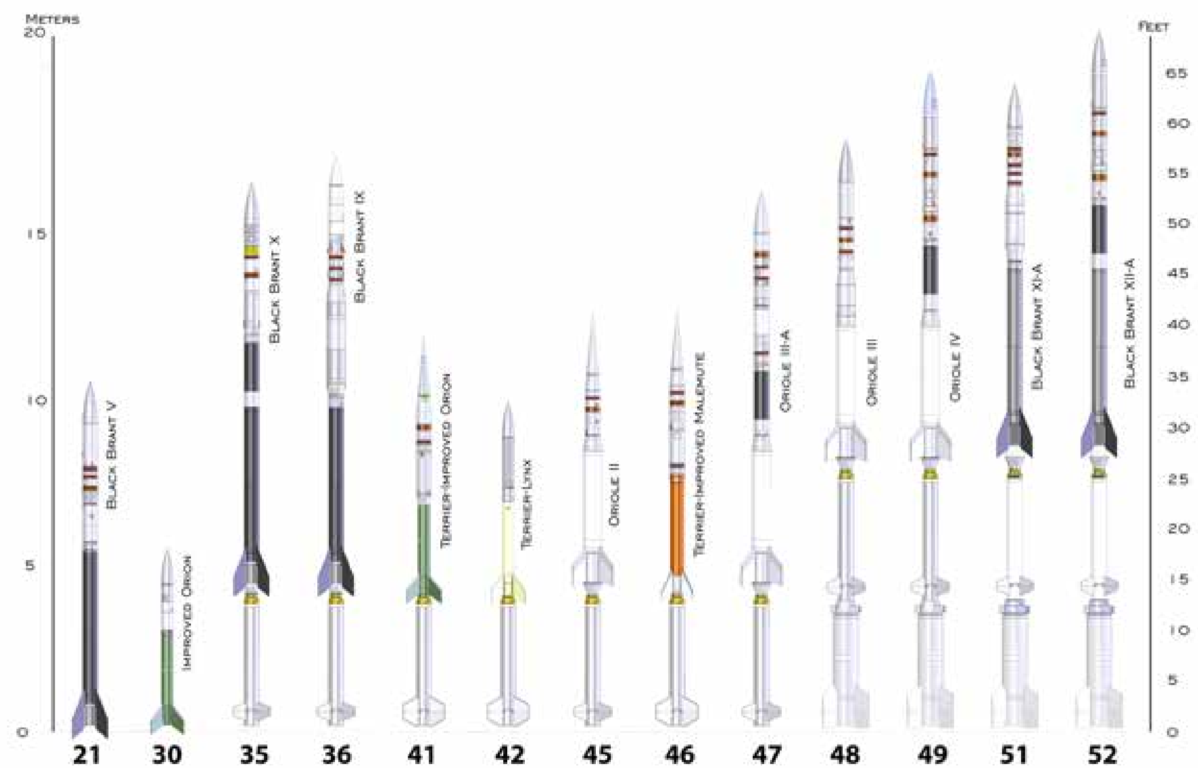
Additionally, sounding rockets are well suited for testing new technologies for future space missions. For example, parachute technologies for the Mars 2020 mission were tested on sounding rockets.

End-to-End Mission Support

The NASA Sounding Rocket Program provides comprehensive mission support and management services from concept through post flight data distribution. This end-to-end support capability enables the Principal Investigator (PI) to focus on the research aspect of the mission.

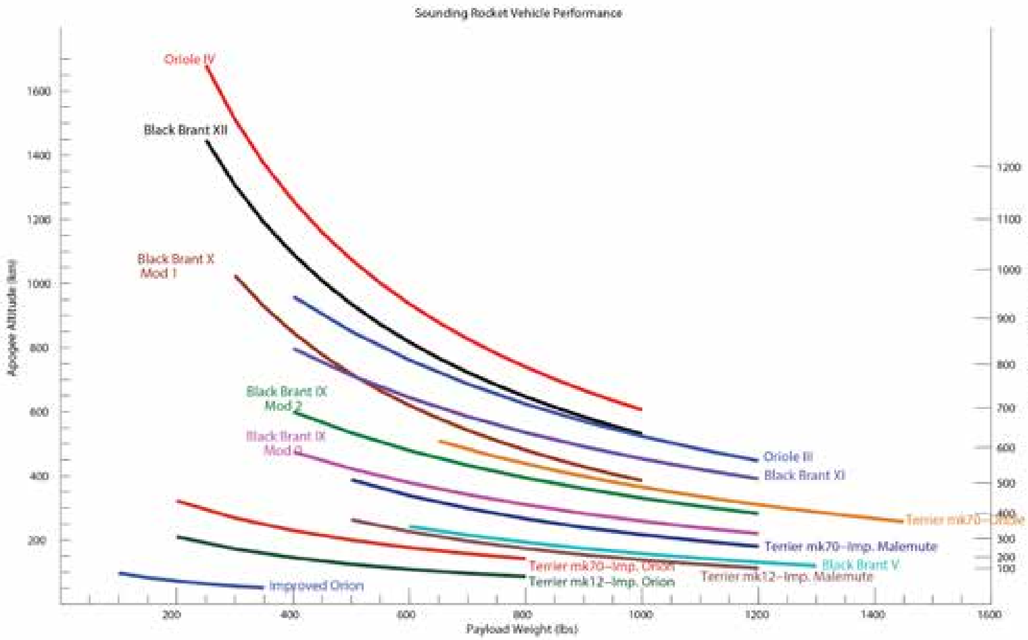
Extensive experience, over 2,500 missions flown, has lead to streamlined processes and efficient design, manufacturing and assembly techniques. Management and technical support is provided for all facets of a mission and includes engineering design, manufacturing, integration, and testing and evaluation. Periodic reviews are conducted to ensure mission requirements are being met on time and on budget.

Launch Vehicles



Sounding Rocket Vehicles

The Sounding Rocket Program offers multiple proven launch vehicles to meet the needs of most researchers. New vehicles are brought online periodically to meet customer requirements and enhance capability. Currently, 13 vehicles are provided "off-the-shelf" and range in performance from a single stage Orion to a four stage Black Brant XII-A and Oriole IV.

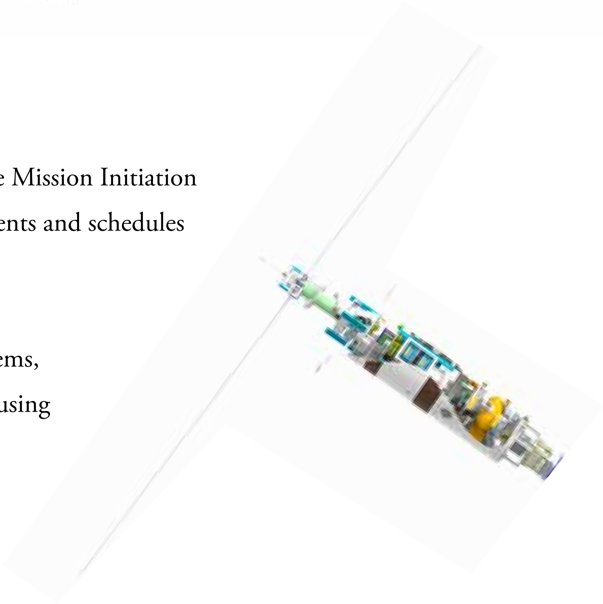


Sounding Rocket Vehicle Performance

Payload Design

The payload design process begins immediately after the Mission Initiation Conference (MIC) is completed. Initial flight requirements and schedules are discussed at the MIC.

All payload components, mechanical and electrical systems, telemetry, recovery and other sub-systems are designed using state-of-the-art software, modelling and analysis tools. 3-D visualization tools facilitate the iterative design process by allowing flexibility in design updates and changes. The integrated multi-disciplinary design methods are effective in meeting the needs of the PI.



3D model of payload.

Manufacturing

Extensive in-house manufacturing capability is vital in a program with many customization requirements. The machine shop includes a vast assortment of machinery such as Computer Numerical Controlled (CNC) milling machines, lathes, welders, sheet metal breaks/shears/rollers and additional tools/processes to support the mechanical needs of the program. A waterjet cutting machine enables fast manu facturing of small parts in large quantities.

Machine shop in Building F–10 at Wallops Flight Facility.

Assembly

Payload electrical and mechanical assembly begins with decks, longerons and electrical wiring and ends with the integration of all sub-systems and science instruments. Electrical and mechanical technicians are assigned to a mission at the MIC and, to the extent possible, stay with the assigment through flight, contributing greatly to a responsive and customer focused program.

Payload assemblies during integration.

Sub-systems

The Sounding Rocket Program provides standard sub-systems such as recovery, ACS, and the S-19 boost guidance system as required by the mission profile. Custom systems such as telemetry, based on heritage components, are also available.

The boost guidance system controls the path of the rocket during the initial 18 seconds of flight where air density is adequate to permit course correction by means of movable fins. The vehicle pitch and yaw angles are detected by a gyro platform which produces corresponding output signals; the signals are processed in an autopilot and, after roll resolution, are used as servo command signals.

Several types of sensors are used, singly or in combination to provide payload attitude information. They include Magnetometers, Gyroscopes, Solar/Lunar Sensors, Horizon Sensors, Television Cameras, and Film Cameras. The Attitude Control System positions the payload as required using compressed gas that is released through small nozzles located on the payload skin.

Magnetic Attitude Control Systems testing.

Electrically operated vacuum doors are available for most telescope payloads.

Deployment mechanisms actuated by pyrotechnic, electric or mechanical means are available for doors, booms, shutters, etc.

In instances where missions require measurements from multiple widely spaced platforms a special payload is created to permit separation into several sub-payloads. Each sub-payload has it's own Telemetry link to transmit all science and housekeeping data for that section.

Open shutter door with instrument visible during testing at Wallops.

Telemetry systems are designed to support the requirements of a mission and the configuration is determined by the complexity of the experiment, the configuration of the detectors, and the size of the rocket. Systems vary in complexity from a single link with no command or trajectory equipment to systems containing as many as eight downlinks, and complex command and trajectory hardware.

When payload recovery is required, flight performance engineers predict the radius within which the payload will land; the re-entry path is tracked by radar and the recovery achieved by parachuting the payload to a land or water landing. Recovery is accomplished by boat, helicopter or land vehicle. Additionally, payloads may be designed with gas or liquid tight bulkheads fitted with sealed passages for electrical wiring or piping.

Payload recovery at White Sands Missile Range, NM.

Testing and Evaluation

The launch and flight phases of a sounding rocket mission are stressful events for the scientific payload. The sum of the stressful elements to which such a payload is exposed is called the "payload environment." A rigorous environmental test plan helps to ensure that a payload will survive this hostile environment and continue working through the successful completion of its mission.

The ultimate purpose of environmental testing and evaluation is to determine if a particular payload can survive the environment specific to the vehicle configuration designated for that mission. A comprehensive preflight qualification process involves subjecting the complete payload, in its flight configuration, to a series of environmental elements such as vibration, bending, heating, spin, de-spin, and vacuum exposure.

Vibration Testing

The test specifications used for a particular payload are determined by the ignition and burn parameters of the rocket motors used for that launch. Vibration tests are performed in three payload axes - thrust and two orthogonal laterals. There are two types of vibration inputs – sine and random – for each axis. Shock pulses can also simulate motor ignition or payload separation events. A payload's response to an input vibration depends on the size, weight distribution, and harmonic frequencies of the assembly. A test is considered successful when the payload continues to perform all functions as designed after each round of vibration.


Payload on vibration table.

Bend Testing

The pressure effects of high velocity atmospheric flight create bending moments along the length of a payload, with the maximum moment occurring at the base where the payload attaches to the motor. The severity of this moment and the resultant payload bending are predicted during a detailed performance analysis prior to testing. Commonly, deflection is measured at the tip to determine the sum of all joint deflections under the anticipated bending moment. A test is considered successful if the total tip deflection is equal to or less than that predicted in the performance analysis, and if the deflection at an individual joint is within acceptable limits.


Bend testing of payload.

Spin Testing - Operational and Deployment

Sounding rockets are spin stabilized. Motor vehicle fin cants ensure that the assembly begins to spin-up as soon as it leaves the launch rail. The amount of spin at any given time in the flight sequence is referred to as the roll rate. Payloads often use the resultant centrifugal force to deploy doors, sensors, and other devices. Some deployments increase the spin inertia and thereby decrease the roll rate. Some payloads are designed to operate at zero roll rate and de-spin weights can be deployed to achieve that effect. Roll rate gradients occur during the intervals of rate change. Maximum spin rates, maximum rate gradients, and even the entire flight sequence spin rate profile can be reproduced in the spin test bay.


Payload with deployed booms and instruments.

Most spin deployments are performed in the same facility and photo or video data are collected. Using this optical data, in conjunction with telemetry signal data monitored during the tests, the payload team can verify that payload instruments are functioning properly throughout these events, and that the deployments can be performed successfully in flight, and/or they can identify problems which need to be addressed.

Mass Properties Measurements

Payload place on mass properties measurement table.

A payload's mass properties – weight, center of gravity, and moments of inertia – are calculated during the design phase. These numbers are incorporated into the early performance and ACS analyses to verify flight and control stability. Design changes are incorporated to enhance stability, to incorporate customer requirement changes, and to reacquire stability in an iterative process that may continue right up to the brink of test time. Accurate mass property measurements of the launch and control configurations are used to confirm the theoretical calculations and to provide the performance and ACS analysts with data to be used in the final pre-flight performance predictions.

Static And Dynamic Balancing

Payload being prepared for balancing.

Dynamic imbalances in the launch configuration could cause an unstable flight profile such as coning, which would decrease apogee altitude and experiment data collection time. Static or dynamic imbalances in the control configuration could degrade the attitude control system's ability to align property and acquire the mission target(s). The balance facility uses technology similar to that used for automobile tires but it is more accurate. Imbalances are first detected, and adjusted using lead or brass correction weights, then re-measured to verify that the problem has been resolved. Each payload has its own imbalance limits, determined by the launch, control, and mass property parameters specific to that payload.

Thermal Testing

Thermal testing verifies the ability of a payload or component to withstand elevated temperatures, caused by friction or onboard heat souces such as a transmitter. Several thermal testing chambers are available to accommodate components and systems of various sizes.

Vacuum Testing

Payload ready to enter the thermal–vacuum chamber.

Vacuum testing is conducted to verify that component shields and conductive heat sinks are designed such that the components will survive space conditions and function properly throughout all phases of exo-atmospheric flight. Out-gassing is a release of molecules from a material caused by exposure to vacuum and/or heat. Scientific detectors are often very sensitive to contamination and must be isolated from materials that out-gas excessively. Materials that cannot be isolated from the detectors must be thoroughly cleaned and then forced to out-gas completely by high temperature baking and other methods. Subsequent thermal vacuum testing can verify that these materials have been rendered inert.

Launch operations support

Both established and temporary launch sites world wide are available to accommodate the needs of the PI. Established launch ranges exist in Alaska, New Mexico, Virginia, Norway, Sweden and Australia. Coupled with temporary sites in Greenland, Marshall Islands, Puerto Rico and Brazil provide extensive access to phenomena of interest to the science community.

The Sounding Rockets Program, in cooperation with the Wallops Range, provide all necessary personnel and equipment to conduct successful missions anywhere in the world.

Additionally, ground and flight safety analyses are provided by the NASA Safety group at Goddard Space Flight Center's Wallops Flight Facility, home of the Sounding Rockets Program.

Past and present world wide launch sites used by the Sounding Rockets Program to conduct scientific research:

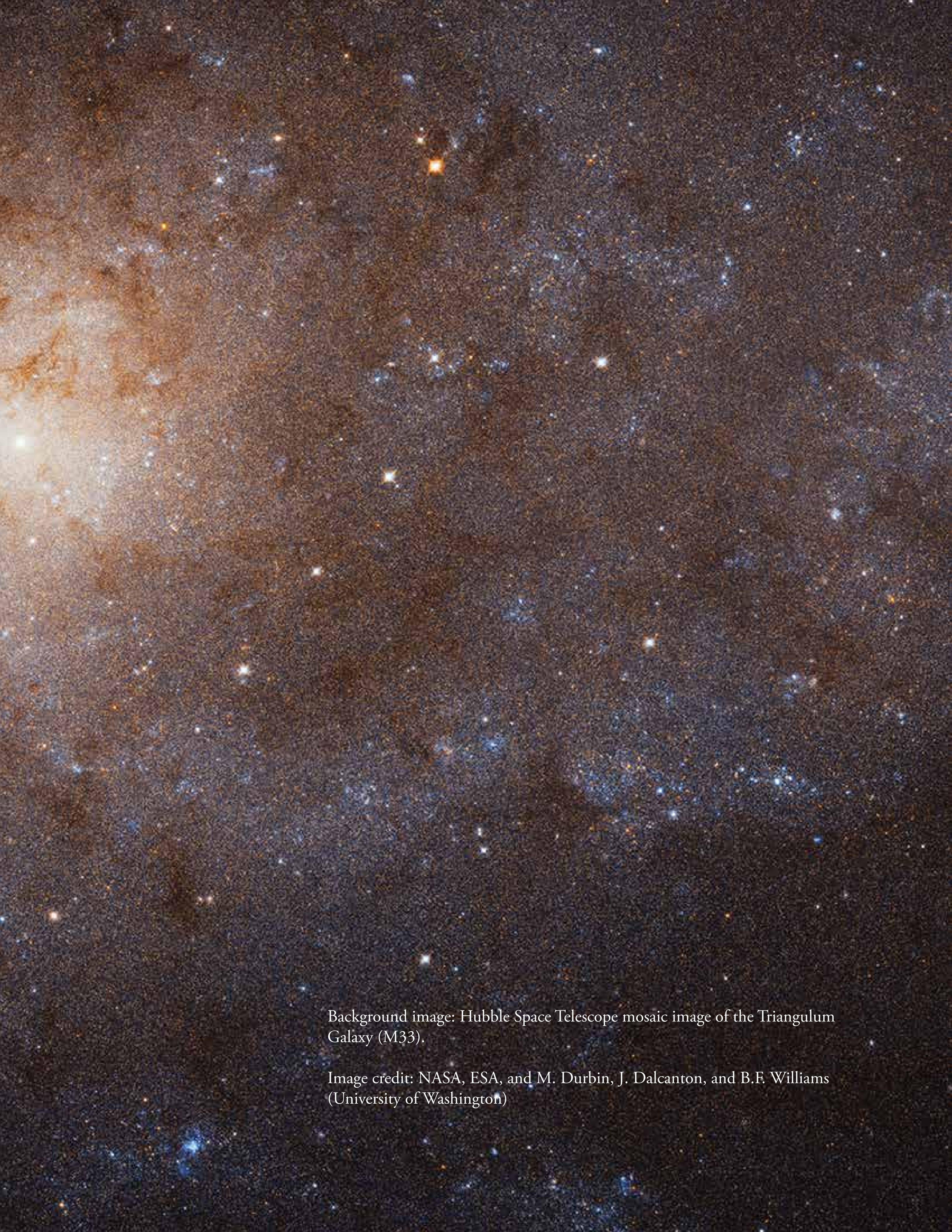
1. Kwajalein Atoll, Marshall Islands
2. Barking Sands, HI
3. Poker Flat, AK
4. White Sands, NM
5. Punta Lobos, Peru *
6. Alcantara, Brazil *
7. Camp Tortuguero, Puerto Rico *
8. Wallops Island, VA
9. Fort Churchill, Canada *
10. Greenland (Thule & Sondre Stromfjord) *
11. Andøya, Norway
12. Esrange, Sweden
13. Svalbard, Norway
14. Australia (Equatorial Launch Australia (ELA) & Woomera)

* Inactive launch sites

Two sounding rockets launching from Poker Flat Research Range, AK.
Photo by: Wallops Imaging Lab

Astrophysics Missions 2020

In 2020 three Astrophysics missions were flown. Two missions, Determining Unknown yet Significant Traits (DUST) 1 and 2, were part of a new discipline, Laboratory Astrophysics. The third Astrophysics mission, Far-ultraviolet Off Rowland-circle Telescope for Imaging and Spectroscopy (FORTIS), studied Galaxy M33 in the Ultraviolet. All three missions were successfully flown from White Sands Missile Range, NM.



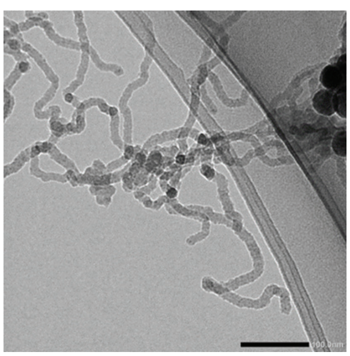
Background image: Hubble Space Telescope mosaic image of the Triangulum Galaxy (M33).

Image credit: NASA, ESA, and M. Durbin, J. Dalcanton, and B.F. Williams (University of Washington)

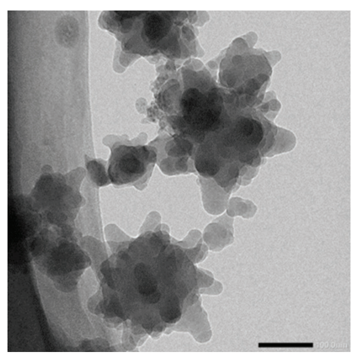
Determining Unknown yet Significant Traits (DUST)*

The purpose of the Determining Unknown yet Significant Traits (DUST) experiment was to measure important variables in the end-to-end process of grain formation in circumstellar outflows around AGB stars and model the physical and chemical properties of the dust. DUST studied how individual atoms, shed by dying stars and supernovae, stick together. When they do, they form dust grains – some of the basic building blocks of our universe. DUST attempted to determine the most important physical properties controlling dust production and measure the infrared spectrum of the analog dust grains during formation and agglomeration in the laboratory and in microgravity. The DUST instrument included four double wavelength interferometers and two in-situ IR spectrometers.

The DUST experiment studied the nucleation, growth and aggregation of silicate grains. Over a period of 460 seconds in microgravity silicate particles formed following the evaporation of starting materials previously deposited onto tantalum filaments that were resistively heated in six different experimental chambers. Particles formed via homogeneous nucleation from a supersaturated vapor after cooling in a buffer gas of either pure argon or a mixture of argon plus oxygen. The temperature and concentration of the evaporated vapor can be determined by direct imaging of a double-wavelength, Mach-Zehnder type interferometer. Both the payload and the particles produced during the experiment were recovered. After recovery these analog presolar silicates were studied using a transmission electron microscope. The particles have a size distribution centered at ~40 nm in diameter and are mostly amorphous but with some small degree of crystallinity in some grains. While some aggregated grains show clear boundaries between the particles, other samples show complete fusion with no observable boundaries remaining.



The image shows particles condensed from an SiO vapor in pure Ar. Note the very uniform particle size distribution, "head–to–tail" aggregation and significant level of grain fusion while still retaining distinct individual particles.



The image shows particles condensed from Mg + SiO vapor in an Ar + O2 background gas. Addition of O2 appears to increase the surface tension or decrease the melting point (or both?) causing aggregates to form large "blobs." Although aggregates do not form spherical particles, boundaries between silica grains on the edges are blurred or erased.

* Ref. 51st Lunar and Planetary Science Conference (2020), 2289.pdf, Microgravity Nucleation of Iron and Magnesium Silicates. Joseph A. Nuth II, et.al.

Principal Investigator: *Dr. Joseph Nuth/NASA GSFC* • ***Mission Number(s):*** *36.343 GB*
Launch site: *White Sands Missile Range, NM* • ***Launch date:*** *October 7, 2019*

Far-ultraviolet Off Rowland-circle Telescope for Imaging and Spectroscopy (FORTIS)

FORTIS is a multi-object spectro/telescope equipped with a next-generation microshutter array (NGMSA) capable of imaging individual stars within NGMSA slitlets while simultaneously obtaining their far-UV spectra. The primary science goal for this mission was to study massive hot star clusters in the star-forming Galaxy M33.

FORTIS sequence testing at Wallops Flight Facility in August 2019.

The star-forming spiral disk galaxy Messier 33 (M33) is a near naked-eye object in the Triangulum constellation with an angular extent of~60'x35'. This galaxy, located about 3 million light-years from Earth is the third largest member in the Local Group of galaxies, which includes our own Milky Way along its more massive companion the great (naked-eye) galaxy in Andromeda, also as known as M31. The M33 disk is littered with clusters of massive hot stars that have emerged from collapsing cold natal clouds of gas and dust within the past few million years. These clusters emit copious amounts of light at ultraviolet (UV) wavelengths; light which does not penetrate the Earth's atmosphere and can only be observed from space at altitudes greater than 100 km. They also produce strong stellar winds that have blown apart their natal clouds, herding them into compressed regions of gas and dust surrounding the emerging hot star clusters, while simultaneously spewing fountains of hot enriched material into the circumgalactic medium above the disk.

This mission (36.352 UG) measured the far-UV emission stratification of the hot stellar clusters that litter the disk of M33 by quantifying variations in the gas-to-dust ratio, and searching for suspected sources of unidentified emission hinted at by far-UV photometry from the Hubble Space Telescope. The suspected sources of the emissions include supernovae remnants, H II regions, and photo-dissociation fronts. Each of these regions has a unique spectral signature that are predicted to appear at different distances with respect to the cluster core, reflective of local physical conditions. These measurements will inform our understanding of the contribution of hot star clusters to the circulation of material out of the disk and into the circumgalactic medium, a process which is relevant to understanding spectroscopic measurements of regions surrounding similar type galaxies observed a higher redshift where the spatial resolution is lower.

Principal Investigator: *Dr. Stephan McCandliss/Johns Hopkins University* • ***Mission Number(s):*** *36.352 UG*
Launch site: *White Sands Missile Range, NM* • ***Launch date:*** *October 28, 2019*

Determining Unknown yet Significant Traits (DUST) 2

DUST-2, a collaboration between NASA and the Japan Aerospace Exploration Agency, followed up on the DUST mission launched in October 2019. DUST-2's goal is to study how individual atoms, shed by dying stars and supernovae, stick together. When they do, they form dust grains – some of the basic building blocks of our universe. The purpose of the DUST-2 experiment was to measure important variables in the end-to-end process of grain formation in circumstellar outflows around AGB stars and model the physical and chemical properties of the dust. The scientific goal was to determine the most important physical properties controlling dust production and measure the infrared spectrum of the analog dust grains during formation and agglomeration in the laboratory and in microgravity.

DUST–2 team at White Sands Missile Range. Photo by Visual Information Branch/WSMR

Like DUST, the DUST-2 experiment has six sealed chambers, and inside each chamber is a heated filament. The filaments are coated with thin layers of iron, silicon, magnesium and other particles and diffuse into the surrounding chamber as the filament heats. Some of these atoms will collide and stick – the beginnings of a dust grain – while others ricochet away. Each minute, during the approximately 6-minute long flight, a chamber turns on until the payload parachutes back to Earth for recovery.

Results from the DUST showed that dust grains that formed in argon gas with a small fraction (5%) of oxygen tended to merge together more than those formed in pure argon, a non-reactive noble gas. Without the oxygen, when the atoms touched they stuck together. But with oxygen, when the atoms touched, they partially merged together. That result was not expected. The theory is that oxygen lowered the melting point of the dust grain, and incoming particles merged into partly molten material. To test this idea, DUST-2 removed all oxygen and replaced it with a small quantity (about 5%) of hydrogen, which would lead to no merged particles.

The DUST-2 experiment included a new carbon fiber heating filament for more precise control of the temperature. Data from the flight is being analyzed.

Principal Investigator: *Dr. Joseph Nuth/NASA GSFC* • ***Mission Number(s):*** *36.365 GB*
Launch site: *White Sands Missile Range, NM* • ***Launch date:*** *September 8, 2020*

36.343 GB Nuth launches from White Sands Missile Range, NM
Photo by: Visual Information Branch/White Sands Missile Range

Geospace Missions 2020

Geospace Science in 2020 included two missions, as part of the Grand Challenge Initiative (GCI) – Cusp, and one mission from Poker Flat Research Range in Alaska. The Cusp Heating Investigation (CHI), as well as, the international mission, Investigation of Cusp Irregularities (ICI) 5, were launched in FY 2020. CHI and ICI-5 were part of GCI-Cusp. The Polar Night Nitric Oxide (PolarNOx) was launched from Poker Flat Research Range, Alaska.

Background image: Poker Flat Research Range/Photo by Scott Hesh

Investigation of Cusp Irregularities (ICI) 5

The Investigation of Cusp Irregularities (ICI) 5 mission was part of the Grand Challenge Initiative - Cusp, an international scientific data sharing partnership.

Andoya Space Center (ASC) was responsible for the overall management of the mission and provided the ICI-5 payload via the University of Oslo, while NASA provided the launch vehicle.

The cusp is a source of local perturbations in the ionosphere and also a source of ionospheric disturbances that propagate all the way to mid and low latitudes. The ICI payload contained a 4D space module that was designed to deploy six daughter payloads. The main payload contained an instrumentation suite provided by a multinational science team that included researchers from Norway, United States, and Canada.

Due to an anomalous flight, data was not received from the instruments on ICI-5.

ICI–5 lift–off from Ny Ålesund, Svalbard, Norway.
Photo by: Allison Stancil–Erwin/NASA

Principal Investigator: *Dr. Moen/University of Oslo* • ***Mission Number(s):*** *46.029 IE*
Launch site: *Ny Ålesund, Svalbard, Norway* • ***Launch date:*** *November 26, 2019*

Cusp Heating Investigation (CHI)

After waiting diligently for science conditions to be suitable, CHI was launched from Ny Ålesund in Svalbard, Norway on December 10, 2019.

The purpose of the mission was to measure neutral upwelling and high-resolution electric fields over an extended region in the cusp. The measurement technique was eight non-ejecting barium/strontium canister releases distributed across the vehicle trajectory above 180 km altitude.

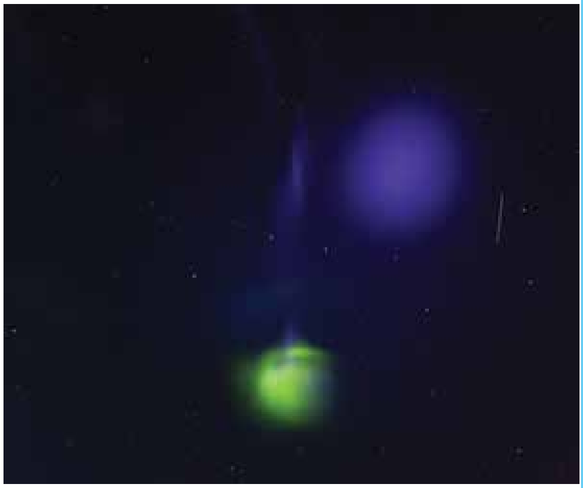
Satellite measurements show consistent evidence of small-scale field-aligned current structure in the region where the cusp neutral upwelling is found.

Numerical modeling studies indicate that Joule heating, produced by the small-scale electric field fluctuations associated with this type of structure, appears to be the most likely driver for the upwelling. So far, a sufficiently comprehensive and detailed data set has not been available to test the model predictions.

CHI was designed to allow both plasma drift measurements, obtained from barium clouds that ionize in sunlight, and neutral wind measurements from strontium clouds that remain neutral. Estimates of Joule heating, including the small-scale contributions, are achieved using a combination of the in-situ rocket measurements and groundbased radar data.

Initial reports indicate that all eight Barium releases, and two of the Strontium releases, occured as planned.

CHI lift–off from Ny Ålesund, Svalbard, Norway.
Photo by: Allison Stancil–Erwin/NASA



CHI vapor trails.
Photo by: Allison Stancil–Erwin/NASA

Principal Investigator: *Dr. Miguel Larsen/Clemson University* • ***Mission Number(s):*** *36.349 UE*
Launch site: *Ny Ålesund, Svalbard, Norway* • ***Launch date:*** *December 10, 2019*

Polar Night Nitric Oxide (PolarNOx)

The Aurora contributes to a process that has an adverse impact on the Earth's ozone as nitric oxide (NO) is created during the auroral light show. The aurora creates NO, but in the polar night, unlike the sunlit atmosphere, there is no significant process for destroying the NO, and it may build up to large concentrations. The purpose of PolarNOx is to measure the abundance and especially the altitude of peak abundance for the NO.

NO under appropriate conditions can be transported to the stratosphere where it will catalytically destroy ozone. Those changes in ozone can lead to changes in stratospheric temperature and wind and may even impact the circulation near Earth's surface.

PolarNOx observed starlight with a high spectral resolution UV spectrograph operating near 215 nanometers. Attenuation of the starlight by NO is used to obtain an NO altitude profile. Data from PolarNOx will aid in the understanding of the abundance of NO in the polar atmosphere, and its impact on ozone.

PolarNOx lift–off from Poker Flat Research Range, AK.
Photo by: NASA Wallops Imaging Lab

PolarNOx payload testing before flight.
Photo by: NASA Wallops Imaging Lab

Principal Investigator: *Dr. Scott Bailey/Virginia Tech* • ***Mission Number(s):*** *36.356 UE*
Launch site: *Poker Flat Research Rangge, AK* • ***Launch date:*** *January 26, 2020*

36.356 UE PolarNOx on the balancing table at Wallops
Photo by: Berit Bland/NSROC

Technology Development Missions 2020

One dedicated Technology Development mission was launched in Fiscal Year 2020. The new emerging technologies tested on this flight include Distributed Payload Communications, as well as, component level improvements to a variety of systems.

Sub-TEC 8 deployable antenna testing
Photo by: Berit Bland/NSROC

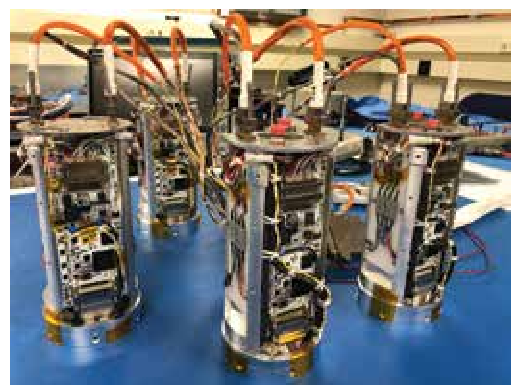
SubTEC-8

The 46.020 Hesh (SubTEC 8) technology demonstration mission launched on October 24, 2019. The mission featured several experiments from NASA and NSROC, designed to test sounding rocket development components and subsystems. The mission objectives included: (1) demonstrate distributed sub-payload to main payload telemetry communication, (2) provide an observation opportunity for one prototype star tracker (3) demonstrate a 40 Mbps telemetry encoder; and (4) provide a test flight opportunity for several sounding rocket development components and subsystems. Experiments from NASA ETD included: distributed measurement communication, low cost star tracker, airborne power supply unit (APSU), autonomous rocket tracker (ART), and solid state altimeter. Experiments from NSROC included: 40 Mbps high data rate encoder, wideband S-band/GPS high temperature combo antenna, GNC integrated power system, and the NIACS with Tern Inertial Navigation System (INS) controlling.

Sub–TEC 8 Payload

Distributed Payload Communication

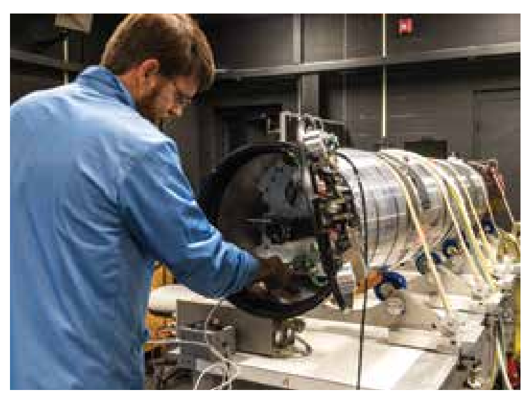
Distributed Payload Communication is a NASA Sounding Rockets Program (NSRP) development effort using matrixed NASA Engineering and Technology Directorate (ETD) engineers to design a system that telemeters data from multiple deploying sub-payloads to the main payload. The ETD design effort encompasses a sub-payload transmitting antenna, a sub-payload command and control board with embedded encoder, a main payload receive software defined radio, and a main payload receive antenna system with filter and low noise amplifier. The SubTEC 8 payload deployed four sub-payloads – two via high velocity springs and two via Commercial-off-the-Shelf (COTS) rocket motors. All four sub-payloads telemetered data at 1 Mbps.



Sub–payloads for SubTEC 8.

Low Cost Star Tracker (LCST)

The LCST is designed to provide arcsecond level pointing accuracy using COTS components. Objectives for this flight was to show lost in space solution on star field and track identified stars. Both objectives were successfully met.



LCST setup for alignment checks.

Principal Investigator: *Ms. Catherine Hesh/NASA GSFC WFF* • ***Mission Number(s):*** *46.020 GT*
Launch site: *Wallops Island, VA* • ***Launch date:*** *October 24, 2019*

High Data Rate Telemetry Encoder

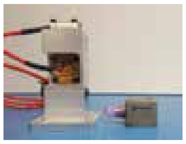
NSROC has selected Curtiss-Wright's Axon system for the high data rate telemetry encoder. Curtiss Wright currently offers a wide variety of data modules including but not limited to, analog and asynchronous with output accommodations for PCM and Ethernet with a roadmap to add additional capabilities every quarter for the foreseeable future. Curtiss Wright also offers options for development of custom modules at a rate of 1 deck per year for required sounding rocket specific data types. The Axon encoder also allows the use of satellite stacks that can be scattered throughout the payload. A prototype unit was configured and flown on SubTEC 8 mission in FY 2020 with a dedicated 40 Mbps telemetry downlink. This successful test monitored accelerometers, magnetometers, and frame counters.

Other technolgies under development

Several other technologies under development by SRPO were flown on SubTEC 8.

High Temp GPS/S-Band Combo Antenna: New Global Positioning System (GPS)/S-Band combo antenna design with a two layer design improves manufacturing yield over older three layer design. The antenna performed well, and the recorded peak temperature during flight was around 225°F.

New Spin Motors; Redesign of the M37 legacy spin motor. New spin motor will maintain the legacy motor performance with new propellant expected to achieve DOT Class 1.3C certification. Both steel and aluminum motor case variants were flown on SubTEC-8. The performance appeared nominal from video and roll rate data.



New Accelerometers: Intended to replace the legacy equipment with smaller footprint and all 3 sensing axes in one package. Equal/better accuracy to legacy sensor. Side-by-side comparison with legacy Setra accelerometers indicates good performance.

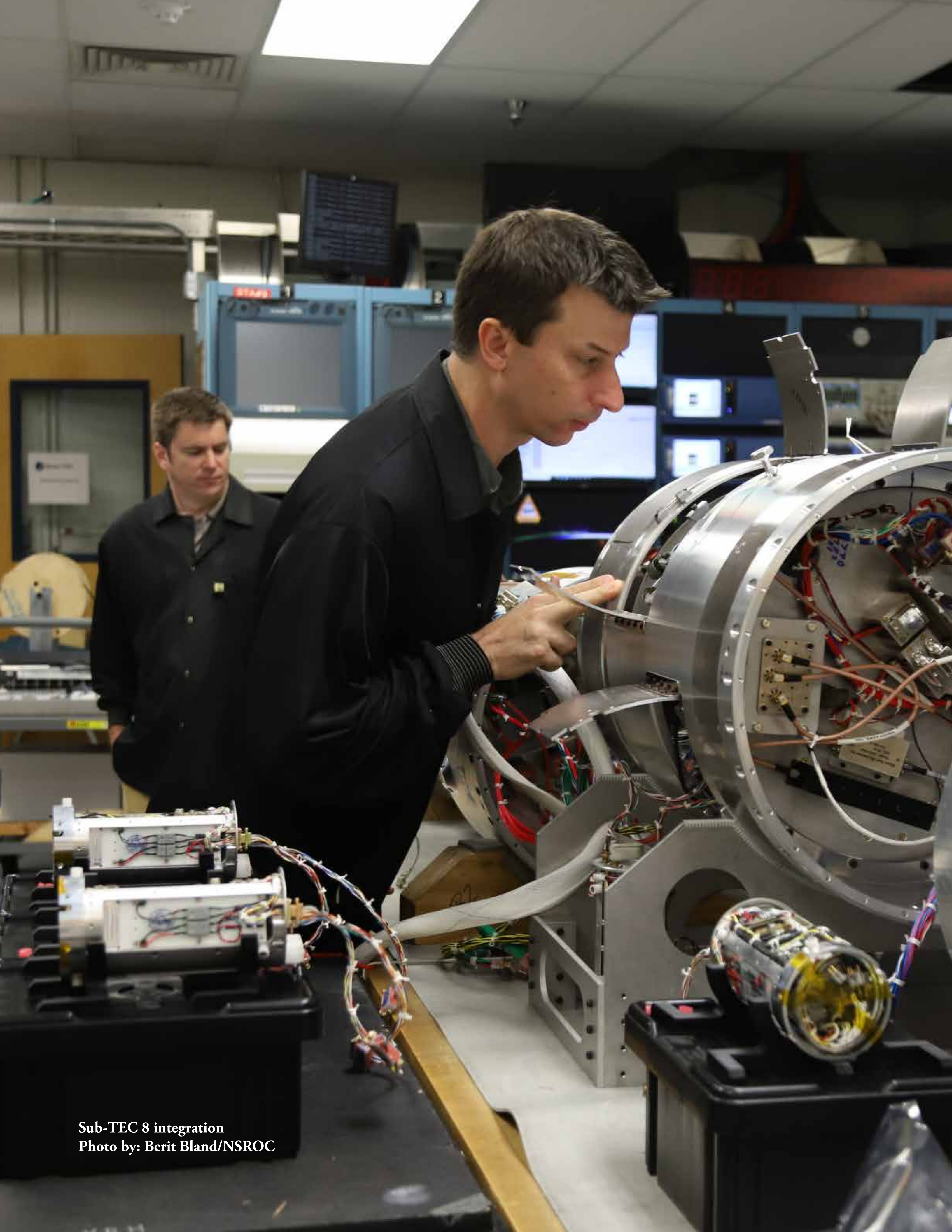
Tern Inertial Navigation System (INS): Replacement to the legacy GLN-MAC devices with better manufacturability and enhanced attitude solution and capabilities. The Tern INS test was successful.

Airborne Power Supply Unit (APSU): Programmable DC/DC converter than can supply dual constant voltage or constant current outputs in a small enclosure, enabling power conditioning from a single bus to multiple outputs with differing requirements. The APSU exhibited nominal performance through entire mission. Input monitors, internal rail monitors, and output monitors were all nominal

Autonomous Rocket Tracker (ART): External nacelle designed to relay GPS coordinates to a remote user via the Iridium satellite network. Design is completely independent from the payload and mounts to the outer payload skin via straps. Two units flown, both sent Iridium message during descent. Only one unit transmitted Iridium and GPS during float. 23 GPS messages received during float from T+10 minutes to T+42 minutes. One unit was fully functional post-flight, the other unit was damaged by water.

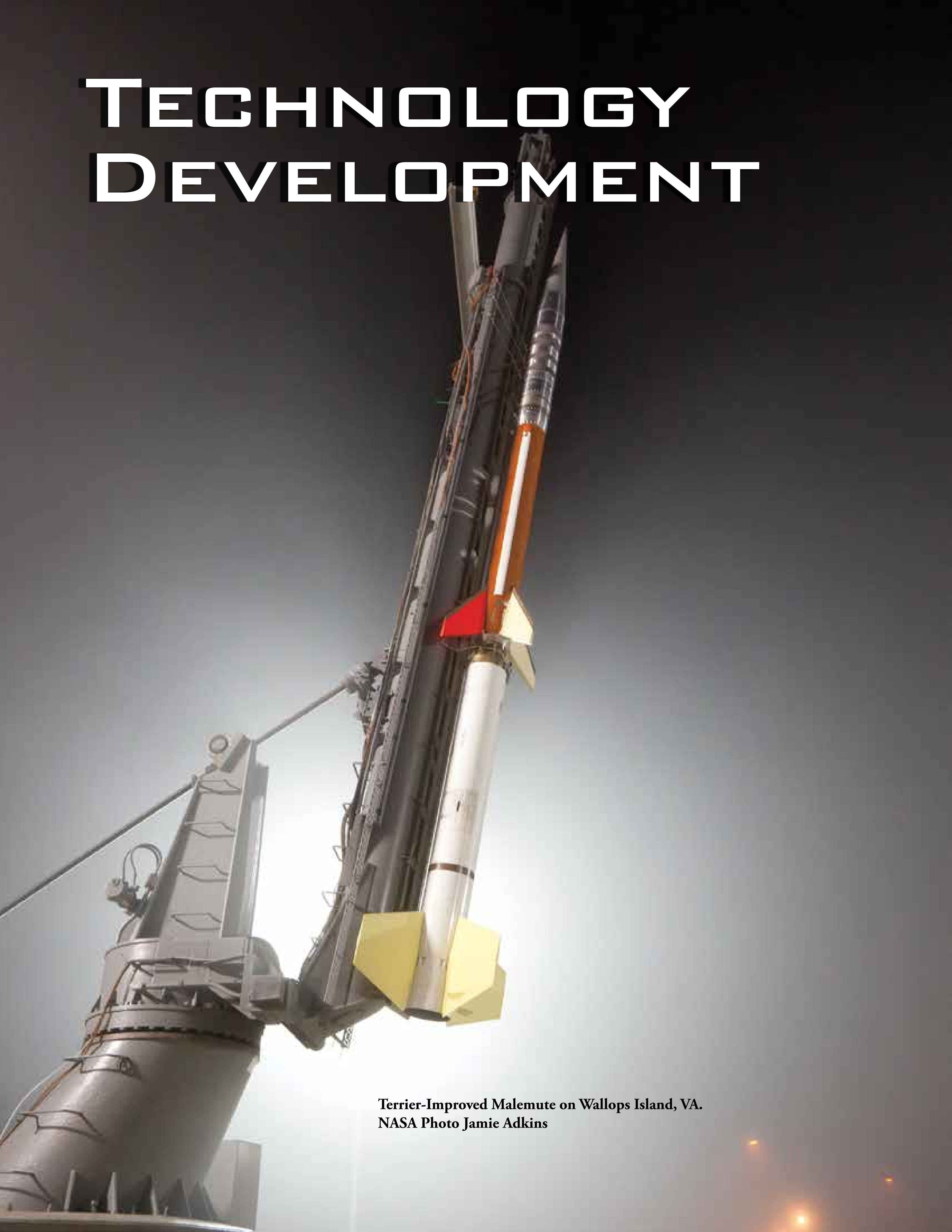
Solid State Altimeter: Replacement for legacy plenum chambers. Smaller footprint and more reliable altitude detection. The Solid State Altimeter performed nominally during flight. All switching occurred as planned, and compared well against GPS altitudes. A ram air spikes was observed on descent.

Autonomous Flight Termination System (AFTS): NASA AFTS to acquire and/or develop capabilities, procedures, and tools needed to satisfy WFF responsibilities associated with certifying and processing an AFTS as the primary safety system. The AFTS detected liftoff within two seconds. Good GPS comparison between two different receivers was recorded. A 5 second GPS data drop was experienced on one receiver, but the receiver recovered.



Sub-TEC 8 integration
Photo by: Berit Bland/NSROC

Technology Development



Terrier-Improved Malemute on Wallops Island, VA.
NASA Photo Jamie Adkins

The NASA Sounding Rocket Program (NSRP) continues to assess new technologies in order to expand the capabilities for our science and technology customers, address obsolescence, and to improve efficiency. The major initiatives of the NSRP technology roadmap continue to focus on (1) providing increased scientific observation time for Solar and Astrophysics missions, (2) increasing the telemetry data rates from the current capability of 10 to 20 Mbps to systems with rates ranging from 40 to ~400 Mbps, and (3) developing free-flying sub-payload technologies. The NSRP leverages resources from NSROC, the NASA Engineering and Technology Directorate (ETD), the WFF Technology Investment Board, Small Business Innovative Research (SBIR), and Internal Research and Development (IRAD) programs to meet our growing technology needs.

The next dedicated technology development flight is SubTEC-9, scheduled for launch in 2022. As with prior technology development missions, SubTEC-9 will carry a multitude of experiments. The high level objectives of the flight are:

- Test high data rate C-band telemetry link (~40 Mbps) to test out both flight and ground components
- Test the Deploying and Retracting Tubular (DaRT) boom system with 360º cameras
- Test the ETD Wallops Integrated Star Tracker (WaIST) in a relevant flight environment
- Provide a test flight opportunity for several NSROC and NASA ETD development components and subsystems
- Provide a testflight opportunity for external piggyback experiments

Main objectives for SubTEC-9

High Data Rate C-band Telemetry Link (NSROC)

A C-band telemetry link will be tested and evaluated as an alternative to the currently used S-band systems. Increasing commercial wireless demand is making S-band use less desireable for SRPO. There are several benefits to transitioning to C-band use:

- C-Band allows 540 MB RF bandwidth (lower C-Band)
- C-Band allows for higher data rates and/or more downlinks
- Flight hardware need minimal Non-recurring engineering (NRE) for C-band compatibility
- Minimal ground station upgrades are required for C-band

Objectives of the SubTEC-9 C-band link includes:

- Demonstrate C-Band Downlink Capability & Functionality
- C-Band downlink using 40 MB Axon RS-422 transmitter

Deploying and Retracting Tubular (DaRT) boom system (ETD)

The SubTEC-9 payload includes the first flight test of the DaRT boom system. For this flight cameras are mounted on the booms, which are then deployed and retracted. The boom systems are mounted in an opposing pair configuration, resulting in a tip-to-tip span of 5 meters.

Opposing pair configuration

DaRT interior view.

Wallops Integrated Star Tracker (WaIST) (ETD)

The main objectives are to test the low cost star tracker in a flight environment, and to show lost in space solution on star field. and tracking of identified stars

Additional SubTEC-9 Technology Development Experiments

NSROC Experiments

Space Eye 320 Ethernet Camera

Objective:

– Provide high data rate source for Ethernet Payload

– View of interest: Motor Fins & Earth

The Space Eye Ethernet Camera requires a C-Band Quasonix EVTM (Ethernet via Telemetry) Transmitter.

Gigabit Ethernet Switch W/ Time Stamping

Objective:

– Facilitate communication and data transfer from camera/payload to ground

PAyloadRegulation System Ethernet Controller (PARSEC)

Objective

– To implement an ethernet-based replacement of the traditional PCD.

– Interface with the new Axon Encoder or directly with an ethernet transmitter.

– To scale down into a smaller/lighter form factor than the traditional PCD.

Haigh-Farr GPS/S-band Combo Antenna Design

Objective:

– Provide a second source for wrap-around GPS/S-band combo antenna.

– Specifications to be the same as the existing qualified design for compatibility.

Wallops Solid State Peripheral Control Relay Board (SPECTR)

Objective:

– Replace electro-mechanical relays.

– Allows more events with further reduction of flight hardware and weight.

Next-Gen Battery (Lithium-Ion)

Objective:

– Demonstrate Parallel Pack and Single Pack Design. Battery design allows for paralleling packs in equipment to create a larger capacity, Parallel design as the first option and the single pack design as the alternate

– Power for the PARSEC experiment

Improved Malemute Igniter Re-design

Objective:

–Develop a replacement igniter for the IM motor

Strain Gauge Monitoring System (SGMS)

Objective:

– Test the SGMS in a flight environment

NSROC Ethernet Sensor Suite

Objective:

– To provide a low cost flight test of the Ethernet downlink capability of next generation encoders.
– Data will be collected with an Arduino based device
– Data will be transmitted via Ethernet
– Sensors include: 3-axis Magnetometer, Accelerometer and Gyro, Current Sensing and Voltage Monitoring

Command Uplink (CU) D/A Board Redesign

Objective:

– Consolidate WFF-93 Command Deck functionality into CU D/A Board
– Eliminate the WFF-93 Command Deck in WFF-93 stack
– Make the CU D/A Board all surface mount components

ETD Experiments

High Data Rate Recorder

Objective:

– Record Gigabit Ethernet data at maximum throughput
– 0.25 TB of data stored to solid-state medium
– Mission data retrievable over USB 3.0 connection

Piggyback Experiments

Printed Hybrid Electronics (PHE) Demonstration

This test will evaluate the performance of PHE, and will include additively manufactured Arduino-type circuits including Temperature and Humidity sensors on the inside and outside of a waterproof sounding rocket payload door. The objectives include collecting data and recovery of circuits from experiment to evaluate performance after flight and robustness of the circuits.

Dual Band Datalink Antenna System for Ballistic Missile Defense (BMD) Assets

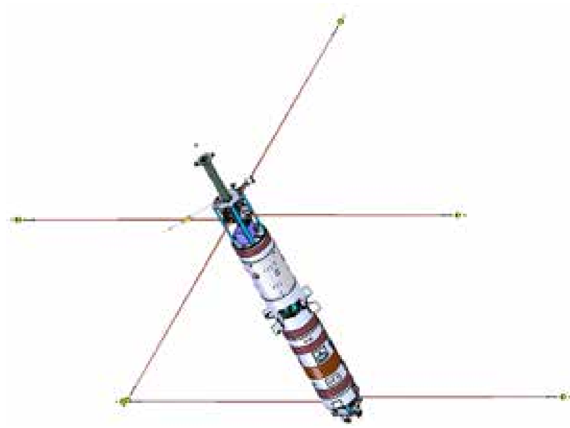
The overall objective is to develop a lightweight, low profile dual band datalink antenna system for BMD platforms

Additional Technology Development

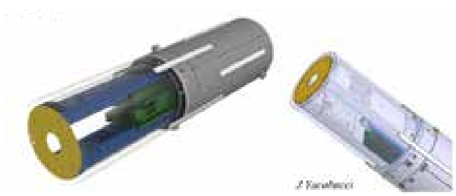
In addition to the dedicated technology development missions, such as the upcoming Sub-TEC 9, the SRPO provides enhancements to new technologies for science missions. For the Kinetic-scale Energy and momentum Transport eXperiment (KiNET-X) mission several upgrades are being made to the Distributed Payload Communication sub-payload system (see page 28.) KiNET-X is designed to enhance our understanding of a key aspect of heliophysics; the energy and momentum coupling between spatially separate but magnetically linked plasma regimes. With known energy and momentum input, KiNET-X is designed to test the understanding of kinetic-scale transport. In particular, these questions are addressed: 1) how momentum transport is affected by ion kinetic-scale physics, 2) how electromagnetic energy is converted into plasma kinetic and thermal energy, 3) the interplay between fluid- and kinetic-scale processes.

KiNET-X is a multi-instrument payload with participation from several science institutions and organizations, currently scheduled for launch from Wallops Island, VA in 2021. The Principal Investigator is Dr. Peter Delamere from University of Alaska, Fairbanks. The deployable sub-payloads, developed by SRPO and ETD, contain instruments provided by Co-Investigator Dr. Kristina Lynch from Dartmouth College.

Several modifications are being made to the sub-payloads for this mission. A modular battery package, for longer data collection times on the sub-payloads, and a miniature GPS package, for improved location information during flight, are being added. The GPS antenna has been tested with good results. Additionally, a dual-channel "Marko" receiver for the main payload has been developed. This enables one receiver to track two ejectables, or two receivers to track four ejectables. The prior design used one receiver to track four ejectables that exited the payload at different times. That configuration led to signal loss from the first set of deployables, due to the second set, still inside the main payload, overpowering the weaker signal from the deployed sub-payload.

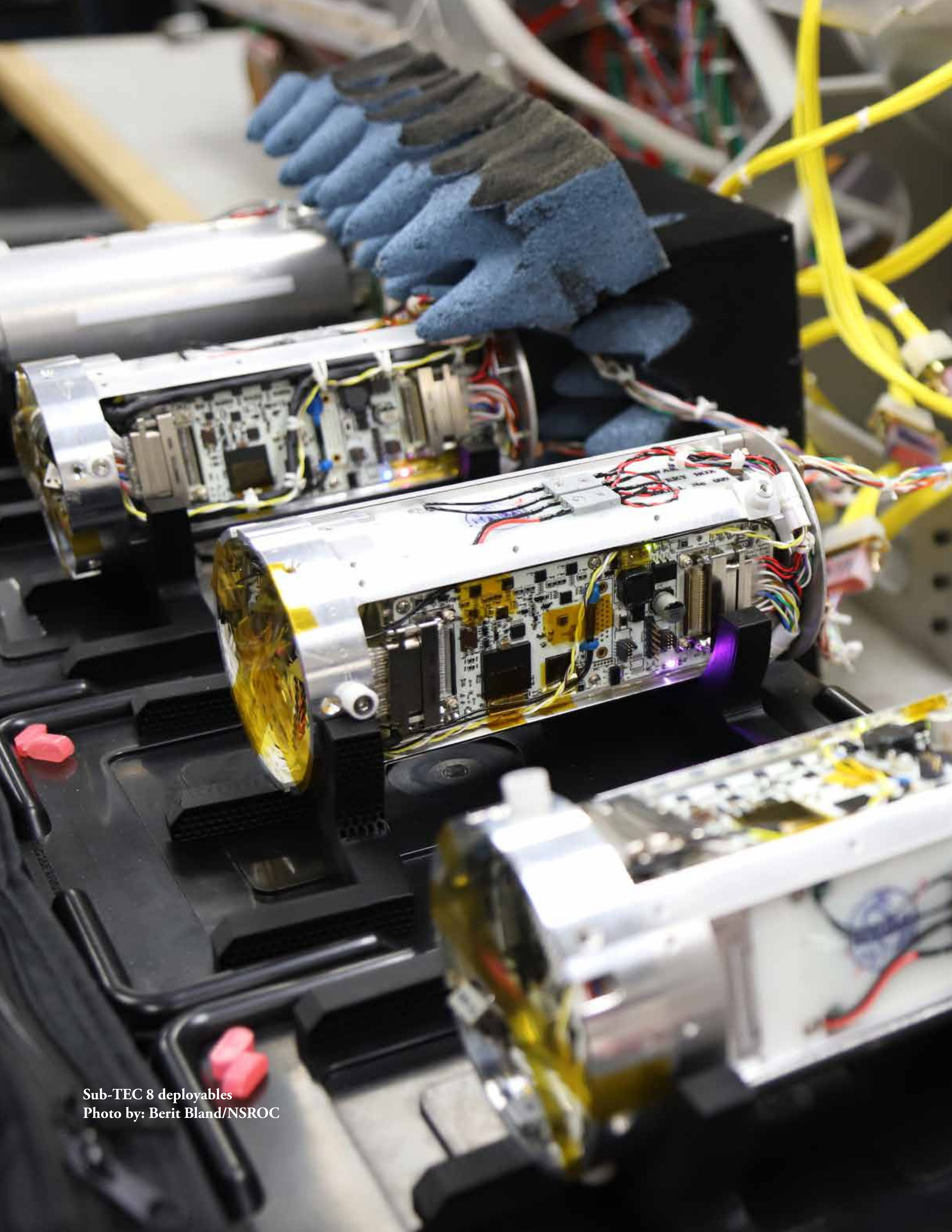


KiNET–X payload



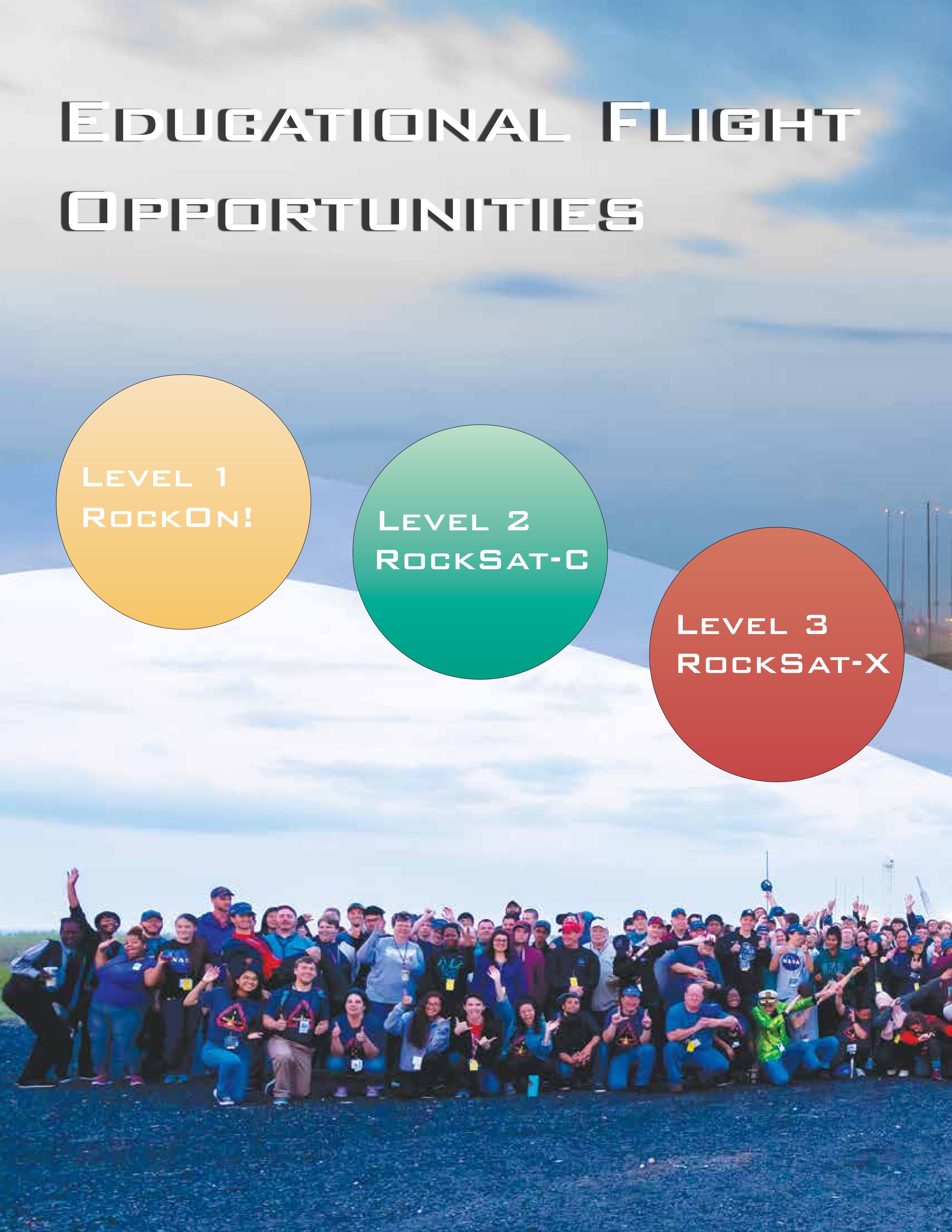
Deployable sub–payloads.

Modified deployable.
3D model by Josh Yaccobucci/NASA ETD



Sub-TEC 8 deployables
Photo by: Berit Bland/NSROC

Educational Flight Opportunities



Level 1
RockOn!

Level 2
RockSat-C

Level 3
RockSat-X

Due to the CoVid-19 pandemic in 2020, the student flight opportunities were postponed. Flights will resume when it is safe to do so.

This section outlines the three University and College level opportunities that have been available since 2008. Students and faculty are encouraged to monitor the Colorado Space Grant website for updates.

RockOn: **https://spacegrant.colorado.edu/national-programs/rockon-home**
RockSat-C: **https://spacegrant.colorado.edu/national-programs/rs-c-home**
RockSat-X: **https://spacegrant.colorado.edu/national-programs/rs-x-home**

RockOn & RockSat-C

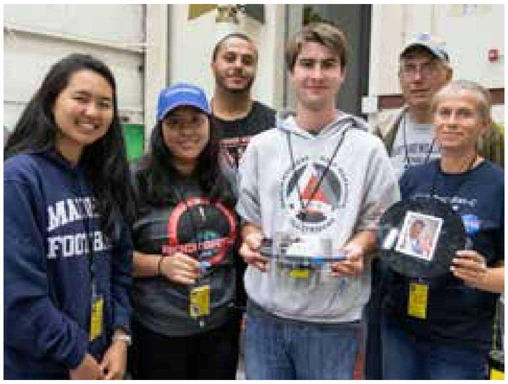
The goal of the ***RockOn*** mission is to teach university faculty and students the basics of rocket payload construction and integration. RockOn also acts as the first step in the RockSat series of flight opportunities, and workshop participants are encouraged to return the following year to design, build, test, and fly their own experiment. The RockOn! experiments are designed to capture and record 3-axis accelerations, humidity, pressure, temperature, and radiation counts over the course

The chart above shows the workflow for the RockOn! and RockSat–C programs.

1. RockOn! workshop participants build their experiment during the workshop.
2. All materials and instructions are provided to complete the experiment.
3. Experiment boards are stacked on an internal structure that accommodates five boards.
4. Experiment stacks are housed in canisters (RockOn!). RockSat–C experiments are not board based but are also housed in canisters.
5. All canisters are integrated with the payload structure.
6. Payload is tested prior to flight. Tests include Moments of Inertia measurement (roll moment measurement shown in picture), vibration, and balancing.
7. Payload is launched with a two–stage Terrier–Improved Orion sounding rocket before the end of the workshop week. Participants view the launch from Wallops Island.

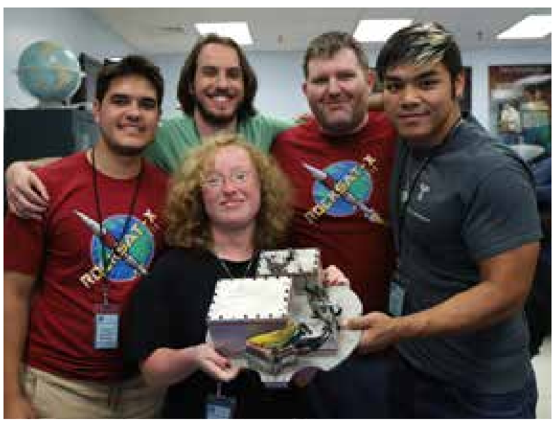
of the mission. All items and instruction necessary to complete the experiment are provided for the participants during the workshop week, and teams of students and faculty work together to build their experiment. The workshop culminates with the launch of the experiments on a Terrier-Improved Orion sounding rocket.

RockSat-C offers students an opportunity to fly more complex experiments of their own design and construction. The intent is to provide hands-on experiences to students and faculty advisors to better equip them for supporting the future technical workforce needs of the United States and/or helping those students and faculty advisors become principal investigators on future NASA science missions. Teaming between educational institutions and industry or other interests is encouraged.



RockSat-X

RockSat-X is the third, and most advanced, student flight opportunity. RockSat-X experiments are fully exposed to the space environment above the atmosphere. Power and telemetry were provided to each experiment deck. Additionally, this payload included an Attitude Control System (ACS) for alignment of the payload. These amenities allow experimenters to spend more time on experiment design and less on power and data storage systems.



RockSat-X team in 2018 with Payload.

The Sounding Rockets Program Office (SRPO) and NASA Sounding Rocket Operations Contract (NSROC) offer opportunities for teachers and students to participate in rocketry related activities.

The Wallops Rocketry Academy for Teachers and Students (WRATS) workshop is offered annually to High School teachers interested in incorporating rocketry activities in their teaching.

NSROC and SRPO staff visit schools to give lectures, arrange rocketry activities, and judge science fairs. Additionally, tours are given to groups of all ages of the payload manufacturing and testing areas.

NSROC manages the internship program and recruits about 10 - 15 interns annually from Universities and Colleges. The interns work with technicians and engineers on rocket missions and gain invaluable work experience.

The CoVid-19 pandemic hampered on-site, in person outreach activities. These will resume when safety allows.

STEM Engagement

The Wallops Rocketry Academy for Teachers and Students (WRATS) is a week long workshop hosted by the Sounding Rockets Program Office and NSROC with support from the Wallops Education Office. The first WRATS workshop was held in 2011. Participating educators teach STEM topics at the High School or Middle School level. The 2020 workshop was postponed until summer 2021, due to the CoVid-19 pandemic.

WRATS offers a unique, in-depth, learning experience where teachers get hands-on practice building model rockets and payloads, Presentation topics such as aerodynamics, propulsion, recovery system design, and trajectory simulations are covered.

WRATS starts with overviews of the Sounding Rockets Program and model rocketry, followed by construction of an E-powered model rocket. Tours of sounding rocket Testing and Evaluation facilities and machine shop are also included. By the end of the first day, all teachers have a flyable model rocket.

On the second day, teachers build an electronic payload to measure acceleration, temperature. and pressure during flight. The payload is based on the Arduino microprocessor and inexpensive sensors. Recovery system design and construction are also completed. Once all the construction activities are completed, the models are launched and recovered at Wallops Flight Facility. Flight data is then plotted and analyzed.

The participants also get an opportunity to watch a sounding rocket launch from Wallops Island.

Internships

Over 200 students have participated in the internship program managed for the Sounding Rockets Program Office by NSROC. The program, now in its 19th year, provides internships and co-op opportunities for students studying engineering, computer science, electrical or mechanical technology, as well as business disciplines. Students work side-by-side with experienced engineers and managers to perform significant, valuable tasks, leading to a better understanding of the work in a highly technical environment. Almost 90 percent of undergraduate students who intern or participate in the co-op program return for additional employment. Several participants in the program have gone on to pursue higher education in the engineering and science fields.

In 2020 five virtual internships were offered. Disciplines included Aerospace, Mechanical and Electrical engineering, as well as, Occupational Safety.

Outreach

Before facility restrictions due to CoVid-19 SRPO and NSROC personnel supported local schools by providing speakers, judging science fairs, and conducting special programs. Additionally, speakers were provided upon request to local civic organizations through the NASA Office of Communications. Tours of sounding rocket facilities were conducted for both school and civic groups September 2019 - February 2020.

NSROC and SRPO staff supported the virtual NASA Community College Aerospace Scholars (NCAS) with mentors and presentations. NCAS is a national STEM focused program where community college students interested in NASA related careers participate in a five-week online learning experience. Top scoring scholars are invited to participate in a 2-week virtual workshop. Three workshop were held in July - September and led by the Education Office.

Tour of the Testing and Evaluation Lab.

New opportunities to conduct science missions in the Southern Hemisphere are being developed by SRPO. The planned return to Australia, originally scheduled for 2021, has been delayed due to CoVid-19 impacts on travel restrictions and quarantine requirements.

FY 2020 included two flights from launch sites in Norway as part of the Grand Challenge Initiative - Cusp. The Grand Challenge - Cusp is an international collaboration between the US, Norway and Japan, to study the physics of the Cusp region.

On the Horizon

New and repeat opportunities to conduct science missions in remote locations abound within the SRPO in FY 2021 and beyond. The new Australian launch range, Equatorial Launch Australia (ELA), was originally set to be operational by mid-year 2021. Due to CoVid-19 impacts the sounding rocket launches planned from ELA are being delayed by one or two years. Operations will continue from regularly used launch sites, Wallops Island, White Sands Missile Range, and Poker Flat Research Range. Over twenty missions are manifested for flight in FY 2021.

Grand Challenge

One NASA launch and one international launch supported by SRPO, were flown in FY 2020. The Norwegian ICI-5 mission was launched from Ny-Ålesund, Svalbard, Norway in November 2019. ICI-5 was supported by SRPO with rocket motors. The Cusp Heating Investigation (CHI) launched from Ny-Ålesund, in December 2019. More information on the Grand Challenge Initiative can be found here:
http://www.grandchallenge.no/

Australia

The SRPO has been working for a number of years to solidify plans that would enable the astrophysics science community to have access to a launch range in the southern hemisphere that also offers up some of the capabilities of our routine launch range in White Sands, New Mexico – primarily telescope recovery. ELA, near Nhulunbuy, Northern Territory has been selected as the launch site for three astrophysics mission, now scheduled for FY 2022 or 2023. This will be NASA's first ever use of a foreign commercial launch range which, while exciting for program also introduces unique challenges. The SRPO has worked closely with the NASA Office of International and Interagency Relations (OIIR) to resolve these challenges in order to bring this new approach to fruition. Relatively new mobile assets, sucha as the Liquid Nitrogen Plant and one Medium Mobile Launcher (MML) will be used to facilitate the campaign. Additionally, the Wallops Flight Facility (WFF) mobile range assets will be used to support this campaign.

The southern hemisphere science missions include:

Suborbital Imaging Spectrograph for Transition region Irradiance from Nearby Exoplanet host stars (SISTINE)

SISTINE will investigate low-mass star UV environments and their effects on potential exoplanet atmospheres. The astrophysical target for SISTINE is the α Centauri A + B System. SISTINE made its first flight in 2019 from White Sands Missile Range, NM.

Dual-channel Extreme Ultraviolet Continuum Experiment (DEUCE-ELA)

DEUCE-ELA is designed to measure the first EUV spectrum, 500 – 900 Å, of the most accessible potential exoplanetary system, the α Centauri A + B System. No other star, except the Sun, has been observed in this spectral range. The high-energy (XUV and FUV; 5 – 911 Å and 912 – 1800 Å, respectively) stellar spectrum is required to understand habitable atmospheres as this emission both drives and regulates atmospheric heating and chemistry on Earth-like planets; and is critical to the long-term stability of terrestrial atmospheres. These observations will provide a crucial, and unique, input for models of planets orbiting G- and K-type stars.

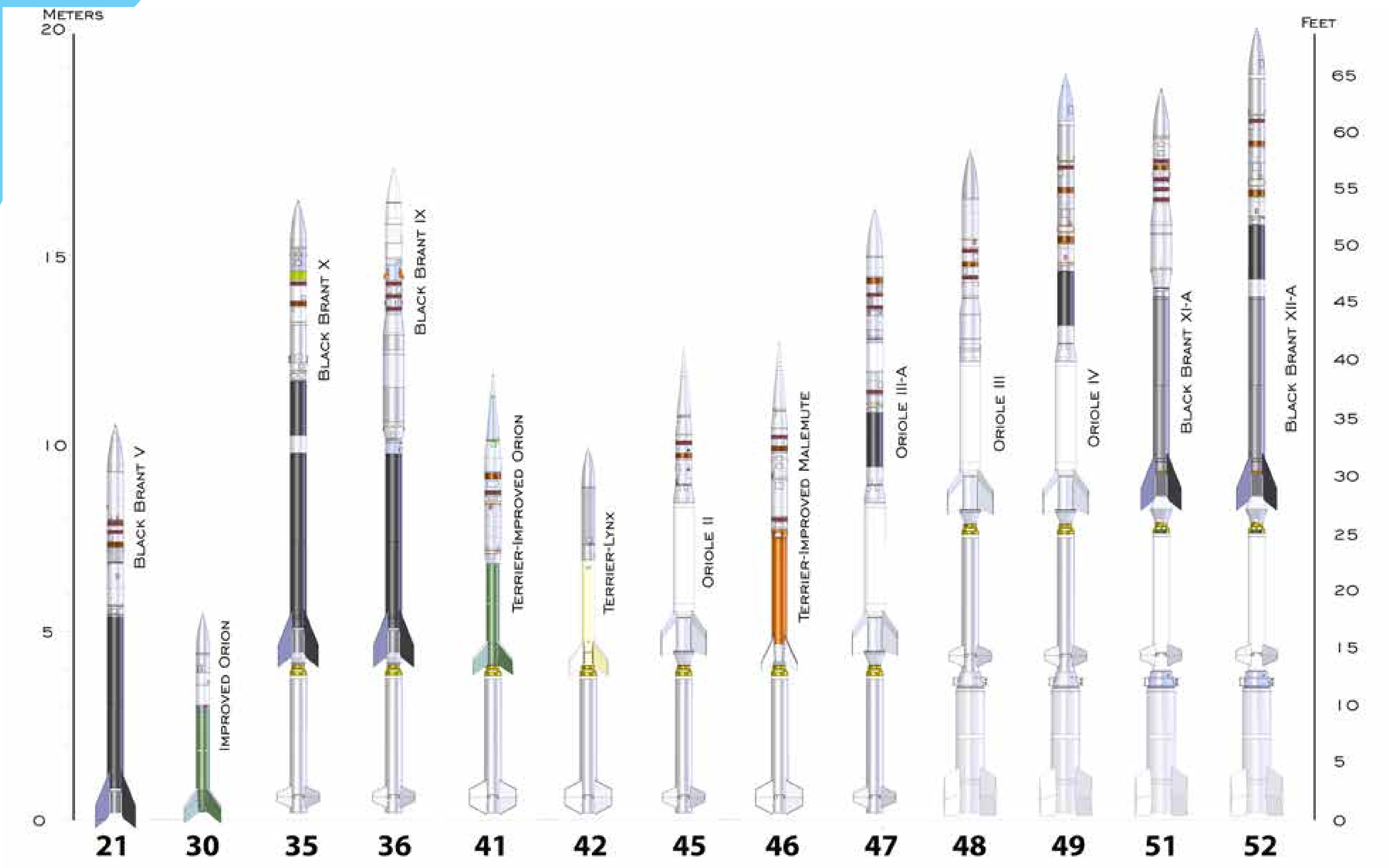
X-ray Quantum Calorimeter (XQC)

The objective of the XQC mission is to measure high resolution spectra of the diffuse X-ray background at 0.1-3 keV. Observations in this energy range have shown that the interstellar medium (ISM) in our Galaxy contains large amounts of previous unsuspected hot gas in the 1 million to 3 million degree temperature range. This gas can have profound effects on the structure and evolution of galaxies, and plays a key role in the distribution and life cycle of the elements produced deep in the interiors of stars. Despite its importance, this hot component of the ISM is still poorly understood. Better understanding requires high spectral resolution observations of the atomic spectral lines that make up the bulk of the X-ray emission. These "plasma diagnostics" convey a rich variety of information about the composition, temperature, motion, and history of the hot gas.

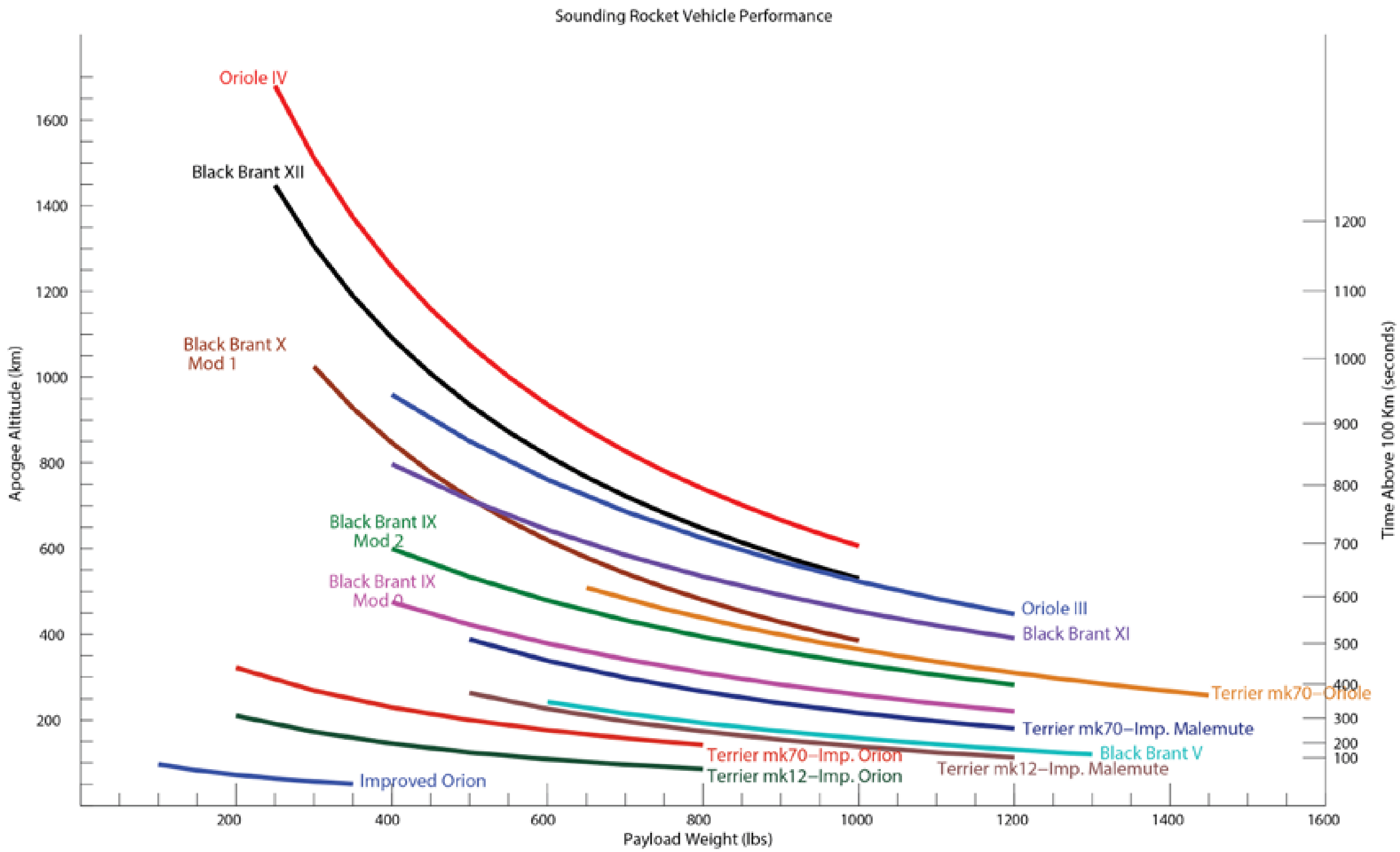
Kwajalein

In June 2022, the SRPO will return to Reagan Test Site (RTS) at Kwajalein Atoll, Marshall Islands, to launch two rockets for Dr. Barjatya, Embry Riddle. The goal of the Sporadic E Electrodynamics (SEED) mission is to collect the first simultaneous multipoint spatial and temporal observations of low-latitude Sporadic-E layers and their associated electrodynamics and neutral dynamics. Two Terrier-Improved Malemute vehicles will be launched in support of SEED.

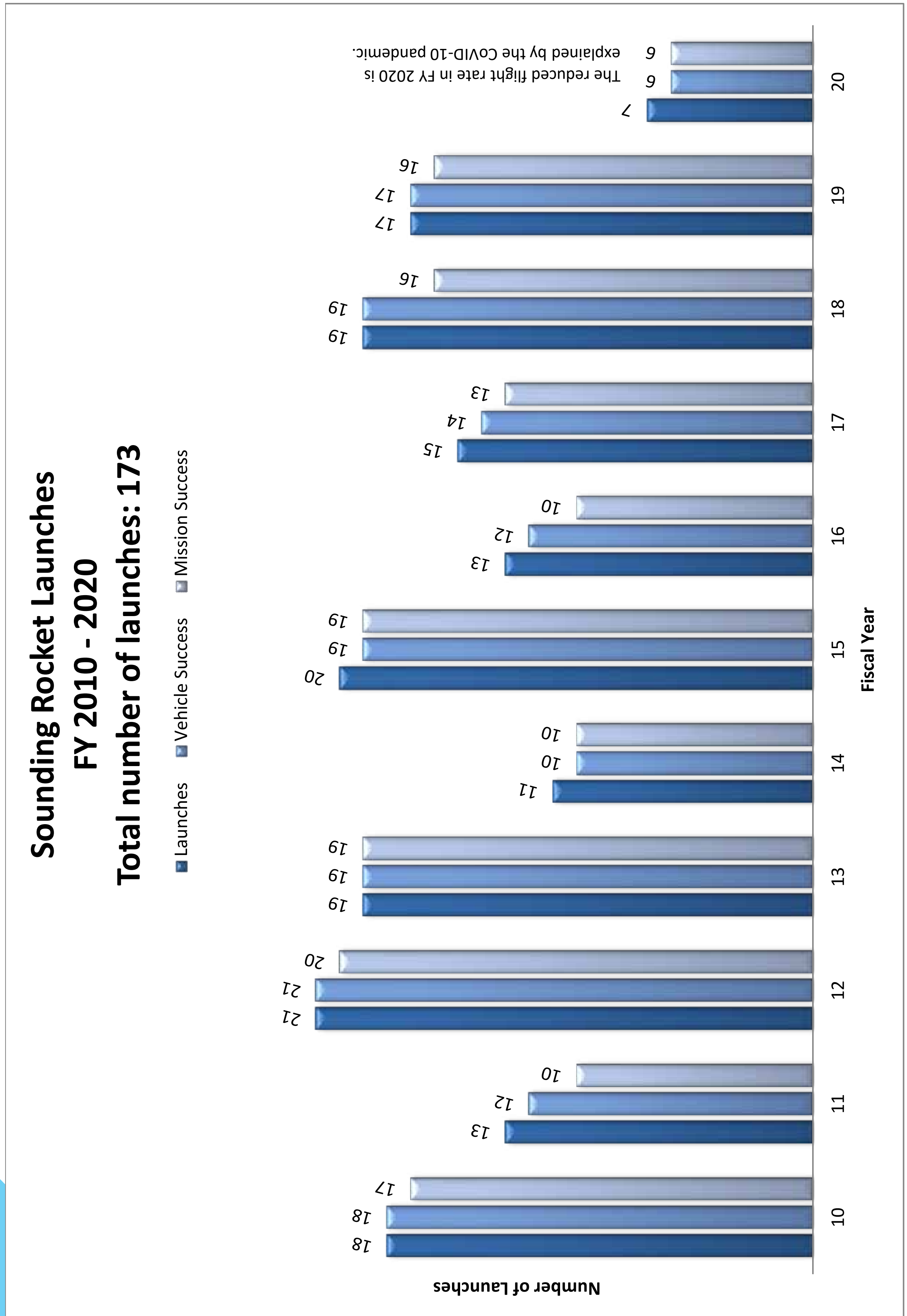
Sounding Rocket Vehicles



Sounding Rocket Vehicle Performance



Sounding Rocket Launch History



Sounding Rocket Launch Sites

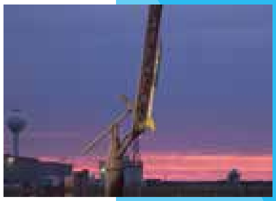
Poker Flat, Alaska

Esrange, Sweden

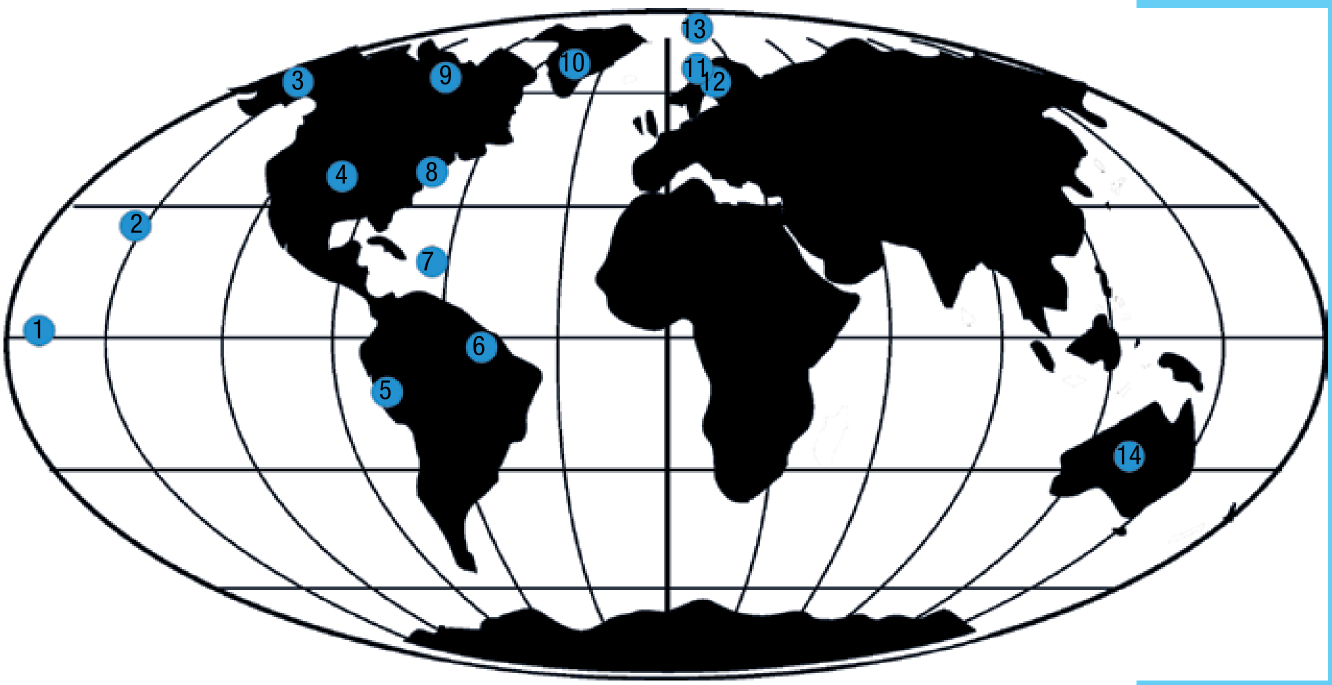
Kwajalein, Marshall Is.

Andøya, Norway

Woomera, Australia



Wallops Island, Virginia



Past and present world wide launch sites used by the Sounding Rockets Program to conduct scientific research:

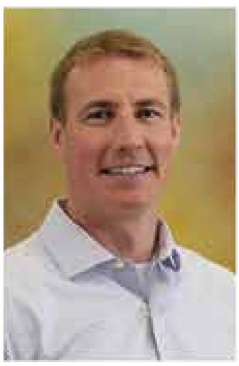
1. Kwajalein Atoll, Marshall Islands
2. Barking Sands, HI
3. Poker Flat, AK
4. White Sands, NM
5. Punta Lobos, Peru *
6. Alcantara, Brazil *
7. Camp Tortuguero, Puerto Rico *
8. Wallops Island, VA
9. Fort Churchill, Canada *
10. Greenland (Thule & Sondre Stromfjord) *
11. Andøya, Norway
12. Esrange, Sweden
13. Svalbard, Norway
14. Australia (Equatorial Launch Australia (ELA) & Woomera)

* Inactive launch sites

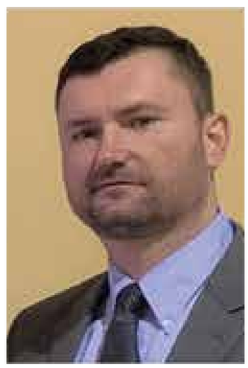
Sounding Rockets Program Office personnel


John Hickman
Assistant Chief


Giovanni Rosanova
Chief


Scott Bissett
Operations Manager


Julie Bloxom
Business/Grants Manager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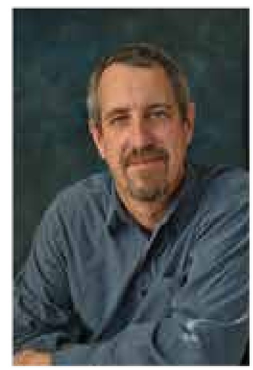
Operations Manager

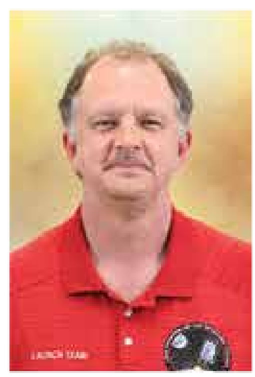

Valerie Brizak
Grants & Project Support


Chuck Brodell
Vehicle Systems Manager


Catherine Hesh
Technology Manager


Scott Hesh
Electrical Engineering


Wyle Maddox
Resources Analyst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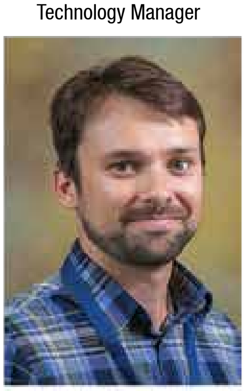
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Libby West
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Joshua Yacobucci
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