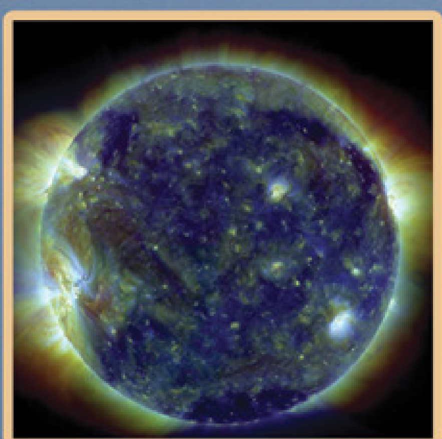
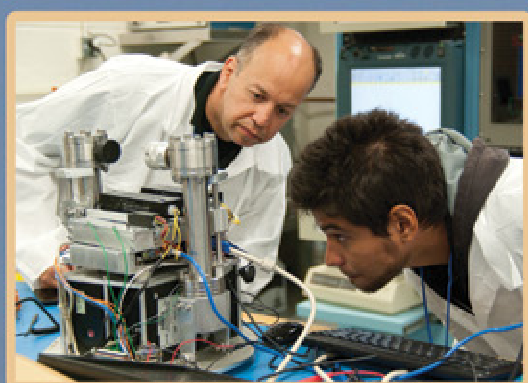
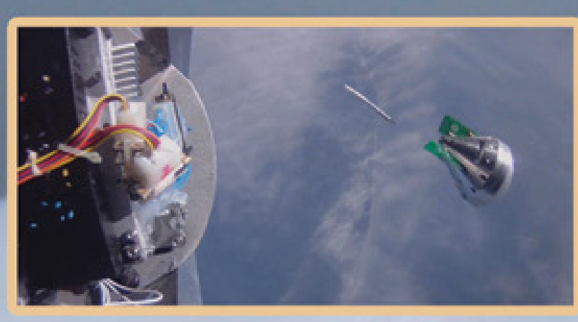
National Aeronautics and Space Administration





NASA Sounding Rockets 2011 Annual Report



Fiscal year 2011 was another eventful year for the NASA Sounding Rockets Program. The program continued to provided launch vehicle, payload subsystem, and mission support for scientific investigations that have helped humankind expand its understanding of the Earth, Sun and Universe. These missions employed astronomical telescopes, electric field detectors, particle detectors, and a host of other sophisticated instruments to accomplish their scientific objectives. We have continued to engage in development efforts that enhance the program's capabilities, with the end goal of enabling the program to fulfill its vital role as NASA's provider of low cost access to space in an even more efficient and cost effective manner. Our efforts in developing higher data rate telemetry will allow for even greater amounts of data to be collected, attitude control system enhancements allow for more efficient maneuvering which puts instruments on target sooner during the flight, and new vehicle configurations based on newly available, re-purposed surplus rocket motor assets result in lower cost launch vehicles.

The program continued to fulfill its commitment to STEM education by providing informative, fun, and inspirational outreach programs to local schools. The NSROC contractor and the Sounding Rocket Program Office also hosted numerous interns and Co-Ops over the course of the year, all of whom made valuable contributions to the program. The program's educational flight missions provided hands-on space flight experience to hundreds of university students and instructors. Additionally, new opportunities for K - 12 educators were created through the establishment of the Wallops Rocket Academy for Teachers and Students (WRATS).This unique educational "pipeline" helps the nation maintain leadership in science, engineering and technology. The NASA Sounding Rockets Program looks forward to continuing this world class support well into the future! This is made possible by the innovative and dedicated men and women, both civil servant and contractor, who make the program a reality. I, as well as everyone else supporting the program, am proud to play an important role in NASA's quest for scientific knowledge.

Phil Eberspeaker
Chief, Sounding Rockets Program Office

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Introduction

The Sounding Rockets Program supports the NASA Science Mission Directorate's strategic vision and goals for Earth Science, Heliophysics and Astrophysics. The approximately 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 worldclass 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 on board 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. An important aspect of most satellite missions is calibration of the space-based sensors. Sounding rockets offer calibration and validation flights for many space missions, particularly solar observatories such as NASA's latest probe, the Solar Dynamics Observatory (SDO).

Missions

Eleven science, technology and education missions were flown in 2011. The technology missions included a NASA employee development mission and two propulsion related testflights. Four geospace science investigations, one each from Norway and Alaska and two from Wallops Island, focused on ionospheric phenomena such as the Aurora Borealis, measuring Nitric Oxides in the upper atmosphere, and studiying the daytime dyanmo effect at mid-latitudes. The Solar Dynamics Observatory (SDO) Extreme ultraviolet Variabillity Experiment (EVE) instrument was calibrated using an instrument flown on a Terrier-Black Brant sounding rocket. Two education missions included student experimentors from universities around the country.

TRaiNED

Principal Investigator:
Dr. Heyne
NASA Jet Propulsion Laboratory

Mission Number:
41.087 NT

Launch site:
White Sands Missile Range, NM

Launch date:
December 6, 2010

The TRaiNED mission was the first sounding rocket mission launched under NASA's new HOPE initiative (Hands-On Project Experience (HOPE) Training Opportunity (TO) initiative). This initiative solicits proposals from NASA Centers for the development of in house payloads that will be launched aboard various low cost carrier systems. All proposals received are critically reviewed with one being selected for the Training Opportunity initiative. The objectives of the HOPE program are to provide hands-on project experience as a developmental exercise to enhance technical, leadership, and project skills within the in-house team supporting the successful proposal effort. An additional objective is to complete a selected scientific or technology development effort that will produce results useful towards the goals of NASA's Science Mission Directorate.

The technical development effort of the TRaiNED mission was to advance Terrain- Relative Navigation (TRN) technology by collecting a set of correlated ground imagery, Inertial Measurement Unit (IMU) and Global Positioning System (GPS) data during a sounding rocket flight and performing post-flight data analysis. In addition, TRaiNED will be developing and verifying a TRN filter for the post-flight data analysis. The imagery was captured through two sets of camera systems: one side looking set collected exoatmospheric data during the ascent and decent portions of the flight and the other aft looking set collected imagery at lower altitudes within the atmosphere. A deployable door anomaly prevented proper functioning of the side looking cameras, however the aft camera suite functioned as designed and the principal training objectives of the mission were completely satisfied.

TRaiNED team.

Rocket Experiment for Neutral Upwelling

Renu

Principal Investigator:
Dr. Lessard
University of New Hampshire

Mission Number:
40.026 UE

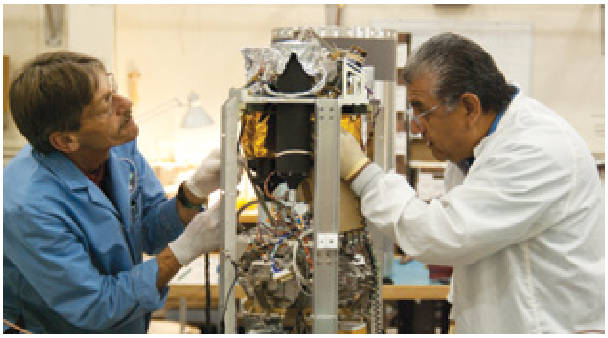
Launch site:
Andoya Rocket Range, Norway

Launch date:
December 12, 2010

At a point beginning near 100 km (60 miles), the atmosphere gets so thin that collisions between atoms become infrequent. Here electrons and protons, energized at even higher altitudes, can collide with the neutral atoms and molecules that make up the atmosphere. This activity results in a distinct layer of electrically charged particles that is the ionosphere.

Early in the space age a connection was made between satellite drag and solar activity, leading to the hypothesis that very large scale electric fields drive the electrically charged ionosphere horizontally. This motion is countered by the "friction" involving collision with the upper atmosphere with the result that both the ionosphere and the upper atmosphere are heated -- this heating or upwelling, tends to expand the upper atmosphere. The heating process itself is called Joule heating.

The objective of RENU was to measure atmospheric bumps associated with aurora and to also measure the precipitating electron characteristics (density, energy, etc) and the electric fields that might drive the Joule heating.



RENU instrument integration at Wallops.

A vehicle related anomaly involving a thrust misalignment during third stage tail-off resulted in excessive coning dynamics that prevented proper nose cone deployment. This resulted in no science data being collected from the forward sensor suite. While the sensor suites on the aft end of the main payload and the deployable subpayload functioned properly, the amount of data collected from the mission was insufficient to meet the scientific objectives.

Far–ultraviolet Imaging Rocket Experiment

FIRE

Principal Investigator:
Dr. Green
University of Colorado

Mission Number:
36.257 UG

Launch site:
Poker Flat Research Range, AK

Launch date:
January 28, 2011

The scientific objective of the first FIRE mission was to image star forming regions within the Whirlpool Galaxy (M51). Star formation typically produces the hottest, brightest types of stars, O stars, 30,000-50,000°C. The emission peaks of O stars are within the FIRE waveband (~900~1100 Å) and constitute a majority of all the observed light emitted at these wavelengths. The 900-1100 Å band provides the most sensitive indicator of young, massive stars and has been previously unexplored astronomically. This imaging band will also help fill the current wavelength imaging observation gap existing from ~620 Å to the Galaxy Evolution Explorer (GALEX) band near 1350Å.

Combining this information with UV and visible wave- length data from other missions and comparing the spectral colors to stellar evolution models will help with the determination of the star formation history. Studying the light of a nearby galaxy will help us understand the red- shifted light arriving from galaxies farther away. When performed over many galaxies at differing redshifts, the star formation history of the universe can be directly studied.

Instrument check–out during payload integration.

Demonstration of the usefulness of the FIRE wavelength band may ultimately lead to the development of space-based missions that could find and study quasars, star forming regions and galaxies, and other UV bright objects. While the vehicle and payload support systems functioned nominally, the mission failed to meet the scientific objectives due to noise within the payload power supply system that comprised the scientific data.

Polar NOx

Principal Investigator:
Dr. Bailey
Viginia Polytechnic Institute

Mission Number:
36.256 UE

Launch site:
Poker Flat Research Range, AK

Launch date:
February 5, 2011

Polar NOx was designed to measure the concentration of nitric oxide, a destroyer of ozone, in the mesosphere and lower thermosphere in the nighttime polar region. The experiment was expected to measure peak concentrations of NO.

The reason the experiment was launched in the polar region is twofold. First, NO is primarily created through reaction of excited atomic nitrogen with O_2
($N^* + O_2 \rightarrow NO + O$).
Odd nitrogen reacts with odd oxygen:
$NO + O_3 \rightarrow NO_2 + O_2$
$NO_2 + O \rightarrow NO + O_2$
Leading to NO being a catalytic destroyer of ozone. A major source of excited N is auroral energetic electrons impacting N_2 and splitting the atom in two ($e^* + N_2 \rightarrow N^* + N + e^*$). Secondly, the primary destruction mechanism of NO is photodissociation and thus in the absence of sunlight, the NO loss mechanism disappears and NO abundance increases, this may allow NO to descend to the stratosphere and destroy ozone.

Spectrographic measurements of the concentration of NO were intended to be made using a UV astronomy payload to observe a well known and characterized star, SPICA, as the payload viewing angle grazes the earth's mesosphere and lower thermosphere at the region of interest (approximately 75km – 170km). While the launch vehicle and payload support systems all functioned as planned, the mission's scientific objectives were not realized due to in-flight contamination of the payload optics


The Polar NOx science team.

EVE Calibration

Principal Investigator:
Dr. Woods
University of Colorado

Mission Number:
36.275 UE

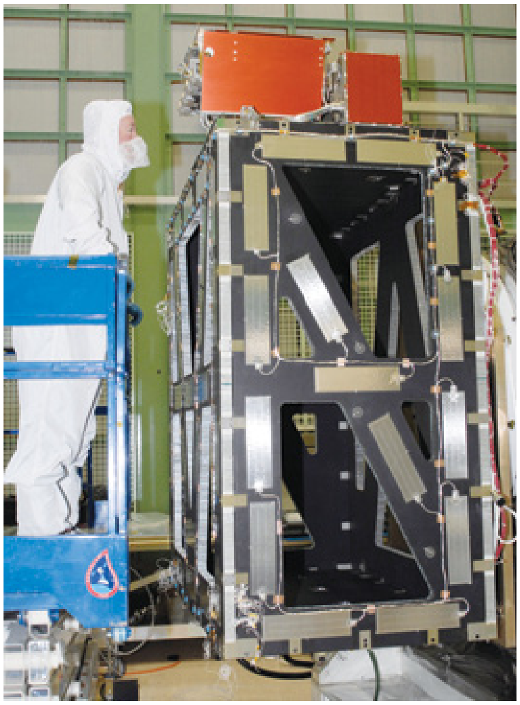
Launch site:
White Sands Missile Range, NM

Launch date:
March 23, 2011

This was the 2nd under-flight calibration mission to provide critical calibration data for the Extreme Ultraviolet Variability Experiment on the Solar Dynamics Observatory (SDO) satellite that was launched on an Atlas V rocket on Feb. 11, 2010. The first under-flight calibration flight was on May 3, 2010 with sounding rocket mission 36.258 UE Woods. The mission was highly successful and all scientific objectives were achieved. The next under-flight calibration mission is currently being planned for the spring of 2012.

For more information on this mission please see the Science Highlight section of this report on page. 17.

After a successful sounding rocket flight the sounding rocket team prepares the recovered payload for a helicopter ride back to the lab, about 50 miles away. It will be inspected, packed into a custom crate, and transported back to the University of Colorado. Rather than the end of the campaign, in many ways this is just the start –– the data obtained from the flight needs to be analyzed and applied for the flight EVE data, and the rocket EVE instrument is taken to the National Institute of Standard and Technology (NIST) for recalibration and then prepared for the next launch to further calibrate the degradation trend of the flight EVE instrument.



The Extreme ultraviolet Variability Experiment (EVE) mounted on the Solar Dynamics Observatory (SDO) spacecraft instrument module in the Goddard Space Flight Center (GSFC) clean room. The “red tag covers” protect delicate surfaces such as thermal radiators, and are removed before the instrument is launched. EVE was designed and built at the University of Colorado’s Laboratory for Atmospheric and Space Physics (LASP). After a spacecraft and instrument checkout period, routine science data has been available since May 1, 2010 and requires a regular calibration using the rocket EVE payload to maintain high accuracy for the solar irradiance data products.

Black Brant flight

Principal Investigator:
Mr. Brodell
NASA GSFC/Wallops Flight Facility

Mission Number:
36.278 NT

Launch site:
Poker Flat Research Range, AK

Launch date:
April 27, 2011

The primary objective of this mission was to conduct a flight performance evaluation test of a Black Brant IX MKI Ver. 4 motor that was cast using a new mixing process. The new mixing process eliminates the pre-blending of the ammonium per chlorate. Small scale testing had earlier indicated this process would yield less erosion and more neutral burning motors. The flight also tested the new one piece carbon phenolic exit cone and the smooth contoured throat with a diameter of 4.230". This configuration has been designated as the MK I Ver. 4. Payload instrumentation included motor pressure, acceleration, rate data, the second flight of Aft Looking Video System (ALVS), and thermistors mounted at critical locations on the motor.

The 36.278 mission was launched on April 27, 2011 at the Poker Flat Research Range (PFRR) two months following the Mission Initiation Conference (MIC). The vehicle and core payload systems performed nominally, providing good diagnostic data for motor performance. The ALVS video system performed well and provided video data throughout flight. In addition to ALVS telemetry, video data was recorded on board collecting data through ground impact. The payload was recovered in good condition with location aid coming from the onboard Iridium system. The onboard and ground-based instrumentation provided adequate data to evaluate motor performance resulting in a successful mission.

Black Brant test flight on the rail at Poker Flat, Alaska.

Sub–TEC

Principal Investigator:
Mr. Hall
NASA GSFC/Wallops Flight Facility

Mission Number:
41.096 GT

Launch site:
Wallops Island, VA

Launch date:
June 10, 2011

The primary experiment on this Sub-TEC mission was the Small Rocket/Spacecraft Technology (SMART) platform. SMART was developed by Goddard technologist Jaime Esper and the Defense Department's Operationally Responsive Space (ORS) Office. The platform promises to provide faster, less expensive access to space because of its modular, reconfigurable design that users can adapt to a variety of missions. The SMART microsatellite can be integrated and readied for launch in as few as seven days and is a creative way to reduce mission lifecycle times. Sounding Rocket mission 41.096 GT was the first flight of the SMART platform, although SMART is intended for orbital missions, particularly as a free-flyer for planetary missions.

The secondary objective of this mission was to provide a flight demonstration for the Goddard-developed SpaceCube processor, which is equipped with Xilinx Virtex-5 field programmable gate arrays, including two commercially available power PC cores that overcome radiation upsets through software techniques. Twenty-five times faster than the current state-of-the-art microprocessor, SpaceCube captured simulated data and transmitted it to the ground using an omnidirectional S-band antenna encircling the Sub-TEC. The mission was highly successful in demonstrating these new technologies with the launch vehicle and all experiments and payload support systems functioning nominally.

The SMART team with the platform.

RockOn!

Principal Investigator:
Mr. Koehler
University of Colorado

Mission Number:
41.095 UO

Launch site:
Wallops Island, VA

Launch date:
June 23, 2011

This mission was the fourth flight of the hands-on, University level rocket flight workshop known as "RockOn!," which is an annual collaborative effort conducted by the Colorado Space Grant Consortium (COSGC), the Virginia Space Grant Consortium (VSGC), and NASA Wallops Flight Facility. The primary objective of the RockOn! workshop is to provide university undergraduate students and instructors with a space flight opportunity that involves minimal cost and a relative low level of complexity. The RockOn! workshop is intended to be an introductory flight opportunity to provide exposure to and spark interest in space-based science missions. The long-term goal of this program is to provide a low cost, self-sustaining, annual training program for the university community. This is accomplished by flying two classes of experiments. The first time participants fly the simpler kit experiments known as the RockSat-W experiments, and as they gain more experience, they progress toward developing their own unique experiments known as the RockSat-C class experiments. The workshop was conducted at Wallops Flight Facility during the students summer break with the actual launch occurring on June 23. The payload carried 19 experiments that were built by students representing Universities from all across America. The launch vehicle performed nominally and the payload was successfully recovered as planned. The vast majority of the student built experiments functioned as planned and collected good data, resulting in a highly successful mission.


RockOn! team building a workshop experiment.

To find out more about this flight opportunity visit the Colorado Space Grant Consortium on the web at: http://spacegrant.colorado.edu/rockon/
For the Virginia Space Grant Consortium at: http://www.vsgc.odu.edu/
For information about the Space Grant program visit:
http://www.nasa.gov/offices/education/programs/national/spacegrant/home/index.html

Daytime Dynamo

Principal Investigator:
Dr. Pfaff
NASA Goddard Space Flight Center

Mission Numbers:
21.141 GE & 41.091 GE

Launch site:
Wallops Island, VA

Launch date:
July 10, 2011

At an altitude of approximately 50 miles begins a dynamic region of the atmosphere known as the ionosphere. The region is filled with charged particles created by extreme ultraviolet radiation from the sun. At the base of the ionosphere, charged particle motions create a global current called the "atmospheric dynamo". Generally moving in loops from the equator to the poles, the dynamo changes daily based on solar heating and magnetic activity – but what keeps it moving isn't well understood.

The Daytime Dynamo experiment was designed to collect data on the charged particles as well as winds of neutral particles that sweep through the lower ionosphere and how each affects the other, ultimately causing these dynamo currents. Understanding the atmospheric dynamo is important both for its influence on satellite communications, but also because it is a fundamental process of Earth's upper atmosphere. Two payload pairs, one instrumented payload and one chemical release payload in each pair, were constructed for this mission.

Instrumented payload.

The first two payloads were launched in July 2011 from Wallops Flight Facility. The experiments included, among others, a daytime lithium release experiment that was to be observed from various ground based camera installations to track the neutral winds in the upper atmosphere. While all other payload and experiment subsystems functioned nominally, the intended lithium releases were not observed by the ground-based cameras. The science team is currently evaluating these results along with the additional data collected from the numerous scientific instruments carried aboard these missions. The two remaining flights are scheduled for 2013. See page 20 of this report for more information on the Daytime Dynamo experiment.

Chemical release payload.

RockSat–X

Principal Investigator:
Mr. Rosanova
NASA GSFC Wallops Flight Facility

Mission Number:
41.095 UO

Launch site:
Wallops Island, VA

Launch date:
July 21, 2011

RockSat-X is a follow on mission to RockOn! that involves more complex student experiments and provides more advanced sounding rocket payload support services, including telemetry and deployable instruments. Three universities participated in the first RockSat-X mission.

University of Northern Colorado provided a method for institutions to utilize a deployable and recoverable payload for future RockSAT-X missions. The amount of data recovered is increased by eliminating the need to transmit otherwise restricted amounts of data to the ground.

University of Wyoming created a platform for capturing high-altitude, atmospheric "space dust," optical photos, and record real-time sensor data.

University of Puerto Rico selected an experiment that includes mass spectroscopy to analyze molecular species and their respective partial pressures in near space.

RockSat–X teams with vehicle on Wallops Island, VA.

The mission also included a flotation aid recovery system developed by Wallops specifically for this mission that incorporated readily available commercial off the shelf personal flotation devices into the recovery system thereby allowing for recovery of the otherwise negatively buoyant payload. The launch vehicle and all payload support systems functioned nominally and the mission was highly successful . This mission demonstrated the next segment in the sounding rocket program's Science, Technology, Engineering, & Technology (STEM) educational pipeline.

Terrier Mk12

Principal Investigator:
Mr. Brodell
NASA GSFC/Wallops Flight Facility

Mission Number:
12.076 GT

Launch site:
Wallops Island, VA

Launch date:
September 8, 2011

The objective of this mission was to conduct a test flight to verify performance of a Terrier MK12 motor that was modified with a one-inch thick steel spring spacer plate installed at the forward side of the cartridge grain. The spacer was required due to shrinkage of the cartridge propellant grain that had occurred over time. The 12.076 mission was launched on September 8, 2011 at the Wallops Flight Facility, one month following the Project Initiation Meeting (PIM). The vehicle and payload systems performed nominally, providing good diagnostic data to evaluate motor performance. The onboard and ground-based instrumentation provided adequate information to evaluate motor performance resulting in a successful mission. This mission was conceived as a risk mitigation measure for future missions that required use of similarly modified Terrier motors. The results of this mission provided a high degree of confidence that this modification could be implemented on future missions when necessary without the introduction of additional risk to launch vehicle performance. Since the successful Terrier Mk12 test flight, this motor modification has been implemented on two additional science missions whose launch vehicles performed nominally.

Terrier Mk 12 lift–off from Wallops Island, VA.

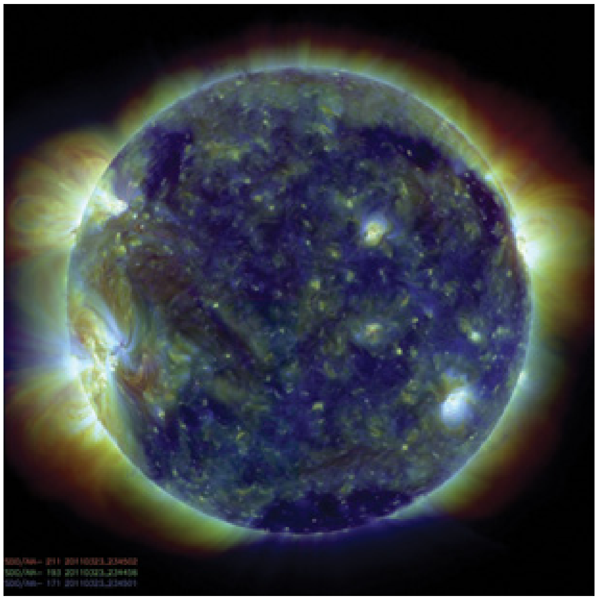
Science

The 2011 science highlights focus on satellite calibration and validation and Geospace Science. Both types of missions are frequently launched using sounding rockets. The satellite calibration mission was an underflight calibration of the Solar Dynamics Observatory/Extreme ultraviolet Variability Experiment (SDO/EVE). The Daytime Dynamo missions, launched from Wallops Island, VA explored the critical transition region between the earth's atmosphere and its ionosphere.

Calibration Rocket Successfully Launched for SDO / EVE

By Dr. Thomas Woods
Principal Investigator
University of Colorado/Boulder

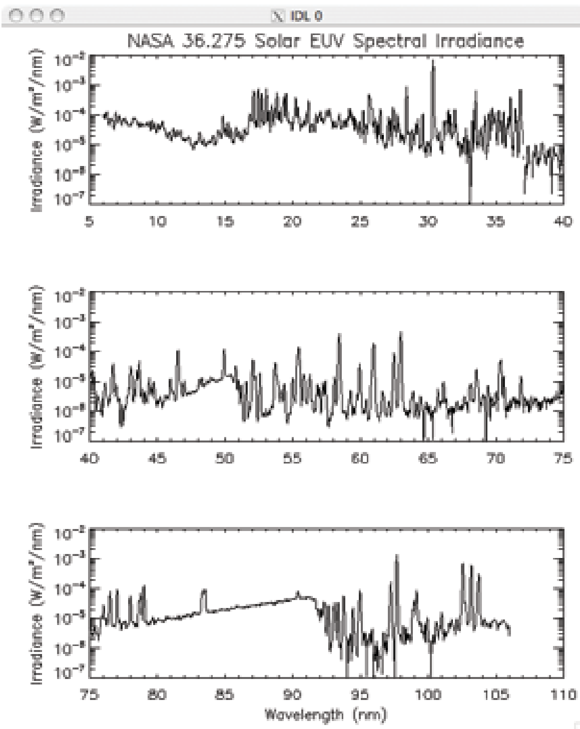
The Solar Dynamics Observatory/Extreme ultraviolet Variability Experiment (SDO/EVE) calibration rocket (PI: Tom Woods, University of Colorado) was launched from the White Sands Missile Range (WSMR) in New Mexico on March 23, 2011.This NASA 36.275 rocket flight provided the second underflight calibration for the SDO/EVE instrument, which was launched into geosynchronous orbit on Feb. 11, 2010. This calibration payload includes solar extreme ultraviolet (EUV) irradiance instruments built at Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado (CU) and at the Space Sciences Center (SSC) at the University of Southern California (USC). They were flown for about 20 minutes in space at a peak altitude of 180 miles to obtain the necessary solar observations above Earth's atmosphere. The rocket calibration flight occurs about once a year to accurately determine the long-term drifts of the flight EVE channels and thus making the long-term variations of the solar EUV irradiance as accurate as possible. These measurements were particularly exciting because SDO EVE just celebrated its first year in space and the launch came soon after a series of large solar flares in February and March. In addition to the studies of solar flares with SDO/EVE data, the solar EUV irradiance observations are used in a variety of space weather applications, such as modeling the response of Earth's ionosphere and thermosphere to the solar flares and these variations affecting our high frequency (HF) communication and GPS navigation systems.



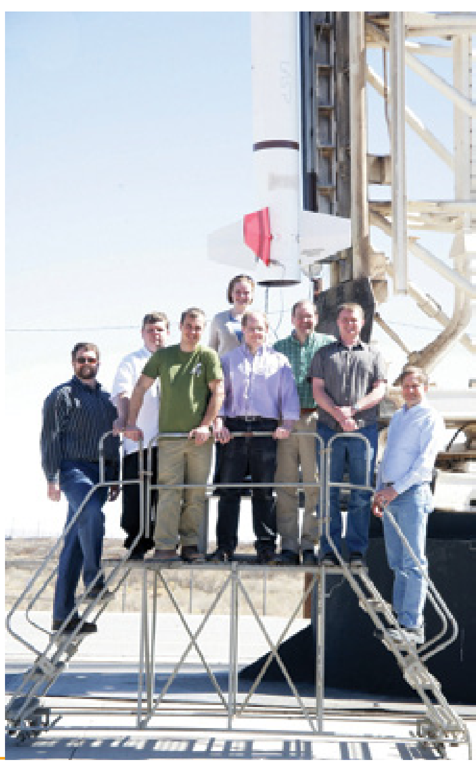
An EUV composite image from the SDO Atmospheric Imaging Assembly (AIA) shows what the Sun looked like in the EUV during the EVE rocket flight. AIA image credit: NASA/Goddard/SDO AIA team.

For this launch, LASP provides the science instruments and NASA provides all the other subsystems (launch vehicles, telemetry, attitude control, parachute / recovery, etc.). Rachel Hock, a PhD student in CU's Astrophysics and Planetary Science program, is a key member of the launch team. "Getting to be part of the integration, testing, launch, and recovery of a rocket payload whose science data form a part of my dissertation is a big thrill and a great learning experience." CU graduate and undergraduate students are an important resource for all of LASP's NASA mission activities.

For more information on the LASP Rocket Program and the launch videos, visit - http://lasp.colorado.edu/rocket/. The SDO/EVE web and data site is at http://lasp.colorado.edu/eve/.



Solar EUV irradiance spectrum from the SDO/EVE calibration rocket. EVE measures over 400 different spectral lines in the Sun's atmosphere, covering a range of temperatures from 50,000 K to 2 MK.



LASP's rocket launch team for NASA 36.275 (left to right): Frank Eparvier, Chris Jeppesen, Blake Vanier, Rachel Hock, Michael Klapetzky, Tom Woods, Matt Triplett, and Rick Kohnert. The base of the launch rail and the Terrier vehicle is visible in the background.

Rachel Hock, a University of Colorado graduate student works in the LASP rocket lab.

Daytime Dynamo Experiment
By Dr. Robert Pfaff
Principal Investigator
NASA Goddard Space Flight Center

NASA's "Dynamo" rockets were designed to explore the critical transition region between the earth's atmosphere and its ionosphere, in which strong electrical currents may be set up in the altitude range of 90-120 km. Because of the combination of the earth's magnetic field and the unique properties of the gases in its upper atmosphere, currents flow in the transition region, centered at around 105 km, that are powered by neutral winds in the upper atmosphere as well as by the earth's global electric field. The currents form a global dynamo current pattern for the Earth, as shown in Figure 1. These fundamental currents are often referred to as the upper atmosphere "dynamo".

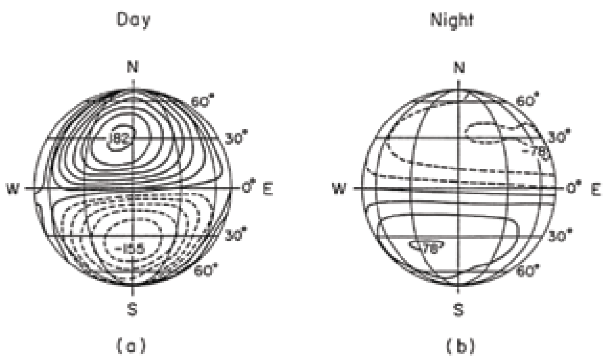


Figure 1

This rocket investigation consists of two pairs of rocket payloads to be launched near simultaneously so that they will gather data at nearly the same time and place. The Black Brant rockets carry "instrumented" payloads, contain state-of-the-art experiments for measuring the earth's electric field, magnetic field (and currents), plasma and neutral density. They also contain an instrument to discriminate the mass of the ions in the lower ionosphere. Instruments on these rocket payloads will thus measure the dynamo currents and the environmental parameters that sustain these currents.

Instrumented Black Brant payload after boom deployment testing at Wallops Flight Facility.

The Terrier Orion rockets with "chemical" payloads release vapor trails to provide a means to illuminate the neutral winds in the upper atmosphere that drive the currents. These rockets also include a special "falling sphere" payload that will provide an additional means of determining the neutral wind.

Scientific measurements on the ground are also essential for the success of this investigation. These ground measurements include the Wallops ionosonde, operated by the University of Colorado, and magnetometer instrument, operated by Goddard, which are part of the Wallops Geophysical Observatory, in addition to remote camera sites that are set up to observe the vapor trails.

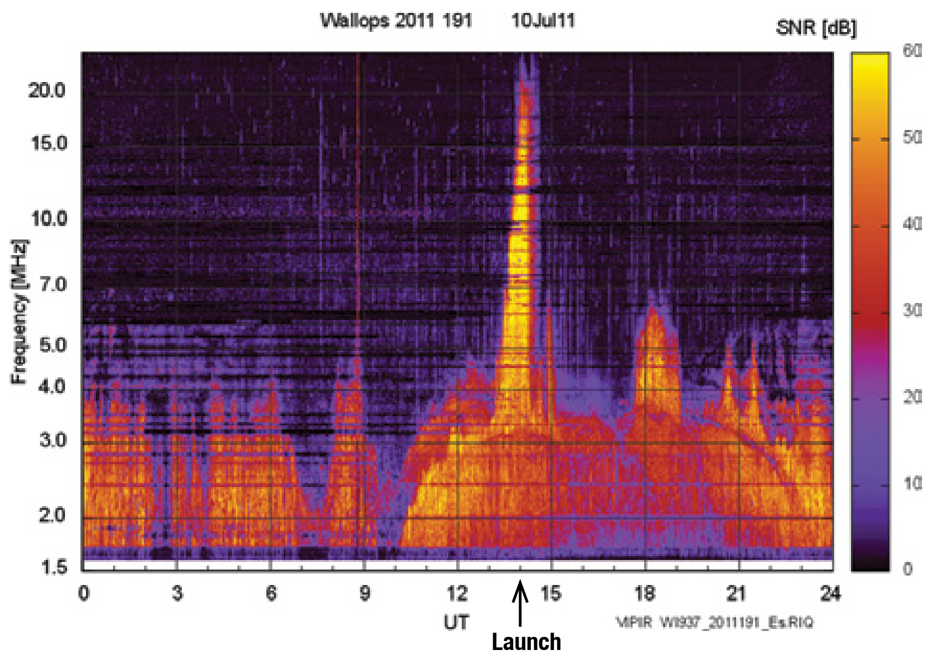


Figure 2

One pair of rockets was launched on July 10, 2011. The Wallops ionosonde data shows how the rocket was launched during an intense daytime sporadic-E event, as shown in Figure 2. The plasma density data from the rocket shows an intense, yet very thin plasma density later at the base of the ionosphere, near 101 km, on both the upleg and downleg, as shown in Figure 3. When combined with the electric field, current, and wind measurements, these unique observations promise to advance our understanding of the daytime lower ionosphere by a considerable degree.

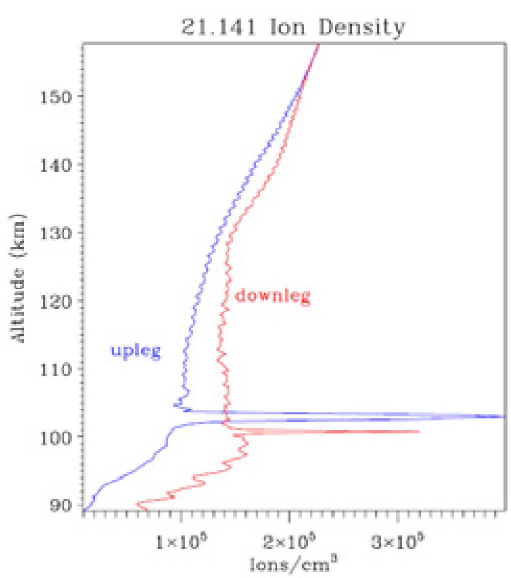


Figure 3

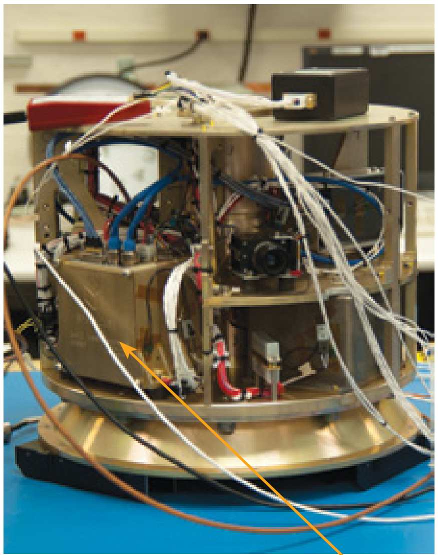
Technology

The Sounding Rocket Program Office through the NSROC, NASA engineering, and other partners continues to plan and implement technology development initiatives with the goal of sustaining core capabilities and introducing new capabilities to our science customers. This year the efforts represent a diverse set of initiatives which include development for payload systems, vehicle systems, ground support equipment, and engineering design & analysis tools. Also, the transition into the NSROC II contract and increased support from NASA engineering brought a renewed interest in strengthening our technology planning and roadmapping efforts to ensure that the development efforts are strongly aligned with the science customer needs and the program goals.

NSROC continues to focus on the phased development of the next generation Flight Termination System to ensure that we have a safe, cost effective, and range-compliant system to meet our science mission manifest. This year the team completed the rigorous qualification testing for the components and subsystems of the Hybrid II FTS System. In addition to ground-based testing, the NSROC team leveraged secondary flight opportunities on the technology demonstration flights launched this calendar year to demonstrate the component functionality in the flight environment. This new FTS system will have its inaugural flight in 4th quarter of CY11. As the Hybrid II FTS system becomes operational, the NSROC team will continue the phased development by incorporating a new ordnance package into the system design.

The development of the Terrier-Improved Malemute surplus vehicle surpassed several milestones this calendar year. Building on the inaugural test flight of this vehicle conducted in CY10, the Program set out to enhance the design of the payload/motor mechanical interface and redesign the Malemute igniter assembly prior to conducting a second test flight in late CY11. The team forged through several design, analysis, and test cycles to develop a new interface between the payload and the Malemute tactical joint which significantly improves joint compliance and reduces slop. This new design should improve the flight stability and payload carrying capacity for this new all-surplus vehicle configuration. The team also successfully completed a redesign of the tactical igniter assembly which included replacing the tactical Safe & Arm device with a mechanical S&A device similar to the design utilized on the Orion motor. This design change will improve safety, simplify the design, and improve reliability. Also, electrical modifications have been made to the igniter design to accommodate the NASA ground safety requirements. With the design goal accomplished, the team will prepare for a second test flight of the Terrier-Improved Malemute vehicle in late CY11.

High data rate telemetry remains at the forefront of the development goals. This year brought the successful test flight of the GSFC SpaceCube flight processor, which demonstrated 2+ Gbps data processing and on-board recording capability on the SubTEC V mission. SRPO and NASA engineering continue to work with GSFC to deliver the SpaceCube design which will be adapted for use as a multi-channel encoder and processor for high rate data recording and transmission. Also, the NSROC team continued the readiness of the PSL MV encoder which will enable 20Mbps S-band telemetry. NSROC worked closely with PSL to successfully resolve minor performance issues with the encoder and is prepared to complete qualification of the encoder by the end of CY11.



The SMART payload with the SpaceCube processor.

SpaceCube processor

In conclusion, the NASA Sounding Rocket Program remains committed to developing new technologies to sustain and enhance program capabilities for our science customers. 2012 will bring a prioritized focus on flight and ground system developments to meet the most urgent needs of our user community. This coming year we hope to realize the operational status of a new vehicle configuration, step closer toward operational status for the high data rate telemetry, closeout the phased FTS development efforts, and move forward on several new initiatives.

Facilities

A consolidated effort to upgrade the facilities at WSMR is nearing completion. The upgrade plan consists of a multi-year, three phase project to provide new integration laboratories, technical work areas, additional office space, and a conference facility. Phase I, a new 2-story addition on the northwest corner of the VAB that will house a new large integration laboratory on the first floor and office and conference space on the second floor, is complete. The Phase II, a single story addition to the VAB for GNC/SPARCS is under construction, with an expected completion 1st quarter calendar 2012. Phase II includes technical work areas for air bearing, optics, pneumatics, solar payload alignment, and electronics. Phase III consist of a major facility rehab of the east side of the VAB, which houses mostly the Telemetry ground station The design for Phase III is complete, the ground station and work areas have been emptied in preparation for demolition.

Once complete, NASA plans to consolidate all operations at WSMR into one geographic location at Launch Complex 36. This will ultimately lead to greater operational efficiency and potential cost savings as older (Navy owned) facilities the SRPO uses at LC- 35 can be abandoned.

The Chakrabarti payload in the new integration facility at White Sands Missile Range.

Education

The Sounding Rockets Program Office expanded its education program offering by adding another university level sounding rocket flight, the Rock-Sat-X mission, and creating new capabilities for K-12 education. The highly successful internship program, managed by NSROC, continued providing opportunities for engineering students.

University level sounding rocket missions

Three different university level experiment opportunities were offered; RockOn!, RockSat-C and RockSat-X.

RockOn!

2011 was the 4th consecutive year the RockOn! workshop was held at Wallops. Approximately 70 college students and educators spent a week completing and integrating their experiments to fly on a suborbital rocket. The mission included 10 RockOn! workshop experiments and 9, more advanced, RockSat-C experiments. The workshop experiments are built from kits, created by the Colorado Space Grant Consortium, consisting of an AVR microprocessor, various sensors, mounting hardware and programming software. Teams of faculty members and students work together to build the experiments. Attending the workshop is the first step toward more elaborate future experiments.

RockOn! workshop.

By mid-week all RockOn! teams had completed their experiment construction, programming and integration. The experiments were installed in the payload structure and transported to Wallops Island for mating with the rocket motors, a two-stage Terrier-Improved Orion. The launch occured early in the morning on June 23rd.

The payload reached an apogee of 119 km and was recovered in the ocean and brought back to Wallops for de-integration. The experiments were returned to the students for postflight checks and data analysis.

RockSat-C

RockSat-C experiments, flying in the same payload with the RockOn! experiments, are completely designed and built by students. Nine RockSat-C teams participated in the 2011 mission and represented eight Universities.

The goal of the **Colorado State University** RockSat team was to design a payload capable of accurately measuring tank ullage in a microgravity environment for use in various spacecraft. There is no way to measure fluid volumes in microgravity without introducing acceleration and current techniques are not cost effective and extremely inefficient. The CSU experiement was looking to prove that interferometry is a viable option for fluid volume measurement and can be designed to withstand the extreme environmental conditions of launch.

The goal of the **Drexel** RockSat team was to develop a platform that rotated opposite the spin-stabilization of the Terrior-Orion sounding rocket during ascent, resulting in a rotationally static platform from an outside reference frame. The project experimentally determined the feasibility of a de-spun platform under high acceleration and turbulence, driven by a low power system. Additionally, the experiment provided a design for a re-usable, stable platform with respect to the exterior environment to accommodate experiments requiring constant frame of reference in a traversing object.

Pre–flight checks of a RockSat–C experiment.

The mission of the RockStars team, from **Temple University**, is to measure the strength of the magnetic field during flight for calibration use on future missions. They will also be flying an IMU and accelerometers. The Sub-orbital Active Vibration Suppression System (SAVSS) team, also from Temple University, designed an experiment to implement and control a vibration damping system using piezoceramic patch dampers.

The team from **Harding University** is looking to obtain flight heritage for a mini-spectrometer. The goal of this mission is to measure the absorption spectrum of Earth's atmosphere as a function of altitude by modifying the spectrometer and interfacing it with a microcontroller.

The MinnSpec and Suborbiball experiments were designed by **University of Minnesota and Augsburg College** The MinnSpec portion of the payload measured the absorption of the ozone layer through UV radiation, testing the compatibility of a GPS module in a very dynamic environment, and testing the durability of an "off-the-shelf" spectrometer. The Suborbiball payload worked with students at local high schools to design a payload that will determine the usability of hardware (mostly off-the-shelf, inexpensive, and quite user-friendly) used by the MnSGC High-Altitude Ballooning Team in suborbital applications. It collected data from basic sensors such as temperature, pressure, relative humidity, cosmic radiation levels, ambient light levels, and acceleration in 3 axes, and incorporate a video of a visual accelerometer within the canister.

The objective of the **West Virginia University** team was to develop a payload to measure properties of the space environment at 110 km during the RockSat flight. The payload measured high-energy particles, low-energy (plasma) density, the magnetic field, the gravitational field, fluid capillary phenomena, and flight dynamics.

The NOIME experiment from **Virginia Tech** measured the concentration of NO in Earth's atmosphere and simultaneously collected inertial data using a PlugNPlay system from AFRL.

University of Colorado team with their RockSat–C canister after recovery.

Postflight analysis of RockSat–C experiment.

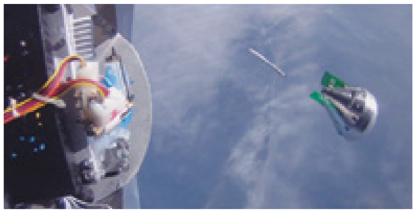
RocketSat VII team from **University of Colorado at Boulder** designed a modular attitude determination system for future RocketSat-C missions. This system used a magnetometer, accelerometers, and two CMOS cameras to back out the attitude of the rocket during flight.

RockSat-X

This mission provided expanded opportunities beyond what has previously been included in RockOn! and includes the development and launch of the first RockSat-X payload. The mission provided experimenters from several schools the opportunity to fly a payload of their design, exposed to the space environment. The design of a payload and vehicle with pre-defined mechanical, power, instrumentation and flight performance capabilities were developed to provide exposure to the space environment for these university student experimenters.

University of Northern Colorado

The Reentry Experiment Sat-X mission (REX SAT-X) was designed to gather detailed inertial and thermal loading data for a small ejectable rocket capsule. The capsule's reentry flight will be used to characterize its environment as it reenters the atmosphere, allowing the team to create a generalized understanding of how the Earth's atmosphere affects descending bodies. The data will be used to refine the capsule's design which will later be offered as a standardized experiment deck for future ejectable RockSat-X projects.



University of Northern Colorado experiment duing integration and testing (top) and captured on HD video during deployment in flight (bottom).

University of Wyoming

University of Wyoming created a platform for capturing high-altitude, atmospheric "space dust," optical photos, and record real-time sensor data. The success of this mission will provide in-situ data of the upper atmosphere. Additionallly the experiment provides a foundation for future RockSat-X missions in the form of thermal, pressure, and vibrational load data, from launch until splashdown.

University of Wyoming with their experiment at Wallops during integration and testing activities.

University of Puerto Rico

This experiment included mass spectroscopy to analyze molecular species and their respective partial pressures in near space. The experiment will contribute valuable information for interstellar travel and advances benefiting space bound crews who may want to collect and replenish essential resources such as water and fuel.

University of Puerto Rico team testing their instrument at Wallops (top) and instrument deploying in flight (bottom) with the REX SAT–X visible in the background on the right.

NRSOC Internship Program

Over 135 students have participated in the internship program managed for the Sounding Rockets Program Office by NSROC. The program, now in its 13th year, provides internships and co-op opportunities for students studying engineering, computer science and electrical or mechanical technology. Students work side-by-side with experienced engineers and perform significant, valuable engineering tasks, leading to a better understanding of engineering, better grades and solid experience in a business environment. Almost 90 percent of undergraduate students who intern or participate in the co-op program return for additional employment prior to graduation. Several participants in the program have gone on to pursue higher education and careers in the engineering and science fields.

Intern Eric Roper with Sub–TEC payload.

Intern Mark Bartels staging a model rocket.

Wallops Rocket Acadamy for Teachers and Students (WRATS)

The first WRATS High School teacher workshop was held in the new education area in building F-7 at Wallops Flight Facility. Twenty-three educators, representing twelve states, attended the workshop and spent June 20 - 24, 2011 learning about sounding rockets, model rockets, electronics, rocket physics and aerodynamics. The participants also visited with the college level workshop RockOn! occuring the same week, and attended the RockOn! Terrier-Orion launch on June 23rd. The first day of the workshop started with a range entry briefing, a general overview of the sounding rockets program, and a presentation on rocket propulsion. The afternoon focused on electronics with the participants building their own electronic payloads for model rockets. The payloads recorded pressure, temperature and acceleration data. Days two and three involved rocket physics, trajectories, and flight performance.Moments of inertia were measured using inertia bars and the educators conducted wind tunnel testing of a model rocket. Hands-on activities for these two days included building model rockets, integrating the payload and conducting launch operations. The rockets were successfully launched on the Wallops airfield.

On June 23rd the WRATS participants attended the RockOn! sounding rocket launch on Wallops Island and the de-integration of the RockOn! payload. Additionally, parachute construction and drops were conducted on Thursday. The last day of workshop, Friday, June 24th, teachers wrote evaluations of the program and also listened to presentations about NASA Explorer Schools and the AESP programs. Six participants stayed for the afternoon computer programming session.

Wintunnel testing.

Model rocket and parachute construction.

WRATS teachers before launch.

Launch.

Eastern Shore Rocketry Challenge

The first Eastern Shore Rocketry Challenge, sponsored by the NASA Sounding Rockets Program Office, took place this summer in cooperation with Worcester County Middle Schools Summer Science, Technology, Engineering and Math (STEM) program. A teacher workshop was held at Wallops in May to familiarize the teachers with model rocketry, sounding rockets and the science and enginering of rocketry. With the exception of the parachute drop testing, the majority of the activities took place in the new WRATS workshop area in F-7. A full day of activities included lectures on sounding rockets, performance analysis, recovery systems and rocket motor performance. Additionally, teachers constructed model rockets and parachutes and participated in a model rocket motor static firing demonstration. NASA educator guides, model rocket flight performance software and other educational documents were provided to each school. Each participating school was also provided with a complete materials kit that included various body tubes, fins, nose cones and motor mounts. The focus of the challenge was to have students design and build a model rocket and participate in a competition event at Wallops. Included in the competition elements were flight performance analysis, testing of flight vehicle stability, logo design and participation in a design review.

During two days of launches, July 14 and 15, an estimated 160 rockets were launched and recovered on the Wallops airfield. Total participation in the Summer STEM program School was approxmately 220 students.

Staging a model rocket for flight.

Students learning about rocket motors.

Launching and ESTES Alpha rocket.

Black Brant V Daytime Dynamo Launch

On the Horizon

Several unique science and technology missions are on the horizon for the next fiscal year. Sounding rockets will be used to test novel exo-planet imaging technologies, fly a sequence of rockets to study turbulent fluctuations at altitudes between 90 and 130 km, and test re-entry technologies. Additionally, new vehicle configurations are under consideration for future development.

Planetary Imaging Concept Testbed Using a Rocket Experiment (PICTURE)

Principal Investigator Dr. Supriya Chakrabarti
Boston University

The Planet Imaging Concept Testbed Using Sounding Rocket (PICTURE) takes the first step towards direct imaging of exoplanets using nulling interferometers. It is a collaboration between Boston University (BU), Jet Propulsion Laboratory (JPL), NASA Goddard Space Flight Center (GSFC) and Charles Stark Draper Laboratory (Draper). Its original goal was to directly image in visible spectral region Epsilon Erdani b, a Jupiter-like planet in a highly elliptical orbit around a Sun-like star. No other facility, whether groundbase or spaceflight, could achieve this goal. However, due to programmatic difficulties, some of the key components could not be developed in a timely fashion, which made it impossible to attain the original goal. Nonetheless, PICTURE can image the debris disk around Epsilon Eridani which are similar to the asteroid belt of our Sun. Such information will tell us about the process of planet formation around stars. PICTURE will flight qualify several key technologies necessary for exoplanet exploration such as, extremely lightweight mirror, visible nulling coronograph, deformable mirror and 0.5 milli arc-sec pointing. Validation of even one of these technologies would be uncommon for most sounding rockets.

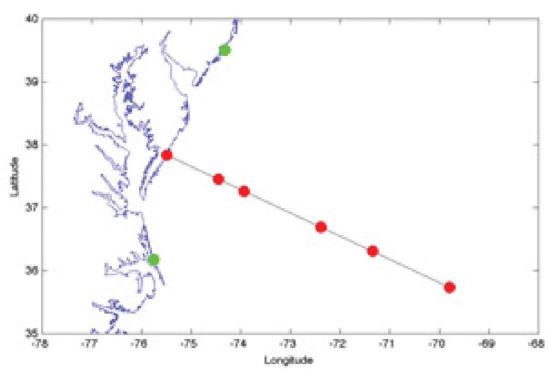
Anomalous TRansport Experiment (ATREX):
Jetstreams in the Earth's Geospace Region

Principal Investigator Dr. Miguel Larsen

Clemson University

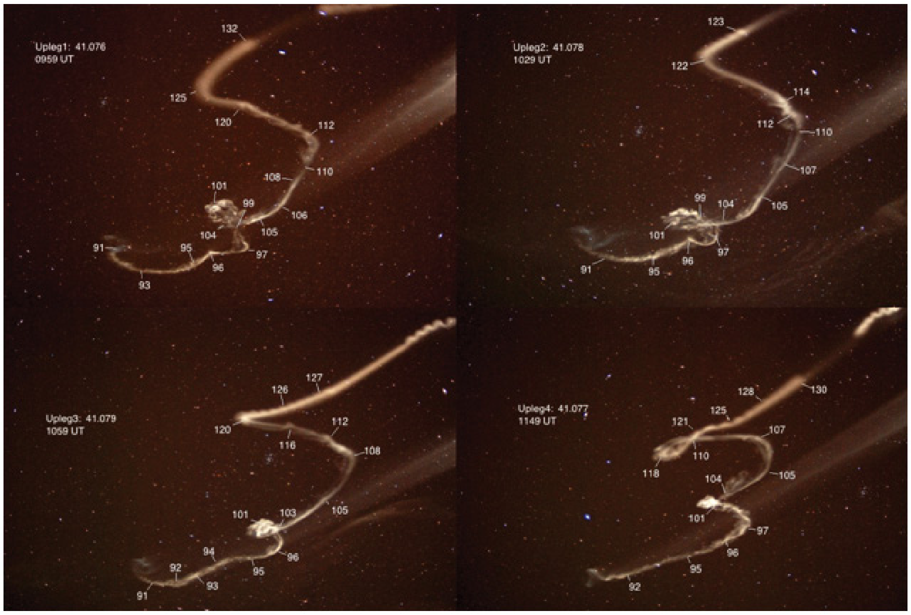
Prof. Miguel Larsen from Clemson University is the Principal Investigator for the Anomalous Transport Rocket Experiment (ATREX) that is scheduled for launch from the NASA/Wallops Flight Facility on the eastern shore of Virginia in March 2012. Five rockets will be launched with instruments to measure pressure and temperature and tracer material releases to track the flow and show small-scale turbulence in the medium over a broad horizontal extent.

The chemical tracer used in the experiment is trimethyl aluminum, a chemical that reacts with oxygen and produces chemiluminescence when exposed to the atmosphere. The products of the reaction are aluminum oxide, carbon dioxide, and water vapor, which also occur naturally in the atmosphere. The experiment will be carried out at night during moonless conditions so that the chemical tracer trails are easily visible to the human eye and to cameras. Cameras will be set up at locations in New Jersey and North Carolina, as well as at the launch site, to track the trails as they move across the night sky. All five rockets will be launched within a period of a few minutes, and all the trails will be visible at the same time. The photographs on the next page show trimethyl aluminum trails from an earlier rocket experiment carried out in Alaska in 2009 and give an indication of how the ATREX trails are expected to look.



Red dots show the location of the tracer releases in the ATREX experiment. Green dots show the camera sites used to support the experiment.

The measurements will provide detailed information needed to better understand the processes responsible for the high-altitude jet-stream flow.



Photographs of four trimethyl aluminum (TMA) trails released from rockets flown from Poker Flat, Alaska, in February 2009. The chemical is chemiluminescent when exposed to oxygen in the atmosphere and can be seen with the naked eye or tracked with cameras. The trails are initially straight but are distorted by the wind shears and turbulence that occur naturally in the atmosphere.

Some Relevant Journal Articles

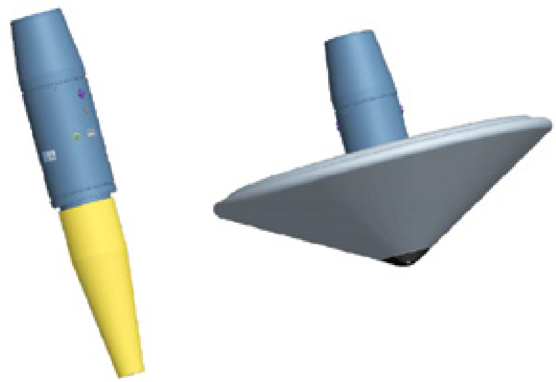
Larsen, M. F. (2002), Winds and shears in the mesosphere and lower thermosphere: Results from four decades of chemical release wind measurements, J. Geophys. Res., 107, doi:10.1029/2001JA000218.

Siskind, D. E., M. H. Stevens, J. T. Emmert, D. P. Drob, A. J. Kochenash, J. M. Russell III, L. L. Gordley, and M. G. Mlynczak (2003), Signatures of shuttle and rocket exhaust plumes in TIMED/SABER radiance data, Geophys. Res. Lett., 30, 1819, doi:10.1029/2003GL017627.

Inflatable Re-entry Vehicle Experiment (IRVE) III

The suite of Inflatable Re-Entry Vehicle Experiments (IRVE) is designed to further our knowledge and understanding of Hypersonic Inflatable Aerodynamic Decelerators (HIADs). Before infusion into a future mission, three challenges need to be addressed: surviving the heat pulse during re-entry, demonstrating system performance at relevant scales, and demonstrating controllability in the atmosphere.

The mission objectives for this third Inflatable Reentry Vehicle Experiment (IRVE III) are to 1) execute a flight-test that demonstrates inflation and survivability at a relevant dynamic pressure, 2) assess the performance of the vehicle from a thermal, and structural dynamics perspective, and 3) validate the analysis and design techniques used in the development of the Reentry Vehicle (RV); all at higher heating loads than previous IRVE missions. IRVE III is a follow-on flight to the successful IRVE II mission, 36.254, launched on August 17, 2009 from Wallops Island.



IRVE III shown in the stowed (left) and inflated (right) configurations.

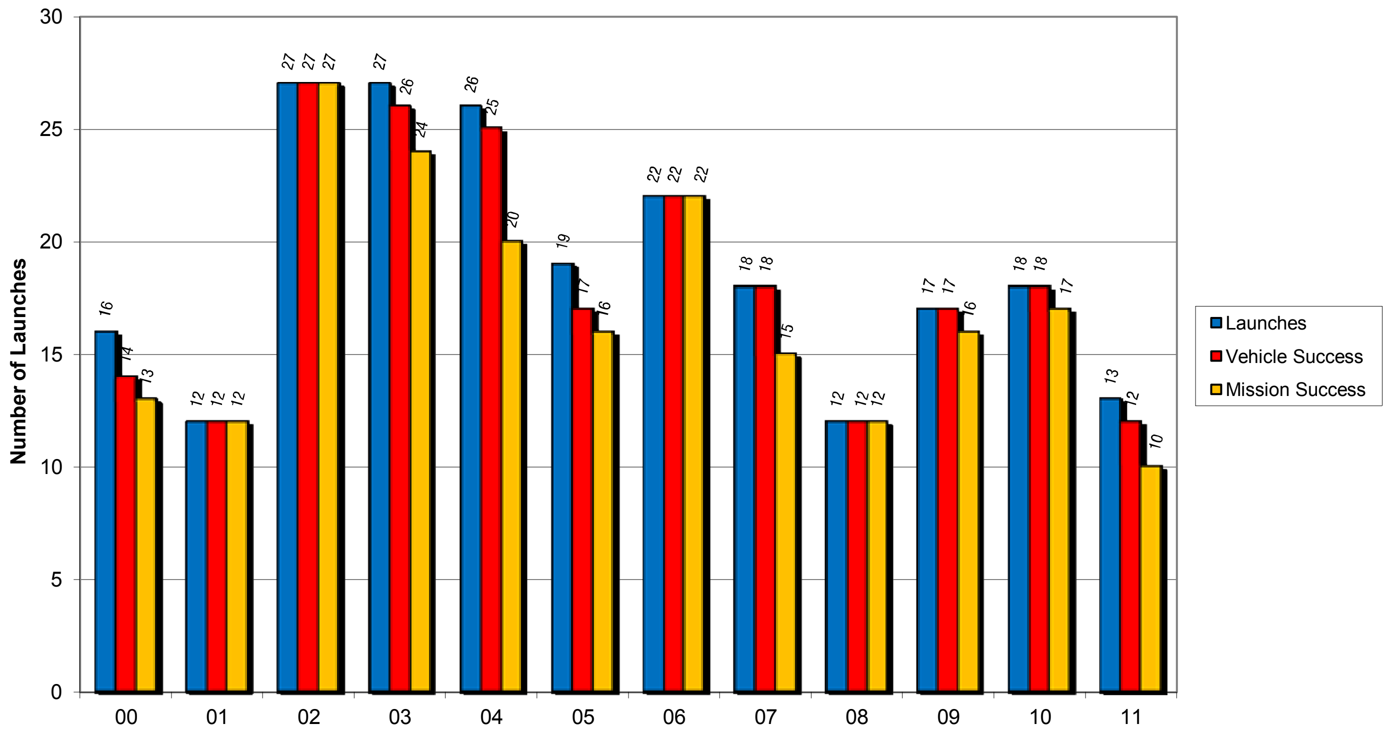
New flight vehicles development

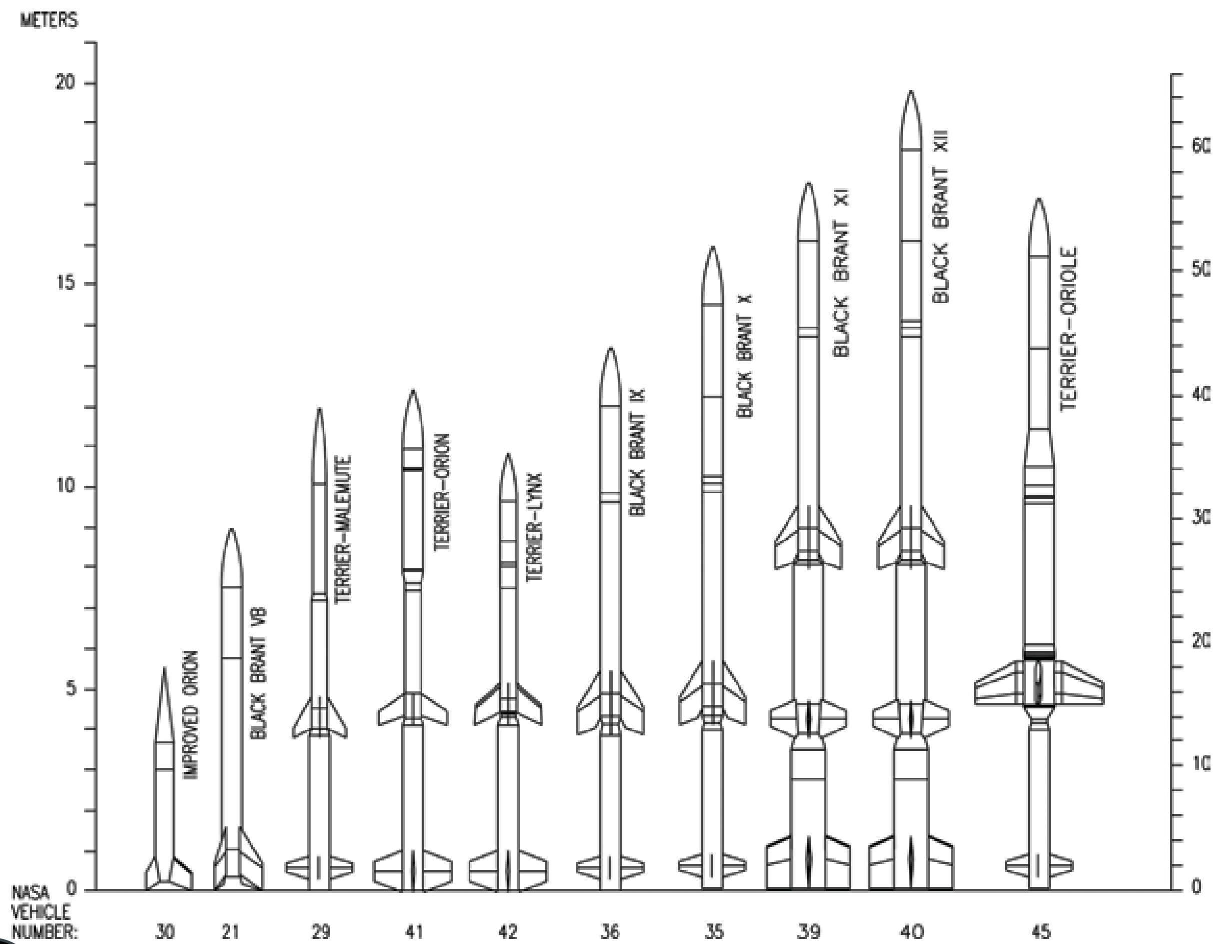
The Sounding Rockets Program Office continues to support vehicle development efforts from small spin motors to multi stage vehicle configurations including integration of propulsion units not currently used by the program. There is continuous attention on availability and acquisition of surplus assets. In addition to NASA initiatives the Sounding Rockets Program Office is collaborating with Department of Defense organizations in development efforts that may potentially augment NASA's capabilities.

Statistics

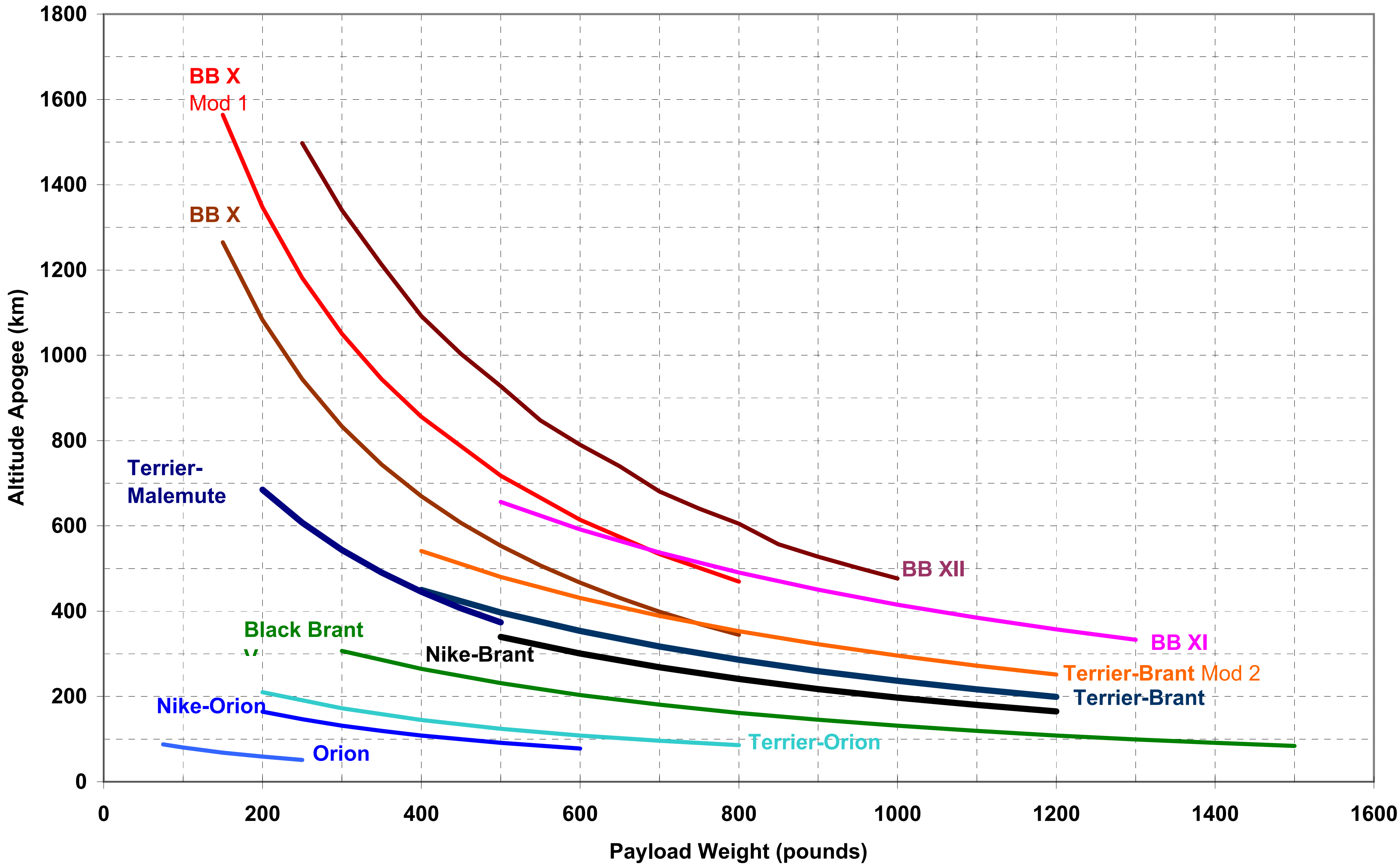
A total of 13 sounding rockets missions were launched in 2011. The current vehicle stable has 10 vehicles, ranging from a single stage Orion to a four stage Black Brant XII. The Statistics section shows launch data since 2000, vehicle configurations, perfomance charts and launch ranges used by the sounding rockets program.

Sounding Rocket Launches
FY 2000 - 2011
Total number of launches: 227





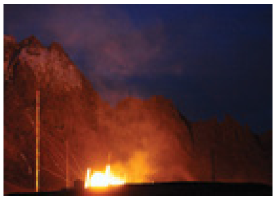
Sounding Rocket Vehicle Performance



Poker Flat, Alaska

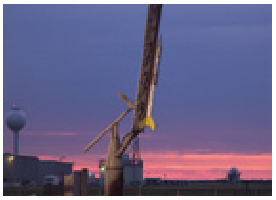
Esrange, Sweden

Kwajalein, Marshall Is.

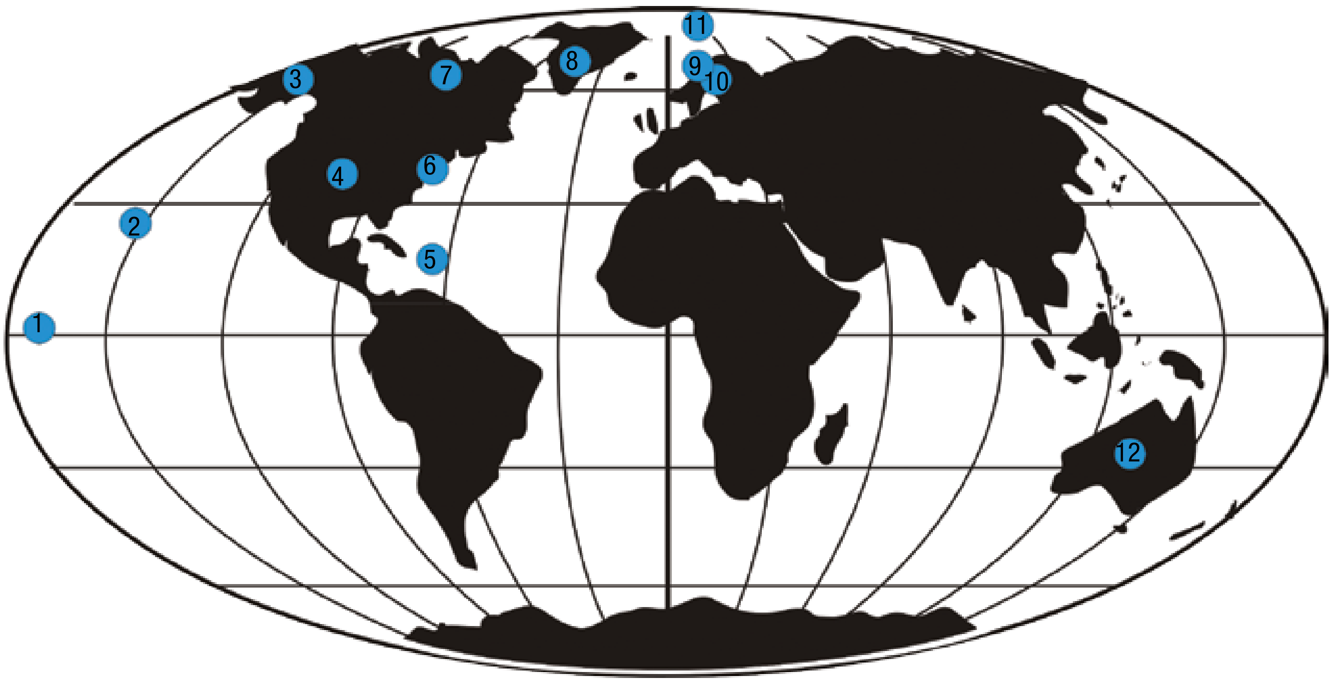


Andoya, Norway

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. Camp Tortuguero, Puerto Rico *
6. Wallops Island, VA
7. Fort Churchill, Canada *
8. Greenland (Thule & Sondre Stromfjord) *
9. Andoya, Norway
10. Esrange, Sweden
11. Svalbard, Norway
12. Woomera, Australia

* Inactive launch sites

Sounding Rockets Program Office Org Chart

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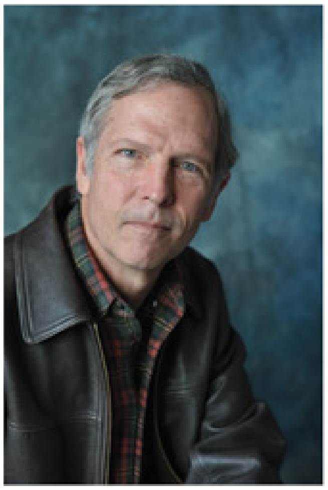
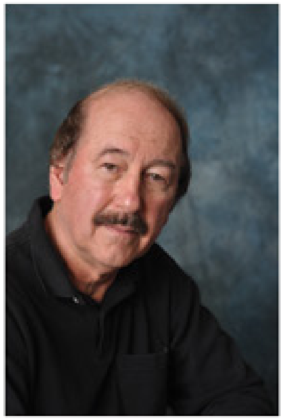
Secretary



Emmet D. Ransone
Assistant Chief



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References

Design Review and Mission Initiation Conference documents for the following missions:

41.087 NT	HEYNE/JPL
40.026 UE	LESSARD/UNIV. OF NEW HAMPSHIRE
36.257 UG	GREEN/UNIV. OF COLORADO
36.256 UE	BAILEY/VPI
36.275 UE	WOODS/UNIV. OF COLORADO
36.278 GT	BRODELL/NASA-WFF
41.096 GP	HALL/NASA-WFF
41.095 UO	KOEHLER/UNIV. OF COLORADO
21.141 GE	PFAFF/NASA-GSFC
41.091 GE	PFAFF/NASA-GSFC
41.092 UO	ROSANOVA/NASA-WFF
12.076 GT	BRODELL/NASA-WFF

SDO/EVE calibration written by Dr. Thomas Woods/University of Colorado/LASP
Daytime Dynamo written by Dr. Robert Pfaff/NASA Goddard Space Flight Center
ATREX article written by Dr. Miguel Larsen/Clemson University
Daytime Dynamo mission information written by Dr. Robert Pfaff/NASA Goddard Space Flight Center
36.278 GT and 12.076 GT mission information written by Mr. Charles Brodell/NASA Wallops Flight Facility

Credits

Photos by Berit Bland/BBCO except as noted below.
Cover: Andromeda Galaxy -Tony and Daphne Hallas, Sun - NASA/Goddard/SDO AIA team.

Page	Photo Credit
2	John Brinton/SRPO
10	Recovery photo - White Sands Missile Range, Satellite photo - Dr. Tom Woods, University of Colorado
11	Wallops Imaging Lab
15	Wallops Imaging Lab
16	Wallops Imaging Lab
19	Sun - NASA/Goddard/SDO AIA team
20	Group photo - White Sands Missile Range, Student photo - Tom Woods
22 & 23	Dr. Rob Pfaff - Goddard Space Flight Cetner
23	Space Cube - Jamie Esper
24	White Sands Missile Range
29 & 30	Instrument deployment - University of Northern Colorado
34	Wallops Imaging Lab
37&38	Dr. Miguel Larsen, Clemson University
45	John Brinton/SRPO

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NP-2011-11-256-GSFC