Research Range Services Annual Report 2009

Enabling Research Worldwide

National Aeronautics and Space Administration
Goddard Space Flight Center

Wallops Flight Facility

This Research Range Services Program Annual Report is dedicated to Tom Taylor, who retired in October 2009 after 34 years of service to Wallops Flight Facility. Taylor's duties over the years have been varied, serving as a computer programmer, system administrator, systems engineer and as the Range Control Center Operations Manager. Over the years, Taylor's talents were so valued by NASA that he was requested to serve at the Johnson Space Center in Houston, Texas, and at Goddard Space Flight Center in Greenbelt, MD, as the GSFC Certification and Accreditation official.

Taylor now is enjoying retirement life with his wife in Snow Hill, MD, but hasn't quite figured out what to do with his spare time. Taylor continues to support Wallops by volunteering as a participant in the Goddard Emeritus Program.

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Wallops Island, Virginia, is where launch assets and many Research Range Services support instrumentation are located.

Radar Technician Garry Tull operates an open sight during a Poker Flat Research Range sounding rocket mission in January 2009.

The National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (GSFC) Wallops Flight Facility (WFF) Research Range Services (RRS) Program had another outstanding year supporting a variety of NASA programs, missions and projects during the fiscal year ending September 30, 2009. The RRS program continued to provide unparalleled support to critical NASA missions across all Directorates, but that support did not happen without considerable personal effort. It took experienced people dedicated to carrying out the mission to make it happen. RRS personnel also continued to support Range operations with ground instrumentation services for reimbursable customers, including the Department of Defense (DoD) and other government agencies, to take advantage of collaborative operations opportunities.

Personnel commitment to excellence upheld the rich heritage of responsiveness and innovation that has been the cornerstone of RRS for more than 60 years. In addition, technological program modernization efforts continued to improve RRS capabilities and allow the Range to remain a viable solution in support of future NASA missions worldwide.

In FY 09, Range personnel supported missions throughout the continental United States and around the world. We continued our prioritized focus on NASA's Sounding Rocket Program, Space Shuttle and International Space Station (ISS) missions. We studied the effects of Parachute-assisted payload drop landings for future Moon and Mars missions and conducted numerous launch operations. We also supported the private sector, studying tire friction effects on the nation's airport runways. In addition, we partnered with the National Oceanic and Atmospheric Administration (NOAA) to enable numerous atmospheric weather data studies. RRS personnel were also involved with community organizations and educational groups to expand awareness of the RRS mission and capabilities and to educate the next generation of scientists and engineers. Finally, we hosted a number of distinguished visitors and guests interested in what RRS provides to NASA.

In summary, RRS continues to enable research worldwide through our premiere engineering and Range operation services and looks forward to supporting launches in 2010.

Mr. Thomas J. "Jay" Pittman
Goddard Space Flight Center
Wallops Flight Facility
Research Range Services

RRS-Supported NASA Goals

1

STRATEGIC GOAL 1

Fly the Shuttle as safely as possible until its retirement, not later than 2010.

Sub-goal 1.1: Assure the safety and integrity of the Space Shuttle workforce, systems and processes while flying the manifest.

2

STRATEGIC GOAL 2

Complete the International Space Station in a manner consistent with NASA's International partner commitments and the needs of human exploration.

Sub-goal 2.1: By 2010, complete assembly of the U.S. On-orbit Segment; launch International Partner elements and sparing items required to be launched by the Shuttle and provide on-orbit resources for research to support U.S. human space exploration.

3

STRATEGIC GOAL 3

Develop a balanced overall program of science, exploration and aeronautics consistent with the redirection of the human spaceflight program to focus on exploration.

Sub-goal 3B: Understand the Sun and its effects on Earth and the solar system.

- 3B.1: Progress in understanding the fundamental physical processes of the space environment from the Sun to Earth, to other planets and beyond to the interstellar medium.

Sub-goal 3E: Advance knowledge in the fundamental disciplines of aeronautics and develop technologies for safer aircraft and higher capacity airspace systems.

- 3E.2: By 2016, develop and demonstrate future concepts, capabilities and technologies that will enable major increases in air traffic management effectiveness, flexibility and efficiency, while maintaining safety, to meet capacity and mobility requirements of the Next Generation Air Transportation System.

4

STRATEGIC GOAL 4

Bring a new Crew Exploration Vehicle into service as soon as possible after Shuttle retirement.

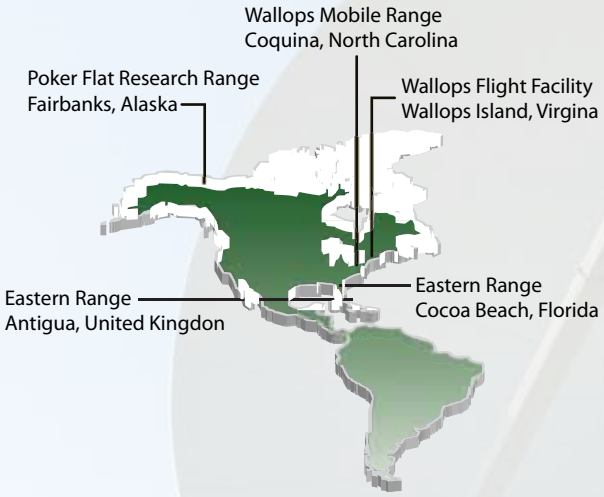
Sub-goal 4.1: No later than 2014, and as early as 2010, transport three crewmembers to the International Space Station and return them safely to Earth, demonstrating an operational capability to support human exploration missions.

Introduction

The NASA RRS Program supports NASA's mission objectives by providing tracking, telemetry, meteorological, optical and command and control services for flight vehicles including orbital and suborbital rockets, aircraft, satellites, the Space Shuttle, balloons and Unmanned Aircraft Systems (UAS) vehicles, providing real-time display and capture of mission-specific flight, payload and science data.

The RRS Program staff operates and maintains a wide variety of range instrumentation systems at WFF and at Poker Flat Research Range (PFRR) in Fairbanks, Alaska, to provide capabilities essential to the success of range operations at these fixed sites and remote locations around the world. Systems and capabilities include:

- Fixed and mobile radar systems for tracking launch vehicles, satellites and aircraft; ground-based and airborne radars for area surveillance to ensure safe flight operations; and ground-based scientific radars to provide atmospheric and weather measurements.
- Fixed and mobile telemetry systems to collect and distribute state-of-health and science data from flight vehicles and payload instrumentation during pre-mission checkouts and flight operations.
- Voice, video and data communications systems to provide coordinated execution of operational missions.
- Data systems to acquire, record and process radar and telemetered information for real-time display, facilitating monitoring of vehicle performance and controlling of flight events.
- Fixed and mobile optical and television systems providing vehicle tracking capabilities, ground-based and aerial video and photography, still photography archiving and printing and post-production services.
- Fixed and mobile command systems to control flight vehicles and provide flight termination capabilities for Range Safety purposes.
- Radio Frequency (RF) spectrum allocation management and coordination and monitoring equipment to detect and locate sources of RF interference.
- Master station time equipment to synchronize Range activities and data.

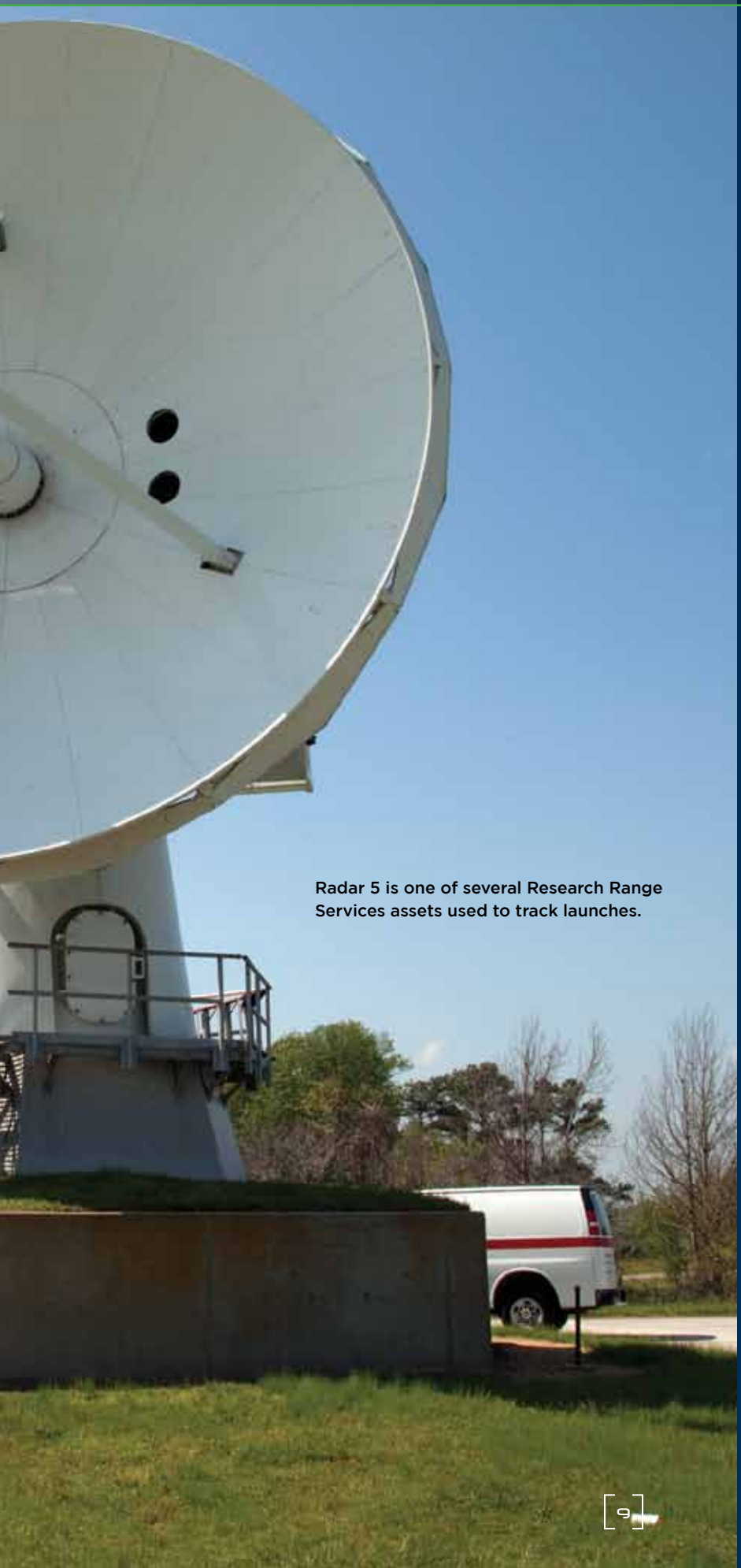


- Range Control Center (RCC) systems to monitor coordinated mission operations and track Range, vehicle and payload status during operations.
- Meteorological instrumentation to measure current atmospheric and weather conditions to develop accurate forecasts for safe Range operations.

Program personnel also provide sustaining engineering and project management services. Sustaining engineering services include verifying instrumentation performance metrics, assisting in determining and correcting root causes to system failures, implementing minor to moderate system upgrades and enhancements and performing link analysis calculations to ensure adequate radar, telemetry and command support of missions.

Engineers are also responsible for helping establish operational sites at remote locations, which routinely include an off-axis site at Coquina, N.C., and the remote PFRR, but also at locations including Florida, Bermuda, Kwajalein, Australia and Norway, where well-engineered range architectures are implemented to support special projects.

To ensure that the RRS Program properly supports all operations and achieves success in support of NASA's overall mission, project managers are assigned to missions. These project managers develop an overall support plan to meet success requirements and ensure Range readiness.



Radar 5 is one of several Research Range Services assets used to track launches.

Research Range Services—A Team of Teams

- **Program Management**
- **Financial Management**
- **Configuration Management**
- **Hardware Engineering**
- **Software Engineering**
- **Systems Engineering**
- **Radar**
- **Photo/Optical**
- **Telecommunications**
- **Meteorological**
- **Range Control**
- **Logistics**

In FY 09, the RRS Program Manager was responsible for continued launch instrumentation support to NASA sub-orbital programs and projects, while simultaneously enabling a major remote campaign, a Wallops mission involving local launch sites and a downrange deployed tracking/command site.

To accomplish these goals and to support additional customers, the RRS personnel met the following mission requirements:

- Proficiently operated all Range instrumentation to satisfy all mission requirements through operator certification, configuration management, pre-mission testing and approved operational procedures.
- Assured that Range instrumentation was available for all missions through mission planning and effective corrective and preventive maintenance.
- Utilized systems sustainment, engineering and technology advancements to meet new mission requirements, improve Range safety, reduce operational costs and replace obsolete equipment.

The RRS Program Manager was also responsible for overseeing the technical performance of contract services including: setting mission priorities, ensuring sufficient staffing levels, identifying and prioritizing engineering upgrades and overseeing efforts between NASA engineering and contractor personnel.

Program Management Overview

Directorate: Science Mission Directorate
Division: Heliophysics
Program Executive: Ms. Cheryl Yuhas
Program Manager: Mr. Thomas J. "Jay" Pittman
Lead Center: Goddard Space Flight Center
Performing Facility: Wallops Flight Facility
Program Type: Research Range Services

RRS Personnel and Resources

The RRS Program in FY 09 included valuable staffing and inventory resources that contributed to the mission success for the year. A combined staffing total of 119 civil service employees and contractors were responsible for more than $231 million in fixed and deployable mobile instrumentation and state-of-the-art communication and support equipment.

Civil Service (10)
RRS Program Manager
Deputy Program Manager
Chief Engineer
Financial Manager
Contract Support
Systems Engineers (5)

Contractor (109)
Management and Engineering (36)
Radar Services (27)
Telecom Services (23)
Meteorological Services (8)
Video and Optical Services (8)
Range Control (7)

RRS Assets: 231.7 (in millions)

Telemetry Systems: $29.2	Per Unit	Quantity	Total
7.3-meter Fixed Antenna	$1.5	2	$3.0
7-meter Mobile Antenna	$1.5	2	$3.0
Mobile Telemetry Van	$1.5	1	$1.5
20-foot Mobile System	$2.0	1	$2.0
Mobile Super Van	$2.5	1	$2.5
10-foot Mobile Antenna	$0.5	1	$0.5
8-foot System	$0.4	2	$0.8
8-foot Mobile Antenna	$0.4	1	$0.4
8-meter Antenna	$2.5	2	$5.0
16-foot System	$0.5	1	$0.5
9-meter Redstone	$6.0	1	$6.0
9-meter System	$4.0	1	$4.0

Atmospheric Radars: $48	Per Unit	Quantity	Total
Space Range Radar	$20.0	1	$20.0
Ultra High Frequency (UHF)	$18.0	1	$18.0
S-band Weather (Tropical Ocean Global Atmosphere)	$5.0	1	$5.0
NASA Polarimetric	$5.0	1	$5.0

Tracking Radars: $108	Per Unit	Quantity	Total
Range Instrumentation Radar – 778C	$6.0	4	$24.0
Range Instrumentation Radar – 716	$7.0	2	$14.0
Range Instrumentation Radar – 706	$70.0	1	$70.0

Surveillance Radars: $13.9	Per Unit	Quantity	Total
Airport Surveillance Radar	$10.0	1	$10.0
Sea Surveillance	$1.0	1	$1.0
Pathfinder	$0.7	2	$1.4
Active Protective System – 143	$2.5	1	$2.5

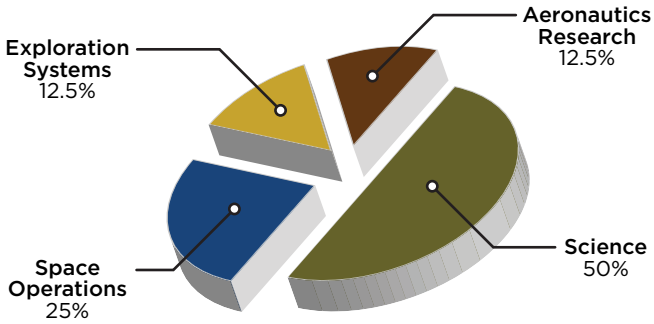
Command & Support Systems: $31.3	Per Unit	Quantity	Total
Fixed UHF Command System	$4.0	1	$4.0
Mobile Command System	$1.4	1	$1.4
Mobile Range Control System	$2.1	1	$2.1
Radio Frequency Communication	$3.0	1	$3.0
Timing System	$0.8	1	$0.8
Control Center	$10.0	1	$10.0
Video and Optical Systems	$10.0	1	$10.0

Mobile Power: $1.2	Per Unit	Quantity	Total
Mobile Power Systems	$0.3	4	$1.2

The customer base for the RRS Program includes a variety of NASA Programs and spans all four Mission Directorates (Science 50%, Space Operations 25%, Aeronautics Research 12.5% and Exploration Systems 12.5%). The program enables and supports the safe and successful execution of the Agency's Sounding Rocket, Space Shuttle and UAS programs through critical involvement of RRS fixed and mobile range assets, services and capabilities at WFF and remote locations. The RRS personnel maintains partnerships and actively coordinates with a number of other federal and local government agencies to plan and conduct these operations.

The RRS Program also supports DoD and civil agency programs and missions. In supporting these activities, the staff works closely with a diverse group of customers and successfully collaborates with the U.S. Navy, the U.S. Air Force, the Missile Defense Agency, the National Weather Service (NWS), the NOAA and others.

RRS FY Customer Distribution



RRS FY 2009 Mission Support

MISSION	# OF LAUNCHES	DATE
Space Transport System (STS) – 126	1	Nov. 14, 2008
ISIS Sounding Rocket	1	Jan. 10, 2009
ACES Sounding Rocket	2	Jan. 29, 2009
Turbopause Sounding Rocket	4	Feb. 18, 2009
MLAS Parachute Drop Test	1	Mar. 6, 2009
STS-119	1	Mar. 15, 2009
CASCADES 2 Sounding Rocket	1	Mar. 20, 2009
STS-125	1	May 12, 2009
TacSat-3	1	May 19, 2009
SOAREX Sounding Rocket	1	May 28, 2009
RockOn II Sounding Rocket	1	June 25, 2009
MLAS Flight Test	1	July 8, 2009
STS-127	1	July 15, 2009
IRVE II Sounding Rocket	1	Aug. 17, 2009
STS-128	1	Aug. 28, 2009
LaRC GTM AirSTAR UAV	1	Sept. 14-15, 2009
CARE Sounding Rocket	1	Sept. 19, 2009
STSS Demo Launch	1	Sept. 29, 2009

NASA Science Mission Directorate

In FY 09, the RRS Program continued supporting a variety of essential planning, coordination and technical services to enable and support 11 Maximum Launch Abort System drop test and sounding rocket operations flying from WFF.

Strategic Goal 3—*"Develop a balanced overall program of science, exploration and aeronautics consistent with redirection of the human spaceflight program to focus on exploration"* and Sub-Goal 3 B.1 to both *"Understand the Sun and its effects on Earth and the solar system"* and *"Progress in understanding the fundamental physical processes of the space environment from the Sun to Earth, to other planets and beyond to the interstellar medium."*

Poker Flat Research Range (PFRR) NASA Sounding Rocket Campaign

Launch Date: Jan. 10, 2009; Jan. 29, 2009 (two rockets); Feb. 18, 2009 (four rockets); Mar. 20, 2009

The RRS Mobile teams supported the 2009 PFRR NASA Sounding Rocket Campaign. The Range is located 20 miles north of Fairbanks, Alaska.

The Campaign consisted of eight rockets used for four separate missions:

ISIS (Ionospheric Science and Inertial Sensing) – a University of Alaska student outreach mission. The principal objective of the ISIS mission was to provide a learning experience for the student team. The scientific objectives of the mission were to measure the plasma and geomagnetic structures of the D-region ionosphere, as well as ozone density at lower altitudes in a high latitude region. The rocket used was a single-stage Orion. The Principal Investigator for ISIS was Dr. Thorsen from the University of Alaska Fairbanks.

ACES (Aurora Current and Electrodynamics Structure) – designed to study electric fields and current structure within an aurora. The primary objectives of ACES were to determine the three dimensional geometry of the current closure within a stable aurora arc, the relative importance of the Hall current to the current closure system and to answer the question of whether the Hall currents are directly tied to the arc current system or if they are closed loop systems. Two rockets (a BBIX and a BBVB) were launched within 90 seconds of one another along similar magnetic coordinates, reaching different altitudes with apogees occurring in close time proximity. The difference in altitude provided a set of measurements allowing a better understanding of the electrodynamics of an auroral arc and the relationship between in-situ measurements and ground-based observations. The Principal Investigator for ACES was Dr. Bounds from the University of Iowa.

Turbopause – a mission to determine the uppermost levels of neutral air turbulence in the Earth's atmosphere by observing the dispersion of Trimethyl Aluminum (TMA) as a tracer and by in-situ measurements of small-scale fluctuations in neutral and electron densities. The experiment sought to identify processes that cause enhanced mixing near the turbopause, observe temporal development of the event, quantify turbulence by observing tracer dispersal and spectrum of density fluctuations and measure high-resolution temperature and wind profiles to determine atmospheric stability. Four Terrier-Orion rockets were launched to conduct this mission. Two of the rockets carried TMA release payloads while the other two carried mother/daughter type payloads comprised of one TMA release section and one instrumented section. All four rockets were

launched in one night, separated by 30 to 50 minutes. The Principal Investigator for Turbopause was Dr. Lehmacher from Clemson University.

CASCADES 2 (Changing Aurora: in-situ and Camera Analyses of Dynamic Electron Precipitation Structure) – investigated the motions and structure of electron precipitation in pre-midnight, pole-ward edge discrete aurora. The principal scientific objective was the investigation of spatial and temporal structures within electron precipitation and low frequency electric field activity in the topside ionosphere. The rocket used was a four-stage Black Brant XII (BBXII). The Principal Investigator for CASCADES 2 was Dr. Lynch from Dartmouth College.

Planning for these missions began in April 2008. One Mobile Telemetry antenna system and approximately 1,000 pounds of ground station receiving equipment were required to be shipped from Virginia to Alaska. These would augment mobile assets already in Alaska, along with existing Poker Flat range architecture. Maintenance trips during the summer and fall readied the Range for the winter campaign.

In order for aurora studies to be successful, science conditions have to be met and often differ from mission to mission. Consequently, operational support often consists of setting up for launch and making a full check-out of all ground equipment, followed by a long wait for science conditions to materialize. Weather is also an issue because there are wind constraints for the rocket and many missions require downrange, ground-based optical sites with clear sky visibility.

The original launch windows called for two missions to be launched in January 2009 and two to be launched in February 2009. The lack of favorable science conditions caused one mission to be delayed until an optional March window. RRS Mobile crews were in Alaska from Jan. 2 to Mar. 25, 2009.

In addition to working in harsh conditions (temperature lows down to -50°F in January), the eruption of Mount Redoubt two days after the final launch caused the cancellation of all flights in and out of Fairbanks, keeping Mobile crew members in Alaska for three to five additional days.

Launch of the ISIS mission occurred on Jan. 10, 2009. All TM antennas and Radar successfully tracked from pad to LOS, with no dropouts. A test of newly engineered Instantaneous Impact Prediction computer and software was successful and subsequently used for the missions that followed. NASA and the Range personnel were pleased with the results.

John Kamps provides optical tracking services during a launch at PFRR.

The two ACES rockets were successfully launched on Jan. 29, 2009. The high-flyer reached apogee at 365.4 km, the low-flyer apogee was 132.7 km. TM antennas and Radar successfully captured all mission data.

Four rockets for the Turbopause mission were successfully launched on Feb. 18, 2009. Unlike the two-rocket salvo for ACES, each of the four were independent launches with no two being in flight at the same time. TM antennas and Radar successfully captured all mission data.

After more than a month of waiting for favorable science conditions, a BBXII rocket lifted the CASCADES 2 payload to an apogee of 564 km on Mar. 20, 2009. Tracking by Radar and TM was very smooth, and all data was captured.

A sounding rocket lifts off from a Poker Flat Research Range launch pad during the 2009 campaign.

RockOn II

Launch Date: June 25, 2009

WFF hosted approximately 100 college students and instructors during the second RockOn workshop, a collaborative effort between the Colorado Space Grant Consortium, the Virginia Space Grant Consortium and the NASA Wallops Sounding Rocket Program.

Research Range personnel supported the workshop that provided a unique, hands-on, university-level rocket flight training experience for aerospace students. The students were exposed to the entire mission process from designing and building the payload to launching the rocket and analyzing data.

The June 2009 mission, supported by RRS personnel, employed a larger two-stage standard sounding rocket consisting of a Terrier Mk12 Stage 1 and an Improved Orion Stage 2. The larger rocket provided greater performance and allowed for a larger number of experiments than the previous RockOn workshop. During the workshop, students assembled 20 kit experiments with the help of NASA engineers. These experiments, along with custom experiments provided by nine participating educational institutions, were packed into special canisters and loaded onto the rocket.

Range instrumentation tracked the rocket's flight using radars to provide trajectory data and to aid in recovery. Onboard data recorders captured the experiment data, alleviating the need for Range telemetry support, but raised the criticality of good radar tracking to located the payload in the ocean.

A Terrier Improved Orion sounding rocket, used for the second RockOn educational workshop held for aerospace students, lifts off in the early morning.

The payload was located and recovered successfully, and students took their experiments and radar trajectory data to correlate their findings.

The experiences that these students bring back to their respective universities are helping to grow the next generation of NASA engineers and project managers.

NASA Exploration System Mission Directorate

In FY 09, the RRS Program supported two separate Maximum Launch Abort System (MLAS) tests that took place at WFF. These experimental tests were designed to help usher in a new era of manned space flight in NASA's near future.

Strategic Goal 4 – "Bring a new Crew Exploration Vehicle into service as soon as possible after Shuttle retirement," and Sub-goal 4.1: "No later than 2014, and as early as 2010, transport three crewmembers to the International Space Station and return them safely to Earth, demonstrating an operational capability to support human exploration missions."

Max Launch Abort System Drop Test

Launch Date: March 6, 2009

The MLAS Drop Test was conducted in support of the overall MLAS Project. Due to the rapid development of the MLAS flight test article, the team decided to use surplus military cargo parachutes. While this approach saved time and money that would otherwise be used to develop a special parachute system, it came with some risk.

The test was planned to ensure that parachutes would adequately support and slow a Crew Module to a safe speed, as well as to evaluate the parachute's performance characteristics. The planning and execution of this test took less than a month, but required coordination with a military flight test unit, special engineering to build a test article and planning range support with radar and photographic assets. The test article was comprised of a stack of steel plates that replicated the mass of the crew module of more than 16,000 pounds. The four main parachutes were tucked inside a Forward Bay Closure, which also descended under a parachute deployed by a lanyard upon release from the helicopter. To ensure that highly accurate radar data would perform analysis on the parachute descent, radar beacons were installed on both the test article and the Forward Bay Cover.

Due to the importance of a successful test and some of the dangers involved, the test was conducted as a separate mission; a test plan and countdown procedures were developed and presented in a readiness review.

On the day of the test, a U.S. Marine Corps CH-53E Super Stallion landed on the runway where the flight test article was being prepared. After an aircrew briefing, the test article was hitched to the helicopter and slowly lifted off the ground. Highway closure was coordinated with local authorities so the CH-53E could cross the highway while carrying the heavy load suspended beneath. One runway radar skin-tracked the helicopter to provide the other radars with acquisition data.

After flying two test passes over the drop zone, the CH-53E dropped the test article and the parachutes all deployed as planned. A radar beacon-tracked the Forward Bay Cover and two additional radars beacon-tracked the test article until landing. Two Wallops optical tracking stations and a military optical tracking station captured video and still photos of the parachute deployments.

The U.S. Navy also flew a helicopter to capture aerial photography of the drop. Range timing and communication were critical to informing the helicopter when they were at the right altitude, the right velocity and within the drop zone. The test was highly successful and the design was implemented in the overall successful MLAS design.

MLAS Flight Test

Launch Date: July 8, 2009

WFF was selected by the Exploration Systems Mission Directorate and NASA Engineering and Safety Center as the lead range and launch site for assembling, integrating and operationally testing an experimental launch abort system (LAS) for the Orion Crew Module that will be launched atop the new Ares I rocket.

The MLAS abort system is an alternate design developed as a risk mitigation measure for the baseline Orion LAS. Wallops was selected based on past launch abort testing experience and current non-involvement in the baseline LAS, ensuring objective testing conditions. This test launch was a proof-of-concept of MLAS.

The purpose of the test launch was to demonstrate MLAS' capability to deliver the Orion Crew Module to a position and orientation from which a safe landing and recovery could be achieved and to demonstrate an alternate landing parachute design. For this reason, and to keep pace with the baseline LAS development and testing schedule, the tested MLAS design did not use its own propulsion as designed in the Forward Fairing. For this flight test only, MLAS test article used a propulsion system mounted in a pusher mode, with solid rocket motors located beneath the Crew Module.

From the moment the concept was sketched on a napkin in June of 2007 to successful implementation a short two years and one month later, WFF personnel were fully engaged, undertaking one of the biggest missions in recent history.

Wallops engineers, technicians and operators helped build and test the MLAS test article, designed and built a whole new ground station and launch pad, developed a new Range architecture and flawlessly executed an array of amazing and well-planned tests and operations.

The Maximum Launch Abort System rocket launches from Wallops Flight Facility in Wallops Island, Va.

To support the assembly and integration of MLAS, one of the Range's primary mobile telemetry systems was emplaced next to the processing facility as a dedicated ground station for telemetry testing. The processing facility was upgraded with Range timing circuits, voice communications equipment and interconnectivity with Range data networks.

Being 18 feet in diameter (25 including the fins) and more than 40,000 pounds, none of the existing launch pads could support the size and weight of the MLAS, so a new pad was poured adjacent to the Wallops Island sea wall. In addition, a new mobile pad shelter was built, and a full array of voice communication, data and firing circuit lines were installed.

Because the hazard area for the launch encompassed all of the existing blockhouses, a new blockhouse was selected off the island on the adjacent Wallops mainland. The mainland blockhouse normally served as a radar site, but was now going to function as the telemetry ground station, blockhouse and VIP viewing area. A full complement of communication terminals, countdown clocks, video displays and firing circuitry was installed in record time. When integration and testing were complete at the processing facility, the mobile telemetry system was relocated next to the new blockhouse, along with a mobile 10-foot telemetry antenna. The Range was ready for final testing by the time MLAS arrived at the new launch pad.

Range photographers captured the processing of MLAS from the moment components arrived at Wallops through its launch, and as each component separated and descended to the ocean. A Time-Lapse Photography system using three cameras was installed in the processing facility to capture the build-up from multiple angles. High speed digital video cameras were mounted to optical trackers to ensure the best quality launch photos. Aerial photographs captured the launch from critical viewing angles and on the recovery ship to document the condition of the components and the recovery operations. High speed photography captured data during motor igniter testing and parachute mortar testing.

RRS personnel were also critical in many administrative aspects of the launch. Operators assisted with Range requirements definition and countdown procedure drafting. RRS engineers wrote all of the test procedures. In addition, much of the special ground station equipment and other material assets and services were acquired through the Research Range.

During the final launch, five Range radars successfully tracked the test article, with some breaking off to track the Forward Fairing and others to continue tracking the Crew Module. The mobile 10-foot telemetry antenna successfully captured all four links and the ground station transmitted the critical data to the RCC. The Flight Control Officer observed the data and sent two commands to initiate flight events, transmitted by the Command Antennas. Four additional telemetry antennas received and recorded the telemetered links, offering a backup if any of the links failed or if the 10-foot antenna failed.

The Maximum Launch Abort System (MLAS) test vehicle sits on the launch pad before its flight test.

Optical tracking was performed from three RRS camera stations and one contracted camera station. During the countdown, a series of ten Global Positioning Satellite (GPS) and radar meteorological balloons were deployed to ascertain the atmospheric density. Data collected helped the Flight Control Officer know when to initiate the flight events. All Range instrumentation performed flawlessly and the mission was a total success. Radar and telemetry data, along with processed Range data, still photos and videos, were all delivered to the project according to the delivery schedule.

With the conclusion of this very successful proof-of-concept, there may be follow-on launches that will test the final MLAS design, using its own abort motors mounted in the forward fairing. Wallops will undoubtedly be called upon again to help engineer, integrate and test that design.

NASA Aeronautics Research Mission Directorate

In FY 09, the RRS Program provided essential services enabling NASA aeronautics research missions using seven different sounding rocket campaigns. Each experiment was launched from the PFRR near Fairbanks, Alaska.

These activities support NASA's Strategic Goal 3 to *"Develop a balanced overall program of science, exploration and aeronautics consistent with the redirection of the human spaceflight program to focus on exploration"* and Sub-Goal 3 E.2 to both *"Advance knowledge in the fundamental disciplines of aeronautics and develop technologies for safer aircraft and higher capacity airspace systems"* and *"By 2016, develop and demonstrate future concepts, capabilities and technologies that will enable major increases in air traffic management effectiveness, flexibility and efficiency while maintaining safety, to meet capacity and mobility requirements of the Next Generation Air Transportation System."*

Generic Transport Model (GTM) Airborne Sub-scale Transport Aircraft Research (AirSTAR)

Flight Dates: June and September 2009

In June and September 2009, RRS program personnel continued providing operational support to the GTM AirSTAR program managed by NASA's Langley Research Center (LaRC) near Norfolk, Va. RRS support included meteorological and other range assets including optical tracking to provide real-time video of mission operations.

RRS personnel supported AirSTAR missions using the T2 aircraft, which is powered by twin turbine engines designed to conduct flight dynamics and control system experiments. The AirSTAR program includes a jet powered Unmanned Aircraft System (UAS) with an associated ground-based control system to investigate flight characteristics of large transport aircraft during extreme flying conditions.

This program contributes to objectives of NASA's Aviation Safety Program by conducting research to address advances in vehicle health monitoring and flight controls technology. The research is intended to provide resilient control for transport airplanes under adverse conditions such as post-stall flight, sensor faults, flight control failure and airframe damage. The AirSTAR program was developed to conduct this research using unmanned, dynamically scaled models of a commercial transport airplane in a safer environment because such flight conditions are extreme and unsuitable for full-scale manned transport airplane flight tests.

A scaled LaRC UAS model is used to test a variety of flight conditions in a much safer way than a manned aircraft.

Sub-Orbital Aerodynamic Re-entry Experiments (SOAREX)

Launch Date: May 28, 2009

The SOAREX Terrier Orion launched May 28 and was one of the most dynamic sounding rocket launches during 2009. The rocket, packed with science experiments from NASA Ames and Systima Technologies, Inc., launched to test deceleration concepts of re-entry probes and a new restraint/ejection system design.

The seven downlinks required to collect all data and video provided ample challenges for RRS Telemetry and Readout Services and Tracking Resources. Multiple antennas, telemetry processing equipment and recording systems were employed to capture the real-time data. Four RRS radars tracked the SOAREX probes and launch vehicle while four telemetry antennas were used to collect experiment data. The mission was highly successful and all systems operated nominally.

IRVE II

Launch Date: Aug. 17, 2009

Research Range Services personnel successfully tracked three rocket launches on Aug. 17, 2009, in support of the NASA's LaRC's Inflatable Re-entry Vehicle Experiment II (IRVE II) program.

Two small Viper 3A Darts and one Terrier-Black Brant (BBIX) sounding rocket were launched to demonstrate how a spacecraft returning to Earth can use an inflatable heat shield to slow and protect itself as it re-enters the atmosphere at hypersonic speeds. The IRVE II flight test also demonstrated inflation and survivability at a realistic dynamic pressure and ballistic coefficient.

Range data acquisition and tracking instrumentation supported this launch; no downrange assets were used. The launch was Wallops' second attempt at executing a flight test that demonstrated the viability of hypersonic inflatable aeroshell technology in terms of both inflation and re-entry survivability.

The key focus of the research came about six and a half minutes into the flight, at an altitude of about 50 miles, when the aeroshell re-entered Earth's atmosphere and experienced its peak heating and pressure measurements for a period of about 30 seconds. An on-board telemetry system captured data from instruments during the test and broadcast the information to engineers on the ground in real time. The technology demonstrator splashed down and sank in the Atlantic Ocean about 90 miles east of Wallops Island.

NASA's LaRC requested that the Wallops Sounding Rocket Program provide the carrier vehicle to conduct the IRVE II test mission. At the post-launch briefing, LaRC expressed pleasure with results and promised to bring more IRVE type missions to this test range.

This test was important to NASA's program because inflatable heat shields hold promise for future planetary missions, according to NASA LaRC researchers. To land more mass on Mars at higher surface elevations, for instance, mission planners need to maximize the drag area of the entry system. The larger the diameter of the aeroshell, the bigger the payload can be.

The Inflatable Re-entry Vehicle Experiment is an example of how NASA is using its aeronautics expertise to support the development of future spacecraft. The Fundamental Aeronautics Program within NASA's Aeronautics Research Mission Directorate funded the flight experiment as part of its hypersonic research effort.

A sounding rocket takes off as part of the Inflatable Re-entry Vehicle Experiment II program.

NASA Space Operations Mission Directorate

The RRS Program continued its role as an integral member of the Space Shuttle mission operations team by tracking Shuttle mission flight information and providing UHF ground-to-air voice communications during ascent to orbit for all of the Space Shuttle missions to the ISS.

RSS support primarily fulfilled NASA Strategic Goal 1 to *"Fly the Shuttle as safely as possible until its retirement, not later than 2010"* and Sub-Goal 1.1 to *"Assure the safety and integrity of the Space Shuttle workforce, systems and processes while flying the manifest."*

However, RRS operations also supported NASA Strategic Goal 2 to *"Complete the International Space Station in a manner consistent with NASA's International partner commitments and the needs of human exploration"* and Sub-Goal 2.1: *"By 2010, complete assembly of the U.S. On-orbit Segment, launch International Partner elements and sparing items required to be launched by the Shuttle; and provide on-orbit resources for research to support U.S. human space exploration."*

In supporting space shuttle missions, RRS personnel partnered with other NASA teams across a range of agency operations and services.

Space Shuttle Support

During FY 09, RRS personnel supported five Space Shuttle missions that included four ISS missions and a Hubble Space Telescope repair mission - Space Transportation System STS 125. Overall, a total of 585 passes were tracked with valuable data transmitted to the Eastern Range Controllers and Johnson Space Center (JSC) Navigators as part of the pre launch, launch and on-orbit mission activities.

The Research Range's two main radars shared the workload of simultaneously tracking the Orbiter and the ISS, as required, during the rendezvous and separation phases of the mission.

Range tracking radars and telemetry systems personnel worked with the Eastern Range Controllers, Goddard Network Managers and JSC Navigators prior to each launch to ensure RRS system readiness.

Voice circuits were thoroughly tested with GSFC and JSC prior to launch to ensure critical backup communications with the Orbiter in the event of an emergency. The voice downlink was received and recorded prior to WFF horizon break and lasted well after horizon set. Voice uplink was handed over to Range personnel from Merritt Island Launch Annex at eight minutes into flight.

The Command Transmitter personnel operated the UHF STS air-to-ground voice system during all high inclination launches. Voice and data circuits were tested during the mission, with simulation data transmitted across dedicated mission circuits to verify high data quality and system performance.

> **“Wallops Flight Facility personnel are key members of the Space Shuttle team. RRS personnel provide tracking of the Space Shuttle during the final minutes of ascent during all missions to the International Space Station. Without this tracking, the mission control team would not have an independent tracking source during those final minutes to make performance assessments and abort determination.”**

Darrin Leleux
Navigation Lead
Mission Operations Directorate
Johnson Space Center

Orbiter: Discovery
Mission: STS-128
Payload: Leonardo
Launch: Aug. 28, 2009
Time: 11:59 p.m. EDT
Site: Pad 39A, Kennedy Space Center (KSC), Fla.
Landing: Sept. 11 @ approx. 8:53 p.m. EDT
Site: Edwards Air Force Base, Calif.

Orbiter: Endeavour
Mission: STS-127
Payload: ISS 2J/A
Launch: July 15, 2009
Time: 6:03 p.m. EDT
Site: Pad 39A, KSC, Fla.
Landing: July 31 @ approx. 10:48 a.m.
Site: Shuttle Landing Facility, KSC

Orbiter: Atlantis
Mission: STS-125
Payload: HST SM-4
Launch: May 11, 2009
Time: 2:01 p.m. EDT
Site: Pad 39A, KSC, Fla.
Landing: May 24 @ 11:39 a.m. EDT
Site: Edwards Air Force Base, Calif.

Orbiter: Discovery
Mission: STS-119
Payload: S6 power truss
Launch: March 15, 2009
Time: 7:43 p.m. EDT
Site: Pad 39A, KSC, Fla.
Landing: March 28 @ 3:13 p.m. EDT
Site: Shuttle Landing Facility, KSC

Orbiter: Endeavour
Mission: STS-126
Payload: ISS ULF2
Launch: Nov. 14, 2008
Time: 7:55 p.m. EST
Site: Pad 39A, KSC, Fla.
Landing: Nov. 30 @ 4:25 p.m. EST
Site: Edwards Air Force Base, Calif.

Wallops Flight Facility Range Control Center personnel monitor and track a rocket during one of the many launches RRS supports throughout the year.

Department of Defense

The RRS Program plays a crucial role in many development and operational test programs for a variety of DoD systems. The program also offers compatibility with DoD Major Range and Test Facility Base Ranges through participation in the Range Commanders Council and voluntary compliance with Inter-Range Instrumentation Group standards, enabling RRS personnel to function in cooperative lead-range/support-range roles with DoD ranges. DoD missions are conducted on a complete reimbursable basis and within the context of a "NASA has first priority" framework that preserves NASA's authority at WFF. Additional RRS capabilities funded by non-NASA customers are usually retained by the WFF and thereby benefit subsequent NASA missions at significantly reduced, if not eliminated, development costs.

TacSat-3

Launch Date: May 19, 2009

The Range staff successfully supported the launch of the United States Air Force (USAF) Tactical Satellite-3 (TacSat-3) on May 19, 2009. The primary objectives of the TacSat-3 mission were to demonstrate the rapid design, build and test of a launch-ready space vehicle and the responsive launch, check-out and operations of the vehicle.

Range personnel were challenged to prepare and coordinate Range instrumentation at the three following sites to track and acquire mission data: Wallops Flight Facility, VA (up-range); Coquina, N.C. (mid-range); Antigua UK (down-range).

In addition, Range personnel were also challenged to support the TacSat-3 launch after conducting successful winter NASA Sounding Rocket Campaign support from the PFRR, Alaska.

By using experience and lessons learned from two previous expendable launch vehicle (ELV) launches (TacSat-2 and NFIRE) and the complex Hypersonic Boundary Layer Transition SOAREX ATK Launch Vehicle (ALV) (HSA) suborbital mission, the RRS TacSat-3 team provided excellent support to the customer. By employing classic project management techniques, scheduling resources appropriately and coordinating with numerous U.S. government agencies, the RRS again provided a data acquisition, range safety and tracking solution as required.

Implications for the future are positive. Because of the RRS success in tracking and acquiring critical mission data in support of an ELV launch, confidence increased for the next suborbital or orbital mission RRS will support.

"Thank you all for your perseverance over the long Tactical Satellite-3 campaign. I was extremely impressed with the professionalism of our Orbital team and Wallops range. As expected, mission success was the result. Kudos from Mr. Payton, to Gen. Kehler, to Gen. Sheridan on all the great work. I add mine to your entire team."

Col. William Scott Handy, USAF
Commander, Space Test Group
Space Development and Test Wing

CARE

Launch Date: Sept. 19, 2009

The **Charged Aerosol Release Experiment** (**CARE**) mission launched a three-stage Black Brant XI sounding rocket from the WFF containing a payload that consisted of a Nihka solid rocket motor (normally the fourth stage as part of a BBXII) and a dual-frequency beacon. The role of the Nihka motor in the experiment was not for propulsion but to simply burn at about 280 km in altitude, releasing combustion products and chemicals into the atmosphere forming an artificial noctilucent cloud of charged particles. These particles were then observed by many instruments (Radar, optical and radios receiving the beacon frequencies) along the East Coast, from New Hampshire to North Carolina, including a boat positioned 80 km off the coast of Wallops Island.

This particular four-stage sounding rocket design (three stages plus the Nihka fourth stage) has been flown 25 times by NASA and is typically launched from Alaska and Norway. In past launches of this vehicle design, the fourth stage is typically timed to ignite about 90 seconds after launch when the vehicle is about 100 km in altitude and climbing. For this launch, the fourth stage was designed to delay ignition so that the vehicle was much higher than normal (280 km) and just past apogee as it began to descend. Thus, the fourth stage products of combustion were dispersed at a much higher altitude than is typical for this type of sounding rocket.

The launch was timed to occur shortly after sunset in clear skies. This allowed the sun to illuminate the noctilucent cloud against a dark horizon. The payload splashed down about 450 km downrange in the Atlantic; there was no requirement for recovery.

This was a reimbursable mission for the U.S. Naval Research Laboratory (NRL). The Principal Investigator for this mission was Dr. Paul Bernhardt from NRL.

In addition to standard Range support, special requirements called for RRS Data Quality section personnel to provide four points of positional data at predetermined times following third stage burn out, but with enough time to calculate a trajectory sufficient to predict the fourth stage firing point. This point was then communicated, via telephone conference call line, to all the stations (Radar, optical and radio) tracking the plume so their respective instruments could be properly pointed at the event. NRL supplied a laptop with the necessary formulas, and RRS Data Quality provided software to capture the four points. Many practice sessions with NRL, Data Quality, and the various instruments were conducted prior to launch to refine the process for efficiency and accuracy. When the launch did occur, the plan worked flawlessly. At the Post-Mission Brief, the NRL remarked how well the plan that RRS personnel developed and refined worked.

The communications and tracking support by the RRS personnel and assets exceeded requirements. All data were recovered and turned over to the CARE Project within two days.

A Black Brant XI sounding rocket launches from Wallops Flight Facility shortly after sunset as part of the Charged Aerosol Release Experiment.

Space Tracking and Surveillance System (STSS)

Launch Date: September 25, 2009

The Space Tracking and Surveillance System (STSS) mission launched on September 25 and used the services of Wallops Precision Tracking Radar (Radar 5) on its flight into orbit. The STSS mission carried a DoD payload as part of a technology demonstration flight.

The Space Demonstration Flight was launched on a Delta II rocket from Cape Canaveral and tracked by NASA's only Missile Precision Radar (MIPR) on its northern trajectory past Wallops Island. It took approximately three minutes for the STSS rocket launched from Cape Canaveral to break horizon at Wallops.

At that time, Radar 5 locked on to the vehicle transponder and began transmitting critical position data to Delta II/STSS Controllers and Range Safety Officers. The data was transmitted over diversity routed circuits that connect the two ranges. One circuit follows a direct route while the other is routed via GSFC.

Throughout its history, the RRS personnel have supported Eastern Range, NASA, DoD and commercial launches. Typically all high inclination trajectories in view of Wallops are supported by one or more of RRS Telemetry Tracking and Command Services.

In FY 09, RRS FPQ-6 Radar 5 was active tracking the Japanese HTV spacecraft during its maiden flight to the ISS, as well as the Hubble Space Telescope during STS-125 (Hubble Repair Mission) and Soyuz missions. The FPQ-6 Radar is a MIPR and is known by the Eastern Range as 86.16 or WLPC. It has been a work horse for both ranges since the 1960s, tracking sounding rockets, aircraft and spacecraft.

For the last 40 years, Radar 5 has supported numerous manned missions including Apollo,

A Delta II rocket launches off as part of STSS mission, September 25. Wallops Precision Tracking Radar (Radar 5) tracked its flight into orbit.

Space lab and Space Shuttle, and expendable launch vehicles like Delta, Atlas and Titan. Upgrades performed over the years have maintained the commonality required for both Wallops and Eastern Range to share important tracking resources for public safety, science and control.

Civil Agencies

In FY 09, the RRS Program continued supporting several Civil Agencies in a variety of weather and aviation missions. The long-standing relationship between the Program and both the NWS and the NOAA yielded important meteorological data for scientists, additional RRS customers and the public. In addition, the RRS personnel once again hosted the annual Runway Friction Workshop to study future benefits of aviation flight safety measures.

National Weather Service (NWS) Support

The RRS Program has been supporting the NWS for more than four decades by launching twice-a-day balloon-borne radiosondes and unscheduled balloon launches, essential to mid-atlantic region NWS forecast, in times of severe weather. In late August 2009, RRS personnel provided weather balloon launches during Hurricane Bill, Tropical Storm Danny and other periods of severe weather and Nor'easters.

Accurately predicting changes in the atmosphere requires adequate observations of the upper atmosphere, and the NWS radiosonde network is the primary source of upper-air data. The balloon-borne radiosonde network is used to simultaneously measure and transmit meteorological data while ascending through the atmosphere. The radiosonde instrument consists of sensors to measure pressure, temperature and relative humidity. NWS meteorologists analyze individual radiosonde soundings to prepare short-term local weather forecasts. Individual soundings help forecasters determine many local weather parameters including atmospheric instability, freezing levels, wind shear, precipitation and icing potential.

Wallops is continuously rated by NWS in the top ten best-performing sites in the United States, and the RRS Program has been ranked number one in station performance of all 92 stations since the NWS began keeping records. This synergistic NASA-NWS relationship provides benefits for both agencies. The NWS benefits by having RRS' highly trained meteorological staff support their launch operations and weather research missions. NASA reaps benefits from this relationship by having access to more than 40 years of locally archived climatology data used by numerous Range customers to determine mission suitability and Range availability.

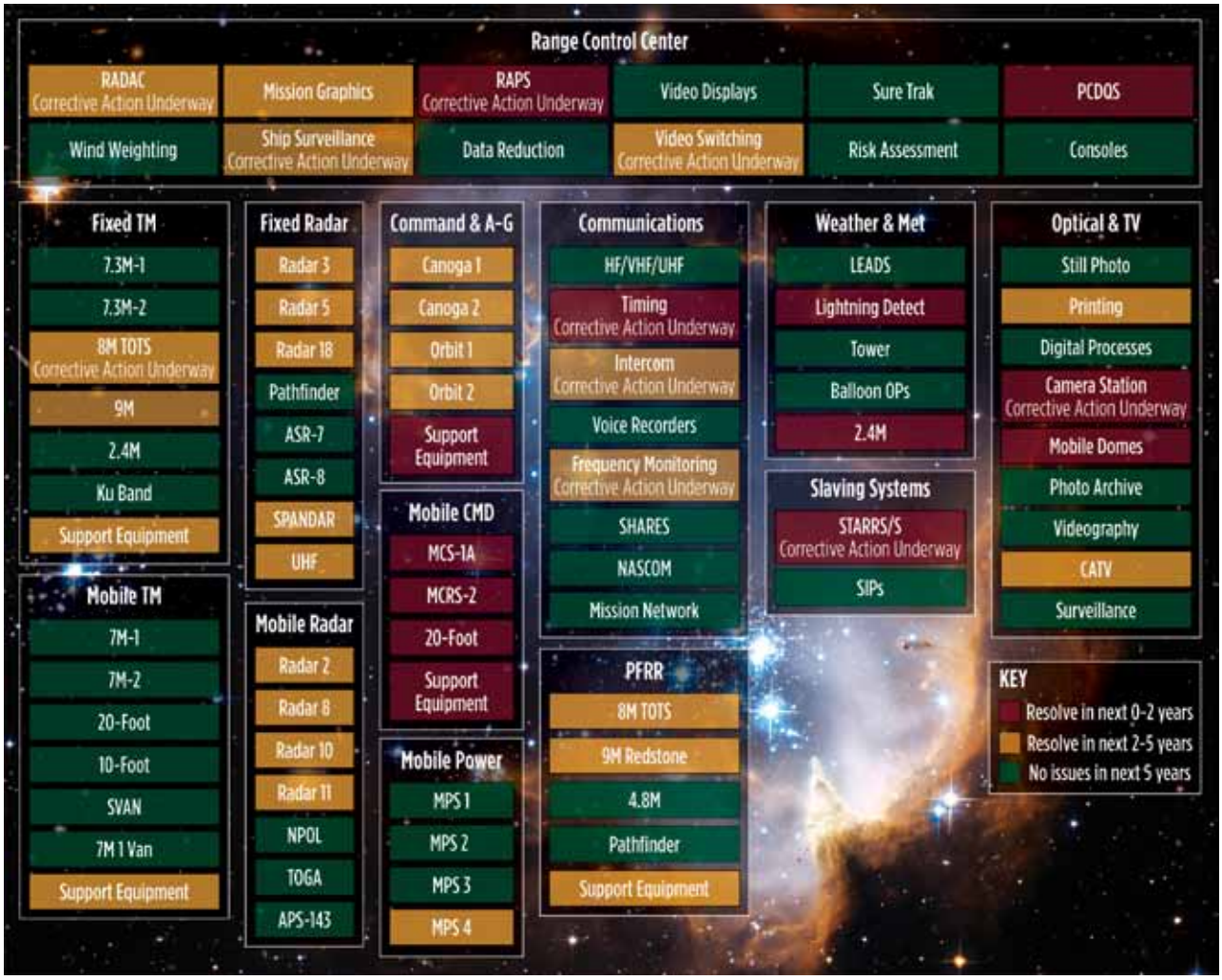
Friction and Wear Development Testing

Since 1978, NASA and the Federal Aviation Administration (FAA) have partnered together to conduct experiments to measure and explore how interactions between tires and pavement surface conditions affect safety of air travel in adverse weather conditions.

In FY 09, NASA's LaRC, in conjunction with Learjet, conducted friction and wear development testing to calculate the type and amount of protective materials that should be used on aircraft skid plates in the event of a wheels-up landing. The goal of the friction and wear development tests is to characterize a few candidate materials to justify a material selection for the skids that would slow the aircraft down while also reducing the possibility of fire. In this case, the airframe would first impact and then slide on the runway on the skids below the wing box, which will be abraded.

The wear of different materials were evaluated by applying them to a pressurized skid plate that was pulled by LaRC's Mobile Tire Test Facility ground vehicle on a runway over concrete and asphalt surfaces at different velocities. Comparative friction, wear and heat measurements were collected on various tape, fabric, aluminum and Kevlar test materials. RRS personnel provided project support, air traffic control, meteorological support and photo/video coverage.

Tire wear is a major economic concern to commercial and military aviation because tire replacement accounts for approximately half of the overall landing gear maintenance cost of jet aircraft. Results of this research have been leveraged in the design of Space Shuttle tires as well as in the design of tires for military and commercial use.



State of Health Management Tool

The RRS Program's Modernization initiative is an ongoing preventive and corrective maintenance effort that includes collaboration with other NASA organizations and external agencies. Program modernization pursues engineering and technological improvement projects to ensure readiness, enable the evolution of space-based metric tracking, telemetry and command relay architecture and avoid equipment/system obsolescence.

One of these modernizations is encrypting command destruct signals using the Enhanced Flight Termination System to ensure positive control of critical launches. Another modernization is improving the Range's data delivery infrastructure from a synchronous serial network to an Ethernet-based network, thereby reducing data delivery delays, improving maintainability and increasing functionality of other systems.

In order to facilitate modernization efforts to address obsolescence issues, the RRS Program developed a "State of Health" chart as a management tool to provide a systematic review and assessment process for all major subsystems and as a guide for the investment of scarce resource dollars into the subsystems whose failure seems more imminent or impacting to mission or safety assurance.

NASA's GSFC provided additional funding and support for key efforts to maximize the impact of required maintenance and upgrades. Notwithstanding, there are still a number of assets that require funding for upgrade and/or replacement.

The RRS Program is focused on Range modernization efforts using **Technology Infusion** to add new capabilities, **Technology Refresh** to sustain critical capabilities or extend the life cycle of key assets and modifications to improve **Information System Security**.

Technology Infusion

Technology infusion is the process of strategically binding technical needs and potential solutions to support customers efficiently and effectively. During FY 2009, RRS technology infusion projects increased capabilities in support of NASA's programs and contributed to the goal of continually modernizing the RRS facilities and processes through advanced technology in hardware upgrades and new or improved software.

Countdown Display System: In 2009, RRS engineers implemented a visual display application for monitoring and tracking launch countdown steps. This application enables the Test Director and Range Operations Assistant to track each step as completed and monitor and identify steps that were skipped or have yet to be completed. Tying this display into the RCC Video Switch enables each RCC console position to monitor the active countdown, thus improving the awareness of the launch progress and communications during critical countdown events.

High Data Rate X-Band Telemetry Link: In an effort to increase the quantity of data for science research, RRS, in partnership with the Sounding Rocket Program, collaborated to develop a high data rate X-Band telemetry link. This technology demonstration will piggyback on the Correlation of High-Frequencies and Auroral Roar Measurements–2 (CHARM-2) mission launched from PFRR, Alaska. The X-Band engineering team designed, procured, tested and is prepared to support the launch of this technology advancement. Increasing the data rate capabilities on sounding rockets enables scientists to capture high resolution measurements for further investigation in oscillations of electron densities in the upper atmosphere.

Leading Environmental and Display System (LEADS): Traditionally, weather forecasters archive written information regarding climate data that includes only temperature and precipitation, but in order to make accurate decisions on launch windows, scientists or experimenters need additional environmental information such as lightning, winds and temperature. Previously, these data items were purchased by the RRS Program from the National Climatic Data Center. In response to frequent customer requests for climate data, RRS engineers developed a new archive capability by initiating the hardware installation and factory acceptance testing of LEADS to allow access to environmental data without having to purchase them from an outside source. In 2009, the LEADS system was transitioned to operations. Future upgrades for 2010 will integrate Toxic and Plume analysis for ELV launches.

Mission Graphics: The Wallops Mission Graphics System provides Range Safety and the RCC with the ability to monitor real-time time, space and position information of the launch vehicle and telemetry data from the vehicle. The new system replaces an obsolete operating system and graphics hardware and utilizes Ethernet-based architecture for data communications. In 2009, RRS engineers developed system requirements and performed a trade study identifying potential commercial off-the-shelf (COTS) solutions.

Debbie Parks monitors information in support of mission graphics.

Mission Operations Voice Enhancement (MOVE): RRS engineers continued to provide critical support to MOVE, the NASA Headquarters' mission voice intercom replacement initiative. We successfully delivered a Critical Design Review (CDR) and commenced installing network upgrades and making facilities changes to support the project. RRS personnel teamed with Wallops Information Technology and Communications Office and Ground Network in generating a Memorandum of Agreement

(MOA) that details operations and maintenance responsibilities for MOVE equipment that will support both Range and Near Earth Network organizations. The MOA also establishes demarcation of ownership and security responsibilities across the three organizations.

Mission Planning Lab (MPL): In 2009, the Mission Planning Lab continued to expand their capability for mission analysis through a collection of COTS, government off-the-shelf and custom software that provides in-depth analysis of mission characteristics supporting pre-launch mission formulation and planning, real-time data monitoring and display and post-flight data analysis and investigation. In 2009, the MPL played a critical role in determining the MLAS launch time for an ideal sun angle and lighting for video capture and optical tracking systems. MPL is now routinely used to generate Collision Avoidance reports prior to launch, and future missions are already being analyzed in the MPL, such as Constellation launch and re-entry events. The MPL has been given a number of awards for their outstanding range services.

Optical Tracking System: In 2009, RRS engineers initiated the implementation of a low-cost, medium range optical tracking system. Leveraging COTS products, RRS engineers designed a low-cost auto-tracking optical tracking system to replace obsolete 1960s-era manually controlled Intermediate Focal Length Optical Tracking systems. The prototype design integrates seamlessly into the Wallops range slaving architecture, providing an additional slave source for acquisition of launch vehicles. Testing and transition to operations are scheduled for early 2010.

RCC Video Switch: Launch operations in the RCC rely heavily on video monitors for viewing launch activities, surveillance of launch pad areas, graphical position data during flight, weather data and air and sea surveillance radar displays. The video switch system enables selection of video sources at each RCC console position. In 2009, RRS engineers completed the installation and transition to operations of the new Video Switch. The new switch utilizes state-of-the-art touch screen displays, increases the number of video sources to 256 and enables up to 256 monitors. This upgrade significantly reduces the level of effort to configure the RCC for launch and improves reliability and quality of the video signals displayed.

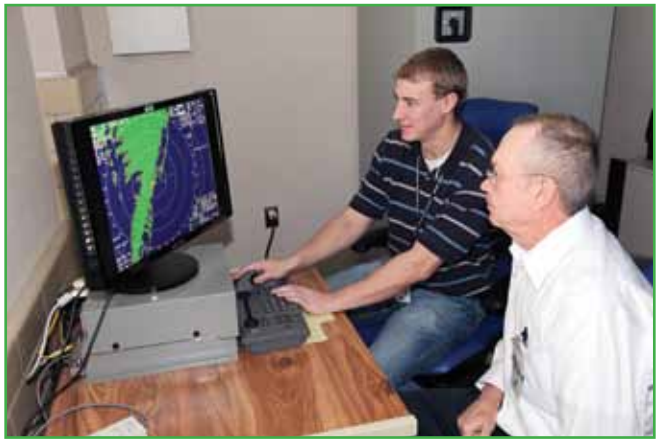
RF Direction Finding: Due to shared frequency spectrum allocation by the FCC, launch operations require monitoring of specific Radio Frequencies during the countdown to ensure that radar, telemetry and command links are not disrupted or hindered. In 2009, RRS engineers implemented a new system that not only improves detection and monitoring of these frequencies but also provides a direction finding component that enables the Test Director and Spectrum Manager to locate the potential interfering signal. 2010 will see the final testing and transition to operations of the RF Direction Finding System.

Selectable Internet Protocol Slaving (SIPS) system: Slaving is an essential launch range capability that enables radar and telemetry antennas to share real-time target position data to expedite acquisition and tracking of the target by all antennas. Currently, more than 20 different slaving systems exist at Wallops. The SIPS system is a flexible, comprehensive, real-time system using network-based communications to provide slaving for antennas that do not currently have this capability while also replacing existing, non-maintainable slaving systems. As a generic slaving system with a library of antenna controller drivers, SIPS can be used with any antenna when the appropriate driver is configured. In 2009, the SIPS development team achieved major milestones in integration and testing of the system on telemetry antennas at Wallops and at PFRR. The SIPS slaving architecture is on schedule for implementation at PFRR in support of the 2010 Sounding Rocket Campaign.

SureTrak Upgrade: SureTrak is a sea and air surveillance system utilizing inputs from multiple sensors including Primary Radar, Secondary IFF Radar (Identification, Friend or Foe) and Automatic Identification System (AIS). In 2009, development continued with integration of two new sea surveillance radar systems and the ability to calculate the probability of launch vehicle debris impacting ocean vessels. Ultimately, the SureTrak development will result in a safety-critical control center system for evaluation-of-risk prior to rocket launches.

Tri-mode Flight Termination System (FTS): In order to ensure that secure communications of flight termination signals to a launch vehicle prevent unintended termination and to comply with NASA information technology security policies, RRS engineers initiated the implementation of new tri-mode flight termination ground systems. Tri-mode

includes standard IRIG, Secure Command and Enhanced FTS modulation schemes. This effort implements new hardware and software in the RCC Transmitter Site on Wallops Mainland and Mobile Command Systems. Once operational, the RRS will be capable of supporting any of the FTS modes currently employed on launch vehicles and will comply with NASA II requirements.



Scott Bissett, left, and Webb Metz test the new Sea Surveillance Radar in the RCC.

Visualization in Real-Time Experiment (VIRTEx): In 2009, RRS Engineers designed, developed and transitioned the VIRTEx system to operations. The VIRTEx system depicts real-time information and provides a "fly-as-tested" representation of mission launch and flight events. VIRTEx is designed to display with 3D graphics the attitude and position of the launch vehicle and payload during flight. This system implementation was so successful that the team was asked to provide this support for all ELVs and guided sounding rockets launched at Wallops. The system provided real-time display of vehicle attitude data for Next Generation Sensor Producibility, SubTEC-II, Beamformer, TacSat-3 and MLAS and is now preparing for SubTEC-III, ORS-1, COTS and LADEE. This application of MPL tools significantly advances the capabilities of the WFF RCC by providing real-time attitude display of these vehicles as well as an immediate quick look back at the mission post-flight in the RCC.

Wind Weighting Remote Capability: RRS engineers increased the volume and capability of support to NASA Sounding Rocket missions that use meteorological balloons by certifying the RRS-developed Wind Weighting software. This software provides plots of launcher settings and has the ability to support multiple simultaneous meteorological balloons using any combination of GPS and radar tracking data. Data from multiple balloons contribute to the same wind table, and this software decreases the necessary tracking time, saving personnel costs and increasing data freshness. This capability provides more than the usual radar-measured wind speed, direction and position; the sensors also provide temperature, humidity, dew point, speed of sound and other environmental parameters. In 2009, RRS engineers migrated the Wind Weighting application to a Windows operating system, mitigating system obsolescence risks, and demonstrated remote capability during the 2009 Poker Flat Sounding Rocket Campaign.

Technology Refresh

Throughout FY 09, the RRS engineering team continued to assess Range obsolescence and upgraded or replaced RRS instrumentation to ensure systems reliability. The team continues to pursue opportunities for technology refresh improvements and evaluate effects of technology infusion as ongoing requirements and changing customer expectations demand.

Air Surveillance: In 2009 the Airport Surveillance Radar-7 (ASR-7) system reached its end of life due to system obsolescence and significant performance degradation. NASA Range Safety and RRS deemed the system unreliable and incapable of providing adequate surveillance of the Wallops air space. A team of RRS engineers and technicians, as well as RRS managers, moved quickly to certify the Airport Surveillance Radar–8 (ASR-8) system for mission support. The ASR-8, located on Wallops Island, is a shared resource between the Naval Air Station at Patuxent River (NAS Pax River) and NASA Wallops that primarily provided data to the FAA. Through our partnership with NAS Pax River, RRS radar operators were trained and the system was certified by NASA Range Safety for launch support. This quick response and action enabled the MLAS project to launch on time without any delays due to Range instrumentation

Mobile Radar Data Acquisition Computer (RADAC) Upgrade: This project started in August 2009 and is scheduled to be completed in FY2010. It replaces an obsolete data acquisition and processing system in the MRCS-2 Mobile Command van. RRS engineers leveraged the Wallops Range Control Center RADAC design as the basis of the replacement Mobile RADAC. Use of this validated design (already certified by

Range Safety) is facilitating rapid development of the system designed to meet tracking source data acquisition, processing, archive and display requirements for NASA range-safety operation at remote locations.

Range Telemetry State of Health: This project was initiated in late FY2009 as a result of opportunities to acquire additional telemetry systems from other agencies and locations. In order to strategically apply limited resources to maintain the "right" number of telemetry assets with the longest calculated life cycle, RRS personnel are conducting testing to specifications and detailed inspections of each fixed and mobile telemetry asset. The capstone deliverable of the analysis will be a report that includes calculated life for each asset and electrical and mechanical recommendations for engineering changes to restore or improve performance and to extend asset life cycle.

Range Timing: RRS engineers are preparing for final installation and cutover to a new COTS Timing System. The replacement introduces autonomous failover and remote monitoring capabilities that improve fault tolerance and reliability of this critical system. As part of the implementation, a Countdown Time "Hold" function and timing distribution matrix switch controller are being developed by RRS engineers. Design phase is complete and the "Hold" function/matrix switch controller CDR is scheduled for November 2009.

Sea Surveillance Radar System Replacement: In 2009, RRS engineers implemented a new X-Band sea surveillance radar system, replacing the obsolete 1980s-era technology Pathfinder radar. This new radar utilizes primary radar and AIS reception to identify ships in and around the launch hazard area. Remote control of the system enables radar technicians to operate and surveillance officers to view the radar display in the RCC for coordination of surveillance activities. This new radar tremendously improves the ability to identify participating and non-participating sea vessels off the coast of Wallops Island. In 2010, RRS engineers plan to compliment the X-Band radar with S-Band radar, improving detection and range in non-ideal weather conditions.

Telemetry Antenna Control Systems: In 2009, RRS engineers continued the modernization effort of replacing obsolete antenna control units. Design of the Wallops 8-meter antenna upgrade, including the antenna control unit, motors and servo control system, was accomplished with integration and testing scheduled for completion in early 2010. This upgrade provides state-of-the-art controllers, enabling improved system tracking performance and reliability and facilitating seamless integration into the Wallops range slaving architecture. In 2010, RRS engineers plan to upgrade an identical 8-meter system at PFRR.

Telemetry Processors (TelPros): The upgrade developed by RRS engineers to extend the life cycle of existing TelPros by migrating the hardware from obsolete DOS-based PCs to Windows PCs was implemented and transitioned to operations in 2009. The upgrade alleviated severe maintenance and obsolescence concerns and made it possible to begin designing the Next Generation TelPro. RRS engineers are in the process of prototyping a system that will eliminate the need to recompile telemetry processing software for each new mission and that will add the capability to extract embedded navigation data and deliver it in appropriate slaving data formats.

Information System Security

NASA's Information Technology (IT) security requirements, adopted in 2007, drove process changes to Range operations, including the need to verify security controls through annual testing and by using the IT security information archival system for reporting. During FY 09, the RRS continued to meet all agency security requirements. Continuous monitoring activities, monthly network scans and contingency plan testing for all five RRS information systems were completed. In addition, RRS security engineers accomplished several noteworthy efforts:

- **Suborbital and Special Orbital Projects Directorate, Deputy Computer Security Engineer (DCSE):** RRS engineer served as DCSE, supporting Center and Agency security initiatives.
- **Incident Reporting and Resolution:** DCSE investigated and mitigated multiple malware incidents at White Sands Missile Range.
- **RADAR Systems Certification & Accreditation:** Obtained Authorization to Process for Wallops and PFRR.
- **Scanning Tools:** Upgraded to NASA-specified tools for network scanning.

U.S. Marine Corps CH-53E Super Stallion demonstrates the new crew module escape system's parachute design.

The WFF RRS Program continues to inspire young minds to the wonders of Earth and space sciences. During FY 09, Wallops continued demonstrating this dedication to young minds with an active, effective and rewarding year of outreach and education efforts. Staff members continued the rich tradition of being involved in their local communities and beyond to support NASA's mission to attract, educate and encourage future explorers to the wonders of space exploration.

To encourage young people to pursue careers in science and engineering, RRS personnel provided weekly interactive tours to primary and secondary school students and to participants in scouting groups and space camps. The goal is to enable children to explore and learn about the technologies and information designed and used by NASA researchers and scientists.

During these tours, RCC employees hosted students as they played various technical support-staff roles such as Test Director, Program Timer, Range Safety Officer and various technicians in a simulated re-enactment of a rocket launch. RRS personnel also enthusiastically responded to requests for interviews and questionnaires from a number of local university students, which provided them with unique and enlightening insights into the RRS Program and the NASA science missions.

Range Commander's Council

In FY 09, the RRS officially participated in the Range Commander's Council (RCC), marking the Range's first year as a formal member of this organization.

Mr. Jay Pittman, Wallops Launch Range and Mission Management Office Chief, became a member of the RCC and served as NASA's Technical Representative to the Council.

The RCC is a community of practice among Range Commanders and provides a framework wherein common needs are identified and common solutions are sought. The Council is dedicated to serving the technical and operational needs of U.S. test, training and operational ranges. They do this by ensuring that technical standards are established and disseminated, joint procurement opportunities are explored, technical and equipment exchanges are facilitated, advanced concepts and technical innovations are assessed and potential applications are identified.

The Council, founded in 1951, was organized to preserve and enhance the efficiency and effectiveness of member ranges, thereby increasing their research and development, operational test and evaluation and training and readiness capabilities. The scope of the RCC is to:

- Resolve common problems
- Discuss common range matters in an organized forum
- Exchange information, thereby minimizing duplication
- Conduct joint investigations pertaining to research, design, development, procurement and testing
- Coordinate major or special procurement actions
- Develop operational test procedures and standards for present and future range use
- Encourage the interchange of excess technical systems and equipment

The RRS' participation in the RCC continues the Range's tradition of community leadership, which predates NASA's membership in RCC. Participation in this group has included leadership roles in the RCC Safety Group, the RCC Telemetry Group, the RCC Optical Group and the RCC Electronic Trajectory Measurement Group.

Wallops Flight Facility features a full-service airport with three runways and several Research Range Services fixed telemetry and radar assets.

Ares I-X Flight Test

Launch Date: October 28, 2009

On Oct. 28, 2009, NASA's Ares I-X test rocket launched from the KSC in Florida in anticipation of bringing the agency one step closer to its future exploration goals – to transport astronauts to the ISS and explore destinations beyond low Earth orbit.

RRS team members Ron Taylor, Matt Schneider and Dave Chevillar stand on Launch Pad39B rigging in support of the Open Loop RF test in July 2009.

Range personnel were instrumental to flight operations during the 327-foot-tall rocket test launch.

Wallops engineers and technicians designed and integrated telemetry ground systems to receive and record data from more than 700 sensors placed throughout the rocket. Range personnel led and supported the implementation of the Designed Mobile Telemetry racks at two locations – the Eastern Range Telemetry at the Eastern Range Central Telemetry Facility (Tel-4) and the Jonathan Dickinson Missile Tracking Annex.

Test flight results are expected to provide NASA with an enormous amount of data that will be used to improve the design and safety of the next generation of American spaceflight vehicles, which could, again, take humans beyond low Earth orbit. Data collected from the test flight will be used to confirm vehicle safety and stability during flight before astronauts begin travelling into orbit during future flights.

NASA's Ares I-X test rocket sits on the launch pad at the Kennedy Space Center in Florida.

The flight also allowed NASA to gather critical data during ascent of the integrated stack, which includes the Ares I launch vehicle with a simulated upper stage, Orion crew exploration vehicles and LAS.

The telemetry launch support was considered 100 percent successful with the reception of the vehicle telemetry links and delivery of real-time telemetry data to KSC Launch Control and Range Safety. This data showed the performance of the vehicle and its 700 sensors during the mission.

Parachutes deployed for recovery of the booster and the solid rocket motor, which were recovered at sea and were towed back to Florida by the booster recovery ship, Freedom Star, for later inspection. The simulated upper stage, Orion crew module and LAS were not recovered.

Lunar Atmosphere and Dust Environment Explorer (LADEE)

The Lunar Atmosphere and Dust Environment Explorer (LADEE), scheduled to launch in October 2012, is a strategic lunar science mission to address the NRC Scientific Context for Exploration of the Moon Goal 8a of determining the global density, composition and time variability of the fragile lunar atmosphere before it is further perturbed by future human activity. In addition, it will address Goal 8b to determine the size, charge and spatial distribution of electrostatically transported dust grains and assess their likely effects on lunar exploration and lunar-based astronomy.

Other objectives will demonstrate the ability to utilize optical laser communications equipment to provide high bandwidth communication from the Moon, demonstrate a low-cost approach to mission development and reusable spacecraft bus architecture for future Planetary Science missions and demonstrate the use of a small class ELV.

The last objective puts this mission on the Wallops Research Range map. The Range has earned an outstanding reputation for cost effective launch operations using small class ELVs, launching Scout, Pegasus and Minotaur I launch vehicles. LADEE will be the first Lunar mission ever launched from Wallops.

LADEE will be launched on a new ELV, the Minotaur V, - Orbital Science Corporation's new five-stage vehicle, which uses three decommissioned Peacekeeper ICBM boosters combined with commercial motors on the upper two stages. This rocket will be substantially larger and more complicated than systems previously launched from the Range. Integrating the Range with the new vehicle will bring challenges to which the RRS has been building in recent years by supporting the successful Minotaur I.

The unique trajectory planned will place the LADEE spacecraft into a highly elliptical staging orbit before the spacecraft's propulsion system will provide the impulse required for trans-lunar trajectory. The tracking and data communication requirements during launch will pose a unique set of challenges for the Range architecture. The mission will be reliant on resources spread from Virginia to North Carolina, out to Bermuda, and possibly as far away as the Western Coast of Africa.

Artist's Conception of LADEE

The RRS is working with the LADEE mission and Orbital to investigate alternate methods to effect reliable tracking and data communication. One potential solution is to develop Low Cost Tracking and Data Relay Satellite (TDRS) System Transmitter, a telemetry transmitter that uses the space-based TDRS network instead of multiple downrange tracking sites.

Currently, RRS personnel are engaged in several planning and engineering support tasks for the mission. Engineers have been asked to investigate telemetry and radar links from stations along the trajectory. Facilities personnel are working to understand the requirements for launch site improvements, and Range management is developing plans and schedules to integrate and ultimately support a safe, successful launch of the LADEE Spacecraft.

ORS-1 Satellite Mission

In late 2010, the RRS Program will support its fourth Minotaur I orbital spacecraft launch from Wallops. This mission is for DoD's Operationally Responsive Space (ORS) office at Kirtland Air Force Base (AFB), N.M., and is called ORS-I. RRS is being funded by the USAF Space and Missile Systems Center's Space and Development Test Wing (SDTW) at Kirtland AFB, N.M.

The Minotaur I is a four-stage launch vehicle developed for the Air Force by Orbital Sciences Corporation; it consists of two government supplied surplus Minuteman II stages plus two commercial stages. The main objective of the ORS-1 mission is to respond to a U.S. Central Command 'urgent need' requirement. This includes the rapid design, construction, integration and test of a launch-ready space vehicle; demonstrating responsive launch operations within days of alert and providing real-time data collected from space to combatant commanders in the field.

The RRS personnel will provide tracking and telemetry data collection of the Minotaur launch vehicle during its trajectory. The staff will also coordinate the use of operating area airspace for the ascent to orbit and will provide frequency spectrum management during the launch. RRS support for this mission will include ground instrumentation at WFF plus two downrange sites and the coordination of flight vehicle and payload operations during the countdown, launch and orbit insertion.

NASA has benefitted from supporting SDTW for this and the prior three Minotaur I launches from WFF. These launches have helped in preparing RRS to support future orbital launches of NASA spacecraft from Wallops, such as the planned Taurus II/COTS resupply missions to the ISS and the planned Minotaur V/LADEE mission to the Moon.

Poker Sounding Rocket Campaign

RRS personnel will use mobile range assets to facilitate two launches in 2010 from PFRR outside Fairbanks, Alaska, in support of NASA's Sounding Rocket Program. In order to prepare for the upcoming campaign, RRS crews performed a maintenance trip in August to ensure that Range instrumentation systems are operating nominally.

Engineers visited PFRR for testing of the new range slaving system, which utilizes an Ethernet architecture that will support the campaign as backup and is to be transitioned after the campaign as the prime slaving system for future missions. RRS crews will return to PFRR to support the sounding rocket launches February 2010.

RRS personnel will staff four PFRR telemetry antennas that will provide telemetry tracking and data reception, recording, processing and displays. Personnel will also check out and operate radar systems to provide tracking data on the sounding rockets during flight, collect wind and weather measurements during the pre-launch preparations and provide timing and voice communications systems to ensure that telemetry and radar assets are slaved together for coordinated support. The science missions to be carried into space aboard these sounding rocket campaign launches include:

- CHARM-2: to answer several questions about the physics of high-frequency waves in the Earth's aurora by using instruments aboard the sounding rocket payload to measure rapid oscillations of the electron density in the plasma in Earth's upper atmosphere and correlate them with auroral electrons of various energies.
- TMA: to explore the origins and consequences of small wind gradients in Earth's auroral thermosphere while testing a new approach, using one sounding rocket payload to deploy multiple sets of chemical tracers at multiple altitudes as the rocket ascends.

Taurus II

During 2009, RRS made tremendous strides in preparation to process and launch Orbital Sciences Corporation's new Taurus II vehicle as a supplier to NASA for the ISS Commercial Re-supply Services Contract. The first demonstration launch of the Taurus II is scheduled for March 2011, when it will carry a pressurized cargo module to low Earth orbit and dock with the ISS.

Orbital Artist Rendering

This will be the largest rocket ever launched from WFF, requiring substantial improvements to WFF launch site infrastructure. Commercial, Federal and Virginia State funds are being invested in related projects including a new launch pad, a new processing facility and a new liquid fueling facility. Work is already underway grading ramps, drilling support pilings and procuring propellant storage tanks, as well as completing designs for the Horizontal Integration and Liquid Fueling Facilities. RRS personnel are fully engaged in these engineering efforts and are helping to define Range requirements and concepts of operations to ensure a streamlined and successful mission. Personnel have also been successfully interfacing with the Bermuda government to establish a downrange tracking station in support of this and other missions.

The next year will be a challenging and exciting time as the facilities are constructed, vehicle components arrive and begin integration and systems undergo testing. RRS personnel and instrumentation will support all vehicle testing, which includes propellant flow tests and a 52-second Main Engine static fire test.

Upon successful completion of the demonstration launch, multiple Taurus II launches per year are anticipated. The RRS Program will continue to be especially critical in support of the Taurus II program, providing tracking, telemetry, command, optical and communications services.

Abbreviation List

ACES	Aurora Current and Electrodynamics Structure
AirSTAR	Airborne Sub-scale Transport Aircraft Research
ALV	ATK Launch Vehicle
CARE	Charges Aerosol Release Experiment
CASCADES	Changing Aurora: in-situ and Camera Analyses of Dynamic Electron Precipitation Structure
COTS	Commercial off the Shelf
DoD	Department of Defense
ELV	Expendable Launch Vehicle
FAA	Federal Aviation Administration
GPS	Global Positioning Satellite
GSFC	Goddard Space Flight Center
GTM	Generic Transport Model
IT	Information Technology
ISIS	Ionospheric Science and Inertial Sensing
ISS	International Space Station
IRVE	Inflatable Re-entry Vehicle Experiment
JSC	Johnson Space Center
KSC	Kennedy Space Center
LaRC	Langley Research Center
LEADS	Leading Environmental and Display System
LADEE	Lunar Atmosphere and Dust Environment Explorer
LAS	Launch Abort System
MLAS	Max Launch Abort System
MOVE	Mission Operations Voice Enhancement
MPL	Mission Planning Lab
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NRL	Naval Research Lab
NWS	National Weather Service
ORS	Operationally Responsive Space
PFRR	Poker Flat Research Range
RADAC	Radar Data Acquisition Computer
RCC	Range Control Center
RCC	Range Commanders Council
RF	Radio Frequency
RRS	Research Range Services
SDTW	Space and Development Test Wing
SIPS	Selectable Internal Protocol Slaving
SOAREX	Suborbital Aerodynamic Re-entry Experiments
STS	Space Transportation System
STSS	Space Tracking and Surveillance System
Sub-TEC	Suborbital Technology Experiment Carrier
TacSat	Tactical Satellite
TelPros	Telemetry Processors
TMA	Trimethyl Aluminum
UAS	Unmanned Aircraft System
UHF	Ultra High Frequency
USAF	United States Air Force
VIRTEx	Visualization in Real-Time Experiment
WFF	Wallops Flight Facility

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