2011

NASA Range Safety Annual Report

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I. INTRODUCTION

Welcome to the 2011 edition of the NASA Range Safety Annual Report. Funded by NASA Headquarters, this report provides a NASA Range Safety overview for current and potential range users. As is typical with odd year editions, this is an abbreviated Range Safety Annual Report providing updates and links to full articles from the previous year's report. It also provides more complete articles covering new subject areas, summaries of various NASA Range Safety Program activities conducted during the past year, and information on several projects that may have a profound impact on the way business will be done in the future.

Specific topics discussed and updated in the 2011 NASA Range Safety Annual Report include a program overview and 2011 highlights; Range Safety Training; Range Safety Policy revision; Independent Assessments; Support to Program Operations at all ranges conducting NASA launch/flight operations; a continuing overview of emerging range safety-related technologies; and status reports from all of the NASA Centers that have Range Safety responsibilities.

Every effort has been made to include the most current information available. We recommend this report be used only for guidance and that the validity and accuracy of all articles be verified for updates. Once again the web-based format was used to present the annual report. We continually receive positive feedback on the web-based edition and hope you enjoy this year's product as well.

As is the case each year, contributors to this report are too numerous to mention, but we thank individuals from the NASA Centers, the Department of Defense, and civilian organizations for their contributions.

In conclusion, it has been a busy and productive year. I'd like to extend a personal Thank You to everyone who contributed to make this year a successful one, and I look forward to working with all of you in the upcoming year.

Alan G. Dumont
NASA Range Flight Safety Program Manager

II. RANGE SAFETY PROGRAM OVERVIEW AND 2011 HIGHLIGHTS

2011 continued the busy pace of previous years in Range Safety. Before highlighting the areas covered in this year's edition, it's important to restate the goal of the NASA Range Safety Program as defined in NPR 8715.5 Rev A, "Range Flight Safety Program," dated September 19, 2010, and signed by the Office of Safety and Mission Assurance. The goal of the program is to protect the public, the workforce, and property during range operations such as launching, flying, landing, and testing launch/flight vehicles. This goal applies to all centers and test facilities and all NASA vehicle programs, including manned flight programs, expendable launch vehicles, reusable launch vehicles, and unmanned aircraft systems, Also included in this group are NASA-funded commercial ventures that involve range operations. We meet the goal of NPR 8715.5 Rev A by evaluating, mitigating, and controlling the hazards associated with range operations such as debris, distant focusing overpressure, and toxics.

This is our sixth year providing the annual report via a web-based format. As always, this report takes a comprehensive look at Range Safety to demonstrate how we meet or implement the Range Safety Program.

During 2011, we continued to be extremely busy teaching the NASA Range Safety Training Classes, providing launch support for a multitude of missions including the very last Space Shuttle, working with KSC and the Eastern Range to update local NASA/Air Force policy, supporting efforts in the Range Commanders Council meetings and Common Standards Working Group, performing independent assessments at various NASA Centers, and providing Range Safety support to new programs such as Morpheus and the Commercial Crew Program.

A summary of these efforts is highlighted in this report.

III. AGENCY PROGRAM

A. Development, Implementation, Support of Range Safety Policy

1. Launch Support Policy

In 2011, NASA Range Safety assisted the KSC RS Rep in working with the 45th Space Wing to coordinate the review and update to KCA-1308, "Memorandum of Agreement (MOA) Establishing the Joint Operating Procedure (JOP) Between The United States Air Force (USAF) 45th Space Wing (45 SW) and the National Aeronautics and Space Administration's John F Kennedy Space Center (NASA-KSC) for Safety". This MOA establishes relationships between the 45 SW and NASA-KSC for safety support for things such as hazardous operations, mishap/accident investigations, and transporting hazardous commodities.

2. Range Commanders Council Range Safety Group (RSG) Recap

The Range Commanders Council (RCC) was founded in 1951 to provide a way for DoD test ranges to communicate and discuss common problems.

The RCC Range Safety Group (RSG) continues to provide a forum in which ranges can standardize, develop, and improve on a variety of subjects and processes related to range safety. NASA participates in this forum on a regular basis and became an official voting member in 2008. Range Safety representatives from NASA HQ, KSC, DFRC, and WFF) actively support the RSG and its subcommittees on a regular basis. DFRC is currently the Flight Termination Systems Committee Chair while WFF became the RSG Chair in 2011 and led the entire RSG. Two RSG meetings were held during 2011, as summarized below.

a. 108th Range Safety Group Conference

The 108th Range Safety Group Conference was hosted by the Air Armament Center (AAC) located at Eglin Air Force Base on May 17-19, 2011. The RSG main committee, Risk Committee, and Flight Termination Systems Committee (FTSC) participated in the conference.

In the main committee, Eglin-AAC, the host range, presented an orientation briefing regarding operations occurring at AAC. Other presentations in the main committee were RCC Executive Committee updates and a briefing regarding an advanced Flight Termination System being developed by the L-3 Communications Fuzing and Ordnance Systems directorate.

Several topics were discussed at length by the group in the Risk Committee, including aircraft protection, aircraft hazard area analysis, launch and reentry benchmarks, debris catalog discussion, probability of failure database and guidelines for ELVs, and population and sheltering guidelines.

In the FTSC, DFRC gave a presentation regarding Enhanced Flight Termination System (EFTS) implementation and testing efforts occurring at DFRC/Edwards AFB. Vandenberg Air Force Base (VAFB) personnel gave a briefing developed by the Common Standards Working Group (of which NASA Range Safety is part) regarding potential changes to battery requirements of RCC 319 based on range user inputs.

b. 109th Range Safety Group Conference

The 109th Range Safety Group Conference was hosted by Pacific Missile Range Facility (PMRF) on November 15-17, 2011. The RSG main committee, Risk Committee, and FTSC participated in the conference.

In the main committee, the host range (PMRF) gave an introductory brief on the various operations they conduct. Other presentations in the main committee were range reports along with a "Green Fuel" presentation by WFF and an update on the statuses of group tasks. The 110th Range Safety Group Conference is tentatively scheduled to take place at Point Mugu in the spring of 2012.

Several topics were discussed in the Risk Committee (RC), including debris catalogue models, ship surveillance guidelines, and the use of FAA air traffic data.

Regarding debris catalogues, launch vehicle providers, as launch systems experts, were expected to provide debris catalogues for their respective launch vehicles. These catalogues are used in a variety of risk models used by the Eastern Range (ER) and Western Range (WR). The ER developed a debris catalogue model for solid-fueled vehicles called FRAG45 so that user-provided catalogues could be reviewed in an independent fashion. While not widely used, the RC is evaluating the model and its suitability for widespread use. The ER took this a step further by producing a model for liquid-fueled vehicles as well and presented highlights. The RC will be studying if and how these models might be used in future discussions.

Regarding ship surveillance guidelines, the RC is examining whether there should be RSG guidelines defining when ship surveillance activities are undertaken. At present, each range handles this decision in accordance with local guidelines. The following questions will need to be addressed by the RC if guidelines are to be written:

1. What drives the range surveillance decision?
2. What are the legal ramifications of merely informing shipping traffic via announcements should a casualty occur?
3. How effective have past notices been?
4. Is surveillance done only for planned debris?

The Federal Aviation Administration (FAA) presented interesting air traffic data. Current practice is to determine aircraft hazards areas based on an aircraft the size of a 747. Air traffic data suggests that using an aircraft the size of 747 may be too conservative of an approach and indicates that a 737-sized aircraft may be more appropriate. This discussion will continue within the RC over the next six months to a year.

In the FTSC, status updates were provided on EFTS upgrades at White Sands Missile Range, Wallops Flight Facility, and Dryden Flight Research Center. Herley Industries provided a briefing on their new FTS receivers updating from the HFTR60-1 model to the HFTR60-2 model. Wallops Flight Facility also provided an update on their efforts in AFSS development. The committee then went over comments on proposed updates to the RCC 319 document.

For more background and information on the Range Commanders Council and the Range Safety Group, *click here*.

3. Common Standards Working Group (CSWG)

The Common Standards Working Group (CSWG) is an interagency organization that was formally chartered in 2004 to "establish common public safety requirements for space transportation at Federal and non-Federal sites." This includes the launch and reentry of expendable and reusable vehicles. NASA is a founding member of the CSWG, which was initially co-chaired by the FAA and USAF. In 2010, the CSWG revised its charter to incorporate NASA as a tri-chair and designated the Office of Safety and Mission Assurance (OSMA) Chief Engineer as the NASA member of the Senior Steering Group (SSG) that provides senior executive leadership and guidance to the CSWG. Each agency has a designated tri-chair representative identified and confirmed by the SSG membership; the tri-chairs are responsible for executing the direction of the SSG via the various CSWG subgroups. Mike Dook is the designated NASA tri-chair for the CSWG.

In 2011, one of the primary areas of focus was launch vehicle Probability of Failure (POF). The CSWG has worked to develop a set of guidelines for POF analysis for new expendable launch vehicles. CSWG members from the FAA, Air Force Space Command (AFSPC), 45th Space Wing, 30th Space Wing, and NASA (WFF, KSC, and HQ) have worked together diligently to develop this guideline for use in future launch vehicle analysis. This group will continue to work to provide a common set of guidelines that all members can utilize for future endeavors.

In 2011, the CSWG was asked by various range users to involve the range safety community in a review of Flight Termination System battery requirements to allow for current designs to meet the intent of the requirements. The FAA, NASA, and Air Force personnel collaborated to discuss the concerns raised by the range user community and resolved the issue by making minor changes to the battery requirements which will be implemented in the next version of AFSPCMAN 91-710 Volume IV and RCC 319.

B. Independent Assessments

NASA Range Safety supports NASA HQ audits and reviews on a regular basis, including Institutional/Facility/Operational (IFO) audits and Inter-Center Aircraft Operations Panel (IAOP) reviews. NASA Range Safety participated in IAOP reviews at JSC in April 2011, LaRC in September 2011, and Goddard Spaceflight Center/Wallops Flight Facility (GSFC/WFF) in October 2011. NASA Range Safety participated in an IFO audit at GSFC/WFF, also in October 2011.

The IAOP provides peer review and objective management evaluation of the procedures and practices being used at the operating centers to ensure safe and efficient accomplishment of assigned missions and goals. The review teams also identify deficiencies in, or deviations from, Agency-wide NASA policies, procedures, and guidelines. The primary focus of the Agency Range Safety Program during IAOP reviews is on the application of range safety requirements and techniques to NASA operations involving UAS. The intersecting aviation safety and range safety requirements that apply to NASA UAS operations dictate the need for close coordination between the NASA aviation and range safety offices. To facilitate a coordinated review process, NASA Range Safety personnel participate in IAOP reviews at NASA Centers that conduct and/or host UAS operations. At this time, those Centers include: ARC, DFRC, LaRC, and GSFC/WFF. KSC and SSC expressed interest in future UAS operations. Range safety findings during IAOP reviews and associated Center corrective actions are documented and tracked using IAOP systems and processes established by the NASA aviation office. The

Range Safety team participated in the IAOP reviews at JSC, LaRC, and WFF to understand each Center's Range Safety Office UAS support activities and to assess compliance with NPR 8715.5 requirements.

The IAOP review at JSC represented an opportunity to assess the Center's Morpheus project and potential range flight operations at JSC. Morpheus is a vertical test bed demonstrating new green propellant propulsion systems and autonomous landing and hazard detection technology. Morpheus is designed, developed, manufactured, and operated in-house by engineers at JSC (for more on Morpheus go to http://morpheuslander.jsc.nasa.gov/). Morpheus falls into the category of a guided suborbital reusable rocket. To date, Morpheus operations at JSC have been limited to tethered test firings, where the vehicle is suspended from a crane on cables that limit any vehicle motion. During the JSC IAOP review, the Range Safety team focused on plans for potential low altitude, untethered test flights at JSC. Such flights would be subject to NASA range flight safety requirements.

Range operations other than UAS operations are subject to IFO audits led by the NASA Safety Center (NSC). Such non-UAS range operations include space launch/entry and scientific balloon operations. NASA Range Safety participates in IFO audits of NASA centers that conduct and/or host non-UAS range operations. At this time, those centers include KSC and GSFC/WFF. Range Safety findings during IFO audits and associated center corrective actions are documented and tracked using IFO systems and processes established by the NSC. The Range Safety team participated in the IFO audit at GSFC/WFF to understand the Center's Range Safety Office support for orbital and suborbital space launch and scientific balloon activities and to assess compliance with NPR 8715.5 requirements.

C. Range Safety Training 2011 Updates

The NASA Range Safety Training Program was initiated in 2004. To date, NASA Range Safety has conducted over 48 training courses for NASA, Department of Defense (DoD), Federal Aviation Administration (FAA), and contractor personnel. The course breakout and number of students is shown in Figure 1.

Courses	# Classes	# Students
Range Safety Orientation	26	684
Range Flight Safety Analysis	7	127
Range Flight Safety Systems	11	155
Range Safety Operations	4	24

FIGURE 1: TOTAL NUMBER OF CLASSES AND STUDENTS TAUGHT

NASA Range Safety taught three NASA Safety Training Center (NSTC) sponsored classes in 2011. The dates are listed below in Figure 2.

Course	Date	Location
Range Safety Orientation	26-27 Apr	KSC
Range Flight Safety Systems	2-4 Aug	KSC
Range Safety Orientation	30-31 Aug	KSC

FIGURE 2: 2011 NSTC COURSE SCHEDULE

As in past years, NASA Safety Training Center (NSTC) funding has been severely reduced for 2012. Therefore, the two classes that were scheduled for FY12 have been cancelled. However, there are plans to teach the Flight Safety Systems course at Wallops Flight Facility (WFF) in early 2012. There are also plans to teach the first pilot course of the revamped Flight Safety Analysis course in spring of 2012 with possible follow-on classes in summer of 2012. The Range Safety Operations course will also be taught at WFF with new instructors in early 2012 with possible follow-on classes as well.

In addition to the NSTC courses being taught, the Commercial Crew Program (CCP) also requested that all four classes be instructed for their program and interested parties. As shown in Figure 3, two Range Safety Orientation classes were taught in October at KSC. A CCP Flight Safety Systems course was also taught in December. The current Flight Safety Analysis course will be taught twice as well at KSC in early 2012. There are also plans to teach two Range Safety Operations classes at WFF in early 2012.

Course	Date	Location
Range Safety Orientation	6-7 Oct 2011	KSC
Range Safety Orientation	13-14 Oct 2011	KSC
Range Flight Safety Systems	7-8 Dec 2011	KSC
Range Flight Safety Analysis	7-10 Feb 2012	KSC
Range Flight Safety Analysis	20-23 Mar 2012	KSC
Range Flight Safety Operations	Early 2012	WFF
Range Flight Safety Operations	Early 2012	WFF

FIGURE 3: COMMERCIAL CREW PROGRAM COURSE SCHEDULE

Another Agency Range Safety Training initiative is to provide hands-on training of the Joint Advanced Range Safety System (JARSS) Tool to multiple NASA centers that are or will be performing flight operations with a need to perform range safety risk analysis. This tool will provide that capability to the Range Safety Representatives at each respective center. This training will be provided to Ames Research Center (ARC), Stennis Space Center (SSC), and Langley Research Center (LaRC) in early 2012. Dryden Flight Research Center (DFRC) and Wallops Flight Facility (WFF) currently utilize this tool, and by providing this capability to other NASA centers, the NASA Range Safety Program ensures that each center has the necessary tools to protect NASA personnel, property, and the general public from possible hazards occurring from range/flight operations.

1. Range Safety Orientation (SMA-SAFE-NSTC-0074)

The Range Safety Orientation Course is designed to provide an understanding of the Range Safety mission, associated policies and requirements, and NASA roles and responsibilities. It introduces the students to the major ranges and their capabilities, defines and discusses the major elements of range safety (flight analysis, flight safety systems, and range operations), and briefly addresses associated range safety topics such as ground safety, frequency management, and unmanned aircraft systems (UASs). The course emphasizes the principles of safety risk management to ensure the public and NASA/range workforces are not subjected to risk of injury greater than that of normal day-to-day activities.

The Range Safety Orientation Course is designed to inform the audience of the services offered by the Range Safety organization, present timeframes that allow adequate interface with Range Safety during program/project startup and design in an effort to minimize potential delays and costs, and recommend ways of making the working relationship with Range Safety the most beneficial for the Range User. This course includes a visit to Range Safety facilities at Cape Canaveral Air Force Station (CCAFS)/KSC when the course is presented at the Eastern Range (ER). If you wish to discuss presenting the class at your location, please contact the NSTC staff.

Target Audience:

- Senior, program, and project managers
- Safety, Reliability, Quality, and Maintainability professionals with an interest in range safety activities

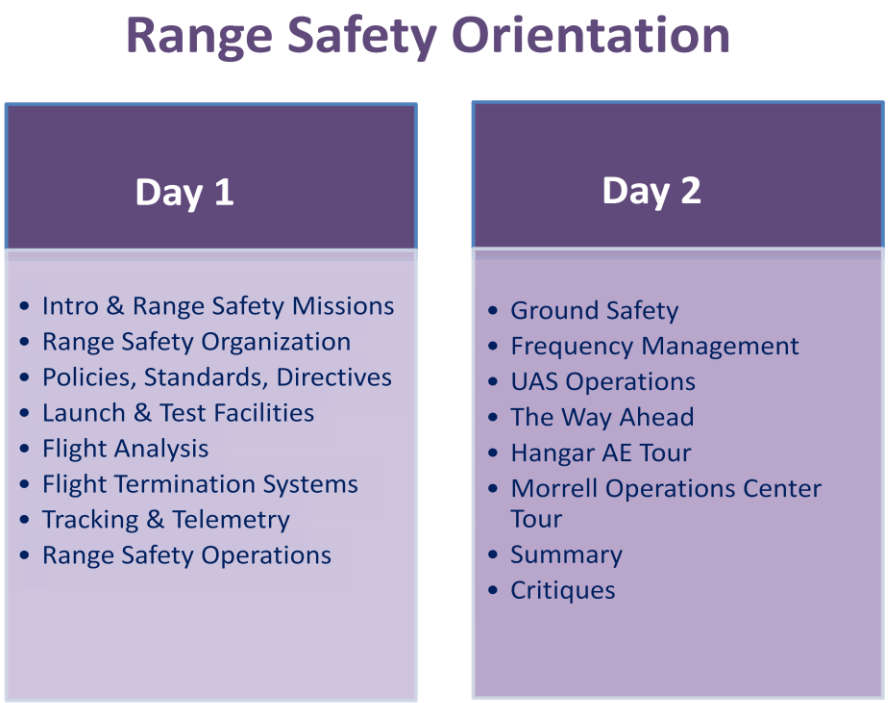

FIGURE 4: RANGE SAFETY ORIENTATION COURSE OUTLINE

2. Range Flight Safety Analysis (SMA-SAFE-NSTC-0086)

The Range Flight Safety Analysis course was not conducted in 2011 due to lack of funding. In the interim, however, the NASA Range Safety (NRS) office is continuing the development of a new NASA-centric course. The new course is designed to provide a broader understanding of Range Safety considerations, but it will focus more on NASA processes rather than on Air Force procedures at the Eastern Range. The current course will remain a standalone offering for DoD and FAA customers. It includes NASA, DoD, and FAA requirements for flight safety analysis (FSA); a discussion of range operations hazards, risk criteria, and risk management processes; and in-depth coverage of the vehicle containment and risk analysis methods performed for expendable launch vehicles (ELVs). An outline of the current FSA course structure is shown in Figure 5.

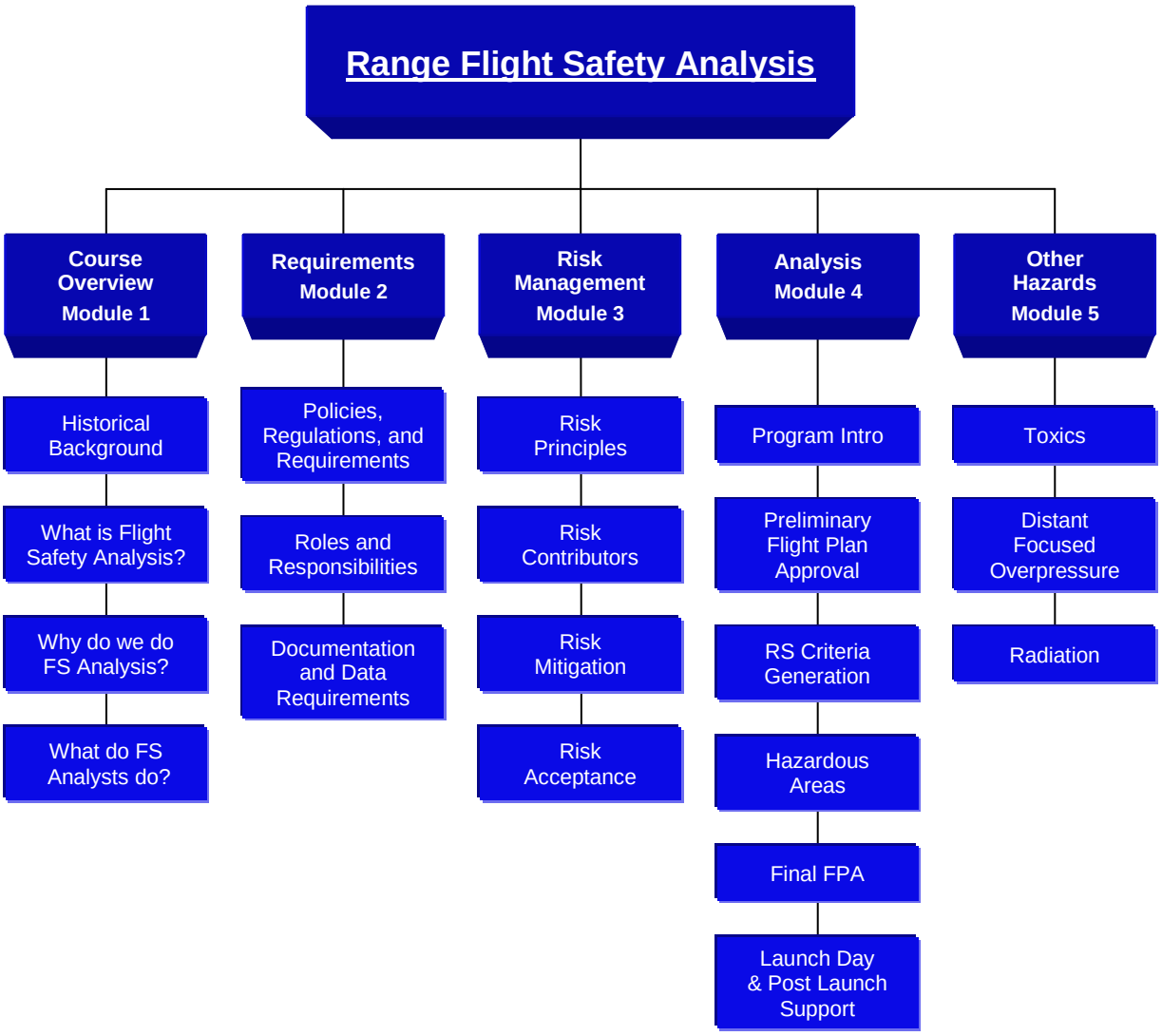

FIGURE 5: CURRENT FSA COURSE OUTLINE

The new FSA course will cover methods used for other vehicles such as reusable launch vehicles (RLVs), UASs, and research balloons. In addition, it will highlight unique range safety

processes used at several NASA ranges. There will still be coverage of debris hazards and related analyses, as well as an overview of toxic, blast, and radiation hazards and risks. Class exercises will be used to cover key aspects of FSA in a way that helps students absorb the information presented. Figure 6 outlines the new FSA course structure.

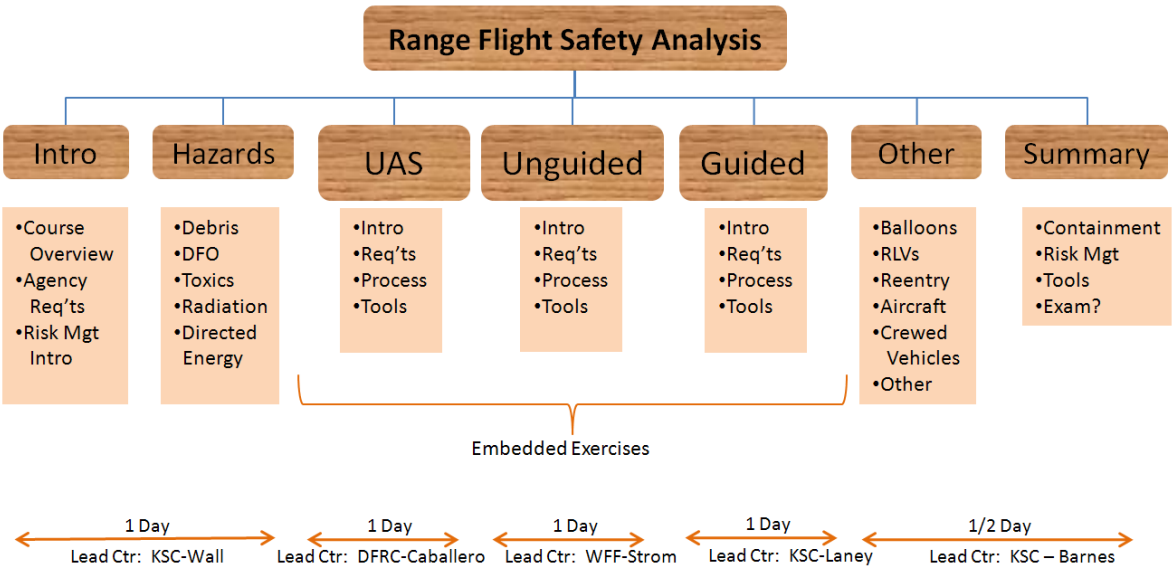

FIGURE 6: NEW FSA COURSE OUTLINE

NRS staff at KSC are developing a hazards module to form the backbone for the new course. This material will cover common aspects of FSA so that in later modules, more space can be devoted to methods and processes specific to particular ranges and vehicle types. Selected material has been extracted from the current FSA course and updated to support the new course, particularly for the Toxic Hazards and Distant Focused Overpressure (DFO) modules. Two rapid development sessions were held this summer: one at WFF to concentrate on an Unguided Vehicles module, and the other at DFRC to develop a UAS Vehicles module. Other modules to be developed by KSC include a Guided Vehicles module to cover ELVs and an Other Vehicles module to cover RLVs, re-entry vehicles, aircraft, etc.

Prerequisite: Completion of NSTC Course 074, "Range Safety Orientation," or equivalent experience.

Target Audience:

- NASA, FAA, and DoD Range Safety analysts
- Range Safety personnel in other disciplines
- Program/project managers and engineers who design potentially hazardous systems to operate on a range

3. Range Flight Safety Systems (SMA-SAFE-NSTC-0096)

The Flight Safety Systems (FSS) Course describes FSS responsibilities and Flight Termination System (FTS) design, test, performance, implementation, analysis, and documentation

requirements. The course also includes a review of Unmanned Aerial Vehicle (UAV) flight termination systems, balloon universal termination packages, and the Enhanced Flight Termination System (EFTS). The FSS class concludes with a description of the Autonomous Flight Safety System (AFSS) and a tour of the Naval Ordnance Test Unit (NOTU) facilities when the class is held at Kennedy Space Center.

Prerequisites:

1. Completion of NSTC 074, "Range Safety Orientation," or equivalent level of experience or training, is required
2. Completion of NSTC 002, "System Safety Fundamentals," or NSTC 008, "System Safety Workshop," is recommended

Target Audience:

- NASA, FAA, and DoD Range Safety Personnel working Flight Safety Systems issues
- Range safety personnel in other disciplines
- Program/project managers and engineers who design potentially hazardous systems to operate on a range
- Personnel who conduct hazardous operations on a range

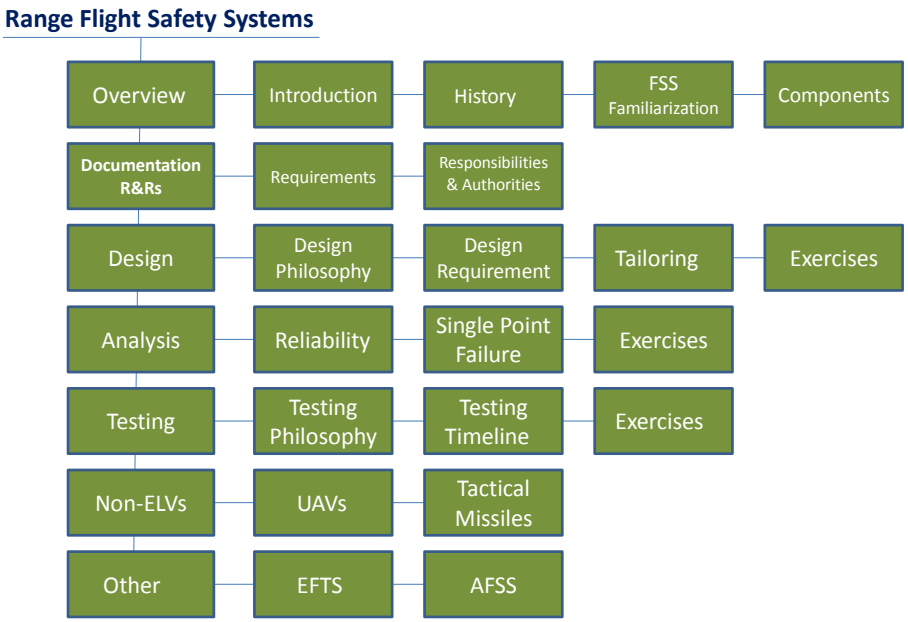

FIGURE 7: RANGE FLIGHT SAFETY SYSTEMS COURSE OUTLINE

4. Range Safety Operations Course (SMA-SAFE-NSTC-0097)

To ensure mission success and safe operations for the range, a formal process has evolved within the range community to provide range safety operations. This course addresses the roles and responsibilities of the Range Safety Officer (RSO) for range safety operations as well as real-time support, including pre-launch, launch, flight, re-entry, landing, and any associated mitigation. Mission rules, countdown activities, and display techniques are presented.

Additionally, tracking, telemetry, and vehicle characteristics are covered in detail. Finally, post operations, lessons learned, and the use and importance of contingency plans are presented. Students receive hands-on training and exercises to reinforce the instruction.

This course is only presented at WFF and is limited to six participants. To reduce cost and increase course availability, the goal is to have WFF personnel instruct this course beginning in 2012. NASA Range Safety will help organize the first courses to be taught and possibly provide instructors. The NASA Range Safety Office will still continue to review and control the course content to ensure its applicability across all centers.

Prerequisites:

1. Completion of NSTC course 074, "Range Safety Orientation," or equivalent experience and/or training, and a background in range safety
2. Completion of NSTC course 0086, "Range Flight Safety Analysis," or equivalent experience and/or training
3. Completion of NSTC course 0096, "Flight Safety Systems," or equivalent experience and/or training

Target audience: Persons identified as needing initial training for future/current job as RSO with NASA or RSO management.

FIGURE 8: RANGE SAFETY OPERATIONS COURSE OUTLINE

If you wish to attend any of the courses offered, please contact your center training manager, or refer to the NSTC web site course catalogue located at: https://satern.nasa.gov/elms/learner/catalog/

IV. CENTER REPORTS

A. Ames Research Center

Ames Research Center (ARC) operates or oversees the operation of a variety of UAS for Earth science missions, flight controls research, and technology demonstration. The largest ARC UAS is the Science Instrumentation Evaluation Remote Research Aircraft (SIERRA) (Figure 9), which has a wingspan of 20 feet and a takeoff gross weight of 370 pounds and a payload capacity up to 100 pounds. SIERRA is capable of cruising at 55 knots for over 10 hours.

FIGURE 9: SCIENCE INSTRUMENTATION EVALUATION REMOTE RESEARCH AIRCRAFT (SIERRA) UAS

In June, a research team took the SIERRA to Railroad Valley, Nevada to conduct an air sampling mission over the high desert playa. Operations were conducted from a dirt runway utilizing a mobile Ground Control Station in a van to chase the aircraft to the sampling sites. The SIERRA performed 5 flights totaling 8.6 hours during the successful deployment.

The long transit distances and large area of overflight presented challenges to the Range Safety personnel. Multiple safety observers coordinated closely to meet the see-and-avoid responsibility effectively and to deconflict issues involving other airborne traffic.

ARC has also developed an electric conversion of a giant scale radio-controlled aircraft, calling it the Giant Scale Electric Trainer (GSET) (Figure 10). The GSET has a wingspan of 80 inches and weighs 15 pounds. It is used for proficiency and currency flights and to train and checkout new pilots. The GSET is a surrogate aircraft for these routine operations, allowing ARC to avoid putting more valuable UAS at risk.

The GSET was first flown at the more remote UAS operating site of Crows Landing. The accumulation of successful flights demonstrated the reliability of the aircraft systems and the proper function of the primary contingency management system (failsafe). This allowed the range safety analysis required for the GSET to return to the more densely populated Moffett Federal Airfield and operate within range safety guidelines.

FIGURE 10: GIANT SCALE ELECTRIC TRAINER UAS

B. Dryden Flight Research Center

The Dryden Flight Research Center (DFRC), located at Edwards Air Force Base, California, is NASA's primary installation for flight research and flight testing. The Center supports operations and development of future access-to-space vehicles, conducts airborne science missions and flight operations, and develops piloted and UAS test beds for research and science missions. Projects at DFRC over the past 65 years have led to major advancements in the design and capabilities of many civilian and military aircraft. DFRC has also conducted tests in support of the Agency's space programs.

Range Safety operations at Dryden are managed by the Range Safety Office (RS Office). The RS Office was established by the DFRC Director to provide independent review and oversight of Range Safety issues under an alliance agreement with the Air Force Flight Test Center (AFFTC). The RS Office supports the Center by providing trained Flight Terminations System (FTS) engineers, Range Safety risk analysts, and Range Safety Officers to provide mission and project support primarily for UAS Projects. The DFRC/AFFTC Range Safety Alliance allows each RS Office to work on the other's projects, providing experience that may not have been available otherwise.

1. Enhanced Flight Termination System

The DFRC/AFFTC Range Safety Alliance has an operational Enhanced Flight Termination System (EFTS) transmitter site. The EFTS transmitter site has successfully been used to support three UAS projects. Modifications are being planned to address the needs of upcoming flight projects. Dryden also continues to support flight projects with Inter-Range Instrumentation (IRIG) FTS.

2. DRFC/AFFTC Range Safety Alliance

The Dryden Range Safety Office continues to provide FTS support to AFFTC projects such as X-47B and has provided FTS support on the Global Observer Project.

Dryden continues to support the testing of UASs. The UASs that were flown with Dryden assistance include the following:

a. Small UASs

Small UASs (sUAS) are in the model-type classification of flight vehicles. Dryden has established an area that offers sUAS projects a unique opportunity to conduct flights within the restricted airspace. Dryden has also established a streamlined flight approval process for sUASs that makes the airworthiness and safety review quicker and easier than those performed for larger UASs. Dryden has supported many hours of operations on multiple platforms from different manufacturers.

Dryden currently operates two Radio Controlled (RC) model aircraft named Dryden Remotely Operated Integrated Drones (DROID) (Figure 11). The first of these vehicles is used for low cost flight research. Currently, the DROID team is integrating Dryden's Auto Ground Collision Avoidance System software with the goal of eventually incorporating the software into larger UAS platforms such as Dryden's Ikhana. The second DROID aircraft is used as a UAS trainer for Dryden's UAS Pilots.

FIGURE 11: DRYDEN REMOTELY OPERATED INTEGRATED DRONES (DROID)

b. Blended Wing Body Low Speed Vehicle

The Blended Wing Body (BWB) Low Speed Vehicle (LSV) UAS, also known as X-48B LSV (Figure 12), is a dynamically scaled version of the original concept vehicle. The X-48B LSV Project is a partnership between NASA, Boeing, USAF Research Laboratory, and Cranfield Aerospace. The primary goals of the test and research project are to study the flight and

handling characteristics of the BWB design, match the vehicle's performance with engineering predictions based on computer and wind tunnel studies, develop and evaluate digital flight control algorithms, and assess the integration of the propulsion system to the airframe. The BWB testing will address several key goals of NASA's Environmentally Responsible Aviation (ERA) Project, namely noise reduction, emissions reduction, and improvement in fuel economy. Industry studies suggest that because of its efficient configuration, the BWB would consume 20 percent less fuel than jetliners of today, while cruising at high subsonic speeds on flights of up to 7,000 nautical miles. To date, the project has conducted 86 successful flights, all with LSV #2.

LSV #2 is currently undergoing modifications to make the vehicle quieter and more fuel efficient. These modifications include reducing the number of engines from three to two more efficient model engines, the installation of noise-shielding vertical fins, and the removal of the winglets. The designation for this new configuration is X-48C. The first X-48C flight is expected to occur in early 2012.

FIGURE 12: BLENDED WING BODY LOW SPEED VEHICLE

c. NASA Global Hawk

Dryden has acquired two former United States Air Force (USAF) Advanced Concept Technology Demonstration (ACTD) Global Hawk UASs (Figure 13). These pre-production Global Hawks were built by Northrop Grumman for the purpose of carrying reconnaissance payloads. The vehicles will begin a new life as a supplement to NASA's Science Mission Directorate by providing a high altitude, long endurance airborne science platform. The vehicle has an 11,000 nautical mile range and 30+ hour endurance at altitudes above 60,000 feet MSL. To date, NASA Global Hawks have flown 9 successful flights with NASA 871 and 43 successful flights with NASA 872. NASA Global Hawks supported three successful earth science campaigns this year: Winter Storms and Pacific Atmospheric Rivers (WISPAR 2011), Hurricane and Severe Storm Sentinel (HS3 2011), and Airborne Tropical Tropopause Experiment (ATTREX 2011).

The Range Safety Office has supported flight planning and risk analysis tasks in support of FAA Certificate of Authorization (COA) applications as well as real-time operations support.

FIGURE 13: NASA GLOBAL HAWK

d. Ikhana

NASA's Ikhana UAS (Figure 14) is a General Atomics Predator-B modified to support the conduct of Earth science missions for the Science Mission Directorate. The aircraft is designed to be disassembled and transported in a large shipping container aboard standard military transports.

Ikhana has been registered with the FAA and given the tail number N870NA.

The Range Safety Office has supported flight planning and risk analysis tasks in support of FAA Certificate of Authorization (COA) applications as well as real-time operations support. The vehicle has flown 19 flights this year.

FIGURE 14: NASA'S IKHANA UAS

e. Boeing Phantom Ray

Phantom Ray (Figure 15) is a fighter-sized flying test bed to develop future UAS technology opportunities. The vehicle successfully completed all flights.

FIGURE 15: BOEING PHANTOM RAY

Dryden Flight Research Center Missions 2011				
Date	**Project Name**	**Mission**	**Location**	**Mission Result**
01/13/2011-01/14/2011	Ikhana	Flight # 119; TRACER Flight 11	Yuma, AZ	Success
01/19/11	NASA Global Hawk (872)	Flight # 22; Dropsonde Test @ 15k ft MSL	Edwards AFB	Success
01/19/2011-01/20/2011	Ikhana	Flight # 120; TRACER Flight 12	Yuma, AZ	Success
01/21/11	NASA Global Hawk (872)	Flight # 23; Wake Survey with Proteus	Edwards AFB	Success
01/25/2011-01/26/2011	Ikhana	Flight # 121; TRACER Flight 13	Edwards AFB	Early RTB
01/26/2011-01/27/2011	NASA Global Hawk (872)	Flight # 24; Dropsonde Test @ 30k ft MSL	Edwards AFB	Success
02/03/2011-02/04/2011	Ikhana	Flight # 122; TRACER Flight 13	Yuma, AZ	Success
02/04/11	NASA Global Hawk (872)	Flight # 25; High Altitude Dropsonde Test	Pacific Ocean	Success
02/10/2011-02/11/2011	Ikhana	Flight # 123; TRACER Flight 14	Yuma, AZ	Success
02/11/2011-02/12/2011	NASA Global Hawk (872)	Flight # 26; WISPAR Science Flight 1	Pacific Ocean	Early RTB

Dryden Flight Research Center Missions 2011				
Date	**Project Name**	**Mission**	**Location**	**Mission Result**
03/02/11	NASA Global Hawk (872)	Flight # 27; Functional Check Flight	Edwards AFB	Success
03/03/2011-03/04/2011	NASA Global Hawk (872)	Flight # 28; WISPAR Science Flight 2	Pacific Ocean	Success
03/09/2011-03/10/2011	NASA Global Hawk (872)	Flight # 29; WISPAR Science Flight 3	Alaska; 80 deg North Latitude	Success
03/29/11	NASA Global Hawk (872)	Flight # 30; Pilot Proficiency Flight	Edwards AFB	Success
03/29/11	NASA Global Hawk (872)	Flight # 31; Pilot Proficiency Flight	Edwards AFB	Success
04/14/11	Ikhana	Flight # 124; Pilot Proficiency Flight	Edwards AFB	Success
04/27/11	Ikhana	Flight # 125; Pilot Proficiency Flight	Edwards AFB	Success
04/27/11	Phantom Ray	First Flight	Edwards AFB	Success
05/04/11	Ikhana	Flight # 126; Pilot Proficiency Flight	Edwards AFB	Success
05/05/11	Phantom Ray	Flight 2	Edwards AFB	Success
05/10/11	NASA Global Hawk (872)	Flight # 32; Functional Check Flight	Edwards AFB	Success
05/12/11	NASA Global Hawk (872)	Flight # 33; Pilot Proficiency Flight	Edwards AFB	Success
05/12/11	NASA Global Hawk (872)	Flight # 34; Pilot Proficiency Flight	Edwards AFB	Success
05/19/11	Ikhana	Flight # 127; Pilot Proficiency Flight	Edwards AFB	Success
05/21/11	Ikhana	Flight # 128; Pilot Proficiency Flight/Dry Run for USAF Test Pilot School Student Flight	Edwards AFB	Success
05/21/11	Ikhana	Flight # 129; TPS Student Flight	Edwards AFB	Success
05/25/11	Ikhana	Flight # 130; TPS StudentFlight	Edwards AFB	Success
06/01/11	Ikhana	Flight # 131; TPS StudentFlight	Edwards AFB	Success
06/04/11	Ikhana	Flight # 132; TPS StudentFlight	Edwards AFB	Success
06/09/11	Ikhana	Flight # 133; TPS StudentFlight	Edwards AFB	Success

Dryden Flight Research Center Missions 2011				
Date	**Project Name**	**Mission**	**Location**	**Mission Result**
06/15/11	Ikhana	Flight # 134; TPS StudentFlight	Edwards AFB	Success
06/16/11	Ikhana	Flight # 135; TPS StudentFlight	Edwards AFB	Success
06/21/11	Ikhana	Flight # 136; TPS StudentFlight	Edwards AFB	Success
06/28/11	Ikhana	Flight # 137; TPS StudentFlight	Edwards AFB	Success
09/01/11	NASA Global Hawk (872)	Flight # 35; Dropsonde Test	Edwards AFB	Success
09/08/2011-09/09/2011	NASA Global Hawk (872)	Flight # 36; HS3 Science Flight 1	Pacific Ocean	Success
09/13/2011-09/14/2011	NASA Global Hawk (872)	Flight # 37; HS3 Science Flight 2	Gulf Of Mexico	Success
10/20/11	NASA Global Hawk (872)	Flight # 38; Functional Check Flight	Edwards AFB	Success
10/24/11	NASA Global Hawk (872)	Flight # 39; ATTREX Science Flight 1	Pacific Ocean	Early RTB
10/28/2011-10/29/2011	NASA Global Hawk (872)	Flight # 40; ATTREX Science Flight 1	Pacific Ocean	Success
11/05/2011-11/06/2011	NASA Global Hawk (872)	Flight # 41; ATTREX Science Flight 2	Pacific Ocean	Success
11/09/2011-11/10/2011	NASA Global Hawk (872)	Flight # 42; ATTREX Science Flight 3	Pacific Ocean	Success
11/21/11	NASA Global Hawk (872)	Flight # 43; GHMOF Checkout Flight	Edwards AFB	Success

FIGURE 16: 2011 DRYDEN MISSIONS

C. Johnson Space Center

1. Space Shuttle

As the Space Shuttle Program was expected to end in 2010, the Space Shuttle Range Safety Panel wrapped up almost all “new business” during that year. The only carryover from 2010 was the actual implementation of the new U.S. Air Force Launch Collision Avoidance (COLA) screening process, which the accomplished without incident during STS-133. There were no substantial range safety anomalies or incidents during any of the final three Shuttle flights in 2011. The Space Shuttle Program formally disestablished the Space Shuttle Range Safety Panel at “wheels stop” of STS-135, the 135th and last Space Shuttle mission.

FIGURE 17: STS-133 SPACE SHUTTLE LAUNCH

2. Morpheus

The Morpheus Project provides an integrated vertical test bed (VTB) platform for advancing multiple subsystem technologies. Morpheus (Figure 18) is designed to integrate and demonstrate two key technologies. The first is a liquid oxygen (LOX) / liquid methane propulsion system, and the second technology is autonomous landing and hazard avoidance. Although initial plans included free flight tests in 2010, only hot fire and tethered tests were conducted. The Range Safety plan is in work but has not been approved.

FIGURE 18: MORPHEUS TESTING

3. Multi-Purpose Crew Vehicle (MPCV) Exploration Flight Test 1 (EFT-1)

JSC provided range safety expertise to EFT-1 as the flight test team continued range safety work in 2011. JSC Range Safety personnel participated in the introduction with the Range and review of AFSPCMAN 91-710 tailoring. Additionally, FAA requirements were explored to provide an initial understanding of the required products. JSC Range Safety personnel also supported the regular EFT-1 safety meetings and provided expertise on trajectory analysis methodology. Recommendations were provided on debris catalog development and a peer review was conducted of the FTS determination analysis.

4. Human Exploration Range Safety Panel (HERSP)

With the emergence of the new NASA program structure for human exploration, a new range safety panel was established called the Human Exploration Range Safety Panel (HERSP). The HERSP is co-chaired by NASA and the Air Force 45th Space Wing. The HERSP will provide functions including approval authority for Range Safety System (RSS) products, independent review of the Flight Termination System (FTS) to ensure public safety during launch, and communicating with the NASA programs regarding the Range Safety System (RSS). The HERSP will work technical issues through its three associated working groups: Flight Analysis, Vehicle Flight Safety System (FSS), and KSC Ground Ops. An initial organizational HERSP was held in the fall 2011, with plans for more regular meetings in 2012.

D. Kennedy Space Center

In addition to hosting the NASA Range Safety Staff, KSC has its own Center Range Safety team led by the KSC Range Safety Representative. The KSC Range Safety Representative is tasked with implementing NASA policy and keeping the NASA Range Safety Manager informed of all KSC activities related to range safety. Over the course of the past year, KSC Range Safety supported a multitude of range safety activities including Design, Development, Test, and Evaluation (DDT&E) support to new programs, and support to Shuttle and ELV launch operations on both coasts. The following articles provide a brief summary of these activities.

1. DDT&E Support

a. Ground Systems Development and Operations (GSDO) Program

The advent of the GSDO Program, formerly 21st Century Space Launch Complex, and the Range Interface and Control Services Product Line in particular provides a unique opportunity for NASA and the USAF to work together to increase the flexibility, responsiveness, affordability, and capacity to support launches with the frequency and turnaround times necessary to meet customers' needs.

KSC Range Safety provided technical support and leadership to the GSDO Range Interface and Control Services (RICS) product line in 2011. KSC Range Safety and 45th Space Wing (45 SW) safety personnel proposed several potential GSDO projects and became the technical co-leads for the Range Architecture Study Tools & Processes sub-team which contains most of the range safety-related projects. KSC Range Safety worked closely with 45 SW safety personnel and Space and Missile System Center (SMC) personnel in 2011 to research fully, justify, and plan the technical approach and acquisition strategy for these projects, in addition to developing

an overall range architecture for the future (2012 goal). Selected projects approved by the GSDO Program Control Board in 2011 are highlighted below.

(1) Chevron and Destruct Line Automation

This project replaces the chevron and destruct line manual AutoCAD processing with automated processing using the 45 SW's Safety Hazard Analysis and Risk Processing (SHARP) toolset. Other range processes have already been developed, certified, and replaced at the 45 SW using SHARP. Chevron lines enable rapid interpretation and response of an anomalous vehicle and provide higher fidelity in the immediate launch area where it is needed. This project could reduce the flight analysis mission support timeline by as much as three to five days.

(2) Risk-Based Safe Siting Tools

This project develops a suite of software tools for risk-based explosive safe siting and hazard assessment (RES). Traditional Quantity-Distance safe siting is by simple equation, based only on weight and type of energetic material. RES approach allows for more realistic analysis of fragmentation, thermal effects, acoustics, toxics, etc., and integrates with a detailed evaluation of hazards. The RES toolset can be used across NASA for hazardous operations analysis to reduce conservatism and increase flexibility. With physics-based tools, the safety staff can focus on protecting people and critical equipment while identifying unnecessary/costly mitigations. A product of one of the tools being developed by ACTA, Inc is shown in Figure 19.

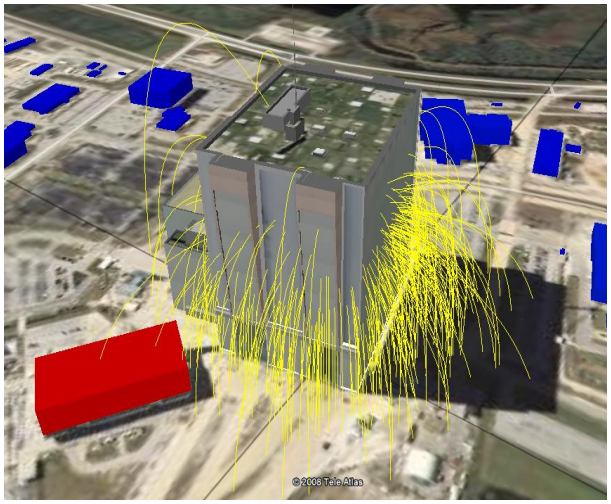

FIGURE 19: VEHICLE ASSEMBLY BUILDING (VAB) RISK-BASED EXPLOSIVE SAFE SITING AND HAZARD ASSESSMENT (RES) DEMO

(3) Central Command Remoting System (CCRS) Upgrade

This project replaces the current 1970s technology Central Command Remoting System (CCRS) located in the Morrell Operations Center (MOC) at CCAFS. The current system has vanishing spares and equipment failures that have caused Range Red conditions for several missions. The Air Force is currently funding FY10 development and testing of a prototype system that includes Enhanced Flight Termination System (EFTS) flight code capability. The current CCRS does not have EFTS capability, which must be in place by 2015 to meet USAF

requirements. This project will help fund the installation, testing, and operational acceptance of the new CCRS system at Jonathan Dickinson Missile Tracking Annex (Figure 20).

FIGURE 20: JONATHAN DICKINSON MISSILE TRACKING ANNEX

b. Commercial Crew Program Office (CCPO)

KSC Range Safety provided technical support to the Commercial Crew Program Office (CCPO) in 2011 by developing the Range Safety inputs for the Commercial Crew suite of requirements and standards documents.

The requirements document will contain the technical, safety, and crew health and medical requirements that are mandatory for commercial provider's attempting to obtain a Crew Transportation System Certification to transport NASA crew and limited cargo to and from the International Space Station. The NASA Range Flight Safety Program (NPR 8715.5 Rev A) requirements are currently listed as part of these mandatory requirements. If the commercial crew missions are licensed by the FAA, then FAA Safety regulations will apply and NPR 8715.5 will not. Thanks to the efforts of the Common Standards Working Group, any differences between the FAA regulations and NASA range safety requirements are minimal. NASA range safety would remain engaged as needed to support the CCPO and coordinate with safety authorities regarding any FAA licensed activities.

The requirements document will contain descriptions of processes, standards, and specifications, as well as the criteria that will be used to evaluate the acceptability of the commercial provider's proposed processes, standards, and specifications. Portions of NPR 8715.5 Rev A and/or its referenced documents may be included in this document.

The KSC Range Safety Office will continue to support refinement of these documents and the associated range safety requirements for commercial crew as the program evolves in 2012.

c. Exploration Flight Test One (EFT-1)

KSC Range Safety provided technical support to the EFT-1 program (formerly Orion Flight Test One) in 2011 by assisting in the development of requirements, participating in working group meetings, and reviewing proposed tailoring to AFSPCMAN 91-710 Range Safety Requirements.

Since no decision has been made regarding whether EFT-1 will be developed as an FAA-licensed launch operation or as a NASA-led operation, KSC Range Safety interfaced with JSC and Lockheed Martin to discuss the affect on Range Safety requirements each option would present.

The KSC Range Safety office will continue to provide support in establishing and reviewing requirements and operations for the EFT-1 program as it continues toward launch in late 2013.

2. Current Operations (Eastern and Western Range)

NASA/KSC Range Safety supported 13 launches this year. There were ten launches from the Eastern Range (three NASA-sponsored expendable launch vehicles, four non-NASA launches in the 45th Space Wing Risk Assessment Center, and the final three Shuttle launches). The remaining three launches were NASA-sponsored expendable launch vehicles from the Western Range (Vandenberg Air Force Base).

In order to ensure the requirements of NPR 8715.5 are met during pre-launch, launch, and post launch operations, NRS personnel worked side-by-side with our Department of Defense counterparts in the Eastern or Western Range Operations Control Centers. NRS personnel ensured any range safety-related activities that could have an impact on NASA launch criteria were communicated to the NASA Safety and Program decision makers to ensure safe flight and compliance with requirements identified in NASA Range Safety directives.

We look forward to 2012 and supporting the numerous ELV launches at both the Eastern and Western Ranges.

Eastern and Western Range				
Mission	**Vehicle**	**Launch Site**	**Launch Date**	**Responsible Org**
ULF-5	STS-133	KSC	02/24/11	NASA
GLORY	Taurus	VAFB	03/04/11	DoD
OTV-2	Atlas V	CCAFS	03/05/11	DoD
NROL-27	Delta IV	CCAFS	03/11/11	DoD
SBIRS GEO 1	Atlas V	CCAFS	05/07/11	DoD
ULF-6	STS-134	KSC	05/16/11	NASA
SAC-D/Aquarius	Delta II	VAFB	06/10/11	DoD
ULF-7	STS 135	KSC	07/08/11	NASA
GPS 2F-2	Delta IV	CCAFS	07/16/11	DoD
JUNO	Atlas V	CCAFS	08/05/11	DoD
GRAIL	Delta II	CCAFS	09/10/11	DoD
NPP	Delta II	VAFB	10/28/11	DoD
MSL	Atlas V	CCAFS	11/26/11	DoD

FIGURE 21: EASTERN AND WESTERN RANGE MISSIONS SUPPORTED BY KSC IN 2011

E. Langley Research Center (LaRC)

1. LaRC Small Unmanned Aircraft Systems (sUAS) Facilities

In January 2011, the sUAS Range Safety Office initiated a sUAS Working Group which meets monthly. The purpose of the sUAS Working Group is to implement and coordinate consolidation activities in terms of sharing common recourses, to provide pilot and observer training, and to integrate operations policy requirements from Headquarters, the Center, and funded projects. Figure 22 shows the Technology Development and Operations Model that provides the matrix support and program funding sources. Key elements include the airworthiness, concept of operations (CONOPS), and mission approval where governing policies, processes, procedures, and reviews are interfaced and integrated for sUAS work to be safely accomplished at the Center.

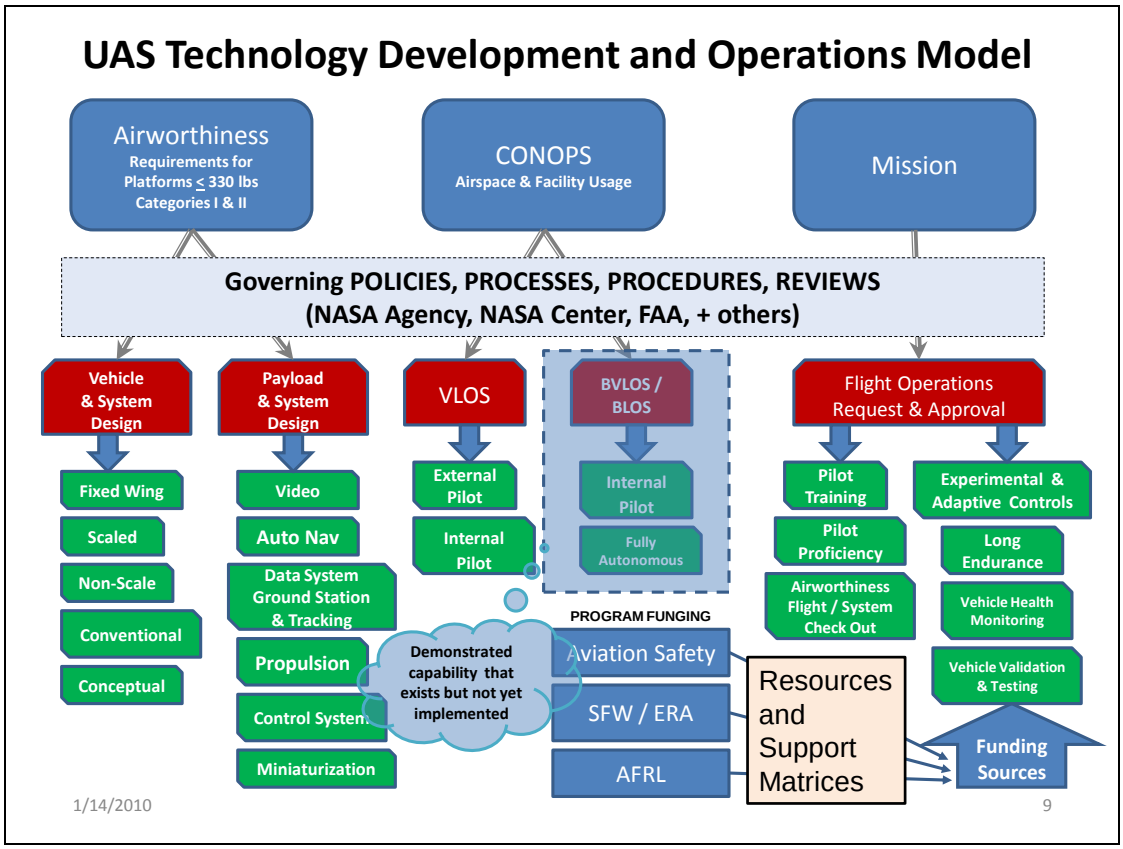

FIGURE 22: SUAS WORKING GROUP TECHNOLOGY DEVELOPMENT AND OPERATIONS MODEL

2. LaRC Range Safety and sUAS Operation Oversight

During FY2011, the LaRC Range Safety Office provided oversight for sUAS fight operations in both the National Air Space (NAS) and in Restricted Air Space. NASA LaRC Range Safety continued to work closely with the FAA UAS Program Office and with the respective organizations that manage Restricted Air Space. The primary goal of this effort was twofold: 1) To maintain safety of flight for the public, public property, and test personnel, and 2) To ensure that NASA Range Safety requirements were in alignment with NPR 8715.5, NASA

Range Flight Safety Program. LaRC currently maintains Certificate of Authorizations (COAs) to fly in the NAS at Allen C. Parkinson Fort Pickett Army Airfield, Blackstone, Virginia (BKT) and at 31VA Aberdeen, Smithfield, Virginia. Operations in Restricted Air Space include Finnegan UAS Air Field at Fort A. P. Hill, Virginia; Wallops Fight Facility on Wallops Island, Virginia; and at the UA Navy Webster Air Field, Maryland. A total of 73 deployment days were logged across these facilities that included requirements for UAS pilot flight training / proficiency and for programmatic experimental flight research support.

3. FY 2011 sUAS Flight Projects

a. AirSTAR

The Airborne Subscale Transport Aircraft Research (AirSTAR) project completed all its phase IV major milestones via deployments to Allen C. Parkinson, Fort Pickett Army Airfield, Blackstone, Virginia in September 2010 and is now planning Phase V for the project. The AirSTAR sUAS consists of a Mobile Operations Station (MOS) and a dynamically scaled, fully instrumented 5.5 percent scale Generic Transport Model (GTM) as shown in Figure 23. The Phase V CONOPS will transition from visual line-of-sight with an external safety pilot (EP) who monitors nominal flight conditions as research fight tests are performed by an internal research pilot (IP) stationed inside the MOS to beyond visual line-of-sight. Should an off nominal event occur, the Range Safety Officer will have Flight Termination Authority in the event that the on-board autopilot fails to return the vehicle to a “home waypoint.” The RSO is working with the project to help define and implement failsafe and Flight Termination System (FTS) requirements.

FIGURE 23: AIRSTAR MOS GENERIC TEST VEHICLE T2

b. J-FliC

The Jet Flying Controls Testbed (J-FLiC) lab provides low cost sUAS for experimental flight control testing with small aircraft like the one shown in Figure 24, below. The flight campaigns include evaluation of various commercial off-the-shelf (COTS) UAS autopilot systems with the capability to operate in either manual or the full autonomous flight modes of operation.

The flight operations took place at the US Navy Webster Field, Maryland and at Fort A.P. Hill, Virginia. Both manual and autonomous flights were performed for pilot training and proficiency. Safety of flight and air space management was conducted through the interface of the respective Navy Range Safety and Army Range Safety Operations Offices and coordinated through the NASA RSO flight operation.

FIGURE 24: JET TURBINE POWERED (J-FLIC)

c. Rapid Evaluation Concept (REC)

A Rapid Evaluation Concept (REC) vehicle designed to test a suite of integrated instrument and data gathering packages sustained fire damage during radio range testing (Figure 25). The incident was a slow burning fire that resulted from an overheated electronic speed controller on one of the two electric motor systems. Damage assessment was limited to the forward motor mount along with limited corrosion damage from the fire retardant used for fire suppression. Potential causes included motor system wire damage during cowling installation prior to the radio range test or new ground wires installed for avionics noise suppression. Corrective actions included the design of a new avionics grounding system to prevent ground loops. The RSO worked with the REC lab to investigate the incident and then reviewed the corrective actions and final airworthiness of the vehicle prior to its return to flight.

FIGURE 25: FIRE DAMAGE OF A RAPID EVALUATION CONCEPT (REC) OF A LOW COST INSTRUMENTED SUAS

F. Stennis Space Center

Stennis Space Center (SSC) established a Range Safety Program through the issuance of Stennis Procedural Requirement SPR 8715.7, John C. Stennis Center Range Safety Program. The Range Safety Manager supports the Range Safety program per the requirements of this document.

Stennis Space Center uses an electronic range request system called the Application for Air Range Information (AARIN) system that can be accessed both onsite and offsite to notify key Center personnel of flight activities. This system allows the Range Safety Manager to de-conflict air operation and ground testing activities at the Center and provides a permit issued to personnel entering the site through an air asset.

1. Engine Testing

As a safety precaution to general aviation in the immediate airspace, Restricted Airspace R-4403 is activated during engine testing. Between January 2011 and October 2011, R-4403 was activated 7 times for J2X engine testing and 13 times as a result of RS68 testing.

2. Small Arms Range

During 2011, over 7,000 persons trained on the Small Arms Range through the Naval Special Warfare Detachment Stennis.

3. Special Forces Integrated Training

The Range Safety Manager provides de-confliction and Center oversight to augment the Special Forces training and certification activities conducted at Stennis Space Center; specifically Emerald Warrior 11 and Trident Fury.

Emerald Warrior 11 was an integrated training event the United States Special Operations Command (USSCOM) conducted at Stennis Space Center (SSC) within the Western Maneuvering Area (WMA). Stennis Space Center is one of six ranges who participated in the event which utilized rotary and fixed wing aerial assets to complete the exercise as well as civilian-style ground transport and Special Boat Team 22's Special Operations Craft, Riverine. Nongovernment and government agencies trained together to simulate real world situations. The Chairman of the Joint Chiefs of Staff noted the success of Emerald Warrior 11 on the Stennis Range.

The mission rehearsal exercise, Trident Fury, was conducted at SSC and the Western Maneuvering Area (WMA) by Naval Special Warfare Group Two (NSWG-2). Trident Fury combined air assets with ground movement to create an integrated training/certification opportunity for the war fighter. Rotary UAVs and fixed wing aerial assets were utilized to complete the exercise as well as civilian-style ground and air transport and Special Boat Team 22's Special Operations Craft, Riverine (SOC-R). With respect to the Stennis Range, Trident Fury – SEAL Team 2 Squadron Integrated Training Exercise (SITEX) was a noted as a success.

4. Stennis International Airport

Stennis International Airport (HAS) is located inside of the buffer zone. Hancock County Development Commission is owner and operator of the facility and is responsible for all safety considerations at the airport. Operational statistics for February 2010 through January 2011 (from www.airport-data.com) are available in Figure 26.

Stennis International Airport Statistics: Feb 2010 - Jan 2011	
Total Aircraft Operations	**175 per day**
General Aviation – Local	**25.2%**
General Aviation – Itinerant	**64.4 %**
Military	**10.2 %**

FIGURE 26: STENNIS INTERNATIONAL AIRPORT STATISTICS: FEB 2010 - JAN 2011

5. Unmanned Aerial Vehicles – Certificate of Authority

Currently, the Department of Defense Special Operations Command (SOCOM) is the only agency operating UASs at Stennis Space Center. The Certificates of Authority (COAs) for SOCOM are:

- WASP, 2009-ESA-37, effective 22 Mar 10 to 21 Mar 11.
- Raven, 2009-ESA-36, effective 21 Jul 10 to 20 Jul 11.

- 2011-ESA-42, effective 20 July 11 to 19 July 12.
- Puma, 2009-ESA-40, effective 21 July 10 to 20 July 11.
- 2011-ESA-43, effective 20 July 11 – 19 July 12.

While SOCOM applies for the COAs, maintains the vehicles, and operates the UAVs, the Stennis Space Center Range Safety Manager provides de-confliction between the Special Forces flights and NASA missions.

G. Wallops Flight Facility (WFF)

Wallops Flight Facility (WFF) is NASA's principal facility for the management and implementation of suborbital science research programs. The research and responsibilities of WFF are centered on the philosophy of providing a fast, low cost, highly flexible, and safe response to meet the need of aerospace technology interests and science research. Listed below are various project/programs that the Safety Office supported in 2011.

1. Expendable Launch Vehicle Support

a. Minotaur 1 ORS-1

The U.S. Air Force Minotaur 1 rocket carrying the Department of Defense's Operationally Responsive Space office's ORS-1 satellite successfully launched from NASA's Launch Range at the Wallops Flight Facility and the Mid-Atlantic Regional Spaceport on June 29, 2011 (Figure 27). A video of the launch is available at: http://www.nasa.gov/multimedia/videogallery/index.html?collection_id=13587&media_id=98860351.

WFF Ground Safety personnel supported all ground processing of the vehicle and payload while at WFF and supported certification of the Flight Termination System (FTS). WFF Flight Safety supported on pad testing with Orbital Sciences Corporation (OSC) for validation and verification of vehicle systems, including the FTS final certification for launch. WFF provided the Range Safety Officer (RSO) along with other safety team members for the launch countdown and in-flight termination if needed.

FIGURE 27: ORS-1 LAUNCH

b. Minotaur IV TacSat-4

WFF Range Safety personnel supported the launch of a Minotaur IV rocket on September 27, 2011, from Kodiak Alaska (Figure 28). The Minotaur IV carried the TacSat-4, an experimental communications satellite for the United States Navy and Operationally Responsive Space Office. In addition to flight safety risk analysis and certification of the Flight Termination System, WFF provided on-console launch support, including the RSO for pre-launch Go/No Go decisions and in-flight termination, if needed. This mission is the second of two missions for WFF where no radar tracking sources were used by the Safety team. Instead, WFF utilized two independent GPS-based data sources from the launch vehicle. This solution was certified jointly by WFF and Vandenberg Flight Safety to meet the requirements of the NASA Range Flight Safety Program.

FIGURE 28: TACSAT-4 LAUNCH

2. Facility Construction and Improvements

In early 2011, NASA/WFF completed construction of the Horizontal Integration Facility (HIF) (Figure 29). The HIF was built in response to NASA's plans to expand WFF launch capabilities to accommodate medium-class expendable launch vehicle integration activities. Upon completion, Orbital Sciences Corporation took occupancy and has begun processing of the initial Taurus II vehicles (see Figure 30).

FIGURE 29: HORIZONTAL INTEGRATION FACILITY

Taurus II (Artist Rendition)

FIGURE 30: TAURUS II

The Mid Atlantic Regional Spaceport (MARS) also continued construction of the renovated Pad 0A. Construction of the new medium-class ELV pad has been completed, along with associated liquid fueling facilities. NASA certification of the new MARS facilities is underway and initial operations from Pad 0A are expected to begin in early CY2012.
Orbital Sciences' first International Space Station (ISS) cargo carrier vehicle (Cygnus) arrived at WFF in the Fall 2011 and is being prepared for initial flights in 2012 aboard Taurus II as part of NASA's Commercial Resupply of Station (CRS) program. NASA personnel have provided both technical development support and safety certification of the Taurus II launch program, including both facility and flight hardware systems.

The Ground Safety Group has been working closely with the construction activities to ensure the operational safety of these new systems, including a new launch pad (Pad 0A), the

transporter/erector/launcher (TEL) system used to transport the launch vehicle from the HIF to the pad and the liquid fueling farm, used to fuel the vehicle once erected on the Pad. Many of these systems are new to WFF, so significant effort has been put into ensuring adequate safety factors are in place, hazardous procedures and test plans are being approved and operational oversight provided during hazardous operations. These efforts will continue until all the new systems have been proven safe for operational use.

NASA Flight Safety personnel are conducting risk assessments of the test flight and first flight of the Cygnus, both planned for 2012. WFF is working closely with the FAA in meeting the needs of the commercial licensing and ensuring both WFF and FAA criteria are met.

3. Sounding Rocket Program

NASA/WFF Range Safety personnel supported 12 missions conducted by the WFF Sounding Rockets Program (SRP) in 2011. The launch manifest consisted of three technology development/demonstration missions (including the GSFC/ORS Small Rocket / Spacecraft Technology Platform (SMART) payload, two undergraduate student outreach missions, six science missions (including space physics investigations and satellite under-flight calibrations, among others), and one reimbursable mission for the DoD. Launch sites included Wallops Island (five launches), Poker Flat Research Range (three launches), White Sands Missile Range (two launches), Andoya, Norway (one launch), and San Nicholas Island (one launch).

The Daytime DYNAMO missions 21.141 and 41.091 UE Black Brant and Terrier-Improved Orion (Figure 31) were launched from Wallops Island, VA on July 10, 2011. The purpose of this mission was to explore, for the first time, the ion-neutral coupling, wind shears, and electrodynamics of the mid-latitude lower ionosphere during the daytime. Specifically, the mission hopes to determine the cause of intense daytime irregularities that are consistently observed in the mid-latitude ionosphere during the summer.

FIGURE 31: DAYTIME DYNAMO MISSION

The Ground Safety Group provided risk assessments and safety plan documentation for all launches and supported ground processing for the launches at WFF, Poker, and Norway. Ground Safety Data Packages are provided to other US Ranges.

The Flight Safety Group provided risk assessments and safety plan documentation for the missions at WFF, Poker, and Norway. On console launch support (RSO) was provided for WFF and Poker. A WFF Range Safety Officer supported the launches at Norway to audit the Flight Safety Program at the Andoya Rocket Range, a Norwegian-owned and operated range.

4. Balloon Program Office

NASA/WFF Range Safety personnel support 16 missions conducted by the Balloon Program Office (BPO) during 2011. Flight operations were conducted from Palestine, Texas; Fort Sumner, New Mexico; McMurdo, Antarctica; Kiruna, Sweden; and Alice Springs, Australia in support of Space Science payloads as well as a test flight for a new balloon design. The Cosmic Ray Energetics and Mass (CREAM VI) experiment, launched on December 20, 2010, is investigating high-energy cosmic-ray particles that originated from distant supernovae explosions in the Milky Way (Figure 32).

FIGURE 32: CREAM VI

The BPO also conducted a test flight of a 14-million-cubic-foot balloon, the largest single-cell, fully-sealed, super-pressure structure ever flown. The Super Pressure Balloon (Figure 33) is twice the size of a similar balloon flown over Antarctica for 54 days from December 2008 to February 2009. NASA's goal is to eventually develop a 26-million cubic-foot super-pressure balloon, nearly the size of a football stadium.

FIGURE 33: SUPER PRESSURE BALLOON

The Ground Safety Group provided risk assessments, safety plan documentation, and supported ground processing at all sites. For the final campaign of the year (Antarctica 2011), the duties of overseeing ground processing was turned over to Columbia Scientific Balloon Facility (CSBF) personnel, per the WFF Operational Safety Supervisor training requirements.

The Flight Safety Group provided risk assessments and safety plan documentation for all missions. On console launch support (RSO) was provided for all missions, with the exception of

Sweden. A waiver was granted for the Swedish Safety Office, which was provided training at WFF, to serve in the RSO role.

5. WFF Aircraft Office

The WFF Aircraft Office supported multiple manned airborne science missions aboard the NASA P-3 aircraft during 2011 including the Deriving Information on Surface Conditions from COlumn and VERtically Resolved Observations Relevant to Air Quality (DiscoverAQ), Operation IceBridge, ECHO 3D, and Carve. Also supported were Viking 300 UAS flights conducted on the WFF UAS runway on Wallops Island in support of the NASA UAV Technology Project.

The Ground Safety Group provided risk assessments and safety plan documentation for all missions, including any airborne hazards such as lasers. On site ground processing support was provided for the Viking 300 flights from the WFF Island runway.

The Flight Safety Group provided risk assessments, safety plan documentation and on-console support (RSO) of flight operations for the Viking 300 mission. The WFF Aviation Safety Officer (ASO) provided flight safety for manned missions.

FIGURE 34: P-3 AIRCRAFT

Wallops Flight Facility Missions 2011				
DATE	**VEHICLE**	**ACRONYM**	**LOCATION**	**RESULT**
12/6/2010	41.087 NT Terrier Improved Orion	TRaiNED (Terrain Relative Navigation and Employee Development)	White Sands Missile Range, NM	Success
12/12/2010	40.026 UE Black Brant XII	RENU (Rocket Experiment for Neutral Upwelling)	Norway	Failure*
1/22/2011	Terrier Oriole - Track-Ex		Wallops Island, VA	Success
1/28/2011	36.257 UG Black Brant IX	FIRE (Far-ultraviolet Imaging Rocket Experiment)	Poker Flat Research Range, AK	Partial**
2/5/2011	36.256 UE Black Brant IX	Polar NOx (Polar Night Nitric Oxide)	Poker Flat Research Range, AK	Partial***
3/23/2011	36.275 UE Black Brant IX	EVE (EUV Variability Experiment)	White Sands Missile Range, NM	Success
4/27/2011	36.278 GT Black Brant IX	N/A	Poker Flat Research Range, AK	Success
5/9/2011	Viking 300 UAV		Wallops Island, VA	Success
6/10/2011	41.096 GP Terrier Orion	SubTEC 5	Wallops Island, VA	Success
6/23/2011	41.095 UO Terrier Orion	RockSat/RockOn	Wallops Island, VA	Success
6/28/2011	ORS-1		Wallops Island, VA	Success
7/9/2011	21.141 GE Black Brant VB	Daytime DYNAMO	Wallops Island, VA	Success
7/9/2011	41.091 GE Terrier Orion	Daytime DYNAMO	Wallops Island, VA	Success
7/21/2011	41.092 UO Terrier Orion	RockSat-X	Wallops Island, VA	Success
9/8/2011	12.075 GT Test Rocket	N/A	Wallops Island, VA	Success
9/11/2011	Viking 300 UAV		Wallops Island, VA	Success
10/11/2011	36.225 UG Terrier Black Brant	PICTURE (Planet Imaging Concept Test bed Using a Rocket Experiment)	White Sands Missile Range, NM	

*Vehicle Failure
**Experiment Failure
***Experiment Failure

FIGURE 35: WALLOPS FLIGHT FACILITY MISSIONS 2011

Wallops Flight Facility Balloon Launches 2011			
DATE	VEHICLE	LOCATION	RESULT
12/13/2010	612N MILLAN/Dartmouth Unv	Antarctica	Success
12/17/2010	613N MILLAN/Dartmouth Unv	Antarctica	Success
12/21/2010	614N SEO/UMD	Antarctica	Partial*
12/27/2010	615N DEVLIN/Unv PENN	Antarctica	Success
1/9/2011	616NT PIERCE/WFF	Antarctica	Success
4/1/11	1596P ROBERTS/ULL	Palestine, TX	Success
4/18/11	617N RAMSEY/MSFC	Alice Springs, Australia	Success
5/27/11	618N CLEM/Univ DE	Kiruna, Sweden	Success
6/10/11	619BN CLEM/Univ DE	Kiruna, Sweden	Success
6/13/11	620N WU/NCAR	Kiruna, Sweden	Success
8/31/11	621N GUZIK/LSU	Fort Sumner, NM	Success
9/8/11	622NGUZIK/LSU	Fort Sumner, NM	Success
9/17/11	623N LUBIN/UCSB	Fort Sumner, NM	Success
9/23/11	624N McCONNELL-RYAN /UNH	Fort Sumner, NM	Success
9/23/11	625N MARGITAN/JPL	Fort Sumner, NM	Success
9/28/11	626NT FAIRBROTHER/WFF	Fort Sumner, NM	Success
*Balloon Failure / Mission Success			

FIGURE 36: WALLOPS FLIGHT FACILITY BALLOON LAUNCHES 2011

H. NASA Headquarters

The Safety and Assurance Requirements Division (SARD) at NASA Headquarters (HQ) Office of Safety and Mission Assurance (OSMA) provides corporate leadership in the definition and implementation of NASA's Agency-wide Safety and Mission Assurance policies, procedures, standards, tools, techniques, and training. The HQ Range Safety Representative is located within SARD and serves as the HQ Executive for the Agency Range Flight Safety Program and ELV Payload Safety Program.

The HQ Range Safety Representative participated in many Agency Range Safety activities in 2011. These included leading the Range Safety team during Intercenter Aircraft Operations Panel (IAOP) Reviews at JSC, LaRC, and GSFC/WFF and during an IFO audit at GSFC/WFF (see the article on Independent Assessment in Section II.C of this Report).

The HQ Range Safety Representative continued as the NASA Co-Chair to the AF/FAA/NASA Common Standards Working Group (CSWG). The CSWG functions to implement provisions of U.S Space Transportation Policy directing coordination between the USAF, FAA, and NASA to establish common public safety requirements for space transportation. The CSWF co-chairs met by phone every two weeks throughout 2011 and continued to oversee activities and products that focus on protecting the public from hazards associated with space launch and entry events.

The HQ Range Safety Representative is responsible for facilitating the development and promulgation of Agency Range Safety-related policy and requirements. During the past year, the HQ Range Safety Representative worked as a member of the ELV Payload Safety Agency Team to complete and release the new NASA-STD 8719.24, NASA Expendable Launch Vehicle Payload Safety Requirements. The two-year effort to develop this standard involved close coordination between the NASA ELV payload community and range safety personnel from both the Air Force Eastern and Western ranges to develop a joint set of payload safety requirements. This NASA standard applies to all NASA ELV payload projects wherever they might be launched and will be accepted by the Air Force as a tailored version of AFSPCMAN 91-710 for all NASA Payload projects launching from the Eastern or Western ranges.

Other activities included participating as a member of the Range Commanders Council Range Safety Group, support to the Commercial Crew Program's coordination with the FAA on issues of commercial launch licensing and applicability of the FAA public safety regulations to future commercial crew launches, support to research and development projects like Autonomous Flight Safety System and Enhanced Flight Termination System, and development of range safety training courses.

V. EMERGING TECHNOLOGY

A. Autonomous Flight Safety System (AFSS)

The NASA Autonomous Flight Safety System (AFSS) software has been transferred to the Test Resource Management Center for development of AFSS hardware for Operationally Responsive Space (ORS) by ATK. The software has also been transferred to the Air Force Research Laboratory for use with Northrop Grumman's work on flyback reusable boosters.

The NASA Independent Verification and Validation (IV&V) facility continues to support the analysis of the AFSS code. Initial code coverage and branch testing has been completed. A hazard and fault-tree analysis is in progress.

AFSS software and testing requirements are being developed using funding provided by the Ground Systems Development and Operations (GSDO) Program. There will be a Software Requirements Review with interagency support early in 2012. GSDO is also supporting development of a tab in the NASA Joint Advanced Range Safety System (JARSS) software to output the mission safety rules in the XML format AFSS needs. The configuration files will be verified by playing them back through a hardware-in-the-loop system at KSC that includes a GPS simulator.

For more background and information on the Autonomous Flight Safety System from previous annual reports, *click here*.

B. Joint Advanced Range Safety System (JARSS)

The Joint Advanced Range Safety System (JARSS) is a collaborative effort between several government organizations to develop a government-owned, state-of-the-art mission planning, risk analysis, and risk management tool for range safety. JARSS is designed to provide comprehensive range safety support for UASs, expendable launch vehicles (ELV), and reusable launch vehicles (RLV). A more detailed overview of JARSS is found in last year's NRS Annual Report.

JARSS consists of two primary elements: a Mission Analysis Software Tool and the Real-Time Operations Tool. The JARSS Mission Analysis Software Tool is also known as JARSS Mission Planning (JARSS-MP). The Real-Time Operations Tool is known as JARSS-RT.

Major accomplishments this year include expanded training on the toolsets, updated training materials for JARSS Mission Planning, and successful support of the safe landing of the X-37B Orbital Test Vehicle (OTV) at Vandenberg Air Force Base. The X-37 program, while originally a NASA initiative, is now led by the Air Force's Rapid Capabilities Office. The Air Force's OTV-1, (shown in Figure 37) launched from Cape Canaveral Air Force Station on April 22, 2010 atop an Atlas V launch vehicle. OTV-1 performed on orbit for 224 days, 8 hours, and 24 minutes traveling approximately 91 million miles.

FIGURE 37: ORBITAL TEST VEHICLE (OTV-1) ENCAPSULATION

Without JARSS, the 30th Space Wing could not have met the critical time lines for this mission. JARSS-RT (Figure 38 and Figure 39) handled the telemetry data at both rates perfectly and provided both critical flight safety information and high fidelity mission awareness information. OTV-2 launched on 5 March from CCAFS and is currently still performing its on-orbit mission. The JARSS tool will once again be used to support the landing upon mission completion at VAFB. NASA Kennedy Space Center is closely following the X-37 project because OTV missions could land at KSC using the Shuttle Landing Facility in the near future.

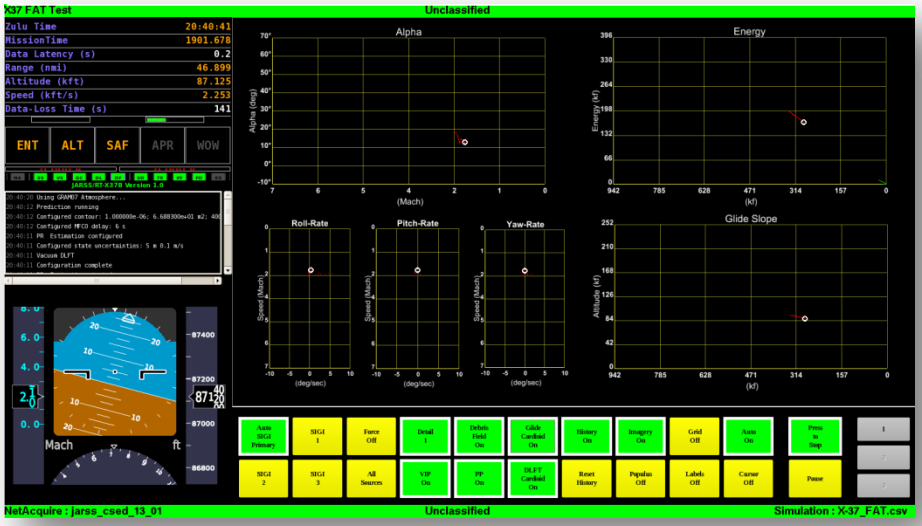

FIGURE 38: JARSS-RT 19-INCH LCD TOUCHSCREEN

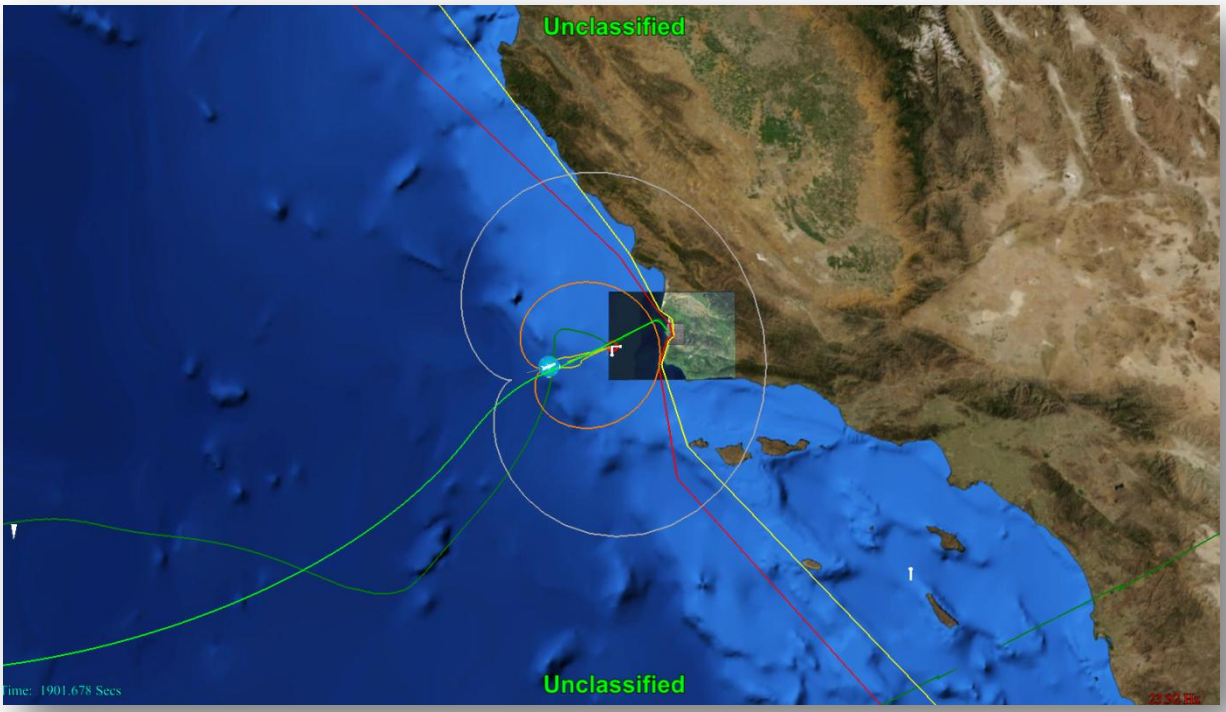

FIGURE 39: JARSS-RT 19-INCH LCD DISPLAY

For more background and information on the Joint Advance Range Safety System from previous annual reports, *click here*.

SUMMARY

Range Safety was involved in a number of exciting and challenging activities and events in 2011 involving the development, implementation, and support of range safety policies and procedures.

Range Safety representatives took part in a number of panels and councils, including the Range Commanders Council Range Safety Group and its subgroups. Range Safety representatives from NASA HQ Office of Safety and Mission Assurance, KSC, DFRC, and WFF are actively supporting the Range Safety Group. DFRC is currently the Flight Termination Systems Committee Chair while WFF became the RSG Chair in 2011 and led the entire RSG.

Advancing our effort to provide training at various levels of Range Safety, NASA Range Safety has conducted over 48 training courses for NASA, DoD, FAA, and contractor personnel. Over 900 students have participated to date, with 684 students participating in 26 Range Safety Orientation courses. While NSTC funding for this training has been significantly reduced, the Commercial Crew Program has requested that NASA Range Safety provide all four NASA Range Safety training courses to their program and other interested parties.

Range Safety also participated in the evaluation of several emerging technologies, including the Autonomous Flight Safety System (AFSS) for expendable launch vehicles. AFSS software and testing requirements are being developed using funding provided by the Ground Systems Development and Operations (GSDO) Program. There will be a Software Requirements Review with interagency support early in 2012. GSDO is also supporting development of a tab in the NASA Joint Advanced Range Safety System (JARSS) software to output the mission safety rules in the XML format AFSS needs. Major JARSS accomplishments this year include expanded training on the toolsets, updated training materials for JARSS Mission Planning, and successful support of the safe landing of the X-37B Orbital Test Vehicle (OTV) at Vandenberg Air Force Base. Without JARSS, the 30th Space Wing could not have met the critical time lines for this mission.

Most memorably, NASA Range Safety supported the final 3 Space Shuttle launches and landings in 2011. For the past 30 years, the United States Space Program has lifted men and women from all corners of the Earth into space on the shoulders of the Space Shuttle. Earlier this year, on July 21, 2011, Space Shuttle Atlantis touched down at Kennedy Space Center after a 12 day mission to the International Space Station. As we turn the pages on the lives of the Space Shuttles and see what they have accomplished, it is truly remarkable: 135 flights, dockings with two different space stations, putting satellites into orbit, the Hubble telescope, and countless manned experiments conducted in low Earth orbit.

For all the achievements of the Shuttle program, let us not forget the brave astronauts who lost their lives in the name of exploration. For the crews of Columbia (STS-107) and Challenger (STS-51L), who paid with their lives, Godspeed, and you will always be in our prayers. For the men and women on the ground who have dedicated their lives to processing and launching the Space Shuttle, we are all sad to see this program end, but we are anxious to see what the future brings.

We hope you found our web-based format for the Range Safety Annual Report to be usable and informative. As we move into 2012, we look forward to the opportunities and challenges of ensuring the safety of NASA activities and operations.

Anyone having questions or wishing to have an article included in the 2011 Range Safety Annual Report should contact Alan Dumont, the NASA Range Safety Program Manager located at the Kennedy Space Center, or Michael Dook at NASA Headquarters.