2009

NASA Range Safety Annual Report

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I. INTRODUCTION

Welcome to the 2009 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. This year, NASA Range Safety transitioned to a condensed annual report to allow for Secretariat support to the Range Safety Group, Risk Committee. In the future, traditional annual reports will be written in even years and condensed versions will be written in odd years. Although much shorter than in previous years, this report contains full-length articles concerning various subject areas, as well as links to past reports. Additionally, summaries from various NASA Range Safety Program activities that took place throughout the year are presented, as well as information on several projects that may have a profound impact on the way business will be done in the future.

The sections include a program overview and 2009 highlights; Range Safety Training; Range Safety Policy; Independent Assessments Support to Program Operations at all ranges conducting NASA launch operations; a continuing overview of emerging range safety-related technologies; and status reports from all of the NASA Centers that have Range Safety responsibilities.

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. We've made a great effort 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 we have utilized this web-based format for the annual report. We continually receive positive feedback on the web-based edition, and we hope you enjoy this year's product as well.

It has been a very busy and productive year, as hopefully you will note following a review of this year's report. 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 years to come.

Richard W. Lamoreaux
NASA Range Safety Manager

II. AGENCY RANGE SAFETY PROGRAM OVERVIEW AND 2009 HIGHLIGHTS

2009 continued the fevered 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. The program is defined in NPR 8715.5, dated 8 July 2005, and is signed by the NASA Administrator. 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 expendable launch vehicles, reusable launch vehicles, unmanned aerial systems, the Space Shuttle, and the Constellation Program. Also included in this group are NASA-funded commercial ventures that involve range operations. We meet the goal of NPR 8715.5 by evaluating, mitigating, and controlling the hazards associated with range operations such as debris, distant focusing overpressure, and toxics. With that in mind, we continued our revision effort of the NPR, identifying areas that needed updating and suggesting additions to strengthen the policy arm of NASA Range Safety as well as focusing on common standards between NASA, DoD, and the FAA.

This is our fourth year providing the annual report via a web-based format, which continues to evolve. This year we continue our approach to updating articles; instead of repeating standard article information, we only include updates and provide links back to the original articles. We believe this provides a more user-friendly format. Additionally, we transitioned to a mini-annual report for odd years, maintaining a full annual report for even years. It takes a herculean effort each year to publish the annual report, and this transition allows us to provide additional support in other areas, such as the Range Commanders' Council during odd years. Several areas of Range Safety will be covered that demonstrate how we meet or implement the Range Safety Program. A primary focus is training and our continuing efforts regarding the NASA Range Safety Training Program.

We remain extremely busy in the development, implementation, and support of Range Safety policy. The Constellation Program took center stage this year with the successful test flight of the Ares I-X launch vehicle. The launch was a culmination of more than three years of cooperative effort between representatives from many NASA centers, contractors, and the 45th Space Wing. Additionally, we supported a number of Space Shuttle and Expendable Launch Vehicle launches this year, as well as working updated agreements with our partners at the Eastern and Western Ranges.

NASA Range Safety personnel continue to support the Range Commander's Council meetings and have been involved in updating policy related to flight safety systems and flight safety risk criteria. A summary of these efforts is highlighted in this report. Additionally, we continue to support HQ-sponsored Infrastructure, Facilities, and Operations (IFO) Audits, and we provide a synopsis of the inspection conducted at Langley Research Center. We also address launch operations at KSC and the Eastern and Western Range.

Emerging range safety technology continues to interest many in the Range Safety community. This year we focused on the Autonomous Flight Safety Systems.

As always, we will conclude with Range Safety reports from the NASA centers that were actively involved with Range Safety issues throughout the year. Figure 1 gives a brief overview of the major topics contained in this report.

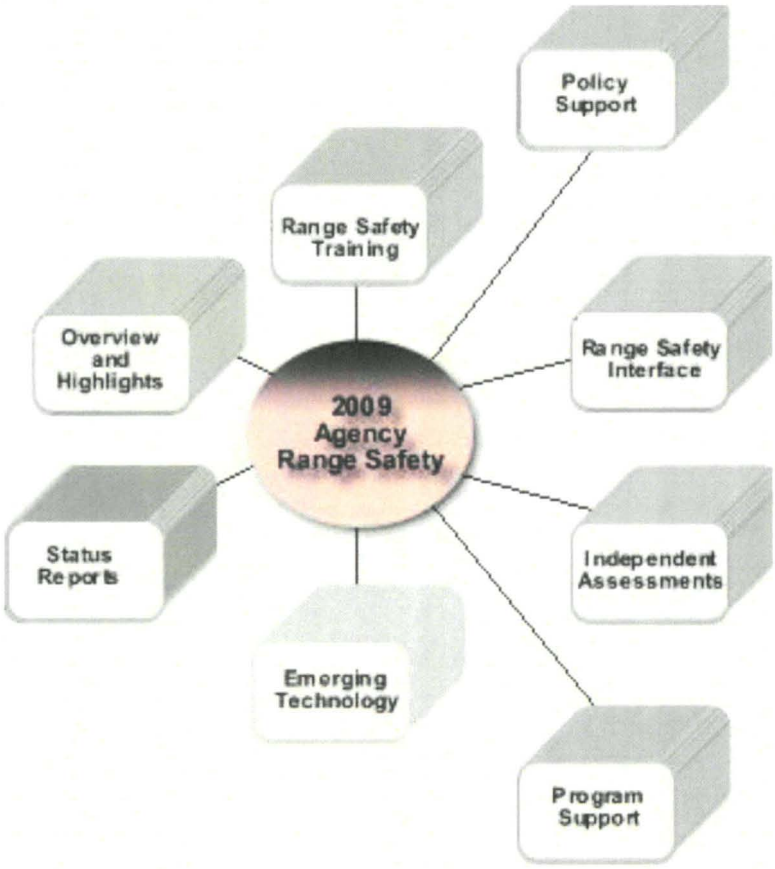

FIGURE 1: 2010 RANGE SAFETY REPORT OVERVIEW

A. Range Safety Training 2009 Updates

Link to 2008 Agency Range Safety Training article

To date, we have conducted 21 Range Safety Orientation Courses with a total of 562 students. 7 Flight Safety Analysis Courses were presented to a total of 127 students, 7 Flight Safety Systems Course were presented to a total of 105 students, and 4 Range Safety Operations Course were presented to a total of 24 students. The schedule for all courses for 2010 is depicted in Figure 2 below.

FIGURE 2: 2010 COURSE SCHEDULE

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

The Range Safety Orientation Course, as outlined in Figure 3, 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 termination systems, and range operations), and briefly addresses associated range safety topics such as ground safety, frequency management, and unmanned aerial systems (UAS). 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 course is designed to inform the audience of the services offered by the Range Safety organization, to 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 to recommend ways of making the working relationship with Range Safety beneficial for the Range User. This course includes a visit to Range Safety facilities at CCAFS/KSC and will normally only be presented at the Eastern Range. 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

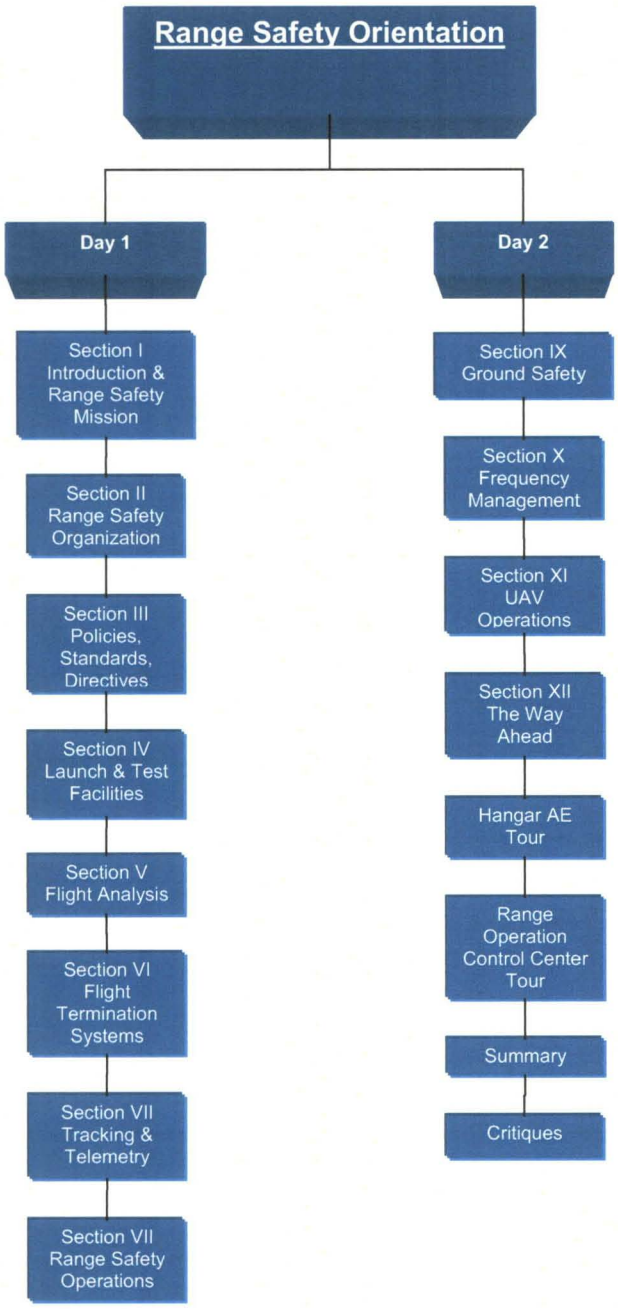

FIGURE 3: ORIENTATION COURSE OUTLINE

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

The Range Flight Safety Analysis course is designed to give the student a detailed understanding of range safety analysis. As detailed in Figure 4, the course includes NASA, FAA, and DoD requirements for flight safety analysis; a discussion of range operation hazards, risk criteria, and risk management processes; and an in-depth coverage of the containment and risk management analyses performed for expendable launch vehicles (ELV) at the Eastern Range.

Although the course is based on ELVs at the Eastern Range, the overall analysis process and concepts are also applicable to other vehicles and other ranges. The course concentrates on debris hazards and analyses but also includes an overview of toxic, blast, and radiation risks and analyses. The course includes class exercises that cover certain aspects of the flight analysis process.

Prerequisite: Prior attendance at 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

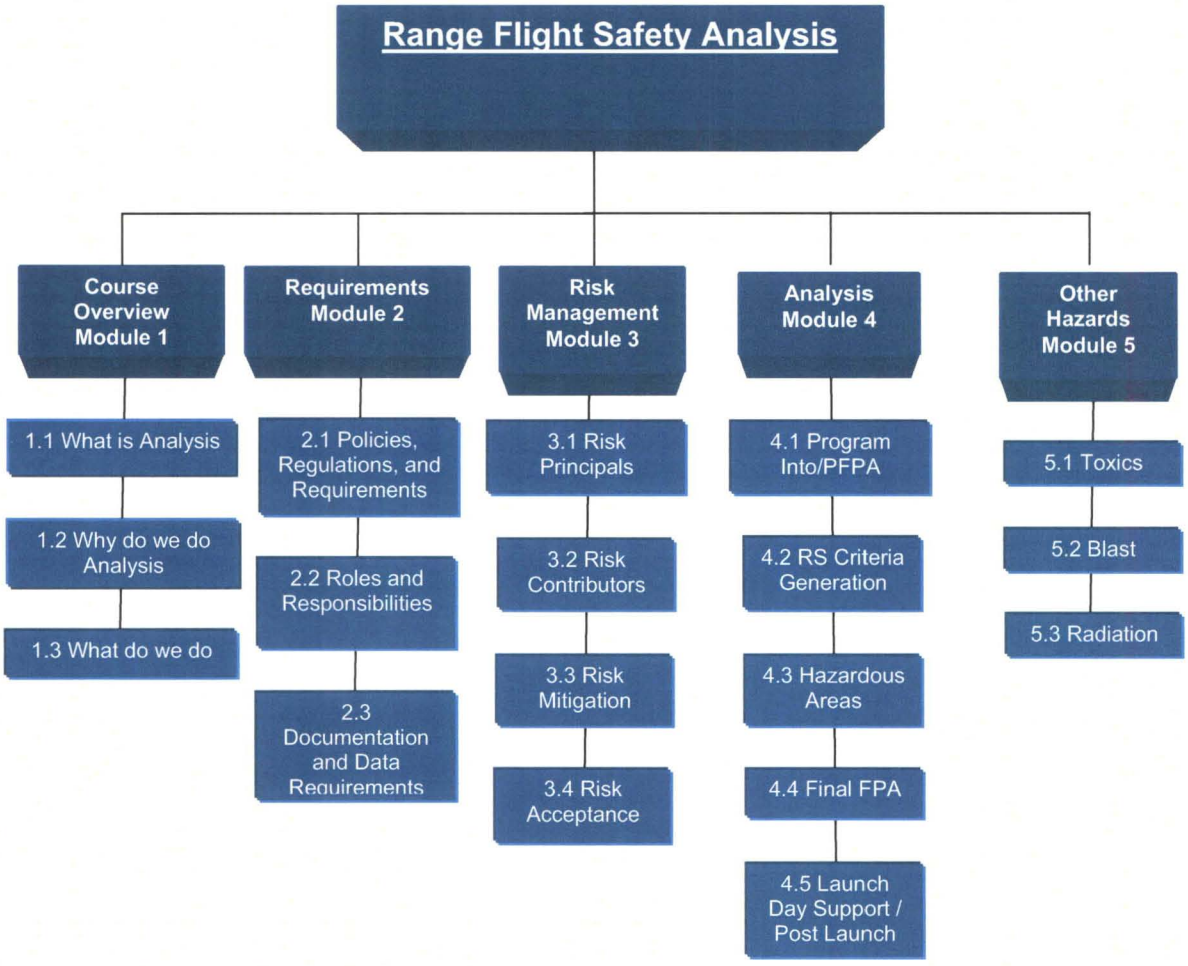

FIGURE 4: RANGE FLIGHT SAFETY ANALYSIS COURSE OUTLINE

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. As detailed in Figure 5, 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 will conclude 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

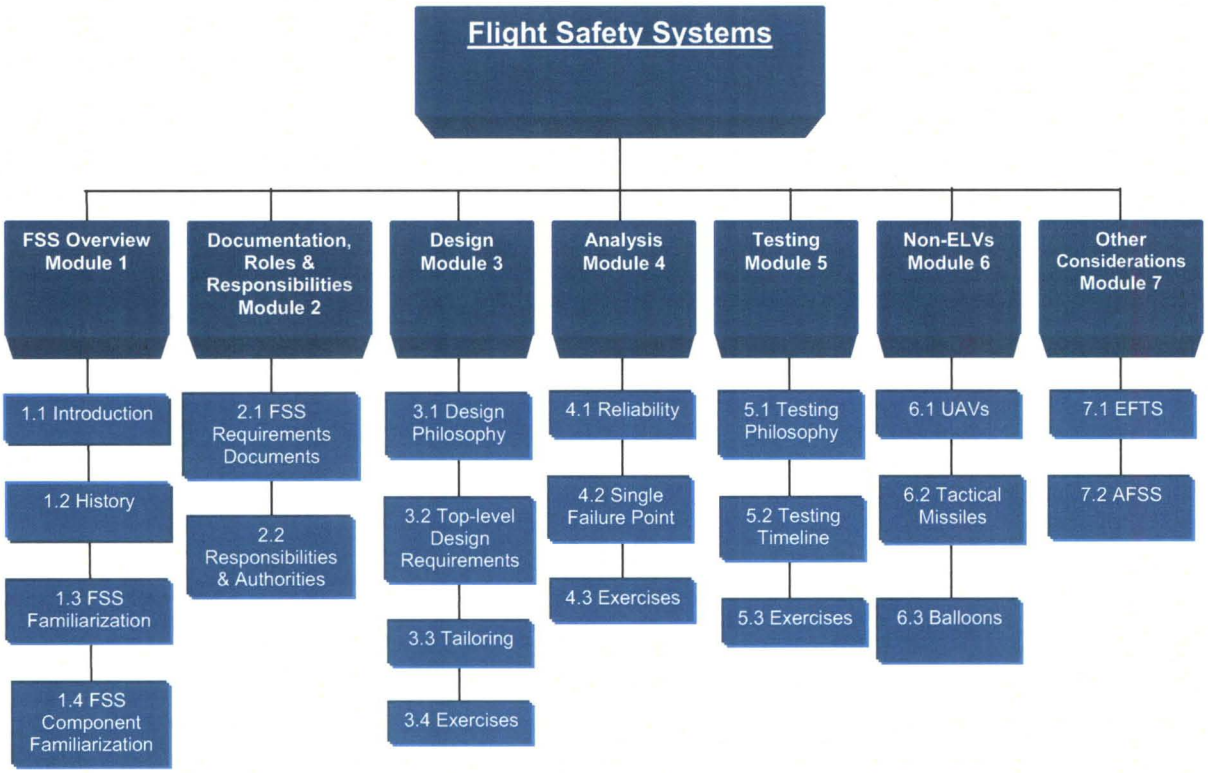

FIGURE 5: RANGE FLIGHT SAFETY SYSTEMS COURSE OUTLINE

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 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. Those participating in the course receive hands-on training and exercises to reinforce the instruction. It is important to note– that this course is only presented at WFF (Wallops Flight Facility) and is limited to six participants. The course centers on the topics shown in Figure 6 below.

Prerequisites:

1. NSTC course 074, *Range Safety Orientation*, or equivalent experience and/or training, and a background in range safety.
2. NSTC-0086, *Range Flight Safety Analysis*, or equivalent experience and/or training.
3. NSTC-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.

Although not being offered through NSTC this year due to restricted funding resources, centers or other organizations may request this class if funding is provided.

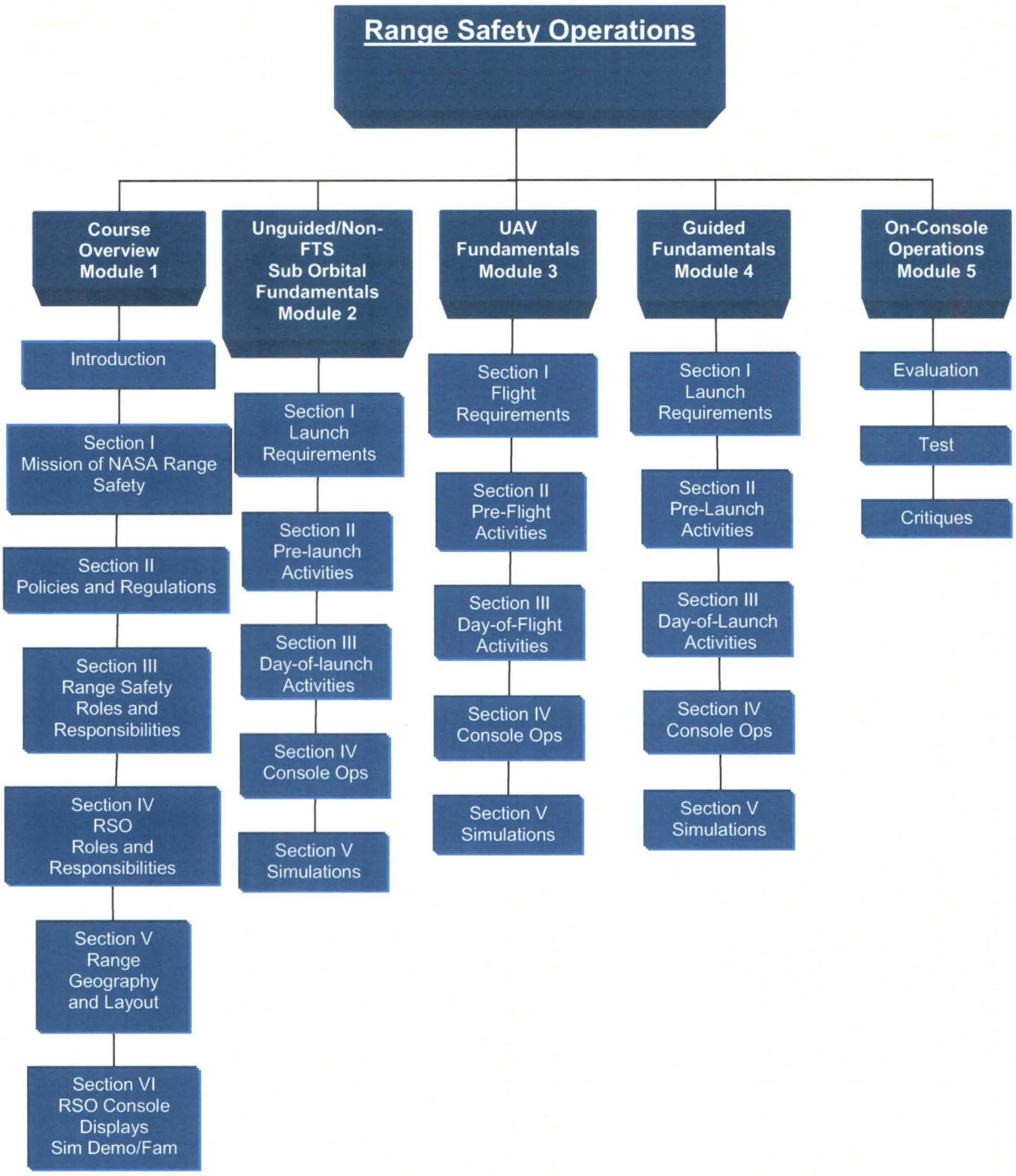

FIGURE 6: RANGE SAFETY OPERATIONS COURSE

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/

B. Development, Implementation, Support of Range Safety Policy

1. Range Safety Launch Support Policy

In 2009, NASA Range Safety continued to revise NASA Procedural Requirement (NPR) 8715.5, Range Safety Policy, working toward a July 2010 posting. One of the primary update areas is the transition from the currently published acceptable risk criteria to the Range Commanders Council recommended aggregate risk criteria. A great deal of work is also being done concerning Uninhabited Aerial Systems guidelines and criteria. Additionally, the need for Programs to have a formal Range Safety Risk Management Plan may be adjusted to allow them to identify how risk is managed and implemented in other Program plans and documentation. Along with these updates, there will be numerous administrative changes that have been identified since the signing of NPR 8715.5 in 2005.

NRS rolled the information in KSC-PLN-2804, KSC Range Safety landing Implementation Plan for Space Shuttle, into the existing KSC-PLN-2805, KSC Risk Management for Launch and Landing of the Space Shuttle. This allowed for the consolidation of both documents into a single document which also contained updated acceptable risk criteria for CY 2009 due to the Ares I-X launch from KSC.

We also coordinated a review of our current MOA with the 45 SW, which was scheduled for its triennial review in February 2009. During this review process, we jointly determine the applicability of each piece of the agreement and made updates and/or deletions that were necessary. Review of this document will continue into early CY 2010. Our initial Range Safety MOA with the 30 SW is still being coordinated through Vandenberg Air Force Base leadership. We expect this MOA to be signed soon.

We were also very active in development and implementation of tailored requirements for the Constellation Program for both Ares I-X and Ares I. Throughout 2010, we will continue to focus on joint tailoring for Ares I as required, allowing shared responsibility of range safety requirements as described in AFSPCMAN 91-710 and NPR 8715.5.

For more background and information on Range Safety Launch Support Policy, *click here.*

2. Range Safety Interface

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

a. Range Commanders Council Range Safety Group Recap

The Range Commanders Council (RCC) was founded in 1951 to provide a way for DoD test ranges to communicate and discuss common problems affecting all parties. Prior to 2008, NASA was an Associate Member of the RCC with representatives on 6 of the 14 RCC working groups. NASA became an official voting member in July 2008.

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. Range Safety representatives from NASA HQ, KSC, DFRC, and Wallops actively

support the RSG and its subcommittees on a regular basis. There were two RSG meetings in 2009, summarized below.

b. 104th Range Safety Group Conference

The 104th RSG conference was hosted by Wallops Flight Facility (WFF), VA, on 14-16 April. The RSG main committee, Risk Committee (RC), Flight Termination Systems Committee (FTSC), and Directed Energy Range Safety Committee (DERSC) met.

In the main committee, special presentations were made by Wallops Flight Facility focusing on their capabilities and the failed Alliant Techsystems (ATK) ALV X- test launch. The latter presentation included a video of the launch. These presentations were followed by range reports from each range. The next RSG meeting was scheduled for 3-5 November, 2009 at China Lake, CA.

Some of the topics discussed in the FTSC included the Enhanced Flight Termination System (EFTS) program update and status, EFTS receiver testing requirements, updating RCC 319 to include EFTS requirements, and a Subminiature Flight Safety System (SFSS) update. Special topics included a Moog Inc. presentation regarding testing requirements for hydraulic actuators and related systems. Additionally, Mr. Michael Young of NASA DFRC was elected as the new FTSC chairperson.

During the RC meeting, task leads presented briefings concerning model uncertainty, conditional risk, asset protection, aircraft risk vulnerability, and a Federal Aviation Administration proposal focusing on debris catalogs. The RC chair presented a schedule and way ahead for completion of all tasks prior to the next RSG in November 2009. In addition, NASA Range Safety volunteered to conduct the secretariat duties during this revision cycle.

c. 105th Range Safety Group Conference

The 105th RSG conference was hosted by Naval Air Warfare Center (NAWC), China Lake, California, 2-6 November. The RSG main committee, RC, FTSC, and DERSC met. The next meeting was scheduled for April 2010 at Aberdeen Proving Ground, MD.

In the RSG main committee, NAWC gave a briefing on their facilities and operations, which include one of the nation's largest overland test ranges. WFF also gave an in-depth presentation and discussion on the recent discovery of a boat in a rear marsh within the boat exclusion area during a launch. These presentations were followed by the standard activity reports from each range.

Topics discussed in the FTSC were Enhanced Flight Termination System (EFTS) implementation at various ranges, updating RCC 319 to include EFTS requirements, creating a new RCC document similar to RCC 313 regarding test methodology of EFTS receivers, NASA and ATK Autonomous Flight Safety Systems, L-3 Communications electronic safe and arm device (in-line FTSA), and the L-3 Communications plans for a Subminiature Flight Safety System (SFSS).

During the RC meeting, the group discussed and voted for inclusion into RCC 321-10 the tasks that were worked during the year. Those tasks were: Asset Protection, Aircraft Vulnerability Modeling, Uncertainty Modeling and Catastrophic Risk Aversion, Asset Protection Criteria; and Conditional Risk. The chair briefed the possible use of an Air Force staff summary package to

coordinate the updates to the standard within the various organizations. Additionally, the group approved the proposal of Dr. Paul Wilde of the FAA, as the new chair for the Risk Committee. His name will be forwarded to the Executive Committee for approval.

C. Range Safety Independent Assessments

NASA headquarters has the responsibility for conducting independent process verification reviews at NASA centers and ranges to ensure, among other things, the mitigation of operational, health, and system hazards. Reviews also include compliance with laws, executive orders, publications and standards, local operating procedures, and special interest items that pertain to the center or range.

In response to this requirement, the NASA Range Safety Manager participated in one independent assessment in 2009 at Langley Research Center (LaRC).

Findings are categorized as follows:

- Observation – a condition not contrary to documented requirements but warrants improvement or clarification
- Non-Compliance – failure to comply with documented requirements
- Commendation – a process that is performed extraordinarily well or that would provide significant benefit to other centers or ranges

The assessment was an Institutional/Facility/Operational (IFO) safety audit at Langley Research Center, conducted from in July, 2009.

1. Purpose

In response to an April 2009 Intercenter Aircraft Operations Panel (IAOP) finding regarding LaRC UAS flight operations and the need to satisfy requirements of NPR 8715.5, NASA Range Safety Program, the NASA Range Safety Team performed the following:

- Reviewed LaRC UAS operations and identified the scope of range safety activities needed to comply with Agency policy.
- Used fact-based observations as a basis for comments about compliance with range safety requirements.
- Initiated an exchange of information that will help LaRC to establish Center range safety processes appropriate to it needs.
- Interpreted and complied with the Agency range safety requirements.
- Provided suggestions on how to prepare and implement required procedures and plans.
- Ensured safe flight operations.
- Identified training, tools, and other assistance that the NASA Range Safety Program can provide LaRC.

2. Recommendation

NASA Range Safety submits the following Recommendations/Positive Observation:

- The Center should develop an oversight position, "independent" of UAS Projects to ensure the requirements and policies of NASA's range safety program (NPR 8715.5, Range Safety Policy) are implemented.
- The Center should ensure that appropriate Range Safety Risk Management Plan (RSRMP) requirements are documented for UAS operations.
  - Casualty Expectations (Ec).
  - Risk Mitigation.
  - FAA Certificate of Authorization Compliance.

3. Positive Observations

- All UAS projects are receiving a thorough review and approval to fly through the LaRC Airworthiness and Safety Review Board (ASRB).
- Research Services Directorate (RSD) is very proactive in ensuring safe UAS operations.

III. RANGE SAFETY SUPPORT TO PROGRAM OPERATIONS

NASA and KSC Range Safety supported 19 launches this year: 4 from the Western Range and 15 from the Eastern Range (3 NASA sponsored expendable launch vehicle launches, 6 non-NASA launches in the Risk Assessment Center, 5 Shuttle launches, and the Ares I-X test launch).

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

We look forward to 2010 and supporting the numerous ELV launches at both the Eastern and Western Ranges. Additionally, we anticipate supporting five Shuttle missions.

Click here to view 2008 article.

EASTERN AND WESTERN RANGE

Mission	Vehicle	Launch Site	Launch Date	Responsible Org
NROL-25	Delta IV-H	CCAFS	1/17-18/09	DoD
NOAA-N Prime	Delta II	VAFB	2/6/2009	DoD
OCO	Taurus XL	VAFB	2/24/2009	DoD
Kepler	Delta II	CCAFS	3/6-7/09	DoD
ISS 15A	STS 119	KSC	3/15/2009	NASA
GPS 2R-20 (M7)	Delta II	CCAFS	3/24/2009	DoD
WGS 2	Atlas V	CCAFS	4/3-4/09	DoD
STSS-ATRR	Delta II	VAFB	5/5/2009	DoD
HST Servicing	STS 125	KSC	5/11/2009	NASA
LRO	Atlas V	CCAFS	6/18/2009	DoD
GOES	Delta IV	CCAFS	6/27/2009	DoD
ISS 2J/A	STS 127	KSC	7/15/2009	NASA
GPS IIR-21	Delta II	CCAFS	8/17/2009	DoD
ISS 17A	STS-128	KSC	8/28-29/09	NASA
PAN	Atlas V	CCAFS	9/8/2009	DoD
STSS Demo	Delta II	CCAFS	9/25/2009	DoD
Worldview 2	Delta II	VAFB	10/8/2009	DoD
DMSP F18	Atlas V	VAFB	10/18/2009	DoD
Test Flight	Ares 1-X	KSC	10/28/2009	NASA
ISS ULF 3	STS 129	KSC	11/16/2009	NASA
Intelsat 14	Atlas V	CCAFS	11/23/2009	DoD
WGS3	Delta IV	CCAFS	12/5-6/2009	DoD
WISE	Delta II	VAFB	12/14/2009	NASA

FIGURE 7: EASTERN AND WESTERN RANGE MISSIONS 2009

Dryden Flight Research Center Missions 2009				
Date	Project Name	Mission	Location	Mission Result
01/21/09	X-48B LSV (Blended Wing Body)	Flight # 40	Edwards AFB	Success
01/28/09	X-48B LSV	Flight # 41	Edwards AFB	Success
01/30/09	X-48B LSV	Flight # 42	Edwards AFB	Early RTB[1]
02/04/09	X-48B LSV	Flight # 43	Edwards AFB	Success
02/10/09	X-48B LSV	Flight # 44	Edwards AFB	Success
02/15/09	X-48B LSV	Flight # 45	Edwards AFB	Success
03/05/09	X-48B LSV	Flight # 46	Edwards AFB	Success
03/05/09	X-48B LSV	Flight # 47	Edwards AFB	Early RTB[2]
03/18/09	X-48B LSV	Flight # 48 and Flight # 49	Edwards AFB	Success
04/02/09	X-48B LSV	Flight # 50	Edwards AFB	RTB[3]
06/04/09	X-48B LSV	Flight # 51	Edwards AFB	Success
06/17/09	Ikhana (NASA Predator B)	Flight # 75; Functional Check Flight	Edwards AFB	Success
06/18/09	Ikhana	Flight # 76; Functional Check Flight	Edwards AFB	Success
06/23/09	Ikhana	Flight # 77; Functional Check Flight	Edwards AFB	Success
07/08/09	Ikhana	Flight # 78; Acoustic Research Dry Run	Edwards AFB	Success
07/10/09	Ikhana	Flight # 79; Acoustic Research	Edwards AFB	Success
07/11/09	Ikhana	Flight # 80; Acoustic Research	Edwards AFB	Success
07/15/09	X-48B LSV	Flight # 52	Edwards AFB	Success
07/17/09	X-48B LSV	Flight # 53	Edwards AFB	Success
07/21/09	X-48B LSV	Flight # 54	Edwards AFB	Success
07/30/09	X-48B LSV	Flight # 55	Edwards AFB	Early RTB[4]
08/11/09	X-48B LSV	Flight # 56	Edwards AFB	Success
08/18/09	Ikhana	Flight # 81; Pilot Proficiency Flight	Edwards AFB	Success
08/18/09	X-48B LSV	Flight # 57	Edwards AFB	Success
08/20/09	X-48B LSV	Flight # 58	Edwards AFB	Success
08/27/09	Ikhana	Flight # 82; Pilot Proficiency Flight	Edwards AFB	Success
09/01/09	Ikhana	Flight # 83; Pilot Proficiency Flight	Edwards AFB	Success
09/01/09	X-48B LSV	Flight # 59 and Flight # 60	Edwards AFB	Success
09/03/09	Ikhana	Flight # 84; Pilot Proficiency Flight	Edwards AFB	Success
09/03/09	X-48B LSV	Flight # 61	Edwards AFB	Success
09/10/09	X-48B LSV	Flight # 62 and Flight # 63	Edwards AFB	Success
09/11/09	Ikhana	Flight # 85; Pilot Proficiency Flight	Edwards AFB	Success
09/15/09	X-48B LSV	Flight # 64	Edwards AFB	Success
09/17/09	X-48B LSV	Flight # 65	Edwards AFB	Success
09/23/09	X-48B LSV	Flight # 66	Edwards AFB	Success
09/29/09	X-48B LSV	Flight # 67	Edwards AFB	Success
10/06/09	X-48B LSV	Flight # 68	Edwards AFB	Success
10/08/09	X-48B LSV	Flight # 69	Edwards AFB	Success
10/15/09	Ikhana	Flight # 86; Pilot Proficiency Flight	Edwards AFB	Success
10/21/09	X-48B LSV	Flight # 70	Edwards AFB	Success
10/23/09	NASA Global Hawk	Flight # 1 (1st NASA Flight)	Edwards AFB	Success
10/29/09	NASA Global Hawk	Flight # 2	Edwards AFB; R-	Success
11/04/09	NASA Global Hawk	Flight # 3; Pilot Proficiency Flight	Edwards AFB; R-	Success
11/09/09	NASA Global Hawk	Flight # 4 and Flight # 5; Pilot Proficiency	Edwards AFB; R-	Success
11/18/09	Ikhana	Flight # 87; Functional Check Flight	Edwards AFB	Success
11/19/09	Ikhana	Flight # 88; Post Survey of Station Fire	Edwards AFB	Success
12/02/09	X-48B LSV	Flight # 71 and Flight # 72	Edwards AFB	Success

[1] Faulty telemetry.
[2] An engine shutdown during flight.
[3] An engine shutdown during flight.
[4] Complete loss of GPS after takeoff.

FIGURE 8: DRYDEN FLIGHT RESEARCH CENTER MISSIONS 2009

DATE	VEHICLE	ACRONYM	LOCATION	LAUNCH RESULT
1/10/2009	Orion 30.073 UO	ISIS (Ionospheric Science and Inertial Sensing)	Poker Flat Research Range, AK	S
1/29/2009	Black Brant IX 36.242 UE	ACES-High (Aurora Current and Electrodynamics Structure)	Poker Flat Research Range, AK	S
1/29/2009	Black Brant VB 21.139 UE	ACES-Low (Aurora Current and Electrodynamics Structure)	Poker Flat Research Range, AK	S
2/18/2009	Terrier Orion 41.076 UE	Generation and Development of Turbulence in the 100-km	Poker Flat Research Range, AK	S
2/18/2009	Terrier Orion 41.077 UE	Generation and Development of Turbulence in the 100-km	Poker Flat Research Range, AK	S
2/18/2009	Terrier Orion 41.078 UE	Generation and Development of Turbulence in the 100-km	Poker Flat Research Range, AK	S
2/18/2009	Terrier Orion 41.079 UE	Generation and Development of Turbulence in the 100-km	Poker Flat Research Range, AK	S
2/25/2009	Terrier Black Brant 36.226 UG	CIBER (Cosmic Infrared Background ExpeRiment)	White Sands Missile Range, NM	S
3/20/2009	Black Brant XII 40.023 UE	Analyses of Dynamic Electron precipitation Structures)	Poker Flat Research Range, AK	S
5/19/2009	TacSat-3 Minotaur 1		Wallops Island, VA	S
5/28/2009	Terrier Mk-12-Improved Orion 41.080 UO	SOAREX (Sub-Orbital Aerodynamic Re-entry EXperiments)	Wallops Island, VA	S
6/25/2009	Terrier Mk-12-Improved Orion 41.083 UO	University level rocket flight training workshop know as RockOn	Wallops Island, VA	S
6/27/2009	Terrier Black Brant 36.244 UG	DICE (Diffuse Interstellar Cloud Experiment)	Wallops Island, VA	S
7/8/2009	Max Launch Abort System	MLAS	WAllops Island, VA	S
8/10/2009	36.229 DR	MARTI (Missile Alternative Range Target Instrument)	San Nicolas Island	S
8/17/2009	Terrier Black Brant 36.254 NR	IRVE II (Inflatable Reentry Vehicle Experiment II)	Wallops Island, VA	S
9/14/2009	Black Brant IX 36.221 DS	HELiosphere)	White Sands Missile Range, NM	S
9/19/2009	Black Brant XI 39.009 DR	CARE (Charged Dust Release Experiment)	Wallops Island, VA	S
11/14/2009	Black Brant IX 36.252 UH	CyXESS-II (Cygnus X-ray Emission Spectroscopic Survey II)	White Sands Missile Range, NM	S
	2009 Balloon Launches			
5/5/2009	0.8 MCM Balloon Musser/Indiana Unv		Ft. Sumner, NM	S
5/17/2009	1.12 MCM Balloon Boggs/Unv CA		Ft. Sumner, NM	S
5/21/2009	1.12 MCM Balloon Clem/Univ Delaware		Esrange/Sweden	S
6/6/2009	1.12 MCM Balloon Clem/Univ Delaware		Esrange/Sweden	S
6/8/2009	0.97 MCM Balloon Solanski/Max Inst		Esrange/Sweden	S
6/8/2009	1.12 MCM Balloon Martin/Cal Tech		Ft. Sumner, NM	S
6/11/2009	0.97 MCM Balloon Hanany/Univ Minn		Ft. Sumner, NM	S
6/22/2009	.40 MCM BalloonPierce/WFF		Esrange/Sweden	TEST FLT
9/11/2009	11.8 MCM Balloon Guzik/LSU		Ft. Sumner, NM	S
9/19/2009	1.12 MCM Balloon Fairbrother/WFF		Ft. Sumner, NM	TEST FLT

FIGURE 9: WALLOPS FLIGHT FACILITY MISSIONS 2009

IV. EMERGING TECHNOLOGY

A. Autonomous Flight Safety System (AFSS)

The Autonomous Flight Safety System (AFSS) is a joint Kennedy Space Center and Wallops Flight Facility (WFF) project intended for use as an independent and autonomous flight termination subsystem for expendable launch vehicles. It uses tracking and attitude data from onboard Global Positioning System (GPS) and Inertial Measurement Unit (IMU) sensors and configurable rule-based algorithms to make flight termination decisions. The objectives of the AFSS are to increase capabilities by allowing launches from locations that do not have existing range safety infrastructure, to reduce costs by eliminating downrange tracking and communications assets, and to reduce the reaction time for flight termination decisions.

AFSS will have its third rocket flight in January 2010. A loosely coupled GPS/INS Kalman-filtered navigation solution will be tested, and an improved ground support computer will be used to input configuration files and initialize the system in addition to other specific improvements mentioned in last year's report.

The system requirements are being finalized and the proof-of-code is beginning the formal review process where each code module will be reviewed and tested.

The biggest change this year has been the decree by Air Force Space Command that all Air Force ranges will use an autonomous flight safety system by 2018 (although not necessarily the NASA system). The NASA AFSS team is an integral member of the Air Force Community of Interest on converting the ranges to an autonomous flight safety system and has briefed at many meetings. The NASA AFSS team believes the best way to implement an autonomous flight safety system on all ranges is to have one set of carefully controlled, government-furnished software (hopefully based on the NASA software) run with user-supplied configuration files so that the software only needs to be vetted once before being accepted for use on multiple ranges. This idea is gaining momentum, and the NASA AFSS team will certainly play an important role in the process.

B. VAB Hazard Analyses for Constellation Processing

As reported last year (*see 2008 Article*), the Vehicle Assembly Building (VAB) must be re-sited, from an explosive safety perspective, to support hazardous operations for the Constellation Program. The current Quantity-Distance (QD) Safe Siting radius for Shuttle processing is based on having no more than 16 Reusable Solid Rocket Motor (RSRM) segments present at one time. Plans for Constellation processing may require 40 or more RSRM segments since the Ares I first stage is expected to consist of 5 segments and Ares V boosters may contain 5 ½ segments each. In addition to these potentially explosive components, the Orion Service Module could also be present in the VAB, which may contain a full load of hypergolic liquid propellants, possibly in excess of 19,000 pounds [35% Monomethyl Hydrazine (MMH), and 65% Nitrogen Tetroxide (NTO)]. Since this collection of dangerous commodities presents a variety of hazards to personnel and surrounding facilities, a study was initiated in 2007 to evaluate and document the Maximum Credible Event (MCE) that could be expected from simultaneous vehicle processing in the VAB.

Since mid-2008, the KSC Safety & Mission Assurance Integration Office (KSC/SA-G) has led the overall MCE effort, and KSC Range Safety personnel have played a support role, along with a large team of contributors that was assembled to pursue various portions of this complex endeavor. There has been collaboration and close coordination with Explosive Safety leaders at KSC and HQ-NASA, as well. Early this year, the NASA Engineering and Safety Center (NESC) wrapped up a thermal hazard study based on two five-segment solid motors burning in one VAB high bay. To ensure a worst case result, motors were assumed stationary with no structural failure. Work on this bounding case was shared by Ames Research Center (ARC), where Computational Fluid Dynamics (CFD) analyses continue to play a role in ongoing investigations. Also involved were the Navy's China Lake research facility, where thermal radiation analysis was conducted; Hughes Associates, Inc., where human burn injury modeling was performed; ATK Space Systems, who manufactures the RSRM segments and other solid motor hardware; and the KSC Engineering Design & Development Office (KSC/ NE-D), which provided focused technical and project management services. A detailed analysis of exhaust gas convection, radiation, and through-the-case conduction indicated that assembled solid motors in other high bays would likely not be ignited due to thermal transport from the burning motor pair. As a result, the largest hazard radius due to thermal radiation beyond a rising exhaust plume was estimated to be slightly smaller than the existing Shuttle QD arc (1310 feet).

Traditional QD Siting, implemented using table lookup against a total weight of potentially explosive material, is intended to account for general blast and fragmentation hazards, as well as thermal effects associated with a fireball. More specific hazards to be considered under the MCE approach include acoustic energy and toxic materials in and around the VAB (commonly referred to as "near-field" toxic hazards).

In addition to the safe siting activity, which establishes a logistical control boundary, NASA regulations also require that all potential hazards be investigated to determine if reasonable mitigations are warranted. Additional hazards to be reviewed under an Integrated Hazard Assessment (IHA) include structural failures and possible collapse, propulsive components that could break free of restraints, and toxic clouds that could be transported by the wind and settle to the ground at considerable distances from the VAB (commonly referred to as "far-field" toxic hazards).

Figure 10, below, attempts to illustrate this array of relevant hazards and their relationships to QD, MCE, IHA, and NPR 8715.3C (NASA General Safety Program Requirements, Change 3). Note that hazards inside the VAB (right half of diagram) have been distinguished from hazards outside (left half of diagram) since the circumstances and corresponding analysis methods often differ. Also, propulsive hazards outside the VAB are shown in a lighter shade because they may eventually be analyzed and documented separate from the primary IHA.

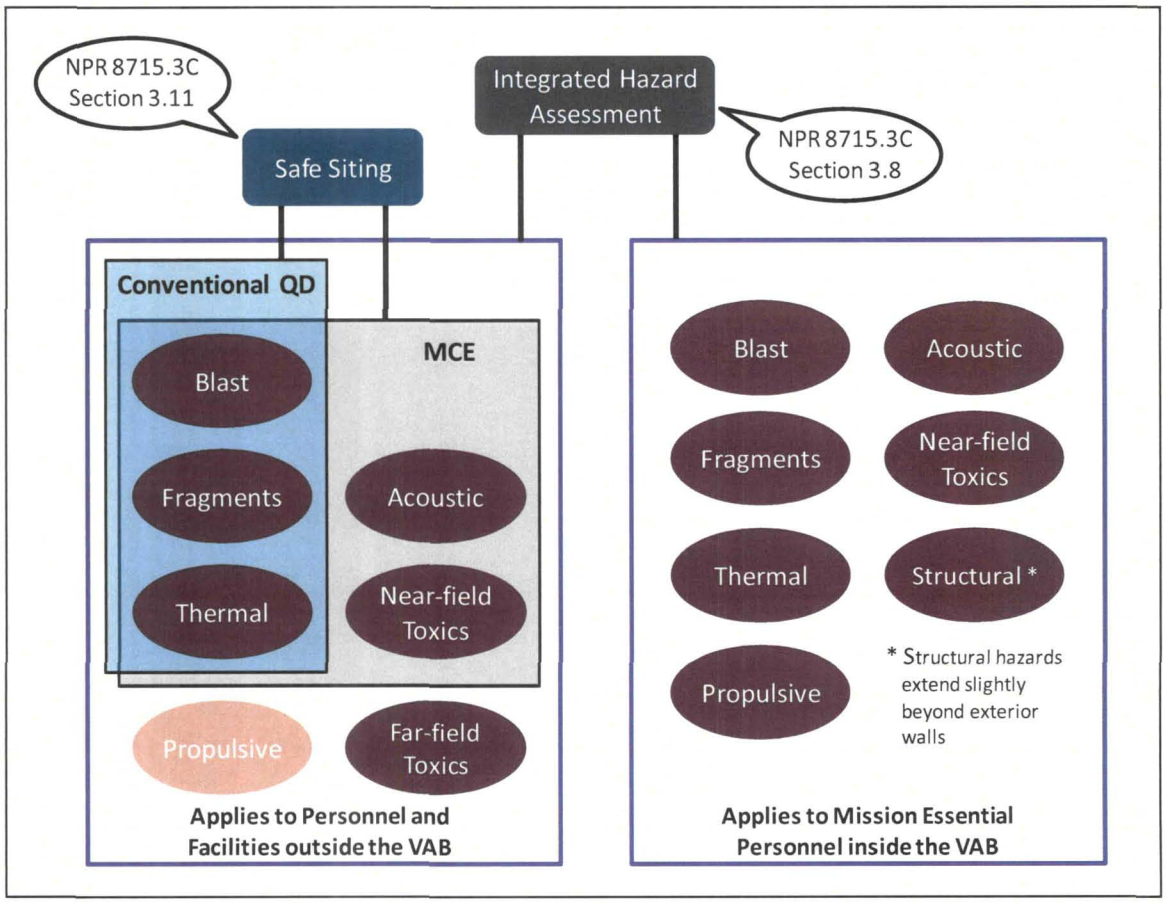

FIGURE 10: VAB HAZARD ANALYSIS CATEGORIES

By mid-2009, the Ares V booster configuration had changed from 5 to 5 ½ RSRM segments, and the KSC team decided to assume two 4 ½-segment open stacks burning while anchored in one high bay. Previous thermal analyses were performed assuming stationary 5-segment capped motors for worst-case estimation purposes. The more credible events were determined to involve inadvertent ignition of, at most, two uncapped stacks since they would generate limited propulsive forces. Consideration will be given to ignition propagation between boosters within a single bay and potential spreading to other bays within the VAB. Several other ignition cases will be considered which would involve lesser amounts of propellant within a bay or at other locations, such as the Transfer Aisle. CFD analyses were resumed at ARC with an initial emphasis on bay-to-bay ignition propagation.

ATK was asked to examine radiation effects and through-the-case heat transfer as well as ignition criteria and the likelihood of deflagration when ignition occurs at the outer propellant interface with the liner and insulation layers. Due to resource limitations at ARC, SAIC was brought in to perform CFD analyses extending well outside the VAB walls and to evaluate thermal radiation effects on personnel beyond the rising exhaust plume. Their CFD output will also be used by ACTA, Inc., an Air Force and NASA Range Safety contractor, to evaluate near-field and far-field toxic hazards. It is possible that the largest distance to a safe near-field concentration level could become the driver for MCE purposes.

ACTA has also performed verification of blast and fragmentation analyses, conducted originally by Engineering Associates, Inc. (EAI), and managed by the KSC Constellation Project Ground Systems Office (KSC/ LX-D). EAI's work is largely directed toward the design of hazard mitigations in the VAB. Such facility upgrades might include the addition of cladding to selected walls and protective gates (or doors) to enclose hypergol processing cells. Some of EAI's outputs have also been used to support hazard radius determination. After confirming their fundamental results, ACTA expanded on the EAI approach and has begun generating comprehensive estimates of maximum injury distances defined by fragment density and kinetic energy. Blast hazard radii are generally smaller than fragmentation radii and do not typically drive the QD arc. It should be noted that ACTA will be applying their expertise in toxics modeling and using existing Range Safety software to estimate dispersion effects in FY2010.

KSC/NE-D has completed an acoustic hazard analysis that includes both 4 ½-segment open stack and 5 ½-segment capped motor cases. An injury criteria for personnel was developed to establish safe separation distances with an ability to egress being the basis. Any sound levels above the human ear's threshold of pain (140 dBA) would quickly impede a person's ability to exit the building safely. At this exposure level, a safe separation distance was found to exceed a thousand feet, but fall within the current QD arc defined for Shuttle processing. These results are not expected to significantly influence the MCE outcome, but they do indicate a significant ear damage hazard to personnel inside the VAB.

Lastly, the KSC Launch Vehicle Processing Constellation Operations Office (KSC/ PH-C) has been working with ATK and structural simulation experts at ARC to investigate hazards posed by potentially propulsive components, as well as the failure and possible collapse of structural elements. How long after an inadvertent ignition would a fully stacked and capped RSRM break free and begin rising off the Mobile Launch Platform (MLP)? How much speed could it build up before impacting an overhead crane or the VAB sub-roof? Is there enough kinetic energy and structural toughness to perforate the roof slab and continue flying outside the building? Could heat generated by burning motors or partially stacked segments cause the MLP, elevated structures, or load-bearing beams inside the VAB to fail? These questions and others are being considered by this team, which includes KSC/NE-D and a KSC Range Safety engineer. Answers will likely take an additional two or more years to achieve.

C. Joint Advanced Range Safety System (JARSS)

The Joint Advanced Range Safety System (JARRS) is a collaborative effort between Dryden Flight Research Center and the Air Force Flight Test Center at Edwards Air Force Base to develop a state-of-the-art mission planning, risk analysis, and risk management tool for range safety. The Range Safety organizations from all Major Range and Test Facility Bases are being asked to support the development, testing, and operation of unmanned aerial systems (UAS) and reusable launch vehicles (RLV). It is the vision of JARRS to provide range safety support for these missions.

JARRS consists of two primary elements: a Mission Analysis Software Tool and the Real-Time Operations Tool.

The Mission Analysis Software Tool will quantify the range safety risk for a given flight path and its associated vehicle parameters using a computerized method. This method will streamline the range safety analysis by providing a consistent, high fidelity solution in less time than required by present methods of analysis.

The Real-Time Operations Tool will provide the Range Safety Officer with near real-time assessment of the range safety risks during flight. This capability has many possible applications to the UAS or RLV operator, including assessment of UAS overflight of populated areas, allowing extended flight of an anomalous vehicle, recovery of an off-nominal vehicle at an alternate landing site, or selection of an alternate flight or entry path.

Major accomplishments this year include using JARSS Mission Planning to calculate range safety risk for the upcoming NASA Global Hawk GloPac 2010 missions near Hawaii and Alaska. The 30th Space Wing at Vandenberg AFB has funded the development of JARSS Real Time and is currently in the process of testing the system for possible operational use.

V. STATUS REPORTS

A. Kennedy Space Center

The Kennedy Space Center Range Safety Representative is tasked with implementing NASA policy and keeping the Agency Range Safety Manager informed of all activities related to range safety. Over the course of the past year, the KSC Range Safety Representative supported a multitude of range safety activities, ranging from pre-launch policy interpretation and guidance to providing on-console support during launch campaigns.

1. Constellation Program

The Kennedy Space Center Range Safety Representative participated in many meetings and technical exchange sessions in support of finalizing a set of tailored range safety requirements and developing launch support and countdown documentation for the Ares I-X Test Flight Mission. The Ares I-X Test Flight Mission was successfully launched on 28 October from Space Launch Complex 39B. The mission was required to meet both Air Force Space Command Manual (AFSPCMAN) 91-710, *Range Safety User Requirements*, and NASA Procedural Requirements (NPR) 8715.5, *Range Safety Program Requirements*. Working through the Launch Constellation Range Safety Panel (LCRSP), the 45th Space Wing Safety Office, Constellation Program Office, and NASA Range Safety successfully developed a single joint tailored document that included all range safety requirements. This unique teaming process has set a precedent for future Constellation Program range safety requirements tailoring. The effort also exemplified NASA's philosophy of accepting (or sharing) responsibility for all aspects of range safety. A draft set of tailored requirements for the Ares 1 Launch Vehicle is underway.

The Range Safety Representative also provided continued support to the LCRSP and associated Constellation Program working groups.

2. Space Shuttle Program

For the Space Shuttle Program, the KSC Range Safety Representative prepared and issued an update to the Program's Range Safety Risk Management Plan (RSRMP). The update combined documents KSC-PLN-2804, *Range Safety Landing Implementation Plan for Space Shuttle*, and KSC-PLN-2805, *Range Safety Risk Management Plan for Launch and Landing of the Space Shuttle*. It also updated acceptable criteria for Shuttle ascent to reflect the 2009 flight of Ares 1-X and clarified how the annual criteria clause of the NPR is implemented for the Shuttle Program. Population definitions and the facilities considered "Center Essential" for Shuttle launches were also added.

Launch and entry risk estimates were evaluated for STS-119, STS-125, STS-127, STS-128, and STS-129, with mitigation efforts initiated through the KSC Emergency Operations Center when appropriate.

The KSC Range Safety Representative also provided continued support to the Shuttle Range Safety Panel and supported all the above listed Shuttle launches on console in the Morrell Operations Center (MOC).

3. Launch Services Program

The KSC Range Safety Representative supported a number of NASA expendable launch vehicle campaigns for the Launch Service Program (LSP), including NOAA-N Prime, OCO, KEPLER, STSS-ATRR, LRO, STSS-DEMO, and WISE. This effort involved attending all the NASA and Air Force Safety readiness reviews, ensuring NPR requirements were being met, and identifying, documenting, and obtaining acceptance/approval of any variances during the respective prelaunch and launch countdowns.

4. Eastern Range Launch Support

In 2009, the KSC Range Safety Representative began providing launch support for non-NASA Eastern Range missions. Serving as the liaison between the 45th Space Wing Safety Office Risk Assessment Center and the KSC Emergency Operations Center (EOC), the KSC Range Safety office evaluated and interpreted range safety risks to KSC personnel and property due to CCAFS launches and suggested mitigation actions when appropriate. In this capacity, the KSC Range Safety Representative supported the GOES-O, GPS 2R-21, PAN, INTELSAT 14, and WGS-3 missions.

5. Agency Activities

The KSC Range Safety Representative served as a NASA point of contact to the Range Safety Group and supported several committees charged with developing or rewriting nationwide standards on a number of important range safety issues. These topics included developing reusable launch vehicle and unmanned aerial vehicle and system requirements, and proposed requirements for active satellite and cataloged orbital debris Collision Avoidance. The KSC Range Safety Representative was also active in the development of a proposed policy for the future use of autonomous flight safety systems within NASA. KSC is closely monitoring the status and AFSPC-proposed decommissioning of Eastern and Western Range ground tracking and command assets through their Future Range Architecture Team.

2009 was a challenging year, supporting an increased number of launch and entry campaigns, providing critical support to the Constellation Program and the launch of the Ares I-X launch vehicle, continuing to ensure Kennedy Space Center safely implements NASA Range Safety requirements, and tracking emerging technologies. The coming year promises to be equally busy, and the Kennedy Space Center Range Safety Representative will continue to provide critical support as necessary when called upon by NASA programs or to address issues as they arise.

B. Wallops Flight facility

The Wallops Safety Office (Code 803) supports all missions at Wallops Flight Facility and provides support at various other locations around the world as needed. This support includes ground safety and flight safety analysis, documentation of operational rules, and active support of ground processing and flight operations. Listed below are various project/ programs that the Safety Office supported in 2009.

1. TacSat-3

TacSat-3 was successfully launched from Wallops Island on 19 May 2009. TacSat-3 featured three revolutionary trials: the Raytheon Company-built Advanced Responsive Tactically Effective Military Imaging Spectrometer hyperspectral imager, the Office of Naval Research's Satellite Communications Package, and the Air Force Research Laboratory's Space Avionics Experiment.

FIGURE 11: TACSAT-3

2. Max Launch Abort System (MLAS)

The Max Launch Abort System (MLAS) was successfully tested in a simulated pad abort test at Wallops Flight Facility on 8 July 2009. The test vehicle weighed over 45,000 pounds and was over 33 feet tall. The unpiloted launch tested an alternate concept for safely propelling a future spacecraft and its crew away from a problem on the launch pad or during ascent. The MLAS consists of four solid rocket abort motors inside a bullet-shaped composite fairing attached to a full-scale mockup of the crew module.

FIGURE 12: MLAS SIMULATED PAD ABORT TEST

The MLAS vehicle was launched to an altitude of approximately one mile to simulate an emergency on the launch pad. The flight demonstration began after the four solid rocket motors burned out. The crew module mockup separated from the launch vehicle at approximately seven seconds into the flight and parachuted into the Atlantic Ocean.

3. Sounding Rocket Program

The Sounding Rocket Program conducted 16 missions in 2009 with an overall mission success rate of 100%.

The Inflatable Re-entry Vehicle Experiment, or IRVE, was vacuum-packed into a 15-inch diameter payload "shroud" and launched on a small sounding rocket from NASA's Wallops Flight Facility on August 17, 2009. Nitrogen inflated the 10-foot (3 m) diameter heat shield, made of several layers of silicone-coated industrial fabric, to a mushroom shape in space several minutes after liftoff.

FIGURE 13: IRVE

Inflatable heat shields hold promise for future planetary missions, according to 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.
A.

4. Balloon Program Office

The Balloon Program Office at Wallops Flight Facility conducted 13 missions during fiscal year 2009. Flight operations were conducted from Fort Sumner, New Mexico; McMurdo, Antarctica; and Kiruna, Sweden in support of Space and Earth science payloads as well as developmental test flights for new balloon design and balloon film qualification. Flight durations ranged from 4 hours to 54 days with the longest flight occurring over Antarctica on the 7 million cubic foot volume super pressure test flight. The Balloon Program Office continued the Ultra Long Duration Balloon (ULDB) vehicle development. Test flights of larger scale designs of the ULDB super pressure balloon is planned for 2010. The balloon is being developed to provide extended duration flights upwards of 60-100 days at constant float altitudes. The Balloon Program plans to conduct remote campaigns from McMurdo, Antarctica; Alice Springs, Australia; and Fort Sumner, New Mexico.

FIGURE 14: SUNRISE 1-METER BALLOON TELESCOPE READY FOR LAUNCH, ESRANGE, JUNE 2009

C. Dryden Flight Research Center

For more background and information on the DFRC Status Report, *click here.*

The Dryden Flight Research Center (DFRC), located at Edwards Air Force Base, California, is NASA's primary installation for flight research and testing. Over the past 63 years, projects at Dryden have led to major advancements in the design and capabilities of many civilian and military aircraft. In the past, DFRC has also conducted tests in support of the Agency's space programs.

The Center supports operations of the Space Shuttle and development of future access-to-space vehicles, conducts airborne science missions and flight operations, and develops piloted and uninhabited aircraft test beds for research and science missions.

Range Safety operations at Dryden are managed by the Range Safety Office (RS Office). The RS Office was established by the Dryden Center Director under an alliance agreement with the Air Force Flight Test Center (AFFTC) to provide independent review and oversight of Range Safety issues. The Office supports the Center by providing trained Flight Termination System (FTS) engineers, Range Safety risk analysts, and Range Safety Officers to provide mission and project support for Unmanned Aerial System (UAS) Projects. The DFRC/AFFTC range safety alliance allows both offices to work together, each providing expertise on projects the other office may not be as familiar with.

The DFRC/AFFTC Range Safety alliance is planning to install and test a fixed Enhanced FTS (EFTS) transmitter site which will be operational by the end of next calendar year.

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

1. 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. During the last year, Dryden has supported over 270 hours of operations on multiple platforms from 6 different manufacturers.

2. Blended Wing Body Low Speed Vehicle

The Blended Wing Body (BWB) Low Speed Vehicle (LSV) UAS, also known as X-48B LSV, 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 areas that future aeronautical designs will face including noise reduction, emissions reduction, and improvement in fuel economy. Industry studies suggest that because of its efficient configuration, the BWB would consume 20% less fuel than the jetliners of today while cruising at high subsonic speeds on flights of up to 7,000 nautical miles. To date, the project has conducted 72 successful flights, all conducted with LSV #2.

LSV #1, the wind tunnel vehicle, has been heavily modified to make the vehicle quieter. The modifications include reducing the number of engines from three to two, the installation of noise-shielding vertical fins, and the removal of the winglets. The designation for this new configuration is X-48C. The first flight of this vehicle is expected to occur in late 2010.

3. NASA Global Hawk

Dryden has acquired two former United States Air Force (USAF) Advanced Concept Technology Demonstration (ACTD) Global Hawk UASs. 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 mean sea level (MSL). NASA's first Global Hawk flight was successfully flown this year. To date, the Project has flown 5 successful flights, all with NASA 872. NASA 871 is expected to fly its first NASA flight in the summer of 2010. The first airborne science mission flight is scheduled for Spring 2010.

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

4. Ikhana

NASA's Ikhana UAS 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. The vehicle successfully flew multiple missions in support of acoustic research and one flight to map post-wildfire damage.

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

The Range Safety Office has supported Ikhana UAS 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 14 flights this year with durations lasting as long as 7 hours.

5. Orion

The Orion Project is an element of the Agency's Constellation Program. The Orion Project consists of the Crew Module (CM) and the Launch Abort System (LAS). Dryden is responsible for conducting a series of flight tests to demonstrate proper operations of the LAS and CM recovery systems in response to abort events initiated on the launch pad and during the initial ascent phase of flight. The abort flight tests will be conducted at the U.S. Army's White Sands Missile Range (WSMR) in New Mexico.

Dryden is currently in the process of integrating the Crew Module test article for Pad Abort 1 test flight. Dryden will also be responsible for integration of the second Crew Module test article for Ascent Abort 2 test flight.

The most significant events of Calendar Year 2009 include the completion of the Pad Abort Launch facilities, the delivery of the PA-1 Jettison and Abort motors to WSMR in May, and the delivery of the PA-1 Crew Module to WSMR in August. The jettison motor is a solid rocket motor designed to separate the LAS from the Crew Module. The abort motor is a solid rocket motor designed to separate the LAS and Crew Module away from the Ares I launch stack in the event of a problem on the launch pad or anytime during first stage burn.

The RS Office tailored NASA Procedural Requirements (NPR) 8715.5, Range Safety Program, for Pad Abort #1 and provided input to RCC 319, Flight Termination Systems Commonality Standard tailoring for Ascent Abort #2.

D. Johnson Space Center

1. Constellation Range Safety Panel (LCRSP)

The Launch Constellation Range Safety Panel (LCRSP) manages launch Range Safety matters for Constellation program vehicles, including specifying key interfaces with the Department of Defense (DoD) for launch Range Safety.

This section summarizes the work conducted through the LCRSP and its two chartered working groups.

a. LCRSP Trajectory Working Group:

The Trajectory Working Group (TWG) was the first sub-group chartered by the LCRSP. The primary responsibility of the group is to ensure that each Range Safety trajectory analysis requirement, as specified by the 45th Space Wing (45 SW), is coordinated among the proper NASA centers.

During 2009, the working group's efforts were focused primarily on the development of the Final Flight Data Package (FFDP) that was delivered to the 45 SW for the Ares I-X test flight which launched in late October 2009. The development of the FFDP was a multi-center effort led by trajectory analysts at Langley Research Center (LaRC). Engineers from Johnson Space Center (JSC) and Marshall Space Flight Center (MSFC) were also heavily involved, performing the necessary Verification and Validation (V&V) activities. The TWG served as the primary forum for coordination with the Eastern Range, as well as the review panel for each of the Ares I-X FFDP trajectory products. Representatives from the 45 SW were also regular participants in the working group and provided technical assistance on many occasions.

The following official products were completed and delivered for the Ares I-X FFDP:

- Nominal Ascent and Reentry Trajectories
- 3-Sigma Trajectory Envelopes
- Malfunction Turn Trajectories
- First Stage Impact Location Footprints
- Upper Stage Disposal Footprints
- Sonic Boom and Acoustic Analysis
- Debris Catalog Data

b. LCRSP Probabilistic Risk Assessment Working Group:

The Probabilistic Risk Assessment (PRA) Working Group was first chartered in early 2007 as the forum through which all launch vehicle range safety-related reliability analyses and products would be coordinated for the Constellation Program. This technical forum supports the Launch Constellation Range Safety Panel in all matters related to vehicle failure probability estimation for range safety risk assessments in compliance with the requirements of the Constellation Program, NASA's NPR 8715.5, Range Safety Program, and applicable Air Force Range Safety policy and requirements. The members of the working group include representatives from the Launch Vehicle Project Office (Ares, Ares I-X), Mission Operations, Safety and Mission Assurance, and the 45 SW.

In 2009, the working group generated the final Ares I-X probability estimates for all of the possible vehicle failure modes that were identified by the team. This PRA was finalized and delivered to the 45 SW as part of the Ares I-X FFDP. The PRA results also contributed towards the completion of the Ares I-X trajectory analysis tasks by identifying the possible malfunction turn (i.e., off-course) failure scenarios and listing their relative likelihood. In addition, the PRA Working Group coordinated with the 45 SW to develop a new methodology for adjusting the probability estimates for mature systems to account for the inherent risks associated with a new launch vehicle design. The process to develop these "first flight adjustments" was considered to be groundbreaking work since previous NASA risk assessments typically involved mature

vehicles. The work and collaboration between NASA and the 45 SW on this issue will continue to evolve as new launch vehicles are developed and flown.

The FFDP PRA products were developed by Safety and Mission Assurance personnel at Johnson Space Center, Marshall Space Flight Center, and Langley Research Center.

c. Ares & Orion Range Safety Topics:

Throughout 2009, the LCRSP discussed a number of Range Safety topics related to the Ares launch vehicle and Orion spacecraft. These topics included the following:

- Launch Enterprise Transformation Study (LETS)
- Ares & Orion Debris Catalog Development
- Tailoring of AFSPCMAN 91-710 and NPR 8715.5
- Ares Flight Termination System (FTS) Delay Time / Abort Sequencing
- Ares & Orion Abort Disposal Constraints

This section highlights just a few of the examples of the complex projects and tasks that were completed by LCRSP participants nationwide. The launch of Ares I-X signified the culmination of a range safety analysis and development effort that spanned several years and involved multiple NASA centers and contractor organizations. In the end, 2009 proved to be a very active and successful year for the Constellation Range Safety community.

2. Space Shuttle Range Safety Panel

In 2009, the Space Shuttle Range Safety Panel dealt with a number of topics related to the Space Shuttle. Included were the Launch/Range Enterprise Transformation Study, the Launch Collision Avoidance (COLA) Process, the Meteorological System Computer, Command Receiver Decoder Retest Requirements, Balloon COLA's, and MCLARA Weather Inputs.

a. Launch/Range Enterprise Transformation Study

The Launch/Range Enterprise Transformation Study (LETS) is a proposed major restructuring of the U.S. Air Force range architectures and processes. Although the proposal will affect all range users eventually, the effect on the Shuttle Program is limited since the Shuttle program will end before many of the proposed changes can go into effect.

Since all future launch vehicles will be required to use GPS for range safety functions, a major component of the LETS architecture is the proposed retirement of many ground-based tracking radars. Some of these radars would be retired in the near-term, and these retirements could potentially impact Shuttle launches and landings.

After extensive analysis, the Shuttle Range Safety Panel made recommendations to LETS regarding which radars should be retained and which should be retired in order to minimize the impact of LETS on the remaining Shuttle launches. Discussion and negotiation regarding the impact of LETS on the Constellation Program will continue for some time.

b. Launch Collision Avoidance (COLA) Process

The year began with an extended discussion of a proposed Air Force Special Instruction (SPINS) that would have implemented a new Air Force process for prelaunch conjunction and collision avoidance screening. However, the proposed SPINS was cancelled. Several months later, the 14th Air Force issued a new draft Air Force Instruction 91-217 which proposed a similar prelaunch screening process.

That memo was subsequently signed by the Air Force in October of 2009 and will be first implemented for the launch of STS-130 in 2010. The new process will have 614AOC screen all launches from the Eastern and Western Ranges based on the Satellite Catalog. For manned vehicles, they will use either a 200 km sphere, a 200 x 50 x 50 km ellipsoid, or a probability of 1 in 1 million. For active spacecraft and debris, they will use a 25 km sphere or a probability of greater than 10 in 1 million.

Although the use of the probability method would have provided great benefits for the Shuttle program, technical difficulties precluded doing so, and remedying those difficulties will not be possible during the remaining life of the Shuttle program. So, reluctantly, the Range Safety Panel concluded that volume based screening was the only practicable alternative. After some analysis based on known Shuttle maneuver tolerances and navigation system uncertainties, the Range Safety Panel recommended the use of a miss distance of 8 x 30 x 30 km, which would be equivalent to a probability of 1 in 1 million for Shuttle launches. Although initially receptive to the use of this Shuttle-specific screening volume, the Air Force later decided to retain the generic 25 km sphere for screening against all unmanned objects. Subsequently, a letter was drafted by the Space Shuttle Program Manager to the Air Force requesting the use of the 8 x 30 x 30 km volume. At the end of the year, the Air Force was still considering that request.

c. Meteorological System Computer

The Meteorological System Computer (MSC), which processes balloon data to derive atmospheric wind profiles, experienced a major failure during the STS-126 launch at the end of 2008. Both prime and backup computers became overloaded and crashed, and some data was lost while other data was delayed. The MSC system is old and scheduled for upgrade / replacement in a year or two, but the replacement will not be available during the planned life of the Shuttle program.

In response, the Shuttle Range Safety Panel helped facilitate the development of a mitigation plan which would limit the amount of data that the MSC would be asked to process at any one time and thus, hopefully, prevent any future crashes.

The mitigation plan has two parts. The first part attempts to limit the amount of data the MSC will be asked to process during nominal operations to that which experience shows it can process without experiencing difficulty. The second part would be invoked if a slowdown is experienced and would even further restrict processing requests to the minimum necessary to actually launch.

For the remainder of 2009, no MSC processing anomalies were experienced during any of the Shuttle launches to the International Space Station (ISS) (i.e., the STS-119, STS-127, STS-128, and STS-129 launches). The only anomaly was during STS-125, a Hubble Space Telescope (HST) servicing mission. The longer launch window for the HST mission (approximately one

hour for HST missions vs. ten minutes for ISS missions) required multiple balloon launches in order to cover the entire launch window. This led to higher loading than experienced during typical ISS missions which, in turn, resulted in overloading the MSC and caused a slowdown in processing.

When this happened, the part two processing restrictions described above were invoked for the MSC, and, although the processing slowdown did persist for some time, the system did not crash and was able to process all of the data required for the launch. The system experts believe that the mitigation plan put into place after STS-126 is the reason that the system did not crash during the STS-125 count, and that is the plan that will be carried for the remaining Shuttle launches.

d. Command Receiver Decoder Retest Requirements

There had been concern that Shuttle Range Safety Command Receiver Decoder (CRD) open-loop and closed-loop end-to-end tests were not being planned within 6.5 days of the scheduled launch as expected by the 45th Space Wing (45SW). There was also concern that the unexpected assembly/checkout operations in the forward skirt after closeout may threaten the integrity of the Range Safety System (RSS). The Range wanted to make sure that it was documented that they had representatives available to verify the integrity of the RSS and request a retest, if necessary. Recent Shuttle processing experience shows the typical test planning target is 11 days prior to a scheduled launch. Testing later in the processing flow is constrained by safety-critical ops such as fuel loading and interface closeout verifications. Ground ops agreed to move closed-loop tests further from launch to accommodate some of these processes. Historical data shows that up to 14 days can elapse between S5009 Final Ordinance Connection and Closeout operations and the first planned launch attempt.

The 30A90506 specification document will be revised to establish a test planning requirement of no earlier than 14 days from command closed-loop end-to-end tests to the scheduled launch date. The document will also be revised to capture a requirement for an ER safety representative to be present during reentry of the SRB forward skirts to verify the integrity of the RSS. A general requirement on SRB forward skirt access is being drafted, and a separate Requirements Change Notice (RCN) will be generated for the 14-day requirement. This will be combined with the 270-day CRD bench test requirement. All of these changes were approved by the Shuttle Range Safety Panel.

e. Balloon COLA

A collision between a weather balloon and a Shuttle launch has never been considered a credible hazard because, A) the weather balloons are seldom blown across the Shuttle launch trajectory, and B) the balloons are very small and so, overall, the likelihood of a collision is remote. For that reason, there is no NASA requirement for anyone to do balloon collision avoidance analysis. Interestingly, however, during the STS-128 launch attempt on August 24, 2009, the Day-of-Launch I-Loads Update group (DOLILU) observed balloons actually were being blown back toward the Cape and across the shuttle's trajectory, thus elevating the possibility of a collision from completely impossible to theoretically possible. It was determined that the only balloon that could possibly be in the area of the Shuttle track at the time of launch was the L-1h25m balloon. Since this balloon was not required in order to launch, and even though no action was required on their part, the DOLILU group consulted with the Ascent Flight Director and elected not to launch the balloon in question on that day.

After the STS-128 launch, the Shuttle Range Safety Panel first received a briefing on the capabilities of the 45SW to project balloon tracks. It turns out that the 45SW can only project balloon tracks for balloons that continuously rise. Since the balloons in question top out at about 60,000 ft., the 45SW cannot project the tracks of those balloons and could not acquire that capability in time to be of use for any Shuttle launch.

Given this, for all remaining Shuttle launches, the DOLILU group will assess the balloon ground tracks just as they did during STS-128. If balloon tracks cross the Shuttle ground track, DOLILU will notify the flight director and adjust the balloon schedule if that can be done without adversely impacting launch preparations. If they cannot, then the launch will continue since the remote risk of a collision has already been accepted by the Shuttle program.

f. MCLARA Weather Inputs

In the past, seasonal climatalogical data has been used by the Eastern Range (ER) Safety Risk Analysis Office to assess the risk associated with STS launches. More recently, the Range has been transitioning to the use of North American Mesoscale (NAM) model forecast data and had previously implemented the use of NAM data for the computation of risk from toxic gases. For the last Shuttle launch of 2008, STS-129, the Range was ready to complete the transition and begin use of NAM data for the computation of debris risk.

KSC personnel initially expressed concern that the use of "forecast" data might result in instability in the risk calculations and result in the identification of risks too late in the count to take proper mitigating action. However, 45SW personnel were able to show that the use of NAM data does produce stable results inside T-84 hours when the transition is made from seasonal data to NAM output. KSC was reassured by these results, and the Shuttle Range Safety Panel concurred with the use of NAM data for STS-129.

SUMMARY

Range Safety was involved in a number of exciting and challenging activities and events in 2009 involving the development, implementation, and support of range safety policies and procedures.

Activities included the updating of policy related to flight safety systems and flight safety risk criteria, including the coordination of a review of our MOA with the 45th Space Wing, up for its triennial review in February 2009, and the development and implementation of tailored requirements for the Constellation Program. Range Safety also continued efforts to revise NPR 8715.5, Range Safety Program, to accommodate developments in our evolving discipline, and is working toward a July 2010 posting.

Range Safety representatives took part in a number of panels and councils, including the Range Commanders Council (RCC) Range Safety Group (RSG) and its subgroups. NASA also participated in the RSG with Range Safety representatives from NASA HQ, KSC, DFRC, and Wallops, actively supporting the RSG.

Advancing our effort to provide training at various levels of range safety, a total of 562 students have participated in 21 Range Safety Orientation Courses. Additionally, NASA and KSC Range Safety supported 19 launches this year consisting of 4 from the Western Range and 15 from the Eastern Range, including 5 Shuttle launches and the Ares I-X test launch.

Range Safety also participated in the evaluation of several emerging technologies, including the Autonomous Flight Safety System for expendable launch vehicles, and the explosive re-siting of the VAB to support hazardous operations for the Constellation Program. The Enhanced Flight Termination System continues to advance, with the Dryden Flight Research Center/Air Force Flight Test Center planning to install and test a fixed Enhanced Flight Termination System transmitter by the end of calendar year 2010. The Joint Advanced Range Safety System also continues to make progress toward achieving its goal of supporting Unmanned Aerial Systems and Reusable Launch Vehicles at all ranges.

We hope you found our web-based format for the Range Safety Annual Report to be usable and informative, and we hope that linking to the original articles has reduced the need for repetition in this report without sacrificing the quality of the information presented. As we move into 2010, 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 2010 Range Safety Annual Report should contact Richard Lamoreaux, the NASA Range Safety Program Manager located at the Kennedy Space Center, or Michael Dook at NASA Headquarters.

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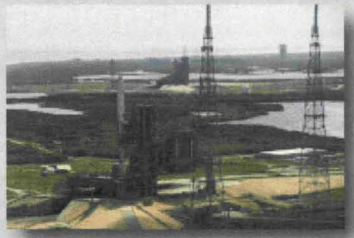
NASA Official: Rich Lamoreaux NASA Range Safety Manager



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- Previous Reports
- NASA Range Safety Home

Site Last Updated: February 23, 2010
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I. Introduction

Welcome to the 2009 edition of the NASA Range Safety Annual Report

This 2009 Range Safety Annual Report
is produced by virtue of support from the following:

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I. Introduction

Welcome to the 2009 edition of the NASA Range Safety Annual Report

Welcome to the 2009 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. This year, NASA Range Safety transitioned to a condensed annual report to allow for Secretariat support to the Range Safety Group, Risk Committee. In the future, traditional annual reports will be written in even years and condensed versions will be written in odd years. Although much shorter than in previous years, this report contains full-length articles concerning various subject areas, as well as links to past reports. Additionally, summaries from various NASA Range Safety Program activities that took place throughout the year are presented, as well as information on several projects that may have a profound impact on the way business will be done in the future.

The sections include a program overview and 2009 highlights, Range Safety Training; Range Safety Policy; Independent Assessments Support to Program Operations at all ranges conducting NASA launch operations; a continuing overview of emerging range safety-related technologies; and status reports from all of the NASA Centers that have Range Safety responsibilities.

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. We've made a great effort 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 we have utilized this web-based format for the annual report. We continually receive positive feedback on the web-based edition, and we hope you enjoy this year's product as well.

It has been a very busy and productive year, as hopefully you will note following a review of this year's report. 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 years to come.

Richard W. Lamoreaux
NASA Range Safety Manager

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II. Agency Range Safety Program

Program Overview and 2009 Highlights

2009 continued the fevered 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. The program is defined in NPR 8715.5, dated 8 July 2005, and is signed by the NASA Administrator. 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 expendable launch vehicles, reusable launch vehicles, unmanned aerial systems, the Space Shuttle, and the Constellation Program. Also included in this group are NASA-funded commercial ventures that involve range operations. We meet the goal of NPR 8715.5 by evaluating, mitigating, and controlling the hazards associated with range operations such as debris, distant focusing overpressure, and toxics. With that in mind, we continued our revision effort of the NPR, identifying areas that needed updating and suggesting additions to strengthen the policy arm of NASA Range Safety as well as focusing on common standards between NASA, DoD, and the FAA.

This is our fourth year providing the annual report via a web-based format, which continues to evolve. This year we continue our approach to updating articles; instead of repeating standard article information, we only include updates and provide links back to the original articles. We believe this provides a more user-friendly format. Additionally, we transitioned to a mini-annual report for odd years, maintaining a full annual report for even years. It takes a herculean effort each year to publish the annual report, and this transition allows us to provide additional support in other areas, such as the Range Commanders' Council during odd years. Several areas of Range Safety will be covered that demonstrate how we meet or implement the Range Safety Program. A primary focus is training and our continuing efforts regarding the NASA Range Safety Training Program.

We remain extremely busy in the development, implementation, and support of Range Safety policy. The Constellation Program took center stage this year with the successful test flight of the Ares I-X launch vehicle. The launch was a culmination of more than three years of cooperative effort between representatives from many NASA centers, contractors, and the 45th Space Wing. Additionally, we supported a number of Space Shuttle and Expendable Launch Vehicle launches this year, as well as working updated agreements with our partners at the Eastern and Western Ranges.

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II. Agency Range Safety Program

Program Overview and 2009 Highlighs

NASA Range Safety personnel continue to support the Range Commander's Council meetings and have been involved in updating policy related to flight safety systems and flight safety risk criteria. A summary of these efforts is highlighted in this report. Additionally, we continue to support HQ-sponsored Infrastructure, Facilities, and Operations (IFO) Audits, and we provide a synopsis of the inspection conducted at Langley Research Center. We also address launch operations at KSC and the Eastern and Western Range.

Emerging range safety technology continues to interest many in the Range Safety community. This year we focused on the Autonomous Flight Safety Systems.

As always, we will conclude with Range Safety reports from the NASA centers that were actively involved with Range Safety issues throughout the year. Figure1 below gives a brief overview of the major topics contained in this report.

FIGURE 1: 2010 RANGE SAFETY REPORT OVERVIEW

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II. Agency Range Safety Program

A. Range Safety Training 2009 Updates

Link to 2008 Agency Range Safety Training article

To date, we have conducted 21 Range Safety Orientation Courses with a total of 562 students. 7 Flight Safety Analysis Courses were presented to a total of 127 students, 7 Flight Safety Systems Course were presented to a total of 105 students, and 4 Range Safety Operations Course were presented to a total of 24 students. The schedule for all courses for 2010 is depicted in Figure 2 below.

FIGURE 2: 2010 COURSE SCHEDULE

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II. Agency Range Safety Program

A. Range Safety Training 2009 Updates

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

The Range Safety Orientation Course, as outlined in Figure 3, 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 termination systems, and range operations), and briefly addresses associated range safety topics such as ground safety, frequency management, and unmanned aerial systems (UAS). 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 course is designed to inform the audience of the services offered by the Range Safety organization, to 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 to recommend ways of making the working relationship with Range Safety beneficial for the Range User. This course includes a visit to Range Safety facilities at CCAFS/KSC and will normally only be presented at the Eastern Range. 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

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A. Range Safety Training 2009 Updates

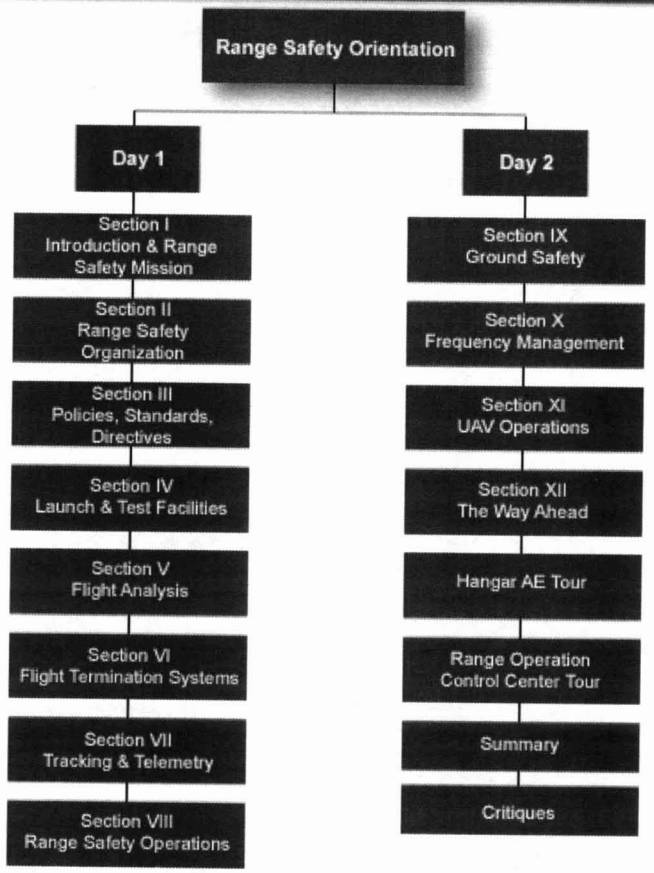

FIGURE 3: ORIENTATION COURSE OUTLINE

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II. Agency Range Safety Program

A. Range Safety Training 2009 Updates

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

The Range Flight Safety Analysis course is designed to give the student a detailed understanding of range safety analysis. As detailed in Figure 4, the course includes NASA, FAA, and DoD requirements for flight safety analysis, a discussion of range operation hazards, risk criteria, and risk management processes; and an in-depth coverage of the containment and risk management analyses performed for expendable launch vehicles (ELV) at the Eastern Range.

Although the course is based on ELVs at the Eastern Range, the overall analysis process and concepts are also applicable to other vehicles and other ranges. The course concentrates on debris hazards and analyses but also includes an overview of toxic, blast, and radiation risks and analyses. The course includes class exercises that cover certain aspects of the flight analysis process.

Prerequisite: Prior attendance at 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

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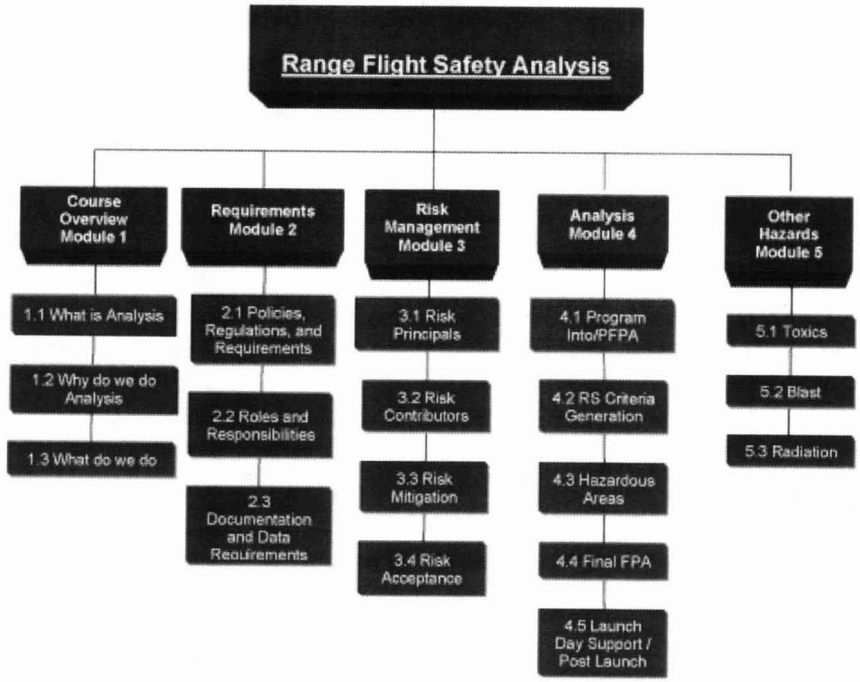

FIGURE 4: RANGE FLIGHT SAFETY ANALYSIS COURSE OUTLINE

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II. Agency Range Safety Program

A. Range Safety Training 2009 Updates

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. As detailed in Figure 5, 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 will conclude 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

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II. Agency Range Safety Program

A. Range Safety Training 2009 Updates

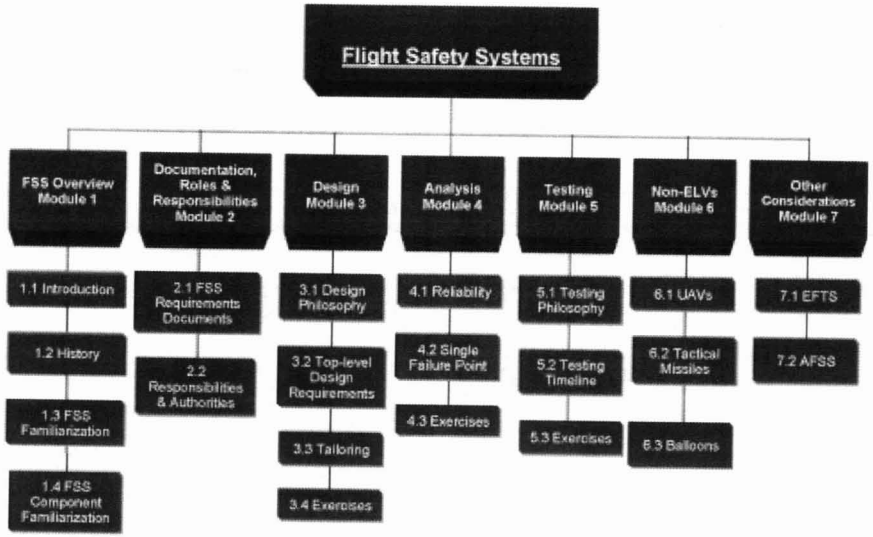

FIGURE 5: RANGE FLIGHT SAFETY SYSTEMS COURSE OUTLINE

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A. Range Safety Training 2009 Updates

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 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. Those participating in the course receive hands-on training and exercises to reinforce the instruction. It is important to note-- that this course is only presented at WFF (Wallops Flight Facility) and is limited to six participants. The course centers on the topics shown in Figure 6 below.

Prerequisites:

1. NSTC course 074, *Range Safety Orientation*, or equivalent experience and/or training, and a background in range safety.
2. NSTC-0086, *Range Flight Safety Analysis*, or equivalent experience and/or training.
3. NSTC-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.

Although not being offered through NSTC this year due to restricted funding resources, centers or other organizations may request this class if funding is provided

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II. Agency Range Safety Program

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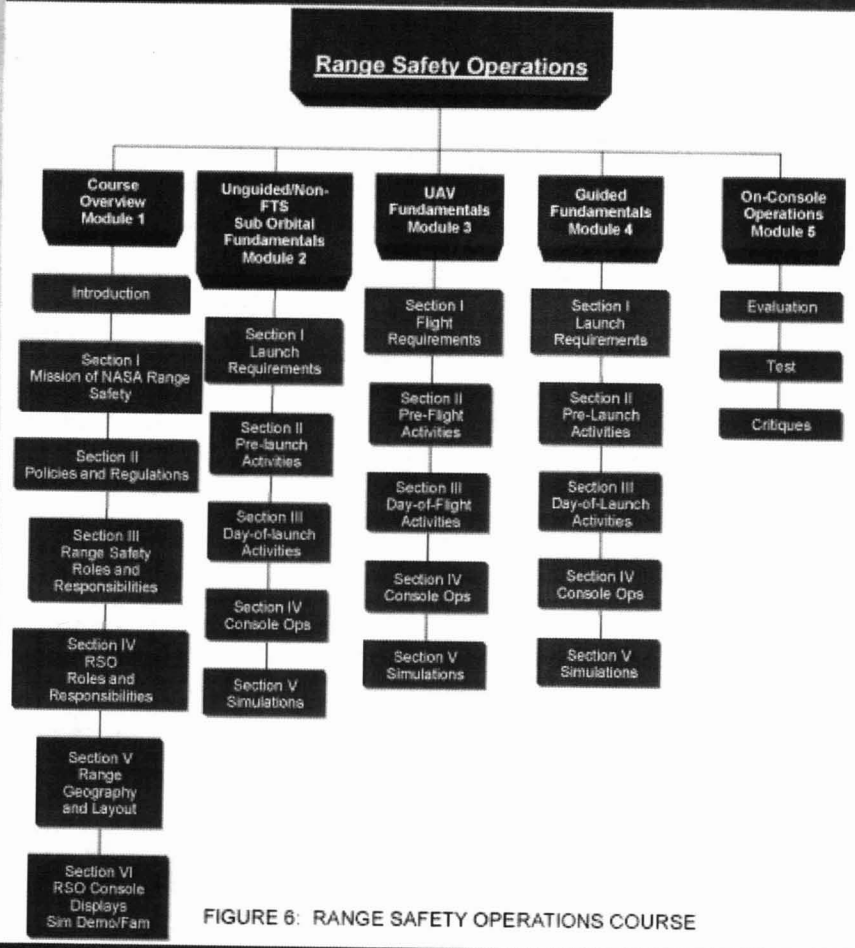

FIGURE 6: RANGE SAFETY OPERATIONS COURSE

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A. Range Safety Training 2009 Updates

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//customcontent/splash_page/SATERN_Splash.html

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II. Agency Range Safety Program

B. Development, Implementation, Support of Range Safety Policy

1. Range Safety Launch Support Policy

In 2009, NASA Range Safety continued to revise NASA Procedural Requirement (NPR) 8715.5, Range Safety Policy, working toward a July 2010 posting. One of the primary update areas is the transition from the currently published acceptable risk criteria to the Range Commanders Council recommended aggregate risk criteria. A great deal of work is also being done concerning Uninhabited Aerial Systems guidelines and criteria. Additionally, the need for Programs to have a formal Range Safety Risk Management Plan may be adjusted to allow them to identify how risk is managed and implemented in other Program plans and documentation. Along with these updates, there will be numerous administrative changes that have been identified since the signing of NPR 8715.5 in 2005.

NRS rolled the information in KSC-PLN-2804, KSC Range Safety landing Implementation Plan for Space Shuttle, into the existing KSC-PLN-2805, KSC Risk Management for Launch and Landing of the Space Shuttle. This allowed for the consolidation of both documents into a single document which also contained updated acceptable risk criteria for CY 2009 due to the Ares I-X launch from KSC.

We also coordinated a review of our current MOA with the 45 SW, which was scheduled for its triennial review in February 2009. During this review process, we jointly determine the applicability of each piece of the agreement and made updates and/or deletions that were necessary. Review of this document will continue into early CY 2010. Our initial Range Safety MOA with the 30 SW is still being coordinated through Vandenberg Air Force Base leadership. We expect this MOA to be signed soon.

We were also very active in development and implementation of tailored requirements for the Constellation Program for both Ares I-X and Ares I. Throughout 2010, we will continue to focus on joint tailoring for Ares I as required, allowing shared responsibility of range safety requirements as described in AFSPCMAN 91-710 and NPR 8715.5.

For more background and information on Range Safety Launch Support Policy, *click here*.

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II. Agency Range Safety Program

B. Development, Implementation, Support of Range Safety Policy

2. Range Safety Interface

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

a. Range Commanders Council Range Safety Group Recap

The Range Commanders Council (RCC) was founded in 1951 to provide a way for DoD test ranges to communicate and discuss common problems affecting all parties. Prior to 2008, NASA was an Associate Member of the RCC with representatives on 6 of the 14 RCC working groups. NASA became an official voting member in July 2008.

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. Range Safety representatives from NASA HQ, KSC, DFRC, and Wallops actively support the RSG and its subcommittees on a regular basis. There were two RSG meetings in 2009, summarized below.

b. 104th Range Safety Group Conference

The 104th RSG conference was hosted by Wallops Flight Facility (WFF), VA, on 14-16 April. The RSG main committee, Risk Committee (RC), Flight Termination Systems Committee (FTSC), and Directed Energy Range Safety Committee (DERSC) met.

In the main committee, special presentations were made by Wallops Flight Facility focusing on their capabilities and the failed Alliant Techsystems (ATK) ALV X- test launch. The latter presentation included a video of the launch. These presentations were followed by range reports from each range. The next RSG meeting was scheduled for 3-5 November, 2009 at China Lake, CA.

Some of the topics discussed in the FTSC included the Enhanced Flight Termination System (EFTS) program update and status, EFTS receiver testing requirements, updating RCC 319 to include EFTS requirements, and a Subminiature Flight Safety System (SFSS) update. Special topics included a Moog Inc. presentation regarding testing requirements for hydraulic actuators and related systems. Additionally, Mr. Michael Young of NASA DFRC was elected as the new FTSC chairperson.

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B. Development, Implementation, Support of Range Safety Policy

During the RC meeting, task leads presented briefings concerning model uncertainty, conditional risk, asset protection, aircraft risk vulnerability, and a Federal Aviation Administration proposal focusing on debris catalogs. The RC chair presented a schedule and way ahead for completion of all tasks prior to the next RSG in November 2009. In addition, NASA Range Safety volunteered to conduct the secretariat duties during this revision cycle.

c. 105th Range Safety Group Conference

The 105th RSG conference was hosted by Naval Air Warfare Center (NAWC), China Lake, California, 2-6 November. The RSG main committee, RC, FTSC, and DERSC met. The next meeting was scheduled for April 2010 at Aberdeen Proving Ground, MD.

In the RSG main committee, NAWC gave a briefing on their facilities and operations, which include one of the nation's largest overland test ranges. WFF also gave an in-depth presentation and discussion on the recent discovery of a boat in a rear marsh within the boat exclusion area during a launch. These presentations were followed by the standard activity reports from each range.

Topics discussed in the FTSC were Enhanced Flight Termination System (EFTS) implementation at various ranges, updating RCC 319 to include EFTS requirements, creating a new RCC document similar to RCC 313 regarding test methodology of EFTS receivers, NASA and ATK Autonomous Flight Safety Systems, L-3 Communications electronic safe and arm device (in-line FTSA), and the L-3 Communications plans for a Subminiature Flight Safety System (SFSS).

During the RC meeting, the group discussed and voted for inclusion into RCC 321-10 the tasks that were worked during the year. Those tasks were: Asset Protection, Aircraft Vulnerability Modeling, Uncertainty Modeling and Catastrophic Risk Aversion, Asset Protection Criteria; and Conditional Risk. The chair briefed the possible use of an Air Force staff summary package to coordinate the updates to the standard within the various organizations. Additionally, the group approved the proposal of Dr. Paul Wilde of the FAA, as the new chair for the Risk Committee. His name will be forwarded to the Executive Committee for approval.

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II. Agency Range Safety Program

C. Range Safety Independent Assessments

NASA headquarters has the responsibility for conducting independent process verification reviews at NASA centers and ranges to ensure, among other things, the mitigation of operational, health, and system hazards. Reviews also include compliance with laws, executive orders, publications and standards, local operating procedures, and special interest items that pertain to the center or range.

In response to this requirement, the NASA Range Safety Manager participated in one independent assessment in 2009 at Langley Research Center (LaRC).

Findings are categorized as follows:

- Observation – a condition not contrary to documented requirements but warrants improvement or clarification
- Non-Compliance – failure to comply with documented requirements
- Commendation – a process that is performed extraordinarily well or that would provide significant benefit to other centers or ranges

The assessment was an Institutional/Facility/Operational (IFO) safety audit at Langley Research Center, conducted from in July, 2009.

1. Purpose

In response to an April 2009 Intercenter Aircraft Operations Panel (IAOP) finding regarding LaRC UAS flight operations and the need to satisfy requirements of NPR 8715.5, NASA Range Safety Program, the NASA Range Safety Team performed the following:

- Reviewed LaRC UAS operations and identified the scope of range safety activities needed to comply with Agency policy.
- Used fact-based observations as a basis for comments about compliance with range safety requirements.
- Initiated an exchange of information that will help LaRC to establish Center range safety processes appropriate to it needs.
- Interpreted and complied with the Agency range safety requirements.
- Provided suggestions on how to prepare and implement required procedures and plans.
- Ensured safe flight operations.
- Identified training, tools, and other assistance that the NASA Range Safety Program can provide LaRC.

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C. Range Safety Independent Assessments

2. Recommendation

NASA Range Safety submits the following Recommendations/Positive Observation:

- The Center should develop an oversight position, "independent" of UAS Projects to ensure the requirements and policies of NASA's range safety program (NPR 8715.5, Range Safety Policy) are implemented.
- The Center should ensure that appropriate Range Safety Risk Management Plan (RSRMP) requirements are documented for UAS operations.
  - Casualty Expectations (Ec).
  - Risk Mitigation.
  - FAA Certificate of Authorization Compliance.

3. Positive Observations

- All UAS projects are receiving a thorough review and approval to fly through the LaRC Airworthiness and Safety Review Board (ASRB).
- Research Services Directorate (RSD) is very proactive in ensuring safe UAS operations.

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III. Support to Program Operations

Range Safety Support to Program Operations

NASA and KSC Range Safety supported 19 launches this year: 4 from the Western Range and 15 from the Eastern Range (3 NASA sponsored expendable launch vehicle launches, 6 non-NASA launches in the Risk Assessment Center, 5 Shuttle launches, and the Ares I-X test launch).

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

We look forward to 2010 and supporting the numerous ELV launches at both the Eastern and Western Ranges. Additionally, we anticipate supporting five Shuttle missions.

Click here to view 2008 article.

Vandenberg Air Force Base United Launch Allieance Deltaii rocket with NASA's Wide-Field Infrared Survey Exployer, or WISE, satellite aboard....Read more

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III Support to Program Operations

FIGURE 7: EASTERN AND WESTERN RANGE MISSIONS 2009

Mission	Vehicle	Launch Site	Launch Date	Responsible Org
NROL-25	Delta IV-H	CCAFS	1/17-18/09	DoD
NOAA-N Prime	Delta II	VAFB	2/6/2009	DoD
OCO	Taurus XL	VAFB	2/24/2009	DoD
Kepler	Delta II	CCAFS	3/6-7/09	DoD
ISS 15A	STS 119	KSC	3/15/2009	NASA
GPS 2R-20 (M7)	Delta II	CCAFS	3/24/2009	DoD
WGS 2	Atlas V	CCAFS	4/3-4/09	DoD
STSS-ATRR	Delta II	VAFB	5/5/2009	DoD
HST Servicing	STS 125	KSC	5/11/2009	NASA
LRO	Atlas V	CCAFS	6/18/2009	DoD
GOES	Delta IV	CCAFS	6/27/2009	DoD
ISS 2J/A	STS 127	KSC	7/15/2009	NASA
GPS IIR-21	Delta II	CCAFS	8/17/2009	DoD
ISS 17A	STS-128	KSC	8/28-29/09	NASA
PAN	Atlas V	CCAFS	9/8/2009	DoD
STSS Demo	Delta II	CCAFS	9/25/2009	DoD
Worldview 2	Delta II	VAFB	10/8/2009	DoD
DMSP F18	Atlas V	VAFB	10/18/2009	DoD
Test Flight	Ares 1-X	KSC	10/28/2009	NASA
ISS ULF 3	STS 129	KSC	11/16/2009	NASA
Intelsat 14	Atlas V	CCAFS	11/23/2009	DoD
WGS 3	Delta IV	CCAFS	12/5-6/2009	DoD
WISE	Delta II	VAFB	12/14/2009	NASA

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III Support to Program Operations

FIGURE 8: DRYDEN FLIGHT RESEARCH CENTER MISSIONS 2009

[1] Faulty telemetry.
[2] An engine shutdown during flight
[3] An engine shutdown during flight
[4] Complete loss of GPS after takeoff

Date	Project Name	Mission	Location	Mission Result
01/21/09	X-48B LSV (Blended Wing Body)	Flight # 40	Edwards AFB	Success
01/28/09	X-48B LSV	Flight # 41	Edwards AFB	Success
01/30/09	X-48B LSV	Flight # 42	Edwards AFB	Early RTB[1]
02/04/09	X-48B LSV	Flight # 43	Edwards AFB	Success
02/10/09	X-48B LSV	Flight # 44	Edwards AFB	Success
02/15/09	X-48B LSV	Flight # 45	Edwards AFB	Success
03/05/09	X-48B LSV	Flight # 46	Edwards AFB	Success
03/05/09	X-48B LSV	Flight # 47	Edwards AFB	Early RTB[2]
03/18/09	X-48B LSV	Flight # 48 and Flight # 49	Edwards AFB	Success
04/02/09	X-48B LSV	Flight # 50	Edwards AFB	RTB[3]
06/04/09	X-48B LSV	Flight # 51	Edwards AFB	Success
06/17/09	Ikhana (NASA Predator B)	Flight # 75; Functional Check Flight	Edwards AFB	Success
06/18/09	Ikhana	Flight # 76; Functional Check Flight	Edwards AFB	Success
06/23/09	Ikhana	Flight # 77; Functional Check Flight	Edwards AFB	Success
07/08/09	Ikhana	Flight # 78; Acoustic Research Dry Run	Edwards AFB	Success
07/10/09	Ikhana	Flight # 79; Acoustic Research	Edwards AFB	Success
07/11/09	Ikhana	Flight # 80; Acoustic Research	Edwards AFB	Success
07/15/09	X-48B LSV	Flight # 52	Edwards AFB	Success
07/17/09	X-48B LSV	Flight # 53	Edwards AFB	Success
07/21/09	X-48B LSV	Flight # 54	Edwards AFB	Success
07/30/09	X-48B LSV	Flight # 55	Edwards AFB	Early RTB[4]
08/11/09	X-48B LSV	Flight # 56	Edwards AFB	Success
08/18/09	Ikhana	Flight # 81; Pilot Proficiency Flight	Edwards AFB	Success
08/18/09	X-48B LSV	Flight # 57	Edwards AFB	Success
08/20/09	X-48B LSV	Flight # 58	Edwards AFB	Success
08/27/09	Ikhana	Flight # 82; Pilot Proficiency Flight	Edwards AFB	Success
09/01/09	Ikhana	Flight # 83; Pilot Proficiency Flight	Edwards AFB	Success
09/01/09	X-48B LSV	Flight # 59 and Flight # 60	Edwards AFB	Success
09/03/09	Ikhana	Flight # 84; Pilot Proficiency Flight	Edwards AFB	Success
09/03/09	X-48B LSV	Flight # 61	Edwards AFB	Success
09/10/09	X-48B LSV	Flight # 62 and Flight # 63	Edwards AFB	Success
09/11/09	Ikhana	Flight # 85; Pilot Proficiency Flight	Edwards AFB	Success
09/15/09	X-48B LSV	Flight # 64	Edwards AFB	Success
09/17/09	X-48B LSV	Flight # 65	Edwards AFB	Success
09/23/09	X-48B LSV	Flight # 66	Edwards AFB	Success
09/29/09	X-48B LSV	Flight # 67	Edwards AFB	Success
10/06/09	X-48B LSV	Flight # 68	Edwards AFB	Success
10/08/09	X-48B LSV	Flight # 69	Edwards AFB	Success
10/15/09	Ikhana	Flight # 86; Pilot Proficiency Flight	Edwards AFB	Success
10/21/09	X-48B LSV	Flight # 70	Edwards AFB	Success
10/23/09	NASA Global Hawk	Flight # 1 (1st NASA Flight)	Edwards AFB	Success
10/29/09	NASA Global Hawk	Flight # 2	Edwards AFB; R-2508 Complex	Success
11/04/09	NASA Global Hawk	Flight # 3; Pilot Proficiency Flight	Edwards AFB, R-2508 Complex	Success
11/09/09	NASA Global Hawk	Flight # 4 and Flight # 5; Pilot Proficiency	Edwards AFB; R-2508 Complex	Success
11/18/09	Ikhana	Flight # 87; Functional Check Flight	Edwards AFB	Success
11/19/09	Ikhana	Flight # 88; Post Survey of Station Fire	Edwards AFB	Success
12/02/09	X-48B LSV	Flight # 71 and Flight # 72	Edwards AFB	Success

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FIGURE 9: WALLOPS FLIGHT FACILITY MISSIONS 2009

DATE	VEHICLE	ACRONYM	LOCATION	LAU RE
1/10/2009	Orion 30.073 UO	ISIS (Ionospheric Science and Inertial Sensing)	Poker Flat Research Range, AK	
1/29/2009	Black Brant IX 36.242 UE	ACES-High (Aurora Current and Electrodynamics Structure)	Poker Flat Research Range, AK	
1/29/2009	Black Brant VB 21.139 UE	ACES-Low (Aurora Current and Electrodynamics Structure)	Poker Flat Research Range, AK	
2/18/2009	Terrier Orion 41.076 UE	Generation and Development of Turbulence in the 100-km	Poker Flat Research Range, AK	
2/18/2009	Terrier Orion 41.077 UE	Generation and Development of Turbulence in the 100-km	Poker Flat Research Range, AK	
2/18/2009	Terrier Orion 41.078 UE	Generation and Development of Turbulence in the 100-km	Poker Flat Research Range, AK	
2/18/2009	Terrier Orion 41.079 UE	Generation and Development of Turbulence in the 100-km	Poker Flat Research Range, AK	
2/25/2009	Terrier Black Brant 36.226 UG	CIBER (Cosmic Infrared Background ExpeRiment)	White Sands Missile Range, NM	
3/20/2009	Black Brant XII 40.023 UE	Analyses of Dynamic Electron precipitation Structures)	Poker Flat Research Range, AK	
5/19/2009	TacSat-3 Minotaur 1		Wallops Island, VA	
5/28/2009	Terrier Mk-12-Improved Orion 41.080 UO	SOAREX (Sub-Orbital Aerodynamic Re-entry EXperiments)	Wallops Island, VA	
6/25/2009	Terrier Mk-12-Improved Orion 41.083 UO	University level rocket flight training workshop know as RockOn	Wallops Island, VA	
6/27/2009	Terrier Black Brant 36.244 UG	DICE (Diffuse Interstellar Cloud Experiment)	Wallops Island, VA	
7/8/2009	Max Launch Abort System	MLAS	WAllops Island, VA	
8/10/2009	36.229 DR	MARTI (Missile Alternative Range Target Instrument)	San Nicolas Island	
8/17/2009	Terrier Black Brant 36.254 NR	IRVE II (Inflatable Reentry Vehicle Experiment II)	Wallops Island, VA	
9/14/2009	Black Brant IX 36.221 DS	HELiosphere)	White Sands Missile Range, NM	
9/19/2009	Black Brant XI 39.009 DR	CARE (Charged Dust Release Experiment)	Wallops Island, VA	
11/14/2009	Black Brant IX 36.252 UH	CyXESS-II (Cygnus X-ray Emission Spectroscopic Survey II)	White Sands Missile Range, NM	
	2009 Balloon Launches			
5/5/2009	0.8 MCM Balloon Musser/Indiana Unv		Ft. Sumner, NM	
5/17/2009	1.12 MCM Balloon Boggs/Unv CA		Ft. Sumner, NM	
5/21/2009	1.12 MCM Balloon Clem/Univ Delaware		Esrange/Sweden	
6/6/2009	1.12 MCM Balloon Clem/Univ Delaware		Esrange/Sweden	
6/8/2009	0.97 MCM Balloon Solanski/Max Inst		Esrange/Sweden	
6/8/2009	1.12 MCM Balloon Martin/Cal Tech		Ft. Sumner, NM	
6/11/2009	0.97 MCM Balloon Hanany/Univ Minn		Ft. Sumner, NM	
6/22/2009	.40 MCM BalloonPierce/WFF		Esrange/Sweden	TES
9/11/2009	11.8 MCM Balloon Guzik/LSU		Ft. Sumner, NM	
9/19/2009	1.12 MCM Balloon Fairbrother/WFF		Ft. Sumner, NM	TES

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IV. Emerging Technology

A. Autonomous Flight Safety System (AFSS)

The Autonomous Flight Safety System (AFSS) is a joint Kennedy Space Center and Wallops Flight Facility (WFF) project intended for use as an independent and autonomous flight termination subsystem for expendable launch vehicles. It uses tracking and attitude data from onboard Global Positioning System (GPS) and Inertial Measurement Unit (IMU) sensors and configurable rule-based algorithms to make flight termination decisions. The objectives of the AFSS are to increase capabilities by allowing launches from locations that do not have existing range safety infrastructure, to reduce costs by eliminating downrange tracking and communications assets, and to reduce the reaction time for flight termination decisions.

AFSS will have its third rocket flight in January 2010. A loosely coupled GPS/INS Kalman-filtered navigation solution will be tested, and an improved ground support computer will be used to input configuration files and initialize the system in addition to other specific improvements mentioned in last year's report.

The system requirements are being finalized and the proof-of-code is beginning the formal review process where each code module will be reviewed and tested.

The biggest change this year has been the decree by Air Force Space Command that all Air Force ranges will use an autonomous flight safety system by 2018 (although not necessarily the NASA system). The NASA AFSS team is an integral member of the Air Force Community of Interest on converting the ranges to an autonomous flight safety system and has briefed at many meetings. The NASA AFSS team believes the best way to implement an autonomous flight safety system on all ranges is to have one set of carefully controlled, government-furnished software (hopefully based on the NASA software) run with user-supplied configuration files so that the software only needs to be vetted once before being accepted for use on multiple ranges. This idea is gaining momentum, and the NASA AFSS team will certainly play an important role in the process.

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IV. Emerging Technology

B. VAB Hazard Analyses for Constellation Processing

As reported last year (*see 2008 Article*), the Vehicle Assembly Building (VAB) must be re-sited, from an explosive safety perspective, to support hazardous operations for the Constellation Program. The current Quantity-Distance (QD) Safe Siting radius for Shuttle processing is based on having no more than 16 Reusable Solid Rocket Motor (RSRM) segments present at one time. Plans for Constellation processing may require 40 or more RSRM segments since the Ares I first stage is expected to consist of 5 segments and Ares V boosters may contain 5 ½ segments each. In addition to these potentially explosive components, the Orion Service Module could also be present in the VAB, which may contain a full load of hypergolic liquid propellants, possibly in excess of 19,000 pounds [35% Monomethyl Hydrazine (MMH), and 65% Nitrogen Tetroxide (NTO)]. Since this collection of dangerous commodities presents a variety of hazards to personnel and surrounding facilities, a study was initiated in 2007 to evaluate and document the Maximum Credible Event (MCE) that could be expected from simultaneous vehicle processing in the VAB.

Since mid-2008, the KSC Safety & Mission Assurance Integration Office (KSC/SA-G) has led the overall MCE effort, and KSC Range Safety personnel have played a support role, along with a large team of contributors that was assembled to pursue various portions of this complex endeavor. There has been collaboration and close coordination with Explosive Safety leaders at KSC and HQ-NASA, as well. Early this year, the NASA Engineering and Safety Center (NESC) wrapped up a thermal hazard study based on two five-segment solid motors burning in one VAB high bay. To ensure a worst case result, motors were assumed stationary with no structural failure. Work on this bounding case was shared by Ames Research Center (ARC), where Computational Fluid Dynamics (CFD) analyses continue to play a role in ongoing investigations. Also involved were the Navy's China Lake research facility, where thermal radiation analysis was conducted; Hughes Associates, Inc., where human burn injury modeling was performed; ATK Space Systems, who manufactures the RSRM segments and other solid motor hardware; and the KSC Engineering Design & Development Office (KSC/ NE-D), which provided focused technical and project management services. A detailed analysis of exhaust gas convection, radiation, and through-the-case conduction indicated that assembled solid motors in other high bays would likely not be ignited due to thermal transport from the burning motor pair. As a result, the largest hazard radius due to thermal radiation beyond a rising exhaust plume was estimated to be slightly smaller than the existing Shuttle QD arc (1310 feet).

Traditional QD Siting, implemented using table lookup against a total weight of potentially explosive material, is intended to account for general blast and fragmentation hazards, as well as thermal effects associated with a fireball. More specific hazards to be considered under the MCE approach include acoustic energy and toxic materials in and around the VAB (commonly referred to as "near-field" toxic hazards).

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B. VAB Hazard Analyses for Constellation Processing

In addition to the safe siting activity, which establishes a logistical control boundary, NASA regulations also require that all potential hazards be investigated to determine if reasonable mitigations are warranted. Additional hazards to be reviewed under an Integrated Hazard Assessment (IHA) include structural failures and possible collapse, propulsive components that could break free of restraints, and toxic clouds that could be transported by the wind and settle to the ground at considerable distances from the VAB (commonly referred to as "far-field" toxic hazards).

Figure 10, below, attempts to illustrate this array of relevant hazards and their relationships to QD, MCE, IHA, and NPR 8715.3C (NASA General Safety Program Requirements, Change 3). Note that hazards inside the VAB (right half of diagram) have been distinguished from hazards outside (left half of diagram) since the circumstances and corresponding analysis methods often differ. Also, propulsive hazards outside the VAB are shown in a lighter shade because they may eventually be analyzed and documented separate from the primary IHA.

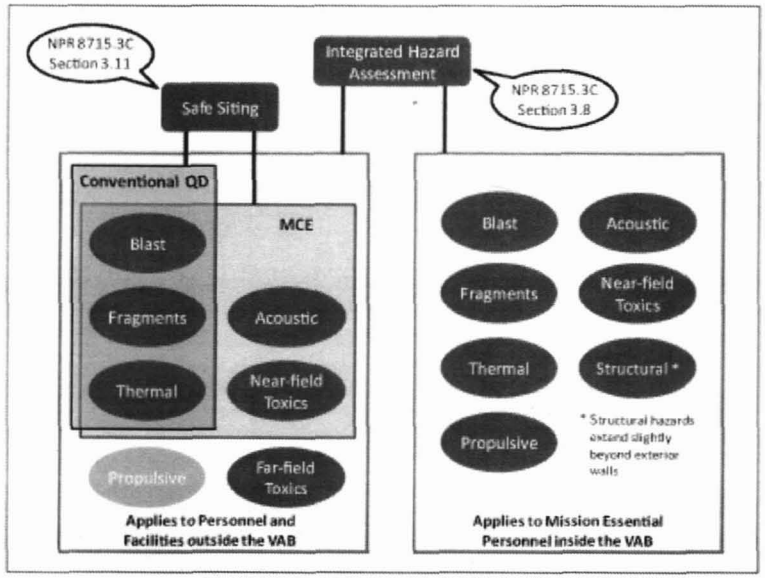

FIGURE 10: VAB HAZARD ANALYSIS CATEGORIES

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B. VAB Hazard Analyses for Constellation Processing

By mid-2009, the Ares V booster configuration had changed from 5 to 5 ½ RSRM segments, and the KSC team decided to assume two 4 ½-segment open stacks burning while anchored in one high bay. Previous thermal analyses were performed assuming stationary 5-segment capped motors for worst-case estimation purposes. The more credible events were determined to involve inadvertent ignition of, at most, two uncapped stacks since they would generate limited propulsive forces. Consideration will be given to ignition propagation between boosters within a single bay and potential spreading to other bays within the VAB. Several other ignition cases will be considered which would involve lesser amounts of propellant within a bay or at other locations, such as the Transfer Aisle. CFD analyses were resumed at ARC with an initial emphasis on bay-to-bay ignition propagation.

ATK was asked to examine radiation effects and through-the-case heat transfer as well as ignition criteria and the likelihood of deflagration when ignition occurs at the outer propellant interface with the liner and insulation layers. Due to resource limitations at ARC, SAIC was brought in to perform CFD analyses extending well outside the VAB walls and to evaluate thermal radiation effects on personnel beyond the rising exhaust plume. Their CFD output will also be used by ACTA, Inc., an Air Force and NASA Range Safety contractor, to evaluate near-field and far-field toxic hazards. It is possible that the largest distance to a safe near-field concentration level could become the driver for MCE purposes.

ACTA has also performed verification of blast and fragmentation analyses, conducted originally by Engineering Associates, Inc. (EAI), and managed by the KSC Constellation Project Ground Systems Office (KSC/ LX-D). EAI's work is largely directed toward the design of hazard mitigations in the VAB. Such facility upgrades might include the addition of cladding to selected walls and protective gates (or doors) to enclose hypergol processing cells. Some of EAI's outputs have also been used to support hazard radius determination. After confirming their fundamental results, ACTA expanded on the EAI approach and has begun generating comprehensive estimates of maximum injury distances defined by fragment density and kinetic energy. Blast hazard radii are generally smaller than fragmentation radii and do not typically drive the QD arc. It should be noted that ACTA will be applying their expertise in toxics modeling and using existing Range Safety software to estimate dispersion effects in FY2010.

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B. VAB Hazard Analyses for Constellation Processing

KSC/NE-D has completed an acoustic hazard analysis that includes both 4 ½-segment open stack and 5 ½-segment capped motor cases. An injury criteria for personnel was developed to establish safe separation distances with an ability to egress being the basis. Any sound levels above the human ear's threshold of pain (140 dBA) would quickly impede a person's ability to exit the building safely. At this exposure level, a safe separation distance was found to exceed a thousand feet, but fall within the current QD arc defined for Shuttle processing. These results are not expected to significantly influence the MCE outcome, but they do indicate a significant ear damage hazard to personnel inside the VAB.

Lastly, the KSC Launch Vehicle Processing Constellation Operations Office (KSC/ PH-C) has been working with ATK and structural simulation experts at ARC to investigate hazards posed by potentially propulsive components, as well as the failure and possible collapse of structural elements. How long after an inadvertent ignition would a fully stacked and capped RSRM break free and begin rising off the Mobile Launch Platform (MLP)? How much speed could it build up before impacting an overhead crane or the VAB sub-roof? Is there enough kinetic energy and structural toughness to perforate the roof slab and continue flying outside the building? Could heat generated by burning motors or partially stacked segments cause the MLP, elevated structures, or load-bearing beams inside the VAB to fail? These questions and others are being considered by this team, which includes KSC/NE-D and a KSC Range Safety engineer. Answers will likely take an additional two or more years to achieve.

External Tank in VAB Read more...

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C. Joint Advanced Range System System (JARSS)

The Joint Advanced Range Safety System (JARRS) is a collaborative effort between Dryden Flight Research Center and the Air Force Flight Test Center at Edwards Air Force Base to develop a state-of-the-art mission planning, risk analysis, and risk management tool for range safety. The Range Safety organizations from all Major Range and Test Facility Bases are being asked to support the development, testing, and operation of unmanned aerial systems (UAS) and reusable launch vehicles (RLV). It is the vision of JARRS to provide range safety support for these missions. .

JARRS consists of two primary elements: a Mission Analysis Software Tool and the Real-Time Operations Tool.

The Mission Analysis Software Tool will quantify the range safety risk for a given flight path and its associated vehicle parameters using a computerized method. This method will streamline the range safety analysis by providing a consistent, high fidelity solution in less time than required by present methods of analysis.

The Real-Time Operations Tool will provide the Range Safety Officer with near real-time assessment of the range safety risks during flight. This capability has many possible applications to the UAS or RLV operator, including assessment of UAS overflight of populated areas, allowing extended flight of an anomalous vehicle, recovery of an off-nominal vehicle at an alternate landing site, or selection of an alternate flight or entry path.

Major accomplishments this year include using JARSS Mission Planning to calculate range safety risk for the upcoming NASA Global Hawk GloPac 2010 missions near Hawaii and Alaska. The 30th Space Wing at Vandenberg AFB has funded the development of JARSS Real Time and is currently in the process of testing the system for possible operational use.

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A. Kennedy Space Center

The Kennedy Space Center Range Safety Representative is tasked with implementing NASA policy and keeping the Agency Range Safety Manager informed of all activities related to range safety. Over the course of the past year, the KSC Range Safety Representative supported a multitude of range safety activities, ranging from pre-launch policy interpretation and guidance to providing on-console support during launch campaigns.

1. Constellation Program

The Kennedy Space Center Range Safety Representative participated in many meetings and technical exchange sessions in support of finalizing a set of tailored range safety requirements and developing launch support and countdown documentation for the Ares I-X Test Flight Mission. The Ares I-X Test Flight Mission was successfully launched on 28 October from Space Launch Complex 39B. The mission was required to meet both Air Force Space Command Manual (AFSPCMAN) 91-710, *Range Safety User Requirements*, and NASA Procedural Requirements (NPR) 8715.5, *Range Safety Program Requirements*. Working through the Launch Constellation Range Safety Panel (LCRSP), the 45th Space Wing Safety Office, Constellation Program Office, and NASA Range Safety successfully developed a single joint tailored document that included all range safety requirements. This unique teaming process has set a precedent for future Constellation Program range safety requirements tailoring. The effort also exemplified NASA's philosophy of accepting (or sharing) responsibility for all aspects of range safety. A draft set of tailored requirements for the Ares 1 Launch Vehicle is underway.

The Range Safety Representative also provided continued support to the LCRSP and associated Constellation Program working groups.

2. Space Shuttle Program

For the Space Shuttle Program, the KSC Range Safety Representative prepared and issued an update to the Program's Range Safety Risk Management Plan (RSRMP). The update combined documents KSC-PLN-2804, *Range Safety Landing Implementation Plan for Space Shuttle*, and KSC-PLN-2805, *Range Safety Risk Management Plan for Launch and Landing of the Space Shuttle*. It also updated acceptable criteria for Shuttle ascent to reflect the 2009 flight of Ares 1-X and clarified how the annual criteria clause of the NPR is implemented for the Shuttle Program. Population definitions and the facilities considered "Center Essential" for Shuttle launches were also added.

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A. Kennedy Space Center

Launch and entry risk estimates were evaluated for STS-119, STS-125, STS-127, STS-128, and STS-129, with mitigation efforts initiated through the KSC Emergency Operations Center when appropriate.

The KSC Range Safety Representative also provided continued support to the Shuttle Range Safety Panel and supported all the above listed Shuttle launches on console in the Morrell Operations Center (MOC).

3. Launch Services Program

The KSC Range Safety Representative supported a number of NASA expendable launch vehicle campaigns for the Launch Service Program (LSP), including NOAA-N Prime, OCO, KEPLER, STSS-ATRR, LRO, STSS-DEMO, and WISE. This effort involved attending all the NASA and Air Force Safety readiness reviews, ensuring NPR requirements were being met, and identifying, documenting, and obtaining acceptance/approval of any variances during the respective prelaunch and launch countdowns.

4. Eastern Range Launch Support

In 2009, the KSC Range Safety Representative began providing launch support for non-NASA Eastern Range missions. Serving as the liaison between the 45th Space Wing Safety Office Risk Assessment Center and the KSC Emergency Operations Center (EOC), the KSC Range Safety office evaluated and interpreted range safety risks to KSC personnel and property due to CCAFS launches and suggested mitigation actions when appropriate. In this capacity, the KSC Range Safety Representative supported the GOES-O, GPS 2R-21, PAN, INTELSAT 14, and WGS-3 missions.

5. Agency Activities

The KSC Range Safety Representative served as a NASA point of contact to the Range Safety Group and supported several committees charged with developing or rewriting nationwide standards on a number of important range safety issues. These topics included developing reusable launch vehicle and unmanned aerial vehicle and system requirements, and proposed requirements for active satellite and cataloged orbital debris Collision Avoidance. The KSC Range Safety Representative was also active in the development of a proposed policy for the future use of autonomous flight safety systems within NASA. KSC is closely monitoring the status and AFSPC-proposed decommissioning of Eastern and Western Range ground tracking and command assets through their Future Range Architecture Team.

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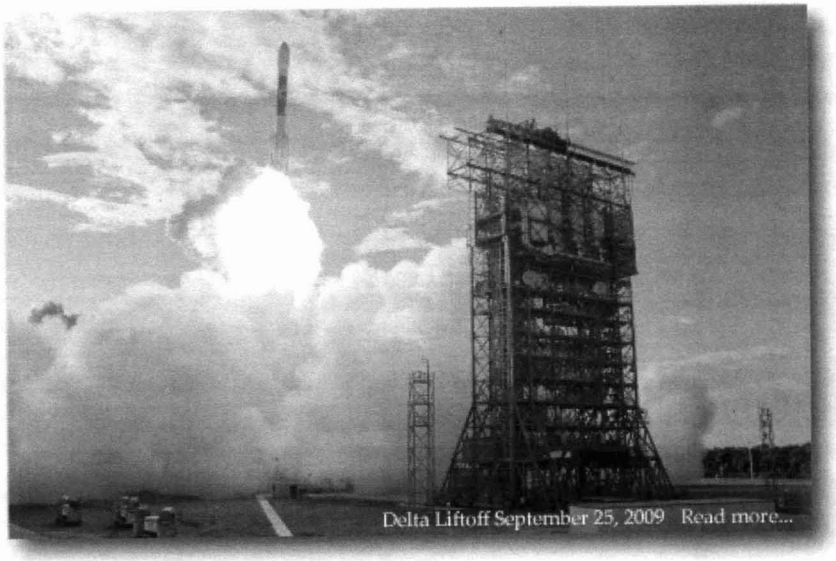
A. Kennedy Space Center

2009 was a challenging year, supporting an increased number of launch and entry campaigns, providing critical support to the Constellation Program and the launch of the Ares I-X launch vehicle, continuing to ensure Kennedy Space Center safely implements NASA Range Safety requirements, and tracking emerging technologies. The coming year promises to be equally busy, and the Kennedy Space Center Range Safety Representative will continue to provide critical support as necessary when called upon by NASA programs or to address issues as they arise.



Delta Liftoff September 25, 2009 Read more...

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B. Wallops Flight Facility

The Wallops Safety Office (Code 803) supports all missions at Wallops Flight Facility and provides support at various other locations around the world as needed. This support includes ground safety and flight safety analysis, documentation of operational rules, and active support of ground processing and flight operations. Listed below are various project/ programs that the Safety Office supported in 2009.

1. TacSat-3

TacSat-3 was successfully launched from Wallops Island on 19 May 2009. TacSat-3 featured three revolutionary trials: the Raytheon Company-built Advanced Responsive Tactically Effective Military Imaging Spectrometer hyperspectral imager, the Office of Naval Research's Satellite Communications Package, and the Air Force Research Laboratory's Space Avionics Experiment.

FIGURE 11: TAC SAT-3

2. Max Launch Abort System (MLAS)

The Max Launch Abort System (MLAS) was successfully tested in a simulated pad abort test at Wallops Flight Facility on 8 July 2009. The test vehicle weighed over 45,000 pounds and was over 33 feet tall. The unpiloted launch tested an alternate concept for safely propelling a future spacecraft and its crew away from a problem on the launch pad or during ascent. The MLAS consists of four solid rocket abort motors inside a bullet-shaped composite fairing attached to a full-scale mockup of the crew module.

FIGURE 12: MLAS SIMULATED PAD ABORT TEST

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B. Wallops Flight Facility

3. Sounding Rocket Program

The Sounding Rocket Program conducted 16 missions in 2009 with an overall mission success rate of 100%.

The Inflatable Re-entry Vehicle Experiment, or IRVE, was vacuum-packed into a 15-inch diameter payload "shroud" and launched on a small sounding rocket from NASA's Wallops Flight Facility on August 17, 2009. Nitrogen inflated the 10-foot (3 m) diameter heat shield, made of several layers of silicone-coated industrial fabric, to a mushroom shape in space several minutes after liftoff.

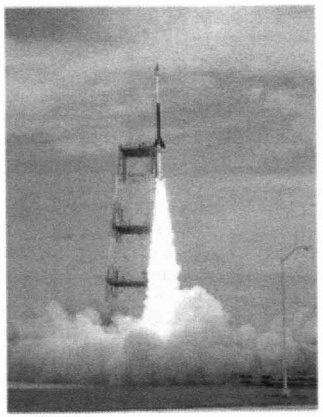

FIGURE 13: IRVE

Inflatable heat shields hold promise for future planetary missions, according to 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.

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B. Wallops Flight Facility

4. Balloon Program Office

The Balloon Program Office at Wallops Flight Facility conducted 13 missions during fiscal year 2009. Flight operations were conducted from Fort Sumner, New Mexico; McMurdo, Antarctica; and Kiruna, Sweden in support of Space and Earth science payloads as well as developmental test flights for new balloon design and balloon film qualification. Flight durations ranged from 4 hours to 54 days with the longest flight occurring over Antarctica on the 7 million cubic foot volume super pressure test flight. The Balloon Program Office continued the Ultra Long Duration Balloon (ULDB) vehicle development. Test flights of larger scale designs of the ULDB super pressure balloon is planned for 2010. The balloon is being developed to provide extended duration flights upwards of 60-100 days at constant float altitudes. The Balloon Program plans to conduct remote campaigns from McMurdo, Antarctica; Alice Springs, Australia; and Fort Sumner, New Mexico.

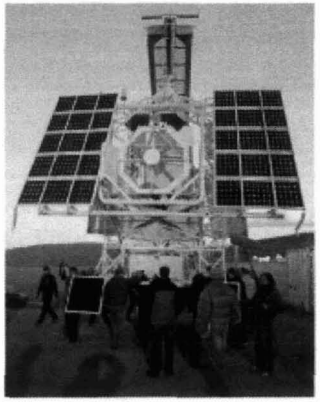

FIGURE 14: SUNRISE 1-METER BALLOON TELESCOPE READY FOR LAUNCH, ESRANGE, JUNE 2009

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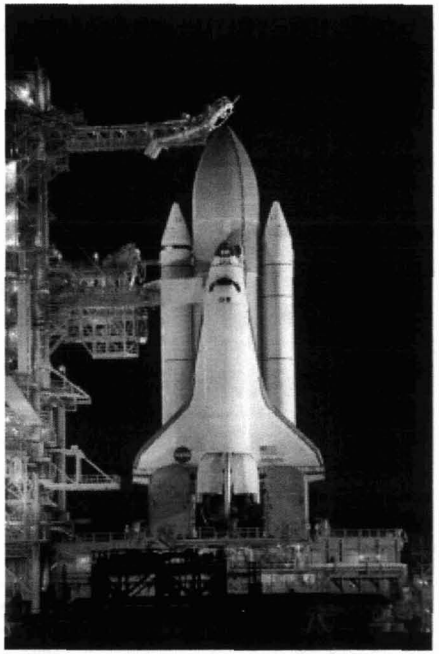

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C. Dryden Flight Research Center

For more background and information on the DFRC Status Report, *click here*.

The Dryden Flight Research Center (DFRC), located at Edwards Air Force Base, California, is NASA's primary installation for flight research and testing. Over the past 63 years, projects at Dryden have led to major advancements in the design and capabilities of many civilian and military aircraft. In the past, DFRC has also conducted tests in support of the Agency's space programs.

The Center supports operations of the Space Shuttle and development of future access-to-space vehicles, conducts airborne science missions and flight operations, and develops piloted and uninhabited aircraft test beds for research and science missions.

Range Safety operations at Dryden are managed by the Range Safety Office (RS Office). The RS Office was established by the Dryden Center Director under an alliance agreement with the Air Force Flight Test Center (AFFTC) to provide independent review and oversight of Range Safety issues. The Office supports the Center by providing trained Flight Termination System (FTS) engineers, Range Safety risk analysts, and Range Safety Officers to provide mission and project support for Unmanned Aerial System (UAS) Projects. The DFRC/AFFTC range safety alliance allows both offices to work together, each providing expertise on projects the other office may not be as familiar with.

The DFRC/AFFTC Range Safety alliance is planning to install and test a fixed Enhanced FTS (EFTS) transmitter site which will be operational by the end of next calendar year.

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

1. 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. During the last year, Dryden has supported over 270 hours of operations on multiple platforms from 6 different manufacturers.

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C. Dryden Flight Research Center

2. Blended Wing Body Low Speed Vehicle

The Blended Wing Body (BWB) Low Speed Vehicle (LSV) UAS, also known as X-48B LSV, 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 areas that future aeronautical designs will face including noise reduction, emissions reduction, and improvement in fuel economy. Industry studies suggest that because of its efficient configuration, the BWB would consume 20% less fuel than the jetliners of today while cruising at high subsonic speeds on flights of up to 7,000 nautical miles. To date, the project has conducted 72 successful flights, all conducted with LSV #2.

LSV #1, the wind tunnel vehicle, has been heavily modified to make the vehicle quieter. The modifications include reducing the number of engines from three to two, the installation of noise-shielding vertical fins, and the removal of the winglets. The designation for this new configuration is X-48C. The first flight of this vehicle is expected to occur in late 2010.

3. NASA Global Hawk

Dryden has acquired two former United States Air Force (USAF) Advanced Concept Technology Demonstration (ACTD) Global Hawk UASs. 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 mean sea level (MSL). NASA's first Global Hawk flight was successfully flown this year. To date, the Project has flown 5 successful flights, all with NASA 872. NASA 871 is expected to fly its first NASA flight in the summer of 2010. The first airborne science mission flight is scheduled for Spring 2010.

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

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C. Dryden Flight Research Center

4. Ikhana

NASA's Ikhana UAS 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. The vehicle successfully flew multiple missions in support of acoustic research and one flight to map post-wildfire damage.

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

The Range Safety Office has supported Ikhana UAS 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 14 flights this year with durations lasting as long as 7 hours.

5. Orion

The Orion Project is an element of the Agency's Constellation Program. The Orion Project consists of the Crew Module (CM) and the Launch Abort System (LAS). Dryden is responsible for conducting a series of flight tests to demonstrate proper operations of the LAS and CM recovery systems in response to abort events initiated on the launch pad and during the initial ascent phase of flight. The abort flight tests will be conducted at the U.S. Army's White Sands Missile Range (WSMR) in New Mexico.

Dryden is currently in the process of integrating the Crew Module test article for Pad Abort 1 test flight. Dryden will also be responsible for integration of the second Crew Module test article for Ascent Abort 2 test flight.

The most significant events of Calendar Year 2009 include the completion of the Pad Abort Launch facilities, the delivery of the PA-1 Jettison and Abort motors to WSMR in May, and the delivery of the PA-1 Crew Module to WSMR in August. The jettison motor is a solid rocket motor designed to separate the LAS from the Crew Module. The abort motor is a solid rocket motor designed to separate the LAS and Crew Module away from the Ares I launch stack in the event of a problem on the launch pad or anytime during first stage burn.

The RS Office tailored NASA Procedural Requirements (NPR) 8715.5, Range Safety Program, for Pad Abort #1 and provided input to RCC 319, Flight Termination Systems Commonality Standard tailoring for Ascent Abort #2.

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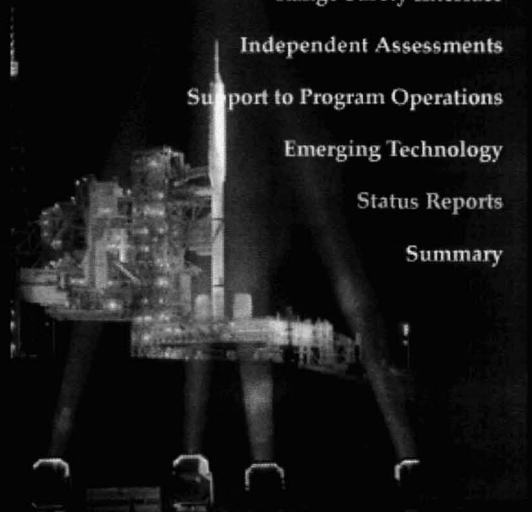

Launch Complex 39B Ares I-X Rocket Read more...

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D. Johnson Space Center

1. Constellation Range Safety Panel (LCRSP)

The Launch Constellation Range Safety Panel (LCRSP) manages launch Range Safety matters for Constellation program vehicles, including specifying key interfaces with the Department of Defense (DoD) for launch Range Safety.

This section summarizes the work conducted through the LCRSP and its two chartered working groups.

a. LCRSP Trajectory Working Group:

The Trajectory Working Group (TWG) was the first sub-group chartered by the LCRSP. The primary responsibility of the group is to ensure that each Range Safety trajectory analysis requirement, as specified by the 45th Space Wing (45 SW), is coordinated among the proper NASA centers.

During 2009, the working group's efforts were focused primarily on the development of the Final Flight Data Package (FFDP) that was delivered to the 45 SW for the Ares I-X test flight which launched in late October 2009. The development of the FFDP was a multi-center effort led by trajectory analysts at Langley Research Center (LaRC). Engineers from Johnson Space Center (JSC) and Marshall Space Flight Center (MSFC) were also heavily involved, performing the necessary Verification and Validation (V&V) activities. The TWG served as the primary forum for coordination with the Eastern Range, as well as the review panel for each of the Ares I-X FFDP trajectory products. Representatives from the 45 SW were also regular participants in the working group and provided technical assistance on many occasions.

The following official products were completed and delivered for the Ares I-X FFDP:

- Nominal Ascent and Reentry Trajectories
- 3-Sigma Trajectory Envelopes
- Malfunction Turn Trajectories
- First Stage Impact Location Footprints
- Upper Stage Disposal Footprints
- Sonic Boom and Acoustic Analysis
- Debris Catalog Data

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LCRSP Probabilistic Risk Assessment Working Group:

The Probabilistic Risk Assessment (PRA) Working Group was first chartered in early 2007 as the forum through which all launch vehicle range safety-related reliability analyses and products would be coordinated for the Constellation Program. This technical forum supports the Launch Constellation Range Safety Panel in all matters related to vehicle failure probability estimation for range safety risk assessments in compliance with the requirements of the Constellation Program, NASA's NPR 8715.5, Range Safety Program, and applicable Air Force Range Safety policy and requirements. The members of the working group include representatives from the Launch Vehicle Project Office (Ares, Ares I-X), Mission Operations, Safety and Mission Assurance, and the 45 SW.

In 2009, the working group generated the final Ares I-X probability estimates for all of the possible vehicle failure modes that were identified by the team. This PRA was finalized and delivered to the 45 SW as part of the Ares I-X FFDP. The PRA results also contributed towards the completion of the Ares I-X trajectory analysis tasks by identifying the possible malfunction turn (i.e., off-course) failure scenarios and listing their relative likelihood. In addition, the PRA Working Group coordinated with the 45 SW to develop a new methodology for adjusting the probability estimates for mature systems to account for the inherent risks associated with a new launch vehicle design. The process to develop these "first flight adjustments" was considered to be groundbreaking work since previous NASA risk assessments typically involved mature vehicles. The work and collaboration between NASA and the 45 SW on this issue will continue to evolve as new launch vehicles are developed and flown.

The FFDP PRA products were developed by Safety and Mission Assurance personnel at Johnson Space Center, Marshall Space Flight Center, and Langley Research Center.

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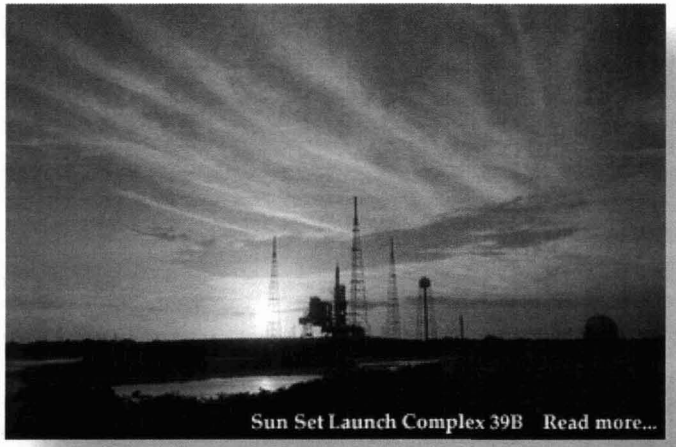
c. Ares & Orion Range Safety Topics:

Throughout 2009, the LCRSP discussed a number of Range Safety topics related to the Ares launch vehicle and Orion spacecraft. These topics included the following:

- Launch Enterprise Transformation Study (LETS)
- Ares & Orion Debris Catalog Development
- Tailoring of AFSPCMAN 91-710 and NPR 8715.5
- Ares Flight Termination System (FTS) Delay Time / Abort Sequencing
- Ares & Orion Abort Disposal Constraints

This section highlights just a few of the examples of the complex projects and tasks that were completed by LCRSP participants nationwide. The launch of Ares I-X signified the culmination of a range safety analysis and development effort that spanned several years and involved multiple NASA centers and contractor organizations. In the end, 2009 proved to be a very active and successful year for the Constellation Range Safety community.



Sun Set Launch Complex 39B Read more...

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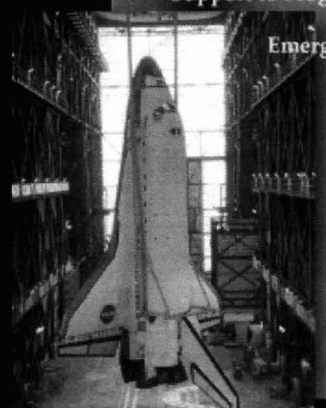

Space Shuttle Atlantis, secured to the yellow framework of a sling. Read more...

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2. Space Shuttle Range Safety Panel

In 2009, the Space Shuttle Range Safety Panel dealt with a number of topics related to the Space Shuttle. Included were the Launch/Range Enterprise Transformation Study, the Launch Collision Avoidance (COLA) Process, the Meteorological System Computer, Command Receiver Decoder Retest Requirements, Balloon COLA's, and MCLARA Weather Inputs.

a. Launch/Range Enterprise Transformation Study

The Launch/Range Enterprise Transformation Study (LETS) is a proposed major restructuring of the U.S. Air Force range architectures and processes. Although the proposal will affect all range users eventually, the effect on the Shuttle Program is limited since the Shuttle program will end before many of the proposed changes can go into effect.

Since all future launch vehicles will be required to use GPS for range safety functions, a major component of the LETS architecture is the proposed retirement of many ground-based tracking radars. Some of these radars would be retired in the near-term, and these retirements could potentially impact Shuttle launches and landings.

After extensive analysis, the Shuttle Range Safety Panel made recommendations to LETS regarding which radars should be retained and which should be retired in order to minimize the impact of LETS on the remaining Shuttle launches. Discussion and negotiation regarding the impact of LETS on the Constellation Program will continue for some time.

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2 Shuttles on Pad, April 2009
Credit: Rod Ostoski click to enlarge

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b. Launch Collision Avoidance (COLA) Process

The year began with an extended discussion of a proposed Air Force Special Instruction (SPINS) that would have implemented a new Air Force process for prelaunch conjunction and collision avoidance screening. However, the proposed SPINS was cancelled. Several months later, the 14th Air Force issued a new draft Air Force Instruction 91-217 which proposed a similar prelaunch screening process.

That memo was subsequently signed by the Air Force in October of 2009 and will be first implemented for the launch of STS-130 in 2010. The new process will have 614AOC screen all launches from the Eastern and Western Ranges based on the Satellite Catalog. For manned vehicles, they will use either a 200 km sphere, a 200 x 50 x 50 km ellipsoid, or a probability of 1 in 1 million. For active spacecraft and debris, they will use a 25 km sphere or a probability of greater than 10 in 1 million.

Although the use of the probability method would have provided great benefits for the Shuttle program, technical difficulties precluded doing so, and remedying those difficulties will not be possible during the remaining life of the Shuttle program. So, reluctantly, the Range Safety Panel concluded that volume based screening was the only practicable alternative. After some analysis based on known Shuttle maneuver tolerances and navigation system uncertainties, the Range Safety Panel recommended the use of a miss distance of 8 x 30 x 30 km, which would be equivalent to a probability of 1 in 1 million for Shuttle launches. Although initially receptive to the use of this Shuttle-specific screening volume, the Air Force later decided to retain the generic 25 km sphere for screening against all unmanned objects. Subsequently, a letter was drafted by the Space Shuttle Program Manager to the Air Force requesting the use of the 8 x 30 x 30 km volume. At the end of the year, the Air Force was still considering that request.

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c. Meteorological System Computer

The Meteorological System Computer (MSC), which processes balloon data to derive atmospheric wind profiles, experienced a major failure during the STS-126 launch at the end of 2008. Both prime and backup computers became overloaded and crashed, and some data was lost while other data was delayed. The MSC system is old and scheduled for upgrade / replacement in a year or two, but the replacement will not be available during the planned life of the Shuttle program.

In response, the Shuttle Range Safety Panel helped facilitate the development of a mitigation plan which would limit the amount of data that the MSC would be asked to process at any one time and thus, hopefully, prevent any future crashes.

The mitigation plan has two parts. The first part attempts to limit the amount of data the MSC will be asked to process during nominal operations to that which experience shows it can process without experiencing difficulty. The second part would be invoked if a slowdown is experienced and would even further restrict processing requests to the minimum necessary to actually launch.

For the remainder of 2009, no MSC processing anomalies were experienced during any of the Shuttle launches to the International Space Station (ISS) (i.e., the STS-119, STS-127, STS-128, and STS-129 launches). The only anomaly was during STS-125, a Hubble Space Telescope (HST) servicing mission. The longer launch window for the HST mission (approximately one hour for HST missions vs. ten minutes for ISS missions) required multiple balloon launches in order to cover the entire launch window. This led to higher loading than experienced during typical ISS missions which, in turn, resulted in overloading the MSC and caused a slowdown in processing.

When this happened, the part two processing restrictions described above were invoked for the MSC, and, although the processing slowdown did persist for some time, the system did not crash and was able to process all of the data required for the launch. The system experts believe that the mitigation plan put into place after STS-126 is the reason that the system did not crash during the STS-125 count, and that is the plan that will be carried for the remaining Shuttle launches.

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d. Command Receiver Decoder Retest Requirements

There had been concern that Shuttle Range Safety Command Receiver Decoder (CRD) open-loop and closed-loop end-to-end tests were not being planned within 6.5 days of the scheduled launch as expected by the 45th Space Wing (45SW). There was also concern that the unexpected assembly/checkout operations in the forward skirt after closeout may threaten the integrity of the Range Safety System (RSS). The Range wanted to make sure that it was documented that they had representatives available to verify the integrity of the RSS and request a retest, if necessary. Recent Shuttle processing experience shows the typical test planning target is 11 days prior to a scheduled launch. Testing later in the processing flow is constrained by safety-critical ops such as fuel loading and interface closeout verifications. Ground ops agreed to move closed-loop tests further from launch to accommodate some of these processes. Historical data shows that up to 14 days can elapse between S5009 Final Ordinance Connection and Closeout operations and the first planned launch attempt.

The 30A90506 specification document will be revised to establish a test planning requirement of no earlier than 14 days from command closed-loop end-to-end tests to the scheduled launch date. The document will also be revised to capture a requirement for an ER safety representative to be present during reentry of the SRB forward skirts to verify the integrity of the RSS. A general requirement on SRB forward skirt access is being drafted, and a separate Requirements Change Notice (RCN) will be generated for the 14-day requirement. This will be combined with the 270-day CRD bench test requirement. All of these changes were approved by the Shuttle Range Safety Panel.

e. Balloon COLA

A collision between a weather balloon and a Shuttle launch has never been considered a credible hazard because, A) the weather balloons are seldom blown across the Shuttle launch trajectory, and B) the balloons are very small and so, overall, the likelihood of a collision is remote. For that reason, there is no NASA requirement for anyone to do balloon collision avoidance analysis. Interestingly, however, during the STS-128 launch attempt on August 24, 2009, the Day-of-Launch I-Loads Update group (DOLILU) observed balloons actually were being blown back toward the Cape and across the shuttle's trajectory, thus elevating the possibility of a collision from completely impossible to theoretically possible. It was determined that the only balloon that could possibly be in the area of the Shuttle track at the time of launch was the L-1h25m balloon. Since this balloon was not required in order to launch, and even though no action was required on their part, the DOLILU group consulted with the Ascent Flight Director and elected not to launch the balloon in question on that day.

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After the STS-128 launch, the Shuttle Range Safety Panel first received a briefing on the capabilities of the 45SW to project balloon tracks. It turns out that the 45SW can only project balloon tracks for balloons that continuously rise. Since the balloons in question top out at about 60,000 ft., the 45SW cannot project the tracks of those balloons and could not acquire that capability in time to be of use for any Shuttle launch.

Given this, for all remaining Shuttle launches, the DOLILU group will assess the balloon ground tracks just as they did during STS-128. If balloon tracks cross the Shuttle ground track, DOLILU will notify the flight director and adjust the balloon schedule if that can be done without adversely impacting launch preparations. If they cannot, then the launch will continue since the remote risk of a collision has already been accepted by the Shuttle program.

f. MCLARA Weather Inputs

In the past, seasonal climatalogical data has been used by the Eastern Range (ER) Safety Risk Analysis Office to assess the risk associated with STS launches. More recently, the Range has been transitioning to the use of North American Mesoscale (NAM) model forecast data and had previously implemented the use of NAM data for the computation of risk from toxic gases. For the last Shuttle launch of 2008, STS-129, the Range was ready to complete the transition and begin use of NAM data for the computation of debris risk.

KSC personnel initially expressed concern that the use of "forecast" data might result in instability in the risk calculations and result in the identification of risks too late in the count to take proper mitigating action. However, 45SW personnel were able to show that the use of NAM data does produce stable results inside T-84 hours when the transition is made from seasonal data to NAM output. KSC was reassured by these results, and the Shuttle Range Safety Panel concurred with the use of NAM data for STS-129.

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Range Safety was involved in a number of exciting and challenging activities and events in 2009 involving the development, implementation, and support of range safety policies and procedures.

Activities included the updating of policy related to flight safety systems and flight safety risk criteria, including the coordination of a review of our MOA with the 45th Space Wing, up for its triennial review in February 2009, and the development and implementation of tailored requirements for the Constellation Program. Range Safety also continued efforts to revise NPR 8715.5, Range Safety Program, to accommodate developments in our evolving discipline, and is working toward a July 2010 posting.

Range Safety representatives took part in a number of panels and councils, including the Range Commanders Council (RCC) Range Safety Group (RSG) and its subgroups. NASA also participated in the RSG with Range Safety representatives from NASA HQ, KSC, DFRC, and Wallops, actively supporting the RSG.

Advancing our effort to provide training at various levels of range safety, a total of 562 students have participated in 21 Range Safety Orientation Courses. Additionally, NASA and KSC Range Safety supported 19 launches this year consisting of 4 from the Western Range and 15 from the Eastern Range, including 5 Shuttle launches and the Ares I-X test launch.

Range Safety also participated in the evaluation of several emerging technologies, including the Autonomous Flight Safety System for expendable launch vehicles, and the explosive re-siting of the VAB to support hazardous operations for the Constellation Program. The Enhanced Flight Termination System continues to advance, with the Dryden Flight Research Center/Air Force Flight Test Center planning to install and test a fixed Enhanced Flight Termination System transmitter by the end of calendar year 2010. The Joint Advanced Range Safety System also continues to make progress toward achieving its goal of supporting Unmanned Aerial Systems and Reusable Launch Vehicles at all ranges.

We hope you found our web-based format for the Range Safety Annual Report to be usable and informative, and we hope that linking to the original articles has reduced the need for repetition in this report without sacrificing the quality of the information presented. As we move into 2010, 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 2010 Range Safety Annual Report should contact Richard Lamoreaux, the NASA Range Safety Program Manager located at the Kennedy Space Center, or Michael Dook at NASA Headquarters.