

## **V. STATUS REPORTS**

### **A. NASA Headquarters**

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

The HQ Range Safety Representative participated in Agency Range Safety activities throughout 2012. These included Co-Chairing the Autonomous Flight Safety System Requirements Review Panel at KSC in February; participating in the development of NASA Range Safety training courses; and participating as a member of the Range Commanders Council Range Safety Group in the Risk Committee and the Flight Termination System Committee.

The HQ Range Safety Representative continued as the NASA Co-Chair to the AF/FAA/NASA Common Standards Working Group (CSWG). The CSWG functions to implement provisions of U.S. Space Transportation Policy directing coordination between the USAF, FAA, and NASA to establish common public safety requirements for space transportation. The CSWG Co-Chairs met by phone periodically throughout 2012 and continued to oversee activities and products that focus on protecting the public from hazards associated with space launch and entry events.

The HQ Range Safety Representative is responsible for facilitating the development and promulgation of Agency Range Safety-related policy and requirements. During the past year, the HQ Range Safety Representative worked with the NASA Range Safety Manager and the NASA range safety community to develop and release Change 1 to NPR 8715.5A, Range Flight Safety Program. This Change addresses issues and incorporates lessons learned since Revision A to NPR 8715.5 was published in 2010. The HQ Range Safety Representative continued as a member of the ELV Payload Safety Agency Team. The Agency Team began work on Revision A to NPR 8715.7, Expendable Launch Vehicle (ELV) Payload Safety Program. This Revision will update the ELV payload safety process and reflect the new NASA-STD 8719.24, NASA Expendable Launch Vehicle Payload Safety Requirements that was published in 2011. NPR 8715.7 Revision A is expected to be published by May of 2013.

Other activities included support to the Commercial Crew Program's coordination with the FAA on issues of commercial launch licensing and applicability of the FAA public safety regulations to future commercial crew launches.

## B. Ames Research Center (ARC)

ARC operates or oversees the operation of a variety of UAS for Earth science missions, flight controls research, and technology demonstration. Range Safety played a role in these missions.

### 1. Bat-4 UAS mission to Sugarloaf Shores, FL (May 13-24, 2012)

The Bat-4 is a 100-pound class UAS with a 13-foot wingspan (Figure 13). During the mission to Sugarloaf Shores, Bat-4 carried an imaging system over sea grass and coral to evaluate the effects of climate change on near shore environments. Ames provided the Designated Range Safety Officers (DRSOs) to ensure deconfliction of the UAS and manned aircraft traffic. The DRSOs were prepositioned and daisy-chained so that a pair of eyes was on the UAS at all times during its transit from Sugarloaf Shores airport to the data collection area and back.



**FIGURE 13: BAT-4 UAS**

The Bat-4 carried an altitude encoding transponder with a unique squawk code assigned by Key West Approach. Approach was very helpful in providing advisories to manned aircraft traffic and warning our range safety personnel when an uncooperative (non-communicating) aircraft was in the area.

Due to frequent skydiving activity out of Sugarloaf Shores airport, close coordination and communication with the skydiving operator was required during launch and recovery of the Bat-4. Sometimes a very small window of just a few minutes was available to get the Bat-4 clear of the drop zone or back on the ground. For this mission, a total of six imaging flights were conducted.

### 2. Sensor Integrated Environmental Remote Research Aircraft (SIERRA) UAS mission to Surprise Valley, CA (31 Aug – 7 Sep, 2012)

SIERRA is a 400-pound class UAS with a wingspan of 20 feet (Figure 14). It can carry up to 100-pound payloads with a range of 550 nautical miles (nm) at a 55-knot cruise speed. The payload on the mission shown in Figure 14 consisted of two magnetometers used to map the magnetic field in a seismically active valley near the Oregon border.



**FIGURE 14: SIERRA ON THE AMES RESEARCH CENTER RAMP**

The 50 nm length of the valley made the use of ground-based observers impractical, so a Cessna 172SP chase

aircraft with a pilot and dedicated observer was used to satisfy the see-and-avoid requirement. The chase aircraft was stationed at a different airport (Alturas), where aviation fuel was available. The flight operation was coordinated so the chase aircraft would arrive overhead as the SIERRA was flying the local pattern at Cedarville Airport in Surprise Valley (Figure 15). The ground control station and chase crews made periodic radio calls on the airport Unicom frequency to advise any manned aircraft of the UAS operation.

The faster flight speed of the Cessna created some challenges for the chase pilot. It was necessary to fly a zigzag course to avoid overtaking the slower SIERRA. The SIERRA flights lasted up to four hours, which also taxed the endurance of the chase crew. A total of five flights were conducted.



**FIGURE 15: SIERRA ON THE RAMP AT CEDARVILLE AIRPORT IN SURPRISE VALLEY, CA**

### **3. SIERRA UAS mission to Key West, FL (Oct 11-23, 2012)**

For the mission to Key West, FL (Figure 16), a hyperspectral imager was installed in the SIERRA nose section, and data was collected over the same sea grass and coral areas that Bat-4 had flown over earlier in the year. The SIERRA was hangared at Key West Naval Air Station (KWNAS), and the deployment benefitted from the excellent infrastructure and support of the Navy.

Per FAA requirements, concurrent flights of manned and unmanned aircraft were not allowed in the KWNAS Class D airspace, so close coordination was needed to get SIERRA in and out of the airport traffic area. Due to the very high level of fighter activity in the airspace of KWNAS, the SIERRA would hold outside of the airport airspace to await a window of opportunity to return and land.



**FIGURE 16: SIERRA ON THE KEY WEST NAVAL AIR STATION RAMP**

Daisy-chained ground observers were used during the transit to and from the data collection area over the ocean where a boat-based observer was stationed. All observers utilized the trunking radios provided by KWNAS, resulting in excellent voice communications. Key West Approach provided a great service deconflicting the general aviation traffic passing through the area and significantly improved the safety of the operation. A total of six flights were conducted, and the SIERRA will return to KWNAS in May 2013 for additional imaging flights.

### **C. Dryden Flight Research Center (DFRC)**

DFRC, located at Edwards Air Force Base, California, is NASA's primary installation for flight research and flight testing. DFRC supports operations and development of future access-to-space vehicles, conducts airborne science missions and flight operations, and develops piloted and UAS test beds for research and science missions. Projects at Dryden over the past 66 years 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.

Range Safety at Dryden was established by the Dryden Center Director under an alliance agreement with the Air Force Test Center (AFTC) to provide independent review and oversight of Range Safety issues. Range Safety supports the Center by providing trained FTS engineers, Range Safety risk analysts, and Range Safety Officers to provide mission and project support primarily for UAS Projects.

#### **1. Enhanced Flight Termination System (EFTS)**

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

Dryden has supported other Ranges by assisting in the verification process for their respective fixed EFTS transmitter sites.

#### **2. DRFC/AFTC Range Safety Alliance**

Dryden Range Safety continues to provide FTS support to AFTC Projects such as X-47B. Dryden is also providing assistance to the AFTC Range Safety Office as it undergoes a major re-organization.

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

##### **a. Small UASs (sUAS)**

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

Dryden currently operates two Radio Controlled (RC) model aircraft named Dryden Remotely Operated Integrated Drone (DROID) (Figure 17). One of the vehicles is used for low-cost flight research. The second DROID aircraft is used as a UAS trainer for Dryden's UAS Pilots. In May, the DROID team successfully completed flight testing of Dryden's Auto Ground Collision Avoidance System.



**FIGURE 17: DRYDEN REMOTELY OPERATED INTEGRATED DRONES (DROID)**

### **b. Blended Wing Body (BWB) Low Speed Vehicle (LSV)**

The BWB LSV UAS, also known as X-48 LSV (Figure 18), is a dynamically scaled version of the original concept vehicle. The X-48 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



**FIGURE 18: BLENDED WING BODY LOW SPEED VEHICLE**

propulsion system to the airframe. The BWB testing will address several key goals of NASA's Environmentally Responsible Aviation Project, namely noise reduction, emissions reduction, and improvement in fuel economy. Industry studies suggest that because of its efficient configuration, the BWB would consume 20 percent less fuel than jetliners of today, while cruising at high subsonic speeds on flights of up to 7,000 nautical miles.

In early 2012, the X-48 was modified by reducing the number of engines from three to two more efficient model engines, the installation of noise-shielding vertical fins, and the removal of the winglets. These modifications were made to make the vehicle quieter and more fuel efficient. The designation for this new configuration is X-48C.

To date, the Project has conducted 92 successful flights in the X-48B configuration and 12 successful flights in the X-48C configuration, all with LSV #2. LSV #2 achieved the 100th flight milestone in October 2012.

### c. NASA Global Hawk

Dryden has acquired two former United States Air Force Advanced Concept Technology Demonstration Global Hawk UASs (Figure 19). 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 nm range and 30+ hour endurance at altitudes above 60,000 feet MSL. To date, NASA Global Hawks have flown 15 successful flights with NASA 871 and 62 successful flights with NASA 872. NASA 872 supported one successful earth science campaign this year, Hurricane and Severe Storm Sentinel (HS3 2012), based out of WFF. NASA Global Hawks also supported DARPA's KQ-X program which tested autonomous aerial refueling capabilities between two unmanned vehicles (Figure 20).



**FIGURE 19: NASA GLOBAL HAWK**

Dryden Range Safety has supported flight planning and risk analysis tasks in support of FAA certificate of authorization applications as well as real-time operations support during KQ-X.



**FIGURE 20: GLOBAL HAWKS AERIAL REFUELING**

#### **d. 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 (Figure 21). Ikhana was registered with the FAA and given the tail number N870NA. The vehicle is undergoing upgrades in order to standardize the vehicle with the rest of the Predator-B fleet.

The Range Safety Office has supported flight planning and risk analysis tasks in support of FAA certificate of authorization applications.



**FIGURE 21: NASA'S IKHANA UAS**

#### **e. Boeing Phantom Eye**

Phantom Eye is an autonomous, hydrogen-powered, high-altitude, long endurance vehicle built by Boeing to develop future UAS technology opportunities (Figure 22). The vehicle completed its first flight in June 2012 and a video capturing this milestone can be viewed here:

<http://www.youtube.com/watch?v=To5fcvaC1eg>

Several more flights are scheduled with the next one starting in early 2013.



**FIGURE 22: BOEING PHANTOM EYE**

#### **f. Sierra Nevada Corporation (SNC) Dream Chaser Engineering Test Article (ETA)**

SNC Dream Chaser ETA is an unpowered, autonomous test bed that has the same outer mold line as manned Dream Chaser vehicle. Dream Chaser is one of the vehicles competing in NASA's Commercial Crew Development Program. The vehicle is based on the NASA HL-20 lifting body design. The first drop flight is scheduled for early Spring 2013. A video of the captive carry flight can be viewed here: <http://www.space.com/15954-dream-chaser-space-plane-flight-test.html>



**FIGURE 23: DREAM CHASER**

#### **g. Lockheed Martin X-56A**

The X-56A is a low speed, subscale vehicle designed to test lightweight flexible wing/fuselage technologies. The first flight is scheduled for early 2013 and an informational video can be viewed here: <http://www.engineeringtv.com/video/Lockheed-Martins-X-56A-UAV-Test>



**FIGURE 24: LOCKHEED MARTIN X-56A**

### **D. Johnson Space Center (JSC)**

#### **1. Human Exploration Range Safety Panel (HERSP)**

The Human Exploration Range Safety Panel (HERSP) was formally chartered in 2012 to manage range safety activities for Space Launch Systems, Multi-Purpose Crew Vehicle/Orion, and Ground Systems Development and Operations Programs within the Human Exploration and Operations Mission Directorate. The HERSP works technical issues through its three

associated working groups: Flight Analysis, Flight Safety System, and Range Ground. The HERSP also produced and delivered the Program Introduction for Orion/SLS Exploration Missions (EM) allowing the initiation of requirements tailoring with the Eastern Range.

## 2. Morpheus

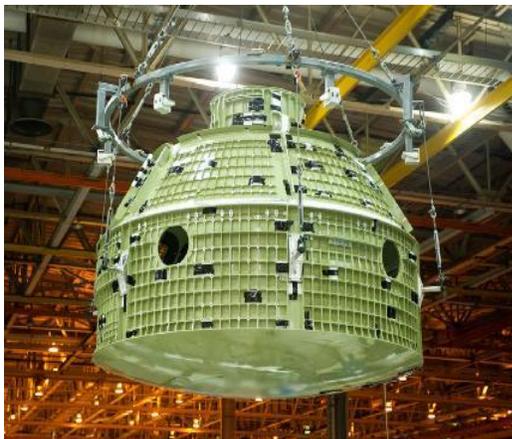
The Morpheus Project provides an integrated vertical test bed platform for advancing multiple subsystem technologies. Morpheus is designed to integrate and demonstrate two key technologies. The first is a LOX / liquid methane propulsion system, and the second technology is autonomous landing and hazard avoidance. After extensive tethered and hot fire testing at JSC in 2012, the vehicle was taken to KSC for free flight testing. On the second free flight, the vehicle lost control and crashed. An investigation indicated that the vehicle had a loss of the inertial reference most probably due to operation of the Space Integrated GPS/INS (SIGI) outside its vibroacoustic certification at launch. Morpheus 1.5B is under construction and will be test fired at JSC in the late spring of 2013. All free flight tests will again occur at KSC.



**FIGURE 25: MORPHEUS TEST FIRING**

## 3. Multi-Purpose Crew Vehicle (MPCV) Ascent Abort 2 (AA-2) Flight Test

The MPCV Flight Test Management Office identified range safety as a discipline of focus for advancing AA-2. In 2012, range safety personnel, roles, and responsibilities were established along with a schedule for addressing AA-2 range safety issues in the next year. The range flight safety analysis completed for this flight test will be extremely valuable in defining analysis expectations and methodologies that will be employed for future MPCV analyses for EM missions.



**FIGURE 26: MULTI-PURPOSE CREW VEHICLE**

## 4. MPCV Exploration Flight Test 1 (EFT-1)

JSC continued to provide range safety expertise to the broader EFT-1 team, supporting regular safety meetings and reviewing analysis products, as focus has begun to shift towards operations ahead of the upcoming flight test. In addition, JSC personnel collaborated with the FAA to facilitate steps in the commercial licensing process and develop a better understanding of the unique licensing aspects of this flight.

## E. Kennedy Space Center (KSC)

In addition to hosting the NASA Range Safety Staff, KSC has its own Center-level KSC Range Safety Representative tasked with implementing NASA policy and keeping the NASA Range Safety Manager informed of all KSC activities related to range safety. Over the course of the past year, KSC Range Safety supported a multitude of Range Safety activities including design and range safety requirement tailoring support to new projects and programs and support to ELV launch operations at multiple locations. The following articles provide a brief summary of these activities.

### 1. Rocket University

Rocket University develops flight-systems engineering skills and expertise by exposing NASA engineers to coursework and hands-on activities involving many aspects of flight systems engineering. Rocket University has partnered with different NASA Centers (HQ, KSC, JSC, MSFC, GRC, WFF), several universities (University of Central Florida, Embry Riddle University, Virginia Tech, Sand Diego University), and external partners (Space Florida, Florida Space Institute, National Association of Rocketry) to provide mentoring and expertise to the program.

NASA Range Safety ensures the Rocket University program meets the range safety requirements of NPR 8715.5A, FAA 14 CFR Part 101, and AFSPCMAN 91-710 when operating balloons, UAS, and rockets on and off KSC property.

#### a. Balloons Program

The purpose of the near-space environments labs (high-altitude balloons, as shown in Figure 27) is to further develop NASA engineers skills in flight systems engineering, launch operations, avionics, structures, and flight dynamics. A secondary purpose is to provide a low-cost, high altitude platform for demonstrating technology or researching the near-space environment.

To date, NRS has supported three Rocket U Near-Space Environments Balloon operations. Two of the balloon operations were moored balloons. These operations were mainly for experience purposes, learning different components and interfacing with the 45th Space Wing. During NRS's inspection of the moored balloons, it was noted that pursuant to FAA regulations 14 CRF Part 101Subpart B, a rapid deflation device was required to be added to the moored balloons in case the tether should fail.



**FIGURE 27: NEAR-SPACE ENVIRONMENT LABS PAYLOAD**



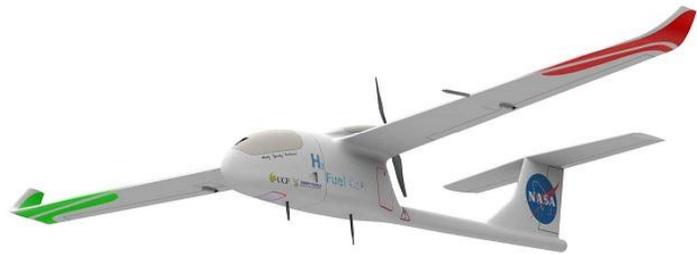
**FIGURE 28: MARAIA PAYLOAD AT ALTITUDE**

The third balloon operation was for a small-scale Maraia capsule test. This balloon operation released a high-altitude weather balloon with two payloads that would be released at different times and heights. NRS worked with the flight team to determine if the risk levels at KSC and CCAFS associated with the proposed flight plans would be acceptable. NRS worked to review the proper FAA, AF, and NASA regulation that would have to be met in order to approve the flight. Due to time constraints, this mission was launched outside of KSC property with a planned capsule drop off KSC and Air Force property.

### **b. Unmanned Aircraft System (UAS) Program**

Rocket University's UAS training project is designed to develop UAS skills by conducting flight operations off of KSC property. These tests include three major flight modes:

- Remote Control (RC) within operator visual range similar to recreational model aircraft activities.
- Semi-autonomous operations in which the aircraft remains within visual range but is under partial control of the onboard autopilot.
- Fully autonomous operation in which the aircraft will demonstrate waypoint navigation and the imaging of objects of interest (e.g., wildlife) in the flight operations area



**FIGURE 29: UAS TRAINING VEHICLE**

NRS has worked with Rocket U and the 45th SW to go over the criteria in RCC 323-99 to ensure proper provisions are taken before any UAS activity can precede at KSC. NRS and the KSC Aviation Working Group identified key facilities that have been made "no-fly zones" inside the area of operations. NRS will review the proposed Op Plan for the first UAS planning to fly out of the SLF in January, and then the KSC Airworthiness Flight Safety Review Board will give final approval for this certification flight.

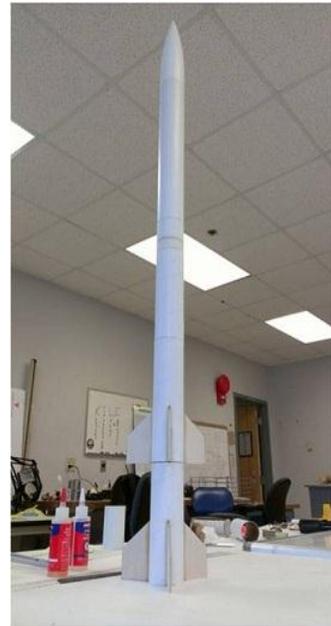
### **c. Rocketry Program**

Rocket University's Rocketry Program builds on a broader understanding of flight systems engineering and development by designing, building, analyzing, testing, and flying High Powered Rockets.

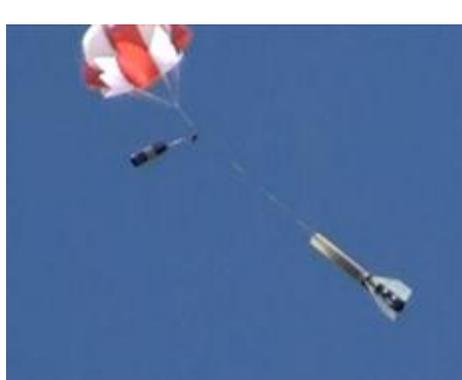
At the FAA approved launch site in Bunnell, FL, Rocket U participants have launched several successful amateur rockets that reach up to 10,000 feet above ground level (AGL) using level 2 K and L motors. Engineers are now setting their sights on launching from LC-39A in hopes of reaching up to 15,000 feet AGL, with planned future flights up to 150,000 feet AGL using level 3 O motors.

Once Rocket U made the decision to launch from KSC property, NRS reviewed the proposed flight package and identified additional concerns that had to be addressed before concurring with plans to launch from LC-39A. After collaborating with several NASA directorates and several Air Force organizations, it was determined that Rocket U could proceed with these launches as long as the program was compliant with FAA 14 CFR, Part 101C for Unmanned Rockets and National Fire Protection Association (NFPA) 1127 guidelines for High Power Rocketry.

NRS also worked with the 45th Space Wing and Rocket U to enter into a Memorandum of Understanding (MOU) between NASA and the Air Force to enable the launch of small scale



**FIGURE 30: SMALL SCALE ROCKET**



**FIGURE 31: SMALL SCALE ROCKET DEPLOYING CHUTE**

amateur rocket projects off of KSC property provided that the amateur rocket does not create a hazard outside of KSC property, and as long as an NRS-approved analysis has been performed to show worst case conditions before each flight.

NRS has worked with the four different rocket teams to review their analyses to ensure these rockets cannot create a hazard outside KSC property. NRS has also worked with KSC Safety and Mission Assurance to develop a flight hazard analysis to capture different possible failure scenarios and also to develop a Launch Commit Criteria for launch day. Rocket U expects to launch their first rocket before the end of the calendar year or early 2013.

## 2. Space Florida Balloon Operations

The Space Academy is a joint venture between Space Florida and the NASA/Florida Space Grant Consortium. This program hosts Florida undergraduates, teachers, middle school, and high school students in a range of scientific and hands-on activities at KSC Visitors Complex Education Center. The program is specifically designed to focus on engineering and science in ways not currently addressed by existing curricula and to encourage students to continue their studies in science-based programs at their college or university through continuing studies, KSC internships, and science-based research programs.

The scientific balloon activity is a good example of the type of project conducted with participants and is an activity that involves coordination with NASA Range Safety. The scientific

balloons are designed to climb to an approximate altitude of over 100,000 feet carrying small payloads to relay back to the students pictures taken at high altitude showing the curvature of the Earth as well as the blackness of space. The students launch scientific balloons with the following payloads on board:

- A "live" camera relaying pictures to a ground receiver and monitor
- A GPS designed to chart the flight pattern of the balloon



**FIGURE 32: SCIENTIFIC BALLOON RELEASE**

Prior to balloon release, NASA Range Safety, Air Force 45th Space Wing, and the FAA inspect all payloads to ensure requirements and common sense practices are satisfied. Those include:

- Any individual payload package weighing over 4 pounds must have a surface density of less than 3 ounces per square inch
- Any individual payload package must weigh less than 6 pounds
- The total payload must weigh less than 12 pounds (Space Florida payloads usually weigh less than 1 pound)

These are the same requirements used for the daily weather balloon releases by the 45th Space Wing at CCAFS Weather Facility. Balloons flown under these requirements are exempt from notification to FAA control facilities, but Space Florida makes pre-launch courtesy notifications to the Kennedy Space Center Shuttle Landing Facility/Military Radar Unit and to the 45th Space Wing, 1st Range Operations Squadron, since the release location is inside restricted airspace under their control. Once all of these requirements and notifications have been satisfied, the 45th Space Wing Safety Office issues an approval letter with concurrence from NASA Range Safety to Space Florida to conduct their balloon release. NASA Range Safety supported one Space Florida balloon release this year.

### **3. Morpheus Operations**

JSC brought their Morpheus lander vehicle (Figure 33) to KSC in July 2012 for flight test operations and to demonstrate the capability of the Autonomous Landing and Hazard Avoidance Technology instrument. KSC constructed a hazard field at the end of the SLF runway (Figure 34) to help simulate a lunar landing environment for Morpheus operations. JSC developed a Morpheus Range Safety Plan for flight operations at KSC which covered everything from vehicle description to flight ops to Contingency Management System (CMS) functions. This document was coordinated with the KSC Range Safety Representative and concurred on by the NASA Range Safety Manager. It was also approved by the KSC Center Director and the Morpheus Project Manager.

The RSO function for operations at KSC was performed by JSC personnel due to their familiarity with the Morpheus vehicle and training with Morpheus tethered test operations at JSC. The RSO worked with the KSC Range Safety Representative to establish boundaries and conditions for CMS activation.

Operations began with a successful tethered flight to verify that all systems were functional after transport from JSC. This was to be followed by free flight hops which would increase in distance upon each successful flight culminating with a final flight test that would cover a 1.1 kilometer distance along the runway with a landing in the hazard field. The first free flight test was soft-aborted autonomously by the Morpheus vehicle when it detected an abnormal condition and shut down only several inches off of the ground. The abnormal condition was determined to be a software issue and no hardware problems were identified, so the Morpheus vehicle team pressed on with the next free flight test. During this test, the Morpheus vehicle lifted off the ground and then experienced a hardware component failure which prevented it from maintaining stable flight. It crashed on the launch pad area. There were no injuries and the fire was contained in the launch pad area. The failure



**FIGURE 33: MORPHEUS TETHERED FLIGHT AT KSC**



**FIGURE 34: HAZARD LANDING FIELD AT KSC SLF**

investigation determined the leading cause to be hardware component failure, possibly due to launch vibration.

JSC is currently building an updated version of the Morpheus vehicle which is planned to be back at KSC for flight testing in mid-2013. KSC Range Safety will continue to provide support for future Morpheus operations at KSC in 2013.

To view the flight:

[http://www.youtube.com/watch?v=hvIG2JtMts&feature=player\\_detailpage](http://www.youtube.com/watch?v=hvIG2JtMts&feature=player_detailpage)

#### **4. Range Architecture Study**

The goal of the KSC GSDO Program's Future State Definition (FSD) project is to develop the products necessary to help modernize the Nation's space launch bases and ranges. Three focus areas were defined: Architecture Focus Area (AFA), Policy Focus Area (PFA), and Concept of Operations Focus Area (CFA). The purpose of the FSD AFA is to develop a strategic vision for current and future range capabilities at the Eastern Range and KSC. This vision will encompass both near term (year 2015) and far term (year 2025) range architectures.

The FSD AFA Integration and Management team designated four sub teams for the near term architecture activities: Communications and Timing, RF and Optics, Tools and Processes, and Weather. KSC Range Safety provided leadership and technical support to the Tools and Processes sub team in 2012. This sub team addressed the range safety, data handling, surveillance, and scheduling super systems along with customer interface processes. Two long term recommendations were developed by the Tools and Processes sub team. The first dealt with testing and support for AFSS development. The second involved the acquisition of a next generation Range Safety Display System that would have easily upgradeable, open system architecture to support future architecture needs. These recommendations were coordinated with the Eastern Range Safety Office and vetted by the AFA Integration Management.

## 5. Launch Operations Support

NASA/KSC Range Safety supported 11 launches this year. There were ten launches from the Eastern Range (one NASA-sponsored expendable launch vehicle and nine non-NASA launches supported for KSC risk assessment). The remaining launch was a NASA-sponsored expendable launch vehicle from the Kwajalein Missile Range at the Reagan Test Site.

In order to ensure the requirements of NPR 8715.5 are met during pre-launch, launch, and post launch operations, NRS personnel worked side-by-side with our DoD counterparts in the Morrell Operations Center and Hangar AE at CCAFS for the NASA sponsored launches. NRS personnel ensured any range safety-related activities that could have an impact on NASA launch criteria were communicated to the NASA Safety and Launch Service Program decision makers to ensure safe flight and compliance with requirements identified in NASA Range Safety directives.

Eastern Range and Kwajalein Missile Range				
Mission	Vehicle	Launch Site	Launch Date	Responsible Org
WGS-4	Delta IV	CCAFS	1/20/12	DoD
MUOS-1	Atlas V	CCAFS	2/24/12	DoD
AEHF-2	Atlas V	CCAFS	5/4/12	DoD
Dragon C2	Falcon 9	CCAFS	5/22/12	Commercial
NuSTAR	Pegasus XL	KMR	6/13/12	NASA
NROL-38	Atlas V	CCAFS	6/20/12	NRO
NROL-15	Delta IVH	CCAFS	6/29/12	NRO
RBSP	Atlas V	CCAFS	8/30/12	NASA
GPS 2F-3	Delta IV	CCAFS	10/4/12	DoD
Dragon CRS-1	Falcon 9	CCAFS	10/7/12	Commercial
OTV-3	Atlas V	CCAFS	12/11/12	DoD

**FIGURE 35: EASTERN RANGE AND KWAJALEIN (KMR) MISSILE RANGE SUPPORTED BY KSC IN 2012**

We look forward to 2013 and supporting the numerous ELV launches at both the Eastern and Western Ranges.

## **F. Langley Research Center (LaRC)**

The LaRC Small UAS (sUAS) Range Safety Office's sUAS Operations Working Group, which began in 2011, continued to expand and develop during FY 2012. The genesis of the sUAS Operations Working Group was to implement and coordinate consolidation activities in terms of sharing common recourses, providing pilot and observer training, and integrating operations policy requirements from Headquarters, the Center, and other organizations including the FAA, DoD, and the Department of Homeland Security (DHS). The sUAS Operations Working Group was chartered with membership from all UAS operational labs and projects at LaRC flying in the National Airspace (NAS) or restricted airspace. The goal is to ensure compliance with governing policies, processes, procedures, and reviews of the ever-growing UA infrastructure.

All sUAS projects at LaRC are governed by the NASA LaRC Langley Policy Requirements document LPR 1710.16, Aviation Operation Safety Manual. Also contained within this document are the Range Safety Requirements tailored for the unique needs of the Center in order to meet compliance under the requirements of the NPR 8715.5, NASA Range Safety Program.

### **1. LaRC Range Safety and sUAS Operation Oversight**

LaRC Range Safety Office provided oversight for sUAS flight operations in both the NAS and in Restricted Air Space in 2012. NASA LaRC Range Safety continued to work closely with the FAA's UAS Program Office and with the respective organizations that manage Restricted Air Space. The primary goal of this effort was twofold: 1) to maintain safety of flight for the public, public property, and test personnel, and 2) to ensure that NASA Range Safety requirements were in alignment with NPR 8715.5, NASA Range Fight Safety Program. LaRC currently maintains Certificate of Authorizations (COAs) to fly in the NAS at Allen C. Parkinson (Fort Pickett Army Airfield Blackstone) and at 31VA Aberdeen, Smithfield, Virginia.

This year, LaRC acquired a new COA at 42VA Virginia Beach at the Military Aviation Museum in support of the NASA integration in the NAS program. A working group assigned by the ExCom, (Executive Committee members representing NASA, DoD, DHS, and the FAA) Senior Steering Group, focused on streamlining access to class G airspace. With that assignment, the following issue was addressed:

“ExCom agencies need to be able to conduct day and night operations with small (55 pounds or less) UAS in Class G airspace at specifically identified locations and boundaries (outside of 5 NM of a military or public-use airport, heliport or seaplane base) using notification and other appropriate airspace de-confliction procedures.”

This activity included flight demonstrations in the NAS in both day and night operation conditions. As part of the process, the working group obtained permission from the FAA (via COA) to fly sUAS in this class G airspace, the Range Safety Office had to obtain permission to use the privately owned airfield at 42VA on a non-interference bases, and the RSO had to complete the required Range Safety Hazards Analysis in order to comply with NASA's Range Safety Program. It is anticipated that a memorandum of agreement will be signed between NASA and FAA Headquarters providing a new notification process for obtaining access to class G airspace in the NAS within the near future.

The Range Safety Office also supported several deployments to Finnegan UAS Air Field at Fort A. P. Hill, Virginia (operations in Restricted Air Space) and at the US Navy Webster Air Field, Maryland. A total of 47 deployment days were logged across these facilities that included

requirements for UAS pilot flight training / proficiency and for programmatic experimental flight research support.

The RSO at NASA LaRC was able to complete JARSS training provided by the Millennium Engineering & Integration Company in March of 2012. As a result, this mission planning and risk mitigation tool was applied to the work that was completed later in the year in support of the access to class G airspace activity and the completion of the Range Safety Hazards Analysis report for UAS operation at 42VA, Virginia Beach.

## **2. FY 2012 sUAS Flight Projects**

### **a. Airborne Subscale Transport Aircraft Research (AirSTAR) project**

The AirSTAR project began working on Phase V of the project. The AirSTAR test facility consists of a Mobile Operations Station (MOS) and a new experimental test-bed called a BAT-4, shown in Figure 36. The BAT-4 is currently being flown by an external pilot at 31VA in the NAS within visual line-of-sight for the purpose of initial checkout of the vehicle, flight control, and propulsion systems. The BAT-4 will be used as a low-cost test-bed for evaluating the Phase V CONOPS, on-board avionics, flight controls, navigation, and FTS systems.



**FIGURE 36: AIRSTAR BAT-4 EXPERIMENTAL TEST-BED BEING FLOWN BY AN EXTERNAL PILOT IN RC MODE WITHIN VISUAL LINE OF SIGHT**

The Phase V CONOPS will be flown by a remote internal pilot stationed inside the MOS as shown in Figure 37. Figure 37 shows the IP and glass cockpit set up inside the MOS. Should an off nominal event occur, the Range Safety Officer will have Flight Termination Authority in the event that the on-board autopilot fails to return the vehicle to a “home waypoint.” The RSO is working with the project to help define and implement failsafe and FTS requirements.



## PILOT & TEST CONDUCTOR



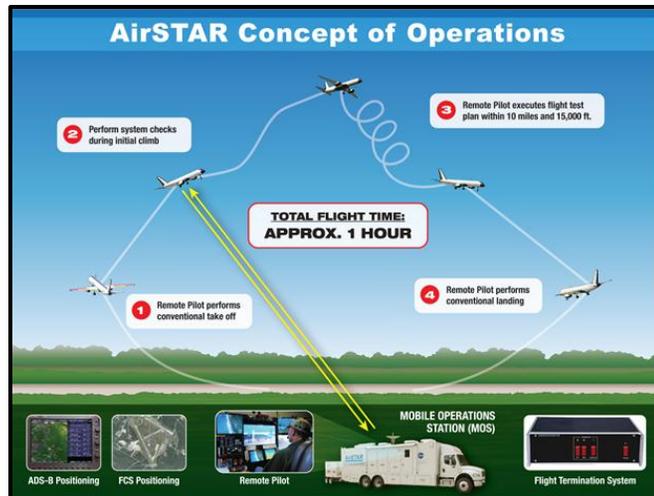
**FIGURE 37: AIRSTAR REMOTE INTERNAL PILOT AND GLASS COCKPIT CONFIGURATION LOCATED INSIDE THE MOS**

### **b. AirSTAR Beyond Visual Range CONOPS**

The AirSTAR Beyond Visual Range (BVR) flight system is designed to enable operations of up to 10 miles and 15,000 foot distances from the MOS. Primarily, this capability is intended to support larger aircraft and more complex research maneuvers that cannot be supported in the current “within visual range” operations. The visual range requirement required by the use of an external pilot restricts the size of the test range (both ground distance and altitude) and, as a result, restricts the aircraft size. Research quality is also affected due to the more restricted operations area in order to keep the aircraft within visual range of the external pilot. The restricted hazard area currently causes 50 percent of flight time to be spent in turns to remain within the hazard area, and causes research to be restricted to maneuvers capable of being complete in the 20-second window it takes the aircraft to traverse a straight-leg in the flight pattern.

The general AirSTAR BVR system CONOPS are as follows as illustrated in Figure 38:

1. Remote Pilot (MOS pilot) performs conventional take-off
2. System checks performed during initial climb to research altitude
3. Remote Pilot executes the flight test plan
4. Operational area is within 10 miles and 15,000 feet
5. Remote Pilot returns to runway and performs conventional landing
6. Total flight time is approximately 1 hour



**FIGURE 38: AIRSTAR REMOTE INTERNAL PILOT AND CONOPS FOR BEYOND VISUAL RANGE (BVR) OF SIGHT RESEARCH OPERATIONS**

AirSTAR BVR contingency systems consist of the following:

1. ADS-B system to provide redundant positioning information that is independent of the flight computer system.
2. Onboard autopilot is capable of taking over flight of the aircraft and returning aircraft to holding pattern in the case of lost telemetry and command and control link. Autopilot is also capable of auto-landing capability (though this may not be initially supported by the AirSTAR system).
3. Flight Termination System is capable of forcing the aircraft down within a certain ground range of its current position when commanded from inside the MOS. The FTS utilizes forced surface positions to force the aircraft to the ground.

**c. Automated Flight Control Lab**

The Automated Flight Control Lab conducted UAS flights during the July and August time period in support of developing a memorandum of agreement between the FAA and several agencies (NASA, DoD, and DHS) that would provide both day and night access to class G airspace for UASs under 55 pounds. The culmination of this effort resulted in two successful flight demonstrations requested by the FAA and DoD in class G airspace: day operations conducted at the Virginia Military Aviation Museum (42VA, Virginia Beach) on September 5, and night operations conducted at Aberdeen airfield in Smithfield (31VA) on September 11.

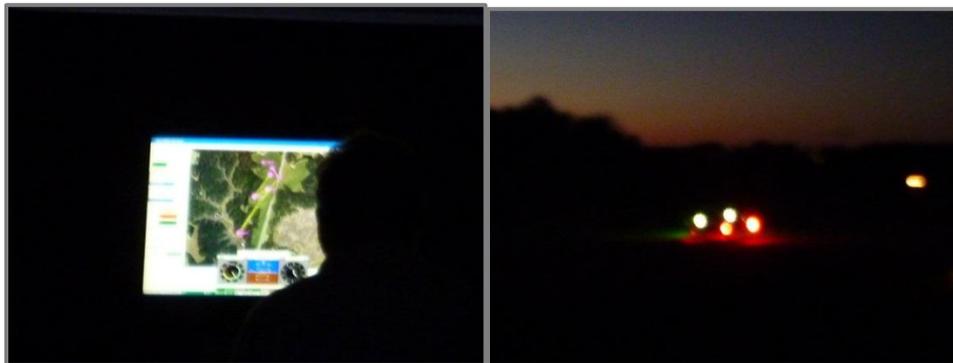
Proven automated Flight Control Test-beds (FLiC) were outfitted with navigational lights and anti-collision strobes to provide nighttime visual orientation. Initial flights were conducted in restricted airspace at Fort A.P. Hill, where the lighting configuration was clearly visible at typical visual range distances up to a half mile in both twilight and night darkness. Takeoff roll and rotation were performed manually and the autopilot was engaged at approximately 50 feet above ground level. Commands from the ground station were issued to have the autopilot execute return to home, approach, and landing patterns as well as adjustments to altitude and airspeed. Final runway alignment, landing flare, and rollout were performed manually.

Dr. Mark A. Motter provided technical direction for the required modifications to the FLiC and was the external pilot for both day and night operations. Figure 39 shows Mark preparing the FLiC test-bed for one of the flights at 31VA as sunset conditions approach. James High provided logistical support and was the ground station operator shown in Figure 40 which also shows the vehicle back taxi upon completion of a successful autopilot night flight after sunset.



**FIGURE 39: FLIGHT CONTROL TEST-BED (FLiC) BEING PREPARED FOR NIGHT FLIGHT DEMONSTRATION AT 31VA IN THE NAS**

The development of the experimental FLiC test-bed was supported by various funded projects at the Center and continues currently under the Center Innovation Fund (CIF) for Neuromorphic UAS collision avoidance. All of the automated flights for this effort were conducted on a test-bed flown at the 2005 AUVSI UAV Demo, still in service after several hundred flights.



**FIGURE 40: GROUND STATION OPERATOR (LEFT) MONITORS FLiC POSITION IN FLIGHT AND VEHICLE ON RUNWAY (RIGHT) DURING BACK TAXI AFTER A SUCCESSFUL NIGHT FLIGHT OPERATION**

#### **d. Small Unmanned Aircraft Vehicle Laboratory (SUAVeLab)**

SUAVeLab at NASA Langley is performing research funded by the government to develop the technologies required to combine 2 opposing characteristics into a single UAS vehicle: achieving 24 hour endurance while also achieving Vertical Takeoff and Landing (VTOL) capability. Existing UAS rotorcraft achieve Lift to Drag (L/D) ratios of about 4, which is an effective measurement of aerodynamic efficiency. The SUAVeLab research will achieve an L/D of about 20, so a five-fold improvement in L/D is the key research goal with secondary goals being VTOL and ultra-low community noise. The project performs spiral development of

competing concepts through analysis and prototyping of sub-scale demonstration models. Subsequently, the most robust transitioning/controllable vehicle is being developed at full-scale to validate all flight technologies.

Test flights for three concept UAS configurations were conducted over a period of three one-week deployments in restricted airspace at Fort A. P. Hill, Virginia. Figure 41 was taken during one of the deployments and shows the three concept vehicles that were test flown along with the research team of NASA engineers, contractors, and summer college students. Testing is expected to continue through FY13.

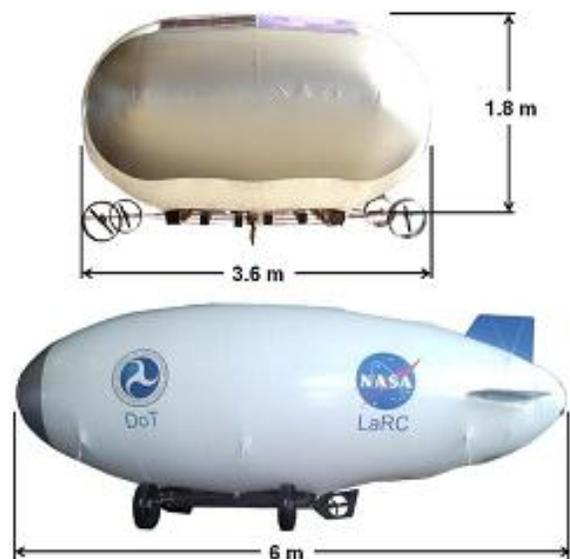


**FIGURE 41: SUAVELAB RESEARCH TEAM WITH THREE TEST BED CONCEPTS THAT WERE FLIGHT TESTED AT FT. A. P. HILL, VIRGINIA**

#### e. Solar Power Airship

A flight safety hazards analysis was evaluated for a solar powered unmanned airship for both indoor and outdoor flight testing. The airship (Figure 42) was designed and built at NASA LaRC for the purpose of demonstrating solar power (Figure 43) as an alternative green energy source for larger unmanned solar powered UAS for possible use in the future. The first flight test was made on October 13, 2011, and the final demonstration flight was made on October 26, 2012 (Figure 44) with NASA Langley and Department of Transportation staffs. Indoor flight tests were made at a large hangar on LaRC. During the indoor flight test, four batteries were used to power up the airship. For the outdoor test, batteries were completely removed and the airship was powered by sunlight only as it was attached to its tie down structure (seen in Figure 45). Outdoor free-flight of the airship did not occur because the wind conditions (speed and direction) were not within the set boundaries. Nevertheless, all the important factors such as total propulsion thrust, power delivery and consumption from the direct sunlight, 10 degree vector propulsion control, and avionics were measured under the direct sunlight in a tethered airship control mode outside of the hangar.

The airship was designed to have a single helium envelope consisting of two cylindrical components separated by a middle section. Such a



**FIGURE 42: AIRSHIP CONFIGURATION AND DIMENSIONS.**

configuration offers more lift than the conventional (cigar-shaped) design while still featuring a slender, aerodynamic shape. It also offers more surface area for the solar cells and the gondola for supporting eight cargo containers. The airship was also designed to have neutral buoyancy with payload (cargo containers). The dimensions were determined by calculating the lift for the envisioned configuration. The lift was calculated with consideration for the:

1. Number and size of solar cells and wiring to power the motors for propulsion
2. Design and materials for the gondola with propulsion motors
3. Weight of the eight cargo containers
4. Surface area (weight) of the helium envelope
5. Weight of fins, tie-down bridle straps, and suspended tethers



**FIGURE 43: PICTURE OF THE 12-CELL SOLAR PANELS BEING ATTACHED TO THE POLYURETHANE ENVELOPE WITH HOOK AND LOOP STRIPS**



**FIGURE 44: VIDEO SCENE OF THE INDOOR FLIGHT TEST OF THE SOLAR AIRSHIP**



**FIGURE 45: FULLY ASSEMBLED SOLAR AIRSHIP WAITING FOR FLIGHT TEST SECURED TO TIE DOWN STRUCTURE**

#### **f. Rapid Evaluation Concept Lab (REC Lab)**

The REC Lab is utilizing an all-electric Edge 540T 33 percent subscale as sUAS research vehicle test-bed (Figure 46). It has a wing span of 8 feet and a nose to tail length of 8 feet. It is built from an off-the-shelf mid-wing aerobatic radio controlled model kit. Its nose mounted, single 26"x10" propeller develops a maximum of 35 pounds of thrust. The propeller is driven by dual tandem electric motors powered by four 5500 mAh lithium polymer batteries. The sUAV weight is about 46 pounds which includes approximately 12 pounds of research instrumentation.



**FIGURE 46: EDGE 540T 33% SUBSCALE VEHICLE BEING FLOWN AT FINNEGAN FIELD, FT. A. P. HILL, VIRGINIA**

It is being used to research and test prognostic algorithms for battery health, software health, and air traffic conflict detection and resolution. The follow-on research is to use the prognosis results to feed decision models and algorithms which form the basis of robust on-board flight and mission management systems. This research challenge includes demonstrating the software capability using traffic conflict scenarios to trigger on-board decision events.

Collectively, the Edges have flown nearly 100 successful flights at 31VA Aberdeen in the NAS, and Ft. A. P. Hill, Finnegan Field in restricted airspace. These flights include check flights, tests of battery and software health systems, autopilot test and tuning, ADS-B receiver testing, and software integration tests. A progressively autonomous approach is being used to develop the system and operational expertise to ultimately field multiple vehicles in traffic conflict scenarios and demonstrate on-board prognostics based contingency management.

The Range Safety Office is working with the FAA to obtain a COA which will allow multi-vehicle operations to take place in support of this research effort. Data obtained from these traffic conflict scenarios will be shared with the FAA through the NASA Integration in the NAS Program

for developing technologies, processes, and procedures for the decision making efforts focused at full integration of UAS in the NAS by 2015. An additional milestone was achieved this year when the FAA assigned registration “N” numbers to two of these REC Lab sUAS vehicles.

## **G. Stennis Space Center (SCC)**

SSC developed and released SPR 8715.7, SSC Range Safety Program, which defines the requirements and parameters of range safety at SSC. Several activities have been initiated in calendar year 2012 aimed at improving range safety process effectiveness.

- To enable tracking and communication, the Application for Air Range Information and Notification (AARIN) was developed to allow pilots inside and outside of Stennis to request access to the airspace.
- The Stennis CIF awarded an analysis of technologies available for potential surveillance systems and their application at Stennis. Technologies as well as available existing resources will be reviewed and rated according to ease of use, availability, and cost. The recommended technology will provide valuable information for the decision for what system to use for Stennis airspace.
- In addition to reducing risk through surveillance, the risk associated with potential locations for military training operations is being analyzed. The risk assessments of potential locations based on the possible aircraft and operation types will be used to streamline response to requests for use of land, water, and air by military tenants. This risk analysis will provide operational alternatives that allow increased confidence in the level of risk SSC is assuming to its onsite facilities.
- NASA SSC and the Naval Special Warfare Command (NSW) are proposing modifications to special use airspace associated with the Space Center. The purpose of this action is to provide containment capabilities conducive to protecting the general aviation community while supporting engine testing and tenant missions at the Center.

### **1. Engine Testing**

As a safety precaution to general aviation in the immediate airspace, Restricted Airspace R-4403 is activated during engine testing. During 2012, the test stands operated 7 projects resulting in approximately 152 hot fire tests. R-4403 was activated for 26 tests, like the one shown in Figure 47, for a total of 6,564 seconds.



**FIGURE 47: TEST STAND AT STENNIS SPACE CENTER**

## **2. Center Innovation Funding**

The Center Innovation Funding provided an evaluation and identification of unauthorized aircraft entering Restricted Airspace R-4403 located within the SSC Fee Area. Potential solutions were investigated, systems level set of requirements were reviewed, and the impact the technology to the Center were identified.

## **3. Application for Air Range Information and Notification (AARIN)**

The Range Safety Manager provides de-confliction and Center oversight for the flight training operations and certification activities conducted at Stennis Space Center. Aerial access to the Center is requested in AARIN. Fifteen requests were submitted to the AARIN system, eight of which were approved and the remainder were denied.

## **4. Special Use Airspace**

NASA, SSC, and the NSW are proposing modifications to special use airspace associated with SCC, specifically modifications to Restricted Airspace R-4403. The purpose of this action is to provide containment capabilities conducive to protecting the general aviation community while maintaining priority of engine testing and supporting tenant missions at the Center. Additionally, protection to the surrounding communities from noise and aerial impacts (i.e., turbulence) is critical to maintaining engine testing capabilities at SSC. For mission success within the Federal City and to protect the public including the general aviation community from future testing, Special Use Airspace R-4403 is being modified.

## **5. Unmanned Aircraft Vehicles - Certificate of Authority**

Currently, the DoD Special Operations Command (SOCOM) is the only agency operating UASs at SCC. The COAs for SOCOM are:

**a. Raven 2012-ESA-28-COA-R**

Raven 2012-ESA-28-COA-R, effective from July 20, 2012 through July 19, 2014. Operation of the Raven UAS in Class G airspace at or below 1000 feet AGL, except in the northern airspace area under the Picayune Class E airspace where the Raven will remain at or below 500 feet AGL. Night flight is acceptable.



**FIGURE 48: RAVEN UAV**

**b. Puma 2012-ESA-29-COA-R**

Puma 2012-ESA-29-COA-R effective from July 20, 2012 through July 19, 2014. Operation of the Puma AE UAS in Class G airspace at or below 1000 feet AGL, except in the northern airspace area under the Picayune Class E airspace where the Puma will remain at or below 500 feet AGL. Night flight is acceptable.



**FIGURE 49: PUMA UAV**

**c. Wasp 2012-ESA-1-COA**

Wasp 2012-ESA-1-COA effective from March 22, 2012 through March 21, 2013. Operation of the Wasp in Class G airspace at or below 500 feet AGL.

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



**FIGURE 50: WASP UAV**

**H. Wallops Flight Facility (WFF)**

WFF is NASA's principal facility for the management and implementation of suborbital science research programs. The research and responsibilities of Wallops are centered on the philosophy of providing a fast, low cost, highly flexible, and safe response to meet the need of aerospace technology interests and science research. Listed below are various project/programs that the Safety Office supported in 2012.



**FIGURE 51: ANTARES LAUNCH VEHICLE**

**1. Expendable Launch Vehicle Support**

WFF Safety Office continues to support the Antares Launch Vehicle (Figure 51), which involves facility construction, testing of Ground Support Equipment, and testing in support of NASA's Commercial Resupply to Station (CRS) activities. Multiple Antares pathfinders have been conducted in preparation for cold flow testing of liquid oxygen (LOX)/kerosene for first stage fueling, followed by a static hot fire from Pad 0A before eventual first launch by year's end.

## 2. Sounding Rocket Program Office (SRPO)

NASA/WFF Range Safety personnel supported 21 missions conducted by the WFF SRPO in 2012. The launch manifest consisted of 2 technology development/demonstration missions, 2 undergraduate student outreach missions (Rock-Sat X and Rock-On), 14 science missions, and 2 reimbursable missions for the DoD. Additionally, 1 highly visible reimbursable NASA mission was conducted for LaRC (IRVE 3 described below). Launch sites included Wallops Island (12 launches), Poker Flat Research Range (1 launch), and White Sands Missile Range (8 launches). Two of the more significant launches from WFF are discussed below.

### a. Anomalous Transport Rocket Experiment (ATREX)

The ATREX missions 41.097, 41.098, 45.004, 46.002, and 46.003 (Figure 52) were launched from WFF on March 27, 2012. ATREX involved launching 5 rockets in approximately 5 minutes to obtain measurements of the turbulent fluctuations over an extended horizontal range of 550km. The purpose of the experiment was to gather information needed to better understand the process responsible for the high-altitude jet stream located between 95km and 105km (60 and 65 miles) above the surface of the earth. The winds found in that region typically have speeds of 225 to 335 miles per hour and create rapid transport from mid-latitudes to polar regions. The winds were discovered in the last 10 years and are still very poorly



**FIGURE 52: ATREX MISSION PRELAUNCH TESTING**



**FIGURE 53: ATREX TIME-LAPSE**

understood although it is known that they have a significant impact on the formation and severity of so called “space storms” which disrupt the normally stable ionosphere. ATREX was a challenging mission to execute in terms of the operational planning; the resources required both in terms of hardware and personnel, and the complexity of the Safety operational support.

### b. Inflatable Re-entry Vehicle Experiment (IRVE 3)

The third launch in the series of IRVE 3 was launched on July 23, 2012 from WFF aboard a Talos, Terrier, Black Brant three-stage Sounding Rocket (mission 39.011). LaRC was the lead NASA Center for designing and testing the IRVE 3 payload. IRVE 3 is the study and test of inflatable (as opposed to the more familiar rigid) aeroshell technology for deceleration purposes. Current rigid aeroshell capabilities limit landing options and complicate packaging of payloads, especially for some proposed payloads which are larger in size and mass. Inflatable aeroshells provide advantages in

both the stowed and inflated configuration, including allowing access to payload after launch vehicle integration, minimizing volume requirement during launch, beginning deceleration at higher altitudes, lower heat flux during reentry, and delivery of more mass to the surface.

### 3. Balloon Program Office (BPO)

NASA/WFF Range Safety personnel supported nine missions conducted by the BPO during 2012. Flight operations were conducted from Fort Sumner, New Mexico; McMurdo, Antarctica; and Kiruna, Sweden in support of Space Science payloads as well as a test flight for a new balloon design. The Stratospheric Terahertz Observatory (STO) experiment, launched on December 25, 2011, is investigating the life cycle of the galactic interstellar gas and the parameters that affect star formation in the galaxy (Figure 54).



**FIGURE 54: STRATOSPHERIC TERAHERTZ OBSERVATORY (STO) LAUNCH**

The BPO also conducted a deployment test flight of an 18.8-million-cubic-foot balloon, the largest single-cell, fully-sealed, super-pressure structure ever flown from Kiruna, Sweden.

This super pressure balloon (Figure 55) is a larger scale version of a similar balloon flown over Antarctica for 22 days from January to February 2010. The next developmental step will be additional flights of the 18.8-million-cubic-foot balloon to qualify this balloon for science flights. Further plans include a larger ~26-million cubic-foot super-pressure balloon, nearly the size of a football stadium, that will fly at a slightly higher altitude. NASA's goal is to provide circum-global science flights at mid-latitudes for over 100 days.



**FIGURE 55: SUPER PRESSURE BALLOON**

#### 4. WFF Aircraft Office

The WFF Aircraft Office supported multiple airborne science missions during 2012 involving manned aircraft. The Wallops Safety Office minimally supports these missions through review of hazardous systems being flown on those aircraft.

The Aircraft Office also supported UAS work, including the Hurricane and Severe Storm Sentinel (HS3) mission. The purpose of the HS3 mission is to obtain critical measurements in hurricane environments to identify key factors and their role in storm intensity change. Two NASA Dryden Global Hawk (GH) UAS aircraft are being equipped with sensors to gather science data about hurricanes in the Atlantic Basin. One aircraft (GH N872NA, also called 872 and AV-6) is known as the “Environmental GH” and has three sensors used as it flies around the perimeter of hurricanes. The other aircraft (GH N871NA, also called 871 and AV-1) is known as the “Over-Storm GH” and uses three sensors as it flies through the top of hurricanes. Each aircraft will typically fly for up to 26 hours and can fly up to 28 hours under ideal conditions. These two GHs have flown for almost 500 flight hours since being acquired by NASA Dryden and are considered operational UAS aircraft.



**FIGURE 56: NASA GLOBAL HAWK**

HS3 is a five-year project including about ten Global Hawk science flights per year using both the Global Hawk aircraft operating from the Wallops Airport and flying in the Gulf of Mexico, Caribbean, and the western, central, and eastern Atlantic. Since the GHs operate from Wallops Airport, these areas are considered part of the Wallops Range for HS3 missions. Figures 56 and 57



**FIGURE 57: NASA GLOBAL HAWK TOUCHDOWN**