**National Aeronautics and Space Administration** 



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# Wallops Flight Facility Integration and Testin  $\mathbf{C}$ Gustomer landbouk

**NASA Goddard Space Flight Center Wallops Flight Facility Wallops Island, Virginia 23337** 

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#### WALLOPS I&T CAPABILITIES HANDBOOK



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## **1 INTRODUCTION**

The NASA Goddard Space Flight Center (GSFC) Wallops Flight Facility (WFF) , which will be referred to as 'Wallops' in this document, claims a heritage of low-cost operations, experienced personnel, customer-focused support, and a common-sense safety program. As an operational research site for the next generation of low-cost launch technologies, Wallops supports the development of space technologies and the dissemination of information through educational and outreach programs. Wallops is recognized as a role model for pioneering productive and innovative government, industry, and academic partnerships. Our ongoing programs and projects support all NASA centers, science, and technology focuses.

Wallops' key mission elements include:

**Suborbital Flight Projects**—Wallops manages and implements NASA's sounding rocket, balloon, and scientific aircraft programs in support of Earth and space sciences. New technologies, such as ultra-long duration balloons, are integrated into the program.

**Low-Cost Orbital Missions**—Wallops manages and provides technical support for small spacecraft carriers.

**Mission Operations**—Wallops provides fixed and mobile launch ranges and a research airport. The range provides the services necessary for a wide variety of research, development, and operational missions, including rocket, balloon, and aerial vehicle flights. Wallops also manages and operates satellite tracking stations locally. Wallops supports all five NASA mission directorates including the Science Mission Directorate (SMD), Exploration Systems Development Mission Directorate (ESDMD), Space Operations Mission Directorate (SOMD), and the Space Technology Mission Directorate (STMD) as well as the Department of Defense (DoD), commercial, and academic organizations.

**Science and Technology**—Wallops Earth scientists research global climate change. Wallops engineers develop new technologies that improve capabilities of flight projects or lower costs of access to space.

**Educational Outreach**—Partnerships formed with industry and academia foster educational outreach programs. Wallops also carries out a wide array of education and outreach programs that support the development of future engineers and scientists.

#### **1.1 Purpose**

The Wallops Integration and Testing Handbook is a guide for planning operations at Wallops testing facilities. It provides a summary of the capabilities and technical specifications of available facilities. This handbook prescribes the information to be provided by the user that will enable the integration and testing team to effectively plan for and support the facility user's project. Note that each facility plans for availability based on current workloads/ mission schedules. For example, sounding rockets may have between 20 and 35 missions in work at one time. Also note that special training, such as cleanroom certification, electrostatic discharge (ESD) or confined space training may be required for entrance to some facilities. Contact Scott Schaire at: scott.h.schaire@nasa.gov for additional information.

#### **1.1.1 Building E-109: Engineering**

Table 1 lists the engineering facilities in Building E-109.





## **1.1.2 Building F-7: Integration and Test**

Table 2 lists the integration and test (I&T) facilities in Building F-7.





#### **1.1.3 Building F-10: Test and Evaluation**

Table 3 lists the test and evaluation facilities in Building F-10.

Facility	Refer to section	
<b>Telemetry Ground Stations</b>	2.7	
Thermal Chambers	3.2	
<b>Vibration Tests</b>	3.4	
<b>Balancing Machines</b>	3.6	
<b>Mass Properties Measurement</b>	3.7	
Spin Deployment	3.8	
<b>Bend Test Facility</b>	3.9	
Payload Fabrication	4.1	
<b>Attitude Control Testing Facility</b>	4.2	
Sounding Rocket Payload Integration	4.3	
Machine Shop	4.1	

*Table 3: Building F-10 Test and Evaluation Facilities* 

#### **1.2 Facility History**

For more than 60 years, Wallops has provided launch support for some of the highest priority research programs in the United States. Founded in 1945, Wallops was established by the National Advisory Council on Aeronautics (NACA) as a test site for aeronautics research projects. During the 1940s and 1950s, prior to the era of high-speed wind tunnels, Wallops activities focused on providing operational testing for new aerodynamic configurations aboard rockets. During the 1960s, Wallops focused on support for numerous flight projects leading to human exploration of space, such as Little Joe, which tested the ejection system for the Mercury capsule. From the 1960s through the 1980s, Wallops supported the launch of more than 40 Scout rockets. During the 1990s, Wallops evolved its mission beyond operational support to include project management and implementation of various NASA space and Earth science activities aboard suborbital and small orbital carriers. During its history, Wallops has conducted more than 16,000 launches. For a more detailed history of Wallops, visit https://www.nasa.gov/centers/wallops/home.

#### **1.3 Wallops Main Base Overview**

Wallops Flight Facility encompasses more than 6,000 acres over three different land parcels: Wallops Main Base, Mainland, and Island. The Wallops Main Base is located on Virginia's Eastern Shore, 5 miles south of the Maryland state line.

The Main Base (see Figure 1) is home to most of NASA's administrative, engineering, fabrication, testing, and project management activities, as well as the Research Airport and Range Control Center.



*Figure 1: Main Base and Airfield* 



*Figure 2: Launch Range* 



*Figure 3: Main Base and I&T Building Locations* 

#### **1.4 Wallops Island Overview**

The mainland and Wallops Island are located approximately 7 miles to the southeast of the Main Base, adjacent to the Atlantic Ocean. Wallops Island is the site of the Wallops Launch Range (see Figure 2) and many supporting facilities. The locations of the I&T buildings are shown in Figure 3. Wallops Range has facilities for the receipt, inspection, assembly, checkout, and storage of rocket motors and other pyrotechnic devices. The Wallops Island launch site is comprised of launch pads, control rooms, blockhouses for launch control, and assembly buildings to support the preparation and launching of suborbital and orbital launch systems. Figure 4 depicts an aerial map of Wallops Island and the mainland. The top of the figure shows the mainland with supporting tracking radars. The bottom of the figure shows Wallops Island with the launch range and support facilities connected to mainland by the causeway bridge.



*Figure 4: Wallops Island* 

## **2 ELECTRICAL INTEGRATION AND TESTING**

#### **2.1 aEMI/EMC Measurement Facility (Building F-7)**

The electromagnetic interference / electromagnetic compatibility (EMI/EMC) Measurement Facility (Figure 5) is Military Standard (MIL-STD) 461/462-compliant and American National Standards Institute (ANSI) C63 pre-compliant for radiated emissions (RE102), radiated susceptibility (RS103), and

conducted emissions (CE102). The test chamber is lined with absorbers rated to 40 gigahertz (GHz) with 100 dB shielding. The test chamber provides a low noise environment and may be used for payload selfcompatibility testing and radio frequency (RF) sensitive device characterization. Two adjoining chambers house the control room and the payload support room. Electrical pass-throughs allow for connection to customer-provided ground support equipment (GSE) in the payload support room. See Table 4 for a summary.



*Figure 5: EMI/EMC Measurement Facility* 

#### *Table 4: EMI/EMC Facility Specifications*



## **2.2 Anechoic Chamber Facility (Building F-7)**

The Anechoic Chamber facility (Figure 6 through Figure 9) is home to a shielded dual-mode far field/compact range chamber for measurement and analysis of linear and circular polarization antenna pattern. Its specifications are shown in Table 5. The Agilent PNA Orbit/FR spectrum-based automated data collection system allows both phase and amplitude pattern measurements with configurable settings for azimuth/elevation/roll range, and step sizes with source feeds in co-polarization or cross-polarization. The Anechoic Chamber maintains feeds and standard gain horns for the following bands: ultra-high frequency (UHF), L, S, C, X, Ku, and Ka.







*Figure 6: Anechoic Chamber Facility Az/El Positioner Tower* 



*Figure 7: Anechoic Chamber Facility Compact Range Source Feed* 



*Figure 8: Anechoic Chamber Facility Compact Range Reflector*



*Figure 9: Anechoic Chamber Facility Far Field Source Feed* 

#### **2.3 GPS Simulation Lab Facility (Building E-109)**

The Global Positioning System (GPS) Simulator Facility, shown in Figure 10, is located in Building E-109 and is comprised of a 4-output Spirent GPS simulator capable of reproducing L1 and L5 RF signals. These signals would be received by a GPS receiver as it travels any trajectory at any time, with parameters such as signal strength, multipathing, antenna patterns controllable for testing of navigation and attitude receivers, a single output Spirent GSS GPS receiver programmable and transportable for use in the field, and a Navigation Laboratories Tapestry GPS/Inertial Measurement Unit (IMU) simulator.



*Figure 10: GPS Simulator Lab* 

#### **2.4 Radar Lab Facility (Building E-109)**

The Radar Laboratory Facility contains the transponder and Flight Termination Receiver System (FTS) certification benches (see Figure 11). Table 6 lists the facility specifications. The Test Equity Model 115 Thermal Cycle Chamber is shown in Figure 12. The transponder rack and parts of the FTS bench are mobile so they can be moved for remote transponder and FTS testing. For example, these are used to perform in-vehicle testing and end-to-end (ETE) testing with the Antares vehicle at the Horizontal Integration Facility (HIF).

The portable thermal cycle chamber allows for component characterization over a wide temperature range.

Ample bench space is available for component test and measurement.



*Figure 11: Flight Termination Receiver System Certification Bench* 



*Figure 12: Test Equity Model 115 Thermal Cycle Chamber* 



## **2.5 Microwave Lab Facility (Building E-109)**

The Electrical Engineering Microwave Lab, shown in Figure 13 and Figure 14, provides instrumentation (Figure 15) and development tools for telemetry system RF communications hardware. The lab supports testing of flight and ground support hardware, as shown in Table 7.



*Figure 13: Microwave Lab Facility* 

*Table 7: Microwave Lab Specifications* 

Location: Building E-109

RF test and measurement capability to 30 GHz

BPSK, QPSK, 8PSK modulation and demodulation to 480

megabits per second (Mbps)

ESD Test and Assembly Benches

Keysight Advanced Design System (ADS) software

Field Programmable Gate Array (FPGA) development software



*Figure 14: Microwave Lab Facility* Figure 15: Agilent 8722ES Network Analyzer

## **2.6 Electrical Lab (Building E-109)**

The Wallops Electrical Engineering Branch Electrical Lab (Room 272) supports multiple engineering and integration and testing efforts for components and small payloads. The lab, shown in Figure 16, can support class 1A to class zero missions for electrostatic discharge. A portable thermal chamber, portable laminar flow hood, and portable vacuum jar allow for environmental test capability and contamination control protections when required.



*Figure 16: Electrical Lab (Building E-109)* 

## **2.7 Telemetry Ground Stations (Building F-10)**

The NASA Sounding Rocket Operations Contract (NSROC) has a total of three primary ground stations with the ability to support an auxiliary testing location. Each ground station is designed to support up to eight RF links in various combinations. The typical combination is two payloads with three RF links each. The ground station can support lower S-band frequencies (2,200 to 2,300 MHz) and some upper S-band frequencies (2,382.5 MHz). Typically, most payloads are contained to lower S-band. The ground stations are in the process of being upgraded to support the C-band RF spectrum (4,400 to 4,850 MHz).

The ground stations, located in Building F-10, are configured to support multiple pulse-code modulation (PCM) links (defined by Inter-Range Instrumentation Group (IRIG) 106 Chapter 4). They can generate multiple outputs that can range from clock and data outputs to the raw demodulated signal if the customer decides to handle the data themselves. The ground stations can support both PCM and SOQPSK modulation with a maximum bit rate of 40 Mbps. They are also capable of demodulating television (TV)/frequency modulation (FM) and baseband links.

The ground stations are also capable of outputting experimenter asynchronous data embedded within the telemetry downlink. This must be the RS-232 / RS-422 asynchronous protocol and our current maximum baud rate is 230.4 kilobaud. Each ground station has a dedicated IRIG CH10 recorder that can record multiple sources both inside and outside of the ground station. Every ground station is also capable of supporting paper chart recorders with a maximum of 16 channels per chart. All ground stations can simulate a command uplink for payloads that wish to have remote control during flight. This is used in combination of an on-board payload system that allows the user to control relays and uplink asynchronous data. Figure 17 shows a typical ground station setup.



*Figure 17: Telemetry Ground Station* 

## **3 MECHANICAL INTEGRATION & TESTING**

## **3.1 Thermal Chambers (Building F-7)**

#### **3.1.1 Thermal Vacuum Chamber (Building F-7)**

The cylindrical thermal vacuum (T-Vac) chamber in Building F-7 (Figure 19, Figure 20 and Figure 21) is used for thermal vacuum testing of small components. The chamber shroud is broken up into twelve panels (ten circumferential, one on the door, and one at the rear of the chamber), all controlled independently of one another. The shroud panels utilize liquid nitrogen and block heaters for temperature control, and can maintain temperatures between –100°C and +100°C. A portable 10K (International Standards Organization (ISO) 7) clean tent (12 feet by 16 feet) adjoining the chamber for test article processing can be utilized based on customer need.

The vacuum system consists of a two-stage pumping system. For higher-pressure tests (0.1 torr to 760 torr) such as those for balloon and aircraft tests and for initial rough pump of the cryogenic pump, the chamber utilizes an oil-free mechanical pump. For very lowpressure tests, such as those used for space flight qualification  $(<1x10^{-5}$  torr), the second stage of the vacuum system consists of a cryogenic pump.

All chamber systems (vacuum and temperature) are controlled via a personal computer (PC) with LabView and a National Instruments data acquisition system and digital input/output (I/O) card.



*Figure 18: Overview of Building 7 Thermal Vacuum Chamber* 



*Figure 19: Thermal Vacuum Chamber* 



*Figure 20. Thermal Vacuum Chamber Ports* 

Temperature measurement of test articles and associated GSE are accomplished via a Fluke 2686A data acquisition unit with Precision Analog Input (PAI) modules. The unit can read up to 120 thermo-couples (or other twowire analog inputs). Additionally, chamber GSE includes type-T thermocouples, suitable for use in vacuum environments. These plates accommodate a variety of hermetic connectors in different configurations that accommodate



*Figure 21: Thermal Vacuum Chamber* 



*Figure 22: Thermal Vacuum Chamber used for small spacecraft, subsystems, and components* 



*Figure 23. Thermal Vacuum Chamber used for testing Balloon High Gain Antenna (HGA)* 

power, signal, and RF interfaces. Plates with plumbing feedthroughs are available for external chillers, or custom feedthrough plates can be developed.

Mechanical GSE includes large and small open-framed carts for mounting of test articles. These carts slide on rails inside the chamber (Figure 22) and provide ample view to the bottom shroud panels. Additionally, four heater plates and two heater-controlled enclosures are available for component and subsystem testing, utilizing a cold chamber as their heat sink.

#### *Table 8: F-7 T-Vac Chamber Specifications*



Figure 23 shows an example of using the chamber to test a component or subsystem of a much larger mission, in this case a critical subsystem for large scientific balloon missions. Smaller projects, such as Small Satellites (SmallSats), can be accommodated completely inside the chamber for testing.

Specifications for the F-7 Thermal Vacuum chamber are shown in Table 8.



#### **3.1.2 Thermal Chamber (Building F-7)**

*Figure 24: Thermal Chamber (Building F-7)* 

The thermal chamber in Building F-7, shown in Figure 24, provides 32 cubic feet of test volume with touch screen control, programmable thermal test profiles, data logging capability, and ethernet connectivity. A dry air purge is provided to eliminate condensation buildup on test components. The chamber offers a temperature range of -70 $\degree$ C to +180 $\degree$ C with +/-0.5 $\degree$ C control ability (see Table 9). This chamber is located within close proximity to the F-7 EMI and Anechoic chambers allowing for thermal conditioning of components or antennas prior to testing in those chambers.



#### *Table 9: Espec Thermal Chamber Specifications*

## **3.2 Thermal Facilities (Building F-10)**

#### **3.2.1 Thermal Vacuum Chamber (Building F-10)**

The thermal vacuum chamber in Building F-10 (see Figure 25) has an Agilent turbopump vacuum system with an oil-free roughing pump. It includes a thermal plate for hard attachment of the test item to ensure the best thermal transfer, five available thermocouples, two 37-conductor interfaces (one twisted pair, one not), with 37 pin cannons inside and out, and multi RF connectors. Typical testing is done in two days per cycle; day one hot, day two cold, with the chamber left in vacuum overnight. Data logging captures the temperature of the test article and the vacuum level.



*Figure 25. Thermal Vacuum Chamber (Building F-10)* 

#### **3.2.2 PV/T Vacuum Chamber (Building F-10)**

The PV/T or "White Elephant" shown in Figure 26 is the largest chamber at 7 feet in diameter and 12 feet long. It is primarily used for performing corona checks on subsystems that utilize high voltage components.

#### **3.2.3 Altitude Bell Jar (Building F-10)**

The bell jar is shown in Figure 27 and is used primarily for automated altitude switch testing; however, it can be interfaced for small component corona tests as well.



*Figure 26: PV/T Vacuum Chamber Figure 27: Altitude Bell Jar* 



#### **3.2.4 Espec ESZ-4CA Thermal Chamber (Building F-10)**

There are two full-time Espec thermal chambers, one of which is shown in Figure 28. They are fully automated and have Product Temperature Control, Air Temperature Control, and Soak Control functions. One of the chambers has liquid nitrogen cooling capability allowing for cooling rates as fast as 5°C per minute. Table 10 summarizes technical data on all these chambers.



*Figure 28: Espec ESZ-4CA Thermal Chamber* 

<b>Manufacturer</b>	<b>Tenney Space</b> <b>Simulation</b> <b>System</b> (3.2.1)	$PV/T$ Inc. (3.2.2)	<b>Altitude Bell</b> Jar (3.2.3)	Espec ESA- 4CA (Qty. 2) (3.2.4)	<b>Vacuum Test</b> Stand (3.2.5)
<b>Inside</b> <b>Dimensions</b>	2 feet diameter x 2 feet long	7 feet diameter x 12 feet long	$1.5$ feet diameter x 1.5 feet long	3 feet diameter x 3 feet long	Up to $22$ inches diameter
<b>Minimum</b> <b>Pressure</b>	$5 \times 10^{-6}$ torr	$8 \times 10^{-2}$ torr	$1.4 \times 10^{-1}$ torr	N/A	$1 \times 10^{-6}$ torr
<b>Temperature</b> Range	$-75^{\circ}$ C to $+100$ °C	Heat lamps used if needed	N/A	$-70$ °C to $+150$ °C	N/A
<b>Pump Type</b>	Turbo	Mechanical	Mechanical	N/A	Turbo
<b>Clean</b> <b>Environment?</b>	Yes	N <sub>o</sub>	N <sub>o</sub>	Yes	N <sub>0</sub>

*Table 10: Building F-10 Thermal Chamber Summary* 

#### **3.2.5 Vacuum Test Stand (Building F-10)**

The Vacuum Test Stand is a purpose-built apparatus for testing the Sounding Rocket Program's shutter doors and sealed skin sections. Shutter doors of 22 inches and 17 inches diameter can be checked to

ensure they will hold the required vacuum throughout the mission lifecycle and flight, as well as seal after opening and closing on the ground and in flight. Various sealed skins and sealed payload sections are also tested for vacuum capability on the test stand. In addition, the test stand can check for leaks; if a sealed system has an unacceptable leak rate, the test stand can be used to assist technicians by locating the source of the leak with its integrated helium leak check.



 *Figure 29: Vacuum Test Stand* 

#### **3.3 Environmental Test Chamber (Building E-109)**

The Environmental Test Chamber (Model T5ST) from Lunaire LTD Tenney Environment Inc., shown in Figure 30, is a small temperature-controlled chamber used for thermal conditioning of small components. The portable chamber loads through a front opening door that has a viewing window. The instrumented payload is installed in the chamber with no special handling or mounting fixtures and is connected to the ground support equipment via a port.

Typically, temperature is set prior to setting pressure. The payload is heated or cooled to the desired temperature with air in the chamber and remains for an hour or more. Then the pressure is set, and the temperature may change toward ambient.

The chamber uses room air. There is a manual system to add dry air to the chamber once closed to minimize the humidity in the chamber. If this is not done, frost almost certainly will appear inside the chamber at below freezing temperatures. Even with the dry air purge it is possible for a small amount of frost to form.



*Figure 30: Environmental Test Chamber Model T5ST* 

The chamber has a 55-pin pass-through connector for users to make harnesses for inside and outside the chamber. The connectors are such that the internal and external connectors can be mated for bench testing. There is also a terminal strip with approximately 25 lines for quick and simple pass-through. There is a pass-through connector consisting of Ethernet CAT 6, FireWire, and USB-C cables, with lengths of about 4 feet inside the chamber and about 6 feet outside the chamber. All connections except the terminal strip are mounted on ISO NW100 LF plates; users can make custom pass-throughs using their own ISO NW100 LF plates. Table 11 lists the chamber specifications.





#### **3.4 Vibration Test Facilities (Building F-10)**

An overview of the vibration test facility in Building F-10 is shown in Figure 31.



*Figure 31: Building F-10 Vibration Facility* 

There are four shakers used for component and payload vibration tests at Wallops with the technical information shown in Table 12. Figure 32 shows a typical test setup. Figure 33 shows the Unholtz Dickie (UD) Small Chamber.



*Figure 32: Vibration Table* 



*Figure 33: UD Small Chamber* 



#### *Table 12: F-10 Shaker Specifications*

**NOTE:** The F-10 Shaker test facilities have 11-inch cube fixtures available for testing small components in all three axes by mounting the test article in different orientations. In addition, Wallops can support design and fabrication of custom vibration fixtures to interface between the test article and shaker head.

At the engineer or principal investigator's request, sensors can be mounted to components or areas of interest. F-10 Shaker test facilities have 16-channel capability; through this in-test data and the vibration control software, test profiles can be force limited to prevent damage to the test article. Specific test profiles, including reduced inputs at given frequencies (notching), can be created using the vibration control software as well.

## **3.5 Vibration Test Facilities (Building E-109)**

There is an additional vibration test facility in Building E-109, as described in Table 13 and shown in Figure 34.



#### *Table 13: E-109 Vibration Test Facilities*



*Figure 34: Vibration Test* 

## **3.6 Balancing Machines (Static and Dynamic) (Building F-10)**

At Wallops, a Gisholt Rocket Balancing Machine, shown in Figure 35, is used to balance sounding rocket payloads.

This machine's specifications are listed in Table 14:

#### *Table 14: Balancing Machine Specifications*





*Figure 35: Balancing Machine* 

## **3.7 Mass Properties Measurement System (Building F-10)**

The Environmental Testing and Evaluation Group at NSROC is equipped with an Airdyne Mark 8 mass properties measurement system shown in Figure 36 through 37. This unit is used for measuring center of gravity (CG) locations and moments of inertia (MOI) on sounding rocket subsystems and payload stacks. Important technical data is shown in Table 15:







 *Figure 36: Mass Properties Measurement System* 



*Figure 37: Mass Properties Measurement System* 



*Figure 38: Mass Properties Measurement System* 



*Figure 39: Mass Properties Measurement System* 

## **3.8 Spin Deployment Facility (Building F-10)**

Payloads with deployable booms, nose cones, doors, etc. can be tested for proper operation using the spin deployment and separation chamber located in Building F-10, as shown in Figure 40. The rotary table can spin a payload to a rate of 20 RPS while withstanding an imbalance of up to 3,000 ft-lb. 5 feet above the table surface. The chamber is equipped with a heavyduty Kevlar® tarpaulin around the rotary table for catching deployed components. There are also video cameras mounted on the chamber walls for recording and timing the deployment events. Pyrotechnic release devices can be activated by connecting lead wires through a 20-channel slip ring that allows the table to rotate while maintaining electrical continuity.



*Figure 40: Spin Deployment Facility* 

## **3.9 Bend Test Facility (Building F-10)**

Every sounding rocket payload is subjected to a bend test to determine the overall stiffness of the body. This information is used by the Flight Performance Group to verify payload stability during flight. The bend test fixtures in F-10 consist of a base plate mounted to the concrete floor and a pneumatic linear actuator mounted to a steel I-beam pillar. The pistons are equipped with load cells, which are used to measure and control the applied load. The aft end of the payload is fastened to a base plate, and the actuator's position along the pillar can be adjusted to the proper height on the payload being tested. Land surveying equipment is used to accurately measure the tip deflection of the payload as the actuator applies lateral loads in both directions. Table 16 lists the fixture specifications. Figure 41 shows a typical test setup.

#### *Table 16. Bend Test Fixture Specifications*





*Figure 41: Bend Test Fixture* 

## **4 PAYLOAD FABRICATION, INTEGRATION & TESTING**

## **4.1 Payload Fabrication (Building F-10)**



#### *Figure 42: Fabrication Facility*

Wallops has a fully equipped machine shop in Building F-10, as shown in Figure 42 and Figure 43, that can provide electronic, electrical, and mechanical support. The 26,000-square-foot machine shop includes a large selection of Computer Numerical Control (CNC) mills and lathes, manual machines, sheet metal fabrication, welding, and heat-treating facilities. Capabilities include full computer-aided design and manufacturing (CAD/CAM) implementation in developing and fabricating mechanical systems, optical instrumentation, and payload components for flight research. The fabrication area performs functions such as sounding rocket launcher refurbishment, design and fabrication of mobile telemetry and mobile radar support vans and antenna systems. The machine shop includes mechanical technician areas for assembly of scientific sounding rocket payloads. While the facility primarily supports the Sounding Rocket Program, it regularly supports other NASA and reimbursable projects. The facilities are managed through the NSROC.



*Figure 43: Fabrication Facility* 

## **4.2 Attitude Control System Testing (Building F-10)**

Wallops supports Attitude Control System (ACS) testing for subsystems such as IMUs, star trackers, magnetometers, sun sensors, reaction wheels and torque rods. High intensity light sources in a clean room may be used to examine sun sensors. A star simulator is available for star tracker functional verification. A single axis rate and magnetic torque table are available with hand crank for basic verification of reaction wheels, torque rods, accelerometers, and IMUs. The Magnetic Calibration Facility in Building F-10, shown in Figure 44 and Figure 45, may be used for magnetometer and torque rod testing. The Magnetic Calibration Facility is used to conduct magnetic calibration of magnetometers on sounding

rocket payloads and to perform functional tests on magnetic attitude control systems. When required, magnetic calibration tests are done – generally for all payloads with magnetometers except those in which the magnetometers are used as roll or yaw indicators. The testing equipment consists of a three axis, 40-foot square Braunbek system which can cancel the effects of the Earth's magnetic field and then generate a test field in any direction. Technical data are listed in Table 17:



*Figure 44: Magnetic Calibration Facility* 

*Table 17: Magnetic Calibration Facility Specifications* 

<b>Physical Dimensions:</b> <b>Access Opening</b>	8 feet 8 inches high by 7 feet 5 inches wide
<b>Static Field Environment:</b>	
Magnitude (each axis)	$\pm 100K$ Gamma
<b>Step Resolution</b>	$\pm$ 3.7 Gamma
Stability	$\pm 10$ Gamma / minute for first 30 minutes
	$\pm$ 3 Gamma / minute after first 60 minutes
Homogeneity	0.02% 6-foot spherical diameter
<b>Dynamic Field Environment:</b>	
Magnitude	$+60K$ Gamma
Frequency	10 Hz (although 10 Hz to 100Hz $@1K$ Gamma has been performed)
<b>Turntable</b>	4-foot diameter
<b>Coil Orthogonality</b>	1.8 arcminutes
<b>Fields</b>	Earth, 0 to 15 Volts direct current $(DC)$ , 0 to 25 Amps Test (3-axis), 50 Volts DC, $\pm 8$ Amps Gradient 15 Volts DC, 6 Amps
<b>Payload Dimensions</b>	22 inches diameter structure maximum 172 inches maximum height from fixture to upper limit of theoretical "sphere" the test instrument must fall within
<b>Payload Mass</b>	Orthogonality within $0.05^{\circ}$ 800 lbs. mass limit



*Figure 45: Magnetic Calibration and Testing* 

## **4.3 Sounding Rocket Payload Integration (Building F-10)**

Building F-10 has three independent payload I&T areas (see Figure 46 and Figure 47 for representative facilities).

Payload integration is the first-time assembly of all the parts and pieces with experiment hardware into the launch configuration. All aspects of the design and operation are checked including mechanical fit and operation, telemetry and electrical systems operation, and systems compatibility. Pretesting sequence tests are performed to ensure the event-programming system functions properly. Each I&T area has its own independent telemetry ground station. The telemetry ground station can support multiple links for all systems flown.



*Figure 46: Payload Integration and Testing* 



*Figure 47: Payload Integration and Testing* 

## **4.4 Solar Simulator (Building E-109)**

This solar simulator is based on a Fresnel lens to collimate the light beam from the 3.0 kilowatts (kW) Xenon short arc lamp source, resulting in highly collimated illumination of the target spot. The spectral distribution of the xenon light source, along with the use of specially calibrated air mass filters, closely simulates the Sun's true spectral distribution in various conditions on Earth.

This is a single star simulator, shown in Figure 48, with features described in Table 18 and Table 19:

#### *Table 18: Solar Simulator Specifications*

Location: Building E-109

Canadian optics with ultraviolet (UV) browning plastic

3 kW Fresnel Lens,

Xenon Lamp Solar Simulator

11-inch beam diameter

 $\sim$ 1350 W/m<sup>2</sup> maximum output

Two-axis gimbal and linear actuators available





#### *Figure 48: E-109 Solar Simulator*

#### *Table 19: Gimbal Specifications*



#### **4.5 SmallSat and Balloon Payload Integration (Building F-7)**

Wallops Flight Facility Building F-7 (Figure 49 and Figure 50) houses the main base SmallSat and Balloon payload integration facilities.

Figure 51 shows supplemental integration workspace that supports work station setup for small mission I&T as well as thermal vacuum testing.



*Figure 49: Integration and Test (Building F-7)* 



*Figure 50: Integration and Test (Building F-7)* 



*Figure 51: Building F-7 Supplemental Integration Workspace* 

## **4.6 Payload Processing Facility**

The Payload Processing Facility (PPF), H-100, is located outside Wallops Main Gate behind the Marine Science Consortium.

There are two Class 100K clean rooms, one high bay and one low bay with adjoining work spaces supported by redundant chillers for high reliability. The spacecraft launch control center, located adjacent to the high bay, has pass-throughs for GSE cabling and tools, as well as a display for visibility during spacecraft fueling integration and launch. The PPF has an extensive flexible support capability, as shown in Figure 52, that boasts bridge cranes, scissor and fork lifts, pressurized commodity systems for clean nitrogen, helium, and air, secure access and 24 hour video surveillance, visitor area, staging pad, and other support amenities. Office space for the payload team is available with 24 cubicles, kitchen adjacent conference room with observation windows overlooking the payload bays.



*Figure 52: Payload Processing Facility* 

## **4.7 SmallSat Multi-Payload Processing Facility (Building F-7)**

The Multi-Payload Processing Facility (MPPF, Building F-7) includes a minimum of two dedicated lab spaces for the purpose of small satellite assembly, integration, and test, as shown in Figure 53 and Figure 54. Lab spaces include full electrostatic discharge (ESD) work-stations and clear work areas including multiple laminar flow benches, a small thermal chamber and other small-scale test equipment. One lab space includes a dedicated optical bench work area to support development and assembly, integration and test activities for optical experiments and subsystems.

Adjacent workspaces in the MPPF available to support small satellite



*Figure 53: SmallSat Lab* 

processing include the F-7 thermal vacuum chamber, an EMI/EMC chamber, and an Anechoic chamber for antenna pattern testing. In addition, there are temporary office workspaces, as shown in Figure 55, for visiting project personnel including conference capabilities, and open work areas for larger assembly work and a small machine shop.





*Figure 54: SmallSat Lab Figure 55: Supplemental Integration Workspace* 

#### **4.8 Rideshare Mission Integration Services (Building F-7)**

The east end of the MPPF has been configured to provide end-to-end small mission integration services, most recently demonstrated for the Landsat-9 Expendable launch vehicle Secondary Payload Adapter (ESPA) Flight System (L9EFS) project.

Custom I&T hardware, mechanical ground support equipment (MGSE), and electrical ground support equipment (EGSE), shown in Figure 56, Figure 57, and Figure 58, developed to support L9EFS are now available for future Rideshare mission support along with similar I&T hardware and capabilities for other complex special projects such as attached International Space Station (ISS) payloads and ESPA-class spacecraft. Facilities are ideal for receipt, inspection, and preparation of ESPA hardware, integration activity (payload-to-ESPA), and integrated ESPA pre-ship checkout prior to shipment to launch vehicle site.



 *Figure 56: Landsat 9 Integration* 

Facility capabilities to support Rideshare/ESPA and other mission I&T include a Class 100K clean room with internal Class 10K tent, an adjacent gowning area that includes equipment and cable pass-throughs (see Figure 60 and Figure 61), a receipt/shipping anteroom with airlock, adjacent support labs for equipment not required to be in the clean roomm and other supporting workspaces. The East I&T complex is also adjacent to the F-7 thermal vacuum chamber, the EMI/EMC chamber, a small machine shop, and available office space for visiting project personnel.



*Figure 57: Integrated ESPA ring prior to leaving Wallops (Building F-7)* 



*Figure 58: EFS Assembly Stand* 



*Figure 59: Clean Room Access Figure 60: Gowning Room Access*



*Figure 61: Building 7 Clean Room Gowning Area* 

## **4.9 High Bays (Building E-109)**

Building E-109 is equipped with two integration high bays, see Figure 62, – Room 158, or East High Bay and Room 159, or West High Bay. Both rooms are approximately 885 square feet each and both have a 5 ton monorail crane with a hook height of 17 feet. The crane in Room 158 is critical, and the crane in Room 159 is non-critical. Both rooms have large roll-up doors leading to the Building E-109 loading dock for equipment loading or off-loading. There is a large interior roll-up door allowing access from one high bay to the other for projects needing the extended space of both high bay rooms. Either room can be configured for ESD operations and cleanliness requirements can be met with project-provided portable flow hoods or portable clean tents.



*Figure 62: Building E-109 High Bays* 

## **4.10 High Bay East (Building F-7)**

Building F-7 High Bay East holds a Class 100K cleanroom with a Class 10K clean tent, see Figure 63 and Figure 64, with a 40-foot by 60-foot cleanroom with 20-foot by 40-foot Airlock/ Ante Room, and a 5-ton critical bridge crane with a 25-foot hook height and remote controls. High Bay East specifications are shown in Table 20**.** 



#### *Table 20: F-7 High Bay East Specifications*



*Figure 63: High Bay East Cleanroom Tent with ESPA ring integration ground support equipment in the foreground* 



*Figure 64: High Bay East Cleanroom* 

## **4.11 High Bay West (Building F-7)**

Building F-7 High Bay West, Figure 65, is where balloon payloads and Wallops Arc Second Pointer (WASP) systems are typically integrated. It is 1789 square feet and approximately 34 feet by 52 feet. Please see Table 21 below for specifications:

<b>Doors</b>	Rollup facing north and south
Cranes	Monorail with two five-ton trollies at 30-foot hook height
<b>Compressed Air</b>	Clean, dry, compressed air $(\leq 150 \text{ psi})$
Power	110V
<b>High Bay Dimensions</b>	34 feet by 52 feet
<b>High Bay Area</b>	1789 square feet
Location	Building F-7
Clean Work Area (CWA)	None

*Table 21: F-7 High Bay West Specifications* 



*Figure 65: High Bay West* 

#### **4.12 Balloon Research and Development Laboratory (Building F-7)**

The Balloon Research and Development Laboratory (BRDL) in Building F-7, Figure 66, is a specialized facility equipped with customized and unique tools and equipment to support the testing, research, and technology needs for terrestrial and planetary balloons, as well as other lighter-than-air structures. Laboratory resources include static and servo-hydraulic mechanical testing machines, see Figure 67,

equipped with customized sensors and accessories for characterizing thin polymeric films, plastics, fibers, cords, textiles, ceramics, metals, and composites. It is equipped with noncontact strain measurement equipment for testing inflatable structures and other components or subsystems using state-of-the-art equipment and accessories. Other capabilities include pressure systems equipped with various pressure gauges for characterizing inflated structures, environmental chambers for cryogenic and non-ambient testing, and an ultraviolet exposure facility for the assessment of environmental exposure effects on materials and components. The lab has a heat-sealing machine and tools for fabricating test articles as well as capabilities for testing model balloons and other inflatable structures. Staff design, test, calibrate and validate various sensors for inflight balloon performance and related measurements. The BRDL engineers and technicians routinely design and build customized testing tools to meet specific testing or research and development activities or needs. Various drafting and analytical tools are available for design and data analysis. The BRDL supports anomaly and technical investigations as needed and has supported various projects at Wallops and agency-wide.



*Figure 66. Balloon Research and Development Lab* 



*Figure 67. Balloon Research and Development Lab Mechanical Testing Facilities* 

## **5 ENGINEERING SUPPORT**

#### **5.1 Overview**

Engineering support at Wallops includes guidance navigation and control, missions systems engineering, mechanical systems, electrical, and systems software. The engineering team offers a broad range of skills in conjunction with Wallops' exhaustive array of I&T facilities. Wallops engineering provides an array of useful tools to support the life cycle of mission operations including pointing systems for balloon and ISS payloads such as the Wallops Arc Second Pointer (WASP, see Figure 68) and planning tools for small satellite and suborbital payloads in the Mission Planning Lab (MPL).



*Figure 68: Wallops Arc Second Pointer (WASP)* 

## **5.2 Mission Planning Lab (Building E-109)**

The Mission Planning Lab guides early-stage SmallSats through a weeklong study to turn a science concept into a feasible mission that gives the science team a solid foundation on which to build a competitive proposal. Since 2014, the MPL has worked with NASA SmallSat developers and their partners to provide services in systems engineering, 3D modeling, simulation, flight trajectory formulation, and more. The MPL has served mission concepts of all kinds, from formation flying proposals to deep space missions to Mars and Venus. Additionally, MPL has sub-orbital experience and works



*Figure 69: Mission Planning Lab* 

with sounding rockets, balloons, and other platforms. Over the course of one action-packed week, engineers across a range of specialties come together to meet with a mission's science team and crunch numbers. At the end of the process, scientists gain a better understanding of how to achieve their research objectives, and they come away with a valuable packet of information describing the technical details of their mission. Figure 69 shows team members meeting at the Wallops Flight Facility to plan key mission details and better understand technical requirements.

Before the study begins, MPL engineers ask the mission's principal investigator (PI) and team to fill out pre-work forms, detailing the mission's high-level characteristics, which can include mission class, cost, target launch date, instrument and data requirements, mass, and power. MPL staff meet repeatedly with mission leadership to choose team members for the study, set expectations, and gain more insight into the mission before the study begins.

The study launches on Monday morning. By the end of Monday, the team has pulled together the basic components of the mission through brainstorming sessions and whiteboard sketches. The team has also defined the concept of operations and key requirements. On Tuesday, the engineering team drafts a

preliminary baseline of the mission's components, including a computer-aided design (CAD) model. Extraneous capabilities get narrowed down, and the team streamlines the PI's wish list to the most important functionalities. Halfway through the study, engineers tackle any unexpected roadblocks and address risk as they refine subsystem models and run further analyses. Thursday brings the team together to tie up any loose ends and make sure each team member is apprised of the mission's details. With such a fast pace, it's important to regroup and review before the final day of the study. Any unfinished area of the baseline design is worked to closure by the end of the day. On Friday, the engineering team presents their completed mission design back to the science team. Beginning with a systems-level overview of the requirements and a description of the spacecraft, the presentation includes the life of the mission and a "day in the life." About a week later, the engineering team compiles the fruits of the study in a package with the presentation slides, a model of the satellite, images of brainstorming sessions from the whiteboard, charts, cost estimates, and any ancillary information the science team might find valuable moving forward.

#### **5.3 Interconnect Lab (Building E-109)**

The Wallops Electrical Engineering Branch Interconnect Lab (Room 273, see Figure 70) is responsible for fabrication, building, and testing of harnesses and circuit boards in support of multiple missions. Harness fabrication is performed by certified technicians for applications including ground support equipment, bench testing, environmental testing, flight line, and spacecraft. Harness testing may include thermal conditioning, pull tests, hi-pot tests (over 1500 V DC), and automated continuity tests. Board population and repair may be performed in this lab, along with enclosure customizations with an in-lab drill press and engraving machine.



*Figure 70: Interconnect Lab (Building E-109)* 

#### **5.4 Prototype Lab (Building E-109)**

The Mechanical Systems Engineering Branch Prototype Lab, shown in Figure 71, provides capabilities to rapidly build prototype parts to test form, fit and function. This lab has been used on many missions ranging from large spacecraft like Global Precipitation Measurement (GPM) to small electrical boxes for test components on balloon and sounding rocket missions. The Prototype Lab hosts a 3D printer which

enables large build volumes and capabilities to print various types of plastics. Small parts can be printed alone or with other small parts simultaneously to fill the volume. Larger pieces can be sectioned, and individual parts can be built and assembled to prototype larger components. After all the parts are printed, they are assembled in this area either on a shop bench or on a clean horizontal work bench.



*Figure 71: Prototype Lab (Building E-109)* 

#### **5.5 3-D Printer (Building E-109)**

The E-109 Stratasys F370 3-D Printer, shown in Figure 72, is operated by the Mechanical Engineering group and is and located in E-109. Capabilities include the use of three different build materials and their

respective properties to meet the needs of the user. The F370 can provide different layer thicknesses, as the part is fabricated. The layer thickness ranges from .005" to .013" (layer thickness varies with material). Parts can be fabricated within a tolerance range of +/-.002". The printer uses Grab CAD software to upload and select setting to ensure proper build properties and orientation for printing to capture key features of the part.

The printer system consists of two extrusion heads, one for



*Figure 72: E-109 3-D Printer* 

model material, and another for support material. The printer features four primary/backup material bays for build and support materials, which allow for an autonomous and continuous, build of a part within the reusable envelope. The F123 series printer utilizes four different extrusion heads that can switched out to accommodate different print material. Materials include: Acrylonitrile Butadiene Styrene Material (ABSM); Polycarbonate-ABS alloy (PC-ABS); ABS-ESD7, which combines the strength and durability of ABS material with carbon to provide electrostatic dissipative (ESD) properties; acrylonitrile styrene acrylate (ASA); Polylactic Acid (PLA); and Thermoplastic Polyurethane (TPU). See Table 22 for a summary of printer capabilities.





Note: The E-109 vibration table (see section 3.5) is located in the Prototype Lab.

#### **5.6 Machine Shop (Building E-109)**

The mechanical fabrication shop is outfitted with various types of machining equipment to support manufacturing of test parts and rapid modification of flight hardware if needed. Hand tools and benches allow modest changes that need quick turnaround, like tapping threads or enlarging holes on mating parts. Standard manual tooling machines allow technicians to create or modify components with general tolerances. The lab is also equipped with a CNC mini-mill for higher precision parts that require tight tolerances.

## **5.7 Software Development (Building E-109)**

Wallops develops flight and ground data systems for sub-orbital and special orbital Earth and space science missions. The software development team performs prototyping in collaboration with other NASA and Government organizations, universities, and commercial partners to advance the state of the art in implementation of its functions and related technologies.

The Systems Software Engineering Lab (Building E-109, Room 268, as shown in Figure 73) is a software development lab that also provides the capability to test range data systems prior to installation in an operational environment. In the lab are copies (hardware and software) of range data systems that are used to process range data during missions. The lab has access to data on the Range Mission Network, serial and ethernet Radar Data, and Range Data acquisition and Computation (RADAC) mission graphics data and slaving data, as well as Range Timing – including American Standard Code for Information Interchange (ASCII) time, IRIG-B and pseudo IRIG-B/Countdown time. The lab has the ability to record data for future playback. The lab also has the capability to play customer provided Chapter 10 files via telemetry systems located in the lab. An example of lab use is a range customer that utilizes software engineering personnel and the Systems Software Engineering lab to develop and test custom telemetry data display systems prior to use during their launches. The use of the software engineering lab for development and testing provides capability independent from the range and greatly reduces the stress on the range real-time operations team which may be supporting other projects or preparing for other operational support.



*Figure 73: Software Development Lab (Building E-109)* 

## **6 OTHER SUPPORT SERVICES**

## **6.1 Assembly and Processing Facilities**

Wallops Island has the assembly and processing facilities described in Table 23.

#### *Table 23: Assembly and Payload Processing Facilities Wallops Island*





## **6.2 Aircraft Operations Hangar (Building D-1)**

The Aircraft Operations Hangar, Building D-1 (see Figure 74, Figure 75 and Figure 76) has hangar, office, and shop space of varying size and location available for approved aircraft projects. Maintenance personnel should accompany project and research and development (R&D) aircraft when engaged in flight operations at Wallops.

Fuel services are available for U.S. Government program aircraft during normal working hours and after hours by prior arrangement. Fuel is dispensed from trucks equipped with single point refueling fittings. The specifications for Building D-1 are shown in Table 24.



*Figure 74: Aircraft Operations Hangar (Building D-1)* 



*Figure 75: Aircraft Operations Hangar (Building D-1)* 



*Figure 76: Aircraft Operations Hangar (Building D-1)* 





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## **6.3 Aircraft Hangar (Building N-159)**

Hangar and office space are available for approved aircraft projects and vary in size and location. Since Wallops is equipped to support only minor or limited repairs to transient aircraft, maintenance personnel should accompany project and R&D aircraft when engaged in flight operations at Wallops. The N-159 Aircraft Hangar is primarily used to support and maintain NASA aircraft. Due to the number of NASA aircraft housed in this hangar there is limited availability to support additional aircraft.

The specifications for Building N-159 are shown in Table 25:







## **6.4 MARS/VCSFA**

The Virginia Commercial Space Flight Authority (VCSFA), also known as 'Virginia Space,' is a political subdivision of the Commonwealth of Virginia. Virginia Space owns and operates the Mid-Atlantic Regional Spaceport (MARS), MARS Unmanned Aircraft Systems (UAS) Airfield, MARS Payload Processing Facility, MARS Integration and Control Facility, and soon-to-be MARS Port.

Virginia Space aims to provide and is proud to offer full-service launch and drone testing facilities for commercial, government, scientific and academic users, including the Northrop Grumman Antares vehicle (see Figure 77).

The mission of Virginia Space is to serve as a driver for Virginia's New Economy by providing safe, reliable, and responsive space access at competitive prices, and secure facilities for testing of unmanned vehicles for integration into the National Air Space.



*Figure 77: The Northrop Grumman Antares vehicle, on its way to the commercially operated MARS launch pad* 

#### **6.5 Unmanned Aircraft Systems Airfield**

The Mid-Atlantic Regional Spaceport's UAS Airfield, shown in Figure 78, conducts operations including training for first responders, student outreach including ThinSat flights, NASA Langley Research Center

(LaRC) test flights, numerous 14 Code of Federal Regulations (CFR) Part 107 flights involving aerial imagery; environmental and wildlife monitoring, DoD projects and FireScout Training Detachments. This airfield services both commercial and government customers regularly. Attributes of the UAS Airfield are listed in Table 26 and shown in Figure 79 and Figure 80.



*Figure 78: MARS UAS Airfield* 







*Figure 79: 3,000-foot x 75-foot UAS Runway Figure 80: Concrete vertical takeoff and landing* 



 *(VTOL) Pad rated to 5,000 psi* 

#### *UAS Hangar Bay*

The UAS Hangar Bay, shown in Figure 81, has attributes as listed in Table 27.

#### *Table 27: UAS Hangar Bay Specs*



Special use airspace and frequency management



 *Figure 81: MARS UAS Airfield HVAC Conditioned Hangar* 

#### *Ready Room Adjacent to Hangar Bay*

A 'Ready Room' next to the Hangar Bay (see Figure 82) includes the capabilities described in Table 28.

*Table 28: Ready Room Specs*  NASA closed circuit television Weather channels Phone lines

Closed network airfield cameras

Conference table

Work desk area

Next Generation Land Mobile Radios (NGLRM): equipped with KWAL tower communications channel and dedicated airfield operations channel VHF/UHF common traffic advisory frequency (CTAF) capable



*Figure 82: Ready Room Adjacent to Hangar Bay*

#### *Ramp Area*

The ramp area adjacent to the UAS Airfield, as shown in Figure 83, encompasses the facilities described in Table 29.

#### *Table 29: Ramp Area Specs*

55-foot Antenna tower Network switches with multiple cables from top to bottom, configurable

DB9, coax, Cat5 etc.

110 volts convenience power to top

240 volts at bottom

Auxiliary items

Wash-down pad capable of holding MH-60 Seahawk

550-gallon water tank

Mobile air-conditioned restroom facility



*Figure 83: MARS UAS Airfield Ramp Area* 

#### *Direct Access to R6604 Restricted Airspace*

The Special Use Airspace (SUA) access is a NASA-controlled restricted airspace R-6604 with over 300 square nautical miles (NM) of restricted airspace (see Figure 84). The Patuxent River Atlantic Test Range (ATR) has a test track A, B, C, and D, with over 1,500 square NM of SUA. The Fleet Area Control and Surveillance Facility (FACSFAC) Virginia Capes Operating Area (VACAPES) have over 25,000 square NM of SUA. Virginia Capes offers DoD/government customers access to warning areas beyond the test track from surface to space including W-386, W-387 and W-72.



 *Figure 84: Direct Access to R6604 Restricted Airspace* 



## **6.6 MARS Payload Processing Facility**

*Figure 85: MARS Payload Processing Facility* 

The VCSFA Payload Processing Facility (Figure 85) shows an external overview; (see Figure 86, Figure 87 and Figure 88 for views of the interior) has capabilities such as multiple segregated processing spaces, payload integration and fueling, and stage integration. The PPF building is designed to separately process the launch vehicle (LV) and spacecraft (SC). The integration area is built to ISO 8 (100K) clean room standard as well as to Intelligence Community Directive (ICD) 705. The PPF also includes multiple overhead cranes including an overhead processing, a 30-ton crane with a 60' hook height in the vertical integration area, and a dual 15-ton with a 30-foot hook height in the horizontal integration area.



*Figure 86: MARS Payload Processing Facility Solid Motor Processing Bay* 



*Figure 87: MARS Payload Processing Facility Secondary Payload Processing Bay* 



*Figure 88: MARS Payload Processing Facility Control Systems* 

#### **6.7 MARS Port**

The MARS port is planned for construction between 2022 and 2024. Figure 89 shows a summary of proposed upgrades, which will include unmanned underwater vehicle (UUV) and underwater surface vehicle (USV) capability. It will provide opportunities for unmanned and intermodal research and continue science, technology, engineering and mathematics (STEM) outreach/workforce development in technical jobs. The MARS port will also permit the transportation of oversized and hazardous cargo via waterways versus rail and roads. Anticipated activities include inter-governmental test and operations with the Navy, DoD, National Oceanic and Atmospheric Administration (NOAA), NASA, state institutions, research partners, and the Federal Aviation Administration (FAA). The MARS port will enable classified advancements that improve interoperability, redundancy, and research in our nation's transportation system.



*Figure 89: UUV/USV Port Upgrade Summary* 

#### **6.8 Mission Operations Control Center**

The Mission Operations Control Center (MOCC) is a \$16 million, 14,174 square-foot building on the Wallops main base, which serves as the hub for interfacing with and controlling rockets, their payloads and associated launch pad support systems during flight operations at Wallops.

## **6.9 Integration and Control Facility**

The Integration and Control Facility (ICF, shown in Figure 90) construction began in November 2019 and had a Certificate of Occupancy by November 2020. It is the first facility in the Wallops Business Park and sets the standard for future commercial activities in this area. It is currently leased to Rocket Lab by the VCSFA. The integration space is used for the integration of electron launch vehicles. The facility includes a mission control room as well as an office space.



*Figure 90: Integration and Control Facility (ICF)* 

# **APPENDIX A: ABBREVIATIONS AND ACRONYMS**





