

Chapter 5 Research Systems Descriptions

5.1 Structural Modifications

5.1.1 Aperture Pads and Plates

Note: All dimensions shown below are referenced to standard fuselage reference lines: Left and Right Buttock Lines (LBL, RBL and BL); Water line (WL) and Fuselage Station (FS).

Six inlet aperture pads have been installed on the upper fuselage of the GV. Each of these pads is 10 inches long and 7 inches wide, and a drawing showing the inlet aperture pad design is shown in Figure 5.1.

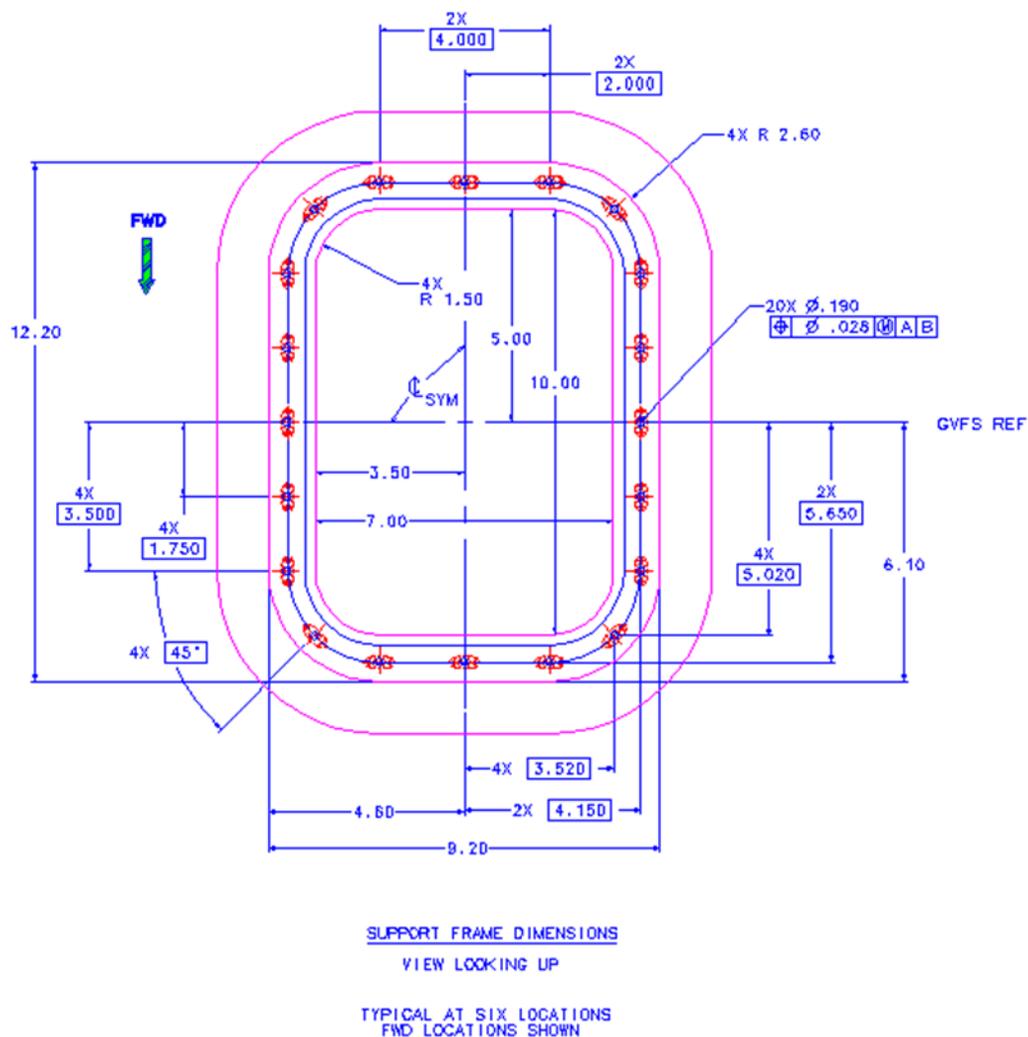


Figure 5.1: Drawing of GV inlet aperture pad

Specific locations of the pads on the upper fuselage are as follows:

- Pad #1: GVFS 255.5, LBL 13.91

- Pad #2: GVFS 255.5, RBL 13.91
- Pad #3: GVFS 328.5, BL 0.0
- Pad #4: GVFS 434.0, LBL 14.84
- Pad #5: GVFS 498.0, RBL 14.84
- Pad #6: GVFS 532.0, LBL 21.7

Figure 5.2 shows the locations on the aircraft of the six inlet aperture pads.

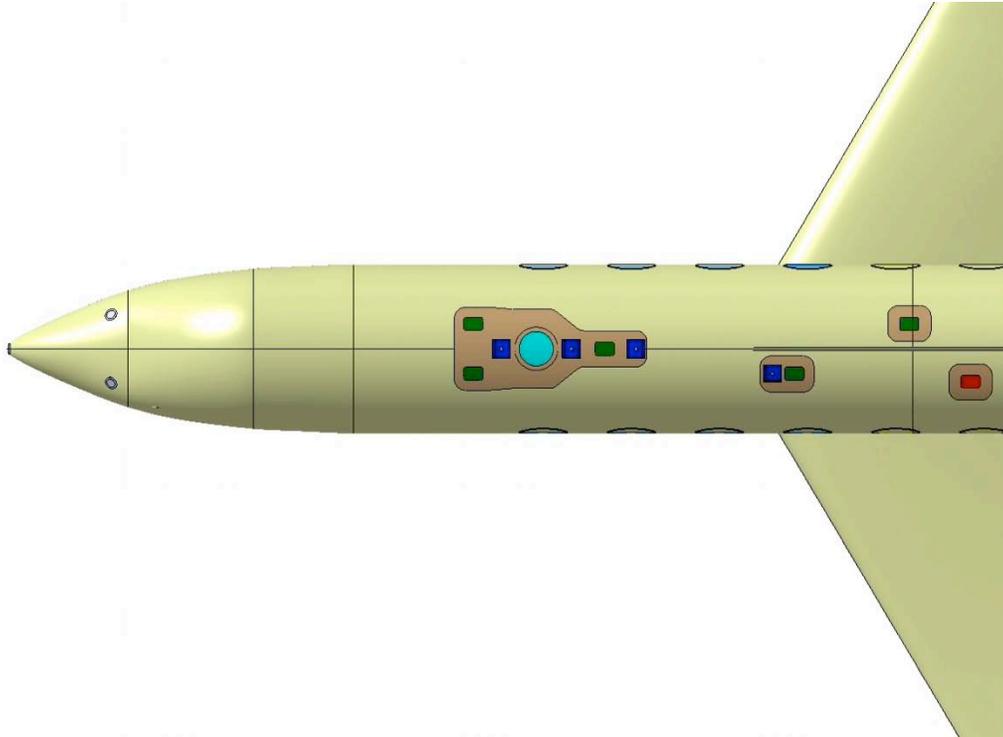


Figure 5.2: View of GV upper fuselage, showing inlet aperture pads (green and red), optical view port (light blue), fuselage mounts (dark blue), and two forward fuselage pads below windscreen (grey circles). Drawing courtesy of Lockheed Martin.

In addition to the inlet aperture pads installed on the upper fuselage, two instrument aperture plates are installed on the lower fuselage at the following locations:

- Plate #1: GVFS 250.0, LBL 9.0
- Plate #2: GVFS 250.0, RBL 9.0

The instrument aperture plates are similar in design to the inlet aperture depicted in Figure 5.1, above. Figure 5.3 below shows the locations of the two lower fuselage instrument aperture plates.

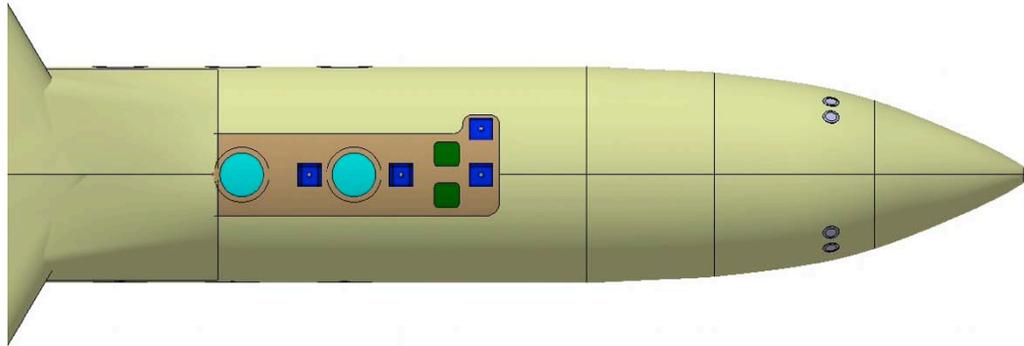


Figure 5.3: View of GV lower fuselage, showing instrument aperture plates (green), optical view ports (light blue), fuselage mounts (dark blue), and four forward fuselage pads (grey circles). Drawing courtesy of Lockheed Martin.

5.1.2 Fuselage Mounts

Eight fuselage mounts are installed on the GV fuselage, with four on the upper fuselage and four on the lower. Six of the upper and lower mounts are installed at various locations on the aircraft centerline, and one each of the upper and lower mounts are installed off of the centerline. Each of the mounts is 4.25 inches long and 3.0 inches wide and has a 1.75-inch diameter hole in the center of the mount to which a second plate can be mounted externally to attach inlets, bulkhead feed-through connectors, or lugs for securing fairings. Figure 5.4 and Figure 5.5 show a fuselage mount and a second (instrument attachment) plate, respectively.

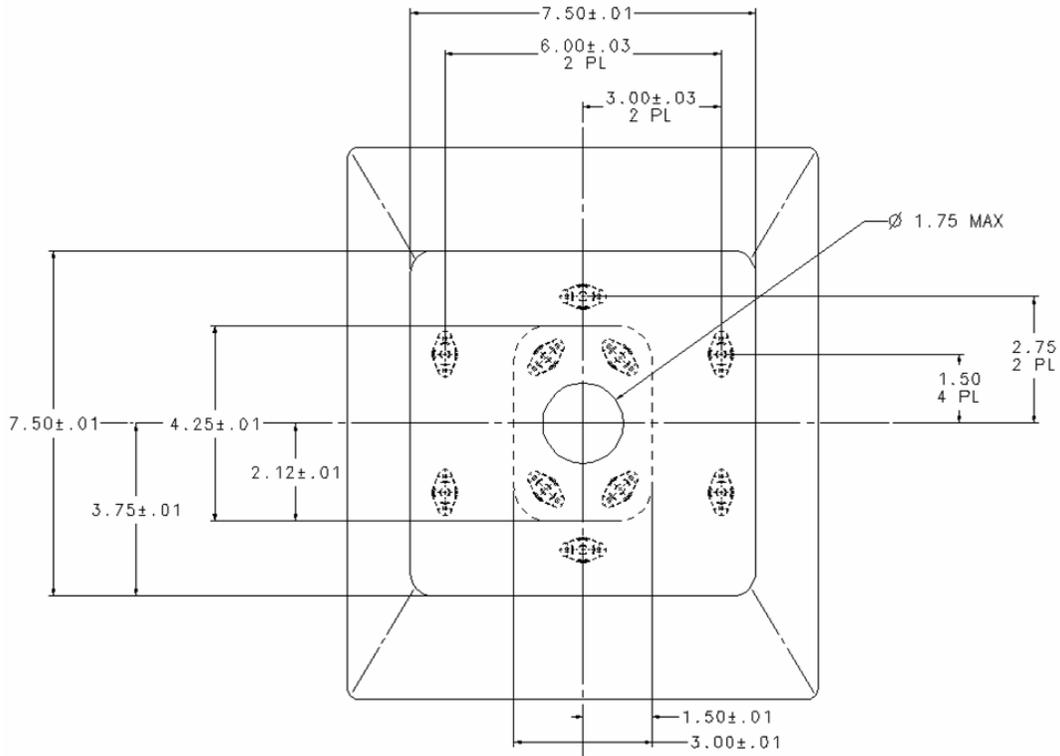


Figure 5.4: Drawing of GV fuselage mount

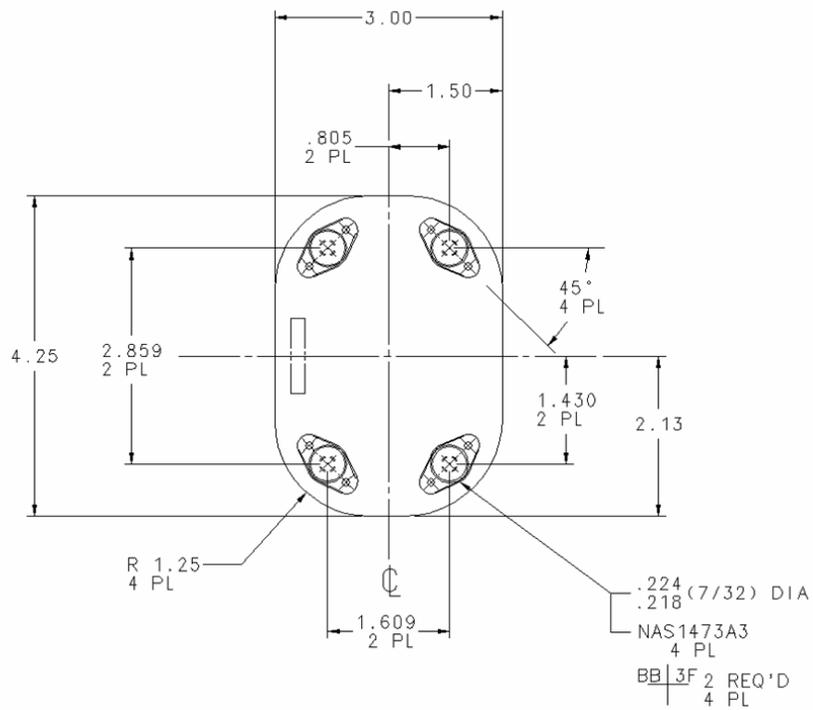


Figure 5.5: Drawing of GV fuselage mount connector plate

Locations of the fuselage mounts are as follows:

- Upper mount #1: GVFS 271.0, BL 0.0
- Upper mount #2: GVFS 310.0, BL 0.0
- Upper mount #3: GVFS 346.0, BL 0.0
- Upper mount #4: GVFS 421.8, LBL 14.8
- Lower mount #1: GVFS 235.0, BL 0.0
- Lower mount #2: GVFS 235.0, LBL 19.97
- Lower mount #3: GVFS 270.91, BL 0.0
- Lower mount #4: GVFS 310.23, BL 0.0

Positions of the upper and lower fuselage mounts are shown in Figure 5.2 and Figure 5.3, respectively.

5.1.3 *Forward Fuselage Pads*

Six forward fuselage (nose) pads have been installed on the NSF/NCAR GV. Four of the pads (two on each side) are located on the sides of the forward fuselage, and the remaining two are located on the upper section of the forward fuselage directly below the aircraft windscreen. Each forward fuselage pad is a mounting plate 4.75 inches by 4.5 inches that has a 2.0-inch diameter hole in the center of the pad to allow for the mounting/internal clearance of a cylinder 2.0 inches in diameter and 4.0 inches in length. Each pad is attached to the aircraft fuselage with eight screws. Figure 5.6 shows one of the forward fuselage pads.

Fuselage locations of the forward fuselage pads are as follows:

- Left Side Pad #1: GVFS 54.0, WL 105.54, LBL 19.0
- Left Side Pad #2: GVFS 82.0, WL 65.8, LBL 27.95
- Left Side Pad #3: GVFS 82.0, WL 60.4, LBL 21.93
- Right Side Pad #1: GVFS 54.0, WL 105.54, RBL 19.0
- Right Side Pad #2: GVFS 82.0, WL 65.8, RBL 27.95
- Right Side Pad #3: GVFS 82.0, WL 60.4, RBL 21.93

Positions of the upper and side fuselage pads are shown in Figure 5.2 and Figure 5.3, respectively.

Five of the six forward fuselage pads (the four located on the sides of the forward fuselage and the left pad below the windscreen) have been used for the permanent installation of temperature, dew point, and pitot sensors on the aircraft.

+ DIA 5/32 PERMANENT FLUSH FASTENER

⊕ DIA 3/16 ADAPTOR/COVER PLATE FASTENERS

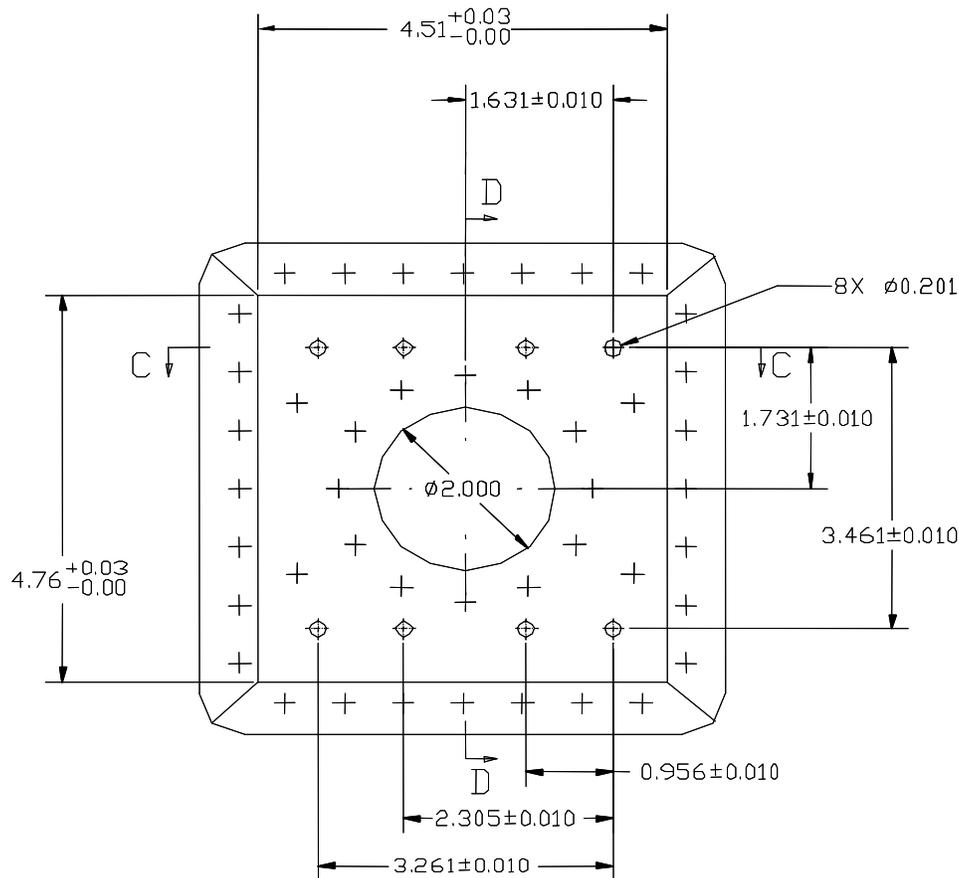


Figure 5.6: Drawing of GV forward fuselage pad

5.1.4 Optical View Ports

Three 20.5-inch diameter (also known as "large") optical view ports are installed on the aircraft centerline in the forward section of the GV fuselage. Two of the view ports are down-looking and one is up-looking. The forward down-looking and up looking-ports are aligned vertically. Additionally, this pair of view ports overlaps with the forward-most window on each side of the aircraft, thereby providing users with the opportunity to perform remote sensing measurements in the up-, down-, and side-looking directions from one instrument mount location. The view ports are designed to provide an unobstructed view from within the GV cabin to the exterior of the aircraft and to accommodate flat optical glass windows. Specific locations for the three optical view ports are as follows:

- Up-looking view port: GVFS 290.5, BL 0.0, WL 142.5 for internal mounting surface
- Forward down-looking view port: GVFS 290.5, BL 0.0, WL 58.25 for internal mounting surface

- Aft down-looking view port:GVFS 339.5, BL 0.0, WL 58.25 for internal mounting surface

Currently approved optical windows for the large viewports are double pane, have a 18 inch clear aperture and pane thickness of 26.5 mm. Material is IR-grade fused silica or quartz (Heraeus Infrasil 302 or equivalent, bubble class 0, index homogeneity < 6 ppm. RAF has windows with coatings optimized for 532, 940 and >1,400 nm wavelength and with broadband UV-VIS antireflective coatings (see Figure 5.7 and Figure 5.8 for details).

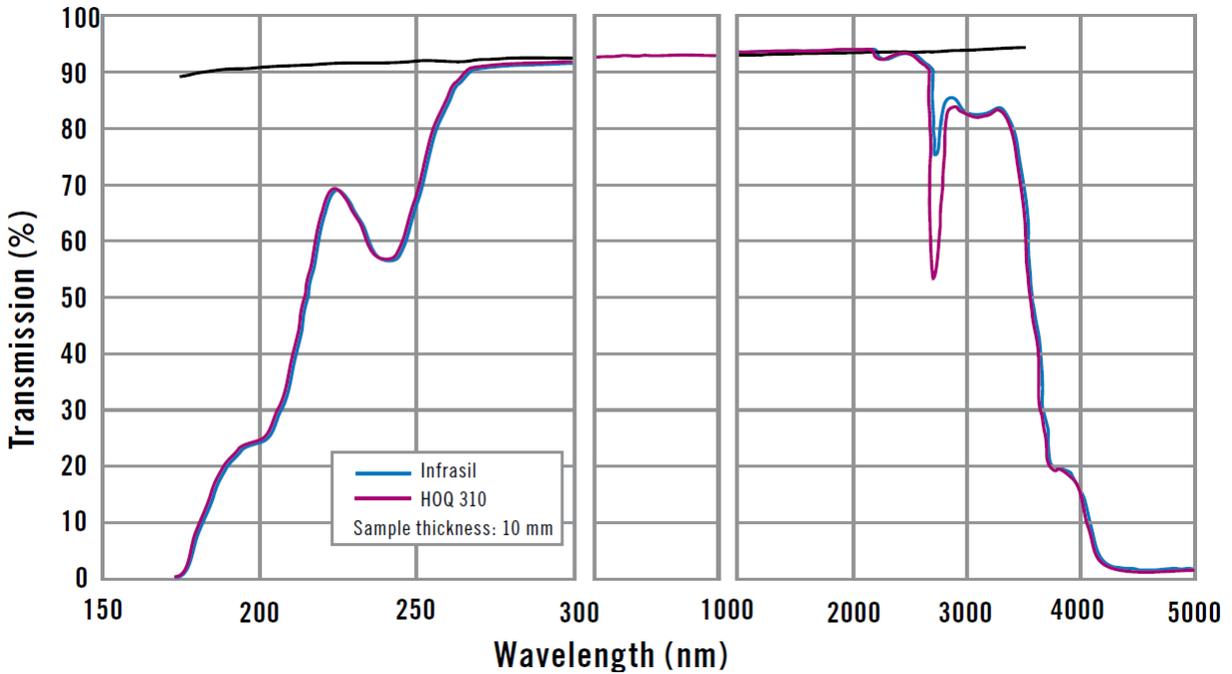
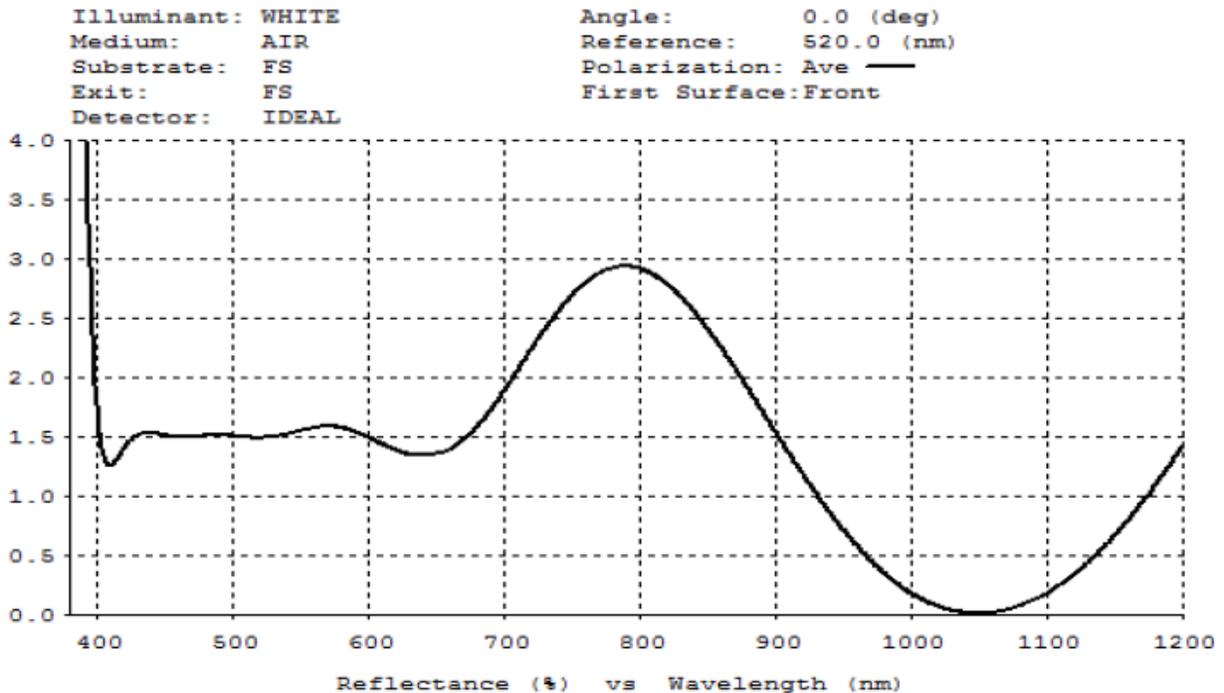


Figure 5.7: Transmissivity of a single, uncoated Infrasil 302 pane, 10 mm thick. (GV panels are 26.5 mm thick) 2 uncoated windows form one complete viewport.



BBAR 520nm plus 1064nm

Figure 5.8: One complete optical port is available with broadband visible anti-reflective coating with also very low reflectivity at 1064 nm. Theoretical curve.

Investigators requiring a different window material or a coating in a different spectral region should contact RAF for more information.

Figure 5.2 and Figure 5.3 above show the positions of the three view ports.

The aft lower viewport plate can support an external instrument/inlet weighing 36 pounds maximum with a center of mass located 10 inches from the aircraft skin. Limit drag and aerodynamic side forces are 60 pounds and 290 pounds respectively. A safety factor of 2 should be applied to aerodynamic limit loads for ultimate. Contact RAF Aeronautical Engineering for additional guidance.

In addition to the large viewports all of the aircraft inlet apertures (see Section 5.1.1) and window blanks (see Section 5.1.6) are capable of carrying a 9-inch oval glass pane (see Figure 5.9).

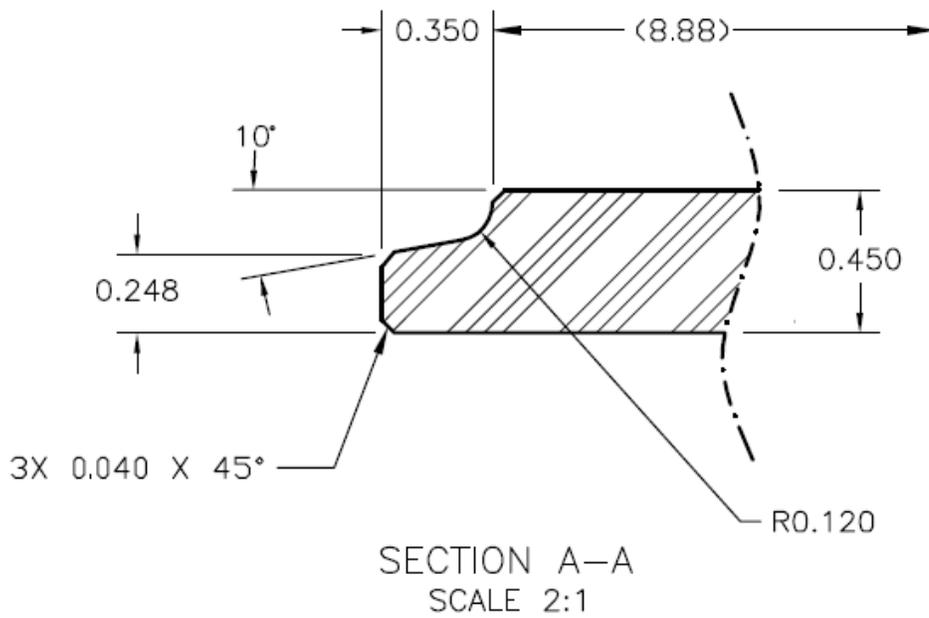
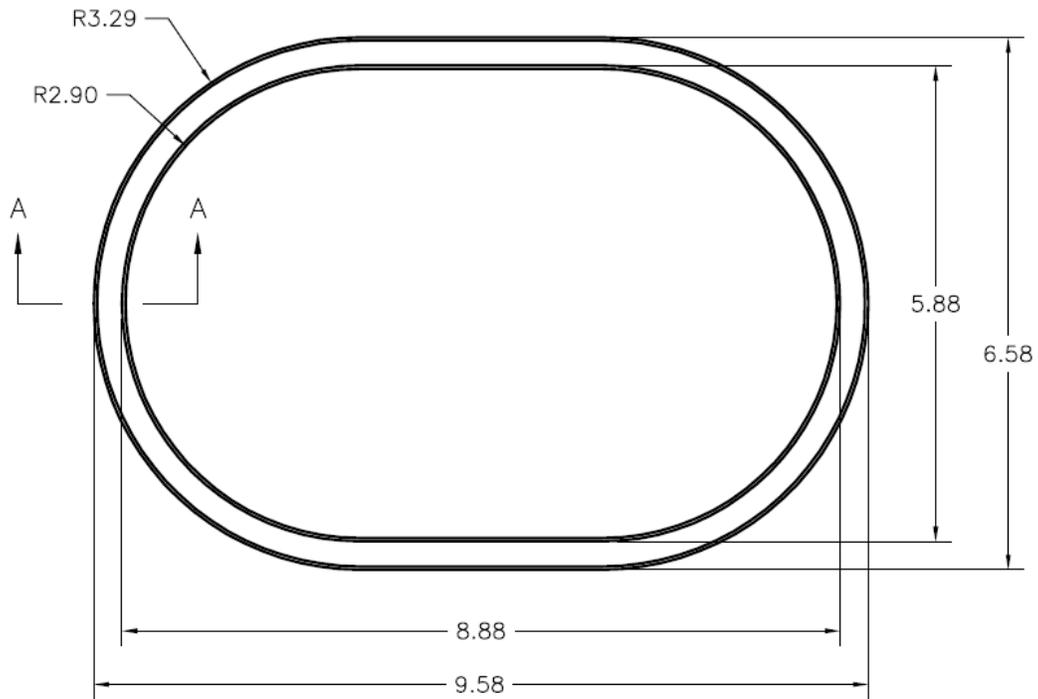


Figure 5.9: Oblong optical aperture, material - SiO₂ or ZnSe. All dimensions in inches.

5.1.5 Wing Hard Points, Pylons, and Pods

Six under wing hard points (three underneath each wing) have been added to the NSF/NCAR GV. The locations for each hard point are as follows:

- Inboard, each wing: BL 123.017, canted 0.22 degrees
- Middle, each wing: BL 192.787, canted 1.25 degrees
- Outboard, each wing: BL 264.133, canted 2.08 degrees

Figure 5.10, below, shows these hard point locations with notional wing stores depicted at each hard point.

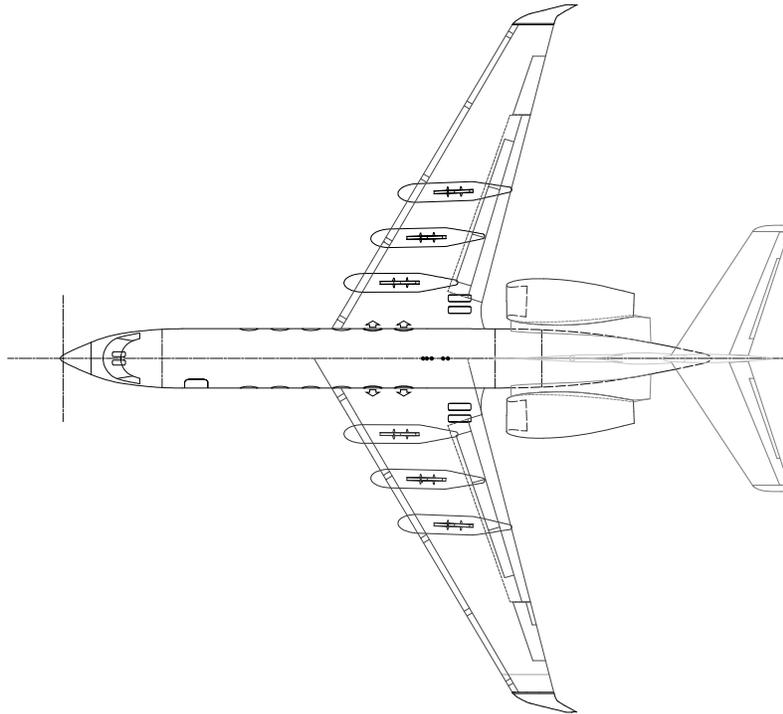


Figure 5.10: View of GV from above showing locations of six under-wing hard points with notional wing stores mounted at each hard point.

Each hard point can carry a maximum static load of 1,500 lbs. This load includes the weight of the wing pod, fairing, and rack mount hardware. Installed hard points are compatible with USAF/NATO rack mount specifications, and each hard point can accommodate either 14-inch or 30-inch rack mount hardware. Power and signal wiring is provided to each wing hard point (see Section 5.2.2 of this chapter for wing power and signal wiring information). All wing stations of the aircraft can be equipped with pylons capable of mounting two standard PMS/DMT style instrumentation cans per pylon. There are two certified GV wing stores configurations: for one such pylon at each outboard hard point or a full set of six pylons. Wing configurations must be symmetrical about the longitudinal axis of the aircraft with individual pylon weight limits of 100 lbs static load.

20" diameter wing pods with a 1,000 lbs weight capability can be installed in the middle wing stations. These pods are only certified to be flown in the full wing store configuration with inboard and outboard stores configured with pylons carrying dual PMS canisters.

See Sections 6.1 and 6.3 of this document for information regarding the airflow and aerodynamics data available from RAF for the various wing pod designs.

Additionally, GAC has performed some initial airflow and aerodynamic load studies for some larger candidate wing pods (one per pylon) being considered for deployment on the NSF/NCAR GV. See Sections 6.1 and 6.3 of this document for additional information regarding the types of airflow and aerodynamics data available from RAF.

5.1.6 Window Blanks

The window frames of the aircraft can each support a modest equipment load (approximately 900 inch-lbs). All instruments mounted on the exterior surface of installed window blanks will require an FAA approved icing analysis to investigate the potential for engine ingestion of ice shed from said instrumentation.

RAF currently has window blanks and designs for installation of optical apertures and small GPS antennas into the window blanks. Details of the window-mounted optical aperture are shown on Figure 5.9.

Potential users of the GV are advised that only the forward-most four windows on each side of the aircraft can be removed for the installation of window blanks. The two rearward-most windows on each side of the aircraft are emergency exits and, as such, cannot be modified.

5.1.7 Tail Deck

The tail deck of the GV (located at the top of the T-tail of the aircraft underneath an aerodynamic cowling, see Figure 5.10 for a picture of this area) is available for the installation of scientific equipment.



Figure 5.11: View of the GV tail deck area available for the mounting of scientific equipment

The area available on the tail deck for instrumentation installation is approximately 12 inches high, 12 inches wide, and 6 feet long. This area normally houses a SATCOM antenna and an upward looking radiometer optical receiver. Up to an additional 50 lbs of equipment can be installed in this area. Users intending to utilize the tail deck should contact RAF in advance because tail fairing modifications would likely be required and extended scheduling of such modifications is necessary.

Conduit is available in the GV tail for running power and signal wires to equipment mounted on the tail deck. Power and signal distribution boxes for the tail deck are located in the aircraft baggage compartment. The tail deck of the GV is not temperature and pressure controlled. Correspondingly, power and signal wiring that is run to instruments mounted on the tail deck will need to pass through bulkhead connectors in the baggage compartment. Also, investigators wishing to install equipment on the tail deck will need to design instrumentation accordingly to compensate for the exposure of tail deck instrumentation to the ambient environment.

5.1.8 Tubing and cable routing pathways

The GV contains infrastructure for connecting scientific equipment components located in the different parts of the aircraft. Several pressure bulkhead feed-throughs exist in the forward cabin, the aft cabin and in the wing root areas on the sides of the cabin at the floor level. All of these pass-throughs require potting of the passing wire, optical fiber or tubing to prevent cabin de-pressurization in flight.

Inlet tubing can be routed along the walls of the cabin utilizing cable troughs (shown in cross section on Figure 2.3) and along the ceiling rail.

Overhead and under floor conduits have also been installed in the GV to allow for the passage of cables and tubing from one side of the aircraft to another as needed. The two overhead conduits are installed in the aft section of the aircraft near the floor stations 5 and 6 (Figure 2.2), and the two under floor conduits are installed in the forward section of the aircraft, with one forward of and one between the two down-looking optical view ports, near floor stations 1 and 2. These conduits are the only means of bringing wiring or tubing across the cabin. See Section 5.2.3 below for more information on these overhead and under floor conduits.

5.1.9 Compressed gas cylinder rack

A permanent rack for securing gas cylinders in flight is permanently installed in the aft cabin of the GV behind the galley. The rack can hold up to three size AL or 100A (48 inches tall and 7.25 inch diameter) aluminum cylinders with regulators. Steel cylinders are not supported.

5.1.10 Baggage compartment rack

A specialized rack installed in the GV baggage compartment can be utilized to install pump or other similar equipment. Connectivity to this equipment involves passing plumbing lines through the secondary pressure bulkhead and may involve substantial effort. Investigators wanting to install pumps in the aft rack should contact RAF in advance to explore this possibility.

5.1.11 Main Cabin Equipment Racks

Main Cabin Instrumentation racks are discussed in detail in Section 6.1.3.1 below.

5.2 Research Power System

5.2.1 System Description

The primary power source in the GV is the Integrated Drive Generators (IDGs). The power supplied by the IDGs is 115/208 VAC, three-phase, 400 Hz. Power from the two IDGs is divided between the two electrical buses, which are designated as the A or B bus (corresponding to the left or right side generators). A third bus (the C bus) can provide additional power (400 Hz, 40 kVA) from the Auxiliary Power Unit (APU) in flight. The APU output degrades at altitudes above approximately 42,000 feet, and GAC recommends not using the APU above this attitude.

The primary research power distribution unit is the Main Power Distribution Box (MPDB), shown in Figure 5.12. Power return circuitry in the GV is not tied to the aircraft frame but is instead returned to the Main Power Distribution Box. The MPDB is referenced to the airframe. Six 3.5 kVA frequency/power converters located in the MPDB provide 115 VAC, 60 Hz power. Three of the converters are powered from the A bus and three from the B bus. This parallel configuration limits the current output to each side of the aircraft to 90 A. The system has excellent voltage regulation and

frequency stability. If the input voltage becomes too low (70 to 90 Vrms) or too high (125 to 132 Vrms), the converters shut down to prevent damage to the load.

RAF flight crew members control the provision of power to investigators on board the GV. A single control switch for the GV research power system is located in the cockpit and is accessible to both the pilot and the co-pilot. Power delivery to the main cabin equipment and wing instruments is further controlled by the MPDB, which is monitored by the ADS operator.

Power from the MPDB is distributed to Secondary Power Distribution Boxes (SPDBs) that are located in the main cabin (eight units), nose (one unit), baggage compartment (one unit), and at each of the six wing hard points. Investigators obtain power for research equipment from the SPDBs. Table 5.1 describes the types of research power available.

Investigators should note that 28 VDC power can only be provided in the main cabin through the use of rack-mounted converters that operate using 115 VAC, 400 Hz power. Regulation and current capacity will vary according to the type of converter in use.

NCAR recommends that investigators plan on using 400 Hz or 60 Hz power (single-phase) as their primary power source whenever possible. Additionally, it should be noted that 50 Hz power is not available on the aircraft. Investigator using equipment that requires this frequency must provide their own converters.

The 60 Hz converters utilized in the GV research power system have overload capability. However, investigators desiring to operate devices with large in-rush currents (e.g. currents associated with the starting of a single phase motor or a vacuum pump motor) must notify the RAF in advance of these requirements, and such operations must be approved by the RAF.

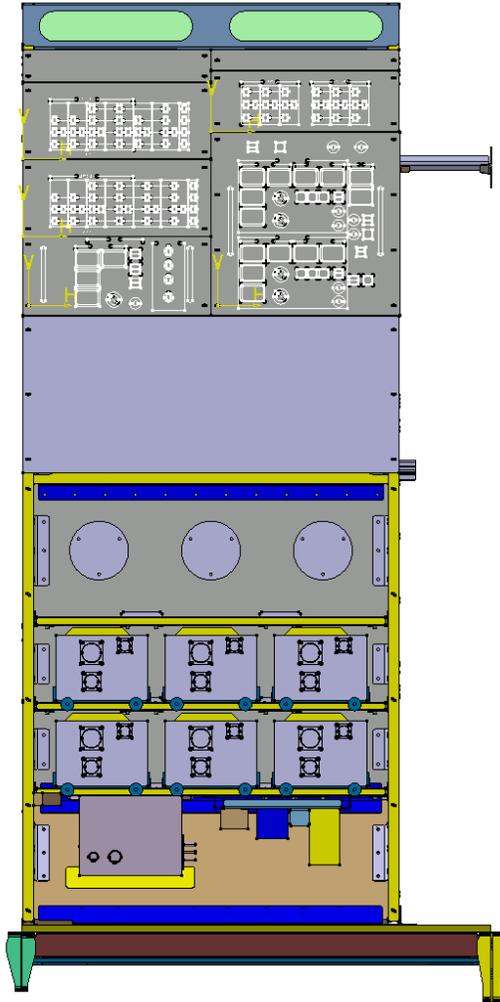


Figure 5.12: View of the GV MPDB, located on the right side of the forward cabin, opposite the main crew entry door.

Type of Power	Location(s)	Total Amount Available
60 Hz, 115 VAC single phase	All SPDBs	21 kVA (nominally)
400 Hz, 115/208 VAC	Single-phase: All SPDBs Three-phase: Main cabin SPDBs 3 and 4 only and baggage compartment SPDB Note: Single-phase power available at nose, cabin, and baggage compartment	20 kVA of single-phase power; or 20 kVA of three-phase Wye-connection power; or combinations of single- and three-phase power totaling no more than 20 kVA

	<i>SPDBs is controlled by a weight-on-wheels (WOW) switch and is available only after the GV is airborne</i>	
28 VDC	Wing hard point SPDBs only Note: <i>28 VDC power at wing SPDBs is controlled by a WOW switch and is available only after the GV is airborne</i>	5 kW; intended primarily for anti-ice purposes

Table 5.1: Types of research power available on the NSF/NCAR GV

5.2.2 Power Distribution Boxes and Connectors

As outlined above, SPDBs located along both walls of the main cabin provide power to equipment racks and to investigator equipment. There are four evenly spaced SPDBs on each side of the fuselage. Figure 5.13 and Figure 5.14 show the locations of the SPDBs in the GV cabin. SPDBs are also provided in the nose, the baggage compartment, and at each of the six wing hard points. The control for each SPDB is provided by switches / circuit breakers on the front panel of the MPDB. Each cabin SPDB has two identical sets of MS3452W connectors. Each set of these connectors are connected to equipment racks by RAF-supplied cables. Generally, the RAF provides all power cabling from the SPDBs and from the Aircraft Data System (ADS) to the mission equipment. Investigators must provide all required mating connectors and are also responsible for providing any cabling required between two or more racks of their own equipment. All wires and cables must comply with the material testing requirements referenced in Section 6.2 of this handbook. Such interconnecting cables may not be routed on the floor or suspended across spaces between racks in order to maintain free access between racks and prevent potential grabbing by hand. Cables that connect racks on opposite sides of the aisle must be routed in one of several cabin pass-throughs (see Section 5.2.3).

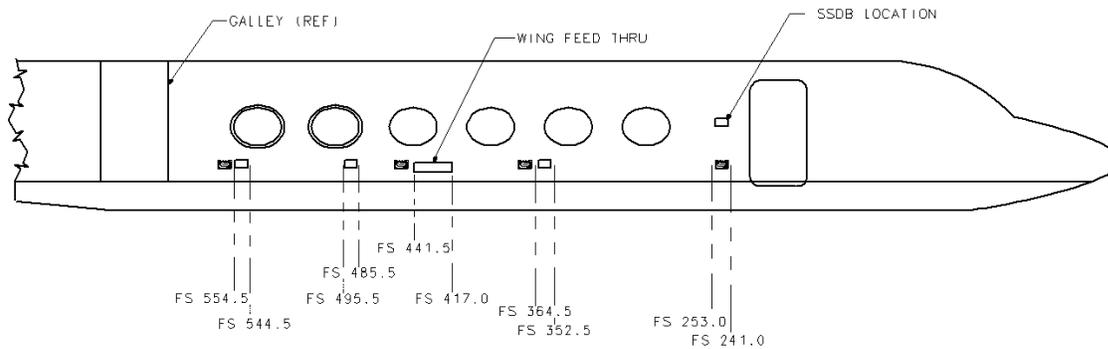


Figure 5.13: Locations of secondary power distribution boxes (SPDBs) and secondary signal distribution boxes (SSDBs) on the left side of the GV cabin. SPDBs are shown in black, SSDBs in white.

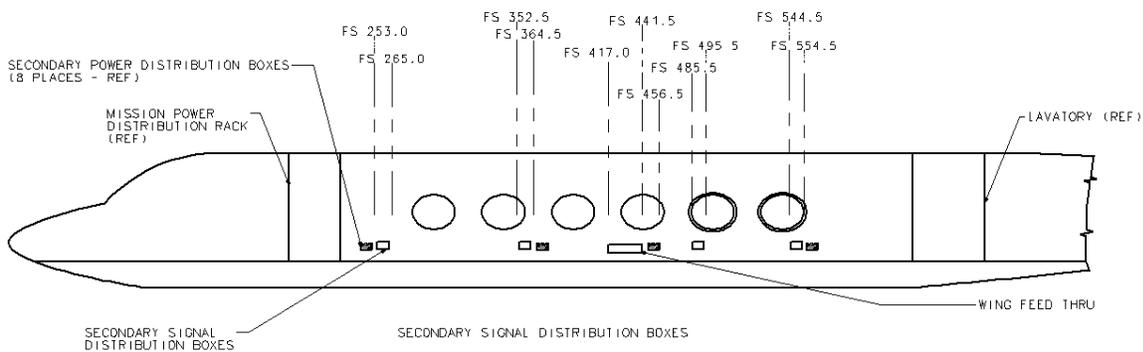


Figure 5.14: Locations of secondary power distribution boxes (SPDBs) and secondary signal distribution boxes (SSDBs) on the right side of the GV cabin. SPDBs are shown in black, SSDBs in white.

Each SPDB in the nose, cabin and baggage compartment provides the following: two circuits with a maximum of 20 amps of 60 Hz power each; one circuit with 20 amps of 400 Hz single-phase; one circuit with 20 amps of 400 Hz three-phase (cabin SPDBs 3 and 4, left and right sides, and baggage compartment SPDB only); and one circuit with 20 amps of 400 Hz single-phase anti-ice power. Figure 5.15 shows the configuration of the GV cabin SPDBs.

The SPDBs will interface to RAF-supplied rack mountable secondary power distribution drop boxes (SPDDBs). Figure 5.16 shows the configuration of the GV cabin SPDDBs. These boxes are compatible with: (a) the 400 Hz three-phase provided via NEMA L15-30R, Pass & Seymour S L1530-R, 208/115 3-Phase receptacles; (b) the 60 Hz panel will accept a standard NEMA 5-15P; and (c) the 400 Hz single-phase panel will accept a NEMA 5-20P.

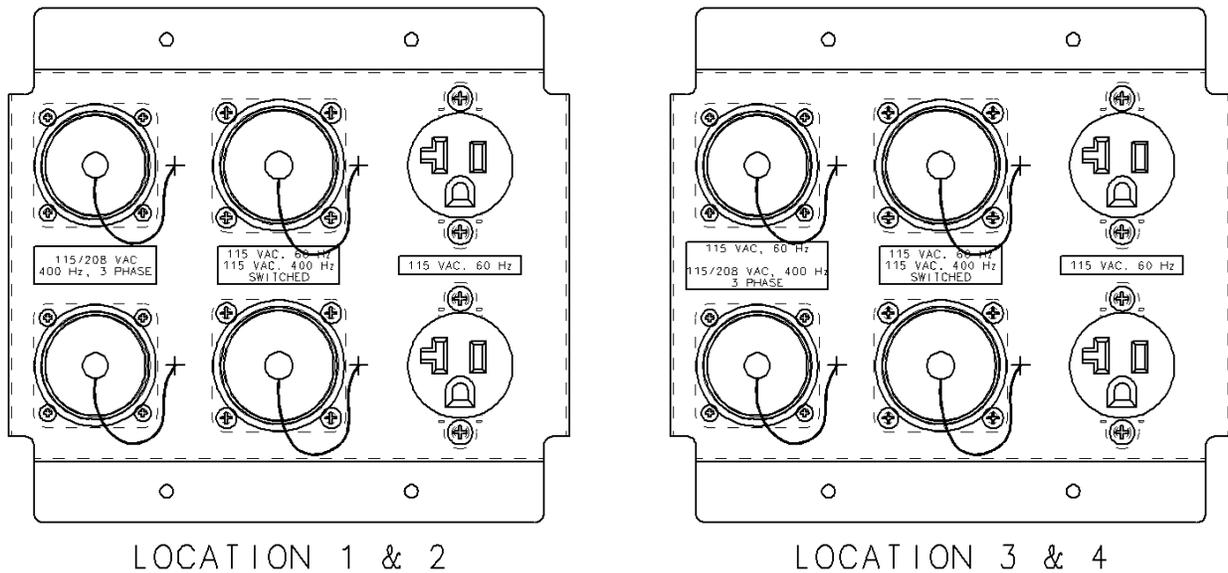


Figure 5.15: GV cabin secondary power distribution boxes (SPDBs)

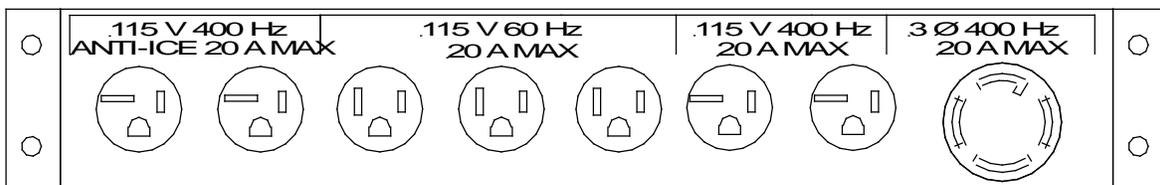


Figure 5.16: GV cabin secondary power distribution drop boxes (SPDDBs)

Power provided to the six (three per side) wing hard points is controlled at the MPDB with switches/circuit breakers. Each wing hard point SPDB provides the following: two 20 amp 115 VAC, 60 Hz circuits; one 20 amp circuit of 400 Hz single-phase; one 20 amp circuit of 28 VDC anti-ice. The two 20 amp 115 VAC, 60 Hz single-phase circuits and the single 20 amp 115 VAC, 400 Hz, single-phase circuit will accept an MS3456W20-15P"x" connector. The single 20 amp 28VDC anti-ice will accept an MS3456W20-14P"x" connector. The "x" designates the connector insert rotation position from the normal position (see below). The wing SPDBs are designated as OUTBOARD, MID and INBOARD locations. Each of these three locations has a different connector insert rotation. (For example, connections made for the INBOARD location will not mate to the MID location.) The following is a list of connectors by locations that the wing SPBD will accept with the rotations:

- OUTBOARD - 400 AND 60 Hz MS3456W20-15PN
- OUTBOARD - 28VDC MS3456W20-14PN
- MID - 400 AND 60 Hz MS3456W20-15PZ
- MID - 28VDC MS3456W20-14PW
- INBOARD - 400 AND 60 Hz MS3456W20-15PW
- INBOARD - 28VDC MS3456W20-14PX

5.2.3 Crossover Conduits Description

The GV aircraft has four crossover conduits in the main cabin. These conduits provide a means for passing research cabling and tubing from one side of the cabin to the other and for gaining access to nearby instrument aperture plates, pads, and fuselage mounts.

The two lower crossover conduits are located under the floor panels at GVFS 260 RH and LH, and GVFS 320 RH and LH. Each of these conduits has a small gap at the approximate midpoint. This gap allows for the routing of cabling and tubing out of the conduit and to the lower instrument aperture plates and fuselage mounts. The conduit size is approximately 2 inches deep by 4 inches wide, with a 0.25-inch corner radius.

The two upper crossover conduits are located underneath the headliner at GVFS 460 RH and LH, and GVFS 579 RH and LH. Each of these conduits has a small gap at the approximate midpoint and are concealed by a removable cover. The gap allows for the routing of cabling and tubing out of the conduit and to upper inlet aperture pads and fuselage mounts. The conduit size is approximately 1-in. deep by 7-in. wide, with a 0.25-in. corner radius.

5.3 Data Acquisition System and Display

The GV Aircraft Data System consists of the aircraft data system server (ADS) and data acquisition system, Distributed System Modules (DSM), Data Displays (typically RAF laptops or instrument computers configured for data display) and associated signal wiring and network infrastructure. The following sections are intended to provide users with a general overview of the basic design characteristics and capabilities of the ADS system.

The ADS is an evolving system. It is linked with the Mission Coordinator Display tools, which were first deployed on a large scale in 2011, and with the EOL Field Catalog system. In combination these tools can be utilized for mission guidance, remote instrument control from the ground and real time research data delivery and distribution.

5.3.1 Data Acquisition System Overview

The GV Aircraft Data System (ADS) is a modular system that utilizes data sampling (a.k.a distributed system) modules (DSMs) installed in the cabin, the nose, the baggage compartment, and the wing pods (as needed). This distributed modular concept allows for straightforward expansion and for ease of installation. It also minimizes the amount of wiring required between instrumentation and the DSMs by keeping the DSM as close as possible to the installed sensors. Data from the DSMs are sent to the ADS server over the aircraft data acquisition gigabit network.

The ADS DSM utilizes an industry standard architecture with a large selection of commercially available off-the-shelf (COTS) hardware. This design approach enables the DSM to accommodate a wide variety of inputs from onboard instrumentation and will also make possible the addition of new instrument interfaces in the future without the need to always develop custom printed circuit boards.

The data collected by DSMs are immediately transmitted to the ADS server (see Section 5.3.4 for additional details). The server runs a data acquisition software that time stamps and logs all received data and also runs a secondary process that re-samples the acquired data to 1 s intervals and prepares them for real time display. All signals recorded through the DSMs by the ADS server are available for display onboard the GV in real time. A configurable subset of these data is transmitted to the EOL ground servers in flight for real time display on the ground. This subset is project specific and can be configured between flights, but not during a flight.

The PC-104 architecture was selected for the GV DSM due to the advantages of its smaller size and the greater availability of suitable COTS instrument interfaces. The standard PC-104 architecture utilizes the ISA 16-bit data bus, with maximum word transfers typically less than 10 MHz. The PC-104 Plus circuit card contains an additional connector, which is the PCI 32-bit bus capable of 33-66 MHz bus transfer rates. The additional PCI connector on PC-104 Plus boards reduces available space on the circuit card for instrument interface circuitry. The PC-104 (ISA bus) is the DSM standard interface. The Plus version will be made available for use in DSM if needed.

The ADS system can be configured to accept calibration parameters in order to present calibrated data on real time displays. Please note that field level data from investigator instruments are not distributed as part of the EOL data delivery and will not be available as part of EOL data files after the end of the field phase of a project.

5.3.2 *Data Interfaces*

5.3.2.1 *Analog inputs*

Analog signals are connected to DSMs using twin-ax cables connected to internal differential input amplifiers. Analog connectors are referenced to the GV airframe through high-value resistors to prevent ground loops while maintaining reference to the airframe. Each analog channel is calibrated via precision voltage sources as part of standard pre- and post-project calibration procedures.

Per-channel software selectable analog sample rates are 10, 100, 1000, and 10,000 Hz.

A DSM provides analog-to-digital (A/D) conversion with 16 effective bits of resolution at the above-specified sample rates below 10,000 Hz. At 10,000 Hz, the A/D resolution will be reduced to 14 effective bits. All analog channels are sampled simultaneously, with a maximum sampling delay between all channels of 1 millisecond.

5.3.2.2 *Digital inputs*

Digital data collection includes the acceptance of both serial and parallel data formats. Pulse counting is also available. Data transfer rates are generally determined by the instrument and typically vary from 1 – 50 Hz. ADS has the capability to sample and record all rates which are multiples of 1 Hz.

5.3.2.3 *Serial Data Interfaces*

Industry standard asynchronous RS-232 and RS-422 interfaces are provided in ADS with rates from 1200 baud to 115 Kbaud.

ARINC-429 transmit and receive channels can be provided at both the standard high and low speeds. A single PC-104 interface card contains at least two receive double-buffered channels. First In – First Out (FIFO) or dual-port memory will be highly advantageous to alleviate the need for interrupt servicing of every received 24-bit word.

The industry standard high level data link control (HDLC) synchronous protocol with clock rates up to 4 MHz and frame buffer sizes up to 4 Kbytes is also provided.

A serial interface based upon programmable logic is available that can be configured to provide custom interfaces such as bi-phase, pulse counting, and APN-232 radar altimeter serial data. In the case of pulse counting, the programmable logic interface is capable of providing at least two 16-bit counters on a single board. All data are double buffered.

Note: *The older-generation PMS 1-D and 2-D serial interfaces are not provided in the GV ADS3.*

5.3.2.4 *Parallel Data Interfaces*

The GV ADS provides a parallel digital I/O interface that can be configured for different widths from 1-bit to 32-bits. In addition, there are up to four separate input/output lines that can be used for data strobes and hardware interrupts. These lines are configurable as 1x, 4x, 8x, 16x, and 32 bits.

5.3.2.5 *UDP interface*

5.3.2.6 *The DSMs are capable of receiving the UDP stream from instruments, and due to the simplicity of the connection this is the preferred way of data acquisition that is utilized more and more on the GV. The interface is configured during the preflight installation of instruments when the RAF software engineers work with the instrument investigators to assign the IP addresses for UDP broadcasts and to configure the data packets for signal interpretation. Specialized interfaces*

Optical, USB and firewire interfaces are also available for data acquisition. These are specialized and require additional advanced consultation with the RAF technical and software groups.

5.3.3 *Network Description*

The aircraft is outfitted with two Ethernet networks. The primary data acquisition network interconnects the DSMs and provides gigabit Ethernet over copper twisted pair Category 6 wire. A similar network is provided for data display and user data traffic. (Fiber optic cable for high bandwidth data transmission is also available, is currently installed in the wings and terminated in the cabin.) Network access is available at the eight SSDBs in the main cabin, and at the SSDBs in the baggage compartment and the nose. Figure 5.13 and Figure 5.14 show the locations of the main cabin SSDBs.

Network wiring extends to all wing hardpoint locations. A separate network links the ADS server to the SATCOM link for transmission to the ground.

5.3.4 Data Recording

All data sampled by ADS is recorded on redundant systems as “raw” data at sample rate and in the RAF ADS format. Data are stored on removable disk drives and/or other portable storage devices. A structured-query language (SQL) database is available for low-rate data storage/access by investigators who wish to have their data stored in a common database but not sampled through the ADS3. User data not going through a DSM may be sent to the database via the display network.

5.3.5 System Timing and Synchronization

A GPS time-of-day signal is distributed to the DSMs and to the entire aircraft instrumentation suite via Ethernet in both IRIG-B and network time protocol (NTP) formats. A master time server (EndRun Technologies Tempus LX) receives the GPS time-of-day information and provides these formats through an Ethernet and IRIG-B coaxial connections. Each DSM includes an IRIG-B time distribution PC-104 card. In addition, all DSMs receive the 1 pulse per second (PPS) start-of-second signal from the GPS. The 1 PPS signal may be used to establish the beginning of each one-second interval. The master time server and DSMs establish time-of-day during the boot-up process via the IRIG-B signal and advance time by counting the 1 PPS. While the IRIG-B signal can be used by the GV ADS and by users to advance time and to identify the beginning of a one-second period, the 1 PPS time advancement method is considered to be more reliable. Both the 1 PPS and IRIG-B signals are made available to users.

5.3.6 Data Display Overview

Real-time display of data on board the GV and on the ground is provided by the NCAR Airborne Environment Research Observing System (AEROS) software package. AEROS can be downloaded from <http://www.eol.ucar.edu/raf/Software>. The AEROS package operates on Windows, Mac and Linux based computers and provides investigators with the capability to generate and view the following types of plots: time series, X versus Y, track, skew T, one-line and streaming ASCII lists, statistics, and size distribution. Only data streams recorded on the GV ADS can be displayed on board using AEROS and only the data sent to the ground via SATCOM can be viewed on the ground using AEROS.

5.3.7 Data Broadcasts

A configurable ASCII serial feed is provided to investigator equipment. The serial port output is typically set to 38,400 baud with N81 for parity data and stop bits once per second. While the configuration of the serial feed changes on a per-project basis, the data stream format always consists of the following parameters in the order given: date, time, and selected and configured variables. All values included in the serial feed are separated by a space, and the line is terminated by a carriage return/line feed pair. A sample ASCII serial feed stream is given below:

```
YY/MM/DD HH:MM:SS 1.234956e+00 8.325723e+02 .... \r\n
```

An Ethernet broadcast of data that is identical in format to the ASCII serial feed is also provided on board the GV. This broadcast consists of a UDP/IP packet sent once per second.

5.4 Satellite Data Communication Link

As outlined in Section 2.5.15, both Iridium and Inmarsat SATCOM systems are installed on the GV. Both systems provide voice and fax communications and data transfer capabilities. The near-global coverage and high bandwidth (128 kbps) characteristics of the Inmarsat system also provide the capability for controlling instruments and the GV ADS from the ground during flight. Semi-autonomous instruments that are connected to ADS can be controlled via the data local area network (LAN) installed in the aircraft. In brief, this involves instrument operators on the ground sending control commands to certain sensors on board the aircraft using the Inmarsat SATCOM system and the data LAN.

The transmission of data products to and from the GV is limited by the available bandwidth of each system (2.4 kbps for the Iridium system and 128 kbps for the Inmarsat system). In the case of the Inmarsat SATCOM system, the available bandwidth must be partitioned between voice communications, instrument control needs, time series and image data transfers, and text messaging in bi-directional mode. An on board computer controlled prioritization algorithm is configured for each GV project to provide control of Inmarsat bandwidth traffic flow and to ensure that critical data and messages are transmitted in a timely fashion.

EOL personnel are currently developing and implementing the software tools that are required for utilization of the GV SATCOM systems for data transfer and instrumentation control. Several tools are already available that will allow real-time web access to either direct field project participants, student groups or even common individuals with a casual interest in aviation research. Direct participants can communicate with onboard observers via text "chat" and the link can be used to transmit radar or satellite images, weather maps or sounding data to help provide in-flight guidance to modify research flight tracks and enable better sampling of targeted phenomena. Data access to in-situ measurements includes up to 20 variables and can include jpeg files taken from digital cameras documenting the flight environment. Outside groups or individuals can access some of this information via the EOL web site (http://www.eol.ucar.edu/flight_data)

5.5 Ground Support Computing

5.5.1 *Flight support system*

The AEROS data display onboard the GV and on the ground can be optionally augmented to several levels by the inclusion of auxiliary data displays called summarily the Mission Coordinator Display (MCD) tools. The MCD provides updating map overlays of data such as satellite imagery, real time flight track display of the GV and, optionally, collaborating research aircraft; lightning strike data; dropsonde data; NEXRAD or onboard weather radar data; vertical temperature data; lidar data etc. These supporting products are not made available to all projects by default but are provided on a request basis at the level necessary for the particular project. They can be used for real-time

flight change requesting, weather targeting or avoidance and fine tuning the flight patterns.

5.5.2 *Field catalog system*

EOL field catalog is another level of mission support software that is designed to ingest, store, distribute and archive a large variety of configurable data products. The catalog typically includes satellite imagery and time loops; model generated products; instrument status reports; flight reports and scientific briefs; picture archives; preliminary datasets from the aircraft instruments and any other data necessary for the project.

5.5.3 *Ground data QC and distribution system*

Depending on the region of operations and the location of the project operations center, there will typically be a ground-based server that will be connected to a LAN where data will be processed post-flight and distributed to users who are connected to the LAN. In real time during a flight the ground server will also be gateway for two-way data communication between the aircraft and the ground. Often connections to a local ISP will be established and data (real time and post flight) can be accessed from remote sites.

5.6 Data Products

Immediately following each GV research flight, EOL personnel will process the collected data and output the results in the network Common Data Form (netCDF) format. More information on netCDF is available on-line at <http://www.unidata.ucar.edu/software/netcdf>. Preliminary data files generated following the completion of research flights are used by RAF personnel to perform initial quality checking of all collected and derived data products. These preliminary files are also made available to investigators for initial review and analysis.

Data from investigator instruments that have been recorded on the GV ADS will be processed by Nimbus and can be released in the preliminary aircraft netCDF data files or removed from them if requested by the instrument investigator. All investigators who record data on stand-alone data systems are responsible for the processing and release of their own collected data products according to the timelines established by the project.

EOL has established a NSF-approved data policy governing the collection and release of data sets collected from all EOL-supported atmospheric observing facilities, including the NSF/NCAR research aircraft. This policy can be viewed on-line at <http://www.eol.ucar.edu/data/data-policy>. Investigators are strongly encouraged to review and become familiar with this policy in advance of the start of the designated field program.