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WB-57 EXPERIMENTER'S HANDBOOK

Aircraft Operations Division

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National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas 77058

Verify that this is the correct version before use.

APPROVAL AUTHORITY

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1.0 INTRODUCTION

This handbook presents information on the National Aeronautics and Space Administration (NASA) WB-57 high-altitude research aircraft and should be used in conjunction with information available on the NASA WB-57 Web site:

https://jsc-aircraft-ops.jsc.nasa.gov/WB57/index.html

2.0 PURPOSE

This handbook provides the information necessary to make your work easier, safer, more efficient, and less expensive. The procedures required prior to flight are essential to ensure the safety of the aircraft, associated equipment, and all individuals involved.

While every effort is made to keep this document as complete and up-to-date as possible, the WB-57 Program is dynamic and changes frequently occur. Please contact the WB-57 Program Office to verify information, request additional details, or to ask questions; contact information is available at the following:

https://jsc-aircraft-ops.jsc.nasa.gov/wb57/contact.html

3.0 SCOPE

This document is applicable to all experiments conducted on NASA WB-57 aircraft.

Reference the Aircraft Operations Division (AOD) EDMS (Electronic Document Management System) Library or https://jsc-aircraft-ops.jsc.nasa.gov/wb57/guide.html to verify latest version of this document.

4.0 RECORDS

Record	Record Custodian
WB-57 Payload Records Maintained	(Contractor) WB-57 Program Office

5.0 REFERENCES

AOD Form 314, Checklist for Test Readiness Review of Payloads and Experiments on JSC AOD Heavy Aircraft

American Welding Society (AWS) D17.1, Specification for Fusion Welding for Aerospace Applications

American National Standard Institute/American Institute of Aeronautics and Astronautics (ANSI/AIAA) S-081/A, Space Systems Composite Overwrapped Pressure Vessels

Federal Motor Vehicle Safety Standards (FMVSS) 304, Compressed Natural Gas Fuel Container Integrity

Johnson Space Center (JSC) Form (JF) 44A, Radio Frequency/Microwave Hazard Evaluation Data

JF 44B, Laser Device Use Request/Authorization

JF 1023, Nonionizing Radiation Training & Experience Summary

JSC Procedural Requirement (JPR) 1700.1, JSC Safety and Health Handbook

JPR 1710.13, Design, Inspection and Certification of Ground-Based Pressure Vessels and Pressurized Systems

NASA Drawing 8593003, Wire, Electric, Interconnection, & Hookup

NASA Drawing 8594001, Preparation of Stress Analysis Reports

National Fire Protection Association (NFPA) 52, Vehicular Gaseous Fuel Systems Code

Society of Automotive Engineers (SAE) AS50881, Wiring Aerospace Vehicle

Technical Order (T.O.) 1-1A-14, Technical Manual, Installation and Repair Practices, Volume 1, Aircraft Electric and Electronic Wiring

NOTE

Contact the NASA WB-57 Program Office for access to all NASA AOD documents.

6.0 DEFINITIONS

Shall and **Will**	Indicates a mandatory requirement.
Should and **May**	Indicates an acceptable or suggested means of accomplishment.

7.0 AIRCRAFT DESCRIPTION

7.1 GENERAL

NASA JSC AOD owns and operates the last three WB-57 aircraft in the world, out of Ellington Field (EFD) in Houston, Texas. The WB-57 aircraft, originally produced as the WB-57F by General Dynamics, is a mid-wing, long-range aircraft capable of operation from sea level to altitudes in excess of 60,000 feet (ft).

NOTE

Flights above 50,000 ft ("high flights") require the aircrew to wear full pressure suits.

Two crewmembers are positioned at separate tandem stations in the forward section of the fuselage. The pilot station contains all the essential equipment for flying the aircraft. The aft, or Sensor Equipment Operator (SEO) station, contains both navigational equipment and controls for the operation of payloads and payload support systems located throughout the aircraft.

NOTE

NASA JSC's WB-57 aircraft (N926NA, N927NA, and N928NA) are not configured identically, although that is the long-term goal. Wherever possible, differences between the three aircraft are specified.

7.2 DIMENSIONS

Figure 1 provides the basic dimensions of the WB-57 aircraft.

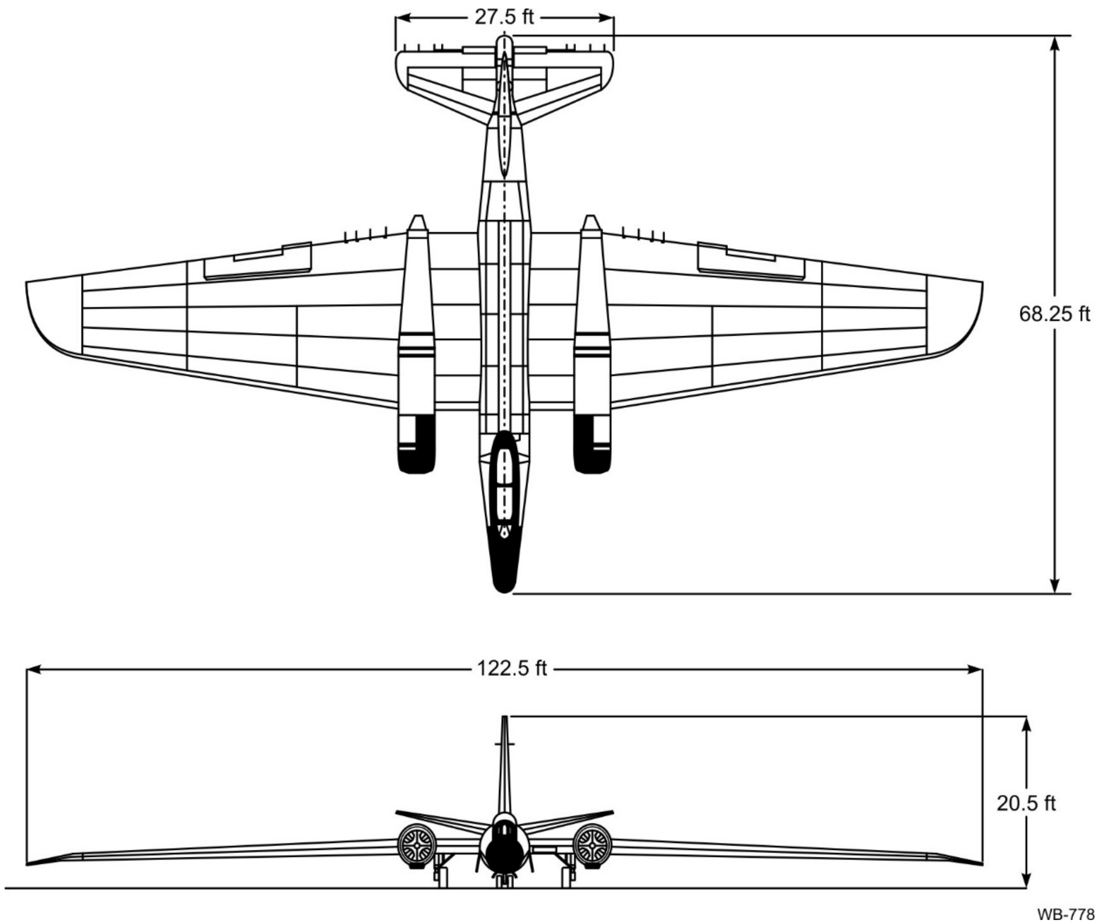


Figure 1. Aircraft Dimensions

7.3 PERFORMANCE

Refer to Table 1 for WB-57 aircraft performance and capabilities.

Table 1. Performances and Capabilities

Aircraft Ceiling	Over 60,000 ft
Maximum Flight Duration	~6.5 hours (not air refuelable)
Range	~2,500 nm
Maximum Gross Weight	72,000 lbs
Maximum Payload Weight	9,700 lbs (including empty weight of pallets, spearpods, and superpods)
Wing Surface Area	2,000 ft^2
Engine Thrust	15,500 lbs per engine
True Air Speed at 60,000+ft	~410 knots (KTS) (maximum Mach 0.78)
Maximum True Air Speed at Sea Level	190 KTS
Minimum Runway Dimensions	7,000 ft × 150 ft (sea level)
Maximum Crosswind Component	15 KTS
Air-to-Ground Communications	Ultra High Frequency (UHF), Very High Frequency (VHF), High Frequency (HF), Satellite (SAT) Phone, Ku-Band Spread Spectrum (KuSS), INMARSAT
Payload Power Options	115 Volts Alternating Current (VAC) 400 Hz 3 Phase 115 VAC 60 Hz Single Phase 28 Volts Direct Current (VDC)

7.3.1 Airspeed

The WB-57 is limited to 190 knots calibrated airspeed (KCAS) below 35,000 ft; and 175 KCAS or Mach 0.78, whichever is less, above 35,000 ft.

7.3.2 Turn Radius

Turn radius is a function of airspeed and bank angle. Airspeed varies with altitude and winds; bank angle is limited to 30 degrees. At altitude, the turn radius with a 30-degree bank angle is approximately 5 nautical miles (nm).

7.3.3 Climb and Descent Rates

Maximum climb rate is approximately 6,000 feet per minute (ft/min). A typical climb profile is shown in Table 2.

Table 2. Climb and Descent Rates

Climb	Descent
0–15,000 ft	4,000 ft/min
15,000–30,000 ft	2,500–3,000 ft/min
30,000–40,000 ft	2,000 ft/min
40,000+ ft	1,000 ft/min

The maximum descent rate is approximately 4,000 ft/min, although the typical descent rate is approximately 2,000 ft/min.

7.3.4 Planning Factors

Based on aircraft performance, the planning factors shown in Table 3 can be used for a typical WB-57 mission. Actual performance will vary depending on payload weight, fuel load, etc.

Table 3. Planning Factors

Altitude (ft MSL)	Time to Climb (minutes)	Loiter Time at Altitude (minutes)	Time to Descend/RTB (minutes)
45,000	0+30	5+00	0+30
50,000	0+35	4+50	0+35
55,000	0+45	4+30	0+45
60,000	1+00	4+00	1+00

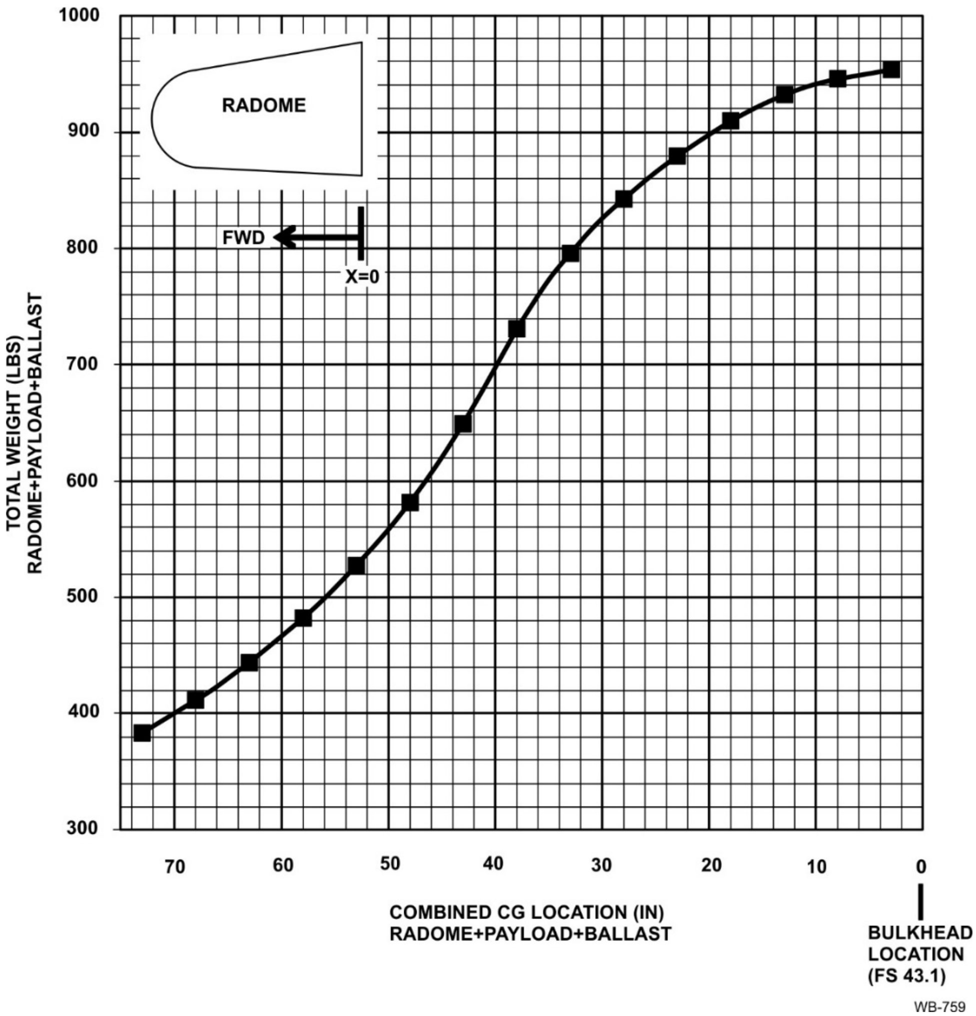
7.4 PAYLOAD WEIGHTS

The WB-57 can carry up to 9,700 pounds (lbs) of payload (including the empty weights of pallets, spearpods, and superpods). Overall payload weight should be kept to a minimum when all other payload design requirements have been satisfied. Refer to Table 4 for maximum **gross** weight limits for the various payload integration locations. The aircraft is sensitive to Center of Gravity (CG) location, so ballast may need to be added (primarily in the nose), which subtracts from overall payload capacity.

Table 4. Maximum Gross Weight Limits

Payload Integration Location	Payload (Maximum)	Empty Weight
3-foot Unpressurized Pallet	1,000 lbs[a]	165 lbs
3-foot Pressurized Pallet	1,000 lbs[a]	~400 lbs (estimated)
6-foot Unpressurized Pallet	2,000 lbs[a]	~247 lbs
6-foot Pressurized Pallet	2,000 lbs[a]	~700 lbs (estimated)
Nose Cone	954 lbs[b]	~232 lbs
Aft Fuselage	CG dependent, contact WB-57 Program Office	
Spearpod Forebody	370 lbs[c]	~90 lbs
Superpod	Pylon and Forebody: 1,420 lbs Forebody: 400 lbs[d]	Pylon: ~508 lbs Forebody: ~140 lbs
Wing Hatch	65 lbs[e]	~5.5 lbs[f]

[a] Including pallet
[b] Including nose radome, CG dependent (see Figure 2)
[c] Including forebody, CG dependent (see Figure 3)
[d] CG dependent (see Figure 4)
[e] Including wing hatch panel
[f] Wing hatch panel



FS (in)	-32.9	-27.9	-22.9	-17.9	-12.9	-7.9	-2.9	0	2.1	7.1	12.1	17.1	22.1	27.1	35.1	40.1	43.1
X (in)	73	68	63	58	53	48	43	40.1	38	33	28	23	18	13	8	3	0
WT (lbs)	383	411	444	482	527	582	649	696	731	796	842	879	909	932	946	954	958

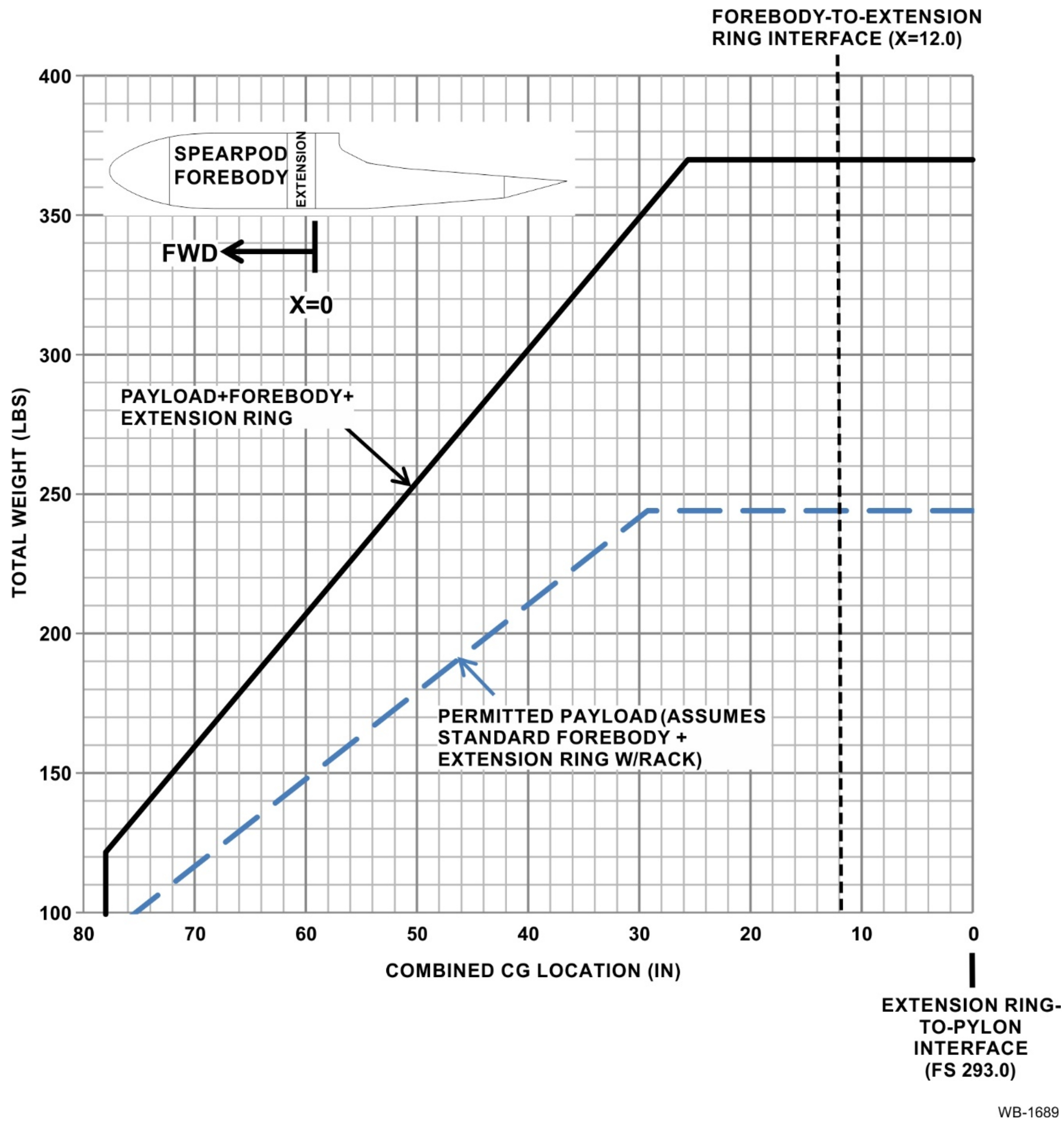
Origin of X dimension is at the forward bulkhead [Fuselage Station (FS) 43.1] and positive running forward.
Ballast amount is governed by overall aircraft weight and balance requirements.

Empty radome weight is 232 lbs at X=23.1 inches (in). These values are approximated for use in planning purposes. Contact the WB-57 Program Office for details about the specific nose cone to be used in the payload.

NOTE

This loading envelope assumes a relatively uniform loading of the WB-57 nose cone attachment ring. For payloads with attachment designs that may result in non-uniform loading of the nose cone attachment ring, contact the WB-57 Program Office for design guidance.

Figure 2. Nose Radome Loading Envelope



Payload+Forebody+Extension w/Rack

X (in)	0	25.6	78	78
WT (lbs)	370	370	122	0

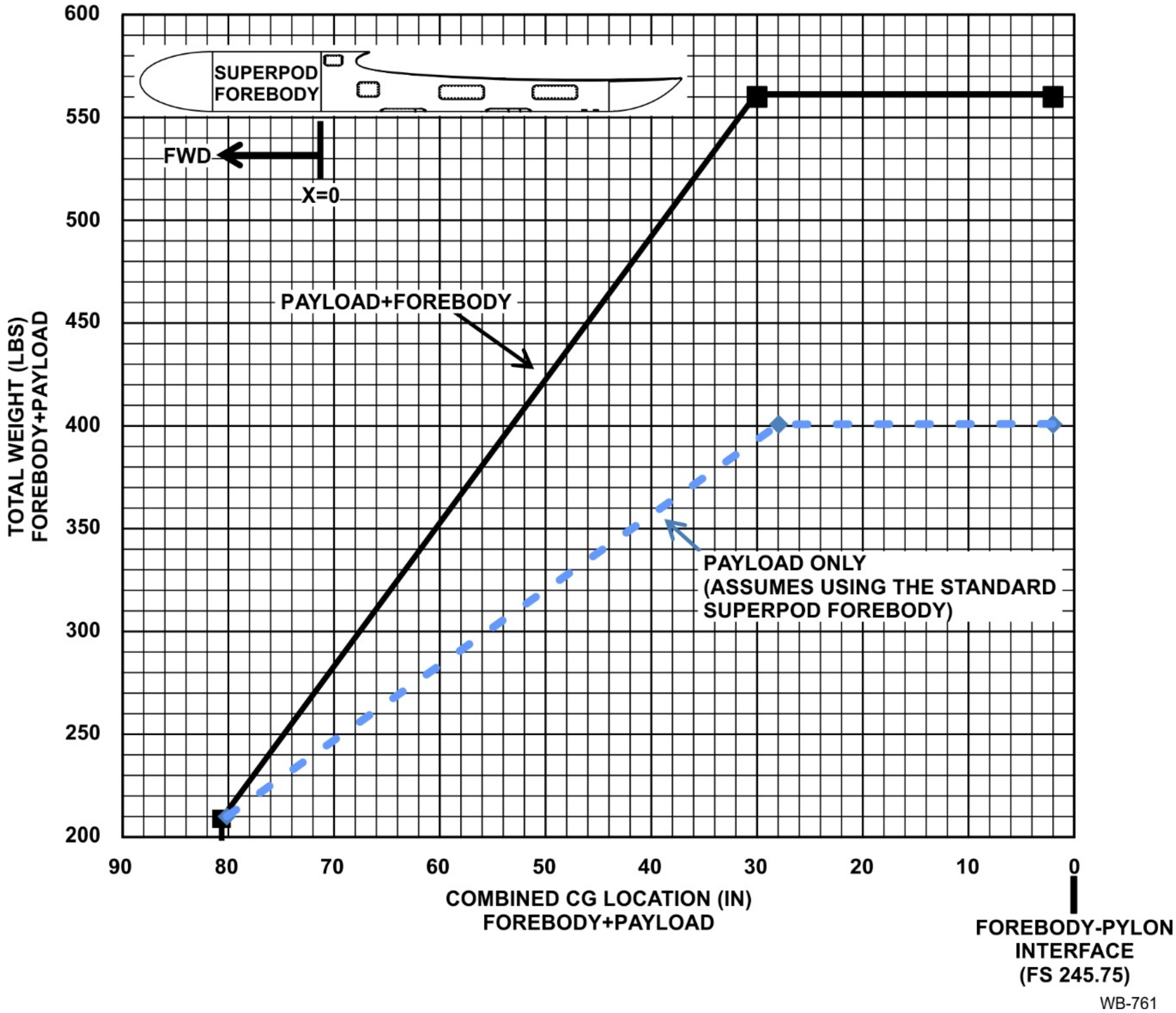
Payload Only (assuming standard spearpod forebody)

X (in)	0	29.3	78	78
WT (lbs)	280	244	92	0

Origin of X dimension is at the extension ring-to-pylon interface (FS 293.0) and positive running forward.
Forebody-to-Extension ring interface is at X=12.0 (FS 281.0).
Standard empty weights:

Forebody (P/N 5726012-301 or P/N RX612): 55 lbs at X=37 in.
Extension Ring (P/N 5726040-701/702) w/Rack: 70 lbs at X-6.0 inches
Combined: 126 lbs at X=14 in.

Figure 3. Spearpod Forebody Loading Envelope



Payload+Forebody

X (in)	2	30	80.6	80.6
WT (lbs)	560	560	208	0

Payload Only (assuming standard forebody)

X (in)	2	28	80
WT (lbs)	400	400	210

Origin of X dimension is at the forebody to pylon interface (FS 245.75) and positive running forward.
Empty standard forebody (P/N EAW-1005-1) weight: 140 lbs at X=34.5 inches.
Weight and balance also governed by overall superpod configuration (forebody+pylon).

Figure 4. Superpod Forebody Loading Envelope

7.5 OPERATING RESTRICTIONS

WB-57 operating restrictions (e.g., airfield, meteorological) are as follows:

- Minimum runway length and width, respectively: 7,000 ft by 150 ft (at sea level)
- Maximum crosswind component for takeoff and landing: 15 KTS

7.5.1 Altitude Limitations

Flight rules dictate that the WB-57 may fly with a minimum altitude of 500 ft AGL (Above Ground Level) subject to NASA management approval and on a case-by-case basis.

Maximum altitude is dictated primarily by gross weight and overall drag. The aircraft is capable of higher altitudes later in flight due to fuel burn, while drag is increased by adding wing pods, instrument inlets, and any other items that protrude outside the aircraft.

7.5.2 Air Traffic Control Limitations

The WB-57 is confined to all Air Traffic Control (ATC) rules, just as any other military or commercial aircraft is. Therefore, it is important to consider all ATC guidelines when planning a flight. In general, clearances above 45,000 ft are obtainable, whereas clearances between 35,000–45,000 ft are more difficult to obtain, especially near metropolitan areas; clearances below 35,000 ft are difficult to obtain unless the flight is in a low traffic area. This is not to say the aircraft cannot pass through these high-traffic areas; however, ATC may not allow the aircraft to maneuver as desired for experimental purposes.

7.5.3 Low Visibility Limitations

For flight operations at night or in cloudy conditions, the pilot will be more conservative with fuel estimations, which may slightly decrease the flight time. The aircraft can be equipped with weather radar, which will aid in deconflicting with thunderstorms during both day and night operations; however, note that certain payloads in the nose may limit or preclude the use of the radar. In these instances, another deconfliction method may be employed with the use of a stormscope and/or ground radar station(s).

8.0 ENVIRONMENT

8.1 PRESSURE

Payload integration locations are typically unpressurized. However, conditioned bleed air provides pressure 5 pounds per square inch gauge (psig) to the nose cone compartment, pressurized pallet compartments, and pressure containers, if required.

8.2 TEMPERATURE

Temperature levels in payload compartments vary according to flight profile and ambient air conditions; however, tarmac temperatures in the summer can reach as high as 140° Fahrenheit (F) [60° Celsius (C)] and temperatures at high altitude drop to as low as -76°F (-60°C). Water condensation in Houston, Texas, is very likely upon descent to landing. GSE (Ground Support

Equipment) provides the capability for payload cooling operations on the ground prior to taxi. Researchers may incorporate heaters and chillers into payloads for use in flight. For detailed pallet temperature data, refer to the following:

https://jsc-aircraft-ops.jsc.nasa.gov/wb57/designaids.html

8.3 LOAD AND ACCELERATION

The WB-57 gravity (g) load envelope is -1.00-g to +2.25-g's.

8.4 AIRFLOW AND BOUNDARY LAYER

For detailed boundary layer data, refer to the following:

https://jsc-aircraft-ops.jsc.nasa.gov/wb57/designaids.html

8.5 STABILITY/ATTITUDE

In level flight, the aircraft pitch attitude ranges from 0 degrees to approximately 8 degrees nose up. The pitch attitude varies with gross weight and indicated airspeed. Pitch attitude increases with increasing gross weight and decreasing indicated airspeed. During normal cruise, or at a normal data collection airspeed of approximately 130 knots indicated airspeed (KIAS), the pitch attitude will range between 0 and 4 degrees nose up, decreasing as fuel is consumed.

The WB-57 autopilot, in smooth air, will control the aircraft to ±1 degree in pitch, roll, and yaw. The autopilot can be coupled to a Global Positioning System (GPS) and will control the aircraft to within approximately 0.1 nm lateral deviation from the desired course. Aircraft heading will differ from the desired course depending on the magnitude of the crosswind component True Airspeed (TAS). This angular difference, known as crab angle, increases with increasing crosswind component and decreasing TAS. Crab angles can be as high as 20 degrees with a high crosswind component and low TAS.

The aircraft's pitch attitude on the ground is approximately 3 degrees nose down. The aircraft can be leveled with jacks, if required, for ground operations.

8.6 VIBRATION AND SHOCK

Vibration levels within the aircraft during flight are minimal. Levels during ground operations are somewhat higher, especially in the low frequency range.

NOTE

No source data is available for the provided plots.

For vibration data, refer to the following:

https://jsc-aircraft-ops.jsc.nasa.gov/wb57/designaids.html

8.7 RADIO FREQUENCY AND ELECTROMAGNETIC INTERFERENCE

Frequency ranges of the navigation, communications, and radar units on the WB-57 are shown in Table 5. Experimenters are cautioned that transmitters on the aircraft may cause interference with equipment.

Table 5. Radio Frequency Chart

Equipment	Transmitting/Receiving Frequency(ies)	Receiving	Transmitting
ADF (Automatic Direction Finder)	190.0 kilohertz (kHz) to 1,750.0 kHz	X	
HF Radio	2.000–29.999 megahertz (MHz)	X	X
Marker Beacon	75.0 MHz	X	
VOR (VHF Omnidirectional Radio Range)	108.00–117.95 MHz	X	
Glideslope Receiver	329.15–335.00 MHz	X	
VHF Radio	118–136.975 MHz	X	X
UHF Radio	225.000–399.975 MHz	X	X
ATC Transponder	1,030 MHz	X	
	1,090 MHz		X
TCAS (Traffic Collision Avoidance System)	1,030 MHz		X
	1,090 MHz	X	
DME (Distance Measuring Equipment) and TACAN (Tactical Air Command and Navigation)	960–1215 MHz	X	X
GPS	1,575.42 (±10.0) MHz	X	
Iridium SAT Phone	1,616–1,626.5 MHz	X	X
Radar Altimeter	4.2–4.37 gigahertz (GHz)	X	X
Weather Radar	9375±30 MHz	X	X
Time Code Generator (IRIG-B)	1,575.42 (±2.0) MHz	X	
INMARSAT Satellite Data Link	1,626.5–1,646.5 MHz	X	
	1,525.0–1,545.0 MHz		X
KuSS	14.0–14.5 GHz		X
	11.55–12.75 GHz	X	

8.8 RADIATION

There are no known radiation effects to personnel or instruments on board the WB-57. Although the WB-57 flies at a higher altitude, radiation effects are not significantly different from those experienced on a standard commercial airliner.

9.0 PAYLOAD ACCOMMODATIONS

9.1 PHYSICAL

9.1.1 Locations and Dimensions

The WB-57 can carry payloads up to 9,700 lbs (including the empty weights of pallets, spearpods, and superpods); typical payload integration locations are detailed in Figure 5. The aircraft employs a pallet system in the main fuselage area that consists of interchangeable pallet modules (pressurized and unpressurized). The pallet system can carry a total of 4,000 lbs, including pallet weight. Large payloads may be installed in the payload bay without use of the pallet system, by attaching the payload directly to the WB-57 airframe. Contact the WB-57 Program Office for further information (refer to Section 2.0, Purpose). Payload bay rails will support a maximum of 5,000 lbs. Lighter, smaller weight payloads can also be carried in the forward and aft transition sections, nose cone, spearpods, superpods, wing hatches, aft fuselage, and/or tail cone. Drawings can be found on the WB-57 Web site:

https://jsc-aircraft-ops.jsc.nasa.gov/WB57/designintegration.html

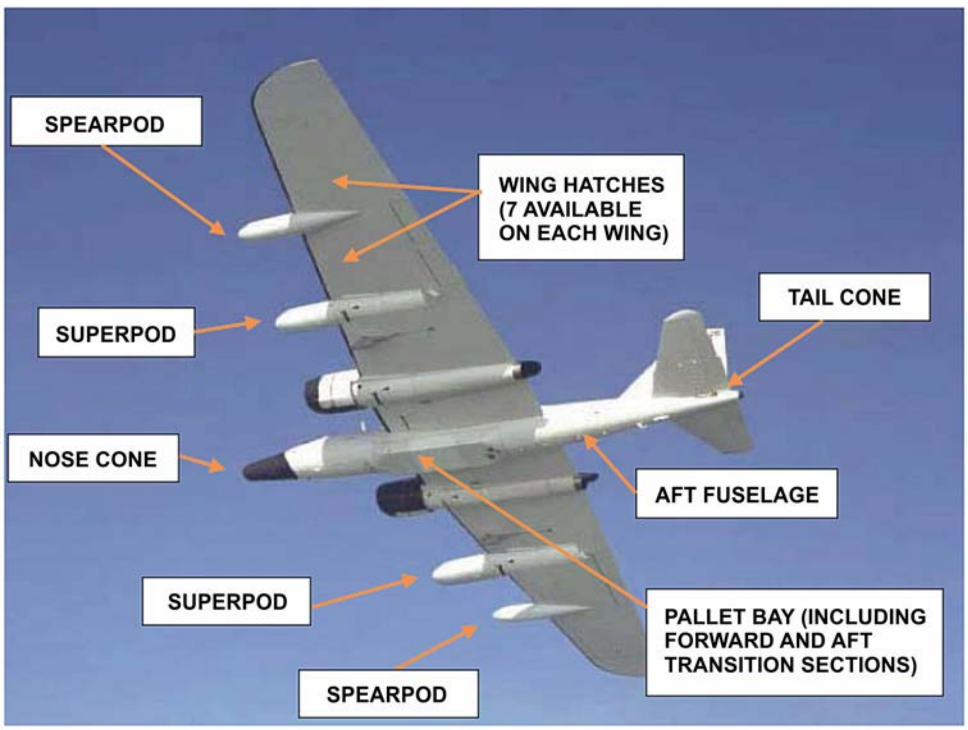


Figure 5. Typical Payload Integration Locations

For integration economy, pallets, spearpods, nose cones, and 15 pounds per square inch (psi) pressure containers are available for shipment to your facility. The modular feature of the pallets, spearpods, nose cones, and pressure containers allow for sensor development, integration, checkout, and maintenance away from the aircraft.

The WB-57 has been modified to provide a standardized electrical interface for payload integration, power, and payload control operations, which permits the aircraft to carry multiple payloads simultaneously.

9.1.1.1 Pallets

Payloads can be easily integrated by use of NASA-provided pallets. Pallets are located mid-fuselage on the belly of the aircraft in the former bomb bay (now known as the pallet bay, payload bay, or Q-bay). Pallets are available in 3-foot or 6-foot sizes (measured longitudinally along the aircraft), pressurized or unpressurized configurations, and have convenient power panels located in close proximity to mounting locations (see Figure 6 for a standard 3-foot pallet).

NOTE

Pressurized pallets are pressurized to cockpit pressure (approximately 5 psig).

All pallets have detachable casters for use during ground operations and most have standard inlet holes available for payload inlets. Seven and one-quarter inch dropdown rails are available on most pallets, which provide added payload volume in the pallet bay, but reduce the ground clearance of the pallet.

NOTE

Modifications to pallets are allowed with WB-57 Program Office approval.

Pallets are available for shipment to researcher laboratories for payload design purposes.

NOTE

As long as the 12 ft of allotted space in the pallet bay is not exceeded, 3-foot and 6-foot pallets can be installed on the aircraft in multiple configurations (e.g., two 3-foot pallets may be installed with one 6-foot pallet, or two 6-foot pallets may be installed with no 3-foot pallets, or four 3-foot pallets may be installed with no 6-foot pallets).

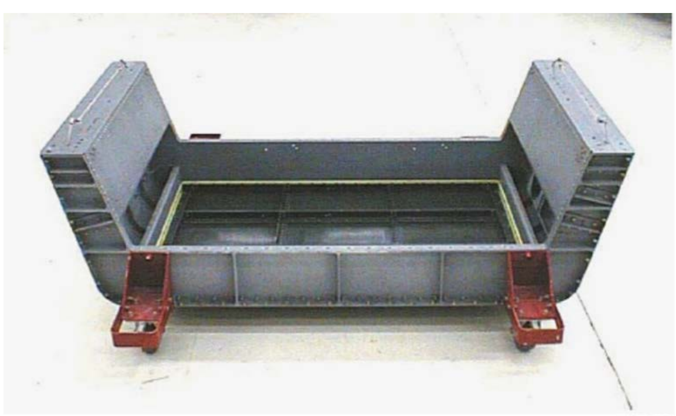


Figure 6. Standard 3-Foot Pallet

9.1.1.2 Pressure Containers

Payloads can be mounted within a standard 15 psi pressure container that will generally maintain one ATM (Atmosphere) pressure at altitude (see Figure 7). This container can be used to house spinning disk drives or other electronics that are sensitive to low-pressure environments. Active pressurization at 5 psig is available from the bleed air system, if desired. The pressure containers have standard panels for pressure relief, check valves, and an electrical interface. Pressure containers are available for shipment to researcher laboratories for payload design purposes.

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Figure 7. Standard 15 psi Pressure Container in 3-Foot Pallet

9.1.1.3 Spearpods

Payloads can be integrated in NASA-provided wing spearpods (see Figure 8) located outboard of the engines. Spearpods are available in one size only, are unpressurized, and have convenient power panels located in close proximity to their mounting location. Rigs/carts are available at EFD for use during ground operations and installation/removal procedures. Spearpods, with available inlet holes, are available for shipment to researcher laboratories for payload design purposes.

NOTE

Modifications are allowed with WB-57 Program Office approval.

Figure 8. Spearpod

9.1.1.4 Superpods

Payloads can be integrated in NASA-provided wing superpods (see Figure 9) located immediately outboard of the engines. Superpods are available in one size only, are unpressurized, and have convenient power panels located in close proximity to their mounting location. The superpod is comprised of two major components: the pylon and the forebody. The pylon provides the interface to the wing, a forward interface ring with latches for mounting of the superpod forebody, and secondary locations for mounting payload hardware. The forebody is the nose of the superpod and primary location for mounting payloads. The forebody is the same type as that used on the NASA ER-2 to allow payload portability between the two platforms. No modifications are currently permitted on superpod forebodies.

WB-783

Figure 9. Superpod

9.1.1.5 Nose Cone

Payloads can be integrated in the nose cone, which can be either pressurized or unpressurized. When pressurized, the nose cone is pressurized at cockpit pressure (approximately 5 psig). The nose cone has convenient power panels, a fiber optics interface, and other interfaces located in close proximity to its mounting location (see Figure 10). A nose cone rig is available at EFD for use during ground operations and installation/removal procedures. A common nose cone bulkhead ring is mounted on each aircraft allowing nose cones to be used on any aircraft without modification.

NOTE

Modifications to nose cones are allowed with WB-57 Program Office approval.

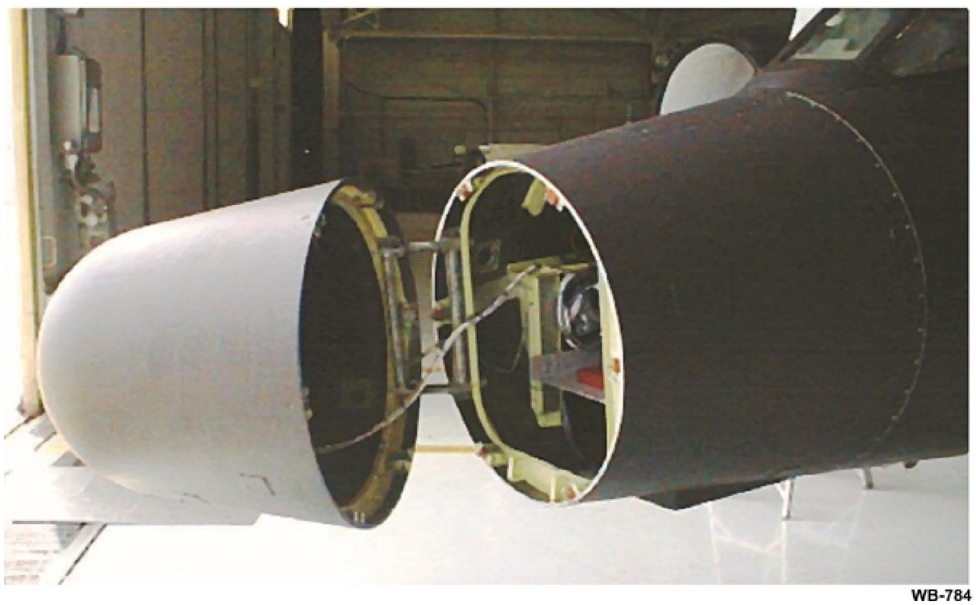

Figure 10. Nose Cone

9.1.1.6 Aft Fuselage/Tail Cone

Payloads can be integrated in the aft fuselage, which is located within the body of the aircraft from mid-wing to the tail cone and is unpressurized.

NOTE

Aft fuselage modifications are allowed with WB-57 Program Office approval.

9.1.1.7 Wing Hatches

Small payloads can be integrated onto dry bay wing hatches. There are 14 total available wing hatches located on the underside of the wings (seven on each wing).

9.1.2 Mass and Moment Constraints

Refer to Section 7.4, Payload Weights.

9.1.3 Cabin and Cargo Access Constraints

Payloads and/or components are not accessible during flight.

9.1.4 Mechanical Interfaces

9.1.4.1 Structural Attachments (Hard Points)

Hard points are located outboard of the engine on each wing for mounting superpods and spearpods. Contact the WB-57 Program Office to inquire about the use of hard points to mount payloads other than the superpods or spearpods.

9.1.4.2 Pods

Payloads can be integrated in NASA-provided spearpods or superpods (refer to Section 9.1.1.3, Spearpods, and Section 9.1.1.4, Superpods).

9.1.4.3 Equipment Bays

The pallet bay, or Q-bay, is the primary equipment bay. It is 12 ft long and can accommodate standard 3-foot or 6-foot payload pallets in the lower fuselage (refer to Section 9.1.1.1, Pallets).

Lighter, smaller weight payloads can also be carried in the forward and aft transition sections, nose cone, spearpods, superpods, wing hatches, aft fuselage, and/or tail cone (see).

9.2 ELECTRICAL POWER AND INTERFACE

Payloads installed in the aircraft have the following power options:

- 115 VAC 400 Hertz (Hz), three-phase (~100 amps/phase maximum)
- 115 VAC 60 Hz, single phase (~50 amps maximum)
- 28 VDC (~400 amps maximum)

These power options are available at all typical payload integration locations through installed power panels. Connections to aircraft power panels are through standard military specification connectors. Internal data bus connections are also available for payloads. WB-57 data buses provide inertial reference system and various aircraft parameters to the payload data processor/recorder (refer to Section 12.3, Electrical Systems, for detailed information on electrical system requirements).

9.2.1 Aircraft/Experiment Electrical Interface

The Experiment Interface Panel (EIP) links the payload to the aircraft electrical system, the Experiment Control Panel (ECP) in the rear cockpit, and the aircraft data system.

- N926NA has six total Mark (Mk) I EIPs (two in the pallet bay and one each in the nose, tail, left wing, and right wing).
- N928NA has six total Mk I EIPs (three in the pallet bay and one each in the nose, left wing, and right wing).
- N927NA has seven total Mk III EIPs (four in the pallet bay and one each in the nose, left wing, and right wing).

In addition, each superpod pylon has one Mk I EIP and one auxiliary power panel.

9.2.1.1 Mk 1 Experiment Interface Panel

Up to five payloads can be connected to each Mk I EIP (see Figure 11) using connectors J1 through J5. Control switches to operate the payloads are located on the rear cockpit ECP. The ECP consists of four rows of five switches (see Figure 12). Each row of switches corresponds to receptacles J1 through J5 on a given EIP. The control switches activate a SPDT (Single Pole, Double Throw) relay (see Figure 13). The relay contacts are rated at 1.0 amp maximum. The contacts are user definable and are available at receptacles J1 through J5 on the EIP.

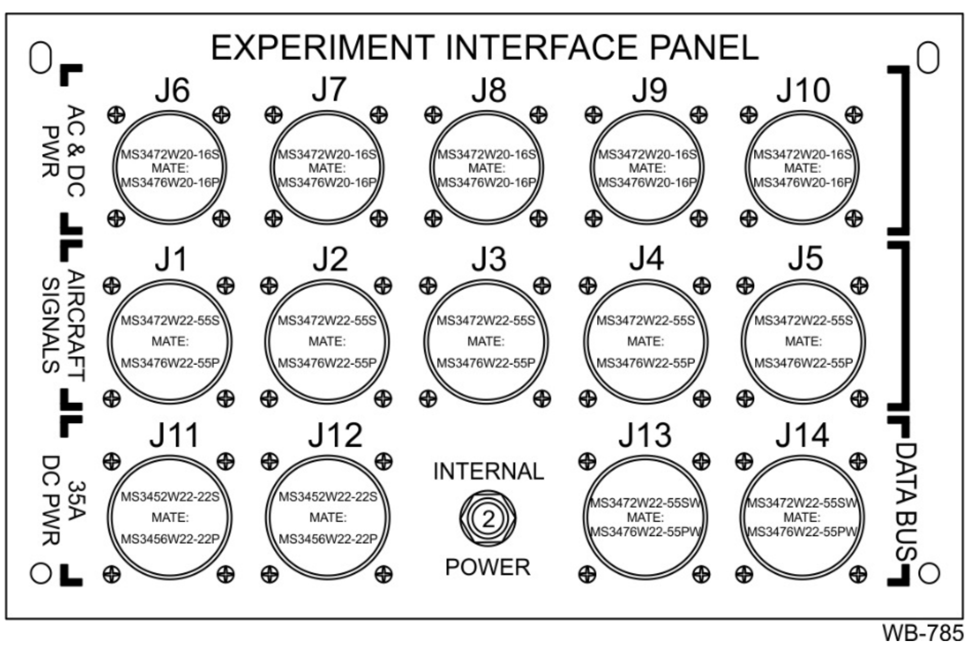

Figure 11. Typical Mk I Experiment Interface Panel

Mk I EIP receptacles J1 through J5 provide the various timing, control, and aircraft navigation signals. The pinout for these receptacles is shown in Figure 15.

Alternating Current (AC) and Direct Current (DC) power are provided through identical Mk I EIP receptacles J6 through J10. Each plug (J6 through J10) contains two 115 VAC 400 Hz 3-phase circuits and two 28 VDC circuits. Each J6-J10 connector contact (AC or DC) is limited to a maximum of 15 amps. All connectors J6-J10 share the two AC circuits and the two DC circuits. Connectors J11 and J12 also share the two DC circuits with J6-J10. The two AC circuits are limited to 35 amps per phase per circuit for the entire EIP. In other words, each EIP is provided a maximum of 70 amps of DC power and 30 amps of AC power per phase that is shared among all power receptacles. Generally, it is desirable for power loads to be balanced. The WB-57 Program Office may assign payloads to specific circuits to achieve a balanced load. See Figure 16 for a pinout of receptacles J6 through J10.

Mk I EIP receptacles J11 and J12 are identical and accommodate higher current DC power connections. These receptacles provide a total (per circuit) of 35 amps. See Figure 17 for a pinout of receptacles J11 and J12.

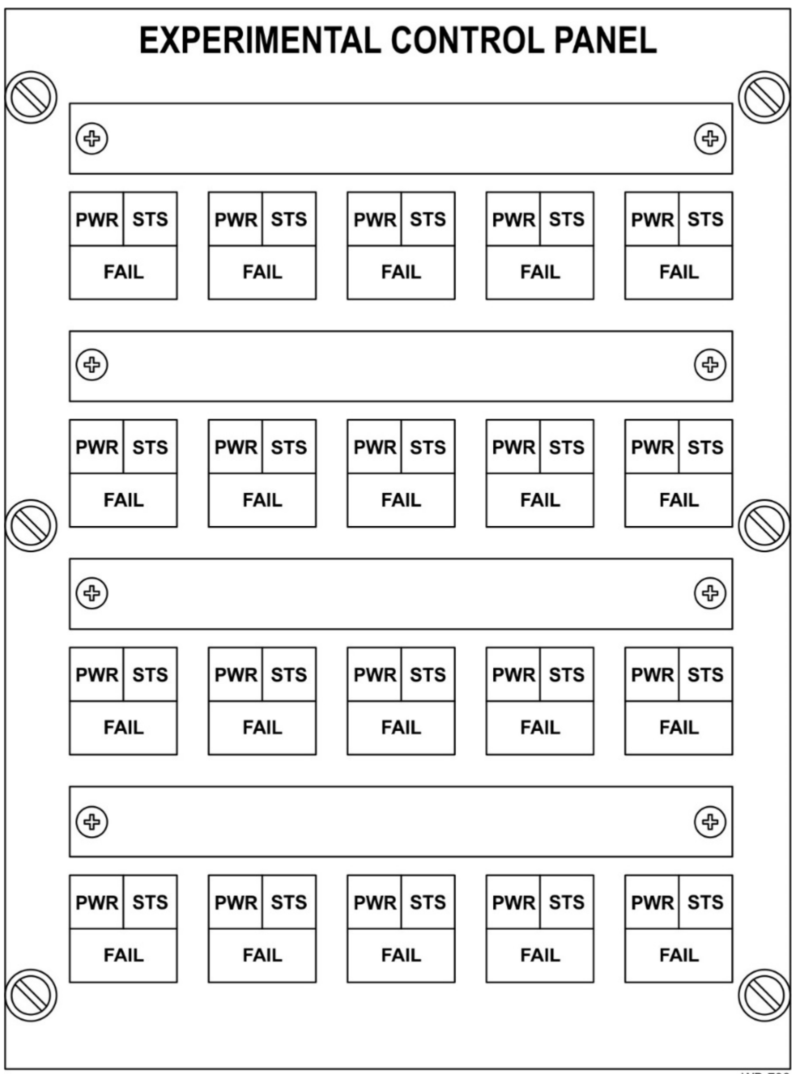

Figure 12. Experimental Control Panel

NOTE

The EIP Power Control Relay shown in Figure 13 is a mechanical relay on J1 through J5 of the Mk I EIP that is installed on N926 and N928.

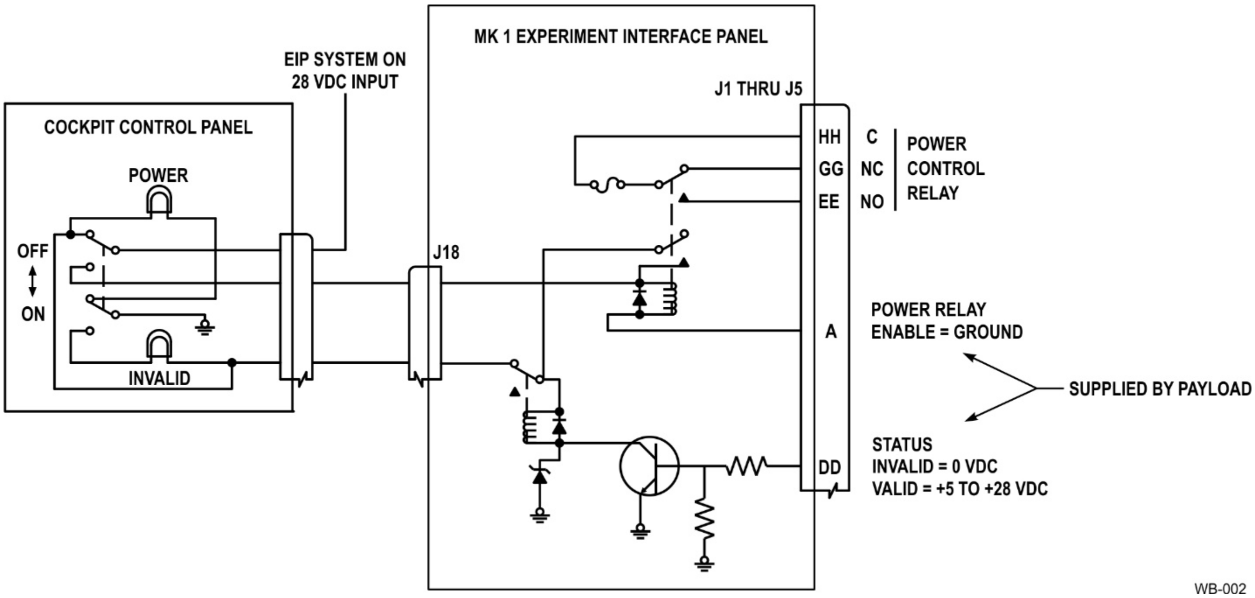

Figure 13. Mk I Power and Status Simplified Schematic (N926NA and N928NA)

NOTE

Mk III EIP is installed on N927NA shown in Figure 14. The relay on J1-J5 of the Mk III EIP is a solid-state power controller requiring a specific direction of current flow. Current flow should be from pin HH to pin EE for all J1-J5 EIP connections. Thereby, payloads can be flown on any of the aircraft without requiring wiring modification. Also, note that with the solid-state power controller there is no normally closed contact. Therefore, pin GG cannot be used on J1-J5 on N927NA EIPs.

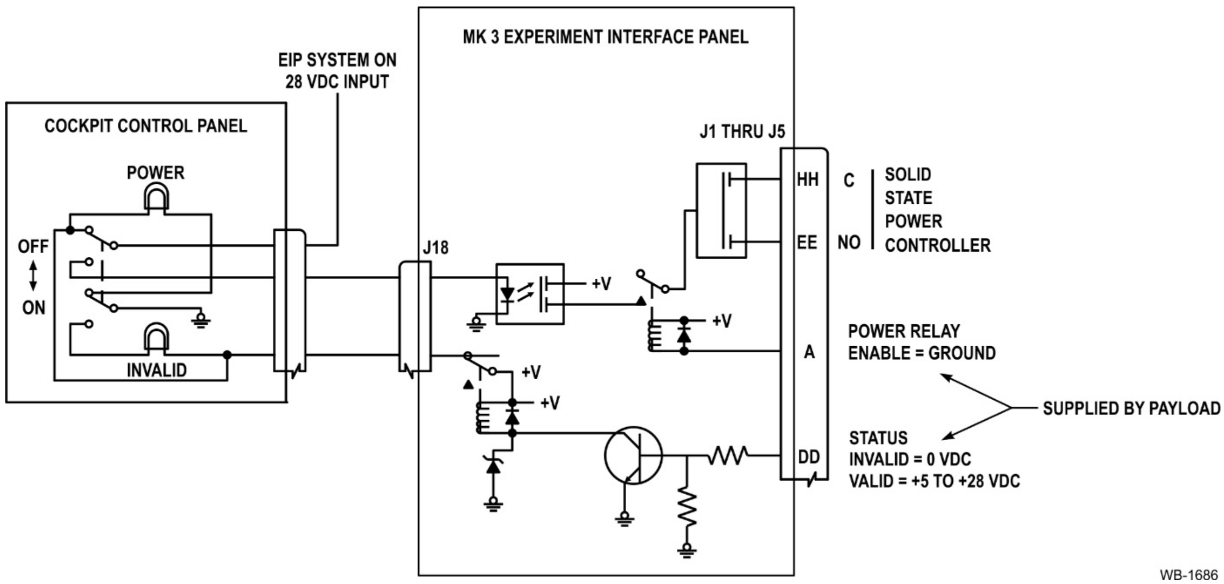

Figure 14. Mk III Power and Status Simplified Schematic (N927NA)

NOTE

PIN GG is applicable to Mk I EIPs only on N926NA and N928NA. For more information, see the note in Figure 13 and Figure 14.

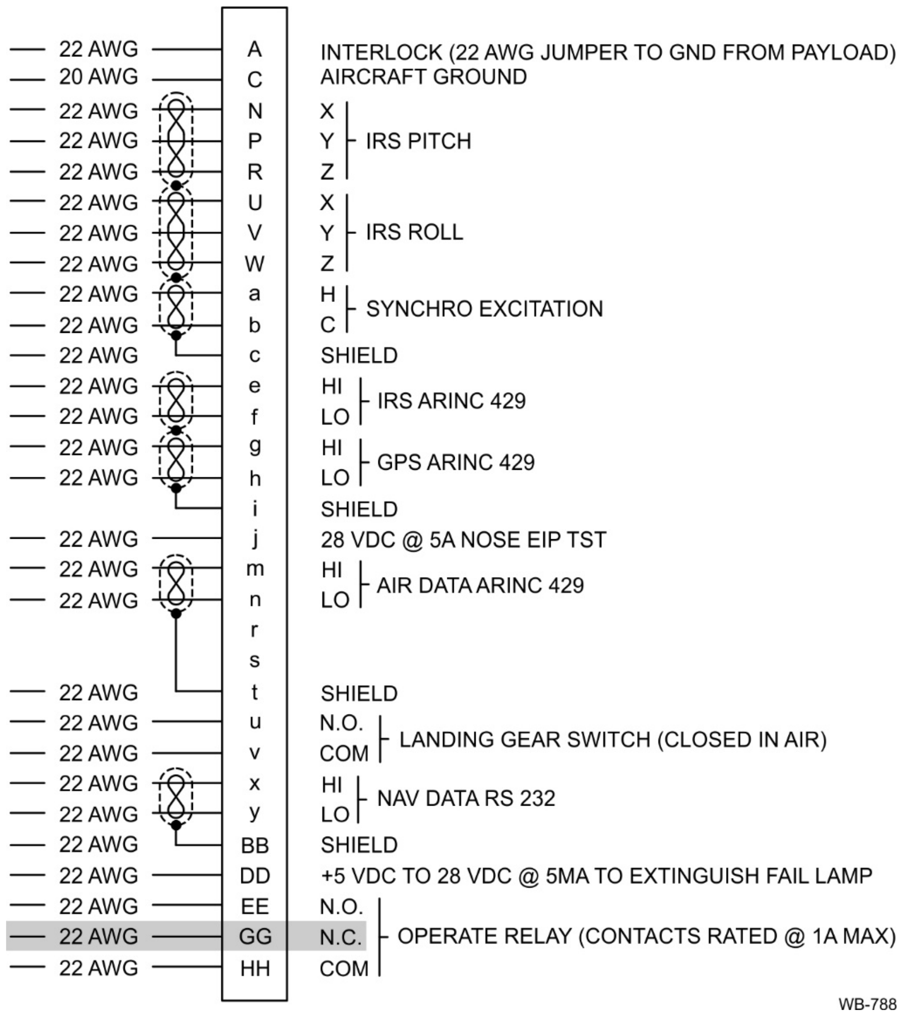

Figure 15. Pinout Receptacles J1 through J5 Configuration (MS3472W22-55S Receptacle)

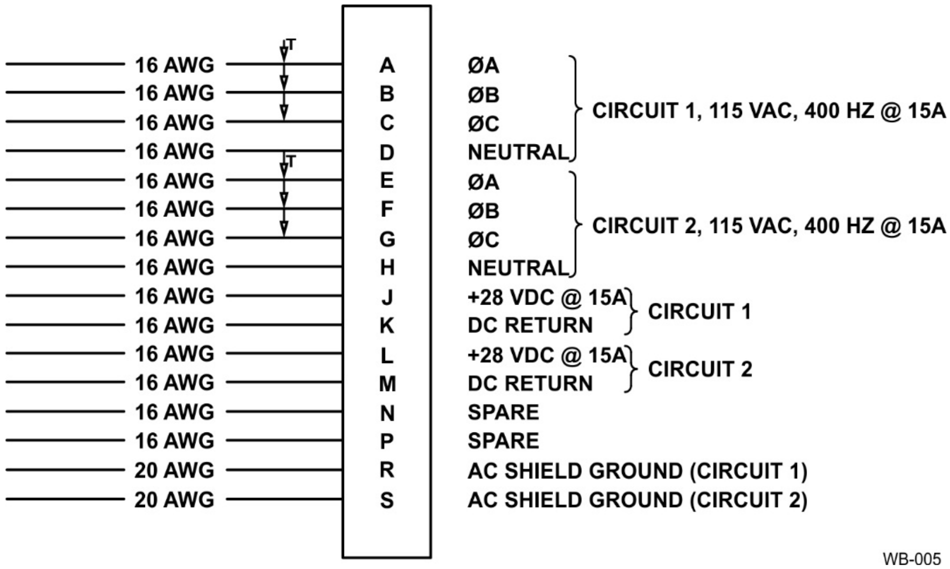

Figure 16. Pinout Receptacles J6 through J10 Configuration (MS3472W20-16S Receptacle)

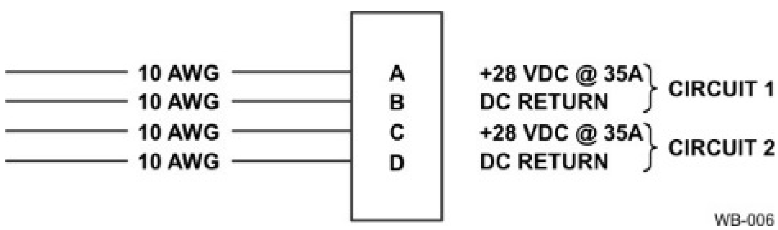

Figure 17. Pinout Receptacles J11 and J12 Configuration (MS3452W22-22S Receptacle)

9.2.1.2 Mk III Experiment Interface Panel

The legacy Mk I EIP functions are incorporated into the Mk III EIP in a virtually identical fashion. However, the connector part numbers and layout on the Mk III EIP are different from the Mk I EIP. To make the three aircraft as common as possible, N927NA has Legacy EIPs installed for payloads to connect. These legacy panels are built to replicate Mk I EIP part numbers of connectors J1-J10. This allows payloads to move from one aircraft to another without requiring different connections.

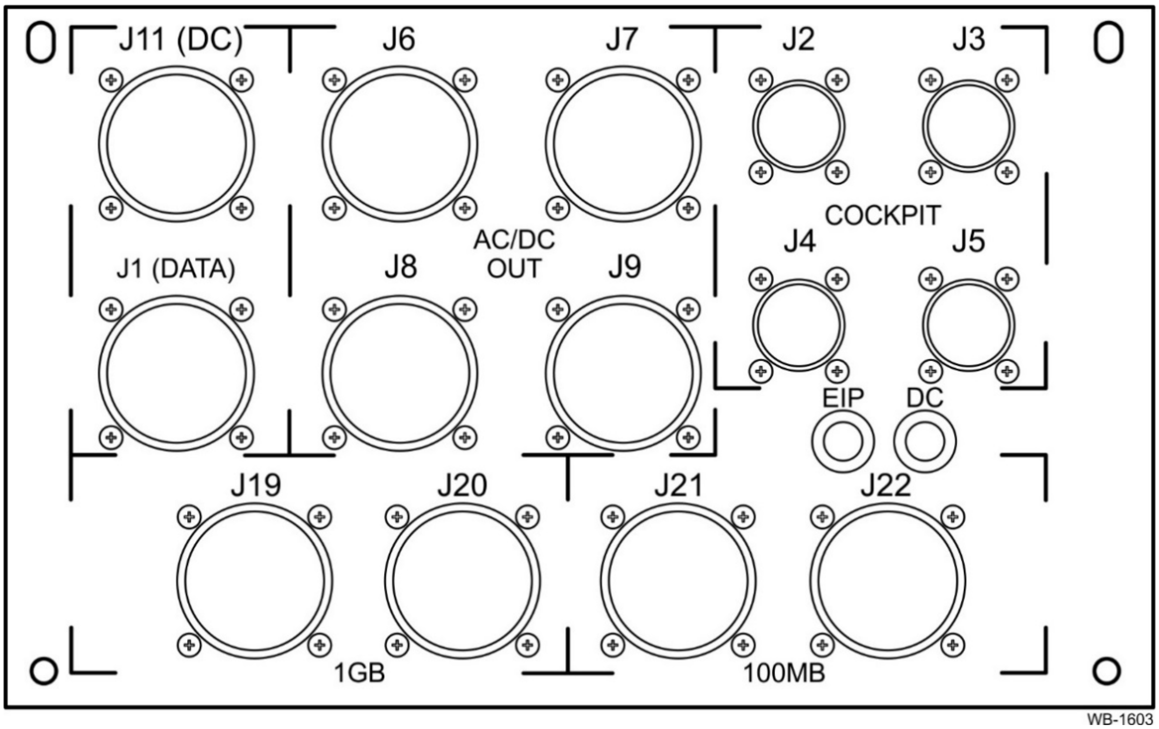

Figure 18. Typical Mk III Experiment Interface Panel

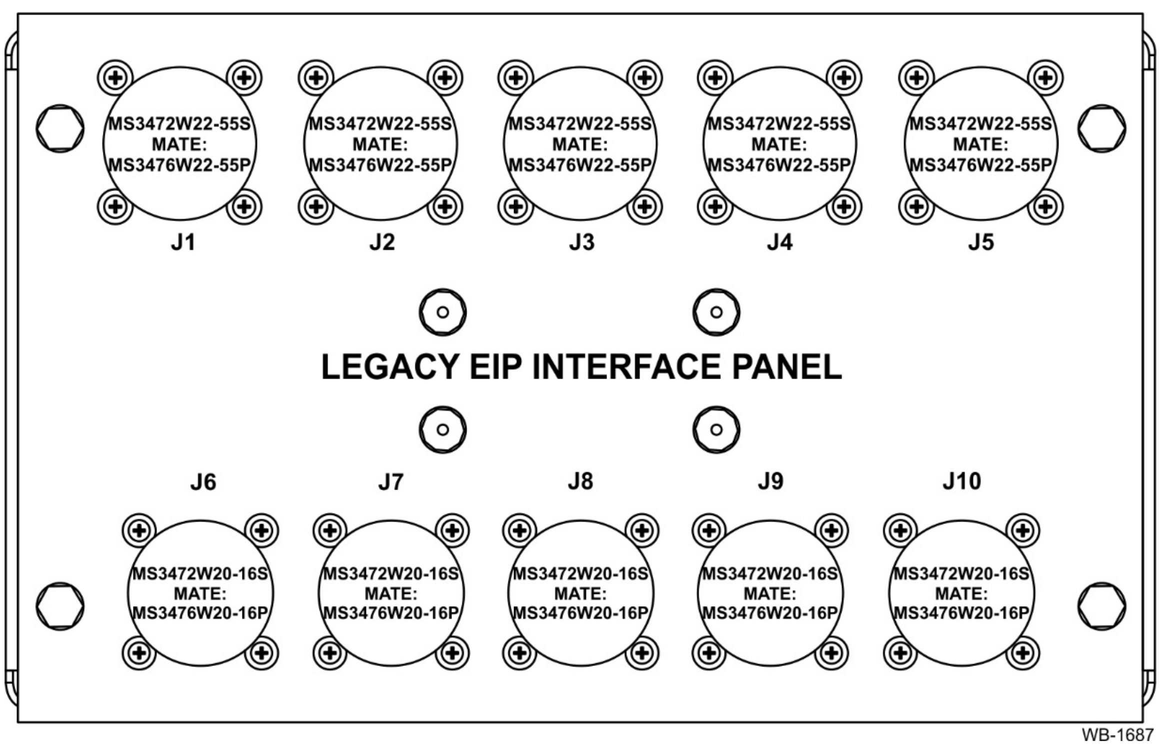

Figure 19. Typical Legacy Experimenter Interface Panel

Up to five payloads can be connected to each Mk III EIP (see Figure 18) using connectors J1 through J5 of the Legacy EIP (see Figure 19). Control switches to operate the payloads are located on the rear cockpit ECP. The ECP consists of multiple rows of five switches (see Figure 12). Each row of switches corresponds to receptacles J1 through J5 on a given Legacy EIP Interface Panel. The control switches activate a solid-state power controller (see Figure 14). The relay contacts are rated at 1.0 amp maximum. The contacts are user definable and are available at receptacles J1 through J5 on the Legacy EIP.

Mk III Legacy EIP receptacles J1 through J5 provide the various timing, control, and aircraft navigation signals. The pinout for the Legacy EIP receptacles is shown in Figure 15.

AC and DC power are provided through identical Mk III Legacy EIP receptacles J6 through J10. Each plug (J6 through J10) contains two 115 VAC 400 Hz three-phase circuits and two 28 VDC circuits. Each J6 through J10 connector contact (AC or DC) is limited to a maximum of 15 amps. All connectors J6 through J10 share the two AC circuits and the two DC circuits. Connectors J11 and J12 also share the two DC circuits with J6 through J10. The two AC circuits are limited to 15 amps per phase per circuit for the entire EIP. The two DC circuits are limited to 35 amps per circuit for the entire EIP. In other words, each EIP is provided a maximum of 70 amps of DC power and 30 amps of AC power per phase that is shared among all power receptacles. Generally, it is desirable for power loads to be balanced. The WB-57 Program Office may assign payloads to specific circuits to achieve a balanced load. See Figure 16 for a pinout of receptacles J6 through J10.

Another notable difference between the Mk III EIP and the Mk I EIP is that the Mk III EIP only has one high-power DC connector instead of two. Receptacle J11 accommodates higher current DC power connections. This receptacle provides a total (per circuit) of 35 amps. See Figure 17 for a pinout of receptacle J11. Receptacle J11 is not extended to the Legacy EIP; payloads needing to use this corrector will be connected directly to the Mk III EIP.

9.2.2 Auxiliary Power Panels

All typical payload integration areas have additional power interface panels. These panels provide connections to 115 VAC 60 Hz power in addition to the 115 VAC 400 Hz and 28 VDC power provided through the EIPs. Configurations for these power panels vary between the payload locations. Table 6, Table 7, and Table 8 detail the typical arrangement and connectors used for each type of power. Power to these panels is not individually controllable like the EIPs; they are energized throughout the entire flight. Since 115 VAC 60 Hz power is limited and therefore not the preferred option, whenever possible, 115 VAC 400 Hz should be used.

The EIPs throughout the WB-57 are the main components for providing 115 VAC 400 Hz and 28 VDC power to the payloads. There are also auxiliary power panels throughout the aircraft that provide 115 VAC 60 Hz power and some alternate connections for 115 VAC 400 Hz and 28 VDC power. Table 6 (N926NA), Table 7 (N928NA), and Table 8 (N927NA) depict the different locations and types of connections that are available.

Amperage value listed in the tables is the maximum for that circuit. Many of the circuits listed are on shared circuit breakers. Therefore, the maximum current listed may not be available when multiple connections are made to a single circuit. Coordinate with the WB-57 Program Office to verify if the required circuit current is available.

Table 6. Auxiliary Power Connections (N926NA)

AIRCRAFT CONNECTOR	PAYLOAD MATING CONNECTOR	LOCATION	QTY
TBF22-22PS 115VAC 400HZ PHA 35A — A 115VAC 400HZ PHB 35A — B 115VAC 400HZ PHC 35A — C 400HZ GROUND — D	MS3456W22-22P	NOSE BULKHEAD	1
MS3119E20-16 115VAC 400HZ PHA 10A — A 115VAC 400HZ PHB 10A — B 115VAC 400HZ PHC 10A — C 400HZ GROUND — D 115VAC 60HZ 10A — F 60HZ GROUND — G 60HZ GROUND — M 28VDC 10A — J DC GROUND — H 28VDC 10A — L DC GROUND — K	MS3476W20-16P	NOSE BULKHEAD	1
MS3452W32-17S 28VDC 100A — A DC GROUND — B 28VDC 50A — C DC GROUND — D	MS3456W32-17P	NOSE BULKHEAD PAYLOAD BAY	1 2

Table 6. Auxiliary Power Connections (N926NA) (concluded)

AIRCRAFT CONNECTOR	PAYLOAD MATING CONNECTOR	LOCATION	QTY
MS3452W20-19S 115VAC 60HZ 30A A 60HZ GROUND B 60HZ GROUND C	MS3456W20-19P	PAYLOAD BAY	4
MS3472W12-3S 115VAC 60HZ 10A A 60HZ GROUND B 60HZ GROUND C	MS3476W12-3P	PAYLOAD BAY	4
MS3452W14S-1S 115VAC 60HZ 15A A 60HZ GROUND B 60HZ GROUND C	MS3456W14S-1P	PAYLOAD BAY TAIL COMPARTMENT LEFT WING RIGHT WING	4 2 2 2
MS3452W14S-1S 115VAC 60HZ 10A A 60HZ GROUND B 60HZ GROUND C	MS3456W14S-1P	LEFT WING RIGHT WING	1 1
MS3452W14S-9S 28VDC 15A A DC GROUND B	MS3456W14S-9P	TAIL COMPARTMENT LEFT WING RIGHT WING	2 2 2
MS3472W14-5S 28VDC 15A A DC GROUND B UNUSED C UNUSED D UNUSED E	MS3476W14-5P	LEFT WING RIGHT WING	3 3

Table 7. Auxiliary Power Connections (N928NA)

AIRCRAFT CONNECTOR	PAYLOAD MATING CONNECTOR	LOCATION	QTY
MS3119E20-16 115VAC 400HZ PHA 10A — A 115VAC 400HZ PHB 10A — B 115VAC 400HZ PHC 10A — C 400HZ GROUND — D 115VAC 60HZ 10A — F 60HZ GROUND — G 60HZ GROUND — M 28VDC 10A — J DC GROUND — H 28VDC 10A — L DC GROUND — K	MS3476W20-16P	NOSE BULKHEAD	1
MS3452W32-17S 28VDC 100A — A DC GROUND — B 28VDC 50A — C DC GROUND — D	MS3456W32-17P	NOSE BULKHEAD PAYLOAD BAY LEFT WING RIGHT WING	1 3 1 1
MS3452W14S-1S 115VAC 60HZ 15A — A 60HZ GROUND — B 60HZ GROUND — C	MS3456W14S-1P	PAYLOAD BAY LEFT WING RIGHT WING	2 2 2
MS3452W14S-1S 115VAC 60HZ 10A — A 60HZ GROUND — B 60HZ GROUND — C	MS3456W14S-1P	PAYLOAD BAY	2

Table 7. Auxiliary Power Connections (N928NA) (concluded)

AIRCRAFT CONNECTOR	PAYLOAD MATING CONNECTOR	LOCATION	QTY
MS3452W14S-1S 115VAC 60HZ 5A — A 60HZ GROUND — B 60HZ GROUND — C	MS3456W14S-1P	PAYLOAD BAY	4
MS3452W14S-9S 28VDC 15A — A DC GROUND — B	MS3456W14S-9P	LEFT WING RIGHT WING	2 2
MS3452W14S-2S 115VAC 400HZ PHA 15A — A 115VAC 400HZ PHB 15A — B 115VAC 400HZ PHC 15A — C 400HZ GROUND — D	MS3456W14S-5P	LEFT WING RIGHT WING	2 2

Table 8. Auxiliary Power Connections (N927NA)

AIRCRAFT CONNECTOR	PAYLOAD MATING CONNECTOR	LOCATION	QTY
MS3119E20-16 115VAC 400HZ PHA 10A — A 115VAC 400HZ PHB 10A — B 115VAC 400HZ PHC 10A — C 400HZ GROUND — D 115VAC 60HZ 10A — F 60HZ GROUND — G 60HZ GROUND — M 28VDC 10A — J DC GROUND — H 28VDC 10A — L DC GROUND — K	MS3476W20-16P	NOSE BULKHEAD	1
MS3452W32-17S 28VDC 100A — A DC GROUND — B 28VDC 50A — C DC GROUND — D	MS3456W32-17P	NOSE BULKHEAD PAYLOAD BAY LEFT WING RIGHT WING	1 4 1 1
MS3452W14S-1S 115VAC 60HZ 15A — A 60HZ GROUND — B 60HZ GROUND — C	MS3456W14S-1P	PAYLOAD BAY LEFT WING RIGHT WING	8 2 2
MS3452W14S-9S 28VDC 15A — A DC GROUND — B	MS3456W14S-9P	PAYLOAD BAY LEFT WING RIGHT WING	8 2 2
MS3452W14S-2S 115VAC 400HZ PHA 15A — A 115VAC 400HZ PHB 15A — B 115VAC 400HZ PHC 15A — C 400HZ GROUND — D	MS3456W14S-5P	PAYLOAD BAY LEFT WING RIGHT WING	8 2 2

9.3 PAYLOAD CONTROL AND INTERFACE

ECP on/off switches in the rear cockpit control power to experiments (see Figure 12). Once power is provided to the instrument, payload operations should be handled internally. For payloads that are not completely automated, contact the WB-57 Program Office to discuss payload control options. Also, see Figure 20 for an example power connection to the EIP for non-automated payloads. The configuration of the SEO (rear cockpit) station is shown in Figure 21 and Figure 22.

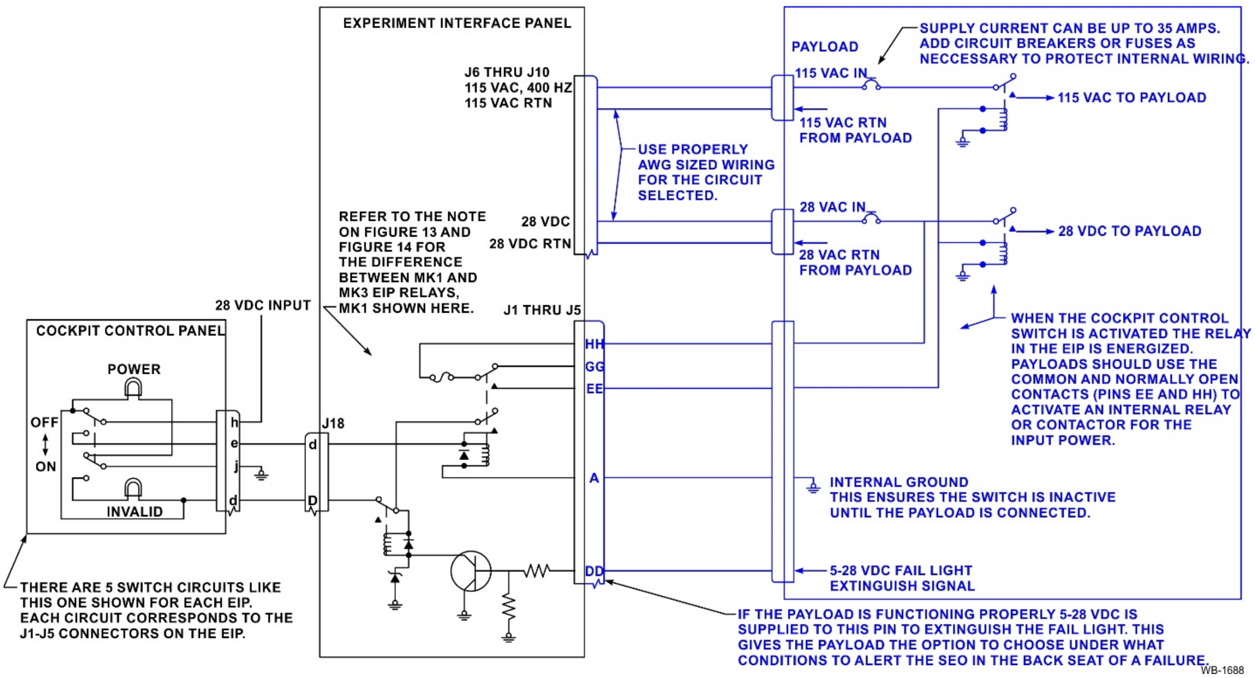

Figure 20. Power Connection for Non-Automated Payloads

Figure 21. Rear Cockpit Right Side Console Configuration

Figure 22. Rear Cockpit Forward Console Configuration

9.4 EXPERIMENTER PORTS

Ports (e.g., viewports, apertures, windows) can be incorporated as required into pallets, nose cones, wing hatches, spearpod forebodies, or superpod pylons. No modifications are currently permitted on superpod forebodies. Contact the WB-57 Program Office for further information (refer to Section 2.0, Purpose).

9.5 PROBES, VENTURIS, AND INLETS

Probes, venturis, and inlets can be incorporated as required into pallets, nose cones, wing hatches, spear pods, or superpod pylons. No modifications are currently permitted on superpod forebodies. Contact the WB-57 Program Office for further information (refer to Section 2.0, Purpose).

9.6 FACILITY INSTRUMENTS

9.6.1 Standard Aircraft Systems (Performance, Calibration)

There are no standard facility instruments currently available on the WB-57.

9.6.2 Cameras and Video

The AIRS (Airborne Imaging and Recording System) nose mounts to the front of the WB-57 and takes the place of the standard nose. Originally designed to carry the WAVE (WB Ascension Video Experiment) optical bench, which filmed the space shuttle during launch, it has since been modified to carry different optical systems to meet various needs.

The current optical system is the Day Night Airborne Motion Imagery for Terrestrial Environments (DyNAMITE), which consists of two independent co-bore sighted video camera systems. One system collects full 1080 (High-Definition) HD color video, and the other system is a Mid-Wave Infrared (MWIR) camera and lens.

One of a kind, long focal length lenses for each system coupled with the HDTV (High-Definition Television) and MWIR sensors provide high-resolution full motion video for day and night operations at extreme ranges. The DyNAMITE system has been tailored with the option to collect individual snapshots (still imagery) for specific targets of interest as well as full video recording capabilities. The snapshots can be stitched together using an in-flight image processor to provide geo-rectified TIFF (Tagged Image File Format) mosaics.

9.7 SCIENCE CREW COMPLEMENT

The WB-57 flight crew consists of the pilot (front cockpit) and the SEO (back cockpit); there are no additional science crewmembers on board the aircraft. The SEO is trained in payload operations by the payload customer.

10.0 COMMUNICATIONS, NAVIGATION, AND DATA ACQUISITION, DISTRIBUTION AND DISPLAY

10.1 VOICE AND DATA COMMUNICATIONS

10.1.1 Voice Communications

Iridium SAT Phone, secure/non-secure UHF, VHF, and HF radios provide a means of communication between flight crew and payload personnel on the ground. The preferred and primary means of communication with payload personnel on the ground is UHF.

10.1.2 INMARSAT

The WB-57 is equipped with a four-channel INMARSAT system, which allows for connection from systems on the aircraft, including payloads, to ground stations at EFD or deployed locations. Customers desiring to use the system are responsible for all costs required to operate the system.

10.1.3 Payload Audio Channels

Two-level programmable transmit/receive audio channels allow a payload to act as two communication radios available to the pilot or SEO. Contact the WB-57 Program Office for further information (refer to Section 2.0, Purpose).

10.1.4 Cockpit Audio Recording

A cockpit voice recorder port allows recording of pilot audio. Contact the WB-57 Program Office for further information (refer to Section 2.0, Purpose).

10.1.5 Ku-Band Spread Spectrum

KuSS allows for connection from systems on the aircraft, including payloads, to ground stations at EFD or deployed locations. Customers desiring to use the KuSS system are responsible for all costs required by the service provider.

10.1.6 Aircraft Network

Each aircraft has a computer network that can host payloads. The SEO can connect to a payload computer through the network by remote login. Payloads can also use this network to communicate data to the ground station through the satellite data link.

10.2 ANTENNAS

The WB-57 has a GPS antenna farm on the upper fuselage, and there is a GPS repeater in Hangar 990 for use in payload ground testing and checkout. Contact the WB-57 Program Office (refer to Section 2.0, Purpose) for specifics on current GPS antennas available for use.

10.3 FLIGHT MANAGEMENT AND NAVIGATION SYSTEMS

To position the aircraft properly to collect required data, the flight crew must enter precise navigational waypoints into the WB-57 Flight Management System (FMS). Waypoint data should be delivered to the flight crew as early as possible. One day prior to the flight is optimal; however, it is understood that is not always possible. Two hours prior to takeoff for all low flights and 3 hours prior for all "high" flights is sufficient in most cases. If the flight profile is particularly complicated or there are a large number of waypoints, then the customer should discuss these requirements with the flight crew early in the operation. A mutual timeline can be coordinated.

10.3.1 Flight Management System Data Entry Methods

There are two methods of entering data into the FMS. If the number of waypoints is small (10 or less), manually entering waypoints is reasonable. If the number of waypoints is significant (more than 10), then data transfer from a digital source is required. Each method requires a unique waypoint format (described below).

NOTE

> If the data transfer method is used, the payload team should provide the flight crew with both methods.

Both methods provide waypoint name, latitude, and longitude.

Waypoint Name – In both formats, "N" is an alphanumeric character in a five-character waypoint name. The name should describe the location of the waypoint (e.g., NW001 could be the northwestern most point and the first to be flown). The number sequence, therefore, should show the order in which the payload team desires the waypoints to be flown. As this is an example only, other naming options are possible. As long as other naming options are coordinated with the flight crew in advance and as long as they remain unique in the navigation database, they should suffice.

Latitude – The "+/-" in front of the first set of numbers indicates North or South latitude, "+" for North and "-" for South.

Longitude – The "+/-" in front of the second set of numbers indicates East or West longitude, "+" for East and "-" for West.

Degrees – The "D" stands for degrees of latitude or longitude.

Minutes – The "M" stands for minutes of latitude or longitude.

10.3.1.1 Manual Format

The manual format should be provided to the flight crew on as few pages as possible; one page is desirable. A map of the waypoints with ground references is highly desirable (Google Earth™ mapping service has been used in the past and works well). The manual method is in degrees and minutes to two decimal places.

NNNNN, +/- DD MM.MM, +/- DDD MM.MM

Example (a waypoint northeast of San Antonio, TX):

NW001, +29 58.50, -098 15.45

10.3.1.2 Data Transfer Format

The data transfer format must be a text file (.txt). As with the manual format, a map of the waypoints is desirable. The data transfer format is in degrees to four decimal places.

NNNNN, +/- DD.DDDD, +/- DDD.DDDD

Example (a waypoint northeast of San Antonio, TX):

NW001, +29.9750, -098.2575

10.4 FLIGHT PARAMETER DATA RECORDING

Aircraft attitude, navigational data (GPS and inertial), ambient flight path atmospheric conditions, and precise timing is recorded throughout the flight on the WB-57 Nav Data Recorder. This data stream is also available to aircraft payloads for data processing/recording.

All ARINC 429 data supplied to the payload EIPs during the flight is recorded and can be supplied to the payloads post-flight. The WB-57 Program can provide the data in either of two formats:

A. CSV (Comma-Separated Values) format

B. ICARRT (International Consortium for Atmospheric Research on Transport and Transformation) (ict) format

10.5 DATA ACQUISITION

Aircraft attitude, navigational data (GPS and inertial), ambient flight path atmospheric conditions, and precise timing are distributed throughout the aircraft through the EIP connectors J1 through J5. The pinouts are described in Figure 15, and the data parameters are detailed in Appendix E, Data/Navigation Parameters. This data is available at each EIP location. Contact the WB-57 Program Office early in the integration design process if you have additional requirements (refer to Section 2.0, Purpose).

10.6 DATA DISTRIBUTION AND INTERFACE

Customers may elect to have embedded computer(s) as part of the payload. A Keyboard-Video-Mouse (KVM) switch hardware, accessible by the user, allows multiple computers [e.g., Red Intelligent Data Acquisition Node (IDAN) and embedded payload computer] to access the video displays, mouse, and keyboard in the rear cockpit (SEO station). Removable drives are preferred to minimize de-integration of payloads. Solid-state hard drives are recommended if a pressure container is not used to house electronics, as spinning hard drives may not operate in a low-pressure environment. Contact the WB-57 Program Office for details of the KVM hardware and interface requirements.

A common fiber optics interface runs from the payload bay to the canted bulkhead (behind the cockpit) to the nose bulkhead (forward of the cockpit). This interface is populated with 37 fiber pairs consisting of: 16x50 micron, 13x62.5 micron, and 8x9 micron fibers. The fiber interface is not used by aircraft systems and may be used by the payload as needed. Mating connectors will be provided upon request.

10.7 DATA DISPLAY

Depending on payload configuration, data display is available to the SEO in the backseat via two monitors (15-inch and 10-inch) (see Figure 22).

10.8 TIME INFORMATION

An Inter-Range Instrumentation Group (IRIG-B) time code generator is available.

11.0 PAYLOAD DESIGN PLANNING, ENGINEERING, AND INTEGRATION PROCESSES

11.1 EXPERIMENT DEVELOPMENT AND PLANNING

11.1.1 Airborne Science Flight Requests

Contact the WB-57 Program Office at least **6 months** prior to flight to discuss the feasibility of flying an instrument on the WB-57, to establish tentative dates, and to answer any specific questions. A payload integration project manager will work with you to guide you through the process. It is beneficial to maintain frequent communications with your payload integration project manager to identify and resolve potential problem areas as early and as smoothly as possible. For current contact information, refer to the following:

https://jsc-aircraft-ops.jsc.nasa.gov/WB57/contact.html

If sponsored by NASA, the principal investigator must also complete a formal Flight Request (FR) via the Science Operations Flight Request System (SOFRS). The FR should be submitted at least **6 months** prior to flight. After processing at NASA Ames Research Center, the FR will be relayed to the WB-57 Program Office. An approved FR is required before the payload can be flown. Refer to http://airbornescience.nasa.gov/sofrs/.

The FR contains general information describing the following:

- Science objectives
- Desired schedule (exact flight dates will be determined later) and location
- Brief description of the scientific instruments and associated equipment
- Special support required or constraints, including security classification of project (if applicable)
- Preliminary hazard analysis identifying hazards and controls (any format is acceptable)
- Data requirements from the WB-57
- Names, addresses, and phone numbers of contacts

The WB-57 Program Office will work with the principal investigator or project manager to establish experiment manifests for individual flight weeks.

11.1.1.2 Funding

The WB-57 Program is a cost-reimbursable program. All payloads that fly on the WB-57 must be funded through direct transfer of funds between the organization conducting the research and NASA JSC. Foreign government organizations requesting flight time on the WB-57 must have a Memorandum of Understanding (MOU) with NASA Headquarters prior to flight. Supplementary support required from NASA (i.e., overtime hours, deployment expenses) will be figured into the total cost of a WB-57 mission as an additional expense. Cost estimates can be provided by the WB-57 Program Office upon request.

11.1.2 Payload Information Form

A NASA Payload Information Form is required for each payload on the WB-57. It provides preliminary information only and should be submitted to the WB-57 Program Office as early as possible to provide awareness of researcher intent and requirements, and to initiate coordination with the AOD Engineering Branch. The Payload Information Form is a basis for planning and is not intended to reflect final design, components, operation, etc. The Payload Information Form is located at:

https://jsc-aircraft-ops.jsc.nasa.gov/wb57/docs/PayloadInfoForm.doc

11.1.3 Payload Data Package

A Payload Data Package (PDP) is required for each payload on the WB-57. This package must provide detailed documentation of the payload and address all aspects of its design and operation. The final signed PDP will be submitted to the WB-57 Program Office no later than **6 weeks** prior to flight to allow time for thorough review prior to the Airworthiness Review (AR) and the Test Readiness Review (TRR). Late submissions may necessitate a 1-day slip to the flight schedule for each day late. Refer to Appendix C for detailed PDP requirements.

11.1.4 Drawing and Other Technical Data

The WB-57 Web site contains drawings and other technical data for payload mounting locations at the following link:

https://jsc-aircraft-ops.jsc.nasa.gov/WB57/designintegration.html

Please contact the WB-57 Program Office to inquire about other drawings or technical data.

11.1.5 Hazards

The use of hazardous materials should be avoided or minimized when possible. If the use of hazardous materials is required, refer to Section 12.7, Hazards, for guidelines.

11.1.6 Aircraft Personnel

A. Payload Integration Project Manager

This WB-57 Program Office representative serves as the primary liaison between the payload customer, engineering, maintenance, flight operations, aviation safety, and quality assurance organizations at JSC AOD, and other organizations as required, to ensure safe and successful payload development and integration onto the WB-57 aircraft. This individual will be the customer's primary point of contact until payload integration is complete. It is beneficial to maintain frequent communications with your payload integration project manager to identify and resolve potential problem areas as early and as smoothly as possible.

B. Mission Manager

This WB-57 Program Office representative manages WB-57 deployments and flight operations. The Mission Manager may also serve as an SEO, maintenance team lead, etc. This individual will be the customer's primary point of contact once payload integration is complete and flight operations begin (whether deployed or at EFD).

C. Project Pilot

This AOD Flight Operations Branch representative coordinates flight scheduling, crew training, and other WB-57 operational issues with crewmembers, mission managers, etc.

D. Project Engineer

This AOD Engineering Branch representative coordinates all engineering activities relative to the WB-57.

E. Maintenance Team Lead

This Contractor Maintenance representative coordinates all maintenance activities relative to the WB-57.

11.2 CERTIFICATIONS, REVIEWS, AND APPROVALS

A. Airworthiness Review (AR)

The AR is an internal AOD Engineering peer review meant to ensure the payload's readiness for a safe and successful flight. The review will address all engineering elements presented in the TRR or Flight Readiness Review (FRR). Successful completion of the AR means that the project can progress to the TRR or FRR.

B. Test Readiness Review (TRR)

A TRR is required for all new and modified payloads flown on the WB-57. The TRR is the final safety review prior to flight for test articles and other payloads. It includes a complete review of supporting documentation, an inspection of the payload, and a final verification of flight readiness. Refer to Section 13.3, Testing, for details.

C. Flight Readiness Review (FRR)

An FRR is required if payload integration incorporates major modifications to the WB-57 aircraft itself. The FRR certifies that the aircraft is safe to fly its intended mission (a TRR is sufficient for payloads that are conducted within the confines of the aircraft including minor protrusions outside of the aircraft that do not significantly affect drag).

D. Operational Readiness Review (ORR)

An ORR is required for all significant aircraft operations to include WB-57 deployments (i.e., flight operations away from EFD). The ORR should describe all aspects of the intended mission including planning for reasonable contingencies. An approved ORR certifies that the intended mission has been properly planned.

11.3 AIRCRAFT INTEGRATION

Payloads proposed for flight on the WB-57 should consider provisions for safe and efficient aircraft integration operations. All payloads must be designed to fit, without aircraft interference, into their designated location on the aircraft, and must meet all design guidelines specified in this document (e.g., structural, electrical). Accurate weight and CG locations must be determined for all payloads, and provisions made for service coils (slack) for electrical connections and/or overboard vent lines.

11.4 SCHEDULES AND TIMELINES

This simplified, generic timeline has been designed to assist researchers with the timely submittal of required documentation to ensure successful payload integration. All times are prior to first flight unless otherwise noted. Depending on specific circumstances, the actual timeline may range anywhere from 2 years or more to 6 months or less.

A. 1+ Year

Contact the WB-57 Program Office with initial inquiry about the feasibility of flying a payload on the WB-57. For very complex payloads, inquiries should be made further in advance.

B. 11 Months

Submit Payload Information Form (refer to Section 11.1.2, Payload Information Form).

C. 10 Months

Submit FR via SOFRS (for NASA-sponsored payloads only) (refer to Section 11.1.1, Airborne Science Flight Requests).

D. 8 Months

Pressure and laser systems should be discussed with the WB-57 Program Office as early as possible. The more complex and hazardous, the longer the approval process.

E. 6 Months

Submit JSC Form 44A, Radio Frequency/Microwave Hazard Evaluation Data, and/or JSC Form 44B, Laser Device Use Request/Authorization, with JF1023, Nonionizing Radiation Training and Experience Summary (if applicable) (refer to Section 12.7.1, Lasers, and Section 12.7.4, Radiation Sources).

F. 3 Months (prior to arrival)

Submit a draft PDP. This should include, if applicable, laser information for JF44A, JF44B, and JF1023 (refer to Section 12.7.1, Lasers, and Section 12.7.4, Radiation Sources) as well as the necessary information for NASA to complete an Operation Configuration Control Plan (OCCP) for any pressure/vacuum systems (refer to Section 12.5.1, Pressure/Vacuum Systems).

Submit badging request for foreign nationals (if applicable) [refer to Section 14.4, Access (Including Badging)].

G. 6 Weeks

Submit final, signed PDP (refer to Section 11.1.3, Payload Data Package, and Appendix C, Payload Data Package Requirements).

H. 3 Weeks

Submit AOD Form 314, Checklist for Test Readiness Review of Payloads and Experiments on JSC AOD Heavy Aircraft (refer to Section 13.3, Testing).

I. 2 Weeks (prior to arrival)

Submit badging request for all United States (U.S.) citizens and permanent resident aliens (if applicable) [refer to Section 14.4, Access (Including Badging)].

J. 3 Days to 2 Weeks

Ensure payload hardware arrives at EFD and is installed on the WB-57. Complete electrical and control checkouts. Coordinate with the SEO to finalize the payload operation checklist (refer to Section 11.4.1, Arrival at Ellington Field, and Section 12.1, Flight Safety).

K. 1 to 3 Days

Participate in pre-TRR and TRR. Complete any resulting action items (if applicable) (refer to Section 13.3, Testing).

L. Zero Days

Go Fly! [Refer to Section 13.1, Operational Scenarios (Flight Hours and Duty Days).]

11.4.1 Arrival at Ellington Field

Payloads and equipment should be received at JSC EFD in a timely manner to allow for unpacking, assembly, weighing, aircraft installation, electrical checkout, pre-TRR, and TRR.

The address to use for shipping is:

NASA/DynCorp International
WB-57 Program Office/Your Payload Name
Attn: POC Name/POC Phone #
Building 270, Ellington Field
Houston, Texas 77034

With prior coordination, larger shipments can be sent directly to Hangar 990 or Building 994 (refer to Section 14.1.3, Shipping and Receiving). During your time at EFD, it is recommended that smaller shipments be shipped to your hotel if possible. NASA's shipping and receiving department has limited hours.

The assembly of instrumentation is solely the responsibility of the researcher. The WB-57 Program Office provides toolboxes with standard tools in English and metric units. Contact the WB-57 Program Office for a list of tools available in the toolbox. The researcher must provide special tools and checkout equipment.

11.4.2 Departure from Ellington Field

After final flight at EFD, payloads will be offloaded and prepared for shipment by the user. It is the researcher's responsibility to ensure that all payloads and ground equipment used for the mission (i.e., compressed gas cylinders, chemicals, packing, crating) are removed promptly from Building 994 and Hangar 990. It is also the responsibility of the user to arrange for the shipment of all equipment. Be sure to advise your shipper that pickups must be made no later than 3:15 p.m. CST (Central Standard Time), Monday through Friday only.

Customer feedback received concerning the facilities, staff, and the WB-57 Program is greatly appreciated in order to improve customer service. A customer feedback form will be provided to each participant at the conclusion of the mission.

12.0 PAYLOAD DESIGN AND FABRICATION REQUIREMENTS

This section provides a detailed description of payload design specifications that must be met before a payload is approved for flight on the WB-57. Retain all documentation throughout the design process so that it may be presented later in the flight approval process. The safety guidelines presented in this section are the minimum required. We encourage you to take steps to exceed these guidelines when practical, while keeping overall payload weight and drag to a minimum. In the absence of specific guidance in this document, it is recommended that appropriate sections of Federal Aviation Administration (FAA) Advisory Circular 43.13-1B/2A, Acceptable Methods, Techniques, and Practices – Aircraft Inspection, Repair, and Alterations, be adhered to whenever possible during payload design and fabrication to ensure safety and compliance with common aerospace industry standards.

12.1 FLIGHT SAFETY

Safety of the aircraft, flight crew, and ground personnel is paramount during all aspects of payload design, integration, and operations. The WB-57 flight crew consists of the pilot (front cockpit) and SEO (rear cockpit).

The pilot is responsible for flying the aircraft (including navigation, radio, and system diagnostic responsibilities) during all phases of a flight. The pilot is ultimately responsible for the safety of the crew and aircraft, and has the final say as to whether or not the flight will proceed.

The SEO is responsible for the safe operation of all payloads on the WB-57 as well as some navigational and pilot assistance responsibilities. The SEO, in coordination with the pilot, has the authority to shut down all payloads for safety of flight issues. Payload operation checklists will be generated and certified for flight through regularly scheduled briefings attended by the researcher, pilot, and SEO. Deviations from the payload operation checklist are allowed to address issues pertaining to the overall safety of the flight.

Payload Fail-Safing – All equipment will be designed so that in the event of payload power loss (expected or unexpected), power surge, rapid depressurization, fluid leak, fire, etc., the payload will fail to a safe configuration and there will be no chance of inducing another hazardous situation. Researchers shall coordinate with the WB-57 Program Office to develop appropriate emergency procedures in checklist format for payload fail-safing. WB-57 flight crew will be trained on how to fail-safe the payload so they are able to safely and efficiently initiate emergency procedures when required.

12.2 MECHANICAL SYSTEMS

12.2.1 Loads and Structures Payload Data Package Requirements

WB-57 payloads must comply with the following structural design requirements and provide documented proof of compliance via the PDP (refer to Section 11.1.3, Payload Data Package, and Appendix C, Payload Data Package Requirements). Structural designs should allow for ease of aircraft integration, payload maintenance, and replacement of components, when required. All hardware shall be designed for aircraft installation with enough clearance to avoid the risk of damaging aircraft structure (i.e., 1 inch from moving or critical surfaces, 1/2 inch from static surfaces). Hardware shall also be designed to be compatible with standard materials handling equipment and procedures. Equipment that is manually handled (i.e., handles, lifting bars, points) shall be designed so that no person lifts more than 50 lbs.

Structures are to be designed with both limit and ultimate load cases in mind. Limit and ultimate loads for the WB-57 are defined as follows:

A. Limit Loads

Limit loads are defined as the maximum loads anticipated on the aircraft during its lifetime of service. These loads are typically based on the maximum accelerations the aircraft is expected to experience during operation. The structure shall be able to support limit loads without detrimental permanent deformation.

For externally mounted payloads, aerodynamic loads shall be combined with the inertial limit loads.

NOTE

Limit loads are calculated by dividing the ultimate loads by a factor of 1.5.

B. Ultimate Loads

Ultimate loads are defined as the limit loads multiplied by a **Factor of Safety (FS) = 1.5**. The structure must be able to support ultimate loads without failure for at least 3 seconds. Ultimate load factors are listed in Section 12.2.1.1, Ultimate Load Factors. For example, payloads mounted in a pallet must be able to withstand 3-g's in the forward direction, 1.5-g's in the aft direction, etc. Each load direction should be analyzed independent of the other load cases.

12.2.1.1 Ultimate Load Factors

All structures, attachments, and fasteners for equipment installed in the aircraft shall be designed to withstand the load conditions listed below. These load factors, when applied one at a time, shall not produce a stress in any structural element beyond the accepted ultimate strength of the construction material. See Figure 23 for loading directions.

- Forward: 3-g's (ultimate)
- Aft: 1.5-g's (ultimate)
- Up: 3-g's (ultimate)
- Down: 6.1-g's (ultimate)
- Lateral: 1.5-g's (ultimate)

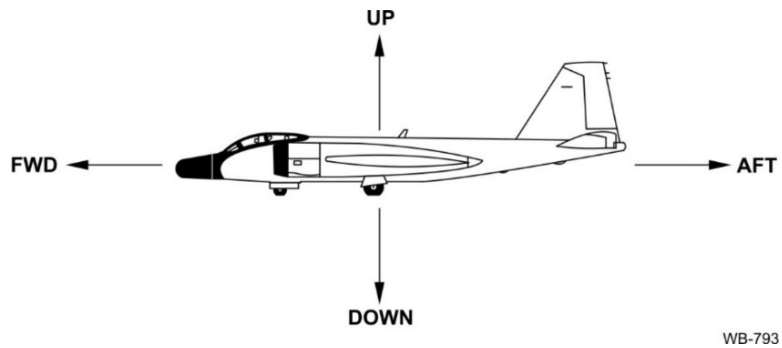

Figure 23. Axis Configuration for Ultimate Loads

12.2.2 Inlet Systems

There are no standard inlets on the WB-57 aircraft. There are existing provisions for inlets on pallets. Inlets may be added to other payload locations with WB-57 Program Office approval.

12.2.3 Fasteners

Fasteners used in structural designs shall be of an aerospace grade [e.g., Army-Navy (AN), Military Specification (MS), National Aerospace Standard (NAS)] or equivalent, and shall possess documented fastener strengths. Common fasteners used in payload structures include bolts, screws, rivets, and nut plates. Proper fastener installation will be practiced at all times by using correct fastener sizes, spacing [e.g., Edge Distance (E/D) no less than 2.0], torque loads, locking hardware (e.g., safety wire, locking nut plates, locking helicoils, lock nuts), and rivet bucking procedures.

NOTE

The #8 size threaded fasteners (or smaller) are not considered sufficiently sized fasteners for structural purposes.

Only use #10 size (0.190 inches in diameter) or larger fasteners when selecting fasteners for load bearing structures. Threaded fasteners shall have threads engaged sufficiently. This requires at least two threads to be visible beyond the locking nut or nut plate. If more than four threads are exposed, a shorter grip length should be selected.

The following applies to fasteners used in safety critical joints. A safety critical joint is defined as a joint whose failure could result in a catastrophic hazard such as critical damage to the aircraft or injury to personnel.

- Fasteners shall be properly torqued using calibrated tools.
- Fully threaded fasteners (threads in the shear plane) shall not be used. Fasteners shall be sized to allow for an unthreaded shank in the shear plane.
- Fasteners must include a self-locking feature or be safety wired. Lock washers shall not be used without WB-57 Engineering approval.

- The use of locking or staking compounds such as threadlocking adhesives or epoxy staking compounds is not recommended. Proposed applications that use these compounds in safety critical joints must include a detailed analysis verifying their use and be approved by AOD Engineering.

12.2.4 Welding

Structural welds shall be performed in accordance with (IAW) AWS D17.1, Specification for Fusion Welding for Aerospace Applications. The structural analysis for the hardware must consider the new material properties in the Heat-Affected Zone (HAZ). The HAZ is the area of base material that has had its microstructure and properties altered by welding or heat intensive cutting operations. The heat from the welding process and subsequent re-cooling causes this change in the area surrounding the weld. The extent and magnitude of property change depends primarily on the base material, the weld filler metal, and the amount and concentration of heat input by the welding process.

12.3 ELECTRICAL SYSTEMS

NOTE

> Brief interruptions of electrical power during engine start-up and momentary interruptions of electrical power may occur during flight. Although infrequent, brief power interruptions may disrupt certain sensitive instruments. Sensitive test equipment should incorporate protective devices to prevent data loss.

12.3.1 Wiring

All electrical wiring and interconnect cabling shall be fabricated and installed IAW SAE AS50881, Wiring Aerospace Vehicle; T.O. 1-1A-14, Technical Manual, Installation and Repair Practices, Aircraft Electric and Electronic Wiring; and/or JPR 1700.1, JSC Safety and Health Handbook, as applicable. Also, refer to FAA Advisory Circular 43-13-1, Acceptable Methods, Techniques, and Practices – Aircraft Inspection and Repair, for general guidelines. Wire types shall be IAW NASA Drawing 8593003, Wire, Electric, Interconnection, and Hookup. Contact the WB-57 Program Office for copies of these documents.

All wires should be made of copper and have a wire temperature rating of at least 140°F/60°C. Higher rated wire (i.e., 221°F/105°C) is strongly encouraged.

Materials or insulation that are flammable, produce smoke, or emit toxic fumes when exposed to a combustible or high-temperature environment shall not be used in payload assemblies. The following materials are not acceptable for use in payloads to be carried onboard the WB-57 if there is any possibility that smoke and/or fumes could enter the cockpit pressurization system:

- Polyester
- Nylon
- Polyvinyl Chloride (PVC)

- Polyethylene (PE)
- Polypropylene
- Polyurethane
- Kapton® (polyimide resin), with the exception of Kapton® tape

Specialty purposes cables such as Universal Serial Bus (USB), Ethernet, and video cables are typically purchased with PVC jackets, which are hazardous when burned. The WB-57 Program Office requires the use of Low Smoke Zero Halogen (LSZH) cables when these types of cables are installed on the payload. A web search for LSZH cables will produce several options or contact the WB-57 Program Office for suggested cables.

12.3.2 Cabling

All electrical aircraft interface cables shall have a descriptive tag secured to each end with information to include the payload name, cable number, voltage, maximum current required from the aircraft outlet, and manufacturer-printed wire gauge label. All cables within the payload shall be adequately restrained and clamped, and electrical insulation shall be protected against abrasion and chafing. All exposed power leads and electrical contacts must be covered to protect personnel as well as the equipment and aircraft.

All experiment cables, including power cables, must be of the appropriate size (or gauge) for the intended current draw across the wire. All experiments are required to comply with the wire sizing guidelines shown in Table 9.

Table 9. Minimum Wire Gauges

Maximum Current	Minimum Wire Gauge
5 Amps	18
10 Amps	16
15 Amps	14
20 Amps	12
25 Amps	10
30 Amps	8
50 Amps	4

Customers are responsible for providing all payload electrical cables that interface with the aircraft. As a general rule, electrical interface cables for pallet payloads should be approximately 15 ft long to allow for installation in any of the four pallet positions.

12.3.3 Connectors

Connectors shall be suitable aircraft-type connectors. Where suitable aircraft-type connectors cannot be used, the connector shall be mechanically secured to prevent un-mating due to aircraft vibrations.

12.3.4 Circuit Protection

Circuit breakers shall be IAW SAE AS50881. The payload shall be self-protected with an incorporated circuit breaker or other current-limiting device. The limiting value of each device should be carefully chosen with the maximum current of the protected components in mind. When selecting circuit breaker values, the sum of the maximum device currents cannot exceed the rated current of the power source or the circuit breaker itself. Ideally, each circuit should be designed so that the total nominal current of all devices does not exceed 80% of the rated supply current. Any exposed metal surfaces shall be adequately grounded to prevent electrical shock.

12.3.5 Batteries and Uninterruptible Power Supplies

The payload shall have emergency shutdown capabilities to completely de-energize the entire payload including backup power systems such as batteries or UPSs (Uninterruptible Power Supplies).

Small numbers of AA or D type alkaline or "button" Nickel Cadmium batteries can be used without special approval. All other battery usage on the aircraft, including Lithium chemistry batteries, requires approval of the WB-57 Program Office and should be presented early in the design phase of the payload. Whenever possible, select benign battery chemistries with hermetically sealed cell designs from the following:

- Alkaline (Zn/MnO2)
- Silver-Zinc
- Nickel Cadmium
- Sealed Lead Acid (starved electrolyte or immobilized electrolyte type)

Batteries shall be of the dry cell or gel-cell type. Liquid electrolyte batteries are not allowed on the aircraft. Recharging in flight is not permitted for non-aircraft batteries.

12.3.6 Motors and Pumps

As such motors do not introduce starting transient loads on the 60 Hz power converters employed on the aircraft, the use of 400 Hz motors is preferred. Larger motors (e.g., those used in vacuum pumps) shall be protected by a thermal overload device. Additionally, single-phase motors must be equipped with solid-state switches to inhibit arcing at the contacts during start up. In the absence of arc suppressors, motors must be shown to be spark-free during operation. Motors that are rated as explosion-proof or totally enclosed and non-ventilated are recommended for use on the aircraft.

12.3.7 Power Distribution

Total electrical power loads (including peak or in-rush currents) shall be calculated and electrical power requirements coordinated with the WB-57 Program Office.

12.3.8 Electromagnetic Interference

All electrical components on payloads should meet reasonable requirements for Electromagnetic Interference (EMI) transmission and EMI susceptibility. Treat equipment generating Radio

Frequency (RF) energy between 30 Hz and 30,000 MHz as a cause of interference unless you provide the equipment with power line filters, shielding, bonding, and grounding. Any experiment determined to be interfering with other experiments or aircraft instrumentation systems during any phase of flight will be powered down. Experiments may also be powered down to help troubleshoot an EMI problem.

12.4 MATERIALS

12.4.1 Metallic

Materials used in a payload structural design must have documented allowable strengths. Typical materials used in structural design are aluminum, steel, and stainless steel.

12.4.2 Non-Metallic

If non-metallic materials are used, some restrictions apply. Researchers must provide documentation (usually the material specification sheet) that the non-metallic items are non-flammable and that they will not support combustion. The researcher is also required to supply the WB-57 Program Office with Safety Data Sheets (SDSs), via the PDP (refer to Appendix C), for the non-metallic materials being used. Glass or plastic windows or panels require a higher factor of safety than metal components. Contact the WB-57 Program Office for further information (refer to Section 2.0, Purpose).

12.4.3 Hazardous Material

HAZMAT (Hazardous Material) is defined as anything with a flashpoint below 140°F/60°C or with a TLV (Threshold Limit Value) below 500 parts per million (ppm), below 500 milligrams per cubic meter (mg/M^3) for fumes, below 10 mg/M^3 for dust, or with a single oral dose (if liquid) at 50% lethality below 500 milligrams per kilogram (mg/kg). As a note, materials with flash points at or above 100°F/38°C are considered combustible; flash points below 100°F/38°C are considered flammable. If possible, avoid the use of hazardous materials including high pressure, toxic, corrosive, explosive, flammable, and combustible materials. If such materials are required, whether in-flight or on the ground, proper containment and hazard controls shall be provided. Early contact with the WB-57 Program Office for discussions on proper hazard controls and containment of proposed hazardous materials may prevent delays in obtaining approval for the use of such materials. If such materials are necessary, provisions for dumping and purging in flight may be required. A current SDS shall be supplied for each hazardous material via the PDP (refer to Appendix C). It is the researcher's responsibility to store hazardous materials as specified in the SDS, and to provide and use appropriate Personal Protective Equipment (PPE) IAW the applicable SDS.

12.5 PRESSURE AND HYDRAULIC SYSTEMS

12.5.1 Pressure/Vacuum Systems

All pressure/vacuum systems proposed for flight and/or ground use must comply with JPR 1710.13, Design, Inspection, and Certification of Ground-Based Pressure Vessels and Pressurized Systems (contact the WB-57 Program Office for access to this document). An OCCP will likely be required depending on the type of pressure/vacuum system proposed. Instructions for requesting an OCCP can be found at https://jsc-aircraft-ops.jsc.nasa.gov/WB57/datapackage.html. The OCCP is completed and approved by the JSC Structural Engineering Division based on the customer request, and an approved OCCP is required prior to ground testing or use of the system on the WB-57. Coordination with the WB-57 Program Office early in the design process will facilitate approval of the pressure/vacuum system and prevent potential redesign.

NOTE

Sealed containers do not require an OCCP but must still be documented in the PDP. To be approved as a sealed container, the following requirements must be met:

- Item is a single, independent container, component or housing that is not a part of a/the pressure system.
- Container is not vented or actively pressurized.
- Leakage of the fluid is non-hazardous.
- Loss of pressure in the container will not pose a hazard to continued operation of the aircraft or result in a catastrophic event.
- Container Maximum Operating Pressure (MOP) is less than 100 pounds per square inch absolute (psia).
- The stored energy of the container must be less than 14,240 foot-pounds (ft-lbs) based on adiabatic expansion of a perfect gas. The contained energy of the container is calculated using the following equation at the highest pressure differential to be seen during operation:

$$E = \frac{P_i V}{K - 1} \left[1 - \left(\frac{P_e}{P_i} \right)^{\left(\frac{K-1}{K} \right)} \right]$$

Where:

E = container stored energy [in-lbs (inch-pounds)]

P_i = internal pressure (psia)

P_e = external pressure (psia)

V = internal volume [cubic inch (in^3)]

K = ratio of specific heats C_p (constant pressure)/C_v (constant volume) (1.4 for air)

12.5.2 Purge/Vent Systems

An overboard vent line is available in the WB-57 pallet bay. The manifold fittings on the multi-user vent line are female (internally threaded) 3/8-inch National Pipe Thread (NPT) fittings. Researchers must provide a suitable type and length of hose to reach the manifold from their pallet integration location. Service coils (slack) must be figured into the length of the hose for ease of payload integration and maintenance. Requests for use of the overboard vent system shall be made by contacting the WB-57 Program Office.

The chemical composition, physical characteristics, and quantity of the vented gas shall be entirely known and documented by the researcher, and no liquid shall be present in the vented gas line for "freeze-up" purposes. It is the responsibility of the researcher to inform the WB-57 Program Office, via the PDP (refer to Appendix C), of all possible hazards associated with the vent gas, along with mitigation and potential interaction. This includes, but is not limited to, the possibility of freeze-up, blockage, ignition, corrosion, and chemical reaction with other agents that could be introduced by another payload on the same vent line.

12.5.3 Cylinders

For pressure vessel requirements, it is recommended that Type I (all metal) cylinders be used whenever possible. Metal cylinders must be Department of Transportation (DOT) approved. Composite Overwrapped Pressure Vessels (COPV) are susceptible to impact damage and require detailed visual inspection by a trained visual inspector. COPVs have specific inspection, installation, and documentation requirements, but may be used if desired or if weight is an issue. All COPVs require a protective cover to guard against damage during maintenance activities (e.g., dropped tools). DOT/Natural Gas Vehicle (NGV2) COPVs will be required to meet FMVSS 304, Compressed Natural Gas Fuel Container Integrity, requirements for inspection and NFPA 52, Vehicular Gaseous Fuel Systems Code, for installation, at a minimum. Any flight weight COPVs will require adherence to the ANSI/AIAA S-081/A, Space Systems-Composite Overwrapped Pressure Vessels, standard and Damage Control Plan approval by the JSC Fracture Control Board. All cylinders shall have proof of current inspection. Contact the WB-57 Program Office for further information regarding pressure vessel usage.

12.6 THERMAL

12.6.1 Temperature Limits

Payloads using heaters or other heat-producing devices shall maintain a touch temperature of no greater than 130°F/54°C. Guards or other protection measures will be employed for research hardware where the touch temperatures are greater than 130°F/54°C. Cold surface temperatures shall also be guarded if below 32°F/0°C.

12.6.2 Control

While there is limited capability for SEO thermal control of payloads, in general, overall payload thermal control should be autonomous, requiring no SEO monitoring or input. Indication of an off-nominal thermal condition shall be provided to the SEO. Provisions shall be provided for the SEO to shut down a portion of or all of a payload, as required, in the event of an off-nominal condition.

12.6.3 Heaters

It is possible to install heaters in payload locations to help moderate payload temperature, and for external heating to be supplied to payload locations on the ground. Heater provisions are the responsibility of the payload customer. Heaters shall not be in contact or in close proximity with any materials that could be a fire hazard.

12.6.4 Chillers

It is possible to install cooling systems in payload locations to help moderate payload temperatures, and for external cooling to be supplied to payload locations on the ground. Chiller provisions are the responsibility of the payload customer.

12.7 HAZARDS

12.7.1 Lasers

All lasers proposed for flight and/or ground use must comply with JPR 1700.1 (http://jschandbook.jsc.nasa.gov/). All Class 3 and 4 lasers must be registered and approved for use with JF44B. JF1023, Nonionizing Radiation Training and Experience Summary, must also be completed for each laser operator. Both forms may be found at https://jsc-aircraft-ops.jsc.nasa.gov/WB57/datapackage.html.

12.7.2 Gases

All compressed gases used, either in-flight or on the ground, must be documented in the PDP and accompanied by an SDS. Local gas suppliers are available upon request.

12.7.3 Cryogens

All cryogens proposed for flight and/or ground use must comply with JPR 1700.1 (http://jschandbook.jsc.nasa.gov/).

12.7.4 Radiation Sources

All radioactive materials or radiation-producing equipment proposed for flight and/or ground use must comply with JPR 1700.1 (http://jschandbook.jsc.nasa.gov/) (ionizing and non-ionizing radiation). Depending on the situation, authorization for use may be required from the JSC Radiation Safety Committee. RF transmitters such as radar systems must be registered and approved for use with a JF44A. JF44A may be found at the following:

https://jsc-aircraft-ops.jsc.nasa.gov/WB57/datapackage.html.

12.7.5 Other

Fluids approved for flight on the WB-57 must be contained in a system that is structurally capable to withstand design and ultimate loads specified in Section 12.2.1, Loads and Structures. Hardware used to contain fluid must be designed with suitable provisions for leak control to ensure a leak free system during ground and flight operations. In the event of payload power loss, power surge, rapid depressurization, etc., all hardware must fail to a mode allowing for sound fluid containment. If fluid is drained to an ambient pressure reservoir during flight operations, fluid absorption methods must be installed to eliminate the chance of leaks through loose seals. If possible, avoid the use of toxic, corrosive, and explosive fluids. An SDS must be submitted via the PDP (refer to Appendix C) for all fluids other than water.

NOTE

- All hard and sharp edges that could conceivably be accessed by voluntary or involuntary contact shall be guarded.
- Any frangible items [i.e., glass, Cathode Ray Tubes (CRT), gauges, windows, or other objects that are susceptible to shattering] will be entirely contained to prevent injury or Foreign Object Debris (FOD) damage.

12.8 ACCESS, EGRESS, AND PHYSICAL INTEGRATION

Access to the aircraft is controlled. An AOD employee must accompany anyone requiring access to the aircraft. The Payload Integration Project Manager or Mission Manager will advise when the aircraft is available for payload integration or testing. Special qualifications are required for access to the cockpit (front or rear) due to safety hazard posed by ejection seats.

13.0 FLIGHT OPERATIONS

13.1 OPERATIONAL SCENARIOS (FLIGHT HOURS AND DUTY DAYS)

The crew duty day for WB-57 crewmembers is 12 hours. The standard crew rest period prior to flight is 10 hours. Crewmembers must wear a full pressure suit for flights above 50,000 ft ("high" flights). After a high flight of 5.5 hours duration or longer, 30 hours crew rest is required before another high flight can be flown. If high flights are scheduled every day, two crews will generally be required.

Researchers shall coordinate with the SEO to develop an effective flight crew checklist to operate each payload. Researchers shall also establish proper security protocols for payload ground handling, in-flight operation, and data processing during normal operations and possible aircraft emergency divert situations.

One to two days prior to the flight, a list of the payloads to be flown and an operational checklist will be posted. All checklist changes must be marked by noon on the day prior to the flight. Prior to all flights, the mission researchers and flight crew will attend a pre-flight briefing. The briefing will cover the flight plans, meteorology, go/no-go criteria, contingency plans, etc.

The standard pre-flight timeline for both low and high flights is shown below.

A. Low Flight (at or below 50,000 ft)

T-4 hours: Maintenance Preparation of Aircraft

T-3 hours: Researcher Payload Time with Aircraft

T-2 hours: Researcher Hands Off; Maintenance Tow Out and Fueling

T-1.5 hours: Pre-flight Briefing

T-1 hour: Aircrew Pre-flight

T-0 hours: Aircraft Takeoff

B. High Flight (above 50,000 ft)

T-5 hours: Maintenance Preparation of Aircraft

T-4 hours: Researcher Payload Time with Aircraft

T-3 hours: Researcher Hands Off; Maintenance Tow Out and Fueling

T-2.5 hours: Pre-flight Briefing

T-2 hours: Aircrew Pre-flight

T-1 hour: Aircrew Pressure Suit-up

T-0 hours: Aircraft Takeoff

13.2 IN-FLIGHT ACTIVITIES AND PROTOCOLS

The flight crew may contact ground personnel via aircraft radios, satellite phone, or text chat if there are any problems or questions regarding instrumentation. At times, this communication may not be available; therefore, researchers should take care to properly convey all failure procedures to the SEO.

13.2.1 Post-Flight

A post-flight debriefing will be held immediately after landing to review all aspects of the flight. This review includes the profile executed, general payload operation information, and/or any anomalies that occurred during the flight.

Payloads should be offloaded from the WB-57 for data processing immediately after the aircraft is towed into the hangar. Take care to ensure your payload is removed from the aircraft according to your wishes prior to the departure of the ground crew.

13.3 TESTING

The TRR is the final safety review of a payload prior to its flight. It includes a complete payload review of supporting analyses and documentation, an inspection of the payload hardware, and a final integrated verification of flight readiness. The final signed PDP is the primary source of payload documentation and will be provided to the WB-57 Program Office no later than **6 weeks** prior to flight to allow sufficient time for review. Late submissions may necessitate a one-day slip to the flight schedule for each day late. Refer to Section 11.1.3, Payload Data Package, and Appendix C, Payload Data Package Requirements.

A TRR is required for all new and modified payloads. For payloads that have flown previously on the WB-57 but have been modified since the last TRR, the TRR will take the form of a delta TRR. The delta TRR will focus only on the changes to the payload since the last TRR. Modifications to the payload from its previous approved and flown configuration shall be documented in a revision to the PDP. Ideally, PDP Revision A documents delta TRR #1, PDP Revision B documents delta TRR #2, etc. The revised PDP shall clearly show the differences between the “old” and “new” configurations to include components, mounting hardware, power requirements, weights, etc. The revised PDP will be provided to the WB-57 Program Office no later than **6 weeks** prior to flight to allow sufficient time for review.

An informal “pre-TRR” will normally be conducted 1 or 2 working days prior to the TRR. This is an opportunity for engineering, quality assurance, safety, pressure systems, etc. to inspect hardware and identify issues that can be corrected before the TRR. Researchers are required to be available for the pre-TRR.

The TRR will normally be conducted at EFD in Building 994 or Hangar 990, 1 to 3 working days prior to the first flight. Occasionally, the TRR may be conducted up to several weeks prior to first flight depending on the circumstances. Researchers are required to attend the TRR and may be required to operate their equipment during the TRR. During the TRR, each payload will be “approved,” “approved pending corrections indicated,” or “not approved” for flight. A unanimous decision from the reviewers is required for flight approval. Payloads that have not been approved may be scheduled for a subsequent review when deficient areas have been corrected.

AOD Form 314, Checklist for Test Readiness Review of Payloads and Experiments on JSC AOD Heavy Aircraft, is required to be completed and signed for the payload prior to each TRR or delta TRR. Researchers are encouraged to review and incorporate AOD Form 314 at the start of payload design to help ensure a successful TRR.

13.4 FIELD DEPLOYMENTS

The primary operating location for the NASA WB-57s is EFD in Houston, Texas. If necessary, the WB-57 can be deployed to both domestic and international locations. A site survey will be performed by the WB-57 Program Office to assess remote site support facilities, logistics support, runway parameters, meteorological/operational issues, and if located outside the U.S., foreign government permission. The WB-57 has operated in many remote sites including Key West, Florida; Costa Rica; Guam, and Kwajalein Atoll, part of the Republic of the Marshall Islands. Contact the WB-57 Program Office with any inquiries about remote site deployments.

14.0 GROUND OPERATIONS

14.1 FACILITIES

Hangar 990 at EFD is the home of the WB-57 aircraft and the WB-57 Program Office. Parking for all NASA facilities near Hangar 990 is located in the lot across the street from the pedestrian gate at the north end of Hangar 990. Visitors will not drive or park inside the fence.

Building 994 (see Figure 24), on the flight line side of Hangar 990, provides visiting researchers with a payload lab area that is generally available 24/7 (see Figure 25). This air-conditioned workspace is available for payload assembly and checkout. The building is equipped with a small conference room, workbenches, phones/fax, Wi-Fi, and computer network drop lines for researcher use. Access to Building 994 includes a 12 ft x 12 ft roll-up door. The following power options are available:

- 115 VAC – 60 Hz, single phase, 20 amps
- 115 VAC – 60 Hz, single phase, 30 amps
- 115 VAC – 400 Hz, three-phase, 20 amps
- 208 VAC – 60 Hz, single phase, 20 amps
- 208 VAC – 60 Hz, three-phase, 60 amps
- 460 VAC – 60 Hz, three-phase, 50 amps
- 28 VDC – 20 amps

NOTE

Building 994 does not have a vent hood for the mixing of chemicals inside the building.

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Figure 24. Building 994 WB-57 Payload Laboratory

Figure 25. Building 994 High Bay Work Area

14.1.1 Building 994 Computer Network Access, Printers, and Phones

Researchers should plan to bring their own laptops. Multiple network drops are available at each workstation and in the conference room, and printer access can be arranged. Wi-Fi access is also available; contact the WB-57 Program Office to arrange a JSC guest account for Wi-Fi. Phones are located throughout Building 994. Incoming calls or faxes for the researcher should use the following numbers:

High Bay: 281-244-9629
Small Lab: 281-244-9684
Conference Room: 281-244-9026
Fax: 281-244-9788

14.1.2 Payload Equipment and Material Storage

Limited storage space is available. Limited chemical storage is available in the payload lab area. Requests for space must be prearranged with the WB-57 Program Office. Storage and customer work areas are secured.

14.1.3 Shipping and Receiving

The shipping address for payload hardware is:

NASA/DynCorp International
WB-57 Program Office/Your Payload Name
Attn: POC Name, POC phone #
Building 270, Ellington Field
Houston, Texas 77034

Shipping arrangements should be made with the WB-57 Program Office prior to shipment.

NOTE

Oversized shipments (i.e., those requiring a forklift, flatbed, or pickup truck to move) may be shipped directly to Hangar 990 or Building 994 with prior coordination. Delivery trucks must first stop at Guard Post 18 for inspection, and then NASA security must escort and provide gate access to Hangar 990/Building 994. Contact the WB-57 Program Office to discuss this option.

14.2 GROUND SUPPORT EQUIPMENT

Building 994 is equipped with a 2,000 lb capacity A-Frame hoist. Forklifts are available for the unloading and loading of payload equipment. Contact the WB-57 Program Office for any special handling requirements.

14.3 TOOL CONTROL

The WB-57 Program Office provides an inventoried toolbox designated for researcher use (see Figure 26). The toolbox contains standard tools in both English and metric units. This toolbox is shadowed to enable ease of inventory. Prior to flight, this toolbox and all tools assigned to the WB-57 aircraft will be inventoried (a missing tool will ground the aircraft until found).

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Figure 26. Building 994 Toolbox

Before bringing tools to EFD, contact the WB-57 Program Office to confirm if it will be necessary. Any researcher tools brought to EFD must be inventoried and accounted for prior to all WB-57 flights. Researcher tools and support equipment brought to EFD should be kept to a minimum and controlled in an organized fashion to mitigate any FOD hazards to the WB-57. All tools should be stored in a proper container such as a tool bag or box. Each container should have an inventory sheet listing all the tools contained. Tools needed for aircraft/payload integration will be briefed to the WB-57 Program Office upon arrival at EFD.

14.4 ACCESS (INCLUDING BADGING)

The WB-57 Program Office will provide arrangements for access to appropriate EFD facilities. Researchers will have 24/7 access to Building 994.

All individuals working at and visiting JSC AOD at EFD must display the appropriate access badge above the waist at all times. There are different badging requirements for U.S. citizens, permanent resident aliens, and other foreign nationals.

14.4.1 United States Citizens

All visiting personnel without a permanent NASA badge will be required to have the appropriate visitor badge during their stay at JSC (EFD). It is the responsibility of the user to provide badge request information (name, organization, and dates of visit) to the WB-57 Program Office **2 weeks** prior to visit. U.S. citizens working for a company or corporation headquartered outside the U.S. shall follow the same procedures as foreign nationals (refer to Section 14.4.3, Foreign Nationals and Foreign Representatives). Individuals in this category are listed as "foreign representatives."

14.4.2 Permanent Resident Aliens ("Green Card" Holders)

Badging for permanent resident non-U.S. citizens who have a Permanent Resident Alien Card ("Green Card" or USCIS Form 1-551) shall follow the same procedures as a U.S. citizen (refer to Section 14.4.1, United States Citizens). The only difference is that when a Permanent Resident Alien arrives at JSC and receives their badge, they must have their (original) Resident Alien Card ("Green Card") in their possession.

14.4.3 Foreign Nationals and Foreign Representatives

Access to JSC facilities by foreign nationals or representatives is strictly controlled. Since access requires many levels of approval, this process should begin **3 months** prior to arrival. Contact the WB-57 Program Office with foreign national badge requests.

U.S. citizens working for a company or corporation headquartered outside the U.S. shall follow the same procedures as foreign nationals. Individuals in this category are listed as foreign representatives.

14.5 SAFETY

Safety of the aircraft, flight crew, and ground personnel is paramount during all aspects of payload design, integration, and operations.

Any work performed by payload personnel on or around the aircraft shall be coordinated in advance with the WB-57 Program Office and/or maintenance. Researchers are generally not authorized access to the cockpit (pilot or SEO seats) due to safety hazards posed by the ejection seats. However, limited exceptions may be granted for researcher access to the rear cockpit. Completion of a safety briefing and a cockpit familiarization session is required. Contact the WB-57 Program Office for further information.

The flight line area can be busy and hazardous. Do not enter the flight line unless accompanied by a WB-57 Program employee. Use caution on the flight line, and do not wander away from the WB-57 area, particularly towards the Coast Guard ramp (restricted area). Always use proper hearing protection during aircraft operations. Earplugs are available inside Hangar 990 and Building 994.

Dress is casual, but consider safety when selecting clothes and shoes. Full foot protection is required when working around aircraft, hangars, and equipment. Shorts are acceptable unless you are handling hazardous products/materials or performing tasks that would require additional protection.

Material shavings, splinters, dirt, and miscellaneous loose objects on payloads pose a very dangerous FOD hazard in flight. Loose objects will shift throughout the various phases of a flight, and could interfere with aircraft systems (e.g., flight controls, engine controls). For this reason, ensure all payload parts are clean and securely fastened during payload assembly. After assembly, vacuum and/or blow out all material shavings created during the assembly phase.

Equipment repairs (i.e., drilling, sanding, filing, or any other operation that may produce shavings or splinters) performed while integrating a payload to the aircraft must be approved by the WB-57 Program Office.

NOTE

Refer to Appendix F for more detailed safety and emergency information.

APPENDIX A
ACRONYMS AND ABBREVIATIONS

A	amp
AC	Alternating Current
ADF	Automatic Direction Finder
AGL	Above Ground Level
AIAA	American Institute of Aeronautics and Astronautics
AIRS	Airborne Imaging and Recording System
AN	Army-Navy
ANSI	American National Standard Institute
AOD	Aircraft Operations Division
AR	Airworthiness Review
ATC	Air Traffic Control
ATM	Atmosphere
AWS	American Welding Society
C	Celsius
CG	Center of Gravity
COPV	Composite Overwrapped Pressure Vessel
C_p	constant pressure
CRT	Cathode Ray Tube
CST	Central Standard Time
CSV	Comma-Separated Value
C_v	constant volume
DC	Direct Current
DME	Distance Measuring Equipment
DOT	Department of Transportation
DyNAMITE	Day Night Airborne Motion Imagery for Terrestrial Environments
E/D	Edge Distance
ECP	Experiment Control Panel
EDMS	Electronic Document Management System
EFD	Ellington Field

EIP	Experiment Interface Panel
EMI	Electromagnetic Interference
F	Fahrenheit
FAA	Federal Aviation Administration
FMS	Flight Management System
FMVSS	Federal Motor Vehicle Safety Standards
FOD	Foreign Object Debris
FR	Flight Request
FRR	Flight Readiness Review
FS	Factor of Safety
ft	feet
ft^2	square feet
ft-lb	foot-pound
ft/min	feet per minute
g	gravity
GHz	gigahertz
GPS	Global Positioning System
GSE	Ground Support Equipment
HAZ	Heat Affected Zone
HAZMAT	Hazardous Material
HD	High-Definition
HDTV	High-Definition Television
HF	High Frequency
Hz	Hertz
IAW	in accordance with
ICCART	International Consortium for Atmospheric Research on Transport and Transformation
IDAN	Intelligent Data Acquisition Node
in-lbs	inch-pounds
in	inch
in^3	cubic inch
INS	Inertial Navigation System

IP	Internet Protocol
IRIG-B	Inter-Range Instrumentation Group – Time Code Format B
JF	JSC Form
JPR	JSC Procedural Requirement
JSC	Johnson Space Center
KCAS	knots calibrated airspeed
kHz	Kilohertz
KIAS	knots indicated airspeed
KTS	knots
KuSS	Ku-Band Spread Spectrum Satellite Communication System
KVM	Keyboard-Video-Mouse
lbs	pounds
LSZH	Low Smoke Zero Halogen
MAX	Maximum
MIN	Minimum
mg/kg	milligrams per kilogram
mg/M^3	milligrams per cubic meter
MHz	Megahertz
Mk	Mark
MOP	Maximum Operating Pressure
MOU	Memorandum of Understanding
MS	Military Specification
MSL	Mean Sea Level
MWIR	Mid-Wave Infrared
N/A	Not Applicable
NAS	National Aerospace Standard
NASA	National Aeronautics and Space Administration
NFPA	National Fire Protection Association
NGV	Natural Gas Vehicle
nm	Nautical Mile
NPT	National Pipe Thread

OCCP	Operation and Configuration Control Plan
ORR	Operational Readiness Review
OSHA	Occupation Safety and Health Administration
P/N	Part Number
PDP	Payload Data Package
PE	Polyethylene
PPE	Personal Protective Equipment
ppm	parts per million
psi	pounds per square inch
psia	pounds per square inch absolute
psig	pounds per square inch gauge
PVC	Polyvinyl Chloride
RF	Radio Frequency
RTB	Return to Base
SAE	Society of Automotive Engineers
SAT	Satellite
SDS	Safety Data Sheet
SEO	Sensor Equipment Operator
SOFRS	Science Operations Flight Request System
SPDT	Single Pole, Double Throw
T.O.	Technical Order
TACAN	Tactical Air Control and Navigation
TAS	True Airspeed
TCAS	Traffic Collision Avoidance System
TIFF	Tagged Image File Format
TLV	Threshold Limit Value
TRR	Test Readiness Review
U.S.	United States
UHF	Ultra High Frequency
UPS	Uninterruptible Power Supply

VAC	Volts Alternating Current
VDC	Volts Direct Current
VHF	Very High Frequency
VOR	VHF Omnidirectional Radio Range
VPN	Virtual Private Network
VPP	Voluntary Protection Program
WAVE	WB Ascension Video Experiment
~	approximately
×	multiplication sign
+	plus
°	degree
=	equal sign
-	minus
±	plus or minus
+/-	north/south latitude or east/west longitude
™	trademark
#	number sign
®	registered trademark
%	percent

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APPENDIX B
PAYLOAD INFORMATION FORM

The Payload Information Form is available at the following link:

https://jsc-aircraft-ops.jsc.nasa.gov/wb57/docs/PayloadInfoForm.doc

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APPENDIX C
PAYLOAD DATA PACKAGE REQUIREMENTS

A Payload Data Package (PDP) is required for each payload on the WB-57. A draft PDP is required no later than 3 months prior to flight, and the final signed PDP will be submitted to the WB-57 Program Office no later than **6 weeks** prior to fligt to allow time for thorough review prior to the Test Readiness Review (TRR). Late submissions may necessitate a 1-day slip to the flight schedule for each day late. All payload documentation requirements are presented in this appendix, as well as the required format. It is imperative that all sections of the PDP be addressed. If a section is not applicable to your experiment, do not leave it out. Instead, address the non-applicable section with a brief statement explaining why it is not applicable to your experiment.

The PDP requirements presented in this appendix are the absolute minimum required. These minimums should be exceeded if necessary to thoroughly explain a payload. Any changes to a payload design occurring after the PDP has been submitted must be approved by the WB-57 Program Office through submitted documentation of the change.

The required PDP format is listed below. Be sure to define all acronyms at their first use.

A. Cover Page

The cover page of the PDP should contain the principal investigator's name, organization, and contact information (i.e., e-mail address, phone number, and mailing address), the payload name and acronym, the date the package was submitted, the revision letter if applicable, and required signatures.

Version Control – The PDP, signed and approved by the customer, is the official payload documentation for the TRR. The original PDP does not have a revision letter (e.g., Rev 0). If payload modifications are made following the TRR, then ideally, PDP Rev A would be the documentation for delta TRR #1, PDP Rev B would be the documentation for delta TRR #2, etc. If partial or incomplete PDPs are submitted for feedback or review, they should be dated and clearly marked "DRAFT" on all pages to avoid confusion. Multiple iterations of draft PDPs are acceptable, but changes from previous draft versions should be clearly noted. A final, signed "official" version will still be required no later than **6 weeks** prior to flight.

Required Signatures – At a minimum, the final, complete PDP shall be signed and dated by the:

- Author/engineer (individual who wrote the report)
- Approver (principal investigator, program manager, or other person authorized to approve report release)

B. Quick Reference Data Sheet

The Quick Reference Data Sheet should be completed in the format shown below and be submitted on a dedicated page.

1. Principal investigator
2. Contact information
3. Payload name and acronym
4. Mission profile/number of flights requested
5. Requested flight date(s)
6. Payload installation location on aircraft (e.g., 3-foot/6-foot pressurized/unpressurized pallet, spearpod, superpod, nose)
7. Payload overall assembly weight [pounds (lbs)]
8. Gas/cryogenic cylinder requests (type and quantity)
9. Hazardous materials to be used (include quantity)
10. Overboard vent requests (yes or no) and type of gas to be vented
11. Payload power requirement (voltage and current required)
12. Ground laboratory workspace requests (include storage requests)
13. Computer network access requests
14. Sheet metal work requests (only on NASA-owned hardware)
15. Electrical wiring requests
16. Miscellaneous requests

Note for PDP Rev A, Rev B, etc. – This page should highlight changes from the previous PDP version [e.g., original payload weight was 400 lbs and new payload weight is now 470 lbs]. If the above information was in table format, there could be a column for "PDP Original" and "PDP Rev A" showing the differences. Entering the deviations in red font is also helpful. Also, include a short "Summary of Changes" paragraph below the data sheet that briefly describes the payload changes from the previous version and references the changed sections of the PDP. Change bars and/or the use of a red font for the changes should also be used in the body of the PDP. The intent is to be able to quickly identify changes to the previously approved flight configuration from the last TRR.

C. Table of Contents

List the sections of the PDP and their corresponding page numbers.

D. Proposed Mission Profile and Flight Schedule

This section should address the type of flights being requested (e.g., where, how high, maneuvers), the number of flights being requested, and the proposed mission timeline with dates. This section should also address whether the experiment is a follow-up of a previous flight, a preliminary step to a future flight, etc. The name of any supporting organization/sponsor should also be listed here.

E. Payload Description

This section should briefly explain the payload design and objective, and the section should be written so that a practicing engineer can understand the experiment. Science (or engineering) goals should be presented along with a description of the expected results.

Include drawings and/or photographs of the payload, its overall weight and Center of Gravity (CG) location, and a proposed dimensional layout of the equipment in the aircraft. Any laser, fluid, chemical, Radio Frequency (RF) transmission, and/or pressure/vacuum system should be described. Any component with special handling requirements or specific hazards must also be described in detail.

F. Electrical

1. Electrical Loads

This section shall list all the electrical loads (watts/amps). Include the standard operating conditions for which the load will be an active load and identify the duration of operation for each load. Transient or warm-up requirements, and the ability of the circuit protection to handle such events, shall be documented.

2. Diagrams

Block diagrams shall be sufficient to understand the required aircraft data/format and the basic power distribution for the incurred loads. Locations for the required components and any interconnections that may be required outside of the payload envelope shall be included. Wiring diagrams or schematics that depict the aircraft-payload interface shall be provided and shall include wire sizes.

3. Antennas

Describe any specialized antennas, required separations, frequency ranges, RF bonding requirements, and RF cable runs that are required.

G. Pressure/Vacuum Systems

Describe the purpose and design of any pressure/vacuum systems, including sealed containers. All pressure/vacuum systems proposed for flight and/or ground use shall comply with JPR 1710.13, Design, Inspection and Certification of Ground-Based Pressure Vessels and Pressurized Systems. An Operation and Configuration Control Plan (OCCP) will likely be required (except for sealed containers). Refer to Section 12.5.1, Pressure/Vacuum Systems, for more information.

H. Laser Systems

For all lasers used in flight payloads and/or on the ground, provide the following information:

- Laser class, type, and manufacturer.
- Description of the laser's purpose, ground or flight.
- Description of the containment controls (i.e., describe the protective housing, interlock switches, emergency kill switch, temperature/fire control, protective eyewear) that will be implemented in the laser system design.

All lasers proposed for flight and/or ground use shall comply with JPR 1700.1, JSC Safety and Health Handbook. All Class 3 and 4 lasers must be registered and approved for use with JSC Form 44B, Laser Device Use Request/Authorization. Refer to Section 12.7.1, Lasers, for more information.

I. Hazard Analysis

A hazard analysis should be provided in the PDP to document the review and implemented control of hazards associated with a specific payload. Reference the hazard source checklist below. If any of the hazards listed pertain to your experiment, describe the hazard and explain the control that exists to eliminate or mitigate the risk involved. If the payload presents a potential hazard for which no suitable hazard control is available, the deficiency must be documented and provided to the WB-57 Program Office. NASA will analyze this hazard and make a decision on risk acceptance.

1. Hazard Source Checklist

Describe identified hazards and explain the control that exists to eliminate or mitigate the risk involved.

a. Flammable/combustible material, fluid (liquid, vapor, or gas)

b. Toxic/corrosive/hot/cold material, fluid (liquid, vapor, or gas)

c. High pressure system (static or dynamic)

d. Evacuated container (implosion)

e. Frangible material

f. Stress corrosion susceptible material

g. Inadequate structural design (e.g., low safety margin)

h. High intensity light source including laser (e.g., unintended reflections)

i. Ionizing/electromagnetic radiation

j. Rotating device

k. Extendible/deployable/articulating experiment element (collision)

l. Stowage restraint failure

m. Stored energy device (e.g., mechanical spring under compression)

n. Vacuum vent failure (e.g., loss of pressure/atmosphere)

o. Heat transfer (habitable area over-temperature)

p. Over-temperature explosive rupture (including electrical battery)

q. High/low touch temperature

r. Hardware cooling/heating loss (e.g., loss of thermal control)

s. Pyrotechnic/explosive device

t. Propulsion system (pressurized gas or liquid/solid propellant)

u. High acoustic noise level

v. Toxic off-gassing material

w Mercury/mercury compound

x. Organic/microbiological (pathogenic) contamination source

y. Sharp corner/edge/protrusion/protuberance

z. Flammable/combustible material, fluid ignition source (e.g., short circuit under-sized wiring/fuse/circuit breaker)

aa. High voltage (electrical shock)

ab. High static electrical discharge producer

ac. Software error or computer fault

ad. Carcinogenic material

ae. Rapid depressurization of aircraft (e.g., optical window fracture)

af. Uninterrupted power supplies

ag. Transfer of liquid or gas in flight

ah. Liquid or gas leak (e.g., improper containment, electrical short circuit)

ai. Other

J. Hazardous Material

Hazardous material is defined as anything with a flashpoint below 140° Fahrenheit (F)/60° Celsius (C) or with a TLV (Threshold Limit Value) below 500 ppm (parts per million). below 500 milligrams per cubic meter (mg/M^3) for fumes, below 10 mg/M^3 for dust, or with a single oral dose (if liquid) at 50% lethality below 500 mg/kg (milligrams per kilogram). As a note, materials with flash points at or above 100°F/38°C are considered combustible and below are considered flammable. Please state whether or not you will be using any toxic, corrosive, explosive, flammable, combustible, and/or other hazardous materials. Describe what the material is, how it will be used, and what quantities will be used. If possible, avoid the use of hazardous materials. If such materials are required for a payload, proper containment must be provided. Please describe how you plan to safely contain and handle any hazardous materials. Early contact with the WB-57 Program Office for discussions on proper use and containment of proposed hazardous materials may prevent delays in obtaining approval for the use of such materials. If such materials are necessary, provisions for dumping and purging in flight and on the ground may be required. A current Safety Data Sheet (SDS) must be supplied for each hazardous material.

K. Ground Support Requirements

Describe what you will need in terms of ground support from the WB-57 Program Office. Please address the following:

- State what type of ground power needed for testing/operating research equipment.
- State the need for any pressurized gas or cryogenics. State how much is needed of each to assess storage space. Procurement of pressurized gases or cryogenics will be the responsibility of the researcher. An SDS must be provided.
- State whether you will be mixing or storing any chemicals that are toxic, corrosive, and/or explosive. If so, what type of material handling procedures will be required?
- Request laboratory space (working and storage), if necessary.
- Request computer network, if necessary.
- Request special ground handling/support equipment (e.g., forklift, crane), if necessary.
- State miscellaneous requests.

L. Mission Procedures

Researchers are responsible for all equipment sent to and from Ellington Field (EFD). The WB-57 Program Office is not responsible for any shipping arrangements (refer to Section 11.4.1, Arrival at Ellington Field; Section 11.4.2, Departure from Ellington Field; and Section 14.1.3, Shipping and Receiving, for additional information on the shipping and receiving of equipment to/from EFD). The information presented in this section of the PDP will describe all of the procedures involved with operating your experiment at EFD or at a remote deployment site.

These procedures should be broken down in the following order:

1. Equipment Shipment

   State how equipment will be shipped (e.g., freight, include the shipping company name), when it will be shipped (i.e., month, day, and time), and what storage requirements are needed to safely store your hardware (e.g., space requirements, temperature).

2. Ground Operations

   Provide the procedures proposed to set-up and operate your equipment on the ground at EFD. All equipment will be inspected at the pre-TRR and TRR (refer to Section 13.3, Testing) prior to flight.

3. Loading

   Provide the procedures proposed to load and integrate your equipment onto the WB-57.

4. Pre-Flight

   Provide the procedures proposed for pre-flight operations.

5. Flight Operations

   Flight checklists for payload operation will be generated through researcher consultation with the SEO (Sensor Equipment Operator). Provide the backseat procedures that will most likely be requested to operate your payload during takeoff, cruise, and/or landing operations.

6. Post-Flight

   Provide the procedures proposed for readying equipment for a subsequent flight.

7. Off-Loading

   Provide the procedures proposed for off-loading your payload from the WB-57 and the shipping arrangements that have been made for the removal of equipment from NASA property.

M. Appendix A – Stress Analysis

A complete stress analysis shall be completed for each payload. The payload stress analysis report is designed to be a stand-alone document, but it should be included as Appendix A to the PDP. Report requirements and format are governed by NASA Drawing 8594001, Preparation of Stress Analysis Reports:

https://jsc-aircraft-ops.jsc.nasa.gov/wb57/guide.html

N. Appendix B – Safety Data Sheet

Include SDSs that apply to any composite, plastic, foam, fabric, chemical, fluid, compressed gas, etc., which you are utilizing with your payload, either in flight or on the ground. The SDS should correlate to descriptions provided in PDP Sections I through K so it the purpose of the materials is understood. An SDS must be provided for all chemicals taken onto NASA property. Copies of each SDS must also be kept with the chemicals at their ground-based storage areas.

APPENDIX D
RACK/MOUNTING LOCATIONS

Not applicable to WB-57 aircraft. Refer to Section 9.1.1, Locations and Dimensions, for payload integration locations.

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APPENDIX E
DATA/NAVIGATION PARAMETERS

RS232 Navigation Data Recorder Output to Payload Areas

Data from all navigation data inputs is accumulated in a time buffer for 1 second. The data is processed and output to the RS232 data bus at 9600 baud. This results in a delay of 1 second between the actual time the data is received and the time it is output on the RS232 data bus. The time is correct to one millisecond. The data bus output format is as follows:

Parameter Name	Output Units	Output Format	String Size	Signed (Y/N)	Positive Sense	ARINC Label No.
soh	N/A	0x01	1	N/A	N/A	N/A
GPS Status	N/A	X	1	N/A	N/A	N/A
Date/Time	N/A	ddd:hh:mm:ss	12	N/A	N/A	N/A
Position Latitude	degrees	N/SXX.XXXXX	9	Y	North	310
Position Longitude	degrees	E/WXXX.XXXXX	10	Y	East	311
True Heading	degrees	+/-XXX.XX	7	Y	CW from N	314
Pitch Angle	degrees	+/-XX.XXXX	8	Y	Up	324
Roll Angle	degrees	+/-XX.XXXX	8	Y	R Wing DN	325
Ground Speed	knots	XXX.XX	6	N	Always +	312
True Track Angle	degrees	+/-XXX.XX	7	Y	CW from N	313
Wind Speed	knots	XX.X	4	N	Always +	315
Wind Direction	degrees	+/-XXX.X	6	Y	CW from N	316
Longitudinal Accel	g's	+/-X.XXX	6	Y	Forward	331
Lateral Accel	g's	+/-X.XXX	6	Y	Right	332
Body Normal Accel	g's	+/-X.XXX	6	Y	Up	333
Track Angle Rate	deg/s	+/-XX.X	5	Y	CW from N	335
Pitch Rate	deg/s	+/-XX.X	5	Y	Up	326
Roll Rate	deg/s	+/-XX.X	5	Y	R Wing DN	327
Inertial Vertical Speed	ft/min	+/-XX.XX	6	Y	Up	365
Magnetic Track Angle	degrees	+/-XXX.XX	7	Y	CW from N	317
Magnetic Heading	degrees	+/-XXX.XX	7	Y	CW from N	320
Drift Angle	degrees	+/-XXX.XX	7	Y	Nose Right	321
Flight Path Angle	degrees	+/-XXX.XX	7	Y	Up	322
Flight Path Accel	g's	+/-X.XXX	6	Y	Forward	323
Pitch Att Rate	deg/s	+/-XX.X	5	Y	Up	336
Roll Att Rate	deg/s	+/-XX.X	5	Y	R Wing DN	337
Inertial Altitude	feet	+/-XXXXX.X	8	Y	Up	361
Along Track Accel	g's	+/-X.XXX	6	Y	Forward	362
Cross Track Accel	g's	+/-X.XXX	6	Y	Right	363
Vertical Accel	g's	+/-X.XXX	6	Y	Up	364
NS Velocity	knots	+/-XXX.X	6	Y	North	366
EW Velocity	knots	+/-XXX.X	6	Y	East	367
Pressure Altitude	feet	+/-XXXXX	6	Y	Up	203
Baro Corrected Altitude	feet	+/-XXXXX	6	Y	Up	204
Mach	unitless	X.XXX	5	N	Always +	205
Computed Airspeed	knots	XXX.XX	6	N	Always +	206
Max Allowable Airspeed	knots	XXX.XX	6	N	Always +	207
True Airspeed	knots	XXX.XX	6	N	Always +	210
Total Air Temperature	deg C	+/-XXX.XX	7	Y	Positive deg	211
Altitude Rate	ft/min	+/-XXXXX	6	Y	Up	212
Static Air Temperature	deg C	+/-XXX.XX	7	Y	Positive deg	213

Parameter Name	Significant Bits	Range (unsigned)	Max BNR Value	Source Units	LSB Weight
soh	N/A	N/A	N/A	N/A	N/A
GPS Status	N/A	N/A	N/A	N/A	N/A
Date/Time	N/A	N/A	N/A	N/A	N/A
Position Latitude	20	180	1048575	degrees	1.71661540662327000E-04
Position Longitude	20	180	1048575	degrees	1.71661540662327000E-04
True Heading	18	180	262143	degrees	6.86648127167233000E-04
Pitch Angle	18	180	262143	degrees	6.86648127167233000E-04
Roll Angle	18	180	262143	degrees	6.86648127167233000E-04
Ground Speed	18	4096	262143	knots	1.56250596048721000E-02
True Track Angle	18	180	262143	degrees	6.86648127167233000E-04
Wind Speed	18	256	262143	knots	9.76566225304509000E-04
Wind Direction	18	180	262143	degrees	6.86648127167233000E-04
Longitudinal Accel	18	4	262143	g's	1.52588472703830000E-05
Lateral Accel	18	4	262143	g's	1.52588472703830000E-05
Body Normal Accel	18	4	262143	g's	1.52588472703830000E-05
Track Angle Rate	18	32	262143	deg/s	1.22070778163064000E-04
Pitch Rate	18	128	262143	deg/s	4.88283112652255000E-04
Roll Rate	18	128	262143	deg/s	4.88283112652255000E-04
Inertial Vertical Speed	18	32768	262143	ft/min	1.25000476838977000E-01
Magnetic Track Angle	18	180	262143	deg	6.86648127167233000E-04
Magnetic Heading	18	180	262143	deg	6.86648127167233000E-04
Drift Angle	18	180	262143	deg	6.86648127167233000E-04
Flight Path Angle	18	180	262143	deg	6.86648127167233000E-04
Flight Path Accel	18	4	262143	g's	1.52588472703830000E-05
Pitch Att Rate	18	128	262143	deg/s	4.88283112652255000E-04
Roll Att Rate	18	128	262143	deg/s	4.88283112652255000E-04
Inertial Altitude	20	131072	1048575	feet	1.25000119209403000E-01
Along Track Accel	18	4	262143	g's	1.52588472703830000E-05
Cross Track Accel	18	4	262143	g's	1.52588472703830000E-05
Vertical Accel	18	4	262143	g's	1.52588472703830000E-05
NS Velocity	18	4096	262143	knots	1.56250596048721000E-02
EW Velocity	18	4096	262143	knots	1.56250596048721000E-02
Pressure Altitude	17	131071	131071	feet	1.00000000000000000E+00
Baro Corrected Altitude	17	131071	131071	feet	1.00000000000000000E+00
Mach	16	4.096	65535	unitless	6.25009536888685000E-05
Computed Airspeed	14	1023.75	16383	knots	6.24885552096686000E-02
Max Allowable Airspeed	12	1024	4095	knots	2.50061050061050000E-01
True Airspeed	15	2048	32767	knots	6.25019074068422000E-02
Total Air Temperature	11	511.75	2047	deg C	2.50000000000000000E-01
Altitude Rate	11	32750	2047	ft/min	1.60000000000000000E+01
Static Air Temperature	11	511.75	2047	deg C	2.50000000000000000E-01

***** Each parameter is followed by a space.

ARINC 429 GPS Output To Payload Areas

The Navigation Data Recorder provides GPS data to all payload areas in ARINC 429 format. The GPS ARINC 429 output format is as follows:

Binary Label	Parameter	Output Rate (Hz)	Numeric Range	Units	Sig Bits*	Resolution	Positive Sense
072	Inertial Latitude	8	±90	degrees	20	0.000172	North from Zero
073	Inertial Longitude	8	±180	degrees	20	0.000172	East from Zero
076	GPS Altitude	1	±131,072	feet	20	0.125	Up
101	GPS HDOP	1	0–1024	meters	15	0.031	Always Positive
102	GPS VDOP	1	0–1024	meters	15	0.031	Always Positive
103	GPS Track Angle	1	±180	degrees	15	0.0055	CW from North
110	GPS Latitude	1	±90	degrees	20	0.000172	North from Zero
111	GPS Longitude	1	±180	degrees	20	0.000172	East from Zero
112	GPS Ground Speed	1	0–4096	knots	15	0.125	Always Positive
120	GPS Latitude-Fine	1	0–0.000172	degrees	11	8.38E-8	North from Zero
121	GPS Longitude-Fine	1	0–0.000172	degrees	11	8.38E-8	East from Zero
130	GPS Integrity Limit	1	0–16	nm	18	6.1E-5	N/A
136	GPS Vert FOM Or EVE	1	0–32,768	feet	18	0.125	Always Positive
150	UTC (BCD Format)	1	23:59:59	hr:min:sec	17	1.0	Always Positive
165	GPS Vert Vel.	1	±32,768	ft/min	15	1.00	Up
166	GPS N-S Velocity	1	±4,096	knots	15	0.125	North
174	GPS E-W Velocity	1	±4,096	knots	15	0.125	East
247	GPS Horiz FOM	1	0–16	nm	18	6.1E-5	Always Positive
60	Date	1	N/A	BCD	6	1 Day	N/A
273	GPS Sensor Status	1	N/A	DIS	19	N/A	N/A

***** Does not include sign bit.

ARINC 429 ADDU Output To Payload Areas

The Navigation Data Recorder provides Air Data to all payload areas in ARINC 429 format. The ADDU ARINC 429 output format is as follows:

Binary Label	Parameter	Output Rate (Hz)	Numeric Range	Units	Sig Bits*	Least Significant Bit Value	Positive Sense
203	Pressure Altitude	20	-1000 to 131072	feet	17	1	Up
204	Baro-Corrected Altitude	20	-1000 to 131072	feet	17	1	Up
205	Mach Number	10	0 to 4.096	mach	16	.0000625	Always Positive
206	Computed Airspeed	10	0 to 1024	knots	14	.0625	Always Positive
207	Max Allowable Airspeed	10	0 to 1024	knots	12	.25	Always Positive
210	True Airspeed	10	0 to 2048	knots	15	.0625	Always Positive
211	Total Air Temperature	4	-60 to 511.75	deg/C	11	.25	Positive Temp
212	Altitude Rate	20	0 to 32752	ft/mn	11	16	Up
213	Static Air Temperature	4	-99 to 511.75	deg/C	11	.25	Positive Temp

ARINC 429 INS Output to Payload Areas

The Navigation Data Recorder provides Inertial Navigation System (INS) data to all payload areas. The following INS parameters are output to all payload areas in the ARINC 429 output format:

Binary Label	Parameter	Output Rate (Hz)	Numeric Range	Units	Sig Bits*	Resolution	Positive Sense
310	Present Position Lat (UPD)	8	±90	degrees	20	0.000172	North from Zero
311	Present Position Lon (UPD)	8	±180	degrees	20	0.000172	East from Zero
312	Ground Speed	32	0–4096	knots	18	0.01563	Always Positive
313	Track Angle True	32	±180	degrees	18	0.000687	CW from North
314	True Heading	32	±180	degrees	18	0.000687	CW from North
315	Wind Speed	16	0–256	knots	18	0.000977	Always Positive
316	Wind Direction True	16	±180	degrees	18	0.000687	CW from North
317	Track Angle (Magnetic)**	32	±180	degrees	18	0.000687	CW from North
320	Heading (Magnetic)**	32	±180	degrees	18	0.000687	CW from North
321	Drift Angle	32	±90	degrees	18	0.000687	Right
322	FLT Path Angle	32	±90	degrees	18	0.000687	Up
323	FLT Path Accel	64	±4	g's	18	0.0000153	Forward
324	Pitch Angle	64	±180	degrees	18	0.000687	Up
325	Roll Angle	64	±180	degrees	18	0.000687	Right Wing Down
326	Body Pitch Rate	64	±128	deg/sec	18	0.000488	Up
327	Body Roll Rate	64	±128	deg/sec	18	0.000488	Right Wing Down
330	Body Yaw Rate	64	±128	deg/sec	18	0.000488	Nose Right
331	Body Longitude Accel	64	±4	g's	18	0.0000153	Forward
332	Body Lateral Rate	64	±4	g's	18	0.0000153	Right
333	Body Normal Rate	64	±4	g's	18	0.0000153	Up
334	Platform Heading	32	±180	degrees	18	0.000687	CW from Zero
335	Track Angle Rate	64	±32	deg/sec	18	0.000122	CW
336	Pitch ATT Rate	64	±128	deg/sec	18	0.000488	Up
337	Roll ATT Rate	64	±128	deg/sec	18	0.000488	Right Wing Down
360	Potential Vert Speed	64	±32,768	ft/min.	18	1.00	Up
361	Inertial Altitude	32	±131,072	feet	20	0.125	Up
362	Along TRK Horiz Accel	64	±4	g's	18	0.0000153	Forward
363	Cross TRK Horiz Accel	64	±4	g's	18	0.0000153	Right
364	Vertical Accel	64	±4	g's	18	0.0000153	Up
365	Inertial Vert Speed	32	±32,768	ft/min	18	0.125	Up
366	N-S Velocity	16	±4096	knots	18	0.0000153	North
367	E-W Velocity	16	±4096	knots	18	0.0000153	East

***** Does not include sign bit

****** Information not valid when latitude is greater than 73° North or 60° South (Arctic/Antarctic Navigation)
UPD = Updated information form GPS

APPENDIX F
DETAILED SAFETY AND EMERGENCY PROCEDURES

The WB-57 High-Altitude Research Program is operated IAW (in accordance with) established NASA safety procedures. Johnson Space Center (JSC) participates in the Occupation Safety and Health Administration (OSHA) VPP (Voluntary Protection Program), which is a cooperative effort between OSHA, management, and employees to achieve a safer, healthier work environment. JSC's safety goal is to become a nationally recognized center of excellence for safety and health.

Due to the critical nature of the WB-57 Program, a multi-stage review and approval procedure has been developed to ensure personnel and flight safety. This section describes the general safety practices and guidelines that all personnel and equipment must comply with to occupy and operate on NASA property. Please contact the WB-57 Program Office with any questions regarding safety practices at Ellington Field (EFD).

A. JSC Requirements

1. All personnel and equipment at EFD must adhere to the safety guidelines as defined in JPR 1700.1, JSC Safety and Health Handbook. The complete current document is available at the following: http://jschandbook.jsc.nasa.gov/

2. Any hazards or injuries shall be reported immediately.

B. Aircraft Operations Division (AOD) Requirements

A safety briefing will be given to all program participants upon arrival at EFD. Attendance at this briefing is mandatory for all program participants. Additional requirements are outlined below.

1. Emergency Procedures

    a. Dial extension 33333 ("five 3's") from any NASA telephone to report an emergency at EFD (from a cell phone, dial 281-483-3333). This is the direct line to the Ellington Fire Department, our primary responders for all incidents. Do not dial 911 as this may actually slow the response time.

    b. If you hear a fire alarm or an air horn (indicating a gas leak), proceed immediately to the nearest designated evacuation assembly point. If you smell gas, sound the nearest air horn. Do not use the telephone or fire alarm to report a gas leak due to explosion hazard.

2. Laboratory/Facility Safety

    a. Only authorized personnel are permitted in the various facilities. Permanent NASA badges or visitor badges issued by JSC Security must be displayed above the waist at all times while on NASA/JSC property.

    b. No driving or parking inside the main fence. Parking is available in the main lot across from the north end of Hangar 990.

c. Smoking is discouraged, but allowed in designated outdoor areas. There is no smoking inside buildings, Government vehicles, or on the flight line. Smoking is not permitted within 50 feet (ft) of aircraft, jet fuel, or other hazardous areas such as liquid oxygen or HAZMAT storage. Smoking is not permitted within 25 ft of doorways, entries, operable windows, and outdoor air intake ducts.

d. All trash/recyclables must be placed in provided receptacles. Use specifically labeled trash receptacles for batteries, oil rags, chemicals, etc.

e. Hazardous materials/chemicals must be properly identified. All requisite precautions consistent with the safe handling of hazardous materials and chemicals must be followed at all times, to include use of PPE (Personal Protective Equipment) such as safety glasses, gloves, aprons, etc. All high-pressure cylinders must be in racks and properly secured. A Safety Data Sheet (SDS) is required for all hazardous materials/chemicals.

f. Tool Control – All equipment (i.e., tools, test hardware, fluids) brought to EFD must be inventoried and accounted for at all times. A tool lost in the aircraft can jam critical control cables or otherwise affect safety of flight. Therefore, the aircraft will be grounded until any missing tools can be found.

g. Equipment – Operation of research or other equipment must be attended at all times.

3. Hangar Safety

a. Aircraft hangars are large industrial work areas. Hazards are always present and may include the following:

- Aircraft and equipment being towed
- Aircraft on jacks
- Hoses, cables, grounding wires, and other trip hazards
- Fuel, hydraulic fluid, water, and lubricant spills on the hangar floor (slip hazard)
- Sharp surfaces on aircraft (e.g., flaps/trailing edge of wings, gear doors)

b. Be cautious and stay in the walkway on the side of the hangar whenever possible. Do not walk through moving hangar doors.

c. When using electrical cords/power strips, all electrical connections shall be a minimum of 18 inches off the ground to prevent ignition of any fuel vapor. There are cones located in Hangar 990 for this purpose.

d. Electric drills and other electric tools shall not be used. Only battery-powered or pneumatic tools are permitted. Sparks from brushed motors or other electric tools may set off the fire suppression system or potentially ignite fuel vapor.

e. Do not operate the hangar doors or any other controls inside the hangar.

f. Dress for an industrial workplace. No high heels or open-toed shoes, or loose clothing that may be caught in machinery, etc.

4. Aircraft Safety

a. Access to the aircraft is controlled. An AOD employee must accompany anyone requiring access to the aircraft. Special qualifications are required for access to the cockpit (front or rear seat) due to safety hazard posed by ejection seats.

b. Stay clear of the aircraft during refueling, liquid oxygen servicing, maintenance, towing, or taxiing.

c. Foreign Object Damage (FOD) is a major concern for any aviation activity. Loose items left in and around the aircraft can cause extensive damage to aircraft engines or other systems. Be sure to secure all pens, pencils, jewelry, badges, hats, sunglasses, cell phones, trash, tools, small hardware, etc. Do not take non-essential items to the aircraft or flight line. If you find FOD on the ramp, please pick it up and dispose of it properly.

5. Flight Line Safety

a. The flight line is a controlled access area. An AOD employee must accompany anyone requiring access to the flight line. Please stay with your group and do not wander away from the immediate vicinity of Hangar 990.

b. Hearing protection is required during all flight operations. Earplugs are readily available at various locations at EFD.

c. Jet exhaust can be hazardous up to 200 ft behind aircraft. Jet intake can be hazardous within 35 ft.

d. Unless you are a ground crewmember, do not operate any ground support, material handling, or aircraft equipment or systems.

e. Be cautious of moving aircraft and vehicles on the flight line. Aircraft, official vehicles, and GSE (Ground Support Equipment) always have the right of way. Look before crossing the flight line road that runs in front of Buildings 993/994.

f. No driving on the flight line.

g. Be sure to protect yourself against the weather and other hazards while on the flight line (e.g., full foot protection, hat, sunscreen, lip balm, no high heels), and drink plenty of water during the hot summer months.

h. Lightning Detection System – Seven 1-second horn blasts accompanied by an amber beacon and/or a lightning announcement indicate lightning in the vicinity. Proceed indoors immediately and remain under cover until the "all clear" is given. "All clear" will be indicated by one continuous 7-second horn blast, amber beacon off, and/or "all clear" announcement made.

6. WB-57 Program Office Requirements

a. Payload Data Package

Refer to Section 11.1.3, Payload Data Package, and Appendix C, Payload Data Package Requirements.

b. Test Readiness Review

Refer to Section 13.3, Testing.

c. Safety of Flight

Refer to Section 12.1, Flight Safety

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APPENDIX G
COMMUNICATION SYSTEM GUIDE

NOTE

Contact the WB-57 Program Office for access to the Communication System Guide.

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