P-3B Orion (N426NA)

Airborne Laboratory
Experimenter Handbook

548-HDBK-0001

Release: Baseline
Effective Date: August 2010

National Aeronautics and Space Administration

Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, Virginia

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CHANGE HISTORY LOG

Effective Date	Revision	Page(s) affected	Description of Changes
Aug. 2010	Baseline		Baseline

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Nomenclature

AC	Alternating Current
A/D	Analog/Digital
ADC	Air Data Computer
ADF	Automatic Direction Finder
ADZ	Air Data System
AED	Automated External Defibrillator
AETD	Applied Engineering Technology Directorate
AFCS	Automatic Flight Control System
AFSRB	Airworthiness and Flight Safety Review Board
AGS	Aircraft Ground System
AHRS	Attitude Heading and Reference System
AIS	Automatic Identification System
AIU	Autopilot Interface Unit
AM	Amplified Modulation
AN	Army Navy
AOA	Angle Of Attack
AOB	Angle Of Bank
APU	Auxiliary Power Unit
ARINC	Aeronautic Radio INC.
ASCII	American Standard Code for Information Interchange text format
ASO	Aviation Safety Officer
ASP	Airborne Science Program
ATC	Air Traffic Control
AWG	American Wire Gauge
BCP	Best Computed Position
BL	Body Line
CADC	Central Air Data Computer
CG	Center of Gravity
COTS	Commercial Off The Shelf
CPU	Central Processing Unit
CR	Configuration Review
DC	Direct Current
DFRC	Dryden Flight Research Center
DME	Distance Measuring Equipment
DOT	Department of Transportation
ECF	Engineering Check Flight
EFIS	Electronic Flight Instrumentation System
ELT	Emergency Locator Transmitter
EMI	Electromagnetic Interference
EPOS	Emergency Passenger Oxygen System
ESK	Emergency Signal Kit
FAA	Federal Aviation Administration
FIIR	Final Installation and Inspection Review
FM	Frequency Modulation
FMS	Flight Management System
FS	Fuselage Station
FTP	File Transfer Protocol
GPS	Global Positioning System
GPSNAV	Global Position System NAVigation

GPWS	Ground Proximity Warning System
GS	Glideslope
GSFC	Goddard Space Flight Center
HF	High Frequency
hp	horsepower
Hz	Hertz or cycles per second
ICS	InterCommunication System
IDLH	Immediately Dangerous to Life or Health
ILS	Instrument Landing System
INMARSAT	INternational MARine SATellite
INS	Inertial Navigation System
I/O	Input/Output
IRIG	Inter-Range Instrument Group
IRS	Inertial Reference System
IRU	Inertial Reference Unit
KIAS	Knots Indicated Airspeed
KTAS	Knots True Airspeed
kt	Knot
kVA	kilo Volt Amps
LCD	Liquid Crystal Display
Li-Ion	Lithium Ion
MAC	Mean Aerodynamic Chord
MAD	Magnetic Anomaly Detector
MADT	Micro Air Data Transducer
MAWP	Maximum Allowable Working Pressure
MFD	Multi Function Display
M/I	Maintenance/Installation
MIL-STD	Military Standard
MOP	Maximum Operating Pressure
MS	Military Specification
MoS	Margin of Safety
MSDS	Material Safety Data Sheet
MSL	Mean Sea Level
MSU	Model Selector Unit
MTOGW	Maximum TakeOff Gross Weight
MZFW	Maximum Zero Fuel Weight
NACA	National Advisory Committee for Aeronautics
NAS	National Aerospace Standard
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NEMA	National Electrical Manufacturers Association
Ni-Cd	Nickel-Cadmium
nm	nautical mile
NSERC	National Suborbital Education Research Center
NTP	Network Timing Protocol
Ops	Operations
PDS	Project Data System
PI	Principal Investigator
PIC	Pilot In Command
PIF	Payload Information Form
PMS	Particle Measuring System

PPE	Personal Protective Equipment
psf	pounds force per square foot
PSLT	Pressurized Sonobuoy Launch Tube
psi	pounds force per square inch
PVC	Polyvinyl Chloride
PV/S	Pressure Vessel/System
RAWS	Radio Altitude Warning System
REVEAL	Research Environment for Vehicle-Embedded Analysis on Linux
RF	Radio Frequency
RGB	Red Green Blue
RMMO	Range and Mission Management Office
rpm	revolutions per minute
RSM	Range Safety Manual
RVSM	Reduced Vertical Separation Minimum
SAT	Static Air Temperature
SATCOM	SATellite COMmunication
SELCAL	Selective Calling System
SHP	Shaft Horsepower
SL	Sea Level
SLA	Sealed Lead Acid
SMD	Science Mission Directorate
SOFR	Safety of Flight Release
SSOPD	Sub-orbital and Special Orbital Projects Directorate
TACAN	TACtical Air Navigation
TAT	Total Air Temperature
TCAS	Traffic alert and Collision Avoidance System
TLV	Threshold Limit Value
UHF	Ultra High Frequency
UND	University of North Dakota
UPS	Uninterruptible Power Supply
URL	Uniform Resource Locator
UTC	Universal Time Coordinated
VDC	Volts of Direct Current
VHF	Very High Frequency
VOR	VHF Omni Range
WFF	Wallops Flight Facility
WGS	World Geodetic System
WL	Water Line
WWW	World Wide Web

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Chapter 1: Introduction

1.1: Overview

Since 1991, NASA has been operating a Lockheed Martin P-3B Orion Aircraft (N426NA) for research activities in Earth, atmospheric, and space sciences. This aircraft, extensively modified as a flying laboratory, is based at the NASA Wallops Flight Facility (WFF), Wallops Island, VA. It is operated primarily for the benefit of researchers whose proposals have been previously approved by NASA Headquarters. Other government agencies and institutions can also request flight time aboard this aircraft. Airborne laboratory flights may be operated out of WFF or from deployment sites worldwide, according to the research requirements.

The P-3B is a four-engine propeller driven aircraft with a range in excess of 3,000 nm (5,500 km), a ceiling of 28,000 ft (8,500 m), and an experiment payload of 14,700 lb (6,600 kg). Special viewports, power systems, and instruments have been installed in the aircraft to support a wide range of research programs.

Airborne research missions for the P-3 are planned, implemented, and managed by the Aircraft Office (Code 830) at WFF. A designated Mission Manager/Director and Operations Engineer (Ops Engineer) are responsible for all phases of an assigned mission prior to and during an experiment upload, and are the official points of contact for experimenters during this time period. Upon completion of the experiment upload the Pilot in Command with assistance from the Mission Manager/Director are the official points of contact for all flight phases of a mission. This team makes all significant decisions regarding mission aircraft operations. The Mission Manager also functions as the onboard Mission Director during flight phases of the mission. The Mission Manager/Director coordinates and monitors science activities on the aircraft during flights and is the interface between the science crew and P-3 aircrew in flight.

For information about the overall WFF Airborne Science Program, including aircraft schedules and Airborne Science flight request procedures, and a customer satisfaction survey navigate to the following URL:

http://wacop.wff.nasa.gov

1.2: Purpose and Scope of Document

The purpose of this handbook is to acquaint prospective P-3 researchers with the aircraft and its capabilities. The handbook also contains procedures for obtaining approval to fly experiments; outlines requirements for equipment design and installation; and identifies the personnel and facilities that are available at WFF for supporting research activities in the P-3 airborne platform. This handbook is managed and revised from time to time by the WFF Aircraft Office and the WFF Applied Engineering Technology Directorate (AETD). Therefore, before arranging for experiments it is advisable to contact the Wallops Aircraft Office or your assigned Ops Engineer for a current issue.

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Chapter 2: Aircraft Description

2.1: General

The NASA P-3B Orion, N426NA, is similar in appearance and performance to other Navy P-3 aircraft as shown in Figure 2-1. The P-3 is a four-engine, low-wing aircraft. It is in the 135,000-pound gross weight class and powered by four T56-A-14 turboprop engines. Each engine provides 4,600 SHP (maximum rated) for takeoff. The fuselage is pressurized from the forward bulkhead of the flight station to the aft bulkhead in the cabin. Entrance to the cabin is by way of the door on the port side of the fuselage. Emergency exit hatches are located over each wing, aft of the pilot side windshield panel, and in the top of the flight station. Lavatory, galley and other convenience facilities are located in the aft cabin.

Basic aircraft performance in standard atmospheric conditions is summarized in the following subsections. Adding external instrument pods or pylons that increase drag will reduce performance parameters correspondingly.

Figure 2-1. General pictures of the P-3B aircraft

2.2: Dimensions

All the geometry pertinent to the P-3B aircraft is presented below and summarized separately for each component of the airplane. In addition, an airplane three-view profile is included (Figure 2-2).

2.2.1: Overall Dimensions

Length –	103.8 feet (without Navy MAD boom)
Span, wing –	99.7 feet
Span, horizontal tail –	42.8 feet
Height, airplane in static ground attitude	
Top of Fuselage –	16.8 feet
Top of Fin –	33.7 feet

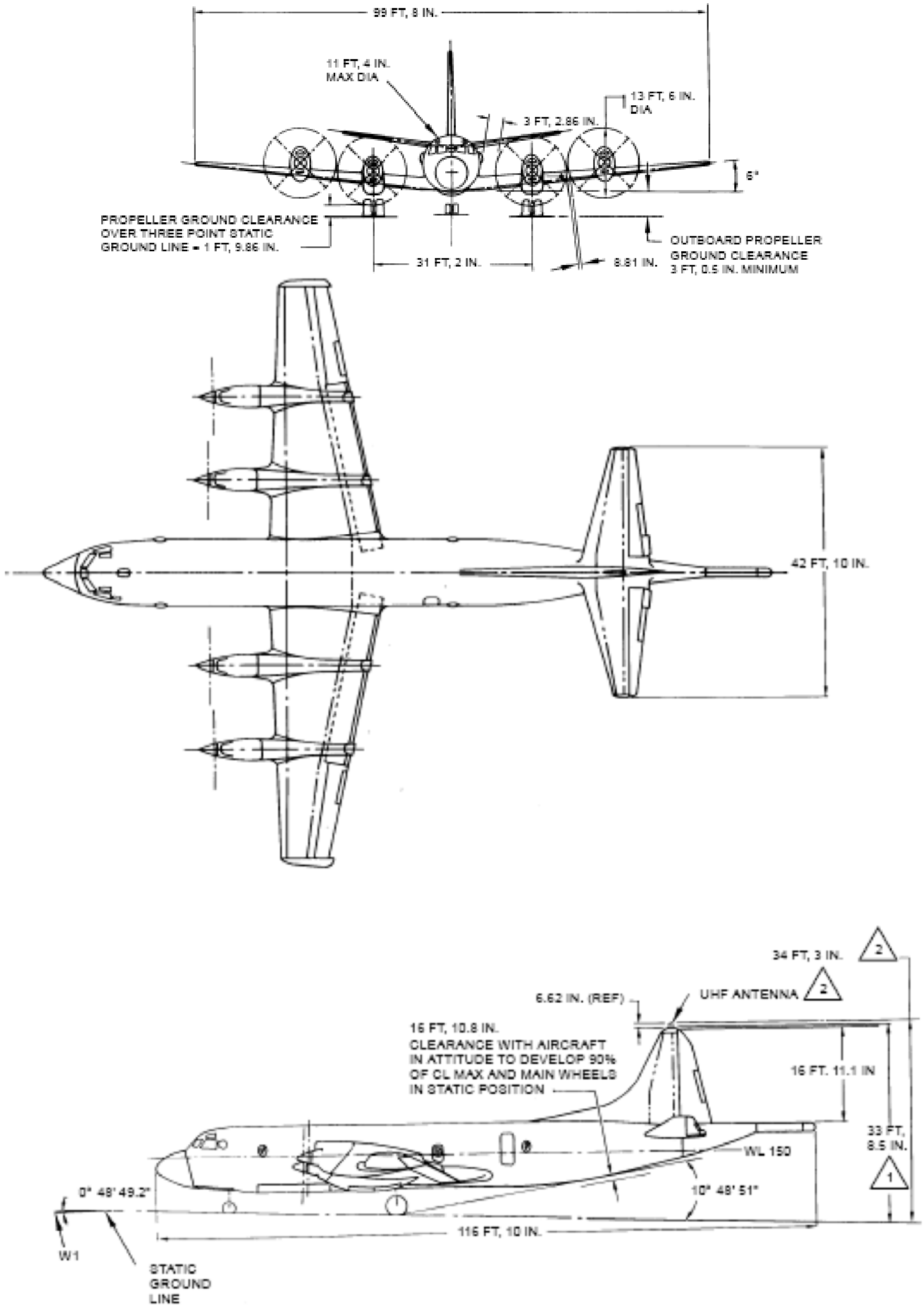

Figure 2-2. General view and overall dimensions of the P-3B
(Note: NASA P-3 does not have MAD boom on tail currently installed.)

2.2.2: Wing

Area –	1,300 Sq. Feet
Span –	99 Feet
Chord, root –	18.92 Feet
Tip (theoretical) –	7.58 Feet
Mean Aerodynamic Chord (MAC) –	14.06 Feet
Leading edge of MAC –	F.S. 545.9 & W.L. 118.97
Location of .25 MAC –	F.S. 588.06
Spanwise location –	W.S. 254.3
Aspect Ratio –	7.5
Taper Ratio –	0.4
Dihedral, measured along .25 chord	
Outboard of W.S. 65 -	5°
Inboard of W.S. 65 -	0°
Sweepback of .15 chord -	0°
Incidence	
Root -	3°
Tip -	0.5°
Twist, geometric -	-2.5°
Waterline of wing ref. plane at aircraft centerline -	W.L. 85.5
Airfoil section	
Root -	NACA 0014-1.10 40/1.051
Tip -	NACA 0012-1.10 40/1.051

2.2.3: Aileron (Each Side)

Area -	45.5 Sq. Feet
Span -	17.58 Feet
Mean Chord -	2.62 Feet
Wing station of inboard end at hinge line -	W.S. 383
Deflection limits -	16.2° (Down), -23.3° (Up)
Tab (per surface)	
Area -	3.67 Sq. Feet
Mean chord -	7.85 inches
Deflection limits -	± 20°

2.2.4: Wing Flaps (Each Side)

Type -	Lockheed – Fowler
Area -	104.05 Sq. Feet
Span -	29.0 Feet
Chord (perpendicular to wing T.E.)	3.58 Feet
Inboard end of L.E. of flap	W.S. 41.2
Deflection	

Maneuver (39% extension) -	10°
Take-Off (78% extension) -	18°
Landing (100% extension) -	40°
Area of wing in region of flap -	430 Sq. Feet

2.2.5: Horizontal Tail

Area -	321.8 Sq. Feet
Span -	42.8 Feet
Chord, root -	11.46 Feet
Chord, tip (theoretical)	3.73 Feet
Mean Aerodynamic Chord (MAC) -	8.21 Feet
Leading Edge of MAC -	F.S. 1161.1
Location of .25 MAC -	F.S. 1185.8
Aspect Ratio -	5.70
Taper Ratio -	.325
Dihedral (measured along .70 chord) -	8.5°
Sweepback of .70 chord -	0°
Incidence -	1.7°
Airfoil section -	NACA 23011 (inverted)
Tail length, .25 wing MAC to .25 tail MAC -	49.8 Feet
Tail volume -	.877

2.2.6: Elevator Total

Area -	81.1 Sq. Feet
Span (per side) -	18.75 Feet
Mean chord -	2.17 Feet
Chord ratio, tip to root -	.354
Hinge line location -	F.S. 1230
Inboard end of elevator -	B.L. 32
Deflection limits -	-30° (Up), +15° (Down)
Trim tab (each)	
Area -	5.25 Sq. Feet
Mean chord -	10.0 inches
Span -	75.5 inches
Deflection limits (elevator neutral) -	-5° (Up), +25° (Down)
Linked Force Tab	
Area (two tabs) -	7.75 Sq. Feet
Chord (effective) -	14.0 inches
Span per tab -	39.87 inches
Deflection limits -	-15° (Up), +6° (Down)

2.2.7: Vertical Tail

Area -	176.2 Sq. Feet
Span (theoretical) -	17.33 Feet
Chord, root (W.L. 207) -	16.08 Feet
Chord, tip (theoretical at W.L. 409)	4.77 Feet
Mean Aerodynamic Chord -	11.57 Feet
Leading edge of MAC -	F.S. 1126.4
Location of .25 MAC -	F.S. 1161.1
Aspect ratio -	1.705
Taper ratio -	.301
Sweepback of .67 chord -	0°
Airfoil section -	NACA 0012-1.10 40/1.051
Tail length, .25 wing MAC to .25 vert. tail MAC -	573.04 inches
Tail volume -	.065
Dorsal area -	36 Sq. Feet

2.2.8: Rudder

Area -	59.9 Sq. Feet
Span (actual) -	16.83 Feet
Mean chord -	3.76 Feet
Lower end of rudder -	W.L. 207
Hinge line location -	F.S. 1216.3
Deflection limits -	+30° (Right), -25° (Left)
Trim tab	
Area -	4.40 Sq. Feet
Mean chord -	9 inches
Span -	70.44 inches
Deflection limits -	± 25°

2.2.9: Fuselage

Length (excluding MAD boom) -	103.8 Feet
Location of nose -	F.S. 105
Maximum Diameter -	11.33 Feet
Forward pressure bulkhead (canted) -	F.S. 166 (Top), F.S. 180 (Bottom)
Aft pressure bulkhead -	F.S. 1117
Forward main ring -	F.S. 571.2
Aft main ring -	F.S. 695.1

2.2.10: Landing Gear

Wheel base -	29.67 Feet
Tread -	31.2 Feet

Wheel size	
Main wheels -	40 x 14
Nose wheels -	28 x 7.7
Tire casing ply rating	
Main wheels -	26 Ply Rating
Nose wheels -	14 Ply Rating
Axle Locations (static)	
Main wheels -	F.S. 621 & W.L. 42.1
Nose wheels -	F.S. 265 & W.L. 43.2

2.2.11: Powerplant

4 x T56-A-14 Allison engines	
Equivalent shaft horsepower/engine	4600 SHP
Speed	
Engine -	13820 rpm
Propeller -	1020 rpm
Propellers	
Hamilton Standard -	Four blade, full feathering & reversible
Diameter -	13.5 Feet

2.3: Performance

2.3.1: Altitude

The time at desired research altitude is dependent upon numerous factors. If a higher altitude is desired, a step-climb can be achieved after aircraft weight has been reduced by fuel burn-off. Factors such as air temperature, aircraft configuration (probes, pylons, antennas, etc.), and air traffic control will determine when the aircraft can climb to a higher altitude. Traditionally, an individual flight plan is developed for each case, to optimize total research requirements. Early coordination with WFF Mission Manager/Directors will provide the most optimum flight profiles. The maximum allowable altitude of the NASA P-3 aircraft is approx. 28,000 ft due to RVSM limitations but the aircraft is capable of 32,000 ft under certain conditions. The P-3 has a minimum altitude of 200 feet AGL for daytime operations and 1,000 feet AGL for nighttime operations provided a flat terrain is being flown over.

Altitude selection has a pronounced affect on fuel consumption. Generally speaking, the lower the aircraft is operated the higher the fuel burn rate. Repeated climbs and descents are also less conservative. Table 2-1 details the theoretical maximum altitudes for a given aircraft gross weight.

Table 2–1. Aircraft gross weight vs. altitude

Aircraft Gross Weight	Altitude
85000	32000
90000	31000
95000	29500
100000	28000
105000	27000
110000	25500
115000	24000
120000	23000
125000	21500
130000	20000
135000	19000

2.3.2: Speed

At standard atmospheric temperature conditions, the indicated airspeed (KIAS) envelope for this aircraft is shown in Figure 2-3. For preliminary planning, normal cruise speed at altitudes above 20,000 ft can be estimated at 330 KTAS. Only KTAS should be used for flight planning purposes.

Based upon aircraft gross weight and altitude, Table 2-2 identifies the minimum allowable airspeed/fuel economy cruise airspeed/maximum allowable airspeed given in knots true airspeed (KTAS). Slower airspeeds are possible with the selection of flaps. However, a considerable increase in fuel burn rate may result and is therefore not recommended.

Table 2–2. KTAS for given aircraft gross weight and altitude

Aircraft Altitude (K Ft)	Aircraft Gross Weight (K lbs)									
	90K	95K	100K	105K	110K	115K	120K	125K	130K	135K
30K	270/349/385	278/353/380	285/356/378	291/360/375	300/350/352	x	x	x	x	x
28K	260/340/392	268/344/391	274/348/386	280/352/383	288/355/376	294/359/370	x	x	x	x
26K	251/332/397	258/336/396	264/339/393	270/343/390	278/347/386	284/350/382	290/354/378	296/357/370	x	x
24K	242/325/400	249/328/400	255/331/395	261/335/393	268/338/391	274/342/389	280/345/387	286/349/380	287/352/372	x
22K	234/317/402	241/320/402	246/324/397	252/327/395	259/330/393	265/334/392	271/337/389	276/340/385	278/344/382	282/346/373
20K	226/310/404	233/313/404	238/316/402	244/319/400	251/322/397	256/326/395	261/329/392	267/332/390	269/335/385	273/338/380
18K	218/303/388	225/305/388	230/309/388	236/312/388	242/315/388	248/318/388	253/321/388	258/324/388	261/328/385	265/330/383
16K	211/296/377	218/299/377	223/302/377	228/305/377	234/308/377	239/311/377	245/314/377	250/317/377	252/320/377	256/323/377
14K	205/289/366	211/292/366	216/295/366	221/298/366	227/301/366	232/304/366	237/307/366	242/310/366	245/313/366	249/317/366
12K	198/283/355	204/286/355	209/289/355	214/292/355	220/295/355	225/298/355	229/301/355	234/304/355	238/238/355	241/310/355
10K	192/277/345	198/280/345	202/283/345	207286/345	213/288/345	218/291/345	222/294/345	227/297/345	230/300/345	234/302/345
8K	186/271/335	192/274/335	196/277/335	201/280/335	183/282/335	211/285/335	215/288/335	220/291/335	223/293/335	202/296/335
S.L.	165/250/300	170/253/300	174/255/300	178/258/300	183/260/300	187/263/300	191/265/300	195/268/300	199/270/300	202/273/300

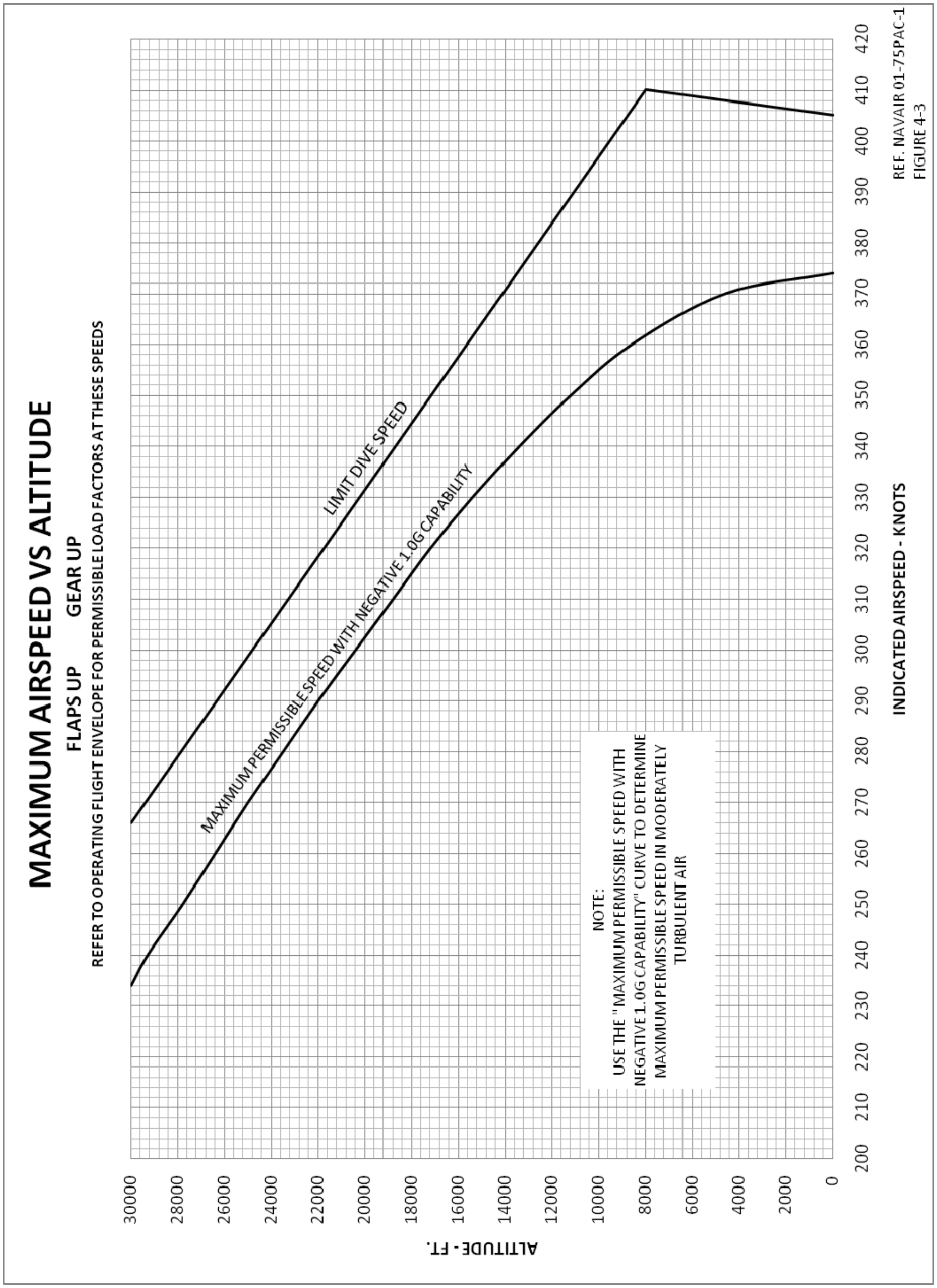

Figure 2-3. Maximum airspeed (KIAS) vs. altitude

2.3.3: Range and Endurance

Maximum aircraft range with normal fuel reserves is shown in Table 2-3.

Table 2–3. Maximum aircraft range with normal fuel reserves

P-3 Altitude, Range and Airspeed Table	High Altitude 25-28K Feet	Medium Altitude 10-25K Feet	Low Altitude 500-10K Feet
Endurance (hours)	12	10	8
Range (Nautical Miles)	3,800	3,000	2,400
Speed (KTAS)	330	260	270

2.3.4: Turn Performance

For certain types of experiments, it may be desirable to fly over several closely spaced checkpoints. Experimenters planning closely spaced checkpoints should consult with their Mission Manager/Director regarding flight planning. Figure 2-4 indicates radius of turn, with no wind, in nautical miles as a function of speed and bank angle.

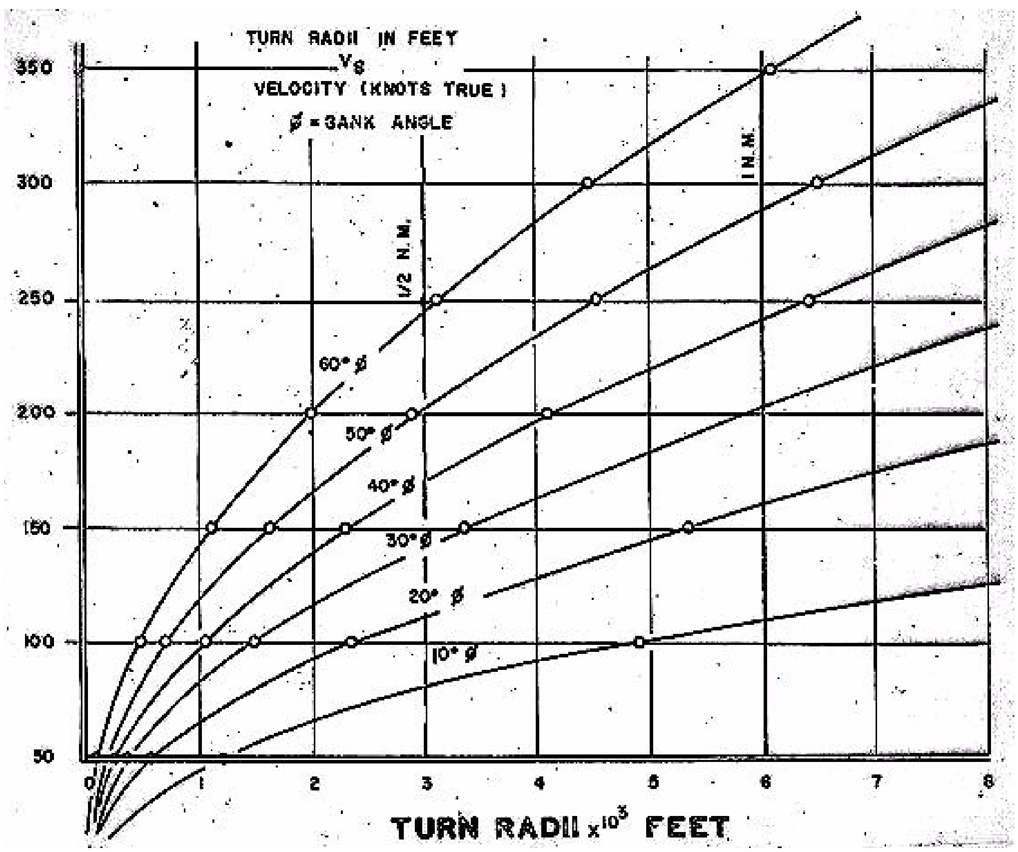

Figure 2–4. P-3B turn radius in feet, as a function of airspeed and bank angle

2.4: Payload Weight

Payload weights seldom exceed 14,700 lbs (6,600 kg), so that a 3,800 nmi (6,100 km) range is usually available except as reduced by special requirements for altitude profiles, flight patterns over ground test sites, external experiments, or headwinds. The maximum zero fuel weight (MZFW) is 77,200 lbs and the maximum take-off gross weight (MTOGW) is 135,000 lbs under normal circumstances.

2.5: Operating Restrictions

2.5.1: Runway Length

At standard sea level conditions, at maximum gross weight, the P-3B typically requires a runway of 8,000 ft (2,438 m). The allowable aircraft take-off gross weight will be reduced by such limiting factors as runway length, weight-bearing capability, slope, height above sea level, as well as by air temperature, wind and obstacles.

2.5.2: Worldwide Capability

The P-3 is equipped and certified to meet airspace, communication, altimetry, and navigation performance specifications worldwide. Due to RVSM limitations N426NA typically cannot exceed 28,000 feet in altitude. All experiment payloads and aircraft configuration changes are reviewed to ensure that worldwide capability is not degraded.

2.5.3: Center of Gravity

The maximum permissible center of gravity (cg) envelope is shown in Figure 2-5.

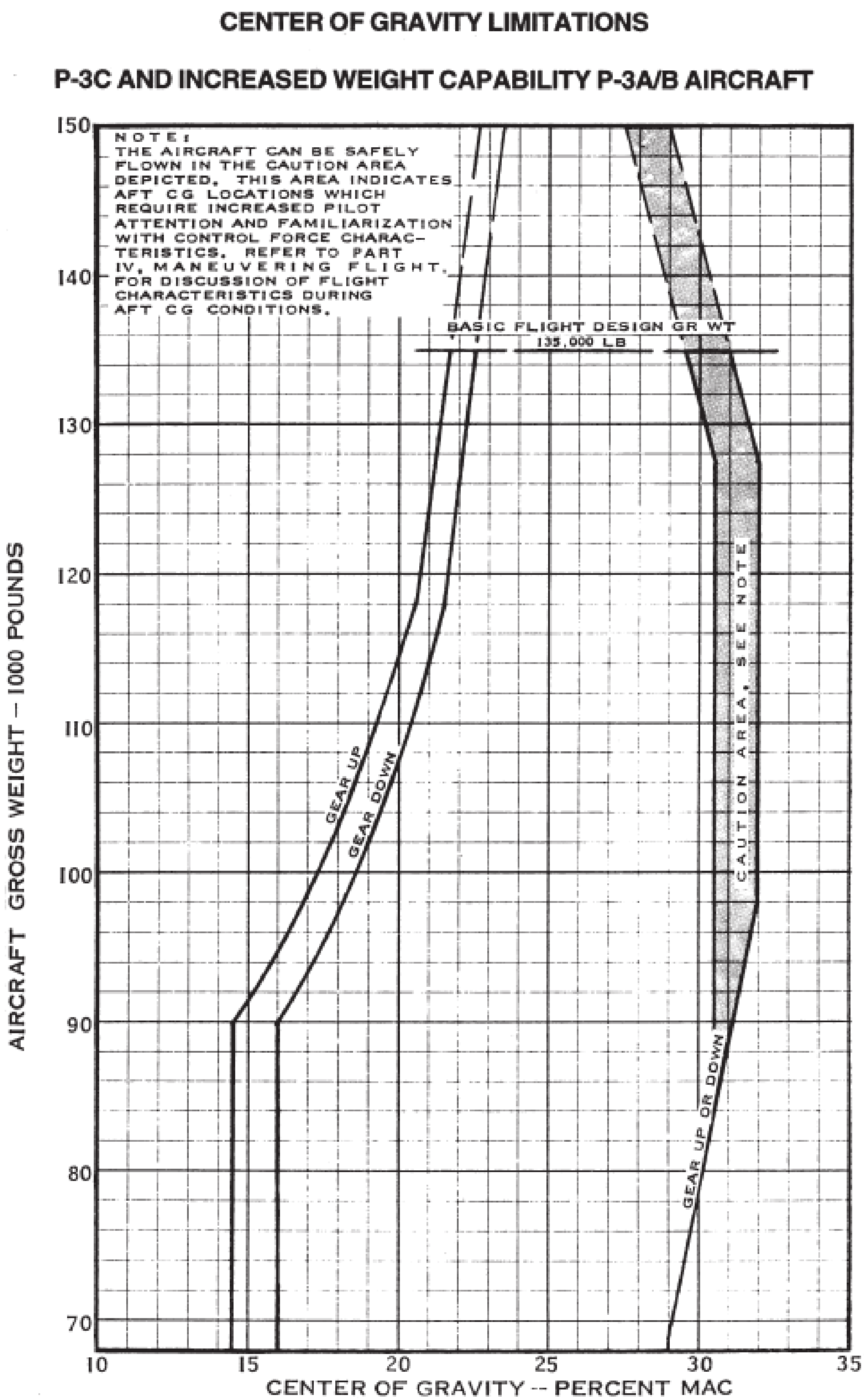

Figure 2–5. P-3B center of gravity limitations

2.5.4: Stall Buffet Speeds

The relationship of stall buffet speed to gross weight for various wing flap settings is shown in Table 2-4 in terms of KIAS. The values given are based on flight tests at various Angles of Bank (AOB) but could vary several knots depending on the actual configuration of the aircraft.

Table 2–4. Airspeed for start of stall buffet

Configuration	Stall Buffet Speed KIAS			
	0° AOB	15° AOB	30° AOB	45° AOB
137,500 LB. GROSS WEIGHT				
Flaps and gear up	143	146	154	170
Maneuver flaps, gear up	137	139	147	162
Takeoff flaps, gear down	128	130	137	152
Land flaps, gear down	122	124	131	145
133,500 LB. GROSS WEIGHT				
Flaps and gear up	141	144	152	168
Maneuver flaps, gear up	135	137	145	160
Takeoff flaps, gear down	126	129	136	150
Land flaps, gear down	120	123	129	143
127,200 LB. GROSS WEIGHT				
Flaps and gear up	138	141	149	165
Maneuver flaps, gear up	132	134	142	156
Takeoff flaps, gear down	123	125	132	147
Land flaps, gear down	118	120	126	140
100,000 LB. GROSS WEIGHT				
Flaps and gear up	122	124	132	146
Maneuver flaps, gear up	116	118	125	139
Takeoff flaps, gear down	109	111	118	130
Land flaps, gear down	104	106	112	124
70,000 LB. GROSS WEIGHT				
Flaps and gear up	102	104	110	122
Maneuver flaps, gear up	97	99	104	116
Takeoff flaps, gear down	91	93	98	108
Land flaps, gear down	87	89	94	104

2.5.5: Restrictions Due to Flight Test

A flight test to verify and recertify aircraft performance will be accomplished when appropriate. If flight testing determines the aircraft does not meet requirements throughout its normal operating envelope and the deficiencies cannot be corrected, limitations may be imposed. Such limitations may restrict the altitude, airspeed, or geographic regions within which the aircraft may operate.

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Chapter 3: Environment

3.1: Pressure

The cabin is pressurized to an equivalent altitude of approximately 7,500 ft (2,286 m) when the airplane is at its 28,000 ft (8.5 km) cruise level. Nadir ports #1, 2 and 3 are located below the cabin floor, which is within the fuselage pressure vessel. The bomb bay, nose radome, and tail radome ports are located outside the fuselage pressure vessel. The pressure in these areas is equivalent to the atmospheric pressure.

3.2: Temperature/Humidity

Cabin humidity during flight nominally averages about 10 percent; the temperature is held between 65 and 74 °F (18 and 24 °C). Different sections of the interior can vary considerably in temperature, however, depending on the airflow patterns and the location of heat-producing equipment. Also depending on operating location, low altitude operations may significantly increase cabin temperature and humidity. Operations in polar regions can cause cabin temperatures to drop below freezing in certain locations, particularly under the cabin floor. Relative humidity normally decreases with time in flight, from the local airfield value at takeoff to a relatively stable 10 to 15 percent within an hour or two. Special provisions should be made for the local control of temperature-sensitive equipment.

3.3: Load and Acceleration

Table 3-1 below details the allowable flight loads and airspeeds for given gross weight and altitude.

Table 3-1. Load and accelerations

		Gross Weight Less Than 125,000 lb	Gross Weight between 125,000 lb and 135,000 lb	Gross Weight between 135,000lb and 139,760 lb
Altitude	Sea Level to 15K	300 KIAS	225 KIAS	215 KIAS
	15K to 20K		235 KIAS	
	20K to 25K		245 KIAS	
	25K and up		255 KIAS	
Symmetrical Flight	Min	0.0g		
	Max	2.5g	2.0g	
Roll Maneuver	Min	1.0g		
	Max	2.0g	1.5g	

3.4: Airflow and Boundary Layer

3.4.1: Boundary Layer

A thin, variable thickness layer of air, known as the boundary layer, exists at the skin of the aircraft. The properties of this air do not represent free stream, undisturbed conditions; therefore, experimenters should place their devices far enough away from the fuselage to be in free stream air. At this time, the boundary layer thickness of the P-3B has not been verified but a good rule of thumb is to keep all boundary layer sensitive installations at least 6 inches away from the fuselage surface.

3.4.2: Angle of Attack

Aircraft angle of attack (AOA) depends on altitude, speed, and aircraft weight. Thus the angle of attack can vary throughout the flight profile of a mission. Typically for AOA sensitive installations, the experimenter is advised to incorporate an approximate 2° offset angle in the pitch axis of the experiment assembly to account for this variation in AOA. Scanners, radiometers and cameras are examples of instruments that often require an accurate nadir view. Close coordination with WFF engineering will ensure the proper AOA offset for a particular design.

3.4.3: Auxiliary Power Unit Exhaust

The P-3 has an Auxiliary Power Unit (APU) installed to provide aircraft electrical power while on the ground when a power cart or commercial power is not available. The APU exhaust door is located at approximately FS300 on the right side of the aircraft. For installations located in the bomb bay and on the forward right side P-3 bubble window the exhaust from this door may affect instruments while the APU is running. Figure 3-1 depicts the location of the APU exhaust door and the flow of exhaust from this location.

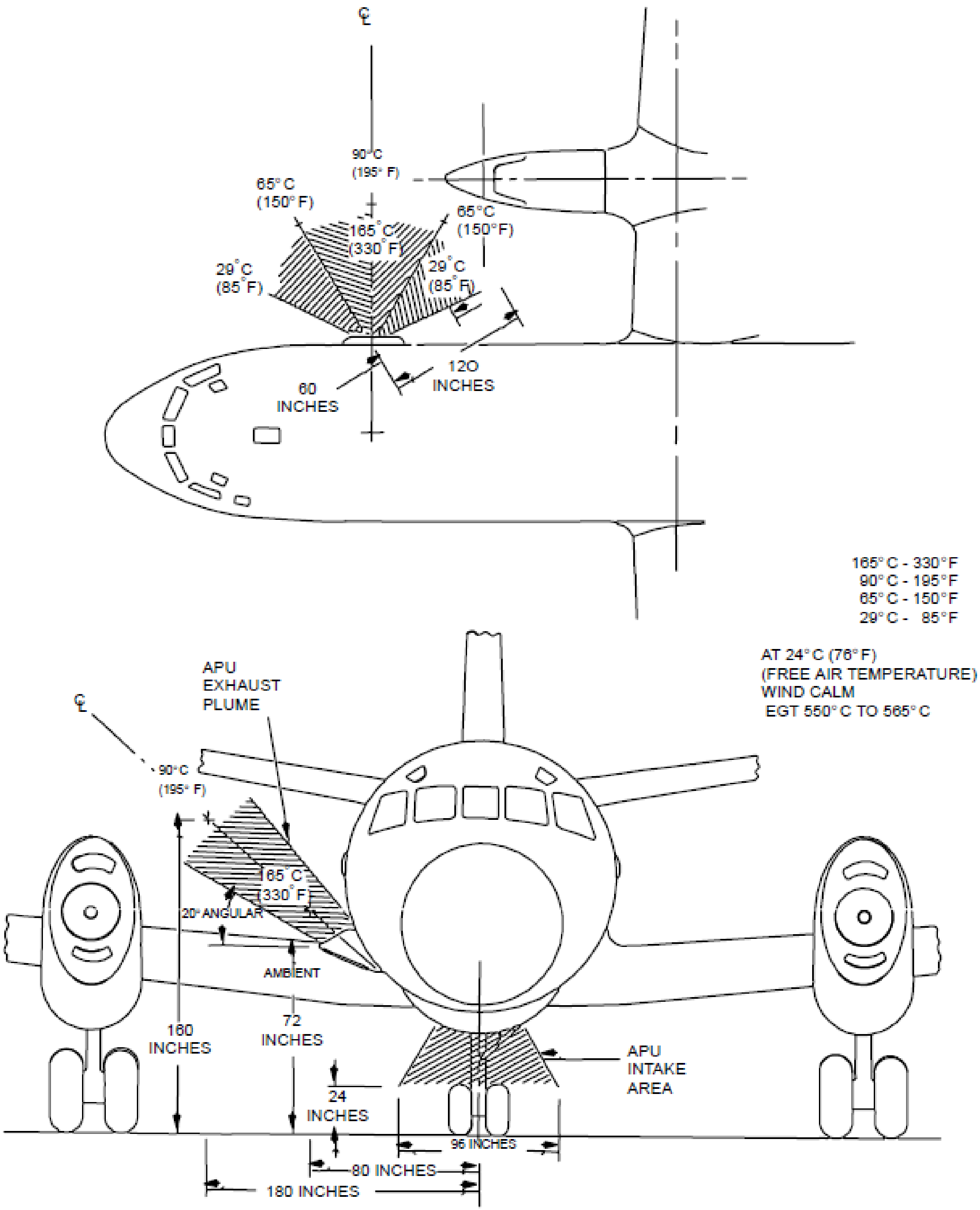

Figure 3-1. APU operational areas

3.5: Stability/Attitude

3.5.1: In-Flight

A PB-20N Automatic Flight Control System (AFCS) controls the heading and altitude of the aircraft. In smooth air, the autopilot limits deviations of pitch, yaw, and roll to within ± 1 degree. When cruising at a constant speed and altitude, the aircraft flies at a 1° to 3° nose-up attitude. A nominal value is 2°; however, the actual angle depends on a combination of gross weight (decreases as fuel is consumed), altitude, and true airspeed. A gross weight increase, altitude increase and an airspeed decrease results in an increased nose-up attitude.

3.5.2: Ground

When parked, the aircraft is typically resting at a 2° nose-down attitude. If necessary, during the installation and/or calibration of equipment, the aircraft can be leveled to zero degrees by elevating the nose.

3.6: Vibration and Shock

Prominent vibrations are always present in the P-3 aircraft during operation. These vibrations are normal and are caused by rotating components within the aircraft and airflow over the aircraft. The main source of vibration in the P-3 is the power plant (engine and propeller) package. Although the powerplant package is the primary source of aircraft vibration inputs, there are many other sources responsible for overall aircraft vibration problems and noise. For example, in normal flight conditions, when the aircraft is flying in the clean configuration, (landing gear and flaps-up) straight and level, below 250 knots, normal vibration amplitude will be the lowest. When the aircraft is flying in the clean configuration beginning at approximately 250 knots and increasing to maximum design speed, the normal vibration and noise level will increase significantly. This increase is due to increased fuselage side pressure pulsation from the propeller blade passage and the increased aerodynamic layer of turbulence from the airflow along the aircraft surface.

The frequency of the rotating components is expressed in Hertz (Hz). The engine and propeller in operation generate certain primary (fundamental/natural) frequencies.

Table 3-2 details these frequencies.

Table 3-2. RPM fundamental frequencies

Frequency	Description
10 Hz	Engine Suspension System natural frequencies
17Hz	Propeller rotational frequency (1P)
68Hz	Propeller blade passage frequency (4P)
230Hz	Engine primary rotational frequency (1E)
1700Hz	Reduction Gear Assembly Planet Gear passage frequency

Several other frequencies are constantly present during engine-propeller operation, such as propeller second harmonic - 34Hz (2P); propeller fourth harmonic – 68Hz (4P);

propeller eighth harmonic – 136Hz (8P); engine second harmonic – 460Hz (2E), etc. However, the displacements at second, third, and/or eighth, etc., harmonics frequencies are normally much less than the fundamental frequency. The presence of these frequencies is inherent in engine and propeller operation.

Experimenters should remember that, except for air turbulence, the most severe vibration usually occurs during taxi, take-off, and landing. For example, on rough runways, printed circuit cards and connectors have become dislodged and optical components have been jolted out of alignment. Such problems may prove difficult to correct in flight, so mechanical support by clamps, brackets or dampeners should be provided as a precaution. Consult WFF for specific guidance on vibration related concerns.

3.7: Radiofrequency and Electromagnetic Interference

Experimenters are cautioned that transmitters on the aircraft may cause interference with their equipment. Frequency ranges of the navigation, radio, and radar units are listed below in Table 3-3.

Table 3-3. Frequencies and interferences

Equipment	Transmitting/Receiving Frequency(ies)	Receiving	Transmitting
Low Frequency ADF	1108 to 118 kHz	X	
HF Radio	2.0 to 30.0 MHz	X	X
Marker Beacon	75 MHz	X	
VHF Omnirange (VOR)	108 to 118 MHz	X	
FM Radio	30 to 87.975 MHz	X	
	156 to 173.975 MHz		X
VHF Radio	118 to 151.975 MHz	X	X
Glideslope Receiver (GS)	329.3 to 335.0 MHz	X	
UHF Radio	225 to 400 MHz	X	X
Air Traffic Control (ATC) Transponder	1030 MHz	X	
	1090 MHz		X
Traffic Alert and Collision Avoidance System (TCAS)	1030 MHz	X	
	1090 MHz		X
Distance Measuring Equipment (DME) and Tactical Air Navigation (TACAN)	960 to 1215 MHz	X	X
Global Positioning System (GPS)	1575.42 (±2.0) MHz	X	

Iridium Satellite Phone	1610 to 1626.5 MHz	X	X
Radar Altimeter	4.2 TO 4.37 GHz	X	X
Weather Radar (X-Band)	5400 (±40) MHz	X	X
Automatic Identification System (AIS)	161.975 & 162.025 MHz		X

3.8: Radiation

There are no known radiation effects to personnel or instruments on board the P-3 aircraft. Personnel and instrumentation flying on board the P-3 will not be exposed to any more natural background radiation than the standard airline passenger flying at the same altitude.

3.9: Engineering Check Flight

The following P-3B test envelope (Table 3-4) will be used for Engineering Check Flights.

Table 3-4. P-3B test envelope

Parameter	Test Envelope		Clearance Limit	
	Minimum	**Maximum**	**Minimum**	**Maximum**
Airspeed (KIAS)	V_{stall}	405 KIAS (1)	V_{stall}	405 KIAS (1)
Altitude	Surface	25,000' MSL	Surface	35,000' MSL
Load Factor	-0.5	+2.5(1)	-1.0	+3.0
AOA	-	22 units ~16°	-	-
Roll	-	±90°	-	±90°(2)
Side Slip	-	±15°	-	±15°

(1) Current NAVAIR limitations recommend maximum sustained airspeed operations of 300 KIAS.
(2) Unloaded 90° rolls are constrained by aircraft 0g oil limitations. Coordinated turns are limited by load factor.

Chapter 4: Payload Accommodations

4.1: Physical

The NASA P-3 is similar in size and basic furnishings to other Navy P-3 aircraft. Passenger seating, windows, lavatory, emergency oxygen supplies, and the general cabin environment conform to current Navy and commercial standards. Extensive modifications have been made to accommodate a wide variety of experiments; these modifications will be described in this chapter.

4.1.1: Locations and Dimensions

Positions longitudinally within the aircraft are identified by fuselage station (FS) numbers (in inches) beginning with 100 at the nose and increasing to 1400 at the rear of the fuselage. Lateral positions are identified by body line (BL) numbers beginning with 0 along the centerline of the aircraft and increasing positively in both the left and right directions. Vertical positions are identified by water line (WL) numbers beginning with 0 at ground level and increasing vertically. The basic structural locators are the belt frames 20 in. apart longitudinally and running throughout the aircraft.

Figure 4-1 gives the general layout of the aircraft areas, illustrating an interior top and side view of the fuselage, and identifying entrances, exits, the data system, and a station for the Mission Manager/Director. Optical viewports and electrical power outlets for experimenter use are also identified at their approximate locations.

Table 4-1 lists the most frequently used experimenter ports and aperture dimensions for each port. Other unique ports are available as detailed in Section 4.4.

Table 4-1. List of ports & port aperture dimensions

Ports	Port Aperture Dimensions
P-3 Bubble Windows	22”W x 24” L
DC-8 Passenger Windows	17”W x 19”L
Forward Bomb Bay Fairing Port	50”W x 51”L
Aft Bomb Bay Fairing Port	50”W x 44”L
Zenith #1	16” dia.
Nadir #1	25”W x 36”L
Nadir #2	25”W x 36”L
Nadir #3	31”W x 36”L

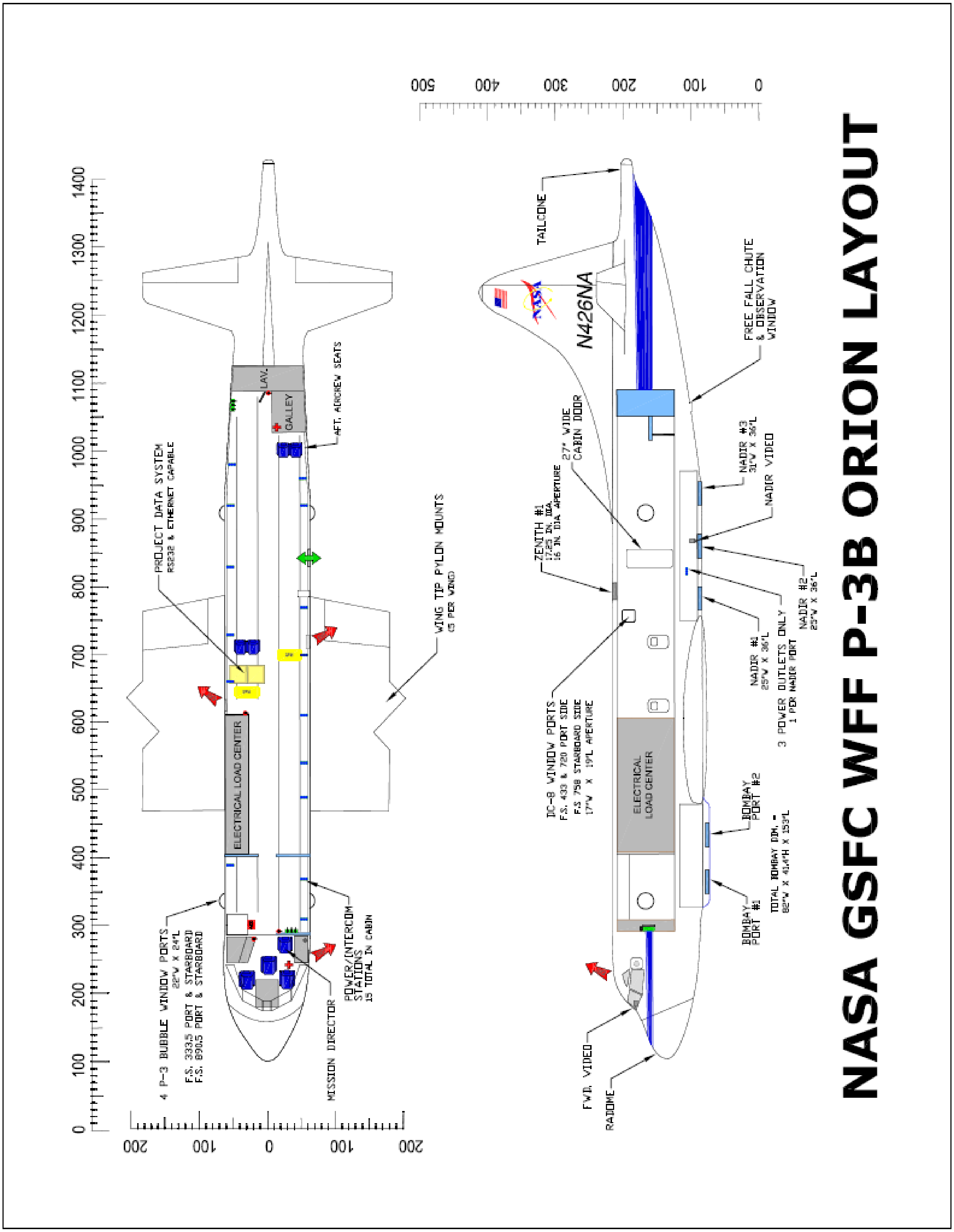

Figure 4-1. Top and side views of the aircraft

4.1.2: Mass and Moment Constraints

Table 4-2 lists the most frequently used experimenter ports and the associated mass/moment arm and moment constraints for each port. Mass/moment constraints for other unique ports are listed in Section 4.4. Drag areas of externally mounted items also affect the moment constraint for a given port. Contact the Ops Engineer to discuss constraints when mounting external items.

Table 4-2. List of ports & port aperture allowable loads

Ports	Mass (lbs) / Moment Arm (in) Constraint	Moment Constraint (in-lbs)
P-3 Bubble Windows	100lbs (150lbs ultimate) / 18 in.	1800 in-lbs (2700 in-lbs ultimate)
DC-8 Passenger Windows	100lbs (150lbs ultimate) / 18 in.	1800 in-lbs (2700 in-lbs ultimate)
Forward Bomb Bay Fairing Port	Custom Analysis Required	Custom Analysis Required
Aft Bomb Bay Fairing Port	Custom Analysis Required	Custom Analysis Required
Zenith #1	280lbs / 10 in. below port opening	2800 in-lbs
Nadir #1	Custom Analysis Required	Custom Analysis Required
Nadir #2	Custom Analysis Required	Custom Analysis Required
Nadir #3	Custom Analysis Required	Custom Analysis Required

4.1.3: Cabin and Cargo Access Constraints

Figure 4-2 illustrates a cross section of the fuselage, which is approximately symmetrical about the vertical centerline. The illustration summarizes the space available in the cabin and below the cabin floor. The main cabin is 117.8 in. wide at floor level, with approximately 90 in. of headroom in aisle center (83 in. from floor to ceiling coverings). Four seat track rails extend the length of the cabin to provide the primary attachment points for seats, equipment racks and other floor mounted equipment. There are also two seat track rails that extend along the length of each cabin wall (WL126 and WL174) for mounting hardware to side walls of the aircraft. The cabin floor can withstand a distributed download; however, fore, aft, and lateral forces must be sustained by the seat-support tracks. The below cabin floor area has seat track rails centered 40 in. (Nadir #1) and 31.5 in. (Nadir #3) apart at floor level, with approximately 36 in. of available vertical space.

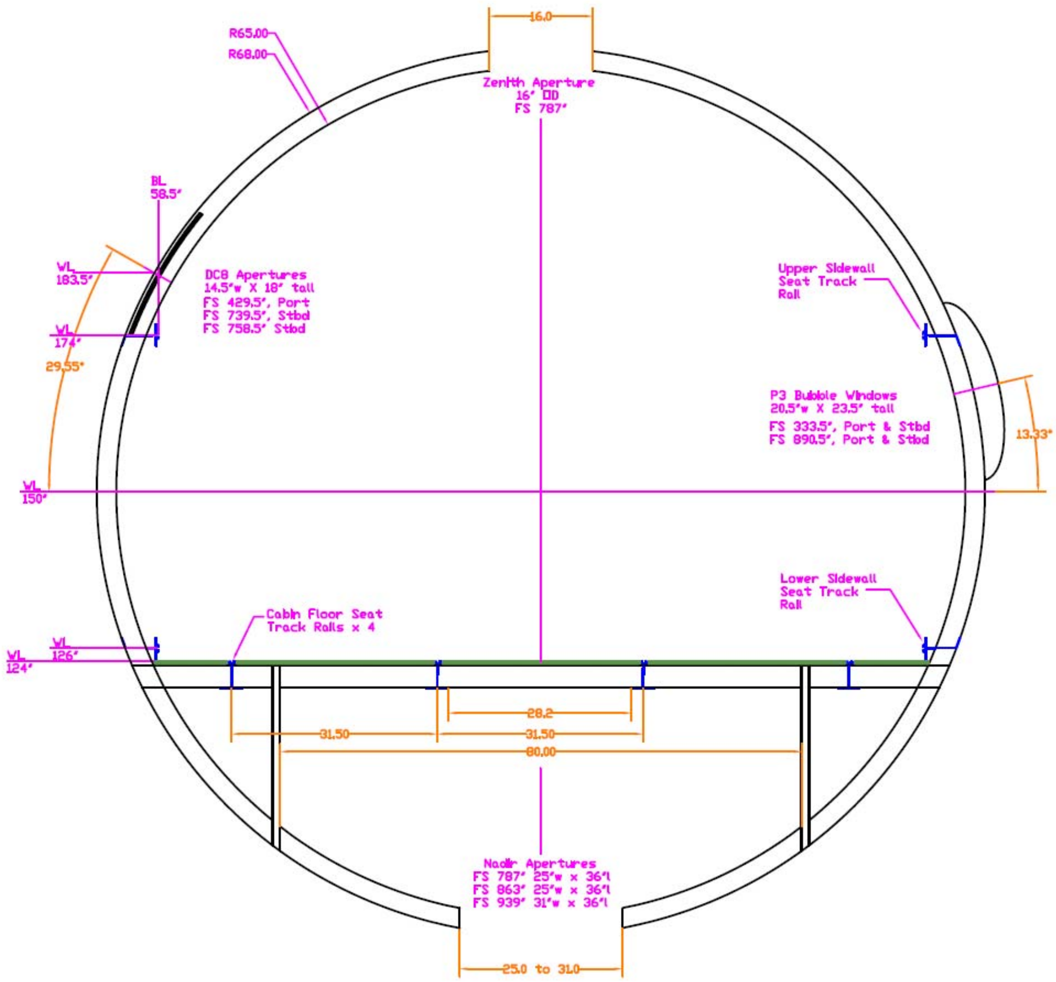

Figure 4-2. Cross section view of the fuselage

4.1.3.1: Main Cabin Door Access

The main cabin has one passenger access door, 27 in. x 72 in., on the left side of the aircraft.

4.1.3.2: Aisles

An aisle at least 20 in. wide will be maintained along the entire length of the main cabin. The aisle may shift locally from one side to the other in the aircraft depending on instrumentation mounted in the center aisle way.

4.1.3.3: Seat Spacing

The nominal passenger seat spacing is 24 in. (60.7 cm). There is a center-located armrest which does not extend forward of the seat cushion but is 26 in. (66 cm) high.

4.1.3.4: Unavailable Areas

The avionics rack (FS270 to FS310 on the right side), the Mission Manager/Director table (FS260 on the left side) in the cockpit, the electrical load center (FS400 to FS610 on the right side), and the galley/lavatory area (FS1050R to 1100) are areas unavailable for internally and externally mounted experiment hardware.

4.1.3.5: Cargo Areas

Limited cargo space is available in the cabin in open areas around seats, racks, and other experiment equipment. There is no dedicated cargo area aboard this aircraft. On deployments, available cargo space must be reserved for aircraft spare parts, support equipment, and baggage. This may require shipping experimenter support equipment to forward locations well in advance of actual P-3 deployment. A four-piece pallet can be installed in the bomb bay to carry up to 2,000 lbs of cargo if the bomb bay ports are not being used for experiments.

4.1.3.6: Below Cabin Floor Areas

The only access to the below cabin floor area is by removing cabin floor panels.

4.1.4: Mechanical Interfaces

Numerous ways exist to install mechanical interface instruments to the P-3 aircraft. With the exception of small and light components mounted to the viewports, all experimenter equipment in the main cabin must be supported by the seat tracks. The following paragraphs detail the various methods of installing instruments in the P-3B aircraft.

4.1.4.1: Internal Fuselage Structural Attachments

4.1.4.1.1: Floor Seat Track Rails

Structural attachment in the cabin area will be primarily by connection to the seat track rails. A pair of rails on each side of the main cabin floor is used to attach the seats and experimenter racks. The standard P-3 decking has been removed between FS288 and FS1117 and replaced with high strength fiberglass and balsa cargo deck panels. Four continuous seat track rails spaced 31.5 in. on center apart from each other, running forward and aft have been installed at BL15.75 and BL41.25 left and right. The two inboard beams run from FS288 to FS1117, and the two outboard beams run from FS288 to FS1052. The BL41.25 right beam is interrupted by the electrical load center. The seat tracks are designed to react to an ultimate load of 10,000 lbs at 38-in. intervals anywhere along their length. The design of the seat tracks is to adequately react to dynamic crash criteria applied to all cabin installations. Special fittings, shown in Figure 4-3, are used to attach experiments to the seat track rails.

Double stud connector

Single stud connector

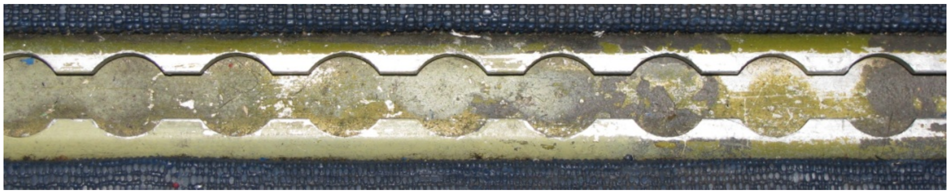

Figure 4-3. Seat track rails and standard mounting hardware

4.1.4.1.2: Sidewall Seat Track Rails

Two seat track rails on the left sidewall of the cabin exist from FS405 to FS975. These rails are interrupted by the main cabin door. Two continuous right sidewall seat tracks exist from FS640 to FS975. Both sets of lower side seat track rail are at WL126 and the upper seat track rails are at WL174. All seat track rails inboard surfaces are at BL58.5. The side rails are also designed to react to the ultimate loads of 10,000 lbs at 38-in. intervals anywhere on their length. Although no modification to the primary structure was necessary to incorporate the side rails, they provide additional strength to the fuselage shell. The rails are designed to react to dynamic crash criteria applied to all cabin installations, including the standard WFF 19-in. instrument racks.

4.1.4.1.3: Below Cabin Floor Area

An under floor access area extends from FS768 to FS958 and between BL15.75. Experimenter equipment can be mounted to the seat track rails in the #1 and #3 nadir port locations. Items in Nadir #2 must either mount directly to a port plug or hang down below the floor from the cabin seat tracks. Due to the limited floor space available on flights based away from WFF, specific below cabin floor installation requirements should be discussed early on in the mission timeline.

4.1.4.1.4: Cabin Window Viewports

Experiment hardware that must be located at a window viewport location may only be attached to the window blank-off plate. Additional support can be provided by connecting the hardware to the airframe but this is not advisable unless absolutely necessary. Contact WFF early in the design process if window mounted hardware needs attachment points to the airframe.

4.1.4.2: Racks

Standard equipment racks that fasten directly to the seat rails have been designed specifically for use in the P-3 aircraft cabin to accept standard rack-mounted 19-in. wide test equipment. The preferred method of mounting equipment is to use these standard racks. The racks are available in single and double bay configurations (see Figure 4-4). Single bay racks come in two sizes: 53” high and 43” high external (50” high and 40” high internal dimensions, respectively) with both sizes having an external width of 22 in. (19” internal) and an external depth of 25 in. (24” internal). The double bay racks also come in two sizes: 58.5” high and 53” high external (55” high and 50” high internal dimensions, respectively) with both sizes having an external width of 43 in. (19” internal per bay) and an external depth of 25 in. (24” internal). Equipment can be mounted on either side of the racks facing forward and/or aft.

Figure 4-4. Example of double bay rack (left) and single bay rack (right)

NOTE: New single bay experimenter racks are currently in the design and analysis process. These racks will be the same size as the single bay racks described above except these rack will be 58.5 in. tall with common mounting rails. In the future two single bay racks will be used to create a double bay and the use of older P-3 racks will be discontinued.

Applicable design criteria that establish the loading limits include a 9G forward “crash” load and 3.2G side gust load. Overall rack limits encompass the total rack assembly and its attachment to the aircraft. Face mounting equipment limits cover the installation of individual units into the rack. The rack-loading configuration must satisfy both limits. Table 4-3 addresses the overall effects between experimenter rack and aircraft. Total allowable loading values are tabulated for each type of rack, both in terms of weight and overturning moment. Values for vertical center of gravity of installed equipment must be known. Figure 4-5 illustrates the rack geometry used to calculate the overturning moment. Note that maximum allowable loads are reduced if unequal weight distribution between bays (left and right) offsets the lateral center of gravity away from the centerline. Table 4-3 below includes any equipment mounted on top of the racks. Moment arms are measured vertically from the floor level to the center of mass of each rack-mounted component. These weight and moment limit values take into account the load factors and allowable loads. Only the rack-mounted equipment weights are used when tabulating the moments; the weight of the rack itself does not need to be included in these calculations. Stress analysis of rack structure or rail attachments is not required, except for nonstandard rack installations. Figure 4-6 shows a typical rack installation, and Figure 4-7 shows loads for a standard rack and connectors.

Table 4-3. Basic loading allowable for P-3 racks[1]

	Single Bay Rack	2 Single Bay Racks – Side by Side	Double Bay Rack
Maximum Total Equipment Weight per Rack Mounting Face (lb)	500	490	345
Maximum Total Equipment Weight per Rack Bay (lb)	500	490	345
Maximum Rack Total Equipment Weight (lb)	500	980	690
Maximum Total Moment Produced by Equipment per Rack Bay (lb·in) $\sum M = h_1 w_1 + h_2 w_2 + \cdots$	14,000 in.-lb	13,720 in.-lb.	9,660 in.-lbs

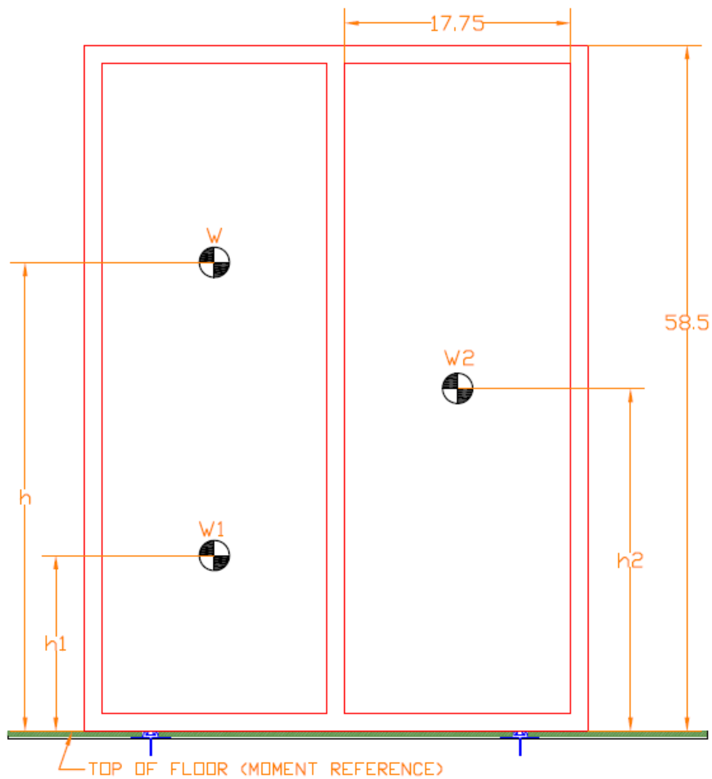

Figure 4-5. Rack geometry used to calculate overturning moment

[1] For rack loads approaching limiting values, the lateral center of gravity should be located at the vertical center post. Deviations from this requirement may reduce the allowable weight for all racks.

Figure 4-6. Typical installation in equipment rack

Face mounted equipment is attached to panels of standard 19 in. width and optional height. The panels bolt onto brackets within either bay on each rack, and can be installed either forward or aft-mounted. Figure 4-8 illustrates the geometric convention for panel height (H) and center-of-gravity location (L) of face-mounted equipment. Equipment with standard 19 in. panels can usually be mounted directly into the vertical support rails. If necessary, rack-mounted support trays are available from WFF. Smaller components and components without mounting panels can be supported on solid trays of structural-grade aluminum. These trays span the full depth of the rack and have flanged edges for stiffness and to facilitate attachment to the vertical rails. Also available are a limited number of panel mounted storage bins in which small test equipment, tools, notes, tapes, etc., may be stored. Drawers mounted in bays of standard instrument racks should be installed 27 in. (69 cm) above the floor to avoid the armrest and seat assembly. Further, it is advisable to place the heavier items near the bottom, whenever possible, to reduce the overturning moment.

NOTE: Please note that the cabin door is 27 in. wide, thus any items that protrude out the front or rear of the rack and exceed this dimension must be removed before installing the rack on the aircraft if using a double bay rack.

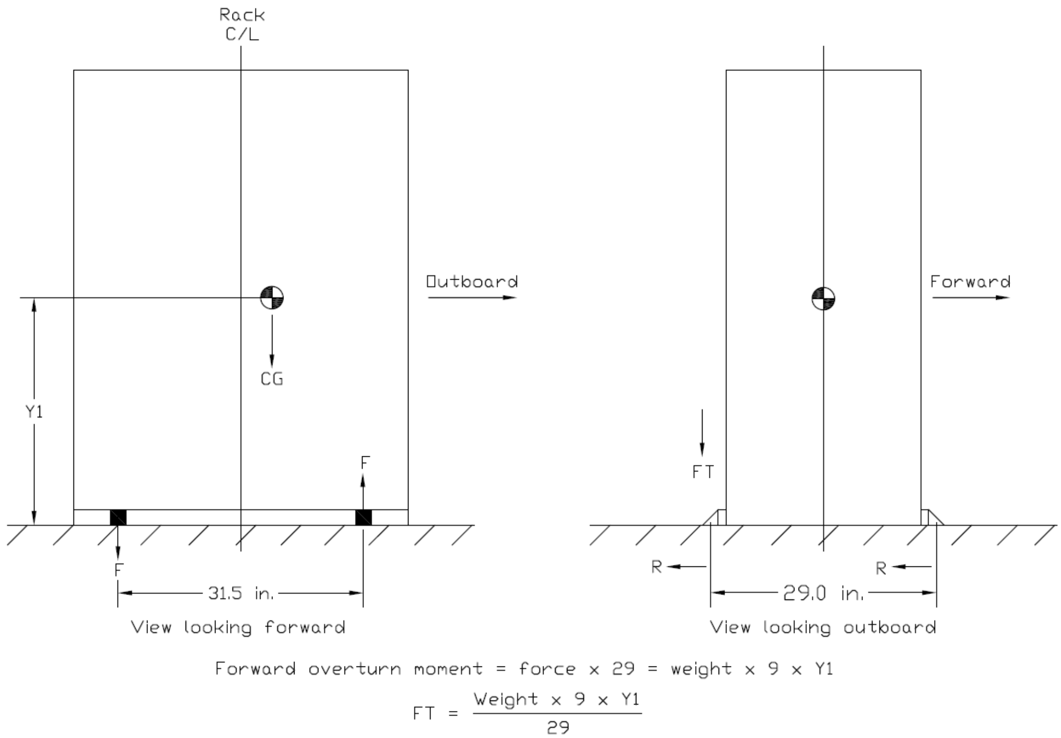

Figure 4-7. Loads for a standard rack and connectors

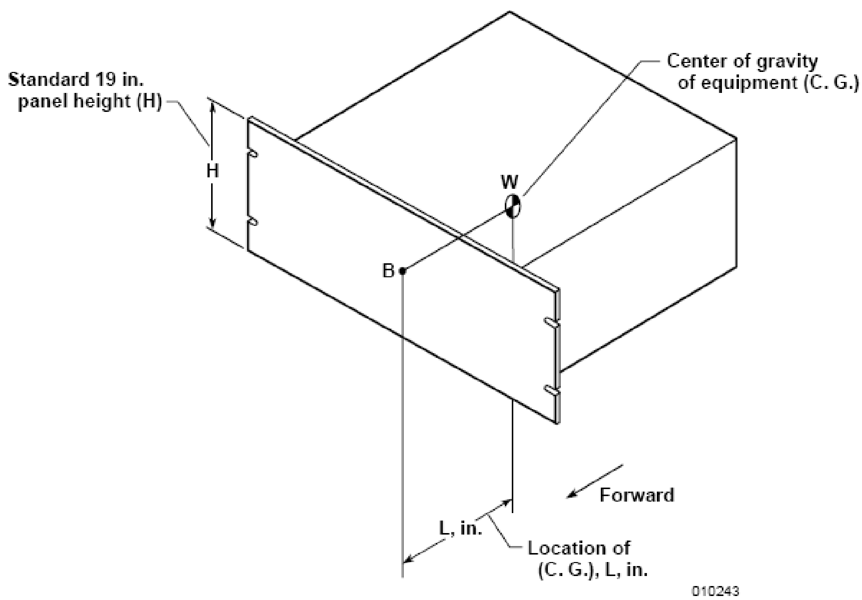

Figure 4-8. Standard face-mounted equipment

The equipment racks are often used as support platforms for mounting equipment. Experimenters should consult with WFF when planning to use the top of any rack to mount equipment. Generally, rack-top mounts use intermediate support plates, which attach to the equipment and span the top surface. These supports are then match-drilled to the existing holes in the top of the racks.

These types of installation requests are considered individually and may, in certain cases, require stress analysis even though the weights and moments do not exceed the maximum allowable rack values. Figure 4-9 shows the positions of double bay P-3 racks in relation to the fuselage side walls and floor.

NOTE: Modifications to the standard equipment racks, however minor, are not permitted under any circumstances by the experimenter.

Racks are available for experimenter use. Racks may be shipped to experimenters prior to upload on the aircraft in order to populate the rack in advance. When a rack is shipped to an experimenter for equipment installation, a supply of clip nuts, aerospace grade fasteners, trays, and bins can be included if arranged in advance. Aerospace grade fasteners must be used throughout the rack assembly. Since unique support requirements cannot be anticipated, experimenters are encouraged to contact WFF for engineering assistance. Once a mission is completed, racks will not be permitted to leave Wallops and must be depopulated prior to an experimenter leaving unless prior arrangements have been agreed upon.

Other aircraft experimenter racks have flown on the P-3 (Twin Otter, NCAR GV and C-130, NASA DC-8 low rack, etc.). Approved designs and in some cases physical mounts exist at WFF to attach these non-P-3 instrument racks to the P-3 seat tracks.

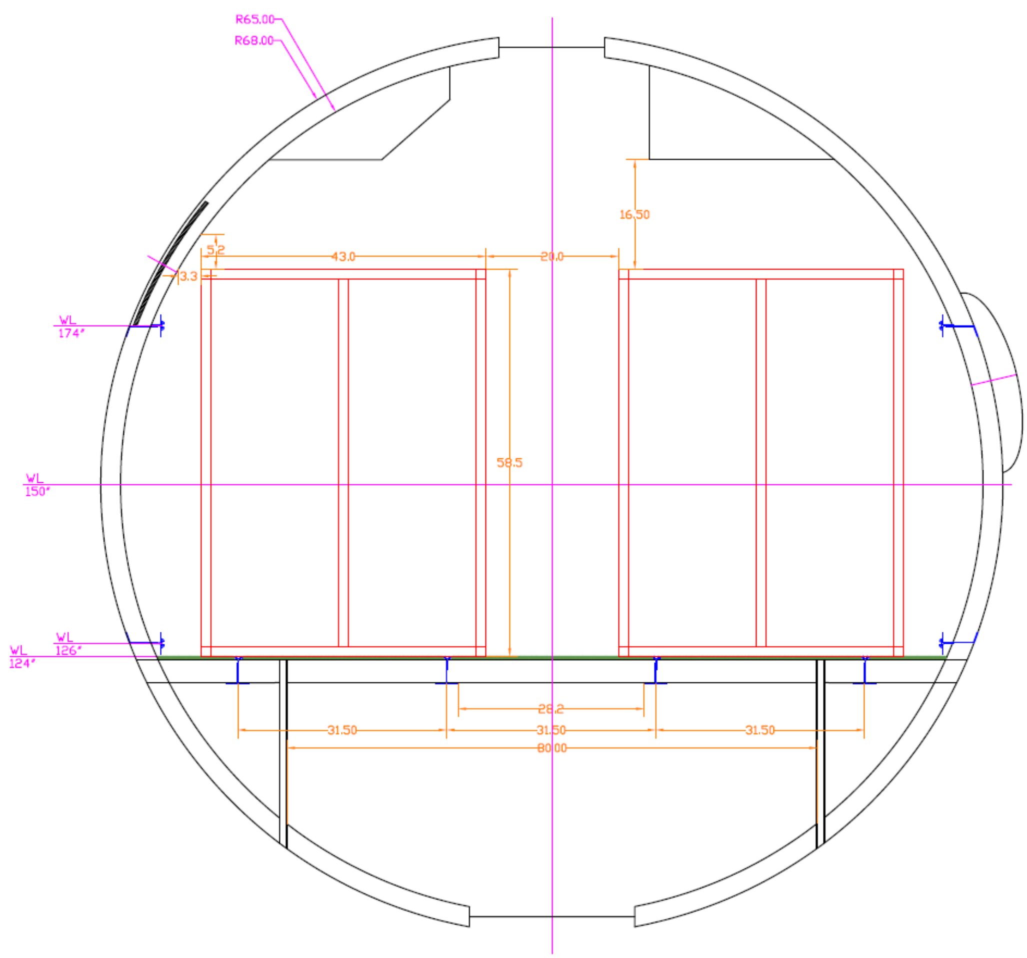

Figure 4-9. Fuselage cross section view with installed equipment racks and viewports

4.1.4.3: Non-Standard Rack Mounts

Due to size, shape, or orientation, certain types of equipment cannot be mounted in the standard racks and require special mounting arrangements. In all cases, including use of a standard equipment rack for supporting non-standard equipment, the experimenter should design, analyze, and fabricate the entire structure. Where circumstances warrant, and within the limits of the available time and manpower, arrangements can be made for design and fabrication support. Modified racks, specially designed experimenter racks, or racks designed for use on another aircraft must have accompanying structural analysis certifying they meet the required structural loads on the P-3. Coordinate the design of all non-standard equipment mounting schemes with WFF. Structural certifications and inspections are required prior to installation and flight. Some special pallets and other supporting structures that were used in the past are available for experimenters who can adapt them to their use.

For equipment that cannot be adapted to the standard rack support structure, the following two techniques are recommended:

- Equipment can be mounted on a framework or custom designed rack that attaches directly to the seat rails. This method is especially applicable for equipment positioned for viewing or sampling through viewports.
- An aluminum pallet can be attached to the seat rails and the equipment then mounted to the pallet. Equipment can also be bolted to the brackets restraining the pallet or attached to it by means of base-plates as shown in Figure 4-10.

Figure 4-10. Typical pallet style installation

NOTE: Do not pre-drill equipment mounting holes prior to aircraft installation. Non-standard equipment will be match-drilled to fit during installation.

4.1.4.4: Bomb Bay Ports

The P-3 bomb bay has been converted into two experimenters' ports housed inside a bomb bay fairing. The bomb bay has been equipped with four longitudinal heavy duty structural seat tracks to support internal instrumentation or cargo loads. The overhead and side mounted seat tracks support experiment loads. Experiments mount inside support structures that tie into seat track rails located in the bomb bay. Lightweight items can be mounted directly to the fairing itself with proper analysis. The bomb bay area is unpressurized and unheated with no access during flight. When the experimenter fairing is removed and the bomb bay doors are installed, the bomb bay door system becomes operational. The doors, currently, can only be opened through exterior controls. If required, the aircraft can be converted back to its original state to allow the doors to open and close in flight.

WARNING:
Only qualified personnel are authorized to operate the bomb bay doors.

4.1.4.5: Under Wing Hard Points

A removable wing pylon (Figure 4-11) can be installed near a wing tip to accommodate experimenter equipment that is required to be far from fuselage air turbulence. The pylon's longitudinal centerline is parallel to the aircraft centerline and is set at a 0° angle-of-attack during normal flight. While the pylon is primarily designed to hold one PMS canister style probe, other instruments can be mounted to existing P-3 wing hard points. Electrical power and signal connections do not exist at each wing station, thus each installation must have custom cables installed for experimenter use. If a non-standard pylon installation or wing mounted instrument is required, it is mandatory that the Ops Engineer be notified at least one year prior to a proposed application to allow sufficient time to perform the required structural and aerodynamic analysis to assure flight safety. In addition, extra flight tests may be required depending on actual equipment size, shape, and weight.

WFF also has several standard Navy wing pylons, spacers, and bomb release units that can be used for attaching various external experiments to the wings. Contact the Ops Engineer for further details.

Figure 4-12 shows an example of a custom under wing installation. Figure 4-13 depicts wing stations that are available for experimenter use. Contact the Ops Engineer for further dimensional details for each wing station.

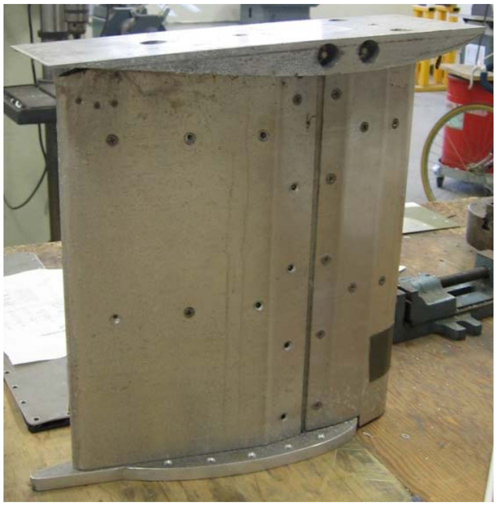

Figure 4-11. Existing wingtip pylon

Figure 4-12. Custom under wing installation for KU MCoRDS antenna array

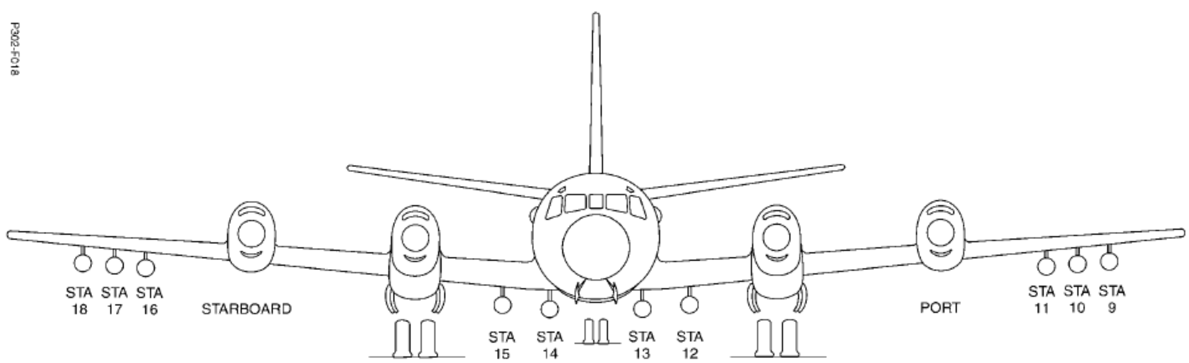

Figure 4-13. Available experimenter wing station locations

4.2: Electrical Power & Interface

Aircraft electrical power is controlled and supplied to the experimenters via the electrical load center. The electrical load center (see Figure 4-14) controls all electrical output to each experimenter station. From this location 115V, 60Hz and 400Hz power along with 28VDC power can be monitored and turned on/off for each experiment station.

Figure 4-14. Electrical load center

The following types of power are available:

- 60kVA of power available on ground and 90kVA power available in flight
- 400Hz, 115 volt, single-phase and three phase AC power
- 60Hz, 115 volt, single-phase AC power
- 28 volt DC power

It is preferred that experimenters provide their own 115V to 28V converter in their experiment racks if 28VDC is desired, but 28VDC can be provided directly from the aircraft if required.

A power interruption of approximately 400 msec occurs when the engines are started, during the change over from APU to aircraft power. A similar delay occurs at the end of a flight, when the engines are shut down.

4.2.1: Power Sources and Frequency Converters

The basic power source within the aircraft, from the engine-powered generators, is 115/200 volt, three-phase, 400Hz AC. The three engine generators are normally paralleled by a synchronizing bus, but in special cases they can be switched to operate independently. 115 volt, single-phase 60Hz power and 115 volt, three-phase 400Hz power is available to experimenters. Also available is 240 volt, 60Hz single-phase power upon request. The ground return wire of the five-wire circuitry is tied to the aircraft structure. Good regulation, excellent waveform, and low ripple are characteristic of this system.

400-Hz three-phase power is converted via 15 3.5kVA converters to 115 volt, 60-Hz single-phase when needed. Three transistorized transformer rectifiers each provide 28 volt DC at 200 Amps. The ground return wire of three-wire circuitry is also tied to the aircraft structure. The system has good voltage regulation, excellent frequency stability, excellent transient regulation, and good waveform relative to commercial standards.

These solid-state converters have transient overload capacity up to 4.3kVA for 5 minutes for starting motors. This accommodates the use of devices with large inrush currents.

NOTE: The 60Hz system is not stable enough for precise timing requirements. Accurate IRIG-B time signals are available from the onboard timing system.

Equipment is not available to supply 50Hz power on the aircraft. An experimenter needing this frequency in a critical application must provide the capacity.

4.2.2: Experimenter Power Stations

Power outlet stations are located along both walls of the main cabin (approximately 73 inches above the floor) as shown in Figure 4-15 and below the cabin floor (Figure 4-16). Bomb bay instrument power is supplied from the cabin area. Contact the Operations Engineer for power information for instruments to be mounted in the nose radome or tailcone. See Figure 4-1 for experimenter power and intercom station locations. Each station is controlled using circuit breakers located at the electrical load center. A maximum of 15 amps of 115 volt, 60-Hz and 400-Hz power and 15 amps of 28 volt DC power is available at each station. However, typically each circuit is not loaded more than 80 percent of its maximum.

Figure 4-15. Typical power and intercom station in cabin

Figure 4-16. Power station below the cabin floor

Power is connected from cabin wall stations to the experiment by WFF-supplied cables that terminate in standard hospital-grade grounded receptacles. Standard plugs for 60Hz and 400Hz are not interchangeable.

Table 4-4 below details the pin-out of the experimenter power connector at each experimenter station as well as the below cabin floor power connectors. A MS3476W18-8P is required to mate to these electrical connectors.

Table 4-4. Experimenter power connector pin out

Pins	Description
A	115V 400Hz
B	115V 400Hz
C	115V 400Hz
D	neutral
E	28VDC +
F	28VDC -
G	115V single phase 60Hz
H	115V 60Hz neutral

- For 115V, 60Hz power Hubbell NEMA 5-15R receptacles are used. On the 60-Hz circuits the receptacles will accept a standard three-prong grounded plug (NEMA 5-15P or 5-20P).
- For 115V, 400Hz power Hubbell L5-15 three wire twist lock receptacles are used. On the 400-Hz circuits the receptacles will accept a three prong grounded plug

(NEMA 6-20P). 400Hz power can also be hard wired to experimenter equipment if desired.

- The two wire 28V DC power lines can be hard wired to experimenter equipment or provisions can be made for an experimenter specified connector.

- A 115V, 60Hz single phase to 240V, 60Hz single phase transformer (11A max with two power outlets) is available for use.

Figure 4-17. 115V, 60Hz power plug and receptacle

4.3: Payload Control & Interface

Experimenter hardware is typically controlled via one or more onboard operators flying in the aircraft. Items located in the bomb bay, nose and aft radomes are controlled through experimenter racks inside the cabin area by manned operators. Autonomous instruments have been flown in the past using aircrew members to only turn power on and off via the electrical load center. Aircrew members will not operate an investigator's instrument. Provisions exist within the REVEAL system and INMARSAT system to remotely control a payload in flight from a ground base via satellite link.

4.4: Experimenter Ports

An assortment of special viewports has been installed in the fuselage at various elevations and longitudinal locations. These special viewports and windows can be used for optical viewing. The ports will also accommodate aluminum plates that can be used to support external gas sample probes, small antennas, radiometers, and other lightweight units that require fuselage penetration.

Viewports and windows in the cabin area are identified by their angle of elevation within the fuselage. There is one zenith (90°) viewport on the aircraft centerline, three DC-8 29.5° upward-looking standard passenger window viewports (two on the left and one on the right hand side), and four Navy style bubble windows. In addition, there are three nadir ports (downward looking). These ports are located aft of the wings and have interchangeable port plugs to allow for various styles of installations. The bomb bay has two unpressurized openings for experiment installations along with room in the nose and aft radomes for equipment installations.

At any viewport, an approved metal plate sized to the port dimensions may be used to mount an instrument or antenna. The load that these inserts can support without attachment to window hardpoints is limited. Each installation is considered individually and must be discussed with the P-3 Ops Engineer during the preliminary planning phase. Correspondingly, when hard-points are used to support equipment that extends through the metal viewport insert (such as a blade antenna), the unique loading and sealing requirements must be treated as a special case.

4.4.1: P-3B Bubble Window Ports

There are four Navy P-3 bubble windows located on the aircraft. Two are located at FS333.5 left and right, respectively, and two are located at FS890.5 left and right, respectively. These windows can be used for basic viewing purposes, installation of experimenter windows on adapter plates, and/or installation of exterior probes on adapter plates (Figure 4-18). Each window is held in place by 36 bolts and is angled up 13.3° from the cabin horizontal centerline at WL150.

Figure 4-18. Typical bubble window viewport

4.4.2: Zenith Port #1

A circular zenith port has been installed at FS796.5 (Figure 4-19). The viewing aperture is 16 in. in diameter. The port is designed for a 1-1/4-in. thick, 17-in. diameter viewing glass. External mounted probes or small diameter windows can be mounted in this port when such an item is attached to an adapter plate. This port uses four hardpoints to hold experimenter hardware in place. The location of this port is directly over the Nadir #1 port to allow for instruments that require a zenith and nadir observation simultaneously.

Figure 4-19. Zenith viewport

4.4.3: DC-8 Passenger Window Ports

Three DC-8 style passenger window ports are installed 29.5° up from the horizontal centerline at WL150 (Figure 4-20). Two window ports are located at FS433 and FS758 on the left side while the third is located at FS740 on the right side of the cabin to accommodate windows or external instruments mounted to adapter plates. For commonality, the ports are fabricated for DC-8 aircraft window framing (19”x21” port frame with a 17”x19” aperture).

Figure 4-20. 29.5° DC-8 passenger window viewport

4.4.4: Nadir #1 Port

The standard Navy camera port located at FS787 has been enlarged to create the Nadir #1 port with overall dimensions of 36” x 25” (Figure 4-21). This port is identical in geometry and reinforcement structure as the Nadir #2 port located directly aft of it. The port closure is a modified sonobuoy port plug door which is installed on sliding tracks for easy installation and removal. This port is located directly below the Zenith #1 port for those experimenters who require simultaneous zenith and nadir observations. Standard cabin seat tracks have been installed on the left and right side of this port for easy installation of various types of experimenter hardware. The primary load path for experimenter installations is the 36-in. long longitudinal seat track, which is spaced 40 in. on center. Various types of port plugs exist for this port. Please contact the Operations

Engineer to determine what port plug will meet your needs. Also, note that the available space for experiment hardware is determined by the type of port plug installed.

Figure 4-21. Nadir #1 port

4.4.5: Nadir #2 Port

Minor framing has been added around the original Navy sonobuoy pressure port to create the Nadir #2 port with overall dimensions of 36" x 25" (Figure 4-22). Nadir #2 is located at FS863 and has an identical port opening as Nadir #1. There are no seat tracks currently installed around this port but can be installed if needed. Experimenter hardware must be mounted in the cabin area over this port and hang down into the below cabin floor area. Various types of port plugs exist to fit this port; please contact the Operations Engineer to determine what port plug will meet your needs. Also, note that the available space for experiment hardware is determined by the type of port plug installed.

Figure 4-22. Nadir #2 port (with custom port plug installed)

4.4.6: Nadir #3 Port

The original Navy Doppler port has been modified to create Nadir #3 at FS940 with overall dimensions of 36” x 31” (Figure 4-23). The original Doppler pressure dome and external fairing have been removed. The external fairing has been replaced by a ¼-in. pressure plate which supports a third 16-in. viewing aperture and a 10”x10” camera window. The instruments are supported by beams attached to the existing port framing. A 36-in. long seat track is located on the left and right side of this port on a 31.5-in. on center spacing. The single port cover plate shown is currently the only one available for installation into this port. Contact the Operations Engineer to determine if a new port cover plate is required and to determine available space based on the port plate selected.

Figure 4-23. Nadir #3 port

4.4.7: Nadir Camera Port

A small viewport is installed at FS867 at BL37 right side for a nadir viewing camera (Figure 4-24). This port provides a 6-in. square aperture inclined at 33°. If requested, this camera port can be adapted for other experiment purposes.

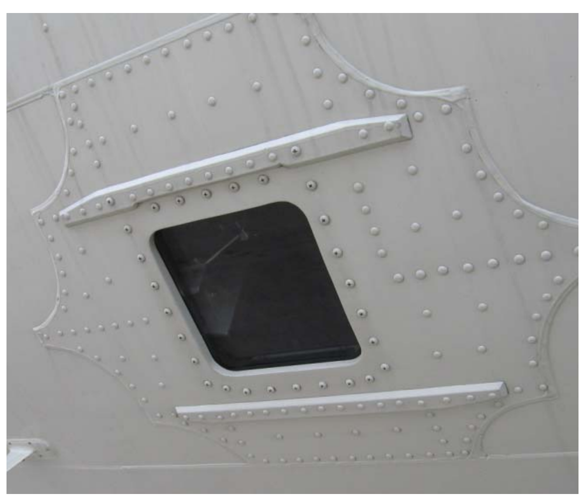

Figure 4-24. Nadir camera port

4.4.8: Free Fall Tube and Observation Window

A cylindrical tube 5.25 in. in diameter and inclined 5° aft from the vertical is installed at FS1085 at BL30 right (Figure 4-25). This port can be used for gravity feed free fall drops of objects such as small dropsondes only below 10,000 feet MSL (non-pressurized deployment). Due to this tube being in the boundary layer of the aircraft past deployments have recontacted the aircraft once leaving the tube. Use of this system will be considered on a case by case basis by WFF engineering. An observation window to watch object deployment is located at FS1090 in the lavatory. If requested this window could be converted to an experimenter port for other uses.

Figure 4-25. Free fall tube and observation window

4.4.9: Bomb Bay Ports

The standard Navy P-3 bomb bay, running from FS330 to FS480, has been converted to two unpressurized, unheated, independent experiment ports with the installation of the bomb bay fairing structure (Figure 4-26). The overall bomb bay measures 82"W x 41.4"H x 153"L. When the bomb bay fairing is installed two port openings measuring approximately 50" x 51" (fwd. port) and 50" x 44" (aft port) are created in the longitudinal direction of the aircraft (see Figure4-27). Seat tracks are mounted on the side walls (WL 93.4, BL41.0 left and right) and overhead each port opening longitudinally (WL 113.4, BL15.75 left and right of center spaced 31.5 in. apart) in the bomb bay for experiment structures to mount to. Both sets of overhead seat track rails are 58 in. long with a 22.5-in. gap between the rails located in the center of the bomb bay. These seat tracks are the same style of seat track rails used in the cabin area. Lightweight structures can be installed directly to the fairing itself with the proper analysis. Sealed cable pass through openings of the pressure bulkhead (two circular openings at FS370 center, one circular opening at FS380 right, and one rectangular opening at FS390 left) are available for electrical and data cables to pass between the bomb bay and cabin areas. The three circular openings have an area 4.5 in. in diameter of available space for connectors. The rectangular opening has an area 4" x 19" available for connectors. The center of the bomb bay fairing has drop down hatches that allow experimenters to access their hardware once it is mounted inside along with removable 45° down looking side panels for easy access after installation. For small lightweight installations these access points can be used to mount experimenter hardware on a case-by-case basis. Contact the Ops

Engineer to determine the proper orientation of experiments with respect to the seat track rails and for additional dimensions.

Figure 4-26. Bomb bay experimenter ports

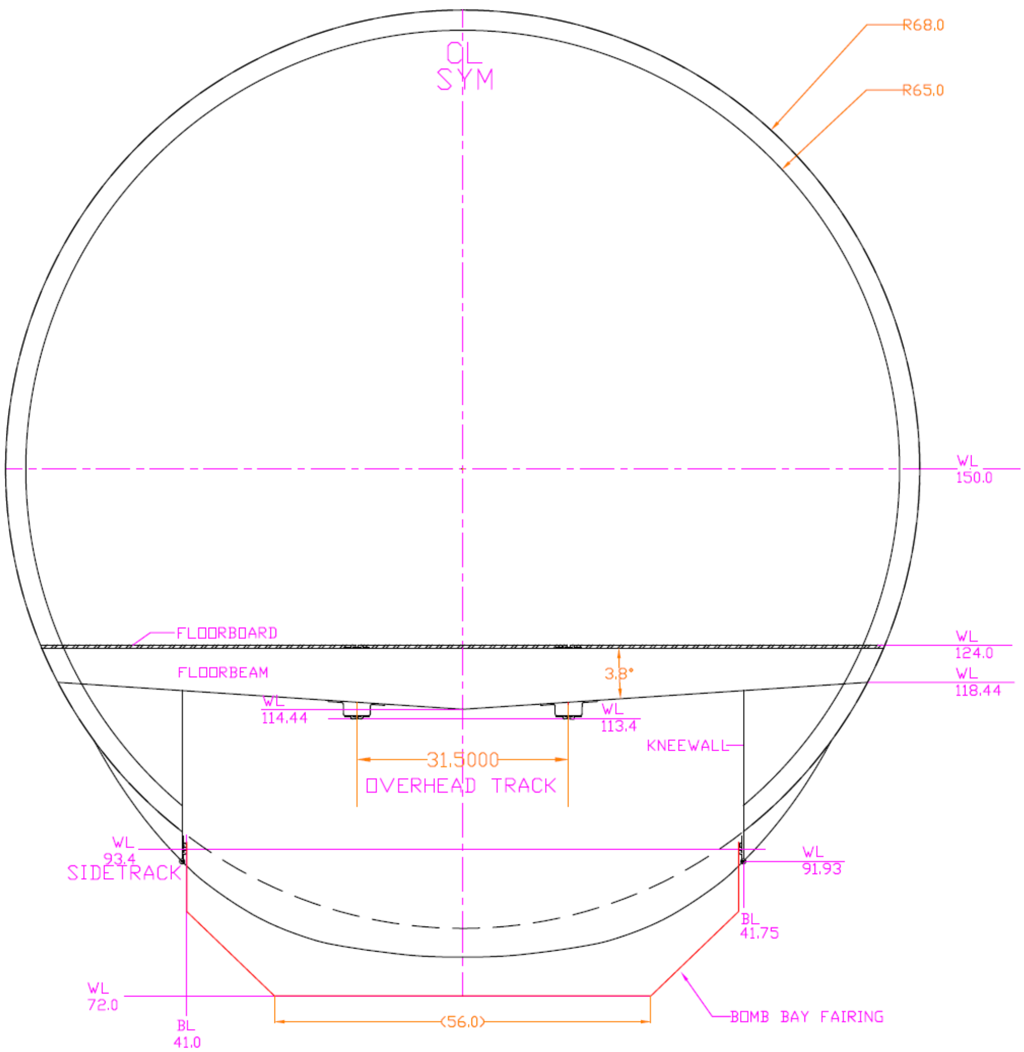

Figure 4-27. Bomb bay cross section with fairing

4.4.10: Radiometer Ports

Several small diameter and custom ports exist on the aircraft (upper and lower surfaces) and have been used in the past for radiometer instruments. Contact the Ops Engineer to get detailed specifications concerning these ports. Figure 4-28 depicts custom radiometer mounts designed by WFF.

Figure 4-28. Radiometer mounts

4.4.11: Nose Radome and Tailcone Ports

Nose radome and tailcone installations are specialized installations. Standardized electrical interfaces exist for the nose radome. Standardized electrical interfaces in the tailcone are currently in the design process. The nose radome and tailcone are fiberglass housings that are RF transparent at certain frequencies (Figure 4-29). Please contact the WFF Ops Engineer to obtain dimensions, electrical information, and discuss design details.

A special nose radome exists that contains a small mount that can deploy and retract instruments from within the radome itself while in flight. Contact the Ops Engineer for further details.

A tailcone with a fiberglass boom previously used for a magnetic anomaly detector (MAD) is available for use (see Figure 4-30). The boom extends aft of the tailcone and can be used for a variety of installations. Contact the Ops Engineer for further design details concerning this installation.

Figure 4-29. Nose radome and tailcone experimenter ports

Figure 4-30. Tailcone with MAD boom extension

4.4.12: Pressurized Sonobuoy Launch Tube (PSLT)

A standard Navy P-3C Pressurized Sonobuoy Launch Tube (PSLT) is available and can be installed in the USS Door located at FS810 on the right side of the aircraft. This door is angled at approximately 25° on the fuselage surface at this location. The PSLT provides the capability of deploying standard Navy “A” size sonobouys at altitudes from sea level to 28,000 ft MSL. The system is capable of deploying objects using a standard pressurization system and pyrotechnically. This tube is a removable installation, thus allowing other uses for the door. Figure 4-31 shows the PSLT installation. At altitudes less than 10,000 ft MSL, with the PSLT not installed, the door can be opened and closed manually if desired. Two sonobuoy racks are available for storing a total of 30 (15 per rack) “A” size buoys in standard Navy “gray pack” storage tubes.

Figure 4-31. PSLT pressurized sonobuoy deployment installation

4.4.13: Experiment Specific Ports

Addition of a new port is considered an exception to normal practice. However, upon request, and well in advance of the mission deployment, new experimenter ports can be added to the aircraft. New ports will be assessed by WFF engineering on an as needed basis. Figures 4-32 and 4-33 depict past experiment specific port modifications.

Figure 4-32. Custom nose radome modification for CAR installation

Figure 4-33. Custom bomb bay modification for the AESMIR installation

4.4.14: Optical Windows

Numerous experimenters on the P-3 have utilized optical quality windows. A limited stock of these windows is available, in various materials, and held in secured storage. Stock full-aperture, 16 in. (40.6 cm) diameter window materials (the only ones supplied by WFF) include borosilicate crown glass (BK-7) and acrylic. WFF maintains a program of window inspection and analysis to meet aircraft safety requirements. Regardless of the source, each optical window (or spare window) that is proposed to fly on the P-3 will be inspected and approved as airworthy at WFF inspection facilities prior to installation.

A window analysis must be performed prior to installation of any experimenter window to determine proper overall fitment and strength. Contact the Ops Engineer early in the design process to determine suitable window requirements. Typical P-3 optical windows have a 16-in. aperture and are 1.125 in. thick. Note that circular shapes are strongly preferred due to lower stress levels, but rectangular windows can be accommodated with the proper supporting analyses.

If an appropriate window is not available from stock, the experimenter must provide one. Either WFF or the experimenter may supply the frames and the port inserts to accommodate the window materials. Adapter plates must be used for all optical windows that do not match existing port openings on the P-3.

Special window requirements should be requested as early as possible, to allow for design, fabrication, and testing. Lead time to acquire finished optical materials can be six months or more, depending on composition and size.

4.5: Probes, Venturis, & Inlets

Various probes/inlets and venturis exist for the P-3 aircraft. Figures 4-34 through 4-36 depict the existing hardware at WFF. Contact the Ops Engineer for specifications concerning existing hardware. New probes/inlets and venturis can be designed and manufactured to an experimenter’s requirements. Such request must be stated at least six months in advance of installation. Complex probes require longer lead times for design and manufacture.

Figure 4-34 (a). Generic inlets available for use

Figure 4-34 (b). Generic inlets available for use

Figure 4-35. Complex inlet manufactured by WFF

Figure 4-36. Venturis available for use

4.6: Facility Instruments

A variety of systems are available to acquire aircraft flight parameters and related environmental data in support of the research activities. Many of these systems are standard on-board facilities; others can be provided on request. Outputs vary from real-time electrical signals distributed to experiments to post mission copies of videos, as outlined in the following section.

The NASA P-3B is equipped with the following items in the cockpit and cabin:

- A five-tube Electronic Flight Instrument System (EFIS) display
- Dual Flight Management Systems (FMS)
- Dual Flight Directors
- A turbulence detection weather radar (X-Band) and lightning sensor system
- Dual laser Inertial Reference Systems (IRS)
- A standby Attitude Heading and Reference System (AHRS)
- A radar altimeter with a Radio Altitude Warning System (RAWS)
- Dual full diversity Mode “S” transponders
- Mechanical emergency backup flight instruments
- Dual digital VHF communication transceivers
- Dual digital VHF navigation receivers with VOR, glide slope and marker beacon
- Dual Distance Measuring Equipment (DME)
- A single Automatic Direction Finding (ADF) receiver
- A single Tactical Air Navigation (TACAN) transceiver
- Dual HF transceivers (one high and one low power)
- Two combination VHF/UHF AM and FM transceivers
- An Emergency Locator Transmitter (ELT)
- A digitally-controlled Intercommunications System (ICS)
- A single Cockpit Voice Recorder
- Ground Proximity Warning System (GPWS)
- Traffic Alert and Collision Avoidance System (TCAS)
- Iridium satellite phone

Additional equipment such as radar tracking beacons and GPS receivers can be installed for experimenter support.

4.6.1: Standard Aircraft Systems

Data acquisition systems listed in Table 4-5 are standard to the aircraft. Output signals and the formats available to experimenters are listed below.

Table 4-5. Standard aircraft data systems available on display screens and data stream

System	Output Data
Inertial Navigation Systems (2)	Pitch, Roll
	Drift Angle
	Latitude, Longitude[1]
	Ground Speed[2]
	True Heading[3]
	Wind Vector[4]
	Distance to Go[5]
	Time to Go[6]
	Cross Track Distance[7]
	Course (Desired Track)[8]
	Track Angle[9]
	Track Error[10]
	Align Status[11]
Global Positioning System (GPS)	Produces items 1 through 11 above
Total Air Temperature Probe	Total Air Temperature
Dew/Frost Point Hygrometer	Prevailing Ambient Dew Point or Frost Point
Surface Temperature Radiometer	Surface or Cloud-top Temperature
Radar Altimeter	Absolute Altitude Above Land or Water
Central Air Data Computer (Flight Instruments)	Pressure Altitude, True Airspeed, Mach Number, Static Air Temperature, Vertical Velocity
Cabin Altimeter	Equivalent Cabin Pressure Altitude
Time Code	IRIG-B
Automatic Identification System (Surface Ship Tracker)	GPS location Vessel's name Course and speed

4.6.1.1: Inertial Reference System

Dual Honeywell LASER Inertial Reference Systems are installed for primary heading and attitude input to the pilot and copilot EFIS instruments, flight directors, and autopilot. Additionally, each IRS provides ARINC 429 data consisting of position, true heading, inertial velocities, and IRS status to each FMS for navigation and display.

Each LASEREF system is composed of an Inertial Reference Unit (IRU) installed in the aircraft's forward avionics rack and a Model Selector Unit (MSU) installed on each pilot side console. An IRS True/Mag Selector Switch is located on the copilot side console. This master switch will cause all EFIS heading displays to reflect true or magnetic heading, depending on selection. Annunciated status lights and selector switches are located on each pilot's forward instrument panel.

4.6.1.2: Attitude Heading and Reference System (AHRS)

A Collins AHRS has been installed in the aircraft as a backup system to the LASEREF Systems. If a LASEREF System should fail, attitude and heading reversion selections to AHRS are available on each pilot's forward instrument panel. The AHC-85 computer unit is located in the forward avionics rack. The ICU-85 compensation unit and FDU-70 flux valve are located in the starboard horizontal stabilizer.

4.6.1.3: Electronic Flight Instrument System (EFIS)

A dual Honeywell EDZ 805 EFIS with Multi Functional Display (MFD) is installed on the P-3.

4.6.1.4: Flight Management System (FMS)

The flight management system is a fully integrated navigation management system designed to provide the pilot with centralized control of the aircraft's navigation sensors and computer based flight planning. The FMS accepts primary position information from short- and long-range navigation sensors. Inputs from DME, VOR, TACAN, and GPS can be utilized to determine the aircraft's position. In addition to the navigational inputs, the system also receives true airspeed and altitude information from the air data computer and heading reference from the INS. The primary position data received from the sensor is filtered within the FMS to derive a "best computed position" (BCP). Using the BCP, the FMS navigates the aircraft along the programmed flight path.

4.6.1.5: Air Data System (ADZ)

Dual Honeywell/IDC AZ-800 Air Data Systems are installed to provide air data to the digital air data computers, altimeters, airspeed indicators, vertical speed indicators, SAT/TAS indicator, and the VNAV/Altitude Alert Controller.

4.6.1.6: Global Positioning System (GPS)

The global positioning system is a system whereby GPS satellites transmit highly monitored position and timing data allowing a receiver to precisely determine its range to the transmitting satellite. By observing multiple satellites, the receiver can accurately determine and track its position in longitude, latitude, and altitude allowing precision point-to-point navigation to be performed. The DoD World Geodetic System of 1984 (WGS-84) is the convention used for all positioning and navigation purposes. Several GPS antennas are available for experimenters to connect to throughout the cabin area.

4.6.1.7: Automatic Flight Control System

An autopilot interface unit (AIU) has been installed to provide flight direction input to the standard P-3B autopilot system. A Flight Director-Autopilot Selector Panel is located on the center console adjacent to the PB-20N control panel. This panel provides flight director (F/D) selection option to the autopilot, and it contains a pitch control wheel to initiate climbs and descents when the F/D is used. An AIU rate gyro selector switch is located on the pilot side console that permits a back-up selection for uncoupled operation if the AIU normal rate gyro malfunctions.

A GPS Navigation (GPSNAV) system can be installed in the cabin area that allows experimenters to input pre-arranged flight lines for the autopilot to fly along during the mission when precision flight line navigation is required. The system receives GPS navigation information through its own antenna array. This information flows to a computer software program located at an experimenter station. The computer generates a simulated ILS signal that is transmitted by hard wire to the aircraft's No. 1 VOR antenna. A switch is installed on the flight station load center to connect or disconnect the simulated ILS signal to the No. 1 VOR. The pilot may fly project flight lines manually by following a visual display or by coupling the signal to the autopilot through the No. 1 navigation selection on the No. 1 Flight Director System.

4.6.1.8: Weather Radar and Lightning Sensor System

A Honeywell Primus P-870 Weather Radar and LSZ-850 Lightning Sensor are installed with controls at each pilot side console and display available on the MFD or either EHSI. The radar antenna is located in the aircraft nose radome area, and the lightning sensor is located in the aft radome.

4.6.1.9: Total Air Temperature System (TAT)

The aircraft Rosemount 102 AH2AG Total Air Temperature system features a probe that measures the total air temperature air (TAT) outside the aircraft, using a platinum-resistance sensing element. This value is warmer than static air temperature (SAT) by reason of aircraft speed. The TAT is used by the central air data computer (CADC) to compute the true airspeed and SAT. Signals from the probe electronics package are sent to the housekeeping rack, and from there they are available to the on-board data system for distribution to experimenters.

A Rosemount Model 102 non-deiced TAT probe is also supported by PDS for air motion measurement applications. This probe utilizes a fast-response platinum sensing element (E102E4AL). The E102E4AL element has a nominal 50-ohm resistance and a 20-ms response time. Rosemount total air temperature sensors normally exhibit a measured temperature of ~ 0.995 total air temperature. A numerical filter is used to recover the high frequency signal that is typically lost due to the presence of the respective element housings.

4.6.1.10: Dew/Frost Point Hygrometer

An EdgeTech Model 137 aircraft hygrometer using the chilled-mirror technique is used to make dew/frost point measurements. The Model 137 hygrometer is capable of making dew/frost point measurements from +60 to -40°C with variable but good response characteristics (2 to 40 seconds). The signal response and lower limit capability of the instrument will vary depending on static air temperature with faster response and lower frost point values being accessible with decreased depression requirements. The manufacturer specifies 0.1°C precision and 0.2° accuracy down to 0°C. Below 0°C the accuracy of the instrument declines to <0.5°C primarily due to an ambiguity associated with the formation of dew/frost on the mirror surface caused by the presence of super-cooled water. Signal outputs from this instrument are recorded to the on-board data system and available for recording and display.

4.6.1.11: Surface Temperature Radiometer

A Heitronics model KT19.85 Series II nadir-viewing infrared radiation pyrometer measures Earth's surface (land or water) or cloud top temperature in the spectral band of 9.6 to 11.5 microns. The radiometer has a 2-degree field of view, and covers the range –50 to +200°C. A signal is sent from the system electronics in the housekeeping rack to the on-board data system for recording and display.

4.6.1.12: Radar Altimeter

A single Honeywell AA-300 Radio Altimeter System is installed to provide aircraft height above terrain. This system, which contains two antennas on the underside of the aircraft, provides radio altimetry to the Sundstrand Mark-VII Ground Proximity Warning System (GPWS).

4.6.1.13: Cabin Altimeter

The equivalent altitude pressure in the cabin is detected by a MKS Instruments 220DA-01000A2B transducer. The output signal is sent to the on-board data system for recording and display.

4.6.1.14: Automatic Identification System (AIS)

An Automatic Identification System (AIS) receiver, along with associated GPS and VHF receive antennas, provides and records detailed information concerning surface ship track below the aircraft in flight. The AIS is the equivalent to a shipboard radar display that marks ships within line-of-sight range with a velocity vector. Each ship mark reflects the actual size of the ship, with position to GPS or differential GPS accuracy. The AIS receives the vessel’s name, course and speed, classification, call sign, registration number, maritime mobile service identities, and other information. The AIS is capable of picking up 4,500 transponder-like reports per minute with update rates as fast as every 2 seconds.

4.6.1.15: Color Printer

A HP Officejet Pro 8500 All-In-One (print, scan, copy, fax, email) printer is available for experimenter use in the cabin upon advance notice. This is a 250-sheet capacity 8.5x11 printer with 1200x1200 dpi resolution when printing in black or 480x1200 dpi resolution when printing in color. It is capable of 19 ppm when printing in black or color. The printer can be accessed via the on-board aircraft network or by plugging directly into the unit and supports Windows Vista, 2000, XP Home, XP Professional, Mac OS X (10.4 or higher) and Linux.

4.6.1.16: Nitrogen

Liquid nitrogen dewars can be located in the main cabin, and arrangements can be made for local storage of smaller amounts of liquid nitrogen near the experimenter's station. A 35L liquid nitrogen dewar is available for experimenter use in flight on board the aircraft. Cylinders of dry nitrogen can be placed adjacent to the experiments. Advance notice to the Ops Engineer is required for these types of facilities.

4.6.2: Cameras and Video

For missions requiring photographic coverage, the Operations Engineer can arrange for various camera systems. These camera systems are frequently used to obtain photographic records of the area surrounding the aircraft's flight path. Experimenters should make their camera requirements known as far in advance as possible of the planned mission. WFF Optical Section has provided still photography and video services in the past for local experiment missions. This service can be provided with advanced notice for local missions.

A King Air B-200 (NASA8) can be used as a chase aircraft for photographic and in-flight monitoring purposes of the P-3 or external instrument on the P-3. This aircraft can only be used for low speed portions of P-3 flight.

4.6.2.1: Forward and Nadir Video Camera

Two Axis 221 Day and Night Network Cameras are installed on the P-3 aircraft. One camera is mounted in the cockpit for forward viewing and the other is mounted in a nadir camera port below the cabin floor at FS787. Both cameras use a 1/3-in. Sony Wfine progressive scan RBG CCD and a Pentax TS2V3110ED, F1.0 varifocal 3.0-8.0 mm DC-iris lens. The progressive scan capability provides full resolution images of moving objects without distortions. The camera is capable of IR for high quality images in low light conditions. Simultaneous JPEG and MPEG-4 movies can be recorded at either ASP or SP profile with 16 different resolutions from 640x480 to 160x120 via API. Up to 45 frames per second in all resolutions are available with 60 frames per second in 480x360 or lower settings.

4.6.2.2: Lipstick or Custom Cameras

Several small diameter “lipstick” cameras can be installed in the cabin or outside the aircraft for viewing purposes. Small cameras in the past have been mounted on the fuselage, wings, and bomb bay to observe externally mounted hardware while in flight. Experimenters should contact the Operations Engineer early in the design process if custom cameras are required to be mounted in or outside the fuselage.

4.7: Science Crew Complement

The P-3 is capable of carrying a maximum of 18 science personnel and 6 air crew members for mission flights. Deployment Additional air crew members may be required depending on the science mission, deployment site and duration of a flight. Listed below are accommodations available for investigator use aboard the P-3:

4.7.1: Mission Manager/Director Table

The Mission Manager/Director is stationed at a small table in the cockpit (Figure 4-37). This console is the central control point for mission operations. From here the Mission Manager/Director can coordinate between the experimenters and flight crew and pass along pertinent information to those flying and/or make radio calls for the flight crew. For missions carrying a Mission Scientist this location can be used by the Mission Scientist for greater view outside the aircraft for science observations or direct link to the flight crew if real-time flight changes are needed due to science requirements.

Figure 4-37. Mission Manager/Director table

4.7.2: Passenger Seats

Conventional Navy crew style swivel seats (Figure 4-38) are installed aboard the aircraft, each accommodating two people and equipped with safety belts and shoulder harnesses. These seats are placed facing forward at intervals between equipment racks throughout the cabin. The location of the seats is fully adjustable, in one-inch increments, throughout the length of the aircraft. Experimenters may indicate their seating preference, coordinating their seating with their equipment location. For those passengers not sitting directly behind experiment hardware standard double passenger seats (Figure 4-39) are available and equipped with lap safety belts only. All safety equipment (life vest, smoke hoods, emergency oxygen) are located within arm's reach of each individual seat.

Figure 4-38. Crew style seat

Figure 4-39. Passenger style seat

4.7.3: Galley & Lavatory

A galley consisting of a 4.3 cu. ft. refrigerator, microwave, and coffee pot is located at the rear of the aircraft (Figure 4-40). The galley is open to all crew members and experimenters when the aircraft is in flight. Also, located just aft of the galley is the aircraft lavatory with chemical toilet.

Figure 4-40. Galley and lavatory

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Chapter 5: Communications, Navigation, and Data Acquisition, Distribution, & Display

5.1: Voice and Data Communications

Detailed below are the voice and data communications systems available on the P-3 for experimenter and/or flight crew use. Voice communication systems that transmit external to the aircraft are controlled from the cockpit. Internal cabin communications, satellite phone, and data communications are controlled from stations located within the cabin area.

5.1.1: VHF Communications

Dual Collins VHF-422A communications transceivers are installed.

5.1.2: VHF/UHF Marine Communications Unit

Dual Collins ARC-182/V VHF/UHF communication units are installed. One control head is located at the copilot position and the other is located at the Mission Manager position. A selector switch is located at the Mission Manager/Director position to allow transmissions from the cabin.

5.1.3: HF/SECAL

Dual HF communication systems are installed. A Bendix/King 950 HF system is located on the pilot's side console. A long range Collins C-10828 HF system is located on the copilot's side console. A Motorola Selective Calling System (SELCAL) is installed to preclude the need to continuously monitor HF communications en route by providing a chime noise when incoming calls are received. The SELCAL control panel is located on the copilot's side console.

5.1.4: Cockpit Voice Recorder

A Universal CVR-30 Cockpit Voice Recorder System is installed. The test panel is located on the copilot side panel. The manual erase feature is not serviceable. This solid state unit erases automatically and continuously, leaving only the most current past 30 minutes of voice recordings.

5.1.5: Intercom and Public Address System

A Baker Electronics (BE) M3000 digital audio system is installed on the P-3 with full capability stations located at the following positions: Pilot, Copilot, Flight Engineer, Mission Manager/Director, Mission Specialist, cabin station 10, and cabin station 11. In addition, 10 ICS-only transmit and receive lines are available for a total of 13 audio stations in the cabin and four in the cockpit.

The aircraft intercom system extends throughout the cabin, with outlets located on overhead power stations. The system has one channel of communication between the Mission Manager/Director and the experimenters. There is a discrete channel to the cockpit available to the Mission Manager/Director.

5.1.6: Iridium Satellite Phone

An Iridium based satellite phone is located at FS650R next to the right side emergency exit (Figure 5-1). A David-Clarke noise cancelling headset is provided with 50 feet of cable for experimenters or aircrew to carry on phone conversations anywhere in the aircraft. A strobe light is mounted on the electrical load center to allow individuals in the cabin to know when there is an incoming call. Current rate for use of this system is $13 per month and $1 per minute. The costs of calls on the Iridium satellite phone are charged to the appropriate mission sponsor as a mission peculiar cost.

Figure 5-1. Iridium satellite phone

5.1.7: Project Data System

Basic aircraft housekeeping data is recorded (10 Hz) and distributed to investigator stations on board the P-3 aircraft via a centralized project data system. The data system is a data acquisition, display, and distribution system for base meteorological and navigational measurements onboard the P-3 aircraft located at FS675L in two single bay P-3 racks. This system is comprised of PC-based high speed CPU computers, network server, video cameras, visual displays, and instrumentation required for supporting meteorological measurements. The project data system interfaces with aircraft flight systems using ARNIC-429 data format and a data/video distribution system via Ethernet, serial, and RGB video interface networks. Respective aircraft instruments and sensors included on the P-3B flight payload configuration are shown in Figure 5-2.

Investigators should specify their desire to use this system early in the mission planning process in order to ensure the proper system setup and coordination between WFF and the University of North Dakota's (UND) National Suborbital Education Research Center (NSERC). The system is currently run by NSERC and requires an on-board operator to ensure proper functionality.

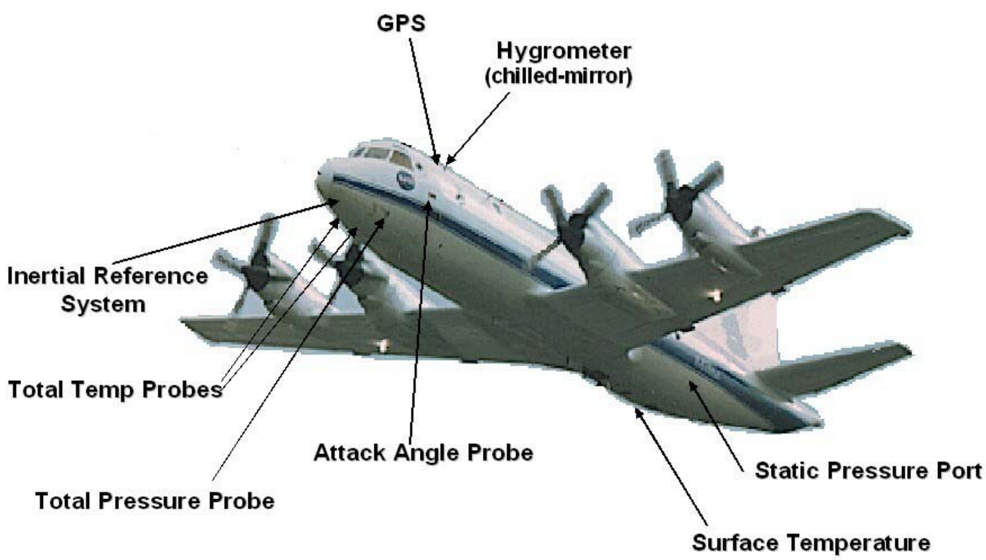

Figure 5-2. Project data system aircraft sensor locations

5.1.8: REVEAL Data Communications

The Research Environment for Vehicle-Embedded Analysis on Linux (REVEAL) system provided by Dryden Flight Research Center (DFRC) is a 6-channel Iridium (with 2 channels of GPS) satellite Ethernet based data distribution system. REVEAL allows investigators to downlink and uplink data packets (instrumentation commands, flight data, mission planning information, etc.) to ground based assets and vice versa to the aircraft using the Iridium satellite system. This system is currently flying on the NASA DC-8, ER-2, WB-57, and Altair UAV as well as on the NASA P-3B. REVEAL consists of two instrumentation boxes and servers all located in the project data system rack. An Iridium antenna farm is permanently mounted to the aircraft at FS480. REVEAL increases the investigator's ability to receive real-time situational awareness, particularly over Earth's poles, using the following items:

- Real time flight tracking on the aircraft and on the ground using Google Earth (Figure 5-3)

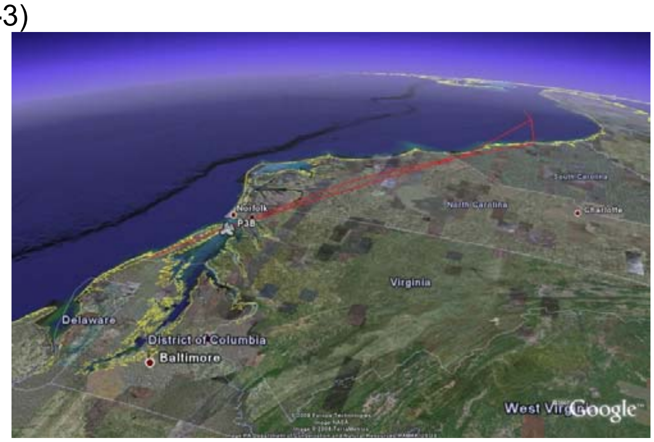

Figure 5-3. Goggle Earth P-3 flight track

- Instant messaging capability between multiple aircraft and ground-based assets
- Access to the Internet in flight (2400 baud connection)
- Transfer of “data” between multiple aircraft and ground-based assets via a ground-based server
- Data distribution throughout P-3 cabin using Ethernet connections

Pictured below in Figures 5-4 and 5-5 are the project data system racks that contain REVEAL, along with the Iridium antenna farm mounted on top of the aircraft.

Figure 5-4. Project data system rack

Figure 5-5. REVEAL antenna farm

Investigators should specify their desire to use this system early in the mission planning process in order to ensure the proper system setup and coordination between WFF, DFRC, and NSERC. The system is currently run by NSERC and requires an on board operator to ensure proper functionality.

5.1.9: INMARSAT Data Communications

The INMARSAT data communication system consists of a phased array INMARSAT antenna on the P-3 aircraft capable of 432 kbps data rate and voice communications optimized for ± 60°north and south latitude regions. The INMARSAT system provides the same functionality as REVEAL but at higher data rates, and uses the INMARSAT satellite system instead of Iridium. This system resides with the project data system racks and is operated from this location with access distributed to each of the experiment stations in the cabin via Ethernet. Pictured below (Figure 5-6) is the INMARSAT antenna array mounted at FS640. Investigators should specify their desire to use this system early in the mission planning process in order to ensure the proper system setup and coordination between WFF and NSERC. The system is currently run by NSERC and requires an on-board operator to ensure proper functionality.

Figure 5-6. INMARSAT antenna array

5.2: Antennas

The aircraft drawing below (Figure 5-7) depicts the layout of antennas on the upper and lower surfaces of the P-3. Numerous GPS antennas onboard the aircraft are available to experimenters.

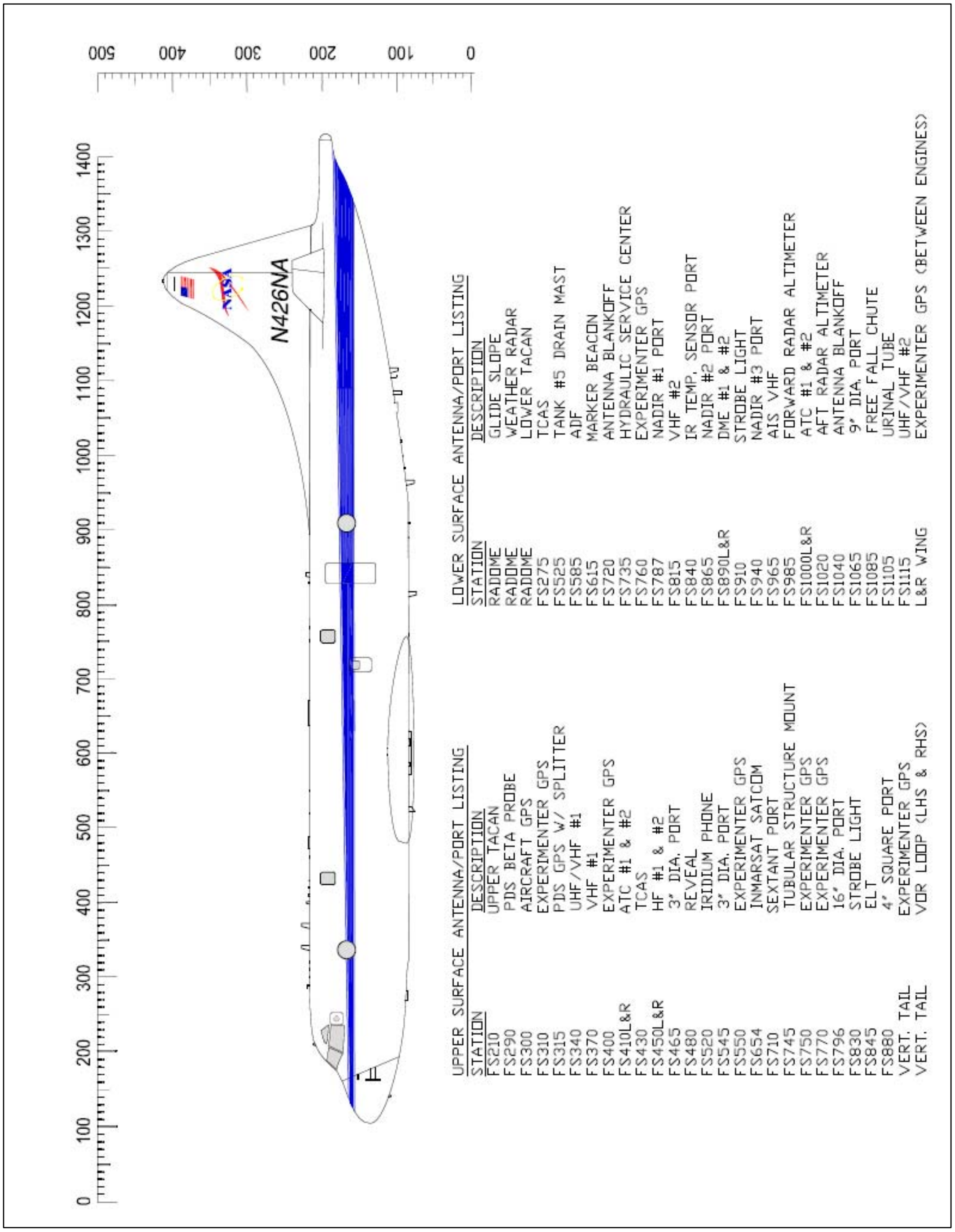

Figure 5-7. P-3 antenna layout

5.3: Flight Management & Navigation Systems

The following are general guidelines of the accuracy attainable with selected systems under average flight and weather conditions.

5.3.1: Global Positioning System (GPS)

The global positioning system provides the most accurate location and motion coordinates for the aircraft. Table 5-1 provides a list of these accuracies.

Table 5-1. GPS measurement parameter accuracies

Parameter	Accuracy
Horizontal Position	49 ft
Altitude	49 ft
Ground Speed	1.0 knot
Track Angle	0.5°
Vertical Velocity	0.1 knot
Horizontal Velocity	1.0 knot

5.3.2: Distance Measuring Equipment (DME)

Distance measuring equipment permits locating the aircraft within a two nautical mile radius. DME measures slant range and is not accurate directly over the station.

5.3.3: Inertial Reference System (IRS)

Three ring laser gyro Inertial Reference System units are capable of providing digital and analog information to the EFIS, FMS, autopilot, flight director, and experimenters. The inputs to the IRS from the ADZ are digital, and initialization of the present position comes from the FMS. The IRS analog output data is pitch, roll, heading and acceleration in both two- and three-wire configurations.

5.3.4: Flight Management System (FMS)

The flight management system accepts primary position information from short and long-range navigation sensors. Inputs from the DME, VOR, TACAN, and GPS are utilized to determine the aircraft’s position. In addition to the navigation inputs, the system also receives true airspeed and altitude information from the air data computer (ADC) and heading reference from the IRS. The primary position data received from the sensor is filtered within the FMS to derive a "best computed position" (BCP). Using the BCP, the FMS navigates the aircraft along the programmed flight path.

5.3.5: ATC Transponder

Dual Mode-S transponders (TDR-94S) are installed.

5.3.6: Radar Tracking Beacons

Radar tracking of the aircraft by a ground station is sometimes needed for certain missions (such as operation near a sounding rocket range, or oceanographic measurements coordinated with a surface ship). Radar beacons to be placed on the aircraft must be supplied by the experimenter. Power supplies and controls for the transponder may be mounted on a standard equipment rack in the main cabin.

NOTE: Information and specifications defining radar beacons must be supplied in advance, to ensure correct interface with aircraft power and fixtures.

5.4: Flight Parameter Data Recording

A final data set of all project data system parameters is provided to investigators to complete final data reduction, analysis, and submission tasks. Data products for field experiments are comprised of a subset of the measurements listed in Appendix D. Tabular and graphical summaries of the housekeeping and ancillary data can be generated for each flight if requested in advance. Distribution of the data products are in the form of a Preliminary Data Archive and a Final Data Archive. The Preliminary Data Archive is assembled using field data products and ancillary and housekeeping measurements within 24 hours after each flight. The Final Data Archive and submittal will contain all supporting measurements and adhere to the protocol and schedule adopted by the science team.

Preliminary flight data recorded by the project data system is made available to investigators following completion of each flight within 24 hours. Electronic and hard copy preliminary flight data summaries are produced for each flight on the P-3B aircraft during the mission and provided to each experiment group. The mission summaries include, but not limited to, the following:

- Time series summary plots for the flight. Plot types include position (latitude and longitude) and time series of altitude, static air temperature, and dew/frost points. (Experimenter signals of various trace species may also be included if agreed by the respective experimenter.)
- Profile plots for each spiral or ramp flight segment. These plots show the vertical distribution of static air temperature and dew/frost points plotted vs. altitude with time as a secondary Y-axis. (Other experimenter signals may also be included if agreed by the respective experimenter.)
- One-second averages of the housekeeping and ancillary data recorded during each flight in ASCII format is recorded on multiple types of storage media (CD, DVD, FTP, etc.). These may be copied/downloaded and used by investigators.
- The digital video files are available for copying and viewing during the mission. Copies of these files are made and distributed upon request post mission.

Listed below in Table 5-2 are the project data system instrumentation and sensor specifications. A sample data file can be provided upon request.

Table 5-2. Instrumentation Specifications

Parameter	Sensor	Range	Resolution	Accuracy	Response
Dew/frost point	EdgeTech Model 137 Hygrometer	+60 to -40°C	0.1°C or °F	±0.2°C	2sec – 10min
Static Air Temperature	Rosemount Model 102	+50 to -50°C	0.006°C	±0.2°C	2 Hz
Total Pressure	Rosemount MADT 2014	30 to 1300 mb	0.02 mb	±0.25 mb	64 Hz
Static Pressure	Rosemount MADT 2014	30 to 1300 mb	0.01 mb	±0.25 mb	64 Hz
Dynamic Pressure	Rosemount MADT 2014	4 to 1000 mb	0.02 mb	±0.50 mb	64 Hz
Pressure Altitude	Rosemount 2014MA1A	-2K to 75K ft	0.5 ft	±8 ft	32 Hz
Angle of Attack (858Y)	Rosemount 1221F2VL	50 mb	0.003 mb	0.1 mb	10 μsec
Time	Truetime XL601 GPS	UTC	1 μsec	2 μsec	1 μsec
True Heading	Honeywell INS	0 to 360°	0.1°	±0.2°	25 Hz
Pitch	Honeywell INS	±180°	0.0002°	±0.1°	50 Hz
Roll	Honeywell INS	±180°	0.0002°	±0.1°	50 Hz
Vertical Velocity	Honeywell INS	±32768 ft/min	1 ft/min	N/A	25 Hz
N/S Velocity	Honeywell INS	±4096 m/s	0.0125 kts	N/A	25Hz
E/W Velocity	Honeywell INS	±4096 m/s	0.0125 kts	N/A	25 Hz
Wind Speed	Honeywell INS	0 to 225 kts	0.00025 kts	±2 kts	10 Hz
Wind Direction	Honeywell INS	0 to 360°	0.00017°	±5°	10 Hz
Ground Speed	Honeywell INS	0 to 4096 kts	0.125 kts	N/A	10 Hz
GPS Latitude	GPS	±180°	1.716E-4 deg	±15 m	1 Hz
GPS Longitude	GPS	±180°	1.716E-4 deg	±15 m	1 Hz
GPS Altitude	GPS	±131072 ft	0.125 ft	±30 m	1 Hz

5.5: Data Acquisition

The project data system data acquisition computers and server are interconnected and host the internal Ethernet and serial network interface. This local network can be extended to include on-board video, printer, FTP, and WWW servers for data displays and exchange. The data acquisition computer collects data from various sources on the aircraft via an ARINC-429 bus interface. These sources include Flight Management System (FMS), Inertial Reference System (IRS), the Air Data Computer (ADC), Global Positioning System (GPS), and Micro Air Data Transducer (MADT). Data from additional meteorology sensors (temperature, dew/frost point, pressure, etc.) are sampled and collected using high-speed analog/digital (A/D) and digital I/O interfaces. These signals are converted to engineering units and utilized to make necessary flight parameter calculations.

The project data system back-up PC is configured to be a clone of the main data acquisition computer. The primary data acquisition and back-up systems are connected via an Ethernet and serial data link. Since the two computers function independently, the back-up PC, in the interim, is used as the network server to record and distribute digital video, generate multi-profile and time series plots using the RTPlot software tool during flight missions.

5.6: Data Distribution & Interface

The network onboard the P-3 is constructed using multi-port Ethernet (10/100/1000M) switches and a network server. The available backup computer on board is used as the network server (DHCP and NAT services) and services RTPlot software routines, network video camera recording software, and WWW/FTP servers. Additional servers can be added as demand and bandwidth warrant. Displays and images from real-time video cameras, alpha-numeric data, and profile/time series plots are accessible from one central Web page containing Web browser (URL) shortcuts to the respective Web page. A network drop is provided to make the Web pages available, via a network Ethernet switch, to experimenters who wish to connect.

5.7: Data Display

Real-time displays of selected housekeeping and ancillary data sets during flight are provided on the P-3B via a RGB and Ethernet distribution system. These displays are viewable on any computers with Ethernet access to the on-board network or selected monitors which can be independently selected. Ethernet access points and monitors are distributed throughout the P-3B to provide visual access to all investigators. Accessible displays include:

- Alpha-numeric displays of selected flight parameters
- Graphical displays of selected flight parameters
- Profile and real-time plots
- Nadir and forward-viewing cameras
- Flight track with selected flight and surface information

The system allows for flexibility to display different types of data formats, which provide multiple options for investigators and give a unique perspective of the overall mission in real time. Optional display formats tailored to the needs of the mission scientist and/or science team can be generated as needed.

5.8: Time Information

5.8.1: Time Code System

A Truetime Model XL-AK GPS synchronized time and frequency receiver is currently installed in the on-board data system rack to provide a standardized time base for data acquisition systems. Timing information is available to each experimenter via an RS-232 data bus and/or an IRIG-B time code. The IRIG-B signal may be used by investigators when a timing accuracy better than 1 second is required. The unit automatically acquires and tracks satellites based on health status and elevation angle. Time and frequency are determined from satellite transmissions and calculations referenced to UTC through the GPS master clock system.

Timing synchronization can also be received from the on-board data system using network timing protocol (NTP) via the on-board network.

5.8.2: Time Display

An IRIG-B time code display unit is located at FS400 in the cabin for experimenter visual reference. Dual Davtron M877 digital precision chronometers are installed on the pilot and copilot forward instrument panels. Special features include a flight time alarm, elapsed time count up or down with alarm, and incandescent display.

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Chapter 6: Payload Design Planning, Engineering, and Integration Processes

6.1: Experiment Development and Planning

6.1.1: Airborne Science Flight Request

The Airborne Science Program (ASP) maintains aircraft and sensor assets to support the Science Mission Manager/Directorate (SMD). The flight request system manages and tracks the allocation of the aircraft and facility sensors. Requests for the P-3 aircraft and the scheduling of the use of the P-3 are made through the Science Operations Flight Request System (SOFRS). This system was designed to allow researchers that are funded by NASA or other agencies to have access to unique NASA aircraft including the P-3. The only way to schedule the use of the NASA P-3 Orion is to submit a Flight Request for approval through SOFRS. The flight request management system is the online interface between scientist and the flight program. This system can be found at http://airbornescience.nasa.gov/sofrs/.

6.1.2: Payload Information Form

Upon successful submittal of the Airborne Science Flight Request and approval experimenters are requested to fill out the Payload Information Form. The Payload Information Form (PIF) is a generic questionnaire used by the P-3 and other NASA airborne science aircraft. The purpose of the PIF is to allow instrument Principal Investigators (PIs) a simple and efficient method to provide NASA aircraft engineering with instrument or sensor information that is sufficient to start the instrument integration process. This form is to be filled out with as much information as possible by the investigators for each instrument (one form per instrument) they wish to fly on the P-3 and returned to the Ops Engineer. The form covers general information about the experimenter and experiment equipment, hazards associated with the experiment, installation, and operations requirements. If exact values are not known provide estimates or TBD in the form fields. Maintenance and updates of the PIF are the responsibility of the PI. The PIF is a standard ASP form and will be accepted by most NASA ASP aircraft organizations. A copy of the PIF can be obtained from the Ops Engineer, Appendix A of this handbook, or the following website: http://airbornescience.nasa.gov/instrument/JASSIWG.html.

6.1.3: Payload Data Package

A Payload Data Package must be prepared for each payload proposed for flight on the P-3. The Payload Data Package must be submitted to the P-3 Ops Engineer and Mission Manager/Director no later than six weeks prior to flight. All payload documentation requirements are presented in Appendix B as well as the recommended format. It is imperative that all sections of the Payload Data Package 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.

6.1.4: Drawing and Other Technical Data

Investigators are required to provide as much technical detail concerning their experiment as possible when submitting their PIF and Payload Data Package. Upon review of the Payload Data Package information further questions or request for additional information may be required of the experimenter.

6.1.5: Hazards

The operation of any potentially hazardous equipment, or use of hazardous materials (such as toxins, flammable gases, corrosive liquids, etc.) on the P-3 or in P-3 facilities, must be reviewed and approved by the appropriate safety personnel. This applies to the shipping, operational use, and disposal of all hazardous materials, including the operation of hazardous equipment in the instrument upload area, or on the aircraft, either in flight or on the ground. Sufficient lead-time must be allowed for the necessary reviews and obtaining the proper authorization. For potential hazards external to the aircraft (such as laser beam, radio frequency, and microwave emissions), special approval may also be required from outside agencies such as the military, FAA, state/local government agencies, and/or agencies in foreign countries. Depending upon the specifics of the experiment, this process can take as long as several months. Information concerning potential hazards identified in the PIF or Payload Data Package must be forwarded to the Ops Engineer as soon as possible to start the hazard analysis process.

6.1.6: Aircraft Personnel

Mission Manager/Director– The Mission Manager/Director is responsible for the overall project management, safety, planning and scheduling of mission related activities prior to flight. This person is the experimenter's primary contact for all information that is non-engineering related. The Mission Manager/Director is the primary interface between investigators and flight deck personnel during an aircraft mission flight.

Operations (Ops) Engineer – The Ops Engineer is the experimenter's primary source of information concerning the aircraft and engineering related matters. The Ops Engineer oversees the installation and removal of instruments and is responsible for engineering and the airworthiness of the aircraft. This person is an investigator's primary contact during upload and download of instrumentation to the aircraft.

Maintenance Chief – The Maintenance Chief is responsible for all aspects of aircraft maintenance. All requests that affect the mechanics and flight crew during upload and download of a mission must be approved by the Maintenance Chief.

Quality Assurance Manager – The Quality Assurance Manager is responsible for inspection of aircraft installations to verify they meet proper standards and are installed according to correct procedures. The Quality Assurance Manager must certify and sign off that all installations are installed correctly before flight.

Pilot in Command – The Pilot in Command (PIC) is the pilot responsible for any aircraft flight. The PIC is in charge of all aspects of an aircraft flight (pre-flight, flight, and post-flight activities) once a mission has been approved for flight and can assist with flight planning. All requests (ground and flight related) during the flight phase of a mission must be approved by the PIC before commencing. The PIC has final authority on all mission related activities, including safety, during the flight phase.

6.2: Certifications, Reviews, & Approvals

It is the responsibility of experimenters to design and construct their research equipment (mechanically and electrically) in accordance with the general specifications of this document. Problems should, of course, be discussed with the appropriate WFF personnel.

Field measurements of the P-3 by the experimenters are strongly recommended when new or modified installations involve tight tolerances to existing aircraft structure. If special requirements do arise, arrangements can be made for WFF engineering design support as available, provided notification is received well in advance.

This material will be evaluated by appropriate WFF personnel and changes will be requested as necessary. Final airworthiness approval is granted from the WFF Airworthiness and Flight Safety Review Board. The actual equipment construction, weight, center-of-mass, and resultant loading are all verified prior to instrument upload and before final approval for installation is given. Experimenters should allow time for this verification when planning installation schedules.

6.2.1: AFSRB Purpose

All new or refly installations must be reviewed by the WFF Airworthiness and Flight Safety Review Board (AFSRB) prior to installation aboard the P-3 aircraft. This includes any alteration, addition, or removal of aircraft structure, components, equipment, or primary instrumentation. Routine maintenance is excluded from this process. The AFSRB is a non-advocate seven standing member board established by the director of Suborbital and Special Orbital Projects Directorate (SSOPD). They are responsible for conducting and documenting formal airworthiness reviews of flight programs and significant aircraft modifications in order to enhance the likelihood of mission and program success, and to minimize risks to persons or property. They ensure that airworthiness and safety issues for the entire aircraft configuration have been adequately addressed, advise the director of SSOPD about AFSRB issues that do not meet GSFC safety policies or requirements (i.e., AFSRB issues needing a waiver), and review the risk assessments and hazard analyses for aviation-related activities. The seven members assigned represent expertise in areas of ground and flight safety, electrical, avionics, structural, aeronautics, flight operations, and quality assurance/process control. The GSFC Aviation Safety Officer is a required member of the board.

The AFSRB requires reviews during the project installation/modification lifecycle, to include the Configuration Review (CR) and Final Installation and Inspection Review (FIIR). All review material is prepared and presented by the Mission Manager/Director and Ops Engineer assigned to each mission. In general, review requirements are proportional and commensurate with the degree of change and level of risk involved in the installation/modification of the aircraft and its flight envelope.

6.2.2: Configuration Review (CR)

Configuration reviews are conducted for every installation or modification to the aircraft. The presentation can vary from a single installation/modification, to a complete mission project. Presentation of the following documentation, as applicable, is required at the CR:

a. Configuration layout drawings/schematics/diagrams
b. Heritage of installation/modification; archived documentation
c. Database of installations; locations, weight estimates, external probes, hazardous systems
d. Preliminary Risk/Hazard analysis
e. Weight and balance approximations

Each component of the installation is analyzed for safety and operational considerations. The AFSRB reviews all installations that meet the following criteria:

a. Installation requires redefinition of the aircraft's published or previously defined flight envelope
b. Installation involves mid-air separation or engagement of components by an aircraft
c. Installation involves hazardous materials
d. Installation requires penetration of any size to the airframe
e. Installation creates new airframe load path
f. Installation requires window modifications
g. Installation of systems affecting control of the aircraft
h. Installation requires external protrusion (mold line change)
i. Other as determined by the AFSRB

Components or installations that pass the AFSRB review criteria are released by the AFSRB for fabrication and/or installation. Components or installations that meet one or more AFSRB review criteria for an action will have an independent peer review or critical design review depending on the complexity of the installation. Components or installations that meet the AFSRB review criteria, but have been previously installed on the aircraft in the same configuration, may be exempt from the peer review provided sufficient evidence of documented analyses, controlled installation drawings, and prior Safety of Flight Release (SOFR) are presented. The AFSRB Chairman documents the CR minutes and action items in a memorandum to the Mission Manager/Director and Ops Engineer.

6.2.3: Final Installation and Inspection Review (FIIR)

A Final Installation and Inspection Review, presented by the Mission Manager/Director and Ops Engineer, is conducted for every installation or modification subject to an AFSRB CR, unless prior exemption is given by the AFSRB at the conclusion of the integration process. Action items assigned at the CR are to be closed prior to the FIIR. Presentation of the following items is required at the FIIR, as applicable:

a. The final configuration layout drawings/schematics/diagrams, annotating revisions since the CR (if any); current status of work.
b. Final installation drawings/schematics/diagrams with evidence of Quality Assurance inspection of the aircraft modification.
c. Review CR action item closeouts and the Peer Review summary.
d. Review the Risk/Hazard analysis; analysis must be advanced to the phase where Risk Assessment Codes are assigned.
e. Review of the flight plan or the Engineering Check Flight (ECF); verify the ECF is planned to address the checkout of both the aircraft and the engineering modifications/installations; verify the ECF will confirm flight safety for the mission configuration.
f. Operations analyses to assess the impact of the installation during the flight activities for which it is being installed; comparison of mission required profiles with modified aircraft capabilities.
g. Pilot assessment of adequacy of cockpit display and monitoring features, and evaluation of estimated aircraft performance and handling characteristics, including response to non-nominal, emergency, and failure conditions.
h. Inspection, configuration control, non-conformance and corrective action plans to be used.
i. Procedures for preventative and corrective maintenance of project hardware.

The Airworthiness Review draws upon the already approved engineering and includes visual conformity checks with approved project documentation. The AFSRB chairman documents the FIIR minutes and action items in a memorandum to the Mission Manager/Director and Ops Engineer.

6.2.4: Safety of Flight Release (SOFR)

Upon satisfaction of the airworthiness process, the AFSRB Chairman will issue a Safety of Flight Release (SOFR) memorandum that permits conduct of the flight evolution as prescribed therein. A SOFR will be issued with an expiration date that best suits the application. In the event that a SOFR expires during an aircraft flight operation of field deployment, the SOFR is considered valid until the completion of such operation. The AFSRB Chairman on an exceptional basis may extend the date of an expired GSFC issued SOFR for extenuating circumstances provided all members of the review board concur. However, in no case will a SOFR expiration date extend beyond 2 years from the date of issuance.

6.2.5: Ops Engineer Approved Installation Re-fly

In the event that an aircraft installation was previously reviewed either individually or as a combination of installations and the installation is specified on a current SOFR document, the installation may be individually reinstalled as previously cleared without further airworthiness review. However, if an installation is flown in any combination that was not previously reviewed, the configuration must be reviewed in its entirety by the review board and a new SOFR must be issued by the AFSRB Chairman.

6.2.6: Engineering Check Flight (ECF) & ECF Anomalies

The Ops Engineer manages the ECF and resolves any anomalies arising from the ECF. All ECF anomalies will be reported to the ASO. Anomalies that have safety implications as determined by either the flight crew, Ops Engineer, the ASO or that require early termination of the ECF will be presented to the AFSRB prior to resumption of the ECF. At the AFSRB Chairman’s discretion, action items may be assigned to the Operations Engineer precluding resumption of the ECF until formally closed. The AFSRB Chairman may also require revision of the Risk/Hazards analysis. The AFSRB Chairman will document the ECF anomaly review minutes and action items in a memorandum to the Operations Engineer. The Operations Engineer will document resolution and closeout of the ECF action items in a memorandum to the AFSRB Chairman. The AFSRB Chairman will then reissue a SOFR upon satisfactory closeout of the action items.

Upon successful completion of the ECF the aircraft is cleared to allow experimenters to fly on the Project Check Flight(s) and Science Mission Flight(s).

6.2.7: Flight Readiness Review (FRR)

A Flight Readiness Review (FRR) is conducted at the successful completion of the Engineering Check Flight. This review is conducted by the WFF Aircraft Office to determine the readiness of a mission to begin science or deployment operations on the P-3 aircraft. This review covers engineering, logistic, science, aircrew, aircraft, and safety readiness to begin a mission. Upon successful completion of this review a “Permission to Proceed” letter is issued by the Director of Suborbital and Special Orbital Project Directorate to start mission operations. If the P-3 aircraft will be the only aircraft involved in a science or deployment operation this is the final review.

6.2.8: Mission Readiness Review (MRR)

If the P-3 aircraft is involved in a campaign along with other aircraft, particularly NASA aircraft, a Mission Readiness Review (MRR) will be conducted. This review is the final review before flight, after successful completion of the FRR, and is typically conducted by NASA HQ or the Earth Science Projects Office at NASA Ames. This meeting reviews the readiness of each aircraft involved, the overall science campaign objectives, and coordination between aircraft or ground assets such as formation flying or coordinated flyovers of specific sites. Once this review is successfully completed all aircraft and science assets are given permission to begin conducting their respective operations.

6.3: Aircraft Integration

The installation of experimenter equipment onto the aircraft is one of the most difficult and time-consuming aspects of airborne research. Accustomed to the relative ease of commercial airline travel, experimenters may not fully comprehend the problems encountered in the secure mounting of airborne test equipment to comply with the mandated safety requirements. For this reason, adherence to the specifications, deadlines, and technical requirements detailed in this handbook are required.

NOTE: Due to manpower limitations, major engineering and/or construction defects cannot, ordinarily, be corrected during equipment installation. Therefore, in the past, some experimenters with unacceptable equipment have been required to withdraw at the last moment. Careful adherence to the standards, procedures, and timing for equipment certification detailed in this handbook will ensure a relatively trouble free installation.

The full and continuous involvement of the experimenters and their teams is required during the mission integration and operation periods at WFF. Once at WFF, the experimenter is responsible for the assembly, installation, checkout, and operation of their equipment to specified aircraft standards. The Mission Manager/Director is responsible for all the mission functions, facilities, schedules, reviews, and support resources. The Mission Manager/Director and the Airborne Science staff are always prepared to assist in the solution of problems that may arise.

6.4: Schedules and Timeline

Due to the unique nature of science requirements and installations investigators are asked to work closely with the Mission Manager/Director and Ops Engineer early on during the mission conception process to establish a realistic schedule. Typical installations of new, never flown before, instruments and entire aircraft mission payloads take 3 to 4 weeks to complete prior to beginning check flights. During the two weeks after the entire aircraft payload has been installed the FIIR, Engineering Check Flight, Project Check Flights, FRR and/or MRR occur, along with mission deployment packing.

Critical reviews can be scheduled on an “as requested” basis; no fixed timeline is required for the reviews just the order in which the reviews are conducted must remain the same. Complex P-3 missions that fill the cabin and majority of the ports take approximately 6 to 8 months to complete. Complex missions that deploy outside the United States typically take a year to complete due to international clearance and other issues. If a mission is a “refly” of previously flown installations the timeline can be drastically reduced, especially for continental U.S. deployments or local missions conducted from WFF. A simple “refly” installation (1 or 2 instruments) being flown within the United States can take as little as 2 weeks from mission initiation to field deployment.

Chapter 7: Payload Design and Fabrication Requirements

7.1: Flight Safety

New designed, commercially-purchased, and other equipment not designed for aircraft use must be evaluated for structural integrity and electrical compliance. If necessary, these installations shall be modified to comply with the criteria outlined in this handbook. The design of aircraft systems and equipment installations for use on the P-3 shall follow standard aircraft engineering design practice and Lockheed Martin design criteria. In addition, current FAA certification standards are to be met to the maximum extent practical, consistent with the intended mission of the payload. Also, all equipment designed for aircraft use will be reviewed for conformity with design and installation specifications for the aircraft documented in "P-3B Orion (N426NA) P-3B Design Requirements, August 2009, 548-RQMT-0001".

Equipment designs that fail to comply with the guidelines given in this handbook or hardware that fails to conform to the design documentation will not be installed on the aircraft until the deficiencies are corrected. In the event that the deficiencies cannot be corrected, the equipment will not be permitted on board the aircraft for flight research. WFF Ops Engineer will assist the user in understanding and complying with the requirements outlined in this handbook. The experimenters and their teams are expected to observe the procedures and constraints stated in this and the preceding chapters, as well as other limits that may need to be set by the Mission Manager/Director or Ops Engineer.

7.2: Mechanical Systems

Brief guidelines for the construction of experimenter equipment follows. Structural analysis is required to substantiate all experimenter installations on the aircraft. These analyses must be received early in the mission preparation to allow for review and approval prior to instrument upload.

7.2.1: Loads and Structures

7.2.1.1: Passenger Cabin / Below Cabin Floor Areas / Bomb Bay

All structures, attachments and fasteners for racks, instruments, pallets, tie-down retainers, carry on items, etc., shall be designed to withstand the load conditions listed in Table 7-1. These load factors, when applied one at a time, shall not result in a stress in any structural element of the equipment beyond the accepted ultimate strength of the construction material used.

Table 7-1. Minimum design load factor

Load Direction	Ultimate Load Factors (g)		
	Passenger Cabin[1]	Below Cabin Floor Area	Bomb Bay
Forward	9.0	3.0	3.0
Downward	6.0	4.5	6.5
Upward	2.0	2.0	3.0
Lateral	3.0 4.0 for Seats	1.5	2.5
Aft	1.5	1.5	1.5

[1] Loads are for equipment in the main cabin from FS280 to FS1130 and from FS740 to FS960 in the below cabin floor area. For installations in other parts of the aircraft refer to 548-RQMT-0001.

The load factors listed are for the structural design of the equipment only. It is not required that alignment, calibration, or other instrument functions be maintained under these load conditions.

7.2.1.2: External Attachments

All external structures shall be designed to withstand the maximum aerodynamic and operational ultimate (gust) loads encountered. The maximum dynamic pressure (q_{max}) for the P-3 is 555 psf (~3.9 psi). Unless a thorough analysis is performed to calculate lift and drag coefficients, then this maximum dynamic pressure value shall be used to calculate the lift and drag loads on external attachments. In addition, a safety factor of 2.0 shall be applied to each of the maximum aerodynamic loads.

The maximum operational ultimate (gust) load factors vary with fuselage station location. However, Table 7-2 gives overall ultimate gust load factors that will satisfy all gust load from FS280 to FS1130 internal and external to the cabin. See 548-RQMT-0001 document for (limit) gust loads outside these flight stations. Factor of Safety of 2 shall also be used to convert limit loads from gust load chart to ultimate loads.

Once the maximum stresses from the aerodynamic and operational ultimate (gust) loads are determined, these values are compared with the ultimate strength of the structural fabrication materials. Positive margins of safety shall be maintained. For installations that protrude outside the aircraft into the airstream, the experimenter is required to provide information about the natural frequency of the assembly. Close coordination with WFF is advised during the design of external attachments.

Table 7-2. Ultimate flight load factors FS280 to FS1130

Load Direction	Ultimate Load Factor (g)
Down	10.2
Up	6.4
Side	3.2

7.2.1.3: Design Pressures in the Cabin Environment

In general, experiment structures (other than optical windows) designed to act as a critical component of the aircraft's pressure vessel shall be designed to the design ultimate pressure, 2*P* (Table 7-3) plus operational ultimate (gust) loads, aerodynamic loads, and suction effects. It is typically best to have WFF perform design of experiment hardware that will be part of the aircraft pressure vessel. If design is performed by the experimenter, close coordination with WFF is required for consultation, review, and approval prior to fabrication.

Table 7-3. Minimum aircraft pressure vessel design criteria

Design Parameter	Pressure Limit (psi)
Maximum Cabin Differential Pressure	5.66
Maximum Emergency Relief Pressure (P)	5.99
Design Limit Pressure (1.33P)	7.97
Design Ultimate Pressure (2P)	11.98
External Fuselage Pressure (Ditching Pressure)	See 548-RQMT-0001

7.2.1.4: Load Test

Items requiring load test shall comply with "NASA-STD-5001, Structural Design and Test Factors of Safety for Spaceflight Hardware." Contact the ops engineer for a current version of this NASA technical standard. All composite structures of significant size designed to be flown external to the fuselage shall be load tested.

7.2.2: Inlet Systems

The mechanical design of inlet systems shall meet the requirements set forth in paragraph 7.2.1.2 of this handbook for those portions of the inlet external to the aircraft. Internal portions of the inlet system shall meet the requirements set forth in paragraph 7.2.1.1 of this handbook.

7.2.3: Windows

All optical windows (glass and non-glass) shall meet all analysis requirements as set forth in the "P-3B Orion (N426NA) Design Elements for Aircraft Optical Windows, July 2009" 548-

RQMT-0002 document. All edges of glass-type materials shall be chamfered and any scratches, digs, or unsmoothed edge chips may disqualify a window for use. All window material shall be isolated from metal inserts or frames by a minimum Grade 40 silicone rubber gasket with sufficient tolerance to prevent strain from thermal and mechanical effects.

Every window assembly, complete with frame and gaskets, is inspected at WFF prior to installation on the aircraft. To allow adequate time for inspection, window parts shall be at WFF at least one week prior to the scheduled installation. Every window shall be marked to identify the cabin side before inspection begins. For more detailed information on window inspections, see “P-3B Orion (N426NA) P-3B Optical Window Inspection Plan, July 2009, 548-PLAN-0001” document.

After inspection, the window assembly is held in secured storage until installation. If any disassembly or alteration is performed during or after storage, the inspection shall be redone. The nominal inspection procedure may be tailored to a specific window material when an appropriate fracture analysis is available.

Assembly, adjustment, or repair operations to an experiment near a window shall be performed with a window safety shield in place. Equipment shall be designed so operations of this type take place with the window covered. A scratch, gouge or chip in the window is likely to immediately disqualify it from further use. Therefore, the space between the optical window and safety shield shall never be used for storage of loose items.

In regions of high humidity, if the aircraft has been cooled at a high altitude and descends quickly to an altitude where the optical surfaces have temperatures below the cabin dew point, condensation can occur on the window. If observations are then to be made, the window shall be manually cleaned with an appropriate solution by an aircraft crew member. If windows need cleaning, special arrangements for cleaning assistance shall be requested through the Mission Manager/Director or Ops Engineer.

7.2.4: Fasteners

Standard aircraft structural fasteners (AN, MS, NAS, or equivalent) shall be used for all structural members and shall be secured by some locking method (such as self-locking nuts, cotter pins, or safety wire). A liquid thread locking compound, such as LockTite, is not considered an adequate thread locking mechanism. This requirement includes the installation of components into standard P-3 equipment racks, and mounting on other support frames or aircraft hard points. These types of fasteners should also be used for other elements of the equipment whenever possible.

Data sheets, giving detailed nomenclature and the engineering specifications for this type of hardware and a list of suppliers is available on request. Table 7-4 provides information on more commonly used aircraft fasteners:

Table 7-4. Aircraft quality fasteners

Designation	Fastener Description
Conventional Rivets	
MS20470AD	Protruding Head Solid Rivet
MS20426AD	Flush, Full Size Head
NAS1097	Flush, Reduced Head
HI-Loks	
HL18	Protruding Shear Head Pin
HL19	Flush Shear Head Pin
HL70	Shear Collar
HL20	Protruding Tension Head Pin
HL21	Flush Tension Head Pin
HL86	Tension Collar
Bolts/Screws	
AN3-AN20	Hex Head Bolt (125 ksi)
NAS6203-NAS6220	Hex Head Bolt (160 ksi)
MS24694	Flush Head, Phillips Drive (125 ksi)
NAS517	Flush Head, Phillips Drive (160 ksi)
AN525	Washer Head, Phillips Drive Screw
MS27039	Pan Head, Phillips Drive (125 ksi)
NAS623	Pan Head, Phillips Drive (160 ksi)
Washers	
NAS1149	Plain Washer
AN970	Large Area Flat Washer
Nuts	
MS21042	Hex Nut, Low Height, Self Lock (160 ksi tension)
MS21044	Hex Head, Full Height, Nylon Lock (125 ksi tension)
NAS1804	12 point, Full height (180 ksi tension)
MS21059	Floating Nutplate, Std Spacing
MS21075	Floating Nutplate, Mini Spacing
MS21061	Floating Nutplate, Std Spacing, One Lug
NAS1473	Self Sealing Nutplate, Std Spacing
NAS1474	Self Sealing Nutplate, Mini Spacing
Inserts	
MS21209	Locking Helical Coil Wire
MS51830	Screw Thread, Key Locked, Regular Duty (Keensert)
MS51831	Screw Thread, Key Locked, Heavy Duty (Keensert)
MS51832	Screw Thread, Key Locked, Extra Heavy Duty (Keensert)
Blind Fasteners	
NAS1669	Hex Head Blind Bolt (Jo-Bolt)
NAS1670	Flush Head Blind Bolt (Jo-Bolt)
M7885/2	Protruding Head Blind Rivet (Cherry-Max CR3213))
M7885/3	Flush Head Blind Rivet (Cherry Max CR3212)
M7885/13	Flush Shear Head Blind Rivet

7.2.5: Welding

Welding structural members of experimental equipment may be acceptable; however, bolting and/or riveting are preferred wherever possible. Welded structures should be avoided for significant load bearing, externally mounted, or cyclically loaded applications. Stainless steel or steel should be used where necessary.

When welding is required, only materials suitable for welding shall be used. The welds shall be performed in accordance with SAE-AMS-STD-2219, "Fusion Welding for Aerospace Applications," and by a welder who is currently certified to AMS-STD-1595 specifications. The assembly should then be heat-treated if full joint strength is required. In addition, non-destructive inspection (such as dye penetrants) shall be performed on the welded assembly to find any weld defects. If the welded assembly does not pass inspection, it may not be permitted on the aircraft. Welding is not permitted on the aircraft. See Appendix B, "Payload Data Package Requirements," for additional documentation requirements.

7.3: Electrical Systems

Safe installation and operation of electrical equipment depends on observance of the following design considerations.

7.3.1: High Voltage

Reduced atmospheric pressure increases the possibility of corona discharge and arcing between high voltage components and ground. Normal cabin pressure is equal to 7,500 ft (2.29 km), and break down distance, for a given voltage, is one-third greater than at sea level pressure. These conditions shall guide equipment design with respect to lead separation, insulating high voltage components, avoiding sharp bends, solder peaks, and other rational practices. High voltage leads shall be sufficiently insulated to prevent flashover. These components and high voltage cables shall be clearly marked and, where practical, electrical and mechanical interlocks shall also be used. Contacts on terminals carrying 50 volts or more to the ground shall have guards to prevent accidental contact by personnel.

7.3.2: Switches

Switches for aircraft use should be selected with extreme caution. In all circuits where a switch malfunction can be hazardous, a switch specifically designed for aircraft service shall be used. These switches are of rugged construction and have sufficient contact capacity to break, make, and continuously carry the connected load current. The position of the switch shall be checked with an electrical meter. The contact ratings shall be adequate for all load conditions and applicable voltages, at both sea level and the operational altitude. Consideration should be given to the variation in the electrical power characteristics.

7.3.3: Wiring

7.3.3.1: Wiring Rating

Wires shall be sized so that they have sufficient mechanical strength to allow for service conditions; do not exceed allowable voltage drop levels; are protected by system circuit protection devices; and meet circuit current carrying requirements.

If it is desirable to use wire sizes smaller than #20, particular attention should be given to the mechanical strength and installation handling of these wires, e.g., vibration, flexing, and termination. Wire containing less than 19 strands shall not be used. Consideration should be given to the use of high strength alloy conductors in small gauge wires to increase mechanical strength. Wires smaller than size #20 shall be provided with additional clamps and be grouped with at least three other wires. They shall also have additional support at terminations, such as connector grommets, strain relief clamps, shrinkable sleeving, or telescoping bushings. They shall not be used in applications where they will be subjected to excessive vibration, repeated bending, or frequent disconnection from screw termination.

Tables 7-5 and 7-6 below show the current carrying capacity and resistance for copper and aluminum wire. Note that the conductor resistance of aluminum wire and that of copper wire (two numbers higher) are similar. Accordingly, the electric current in Table 7-5 can be used when it is desired to substitute aluminum wire and the proper size can be selected by reducing the copper wire size by two numbers and referring to Table 7-6. The use of aluminum wire size smaller than #8 is not allowed.

7.3.3.2: Wire and Cable Insulating Materials

Insulation of wires shall be appropriately chosen in accordance with the environmental characteristics of wire routing areas. Routing of wires with dissimilar insulation, within the same bundle, is not allowed, particularly when relative motion and abrasion between wires having dissimilar insulation can occur. Soft insulating tubing (spaghetti) cannot be considered as mechanical protection against external abrasion of wire, since at best, it provides only a delaying action. Conduit or ducting shall be used when mechanical protection is needed.

Polyvinyl Chloride (PVC) is a thermoplastic material composed of polymers of vinyl chloride. It is widely used for primary insulation or jacketing on a variety of wire and cable types. However, as attractive as it is as an insulating medium, it does possess properties that make it hazardous for use in an airborne environment. When exposed to high temperatures, it has the unfortunate property of out gassing noxious/toxic products as well as heavy black smoke. For these reasons, wire and/or cable using PVC as the primary insulating material or jacket shall not be considered airworthy. Experimenters shall carefully review their drawings and parts lists to ensure that PVC insulated external wire or cable, or PVC hose is not specified. Internal wiring of commercial off-the-shelf (COTS) products, such as computers, is often accepted as is but efforts shall be made to reduce PVC usage in COTS wherever possible.

Electrical wire and cable used by experimenters, external to commercial manufactured components, shall be clad with non-flammable or self-extinguishing insulation, with at least 150 °C rated outer insulation material. Some commonly encountered materials and their usability are listed in Table 7-7.

NOTE: MIL-W-22759/11 or /16 wire is always acceptable.

Table 7-5. Current carrying capacity and resistance of copper wire

Wire Size	Continuous duty current (amps) – Wires in bundles, groups, harnesses, or conduits (See Note #1) Wire Conductor Temperature Rating			Max. resistance ohms/1000ft@20°C tin plated conductor (See note #2)	Nominal conductor area – circ.mils
	105°C	150°C	200°C		
24	2.5	4	5	28.40	475
22	3	5	6	16.20	755
20	4	7	9	9.88	1,216
18	6	9	12	6.23	1,900
16	7	11	14	4.81	2,426
14	10	14	18	3.06	3,831
12	13	19	25	2.02	5,874
10	17	26	32	1.26	9,354
8	38	57	71	0.70	16,983
6	50	76	97	0.44	26,818
4	68	103	133	0.28	42,615
2	95	141	179	0.18	66,500
1	113	166	210	0.15	81,700
0	128	192	243	0.12	104,500
00	147	222	285	0.09	133,000
000	172	262	335	0.07	166,500
0000	204	310	395	0.06	210,900

Note #1: Rating is for 70°C ambient, 33 or more wires in a bundle for sizes 24 through 10, and 9 wires for size 8 and larger, with no more than 20 percent of harness current carrying capacity being used, at an operating altitude of 60,000 feet.
Note #2: For resistance of silver or nickel-plated conductors see wire specification.

Table 7-6. Current carrying capacity and resistance of aluminum wire

Wire Size	Continuous duty current (amps) – Wires in bundles, groups, harnesses, or conduits (See Table 6-3 Note #1)		Max. resistance ohms/1000ft@20°C
	Wire Conductor Temperature Rating		
	105°C	150°C 200°C	
8	30	45	1.093
6	40	61	0.641
4	54	82	0.427
2	76	113	0.268
1	90	133	0.214
0	102	153	0.169
00	117	178	0.133
000	138	209	0.109
0000	163	248	0.085
Note: Observe design practices for aluminum conductors			

Questions about material usage and acceptability should be directed to WFF. Large volume and extended use of non-self-extinguishing insulation in experiments to be flown on the P-3 will not be approved by the aircraft inspectors at time of installation.

Accessories such as identification sleeves, cable ties, chafe guards (spiral wrap), and cable clamps, shall be of similar material. To avoid the time and cost of on-site cable replacement, suitable materials should be utilized to the fullest extent possible when assembling new components and their interconnecting cable assemblies. For those portions of experiments that have flown before, with cable assemblies that fail the above criteria, it is acceptable to use a flame resistant outer sleeve.

Power cords that are permanently attached to commercially procured equipment shall also have approved coverings other than PVC jackets. UL Type SO (neoprene jacketed, 600 volt/90 °C) is recommended, is readily available, and is usually accepted for this application despite a lower temperature rating. Exceptions to this guideline may require special treatment. WFF can provide a limited quantity of approved spiral wrap covering to be used over non-removable power cords. However, experimenters should provide their own protective covering material. Investigators using power cords that are removable, such as monitor and computer power cords, shall replace these cords using approved materials. See Table 7-7 for commonly encountered wire/insulation materials.

Table 7-7. Commonly encountered wire/cable insulation materials

Insulation Material	Maximum Nominal Operating Temperature (°C)
Tetrafluorethylene (TFE), Teflon[1]	+260
Perfluoroalkoxy (PFA), Teflon[2]	+250
Fuorinated Ethylene Propylene (FEP), Teflon[2]	+200
Polytetrafluorethylene (PTFE), Teflon[2]	+150
Ethylene and Tetrafluorethylene (ETFE), Tefzel[2]	+150
Ethylene and Monochlorotrifluorethylene (ECTFE), Halar[2]	+150
Homopolymer of Vinylidene Fluoride (PVDF), Kynar[2]	+135
Silicone Rubber[2,3]	+200
Polysulfone[2]	+130
Chlorosulfonated Polyethylene (CSPE), Hypalon[2]	+90
Polychloroprene, Neoprene[2]	+90
Natural Rubber (NR Isoprene)[2]	+70
Polymide Resin, Kapton[4]	+200
Polyester[5]	+150
Polymide Polymer, Nylon[5]	+105
Polyvinyl Chloride (PVC)[5]	+80 to +105
Polyethylene (PE)[5]	+80 to +105
Polypropylene[5]	+90
Polyurethane[5]	+80

[1] TFE is recommended as the preferred wire insulation for general use on the P-3. Proper installation procedures are credited with avoidance of problems, related to cut-through resistance and cold-flow properties. Some MIL-W-81044, MIL-W-81381, and MIL-W-16878 wire is acceptable in certain applications, but approval should be obtained prior to final product specification to ensure proper airworthiness standards are met.

[2] Acceptable Materials.

[3] Material has good low-temperature flexibility down to -90 °C

[4] Kapton insulated wire (MIL-W-81381 or equivalent) has had a number of reported incidents of short circuit arc tracking (flashover) which resulted in severe propagating destruction of wire bundles in military and aerospace hardware. The use of Kapton insulated wire is prohibited.

[5] These materials are not normally acceptable due to flammability and/or toxic pyrolysis products. Contact WFF for additional guidelines and usage criteria.

7.3.3.3: Wire Damage

Damage to wires shall not exceed the limits specified in Table 7-8 below.

Table 7-8. Allowable nicked or broken strands

Maximum allowable nicked and broken strands			
Wire Size	**Conductor material**	**Number of strands per conductor**	**Total allowable nicked and broken strands**
24-14	Copper or Copper Alloy	19	2 nicked, none broken
12-10		37	4 nicked, none broken
8-4		133	6 nicked, 6 broken
2-1		665-817	
0-00		1,045 – 1,330	
000		1,665 -	
0000		2,109 -	
8 – 000	Aluminum	All numbers of strands	None, None

7.3.3.4: Wire Splicing

Splicing is permitted on wiring as long as it does not affect the reliability and the electromechanical characteristics of the wiring. Splicing of electrical wire shall be kept to a minimum and avoided entirely in locations subject to extreme vibrations. Use of self-insulated splice connector is preferred; however a noninsulated splice connector may be used provided the splice is covered with plastic sleeving that is secured at both ends or is covered with dual wall shrink sleeving of a suitable material. There shall not be more than one splice in any one wire segment between any two connectors or other disconnect points. Splices shall not be used within 12 inches of a termination device. Exceptions to both statements above include when attaching to the spare pigtail lead of a potted connector, to splice multiple wires to a single wire, to adjust wire size to fit connector contact crimp barrel size, and to make an approved repair.

7.3.3.5: Terminals

Terminals are attached to the ends of electrical wires to facilitate connection of the wires to terminal strips or items of equipment. The following shall be considered in the selection of wire terminals: current rating, wire size and insulation diameter, conductor material compatibility, stud size, insulation material compatibility, and solder/solderless. Pre-insulated crimp-type ring-tongue terminals are preferred. The strength, size, and supporting means of studs and binding posts, as well as the wire size, shall be considered when determining the number of terminals to be attached to any one post. Terminal blocks shall be provided with adequate electrical clearance or insulation strips between mounted hardware and conductive parts.

Wires are usually joined at terminal strips. A terminal strip fitted with barriers shall be used to prevent the terminals on adjacent studs from contacting each other. Studs shall be anchored against rotation. When more than four terminals are to be connected together, a small metal bus shall be mounted across two or more adjacent studs. In all cases, the current shall be carried by the terminal contact surfaces and not by the studs themselves. Defective studs shall be replaced with studs of the same size and material since terminal strip studs of the smaller sizes may shear due to over tightening the nut. The replacement stud shall be securely mounted in the terminal strip and the terminal securing nut shall be tight. Terminal strips shall be mounted in such a manner that loose metallic objects cannot fall across the terminals or studs. It is good practice to provide at least one spare stud for future circuit expansion or in case a stud is broken.

Wire terminal lugs shall be used to connect wiring to terminal block studs or equipment terminal studs. No more than four terminal lugs or three terminal lugs and a bus bar shall be connected to any one stud. Total number of terminal lugs per stud includes a common bus bar joining adjacent studs. Four terminal lugs plus a common bus bar thus are not permitted on one stud. Terminal lugs shall be selected with a stud hole diameter that matches the diameter of the stud. However, when the terminal lugs attached to a stud vary in diameter, the greatest diameter shall be placed on the bottom and the smallest diameter on top. Tightening terminal connections shall not deform the terminal lugs or the studs. Terminal lugs shall be so positioned that bending of the terminal lug is not required to remove the fastening screw or nut, and movement of the terminal lugs will tend to tighten the connection.

Terminal studs or binding posts shall be of a size that is entirely adequate for the current requirements of the equipment and have sufficient mechanical strength to withstand the torque required to attach the cable to the equipment. All terminals on equipment shall have barriers and covers provided by equipment manufacturers.

7.3.4: Cabling

WFF provides all cabling to the experiment from the power outlet boxes and the aircraft data system; the experimenter provides matching connectors. The experimenters shall be responsible for the cabling between two or more racks of their own equipment. The WFF Ops Engineer will provide approximate cable lengths needed between racks and instruments. Once an aircraft floor plan has been approved it shall be the responsibility of the experimenter to provide the proper length of cabling. Rearrangement of a floor plan to meet cable lengths is not acceptable during the installation phase. Cables shall be routed off the floor to permit free access between racks, if possible. Cables that connect racks on opposite sides of the aisle are routed overhead; 22 ft shall be allowed for the overhead run. Special provisions for running cables across the floor can be made with the proper trip guards used. Sixty feet of cable should be allowed for cable runs between outer wing pylons to cabin area.

All cabling inside the racks shall be clamped to inhibit movement, utilizing existing holes and/or openings. All experimenter cabling not considered a permanent part of the aircraft shall be removed after the completion of the science mission flights.

7.3.5: Connectors

Selected connectors shall be rated for continuous operation under the maximum combination of ambient temperature and circuit current load. Hermetic connectors and connectors used in circuit applications involving high-inrush currents shall be derated. It is good engineering practice to conduct preliminary testing in any situation where the connector is to operate with most or all of its contacts at maximum rated current load. When wiring is operating with a high conductor temperature near its rated temperature, connector contact sizes shall be suitably rated for that circuit load. This may require an increase in wire size also. Voltage derating is required when connectors are used at high altitude in nonpressurized areas. Two-wire power leads and/or plugs are not allowed. Power adapters (i.e., U.S. to European plugs) also cannot be used.

7.3.6: Circuit Protection

All electrical wires shall be provided with some means of circuit protection. Electrical wires shall be protected with circuit breakers or fuses located as close as possible to the electrical power source, especially in the case of heaters and electric motors. Circuit protection devices shall be sized to supply open circuit capability. A circuit breaker shall be rated so that it will open before the current rating of the wire attached to it is exceeded, or before the cumulative rating of all loads connected to it are exceeded, whichever is lowest. A circuit breaker shall always open before any component downstream can overheat and generate smoke or fire. Wires shall be sized to carry continuous current in excess of the circuit protective device rating, including its time-current characteristics, and to avoid excessive voltage drop. Circuit breakers are designed as circuit protection for the wire, not for protection of black boxes or components. Use of a circuit breaker as a switch is not allowed. Use of a circuit breaker as a switch will decrease the life of the circuit breaker.

Table 7-9 may be used as a guide for the selection of circuit breaker and fuse rating to protect copper conductor wire. This table was prepared for the conditions specified. If actual conditions deviate materially from those stated, ratings above or below the values recommended may be justified.

Automatic reset circuit breakers that automatically reset themselves periodically are prohibited as circuit protection devices aboard the NASA P-3.

7.3.7: Batteries & Uninterruptible Power Supplies

While the proper use of small commercial grade batteries (such as AA, AAA, C, and D size Alkaline or Ni-Cd units) is normally acceptable for use on the P-3, the use of large numbers of batteries or large capacity batteries, particularity lithium-based, may present a significant hazard and therefore require appropriate review and approval. There are supplemental safety requirements for the use of Li-Ion batteries (laptop batteries excluded). Please contact the Ops Engineer for details. Battery approval is dependent upon the total aircraft mission configuration and assessed risk level for all potentially hazardous items on board. Approval will be for a particular mission series. Special approval and operating procedures are required to allow unattended operation of any battery-powered equipment aboard the aircraft.

Table 7-9. AC and DC wire and circuit protector table

Wire AN gauge copper	Circuit Breaker amp.	Fuse amp.
22	5	5
20	7.5	5
18	10	10
16	15	10
14	20	15
12	30	20
10	40	30
8	50	50
6	80	70
4	100	70
2	125	100
1		150
0		150

Basics of table:
(1) Wire bundles in 135°F. ambient and altitudes up to 30,000 feet.
(2) Wire bundles of 5 or more wires, with wires carrying no more than 20 percent of the total current carrying capacity of the bundle as given in Specification MIL-W-5088 (ASG).
(3) Protectors in 75 to 85°F. ambient.
(4) Copper wire Specification MIL-W-5088.
(5) Circuit breakers to Specification MIL-C-5809 or equivalent.
(6) Fuses to Specification MIL-F-15160 or equivalent.

7.3.7.1: Batteries

Small numbers of AAA to D size alkaline or "button" Ni-Cd batteries can be used without special approval. All other battery usage on the aircraft requires approval of WFF. Unless application absolutely requires otherwise, select benign battery chemistries with hermetically sealed cell designs from the following:

- Alkaline (Zn/MnO_2)
- Nickel-Cadmium
- Sealed Lead Acid ("starved electrolyte" or "immobilized electrolyte" type)

For safety considerations, acid type batteries with liquid electrolyte shall not be permitted on board. Other types of batteries can be used; however, they must be approved in advance by WFF. Recharging in flight shall not be permitted.

The overall experiment design must consider battery assembly, shipment to the field, storage, packaging safety, shipping restrictions, shelf life limitations, and final disposal (some types require treatment as hazardous waste). Specific design guidelines are as follows:

- Use smallest size (minimum capacity) battery suitable for intended application, thus minimizing stored energy and electrolyte quantity.
- Battery installations shall withstand normal aircraft structural loads, and safely contain battery failure modes. Typical failure modes include cell rupture or explosion and cell overheating.
- All batteries shall be in secondary containment to prevent leakage of electrolyte onto the aircraft interior. Additionally, all liquid electrolyte batteries shall be within sealed secondary containment and vented to the exterior of the aircraft to prevent toxic, corrosive, or oxidizing gases or fumes from entering the cabin. Sealed lead acid (SLA) batteries are exempt from sealed containment and venting and do not require drip trays.
- A fuse or circuit breaker shall be used as close to the battery pack as possible.
- Minimize hazards due to cell failure through use of isolation and/or bypass diodes, thermal cutout switches, electrolyte resistant wire insulation, etc.
- Labels shall be used attached to battery housings with applicable safety warnings displayed (such as corrosive/caustic liquid, flammable gas, high voltage or current capability).
- Unattended battery charging on the aircraft is not allowed. Batteries shall be isolated when not in use.

See Appendix B for additional documentation requirements.

7.3.7.2: Uninterruptible Power Supplies (UPS)

All units will be subjected to safety inspection and battery assembly procedures. The following specific requirements shall be inspected:

- A front panel mounted switch or circuit breaker shall provide complete battery isolation from UPS circuitry. It shall be easily accessible and clearly marked "Battery Isolation."
- The battery shall be a sealed lead acid (SLA) type, or other WFF approved type, with immobilized electrolyte.
- All batteries, except SLA, shall be in secondary containment to prevent leakage of electrolyte onto the aircraft interior. This is accomplished by mounting the battery or UPS on a drip tray or ensuring that the battery housing, or UPS, is sufficiently constructed to prevent leakage from escaping.
- The battery assembly shall be as supplied by the vendor and must have been installed by the vendor, or other qualified personnel. If the experimenter designs the battery assembly, it shall be new (within 90 days) and installed at WFF with an aircraft inspector witness.

- If the battery was installed before arrival at WFF, the unit shall be subject to a "covers removed" inspection for general workmanship and compliance with wiring requirements, containment, and isolation systems.

See Appendix B for additional documentation requirements.

7.3.8: Motors and Pumps

All electrical motors (except very small fan units found in most commercial electronic equipment) and motor assemblies shall be reviewed for electrical safety and sparking potential.

The use of electric motors aboard the aircraft requires individual approval by WFF. Preferred are 400 Hz motors, to avoid starting transients on 60 Hz converters. Larger motors (such as those used in vacuum pumps) shall be protected by thermal overload devices. However, vacuum pump motors, for example, shall be limited to 1/2 hp (375 W) when possible. In addition, single-phase motors shall be equipped with solid-state switches to inhibit arcing at the contacts during start-up. In the absence of arc-suppressors, motors must be spark free during operation. Motors rated explosion-proof or totally enclosed non-ventilated motors are recommended. However, many fractional horsepower AC permanent split-capacitor motors are acceptable depending upon application and location. Large DC brush type motors are generally not acceptable due to the electrical arcing at the brushes. Larger size motors require advance notice and special handling to avoid power outages. Experimenters shall consult with the Ops Engineer when motor loads are planned for 60 Hz power. Early consultations with WFF will help avoid problems at installation. See Appendix B for additional documentation requirements.

7.3.9: Power Distribution

Power distribution equipment and large power conversion equipment require special approval. All non-WFF AC power distribution boxes require inspection and approval for electrical safety. They shall have hospital grade duplex outlets constructed of approved materials (no PVC), an approved three-wire (grounded) power cord, and contain a ground fault interrupter breaker.

Experimenter supplied power distribution equipment (such as outlet strips), which incorporate transient surge and noise suppressors, require special WFF approval. Their use is limited to applications where they are plugged into the normal WFF power receptacles. Modifying or bypassing the grounding pin is not permitted.

7.3.10: Electromagnetic Interference/Grounding

The use of radio frequency (RF) and microwave emitters at WFF and at off-site operations (unless the off-site location has stricter regulations) is governed by WFF Range Safety Manual RSM2002. This document shall be reviewed and complied with by those contemplating the installation of radio frequency or microwave emitters. Contact the Mission Manager/Director for a current copy and for other related documents/forms concerning this topic. No emitters shall be powered on initially without the approval of the WFF Frequency Coordinator.

Experimenters shall engineer their equipment to prevent direct and spurious radiation from interfering with the aircraft avionics equipment, which may cover the frequency range of 10 kHz -10 GHz or more (see Chapter 2). Experimenters are cautioned to limit any output from their systems to 100 milliwatts (as in telemetry). All ground connections in experiment equipment shall be made to the third wire of a 115-volt plug, or the fifth wire of a 400-Hz three-phase plug. These ground conductors then return to their own bus. All power neutral leads from 400 Hz or 60 Hz loads shall be returned to the power system; they cannot be grounded.

If a ground strap is used then stranded 18 or 20 AWG wire shall be used to avoid shock hazard to equipment and personnel. If the end connection is used for shock hazard, the ground wire shall be large enough to carry the highest possible current (0.1 to 0.2 ohms max.). All wing-mounted/pylon experimenter equipment shall be grounded to the airframe. Resistance to ground checks will be performed. Equipment with greater than 1 Ω resistance to ground will require additional grounding.

Also, every effort is made in ground testing before flight to assure that there is no interference between experiments because of their electrical power characteristics. However, occasionally such interference may show up in flight. In such circumstances it may become necessary to rearrange power distribution to eliminate mutual interference. It is incumbent upon the experimenters to assure that their experiment equipment is not adversely affected by any minor voltage transients, and also to assure that operation of their equipment does not adversely affect the other experiments.

Other factors relative to EMI and/or experiments follow:

- Power leads along both sides of the cabin are in close proximity to signal leads. Some physical separation can be arranged at installation, but shielding must be considered for critical cases.
- High-impedance detector circuits are often subject to EMI, (unshielded detector leads may pick up noise from radio frequency fields within the aircraft).

7.4: Materials

7.4.1: Metallic

Certified aircraft grade structural material shall be used on the design of all load-carrying supports. Aluminum alloys such as 2024-T3, 6061-T6, and 7075-T6 are readily available for this purpose and are the only aluminum materials allowed in critical structural applications.

All material property data used in strength calculations shall be from DOT/FAA/AR-MMPDS-02, Metallic Materials Properties Development and Standardization (formerly MIL-HDBK-5J), or other acceptable data.

Material compatibility needs to be reviewed for parts in contact with one another in order to provide protection of structures from corrosion and other detrimental effects. Table 7-10 provides an indication of the galvanic corrosion potential between dissimilar materials.

Table 7-10. Galvanic corrosion potential.

Potential Tendency for Galvanic Corrosion									
The higher the number, the greater the potential. 0-3: ☐ Minimal 4-5: ☐ Marginal 6-12: ☐ High - Avoid if possible, or use sealants and paint barriers to prevent dissimilar material contact.	Mg Alloys	Zn, Galvanized Steel	Pure Al, 5000 & 6000 series Al	Cd, and Cd plating	2000 & 7000 series Al	Low Alloy Steels	Cu, Brass, Bronze	Monel, Ni, Inconel, PH SS	Ti, 300 SS, Graphite
Mg Alloys	0	1	2	4	5	6	10	11	12
Zn, Galvanized Steel		0	1	3	4	5	9	10	11
Pure Al, 5000 & 6000 series Al			0	2	3	4	8	9	10
Cd, and Cd plating				0	1	2	5	6	7
2000 & 7000 series Al					0	1	5	6	7
Low Alloy Steels						0	4	5	6
Cu, Brass, Bronze							0	1	2
Monel, Ni, Inconel, PH SS								0	1
Ti, 300 SS, Graphite									0

7.4.2: Non-Metallic

Experimenters designing their experimental equipment should avoid using flammable materials or materials that emit toxic fumes (e.g., PVC). For example, the external cabling of commercial electronic components shall have self-extinguishing insulation, such as Teflon or Tefzel. To determine the flammability of a material (foam, laser curtain, etc.) a flame test will be performed by WFF personnel. This test involves holding a flame for 5 sec. on a material test coupon and then removing the flame. If the material continues to burn on its own without the flame source then the material is not acceptable for flight.

7.4.3: Hazardous Materials

Hazardous material is defined as anything with a flashpoint below 140 °F or with a threshold limit value (TLV) below 500 ppm, below 500 mg/m^3 for fumes, below 10 mg/m^3 for dust, or with a single oral dose (if liquid) at 50 percent lethality below 500 mg/kg. As a note, materials with flashpoints above 120 °F are considered combustible and below are considered flammable. Each installation is reviewed for potentially hazardous materials. A complete account shall be made of all gases, and dry or liquid chemicals, toxic or otherwise. This includes all cleaning solvents, refrigerants and coolants, and instrument additives, such as butanol and laser dye. The use of toxic gases in the aircraft, during flight or ground operations, is of particular concern. Data on the instrument design, installation, and proposed use of the gases will be evaluated to determine the hazard level. See Appendix B for additional documentation requirements.

Where it is determined that the use and/or transport of a gas presents an unacceptable risk, containment of that gas in a secondary containment vessel shall be required. Generally, secondary containment is required when full release and mixture of the gas into a 4 ft bubble (33.5 ft^3) results in a concentration exceeding 50 percent of the amount known to be immediately dangerous to life and health (IDLH). Handling of hazardous materials at WFF and at off-site operations (unless off-site locations have stricter regulations) is governed by WFF Range Safety Manual RSM2002. Contact the Mission Manager/Director for a current copy and other related documents/forms concerning this topic.

7.5: Pressure & Hydraulic Systems

7.5.1: Pressure/Vacuum Systems

High pressure and vacuum systems (including research dewars) are reviewed to assess the hazards associated with failures. These, along with the use of compressed gases during ground and flight operations onboard the P-3, are controlled by NASA STD-8719.17, "NASA Requirements for Ground-Based Pressure Vessels and Pressurization Systems (PV/S)". Hydraulic and pneumatic lines and fittings shall be aircraft grade or equivalent and should operate at the lowest pressure possible. Fluids shall be non-flammable, non-corrosive, and non-toxic whenever possible. See Appendix B for additional documentation requirements.

7.5.2: Purge/Vent Systems

It is required that all flight pressure systems follow the safety manifold system as shown in Figure 7-1 when purge gas is required. Relief devices shall be set at 10 to 20% above the Maximum Operating Pressure (MOP) – the maximum pressure at which the experimenter is planning to operate. However, the relief shall not exceed the Maximum Allowable Working Pressure (MAWP) of any device within the experimenter system such as the maximum pressure rating of any tubing. Variable relief valves are not allowed. Pressure gauges shall have a one piece shatter-proof window and a blow out back, or equivalent. For all other pressure systems not being used for purge purposes a vent valve is required between the high pressure gas bottle/cylinder and the regulator to vent the system prior to disconnecting the regulator from the gas source. If the downstream portion of the pressure system has any possibility of holding pressure then a vent valve shall be required downstream of the relief valve as well.

In addition, all tubing (flexible or rigid) on the aircraft shall be secured and labeled with the type of gas carried inside for easy identification. Bottle manifolds are allowed but only one bottle may be open at any given time.

All gauges, regulators, and valves shall to be pressure tested, certified, and tagged by WFF prior to installation and use of the pressure system. Tubing is not required to be certifed by NASA as long as the tubing rating is known.

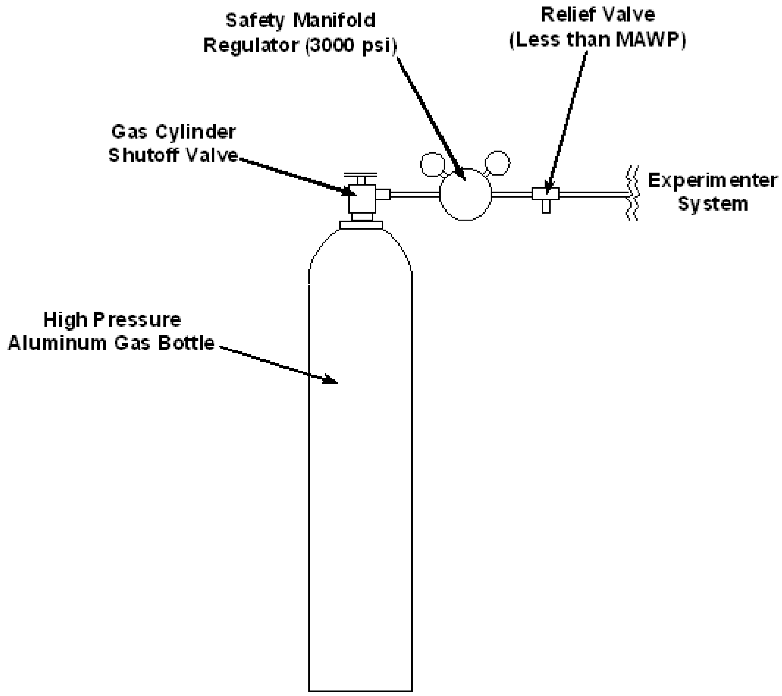

Figure 7-1. Pressure system safety manifold configuration (purge configuration only)

7.5.3: Cylinders

Only aluminum gas cylinders are approved for flight and shall be provided by the experimenter. These cylinders are required to be within their current U.S. DOT certification. All compressed gas cylinders shall have protective caps installed or be connected to manifold/regulators and be positively restrained to prevent movement in all three axes. DOT-E certified gas cylinders are not allowed for flight. Experimenters are allowed to manufacture their own pressure vessels but an extensive and stringent NASA design and test process shall be adhered too. Contact the Ops Engineer for further details.

Filling of gas bottles in flight is prohibited unless special permission is obtained from WFF. In the rare case that in-flight bottle filling is allowed there shall be a fill valve located between the regulator and relief valve pictured in Figure 7-1. There shall also be a manual vent valve to relieve any pressure trapped between the fill valve and the regulator when the system is not in use.

7.6: Thermal

7.6.1: Temperature Limits

There are no set maximum or minimum allowable temperature limits for experimenter installations on the P-3 aircraft itself. However, exposed surfaces which are above 113 °F are generally considered safety problems and shall have adequate shielding and caution signs. Cryogenic systems shall have labeling denoting those items carrying cryogens that can cause burns when touched. Experimenters shall keep heated items below the melting temperatures of those items they are in contact with as well as keep cooled items above the freezing point of those items they are in contact with.

7.6.2: Control

Overall thermal control and monitoring shall be conducted from the cabin experimenter rack. While thermal control mechanisms can be located within an instrument external to the cabin area, master control and monitoring of those devices must be maintained in the cabin. This allows monitoring of the instrument in order to determine if a runaway thermal event is occurring and to shut down the instrument or a portion of the instrument if need be.

7.6.3: Heaters

All heater assemblies are reviewed for electrical safety, proper circuit protection devices, hot surfaces that may cause burns to personnel, and the presence of high temperature exposed surfaces that might serve as ignition points for flammable gases. A thermal fuse or circuit breaker shall be located between the controller and the heater for added protection. See Appendix B for additional documentation requirements.

7.6.4: Chillers

All chiller assemblies are reviewed (similar to heaters) for electrical safety and proper circuit protection devices. A thermal fuse or circuit breaker shall be located between the controller and the chiller for added protection. See Appendix B for additional documentation requirements.

7.7: Hazards

To help identify potential hazards, which may require prior approval, the following equipment categorization is used.

7.7.1: Lasers

The use of lasers at WFF and at off-site operations (unless the off-site location has stricter regulations) is governed by WFF Range Safety Manual RSM2002. This document must be reviewed and complied with by those contemplating the installation of laser systems or the use of instruments containing lasers. Contact the Mission Manager/Director for a current copy and for other related documents/forms concerning this topic. See Appendix B for additional documentation requirements.

7.7.2: Gases

All compressed gases are reviewed, like cryogens, with respect to physiological, fire, explosion, and other possible hazards associated with their use and/or transport on board the aircraft. If the particular gas is in the extremely hazardous category, or is used in sufficient quantity to be otherwise considered a high-risk item, special design and risk mitigation practices are required.

Toxic gases (i.e. nitric oxide) require secondary containment pressure vessels with accompanying analysis verifying their ability to contain the compressed gas in the event of a failure of the main system. See Appendix B for additional documentation requirements.

7.7.3: Cryogens

Working with cryogens (liquids with boiling points below -238 °F (-150 °C)) and cryogen systems require established controls to be in place because of the hazards involved. Use of cryogenic liquids at WFF is controlled by the Applied Engineering and Technology Directorate (AETD) Safety Manual 500-PG-8715.1.2 Appendix D. Contact the Ops Engineer for a current copy. All persons working with cryogens shall be familiar with the properties of cryogens and shall observe safe handling practices. Cryogen usage is reviewed with respect to physiological, fire, explosion or other possible hazards associated with the use and/or transport aboard the aircraft. Some cryogens are prohibited from use and/or transport due to exceptional hazards. These cryogenic liquids include:

- Oxygen
- Methane
- Ethylene
- Ethane
- Hydrogen

Each and every portion of the cryogenic system shall have uninterrupted pressure relief following the pressure relief guidelines outlined in paragraph 7.5.2. Any part of a system that can be valved off from the remainder of the system shall have a separate pressure relief device. See Appendix B for additional documentation requirements.

All persons handling cryogens on the ground or in flight shall wear personal protective equipment (PPE) when performing cryogen operations. Eye, hand, and body protection shall be worn to prevent contact with liquid cryogens. At a minimum, safety glasses with side shields are required any time cryogenic liquids, exposed to the atmosphere, are present. Goggles provide the best protection for the eyes. A full face shield is required when a cryogen is poured, for open transfers, and if the fluid in an open container is likely to bubble.

7.7.4: Radiation Sources

The use and/or transport of radioisotopes and/or radiation generating equipment involving the NASA P-3B (unless the off-site location has stricter regulations) is controlled by WFF Range Safety Manual RSM2002. This document shall be reviewed and complied with by those contemplating the installation or transport of such systems containing radioactive materials. Contact the Mission Manager/Director for a current copy. See Appendix B for additional documentation requirements.

7.7.5: Other

Each installation is reviewed for potentially hazardous ground or airborne operations. The use of high power equipment, moving equipment, and/or optical windows will be reviewed. Also, changing gas cylinders in flight, purging and filling of highly flammable and/or toxic substances in an instrument, or other such items may be evaluated as high risk and require some level of risk mitigation.

This approval sequence can take several months and should begin well in advance of the proposed equipment installation date.

7.8: Access, Egress, & Physical Integration

NASA Wallops prepares a floor plan layout of the instrument upload configuration based on experimenter requirements, equipment, auxiliary systems, seating, etc. In certain cases, however, a partial floor plan may be proposed by another organization, coordinating the efforts of several different experimenters. Once equipment installations begin on the aircraft major modifications to the floor plan will result in mission schedule delay. Minor modifications such as moving a rack or seat row a few inches or reversing the orientation of a rack/seat row are acceptable during installation with little impact. Individual requests for specific locations, as well as proposals with partial floor plans, must be provided to the Ops Engineer as early as possible in the mission planning phase.

Experimenter and other non-experiment related (data systems, antennas, etc.) field installations are not permitted unless the items are standard rack mountable items or the installation has flown before and absolutely no changes have occurred since last flight and/or the Ops Engineer has granted prior approval to install. Maintenance related and/or safety related field installations are allowed with the proper approvals.

The assembly and checkout period should be used to full advantage since problems delayed until installation can impact the scheduled sequence of operations for all the experimenters. Each item of equipment must be weighed and its weight marked on it. An inspector can then readily check the total calculated weight and the overturning moment of each rack. Scales are available on the hangar floor. It is customary to hold daily formal group meetings, at which the experimenters discuss their progress and problems with the Mission Manager/Director and Operations Engineer. Timely action will be initiated to resolve problems that may delay the installation schedule.

Before any equipment may leave the experimenter rooms for installation in the aircraft, an inspection shall be conducted for its compliance with all safety requirements. The aircraft inspectors will explain any irregularities and suggest ways of handling them. A clipboard with a discrepancy sheet will be attached to each rack to indicate any problem and proper corrective actions. These shall be signed-off before flight.

The inspectors and Operations Engineer are generally available throughout the checkout period, and they should be asked for advice and assistance regarding the need for straps, trays, or other special restraints during the process of assembly. The inspectors also look for other safety hazards, such as equipment with sharp or projecting edges, and they will request that such hazards be corrected (such as padding with a suitable material). The inspection will also cover conformity to electrical safety requirements. The inspector will check to see that all the cabling is properly secured and protected against abrasion.

To assure a successful inspection prior to installation and corresponding AFSRB safety approval, the experimenter should consult frequently with the Operations Engineer during assembly concerning the use of support hardware, fasteners, and cable ties. The Operations Engineer will be available to sketch small brackets for fabrication and to recommend structural changes to existing hardware.

Following inspection and approval of equipment for aircraft installation, P-3 technicians will transport and install it in the aircraft. Installers will be working to the cabin layout drawings and time schedule provided by the Operations Engineer. The experimenters or their representative shall be present during installation to advise and assist as necessary. Following the mechanical installation, the aircraft technicians will work with the experimenter. They will complete the cabling installation from the aircraft systems to the experiment, and they will advise as requested on cabling between racks and other experiment equipment.

No work shall be done in the aircraft unless a crewman or other designated Airborne Science representative is present (aircraft doors may not be opened or closed by any experiment personnel). The aircraft is usually available from 8:00 a.m. to 4:30 p.m. daily. Additional time, including weekends, requires overtime for the ground crew and must be arranged for in advance. During integration the maximum work hours per day shall not exceed 12 hours and shall not exceed 72 total hours during a 7 day period. The maximum consecutive days worked shall not exceed 13 days (14^{th} day is a mandatory 24 hour down day).

If special positioning of the aircraft is required for experiment alignment or checkout, the maintenance lead or Operations Engineer shall be notified at least one business day in advance. This will allow time for obtaining the proper approval, and scheduling of ramp activities. Laser tests require NASA and FAA approval, which often require several weeks' time.

Power is normally available on the aircraft for checkout when the aircraft is in the hangar (ground power) or parked on the ramp. When on the ramp, power comes from the on-board aircraft Auxiliary Power Unit (APU).

CAUTION: Power distribution in the aircraft is controlled from the electrical load center. Experimenters are not authorized to switch power at this location. Upon request, only the aircraft technicians, the Mission Manager/Director, the Operations Engineer, or a member of the ground crew will switch power to the appropriate station.

Due to periodic maintenance and/or installation procedures, the ground crew may need to shut down electrical power for short periods of time. If power is needed for an uninterrupted period of time for checkout of experimenter equipment within the aircraft, the maintenance lead or Operations Engineer shall be advised well in advance. This will allow the work of the ground crew on the aircraft to be coordinated with experimenter's needs.

The aircraft technicians will designate a time for a power check of all experiments. Each experiment's power station will be turned on sequentially to make current measurements at the electrical load center. This procedure is necessary to balance loads among the fifteen converters, and to minimize interference among experiments from power transients. This also provides an opportunity for experimenters to check for interference from other experiments.

Following equipment installation and checkout, before any mission flights, the aircraft weight and balance will be calculated or measured to determine the center of gravity. Thereafter, weight and location of any equipment that is added or removed shall be noted to the Flight Engineer. Each experimenter is responsible for his own equipment (tool boxes, boxes of manuals, etc.), and shall notify the Flight Engineer when items are removed (even for short periods of time) or returned.

Chapter 8: Flight Operations

8.1: Operational Scenarios

During the early stages of each mission, the Mission Manager/Director develops mission-specific operational guidelines affecting flight frequency and duration. These guidelines take into account the type of flights being proposed by the scientists, the proposed flight duration, the location, take-off times, and other mission specific conditions, and reflect the overall agreement of the aircraft flight crew, Operations Engineer, safety, mission management, and maintenance crew. The following general guidelines can be used for initial planning.

The duty day for WFF personnel, including contractors, is limited to 12 hours maximum. The rest period between duty days must be a minimum of 12 hours. Given requirements for preflight and post-flight aircraft access, maximum flight duration is nominally 8 hours. Longer flights can be made but flight planning will be restricted and crew augmentation may be necessary.

A limit of 40 flight hours in a 7-day period and 100 flight hours per month is used for planning purposes. This has proven to be a practical limit for aircraft maintenance crews and, as experience has shown, for experimenters participating in the flights. Requests to exceed the 40-in-7 guideline will be evaluated on a case-by-case basis.

A typical operational schedule will consist of "fly days," "no-fly days," and "down days." Any day the aircraft flies, or the flight and maintenance crews arrive and start preflight preparations and then the flight is cancelled, is considered a fly day. Generally, the number of consecutive fly days is limited to a maximum of 6, to be followed by a no-fly day or a down day. Any day the aircraft is accessible to experimenters but does not fly is considered a no-fly day. Members of the P-3B crew will be at the aircraft on these days. Fly days and no-fly days are duty days and subject to the limitations outlined above. A down day is a day off. The aircraft is not accessible to experimenters and aircraft crews will perform no mission duties. A down day must be planned at no greater than 10-day intervals. Scheduling will be flexible to accommodate real-time conditions; however, down-day planning must be done from the outset within the overall scheduling of the campaign.

The maximum allowable flight duration is dependent on crew rest and aircraft weight limitations. Also, regulations require that sufficient fuel reserves be maintained at all times to assure adequate fuel for airport and air traffic delays plus reaching an alternate landing field. Fuel loads are subject to the discretion of the Pilot In Command (PIC). The need for this reserve and the distance between possible alternates in remote areas may combine to shorten flight times. Exceptions to this reserve fuel requirement, in order to prolong experiment time, are not permitted.

8.2: In-Flight Activities & Protocols

The following section covers several in-flight rules aboard the P-3.

8.2.1: Emergency Oxygen Equipment

Oxygen masks are located throughout the cabin in designated surface mounted containers. They are within convenient reach of all participants when seated. These units are not suitable for firefighting or intense heat. The use of these masks is solely for cabin depressurization purposes. The crew members and the Mission Manager/Director have portable emergency oxygen bottles, and can assist anyone on the aircraft.

8.2.2: Intercom Regulation

The aircraft intercom system enables the Mission Manager/Director/aft crew member to monitor experimenter operations and become aware of any safety-related problem immediately. At least one member of each research group is required to be on the intercom at all times. Extra-length cables can be provided if necessary to aid experiment operations.

8.2.3: Below Cabin Floor Areas

Access to the below cabin floor area is permitted in flight, but not during take-off and landing. Experimenters must inform the aft crew member and PIC before entering this area. The person going below the floor must wear a safety harness (gunners belt) which ties them to the cabin area as well has have a safety observer standing by.

8.2.4: Proper Attire

Sandals, open-toed or high heeled shoes are not allowed in the experimenter integration rooms, the hangar, or the P-3. Also, skirts and shorts are not appropriate flight attire for the P-3. Flight participants wearing these will be asked to change into long pants or a flight suit before being allowed to fly.

8.2.5: Airport Security

P-3 flight participants are warned not to carry items on the P-3 that are restricted within airport security areas (illegal substances, weapons, etc.). Keep tools aboard the P-3. Prior to transit flights, the Mission Manager/Director will check for visa, passport, and other required identification.

8.2.6: Optical Windows

An aircraft crew member will inspect optical windows after take-off and report their status to the PIC. The PIC will then clear the windows for use.

8.2.7: Repair Equipment

Electric motor-driven hand tools, heat guns, pencil-type soldering irons, and soldering guns cannot be used in flight. Use of volatile solvents on the P-3 is not permitted in flight, and must be cleared for use on the ground.

8.2.8: Smoking

Smoking is not permitted at any time on the P-3 or in any WFF building.

8.2.9: Food and Water

WFF does not provide food or water for flight or ground operations. It is up to each person to bring food and water for consumption on the aircraft. The air can become dry while in flight so it is strongly suggested that individuals drink plenty of water to stay hydrated on long mission flights.

8.2.10: Weight and Balance

No removals or add-ons will be permitted less than two hours before door-close on fly-days. This procedure is necessary to maintain the current weight and balance record.

8.2.11: Engineering Check Flight

When all the experimental equipment for a mission has been installed, but prior to the scientific data flights, one or more envelope verification flights are made. Experimenters may not participate in these flights. No experiments will be powered on and no experimenters will be onboard for this flight. These flights are designed to verify the structural integrity of the instrument installations and that those installations have not affected or reduced the flight envelope of the aircraft. Handling quality and flight performance data gathered during these flights will determine if any flight restrictions are required for science operations.

8.2.12: Project Check Flight

One or more project check flights at simulated mission conditions can be conducted prior to the start of a mission. The purpose of these check flights is to allow experimenters to verify the correct operation of all their equipment, and to become familiar with the flight environment and procedures. These and the subsequent mission flights are scheduled to allow the necessary ground time for aircraft and instrument maintenance procedures.

8.2.13: Lightweight Items

All articles, regardless of size, shall be secured during takeoff and landing. When airborne, it is permissible to relocate items that are necessary for experiment operation or maintenance and that weigh less than 10 lb (4.5 kg). However, these items must be secured again after relocation due to the potential for air turbulence. Personal possessions such as bags, briefcases, cameras, laptops, and binoculars are included in this requirement.

8.2.14: Liquid Disposal

Beverage cups and open containers shall not be left unattended, particularly around experimental equipment where accidental spillage could damage electronic components. Glass beverage containers are not allowed on the aircraft, and no liquids are allowed in the overhead compartments.

8.2.15: Medical / Life Insurance

Participants should arrange for their own insurance. The P-3 is operated as a public law aircraft, and as such does not have, or require, a certificate of airworthiness issued by the Federal Aviation Administration. As a consequence, many commercial riders to insurance policies may not provide insurance protection. Insurance can be purchased from commercial sources, on a yearly basis, covering flights on the P-3 within the U.S. and overseas. Consult with your insurance agent about the coverage of policies you hold.

8.2.16: Hearing Protection

It is recommended when not wearing an intercom headset to use hearing protection. The four turboprop engines are loud and minimal sound proofing is provided by the cabin wall and insulation. Foam ear plugs are available in the storage area above the galley.

Figure 8-1 below depicts various levels of noise exterior to the P-3 while engines are running on the ground.

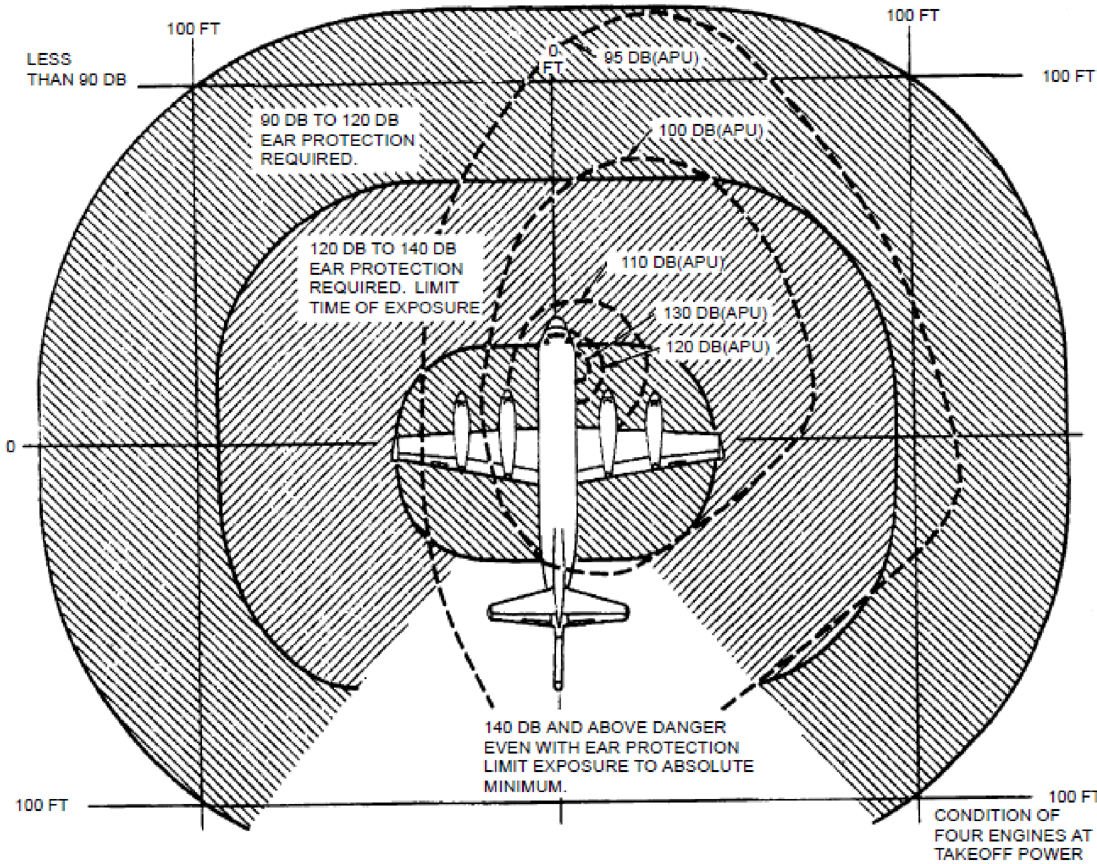

Figure 8-1. P-3 operational noise danger area

8.3: Testing

It is recommended that all experimenter testing of components be completed on the ground prior to flight operations. While no specific requirements exist stating what testing must be done to determine airworthiness it is the Operations Engineer's judgment call to determine what testing may be needed to verify an installation's airworthiness (load test, pressure test, etc.). Close coordination with the Ops Engineer is required to determine if any testing is needed. In-flight testing of an experiment is allowed; however, all pertinent in-flight protocols described in this chapter shall be followed.

Any experimenter preflight or post-flight testing shall be detailed to the Operations Engineer prior to mission flight operations. This will allow for proper approvals and adjustments in crew duty times in order to better support the requested testing. Prior arrangements should be made if electrical power is needed for pre- or post-flight calibration or other purposes. A typical flight day usually consists of power on the plane 1 hour before flight and 1 hour after flight. If these times need to be adjusted (lengthened or shortened) contact the PIC for approval.

8.4: Flight Safety

Aircraft flights in general are governed by specific safety rules. Flight conditions in the P-3 airborne laboratory are different from conditions in commercial passenger airplanes; a major difference is the presence of experimental equipment. This apparatus can pose potential hazards in the aircraft just as it does in conventional laboratories. For this reason, certain safety regulations are implemented for all flights in the P-3, and specialized safety equipment is carried. All participants on P-3 flights are required to abide by these regulations, which will be enforced by the Pilot in Command and the Mission Manager/Director. Before flight, an inspection of equipment items in the aircraft will be conducted to assure that they conform to those regulations.

8.4.1: Access/Egress

8.4.1.1: Main Cabin Door Access

Only the aircrew may operate this door unless in an emergency.

8.4.1.2: Exit Areas

Cabin exit area and all emergency exits (both over-the-wing exits, side cockpit and zenith cockpit exit) will be kept clear at all times.

8.4.1.3: Aisles

An aisle at least 20 in. wide will be maintained along the entire length of the main cabin. The aisle may shift locally from one side to the other in the aircraft depending on instrumentation mounted in the center aisle way.

8.4.1.4: Emergency Exit Lighting

In case of an emergency, a lighting system will automatically illuminate exit signs at each door.

8.4.1.5: Seat Spacing

A minimum nominal distance of 15 in. (38 cm) shall be between the forward edge of any passenger seat and the aft edge of an instrument rack.

8.4.1.6: Emergency Landing

In the event of an emergency landing that requires evacuation of the aircraft emergency exits and procedures will be employed to disembark from the aircraft. Climbing ropes are available over the main cabin door and under the Mission Manager/Director table for use to climb down from these exits if need be. In the event of a water landing only the over-the-wing exits and overhead cockpit exit should be used to prevent the aircraft from flooding prematurely. Flight crew members will provide all needed instructions during an emergency and investigators must obey all flight crew requests.

8.4.2: Specialized Safety Equipment

The P-3 carries safety equipment equal to, and often exceeding, that carried by comparable passenger aircraft.

- <u>Seat belts -</u> All crew seats are equipped with a combination seat belt/shoulder harness. This must be used during take-off and landing. The pilot will indicate when its use is required. The aft crew member will ensure that all passengers comply.
- <u>Emergency Location Transmitter (ELT) -</u> One ELT is installed immediately forward of the main cabin door. An ELT arming switch is located on the pilot's side console.

- Emergency Signal Kits (ESK) - Two ESK are installed with one located next to the pilot position and one on the cabin wall next to the left side over-the-wing emergency exit.
- First Aid Kits - Two first aid kits are carried aboard and are located at the flight station Mission Manager/Director position and in the aft cabin galley area.
- Fire Protection Equipment - Three portable fire extinguishers are carried on board the P-3. One extinguisher is located in the forward cabin close to the crash ax and portable oxygen-smoke mask unit. The other extinguishers are located mid-cabin near the electrical load center and in the aft cabin adjacent to the galley. Two crash axes with protective gloves are located on the aircraft. One set is located forward and one set aft. Six portable oxygen bottles and masks are carried on board. Three bottles are equipped with smoke masks for fire fighting and a minimum of three are equipped with normal masks for first aid or supplemental oxygen. The fire fighting units and first aid units are distributed in the forward and aft cabin areas.

  In addition, individual emergency passenger oxygen system (EPOS) smoke hoods are provided for both experimenters and the flight crew. These fire hoods provide a 15-minute oxygen supply and are located on the cabin wall next to each experimenter station in a blue box.
- Emergency Oxygen Canisters – Emergency oxygen canisters are located near each passenger seat. These oxygen canisters are only to be used during a cabin depressurization event and provide a 15-minute supply of oxygen. The Dixie cup nose and mouth covers work similar to the drop down mask found on commercial aircraft.
- Water Survival Equipment - There are two 12-person life rafts carried on all flights over water. Due to the size limits of these rafts no more than 24 people are allowed to fly on the aircraft at any given time (flight crew + experimenters). They are located in the main cabin next to the over-the-wing emergency exits.

  Individual life vests are stored on the backs of each person's seat. Flights operating at sea below 1000 feet ASL require occupants to wear floatation vests.

  Immersion suits are also carried aboard the plane when missions over cold waters are planned in case of ditching in water where the water temperature is capable of inducing hypothermia.
- Arctic Survival Equipment - Arctic survival kits are carried on all flights over Arctic regions. They are contained in duffels adjacent to the over-the-wing emergency exits or the aft cabin doors. In addition, virtually all the contents of the life rafts can be used in Arctic conditions. Emergency protective clothing (outer garments) is also provided for each flight participant. These duffels stored in the cabin are for emergency use only. Arctic clothing for non-emergency ground use, and all inner clothes layering, are the responsibility of the individual.
- Automated External Defibulator (AED) – The AED is mounted at the front of the P-3 cabin for the delivery of early defibrillation to victims of sudden cardiac arrest. Designated aircraft crew members are trained in the maintenance and use of this equipment.

8.4.3: Tool Control

Experimenters may work on their equipment in flight if it is necessary and can be done without affecting other experiments or creating an unsafe condition. However, the aft crew member's approval shall be obtained before any repair work may begin. Equipment removed from its usual position shall be replaced securely before landing. The use of aisle space for repairs is not permitted. All experimenters shall bring their own tools and shall maintain an itemized list of all tools they bring for inspection. A lost tool will ground the aircraft until found.

8.4.4: Personnel Training & Certification

Safety training sessions are held at the start of each mission. Attendance by all participants is mandatory. These briefings cover the use of emergency exits, life rafts, life vests, fire extinguishers, emergency oxygen (in the event of sudden cabin depressurization), and survival methods following a ditching or arctic surface landing.

P-3 flight participants must be free from significant medical conditions, which would put the individual at risk from flight or travel to another country. All individuals that plan to fly on the P-3 shall have a flight medical clearance prior to flying. This clearance can be obtained through the WFF Medical Clinic by the completion of the WFF medical form.

8.5: Field Deployments

8.5.1: Aircraft Crew

The aircraft crew consists of the flight crew (pilot, copilot, flight engineer), the Mission Manager/Director, and one or two aft crew members (depends on number of passengers). The Mission Manager/Director provides the direct link between experimenters and the flight crew. Stationed in the cockpit, he/she gives pertinent instructions over the intercom and provides general assistance to the experimenters.

One or two technicians accompany each flight to operate the data system and to service the intercom and power systems, if necessary. They may be available to assist experimenters with limited in-flight repairs. A photo technician is available to operate WFF camera equipment, when necessary.

8.5.2: Flight Planning

General flight plans are developed before the start of the flight period. Experimenters shall develop desired plans and acceptable alternates in consultation with the Mission Manager/Director and PIC. Flight planning can be a lengthy process and may require several iterations to develop a plan satisfactory to all personnel concerned. In addition, flight over foreign countries requires approval of specific flight plans by the host country well in advance (at least two months) of the actual flight period.

Selection of a specific flight plan shall be made at least one day in advance, or in accordance with guidelines developed for each specific mission. This will allow the flight planners time to incorporate minor changes, update weather information, and obtain clearance, prior to pilot review and approval. A flight plan including positions, headings, airspeed, and altitude is developed for each segment of the flight. Additionally, a vector map of the route of flight, and when required, an altitude-profile, can be provided.

8.5.3: Logistics

Logistical considerations (notice of flight times, flight lunches, and off-base operations) are briefly outlined in the following text.

8.5.3.1: Flight Times

A notice will be posted in the experimenter integration rooms, and on the aircraft, giving the time and date of each flight. It will also state the time for power-up and door closing. The aircraft door is closed well in advance of the take-off to permit necessary checks to be made. Any experimenter not on board by that time will miss the flight.

8.5.3.2: Flight Lunches

Experimenters are responsible for their own lunches. However, the aircraft galley may be provisioned for flights originating from locations where the purchase of a bag lunch by an individual is inconvenient. This will be announced prior to the flight. Bottled water, coffee, tea, packages of instant soup, and a microwave oven are available in the galley area at the rear of the main cabin.

8.5.3.3: Deployed Operations

Experiment installation and checkout are completed at WFF before transit to a deployment site, but under special circumstances field integrations may be possible (see section 7.8). Whenever possible, experimenters and their support team members will be accommodated on this transit flight. However, as the ground crew may also be on the transit flight, it may be necessary to limit team size. Some participants may be required to fly commercially to the deployment site. The Mission Manager/Director will assign available space for experimenter teams on the P-3. Experimenters' baggage is hand carried aboard the aircraft. Each piece shall be weighed and identified with the owner's name.

Within size and weight limits, which vary for each mission, experimenters may carry spare parts for their experiments on the aircraft. Special arrangements through the Mission Manager/Director can be made for shipping larger amounts of spare equipment and supplies. However, it is the responsibility of the experimenter to arrange for payment, pickup, and delivery of equipment, which will not fit on the aircraft, to the deployment site in a timely fashion. Experimenters are limited to 50 lbs of personal carry-on items on the aircraft. This includes, but is not limited to, luggage, laptops, briefcases, coats, cameras, etc. Experimenter supplies (tool boxes, etc.) are not included in this 50 lbs but should be kept as light and small as possible.

WFF Aircraft Office and/or WFF Range and Mission Management Office normally make arrangements for housing, group transportation at deployment sites, and for customs inspections in foreign countries. The Mission Manager/Director will publish details of these arrangements, including visa and passport requirements, in an experimenters' bulletin.

8.5.3.4: Housekeeping Considerations

Experimenters are responsible to pick up and clean up after themselves. Tools, while not in use, shall be properly stowed and trash or debris must be disposed of each day.

8.5.3.5: Post-Flight Activities

When the flight period is completed, one or two days are scheduled for removal of experiments under the supervision of the Operations Engineer.

Equipment can be removed rack by rack, or by hand-carrying the various components, at the experimenter's discretion. Equipment is then returned to the experimenter integration rooms where research teams pack it for return shipment. Once the experiment team completes the packing, the experimenter shall arrange for transport.

The Mission Manager/Director will hold a mission debriefing to review results, complete requests for aircraft systems data, and to arrange for post-mission science reviews, if required. The Mission Manager/Director will also provide any mission related data held in the WFF Aircraft Project Office archive, upon request. Conversely, the Aircraft Office requests that a copy of any published research results be sent to the Aircraft Office, in order that science accomplishments may be documented. A customer satisfaction survey, supplied by the Mission Manager/Director, is also required from each experiment team at the completion of a mission to provide feedback concerning their Wallops and P-3 flight experience.

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Chapter 9: Ground Operations

9.1: Facilities

The experiment integration rooms are located in Hangar N-159. These rooms provide an area for assembly and checkout of experiments before their installation on the aircraft. Incoming equipment is delivered to this point. The Mission Manager/Director will provide supplies and other routine services on request.

The Mission Manager/Director will arrange engineering, fabrication, and safety resources, as needed, to support mission activities. The staff includes a P-3 Operations Engineer who can assist the experimenter with the interface of equipment to the aircraft. The Operations Engineer is responsible for the airworthiness of the aircraft, the proper integration of the payload, and experiment inspection issues. The Operations Engineer is available for questions regarding aircraft ground operations, airworthiness approvals of experimenter equipment, and integration issues.

Technicians located in the hangar can assist in the interfaces between the experiments and aircraft systems such as aircraft power, data, and the timing systems. The technicians are assigned to the aircraft, and are not available to support work on experimental equipment or rack hardware. Experimenters should include an electronics and mechanical technician on their team, if the need for such assistance is anticipated during experiment assembly and checkout. For special needs, it is not unusual for experimenters to arrange for electronics or mechanical support from local suppliers of specific equipment.

The base wide metal fabrication shop at WFF (Bldg. F-10) is equipped to make special mounting hardware with advanced notice. However, unless requirements are discussed, and agreement reached during the early planning phase with the Operations Engineer, it is assumed that the experimenter will provide such items.

NOTE: Shop facility's ability to support short notice requests or requirements may be limited by other priorities.

9.2: Ground Support Equipment

Hangar N-159 provides: 60-Hz, 400-Hz, and 28 VDC power, compressed air, a freezer for photographic film storage, and oscilloscopes. Gaseous and liquid nitrogen and helium are available for cryogenic or other use by advance request to the Mission Manager/Director. The Mission Manager/Director will assure a continuing supply; however, they should be advised well in advance of requirements for additional amounts of liquid helium. Approved fasteners and other equipment mounting hardware are also available but in limited supply.

9.3: Tool Control

Experimenters shall supply their own tools for installation and repair purposes. Tools belonging to the P-3 maintenance/aircrew will not be loaned to experiment teams. All experimenter tools shall be cataloged prior to use. Only the required tools needed to complete a task will be allowed on or near the aircraft and shall be maintained in a tool bag. All tools must be removed from the aircraft after the completion of a task. Any lost tools shall be reported to the Flight Engineer immediately. A lost tool will ground the aircraft until found.

9.4: Access/Badging

Hangar N-159 is open in the morning at 8:00 a.m. and can be made available for evening work. Requests for evening use must be coordinated with the Ops Engineer or maintenance lead prior to Noon each day evening use is needed. Weekend access must be made 48 hours in advance.

NASA requires 3 months notice for visitors badge processing of foreign national visitors. Foreign national visitors are requested to contact the Mission Manager/Director for details on identification documentation that must be provided for screening purposes. U.S. citizens must request visitor access at least 48 hours in advance of their arrival on base for badge processing. U.S. citizens who arrive without a visitors badge awaiting them will require escorting by a WFF employee each day until a badge is processed. Foreign nationals that arrive without a visitors badge in place will be denied access to the facility. A driver's license or other form of picture identification must be presented with each visitors badge to access the base. Visitors should request afterhours access to the base if they plan to work after 6:00 p.m. on weekdays or on weekends/holidays.

9.5: Safety

At WFF, experimenters work in an environment generally unavailable to the public. The experimenter integration rooms are housed in a large hangar containing a number of aircraft, and it is sometimes necessary to walk through the hangar and on to the ramp area. Therefore, certain safety precautions shall be observed:

- Smoking in the hangar, on the ramp, or in any WFF building is prohibited.
- Look out for cables, hoses, boxes, tow bars, moving vehicles, and movement of the hangar doors when crossing the hangar floor.
- Do not walk directly across the ramp. Travel along the edges of the ramp when entering or exiting the P-3 outside.
- Do not approach aircraft with engines running. Prop wash is dangerous for a considerable distance behind the aircraft.
- Do not walk between propellers or between the propeller and fuselage when aircraft power is on or the APU is running.
- Wear adequate clothing and shoes that totally enclose the foot.
- Ear protection is required while outside the aircraft when engines or APU are running.
- No electric drills or other tools with universal electric motors shall be used in the aircraft.
- Only small, pencil-type soldering irons and electronic-grade rosin-core solder shall be used on the aircraft but not in flight.
- No high wattage heat guns are permitted on the aircraft. If it becomes necessary to heat shrink insulation, the material shall be taken into the experimenter integration rooms, where such treatment can be performed safely.
- No volatile solvents of any kind are permitted without prior approval of the Ops Engineer.
- Two or more persons must be present in the hangar at all times when work is being performed.

IN AN EMERGENCY: **If a WFF employee is not available for immediate assistance, dial this number from any phone:**

911

For Emergency Aid

Fire, Accident, Etc.

This emergency number is available at any hour. Callers should also be able to describe their location, so emergency help can respond promptly.

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Appendix A: Payload Information Form

NASA Airborne Science Program (ASP)
Payload Information Form (PIF)

I. General Information

1. Principal Investigator & Team Members (if citizenship is not U.S., please note if they have a green card):

Name	Organization	Citizenship	Role	Phone Number	Fax Number	Email Address

2. Payload Information

Instrument name and acronym	
Instrument and/or PI website	
What does the instrument measure?	
Aircraft type	
Mission/Program name	
Desired location on aircraft, if known	
Dimensions of major components (inches)	
Total weight (pounds)	
Control method (aircrew switches, onboard researcher, fully autonomous, uplink/downlink)	
Do you require real time aircraft state parameters (time, nav data, etc.)?	
Telemetry/satcom requirements	
Previously flown on this or other aircraft? List last several missions flown and on which aircraft.	
If so, have there been any changes since last flown?	

3. Aircraft Power Requirements

	Power (watts)	Load name	Peak current	Run current	Comments
115V, 60 hz single phase					
115V, 400 hz single phase					
115V, 400 hz three phase					
28V DC					
Other (208, etc.)					

II. Hazardous Materials/Equipment

All gases, cryogens, and chemicals are user supplied unless otherwise arranged. MSDS will be required prior to arrival.

1. Lasers

Laser type	Laser class	Laser wavelength	CW Output power/energy	Pulsed Output (pulse width, repetition rate)	Airborne or ground use	Transmitting external to A/C? NOHD, if known.

2. Radioactive Materials

Source	Half-life	Quantity

3. Radio Frequency Emitters

Description	RF power	Frequency range	Operational constraints	Installation constraints

4. Radio Frequency Susceptibility

Description	RF power	Frequency range	Operational constraints	Installation constraints

5. Pressure Vessels

Description (purpose, contents)	Internal volume	Vessel pressure (psi)	Installation constraints

6. Compressed Gases

Gas description with mixture/concentration	Cylinder internal volume	Cylinder pressure	Number of cylinders (on A/C)	How often serviced?	Airborne or ground use	Specific hazard? (Toxic, flammable, corrosive, etc.)

7. Chemicals **(solids and liquids)**

Description (name, concentration)	Quantity on ground	Quantity on aircraft	Container description	In-flight handling required?	Specific hazard? (Toxic, flammable, corrosive, etc.)

8. Cryogens

Material description	Container description	Quantity on aircraft	Daily Usage Rate	In-flight handling required?	Installation constraints

9. Motors/Pumps

Description	Manufacturer name / model number	Motor type (capacitor start, brush-less, explosion proof)

10. Heaters

Description (system components, location)	Manufacturer name/model number	Maximum control temperatures	Maximum exposed temperatures	Control Method

11. Chillers

Description (system components, location, fluid medium, capacity)	Manufacturer name/model number	Control Method

12. Batteries & Uninterruptible Power Supplies

Description (type, location)	Capacity (Voltage & Power)

13. Aircraft Power Distribution, Converters, and Strips

Manufacturer and Model Number	Description of Use

III. Aircraft Installation Requirements

1. Aircraft Modifications

Modification Required	NASA design support required?	NASA fabrication support required?	Non-NASA Design/Fab Provider

2. Probes/Inlets

Description	Current location and ownership of inlet/probe	Preferred location on A/C	Alignment (with aircraft, with free stream, etc.)	Special installation constraints

3. Exhaust Ports

Description	Current location and ownership of exhaust port	Preferred location on A/C	Content/Quantity of exhaust	Special installation constraints

4. Optical Windows and Viewports

Optical window or viewport size	Certification or NASA serial number (if any)	Current location and ownership of window	Preferred location on a/c	Optical bandpass	Preferred material and coating	Window cleaning requirements	Special installation constraints

5. Antennas

Description (Manufacturer & Model)	Antenna size	Preferred location on A/C	Antenna orientation	RF power	RF frequency	Special installation constraints

6. Equipment/Inlet Coverings or Shields

Description	Operational requirements	Special installation constraints

7. Operator Station Requirements, if applicable

Number of seats	Operator console requirements at seat location	Access to instrument	Frequency of access	Other

8. Government Furnished Equipment (pods, racks, pallets, etc.)

Type (pod, rack, pallet)	Description (low rack, superpod forebody, 3' unpressurized pallet, etc.)	Delivery to PI needed? If so, when?

9. Special Equipment (List any other equipment required)

IV. Operations

1. Aircraft Access

Pre-flight payload time required at aircraft	
Post-flight power/instrument removal time required	
Special aircraft access, power, or environmental conditioning requirements	

2. Aircraft Maneuvers

Describe in-flight calibration maneuvers	
Describe flight altitudes and ascent/descent rates	
Pitch, roll, and yaw limits	
Describe airspeed/mach regime and limitations	
Prohibited flight conditions	

3. Ground Work Space Requirements

Assume all gases, cryogens, and chemicals are user supplied unless otherwise arranged. MSDS will be required.

Space requirements (square feet)	
Tables	
Chairs	
Power (type and amount)	
Network connections	

Gases & cryogens (cylinders needing storage space, special requirements)	
Chemical storage needs (haz mat locker, refrigerator, etc.)	
Exhaust/fume hood requirements	
Special needs (i.e., location relative to other experimenters, wet lab requirements, etc.)	
Items that require storage (i.e., empty boxes, electrical equip, chemicals)	
Amount of storage space required (sq ft of floor space)	

V. PI Revision Control

Date	Author	Sections Modified	A/C Issued to	Reason for Modification

VI. Comments

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Appendix B: Payload Data Package Requirements

B: Introduction

The Payload Data Package 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 Payload Data Package has been submitted must be approved by the P-3 Ops Engineer and/or Mission Manager/Director through submitted documentation of the change.

The Payload Data Package format is below:

1. Cover Page
2. Quick Reference Data Sheet
3. Table of Contents
4. Proposed Mission Profile and Flight Schedule
5. Payload Description
6. Installation Drawings and Analysis
7. Welding
8. Batteries
9. Uninterrupted Power Supplies (UPS)
10. Motors and Pumps
11. Electromagnetic Interference
12. Pressure/Vacuum Systems
13. Heaters
14. Chillers
15. Laser Systems
16. Gases
17. Cryogens
18. Radiation Sources
19. Hazardous Materials
20. Hazard Analysis
21. Ground Support Requirements
22. Mission Procedures

B.1: Cover Page

The cover page to the Payload Data Package shall contain the principal investigator's name, research organization and contact information (email address, phone number, and mailing address), the payload or mission name, and the date the package was submitted.

B.2: Quick Reference Data Sheet

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

P-3 Payload Quick Reference Data Sheet

Note: Please Address Each Payload Separately

Principal Investigator:

Contact Information:

Payload/Mission Name:

Mission Profile/Number of Flights Requested:

Requested Flight Date(s):

Payload Installation Location on Airplane (e.g. bomb bay, nadir port, window, etc.):

Number of Seats Requested (PCF's, Transit, Mission Flights):

Number and Type of Racks Requested:

Payload Overall Assembly Weight (pounds):

Gas/Cryogenic Cylinder Usage (type and quantity):

List any Hazardous Materials to be used (include quantity):

Overboard Vents Requests (Yes or No) and Type of Gas to be Vented:

Payload Power Requirements (Voltage and Current Required):

Ground Laboratory Work Space Requests (including storage requests):

Computer Network Access Requests (names of people):

Design Support Request:

Fabrication Support Request:

Electrical Wiring Request:

Miscellaneous Request:

B.3: Table of Contents

In the Table of Contents, list the sections of the Payload Data Package and their corresponding page numbers.

B.4: Proposed Mission Profile and Flight Schedule

The proposed Mission Profile and Flight Schedule section shall address the type of flights being requested (where, how high, maneuvers, etc.), 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.

B.5: Payload Description

The Payload Description section shall briefly explain the payload design and objective, and 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.

Any laser, fluid, chemical, gas, RF transmission, and/or pressure vessel system should be described. Any component with special handling requirements or specific hazards must also be described in detail.

B.6: Installation Drawings and Analysis

B.6.1: Mechanical/Structural

Include drawings and/or photographs of the payload, its overall weight and CG location, and a proposed dimensional layout of the equipment in the aircraft. Experimenters are required to submit detailed drawings of all equipment to be modified or fabricated, showing dimensions, materials, fastener types and patterns, and component weights. Two dimensional drawings (Autodesk AutoCAD format preferred) or 3D models (Autodesk Inventor format or .stp files preferred) of the instruments or components to be mounted to the aircraft are most helpful. Stress calculations, if available, must accompany the drawings and include an analysis of the support tie down structure and fasteners.

B.6.2: Aerodynamic

Provide any available aerodynamic analysis.

B.6.3: Modal

Provide any vibration modal analysis that is available. If an investigator knows the natural frequency of their installation that shall be provided even if a modal analysis is not available.

B.6.4: Thermal

Provide any available thermal analysis.

B.6.5: Racks and Non-Standard Mounts

The experimenter must submit a functional block diagram of the experiment, scaled and dimensioned layouts (panel height and depth) of equipment mounted in standard or experimenter supplied racks. Photographs of existing equipment are desirable. A rack weight/moment spreadsheet must be completed to determine maximum tip-over moment and rack weights. The completed spreadsheet should be included in this section. For any non-standard rack-mounted installations detailed drawing and analysis for those installations must be provided if available.

B.6.6: Electrical

Detailed electrical drawings are required for any installation that will be interfacing into permanent aircraft systems excluding the standardized experimenter power outlets located throughout the aircraft. Pin-to-pin drawings with connector and wire information shall be provided for all cables that an experimenter wishes WFF to fabricate. Experimenters are required to submit a power breakdown (such as 60 Hz, 400 Hz, single-phase, three-phase) by component for each standard rack, and any other installation elsewhere in the aircraft. A top level electrical block diagram is required showing the design layout and functionality of the installation.

B.7: Welding

In the Welding section the experimenter shall provide the following items for all welds, excluding those in the main cabin area:

- Provide proof that that welder is certified to AMS-STD-1585 and performed the weld in accordance with SAE-AMS-STD-2219.
- If the weld inspection is not performed at WFF then provide proof that a certified weld inspection was performed.

B.8: Batteries

The Battery section shall provide the following items for each battery used:

- Vendor battery specification
- MSDS for battery
- Electrical schematic showing how the battery is used in the installation along with circuit protection, the location of the on/off switch, wire size and wire material.

B.9: Uninterrupted Power Supplies (UPS)

The UPS section shall provide the following items for each UPS used:

- MSDS for battery installed
- If “Battery Isolation” switch is not integral to the unit when purchased then an electrical schematic is required showing the installation of the battery switch.
- If the battery is of the type that requires periodic maintenance, provide documentation that traces the last battery installation date and subsequent UPS use and maintenance history.
- Provide a copy of the owner’s manual if a COTS UPS is used.
- Circuit schematics are required if an experimenter-built UPS (non-COTS) will be used including “Battery Isolation” switch, wire size, and wire material.

B.10: Motors and Pumps

The Motor and Pumps section shall provide the following items for each motor/pump used:

- Provide a copy of the owner's manual for all COTS motors and pumps used.
- Provide starting (inrush) current magnitude/time scale.
- Provide an electrical schematic showing the electrical circuitry from the motor/pump power source to the motor/pump, including all over current and thermal protection devices, wire size, and wire material.

B.11: Electromagnetic Interference

For all RF emitters used in flight payloads and/or on the ground, the following information shall be provided in the Electromagnetic Interference section of the Payload Data Package:

- List of all frequencies (transmit and receive)

A Frequency Utilization form shall be completed before any emitter can begin initial transmitting. Contact the P-3 Mission Manager/Director for more information.

B.12: Pressure and Hydraulic Systems

The Pressure and Hydraulic Systems section shall provide the following items for each pressure/hydraulic system used:

- A diagram from source to exit showing the type of gas/liquid, operating pressure(s) and Maximum Allowable Working Pressure (MAWP), in-line device descriptions with manufacturer's compatibility specifications, settings for all relief valves, tubing specifications including material type and type of pressure vessel (cylinder size) used.
- MSDS for each gas/liquid type
- Describe the volume of gas stored on the ground and/or the aircraft and purpose of usage and how the gas will be handled on the ground and/or in-flight.
- Proof of pressure test certification, if not done by WFF, of all gauges and relief valves.
- Design and test reports for custom built pressure vessels. Contact the Ops Engineer for more details.

B.13: Heaters

The Heaters section shall provide the following items for each heater used:

- An electrical schematic showing the heater, the temperature controller, fuses or circuit breakers, the power supply, the wire size and wire material between the components.
- Provide product literature for the components of the assembly (heater, controller, temperature sensor, etc.)
- Provide a description of the location and function of the heaters. A sketch showing the location of the heaters in relation to instruments and/or probes is required.

B.14: Chillers

The Chillers section shall provide the following items for each chiller used:

- An electrical schematic showing the chiller, the temperature controller, fuses or circuit breakers, the power supply, the wire size and wire material between the components.
- Provide product literature for the components of the assembly (chiller, controller, temperature sensor, etc.)
- Provide a description of the location and function of the chiller. A sketch showing the location of the chillers in relation to instruments and/or probes is required.

B.15: Laser Systems

For all lasers used in flight payloads and/or on the ground, the following information shall be provided in the Laser Systems section of the Payload Data Package:

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

Various laser forms shall be completed and submitted to the appropriate government agency before lasing. Contact the P-3 Mission Manager/Director for more information.

B.16: Gases

In the Gases section investigators shall provide a copy of all MSDS's for gases to be used in the experiment and a description of containment of gas and how the gas will be handled on the ground and/or in-flight. Proof of hydrostatic certification is required for all secondary containment vessels. Gases described in the Pressure/Hydraulics section are exempt from this section.

B.17: Cryogens

The Cryogens section shall provide the following items for each cryogenic system used:

- A diagram from source to exit showing the type of cryogen, operating pressure(s) and Maximum Allowable Working Pressure (MAWP), in-line device descriptions with manufacturer's compatibility specifications, settings for all relief valves, and tubing specifications including material type.
- MSDS for each cryogen type.
- Describe the volume of cryogen to be stored on the ground and/or aircraft and purpose of usage.
- Proof of pressure test certification, if not done by WFF, of all gauges and relief valves.
- Design and test reports for custom built pressure vessels. Contact the Ops Engineer for more details.

B.18: Radiation Sources

The Radiation Sources section shall provide the following items for each radiation source used:

- MSDS for each material.
- Description of containment of material and how material will be handled on the ground and/or in-flight.

B.19: Hazardous Materials

Please state whether or not you will be using any toxic, corrosive, explosive, and/or flammable materials. Describe what that material is, how it will be used, and quantities being used. Please describe how you plan to safely contain and handle any hazardous materials. A current MSDS shall be supplied for each hazardous material.

B.20: Hazard Analysis

A hazard analysis shall be provided in the Payload Data Package to document the review and implemented control of hazards associated with a specific payload. Reference the hazard checklist below. If any of the hazards listed pertain to your experiment, describe the hazard and explain the controls that exist 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. NASA will analyze this hazard and make a decision on risk acceptance. NASA reserves the right to declare a hazard due to an experimenter's system even if the experimenter disagrees.

Hazard Source Checklist

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

_____ Toxic/corrosive/hot/cold material, fluid (liquid, vapor, gas)

_____ High pressure system or cylinders (static or dynamic)

_____ Evacuated container (implosion)

_____ Frangible material

_____ Stress corrosion susceptible material

_____ Inadequate structural design (i.e., low safety factor)

_____ High intensity light source (including laser)

_____ Ionizing/electromagnetic radiation

_____ Rotating device

_____ Extendable/deployable/articulating experiment element (collision)

_____ Stowage restraint failure

_____ Stored energy device (i.e., mechanical spring under compression)

_____ Vacuum vent failure (i.e., loss of pressure/temperature)

_____ Heat Transfer (habitable area over-temperature)

_____ Over-temperature explosive rupture (including electrical battery)

____ High/low touch temperature

____ Hardware cooling/heating loss (i.e., loss of thermal control for heaters or chillers)

____ Pyrotechnic/explosive device

____ Propulsion system (pressurized gas or liquid/solid propellant)

____ High acoustic noise level

____ Toxic off-gassing material

____ Mercury/mercury compound

____ Organic/microbiological (pathogenic) contamination source

____ Sharp corner/edge/protrusion/protuberance

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

____ High static electrical discharge producer

____ Software error or computer fault

____ Carcinogenic material

____ Below cabin floor servicing of hardware

____ Rapid depressurization of aircraft (optical windows)

____ Uninterrupted power supply (UPS)

____ Transfer of a gas or liquid in flight

B.21: Ground Support Requirements

In this section of the Payload Data Package, the investigator shall describe what will be needed in terms of ground support equipment. Please address the following:

- Type of ground power needed for testing/operating research equipment.
- 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.
- State whether or not 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?
- Working hours/access to Building N-159. Will you need access to N-159 during hours other than normal business hours (8:00 a.m. -4:30 p.m., M-F)?
- Laboratory space requested. Working and storage.
- Requests for special ground handling/support equipment (e.g., forklift, crane, etc.).
- Miscellaneous requests.

B.22: Mission Procedures

The information presented in this section of the Payload Data Package shall describe all the procedures involved with operating your experiment at Wallops or at a remote deployment site. These procedures should be broken down in the following order:

B.22.1: Equipment Shipment

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

B.22.2: Ground Operations

State the procedures proposed to set up, test and operate your equipment on the ground at Wallops. This includes testing outside and inside the aircraft while on the ground.

B.22.3: Loading

State the procedures proposed to load and integrate your equipment onto the P-3.

B.22.4: Preflight

State the procedures proposed for preflight operations. Please include the amount of time power is needed on the aircraft to complete your preflight activities.

B.22.5: Post-Flight

State the procedures proposed for readying equipment for the following flight. Please include the amount of time power is needed on the aircraft to complete your post-flight activities.

B.22.6: Off-Loading

State the procedures proposed for off-loading your payload from the P-3. State the shipping arrangements that have been made for removal of equipment from NASA property.

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Appendix C: Rack/Mounting Locations

NASA Wallops Flight Facility
P-3 Orion Rack Tip Over Analysis Worksheet

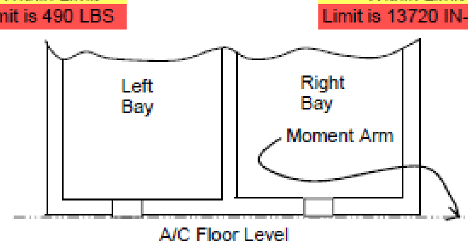
Mission:		Date:	
Experimenter:		Rack Type:	DOUBLE RACK
Rack Location: FS	Left / Right	Rack S/N:	

RIGHT SIDE BAY			
ITEM	Weight (LB)	MOMENT ARM (IN)**	MOMENT (IN * LBS)
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
TOTALS:	0 LB	TOTALS:	0 IN-LB
	Within Limit		Within Limit
	Limit is 490 LBS		Limit is 13720 IN-LBS

LEFT SIDE BAY			
ITEM	Weight (LB)	MOMENT ARM (IN)**	MOMENT (IN * LBS)
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
TOTALS:	0 LB	TOTALS:	0 IN-LB
	Within Limit		Within Limit
	Limit is 490 LBS		Limit is 13720 IN-LBS

** Measurements entered in this form are taken from the moment arm reference shown in the diagram to the right.

*** Include any items mounted on top of rack within the column for the respective bay that is it mounted over



7/9/2010 Double Rack Tipover Moment Calculation Worksheet.xls

Figure C-1: Double bay rack tip over analysis spreadsheet

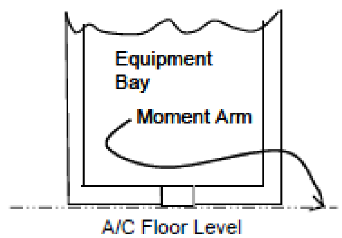
NASA Wallops Flight Facility
P-3 Orion Rack Tip Over Analysis Worksheet

Mission:		Date:	
Experimenter:		Rack Type:	SINGLE RACK
Rack Location: FS	Left	Rack S/N:	
	Right		

ITEM	Weight (LB)	MOMENT ARM (IN)**	MOMENT (IN * LBS)
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
TOTALS:	0 LB	TOTALS:	0 IN-LB
	Within Limit		Within Limit
	Limit is 500 LBS		Limit is 14000 IN-LBS

** Measurements entered in this form are taken from the moment arm reference shown in the diagram to the right.

*** Include any items mounted on top of rack within the column for the respective bay that is it mounted over



7/9/2010 Single Rack Tipover Moment Calculation Worksheet.xls

Figure C-2: Single bay rack tip over analysis spreadsheet

NASA Wallops Flight Facility
P-3 Orion Rack Tip Over Analysis Worksheet

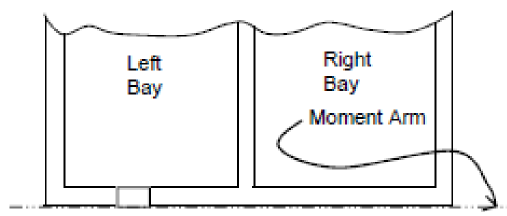
Mission:		Date:	
Experimenter:		Rack Type:	OLD DOUBLE RACK
Rack Location: FS	Left	Rack S/N:	
	Right		

RIGHT SIDE BAY			
ITEM	Weight (LB)	MOMENT ARM (IN)**	MOMENT (IN * LBS)
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
TOTALS:	0 LB	TOTALS:	0 IN-LB
	Within Limit		Within Limit
	Limit is 345 LBS		Limit is 9660 IN-LBS

LEFT SIDE BAY			
ITEM	Weight (LB)	MOMENT ARM (IN)**	MOMENT (IN * LBS)
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
			0
TOTALS:	0 LB	TOTALS:	0 IN-LB
	Within Limit		Within Limit
	Limit is 345 LBS		Limit is 9660 IN-LBS

** Measurements entered in this form are taken from the moment arm reference shown in the diagram to the right.

*** Include any items mounted on top of rack within the column for the respective bay that is it mounted over



7/9/2010 Old Double Rack Tipover Moment Calculation Worksheet.xls

Figure C-3: Old style double bay rack tip over analysis spreadsheet

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Appendix D: Data/Navigation Parameters

Table D-1: Data/navigation parameters

Parameter	Parameter Name	Units	Source	Signal
Universal Time	UTC_Time	Seconds	GPS	IRIG-B
Pressure Altitude	FMS_ALT_PRES	Feet	FMS	ARINC-429
True Air Speed	FMS_TAS	Knots	FMS	ARINC-429
Static Air Temp.	FMS_SAT	°C	FMS	ARINC-429
Latitude	FMS_LAT	Degrees	FMS (GPS)	ARINC-429
	IRS_LAT	Degrees	IRS	ARINC-429
Longitude	FMS_LAT	Degrees	FMS (GPS)	ARINC-429
	IRS_LAT	Degrees	IRS	ARINC-429
Ground Speed	FMS_GS	Knots	FMS	ARINC-429
True Heading	FMS_HDG	Degrees	FMS	ARINC-429
Platform Heading	IRS_HDG	Degrees	IRS	ARINC-429
Track Angle	FMS_TRK	Degrees	FMS	ARINC-429
N/S Velocity	NS_Vel	Knots	IRS	ARINC-429
E/W Velocity	EW_Vel	Knots	IRS	ARINC-429
Wind Speed	FMS_WNS	Knots	FMS	ARINC-429
Wind Direction	FMS_WND	Degrees	FMS	ARINC-429
Pitch	IRS_PITCH	Degrees	IRS	ARINC-429
Roll	IRS_ROLL	Degrees	IRS	ARINC-429
Vert Acceleration	IRS_VERT_ACC	G	IRS	ARINC-429
	A_VertAcc	G	Analog Sensor	Analog
Total Temperature	A_TotalTemp	°C	Rosemount 102 Probe	Analog
Cabin Pressure	A_CabinPressure	PSIA	Druck Transducer	Analog
Pressure Altitude	A_PressureAlt	Feet	Rosemount Transducer	Analog

Dew/Frost Point	A_DewPt	°C	GE1011B Hydrometer	Analog
Static Pressure	MADT_StaticPress	Mb	MADT 2014 Digital Transducer	ARINC-429
Impact Pressure	MADT_DiffPress	Mb	MADT 2014 Digital Transducer	ARINC-429
Surface Temperature	Surf_Temp	°C	Heimann Pyrometer	Analog
Static Air Temp	C_StatTempDegC	°C	Derived from measured parameters	Calculated
Potential Temp	C_PotTempDegK	K		Calculated
Cabin Altitude	C_CabAltitude	Feet		Calculated
Vapor Press (water)	C_VaporPressWater	Mb		Calculated
Vapor Press (ice)	C_VaporPressIce	Mb		Calculated
Relative Humidity	C_RelHum/Water	%		Calculated
Mixing Ratio	C_MixRatio	g/kg		Calculated


P-3 RESEARCH PLATFORM
NASA
Wallops Flight Facility
GSFC