APPENDIX A
NNG10339285R

P-3B Orion (N426NA)

P-3B Design Requirements

548-RQMT-0001

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National Aeronautics and Space Administration

Approval: [signature]
P-3B Operations Engineer

Goddard Space Flight Center
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Wallops Island, Virginia

CHANGE HISTORY LOG

Effective Date	Revision	Page(s) affected	Description of Changes
Aug. 2009	Baseline		Baseline

P-3B DESIGN REQUIREMENTS

1: General Designs

The design of aircraft systems and equipment installation for use onboard the P-3 Airborne Laboratory shall follow good standard aircraft industry design practice. In addition, for aircraft and aircraft systems modifications, current FAA certification standards are to be met to the maximum extent practical, consistent with the intended mission of the aircraft. All NASA and WFF standards, requirements, and directives governing aircraft, aircraft modifications, and aircraft operations shall be met.

Acceptable and certified aircraft materials and hardware shall be used for all aircraft and aircraft systems modifications, as well as for major and significant structures related to experimenter instrumentation (i.e. racks, instrument supports, platforms, pallets, etc.). Designs shall emphasize satisfying performance requirements while minimizing weight, drag, and cost. Each design shall have an accompanying stress analysis, report, or statement, commensurate with the magnitude of criticality and complexity of the system, to show conformance with the requirements in this document. Modifications which affect existing aircraft structure or systems shall be well documented and all possible effects of changes or additions shall be considered in the design process. Revisions to affected manuals, procedural lists, inspection documents, etc. must be followed through.

Deviations, exceptions, and one-time waivers of the requirements in this document constitutes acceptance of risk above normal operations and shall be evaluated by the Airworthiness Flight Safety Review Board (AFSRB) as to determine the proper level of review required. Approvals from such reviews must be obtained prior to placing the article or system in place.

2: Mechanical Design Requirements

2.1: General Considerations

Design of aircraft structure and structures for aircraft applications shall take into account actual and worst case loading criteria such as air loads, landing loads, crash loads, ditching loads, takeoff loads, fuselage pressurization loads, gust loads, weight and inertia loads, etc. In reference to these aircraft loads, the following definitions apply:

"Limit or applied loads are the maximum loads anticipated on the airplane during its lifetime of service. The airplane structure shall be capable of supporting the limit loads without suffering detrimental permanent deformations. At all loads up to the limit loads, the deformation of the structure shall be such as not to interfere with the safe operation of the airplane."[1]

Unless otherwise specified, a factor of safety of 2 must be applied to the limit load and where applicable a fitting form factor of safety should be used and provided in the analysis. A lower factor of safety between 2 and 1.5 can be used if load testing is performed on the structure before flight. A factor of safety of less than 1.5 is not allowed.

When ultimate loads are used, a factor of safety need not be applied to the limit loads. At ultimate load, the structure may yield but must not fail.

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[1] Definition extracted from Bruhn, "Analysis and Design of Flight Vehicle Structures", Jacobs Publishing, Inc., 1973.

The term margin of safety is used to evaluate the safeness of a member. The equation below shows the computations for the margin of safety (*MS*). It is determined by multiplying the design limit stress by the appropriate factor of safety and comparing it to either the yield or ultimate material allowable stress using the following equation:

$$MS = \frac{allowable\ stress}{FS\ x\ actural\ stress} - 1$$

When two or more loads (such as shear, tension, compression, bending, or torsion) act simultaneously, the margin of safety may need to be computed using interaction formulas.[2] Below is the accepted Wallops form of the interaction equation:

$$\left(\frac{(FS) * shear}{shear\ allowable}\right)^3 + \left(\frac{(FS) *\ tension}{tension\ allowable}\right)^2 = 1$$

$$MS = FS - 1$$

The allowable stress shall take into consideration factors such as stress concentrations and fatigue, as well as additional factors of safety required for particular applications where certain unknowns may warrant additional conservatism. High factors of safety are typically used in the design of pressurized components, fittings, castings, welding, windows, composite constructions, etc., and in areas where failure of a component would pose significant risk to personnel or property.

2.2: Applied Loads and Condition

Equipment and its installation must be independently strong enough to withstand the loading conditions specified below. Additional requirements for specific designs are covered in the structural design criteria for the P-3 and by the applicable CARs and FARs. The following loads and conditions are not all inclusive.

2.2.1: Cabin Pressurization [3,4,5]

The pressurization loads used in design are shown in

Table *1*. In general, structures designed to withstand cabin pressurization shall be designed to ultimate pressure (2*P*) plus flight loads and aerodynamic pressure or suction effects. For designs where weight is a factor, and where a detailed analysis is provided for the modification and surrounding aircraft structure, the ultimate pressure can be reduced to 1.5*P* plus flight loads and aerodynamic pressure and hoop tension data. See Section. 2.2.10 and its references for aerodynamic loads.

An ultimate radial inward acting pressure of 1 psi shall be used for doors and window blanks. Ditching loads shall also be considered where applicable per Section 2.2.8.

[2] Refer to MIL-HNBK-5, Rev. E, sections 1.3.3 and 1.5.3.5. Note: MIL-HNBK-5 has recently been superseded by the Metallic Materials Properties Development and Standardization (MMPDS) document, at the time of this writing the most current revision is DOT/FAA/AR-MMPDS-02.

[3] Refer to Lockheed Report 13167, "Part IV – Structural Design Loads – Fuselage", pg 4.175

[4] Refer to Federal Aviation Administration, DOT, 14CFR Chapter 1 (1-1-89 Edition), FAR 25.365.

[5] Refer to CAR 4b.

Table 1. 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 (1.33*P*)	7.97
Design Ultimate Pressure (2*P*)**	11.98

* Refer to Lockheed Report 13167 "Part IV Structural Design Loads – Fuselage", pg 4.175.

** Corresponds to ground pressure test required for aircraft certification under CAR 4.b.216 and FAR 25.365.

2.2.2: Suction Pressures

Suction pressures are used in conjunction with the loads for any flight condition including the corresponding fuselage internal pressure. Lockheed Report 13167 "Part IV Structural Design Loads – Fuselage", page 4.178 (Attachment 1) presents graphically the external suction pressures for the entire fuselage surface from FS288 aft to the rear pressure bulkhead located at FS1117. These pressures are average pressures over relatively large local areas. In the case of local areas such as for the design of cut-outs, doors, hatches, etc. then the pressures presented below in Table 2 are used. These pressures are the maximum obtainable local values for each region considered and are considered limit loads.

Table 2. External pressures on fuselage cut –outs. *

Fuselage Station	Location	Delta Pressure
F.S. 218.4 – 238	Stringers 41-46	-1.67 psi
F.S. 248 – 261.18	Stringers 46 – 48	-1.42 psi
F.S. 264.82 – 288	Stringers 41 – 46	-1.22 psi
F.S. 270 – 288	Air Conditioning Access	-1.22 psi
F.S. 288 – 323	Air Conditioning Exhaust	-1.42 psi
F.S. 390 – 398	Bomb Hoist Access	-0.51 psi
F.S. 496 – 508.66	Stringers 46 – 48	-1.0 psi
F.S. 483.33 – 496	Fuel Pump Access	-1.0 psi
F.S. 553 – 570.97	Control Cable Access	-3.0 psi
F.S. 534 – 548.66	Bottom Centerline	-3.0 psi
F.S. 553 – 570.97	Bottom Centerline	-3.0 psi

* Refer to Lockheed Report 13167 "Part IV – Structural Design Loads – Fuselage", pg 4.173.

2.2.3: Vibration [6]

Equipment to be mounted anywhere on the aircraft (interior or exterior) should be capable of withstanding a 68Hz natural frequency produced by the aircraft. This frequency is produced primarily by propeller blade passage. It is most noticeable in the propeller's plane of rotation. An audible buzzing and/or beat is created in addition to a vibration that can be felt in the deck. The level of excitations at 68Hz varies widely and is dependent on several factors, namely, indicated airspeed, propeller inflow angle, propeller blade tip Mach number, and especially, propeller synchrophaser operations. Propeller blade passage pressure pulsations can induce vibrations in loose or improperly attached structural items. Sensitive items should be vibration isolated if at all possible.

2.2.4: Emergency Landing Criteria for Passenger and Crew Compartments [7,8]

The emergency landing loads used for the design of equipment located in the main cabin are shown in Table 3. The supporting structure must be designed to restrain, under all loads up to those specified, each item of mass that could injure an occupant if it came loose in a minor crash landing. Emergency landing loads act independent and do not need to be combined with other loads such as suction and pressure loads.

[6] Refer to "P-3 Aircraft Vibration" pamphlet
[7] Refer to "P-3B (N426NA) Crash and Gust Load Criteria Change" memo dated 11/23/2007
[8] Refer to Federal Aviation Administration, DOT, 14CFR Chapter 1 (1-1-89 Edition), FAR25.561.

Seats and items of mass (and their supporting structure) must not deform under any loads up to those specified above in any manner that would impede subsequent rapid evacuation of occupants. In addition, seats shall comply with all applicable FAA design standards as outlined in FAR 25.562.

Table 3. Minimum emergency landing load criteria for the main cabin.*

Load Direction	Ultimate Load Factor (g)
Forward	9.0
Down	6**
Up	2.0**
Lateral	3.0** 4.0 for Seats
Aft	1.5

* Crash load factors based on FAR Part 25.561.

** Flight load factors may exceed the emergency landing criteria requirements, see Section 2.2.9.

2.2.5: Emergency Landing Criteria for Below Cabin Floor Area

The emergency landing loads used for the design of equipment located in the below cabin floor area FS740 to FS960 are shown in Table 4.

Table 4. Minimum emergency landing load criteria for the below cabin floor area.*

Load Direction	Ultimate Load Factor (g)
Forward	3.0
Down	4.5**
Up	2.0**
Lateral	1.5**
Aft	1.5

* Refer to DC-8 Experimenter Handbook.

** Flight load factors may exceed the emergency landing criteria requirements, see Section 2.2.9.

2.2.6: Emergency Landing Criteria for Bomb Bay Area

The emergency landing loads used for the design of equipment located in the bomb bay area are shown in Table 5.

Table 5. Minimum emergency landing load criteria for the bomb bay.*

Load Direction	Ultimate Load Factor (g)
Forward	3
Down	6.5**
Up	3**
Lateral	2.5**
Aft	1.5

* Refer to "P-3B (N426NA) Crash and Gust Load Criteria Change" memo dated 11/23/2007.

** Flight load factors may exceed the emergency landing criteria requirements, see Section 2.2.9.

2.2.7: Emergency Landing Criteria for Cockpit

The emergency landing loads used for the design of equipment located in the cockpit area are shown in Table 6.

Table 6. Minimum emergency landing load criteria for the cockpit.*

Load Direction	Ultimate Load Factor (g)
Forward	20
Down	10**
Up	6**

* Refer to Lockheed Report 13167 "Part IV – Structural Design Loads – Fuselage", pg 4.212.

** Flight load factors may exceed the emergency landing criteria requirements, see Section 2.2.9.

2.2.8: Ditching Pressure [9]

Ditching pressure is variable depending on fuselage station location. The lower surface of the fuselage, and in addition the bomb bay doors, nose landing gear doors, and other structures covering cut-out areas of the fuselage structure shall be designed to the following water pressure specifications. Table 7 below shows the ditching pressure distribution. NASA currently waives all ditching load requirements for experiment installations.

[9] Refer to Lockheed Report 13167 "Part IV Structural Design Loads – Fuselage", pg 4.125

Table 7. Ditching pressure distribution.

Area Designation	Longitudinal Station in (%)	Fuselage Station	Pressure (psi) Over Lower Half of Fuselage
A	0 to 5	105 to 170	12
B	6 to 10	171 to 226	12
C	11 to 25	227 to 393	8
D	26 to 60	393 to 783	6
E	61 to 80	783 to 1004	4

2.2.9: Flight Load Factors[10]

Operational ultimate flight load factors shall be considered in addition to crash loads for the design of the aircraft systems and equipment. An additional factor of 1.33 shall be applied to seats and seat attachments. Table 8 denotes the overall gust load factors that apply to all experimenter hardware located between FS280 and FS1130. Should a design fail to meet the Flight Load Factors in Table 8 then Figures 1 and 2 may be used to customize the design for a specific flight station. However, a new analysis will be required if the installation moves to another fuselage station who's gust load requirement is not enveloped by the previous analysis. It recommended that Figures 1 and 2 be used for bomb bay installations.

Table 8. Ultimate flight load factors FS280 to FS1130.[2]

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

[10] Refer to "P-3B (N426NA) Gust Load Criteria Change" memo dated 6/7/2008

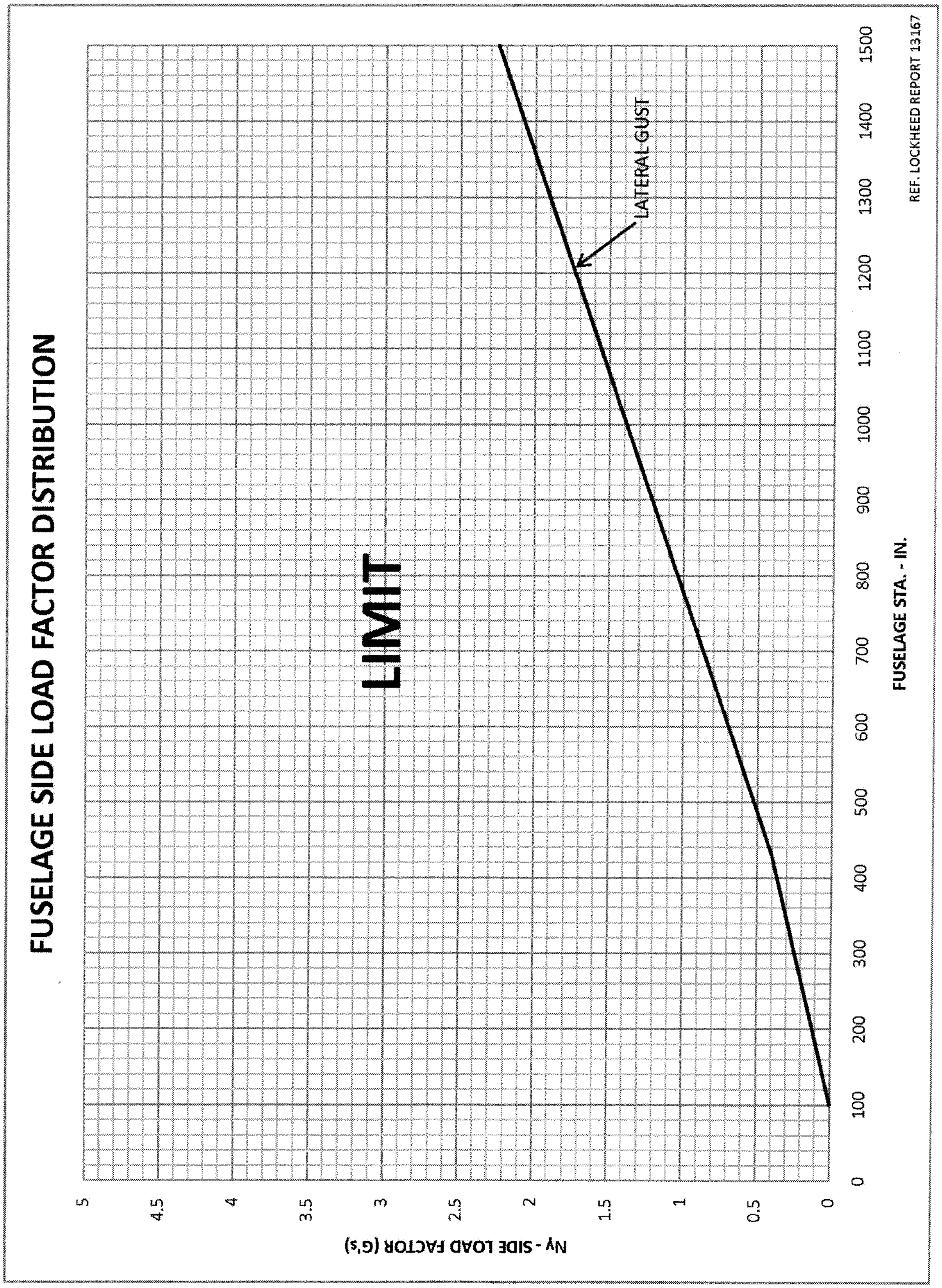

Figure 1. Lateral operational ultimate flight load factors.

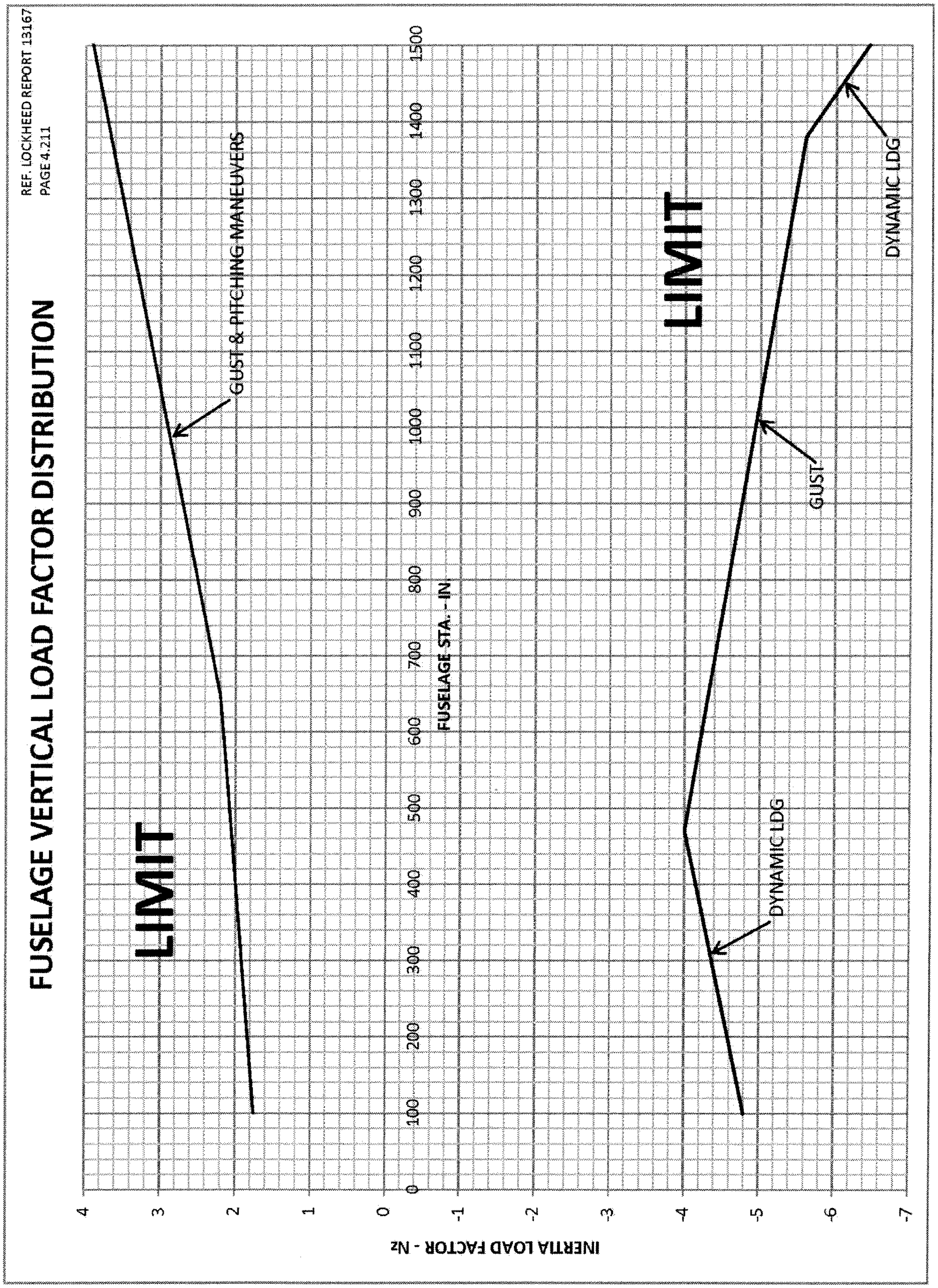

Figure 2. Downward and upward operational ultimate flight load factors.

2.2.10: Equipment Exterior to the Aircraft and Aerodynamic Loads

Consideration must be given to any adverse effects that equipment might have on the stability, control, and performance of the aircraft under normal and emergency conditions. The modes and impact of failures should also be considered for externally mounted equipment. Ground clearance during maximum takeoff rotation, and landing with struts compressed and tires flat should be considered for equipment mounted on the underside of the aircraft.

2.2.10.1: Ground Clearance

Installations that are hung under the aircraft and have significant height shall be checked for ground clearance issues. A 100% compressed nose strut reduces the nose landing gear by 4.75 inches. A 100% flat nose tire reduces the aircraft by 4.75 inches, thus a worse case scenario for a failed nose landing gear (compressed strut and flat tire) is a reduction of 9.5 inches of ground clearance beneath the aircraft at this location.

A 100% compressed main strut reduces the mian landing gear by 4.75 inches. A 100% flat main tire reduces the aircraft by 9.25 inches, thus a worse case scenario for a failed main landing gear (compressed strut and flat tire) is a reduction of 14 inches of ground clearance beneath the aircraft at this location.

Installations that are aft of the main gear shall be checked for ground clearance during takeoff pitch rotation. A typical takeoff pitch rotatation is approximately 5° to 7° (this takes into account the 2° nose down angle of the stationary aircraft). The average pitch angle upon landing is 5° or less.

It is recommended that any instrument installations mounted underneath the aircraft remain 4-6 inches above the ground level after the worse case ground clearance scenario is applied.

2.2.10.2: Aerodynamic Loads

The aerodynamic load of external equipment due to drag and/or lift must be calculated and put into the aircraft structure using appropriate center of pressure and moments. For this load, the dynamic pressure (q) is based on aircraft speed and atmospheric density (altitude and temperature). The dynamic pressure shall be computed at the aircraft's maximum speed, at various operating altitudes, and the greatest value for q used (3.9 psi). The absolute maximum dynamic pressure (q_{max}) for the P-3 is 555 psf (~3.9 psi). This is an ultimate load corresponding to V_d at worst conditions (sea level and 405KIAS). The maximum dynamic pressure is applied at the appropriate structure projected (planform) area. Any boundary layer reductions of loads are discarded.

Both operational load factors along with aerodynamic loads need to be considered for external structures. Conservatively "simple" aerodynamics loads can be calculated using lift and drag coefficient (C_L and C_D) values of 1.0. A limit uniform pressure coefficient of magnitude 1.0 should be applied to closeout panels in viewing apertures. The Prandtl-Glauert correction should be used to estimate the increase in loads caused by compressibility when applicable. A minimum safety factor of 2 shall be used for aerodynamic loads on exterior mounted instruments and support structures.

$$Lift = C_L Q_{max} A_{planform}(SF)$$

$$Drag = C_D Q_{max} A_{planform}(SF)$$

Reduced values of C_L and C_D can be used when more detailed calculations is appropriate. The S.F. Hoerner texts of fluid dynamics lift and drag are accepted references for coefficient values. A maximum flow incidence angle of 5-deg is appropriate for then calculating the resultant loads. Typical lift curve slope values (C_L/α) range from 0.05 to 0.08 for probe (and pylon) cross section shapes ranging from rather blunt to streamlined to airfoil. A fineness ratio (chord/thickness) of at least 3.0 is recommended to alleviate trailing vortex concerns.

2.2.10.3: Sideslip Condition [11]

Sideslip design criteria shall be applied to all externally mounted installations of substantial size. At takeoff flaps and 160 knots the maximum sideslip angle is 30.8°. This condition produces the maximum differential side pressure. An engine out scenario at altitude is also covered by this condition.

2.2.11: Ultimate Load Allowable of Seat Tracks (Cabin Floor) [12]

The floor seat tracks are designed to react to an ultimate load of 10,000 lbs. at 38" intervals anywhere along their length. The design of the floor seat track beams is to react to dynamic crash load criteria applied to all installations. Seat tracks are composed of the Boeing BAC 1520-1773 seat track material.

2.2.12: Ultimate Load Allowable of Seat Tracks (Fuselage Side Rails) [13]

The sidewall cabin mounted seat tracks are designed to react to an ultimate load of 10,000 lbs. at 38" intervals anywhere along their length. The design of the sidewall cabin seat track beams is to react to dynamic crash load criteria applied to all installations, including the standard Wallops 19" racks, if required. Side rails are composed of the Boeing BAC 1520-1773 seat track material.

2.2.13: Seat Track and Mounting Hardware Information

The following information below in Table 9 details the loading limits for the heavy duty seat track that is installed throughout the P-3 (bomb bay- Telair 20864; side walls; cabin floor; and below cabin floor – Boeing BAC 1520-1773). All seat tracks have 1 inch on center hole spacing and are made of 7075-T6 aluminum per MIL-A-8625. Single stud and double stud connectors are described below in Table 10 and are made of heat-treated, cadmium-plated alloy steel.

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[11] Refer to Lockheed Report 13167 "Part IV Structural Design Loads – Fuselage", pg 4.193
[12] Refer to "N426 Supplement to Aircraft Flight Manual", pg FMS-7
[13] Refer to "N426 Supplement to Aircraft Flight Manual", pg FMS-7

Table 9. Seat track design capacity information for both Telair and Boeing tracks.*

Angle from Centerline of Track	Vertical Angle of Pull	Heavy Duty Seat Track Capacity
0°	0°	8,950 lbs
0°	30°	8,075 lbs
0°	60°	9,800 lbs
0°	90°	11,600 lbs
45°	0°	10,950 lbs
45°	30°	8,038 lbs
45°	60°	8,625 lbs
90°	0°	8,225 lbs
90°	30°	7,275 lbs
90°	60°	8,000 lbs

* Refer to Telair International 2004 Product Catalog

Table 10. Seat track stud connectors.

Load Type	Certified Single Stud Load*	Certified Double Stud Load**	Uncertified Single Stud Loads***
Tension	4,000 lbs	6,600 lbs	6,000 lbs
Shear	4,000 lbs	7,000 lbs	2,200 lbs
Bending	N/A	N/A	2,300 inch-lbs
Horizontal load along centerline and 42 inches above the track	N/A	2,750 lbs	N/A
Horizontal load perpendicular to track and 42 inches above track	N/A	3,700 lbs	N/A

* Refer to ANCRA Product Catalog, Part #'s: 40073-16 and -35

** Refer to Telair International 2004 Product Catalog, Part #: 41293-104

*** Uncertified Brownline studs, used Telair 2004 Product Catalog for single stud strengths, these studs have been marked with a "X" on the stud and retainer to defferientate from the certified single studs

Uncertified single mounting seat track studs should only be used for lightweight items such as passenger oxygen bottle and smoke mask mounting. These studs are not recommended for use on items that weigh over 100lbs and moment arms greater than 12 inches from the seat track surface.

2.2.14: Floorboards

The P-3 floor is constructed of multiple 1/2 inch thick floorboard panels called Gillfloor 5007C. These panels are sandwich panels made of polyester fiberglass facings fused to end grain balsa wood cores. Each panel is constructed of 9 pcf balsa wood cores with Gillfab 1074 mat overlays for facing material. Both materials are adhered together using a modified polyester fire resistant adhesive. Below are typical properties for the Gillfloor 5007C panels:

Table 11. Gillfloor 5007C material properties.*

Property	Test Method	Measurement
Weight	ASTM C29	1.09 lb/sq ft
Sandwich Peel	AMS-STD-401	52 in-lb/3 in width
Long Beam Flexural Ultimate Load Facing Stress Deflection @ 100 lbs. load	AMS-STD-401	 431 lb 22.0 ksi 0.629 inches
Flatwise Compression	AMS-STD-401	1,982 lb/sq in
Flatwise Tensil	AMS-STD-401	644 lb/sq in
Insert Shear, (Note: Shurlok Insert 5107-A3 used in test)	BMS 4-17	1,028 lb
Impact Strength	ASTM 3029	84 in-lb
Flammability – 60 sec. vertical Self-Extinguishing Time Burn Length Drip Extinguishing Time	FAR Part 25, Appendix F, Part I	 0 sec. 0.6 sec. 0 sec.
Flammability – 45 Degree Self Extinguishing Time Afterglow Penetration	FAR Part 25, Appendix F, Part I	 0 sec. 0 sec. None

2.2.15: DC-8 Window Allowable Loads of P-3B[14]

The design loads for the DC-8 window frame installations are:

- 1.5*P* (8.99 psi)

[14] Refer to "Engineering Report: GTE Windows FS458.5"P, 739.5"S, and 758.5"P on N4236NA" 2/20/1996

- 100 lbs (limited to 150lbs. ultimate) vertical load with C.G. 18 inches from the viewport mounting surface combined with a drag area of 1 sq. ft.
- 2.0*P* (11.98 psi) acting independently[15]

The external loads are applied to the frame by means of 32, 10-32 bolts that attach the viewport plates to the airframe.

2.2.16: Zenith Frame Allowable Loads[16]

The zenith port installation located at FS795 has a 16" diameter aperture that uses 4 aluminum clips to hold instrumentation or optical windows in place. The maximum allowable weight for objects mounted in this port is 280 lbs. with a CG 10" below the port opening.

2.2.17: P-3B Bubble Window Allowable Loads[17]

The design loads for the P-3 bubble window frame installations are similar to the DC-8 window allowables:

- 1.5*P* (8.99 psi)
- 100 lbs (limited to 150lbs. ultimate) vertical load with C.G. 18 inches from the viewport mounting surface combined with a drag area of 1 sq. ft.
- 2.0*P* (11.98 psi) acting independently[2]

The external loads are applied to the frame by means of 36, ¼-28 bolts that attach the viewport plates to the airframe.

2.2.18: Optical Window Design

All optical windows (excluding standard P-3 aircraft windows) shall comply with the window design standards as outlined in P-3B "Design Elements for Aircraft Optical Windows, 548-RQMT-0002, July 2009". All optical windows shall comply with the "P-3B Optical Window Inspection Plan, 548-PLAN-0001, July 2009". Copies of both documents can be obtained from the ops engineer.

2.2.19: Loads for Tables and Workstations

A limit load of 250 pounds (ultimate load of 500 pounds) shall be used for loads on tables, workstations, or any structure where there is a probability for someone to stand, sit, or otherwise support their weight on the structure.

2.3: Load Test

Items requiring load test must 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.

2.4: Additional Design Constraints and Guidelines

The following are general design constraints and guidelines to use in the design of hardware for use on the P-3.

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[15] Refer to CAR 4b.216.
[16] Refer to 548-STR-0112 "P-3B Orion (N426NA) 16" Zenith Port Loading Envelope Analysis" 4/2008
[17] Refer to 548-STR-0155 "P-3B Orion (N426NA) P-3 Bubble Window Stress Analysis" 2/2009

1. Welded structures should be avoided for significant load bearing and/or externally mounted structure. Where necessary, use stainless steel or steel with appropriate corrosion resistance measures taken.
2. Nutplates through fuselage skins and other significant load bearing structures shall be avoided; gang channels and secondary plates with nutplates are acceptable alternatives.
3. Open holes through the fuselage greater than 0.375 in diameter shall be reinforced with a skin doubler. The edges of the holes should be reamed to a 63 micro-in finish.
4. Maintain minimum fastener edge distance spacing of twice the fastener diameter (2*d*).
5. Maintain minimum fastener to fastener spacing of four times the fastener diameter (4*d*).
6. Avoid open holes and nutplates through frame flanges (caps) and other significant load bearing structures.
7. Allow for drainage where there is a likelihood of water entrapment.
8. Provide breathing holes in enclosed structures, especially outside the aircraft, to prevent over-pressurization loads at altitude.
9. Provide for proper corrosion prevention and control[18]
10. Avoid threaded inserts into significant load bearing structure (i.e. skin, window blanks, frame caps, etc.)
11. All designs involving the flight deck, aircraft exterior or significant weight/balance changes must be cleared and signed off by the appropriate review board.
12. Special windows used by experimenters are considered primary structure. However, they have unique and more restrictive design requirements including inspection.[19]

3: Safety

All practical and necessary steps will be taken to avoid the loss of life, personal injury, property loss, mission failure, or test failure. All potential hazards associated with the operation of new or modified systems must be identified and the risk associated with each identified hazard must be assessed and reduced, if necessary, to an acceptable level.

The failure of a single element (hardware or software) or the commission of a single operator error having a remote or higher probability of occurrence must not cause a critical or catastrophic hazard.

Potential hazards shall be identified, as required, through some (or all) of the processes listed below, as necessary and applicable.

- Configuration Reviews
- Preliminary Design Reviews
- Critical Design Reviews
- Final Installation and Inspection Reviews
- Hazard and Failure Analysis

[18] Refer to P-3 Structural Repair Manual NAV 01-75PAA-3-1.1
[19] Refer to 548-PLAN-0001 "P-3B Orion (N426NA) P-3B Optical Window Inspection Plan", 7/ 2009

- Flight Readiness Reviews
- Mission Readiness Reviews

Potential hazards should be resolved in the following order:

1. Eliminate the potential hazard through redesign.
2. Control the potential hazard by the incorporation of safety devices.
3. Control the potential hazard by the incorporation of alarming devices.
4. Control the potential hazard by operation procedure(s).

All installations are subject to airworthiness and flight safety review, as necessary and applicable.

4: Definitions

4.1: Primary Structure

Primary structure is structure, which upon failure will cause major loads to be transferred to the surrounding structure. These major loads may result in progressive failure of the surrounding structure and possibly the loss of the airplane.

4.2: Secondary Structure

Secondary structure is structure, which can fail and have the surrounding structure successfully carry the loads formerly carried by the failed structure. Although the damaged structure should be repaired as soon as possible, it will not present an immediate hazard.

4.3: Limit (Applied) Loads

"Limit or applied loads are the maximum load anticipated on the airplane during its lifetime of service. The airplane structure shall be capable of supporting the limit loads without suffering detrimental permanent deformations. At all loads up to the limit loads, the deformation of the structure shall be such as not to interfere with the safe operation of the airplane."[20]

4.4: Ultimate Loads

Ultimate loads are the maximum loads for which the structure may yield but must not fail. The ultimate loads are typically defined as the limit loads times a factor of safety. A factor of safety of 2 is used for equipment designed for use on the P-3.

4.5: Load Factor

Load factor is a multiplying factor which defines a load in terms of weight. It is a measure of the magnitude of additional loading on the aircraft structure due to aircraft maneuvers, flying through turbulence, etc.

4.6: Airload

Airloads are loads resulting from aerodynamic forces that are applied to the surfaces of a given structure.

[20] Definition extracted from Bruhn, "Analysis and Design of Flight Vehicle Structures", Jacobs Publishing, Inc., 1973.

5: Basic Checklist for Preparing Engineering Data for a Design

Limit Loads
Flight Loads
Cabin Limit Design Pressure
Thermal Loads/Stresses
Aerodynamic Load Factor
Aerodynamic Loads (Loads time Load Factor)
Stresses from Limit Loads – Must be less than the material yield strength
Limit Load Margins of Safety – Must be positive

Ultimate Loads – Must be more than 2 times the Limit Loads
Design Ultimate Cabin Pressure – Do not add this to crash loads
Passenger Area Crash Loads
Below Cabin Floor Crash Loads
Bomb Bay Crash Loads
Ditching Pressure
Stresses from Ultimate Loads – Must be less than the material ultimate strength
Ultimate Load Margins of Safety – Must be positive

Misc. Design Data
P-3B Bubble Window Frame Allowable Loadings
DC-8 Viewport Frame Allowable Loadings
Zenith Viewport Frame Allowable Loadings