476L

logistics transport support system

SUPER HERCULES · GL207-45

VOLUME **1** *basic proposal*

LOCKHEED AIRCRAFT CORPORATION

476L

ETP 250

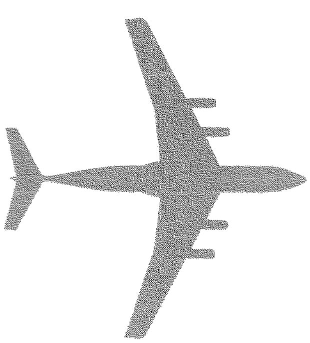
20 DECEMBER 1960

VOLUME 1

basic proposal

W. A. Pulver Vice President and General Manager

SUPER HERCULES · GL207-45



4 7 6 L *ockheed*


MATS
U.S. AIR FORCE
USAF

CONTENTS

CONTENTS (cont.)

FIGURE INDEX

FIGURE INDEX (Cont'd.)

FIGURE INDEX (Cont'd.)

FIGURE INDEX (Cont'd.)

FIGURE INDEX (Cont'd.)

FIGURE INDEX (Cont'd.)

SUPER HERCULES · GL207-45

section 1

SUMMARY

SYSTEM DESCRIPTION (5.1.5)

Program Philosophy

"The Air Force is concerned over the trend toward steadily increasing unit costs of major weapon systems. Small increments of increased capability, marginal in relationship to overall weapon system effectiveness, have contributed to this increase in cost, particularly, when a high degree of complexity in air vehicles subsystems and equipment is a factor. The cumulative total of relatively small individual cost increases invariably obsolete program budget estimates, thereby jeopardizing the weapon system program.

It is not necessary that each weapon system have higher orders of complexity to achieve acceptable mission effectiveness. On the contrary, it is frequently this very complexity and higher-than-budgeted cost which either results in premature program termination or marginal effectiveness in operational service."

This cost philosophy is stated in Paragraph 1.3 of the Introduction to the Statement of Work for Logistics Transport Support System 476L. It is repeated here since it states so completely and succinctly the philosophy which Lockheed has followed in the development of the GL 207-45 Super Hercules, shown in Figure 1-1.

Since mid-1957, Lockheed has been constantly and heavily engaged in preparation for participation in the competition for System 476L. In this period more than 226,000 engineering manhours and 507,000 dollars of wind tunnel test programs have been expended in examining thoroughly all aircraft conceived, based both on the proposed very-advanced, high-thrust powerplants which are under study, and which may be developed, and on currently programmed growth versions of existing powerplants which are available at earlier dates with assured reliability with no additional development funding required.

The Lockheed GL 268, powered with the proposed GE MF239C-3 high thrust engine, represents one advanced configuration which has been developed thoroughly. This airplane, shown in Figure 1-2, represents the degree of sophistication required to exploit the full speed potential of the proposed high thrust engines. It far exceeds most requirements for System 476L.

At a take-off weight of 316,500 pounds the GL 268 can, from a 6,000-foot CAR runway, transport 50,000 pounds of payload for 4,000 nautical miles at an average cruise speed of Mach 0.907; or at an average cruise speed of Mach 0.88, the payload can be raised to 59,300 pounds. For the 5,500 nautical mile mission, for an average cruise speed of Mach 0.88, the payload is 28,000 pounds.

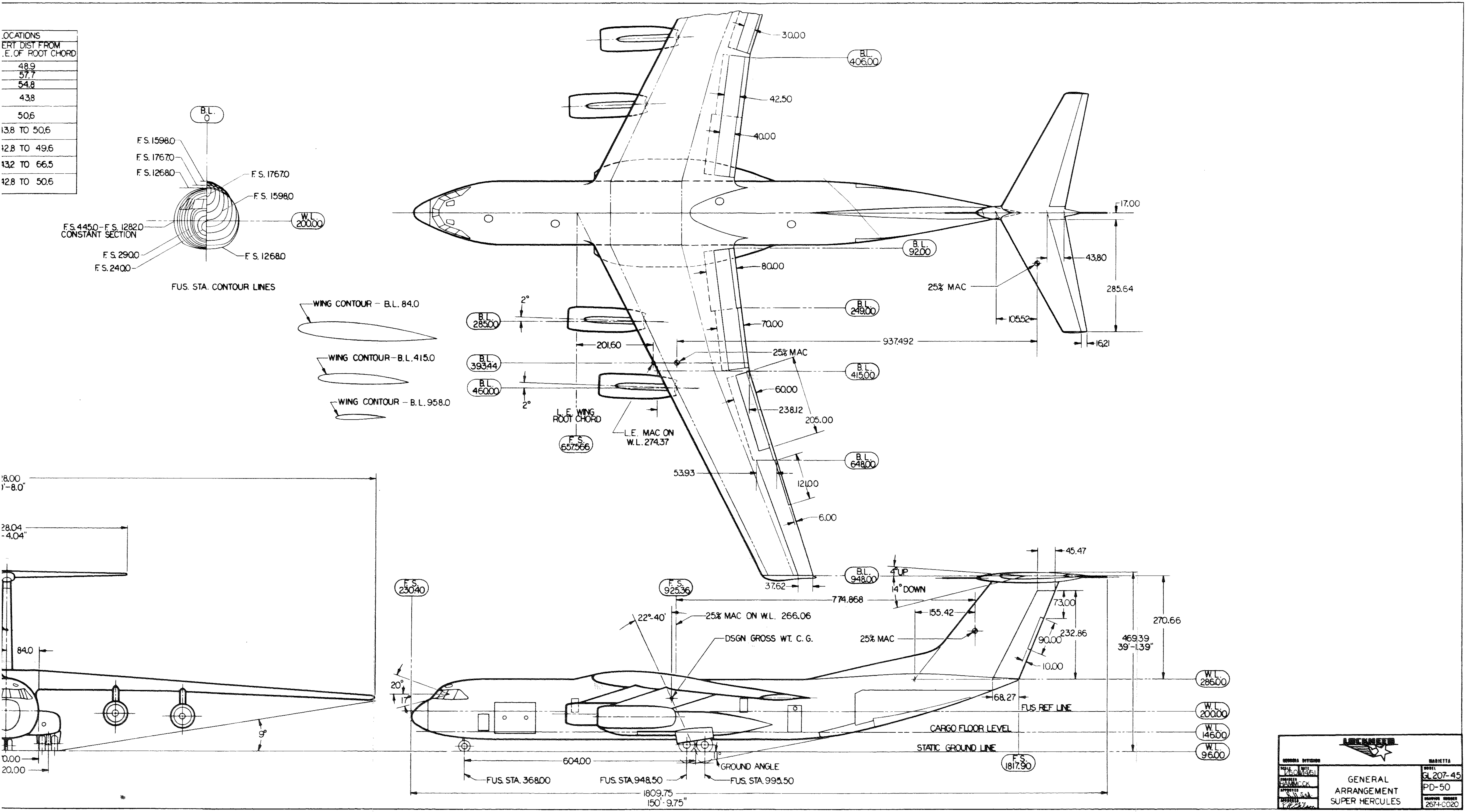
This airplane, together with substantiating data, including wind tunnel results, is presented in Lockheed report ER-4681 which is available upon request. Although this configuration exploits the full speed potential of the proposed high-thrust engines, its capabilities far exceed the stated requirements of System 476L; its developmental costs are substantially greater than configurations utilizing available engines; and, powered by advanced engine yet to be developed, its date of operational availability is more than a year later.

The Lockheed GL 207-45 Super Hercules which, when powered with four Pratt and Whitney (P & W) JT3D-4 turbofan engines, meets or betters every requirement of System 476L, is selected as Lockheed's basic proposal. It is designed from start to finish with the intent of providing, at the earliest possible date, and at the least possible overall program cost, an outstanding cargo airplane for both military and commercial application.

The Super Hercules is of conventional aerodynamic configuration and is based entirely upon today's state-of-the-art. It employs no unconventional nor unproven features and no costly development programs are required since its basic design and manufacturing philosophy lean heavily on the experience gained from the C-130 series. It has the identical C-130 fuselage cross-section, and the structural design concept and much of the functional subsystems are developed directly from those of the C-130. Its design and initial performance are based on the JT3D4 powerplant; however, provisions are made in every airframe for fully exploiting, at any time, the full potential of the JT3D-8A, the growth version of the JT3D-4, when it becomes available. The detail design of the Super Hercules recognizes in every area all applicable military specifications and all civil air requirements except that, where conflict exists, deviations from military requirements are requested.

Lockheed's basic design philosophy for System 476L is based on the following understanding of the Air Force's desires and needs for System 476L:

1. An airplane system is desired which meets or betters every single detail requirement for System 476L.
2. It is desired to have the airplane system in service operation as soon as possible with squadron strength desired by mid-1964.



LOCATIONS
VERT DIST FROM
L.E. OF ROOT CHORD
48.9
57.7
54.8
43.8
50.6
13.8 TO 50.6
12.8 TO 49.6
13.2 TO 66.5
12.8 TO 50.6
B.L. 0
F.S. 1598.0
F.S. 1767.0
F.S. 1268.0
F.S. 1767.0
F.S. 1598.0
W.L. 200.00
F.S. 445.0 - F.S. 1282.0 CONSTANT SECTION
F.S. 290.0
F.S. 240.0
F.S. 1268.0
FUS. STA. CONTOUR LINES
WING CONTOUR - B.L. 84.0
WING CONTOUR - B.L. 415.0
WING CONTOUR - B.L. 958.0
30.00
B.L. 406.00
42.50
40.00
17.00
B.L. 92.00
80.00
43.80
25% MAC
285.64
B.L. 249.00
B.L. 285.00
70.00
105.52
937.492
16.21
201.60
25% MAC
B.L. 393.44
B.L. 415.00
B.L. 460.00
60.00
238.12
205.00
L.E. WING ROOT CHORD
L.E. MAC ON W.L. 274.37
F.S. 657.566
B.L. 648.00
53.93
121.00
6.00
45.47
B.L. 948.00
37.62
4° UP
14° DOWN
774.868
F.S. 230.40
F.S. 925.36
22°-40'
25% MAC ON W.L. 266.06
DSGN GROSS WT. C.G.
155.42
25% MAC
73.00
232.86
90.00
270.66
469.39
39'-1.39"
10.00
W.L. 286.00
20°
17°
68.27
FUS REF LINE
W.L. 200.00
CARGO FLOOR LEVEL
W.L. 146.00
STATIC GROUND LINE
W.L. 96.00
F.S. 1817.90
9°
604.00
GROUND ANGLE
FUS. STA. 368.00
FUS. STA. 948.50
FUS. STA. 995.50
1809.75
150'-9.75"
GENERAL
ARRANGEMENT
SUPER HERCULES
GL 207-45
PD-50
2674-C020

figure 1-1

	WING	HORIZ.	VERT.
AREA SQ.FT.	3228.13	521.14	413.66
ASPECT RATIO	7.897	5.21	1.23
TAPER RATIO	0.374	0.37	0.6117
SWEEP AT 0.25c̄	25.0°	25.0°	35.0°
ROOT CHORD INCHES	398.00	175.20	273.096
TIP CHORD INCHES	132.41	64.83	167.07
MAC INCHES	266.51	128.47	224.34

CONDITION	WEIGHT LB.	CENTER OF GRAVITY LOCATIONS FUS. STA.	% MAC	WATER LINE	VERT DIST FROM L.E. OF ROOT CHORD
BASIC MISSION DSGN GROSS WT.	288,000	916.0	21.3	236.8	48.9
LAND PLANE LDG DSGN GROSS WT.	257,500	904.5	17.0	228.0	57.7
MIN FLYING GROSS WT.	128,082	917.6	21.9	230.9	54.8
MAX DSGN GROSS WT. WITH MAX FUEL	315,000	913.9	20.5	241.9	43.8
MAX DSGN GROSS WT. WITH DSGN PAYLOAD (70,000 LB.)	315,000	913.9	20.5	235.1	50.6
DSGN GROSS WT (GEAR EXTENDED)	315,000	913.9	20.5	241.9 TO 235.1	43.8 TO 50.6
DSGN GROSS WT. (GEAR RETRACTED)	315,000	912.9	20.1	242.9 TO 236.1	42.8 TO 49.6
MOST FWD C. G. AT ANY POSSIBLE WEIGHT	210,000 MAX	893.8	13.0	242.5 TO 219.2	43.2 TO 66.5
MOST AFT C. G. AT ANY POSSIBLE GROSS WEIGHT	315,000 MAX	939.2	30.0	242.9 TO 235.1	42.8 TO 50.6

WING
- DIHEDRAL AT 0.25c̄ — — — — — — — — -1.25°
- INCIDENCE - ROOT, 4.5° - TIP 0.0°
- AIRFOIL SECTION-ROOT — — — — — — — — NACA0012.50M
- AIRFOIL SECTION-0.43 B/2 — — — — — — — NACA0011.00M
- AIRFOIL SECTION TIP — — — — — — — — NACA0010.00M
- AVERAGE AIRFOIL SECTION — — — — NACA0011.15M

FLAPS INBD — CENTER — OUTBD
- AREA SQ.FT. TOTAL — — — — — — 175.9 — — 153.9 — — — 195.8
- DEFLECTION TAKE OFF — — — — 35° — — 35° — — — 35°
- DEFLECTION LANDING — — — — — 50° — — 50° — — — 50°
- MAX DEFLECTION — — — — — — 55° — — 55° — — — 55°
- PERCENT OF WING CHORD — — — — — — — — — — — — 26%
- PERCENT WING AREA AFFECTED — — — — — — — 66.8%
- TYPE — — — — — — — — — — — — LOCKHEED FOWLER

AILERON
- AREA SQ.FT. — — — — — — — — — — — — — — — 190.44
- DEFLECTION DEGREES — — — — — — — — DN.15° - UP 25°
- TYPE — — — — — SEMI-AERODYNAMICALLY BALANCED

VERTICAL TAIL
- RUDDER AREA SQ.FT. — — — — — — — — — — — — — — 90.54
- RUDDER DEFLECTION DEGREES — — — — — — — — — ±35.0
- AIRFOIL SECTION — — — — — — — — — — — — — NACA64A012

HORIZONTAL TAIL
- AERODYNAMIC INCIDENCE DEGREES — — — UP 4.0 DN. 14.0
- ELEVATOR AREA AFT OF HINGE SQ.FT. — — — — — — — 120.12
- ELEVATOR DEFLECTION DEGREES — — — — UP 25.0 DN 15.0
- AIRFOIL SECTION — — — — — — — — — — — NACA64A010
- DIHEDRAL — — — — — — — — — — — — — — — — — — — 0°

POWER PLANT
- FOUR P&W JT3D-4

NOSE GEAR
- TWO-SIZE 32 X 11.5-15 - PLY 24 - TYPE VIII
- FULLY COMPRESSED — 5.25 FROM STATIC
- FULLY EXTENDED — 11.00 FROM STATIC

MAIN GEAR
- EIGHT-SIZE 44 X 16 - PLY 28 - TYPE VIII
- FULLY COMPRESSED — 5.875 FROM STATIC
- FULLY EXTENDED - 31.725 FROM STATIC

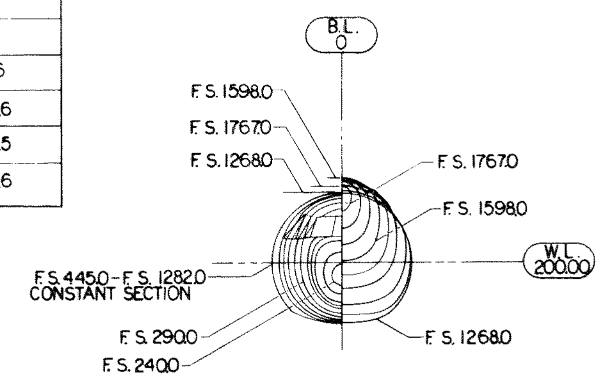
SPOILERS
- AREA SQ.FT. — — — — — — 266.8
- TYPE — — — — — TRAILING EDGE

WETTED AREA (SQ.FT.)
- FUSELAGE — — — — — — — — 4036
- NACELLE — — — — — — — — 243
- WING — — — — — — — — 6123
- TAIL — — — — — — — — 1912
- MISC — — — — — — — — 1394
- TOTAL — — — — — — — — — 14,437

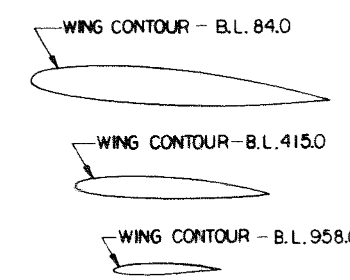
GROUND CLEARANCE OF FUS. WITH FULLY COMPRESSED GEAR — 24.125 IN.

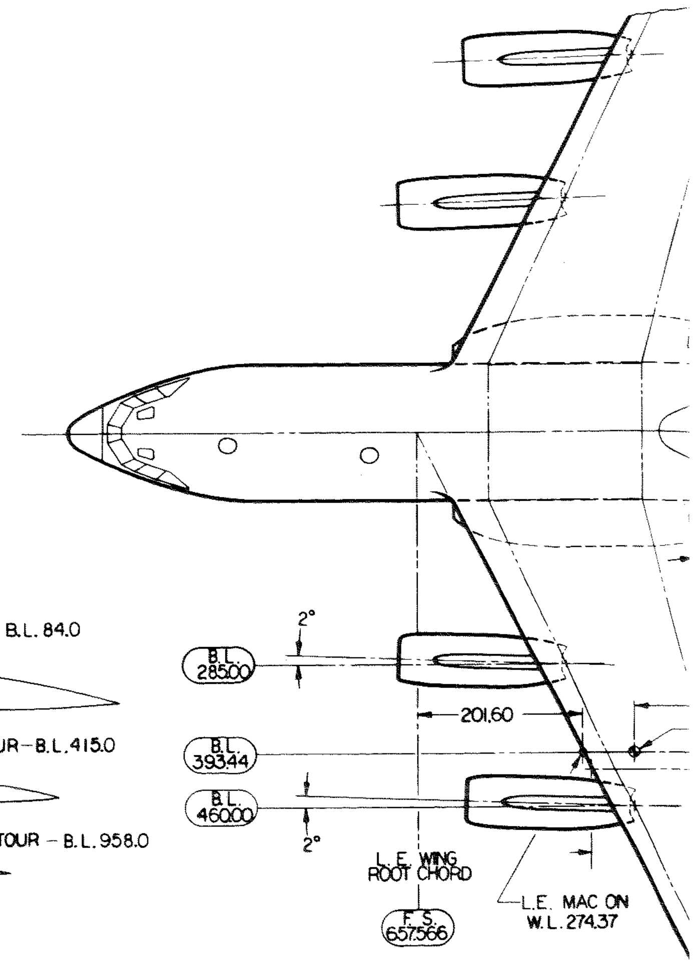
MAX CENTER OF GRAVITY SHIFT DUE TO FUEL FLOW					
CONDITION	WEIGHT	C. G. BEFORE MOVEMENT FUS STA	% MAC	MOVEMENT % MAC FWD	AFT
NOSE UP ATTITUDE	213,000	922.2	23.6	—	2.8
NOSE DOWN ATTITUDE	283,000	909.1	18.7	1.5	—

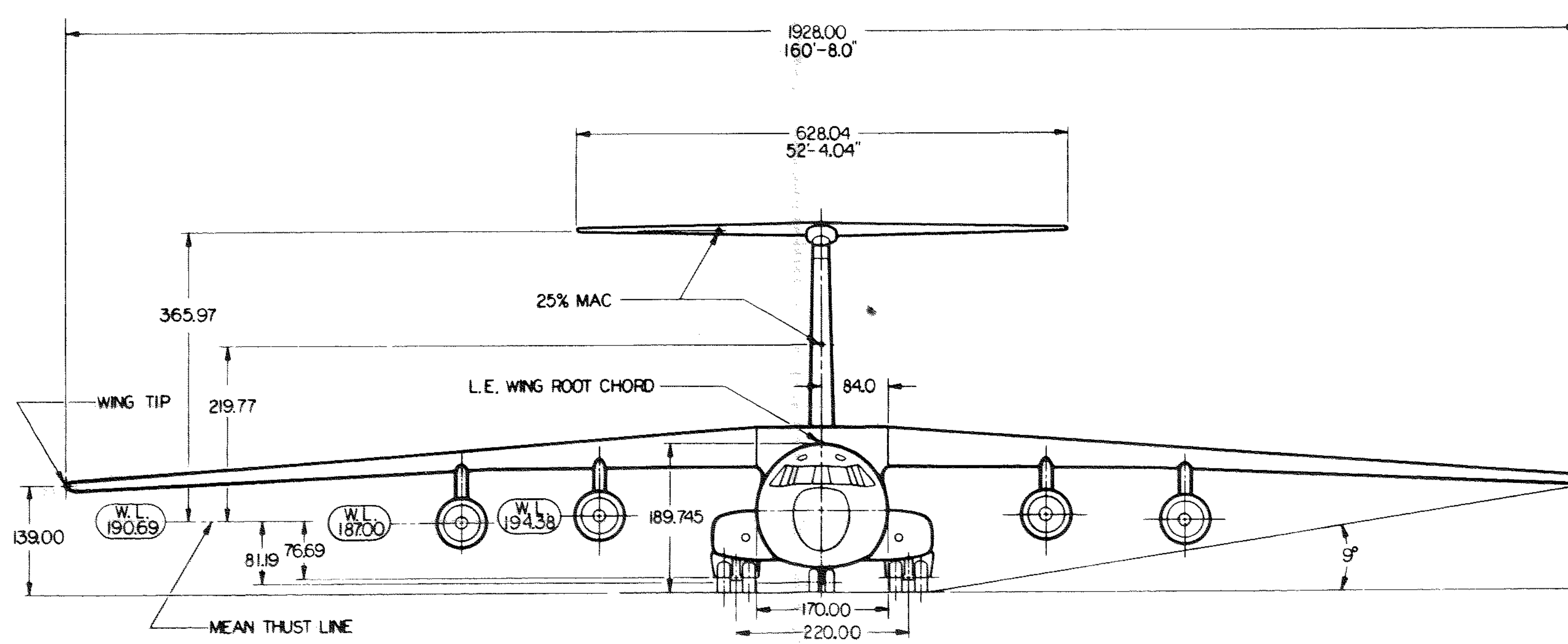
WEIGHTS
- AIRCRAFT WEIGHT EMPTY (LB) — — — — 118,076
- DESIGN USEFUL LOAD (LB) — — — — — 196,924
- DESIGN MAX GROSS WT. (LB) — — — — — 315,000
- MAX ALTERNATE GROSS WT. (LB) — — — 315,000

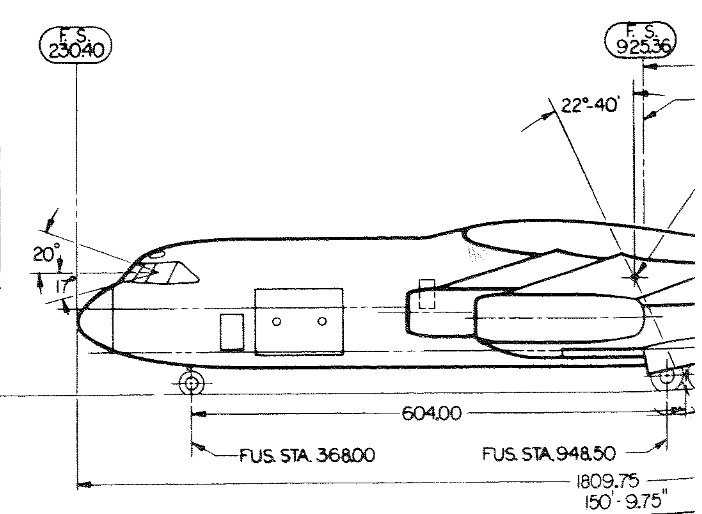


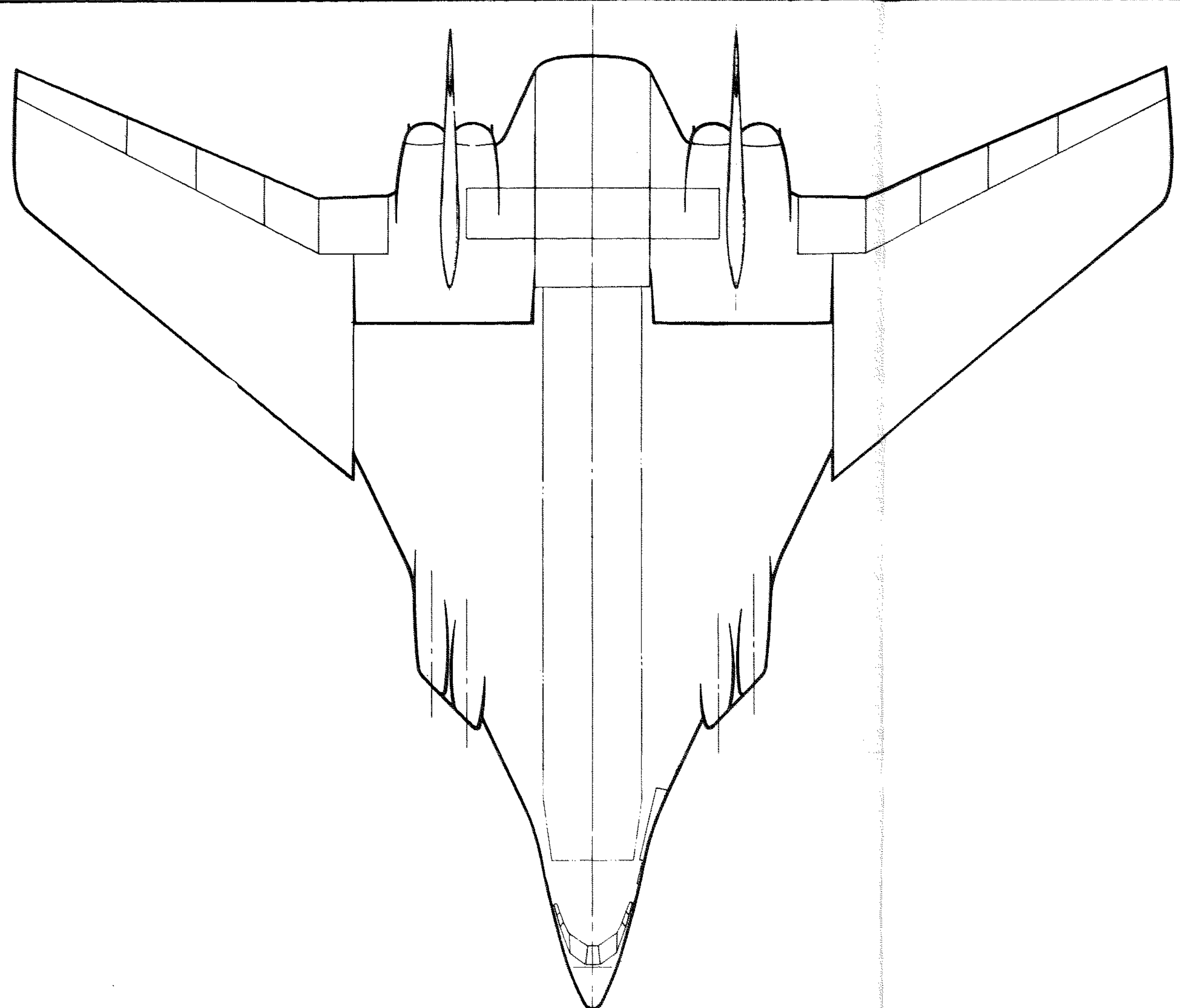
FUS. STA. CONTOUR LINES











		WING	VERT(2)
AERA SQ FT		5889.7	300.0
ASPECT RATIO		3.33	1.4
TAPER RATIO	CENTER SECTION	0.28	0.40
	OUTER PANEL	0.50	
CHORD AT W S 350.0	CENTER SECTION	350.00	—
	OUTER PANEL	392.00	—
ROOT CHORD INCHES		1250.00	250.92
TIP CHORD INCHES		196.00	100.37
MAC INCHES		687.514	186.40

WING

DIHEDRAL AT 0.25c̄ CENTER SECT ——— 7.5°
DIHEDRAL AT 0.25 OUTER PANEL ———— 0.0°
INCIDENCE ROOT 0.0 BREAK 0.0 TIP 0.0
AIRFOIL SECT. ROOT NACA001038
AIRFOIL SECT. W.S. 350.0 CENTER SECT NACA0008 2.20 40/1.575
AIRFOIL SECT. W.S. 350.0 OUTER PANEL { NACA000714 2.20 52/2.3625 FWD OF 40% / NACA000714 2.20 40/1.575 AFT OF 40%
AIRFOIL SECT. TIP { NACA0006 2.20 52/2.3625 FWD OF 40% / NACA0006 2.20 40/1.575 AFT OF 40%
AVERAGE AIRFOIL SECT NACA00837

ELEVON

AREA SQ.FT. ———————— 388.0
DEFLECTION DEGREES ———— DN 25°-UP 40°

PITCH DAMPER

AREA SQ.FT ———————— 103.75
DEFLECTION DEGREES —————— ±25°

VERTICAL TAIL

RUDDER AREA SQ.FT —————— 179.0
RUDDER DEFLECTION —————— ±30°
AIRFOIL SECT. ROOT ———— NACA0011
AIRFOIL SECT TIP ———— NACA0006

POWER PLANT

FOUR MF239C-3

NOSE GEAR

TWO SIZE 39X13-20 PLY-TYPE VII
FULLY COMPRESSED-3.0 FROM STATIC
FULLY EXTENDED — 3.0 FROM STATIC

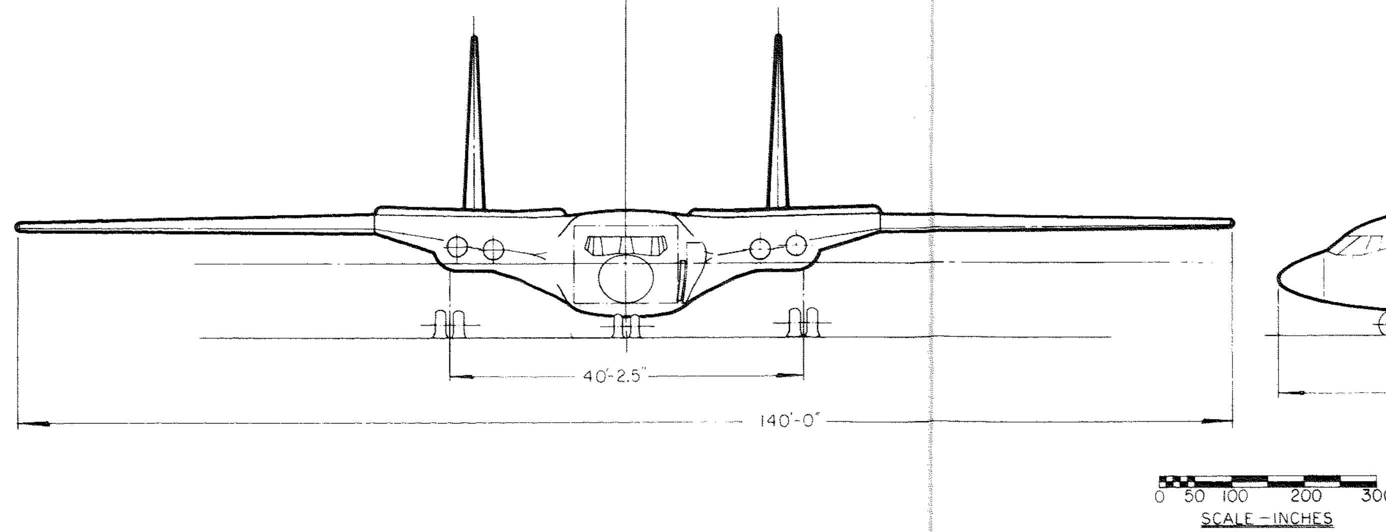
MAIN GEAR

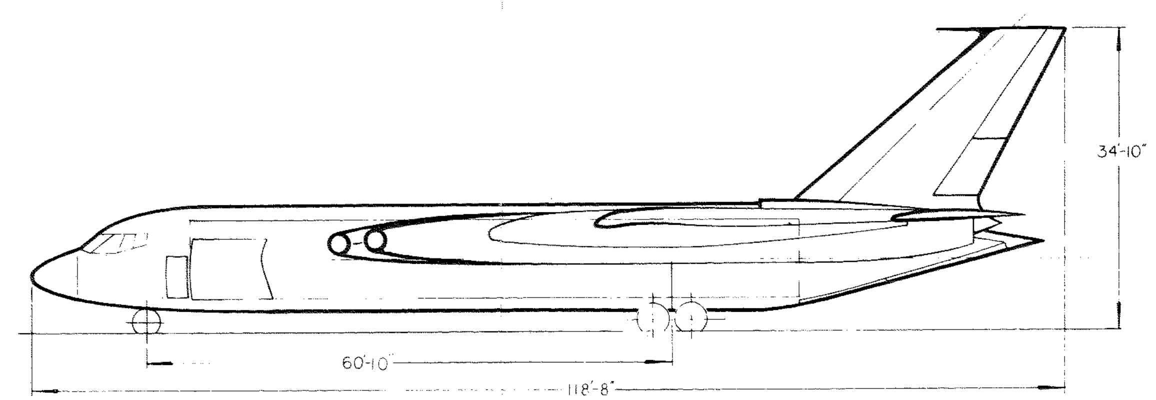
EIGHT SIZE 49X17-26 PLY-TYPE VII
FULLY COMPRESSED-3.0 FROM STATIC
FULLY EXTENDED — 25.0 FROM STATIC

WETTED AREA

WING	13,909.81
TAIL	1,243.73
TOTAL	15,135.54

FUS GROUND CLEARANCE WITH
FULLY COMPRESSED GEAR 270 IN.





LOCKHEED
GEORGIA DIVISION — MARIETTA

SCALE 1/60 — DATE 2-1-60	GENERAL ARRANGEMENT	MODEL GL268-1
ENGINEER J.M.NORMAN		
APPROVED		DRAWING NUMBER 268-1-0007
APPROVED		

figure 1-2

3 The performance requirements established by the Statement of Work will produce an airplane which is adequate to assure that MATS can accomplish its peace-time and war-time missions. Additional expenditures required to procure performance capability over and above the requirements of the Statement of Work will be closely examined to assure their economic justification.

4 Because of the desire for earliest possible availability and minimum program costs, the airplane should be based to the maximum degree possible on today's state-of-the-art so that developmental expenditures and time spans can be kept to a minimum and so that initial reliability and utilization can be as high as possible.

In recognition of this basic philosophy in the selection of the aerodynamic configuration for the GL 207-45, the following two purposes were established as additional fundamental desires for System 476L.

1 In the event proposed high thrust powerplants do not become available, the selected basic configuration should at least meet all requirements of System 476L when powered with currently available powerplants.

2 Additional capabilities exceeding the requirements of system 476L are possible with future advanced high-thrust engines. They should be exploited in the direction of maximum productivity and reduced direct operating costs if they are to be economically justified.

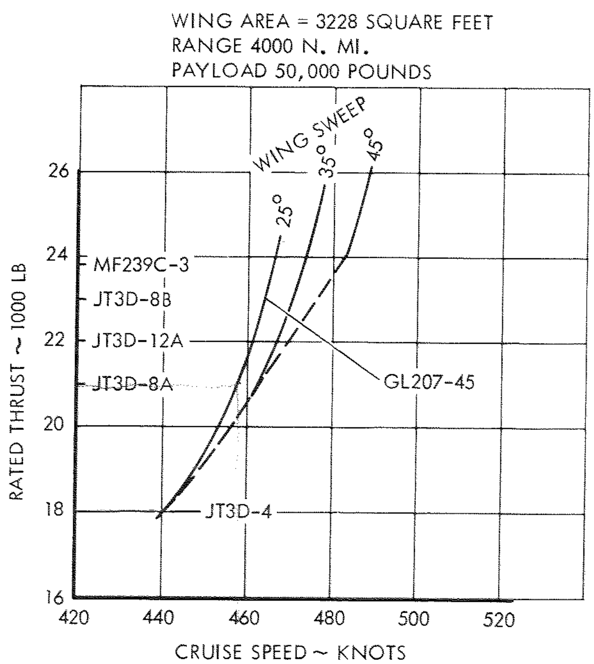


Figure 1-3—GROWTH POTENTIAL—SPEED.

When this selection process is followed it is found that the basic configuration and overall design of the GL 207-45 is near optimum for exploitation of the full productivity potential of growth powerplants which may become available. The results are as shown by the data presented in Figures 1-3 and 1-4 which have been developed on the basis that all airplanes considered are of normal conventional configuration. The airplanes for which data is given in Figure 1-3 are optimized to achieve the maximum possible cruise speed for the required basic mission of 50,000 pounds for 4,000 nautical miles while meeting all other requirements of System 476L. It is apparent that higher speed airplanes with greater sweep angles require advanced powerplants of higher thrust to just meet the other minimum requirements of System 476L.

Figure 1-4 indicates the growth capability available with these same aircraft in terms of added payload capability for a 4,000-nautical mile range which leads to increased productivity and reduced direct operating costs.

This is certainly a consideration in the economic justification for capabilities exceeding the requirements of System 476L. The inherent productivity growth capability of airplanes with lower wing sweep far exceeds that for airplanes with higher wing sweep.

It is apparent that, when minimum operational requirements are met and excess thrust becomes available, overall cargo moving economy is increased most rapidly when additional performance available is directed towards maximizing productivity for the required range at acceptable cruise speeds.

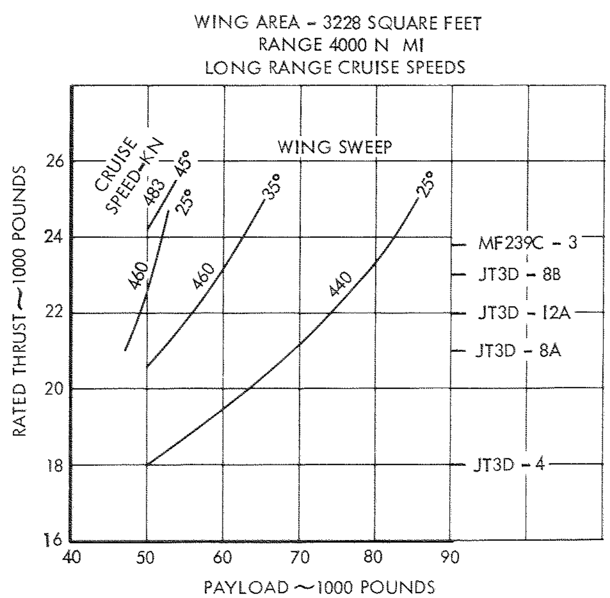


Figure 1-4—GROWTH POTENTIAL—PAYLOAD.

Cost Impact on MATS

This factor is better illustrated in Figures 1-5 thru 1-9 by the results of a study made to determine the impact of the introduction of the proposed new aircraft on the cost of operation of the Military Air Transport Service. Two types of new aircraft were examined. The first, a conventional configuration like the GL 207-45, was considered when powered initially with higher thrust engines which may become available. The second aircraft is typified by the Lockheed GL 268, since this airplane represents the degree of sophistication required to exploit the full speed potential of the proposed high-thrust engines in airplanes required to just meet the other minimum requirements of System 476L.

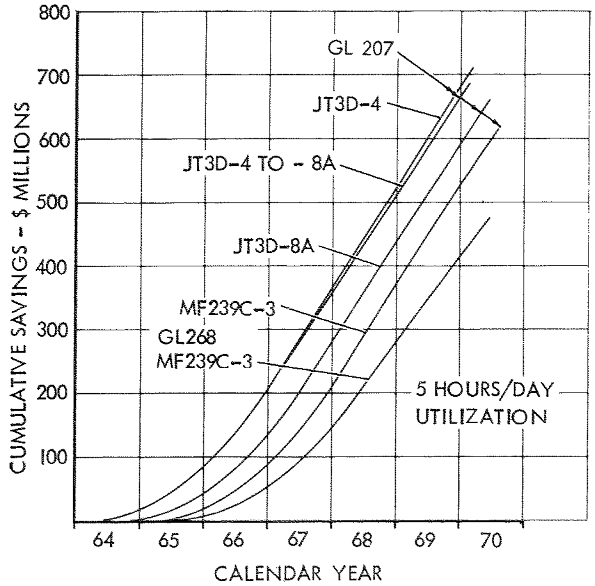


Figure 1-5—FLEET OPERATING COST SAVINGS.

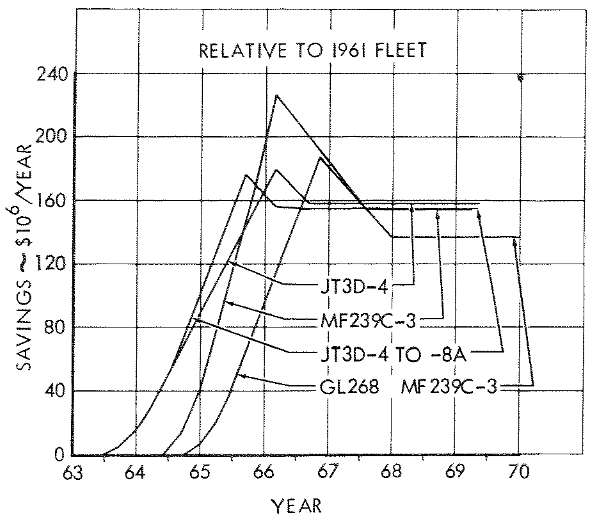


Figure 1-7—ANNUAL SAVINGS FOR AIRCRAFT.

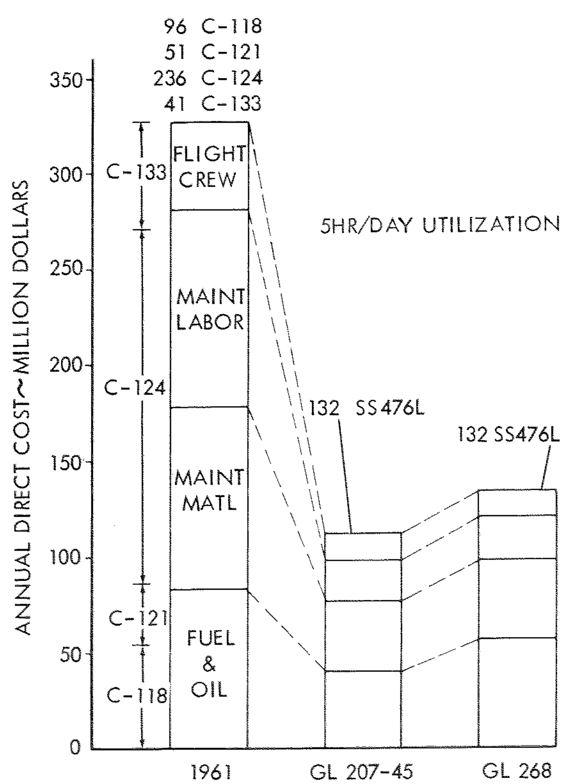


Figure 1-6—ANNUAL OPERATING COST MATS AIRLIFT RESOURCES.

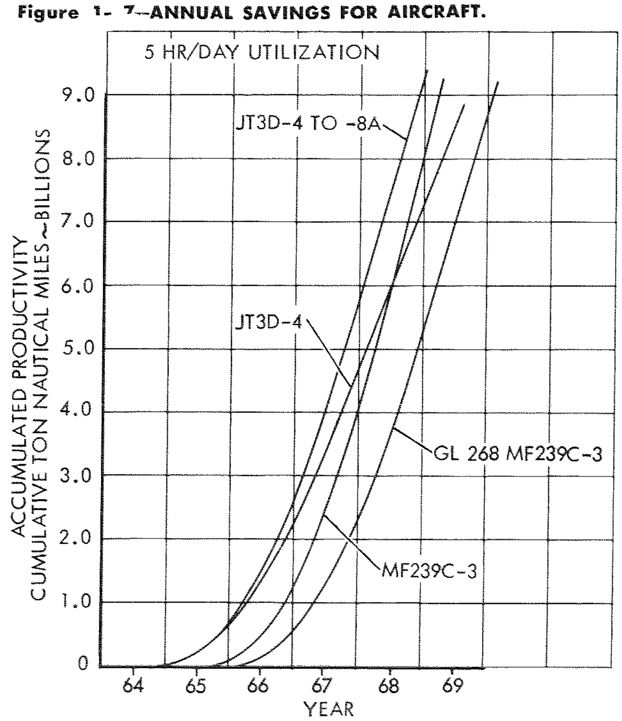


Figure 1-8—ACCUMULATED PRODUCTIVITY.

In assessing the impact of the introduction of System 476L on the cost of MATS operations, a comparison was made of the direct operating cost of the current common user fleet and the troop transport fleet with 132 System 476L airplanes at five hours per day utilization. The results are shown in Figure 1-6. The cost for the current fleet was estimated from Air Force planning data; the cost for the new aircraft was based on the 1960 ATA formula as modified for MATS operations. The cost for 132 GL 207-45 aircraft is seen to be about one-third of the cost for the current airlift resources of MATS. The cost for the advanced GL 268 is seen to be about 20% greater than that of the GL 207-45, due primarily to its greater fuel consumption.

It is obvious from the data of Figure 1-6 that the implementation of new efficient aircraft will introduce cost savings for the maintenance of the airlift resources of MATS. The amount of the cost savings was determined for various engine programs for the GL 207-45 and for the GL 268. The results are shown in Figure 1-5. This figure shows the cumulative cost savings, assuming that the C-118, C-121, and the C-124 were phased out linearly with System 476L deliveries in order that the last of the current fleet was phased out simultaneously with the delivery of the 132nd System 476L airplane. All aircraft were operated at a continuous utilization of five hours per day. It is quite apparent that the cost saving advantage is associated with the early delivery of the System 476L airplanes. Aircraft which have their delivery date tied to a later advanced engine encounter a cost handicap which is directly a function of delivery time. On this comparison, the conversion of the GL 207-45 from the JT3D-4 to the -8A configuration would be easily made by the delivery of 37th airplane. This program would provide one of the most advantageous cost relationships as well as providing the early availability of a higher productivity airplane. It is apparent that the most critical element in the saving of operating costs is the early introduction of the new aircraft.

The former comparison did not consider the productivity of the System 476L fleet. The data of Figure 1-8 shows the build-up of the potential productivity at 100% load factor for the System 476L airplanes operating at a range of 4,000 nautical miles. The GL 207-45 airplane would maintain a productivity advantage over the GL 268 without conversion to the -8A engine until beyond 1970. Conversion of the GL 207-45 to the -8A engine provides productivity somewhat better than that of the GL 268 with the MF239C-3 engine and a significant advantage is shown in the accumulated productivity of the GL 207-45 when compared to that of the GL 268, due to the 15 month spread in delivery date. The case where initial deliveries of the GL 207-45 are made with JTD3D-8A engines was examined and showed that a six-month delay in deliveries which would be encountered could never overbalance the program where initial deliveries were made with JT3D-4 engines in either cost savings or in accumulated productivity.

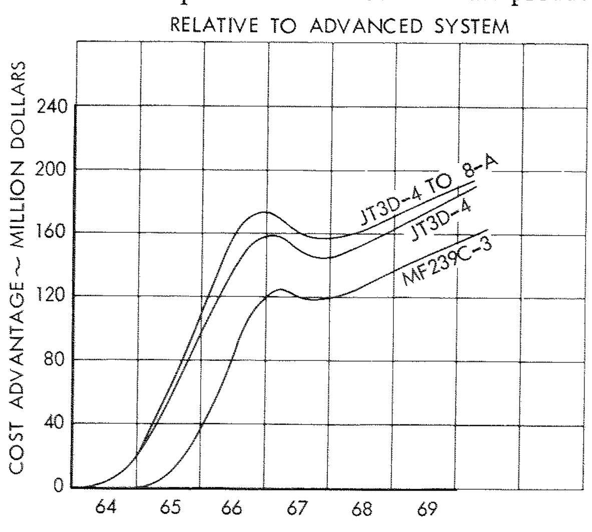


Figure 1-9—COST ADVANTAGE.

Recognizing that the relative differences in the productivity of the current fleet and the System 476L fleet could influence the cost comparison analysis, a further examination was made on the basis that the current fleet would be phased out while maintaining the composite productivity of the fleet at a constant level until all of the C-118, C-121, and C-124 aircraft were gone. The build-up of the annual saving rate is illustrated in Figure 1-7. The peak occurs at the point where the current fleet was phased out. Savings are reduced beyond this point since the hypothetical savings were absorbed by the operational cost of the rest of the 132 aircraft. It can be seen that the cost savings buildup early to a high rate with the GL 207-45 aircraft with the J73D-4 engines and to a higher rate when the J73D-8A is incorporated without delay of the original production schedule. It was assumed that the original 36 airplanes were retrofitted to J73D-8A engines after delivery of the 132nd airplane.

The accumulation of the cost savings, relative to waiting for the development of an advanced airplane matched to the advanced engine, is shown in Figure 1-9. The relative advantage of the GL 207-45 configuration is shown in this figure where, with any propulsion system, it will provide more airlift at lower cost than will the high speed GL 268. With the GL 207-45 configuration, the advantage o f the early availability of adequate powerplants, with the matched to the advanced engine, is shown in Figure additional advantage of conversion to the J73D-8A at a later date, is graphically illustrated. The GL 207-45 is fully capable of exploiting the capabilities of the MF239C-3 engine. The early availability of the JT3D-4 engine will provide a distinct advantage, however, which can be measured quantatively in millions of dollars.

General Arrangement

The general arrangement of the GL 207-45 is shown in Figure 1-1 together with basic weights and dimensional data. The basic configuration is conventional in every respect. The overall dimensions of the airplane permit its ready entry into normal MATS hangars.

The structure is completely conventional and uses design features and manufacturing techniques now in use on the C-130.

The chosen wing has an area of 3,228 square feet, aspect ratio of 7.897, average thickness to chord ratio of 11.15, and taper ratio of 0.374. Sixty percent span Fowler flaps are used and lateral control is by conventional outboard ailerons. Spoilers, located in the wing trailing edge above the flaps, are used only on the ground to reduce wing lift and thereby achieve maximum braking effectiveness. The wing is swept 25 degrees at the quarter chord, which is low enough to greatly reduce most of the problems usually encountered in large swept wing aircraft with higher sweep angles. Sufficient fuel volume is provided within the wing for all fuel required for all proposed missions.

The "T" empennage incorporates a movable horizontal stabilizer for normal airplane trim. This arrangement, which has been completely evaluated in wind tunnel testing, provides excellent pitch and directional control and stability with approximately 30% less surface area than possible with other arrangements.

A thorough flutter analysis has dictated the conservative rigidity employed in the design; use of boosted, rather than irreversible controls eliminates difficulties of the kind experienced by the Navy Seamasters. Also, of course, the horizontal stabilizer is completely removed from danger of damage by trucks and vehicles in the loading area.

The interior arrangement, shown in Figure 1-10, is conventional and much like that of the C-130 series. The cargo compartment is, except for greater length, almost identical with that of the C-130. The combination cargo ramp and pressure door, when in the closed position, provides a pressure bulkhead at the aft end of the cargo compartment, thus eliminating presurization loads from the aft fuselage doors which greatly reduces the structural design and sealing problems.

With its conventional landing gear in normal static position, the cargo floor is 50 inches above, and is parallel with the ground. The cargo floor detailed design is based on experience gained in the development of the C-130, it meets every requirement of System 476L and provides for loading of all desired military cargos. The rollers and restraining rails for the system 463L pallets are provided as an integral part of the floor design. When the pallet is not in use, the rails and rollers retract into recesses to provide a flat cargo floor. In addition to the cargo floor, a space 99 inches long is available for an additional pallet on the cargo loading ramp forward of the pressure door. Nine pallets are normally carried on the main cargo floor and one on the ramp. Palletized volumes are 5,484 cubic feet when a pallet is carried on the ramp and 5,049 feet excluding a pallet on the ramp.

The flight station is designed in compliance with all military and FAA requirements, including vision requirements which have been met or bettered. Four permanent crew positions for the normal crew of pilot, co-pilot, systems engineer, and navigator are designed in complete recognition of all human factors parameters. A flight check seat, mounted on tracks and stowed beneath the forward end of the navigator's table when not in use, provides a fifth position on the centerline of the flight deck aft of the center console. The lower of two bunks at the rear of the flight deck can be used for seating. Complete galley provisions are made for six men. While the crew station is optimized for division of work assignments, control equipment arrangement is such that flight can be safely accomplished with as few as two crew members.

An extra crew compartment, which may be installed in the forward end of the cargo compartment, is shown in Figure 1-11. It meets all requirements and is designed to mate with the 463L pallet system.

The most important feature of the fuselage is the straight-in-tail-loading arrangement shown in Figure 1-12. The faired afterbody, unique for cargo airplanes, provides drag levels during cruise flight equal to those attainable with symmetrical bodies of revolution. Hydraulic operation places both segments of each door in a position approximately parallel to the fuselage centerline when open. A simple straight-forward mechanically sequenced hydraulic and mechanical actuation system controls and limits all door motions to prevent interference damage.

The alighting gear is a modified tricycle type. The nose gear has two free rotating wheels and rack and gear hydraulically powered steering. Provisions for initiating nose wheel steering by rudder pedal action may be included in addition to the standard steering wheel on the pilot's side of the crew station. The main gears each have four bogie mounted wheel and brake assemblies. All gears retract forward and will extend and lock by gravity free fall in emergency. Oleo struts comply with MIL-S-8552 except that they are charged with Monsanto Skydrol 500A fire resistant hydraulic fluid. All gears are hydraulically retracted and extended. All doors are mechanically operated by gear motion.

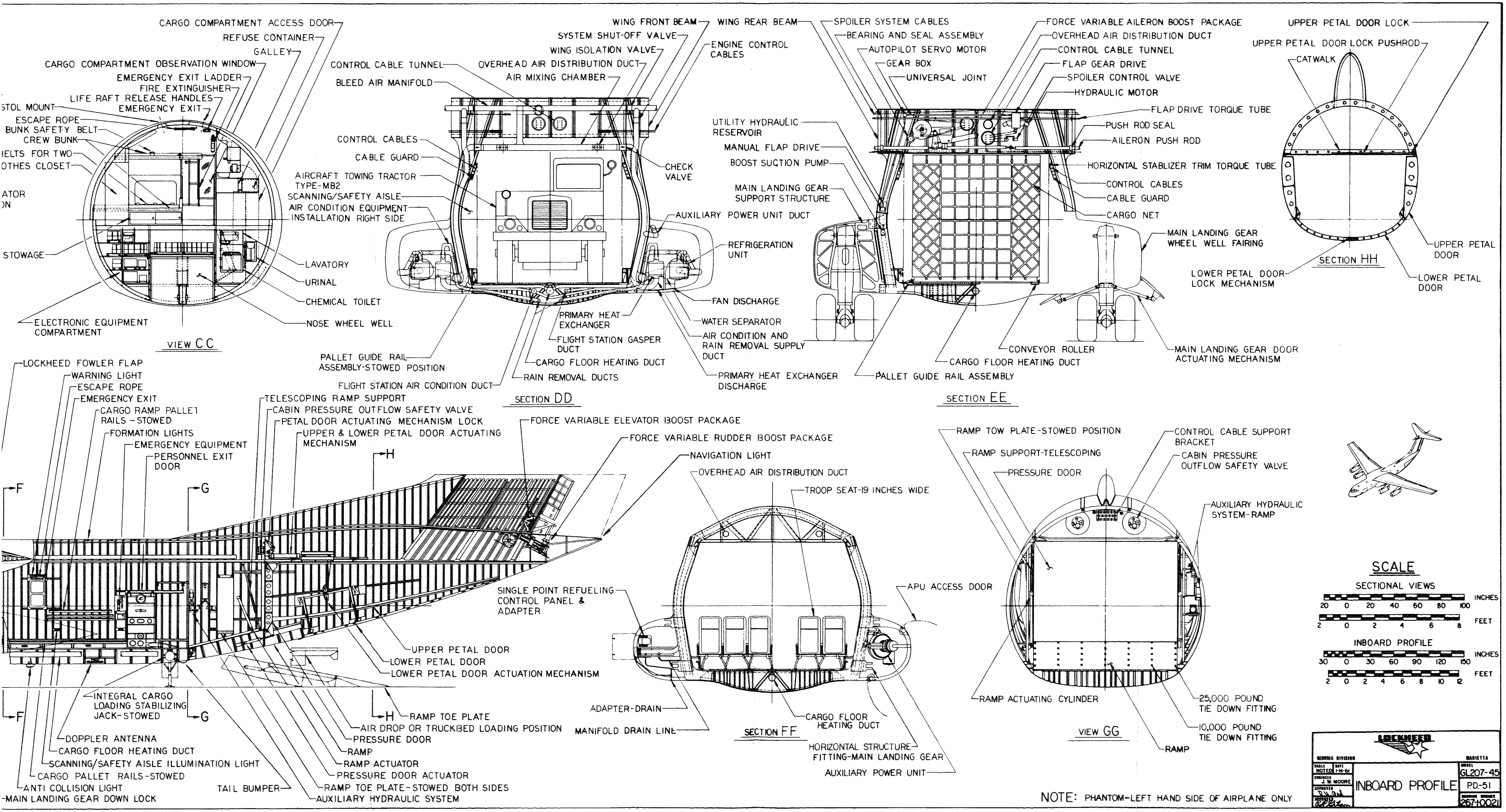
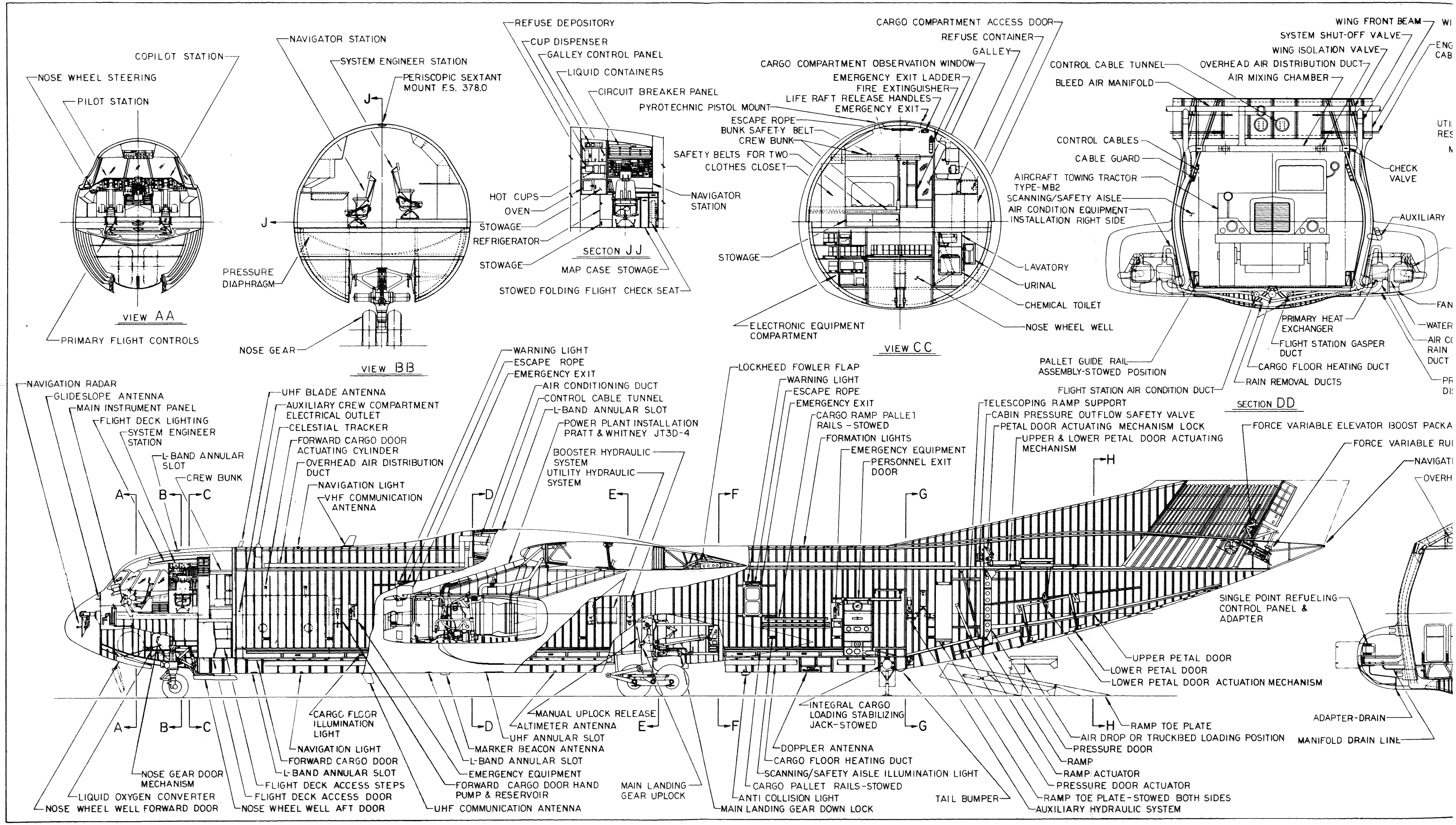

CARGO COMPARTMENT ACCESS DOOR
REFUSE CONTAINER
GALLEY
CARGO COMPARTMENT OBSERVATION WINDOW
EMERGENCY EXIT LADDER
FIRE EXTINGUISHER
LIFE RAFT RELEASE HANDLES
STOL MOUNT
EMERGENCY EXIT
ESCAPE ROPE
BUNK SAFETY BELT
CREW BUNK
BELTS FOR TWO
CLOTHES CLOSET
ATOR
ON
STOWAGE
LAVATORY
URINAL
CHEMICAL TOILET
ELECTRONIC EQUIPMENT COMPARTMENT
NOSE WHEEL WELL
VIEW CC
WING FRONT BEAM
SYSTEM SHUT-OFF VALVE
WING ISOLATION VALVE
OVERHEAD AIR DISTRIBUTION DUCT
AIR MIXING CHAMBER
CONTROL CABLE TUNNEL
BLEED AIR MANIFOLD
ENGINE CONTROL CABLES
CONTROL CABLES
CABLE GUARD
AIRCRAFT TOWING TRACTOR TYPE-MB2
SCANNING/SAFETY AISLE
AIR CONDITION EQUIPMENT INSTALLATION RIGHT SIDE
CHECK VALVE
AUXILIARY POWER UNIT DUCT
REFRIGERATION UNIT
FAN DISCHARGE
WATER SEPARATOR
AIR CONDITION AND RAIN REMOVAL SUPPLY DUCT
PRIMARY HEAT EXCHANGER DISCHARGE
PRIMARY HEAT EXCHANGER
FLIGHT STATION GASPER DUCT
CARGO FLOOR HEATING DUCT
RAIN REMOVAL DUCTS
PALLET GUIDE RAIL ASSEMBLY-STOWED POSITION
FLIGHT STATION AIR CONDITION DUCT
SECTION DD
WING REAR BEAM
SPOILER SYSTEM CABLES
BEARING AND SEAL ASSEMBLY
AUTOPILOT SERVO MOTOR
GEAR BOX
UNIVERSAL JOINT
FORCE VARIABLE AILERON BOOST PACKAGE
OVERHEAD AIR DISTRIBUTION DUCT
CONTROL CABLE TUNNEL
FLAP GEAR DRIVE
SPOILER CONTROL VALVE
HYDRAULIC MOTOR
FLAP DRIVE TORQUE TUBE
PUSH ROD SEAL
AILERON PUSH ROD
UTILITY HYDRAULIC RESERVOIR
MANUAL FLAP DRIVE
BOOST SUCTION PUMP
MAIN LANDING GEAR SUPPORT STRUCTURE
HORIZONTAL STABLIZER TRIM TORQUE TUBE
CONTROL CABLES
CABLE GUARD
CARGO NET
MAIN LANDING GEAR WHEEL WELL FAIRING
CONVEYOR ROLLER
CARGO FLOOR HEATING DUCT
PALLET GUIDE RAIL ASSEMBLY
MAIN LANDING GEAR DOOR ACTUATING MECHANISM
SECTION EE
UPPER PETAL DOOR LOCK
UPPER PETAL DOOR LOCK PUSHROD
CATWALK
SECTION HH
LOWER PETAL DOOR LOCK MECHANISM
UPPER PETAL DOOR
LOWER PETAL DOOR
LOCKHEED FOWLER FLAP
WARNING LIGHT
ESCAPE ROPE
EMERGENCY EXIT
CARGO RAMP PALLET RAILS - STOWED
FORMATION LIGHTS
EMERGENCY EQUIPMENT
PERSONNEL EXIT DOOR
TELESCOPING RAMP SUPPORT
CABIN PRESSURE OUTFLOW SAFETY VALVE
PETAL DOOR ACTUATING MECHANISM LOCK
UPPER & LOWER PETAL DOOR ACTUATING MECHANISM
FORCE VARIABLE ELEVATOR BOOST PACKAGE
FORCE VARIABLE RUDDER BOOST PACKAGE
NAVIGATION LIGHT
F
G
H
UPPER PETAL DOOR
LOWER PETAL DOOR
LOWER PETAL DOOR ACTUATION MECHANISM
INTEGRAL CARGO LOADING STABILIZING JACK-STOWED
DOPPLER ANTENNA
CARGO FLOOR HEATING DUCT
SCANNING/SAFETY AISLE ILLUMINATION LIGHT
CARGO PALLET RAILS-STOWED
ANTI COLLISION LIGHT
MAIN LANDING GEAR DOWN LOCK
TAIL BUMPER
RAMP TOE PLATE
AIR DROP OR TRUCKBED LOADING POSITION
PRESSURE DOOR
RAMP
RAMP ACTUATOR
PRESSURE DOOR ACTUATOR
RAMP TOE PLATE-STOWED BOTH SIDES
AUXILIARY HYDRAULIC SYSTEM
OVERHEAD AIR DISTRIBUTION DUCT
TROOP SEAT-19 INCHES WIDE
SINGLE POINT REFUELING CONTROL PANEL & ADAPTER
APU ACCESS DOOR
ADAPTER-DRAIN
MANIFOLD DRAIN LINE
CARGO FLOOR HEATING DUCT
SECTION FF
HORIZONTAL STRUCTURE FITTING-MAIN LANDING GEAR
AUXILIARY POWER UNIT
RAMP TOW PLATE-STOWED POSITION
RAMP SUPPORT-TELESCOPING
PRESSURE DOOR
CONTROL CABLE SUPPORT BRACKET
CABIN PRESSURE OUTFLOW SAFETY VALVE
AUXILIARY HYDRAULIC SYSTEM-RAMP
RAMP ACTUATING CYLINDER
25,000 POUND TIE DOWN FITTING
10,000 POUND TIE DOWN FITTING
RAMP
VIEW GG
SCALE
SECTIONAL VIEWS
20 0 20 40 60 80 100 INCHES
2 0 2 4 6 8 FEET
INBOARD PROFILE
30 0 30 60 90 120 150 INCHES
2 0 2 4 6 8 10 12 FEET
NOTE: PHANTOM-LEFT HAND SIDE OF AIRPLANE ONLY
LOCKHEED
GEORGIA DIVISION
MARIETTA
J. W. MOORE
INBOARD PROFILE
GL207-45
PD-51

figure 1-10



COPILOT STATION
NOSE WHEEL STEERING
PILOT STATION
VIEW AA
PRIMARY FLIGHT CONTROLS
NAVIGATOR STATION
SYSTEM ENGINEER STATION
PERISCOPIC SEXTANT MOUNT F.S. 378.0
J
PRESSURE DIAPHRAGM
NOSE GEAR
VIEW BB
REFUSE DEPOSITORY
CUP DISPENSER
GALLEY CONTROL PANEL
LIQUID CONTAINERS
CIRCUIT BREAKER PANEL
HOT CUPS
OVEN
STOWAGE
REFRIGERATOR
STOWAGE
NAVIGATOR STATION
SECTON JJ
MAP CASE STOWAGE
STOWED FOLDING FLIGHT CHECK SEAT
CARGO COMPARTMENT ACCESS DOOR
REFUSE CONTAINER
GALLEY
CARGO COMPARTMENT OBSERVATION WINDOW
EMERGENCY EXIT LADDER
FIRE EXTINGUISHER
LIFE RAFT RELEASE HANDLES
PYROTECHNIC PISTOL MOUNT
EMERGENCY EXIT
ESCAPE ROPE
BUNK SAFETY BELT
CREW BUNK
SAFETY BELTS FOR TWO
CLOTHES CLOSET
STOWAGE
LAVATORY
URINAL
CHEMICAL TOILET
NOSE WHEEL WELL
ELECTRONIC EQUIPMENT COMPARTMENT
VIEW CC
WING FRONT BEAM
SYSTEM SHUT-OFF VALVE
WING ISOLATION VALVE
CONTROL CABLE TUNNEL
OVERHEAD AIR DISTRIBUTION DUCT
BLEED AIR MANIFOLD
AIR MIXING CHAMBER
CONTROL CABLES
CABLE GUARD
CHECK VALVE
AIRCRAFT TOWING TRACTOR TYPE-MB2
SCANNING/SAFETY AISLE
AIR CONDITION EQUIPMENT INSTALLATION RIGHT SIDE
AUXILIARY
PRIMARY HEAT EXCHANGER
FLIGHT STATION GASPER DUCT
PALLET GUIDE RAIL ASSEMBLY-STOWED POSITION
CARGO FLOOR HEATING DUCT
RAIN REMOVAL DUCTS
FLIGHT STATION AIR CONDITION DUCT
SECTION DD
NAVIGATION RADAR
GLIDESLOPE ANTENNA
MAIN INSTRUMENT PANEL
FLIGHT DECK LIGHTING
SYSTEM ENGINEER STATION
L-BAND ANNULAR SLOT
CREW BUNK
UHF BLADE ANTENNA
AUXILIARY CREW COMPARTMENT ELECTRICAL OUTLET
CELESTIAL TRACKER
FORWARD CARGO DOOR ACTUATING CYLINDER
OVERHEAD AIR DISTRIBUTION DUCT
NAVIGATION LIGHT
VHF COMMUNICATION ANTENNA
WARNING LIGHT
ESCAPE ROPE
EMERGENCY EXIT
AIR CONDITIONING DUCT
CONTROL CABLE TUNNEL
L-BAND ANNULAR SLOT
POWER PLANT INSTALLATION PRATT & WHITNEY JT3D-4
BOOSTER HYDRAULIC SYSTEM
UTILITY HYDRAULIC SYSTEM
LOCKHEED FOWLER FLAP
WARNING LIGHT
ESCAPE ROPE
EMERGENCY EXIT
CARGO RAMP PALLET RAILS - STOWED
FORMATION LIGHTS
EMERGENCY EQUIPMENT
PERSONNEL EXIT DOOR
TELESCOPING RAMP SUPPORT
CABIN PRESSURE OUTFLOW SAFETY VALVE
PETAL DOOR ACTUATING MECHANISM LOCK
UPPER & LOWER PETAL DOOR ACTUATING MECHANISM
FORCE VARIABLE ELEVATOR BOOST PACKA
A
B
C
D
E
F
G
H
SINGLE POINT REFUELING CONTROL PANEL & ADAPTER
UPPER PETAL DOOR
LOWER PETAL DOOR
LOWER PETAL DOOR ACTUATION MECHANISM
ADAPTER-DRAIN
MANIFOLD DRAIN LINE
CARGO FLOOR ILLUMINATION LIGHT
NAVIGATION LIGHT
FORWARD CARGO DOOR
L-BAND ANNULAR SLOT
FLIGHT DECK ACCESS STEPS
FLIGHT DECK ACCESS DOOR
NOSE WHEEL WELL AFT DOOR
NOSE GEAR DOOR MECHANISM
LIQUID OXYGEN CONVERTER
NOSE WHEEL WELL FORWARD DOOR
MANUAL UPLOCK RELEASE
ALTIMETER ANTENNA
UHF ANNULAR SLOT
MARKER BEACON ANTENNA
L-BAND ANNULAR SLOT
EMERGENCY EQUIPMENT
FORWARD CARGO DOOR HAND PUMP & RESERVOIR
UHF COMMUNICATION ANTENNA
MAIN LANDING GEAR UPLOCK
INTEGRAL CARGO LOADING STABILIZING JACK-STOWED
DOPPLER ANTENNA
CARGO FLOOR HEATING DUCT
SCANNING/SAFETY AISLE ILLUMINATION LIGHT
CARGO PALLET RAILS-STOWED
ANTI COLLISION LIGHT
MAIN LANDING GEAR DOWN LOCK
TAIL BUMPER
RAMP TOE PLATE
AIR DROP OR TRUCKBED LOADING POSITION
PRESSURE DOOR
RAMP
RAMP ACTUATOR
PRESSURE DOOR ACTUATOR
RAMP TOE PLATE-STOWED BOTH SIDES
AUXILIARY HYDRAULIC SYSTEM

Modulating anti-skid braking systems operate through two metering valves for each main gear, one for the forward wheels and one for the aft wheels. Minimum runway width for 180° turn-around is 73 feet. The UCI for the gear at the landing weight for the 60,000-pound payload, 1,000 nautical mile mission is 38 for the main gear and 34 for the nose gear. Maximum turnover angle is 51 degrees, 54 minutes.

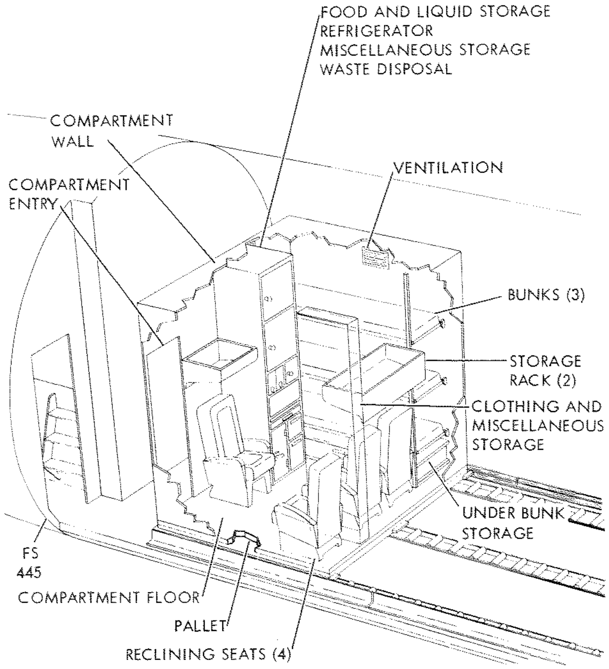


Figure 1-11—EXTRA CREW COMPARTMENTS.

The advantages of this conventional, well-proven configuration include the fact that it puts the landing gear where it belongs, beneath the primary load, and provides added safety in the event of a gear-up belly landing. The main landing gear geometry has been compared with similar gears on the C-123, C-130, and C-133. The anti-tip capability for the Super Hercules is much better than that for the other airplanes; even better than that of the C-130, which has proven itself completely adequate. Also, the Super Hercules exceeds, by a substantial margin, the Air Force HIAD tip-over requirements|

The four P & W JT3D-4 18,000-pound thrust turbofan engines are mounted in interchangeable individual QEC's, two under each wing. The JT3D-4 is a developed domestic engine requiring minimum qualification. It derives from the J57/JT3 family now in service and in Air Force and commercial inventories. It offers early growth potential based on basic proven hardware for each step of growth. The QEC locations and the design of QEC's and pylons provide near-optimum compromises among aero-thermodynamic efficiency, safety, simplicity, serviceability, and Air Force and FAA specification requirements. Each engine installation is fitted with extension fan ducts and a target type thrust reverser assembly. The thrust reversers are operable in flight and on the ground.

The primary flight controls are conventional and utilize elevators, ailerons and rudder without employing supplementary spoilers. Crew station controls conforming to all HIAD and FAA specifications operate the surfaces through cables and utilize Lockheed developed force modulating boosters powered by two separate hydraulic systems. Surface hinge moments are reduced by geared tabs on the ailerons. Manually operated ratio shifters in the booster assemblies are utilized to increase the pilot's mechanical advantage when boost power is off thus allowing the airplane to be flown and landed using only manual pilot effort.

A linear actuator is utilized to trim the moveable horizontal stabilizer. Power for the actuator is a hydraulic motor for the normal manual pilot controlled operation; electric motor and dual magnetic clutch drive for pilot's wheel switch and for automatic flight control operation; and two center control console handwheels and torque tube system for emergency manual trimming. Dual load paths and fail-safe design criteria are utilized throughout the design of the actuator and its attachments. The aileron geared tab is trimmed by a manual crank-knob operating cables to drive an irreversible dual load path linear actuator and push-rod system which trims the neutral reference of the tab. The rudder trim tab is manually operated by a system similar to that used to trim the aileron geared tab.

Wing flaps are conventional ballscrew operated track mounted Lockheed-Fowler type, similar to those

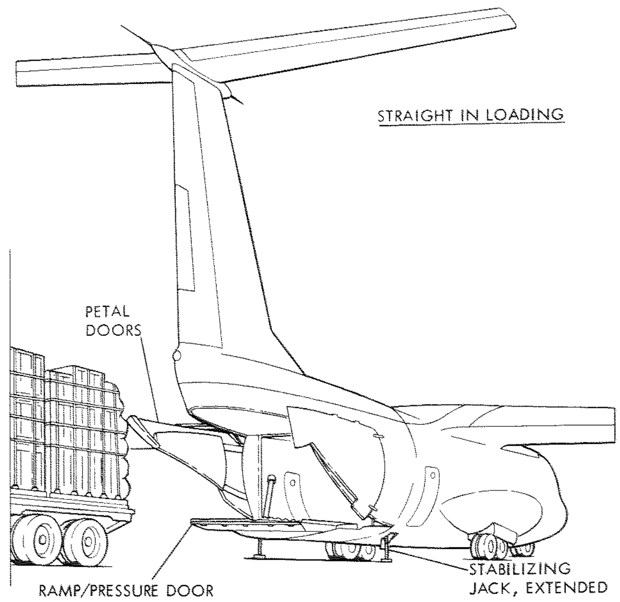


Figure 1-12—CARGO LOADING DOORS—AFT.

used on the C-130. Each of the six flap sections is operated by two screws, all driven by a torque tube which is powered by two hydraulic motors and controlled by a pilot manually operated tandem servo valve. Hydraulic power is supplied from two independent systems, either of which will operate the flaps at reduced speed. Both hydraulic systems are normally used. An emergency manual handcrank is provided in the left aisle of the cargo compartment. C-130 type assymetry brakes function in the event of drive system failures.

Wing trailing edge spoilers are used on the ground for spoiling wing lift and to increase drag. Two hydraulic cylinders, each powered by an independent hydraulic system, operate the cable and crank arrangement connecting all spoiler panels. The control valves are mechanically linked to the nose landing gear oleo to prevent inadvertent operation prior to compressing the nose gear oleo.

Automatic flight controls include an automatic pilot, yaw damper and Mach trim systems. The automatic pilot has roll and pitch axes with the yaw axis incorporating additional features enabling it to function independently as a yaw damper. It is adaptable for use with the advanced navigational systems presently programmed and stipulated in System 476L. An automatic stabilizer trim function is provided which electrically operates the stabilizer actuator in response to automatic pilot or Mach trim signals when either the automatic pilot or the Mach trim system is energized. The Mach trim system senses Mach number and adds a "tuck" compensating pitch trim increment to the pilot's trim settings during manual flight.

The fuel system includes subsystems for: fuel supply, crossfeed, ground defueling, single point refueling, over wing fueling, and fuel jettisoning. A single common line routed through the fuel tanks from wing tip to wing tip is utilized for crossfeed, refueling, defueling and fuel jettisoning. Nine internal wing tanks provide the total fuel capacity of 23,080 U. S. gallons. Plug-in type pumps and valves are used with unitized manifolds where possible to facilitate servicing without defueling. All fuel lines in the tank regions are routed inside the tanks thus minimizing leak hazards. All fuel tanks and lines are located outside of the pressurized portions of the airplane The vent system needs no vent valves yet protects the structure against damage if level control valves fail. Capacitance type multiple probe quantity gaging is provided for all tanks. Airframe strainers are not used since the engine fuel filtration system serves this function.

Three hydraulic power subsystems are provided: booster, utility and auxiliary. Design and installation of these systems follow the applicable MIL and FAA specifications for 3,000 psi systems except that Monsanto Skydrol 500A fire resistant hydraulic fluid is used and materials and finishes compatible therewith are used. Conversion to MIL-H-5606 fluid involves only replacement of seals. The boost and utility systems are each powered by two engine driven variable volume pumps. The auxiliary system pressure is supplied by two electric motor driven variable volume pumps. Handpumps provide power for operation of the forward cargo door and the auxiliary hydraulic systems.

The air conditioning system provides two independent condition packages each utilizing a separate engine bleed air supply. The two packages normally function in parallel; however, either package can operate independently in the event of a failure thus preventing loss of cabin pressure. Temperature and airflow regulation are automatic. Compatibility between ground and flight refrigeration and minimum system weight are achieved by regulating the bleed air pressure at each engine manifold. Refrigeration capacity is provided to maintain temperatures of 75°F in the crew compartment and 80°F in the cargo compartment on an Air Force Hot Day and heating capacity is provided to maintain 80°F in both compartments on an Air Force Cold Day under all flight conditions.

Cabin pressure is controlled by two combination outflow-safety valves which maintain 8,000 feet cabin altitude up to a 50,000-foot flight altitude. Each of the valves provides pressure relief, emergency depressurization and cabin altitude limiting.

The wing leading edge and engine inlets are anti-iced with engine bleed air. These systems are designed to perform satisfactorily under all climb and level flight conditions. The empennage is electrically de-iced by metal-clad heaters, thus providing high reliability and light weight by minimizing the high temperature ducting within the fuselage.

The crew station window areas are electrically anti-iced and defogged. Both pilot's and copilot's windshield panels have jet-blast rain removal designed to provide adequate forward visibility during taxi, takeoff and landing.

The primary AC electric power is supplied by four parallel main-engine driven, 40 kva generators with hydro-mechanical constant speed drives having capability of continuous 50 kva operation. A conventional system with four main load buses and a tie bus is utilized. DC power is converted by two 200-ampere convection-cooled transformer rectifiers. Self-contained auxiliary and emergency power is supplied by a fifth 40 kva generator mounted on the gas turbine auxiliary power unit. A 36 ampere-hour nickel-cadmium battery is installed.

The proposed navigation and communication systems fully comply with the requirements of the Work

Statement. The navigation system functionally divides into two parts: the radio aids to navigation equipment, and the global navigation equipment. The radio aids to navigation include the VHF navigation, glide slope, automatic direction finder, marker beacon, and radar systems. Remote control units for this equipment are installed on the center control console. The global navigation equipment, which includes the inertial platform, doppler radar, digital and dead reckoning computers, and photoelectric sextant, are controlled by the navigator.

The communication system includes dual installation of UHF, VHF, and HF transmitter-receiver units which are controlled by the pilot and copilot from control units on the center control console. The system features a digital data link for automatic ground to air communication for air traffic control and management, advisory, and command/control traffic. The system also meets the requirements for selective calling and variable length messages. The entire system is compatible with present and planned FAA and 480L ground environments. (480L is the USAF global communications system being developed primarily for SAC).

A permanent oxygen system is installed in the crew station. It is capable of serving ten men from a 25-liter liquid oxygen converter. The capacity of this system is sufficient to supply 113 manhours of oxygen at 30,000 feet. A 10-liter liquid oxygen system is supplied in the portable extra crew compartment. Its capacity is 45 manhours of oxygen at 30,000 feet. A portable oxygen system for troops and litter patients may be installed in the cargo compartment. This installation is supplied by four 25-liter liquid oxygen converters capable of supplying 95 troops for over four hours at 30,000 feet. All oxygen systems on the airplane are logistically compatible and employ components readily available in Air Force inventory.

Performance

The payload/range capability of the GL 207-45 is shown in Figure 1-13. The design payload of 70,000 pounds can be carried 3880 nautical miles at the maximum take-off weight of 315,000 pounds. Payloads greater than 70,000 pounds can be carried if the knee in the speed limit curve is raised in altitude. Maximum payload for 315,000 pounds take-off weight is 80,000 pounds at a 2.5 maneuver load factor. Payloads even higher can be carried at lighter take-off weights as wing fuel weight is decreased.

For the basic mission, when powered with the JT3D-4 powerplant and when carrying a payload of 50,000 pounds, a fuel load of 110,200 pounds is required which results in a take-off gross weight of 287,200 pounds which can be flown from a CAR critical field length of 5960 feet with a beginning cruise altitude of 34,200 feet and an average cruise speed of 440 knots for a range of 4,000 nautical miles. Landing weight will be 187,530 pounds and CAR landing field length required is 4910 feet. Reserve fuel upon landing is 10,530 pounds.

For the alternate mission payload of 20,000 pounds, and with a fuel load of 136,100 pounds, take-off weight is 283,100 pounds which requires a CAR critical field length of 5780 feet. Beginning cruise altitude is 34,500 feet, average cruise speed is 440 knots, and range is 5,500 nautical miles. Landing weight for this mission is 158,305 pounds and the CAR critical landing field length required is only 4330 feet. Reserve fuel upon landing is 11,305 pounds.

The maximum design take-off weight of 315,000 pounds may be exploited for maximum cruise speed, in which case the basic 50,000 pound, 4,000 nautical mile mission can be flown at 457 knots; or for improved payload at 440 knots, in which case 67,300 pounds can be carried 4000 nautical miles. At this same take-off weight at a speed of 440 knots, a payload of 38,000 pounds can be carried 5,500 nautical miles.

For a tactical mission to carry 25,000 pounds 1,500 nautical miles, a take-off weight of 191,400 pounds

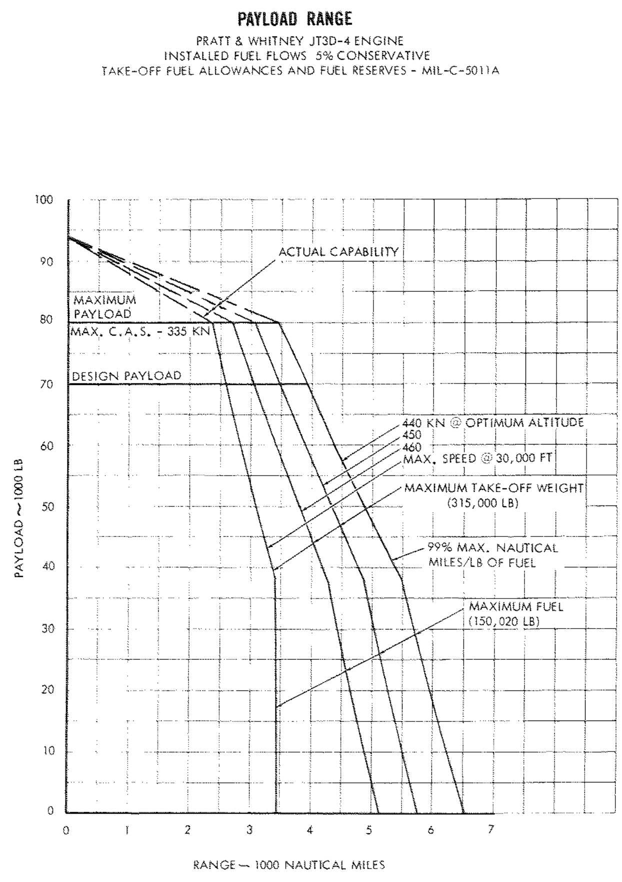


Figure 1-13—PAYLOAD RANGE.

results in a take-off UCI of only 38. Take-off ground roll required is only 1460 feet. Landing weight is 158,480 pounds which results in a landing UCI of only 32. Landing ground roll is 900 feet.

When the basic military version of the Super Hercules is fitted out for commercial application by removing the military equipment not required and substituting a light-weight cargo floor and the Lockheed mechanized loading system, compatible with System 463L, the equipped-weight empty is reduced to 123,200 pounds. The maximum bulk payload capability is 93,000 pounds and, an 84,000 pound palletized payload can be carried at a loaded density of 14.0 pounds per cubic foot. Using a maximum take-off weight of 315,000 pounds, and the minimum-DOC cruise speed of 440 knots, the payload can be carried any range from 850 to 3600 nautical miles at a direct operating cost of only 3.9 cents per ton mile. For operators desiring larger payloads at reduced densities for shorter ranges, the fuselage can be lengthened for one, or a maximum of two, more pallets, increasing usable volume by approximately 10 and 20 percent respectively.

For international commercial operation the equipped-weight empty becomes 124,000 pounds so that, at a take-off weight of 312,400 pounds and with the fuel required for the Work Statement 3,000 nautical mile over-water range, the maximum payload becomes 83,200 pounds and the direct operating cost is 4.5 cents per ton nautical mile.

In addition to the performance already shown, basic mission performance for the Super Hercules has been computed when powered with the JT3D-8A, -8B and -12 and with the GE MF239C-3. These data are summarized in the following table.

PERFORMANCE SUMMARY

Alternate Power Plants)

Data	JT3D-4	JT3D-8A	JT3D-8B	JT3D-12A	MF239C-3
Payload for 400 N. M. at 440 kts.	67,700 (50,500)*	69,000	69,000	67,300	71,200
Max. Cruise Speed for 50,000 lbs/ 4000 N.M.	456 (440)*	457	457	457	462
FAA Crit. Fld. Length	7,720 (5,960)*	6,000	5,500	5,600	5,350
Military DOC at 4000 N.M.	5.97 (7.90)*	5.88	5.88	5.96	5.71

* Figures in Parenthesis are for 287,200 lb. T.O. Wt.

All data are for a takeoff weight of 315,000 pounds except as noted. The payload for the basic 4000 nautical mile mission varies slightly as a function of engine weight. The maximum cruise speed permissible to carry 50,000 pounds for 4000 nautical miles increases slightly with the advanced power plants when the engine weight variation is utilized for additional fuel. Takeoff field length decreases, of course, as engine static thrust level increases. The direct operating costs are remarkably constant, however, indicating the fact that the advanced engines exhibit only modest improvement in fuel consumption in spite of substantial increases in thrust.

One interesting outgrowth of the high speed wind tunnel tests conducted to date is the possible drag savings by the addition of anti-shock bodies to the wing; these might prove desirably compatible with higher cruise speeds without giving up the advantages of the minimum sweep wing.

Flying Qualities

Careful attention has been given to design features which will ensure excellent stability and control characteristics. The center of gravity diagram shown in Figure 1-14 indicates the significant center of gravity envelope for the airplane. Margins are adequate in all areas.

The "T" empennage developed through high as well as low speed wind tunnel tests provides a high level of stability with excellent control through the stall. This unusually high stability level allows:

1 Compliance with the stick force requirements of MIL-F-8785
2 Use of a conventional elevator boost system similar to that which has proven so satisfactory on the C-130 without use of any artificial stability devices
3 Attainment of a large allowable center of gravity travel

The minimum wing sweep, moderate airfoil thickness, large outboard leading edge radius, and care-

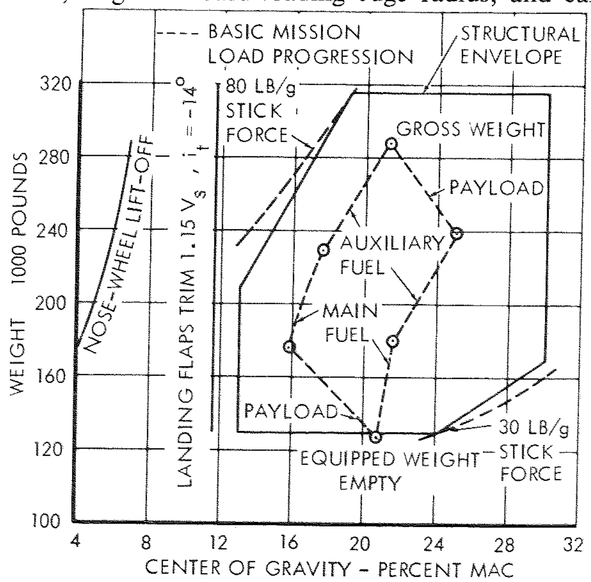


Figure 1-14—CENTER OF GRAVITY DIAGRAMS.

fully selected camber and twist distribution tested on the wind tunnel model, shown in Figure 1-15, provide excellent stall characteristics without requiring use of wing leading edge devices. Low speed wind tunnel tests have shown that excellent roll control is provided throughout the flight speed range through use of conventional ailerons.

Dynamic studies of airplane response to abrupt engine failure have been conducted to determine minimum control speeds. Adequate control power is provided so that the airplane's runway requirements are not affected except at the very lightest weights where field length requirements are far from critical. The vertical tail has been sized to enable the airplane to meet the lateral-directional damper-out dynamic stability requirements of MIL-F-8785 throughout its flight regime. The yaw damper is provided to ensure better-than-required dynamic characteristics.

Development Test Programs

Figure 1-16 summarizes the wind tunnel programs, both completed and planned. Only minor configuration changes are anticipated in the future, but substantial backup data, such as air load distribution and flutter stiffness criteria, must be accumulated using existing, and some new, models. The Cornell transonic and the Lockheed and Georgia Tech low speed tunnels will be used.

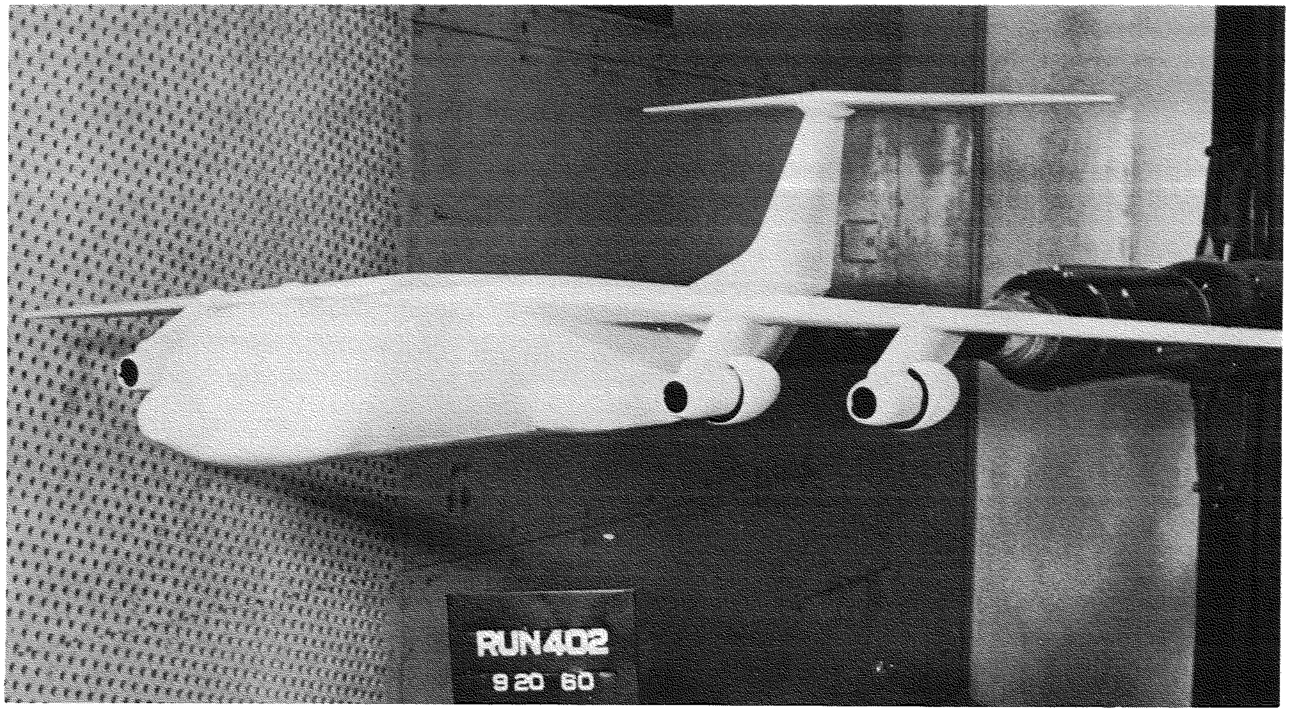


Figure 1-15—HIGH SPEED WIND TUNNEL MODEL.

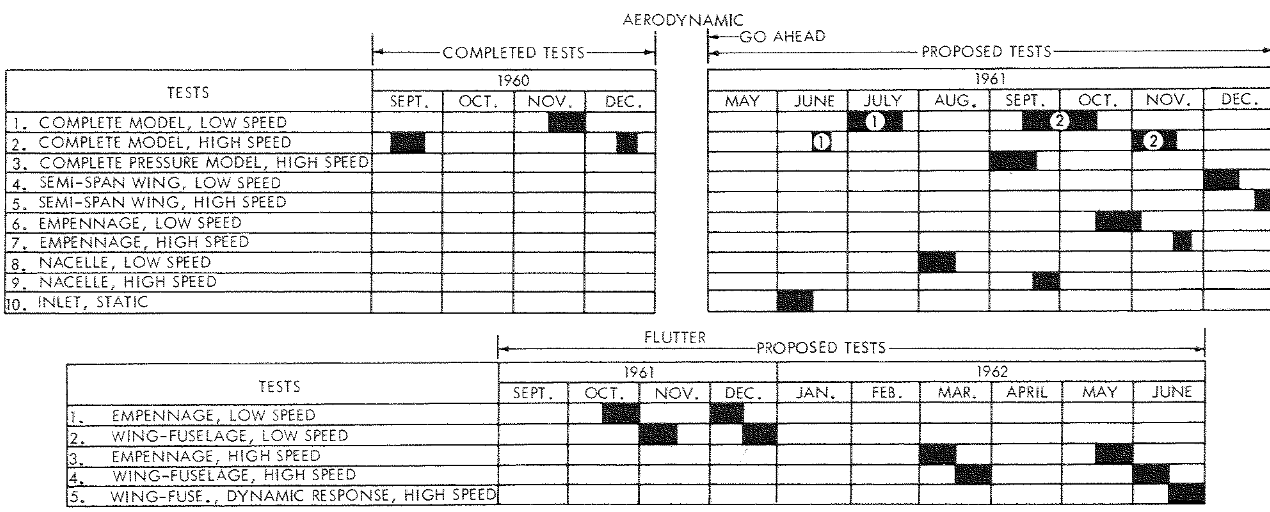


Figure 1-16—WIND TUNNEL PROGRAM SCHEDULE.

Figure 1-17 summarizes the development test and structural test programs, aimed at maximum reliability and integrated with the rapid but realistic aircraft development. Full scale mockups, fuel system mockups, and complete antenna and electronic system tests will provide reliable systems compatible with production schedules.

Comprehensive flight and ground test programs, utilizing an engine test stand and three test aircraft for Category I and FAA certification, are scheduled to achieve a type certification date of 31 August 1964 as shown in Figure 1-18. Two additional aircraft will be used in Category II testing. Past Lockheed certification experience confirms this as an aggressive but realistic schedule. To minimize program interruptions due to ferry requirements and off site spares support and to maximize liaison with other technical program elements, Lockheed considers that Category I tests can best be accomplished at the Georgia Division rather than at Edwards Air Force Base.

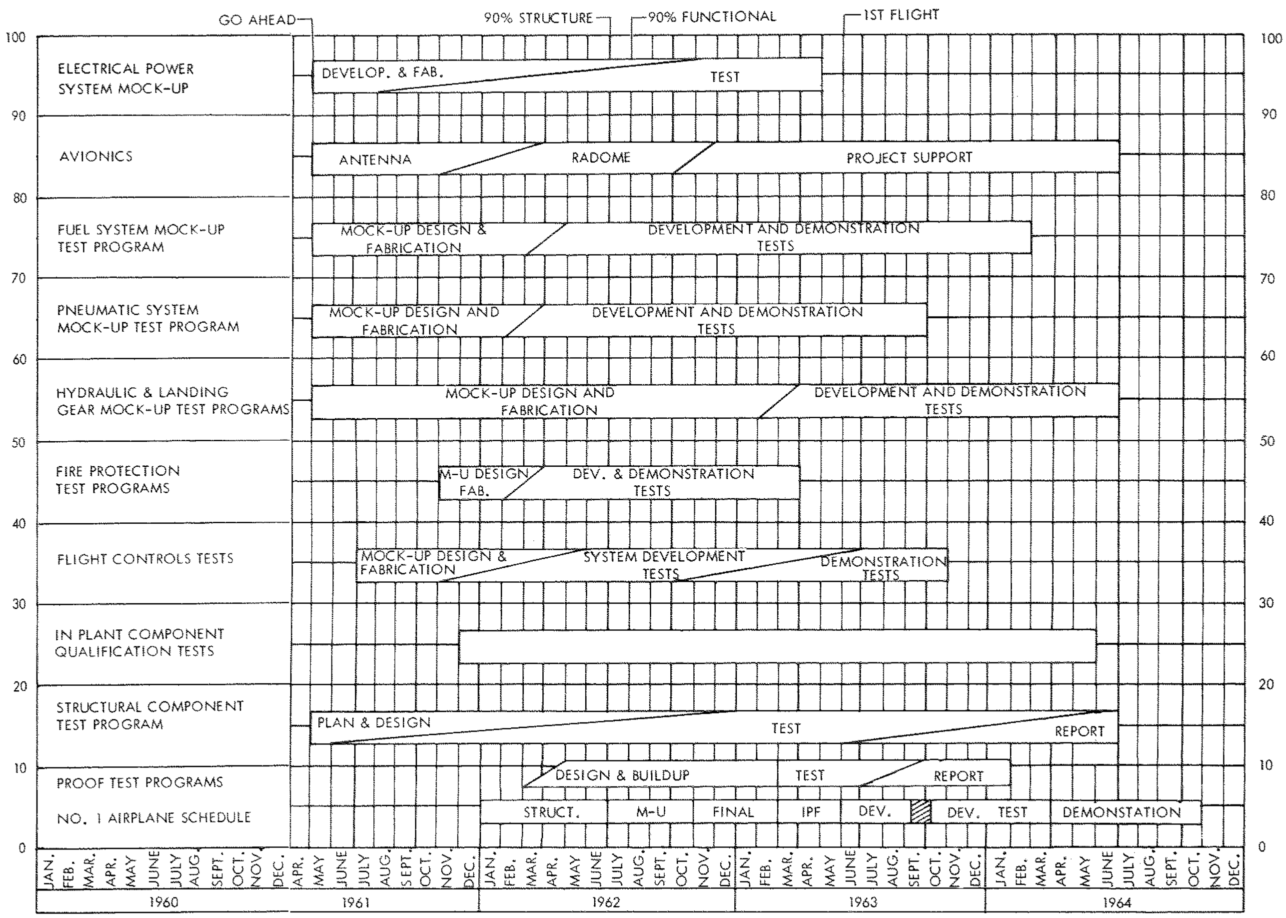


Figure 1-17—DEVELOPMENT TEST PROGRAMS.

MANAGEMENT, PRODUCTION, LOGISTICS AND COST (5.2)

Recognizing the urgency associated with the MATS modernization program, Lockheed proposes a rapid but realistic schedule for the development and production of its GL 207-45 airplane at a price affording maximum economy for the Government. The following is a summary of how Lockheed will accomplish the task of managing this important program.

Master Program Plan

Lockheed's master plan provides an aggressive, attainable schedule for the development, production and support of System 476L. It meets the major schedule requirement of early availability and is based on planning assumptions established in the Air Force Statement of Work:

1 Program go-ahead is 1 May 1961.

2 Total contract quantity of aircraft including flight test articles is 132.

3 Five aircraft are to be used for flight test.

4 FAA type certificate will be obtained.

5 Maximum military production rate will be four per month.

The most important milestones in this fast-moving program are:

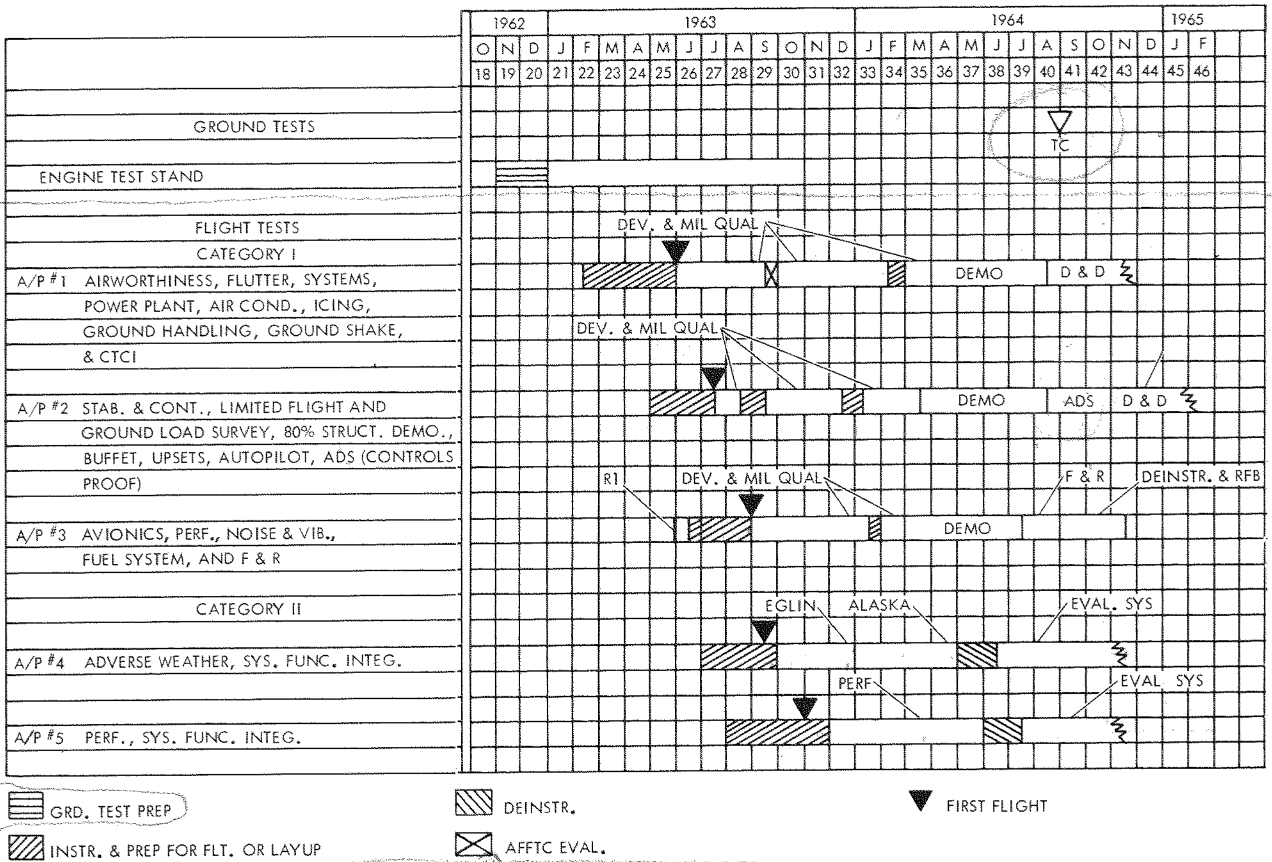


Figure 1-18—FLIGHT TEST PROGRAM SCHEDULE-5 AIRCRAFT.

Development	Dates	Months from Go-Ahead
First Flight	May, 1963	25
FAA Certification	August, 1964	40
Production		
1st Operational Delivery	January, 1964	33
Squadron Strength	September, 1964	41
Delivery 132nd Aircraft	December, 1966	68

Actual schedule performance data, the advantages of carrying forward from Lockheed's C-130 series many characteristics which influence development and production spans, and the fact that preliminary design and other work has been in progress for many months have been considered in this schedule as shown in Figure 1-19. Indicative of the care with which the schedule has been determined is the number of control points considered. More than 150 such controls have been phased across 463 measurable time intervals.

The schedule is based on continuous, though initially limited production in order to derive the substantial benefits from retention of learning. This results in availability of production airplanes, meeting all applicable military specifications, 7 months prior to receipt of type certificate. Delivery of the 15 airplanes available in this period has been assumed, with Lockheed recognizing its obligation to bring these airplanes to type design configuration at no additional cost to the Government.

In the event the Air Force considers obtaining of a type certificate mandatory prior to acceptance of operational airplanes, a test program using 7 aircraft is proposed. This alternate program would result in type certification 37 months after go-ahead.

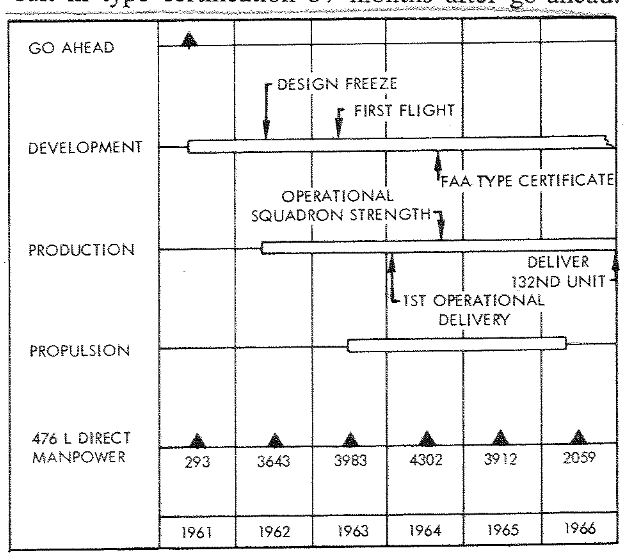


Figure 1-19—MASTER PROGRAM PLAN.

Lockheed's entry in the System 476L competition, the GL 207-45 Super Hercules, derives major benefits from its C-130 predecessor. As the only advanced cargo aircraft now in production for the U.S. military services, the C-130 incorporates major features required by the System 476L specification. This wealth of current related experience provides Lockheed with a substantial base for attainment of the committed objectives.

The advanced monitoring and control techniques provided by Program Evaluation Procedures (PEP) will be fully utilized to provide an additional increment of schedule integrity.

Manpower

Manpower requirements of the System 476L program present no problem for the Georgia Division. The skills required are those which have been developed over the Division's many years of design and production of the C-130 Hercules and the C-140 JetStar and production of the B-47.

The Georgia Division has experienced a decline from approximately 20,000 to 10,000 employees during the past several years. Excluding System 476L manpower requirements, a further decline to an average level of approximately 5,000 employees is projected during the period of System 476L production. Manning the program will be accomplished largely by reassignment of personnel from other projects and by recall of personnel on layoff. Approximately 4500 employees presently on layoff are actively maintaining their recall rights and are available in the immediate area for this proposal. Planned reductions in engineering personnel now assigned to the C-140 JetStar, C-130E, and GV-1 programs coincide with the increase required for GL 207-45.

In the subcontract category, preliminary investigation has shown that many highly qualified sources having ample manpower are available to supply all GL 207-45 items planned for subcontract or purchase.

Organization

Lockheed's Georgia Division, headed by a Vice President and General Manager, operates as an autonomous unit with all the functions necessary to support its assigned product lines. Although the General Manager is held fully responsible for Division accomplishments, he receives continuous support from corporate officers on matters of policy and interdivisional coordination. Thus, the advantages of an autonomous operation are strengthened and complemented by the scope and stability of corporate experience.

The Georgia Division is organized on a functional basis with each major functional organization, such as engineering and manufacturing, reporting directly to the General Manager. Within these functional organizations will be established System 476L project positions and organizations. Figure 1-20 illustrates the System 476L project positions and organizations established within the engineering branch. Similar System 476L project positions and organizations are established in all other affected functional branches. Excellent operational control and high motivation of middle-management personnel result from this project-within-functional organization arrangement.

The scope and importance of System 476L program warrants the constant attention of Lockheed's top management. Accordingly, Assistant General Manager W. B. Rieke will be assigned full time to this program. The Vice President and General Manager has delegated authority to the Assistant General Manager - System 476L to provide complete administration over this program. This proposal presents in depth the organizations established for the System 476L program and the names and qualifications of personnel who will manage these organizations.

Policies and Procedures

Lockheed's system of program planning and control is designed to ensure a sound, consistent approach toward attaining the objectives of the Air Force and the Corporation. Policies and procedures established for a program are implemented by a project plan produced by the master scheduling organization. This plan provides operating directives, schedules, and procedures for attainment of the program objectives. The project plan for System 476L is based on using to the greatest advantage the experience, facilities and skills of the Georgia Division. Techniques for the control of activities of all organizational units are established; many of these controls are monitored by large-scale IBM electronic computers. These program planning and control techniques developed by Lockheed over many years lend themselves readily to the PEP format proposed for System 476L.

The Lockheed quality control system meets or exceeds all requirements of MIL-Q-9858, Quality Control System Requirements, and has been throughly proved by use on C-130 contracts. Complete familiarity with military specifications, Civil Air Regulations Part 4b, and other applicable regulations as demonstrated on current production programs assures compliance with the quality specifications that are mandatory for the System 476L program. Lockheed Georgia Division ! s in operation a reliability program capable of meeting the requirements of MIL-R-26674 and other applicable military specifications.

Lockheed recognizes that maintainability must be inherent in original design to enable the user to meet operational requirements with minimum expenditures of maintenance time, material, and personnel.

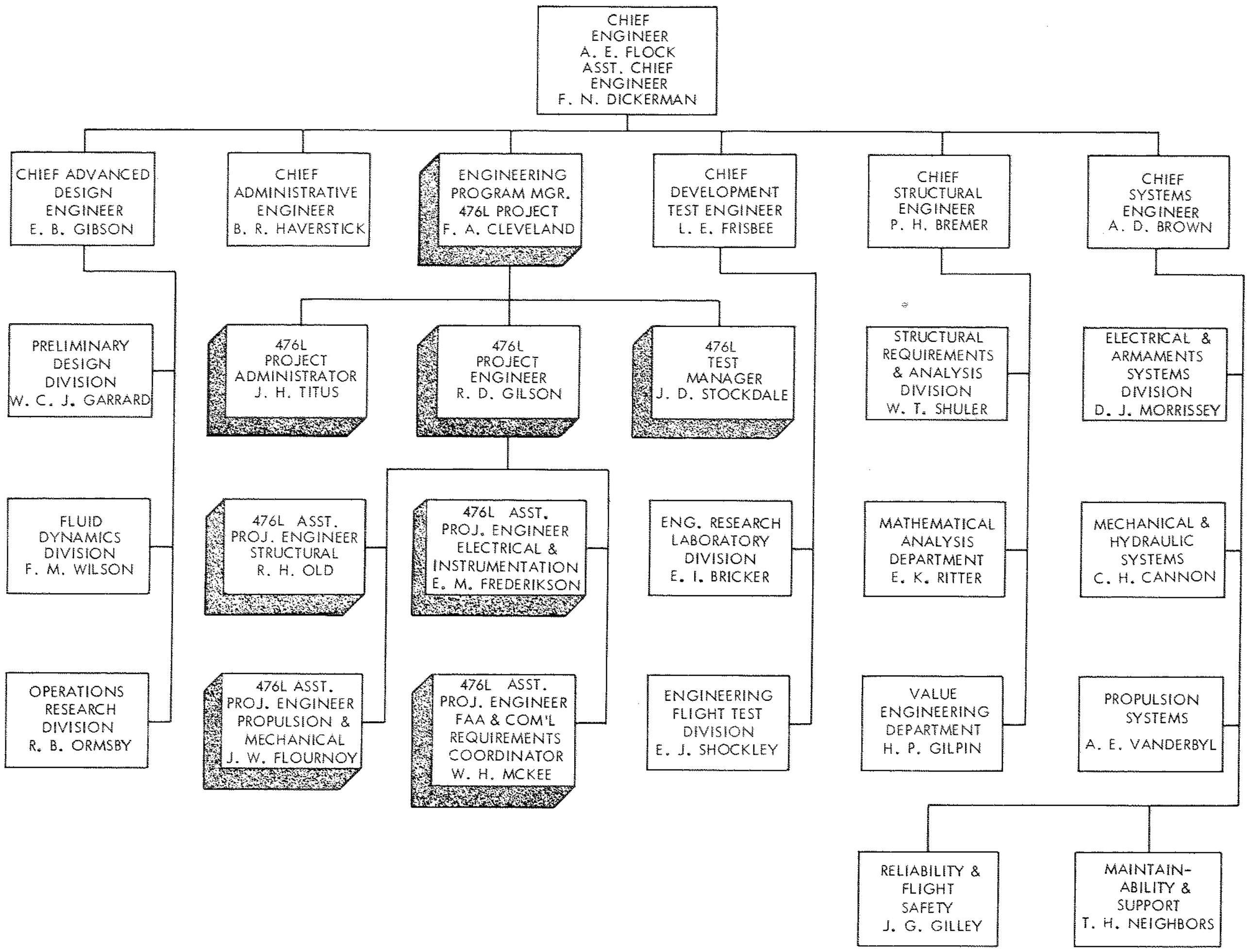


Figure 1-20—ENGINEERING ORGANIZATION.

The maintenance design group, under the chief systems engineer, participates in the design and development of the airplane and related support systems from the earliest design work. For technical and logistic support of the GL 207-45, Lockheed will maintain manufacturing and procurement capabilities in accordance with existing Air Force requirements established by MCP 71-650 and 71-373 and other related specifications. Continuous training is offered for Air Force technical support purposes, and all publications are developed and supplied in strict accordance with Air Force specifications. Subcontracting determinations are made by the Georgia Division Make-or-Buy Policy Committee based on in-plant capabilities, schedules, facilities utilization, transportability, cost, and reliability factors. Lockheed's procurement practices conform to ASPR and AFPI requirements and are performed under Air Force, Army, Navy and NASA contracts.

Production

Production of the GL 207-45 requires a large facility with a wide range of modern manufacturing equipment and staffed by experienced personnel. Lockheed Georgia Division fulfills these requirements.

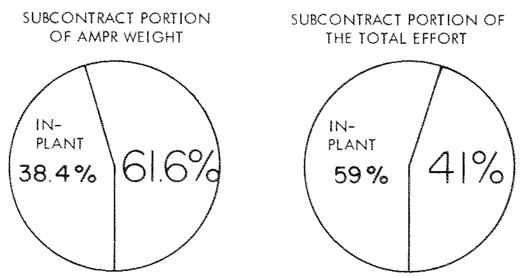
The GL 207-45 is designed and production is planned so as to require no fabrication or assembly equipment or techniques which have not been fully developed and proved. Such additional facilities as may be required will be provided with Lockheed funds. Use of production materials is limited to present state-of-the-art applications, thus assuring that production or performance is not endangered by the failure of new materials to fulfill their promised function.

The tooling policy is to attain the optimum level of economy consistent with quality in the overall effort. Generally, initial tooling will be minimum but designed for expansion or supplementation to final tooling.

During the past many months of preliminary design progress on the GL 207-45, manufacturing engineers have kept closely abreast of every development. As a result, and because producibility is an important Lockheed design consideration, the detailed manufacturing plan is already virtually complete. Ample production space is available. This permits use of a single phase manufacturing layout plan. Costly tool and facility rearrangements involved in multi-phase layouts are thereby avoided.

Production testing is integral with and continues throughout the production cycle, from receipt of raw material to delivery of aircraft. Because of current production of the C-130 Hercules to military specifications and of the C-140 JetStar to FAA specifications, Lockheed can demonstrate current familiarity with and compliance to requirements of this program.

Noteworthy in Lockheed's production plan and illustrated in Figure 1-21 is the size of the subcontract portion, amounting to more than 61 per cent of the AMPR weight. In selecting subcontractors, Lockheed will pay particular attention to depressed areas, to small business, to production sharing programs, and to other airframe manufacturers. All details of the subcontract program will be closely supervised and audited and Lockheed will insist on use of PEP network controls by all subcontractors.



TOTAL VALUE OF PRODUCTION WORK TO BE PROCURED IS $202,442,000

OF WHICH AN ESTIMATED 32% WILL BE PLACED WITH SMALL BUSINESS

Figure 1-21—MAKE-OR-BUY PLAN.

Diligent attention is given to the entire manufacturing process. From the selection of materials and components to the final delivery test of the finished product, it is intended to overlook no opportunity for furnishing the Government an economical, reliable product, designed and delivered to meet the urgent need.

Logistics

Lockheed is extremely aware of the emphasis the military Air Transport Service places on safety, reliability, rapid turn-around capability, self-sufficiency, and responsiveness for instant deployment. These essential requirements set the pattern for System 476L logistic support. It is imperative that the functional elements of logistics support be integrated and responsive one to the other. Lockheed will satisfy these requirements and help to assure a minimum AOCP/ANFE rate throughout the lifetime of the airplane. Meticulous attention to design considerations in terms of simplicity, accessibility, and maintainability serves to minimize maintenance requirements for manpower, special tools, and test equipment. Standard, proved AGE equipment is selected to simplify maintenance support. Supply support is organized to be immediately responsive to requirements. Transportation is programmed carefully to meet the need.

Lockheed C-130 airplanes have been performing missions similar to those planned for GL 207-45 aircraft and well developed, proved concepts of supply, maintainability, accessibility and support systems will be applied to System 476L. At the present time, there are more than 300 C-130 aircraft in operation throughout the world. Their support has been successfully programmed through the coordinated efforts of Air Force, Coast Guard, Navy, Marine Corps, and Lockheed personnel. The valuable experience gained in these programs and the forthcoming opportunity to apply knowledge gained supporting the MATS C-130E squadrons assure Lockheed's ability to implement effectively the logistic support program for System 476L.

Cost

The cost estimating methods and techniques used by Lockheed are fully approved by a number of government agencies. The estimates are supported by historical statistical data obtained from government and industry sources, and lockheed's long experience in the estimating of aircraft development and production. The cost projections for this proposal were developed in accordance with established methodology and are completely supported by historical data.

Lockheed's budgetary and cost control systems utilize the most modern methods and equipment available. Cost control efforts have produced substantial and demonstrable results. Savings amounting to millions of dollars have been realized during 1960 as a result of Value Engineering and Analysis. Manufacturing Research, Electronic Data Processing, and other cost reduction programs which are described in detail subsequently in this proposal. In the immediate future, Lockheed expects to make improvements which represent further significant advances in the state-of-the-art of management planning and control of costs. Cost reduction techniques which have proved their effectiveness in the past will continue to be aggressively applied.

Cost data have been prepared on the premise that the initial procurement program, funded incrementally, will cover the development, test and evaluation of 5 aircraft with 3 follow-on production quantities of 31, 48, and 48 aircraft, to be funded respectively from appropriations for fiscal years 1963, 1964, and

1965. In asmuch as the GL 207-45 aircraft retains many features of the C-130 series, the cost history of the C-130 provides a firm base from which to project costs of this program. Estimates of all elements of the total program cost from design to field support reflect the extensive experience realized from the C-130 series.

A unit average airframe price of $4,138,000 for the total program of 132 aircraft is proposed. The price data shown in the several schedules designated Format A, Pricing Information, are:

Proposed Airframe Prices

Fiscal Year	No. of Airplanes	Program	Airframe Amount (in thousands)
No year	5	DT & E	$121,546
1963	31	Production #1	142,036
1964	48	Production #2	145,072
1965	48	Production #3	137,520
Total for 132 Airframes			$546,174
Unit Average Price			**$ 4,138**

The elements of program costs which must be added to the airframe prices to arrive at total program funding requirements are:

Item	Amount (in thousands)
Total for 132 Airframes	$546,174
Other GFAE	39,625
Initial Spares (for above two Items)	88,994
Peculiar AGE	7,415
Technical Representation and Training	4,886
Training Equipment	7,273
Industrial Facilities	—0—
Total Program Funding	**$694,367**

The total program funding requirement of $694,367,000 can be met by individual fiscal year funding indicated in the schedule below:

Fiscal Year Funding (in thousands)

Fiscal Year	D, T & E	Production	Total
1961	$ 2,772		$ 2,772
1962	64,796		64,796
1963	55,979	177,638	233,617
1964	11,050	194,492	205,542
1965	2,606	185,034	187,640
Total	**$137,203**	**$557,164**	**$694,367**

The GL 207-45 fills the need for a modern cargo airplane with low operating cost for both military and commercial operations. Using 1960 ATA formulae, its direct operating cost of 3.8 cents per ton statute mile in transcontinental service will enable the air freight market to expand on a profitable basis. Using the more stringent cost factors established for the System 476L proposal, a minimum military DOC of 4.9 cents per ton nautical mile (4.3 cents per ton statute mile) is achieved.

Lockheed's Georgia Division has a management team fully competent of administering with excellence this important System 476L program. Strong middle management personnel and managers of supporting organizations are available in depth, and careful attention has been given to selections for System 476L assignments. Lockheed is actively participating with the military services in the development of new management techniques and will apply them effectively to this program.

SUPER HERCULES · GL207-45

section 2

INTRODUCTION

This is one of seven books being submitted to describe Lockheed's proposal for Support System 476L. The complete set, prepared in accordance with the Statement of Work and augmented by guidance resulting from queries to the Air Force, is as follows:

Volume	
1	Basic Proposal
2	Substantiating and Trade-Off Data
3	Operational Data
4	Special Technical and Cost Data
5	Model Specification
6	Large Scale Drawings
7	PEP Networks

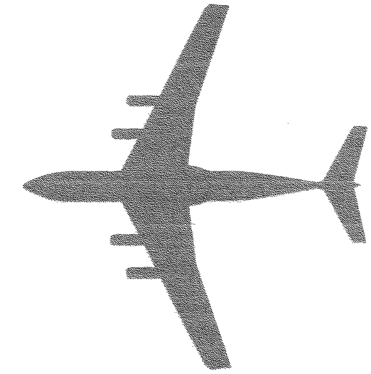
The formats of all volumes containing significant amounts of text are the same except for Volume 5, which is laid out to the customary format for Model Specifications in order that it could serve in future negotiations.

Volumes 1 thru 4 are organized in absolute conformity with the sequence and breakdown of subject headings in the Work Statement. Every decimally numbered paragraph of that document is identified by the same decimal number in this submittal and the sequencing is identical. Thus, Volumes 1 and 2 cover Work Statement Paragraphs 5.1 and 5.2. Volume 3 covers Paragraph 5.3, and Volume 4 covers Paragraph 5.4. It is hoped that this parallelism in detail and in general will facilitate review by the Air Force Evaluation Team.

Volume 1, though employing references to other volumes on occasion, is intended to be substantially self-sufficient. Volume 2, on the other hand, depends upon Volume 1 for basic subject descriptions and is intended principally to substantiate and/or expand on subjects which require more discussion than the page limit of Volume 1 would permit. Volumes 3 and 4 are reasonably independent, but do rely to a degree on familiarity with Volume 1. Volume 5, of course, is self-sufficient, and Volumes 6 and 7 are repositories to permit easy handling of the loose data requested.

SUPER HERCULES · GL207-45

section 3



AIRCRAFT DESCRIPTION

WEIGHT AND BALANCE (5.1.5.1)

The weight and balance summary for equipped weight empty is shown by Figure 3-1 and Figure 3-2 summarizes weight and balance for the basic, maximum payload, and maximum fuel missions. All gross weight conditions fall within the allowable center of gravity limits. The group weights of Figure 3-1 are derived in the weight and balance portion of Section 2 of Volume 2.

	% MAC	Weight	Horizontal Arm	Vertical Arm
Wing		30,631	943	270
Tail		5,515	1,751	456
Fuselage		25,080	959	203
Landing Gear (Extended)		11,190	874	140
Surface Controls		2,150	1,018	263
Nacelle		4,256	771	191
Propulsion		25,660	800	203
Auxiliary Power Unit		465	1,090	166
Instruments		665	548	238
Hydraulics		900	959	192
Electrical		2,850	761	200
Electronics		1,897	500	204
Furnishings		3,372	740	217
Air Conditioning		2,080	784	211
Anti-Icing		1,250	993	302
Auxiliary Gear		115	1,188	164
WEIGHT EMPTY	**23.1**	**118,076**	**920.8**	**228.3**
Crew (4)		860	349	225
Survival Kits		120	349	215
Food and Water		70	440	200
Pyrotechnics		15	440	215
Oil		340	766	206
Loading System		5,849	890	149
Unusable Fuel		1,520	925	260
Life Raft		150	948	215
EQUIPPED WEIGHT EMPTY	**20.7**	**127,000**	**914.3**	**224.9**

Figure 3-1—WEIGHT AND BALANCE SUMMARY.

	% MAC	Weight	Horizontal Arm	Vertical Arm
BASIC MISSION				
Equipped Weight Empty	20.7	127,000	914.3	224.9
Cargo		50,000	869.0	200.0
Fuel		111,000	939.0	267.0
Design Gross Weight	21.3	288,000	916.0	236.8
MAXIMUM FUEL MISSION				
Equipped Weight Empty	20.7	127,000	914.3	224.9
Cargo		37,980	869.0	200.0
Fuel		150,020	925.0	267.0
Design Gross Weight	20.5	315,000	913.9	241.9
MAXIMUM PAYLOAD MISSION				
Equipped Weight Empty	20.7	127,000	914.3	224.9
Cargo		80,000	917	200.0
Fuel		108,000	938	267.0
Design Gross Weight	24.0	315,000	923.1	233.0

Figure 3-2—WEIGHT AND BALANCE SUMMARY, BASIC, MAXIMUM FUEL, AND MAXIMUM PAYLOAD MISSIONS.

Floor weight is based on integrating the conveyor, guide, and restraint provisions to receive the WS 463L pallets. This is a lighter approach than would result from complete integration of the WS 463L system, reference Section 3.1.8 of the Work Statement.

The airplane balance diagram showing pertinent dimensions and fuselage compartmentation is presented in Figure 3-3. The excellent cargo loadability characteristics provided are shown in Figures 3-4 thru 3-7. Wide variations of cargo location are permissible within the allowable center of gravity limits without use of a complicated fuel management program. The number of fuel tanks, individual tank capacity, and tank location are selected to minimize center of gravity travel with fuel burn-off. Special attention has been directed toward adequate compartmentation of fuel tanks to prevent large variations in fuel center of gravity with aircraft attitude.

Rigorous weight control standards will be maintained throughout the design of the GL 207-45. Weight reporting will be done in accordance with MIL-W-25140 as well as with all applicable FAA requirements. An integrated record system has been established, utilizing the IBM 7090 electronic data processing machine. This system will furnish all necessary weight and balance data and mass properties for preparation of military and FAA reports, as well as all required internal data. Since this record is derived from a single set of input data, a greater degree of accuracy and control is assured. A design target weight system will be used extensively, and weight growth will be analyzed in detail. A special weight reduction group will place a continuous supply of weight reduction possibilities at the disposal of management for value analysis. Weight engineering personnel will collaborate closely with Staff Engineering, Equipment and Standards Engineering, Production Engineering, and Structures Engineering to achieve the optimum degree of weight control. The system will permit close monitoring of the individual components and assure meeting target weights during the early stages of design. This policy will assure that no costly weight reduction program will be necessary after actual aircraft construction has begun.

PERFORMANCE (5.1.5.2)

Configuration Selection and Description

The configuration of the GL 207-45 airplane represents the culmination of several years of development engineering, wind tunnel testing, and design studies directed toward the development of a low

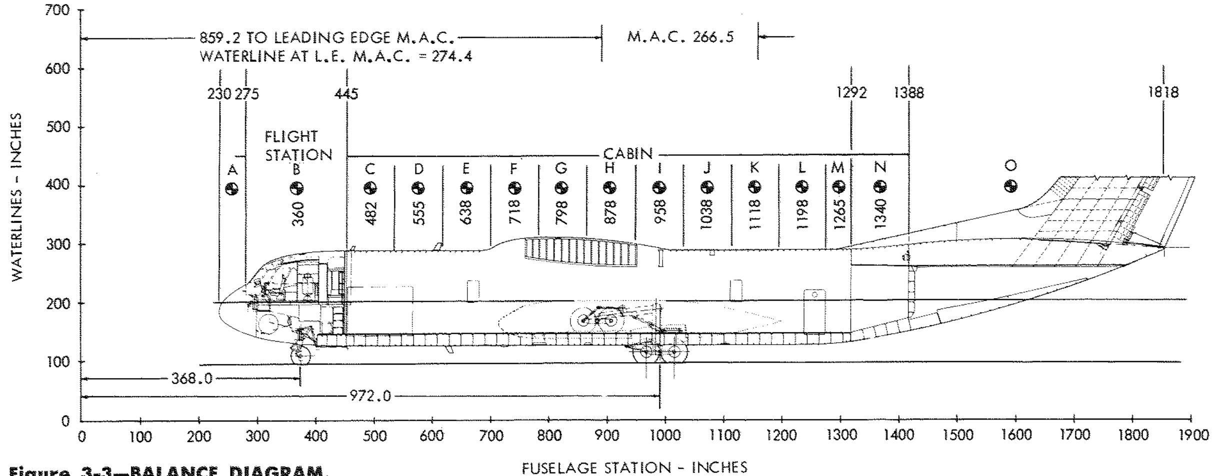


Figure 3-3—BALANCE DIAGRAM.

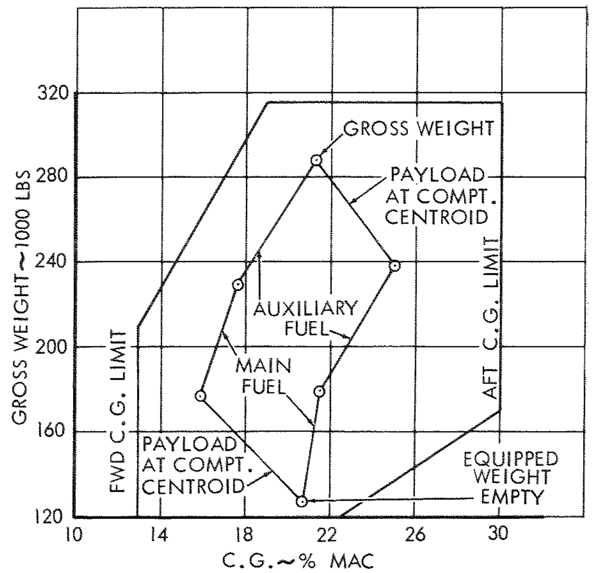


Figure 3-4—CENTER OF GRAVITY DIAGRAM, BASIC MISSION.

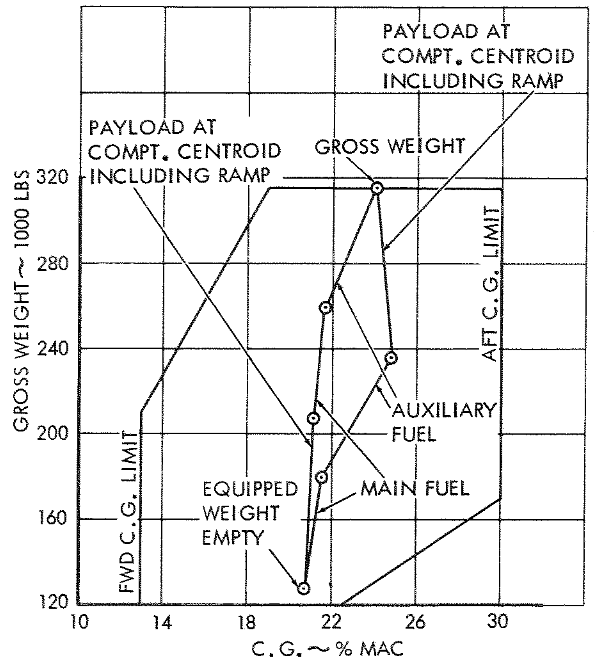


Figure 3-6—CENTER OF GRAVITY DIAGRAM, MAXIMUM PAYLOAD MISSION.

MAXIMUM FUEL MISSION

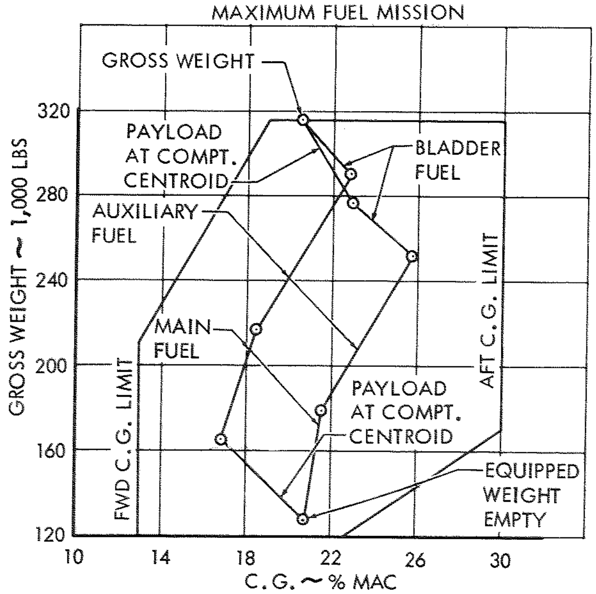


Figure 3-5—CENTER OF GRAVITY DIAGRAM, MAXIMUM FUEL MISSION.

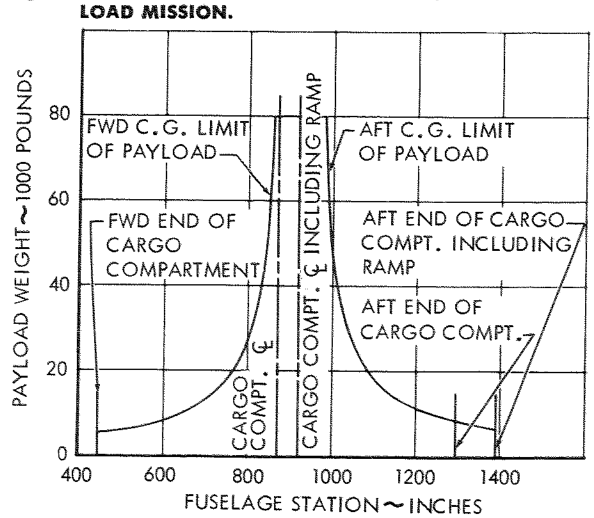


Figure 3-7—CARGO LOADING DIAGRAM.

cost, high speed, all-cargo transport, suitable for both military and civil operation. Much flight test and operational experience, accumulated on the C-130 airplane, together with extensive wind tunnel tests, which have been made at both low and high subsonic speeds during the development of this configuration, assure aerodynamic features which make it an excellent cargo transport for both military and commercial operation.

Previous studies and wind tunnel testing had indicated that with power plants of 18,000 lbs. rated thrust, known to be available without further developmental funding, a cruise speed of 440 knots would be optimum for the design missions of System 476L. The airplane configuration has been selected, therefore, on the basis that it will meet all System 476L requirements when powered with the Pratt and Whitney JT3D-4, engine, while exploiting to the maximum degree possible the added potential of the JT3D-8A and JT3D-8B growth power plants or the new G. E. MF239C-3. The wing selection, in particular, is discussed in greater detail in the trade-off data of Volume 2 of this report.

Wing

The wing has an area of 3228 sq. ft., an average aerodynamic thickness ratio of 11.15%, an aspect ratio of 7.897 and a sweep angle of 25 degrees. This combination of aerodynamic design parameters resulted from extensive studies involving variations of these parameters in order to select the wing design which provides the desired payload range capability at cruise altitudes and speeds, consistent with the most economical operation of the turbofan engines, while at the same time attaining the short take-off and landing field lengths desired. The relatively large wing area provides ample internal fuel volume for the long range (5500 nautical mile) mission, avoiding the use of external fuel tanks. The resulting relatively light wing loading assures compatibility with increased take-off weights and payloads possible with higher thrust advanced power plants. The wing sweep angle of 25 degrees was made as low as possible in order to reduce wing loads and weight, and minimize the undesirable aerodynamic effects of high sweep angles such as roll-yaw coupling, low maximum lift coefficients, poor stall characteristics, and high drag due to lift; and, at the same time, attain the high drag-rise critical Mach number desired for cruise.

The wing airfoil sections are of the modified NACA four-digit series and are defined as follows:

Root 0012.5-1.10-40/1.575 (C_{li}=0.1, a_0=0.9)
BL 415 0011-1.10-40/1.575 (C_{li}=0.2, a_0=0.8)
Tip 0010-2.20-40/1.575 (C_{li}=0.3, a_0=0.8)

These sections were selected for their high drag-rise critical Mach number and high maximum lift characteristics. The large leading edge radius on the outboard wing panel, the thickness and camber distribution across the span, and the 4.5 degree twist from root to tip, were selected to give good stall characteristics and high usable maximum lift coefficients. This wing geometry results in a long-range cruise speed of Mach 0.77 and a maximum cruise speed, with the P & W JT3D-4 engines, of Mach 0.83.

The wing is equipped with large Lockheed-Fowler type flaps similar to those used on the C-130. Low-speed wind tunnel tests have determined that the flaps should be deflected 50 degrees for landing and 35 degrees for take-off. Trailing edge spoilers, actuated on touchdown, provide additional drag and destroy the lift of the flaps, thereby increasing the braking force and reducing the ground roll. Lateral control is provided by conventional 28% chord ailerons extending from 68% of the wing semispan to the tip. The use of conventional ailerons with resulting excellent roll response is made possible by the low wing sweep angle and high wing structural stiffness.

The wing root incidence is 4.5 degrees with respect to the fuselage reference line, which results in a fuselage angle during cruise of from 0 to about 1 degree nose up. The maximum ground clearance angle of 11 degrees provides the same adequate aft fuselage clearance during take-off and landing as is present with the C-130. The wing has a negative geometric dihedral of 1.25 degrees. This value was chosen in order to reduce the high positive effective dihedral, inherent in a high-mounted swept-back wing configuration, and provide satisfactory lateral-directional damping.

Empennage

As is the case with all high-speed swept-wing airplanes, early configuration studies showed the need for a large vertical tail area to obtain satisfactory lateral-directional damping. Extensive design studies and wind tunnel testing involving variations of the horizontal and vertical tail geometry resulted in the selection of a "T" tail configuration. This arrangement proved to have the lightest structural weight and minimum aerodynamic drag because of the smaller tail area required to produce the necessary stability level for satisfactory flying qualities.

The vertical tail has an exposed area of 390 square feet, and is swept back 35 degrees, with an NACA 64A012 airfoil section. The horizontal tail has an area of 521 square feet and is swept back 25 degrees with an NACA 64A010 airfoil section. This horizontal area ratio, S_H/S_W, is only 0.161, a low value compared to that required for most transport aircraft. This tail, however, provides superior longitudinal stability and control characteristics due to its "T" location and no longitudinal dynamic stability damper is required.

A bullet fairing at the intersection of the horizontal and vertical tails provides a favorable reduction in the tail drag between 0.7 to 0.8 Mach number. Longitudinal trim is provided by varying the incidence of the horizontal tail. An incidence range of from +4 degrees to -14 degrees provides hands-off trim throughout the airplane's speed range. The elevator hinge line is located at the 75% chord line of the horizontal tail. The 25% chord rudder is sized so that neither ground nor free flight minimum control speeds are limiting, except at very light take-off weights.

Nacelles

The four engines are pod-mounted on pylons underslung and cantilevered forward from the wing. The configuration and location of the engine pods and the aerodynamic design of the pylons has been studied extensively, both theoretically and in high-subsonic speed wind tunnel testing. The resulting configuration with nacelles canted inboard 2 degrees, and with the pylon cambered at the wing intersection to conform with the local direction of flow, results in little nacelle-to-wing interference drag.

Fuselage

The fuselage represents a major improvement in the design of cargo airplanes with air drop capability. The design philosophy used in developing the after body shape involved determination of the local flow direction in this region. The flow streamlines at the cruise angle of attack tend to be as shown in Figure 3-8. Near-optimum cross-sectional shapes were developed, cut along the streamlines, with specific allowance for fuselage upsweep required to provide structural depth. This concept allows elimination of the beaver-tail effect in the fuselage plan view, since strength is provided through the upsweep. Most importantly, separation is avoided on the undersurface of the fuselage afterbody because desirable aerodynamic cross-sectional shapes are provided along the local streamlines. The drag polar for this arrangement is shown in Figure 3-9 to be essentially the same as that for a streamline body of revolution. This elimination of the drag penalty, normally associated with straight-in-aft loading and air drop capability in the current stable of military cargo transports, results in complete compatability of the commercial and military operation requirements, since commercial operators will not have to absorb an airplane performance penalty resulting from the military air drop requirement.

Basic Data

An area progression curve is shown in Figure 3-10. The maximum cross-sectional area shown results in an equivalent fineness ratio of about 6.3, which is reasonable for an airplane designed to fly most efficiently at about 0.8 Mach number. As is evident, an improvement in the area progression curve could be made by locating the wheel well fairings further aft; this arrangement was evaluated together with other alternates in the wind tunnel. The resulting

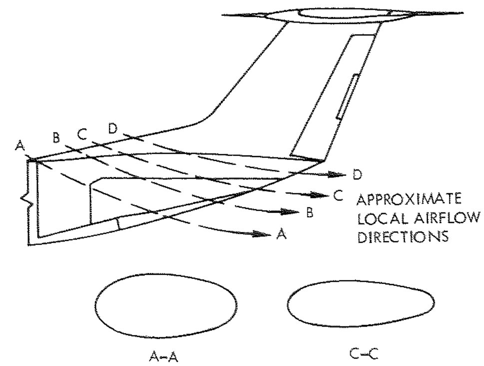


Figure 3-8—REAR FUSELAGE AIR FLOW DIAGRAM.

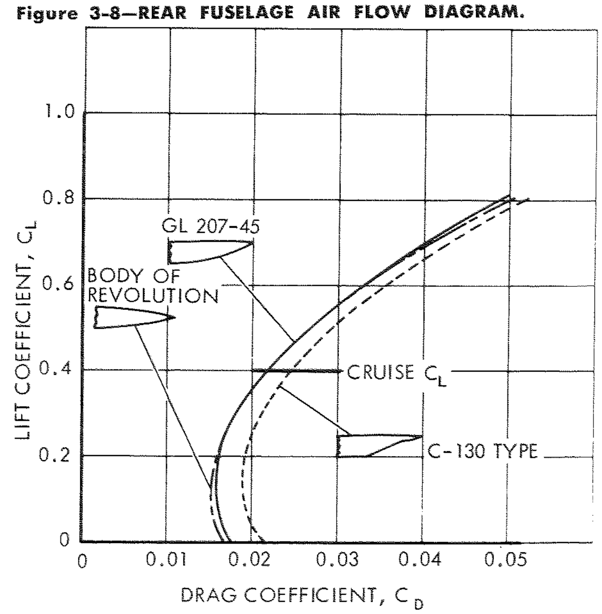


Figure 3-9—AFTERBODY DRAG COMPARISON.

small improvement in drag at normal cruise speeds was not considered sufficient to offset the more complex gear arrangement and the attendant developmental cost.

Another interesting alternate tested was wing-mounted landing gear pods replacing the fuselage landing gear housing. These pods were mounted on the aft 50% of the wing chord just inboard of the inboard nacelle, and extended rearward about half a wing chord. The improvement to the area progression curve is obvious. Although not optimized as such, these pods worked quite well as anti-shock bodies and produced drag savings which became substantial at Mach numbers of 0.80 and above. A number of factors caused the discard of this con-

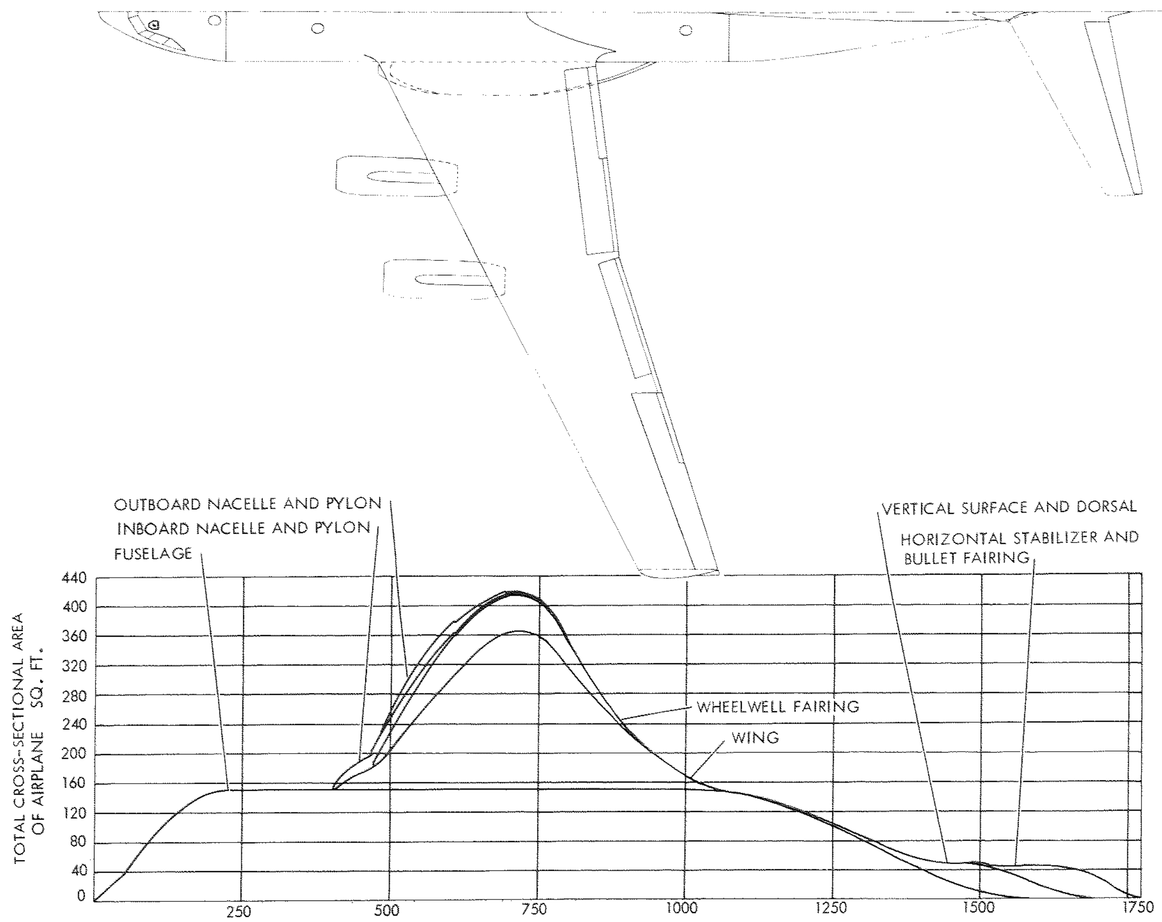


Figure 3-10—AREA PROGRESSION CURVE.

figuration; however, it illustrates how application of the anti-shock body principle might serve, at a later date, to increase cruise speeds while retaining the advantages of the low sweep wing.

A tabular listing of the airplane's physical characteristics and aerodynamic dmiensions is given in Figure 3-11.

Drag

The drag polar for the GL-207-45 airplane shown in Figure 3-12 is based on the results of the wind tunnel tests presented in Volume 2. The wind tunnel skin friction drag for the various airplane components was corrected from the test Reynolds numbers to the flight Reynolds number corresponding to the estimated long-range cruise speed at an average cruise altitude of 40,000 feet. Oil flow visualization studies conducted during the wind tunnel test revealed the extent and location of the laminar and turbulent flow. In correcting the skin friction drag to full scale, recognition has been made of the increased extent of turbulent flow which can be reasonably expected with production surface conditions. The average effective skin friction drag coefficient of this airplane is 0.00354, which reflects conservatism when compared with the value of 0.0033 realized on the Lockheed JetStar and a value of 0.0034 encountered on the Lockheed Electra during flight test. The drag due to lift, the interference drag, and the compressibility drag were used directly in the airplane polar as measured in the wind tunnel tests, except for the horizontal tail drag due to compressibility. The horizontal tail thickness chord ratio was reduced from 12% to 10 % as a result of the tunnel tests, and the appropriate corrections to the horizontal tail drag have been included in the airplane drag polar.

Figure 3-13 presents the contributions of the various components of the airplane to the total profile drag coefficient at the lift coefficient for minimum drag of 0.15 at a speed of Mach 0.675. The profile drag is composed of the skin friction drag of the wing and tail surfaces and the skin friction and pressure drags of the fuselage and nacelles. The drag of each component is given separately and referred to the reference wing area as:

$$C_{Dp} = C_{Df} \frac{S_F}{S_W}$$

Figure 3-12 shows the clean configuration drag polars with the airplane trimmed at a center of grav-

		MIL-D-25671 (USAF)
Weights	Design Gross Weight (Take-off)	315,000 lb.
	Max. Alternate Gross Weight	315,000 lb.
	Weight Empty Design	119,925 lb.
Center of Gravity Data (With respect to L.E. MAC)	Design C.G. (Wheels up)	19.9%
	Max. Forward C.G.	13 %
	Max. Aft C.G.	30 %
Wing	Total Wing Area	3,228 sq. ft.
	Mean Aerodynamic Chord (MAC) Length	266.51 in.
	Aspect Ratio	7.897
	Taper Ratio	0.374
	Sweep Angle (¼ chord line)	25° outbd. panel
	Dihedral Angle	—1° 15′ on $\frac{c}{4}$
	Angle of Incidence of Root to Fuselage Reference Line	4° 30′
	Angle of Incidence of Tip to Fuselage Reference Line	0° 0′
All Airfoil Section Measured Streamwise	Airfoil Section, Root Designation	NACA 0012.50 Mod
	Airfoil Section, .43 semi-span	NACA 0011.00 Mod
	Airfoil Section, Tip Designation	NACA 0010.00 Mod.
	Ave. Airfoil	NACA 0011.15 Mod
Flaps	Type	Lockheed Fowler
	Distance C/L to Inbd. Edge	92.0 inches
	Distance C/L to Outbd. Edge	648.0 inches
	Max. Deflection	55°
	Deflection for Take-off and Landing	35° T.O. and 55° Ldg.
	Chord % Wing Chord	28%
	Percent Wing Area Affected	63.3%

Horizontal Stabilizer	Area	521.136 sq. ft.
	Span	52 ft. 1.28 in.
	Aspect Ratio	5.21
	Incidence to Fuselage Reference Line	All movable L.E. up 4°, L.E. down 4°
	Airfoil Section Designation	NACA 64A010
	Sweep Angle (¼ chord line)	25°
	MAC	128.47 in.
	Location of (¼ chord) MAC From Leading Edge of Root Chort	105.52 in.
	From Mean Thrust Line in Neutral Position	365.97 in.
	Dihedral Angle (degrees)	Zero
	Taper Ratio	0.37
Vertical Tail	MAC	221.522 in.
	Location of (¼ chord) MAC From Leading Root Chord	150.399 in.
	From Mean Thrust Line	226.936 in.
	Total Area	390.016 sq. ft.
	Span	258.088 in.
	Taper Ratio	0.623
	Sweep Angle (¼ chord line)	35°
	Aspect Ratio	1.186
	Airfoil Section Designation	NACA 64A012
Wetted Area (Exposed area)	Fuselage	4036
	Nacelle	243
	Wing	6123
	Tail	1912
	Miscellaneous	1394
	Total	14437 sq. ft.
Dive Brakes Fuselage	Type	None
	Dimensions	
	Area (Actual)	
	Deflection (degrees)	
Spoilers	Type	Trailing Edge
	Area	266.8 sq.ft.
	Deflection	80°

Figure 3-11—PHYSICAL CHARACTERISTICS.

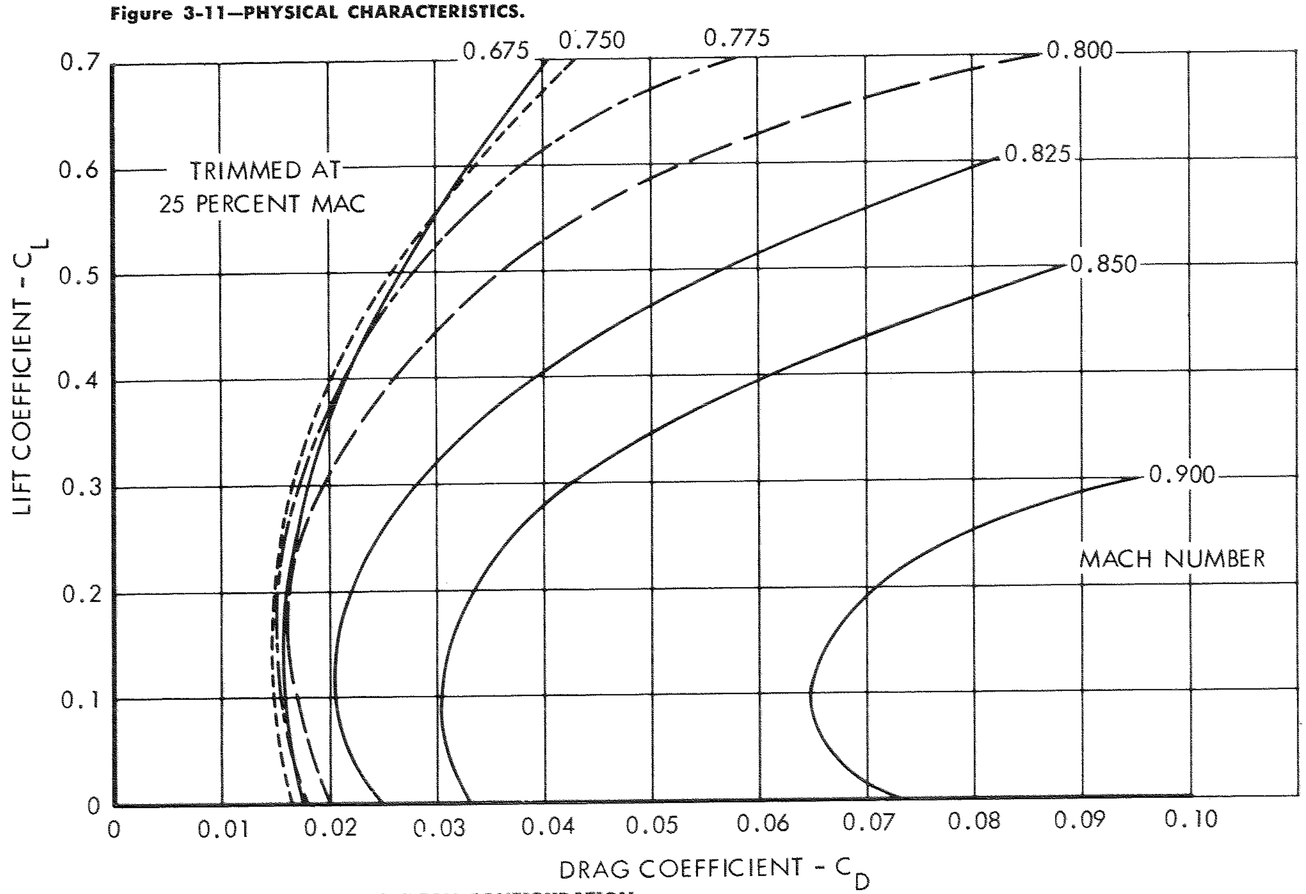


Figure 3-12—DRAG POLARS CLEAN CONFIGURATION.

M = 0.675 $C_L = 0.15$

	Wetted Area	Skin Friction Coeff.	Minimum Parasite Drag Coeff.
	S_F	C_F	C_{D_P}
Fuselage	4,036	0.00304	0.0038
Wheel Wells	994	0.00312	0.0010
Wing	6,123	0.00306	0.0058
Nacelles & Pylons	1,372	0.00353	0.0015
Horizontal Tail & Bullet	1,100	0.00323	00.011
Vertical Tail & Dorsal	812	0.00318	0.0008
Interference Drag			0.0018
TOTALS	**14,437**	**0.00354***	**0.0158**

* Average value of C_F

Figure 3-13—PROFILE DRAG BREAKDOWN, CLEAN CONFIGURATION.

ity of 0.25 MAC. These curves show a reduction in drag from the Mach number of 0.675 base level in the low-lift coefficient range, which results from favorable interference of the bullet fairing at the juncture of the horizontal and vertical tail surfaces. The drag data for the landing and take-off configurations are presented in Figure 3-14 and the effect of spoiler deflection is also shown. The drag increments due to the flaps and the spoilers have been determined directly from the low speed wind tunnel tests and have been determined directly from the low speed wind tunnel tests and have been added to the previously discussed clean configuration data. The effect of the ground has also been determined from low-speed wind tunnel tests made in the presence of a ground board. The data shown are for the airplane with the gear retracted and the cargo doors closed. For gear extended, a $\Delta C_d = 0.0165$ is added, and for the cargo doors in the airdrop configuration $\Delta C_d = 0.016$ is added. It is shown that opening the spoilers at the ground-roll attitude essentially doubles the drag of the airplane.

Lift and Pitching Moment

Lift and pitching moment data are shown in figures 3-15, 3-16, and 3-17 for the clean, take-off, and landing configurations respectively. These data are based on the results of the wind tunnel tests with the necessary corrections applied to recognize the small differences between the wind tunnel models and the final airplane configuration. Maximum lift coefficients are based on the measured wind tunnel values at the low test Reynolds number corrected to full scale Reynolds number on the basis of Lockheed's years of experience correlating Fowler flap wind tunnel and flight test results. This lift coefficient increase is greater on the outboard wing panels than it is inboard, hence a more stable pitching moment break exists at the stall than is indicated by the wind tunnel data.

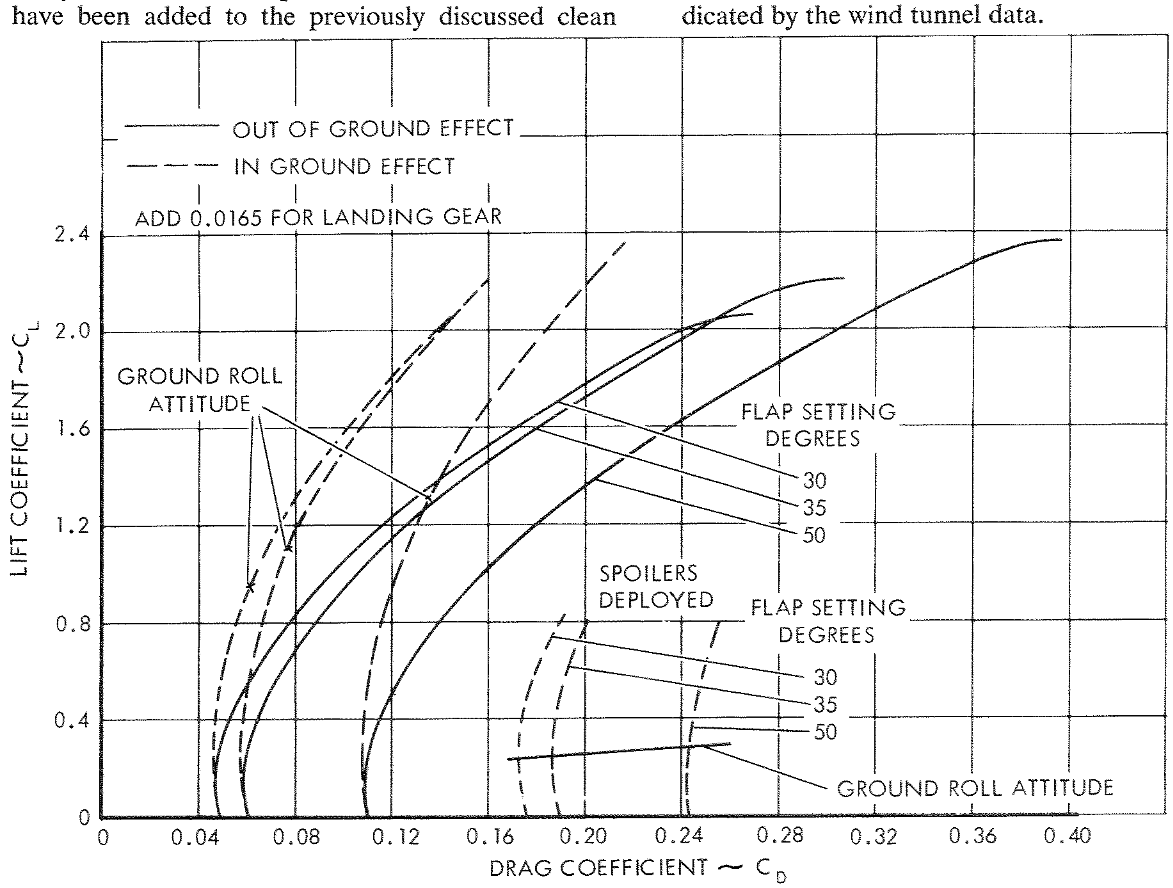


Figure 3-14—DRAG POLARS, FLAPS AND SPOILERS DEFLECTED, TRIMMED AT 25 PERCENT MAC.

The spoiler deflection in the ground roll attitude is shown to reduce the wing lift by about three-fourths, resulting in excellent braking during landing ground roll and aborted take-offs.

The clean configuration lift and pitching moment data shown in Figure 3-15 are for two tyypical conditions. Low-speed rigid data and flexible data corresponding to cruise at 45,000 feet are shown. The effectiveness of the stabilizer is shown between zero degrees and a setting of -7 degrees at low speed, and -6.35 degrees at the cruise speed. In the take-off and landing configuration, shown in Figures 3-16 and 3-17, the effectiveness of the stabliizer is given for a number of settings up to the maximum setting of -14 degrees and the pitching moment input of the lift spoilers is also shown.

The variation of horizontal stablizer and elevator effectiveness with Mach number is shown in Figure 3-18 for both the rigid and flexible cases at sea level, 20,000 feet and 45,000 feet. The rigid data was obtained from the high speed tunnel tests reported in Volume 2 of this report. Corrections have been applied to the tunnel data to reflect the effect of changing the horizontal tail thickness ratio from

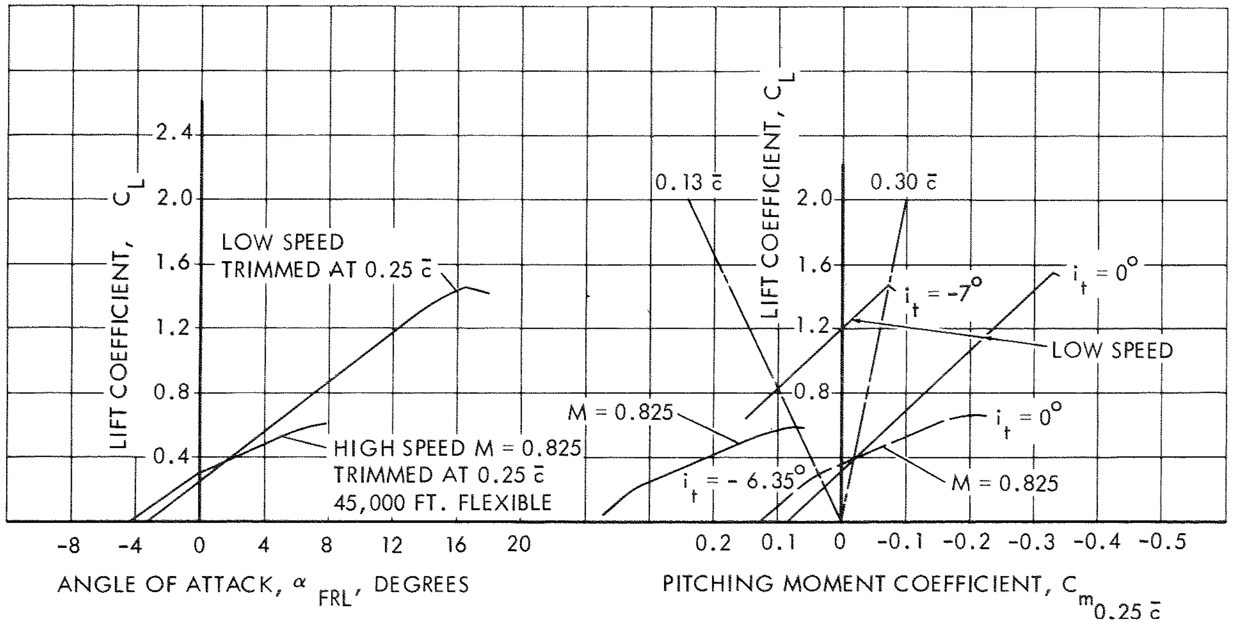


Figure 3-15—AIRPLANE LIFT AND PITCHING MOMENT CHARACTERISTICS, CLEAN CONFIGURATION.

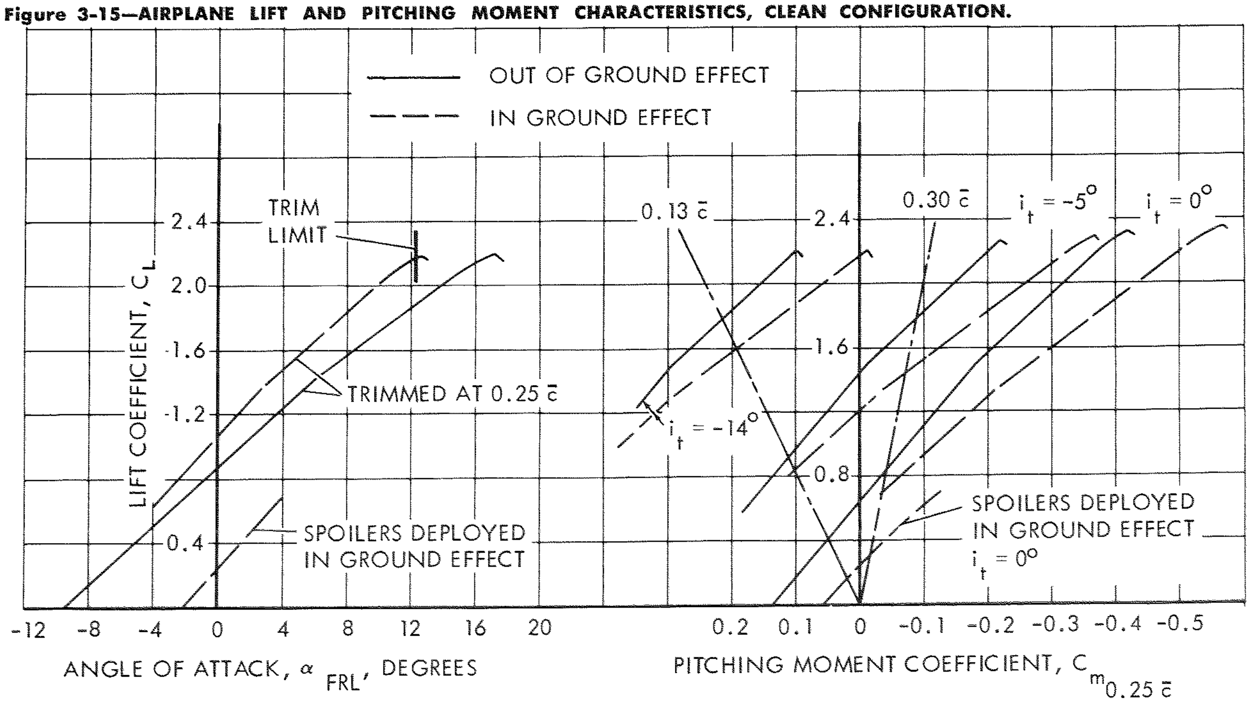


Figure 3-16—AIRPLANE LIFT AND PITCHING MOMENT CHARACTERISTICS, FLAPS DEFLECTED 35 DEGREES, LANDING GEAR UP.

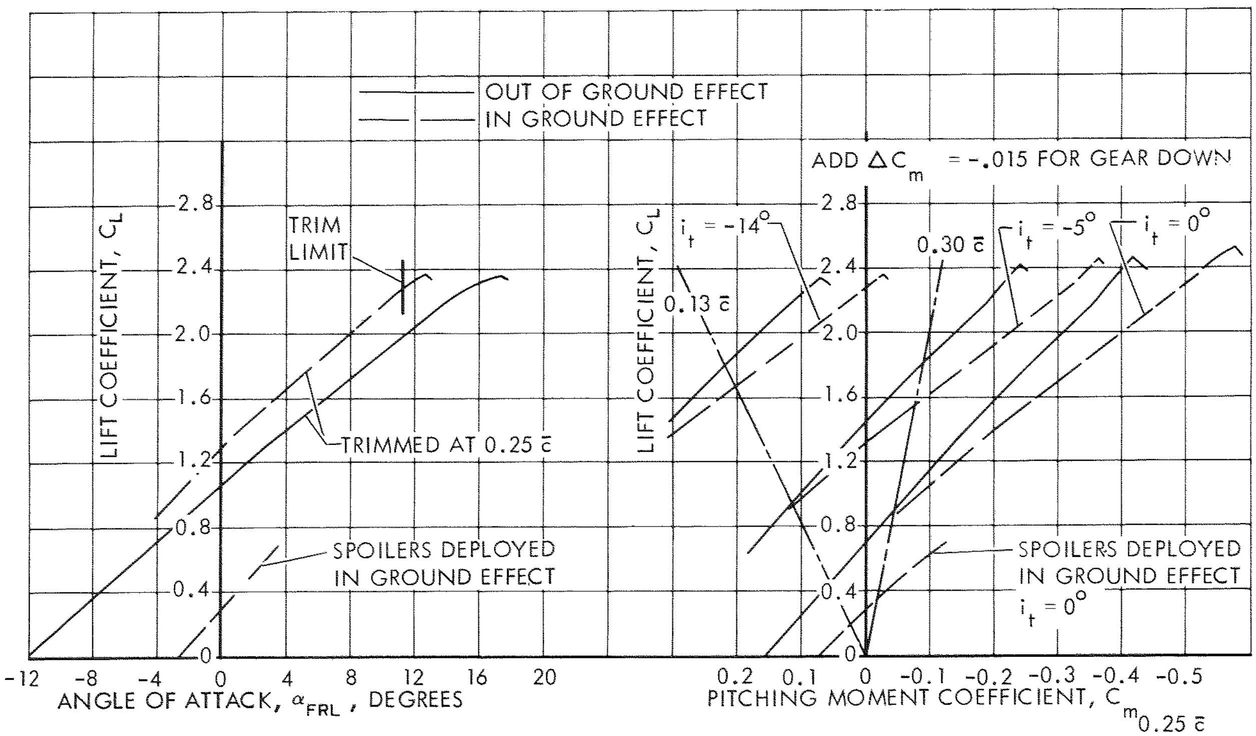


Figure 3-17—AIRPLANE LIFT AND PITCHING MOMENT CHARACTERISTICS, FLAPS DEFLECTED 50 DEGREES, LANDING GEAR UP

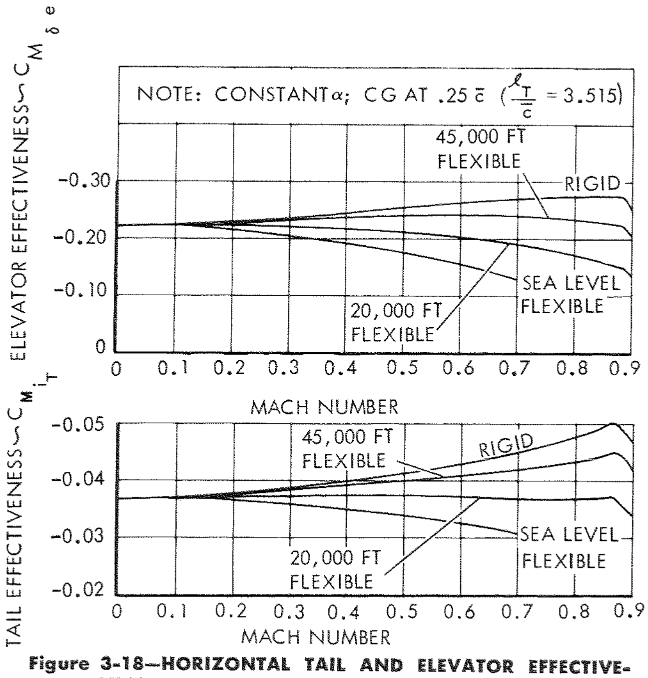


Figure 3-18—HORIZONTAL TAIL AND ELEVATOR EFFECTIVENESS.

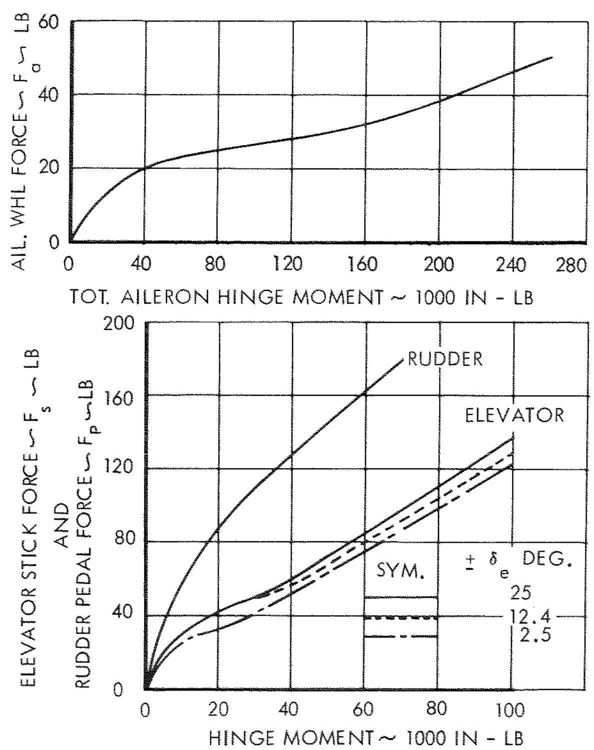


Figure 3-19—CONTROL FORCE CHARACTERISTICS.

12%, as tested on the wind tunnel model, to a value of 10% used on the airplane.

Hinge Moments

Rudder, elevator, and aileron hinge moment characteristics as a function of Mach number, and surface deflection and angle of attack are shown in Volume 2 of this report.

It is shown that the net elevator hinge moment variation with angle of attack is reduced to zero through use of a ventilated internal balance.

The rudder, aileron, and elevator pilot force characteristics are shown in Figure 3-19. All three systems use dual hydraulic boosters combined with a mechanical variation of control force with input hinge moment. This dual-boost system is very similar to that used on the C-130B airplane, and has proved to have an excellent record of flight safety while offering the least complicated and least expensive means of providing pilot forces.

Performance

The payload/range and airport performance characteristics of the GL 207-45 with P & W JT3D-4 engines meets or exceeds all of the mission and airport performance requirements of System 476L. Figures 3-20, 3-21, and 3-22 show military takeoff and landing performance data, and Figures 3-23 and 3-24 show CAR take-off and landing field lengths. Both the military and CAR data are shown for sea level and 5000 feet, and for both standard and hot day conditions at each altitude. Rolling and braking coefficients of friction are as specified in MIL-C-5011A. Military landing distances are shown for four engines in idle, four engines in reverse thrust, and two engines in reverse thrust, one idle, one windmilling. CAR landing field lengths are shown for four engines in idle and for two engines in reverse thrust, one in idle, and one windmilling.

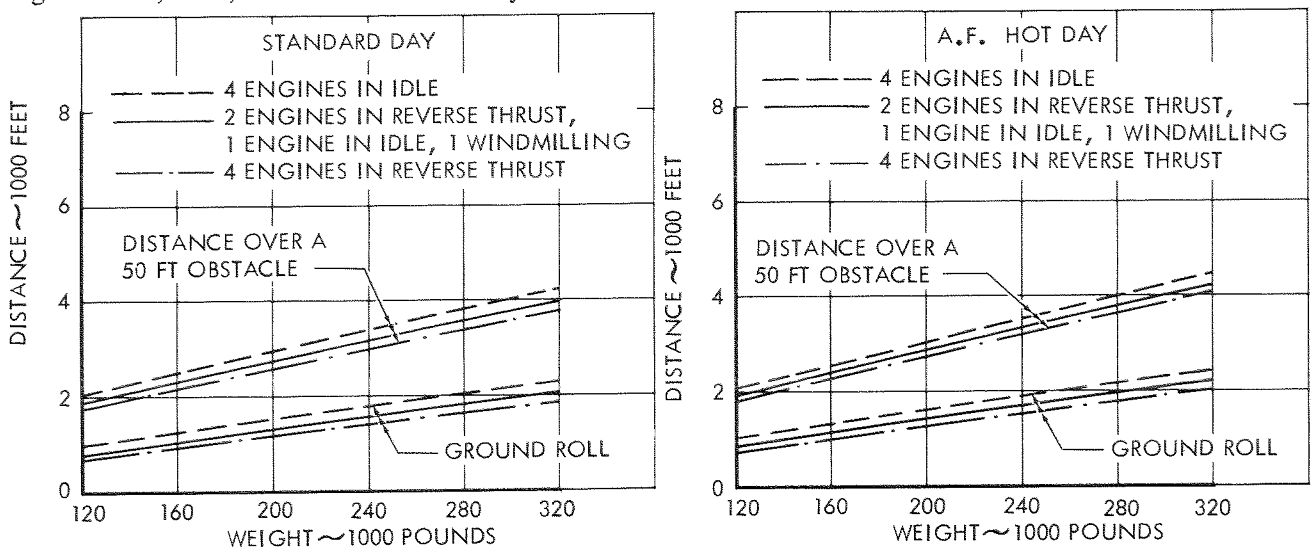


Figure 3-20—MILITARY TAKE-OFF DISTANCES, 35 DEGREE FLAP SETTING, TAKE-OFF POWER, NO WIND, PRATT AND WHITNEY JT3D-4 ENGINE.

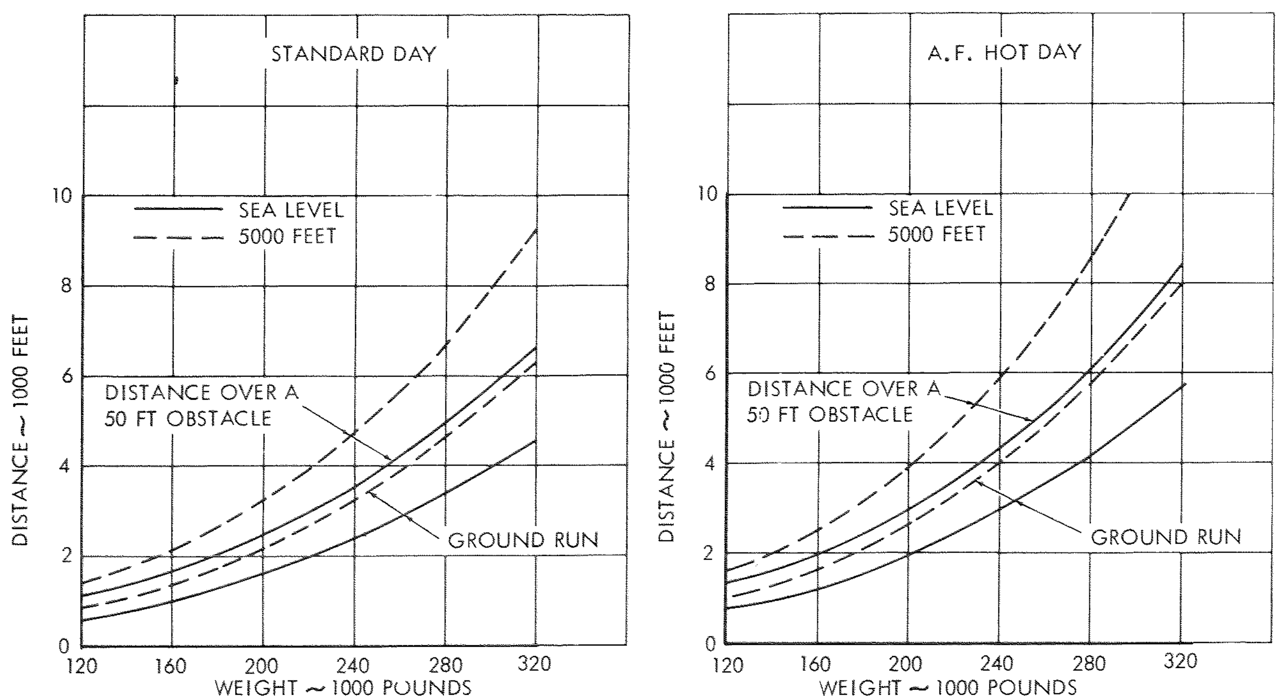


Figure 3-21—MILITARY LANDING DISTANCES, SEA LEVEL, 50 DEGREE FLAP SETTING, NO WIND, PRATT AND WHITNEY JT3D-4 ENGINE.

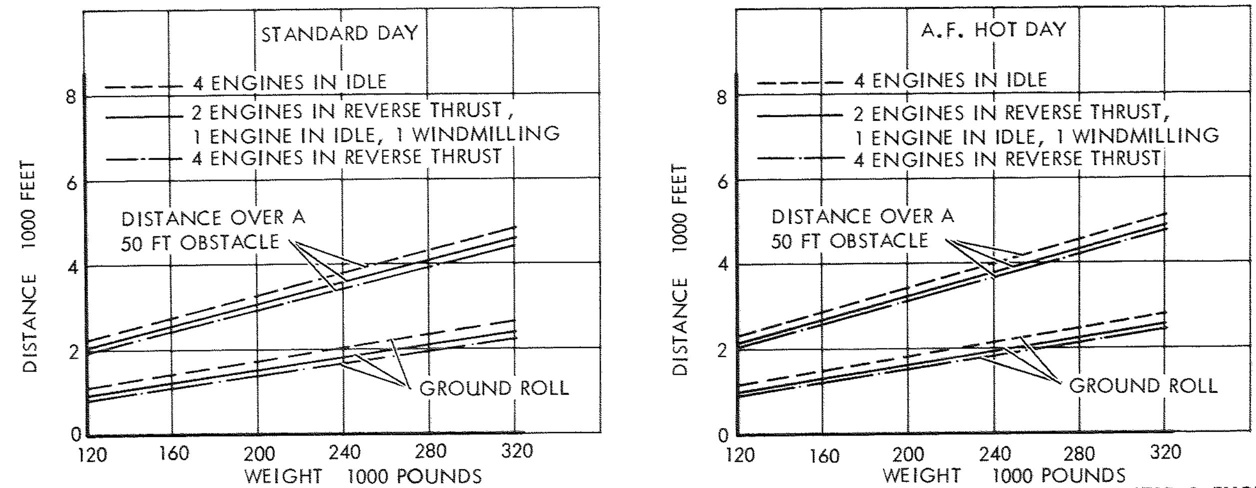


Figure 3-22—MILITARY LANDING DISTANCE, 50 DEGREE FLAP SETTING, NO WIND, PRATT AND WHITNEY JT3D-4 ENGINE.

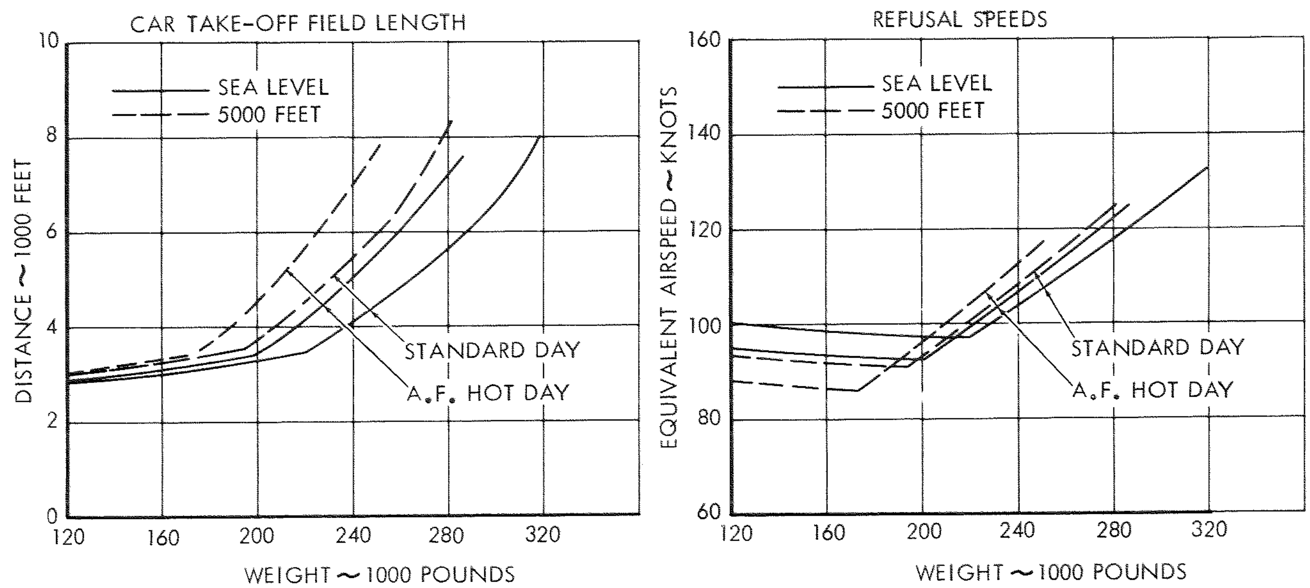


Figure 3-23—CAR TAKE-OFF FIELD LENGTH, 35 DEGREE FLAP SETTING, TAKE-OFF POWER, NO WIND, PRATT AND WHITNEY JT3D-4 ENGINE.

Figures 3-25, 3-26, and 3-27 present the airplane ceilings, stall speeds, and altitude performance, respectively. Four engine and three engine service and cruise ceilings are shown for both military and normal power. The optimum cruise altitude is also shown, and is less than the normal power cruise ceiling.

The altitude performance capability of the airplane is summarized in Figure 3-27. This figure shows instantaneous rate of climb, climb speed, and maximum level flight speed data for the airplane with the engines operating at normal power. At sea level, at a weight of 315,000 lbs., the rate of climb is 2750 feet per minute and at a weight of 288,000 lbs. the rate of climb is 3050 feet per minute. The maximum level flight speed data show that at an altitude of 25,000 feet the high speed capability, at a weight of 280,000 lbs., is 488 knots.

Stall speeds as a function of gross weight are given in Figure 3-26 for flap settings of 0, 30, 35, and 50 degrees. At a weight of 315,000 lbs. and at the take-off flap setting of 35 degrees, the stall speed is 114 knots. At a typical landing weight of 200,000 lbs. with the 50-degree landing flap setting the stall speed is 88 knots. These low stall speeds are made possible by the relatively light wing loading of the GL 207-45 (about that of the C-130) and by the previously discussed wing design philosophy.

Figures 3-28 and 3-29 present CAR weight limitation data for the approach and landing climb segments and for the the first, second and final takeoff climb segments. Data are shown for sea level and 5,000 feet for standard day and Air Force hot day conditions. The second segment climb gradient is shown to be the most critical of the take-off climb requirements. At sea level on a standard day the

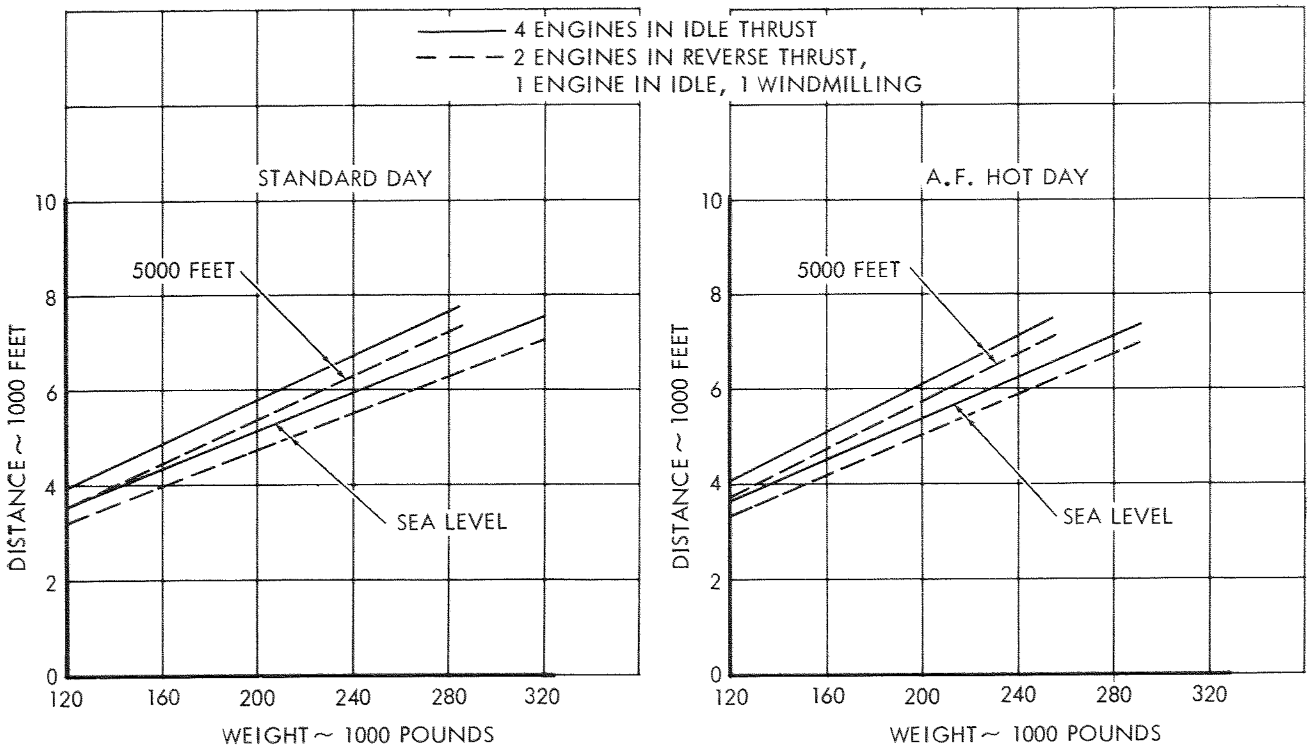


Figure 3-24—CAR LANDING FIELD LENGTH, 50 DEGREE FLAP SETTING, NO WIND, PRATT AND WHITNEY JT3D-4 ENGINE.

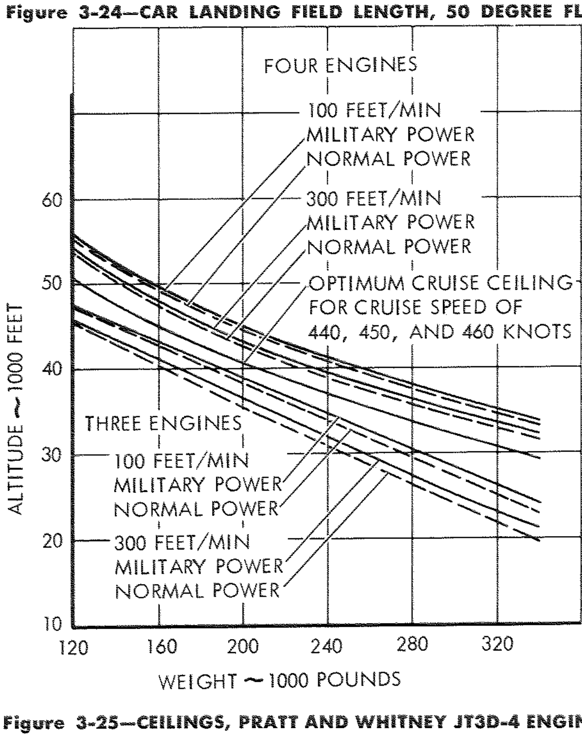


Figure 3-25—CEILINGS, PRATT AND WHITNEY JT3D-4 ENGINE.

maximum weight is limited to 318,000 lbs. and at 5000 feet on a standard day, to 311,000 lbs.

The maximum performance landing weight is shown to be limited by the landing climb gradient. For standard day conditions the weight limitation is 323,000 lbs. and 285,000 lbs. at sea level and 5000 feet respectively.

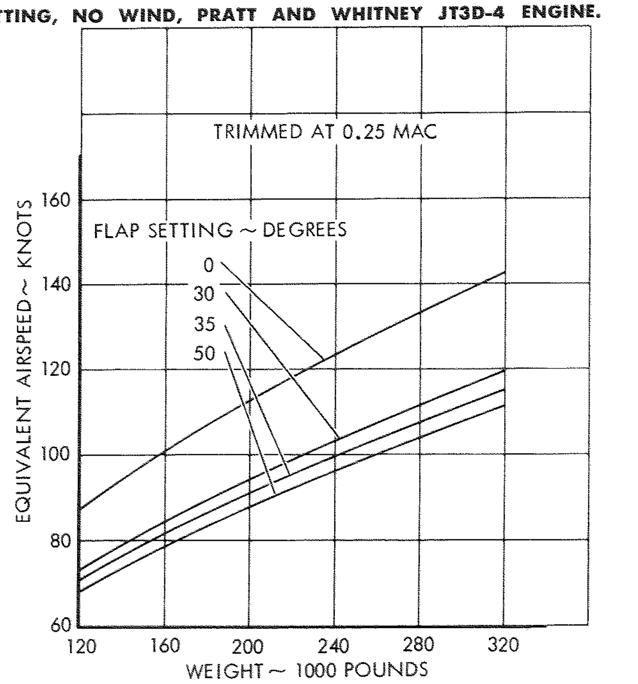


Figure 3-26—STALL SPEEDS, PRATT AND WHITNEY JT3D-4 ENGINE.

The military payload/range data of Figures 3-30 and 3-31 are shown for take-off weights of 288,000 lbs. and 315,000 lbs., respectively, and for airplane average cruise speeds of 440, 450, and 460 knots. Best range is achieved at a cruising speed of 440 knots and a power setting of about 80 percent normal. Higher cruising speeds are optional at some reduction in range as is shown in Figure 3-31. All

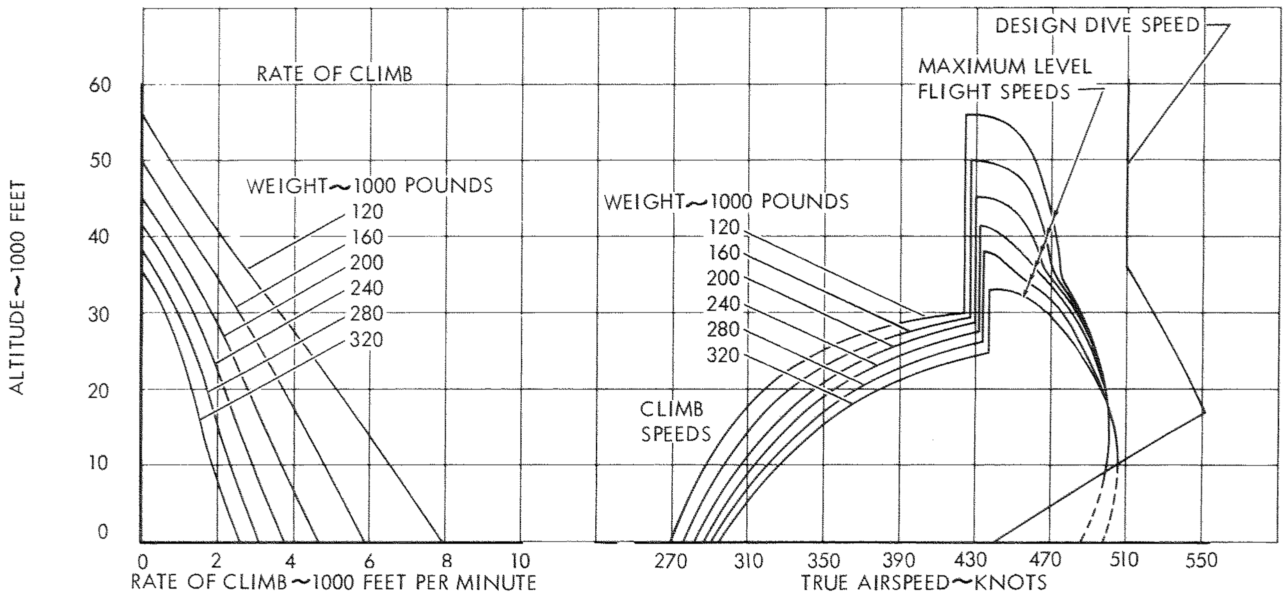


Figure 3-27—ALTITUDE PERFORMANCE, NORMAL POWER, STANDARD DAY, PRATT AND WHITNEY JT3D-4 ENGINE.

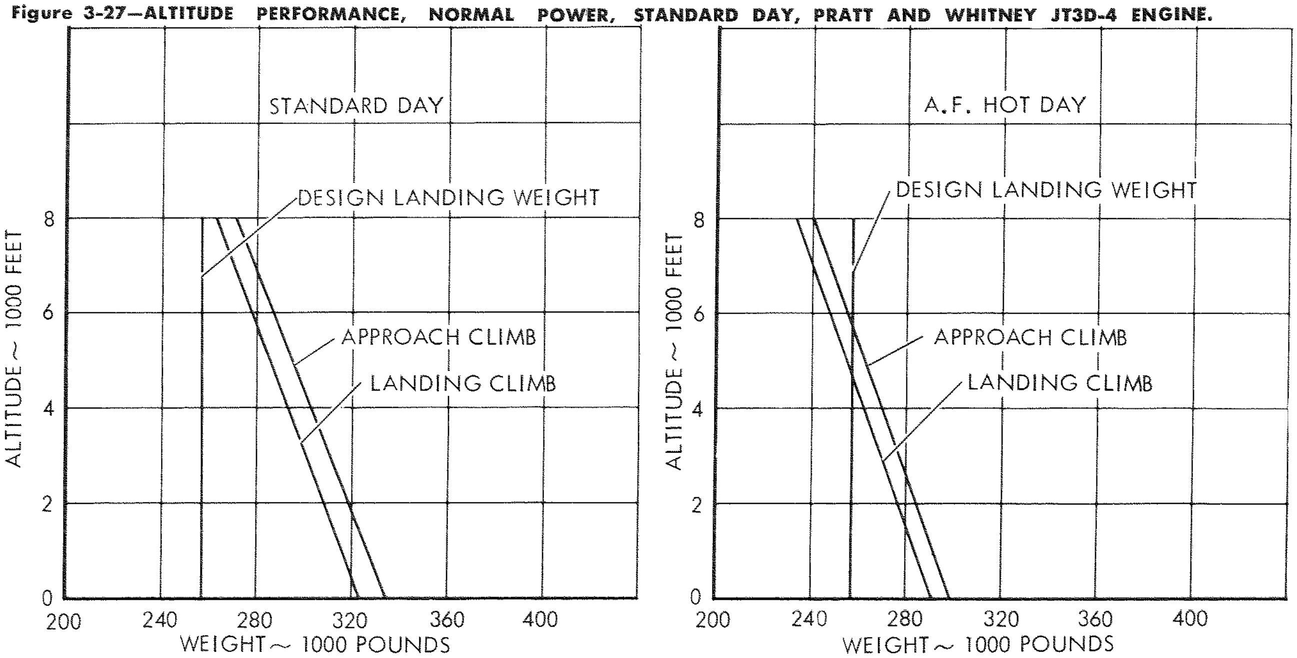


Figure 3-28—CAR WEIGHT LIMITATIONS, APPROACH AND LANDING CLIMB SEGMENTS, TAKE-OFF POWER, PRATT AND WHITNEY JT3D-4 ENGINE.

of the data presented are based on 5% conservative fuel flows, on MIL-C-5011A take-off and reserve fuel allowances, and on cruise climb techniques.

At the take-off weight of 288,000 lbs., where the CAR take-off field length is 6,000 feet on a sea level standard day, as shown in Figure 3-23, the airplane performs the basic design 4,000 nautical mile/50,000 lb. payload and 5,500 nautical mile/20,000 lb. payload missions with slight margins at an average cruise climb of 440 knots.

Other significant points shown in Figure 3-30 are the 3050 nautical mile range with the design payload at the 440 knots cruise speed and the 3160 nautical mile range capability with a 50,000 lb. payload at the 460 knots cruise speed.

The payload range data of Figure 3-31 show the effect of operating the airplane at its design gross weight of 315,000 lbs. The sea level standard day CAR field length at the 315,000 lb. take-off weight is 7720 feet. Figure 3-20 shows that the military take-off distance over a 50 foot obstacle at this take-off weight is only 6,430 feet at sea level on a standard day. The payload at a range of 4,000 nautical miles is 67,300 lbs. for cruise at 440 knots. The maximum payload of 80,000 lbs. can be flown 3,050 miles at a cruise speed of 450 knots and the

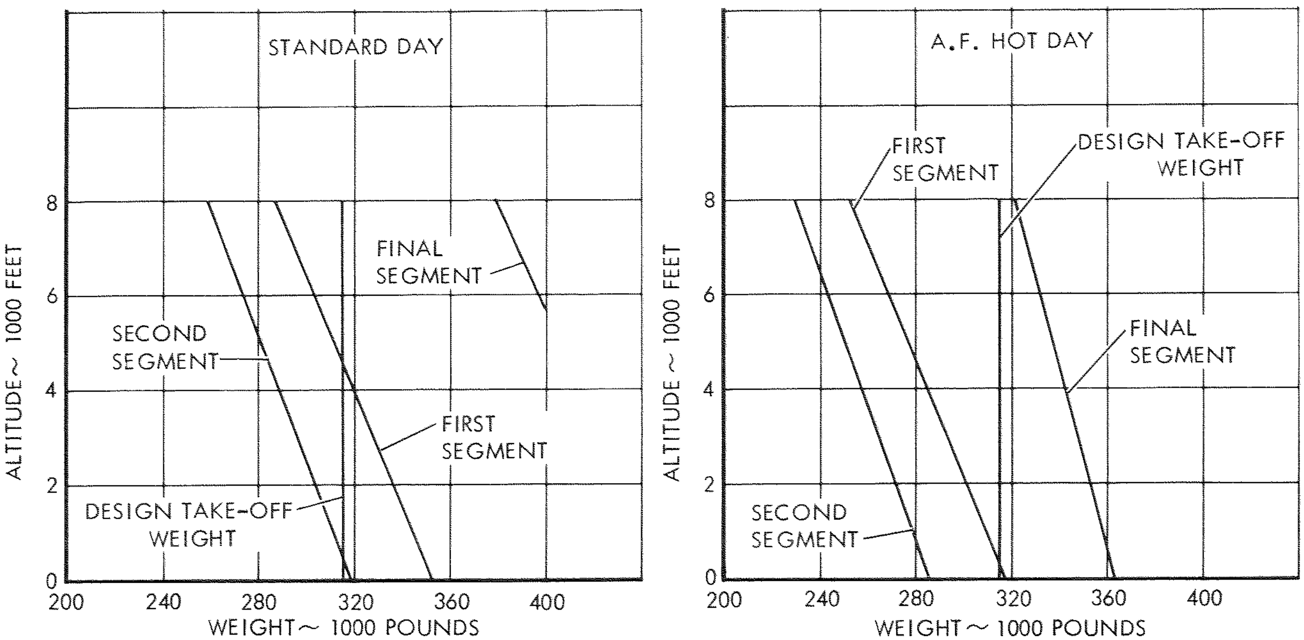


Figure 3-29—CAR WEIGHT LIMITATIONS, FIRST, SECOND AND FINAL CLIMB SEGMENTS, PRATT AND WHITNEY JT3D-4 ENGINE.

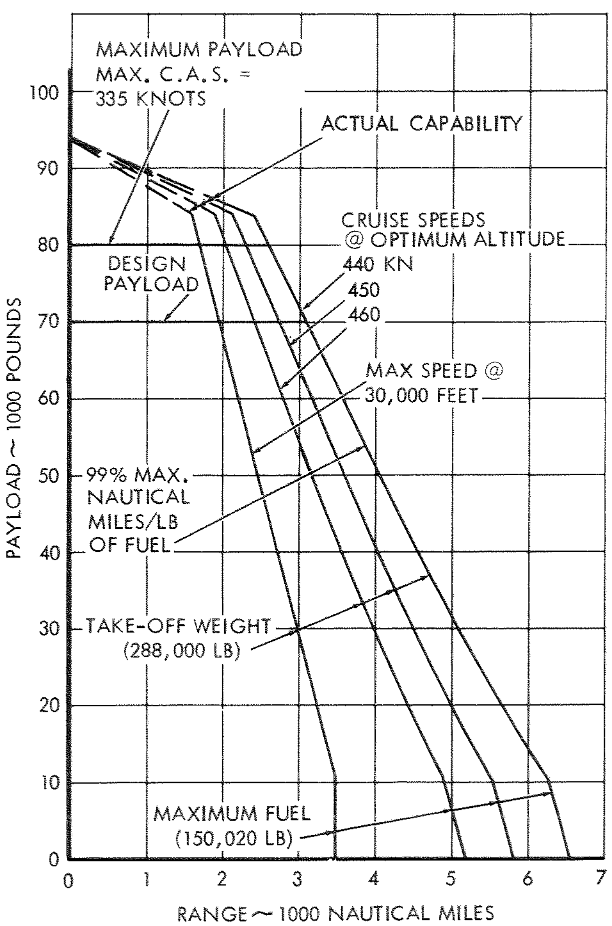


Figure 3-30—PAYLOAD RANGE, MILITARY INSTALLED FUEL FLOWS 5% CONSERVATIVE, TAKE-OFF FUEL ALLOWANCES AND FUEL RESERVES, MIL-C-5011A, PRATT AND WHITNEY JT3D-4 ENGINE.

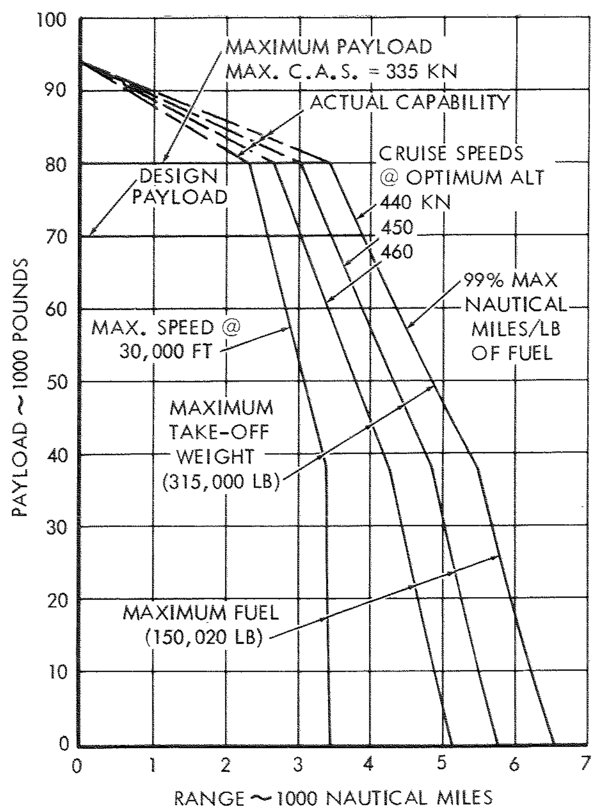


Figure 3-31—PAYLOAD RANGE, INSTALLED FUEL FLOWS 5 PERCENT CONSERVATIVE, TAKE-OFF FUEL ALLOWANCES AND FUEL RESERVE, MIL-C-5011A, PRATT AND WHITNEY JT3D-4 ENGINE.

70,000 lb. design payload can be carried 3030 miles at a cruise speed of 460 knots. It is also significant to note that over 37,000 lbs. of payload can be transported 5,500 nautical miles at the 440 knots cruise speed.

The civil performance capabilities of the GL207-45 airplane are shown in Figure 3-32. Data are presented for the optimum cruise speed of 445 knots for the take-off weights of 288,000 and 315,000 lbs. All of the data shown are based on installed fuel flows and on overwater fuel reserves as defined by SR-327B for flights dispatched without alternates. A step-climb, as opposed to a cruise climb, procedure was used in these calculations. The data show that, at the 3,000 nautical mile range the payload is 65,700 lbs. at the sea level standard day CAR 6,000 foot limited take-off weight of 288,000 lbs. The corresponding payload for the design take-off weight case is 80,000 lbs. as limited by the maximum payload capability. At the 4,000 nautical mile range point the payloads are 46,700 and 62,300 lbs. respectively.

The tabulated data of Figure 3-33 is presented to show that the GL 207-45 airplane meets or betters all of the mission and airport performance requirements of System 476L. The critical performance take-off weight, 287,200 lbs., is that required to perform the 4,000 nautical mile/50,000 lb. payload mission.

A mission profile is shown in Figure 3-34 for the 4,000 nautical mile/50,000 lb. payload mission. This figure shows the fuel consumption, distances, and flight times for the various portions of the mission.

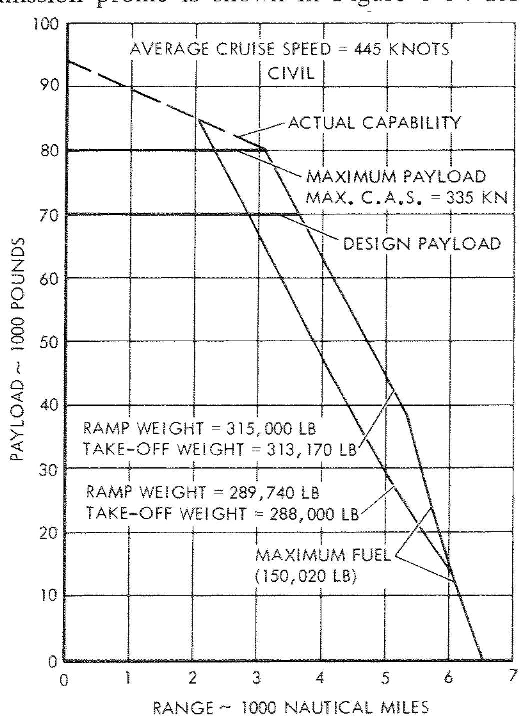


Figure 3-32—PAYLOAD RANGE, CIVIL, INSTALLED FUEL FLOWS, TAKE-OFF FUEL ALLOWANCES AND FUEL RESERVES, SAR 427B, PRATT AND WHITNEY JT3D-4 ENGINE.

Stability and Control

General

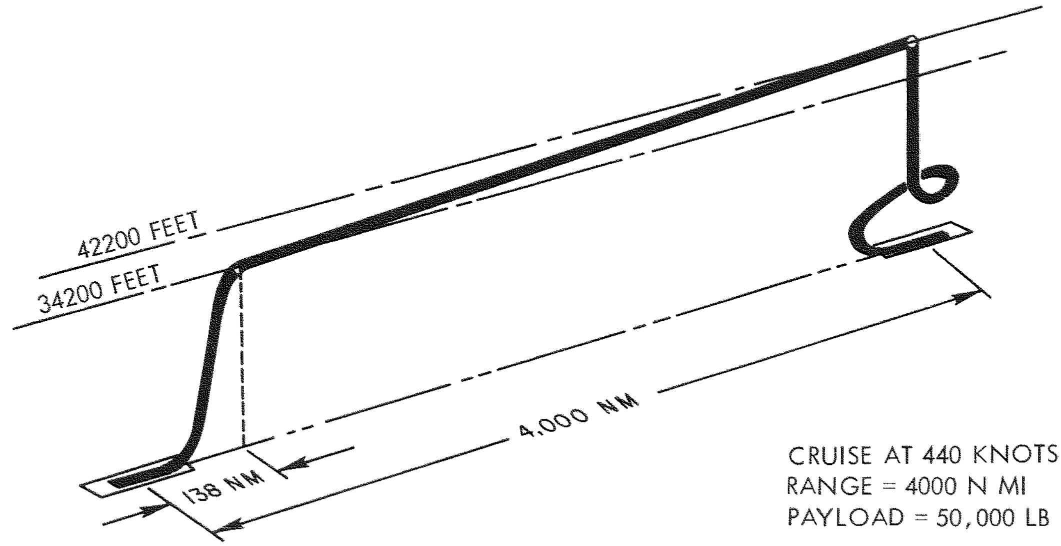
The stability and control characteristics are discussed relative to Civil Air Regulations, Part 4b, paragraphs 4b.120 through 4b.173, Reference 1, and the data show that the airplane meets all the requirements for FAA certification. The flying qualities equal or exceed all stipulations of CAR4b. The military stability and control specification, MIL-F-8785, Reference 2 is followed where requirements are stated that do not conflict with CAR 4b. The aerodynamic data which form the basis of this stability and control analysis have been obtained primarily from comprehensive wind tunnel tests at both high and low speeds on models of this configuration. In addition, these data were supplemented by Lockheed and NASA information on similar configurations.

The effects of flexibility and Mach number are included in the stability and control analysis. Flexibility effects are computed employing a relaxation procedure which has been programmed for the IBM 704 using the Faulkner lifting surface theory for computing the aerodynamic loads for the rigid and all subsequent loads resulting from structural deflections. Aerodynamic loads and center of pressure data generated, using the lifting surface theory, have been correlated with wind tunnel test results

		1	1	2	3
DESIGN RANGE	N. M.	4,000	5,500	3,000	1,000
DESIGN PAYLOAD	Lb.	50,000	20,000	60,000	70,000
RAMP WEIGHT	Lb.	287,200	283,100	282,200	239,470
AT TAKE-OFF WEIGHT	Lb.	287,200	283,100	280,484	237,905
Critical Gradient Limiting Weight	Lb.	318,000	318,000	318,000	318,000
CAR Take-off Field Length at S.L.	Ft.	5,960	5,780	5,700	4,080
Take-off Ground Roll at S.L. (Mil.)	Ft.	3,590	3,480	3,400	2,330
Take-off Distance to Clear 50′ at S.L. (Mil.)	Ft.	5,260	5,050	5,000	3,470
Service Ceiling	Ft.	37,000	37,400	37,500	41,000
Three Engines Operating Service Ceiling	Ft.	28,900	29,400	29,600	34,200
MISSION PERFORMANCE					
Begin Cruise Altitude	Ft.	34,200	34,500	34,400	37,900
Cruise Speed	Knots	440	440	445	445
End Cruise Altitude	Ft.	42,200	45,500	40,200	39,500
AT LANDING WEIGHT	Lb	187,530	158,305	204,700	212,030
Critical Gradient Limiting Weight	Lb.	323,000	323,000	323,000	323,000
CAR Landing Field Length	Ft.	4,910	4,330	5,230	5,400
Landing Ground Roll at S.L. (Mil.)*	Ft.	1,080	900	1,180	1,220
Landing Distance from 50′ at S.L. (Mil.)*	Ft.	2,430	2,130	2,610	2,700

1 MIL-C-5011A reserves
2 Step-climb cruise and SAR 427B reserves
3 Step-climb cruise and CAR 40.396 reserves—alternate—200 N. Mi.
* Brakes, four engines in reverse thrust

Figure 3-33—PERFORMANCE SUMMARY, GL207-45, PRATT AND WHITNEY JT3D-4 ENGINE.



FLIGHT CONDITIONS	WEIGHT POUNDS	DISTANCE NAUTICAL MILES	FUEL POUNDS	TIME HOURS
TAXI AND TAKE-OFF	287200		2640	
CLIMB TO 34,200 FEET	284560	138	8630	.372
CRUISE	275930	3862	88400	8.770
LOITER 30 MINUTES AT SEA LEVEL	187530		5020	
5 PERCENT RESERVE	182510		5510	
ZERO FUEL WEIGHT	177000			
TOTALS		4000	110,200	9.142

NOTE: MIL-C-5011A RULES USED

Figure 3-34—MISSION PROFILE—TYPICAL.

and the agreement has been excellent. In this program the elastic axis concept is used to describe the structural characteristics of the aerodynamic surface.

The center of gravity envelope for the airplane is shown in Figure 3-35. The structural envelope is shown, as well as curves defining several important aerodynamic limits. These curves represent the most critical speed-altitude combination for each case.

A considerable static stability margin exists at the most aft center of gravity location, 30% mean aerodynamic chord. However, the requirements of the longitudinal short period oscillation damping preclude the possibility of any reduction in tail size without also considering the use of a pitch damper. With very little developmental work, however, the most aft center of gravity location could be moved beyond 30% mean aerodynamic chord, if this modification becomes advantageous or necessary. Presently the center of gravity range is quite satisfactory for the anticipated requirements.

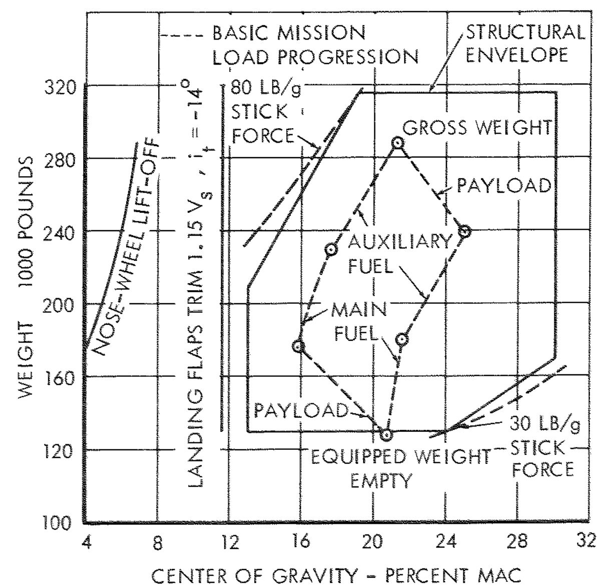


Figure 3-35—CENTER OF GRAVITY DIAGRAM.

All control surfaces are partially aerodynamically balanced, and are equipped with dual boosters similar to those used on the C-130 series, to supply hinge moments not relieved by aerodynamic balance. The trim requirements are met in the lateral (ailerons) and directional (rudder) axes by use of conventional tabs, the tab on the ailerons being also used as a boost tab. Longitudinal trim is accomplished by means of a movable stabilizer.

Longitudinal Control

Brief studies of the ability to push the nose of the airplane down at all speeds down to the stall speed and promptly recover to a speed equal to $1.4_{V_{S1}}$ have been made. The airplane is entirely satisfactory for both flaps up and down conditions in accordance with the requirements of Reference 3.

Longitudinal control effectiveness in the approach and landing configurations was investigated over the weight and center of gravity spectrum covering the requirements of References 2 and 3. When the airplane is trimmed at $1.2_{V_{S1}}$ with power for level flight in the approach configuration at the most forward center of gravity, it is possible to stall the airplane in ground effect with less than maximum available elevator and a stick force of less than 50 lbs. The civil specifications impose control requirements that are much less critical, and can be easily achieved. As shown on the center of gravity diagram in Figure 3-35 the elevator control available for rotation of the airplane is non-limiting for all weights and center of gravity combinations.

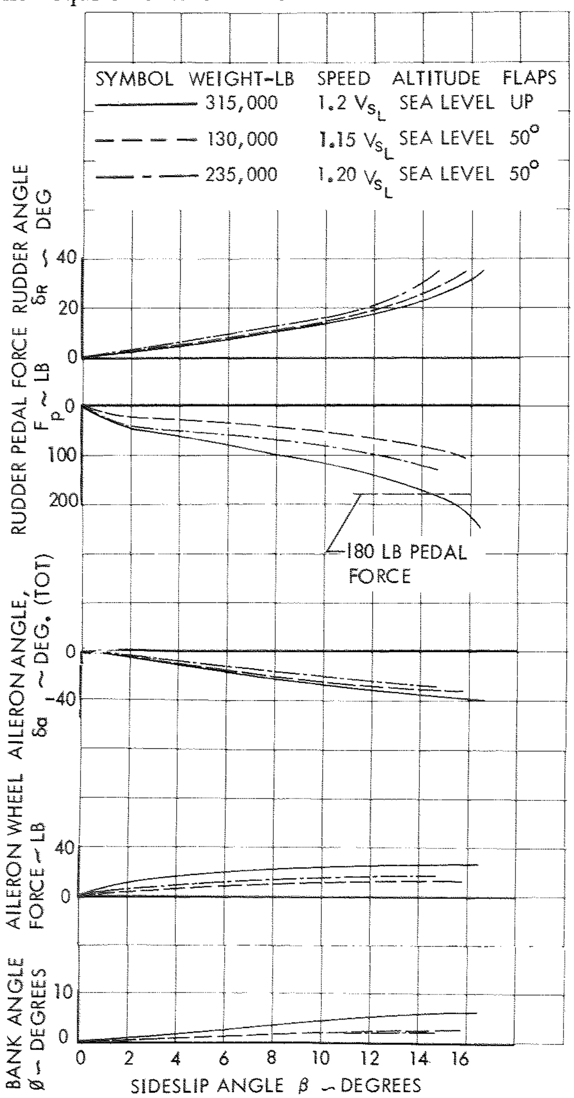


Figure 3-36—SIDESLIP CHARACTERISTICS.

Lateral Directional Control

The lateral-directional control capability is shown in Figure 3-36 for representative flaps up and down configurations in terms of steady sideslip characteristics. Rudder power available for heading changes with two engines inoperative at the best climb speed with flaps up is excellent, only 6.2 degrees of rudder being required for trim. Minimum control speed data in the static case is shown in Figure 3-37 for the light weight case with two possible engine installations. With the proposed engine, it is apparent that the static minimum control speed is not critical at any flying weight and with the highest thrust advanced engine suggested, is critical only at very light weight conditions.

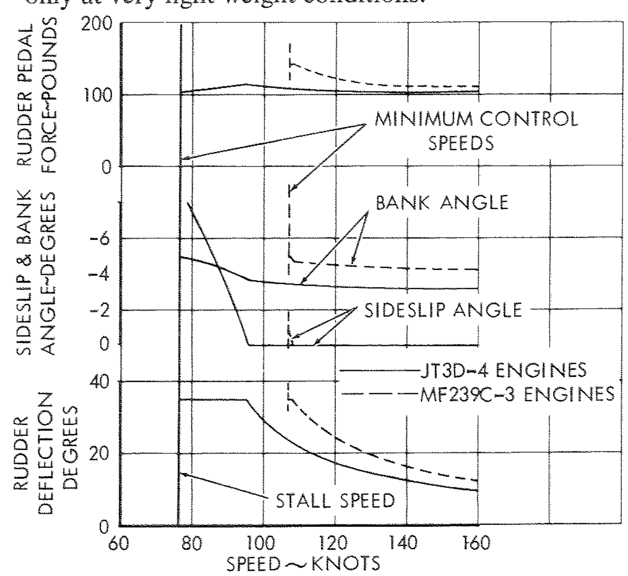


Figure 3-37—MINIMUM CONTROL SPEEDS, STATIC SOLUTIONS, 3 ENGINES AT TAKE-OFF THRUST, RIGHT OUTBOARD ENGINE WINDMILLING, FLAPS 35 DEGREES, SEA LEVEL, STANDARD DAY, WEIGHT — 140,000 POUNDS.

Several dynamic engine failure conditions for evaluation of the minimum control speed were investigated by analog simulation at a weight of 140,000 lbs. for two different engine installations. It may be noted in Figure 3-38 that with the proposed engine it is possible to meet the requirements of Reference 3, of less than 20 degrees heading change with less than 180 lb. of pedal force at a speed as low as approximately 83 knots, which is considerably less than 1.2 V_s at this light weight, and is more critical than the static control case. For a higher thrust engine such as the MF239C-3, a maximum heading change of 20 degrees with maximum pedal force of 180 lb. can be held at a minimum speed of 110 knots. This case would then be 3.5 knots more critical than the static minimum control speed case and is less than $1.2V_S$ at all weights greater than 200,000 lb.

Lateral control is shown in Figure 3-39 as the rolling velocity and wing tip helix angle achievable at sea level, 20,000 feet and 45,000 feet. Flexibility and Mach number effects have been accounted for in the results shown. Excellent rolling capability is available over the whole speed range without exceeding a limit wheel-force of 50 lb. The requirements of Reference 2 are exceeded for all design conditions.

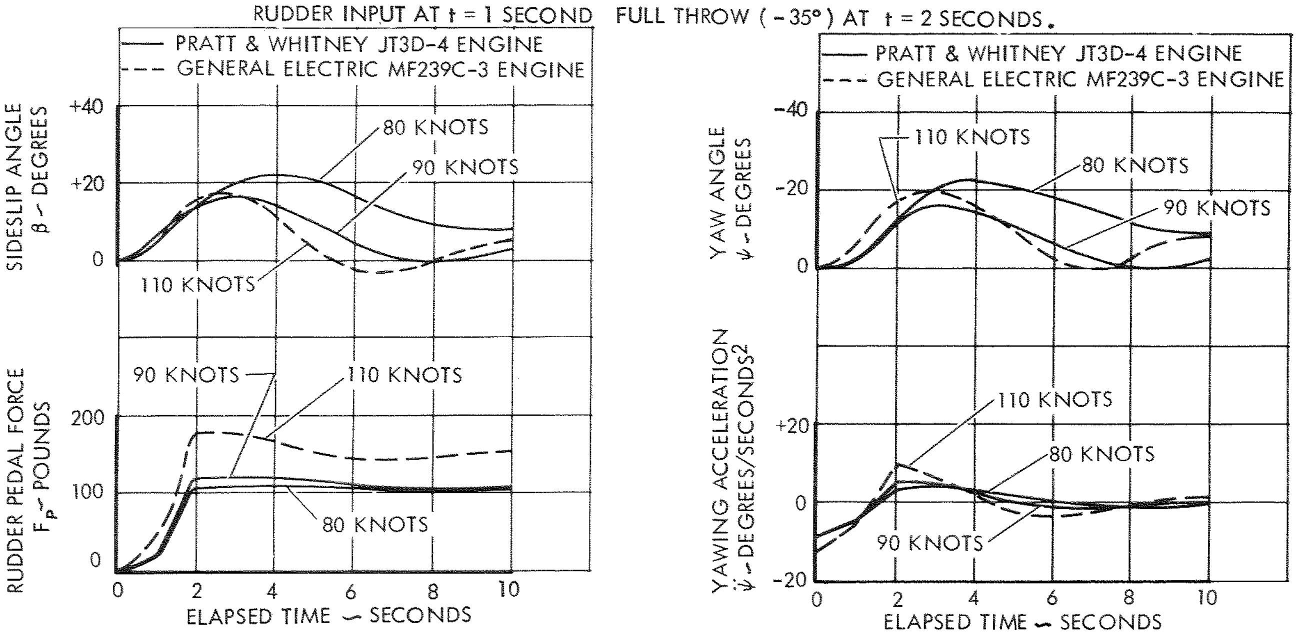


Figure 3-38—DYNAMIC ENGINE FAILURE, LEFT OUTBOARD ENGINE FAILED, TAKE-OFF CONFIGURATION, FLAPS 35 DEGREES, SEA-LEVEL, STANDARD DAY, WEIGHT = 140,000 POUNDS.

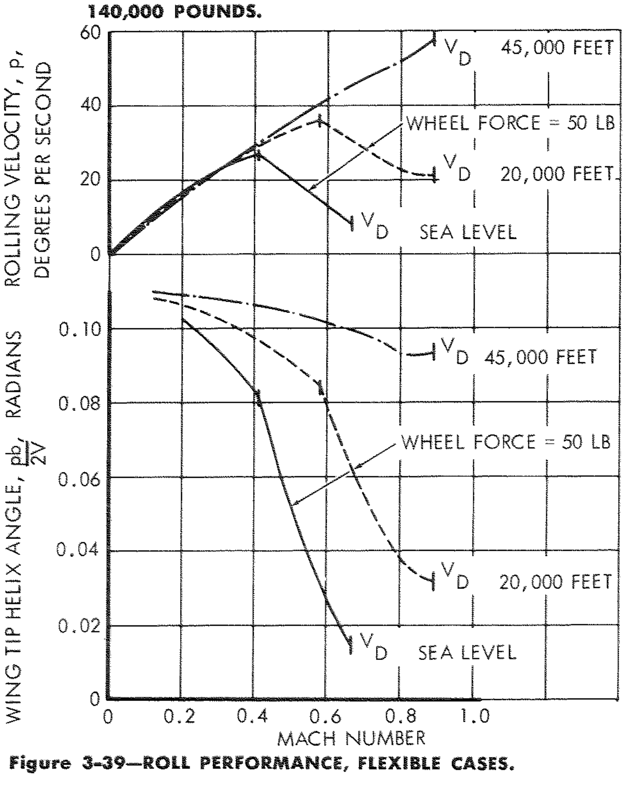


Figure 3-39—ROLL PERFORMANCE, FLEXIBLE CASES.

Longitudinal Trim

The longitudinal trim change requirements of References 2 and 3 for configuration changes such as landing gear and flap lowering and retraction, and changes due to power setting were investigated. It was found that the resulting stick forces were well within the limits of the referenced specification and are easily controlled by the pilot with one hand.

The longitudinal trim capability is excellent, and also exceeds all requirement of References 2 and 3. At the most forward c.g., the limit stabilizer nose down deflection is adequate to achieve a minimum trim speed of V_s in the clean, $1.1V_s$ in the take-off, and $1.14V_s$ in the landing configurations respectively. Longitudinal trim is shown in all cases for the more critical power-off configurations since a slight "nose-up" moment occurs with power.

Lateral and Directional Trim

Lateral trim capability is not critical for this airplane since the crossfeed features of the fuel system minimize the necessity for large amounts of fuel unbalance. In any event, the aileron trim tab is capable of trimming one quarter the full aileron travel. The rudder trim tab power available is sufficient to trim the rudder pedal force to zero during two-engine-out climb.

Stability

The static longitudinal stability in the landing and power approach configurations with flaps fully down, gear down, power off and on, is shown in Figure 3-40. Data are shown at the extremes of the C.G. range hence show the most critical stability as well as control conditions. It can be seen that a pull force is required even in wave-off to reduce speed and a push force is required to increase speed over the entire range from $1.1V_S$ to the flap placard

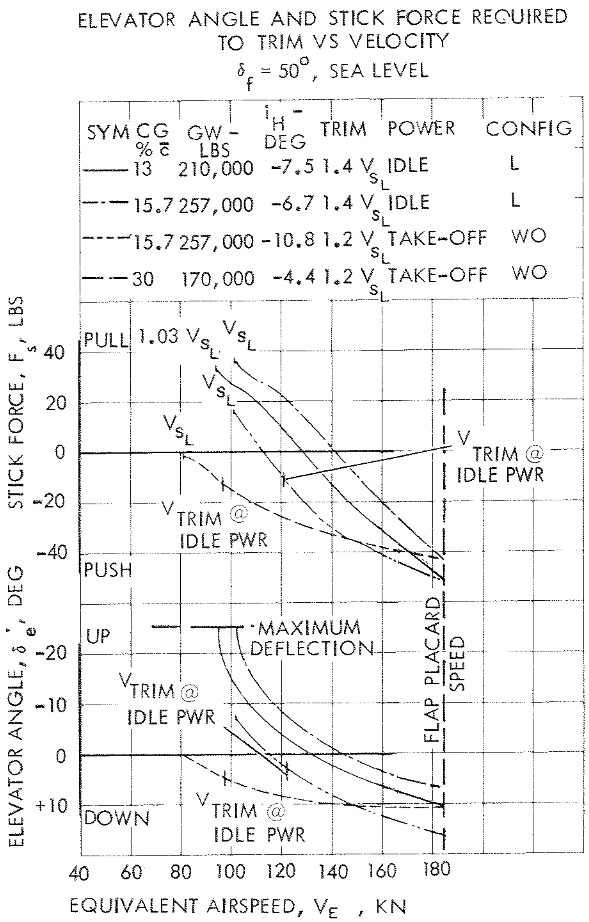


Figure 3-40—SPEED STABILITY, LOW SPEED.

speed. When the airplane is trimmed at $1.4V_{S1}$, the stick force required over the flight range is well below the 80 pound limit of Reference 3.

Static longitudinal stability in the climb configuration and cruise configuration is shown in Figure 3-41. Non-rigid airplane data was used to compute all these cases. The cruise configuration shows an instability in stick force through the trim point when trimmed at 0.825 Mach number. A Mach trim mechanism has been incorporated into the control system which programs a schedule of stabilizer incidence as a function of Mach number so that a stable stick force gradient is realized. The stick-force characteristics with the Mach trim operating are shown. The cases shown represent the most critical conditions which occur at a combination of high Mach number and high lift coefficient. All of

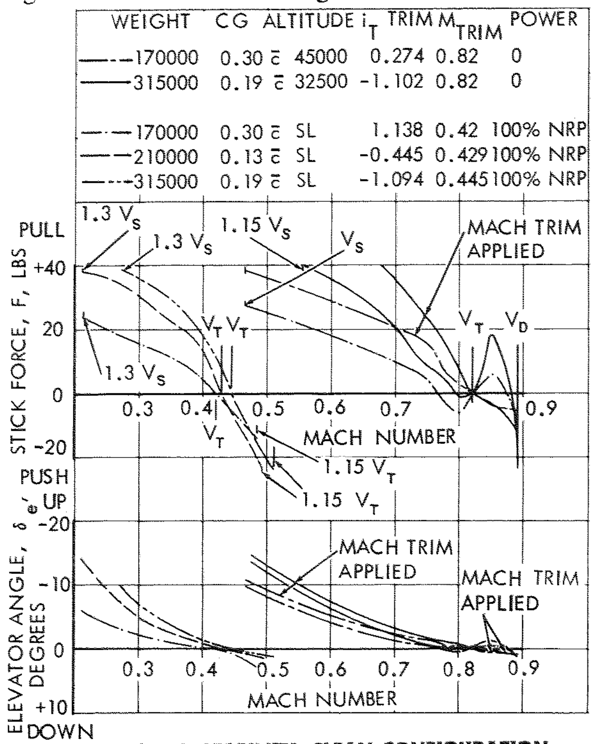


Figure 3-41—SPEED STABILITY, CLEAN CONFIGURATION.

the speed stability requirements of References 2 and 3 are met when the Mach trimmer is operating.

The accelerated stability in turning flight and straight pull-ups was investigated throughout the entire range of speeds, altitudes, gross weights and center of gravity locations. The most critical cases for the highest stick force per "g" and the lowest stick force per "g" are shown in Figure 3-42. The stick forces required are within the limits of Reference 2 and are essentially linear even at speeds up to the design dive speed. For conditions where the maximum lift coefficient is approached, an increase in the stick force per "g" will be noted; this tendency provides a useful form of limiting device for the pilot under these conditions.

Lateral-directional low speed stability characteristics are shown in Figure 3-36. Very stable gradients of rudder deflection and pedal force as well as aileron deflection and wheel force are shown throughout the sideslip angle range. No tendency for pedal force lightening occurs at the maximum sideslip angles attainable.

Longitudinal Damping

Short period damping characteristics were investigated for the extreme fore and aft positions of

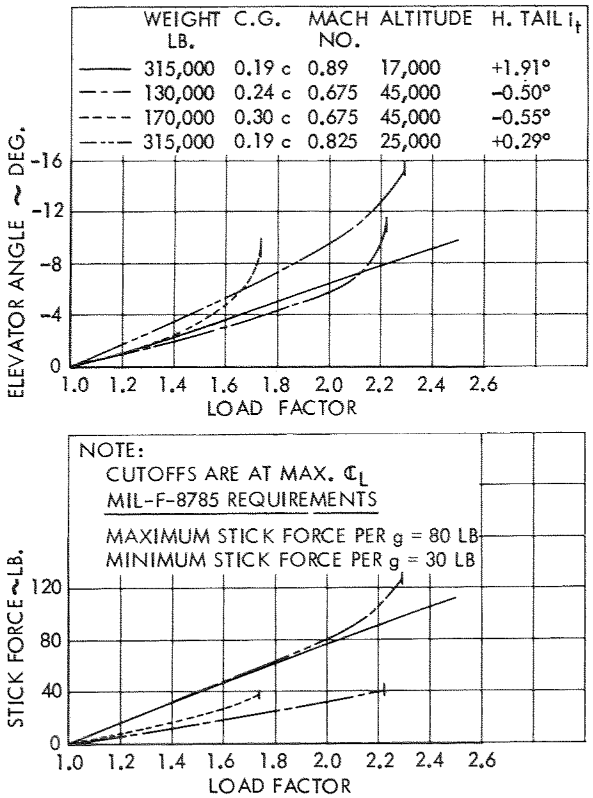


Figure 3-42—ACCELERATED STABILITY.

the center of gravity for all the trim speeds and flight conditions listed in the Table II of Reference 2. The results for the most critical loading at each flight configuration are presented in Figure 3-43 in terms of the cycles required to damp to one-tenth amplitude and the period of the oscillation. Compliance with the requirement of the specification is shown, and no pitch damper is required.

Lateral-Directional Damping

Lateral-directional damping characteristics are shown in Figure 3-44 for the critical cases specified in Table V of Reference 2. The damping exceeds the minimum allowable damper-off values specified in Reference 2 in all cases. Artificial damping is provided by a simple yaw damper which has a gain of 0.3 degrees of rudder per degree per second of yawing velocity. Damping in configurations PA and L is excellent with damper inoperative, therefore the damper operative condition is not shown. For convenience, the values of the parameters used in computing the damping characteristics for a few representative cases are presented in Figure 3-45.

Stall Characteristics

The airplane stalling characteristics can, of course, be determined accurately only from flight test. As discussed previously in the Configuration Selection and Description section of this report, much emphasis in the design of wing airfoil sections, camber, thickness and twist distribution has been directed to assure stable characteristics at the stall.

The high speed wind tunnel test results show stable pitching moment characteristics throughout the entire angle of attack range tested, which was well beyond the maximum usable lift coefficient. The low speed wind tunnel results show a slight pitch-up tendency over a region of about 2 to 4 degrees angle of attack above the maximum lift coefficient, beyond which the pitch characteristics were stable. Tuft studies showed that this slight instability was due to premature spreading of trailing edge separation over the outboard wing panel, as should be expected, considering the low local Reynolds number (about 600,000) at which the outboard panel is operating. At the full-scale flight Reynolds number of about 9,000,000 this phenomena will not occur, hence a completely stable stall break will result. In the low-speed wind tunnel test, buffet of the horizontal tail coincided with initial separation of the inboard wing panel as the wing wake spread to envelop the tail. This will provide excellent aerodynamic stall warning.

Configuration	**CR**	**P**	**P**	**PA**	**L**
Trim Speed	**CR**	V_{NRP}	$0.75\ V_{NRP}$	$1.3\ V_{SL}$	$1.2\ V_{SL}$
Weight (lbs)	180,000	180,000	180,000	315,000	235,000
C.G. at (% c)	28.0	28.0	28.0	28.0	28.0
Altitude (ft)	45,000	45,000	40,000	S.L.	S.L.
Mach No.	0.767	0.785	0.608	0.138	0.175
V_e (knots)	194.0	198.8	173.0	153.9	116.0
e (slugs/ft³)	0.000460	0.000460	0.000585	0.002377	0.002377
u (ft/sec)	742.0	760.0	588.0	259.5	195.5
γ (deg)	0	0	0	0	0
m (slugs)	5595.0	5595.0	5595.0	9780.0	7300.0
Zj (ft)	3.86	3.86	3.86	3.86	3.86
I_{yy} (slugs-ft²)	2,340,000	2,340,000	2,340,000	2,800,000	2,875,000
C_L	0.440	0.418	0.551	1.220	1.610
C_D	0.0232	0.0228	0.0218	0.1185	0.2370
$C_{L\alpha}$ per radian	5.26	5.22	4.70	4.77	4.85
$C_{D\alpha}$ per radian	0.294	0.417	0.292	0.567	0.920
$C_{m\alpha}$ per radian	—1.365	—1.305	—1.270	—1.000	—1.040
$C_{m\alpha}$ per radian	—4.670	—4.760	—3.830	—5.870	—5.300
C_{mq} per radian	—21.24	—21.42	—20.32	—18.33	—18.34
P (sec) short per.	2.83	2.84	3.31	5.90	7.11
C 1/10 (cycles to 1/10 AM)	0.802	0.778	0.740	0.297	0.309

Figure 3-43—PARAMETERS FOR DYNAMIC LONGITUDINAL STABILITY CALCULATION.

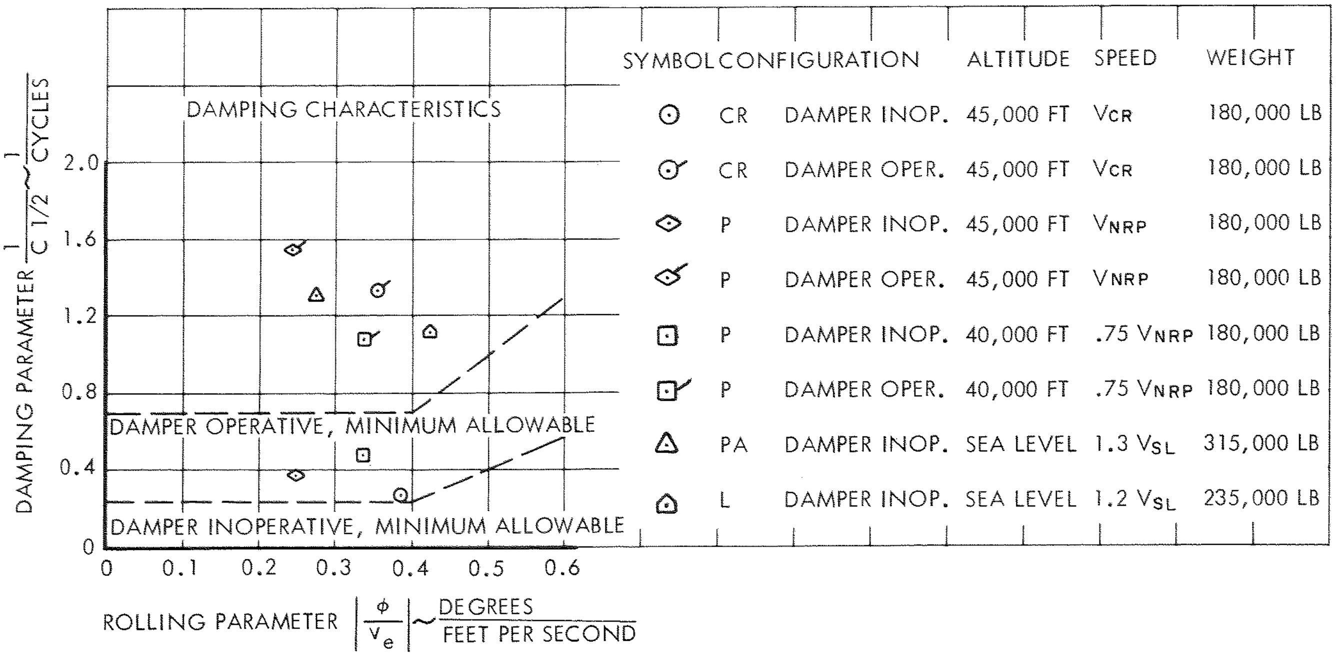


Figure 3-44—LATERAL, DIRECTIONAL DYNAMIC STABILITY, MINIMUM ALLOWABLE PER MIL-S-8785.

Configuration	CR	P	P	PA	L
Trim Speed	**CR**	V_{NRP}	0.75 V_{NRP}	1.3 V_{SL}	1.2 V_{SL}
Weight (lbs)	180,000	180,000	180,000	315,000	235,000
C.G. at (% c)	25	25	25	25	25
Altitude (ft)	45,000	45,000	40,000	S.L.	S.L.
Mach No.	0.767	0.785	0.608	0.236	0.174
q (lb/ft²)	126.5	133.0	101.0	82.9	44.7
m (slugs)	5595.0	5595.0	5595.0	9780.0	7300.0
V_e (knots)	194.0	198.8	173.0	156.5	115.0
U (ft/sec)	742.0	760.0	588.0	264.0	194.0
$C_{L\beta}$	0.440	0.418	0.551	1.179	1.630
$C_{y\beta}$ per radian	0.6740	0.6940	0.5880	0.5680	0.6210
C_l per radian	0.1841	0.1366	0.1492	0.1235	0.1859
C_{lr} per radian	0.2120	0.1820	0.1980	.2737	.2834
$C_{l\rho}$ per radian	0.4770	0.4770	0.4520	0.4850	0.4720
$C_{n\beta}$ per radian	0.1002	0.1155	0.1020	0.0785	0.1156
C_{nr} per radian	0.1176	0.1156	0.1224	0.1263	0.1709
C_{nr} (with damper)	0.3386	0.3317	0.2916	——	——
C_ρ per radian	0.0396	0.0376	0.0497	0.1060	0.1468
I_{xx} (slugs-ft²)	2,280,000	2,280,000	2,280,000	4,000,000	3,650,000
I_{zz} (slugs-ft²)	4,050,000	4,050,000	4,050,000	6,590,000	6,040,000
I_{xz} (slugs-ft²)	101,000	119,000	48,200	43,200	3,880
P (sec)	4.68	4.33	5.11	7.16	6.64
P (sec with damper)	4.45	4.41	4.82	——	——
T ½ (sec)	17.81	11.31	10.71	5.46	7.48
T ½ (sec) w/damper	3.31	2.85	4.40	——	——
1/C-½ (1/cycles)	0.26	0.38	0.48	1.31	1.12
1/C-½ (1/cycles) with damper	1.34	1.55	1.08	——	——
$\frac{\lvert\phi\rvert}{\lvert V_e\rvert}$ $\frac{\text{(deg-sec)}}{\text{ft}}$	0.386	0.250	0.337	0.275	0.480
$\frac{\lvert\phi\rvert}{\lvert V_e\rvert}$ $\frac{\text{(deg-sec)}}{\text{ft}}$ with damper	0.357	0.247	0.338	——	——

Figure 3-45—PARAMETERS FOR DYNAMIC LATERAL-DIRECTIONAL STABILITY CALCULATIONS.

Aileron, rudder and elevator control was shown to be excellent at angles of attack up to 10 degrees beyond the stall angle.

EFFECT OF GROWTH POWER PLANTS

The basic configuration and design of the GL 207-45 is near optimum for exploitation of the full potential of growth power plants which may become available if the following two purposes are recognized as fundamental desires for System 476L:

1 In the event advanced power plants are not funded and do not become available, the selected basic configuration should, if possible, at least meet all requirements of System 476L when powered with currently available power plants in the 18,000 lb. thrust class.

2 Additional capabilities, possible with advanced power plants over and above the requirements of System 476L, should be exploited to achieve maximum productivity and, therefore, reduced operating costs if additional capabilities are to be economically justifiable.

When this selection process is followed the results are as shown by the data shown in Figure 3-46 which have been developed on the basis that these parametric airplanes are of conventional configuration, optimized to achieve the maximum possible cruise speed for the basic mission of 50,000 lbs. for 4000 nautical miles, while meeting all other requirements of System 476L. It is apparent that higher speed airplanes with sweep angles greater than approximately 25 degrees require power plants of higher thrust to meet the other minimum requirements of System 476L. When it is considered that all of the airplanes represented by the curves do not exceed any of the requirements for System 476L except in the area of speed, the price necessary to gain additional speed, for the sake of speed alone, is substantial in terms of required minimum-rated thrust. It is interesting to note that while an airplane like the GL 207-45, optimized to meet all

System 476L requirements with a wing sweep of 25 degrees, requires only 18,000 lbs. of thrust, this identical configuration, if powered with the most advanced power plants of 24,000 lbs. of thrust, can achieve maximum cruise speeds for the required mission within 7 knots of more sophisticated, highly-swept configurations optimized initially to exploit the full speed potential of the proposed high-thrust power plants.

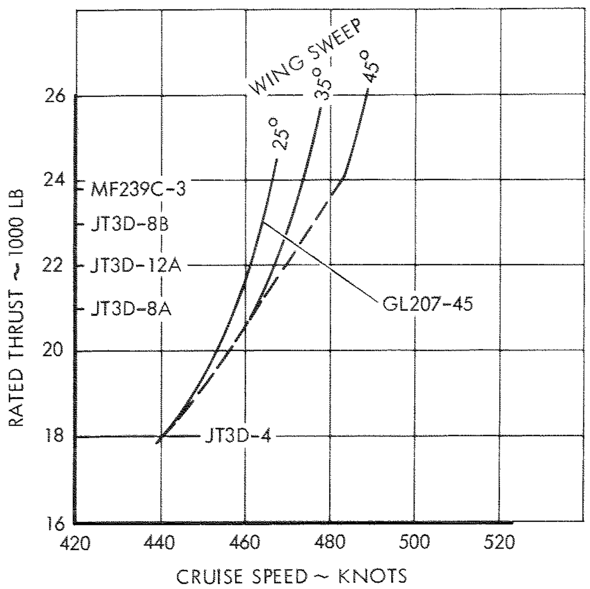


Figure 3-46—GROWTH POTENTIAL, SPEED, RANGE 4,000 NM, PAY LOAD 50,000 POUNDS, WING AREA = 3228 SQUARE FEET.

Figure 3-47 indicates the growth capability available in terms of added payload/for the 4000 N.M. range which leads to increased productivity and, therefore, reduced direct operating costs. This would certainly be a criterion in the economic justification for capabilities exceeding the requirements of System 476L. As in the previous discussion on speed, all data presented is for airplanes designed to at least meet the other requirements of System 476L. On this basis it may be seen that the inherent growth capability of airplanes with lower wing sweep far exceeds that of those with higher wing sweep.

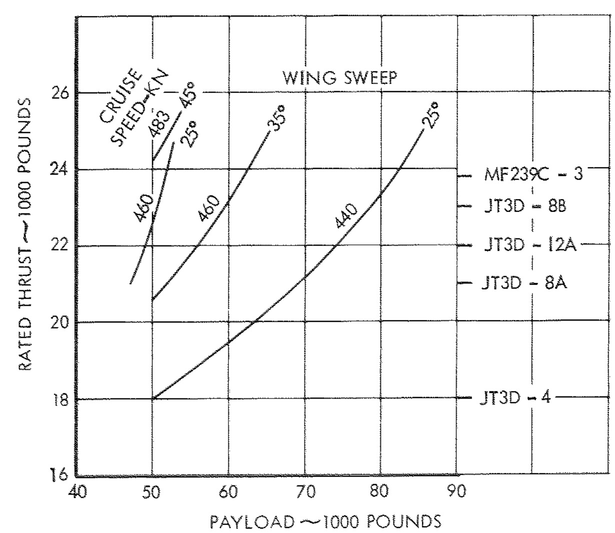


Figure 3-47—GROWTH POTENTIAL, PAYLOAD, RANGE 4000 NM, LONG RANGE CRUISE SPEEDS, WING AREA = 3228 SQUARE FEET.

The data on these two charts simply illustrate a fundamental factor in cargo airplane operating economy: When minimum operational requirements are met and additional performance capability becomes available, overall cargo moving economy is increased most rapidly when additional performance available is directed towards maximizing productivity for the required range. Maximum productivity as a function of increased thrust available may be increased much more rapidly when such increased thrust is directed towards increasing payload/range capabilities at minimum acceptable speeds.

System 476L Impact on Mats Costs

This is better illustrated by the results of a study made to determine the impact of the introduction of the proposed new aircraft on the cost of operation of the Military Air Transport Service.

A comparison was made of the direct operating cost of the current common user fleet and the troop transport fleet with the 132 System 476L airplanes at five hours per day utilization. The results are shown in Figure 3-48. The cost for the current fleet was estimated from Air Force planning data; the cost for the new aircraft was based on the 1960 ATA formula as modified for MATS operations. The cost for 132 GL 207-45 aircraft is seen to be about one-third of the cost for the current airlift resources of MATS. The cost for the advanced GL 268 is seen to be about 20% greater than that of the GL 207-45, due primarily to its greater fuel consumption.

It is obvious from the data of Figure 3-48 that the implementation of new efficient aircraft would introduce cost savings for the maintenance of the airlift resources of MATS. The amount of the cost savings was determined for various engine programs for the GL 207-45 and for the GL 268. The results are shown in Figure 3-49 which shows the cumulative cost savings, assuming that the C-118, C-121, and the C-124 airplanes were phased out linearly with System 476L deliveries in order that the last of the current fleet was phased our simultaneously with the delivery of the 132nd 476L airplane. All aircraft are operated at a continuous utilization of five hours per day. It is quite apparent that the cost saving advantage is associated with the early delivery of the system 476L airplanes. Aircraft which have their delivery date tied to an advanced engine of later availability encounter a cost handicap which is directly a function of delivery time. On this comparison, the conversion of the GL 207-45 from the JT3D-4 to the -8A configuration would be easily made by the delivery of the 37th airplane.

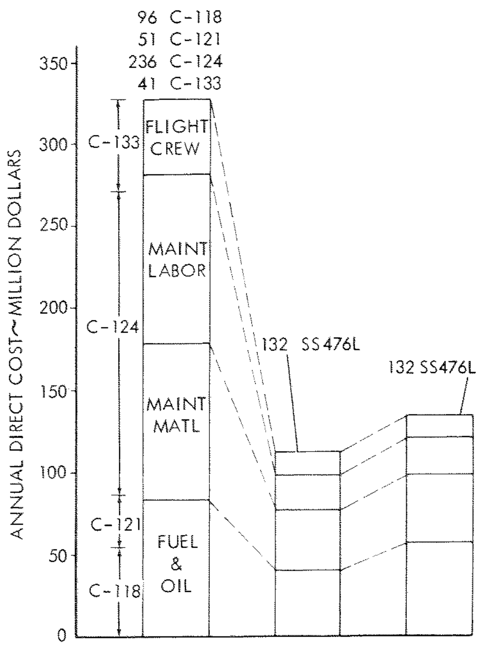


Figure 3-48—ANNUAL OPERATING COST MATS AIR LIFT RESOURCES, 5 HOUR/DAY UTILIZATION.

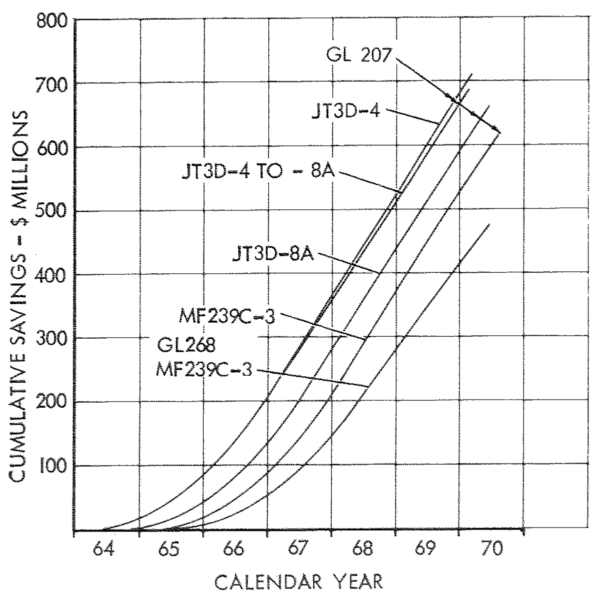


Figure 3-49—AIR CARGO DEMAND, U.S. AND WORLD OVER-OCEAN, 5 HOUR/DAY UTILIZATION.

This program would provide one of the most advantageous cost relationships as well as provide the early availability of a higher productivity airplane. It is apparent that the most critical element in the saving of operating costs is the early introduction of the new aircraft.

The former comparison did not consider the productivity of the System 476L fleet. The data of Figure 3-50 shows the build-up of the potential productivity at 100% load factor for the System 476L airplanes operating at a range of 4,000 N. M. The GL 207-45 airplane would maintain a productivity advantage over the GL 268, without conversion to the -8A engine, until beyond 1970. Conversion of the GL 207-45 to the -8A engine provides productivity somewhat better than that of the GL 268 with the MF 239C-3, and a significant advantage is shown in the productivity of the GL 207 when compared to that of the GL 268, due to the 15-month spread in delivery date. The case where initial deliveries of the GL 207-45 were made with JT3D-8A engines was examined and showed that a 6-month delay in deliveries which would be encountered could never overbalance, in either cost savings or in accumulated productivity, the program where initial deliveries were made with -4 engines.

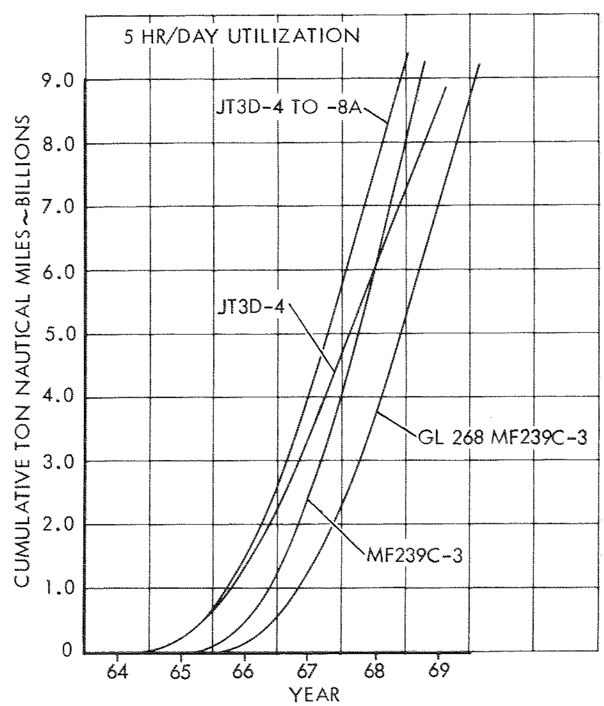


Figure 3-50—ACCUMULATED PRODUCTIVITY, 5 HOUR/DAY UTILIZATION.

Recognizing that the relative differences in the productivity of the current fleet and the System 476L fleet could influence the cost comparison analysis, a further examination was made on the basis that the current fleet would be phased out while maintaining the composite productivity of the fleet at a constant level until all of the C-118, C-121, and C-124 aircraft were gone. The build-up of the annual saving rate is illustrated in Figure 3-51. The peak occurs at the point where the current fleet was phased out. Savings are reduced beyond this point

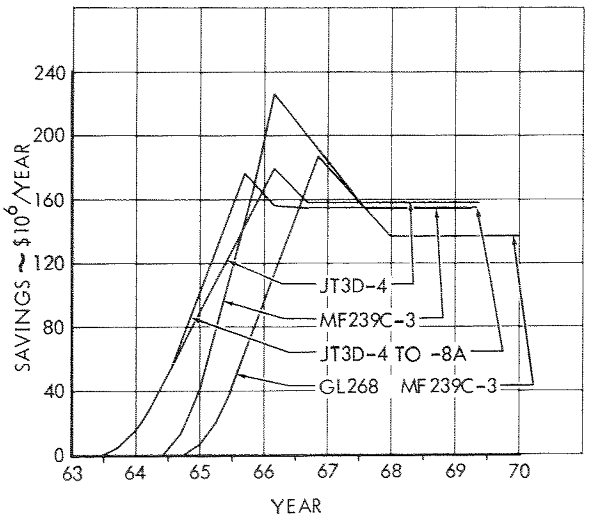


Figure 3-51—ANNUAL SAVINGS FOR AIRCRAFT, RELATIVE TO 1961 FLEET.

since the hypothetical savings were absorbed by the operational cost of the rest of the 132 aircraft. It can be seen that the cost savings build up early to a high rate with the GL 207-45 aircraft with the -4 engines and to a higher rate when the -8A is incorporated without delay of the original production schedule. It was assumed that the original

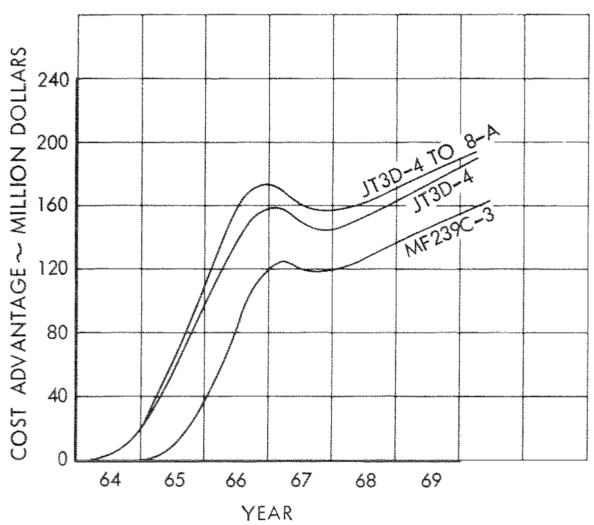


Figure 3-52—COST ADVANTAGE, RELATIVE TO ADVANCED SYSTEM.

36 airplanes were retrofitted to -8A engines after delivery of the 132nd airplane.

The accumulation of the cost savings, relative to waiting for the development of a more sophisticated airplane matched to the advanced engine is shown in Figure 3-52. The relative advantage of the GL 207-45 configuration is shown in this figure where, with any propulsion system, it will provide more airlift at lower cost than will the higher speed GL 268. With the GL 207-45 configuration the advantage of the early availability of adequate power plants, with the additional advantage of conversion to the -8A at a later date, is graphically illustrated. The GL 207-45 is fully capable of exploiting the capabilities of the MF239C-3 engine. The early availability of the JT3D-4 engine will provide a distinct advantage, however, which can be measured quantatively in millions of dollars.

		1	1	2	3
DESIGN RANGE	N. M.	4,000	5,500	3,000	1,000
DESIGN PAYLOAD	Lb.	50,000	20,000	60,000	70,000
RAMP WEIGHT	Lb.	287,000	281,100	281,420	241,750
AT TAKE-OFF WEIGHT	Lb.	287,000	281,100	279,420	239,750
CAR Take-off Field Length at S.L.	Ft.	4,980	4,780	4,720	3,880
Take-off Ground Roll at S.L. (Mil.)	Ft.	2,930	2,800	2,750	1,980
Take-off Distance to Clear 50′ at S.L. (Mil.)	Ft.	4,260	4,080	4,030	3,000
Service Ceiling, Normal Power	Ft.	38,100	38,500	38,600	41,700
MISSION PERFORMANCE					
Begin Cruise Altitude	Ft.	35,400	35,800	35,700	38,500
Cruise Speed	Knots	440	440	444	445
End Cruise Altitude	Ft.	42,500	45,950	40,700	40,000
AT LANDING WEIGHT	Lb.	188,920	159,585	205,800	213,300
CAR Landing Field Length	Ft.	4,930	4,330	5,260	5,420
Landing Ground Roll at S.L. (Mil.)*	Ft.	1,080	900	1,170	1,200
Landing Distance from 50′ at S.L. (Mil.)*	Ft.	2,400	2,100	2,580	2,650

1 MIL-C-5011A reserves
2 Step-climb cruise and SAR 427B reserves
3 Step-climb cruise and CAR 40.396 reserves—alternate—200 N. M.
* Brakes, four engines in reverse thrust

Figure 3-53—PERFORMANCE SUMMARY, GL207-45-1, PRATT AND WHITNEY JT3D-8A ENGINE.

Power Plants

The GL 207-45A meets or betters all performance requirements of System 476L when powered with the JBD-4 Engines. Performance is improved, of course, with the higher thrust engines which may become available. Figures 3-53, 3-54, and 3-55 present a performance summary for the basic system 476L missions when the airplane is powered by the JT3D-8A, the JT3D-12A, and the MF239C-3 engines respectively. More comprehensive data are included in Section 3 of Volume 2. A comparison of the payload/range capabilities of the airplane powered with these several engines is shown in Figure 3-56.

Airplane take-off, altitude, and speed performance and payload/range, as a function of field lengths shorter than 6,000 feet, is of course, improved with increased thrust. However, as shown by Figure 3-56, where 6,000 foot fields are available, and when the airplane is flown at its normal maximum take-off gross weight of 315,000 lbs., payload/range capa-

		1	1	2	3
DESIGN RANGE	N. M.	4,000	5,500	3,000	1,000
DESIGN PAYLOAD	Lb.	50,000	20,000	60,000	70,000
RAMP WEIGHT	Lb.	288,400	283,200	282,670	243,478
AT TAKE-OFF WEIGHT	Lb.	288,400	283,200	280,580	241,550
CAR Take-off Field Length at S.L.	Ft.	4,730	4,560	4,490	3,900
Take-off Ground Roll at S.L. (Mil.)	Ft.	2,770	2,640	2,590	1,880
Take-off Distance to Clear 50′ at S.L. (Mil.)	Ft.	4,060	3,910	3,830	2,900
Service Ceiling, Normal Power	Ft.	40,000	40,500	40,700	44,100
MISSION PERFORMANCE					
Begin Cruise Altitude	Ft.	36,300	36,500	36,500	39,600
Cruise Speed	Knots	440	440	445	445
End Cruise Altitude	Ft.	44,050	47,600	42,000	41,200
AT LANDING WEIGHT	Lb.	190,610	161,330	207,200	215,420
CAR Landing Field Length	Ft.	4,995	4,410	5,310	5,490
Landing Ground Roll at S.L. (Mil.)*	Ft.	1,040	890	1,130	1,200
Landing Distance from 50′ at S.L. (Mil.)*	Ft.	2,400	2,100	2,580	2,670

1 MIL-C-5011A reserves
2 Step-climb cruise and SAR 427-B reserves
3 Step-climb cruise and CAR 40.396 reserves—alternate—200 N. M.
* Brakes, four engines in reverse thrust

Figure 3-54—PERFORMANCE SUMMARY, GL207-45-2, PRATT AND WHITNEY JT3D-12A ENGINE.

		1	1	2	3
DESIGN RANGE	N. M.	4,000	5,500	3,000	1,000
DESIGN PAYLOAD	Lb.	50,000	20,000	60,000	70,000
RAMP WEIGHT	Lb.	282,550	276,050	278,170	240,910
AT TAKE-OFF WEIGHT	Lb.	282,550	276,050	275,920	238,660
CAR Take-off Field Length at S.L.	Ft.	4,330	4,190	4,185	3,870
Take-off Ground Roll at S.L. (Mil.)	Ft.	2,500	2,380	2,380	1,730
Take-off Distance to Clear 50′ at S.L. (Mil.)	Ft.	3,700	3,540	3,535	2,690
Service Ceiling, Normal Power	Ft.	40,400	40,900	40,900	44,000
MISSION PERFORMANCE					
Begin Cruise Altitude	Ft.	37,500	38,100	37,800	41,000
Cruise Speed	Knots	440	440	444	445
End Cruise Altitude	Ft.	45,500	48,800	43,600	42,700
AT LANDING WEIGHT	Lb.	187,455	158,200	203,500	212,380
CAR Landing Field Length	Ft.	5,110	4,560	5,410	5,590
Landing Ground Roll at S.L. (Mil.)*	Ft.	1,000	950	1,090	1,120
Landing Distance from 50′ at S.L. (Mil.)*	Ft.	2,420	2,160	2,580	2,660

1 MIL-C-5011A reserves
2 Step-climb cruise and SAR 427B reserves
3 Step-climb cruise and CAR 40.396 reserves—alternate—200 N. Mi.
* Brakes, four engines in reverse thrust

Figure 3-55—PERFORMANCE SUMMARY, GL207-45-3, GENERAL ELECTRIC MF239C-3 ENGINE.

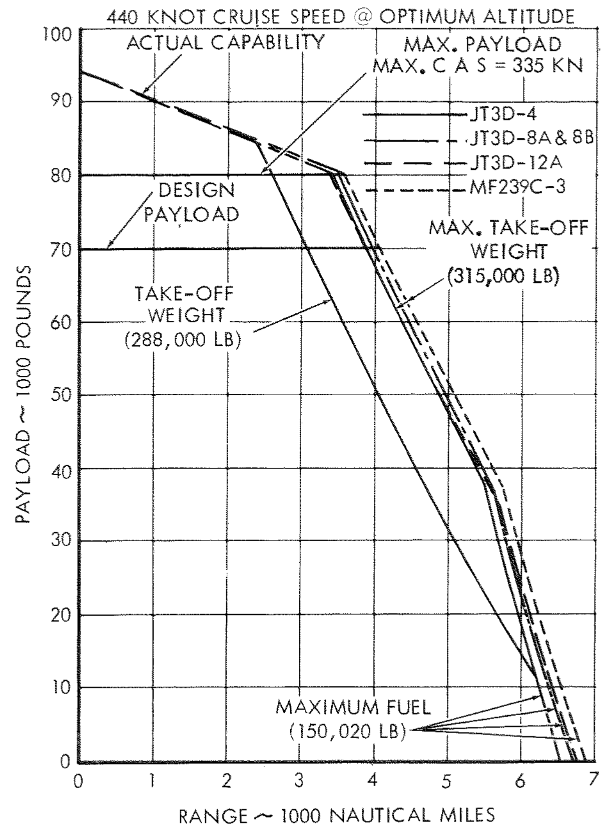


Figure 3-56—PAYLOAD RANGE COMPARISON, JT3D-4 JT3D-8A, JT3D-12A AND MF239C-3 ENGINES, INSTALLED FUEL FLOWS 5 PER CENT CONSERVATIVE TAKE-OFF FUEL ALLOWANCES AND FUEL RESERVES — MIL-C-5011A.

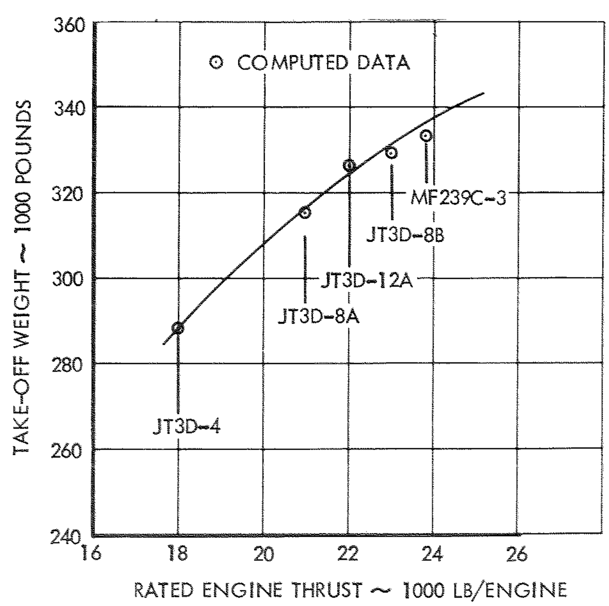


Figure 3-57—MAXIMUM TAKE-OFF WEIGHT, 6000 FEET CAR TAKE-OFF FIELD LENGTHS SEA LEVEL, STANDARD DAY.

bility is not substantially improved with the advanced power plants.

Figures 3-57 and 3-58 indicate the permissible growth in airplane take-off gross weight and payload for a 5,000 nautical mile range together with the resulting growth in equipped weight empty as a function of increased thrust available from the more advanced power plants. It may be seen that, with the most advanced power plants, having static thrust ratings of approximately 24,000 lbs., the takeoff gross weight of the airplane could be as high as 333,000 lbs., and the maximum payload for the 4,000 nautical mile range could be as high as 82,500 lbs. at best cruising speed. Limited by the volume of the cargo compartment required for System 476L, and using System 463L pallets, payloads of this weight are obtained only at rather high densities. It would, therefore, for heavier payloads be desirable to increase the fuselage length to obtain more cargo volume. The effect of 7½ foot and 15 foot increases in fuselage length are shown by the dashed lines. These lengths are chosen since they permit one or two more pallets respectively. On this basis, maximum density for any palletized payload discussed is no more than 13.5 lbs. per cubic foot. Figure 3-59 indicates, for an alternate case, the increase in average cruise speed available as a function of rated power plant thrust for the required 50,000 lb./4,000 nautical mile mission.

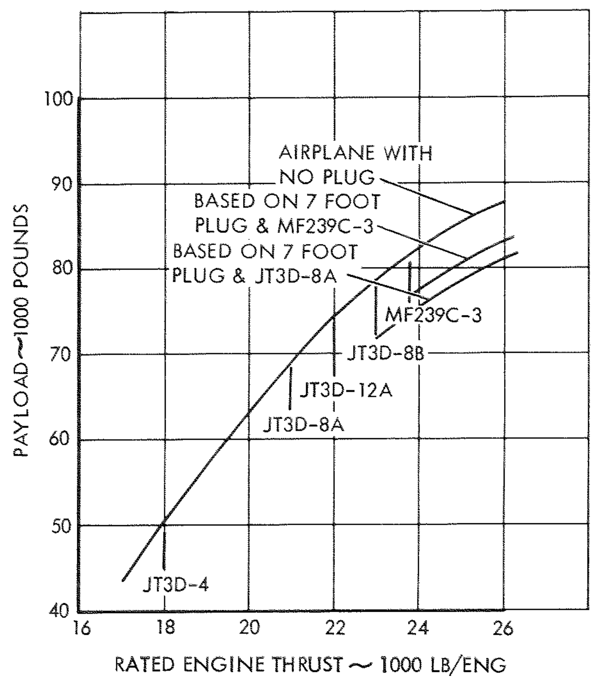


Figure 3-58—MAXIMUM PAYLOAD, 4000 NM RANGE, 6000 FEET CAR TAKE-OFF FIELD LENGTH.

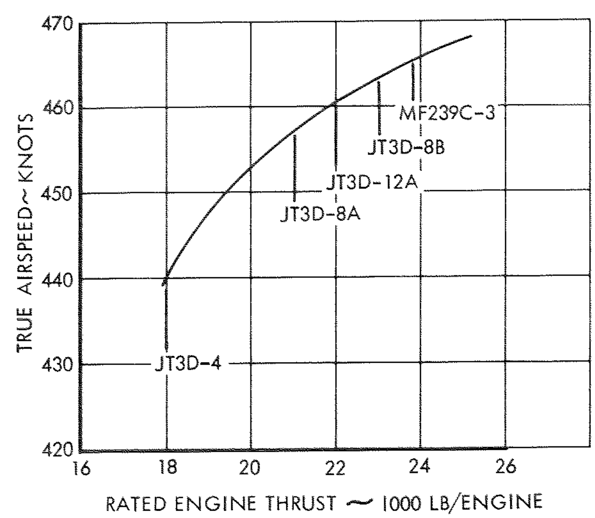
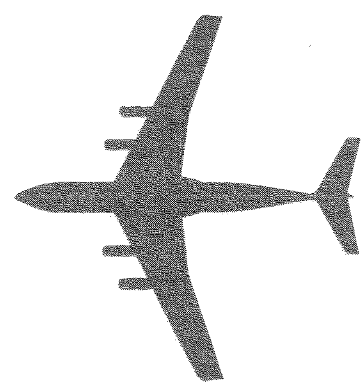


Figure 3-59—MAXIMUM SPEED, 4000 NM RANGE, 50,000 POUND PAYLOAD, 6000 FEET CAR TAKE-OFF FIELD LENGTH.

SUPER HERCULES · GL207-45

section 4



AIRCRAFT DESIGN

AIRFRAME (5.1.5.3)

Structural Data (5.1.5.3.1)

The basic flight and ground load design criteria are evaluated against both the military requirements of MIL-A-8860 and the civil requirements of CAR-4b as specified in Section 1.2.1 and 3.1.2 of the work statement. The criteria selected meet or better CAR-4b requirements and assure FAA type Certification of the design. There are no unique features that require special criteria. Structural design weights and design speeds have been conservatively selected to allow for the (P & W) JT3D-8A as well as the JT3D-4 powerplants. Regid force model test results assure that loads on the structure are proper. Airload distributions conservatively account for effects of aeroelasticity. Further, flexible model and pressure model tests are planned to provide the maximum assurance of structural integrity and minimum development flight testing.

Design Weights

Structural design weights are in accordance with military requirements of MIL-A-8860. The weights consider a range from a minimum flying gross weight of 128,082 lbs. to the maximum design gross weight of 315,000 lbs. Design payloads up to a maximum of 70.000 lbs. of cargo on pallets are considered with wing fuel from the MIL-A-8860 structural reserve of 5% of capacity fuel (7,500 lbs.) to the maximum consistent with maximum design gross weight. Strength is available for an alternate payload of 80,000 lbs. of cargo, and above, on pallets depending upon fuel weight, and speed and maneuver load factor limitations consistent with airframe strength capability originating from the basic design. The maximum landing weight of 257,-500 lbs. is conservatively derived by subtracting 50% of the maximum take-off fuel from the maximum design gross weight and thus exceeds the military requirement of MIL-A-8860.

Design Airspeeds

Structural design speeds, shown in Figure 4-1, provide for cruise at maximum continuous power at all altitudes above 25,000 ft. and overweather cruising capability, and maintain good descent characteristics as well as an ample spread above climb-out speeds. The level flight maximum speed of a constant 0.825 Mach exceeds the speeds attainable with the P&W JT3D-4 engines and provides for power growth even beyond the P&W JT3D-8 engine. The 350-knot calibrated air speed cut-off below 25,000 feet was selected to maintain a minimum airframe weight consistent with the overall mission requirements of Section 2.4.2 of the Work Statement. Since MIL-A-8860, Paragraph 6.2.3.7, implies V_H must be consistent at all altitudes above sea level with the power available, the 350-knot CAS cut-off is a deviation. This deviation is recommended in accordance with Section 5.1 of the Work Statement in order to best meet the system and operational requirements specified. A structural weight penalty of about 10,000 lbs. would result if MIL-A-8860 were literally followed. This weight penalty would result from meeting a 50 fps gust at the speed attainable, 500 knots at sea level, as well as increased rigidity requirements for flutter considerations and would seriously compromise the airplane.

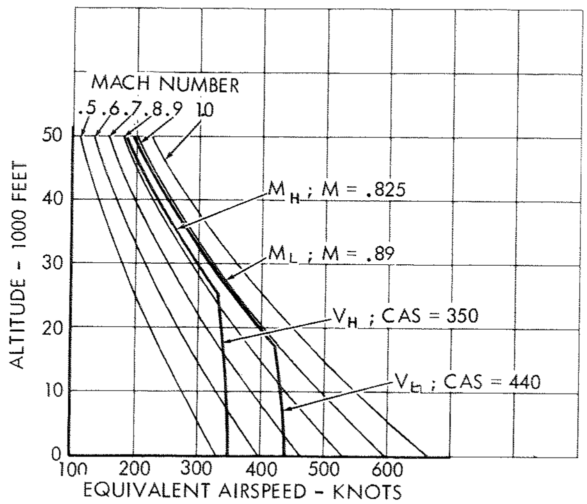


Figure 4-1—DESIGN SPEED—ALTITUDE.

The limit speed (M_L/V_L) provides an ample spread above $M_H V_H$ for recovery from inadventent upsets and to account for speed increases due to dive angles. The limits of 0.89 Mach and 440-knot calibrated airspeed eliminate the need for special speed control devices. Other design speeds such as aerial delivery, design speeds for flaps, and maximum gust intensity are discussed in Volume 2, Section 3.

Design Flight Load Factors

The gust and maneuver V-n diagrams for the critical altitude of 25,000 ft. are shown in Figure 4-3 for the basic configuration. A 2.0 maneuver load factor is provided for the take-off and landing configuration. The V-n diagram for sea level is shown in Figure 4-4.

Design Load Criteria

Figure 4-2 summarizes both the flight and ground structural design criteria considered and the resulting load considerations.

Condition	Configuration	Critical Gross Weight; Pounds	Critical Airspeed (Knots, CAS)	(Knots, EAS)	Mach Number	Critical Altitude; Feet	Vertical Load Factor	Critical Component Designed By Condition
Symmetrical Pull-out	Clean	210,000	440	428	.825	13,000	2.5	Horizontal tail and fuselage aftbody
		315,000	440	428	.825	13,000	2.5	Middle and outer wing
Symmetrical Push-down	Clean	315,000	350	350	.53	S.L.	-1.0	No anticipated critical component
Symmetrical Pull-out	Landing	315,000		185		S.L.	2.0	Flaps, 50° deflection, inboard wing torsion
Symmetrical Push-down	Landing	315,000		185		S.L.	0	No anticipated critical component
Symmetrical Pull-out	Take-off	315,000		200		S.L.	2.0	Flaps, 35° deflection, inboard wing torsion
Symmetrical Push-down	Take-off	315,000		200		S.L.	0	No anticipated critical component
Rolling Pull-down	Clean	257,500	440	440	.665	S.L.	2.0	Wing outer panel
Rolling Push-down	Clean	257,500	440	440	.665	S.L.	0	No anticipated critical component
Rough Air, 66 fps	Clean	206,100		240	.540	20,000	2.8	Wing chord bending
Mod. Turbulence, 50 fps	Clean	206,100	350	338	.754	20,000	3.0	Wing inner panel, fuselage, empennage
Mod. Turbulence, 50 fps	Clean	128,080	350	338	.754	20,000	4.0	Maximum load factor for fixed equipment
Clean Air, 25 fps	Clean	206,100	440	434	.754	7,500	2.1	No anticipated critical component
Mod. Turbulence, 50 fps	Landing	257,500		185		S.L.	1.8	No anticipated critical component
Mod. Turbulence, 50 fps	Take-off	315,000		200		S.L.	1.8	No anticipated critical component
Landing (10 fps)	Landing	257,500		120		S.L.	2.5 at c.g.	Landing gear, attachments and wing down bending
Landing (6 fps)	Landing	315,000		159		S.L.	2.0 at c.g.	No anticipated critical component
2.0g and Dynamic Taxi	Any	315,000					2.0 or 1.5 Dynamic	Landing gear, attachments and wing down bending
Braking, Turning and Towing	Any	315,000	(Horizontal Towing Factor 0.15W)				1.0	NLG and fuselage forebody up-bending
Jacking for Landing Gear and Fuselage	Any	315,000					1.35 2.00	Landing gear Fuselage
Jacking for Wing	Any	257,500					2.00	Wing up bending (from jack point inboard)

Cabin pressure; 9.9 psi with full gust and maneuver loads; 13.2 psi with 1.0g flight loads; + 1.5 to – .4 psi with landing loads.

	Component	Vertical Down	Vertical Up	Forward	Side
Ultimate Load Factor for Fixed Equipment That Might Endanger Crew	Crew seats	8.0	2.0	16.0	4.0
	Permanently fixed fuselage equipment	8.0	2.0	16.0	4.0
	Troop seats	8.0	2.0	16.0	4.0
	Cargo	4.5	2.0	8.0	1.5
	Pallet Epuipment	4.5	2.0	8.0	1.5
	Litter	4.5	2.0	8.0	1.5
	Aerial delivery equipment	4.5	2.0	8.0	1.5

Floor; general, 300 psf or 2000 lbs./lin. ft. or 10,000 lbs. axle. Between F.S. 678 and F.S. 887, 400 psf or 3000 lbs./lin. ft. or 20,000 lbs. axle.

Figure 4-2—STRUCTURAL DESIGN CRITERIA SUMMARY.

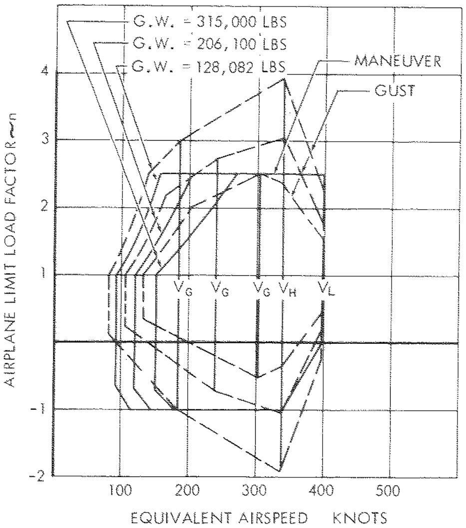


Figure 4-3—V-N DIAGRAMS 25,000 FEET ALTITUDE—CLIMB CONFIGURATION.

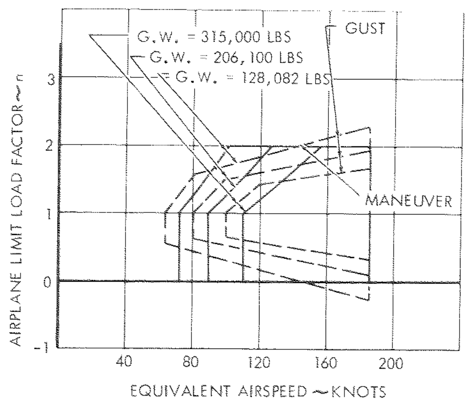


Figure 4-4—V-N DIAGRAMS, SEA-LEVEL LANDING CONFIGURATION.

Airload Distribution

Aerodynamic load distributions are based on a 126-point, lattice vortex arrangement derived from equations originally proposed by V. M. Faulkner in Reference 4. Aeroelastic effects from quasi-static considerations are accounted for in the determination of gust and maneuver flight loadings. The methods of aeroelastic analysis are based on two approaches. These are the well known relaxation method of Reference 5 and the superposition technique of Reference 6. The latter method is advantageous in load analysis since the aerodynamic treatment is basically independent of the structural stiffness, thus facilitating refinement of analysis as the design progresses. Both methods are programmed and available for use on IBM 7090 digital computers.

Flight Loads

The 25-degree swept high wing provides an alleviation of gust loading through its sweep angle and relieving aeroelastic effects. The speeds selected result in critical design wing loads due to gust conditions at the minimum reserve fuel gross weight of 206,100 lbs. with 70,000 lbs. of cargo on pallets at the critical Mach number and gust intensity altitude of 20,000 ft. Designing for loadings due to gusts provides strength for a 2.5g maneuver load factor at the maximum design gross weight of 315,000 lbs. with 80,000 lbs. of payload, and above, on pallets, depending upon fuel weights as is discussed in detail under the loading capability later in this section. This added capability permits certification of the airplane for cargo weights above 70,000 lbs.

The conventional simple aileron system provides roll rates that meet military and civil requirements. The straightforward Fowler flap arrangement accounts for design loads of the inboard wing structure and rear beam. The podded engine nacelle arrangement presents no unusual load problem and will meet all flight and ground load criteria.

The T-tail configuration, which places the horizontal tail above the primary fuselage interference effects, works efficiently and requires minimum structural weight. The critical condition is the down-bending load arising from an equivalent gust of 50 fps at level flight maximum speed. This load, plus the stiffness requirements for flutter prevention, provides strength for abrupt pitching maneuvers as well as for all maneuvers to meet military and civil requirements.

The principal fuselage aftbody loading arises in the doors-open configuration during aerial delivery and designs the fuselage box structure above the doors. The load criteria for aerial delivery are discussed in detail in Section 10 of this volume.

Landing Loads

The GL 207-45 is designed to meet or better all landing and ground handling requirements in MIL-A-8862 and CAR-4b. The long, shock-strut stroke keeps a 1.5g landing load factor from being exceeded. The rate-of-sink requirements as well as the landing weight capability are shown in Figure 4-5. The critical condition is 10 fps at landing design gross weight of 257,500 lbs. Designing for this condition provides a landing capability of 390,000 lbs. at 6 fps sinking speed.

Ground Handling Loads

The landing gear and back-up structure are designed to meet the 2.0g and dynamic taxi conditions which also provide the most severe wing down-bending loads with capacity fuel. Meeting this consideration provides strength for all possible fuel-cargo loading combinations. Experience with the C-130 indicates that the preceding criteria, together with the landing gear UCI rating of approximately 50, reference Section 3.1.2 of the Work Statement, provides for operation on flexible runways and fields.

Jack points on the landing gear and fuselage are designed for loads up to the maximum take-off weight of 315,000 lbs. Wing jack points are designed to carry the airplane landing design gross weight of 257,500 lbs. A pair of jack points on the fuselage, just forward of the ramp, are designed to carry the loads involved when the maximum cargo single axle weight of 20,000 lbs. rolls on to the ramp with a shock factor of 2.0.

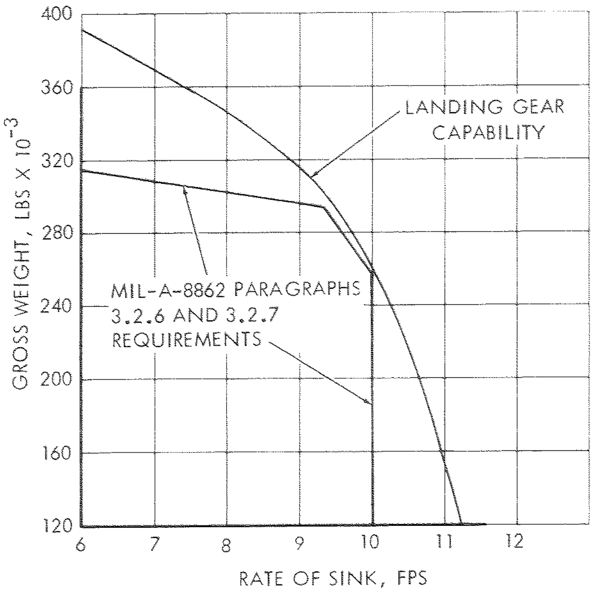


Figure 4-5—RATE OF SINK VS. GROSS WEIGHT.

Floor Design Criteria

Floor design criteria are summarized in Figure 4-2 and comply with Section 3.1.9. of the Work Statement. These criteria are also discussed in Section 9.

Pressurization

The crew and cargo compartment are pressurized to 9.24 psi pressure differential so that 8,000 ft. cabin altitude may be maintained at 50,000 ft., thus meeting the requirement stated in Section 3.5.1 of the Work Statement.

Crash Accelerations

The airplane is designed to meet the requirements, both for crash landings and for ditching, of MIL-A-8865 which exceed the civil requirements. See Figure 4-2 for specific load factor and other stipulations.

Loading Capability

Since the basic design provides a capability for increased payload with a trade-off in speed limits at lower altitudes and/or maneuver load factor limits, the adaptability of the design to other than the basic mission requirements is substantial. Figure 4-6 shows the payload capability for maneuver and the necessary V_H speed limitations associated with 50 fps gust encounters. The speed values shown represent the most critical speed-Mach number combination. This data indicates that FAA certification of 80,000 lbs. of payload and above, as indicated by the heavy dashed line of Figure 4-6, is possible with a 2.5g maneuver load factor and a design cruise speed of 0.825 Mach number with limited airspeed below Mach critical altitude. It should be noted that with payloads greater than 70,000 lbs., the landing weight of 257,000 lbs. is satisfactory for FAA certification but will not meet MIL-A-8860 landing fuel requirements.

Payloads and fuel combinations to the right of the solid lines and above the heavy dashed line of Figure 4-6 are available for emergency use.

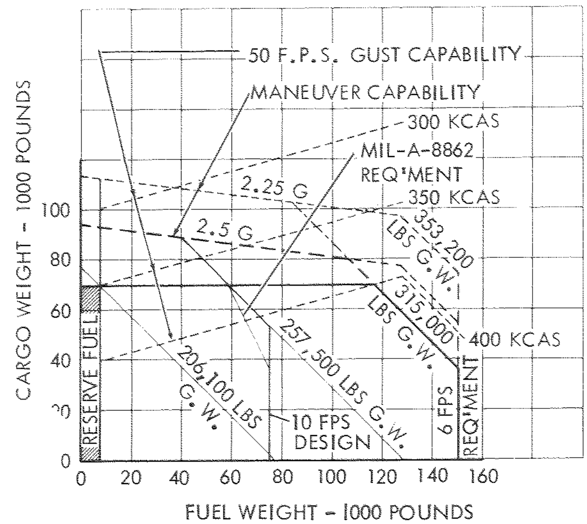


Figure 4-6—PAYLOAD CAPABILITY.

The 2.25g maneuver load factor of Work Statement Paragraph 3.1.2 is reached with capacity fuel and a take-off gross weight 353,200 lbs. This weight is within the 6 fps landing capability shown in Figure 4-5. The wing is good for a 2.0g taxi condition at all fuel weights and the gear and attachment structure are good for a 1.7g limit or 2.5g ultimate taxi factor. It should be noted that the flight speed limits for a 50 fps gust and the 2.25g line result in gross weight limits when the relieving wing fuel outboard of the fuselage reaches its capacity.

Speed Capability

The airplane is designed to withstand severe gusts at the most critical speed-altitude combination associated with maximum level flight speed. At other altitudes, loads are reduced to reduce aerodynamic coefficients, thus, for the same payload, a speed increase becomes possible. For example, a sea level mission capability exists for 40,000 lbs. of cargo for V_H's as high as 470 knots CAS. However, approximately 800 lbs. weight penalty in the wing would be required to increase dive speed to 500 knots, sufficient to exploit this capability. This is discussed further under flutter data. However, the present V_D of 440 knots does provide for reasonable inadevertent upset protection for the 70,000 lb. cargo condition since theoretically no spread would be required at sea level and at an 0.825 Mach the speed spread is ample for a 7½ degrees dive for 20 seconds.

Model Substantiation of Load Data

Load verification will begin immediately upon start of the design. Wind tunnel force model data is complete and is incorporated in the proposal data.

A high-speed wind tunnel rigid pressure model will be tested and the data will be design basis for air-load distribution on each airplane component. Further, since a dynamically and structurally similar model will be used for flutter investigations, it is proposed that this mode be further utilized to back up and verify the analytical aeroelastic loads on all components.

FAA Structural Integrity Flight Demonstration

As discussed in Section 10, a proof loads ground test, a limited air and ground load survey, and an 80% limit load structural demonstration is proposed as a minimum program to substantiate the structural design.

Flutter Data (5.1.5.3.2)

The airplane is free from flutter, buzz, divergence and other related aeroelastic instabilities at all speeds up to 1.2 v_D for all design ranges of altitude, maneuvers, and loading configurations. The applicable requirements of MIL-A-8870 (ASG) and CAR 4b.190, 4b.308, 4b.320, 4b.322, and 4b.401 will be met. Comprehensive detailed theoretical flutter analyses will be made of the wing and empennage, using an IBM 7090 computer and a direct analogy electric analog computer (DAEAC). These analyses, which will establish the effects of various parameters on the flutter characteristics, will be used to optimize the design and establish an efficient flutter model program.

Wing

The wing is of conventional design from a flutter standpoint. The elastic axis is located at approximately 37.5% wing chord and is swept back approximately 23 degrees. The only large concentrated weights on the wing are the engines. Preliminary flutter analyses have been conducted on the wing to establish the necessary wing stiffnesses to preclude flutter. The results of these analyses show the wing to be free from flutter to speeds beyond 1.20 V_D as presented in Figure 4-7 as a flutter boundary and in Figure 4-8 as flutter loops.

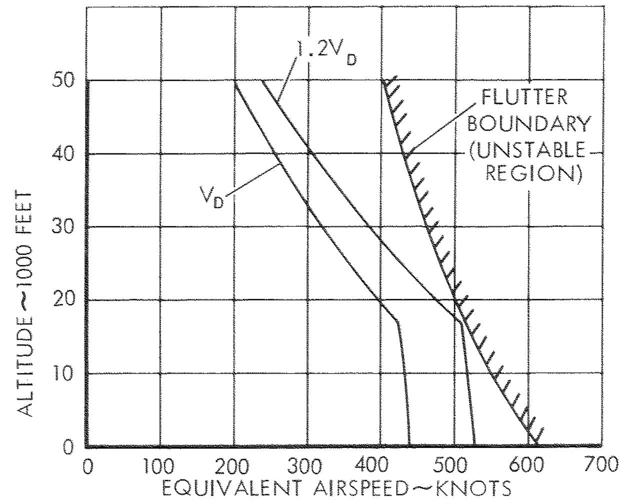


Figure 4-7—WING FLUTTER BOUNDARY.

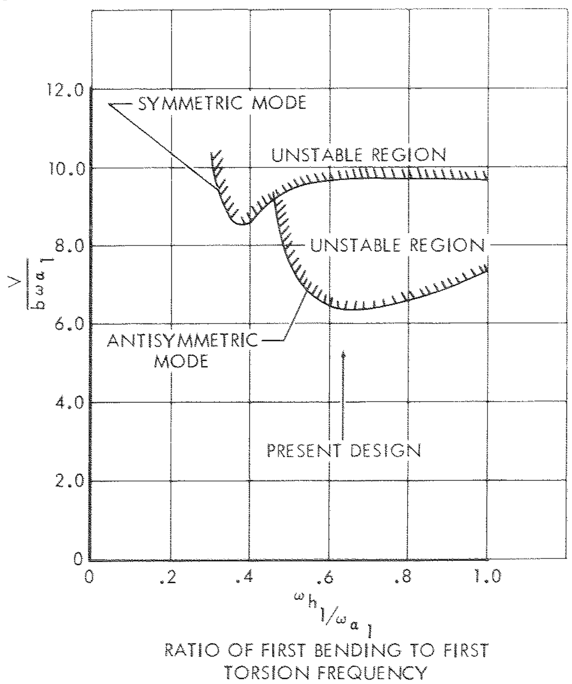


Figure 4-8—WING FLUTTER STABILITY LOOPS, 17,000 FEET ALTITUDE.

Empennage

The empennage employs a T-tail with a horizontal stabilizer located at the top of the fin. The stabilizer rotates in pitch for aircraft trim control and is restrained by an irreversible dual-path actuator attached to the fin front beam. A T-tail configuration is generally considered more flutter critical than conventional configurations. However, a proper structural design, based on flutter considerations, will readily result in a T-tail that is flutter free up to speeds in excess of 1.20 V_D.

Flutter problem areas associated with empennages of this type are an anti-symmetric mode involving fin bending-torsion and fuselage lateral bending, and a symmetric mode involving stabilizer pitching, stabilizer bending, and fuselage vertical bending. The anti-symmetric mode is a function primarily of the fin bending and torsion frequencies. Based on the results of analyses and flutter model tests of similar configurations, fin bending and torsion frequencies of 3.0 cps and 3.4 cps, respectively, are required to prevent flutter at speeds below 1.20V_D. Optimization of the fin structural and flutter design will be made on the basis of detailed calculations and flutter model test results. The symmetric mode is primarily a function of the stabilizer pitch frequency and a frequency of 15 cps will be required to prevent flutter at speeds up to 1.2 V_D.

Control Surfaces

Flutter involving coupling between main surfaces and their associated control surfaces is eliminated since the ailerons, elevators, and rudder are statically and dynamically balanced by weights distributed along their leading edges. All primary control surfaces are actuated by hydraulic boost systems and are not intended to be irreversible. Absence of control surface buzz will be determined theoretically and confirmed by transonic flutter model tests. Provisions will be included in the design for hydraulic dampers, but these will be installed only if necessary.

Flutter Model Program

An extensive flutter model program will be conducted to substantiate the flutter safety of the final aircraft design throughout the speed-altitude range, including malfunction and fail-safe effects. The program will include the following phases: The initial phase will consist of subsonic flutter model tests in the Georgia Tech 9-foot, low-speed wind tunnel during the middle part of 1961. A 1/8th scale model of the T-tail empennage and a 1/24th scale model of the complete airplane will be tested. Additional models of the empennage will be tested in a transonic wind tunnel the latter part of 1961. The final design of the airplane will be tested in a 16-foot transonic tunnel (AEDC or NASA) using a 1/13th scale flutter model of the complete airplane. These tests will establish the flutter safety of the final airplane design and will be completed early in 1962. After completion of the flutter test program the 1/13th scale flutter model can be used to measure dynamic response characteristics, stability and control derivatives, and structural loads due to aeroelastic effects and buffeting.

Ground Vibration Test Program

Comprehensive ground vibration tests will be conducted on the first production aircraft to insure that the mass and stiffness data utilized in the theoretical analyses and flutter model designs satisfactorily represent the actual parameters. These tests will be completed by 1 May 1963.

Flight Flutter Test Program

As the final substantiation of the flutter safety of the aircraft, flight flutter tests will be conducted. The test conditions will be established based on the results obtained from the flutter model tests and theoretical analyses. However, all critical combinations of dynamic pressure, Mach number, and true airspeed will be investigated. Excitation of the airplane structure will be accomplished by controlled exciters. The outputs from vibration pickups will be recorded in the aircraft and also telemetered to a ground station, where the data will be analyzed and evaluated as the test progresses. The flight test program will be conducted in August 1953.

Increased Speed Capability

The airplane has a low altitude speed capability that exceeds the design limit speed of 440 KCAS. In order to exploit this capability it would be necessary to increase V_D to 500 KEAS at sea level up to M=0.89 at approximately 8500 feet. Since the wing design is based on flutter stiffness requirements, the wing structure would require about a 25 percent increase in torsional rigidity, inboard of the outboard engines, totaling 800 pounds. The present design configuration of the T-tail empennage has more than enough flutter capability for this increased speed without increasing its stiffnesses.

Wind Tunnel Tests (5.1.5.3.3)

An extensive wind tunnel test program, utilizing aerodynamic models, has been accomplished to develop the configuration of the Lockheed GL 207-45 and to provide a firm basis for the performance, flying qualities, and aerodynamic loads data quoted in this proposal. The extent of this program as well as that defining further developmental aerodynamic and flutter model testing is summarized in Figure 4-9. This summary delineates the various model programs and tunnel occupancy time spans.

Completed Aerodynamic Tests

The aerodynamic characteristics of the GL 207-45 airplane which are presented in Section 5.1.5.2 of this proposal are based on two series of recently completed wind tunnel tests. The final model configuration used in these studies differed in only minor respects from that of the proposed airplane.

One series of these tests was conducted in November, 1960, in the Lockheed California Division's 8 x 12 ft., low-speed wind tunnel using a 0.06 scale model. This test provided force data concerning maximum lift, longitudinal and lateral-directional stability, and wing and empennage control-surface effectiveness.

The other series of testing was conducted in two phases in September and December, 1960, in the Cornell Aeronautical Laboratory's 8-ft. transonic tunnel at Mach numbers from 0.4 to 0.9. This 0.0275 scale model investigation included studies of wing, nacelle-pylon location, horizontal stabilizer location,

Proposed Aerodynamic Tests

A comprehensive program of aerodynamic wind tunnel tests has been established to provide detailed information early in the structural design phase of the airplane. A detailed discussion of this entire program is presented in Section 3 of Volume 2.

Dynamic Loads Data (5.1.5.3.4)

Dynamic loads data is presented in accordance with MIL-D-25671, Paragraph 3.2.5. Atmospheric gust transient loads, landing impact dynamic loads and capability, taxi loads, ground maneuvering, and braking loads are considered.

AERODYNAMIC

TESTS	COMPLETED TESTS 1960 SEPT.	OCT.	NOV.	DEC.	PROPOSED TESTS (GO AHEAD) 1961 MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1. COMPLETE MODEL, LOW SPEED			■				■ (1)		■ (2)	■		
2. COMPLETE MODEL, HIGH SPEED	■			■		(1)					■ (2)	
3. COMPLETE PRESSURE MODEL, HIGH SPEED									■			
4. SEMI-SPAN WING, LOW SPEED												■
5. SEMI-SPAN WING, HIGH SPEED												■
6. EMPENNAGE, LOW SPEED										■		
7. EMPENNAGE, HIGH SPEED											■	
8. NACELLE, LOW SPEED								■				
9. NACELLE, HIGH SPEED									■			
10. INLET, STATIC						■						

FLUTTER

TESTS	PROPOSED TESTS 1961 SEPT.	OCT.	NOV.	DEC.	1962 JAN.	FEB.	MAR.	APRIL	MAY	JUNE
1. EMPENNAGE, LOW SPEED		■		■						
2. WING-FUSELAGE, LOW SPEED			■	■						
3. EMPENNAGE, HIGH SPEED							■		■	
4. WING-FUSELAGE, HIGH SPEED							■			■
5. WING-FUSE., DYNAMIC RESPONSE, HIGH SPEED										■

Figure 4-9—WIND TUNNEL PROGRAM SCHEDULE.

Transient Response to Gusts

Gust loads and dynamic response of the airplane are determined both by the CAR-4b gust formula, assuming a rigid airframe, and by a conventional U/2 (1 - cos $2\pi Vt/Hc$) gust profile, assuming a flexible airplane and the most critical gust wave length. Further, the effects of the transient gust loads on the fatigue life of the structure will be checked by a random turbulence procedure, the power spectral density (PSD) method, which also assumes flexible airframe response.

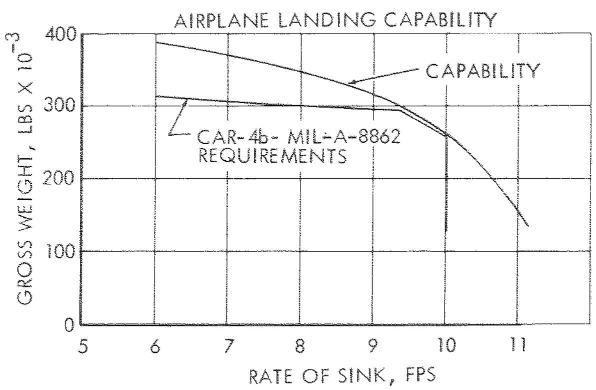
The dynamic response of the wing compares favorably with those of the Lockheed Constellation and C-130B aircraft which have demonstrated satisfactory gust load capability in service. It is considerably better than the measured values for the B-47 airplane and the analytical values derived for the JetStar.

Airplane Landing Capability

The critical landing condition for the airplane is the 10 ft. per second contact sinking speed requirement at the normal design landing weight of 257,500 lbs. Designing for this condition provides the added capability shown in Figure 4-10. At the maximum design landing weight of 315,000 lbs., this figure shows a rate-of-sink capability of 9 ft. per second. It also shows up to 75,000 lbs. overload capability or 390,000 lbs. landing weight capacity at the 6 ft. per second rate specified in both civil and military design criteria for maximum landing weight.

Airplane Taxi Capability

The entire airplane is designed for the 2.0g taxi and dynamic taxi loads at all weights and fuel distributions up to maximum take-off weight of 315,000 lbs. as is discussed later. This design strength



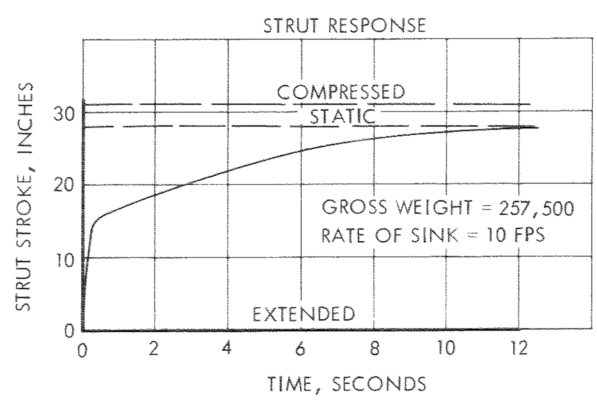


Figure 4-10—AIRPLANE LANDING CAPABILITY AND STRUT RESPONSE.

provides a taxi capability, corresponding to the 2g taxi condition, of 1.7g at the 353,200 lb. gross weight discussed in the airplane landing capability paragraph.

Main Gear Dynamic Response Characteristics

The main gear landing capability is based on the normal design landing configuration and sinking speed. Dynamically, the landing gear has greater capability at higher weights and sinking speeds than the overall airplane capability. This shows good growth potential available within the presently designed dimensions of the gear.

The time history of the strut deflection through both the impact and slow let down to the static position is also shown in Figure 4-10. The delay in reaching static position, so as to give additional aft-fuselage clearance during landing, is evident from this curve.

Wing Response — Landing and Taxi

Envelope values of the maximum time history responses of load factors, wing shear, bending moment, and torsion have been calculated, and the preliminary data indicates that the landing response values are less critical than those for the taxi maneuvers. The dynamic taxi response is treated in the same manner as is the dynamic landing. The response is based on taxiing over a $(1 - \cos \omega t)$ profile of such an amplitude as to induce a 0.5g incremental gear load and of proper frequency to induce first mode wing bending. Full wing fuel with zero cargo is the most critical configuration. The dynamic taxi analysis is supplementary to the 2g nominal load factor for taxiing. The wing is designed for the 2g or the dynamic taxi, where these conditions result in critical loads.

Normal and High-Speed Turns and Braking

The landing gear is designed to meet both CAR and the corresponding AF specifications applying to turning and braking. The minimum runway width for a 180-degree turn is 73 ft., based on the full 80-degree nose wheel steering deflection, which pivots the airplane about one main gear.

The geometry of the main landing gear is such that the tip-over side load factor is higher than the side load factor specified in CAR 4b and MIL-A-8862. Consequently, the airplane will not tip over even in side winds up to and above 50 knots. Adequate clearance for both engine nacelles and wing tips exists at the maximum turning rate for any taxi speed. Section 3 of Volume 2 presents these analyses' results.

The nose gear design strength is adequate to resist 4-engine, maximum static thrust at sea level on a cold day, for high-speed, straight-ahead braking, and for maximum side load during high-speed turns at all weights up to 315,000 lbs.

Transient Response Verification (Taxi, Landing and Flight)

The CAR's do not require transient response verification for taxi and landing conditions. In the event the Air Force requires such a program, tests similar to those conducted on the C-130A, equipped with 450-gal. pylon tanks, and those being completed on the C-130B will be conducted. These tests basically consist of recording the response of the landing gear and wing structure to taxi tests over obstacles of predetermined shape, and to landing impacts. The results will be compared with those obtained from the theoretical analysis.

Landing Gear Drop and Shimmy Tests

The airplane and gear load factors and dynamic response characteristics will be substantiated by the drop test program, to show compliance with the normal and reserve energy requirements of the CAR-4b, Paragraphs 4b.330 thru 4b.332. In addition to the two preceding requirements, the airplane growth tests of the Military Specification MIL-T-6053A, Paragraph 2.1.3.2 will be included in the drop test program to evaluate increased landing weight characteristics and potential of the main and nose gears designs. Both level and taildown attitudes will be included in the tests.

The nose gear will be tested to demonstrate that the damping configuration will prevent nose wheel shimmy. A three-point test spectrum covering the operating range for the GL 207-45 nose landing gear will be (1) damper absorption measurements, (2) forced oscillation stability, and (3) free shimmy response, impulse excited. These tests will demonstrate stable operation of the nose landing gear under all taxi take-off and landing conditions for which this airplane is designed.

Brake Energy Absorption Requirements

The brake energy absorption capacities are based on the most severe requirements of the CAR-4b.-335(c), Aeronautical Standard AS 227C, or MIL-W-5013D, whichever is the most critical. The effects of altitude and temperature up to 6500 ft. and a USAF 41-degree hot day are included for both normal and rejected take-off stopping cases. The preliminary requirements are established on the basis of Method I of AS227C or MIL-W-5013D. Reduction in energy capacity requirements as established by Method II will be evaluated in the later design stages of the airplane, when engine drag data becomes available.

Brake energy absorption requirements are tabulated below:

Method of Analysis and Conditions	Brake Energy, Ft.-Lbs. Per Wheel	
	Normal Landing 100 Stops	Rejected Take-off Single Stops - 1.2Vs
Sea Level, std. day	14,300,000	30,600,000
6500 ft. alt. USAF hot day	18,500,000	40,250,000

Acoustical Noise Data (5.1.5.3.5)

Noise levels in all occupied areas of the aircraft will be within the limits imposed by MIL-A-8806, including those of Table 4. The initial estimates of noise levels in occupied areas of the aircraft are shown in Figure 4-11, and 4-12 for JT3D-4 engines and JT3D-8 engines respectively. In both cases levels

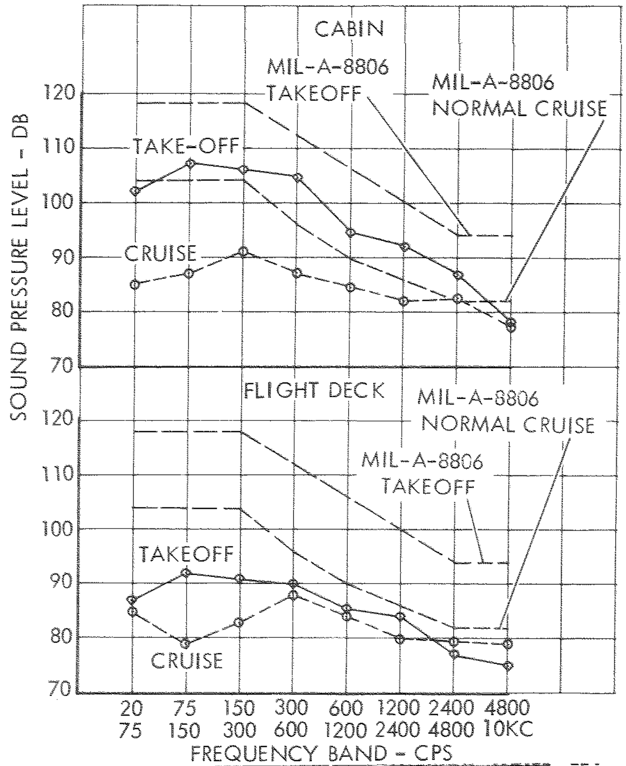


Figure 4-11—ESTIMATED AVERAGES—INTERIOR NOISE LEVELS PRATT AND WHITNEY JT3D-4 ENGINE.

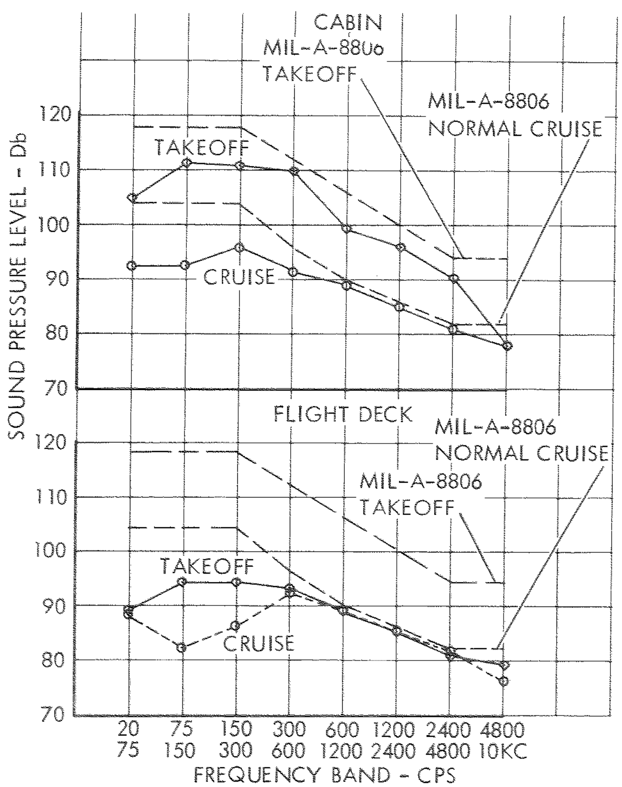


Figure 4-12—ESTIMATED AVERAGES—INTERIOR NOISE LEVELS, PRATT AND WHITNEY JT3D-8 ENGINE.

are below the applicable limits of MIL-A-8806 in the cargo compartment as well as on the flight deck. Levels in the standby crew compartment will be appreciably lower than those of the cargo compartment. Analyses of the acoustic exposures on a 10-hour flight, by the nomograms of AF Regulation 160-3, indicate equivalent exposures of 1,720 EET and 4,440 EET in the 300-600 cps band for -4 and -8 installations respectively. An exposure of 4,800 EET is allowable before use of ear defenders become mandatory. Thus, ear defenders will not be required and the requirements of Work Statement Paragraph 3.5.3 are met.

The following analytical and test program is planned to insure that the required maximums are not exceeded, and to provide additional information needed in the sonic-fatigue and vibration programs:

Analytical Program

A more refined calculation of the internal noise levels in the crew and paseenger compartments, including the variation of levels throughout the aircraft will be conducted. Starting point of the analysis will be the JT3D-4 noise levels currently in publication by P&W. A series of transmission-loss calculations for alternative sound-proofing configurations will be made to screen out the most efficient ones. Special consideration will be given both to new materials and concepts, and to the effects on soundproofing efficiency of detail-design factors which in many cases compromise a soundproofing installation. A series of calculations of the perceived noise level for various gross weights, take-off profiles, and engine power settings will be made to define the optimum operating routines as well as to catalogue the noise characteristics of the airplane (for civil applications). Complete noise-level contour plots for the airplane will be estimated as a basis for categorizing areas which are critical for sonic fatigue and to provide the basis for test levels used in structural-development testing. The acoustic-power output of all aircraft systems having appreciable acoustic output will be made. Results will be appraised to indicate where internal system noise may control the environment so that proper alleviation schemes can be established early in the program. The effects of aerodynamic noise on internal levels will be initially evaluated empirically.

Test Program

Upon receipt of the 1st test engine, a series of near-field and far-field measurements will be made to confirm the levels used in earlier calculations, and to establish the noise environment for ground-handling crews, etc. Spatial correlation measurements will be made so that fatigue life and vibration calculations can be revised to include this very significant parameter. Statistical description of the acoustic loading to be expected on structural surfaces will be determined.

A ground test will be conducted on the first airplane to confirm the environmental conditions used in previous calculations of internal noise and structural vibration. A series of flight tests will be conducted to substantiate noise levels in the crew and cabin areas insofar as the requirements of MIL-A-8806A are concerned. Actual community noise levels on take-off will be determined from flight tests.

A series of transmission-loss measurements of typical structural and soundproofing sections will be made. The test configuration will permit use of the actual radius of curvature of the structure and the simulated edge stiffness of an actual aircraft section.

Vibration Program (5.1.5.3.6)

The order of magnitude of fuselage vibration on the GL 207-45 will be much reduced from that of the C-130B or C-133 for example, both in amplitude and in the area of the fuselage which is involved. As is discussed in detail in Section 3 of Volume 2, no major problems with vibration are anticipated.

Sonic Fatigue Program (5.1.5.3.7)

Figure 4-13 gives estimated sound-pressure contours of the fuselage for the JT3D-4 engines. The contours indicate a maximum level of 151 decibles on

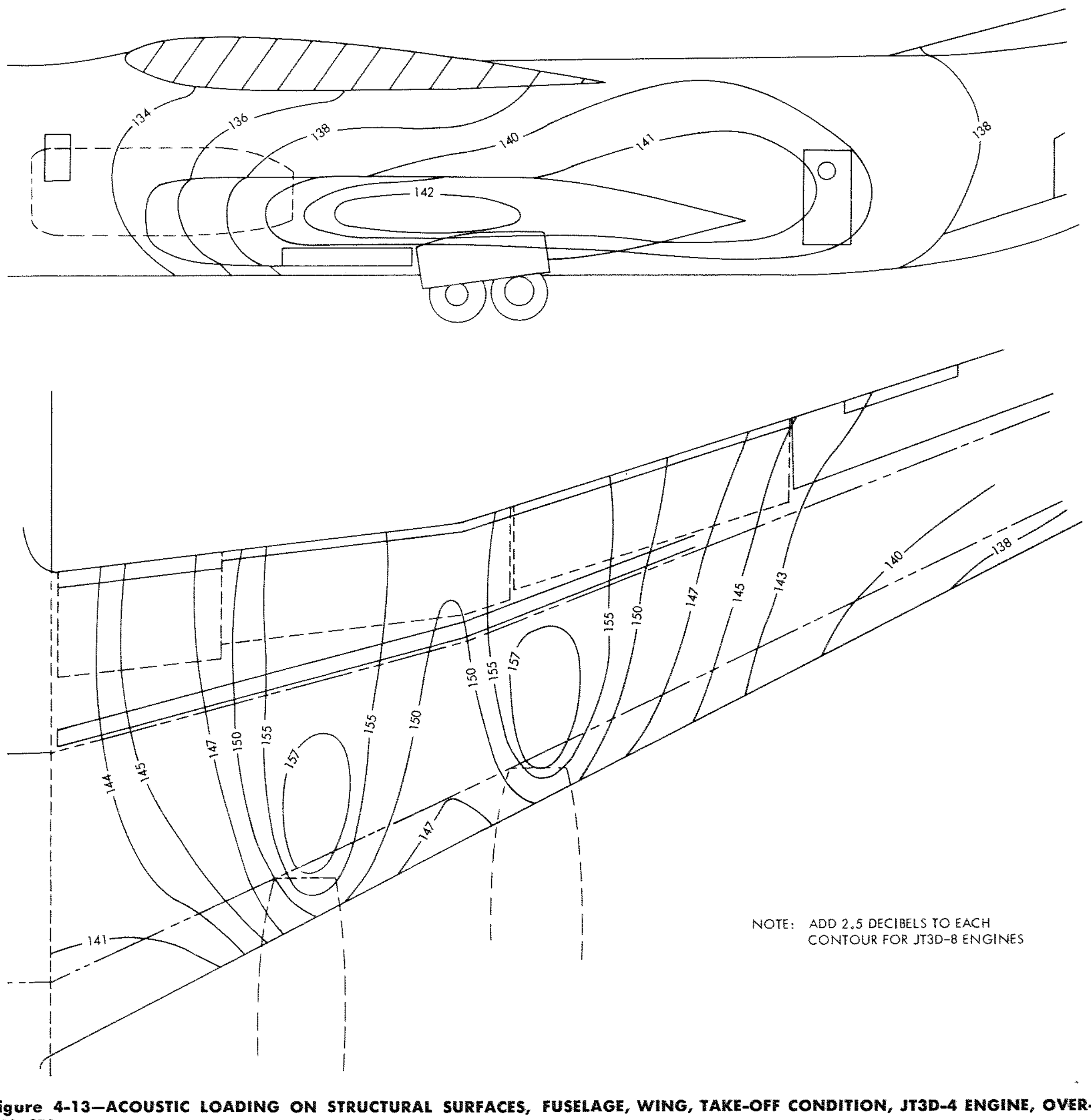


Figure 4-13—ACOUSTIC LOADING ON STRUCTURAL SURFACES, FUSELAGE, WING, TAKE-OFF CONDITION, JT3D-4 ENGINE, OVER-ALL SPL.

the fueslage itself and 142 dbs. on the wheel-well fairing. These levels are well within the capabilities of conventional aluminum skin and no serious sonic fatigue problems should arise. Figure 4-13, which shows estimated wing lower-surface contours, indicates a maximum level with flaps retracted of 157 dbs. This occurs in the area immediately above the engine exhausts where the wing-box build-up will necessitate heavy-gauge plate structure. This factor, in conjunction with the levels themselves, tends to alleviate concern for this particular area.

The wing trailing edge levels run as high as 155 dbs., and these are in an area where lightweight structure is desired. When the flaps are extended, parts of the flap structure will be in the immediate vicinity of the exhaust stream. Noise levels at such points are indeterminable but certain to be higher than those in the retracted position. These considerations lead to the use of honeycomb structure for the flaps and other sections of the wing trailing edge as well.

The same general conclusions arise in considering the JT3D-8 engines. The increased thrust produces a calculated 2.5 dbs. increase in noise levels on the structure. This is not enough to place the fuselage in critical category. However, it is enough to produce levels of approximately 160 lbs. on the wing trailing edge, still well within honeycomb structure tolerance limits.

In addition to the tests discussed under Acoustical Noise Data (5.1.5.3.5), the following analyses and tests will be conducted to substantiate the aircraft against sonic fatigue problems and thus assure that it will be able to maintain the utilization required by Paragraph 2.4.6 and the 30,000-hour service life requirement of Paragraph 3.1.2.1 of the Work Statement.

Analytical substantiation of the airplane structure, subsystems and subsystem components against sonic fatigue for its expected 30,000-hour life will be directed along two lines. These are:

1 Consideration of the response and fatigue life of individual structural panels and systems elements in critical areas, using simplified theory. Preliminary studies indicate that subsystem sonic environment problems will be considerably less significant than structural problems.
2 Consideration of the response of large sections of structure to include correlation effects, using more advanced, inclusive analysis techniques.

Experimental development work will also proceed along two lines:

1 Structural panel and any necessary subsystem testing will be carried out under accelerated life test with pseudo-random and discrete-frequency sirens. Particular attention will be given to the effect of panel edge conditions insofar as life is concerned. This phase of the structural and subsystem development will also be supported with some testing of panels and subsections in the sound field of a JT3D-4 engine operating on a static test stand.
2 Accelerated life test of an entire flap section or an outboard wing section is proposed to be carried out in the sonic fatigue facility at WADD.
3 In order to verify that the actual vibratory amplitudes have been correctly predicted, a ground run of the first aircraft will be conducted to permit measurement of stress or vibration amplitude in all critical areas.

MATERIALS AND CONSTRUCTION (5.1.5.4)

The structural concept of the airplane adapts the materials, processes, and constructions of the C-130 aircraft series to this advanced airframe. Wherever possible, identical or similar structure has been utilized to take advantage of the extensive production, test and service experience with the C-130, and to minimize production cost. Materials used and methods of construction have been selected on the bases of structural integrity, cost, weight, and ease of fabrication and maintenance. No advanced materials or methods of construction are utilized beyond those well established as the current state-of-the-art. As required by the Statement of Work, Section 1.2.1, the airworthiness standards of the CAR as well as military requirements form the basis for detail design of the structure.

Production Design

The airplane breakdown is shown in Figure 4-14. This breakdown reflects the requirements of manufacturing, subcontracting, servicing, and spare parts, with consideration for interchangeability and minimum tooling requirements. Manufacturing techniques, such as use of automatic numerical-computer devices are planned, similar to those presently employed in production of the C-130 and JetStar airplanes to take advantage of existing worker skills, facilities, and manufacturers' capabilities. Thus, the objectives of Section 4.3.2 of the Statement of Work are considered to be met.

Structural Analysis

Conventional procedures are employed for structural substantiation using methods and allowable stresses as outlined in Military Handbook MIL-HDBK-5, the Lockheed Stress Memo Manual, Structures Handbook and related documents. Loads used for analysis have been based upon the require-

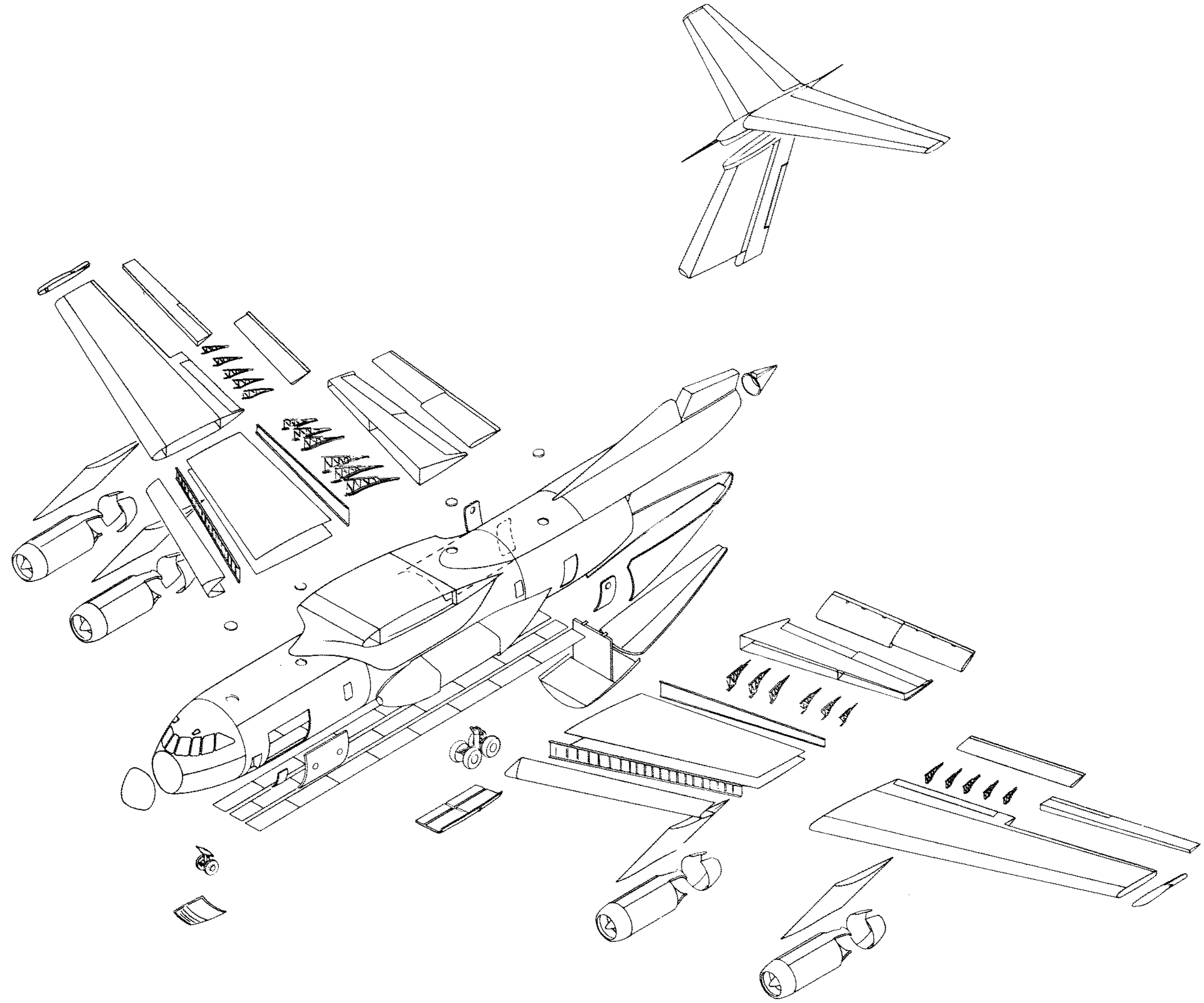


Figure 4-14—AIRPLANE BREAKDOWN.

ments of CAR 4b for Transport Category airplanes or MIL-A-8860 series specifications, whichever is more severe. Computer programs are extensively utilized for structural analysis. A structural test program will be conducted to meet FAA requirements for commercial certification as discussed in Section 10. Ultimate static test and fatigue test programs will be conducted if required by the Air Force, reference Volume 4.

Fatigue Design Criteria

The airplane is designed to be inherently fatigue resistant by eliminating or minimizing the causes of fatigue failure. Operating stress levels are limited to values that will inhibit crack development and propagation. In accordance with the Work Statement, Section 3.1.2, fatigue resistance is provided for an operational life of 30,000 flight hours and 12,000 take-offs and landings. The structure will be investigated in accordance with standard Lockheed fatigue analysis procedures which have proved satisfactory for aircraft like the Constellation series, that have accumulated flight hours of more than 50,000 with landings exceeding 25,000. The method investigates flight gust, maneuver, ground-to-air-to-ground cycle, dynamic taxi and landing fatigue effects for typical missions such as that shown in Figure 4-15. The fatigue resistance of the design should assure 2400-hour reconditioning cycles, per Section 4.4 of the Work Statement, high daily usage rates, and other operational factors. Fatigue tests of structural elements will be completed as the design progresses. Such element tests might economically be supplemented by full-scale fatigue tests as discussed in Volume 4. The fatigue analyses and tests, together with the fail-safe analysis will be helpful in establishing the inspection and repair/replace specifications and schedules discussed in Section 5.2.4.2 of the Work Statement.

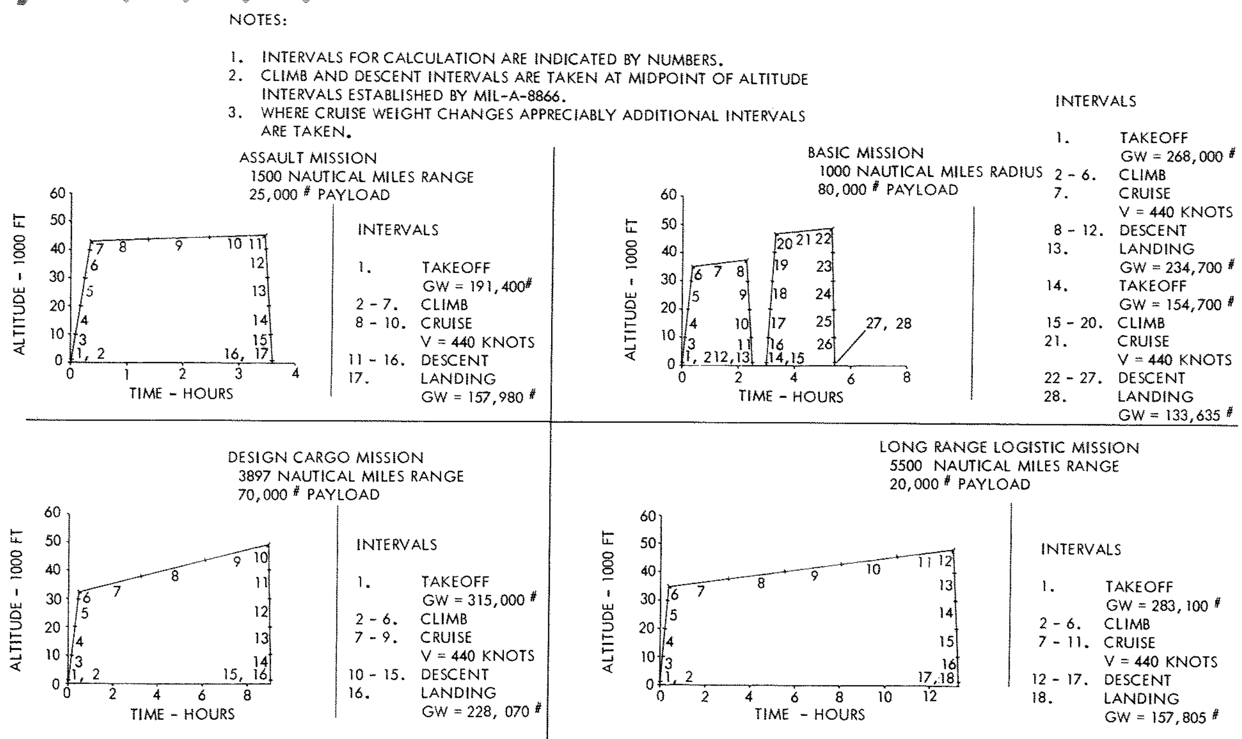


Figure 4-15—TYPICAL COMPOSITE MISSION PROFILE LIFE.

Fail-Safe Criteria

Lockheed, for FAA certification purposes, will show the airplane to be fail-safe for loads exceeding the requirements of CAR, Part 4b. Multiple load path structures have been utilized extensively for flight loads. In the event of failure of any single structural element, structural collapse, loss of control, or flutter of the airplane will not occur. No appreciable weight penalty is associated with this election. A minimum fail-safe test program will be required for civil certification.

Structural Description

The following paragraphs describe the structural design the air-frame and show how fatigue and fail-safe properties have been incorporated in the design. As required by MIL-D-25671 Section 3.2.8, construction drawing are included for the wing, fuselage, and empennage, Figures 4-16, 4-17, and 4-18 respectively.

Wing

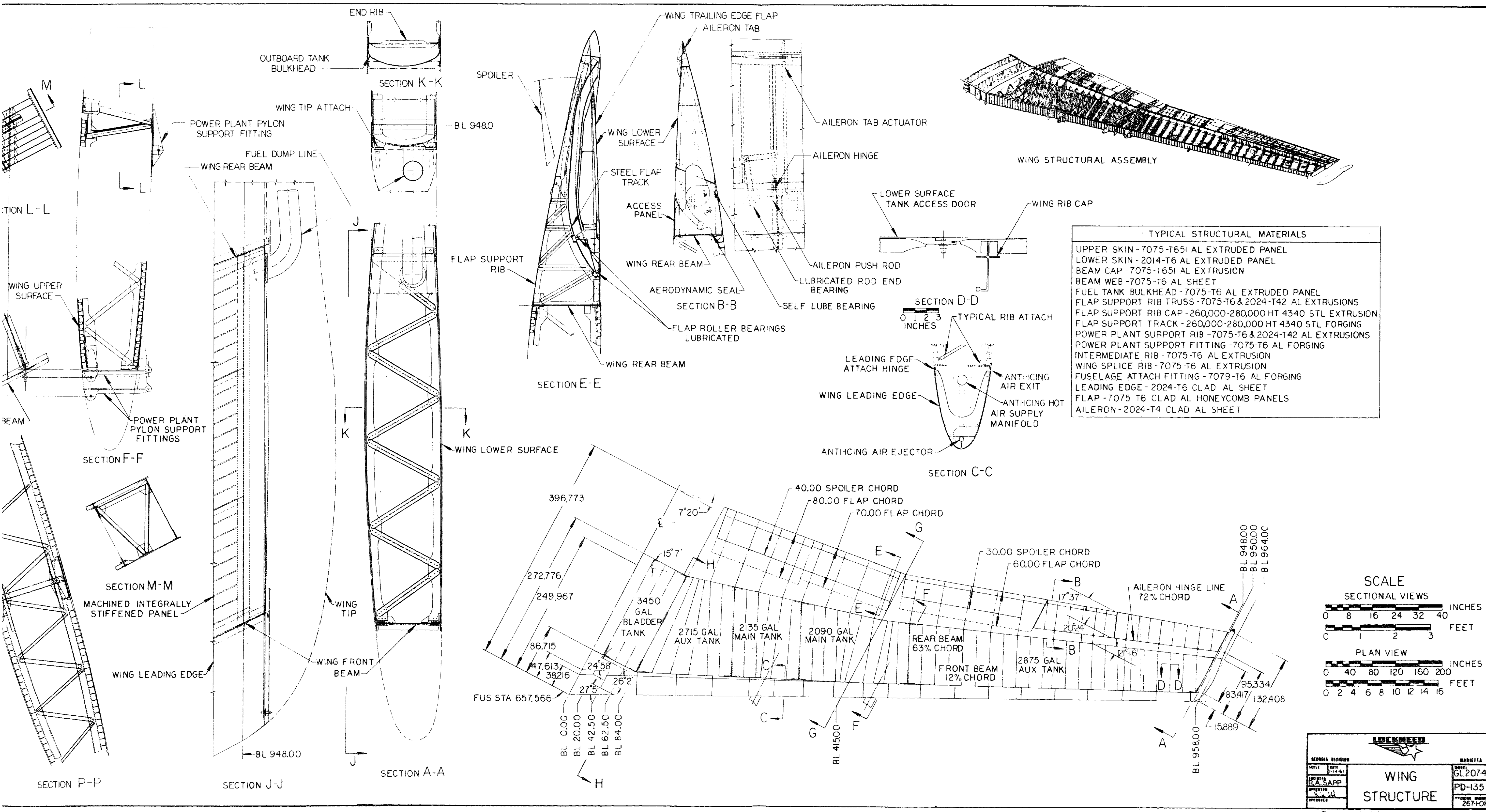
The wing, shown in Figure 4-16, is a conventional two-beam structure swept 25 degrees at the quarter chord line. It is constructed in five sections with manufacturing joints at B.L. 84 and B. L. 415. The materials used in the wing are discussed in Volume 2 Section 3. The wing has a span of 160 ft. and 8 in. with a wing area of 3228. square ft. and a wing aspect ratio of 7.90. The wing contains a platform and thickness change point at B.L. 415 resulting in an average wing thickness of 11.38%. Contained within the primary wing structures is a total of nine tank systems. The tank system contained within the wing center section is a bladder bag tank installation. The remaining eight tanks are integral to the wing, four of which are main engine supply tanks, and four of which are auxiliary tanks.

Wing loads are carried by the structural box formed by the integrally stiffened cover panels and the two beams. Cover panels are planked and assembled by automatic riveting techniques. Ribs are of conventional design, and beam webs are multi-element for fail-safety. Chordwise joints in the wing skins are effected by multiple attachments in double shear designed to be critical in bearing. Beam cap joints are affected by conventional forged bathtub fittings with bolts in tension. At the B.L. 84 joint, kick loads due to the wing sweep are redistributed into the inner wing structure by the joint rib.

The Lockheed, Fowler-type flaps and ailerons are of fail-safe design and are similar to those of the C-130 and are supported and controlled in a similar manner. Wing leading edges are non-structural.

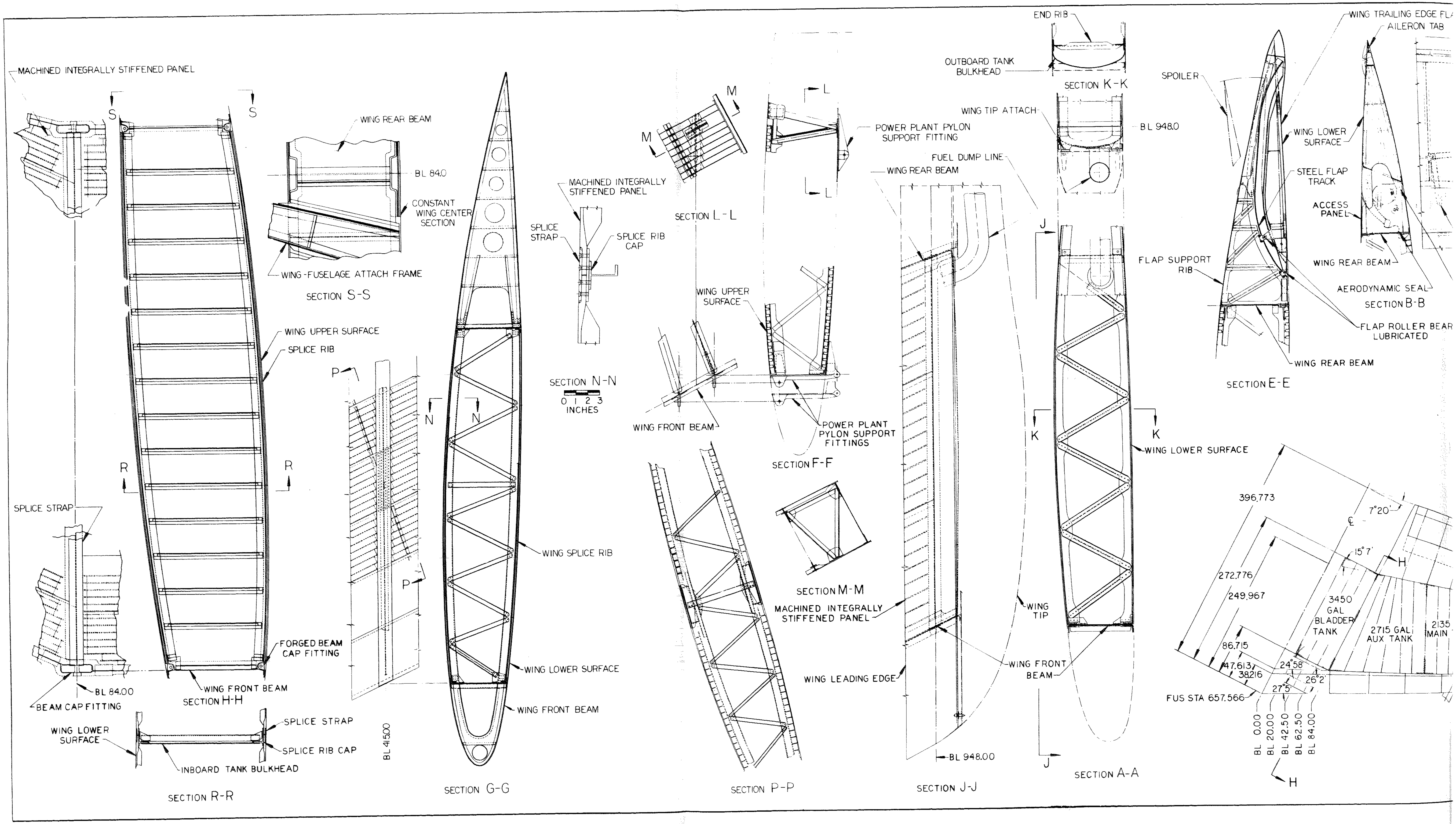
Wing-Fuselage Joint

Vertical loads from the wing are transferred into the built-up fuselage rings at F.S. 744.28 and F.S. 930.23. Redistribution of the wing loads at the joint is affected by the B.L. 62.5 rib, which also carries the vertical component of the fuselage skin hoop tension load. Fore and aft wing loads are

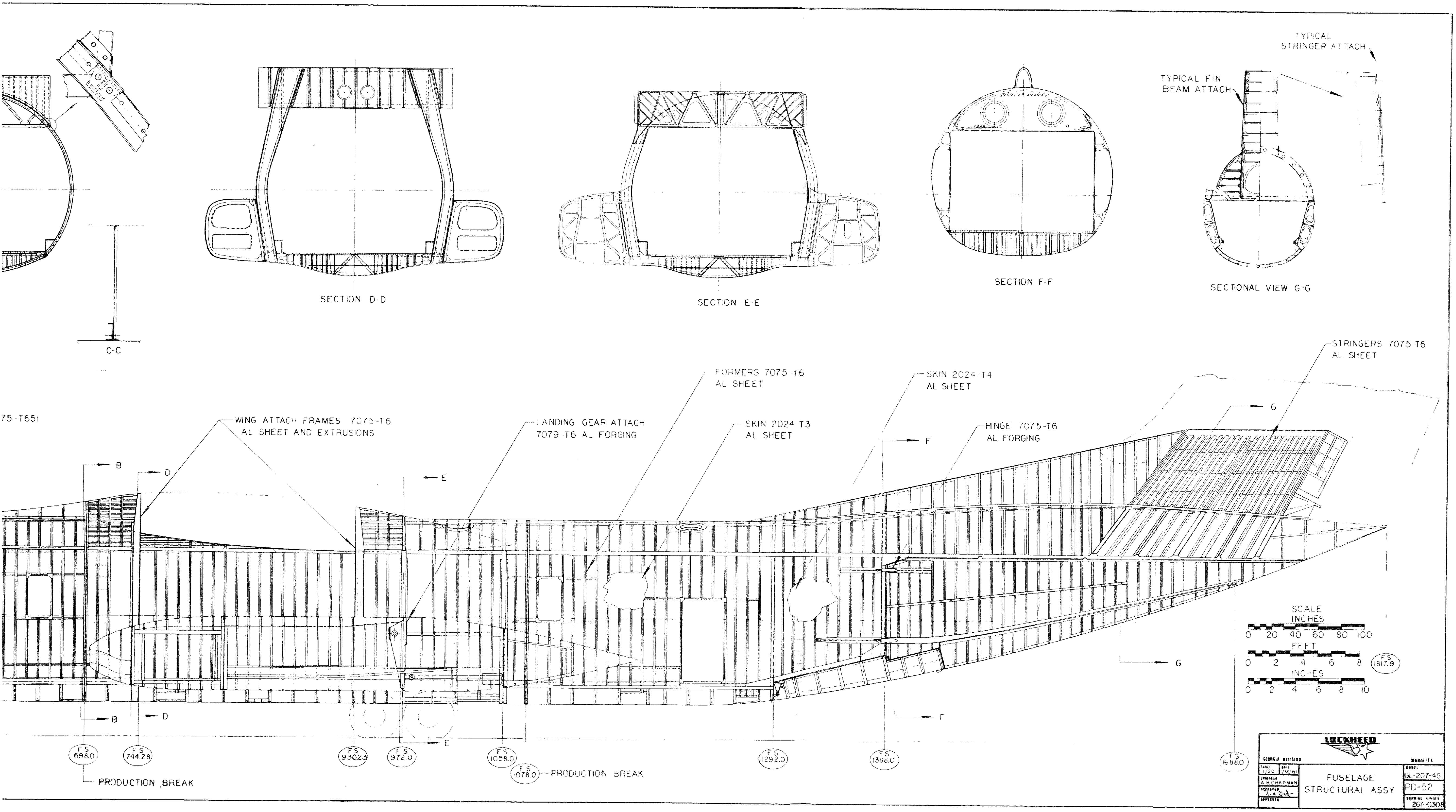


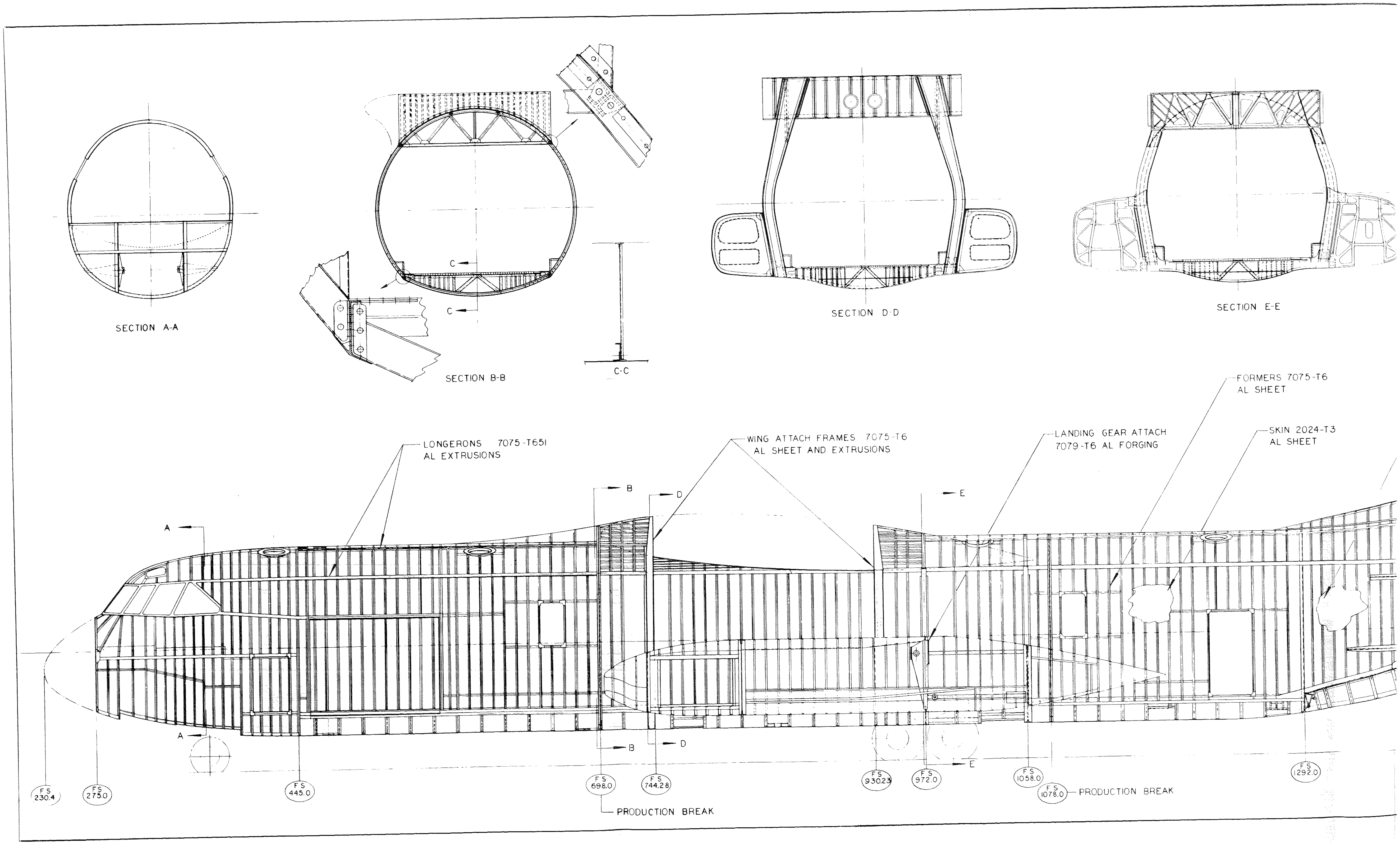
TYPICAL STRUCTURAL MATERIALS
UPPER SKIN - 7075-T651 AL EXTRUDED PANEL
LOWER SKIN - 2014-T6 AL EXTRUDED PANEL
BEAM CAP - 7075-T651 AL EXTRUSION
BEAM WEB - 7075-T6 AL SHEET
FUEL TANK BULKHEAD - 7075-T6 AL EXTRUDED PANEL
FLAP SUPPORT RIB TRUSS - 7075-T6 & 2024-T42 AL EXTRUSIONS
FLAP SUPPORT RIB CAP - 260,000-280,000 HT 4340 STL EXTRUSION
FLAP SUPPORT TRACK - 260,000-280,000 HT 4340 STL FORGING
POWER PLANT SUPPORT RIB - 7075-T6 & 2024-T42 AL EXTRUSIONS
POWER PLANT SUPPORT FITTING - 7075-T6 AL FORGING
INTERMEDIATE RIB - 7075-T6 AL EXTRUSION
WING SPLICE RIB - 7075-T6 AL EXTRUSION
FUSELAGE ATTACH FITTING - 7079-T6 AL FORGING
LEADING EDGE - 2024-T6 CLAD AL SHEET
FLAP - 7075 T6 CLAD AL HONEYCOMB PANELS
AILERON - 2024-T4 CLAD AL SHEET

figure 4-16



MACHINED INTEGRALLY STIFFENED PANEL
S
S
WING REAR BEAM
BL 84.0
CONSTANT WING CENTER SECTION
WING-FUSELAGE ATTACH FRAME
SECTION S-S
WING UPPER SURFACE
SPLICE RIB
R
R
SPLICE STRAP
FORGED BEAM CAP FITTING
BL 84.00
BEAM CAP FITTING
WING FRONT BEAM
SECTION H-H
WING LOWER SURFACE
SPLICE STRAP
SPLICE RIB CAP
INBOARD TANK BULKHEAD
SECTION R-R
P
P
BL 415.00
N
N
WING SPLICE RIB
WING LOWER SURFACE
WING FRONT BEAM
SECTION G-G
MACHINED INTEGRALLY STIFFENED PANEL
SPLICE STRAP
SPLICE RIB CAP
SECTION N-N
0 1 2 3
INCHES
M
M
SECTION L-L
WING UPPER SURFACE
WING FRONT BEAM
SECTION P-P
L
L
POWER PLANT PYLON SUPPORT FITTING
POWER PLANT PYLON SUPPORT FITTINGS
SECTION F-F
SECTION M-M
MACHINED INTEGRALLY STIFFENED PANEL
OUTBOARD TANK BULKHEAD
END RIB
SECTION K-K
WING TIP ATTACH
BL 948.0
FUEL DUMP LINE
WING REAR BEAM
J
J
K
K
WING LOWER SURFACE
WING TIP
WING FRONT BEAM
WING LEADING EDGE
BL 948.00
SECTION J-J
SECTION A-A
SPOILER
WING TRAILING EDGE FL
AILERON TAB
WING LOWER SURFACE
STEEL FLAP TRACK
ACCESS PANEL
FLAP SUPPORT RIB
WING REAR BEAM
AERODYNAMIC SEAL
SECTION B-B
FLAP ROLLER BEAR LUBRICATED
WING REAR BEAM
SECTION E-E
396.773
272.776
249.967
86.715
47.613
38.216
7°20'
15°7'
H
H
3450 GAL BLADDER TANK
2715 GAL AUX TANK
2135 MAIN
24°58'
27°5'
26°2'
FUS STA 657.566
BL 0.00
BL 20.00
BL 42.50
BL 62.50
BL 84.00


TYPICAL STRINGER ATTACH
TYPICAL FIN BEAM ATTACH
SECTION D-D
SECTION E-E
SECTION F-F
SECTIONAL VIEW G-G
C-C
75-T651
WING ATTACH FRAMES 7075-T6 AL SHEET AND EXTRUSIONS
LANDING GEAR ATTACH 7079-T6 AL FORGING
FORMERS 7075-T6 AL SHEET
SKIN 2024-T3 AL SHEET
SKIN 2024-T4 AL SHEET
HINGE 7075-T6 AL FORGING
STRINGERS 7075-T6 AL SHEET
SCALE INCHES
0 20 40 60 80 100
FEET
0 2 4 6 8
INCHES
0 2 4 6 8 10
F.S. 698.0
F.S. 744.28
F.S. 930.23
F.S. 972.0
F.S. 1058.0
F.S. 1078.0
F.S. 1292.0
F.S. 1388.0
F.S. 1688.0
F.S. 1817.9
PRODUCTION BREAK
PRODUCTION BREAK
LOCKHEED
GEORGIA DIVISION
MARIETTA
SCALE 1/20
DATE 1/12/61
ENGINEER A.H. CHAPMAN
APPROVED
FUSELAGE STRUCTURAL ASSY
MODEL GL-207-45
PD-52
DRAWING NUMBER 267-0308
figure 4-17



SECTION A-A
SECTION B-B
C
C
C-C
SECTION D-D
SECTION E-E
FORMERS 7075-T6
AL SHEET
LONGERONS 7075-T651
AL EXTRUSIONS
WING ATTACH FRAMES 7075-T6
AL SHEET AND EXTRUSIONS
LANDING GEAR ATTACH
7079-T6 AL FORGING
SKIN 2024-T3
AL SHEET
A
A
B
B
D
D
E
E
FS 230.4
FS 275.0
FS 445.0
FS 698.0
FS 744.28
FS 930.23
FS 972.0
FS 1058.0
FS 1078.0
FS 1292.0
PRODUCTION BREAK
PRODUCTION BREAK

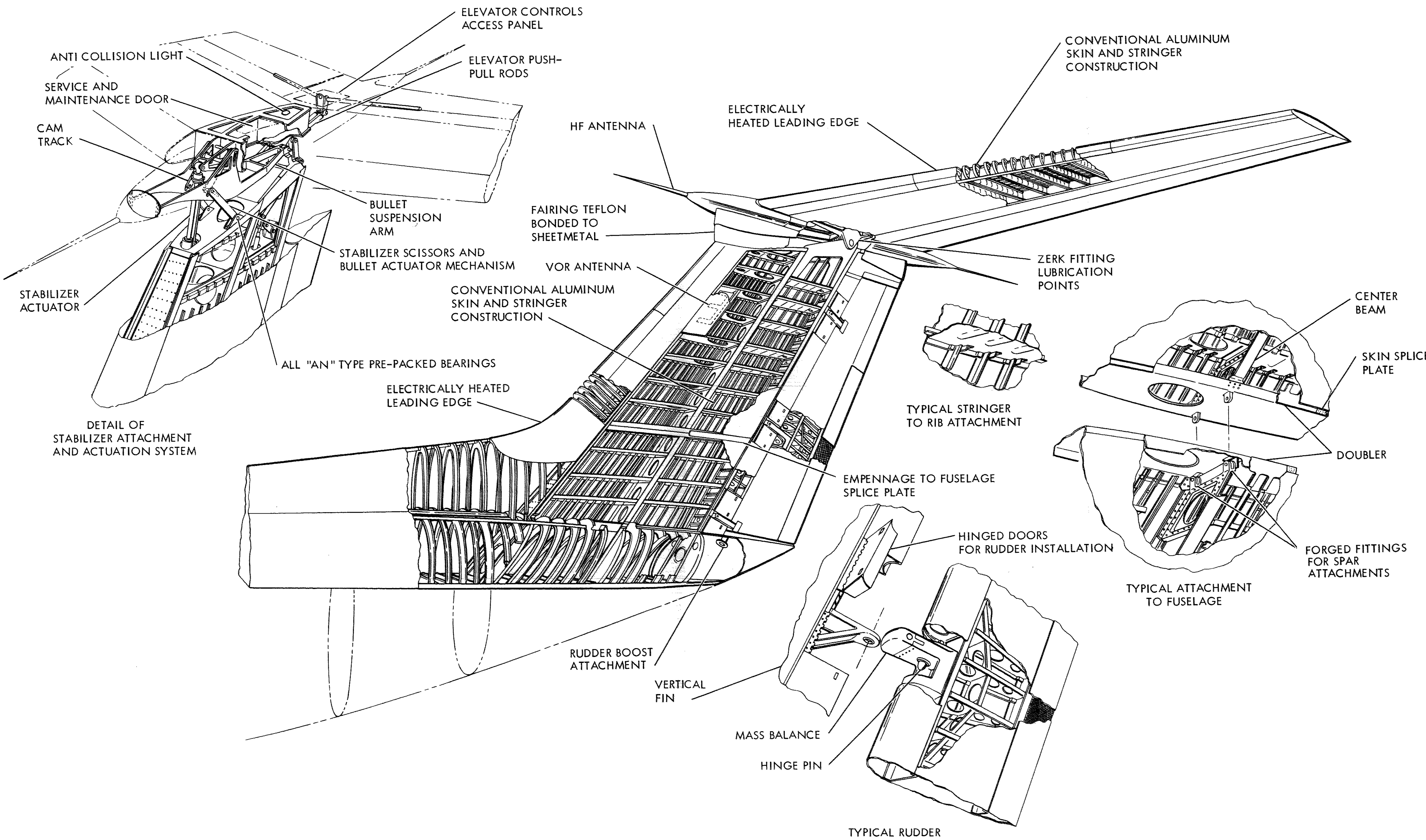


Figure 4-18—EMPENNAGE STRUCTURE.

transferred into the fuselage by drag angles attached to the lower surface of the wing.

Engine Pods and Pylons

The four-podded engines are mounted from the wing by pylons at B.L. 285 and B.L. 460. See Section 5 for pod details. The structural arrangement is based upon installations already in existence for engines in current jet airplanes. Engine loads are transferred into the wing from the pylon structural box at the wing front beam with stabilizing members to carry engine pitching moments.

Fuselage

The fuselage structure shown in Figure 4-17 is based upon the C-130 design. Materials used in the fuselage are shown on the drawing and their bases for selection are discussed in Section 3 of Volume 2. Methods of construction are similar to those of the C-130. Basic bending structure consists of six longerons and the integral load-carrying floor while shear loads are carried by the skins, which also carry all pressurization loads. The fuselage section underneath the wing remains basically circular. Wing and landing gear loads are transferred into the fuselage structure by built-up rings, and external structure within the wheel well fairing. The fuselage lower skin and support structure is designed to carry emergency ditching loads.

Aft Fuselage

Reference to Figure 4-18 will show that behind F.S. 1292 the fuselage structure is interrupted by the cargo doors. When the doors are opened in flight for air dropping, loads are carried by the closed cell subsidiary structure above W.L. 255. When the doors are closed, the upper petal doors form an integral part of the aft fuselage bending structure. All doors assist in carrying torsional loads when closed and locked. The structure behind F.S. 1388 is not pressurized. Pressure loads are carried by the vertical pressure door at F.S. 1388, which forms part of the cargo ramp when lowered. This feature relieves the aft body of pressurization loads with corresponding reduction in weight and sealing problems.

Empennage

Empennage structure is shown in Figure 4-18. Details of the structure and its mounting are shown. Apart from the horizontal to vertical stabilizer joint, the structure is conventional monocoque. Adequate structural stiffness has been provided, as in the aft fuselage, to prevent flutter of the T-tail configuration. Stabilizer hinge fitting, actuator and follow-up screw are designed to provide adequate stiffness and to provide a fail-safe structure. Attention is invited in particular to the multiple beam structure transferring fin loads into the fuselage structure. Materials used in the empennage are discussed in Section 3 of Volume 2.

ALIGHTING GEAR (5.1.5.5)

The conventional tricycle landing gear consists of a nose gear with dual wheels and two main gears with four-wheel bogies yielding the following characteristics: the minimum turning radius is 73 ft.; the ground-to-tire UCI shown in Figure 4-19 is only 38 for the main gear and 34 for the nose gear at the landing weight of 193,640 lbs. for the 1000-nautical-mile mission with military fuel reserves and 60,000 lbs. of cargo; the turnover angle is 52 degrees maximum; the landing load vactor is 1.5 g; the taxi factor is 2.0 g; the total weight for all gears is 3.0% of design take-off weight and 3.65% design landing weight. The struts are to be serviced with fire resistant hydraulic fluid.

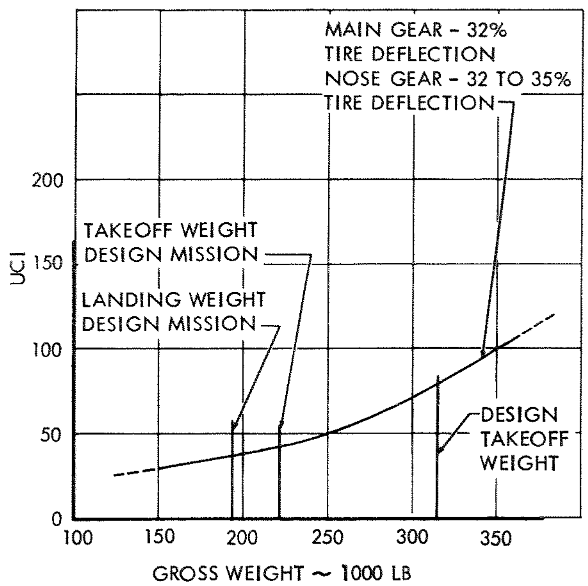


Figure 4-19—UCI VS. GROSS WEIGHT.

Description

Nose Gear

The nose gear is shown in Figure 4-20. The over-all air-oil shock absorber stroke is 12.00 in. with 3.0 0 in. from static to fully compressed. Nose wheels and tires are standard aircraft size 32x11. 50-15 Type VIII. Wheels are free rotating and have a 3-in. trail. The gear is retracted by a hydraulic actuator which extends to retract the gear forward and upward. Initial motion of the retract actuator unlocks the uplock or downlock as required, and door operation is accomplished mechanically with the gear motion. For ground locking, an insertion pin interlocks the movable elements of the drag brace.

The steering is hydraulically actuated by a single linear, double acting cylinder driving a conventional rack and gear. A steering wheel at the left of the pilot controls the nose gear position. The metering-type, hydraulic steering valve is manually operated with cables from the control wheel. Position feed-back is accomplished by a simple linkage interconnection.

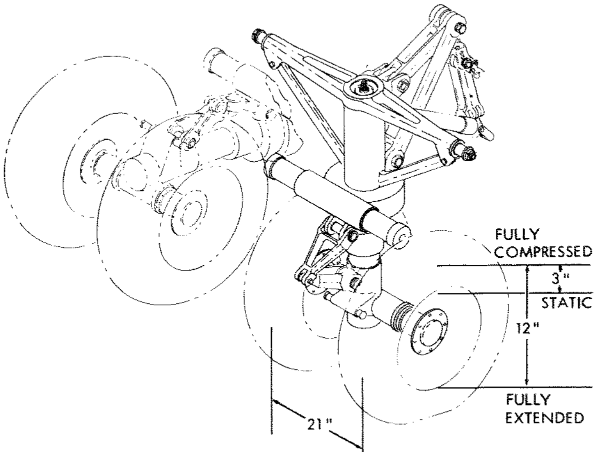


Figure 4-20—NOSE LANDING GEAR INSTALLATION.

Main Gear

The main gear installation is shown in Figure 4-21. The air-oil strut has an overall shock absorber stroke of 31.1 in. From static to fully compressed the stroke is 3.0 in. and from static to fully extended 28.1 in. The main gear wheels and tires are standard aircraft size 44x16 Type VII with a 28 ply rating.

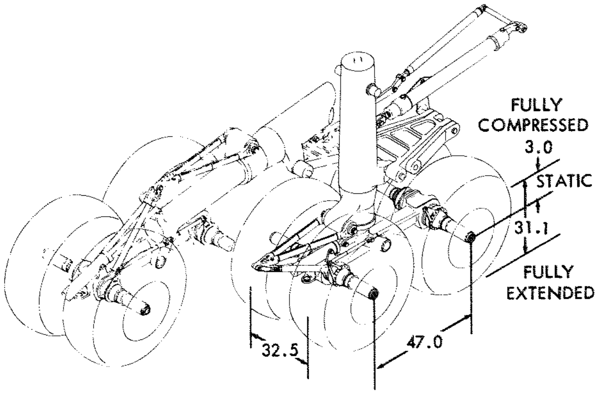


Figure 4-21—MAIN LANDING GEAR INSTALLATION.

The four wheel bogey has dual wheels fore and aft of the shock strut with a beam connecting the respective axles to a trail attachment point on he strut piston. The beam is allowed to truck for runway obstacles and positions the wheels so that all four tend to touch simultaneously during landing. The tail attachment on the piston allows the bogey to be rotated approximately 90 degrees to allow for stowage at retraction. A bungee actuator damps wheel oscillation and positions the wheels for landing and during retraction.

The gear is attached to the structure in a side fuselage fairing. A hydraulic actuator extends to retract the gear forward and upward into the fairing. A pin is installed in the drag brace for the groundlock. Four hinged doors, two inboard and two outboard, enclose the wheel well and a series of links, rods, and levers are incorporated to mechanically sequence these doors with the gears.

The brakes are a standard production model incorporating multiple disc and spot design and utilizing sintered metal brake linings for maximum smoothness and to prevent brake fade-out. Brake equalizer links and snubbers prevent undersirable oscillation and torque in the bogey beam; hydraulic lockout valves prevent progressive failure of all eight brakes, but allow, if one brake should fail, 50% braking on the side affected and 100% on the opposite.

The modulating anti-skid shown in Figure 4-22 is incorporated in the normal brake system. The metering-type, anti-skid valves are used for each gear, one for the forward, and one for the aft wheels with cross-tie between the forward wheel valves and between the aft wheel valves. The skid signal is supplied by an electric wheel velocity transducer. The restulting change modulates the ratio of brake pressure to pilot force via the anti-skid valve, thereby preventing wheel skids.

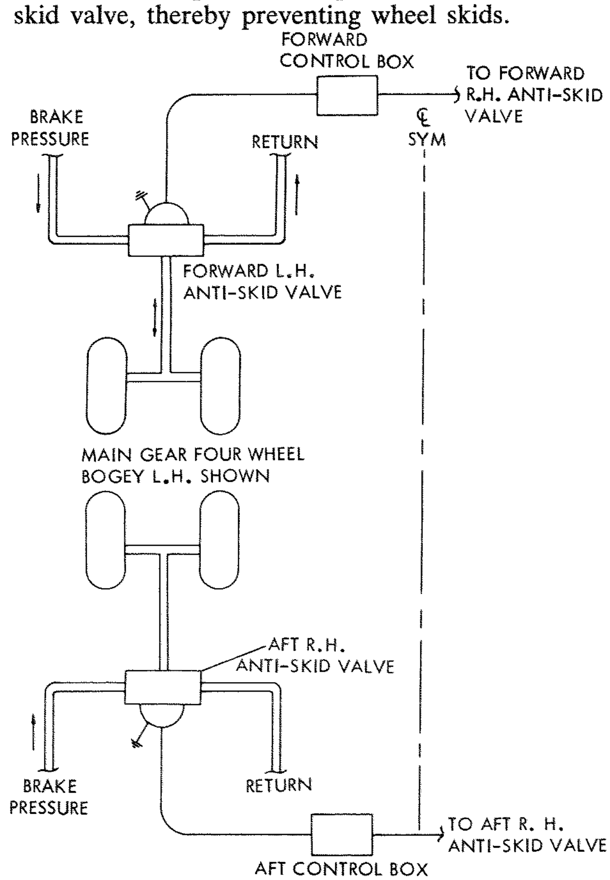


Figure 4-22—ANTI-SKID SCHEMATIC.

Emergency Operation

Emergency extension of the gears is by gravity free fall after cable release of the uplocks. The brakes are fully powered by a second hydraulic system for emergency operations. Separate power brake valves are installed for differential brake operation. Separate lines carry the pressure to shuttle valves adjacent to the wheel brakes. In addition, if the normal hydraulic power source fails, five full brake applications are available from an accumulator in the normal brake system.

Qualification Tests

The alighting gears are designed to be qualified according to the more stringent of the military on FAA requirements. A summary of the tests and applicable requirements is given in Section 3 of Volume 2.

Reliability and Maintainability

Reliability of the alighting gear is achieved by simplicity of design and use of proved design techniques. This philosophy is highlighted by the ability of the gear to free fall and by the use of completely mechanical actuation of the doors.

The shock absorbers can be readily filled with oil or pressurized using standard ground carts. Shock absorbers, wheels, brakes, tires, and antiskid and steering components are easily accessible for inspection or service. All struts or major components are readily removable for maintenance or replacement as assemblies.

Growth Potential

The alighting gear has a growth potential of 10 to 15% which may be realized by no more than a change of tires and wheels.

SUPER HERCULES · GL207-45

section 5

PROPULSION SYSTEM (5.1.5.6)

Description

The propulsion system of the airplane utilizes four P&W JT3D-4 turbofan engines mounted in individual pylon supported nacelles ahead of and beneath the wing. The general arrangement of the nacelle and engine installation shown in Figure 5-1. Propulsion sub-systems include conventional fuel, accessory, oil, pneumatic, anti-icing, electrical, and control systems.

Each QEC unit is interchangeable at all four engine positions. Each JT3D-4 turbofan engine is fitted with long ducts to discharge the fan exhaust at the aft end of the nacelle. These long ducts provide significant improvement in airplane performance, a simplified thrust reverser configuration, and a noise reduction. Each engine is fitted with a flight operable target-type thrust reverser. The pylon structure which supports the nacelle is primarily a closed box structure consisting of spars and closing bulkheads. The pylon provides support for the nacelle access cowl and duct assemblies which, when open, expose the entire length of the engine for maintenance.

The engine control system arrangement in the airplane is shown in Figure 5-2. The system is designed in compliance with the applicable sections of HIAD Volume 1, part C. The aircraft engine control system illustrated consists of a quadrant mounted lever for each engine on the center stand between pilot and co-pilot, pulleys and brackets, flexible cable push rods, and levers. Movement of the power levers on the control quadrant translates motion through rods and cranks below the quadrant to cables and then to the engine power lever to rotate it through an arc of movement.

The engine control system is designed to accommodate a two-lever-arrangement. With this arrangement the engine power and the thrust reverser are controlled with separate levers.

The engine mounted airframe accessories are listed in the airplane model specification, Volume 5.

Provisions for Sound Suppressor

The long duct engine offers a 2db noise reduction compared to a short fan engine, as noted in Paragraph 5.1.5.3.5, the GL 207-45 creates a noise level no greater than existing commercial jet aircraft. There is no anticipated requirement for sound suppressing of the exhaust section. To reduce fan inlet noise, an inlet kit consisting of a perforated liner may be installed, if required as part of the inlet cowling.

Propulsion System Fire Test

The useful data and information obtained in full-scale, nacelle fire evaluation tests is recognized. Lockheed has participated in such a program with the Air Force and the FAA recently on the C-130 nacelle fire test program. The design of the GL-207-45 incorporates all of the known features of fire protection. A full scale nacelle fire evaluation test would be desirable when a suitable facility is made available.

Propulsion Testing and Facilities

An engine test stand will be utilized in the development of the propulsion system. This stand consists of a complete nacelle, pylon, and a wing section which is adequate to permit thrust reverser operaion. The control house and instrumentation utilized in the C-140(JetStar) engine test program is available for this program. This test stand is necessary in the following programs: (1) engine-nacelle compatibility. (2) thrust reverser evaluation, (3) nacelle and oil cooling and (4) simulated flight endurance. Additional laboratory testing of subsystems will be conducted to insure compatibility of the anti-icing system, fuel system, complete pneumatic system, and fire detecting and extinguishing systems.

ENGINES (5.1.5.6.1)

Engine Selection

Performance

In the engine selection process, a preliminary evaluation of airplane performance with respect to mission requirements was made for the various contending engines. Consideration was given only to engines which (1) are domestic turbofans, (2) will be available before January 1964, and (3) produce at least 16,000 lbs. of thrust at sea level static. Those meeting these criteria have been categorized as (1) advanced engines, or those requiring major development, (2) engines requiring moderate development, and (3) engines available without development. For the cruise condition, engine performance and airplane drag were computed at 460 knots for a range of engine thrust settings, altitudes, and airplane weights. From these data a curve of the minimum fuel flow rate versus the airplane weight was determined. An integration of this curve between initial and final cruise weights provided cruise endurance and range at the constant airspeed. A payload-range curve was constructed holding initial cruise weight constant, basing final cruise weight on installed engine weight, and considering various combinations of payload and fuel. Figure 5-3 shows the relative airplane payload capability of each engine installation for a 4000-nautical-mile range.

The relative take-off capability of each engine is shown in Figure 5-4 for take-off weights consistent

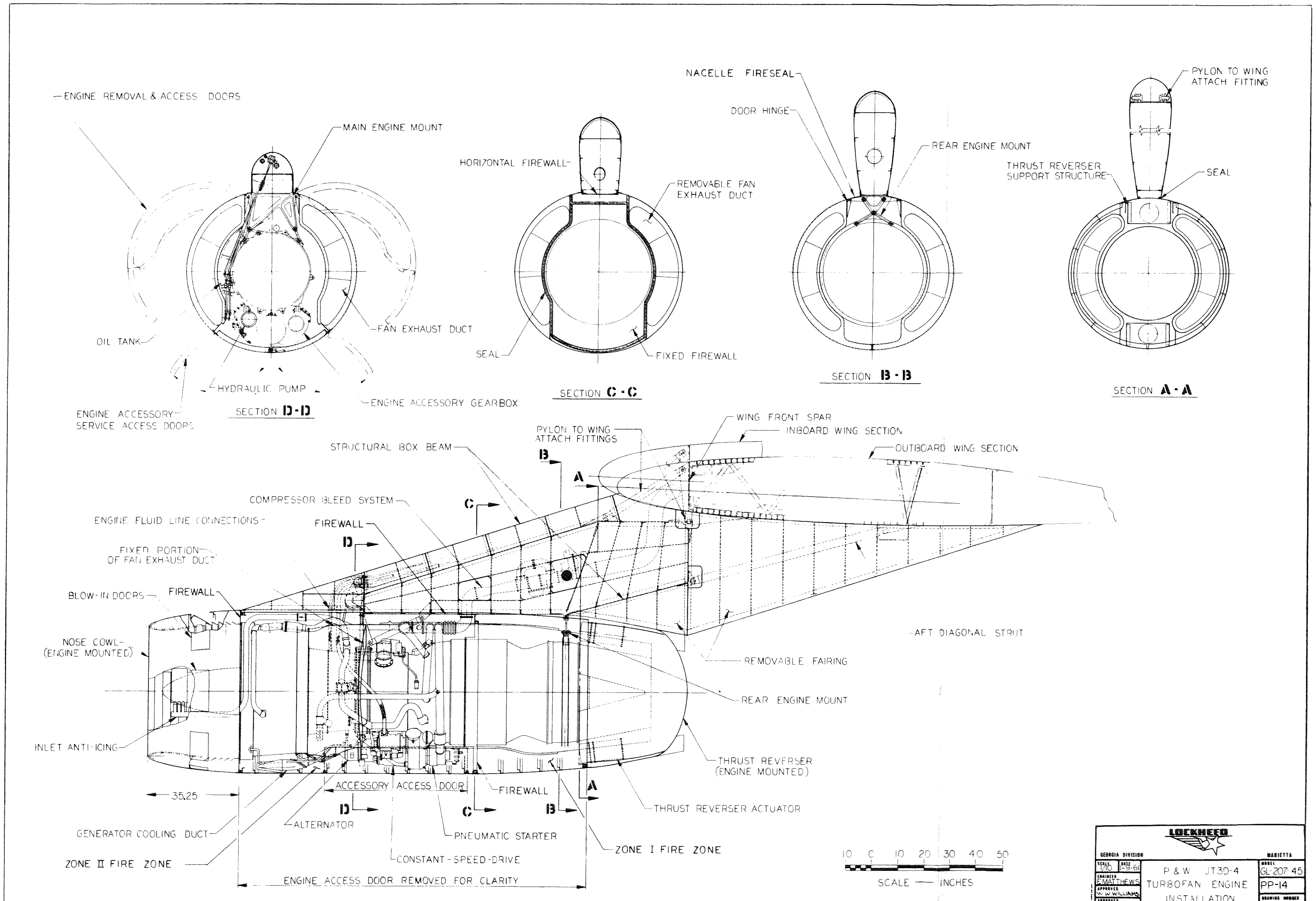


Figure 5-1—ENGINE INSTALLATION, INBOARD PROFILE, PRATT AND WHITNEY JT3D-4 ENGINE.

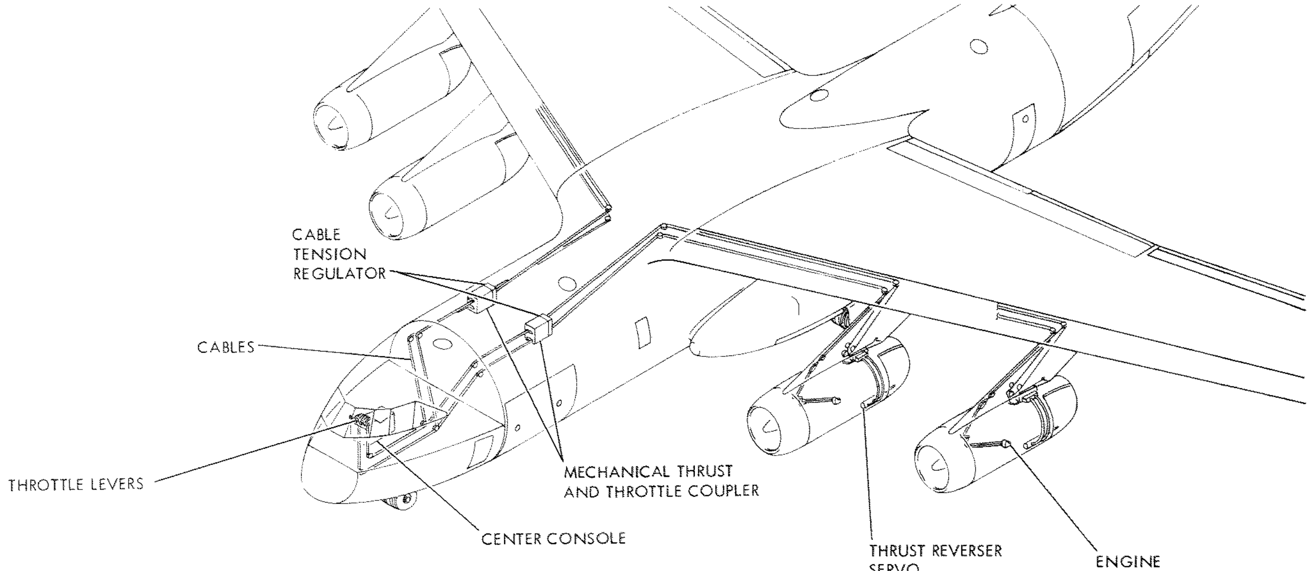


Figure 5-2—CONTROLS, THROTTLE AND THRUST REVERSER SYSTEM.

with the assumed initial cruise weight. Take-off distance is assumed to be inversely proportional to the difference between total engine net thrust and airplane drag at the root-mean-square velocity of the take-off run.

Figures 5-3 and 5-4 indicate the types of fan exhausts and thrust reversers considered. If an option was offered, the configuration selected is the one yielding the highest performance. In the case of the P&W JT3D-4 both options are shown. Comparison shows that the long fan exhaust duct in conjunction with a target-type thrust reverser provides 10% more payload capability than the short-duct, cascade-reverser. The difference in take-off distance is small.

The advanced GE MF239C-3 engine provides the best payload and take-off capability and is the comparison standard. Its quoted performance is significantly better than the other two advanced engines. Of the two engines requiring moderate development, the P & W JT3D-8A is superior. Of those engines available without development, the long-duct version of the P&W JT3D-4 is superior. The long-duct JT3D-4 provides the airplane with suf-

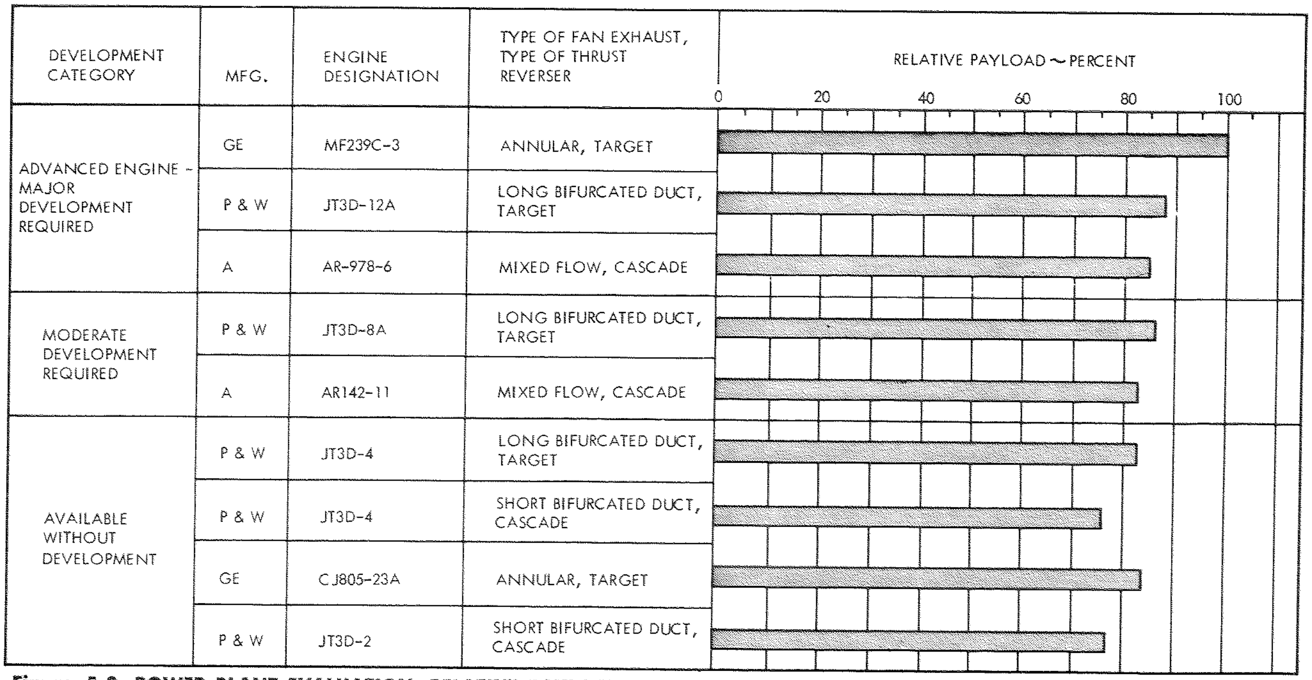


Figure 5-3—POWER PLANT EVALUATION, RELATIVE PAYLOAD CAPABILITY, RANGE- 4,000 NAUTICAL MILES.

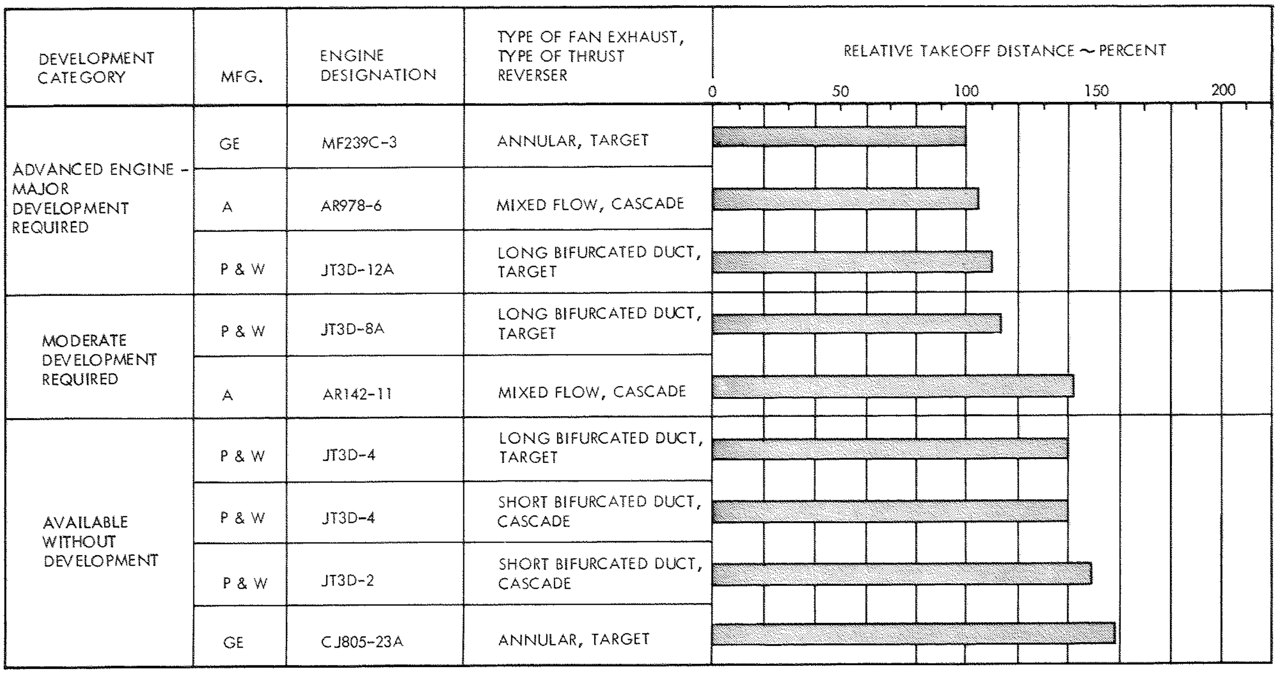


Figure 5-4—POWER PLANT EVALUATION, RELATIVE TAKE-OFF DISTANCE.

ficient capability to meet or better all requirements of System 476L. The JT3D-8A and the MF239C-3 provide performance in excess of requirements.

Similarity to Existing Engines

Of the engines potentially suited for use in the airplane, only the P&W JT3D-4 is directly related to an existing engine. This engine is developed from the TF33-P-3 (JT3D-2) by strengthening discs and changing some of the materials in the hot section. The TF33-P-3 turbofan, presently being flown in the B-52H flight test vehicle, is a direct adaptation of the J57 turbojet engine installed in the B-52, KC-135, F4D, A3D, F8U, F100, F101, F102, and Snark. The JT3D-3 which is the identical commercial version of the selected JT3D-4 is scheduled for production deliveries in June of 1961. The GE MF239C-3 engine is a new engine which combines the best aerodynamic and mechanical features of the J79, J93, and X211 engines. The Allison AR 978-6 is a new engine which is a scaled-up version of the RR163 engine. The AR978-6 utilizes the same engine thermodynamic cycle, pressure ratio, and bypass ratio as the RR163.

Engine Reliability Substantiation

The operating experience accumulated on the basic J57/JT3 gas generator is directly applicable to the JT3D-4 engine. As of January 1961, a total of 11 million engine operating hours have been accumulated on the J57/JT3 turbojet engines. Of this total 3¼ million hours have been accumulated on the JT3C engine by military and commercial operators. During this time, high engine reliability was evidenced by the average operating time of 21,780 hours between inflight shut-downs. The GE J79 engine design and operational experience provide a background for the MF239C-3 engine. As of December 1960, military and commercial versions of the J79 turbojet engine had accrued 280,000 hours. The CJ805-23 commercial turbofan will soon begin flight test in the Convair 990.

Status of Engine Development

The time required from go-ahead to delivery of production engines is a measure of the engineering effort and development time required to perfect the design of a new engine. The degree of confidence in the engine delivery schedules quoted for new engines is reduced as the development time estimated to perfect the design is shortened. Availability of production engines, in terms of months from go ahead, is as follows: 12 mos., P&W JT3D-4; 24 mos., P&W JT3D-8A; 30 mos. P&W JT3D-12A; 30 mos., GE MF239C-3; 41 mos., Allison AR 978-6; and 45 mos., P&W JT3D-8B.

Development of the P&W JT3D-4 is virtually complete since the commercial version of this engine is developed and production deliveries of FAA certified engines are scheduled to commence in June of 1961. The differences between the JT3D-8A and the JT3D-4 are (1) the airflow is increased, (2) a compressor stage is added, (3) the portion of the engine forward of the front-engine mount is lengthened six inches, and (4) internal hardware state-of-the-art improvements are incorporated. The JT3D-8A installation is interchangeable with the JT3D-4 since appropriate allowances are made for the larger fan exhaust ducts. The 1st run of 7,000 hours

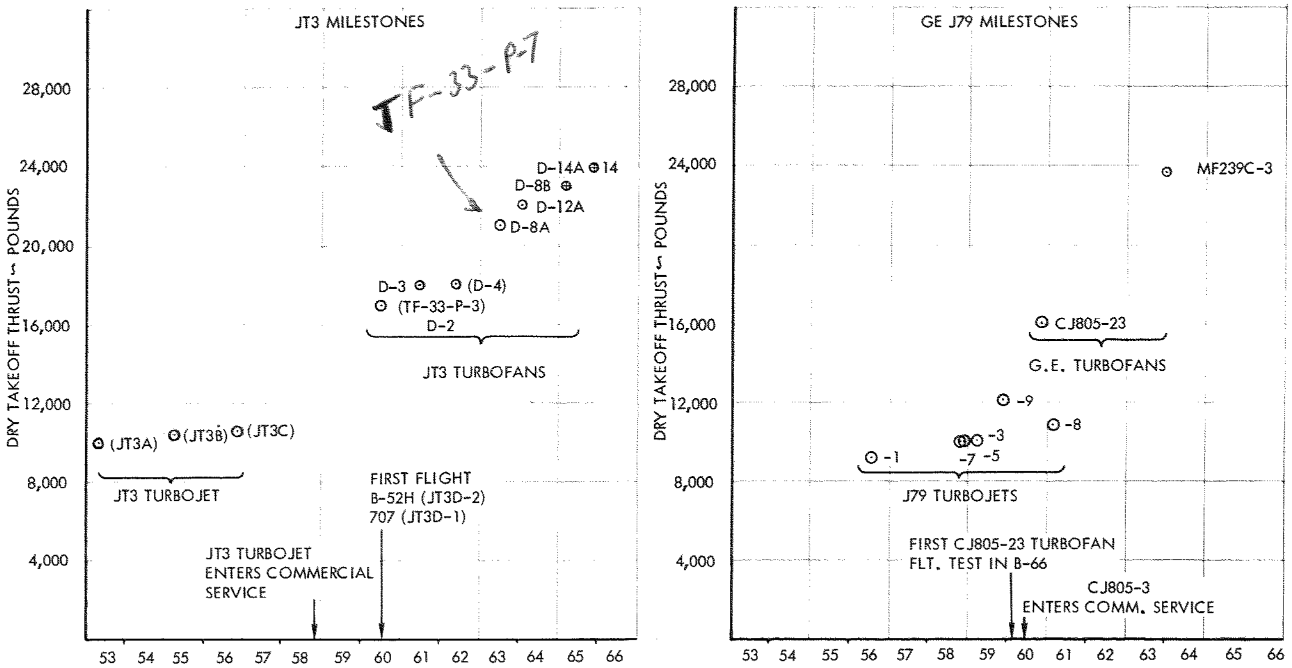


Figure 5-5—MILESTONE CHART, ENGINE DEVELOPMENTS.

full-scale development tests on the JT3D-8A was initiated in January 1961.

The JT3D-12A involves more internal changes to the basic JT3D-4 engine than does the JT3D-8A. These changes are (1) a fan stage is added, and (2) the turbine section is increased in both diameter and length. This engine, therefore, requires somewhat greater development effort than does the JT3D-8A. As previously noted, the MF239C-3 and AR978-6 are essentially new engines.

Engine Growth Potential

The growth potential of the contending engines is shown on the Milestones chart. Figure 5-5. The P&W family of JT3 engines offer two avenues of growth. The JT3D-4 can grow into the -8A, then into the -8B and achieve a take-off thrust increase from 18,000 to 21,000 and 23,000 lbs with a weight increase from 4179 to 4490 and 4600 lbs. The JT3D-12A can grow to the JT3D-14A and achieve a take-off thrust increase from 22,000 to 24,000 lbs at a weight increase from 4825 to 4975 lbs. The GE MF239C-3 and the Allison AR978-6 are both new engines and growth allowances are incorporated in their designs.

Results of Engine Selection Analysis

The major factor considered in the engine selection analysis include performance, similarity to existing engines, engine reliability substantiation, status of engine development and engine growth potential. Based on this analysis, the JT3D-4 engine has been selected to power the airplane for several reasons. Complete aerodynamic performance analysis shows the performance of the JT3D-4 to be adequate to insure that the proposed airplane betters every detailed requirement of system 476L. The JT3D-4 is nearly identical to the TF33 engine in the B-52H and is similar to the J57 engine, both of which are in Air Force inventory where material and maintenance support is presently available. The reliability of the J-57 engines, from which the JT3D-4 is a direct adaption, has been established in both military and commercial applications based on 11,000,000 engine hours of operation. The JT3D-4 engine together with the JT3D-8A and the JT3D-8B offers a program of early availability and reasonable growth based on accumulative experience. Growth engines can be accommodated in the original JT3D-4 nacelles by replacing only the fan discharge duct nozzles and the cowl inlet assembly and adding an adapter to the bifurcated fan exhaust ducts.

ENGINE CONTROLS (5.1.5.6.2)

System Description

The engine and thrust reverser control system arrangement is shown in Figure 5-2. This system is designed in accordance with the applicable sections of HIAD and will meet the requirements of the C. A. R. and military specifications. Control movements are initiated through manipulation of a double set of levers, in one quadrant assembly, installed in the crew station center console. The thrust reverser control levers are mounted to the rear of the power levers and are guarded to the retracted position. Each of these levers are connected by cables and push rods to the corresponding engine fuel control and thrust reverser actuating mechanisms. Features to reduce back lash, hysteresis and frictional losses are incorporated. The cables travel at least 6 in. Cable wrap on pulleys is minimized and tension regulators are used to maintain a nominal rigging load of 30 lbs. in all cables. Regulators are designed to lock immediately upon a cable failure so that the engine setting is not adversely changed.

The two systems are mechanically interlocked within the crew station center console such that advancing the power levers to the full forward position will automatically retract the thrust reversers and movement of the thrust reverser levers to the full extend position will advance the power levers to give 100% thrust from all four engines. This interlock feature is indicated on Figure 5-6. Initial forward movement of a power lever from the stop position opens the fuel control shut-off valve for that engine. At the flight idle position, the power levers drop a short distance onto a second track initiating the start of the inflight operating regime. From this position the power levers can be advanced to the take-off power position. To stop the engines, the power lever must be lifted onto the upper track and moved to the full aft position.

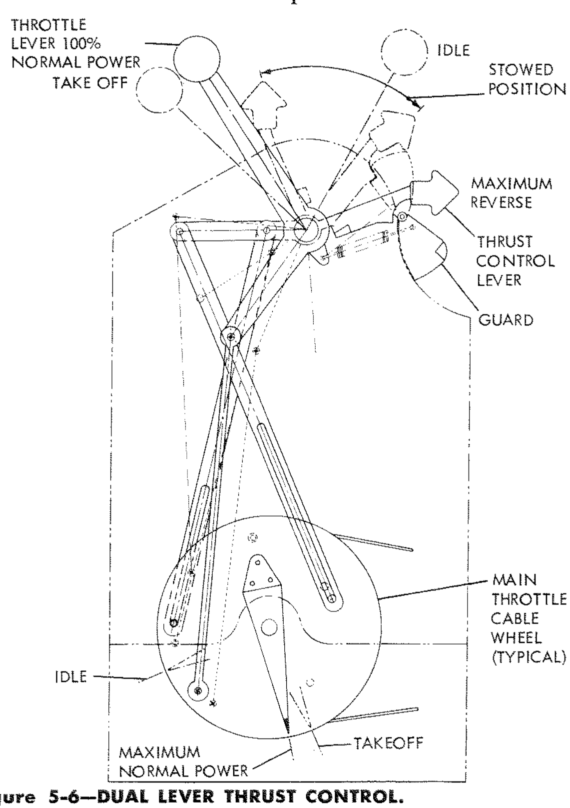


Figure 5-6—DUAL LEVER THRUST CONTROL.

Two hydraulic actuators are used to move the thrust reverser doors on each nacelle. They are controlled by one cable and linkage operated valve. The hydraulic power source and installation of the actuators and doors are discussed as part of the engine installation.

System Protection Features

The four thrust reversers are completely independent and are mechanically actuated. Since loss of any one reverser does not jeopardize the safe landing of the airplane, no emergency power source is provided. An electrical malfunction indicating system will warn the pilot in the event that any of the thrust reversers fail to operate in the normal manner. This warning system consists of a set of position indicators located on the main engine instrument panel, and a set of lights which indicate when the reversers are not stowed and locked. Should one of these lights come on during a landing when reverse thrust is used, the pilot need only to retard the corresponding power lever to the idle position. If hydraulic power to the actuators of any reverser is lost, the engine thrust and aerodynamic drag will drive the doors to a stowed or low-drag position.

Developmental Testing

A complete engine and thrust reverser control system will be installed on an engine test stand where the complete operation of the system can be checked under normal operating environmental conditions. The testing will include slam tests and operation with the engine off, operating at idle power, and at take-off power. These tests will be initiated as soon as a production engine and nacelle assembly become available.

Growth Potential

The system is designed such that modulation rather than two-position actuation, of the reversers can be provided with changes only to the control values and their actuating linkages.

ENGINE STARTING SYSTEM (5.1.5.6.3)

Description

The pneumatic engine starting system provided operates on bleed air from the APU or from another engine. Air is supplied through the existing engine bleed ducting. The system consists of light-weight air turbine engine starters, control valves, flight station controls, and short duct sections. The design is conventional and service proved.

The starter, similar to the Hamilton Standard PS400-12 used on the B-52 airplane, is externally modified to incorporate a containment shroud and an oil dip stick in compliance with CAR 4b.

The starting cycle is controlled from the engine-start control panel located on the flight station overhead panel and convenient to the pilot. During the automatic starting cycle, control relays are actuated to provide the engine with the correct fuel and ignition supply for a normal engine start.

HIAD requirements establish environmental design criteria for the starting system. The system is designed to start the JT3D-4 engine utilizing only the airplane auxiliary power unit (APU) throughout the ambient temperature range of –65°F to +125°F Furthermore, an engine start can be made at an airport elevation of 6000 feet on a +100°F day.

The same design criteria produced the successful start performance, under extreme environmental conditions, of the C-130 air turbine starter and gas turbine compressor as shown in Figure 5-7, the starting system is designed to deliver a starting torque for the JT3D-4 engine within the torque range band recommended by the engine manufacturer.

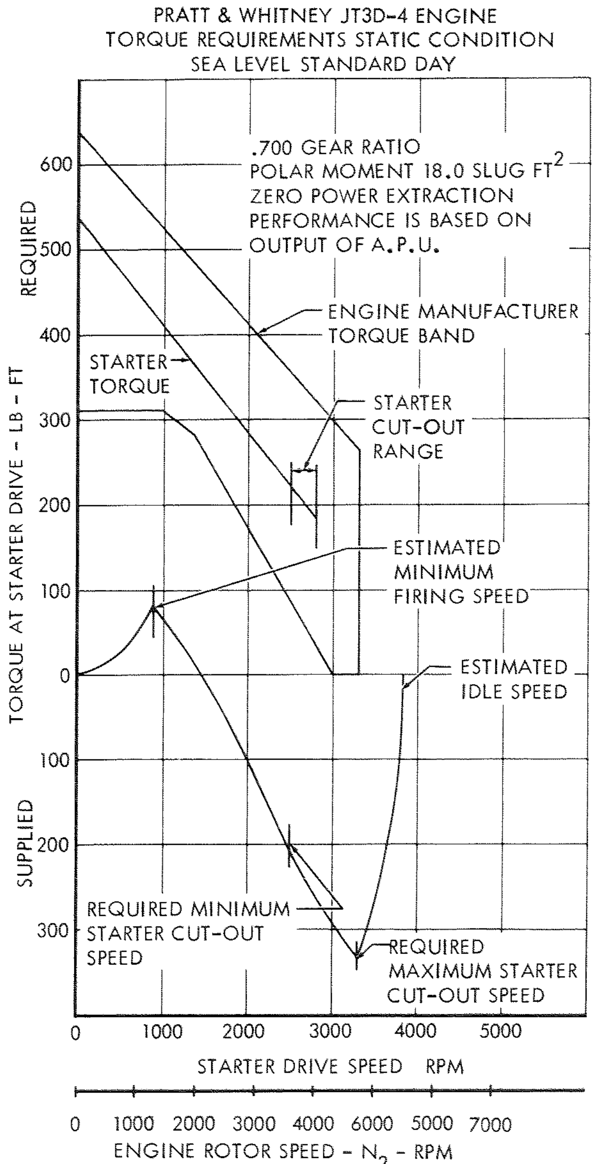


Figure 5-7—STARTING SYSTEM PERFORMANCE.

Failure Analysis

If the centrifugal cut-off switch in the starter fails to de-energize the holding relay for the pressure control valve at the proper engine cut-off rpm, pulling out the starter control button will shut off the air supply to the starter. In the event of an electrical failure, the control valve automatically closes. If a control valve fails and above limit air pressure exists at the starter inlet the starter is protected by an integral pressure limiting valve in the starter. Containment of the starter high-speed rotating components prevents injury to personnel and damage to the aircraft if any part of the rotating machinery fails.

Design and Development Testing

Compatibility tests to demonstrate suitability of the engine starter and associated components are to be conducted on the engine test stand prior to the aircraft flight test program.

Maintenance

Maintenance requirements are minimized by providing a quick-attach-detach (QAD) V-band clamp to allow rapid and convenient installation or removal of the starter from the engine pad. Other than periodic check of oil level, no servicing is required during the overhaul life.

FUEL SYSTEM (5.1.5.6.4)

Description

Figure 5-8 shows the basic fuel tank arrangement to have eight tanks consisting of one main and one auxiliary tank for each engine. A center wing bladder tank completes the total fuel requirements for long range or increased speed missions. The total usable fuel capacity including the extended range tank is 23,080 U. S. gallons and 19,630 gallons not including this tank.

The four main and four auxiliary tanks, as shown on Figure 5-9 are of conventional integrally sealed construction as used on many previous Lockheed aircraft including the C-130 series. The center wing extended range tank consists of interconnected bladder cells contained within an integrally sealed liquid tight compartment. Each tank has an independent wrap-around type vent system terminating at a vent sump box. The vent sump boxes are exhausted to atmosphere at the lowest surface of the wing through non-icing, flame proof outlets. A common sump box is used for several tanks in some instances. Fuel which may be sloshed into the sump boxes is returned to the tank by means of an ejector, which uses main tank boost pump bleed flow as a motive source. Each main tank contains a reservoir which is kept full under all flight conditions through use of a similar ejector system.

There are two ejectors in each main tank, one located at the aft outboard corner to pick up fuel during climb and the other located at approximately the center of the tank to keep the box filled during level flight. Check-valves along the bottom of the box allow inflow of fuel with a nose down attitude. A dual source of pressure is available for the ejector system and since the ejector nozzle

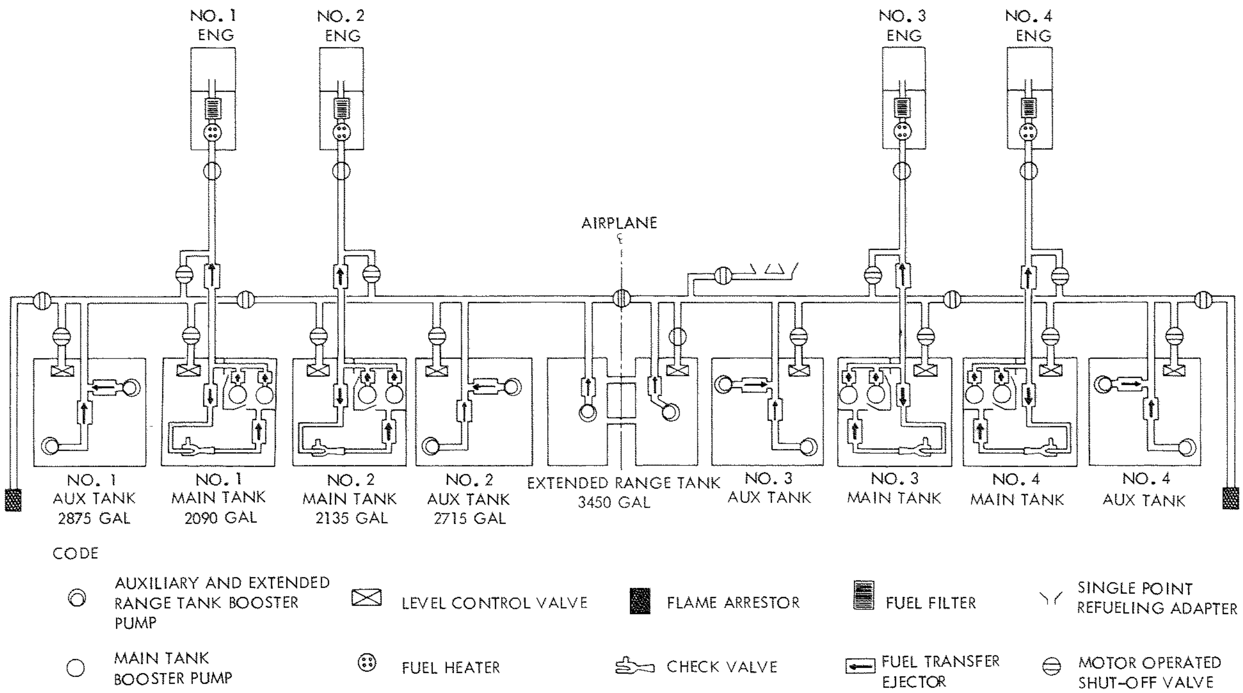


Figure 5-8—FUEL SYSTEM DIAGRAM.

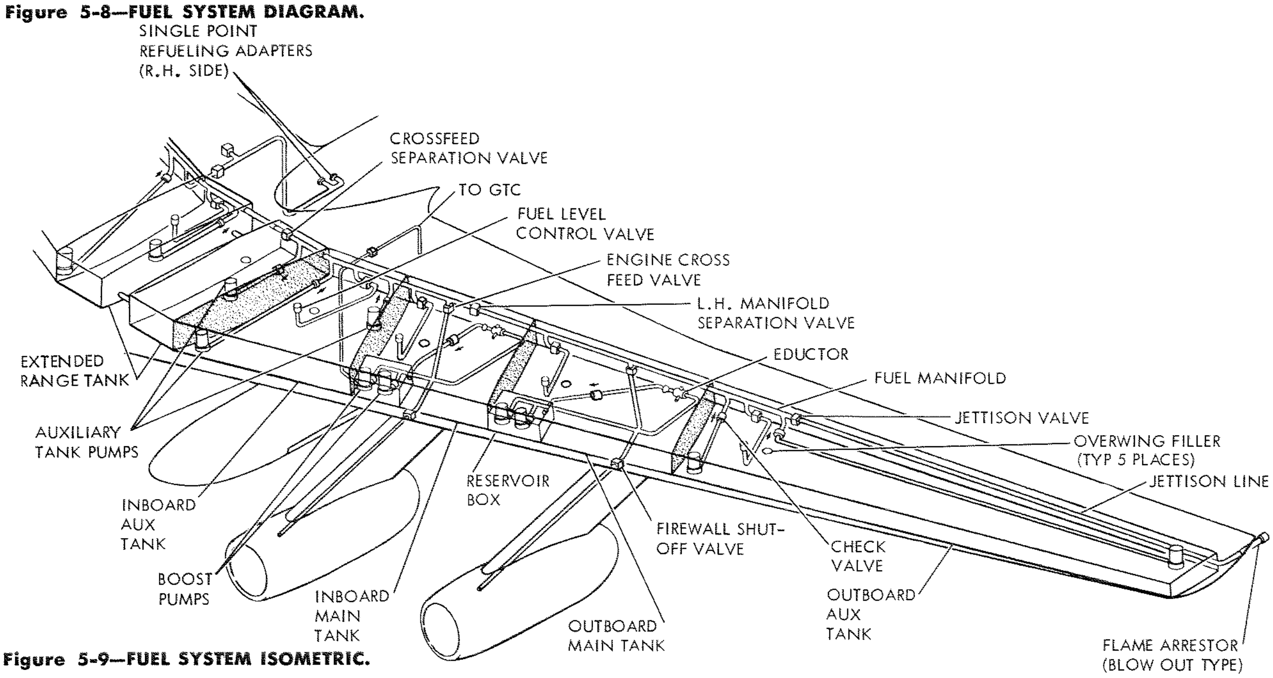


Figure 5-9—FUEL SYSTEM ISOMETRIC.

openings are larger than the boost pump inlet screen opening, the chance of nozzle plugging is remote.

All tanks contain two identical plug-in-type pumps, powered and controlled from separate electrical busses to give maximum reliability and serviceability. The main tank pumps are designed with dual impellers and inlets that, as long as the covered reservoir is full, the upper inlet will provide positive pressure for limited periods (approx. 20 seconds) of negative or zero gravity flight. The outboard location and length of the No. 1 and No. 4 auxiliary tanks may require the incorporation of a surge baffle fitted with gravity controlled valves to prevent excessive tip pressures during roll or slip maneuvers.

The refueling provisions for each tank consist of a connection to the fuel manifold, an electric motor operated plug-in-type valve, and a hydraulic float-type level control valve. The motor operated valve is controlled by the fuel gaging system so any desired quantity of fuel may be loaded by presetting the fuel gage on the ground refueling panel. The hydraulic valve acts as secondary shut-off device when less than full tank is required, but normally acts as the primary shut-off when filling the tank. Prechecking for both systems is provided. Two flush-type refueling adapters located in the RH aft landing gear fairing are connected to the fuel manifold with a 4 in. line. A shut-off valve and air bleed valve permit suction or gravity draining of this line after refueling. A fuel manifold, consisting of a 3 inch line, extending from left wing tip to right wing tip, is used for crossfeed, jettison, refuel, and defuel operations. The three separation valves, center RH and LH are normally closed and serve to maintain spanwise balance as well as an independent fuel supply to each engine.

A dump outlet and valve at each end of the fuel manifold is provided for jettisoning. The auxiliary tank pumps have been sized so a jettison rate in excess of 1½% of the airplane gross fuel per minute is possible. Normally during jettison the crossfeed valves are closed to maintain independent, engine feed; however, fuel may be jettisoned from the main tanks if desired by opening these valves. Defueling of tanks is accomplished by use of the tank booster pumps through a connection to the single point adapters. Two-inch diameter engine feed lines are routed from the pumps in each main tank through the front beam and pylon to the engines. An emergency shut-off valve at the tank exit and a low-pressure warning switch at the engine inlet are provided in each of these lines.

Fuel filtration and anti-icing provisions are furnished by the engine manufacturer so that no airframe strainers other than booster pump inlet screens are provided. The engine mounted filter, which protects both the engine driven gear pump and the fuel control, has a pressure drop switch to warn of impending filter clogging due to icing or contamination. The engine mounted bleed air fuel heater is normally operated on a time cycle, one minute on and 30 minutes off, but can also be operated on an indication by the filter pressure drop warning light.

Design Features

1 One main tank for direct supply to each engine

2 At least two sources of pressure to each engine at all times

3 Each combination of main tank plus is adjacent auxiliary tank has approximately equal capacity to minimize crossfeed operation

4 No single failure can prevent use of fuel under pressure from any tank

5 No fuel transfer from tank to tank in flight

6 Minimum of fuel management required for all aircraft missions

7 Main tanks sized so that jettisoning from these tanks is not required to reach landing weight with maximum cargo.

8 Jettisoning from any or all auxiliary tanks while maintaining independent main tank to engine feed

9 Jettisoning possible from main tanks

10 No single failure can prevent jettisoning from any auxiliary tank

11 All fuel lines routed inside tanks to minimize hazards of leakage

12 All operating components except check valves replaceable without draining tanks or lines

13 Vent systems designed to prevent structural damage in event of level control valve failure. Complete elimination of vent valves

14 All fuel tanks and lines located outside the pressurized compartment of the airplane

15 Each valve or pump used in flight is controlled by a single switch. No electrical interlocks or overrides in fuel system control

System Operation

The design and operation of this system is based on the principle of selective use of fuel from the various tanks as a function of pump output pressure. The auxiliary and extended range tank pumps have been designed such that under all flight conditions they operate in a pressure range which exceeds the no-flow pressure of the main tank pumps. It is, therefore, possible to operate with a main tank and an auxiliary tank furnishing pressure to the engine and still use all fuel from the auxiliary first. This assures that the engine will still have positive pressure when the auxiliary tank runs dry or if either pump should fail in flight.

For all combinations of cargo loading and range, the main tanks are filled first, additional fuel, if required, is divided equally between the four auxiliary tanks, and finally the extended range center wing tank is used. For all missions not requiring extended range fuel the entire flight is made without ever opening or closing a valve.

A detailed discussion of the fuel system operational principles, valving, and failure analysis is given in Section 4 of Volume 2.

OIL SYSTEM (5.1.5.6.5)

An integral engine lubricating system which circulates MIL-L-7808 oil for engine bearing and accessory-drive gear box lubrication is provided on each engine. All components except the supplementary air-oil cooler and its plumbing and controls are furnished by the engine manufacturer.

Oil Coolers

The external oil system contains two oil coolers in series (one engine-furnished and one airframe-furnished), associated valves, stainless steel plumbing and a stainless steel oil storage tank. The engine furnished fuel-oil cooler will maintain the engine oil at approximately 200°F under most operating conditions; however, it is not adequate to meet the full oil cooling requirements of the engine for some ground and flight conditions. The airplane-furnished supplementary engine oil cooler is designed to permit all-weather engine operation under all anticipated ground and flight operating conditions, including ground static take-off thrust operation with 125°F ambient air temperature and 135°F fuel temperature. The airplane-furnished oil cooler for the constant speed drive unit (CSD) meets the above operating envelope with minor generator power restrictions at 125°F ambient air temperature. Performance of the supplementary engine oil cooler as well as the CSD oil cooler is discussed in Section 4 of Volume 2. Both oil coolers are basically the same in size and configuration but have separate oil supplies. The airframe-supplied supplementary engine and CSD coolers are installed in the bifurcated portion of the fan exit ducts as shown in Figure 5-10. The coolers actually form a portion of the duct wall and are fabricated with finned air surfaces and finned oil passages. Each unit is provided with a self-contained, thermostatically-controlled flow control valve. There are no deviations to the military requirements for oil coolers and the development, qualification, and the test schedule of the oil coolers parallel that of the engine oil system.

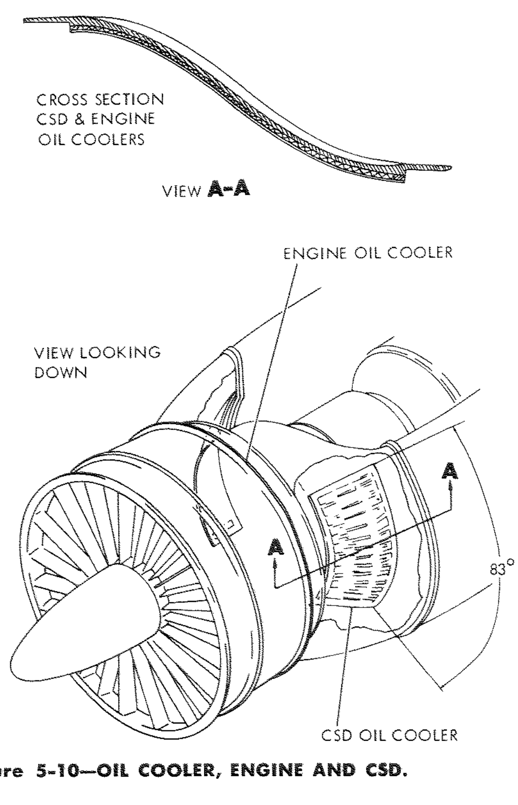


Figure 5-10—OIL COOLER, ENGINE AND CSD.

Engine Oil Tank

The engine oil storage tank is sized to provide sufficient lubricating oil for a maximum endurance mission of more than 15 hours. The filler neck for the oil tank is accessible through a door in the side of the nacelle cowl. An oil shut-off valve is in the tank discharge line to shut off the oil supply in the event of a fire. A low oil level warning light is provided as required by HIAD. The oil tank is designed to be compatible with all of the airplane normal and emergency flight attitudes.

ENGINE INSTALLATION (5.1.5.6.6)

Nacelle and Thrust Reverser Selection

In the selected nacelle configuration, the fan discharge air is carried to the rear of the engine in a bifurcated ducting system and is exhausted at the same station as the hot exhaust gases. A single target-type thrust reverser is used. This long duct configuration is preferable to any short duct arrangement because it provides better performance, a simpler thrust reverser, better accessibility, more available space, a simpler QEC and better accommodation of growth engines. A complete discussion of the nacelle and reverser configuration selection appears in Section 4 of Volume 2.

Nacelle Contours

A circular inlet reference (or lip-leading-edge) area of 1912 sq. in. has been selected. This area is the maximum that can be utilized without developing significant drag divergence on the nacelle forebody while at typical cruise flight conditions; therefore, the induction system total pressure recovery is the maximum consistent with attainment of maximum cruise performance. The nacelle forebody contours conform to NACA 1-Series coordinates from the inlet lip to the maximum cross-section.

The nacelle afterbody conforms to a tangent-parabolic contour, the boattail reaching a nominal 16 degree angle at the base where base-minus-jet area is approximately 8.5% of the maximum nacelle cross sectional area. The estimated afterbody pressure drag coefficient for this configuration is 0.013, based on the maximum nacelle cross sectional area and a speed of mach 0.8. drag coefficient corresponds to a net thrust loss of about 1.25% in the cruise condition. The net base area necessary for the installation of a target-type thrust reverser contributes about 25% of this loss. The afterbody drag of the long duct configurations, including base, is considerably less than that of any short duct configuration even when a fully boat-tailed body is considered for the latter.

Induction System

The engine air induction system, shown in Figure 5-1, consists primarily of a short annular diffuser with low contraction entry and exit sections. Complementing the basic system, an auxiliary induction system supplies airflow, when required, through eight pressure-actuated blow-in doors located on the periphery of the forebody. Maximum induction system total pressure recovery at critical flight conditions and minimum forebody weight and drag have been achieved by several means. The use of a specially designed compressor hub fairing as the centerbody for an annular diffsuer permits a 50% reduction in duct length as compared to conventional design. This approach further permits a 10% decrease in overall nacelle length with a corresponding 0.4% reduction in airplane cruise drag. Since the reference, or lip leading edge, area is set by external flow considerations, the use of a thin internal entry lip permits an increase in throat area which results in less internal diffusion losses and high total pressure recovery at cruise. The use of an auxiliary induction system (blow-in doors) provides distortion relief and total pressure increase for high-thrust low-speed operating conditions.

The diffuser design length is the absolute minimum necessary for efficient diffusion. Based on the empirical performance data from Reference 7, an annular diffuser, near optimum for the required area ratio and cruise inlet Mach number, has been selected. The exit-to-inlet area ratio is 1.079, the overall equivalent conical angle of expansion is 6.4 degrees and, as shown in Figure 5-11, the maximum local value of this design parameter is held to 10 degrees. For the inlet lip selection, the interrelated effects of lip shape, inlet area, and internal contraction ratio on nacelle drag and diffuser performance were considered. Data from Reference 8, 9, and JetStar flight tests were utilized. The selected lip, designated 13E, has a 3.6 to 1 elliptical profile and defines an inlet leading edge area 13% greater than the duct entrance area. The auxiliary induction system is designed to relieve local pressure depressions in the portion of the duct just preceding the compressor. The eight spring-loaded doors, when duct suction reaches a pre-determined level, open to pass air into an annular plenum surrounding the engine duct. Fixed aft-facing louvers in the duct wall permits this air to join the main stream.

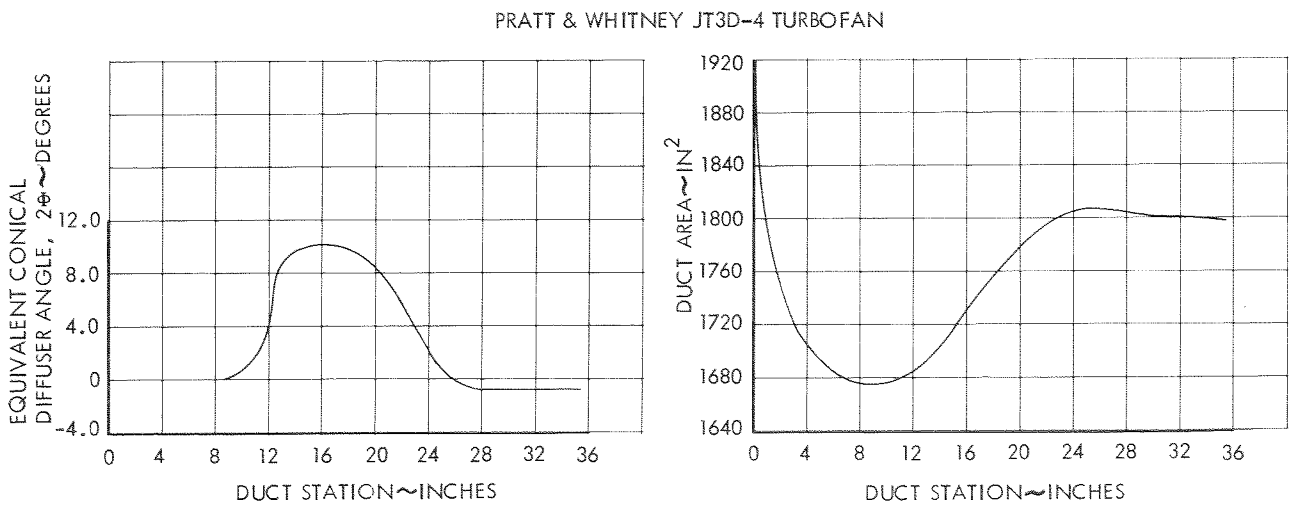


Figure 5-11—INLET DUCT CHARACTERISTICS, PRATT AND WHITNEY JT3D-4 ENGINE.

In order to prevent the injection of foreign objects into the engine inlet, a blowaway jet is incorporated. The jet nozzle diameter is 0.51 in.; the bleed air requirement is approximately 0.3% of the engine primary airflow. This bleed is automatically turned off at nose-wheel lift-off in order minimize its effect on take-off performance.

Nacelle Cooling

The compressor compartment cooling requirements are established by a 250°F temperature limit for the nacelle structure and some of the auxiliary components located in this area. The aft compartment cooling is determined by a 500°F temperature limit of the nacelle structure. Sufficient airflow is provided to maintain temperatures within these allowable limits for all ground and flight conditions including operation at the sea level static condition with 125°F ambient air temperature. A forward-facing louvered inlet is provided on the bottom of each compartment. Exits, located in each compartment near the top of the nacelle, are also the mixing section of ejectors designed to pump the required cooling airflow during ground operation. The primary air for these ejectors is provided by fan discharge bleed and is automatically turned off during take-off at nose wheel lift-off. A small but adequate cooling airflow is assured for all flight conditions by the slight ram recovery of the louvered inlets and by the location of the exits in an area of relatively low nacelle surface static pressure.

Pylon

The pylons and attachments to the wings are designed to permit interchangeability between pylons numbers 1 and 2 and between numbers 3 and 4. As illustrated in Figure 5-12 the attachment consists of two forward fittings and one aft fitting.

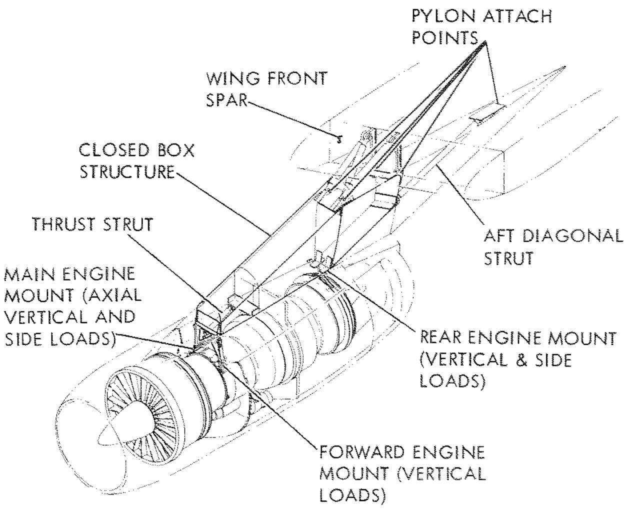


Figure 5-12—ENGINE MOUNTING AND PYLON STRUCTURE.

The pylons are conventional closed box construction, consisting of upper and lower spars with closing bulkheads and stiffened skin. The primary material is aluminum alloy. The lower spar caps, aft diagonal strut, and wing attachment fittings are of high strength alloy steel. The lower spar web and forward vertical bulkhead which serve as firewalls are fabricated from stainless steel. The pylon leading edge is adequate for resistance to hail. The aft removable fairing is supported from the diagonal strut and is designed to resist sonic fatigue.

Thrust, vertical, side and engine seizure loads are transmitted through the forward engine mounts into the pylon and are reacted by combined loads in the diagonal strut, front spar fittings, and diagonal brace fittings respectively.

Pylon Attachment

Pylon attachments are designed for load factors equal to or greater than any encountered in flight or landing. Consideration was given to the use of pylon attachments designed to fail at predetermined loads lower than those which would result in structural damage to wings and fuel cavities during wheels-up or controlled crash landings when the nacelles might provide the initial ground contact. Scale model studies of the GL 207-45 were used to determine areas of contact. The loads imposed upon the pylon attachment in this event are calculated to be within the design strength of the wing at the pylon attachments, and wing spring-back tends to roll the airplane to the horizontal where the fuselage will absorb the contact loads.

The design of this airplane thus prevents the detachment of the powerplants which could become missiles and add to the hazard in a crash; it precludes failure of the pylon attachment due to the application of unpredicted combined loads in flight; and avoids the complexity, cost, and weight of providing means for automatic decoupling of powerplant controls and fluid lines.

Fan Discharge Ducts

As shown in Figure 5-1 three complete duct sections are provided for the discharge of fan air at the aft end of the engine. The bifurcated section of the duct is attached to the fan discharge flange. In the bifurcated section the air from the entire periphery of the fan is divided into two separate ducts which extend aft on either side of the engine. About 20 inches aft of the fan discharge flange is a duct split line, where the bifurcated section ends. The entire section of the duct aft of the split line is built as part of the nacelle access cowl so that it can be raised to expose the engine for maintenance. A suitable seal is provided at the duct joint to prevent leakage. The duct from the fan discharge flange to the aft end of the engine is to be developed by Lockheed in close coordination with Pratt and Whitney.

Nacelle Access Cowl and Fan Discharge Duct Assembly

This assembly, shown in Figure 5-1, is supported at the top from the pylon mid fairing by appropriate hinge fittings. Fireproof seals are provided on the door assembly at the nose inlet cowl split line, at the vertical, engine-mounted firewall, at the fan duct forward split line, and at the thrust reverser split line. These doors are of conventional aluminum alloy frame and skin construction, except for the titanium across the upper 80 degrees (40 degrees each side of vertical centerline) of the nacelle cowl and duct assembly forward of the fan discharge duct split line. The titanium inner skin of the long ducts provides the firewall aft of the fan discharge duct split line. The doors are latched to each other at the bottom centerline with six hook tension latches. Pins adjacent to the latches absorb shear and maintain alignment.

The nacelle access cowling supports the fan discharge duct between the titanium fixed portion of the fan discharge duct on the engine, and the thrust reverser split line. As these sections of duct open with the doors, fireproof seals are provided on the ducts at these connections as illustrated in Figure 5-1. The discharge ducts are protected from a nacelle fire by the use of titanium on the inner surface of the duct forward of the vertical firewall.

This titanium skin contains fire within the nacelle in this area, thus improving the effectivity of the fire extinguishing discharge during a nacelle fire.

As illustrated in Figure 5-1, non-structural engine accessory access doors are located in the bottom of each access cowl and duct assembly. Spring-loaded doors are provided to prevent the build up of internal pressure within the nacelle in the event of a compressor bleed manifold rupture.

Quick Engine Change Unit

The QEC unit assembly shown in Figure 5-13 consists of the JT3D-4 engine, and all equipment, accessories, piping, and wiring which are attached to the engine and removed with the engine.

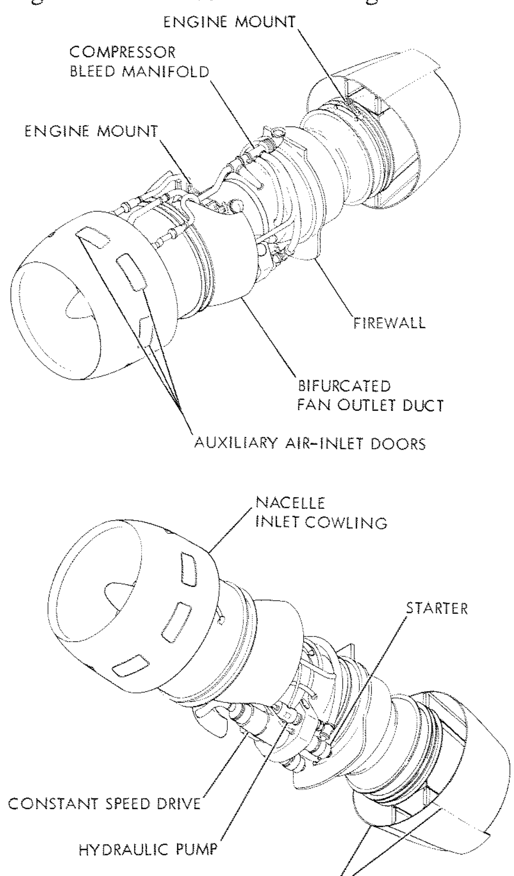


Figure 5-13—ENGINE QEC, PRATT AND WHITNEY JT3D-4 ENGINE.

The major components installed on the basic JT3D-4 engine include the thrust reverser, alternator and constant speed drive, hydraulic pump for the aircraft system and thrust reverser system, pneumatic starter, nose cowl, compressor bleed manifold, constant speed drive oil cooler, and supplementary engine oil cooler, compressor inlet bullet fairing, engine oil tanks, fuel-oil cooler, and all of the oil lines and electrical harness furnished by the engine manufacturer as a part of the engines.

The QEC unit is readily installed or removed as a complete package requiring only the disconnecting of engine mountings, bleed air manifold, fuel and hydraulic lines, electrical connectors, and controls.

THRUST REVERSER

Description

The thrust reverser arrangement shown in Figure 5-14 has two large blocker doors which rotate aft and toward the centerline of the engine exhaust during extension. The doors are supported by upper and lower linkages and actuated by two track-guided hydraulic cylinders. The door linkages pivot about hinge lugs built integrally with upper and lower box support beams. The support beams are attached to the engine tailpipe and turbine casing flanges and provide rigid support for the linkages, doors, and actuators.

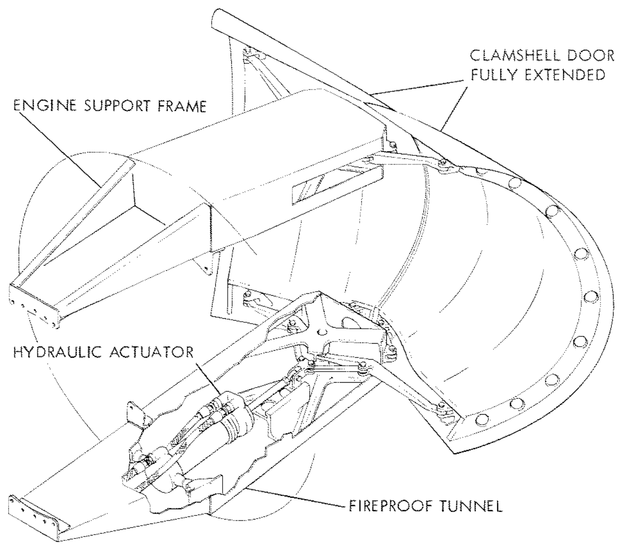


Figure 5-14—THRUST REVERSER ARRANGEMENT.

Design Features

The target-type reverser was selected because of improved engine performance, design simplicity of the doors and actuating mechanism, improved reliability, and reduced weight and cost.

The thrust reverser hydraulic actuating system is completely self-contained on the engine. An engine-driven hydraulic pump provides the power for the movement of the actuators. A fireproof tunnel isolates the hydraulic actuators from the hot exhaust tailpipe.

A hydraulic system was selected to actuate the thrust reverser doors because the linkage can be designed so that the doors fail-safe in the forward thrust position. Furthermore, the hydraulic system insures that the doors can be actuated inflight when the engine is at idle power. The hydraulic system also allows the incorporation of the thrust reverser position modulation feature if this capability is desired to improve the inflight performance of the airplane.

SUPER HERCULES · GL207-45

section 6

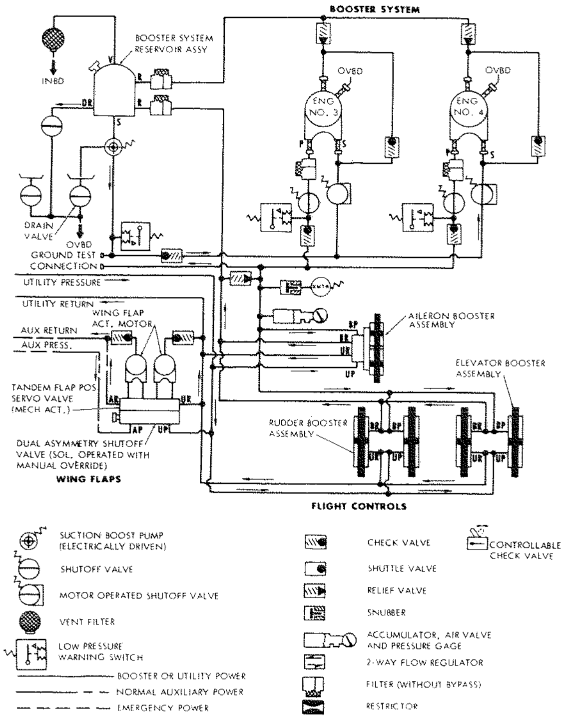
SECONDARY POWER SYSTEMS (5.1.5.7)

HYDRAULIC SYSTEM (5.1.5.7.1)

The hydraulic system shown in Figure 6-1 is comprised mainly of three independent subsystems providing power for flight controls, booster, utility, and auxiliary functions. Each is designed to meet the requirements of MIL-H-5440C except that fire resistant fluid, Skydrol 500A, and seals, materials, and finishes compatible therewith are used. In all other respects, the systems meet the requirements of HIAD and CAR 4b. The systems can be easily converted to use MIL-H-5606 hydraulic fluid by replacing all seals with their compatible counterparts. These systems are Type II, 3000 psi and are designed for maximum system temperature for 220°F. A fourth independent system provides power for the forward cargo door and is identical to the system presently used on the C-130.

System Description

The booster and utility systems each utilize two engine driven variable volume, constant pressure pumps and power dual or tandem actuators of the primary flight controls. The maximum output flow is proportional to engine speed and for each pump varies from 13 gpm at idle to 22 gpm at cruise and take-off. Electric driven suction boost pumps are installed in both the booster and utility systems to provide a positive pressure at the inlet of the engine driven pumps. The booster system powers half of the



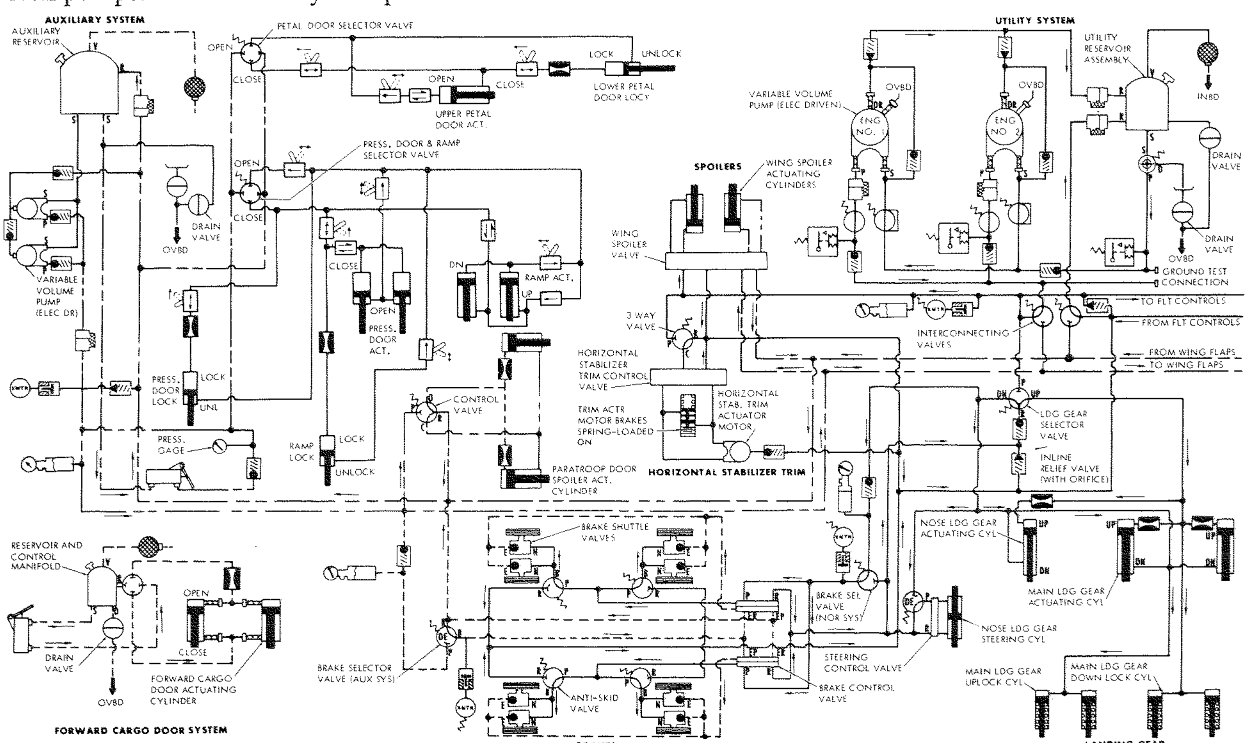


Figure 6-1—HYDRAULIC POWER SYSTEM SCHEMATIC.

primary flight controls of aileron, elevator, and rudder only. In addition to powering the other half of the dual primary flight controls, the utility system powers landing gear extension and retraction, nose wheel steering, normal wheel brakes and the primary mode of horizontal stabilizer trim. Both utility and auxiliary systems furnish power to dual actuators or motors driving the secondary flight controls, spoilers, and flaps. The auxiliary system also supplies normal power for operation of the ramp, pressure door, aft fairing doors, and auxiliary paratroop spoiler doors. It also supplies emergency power for wheel brakes. The auxiliary system is powered by two AC electric motor driven variable volume pumps identical to units used on the C-130. Each pump has a maximum output of 8 gpm and runs essentially at a constant speed. Reservoir location provides a positive head of oil to these units which have a self contained centrifugal boost pump to provide additional inlet pressure. A handpump is provided for power-off operation of the auxiliary system. A second handpump supplies power for the forward cargo door system.

Instrumentation for the hydraulic system is divided between the system engineer's panel and the co-pilot's side of the main instrument panel. The systems engineer is provided with pressure gages to indicate utility, booster, and auxiliary system pressures. The systems engineer is also provided with auxiliary pump switches, four firewall isolation shutoff switches, two suction boost pump low pressure warning lights and switches, and a low pressure warning light for each engine driven pump. The co-pilot's panel contains a dual indicating pressure gage to furnish an indication of brake pressure available from both the utility and the auxiliary system. This panel also contains a brake select switch for selecting normal or emergency (auxiliary) brake pressure, an auxiliary pump switch, an anti-skid control switch, and an "anti-skid inoperative" light.

Design Features

Several system features and components are used to increase system reliability and reduce maintenance. MS flareless fittings with steel nuts are used throughout the system because of their superior sealing characteristics, proven in service on the C-130B and all commercial operating jet aircraft. The "black box concept" is used on all valve panel assemblies to permit rapid recognition of malfunctions and reduce complexity of component removal. The use of teflon hose assemblies and the elimination of elastomeric seals from check valves, restrictors, and other simple valves increases service life of these components. To reduce maintenance and insure clean systems, all oil is filtered before entering the reservoir through the no by-pass return line filters having external indication of the need for filter element change.

The primary flight controls require 15 gpm maximum which can be supplied by either system throughout the engine speed range. Maximum control surface rates are maintained with any single engine or pump failure. At cruise speeds, one pump on each main system can be isolated or shut down without penalty to either control rates or load.

The utility system loads are met for all normal and emergency conditions. The retraction of landing gear requires 20 gpm which can be supplied with a single pump. Although only 3 gpm is available for flight controls under these conditions, the hinge moments are low and can be supplied entirely by the booster system. At idle pump speeds, the utility system can power the flaps and retain 11 gpm for flight controls. If either the utility or auxiliary systems fails, the flaps extension time is increased to 26 seconds which is within HIAD requirements.

As a servicing feature, interconnect valves are installed between the auxiliary and utility systems. The control to operate these valves is only accessible from outside the aircraft and is used to troubleshoot and check out the utility system. The need for ground hydraulics gigs, a frequent source of system contamination is thus reduced.

Firewall shut-off valves are installed in the suction and pressure lines of each engine driven pump for pump isolation. These valves are controlled by switches on the systems engineer's hydraulic control panel. Since the engine continues to turn after both the supply and output valves are closed, normal flow from the pump case drain passes through a check valve back into the suction port of the pump to form a cooling circuit. The check valve in this circuit is normally held closed by the suction boost pump pressure and case drainage flows through the in-line relief valve and back to the system reservoir.

Emergency Operation

Emergency power for operation of all essential functions is provided. The completely dual system on the primary flight controls, and the wing flaps and spoilers of the secondary flight controls, provide automatic emergency operation of these units upon failure of either hydraulic system. All of these units are powered through tandem valves with power delivered from both systems simultaneously. The flaps are provided with a dual asymmetry shut-off valve in the pressure lines.

Emergency operation of the wheel brakes is provided through selector valves and powered by the auxiliary system. The landing gear selector valve is provided with manual override and is easily accessible on the utility valve panel. All landing gears are designed for forward retraction to allow free fall capability in emergency operation. Gear uplocks are mechanically released. The primary mode of operation of the horizontal stabilizer trim is hydraulic, and emergency operation is provided from the electrical system. The petal door and pressure door/ramp selector valves are provided with manual overides for normal power off or emergency operation.

Design and Developmental Testing

A difficulty exists in the absence of hydraulic components qualified to MIL specifications with Skydrol 500A fluid. All system components are available and qualified with Skydrol 500A fluid to commercial specifications and accepted by FAA. No development difficulties in qualification are expected due to the complete state-of-the-art design of the system and the vast commercial experience with this fluid.

A functional laboratory mockup of the hydraulic system will be constructed. The mockup will incorporate all major hydraulically operated components and their simulated loads. The mockup will be used for all system testing involving system functional operation.

Equipment Location

A majority of hydraulic system components are located within the fuselage and are easily accessible for inflight surveillance or ground maintenance. The utility and booster reservoirs and valve panels are located at the aft wing spar between the large fuselage frames. The valve panels incorporate designs to give positive recognition of component failures and allow easy removal of each unit. The aileron boost package and the flap gear box with its servo valve package also located at the aft wing spar above the cargo area. The auxiliary reservoir, valve manifold, and control panel are located on the left side of the fuselage adjacent to the ramp and can be reached by the access aisle on the left side of the airplane.

Reliability and Maintainability

A reliability study of the hydraulic system has been made. Only system and subsystem data are shown here. The assigned required mean-times-to-failure (MTF) and the actual predicted MTF's are based upon complete actual data collected for identical or similar units on the C-130.

	Required MTF 90% Level	Predicted MTF
Hydraulic system	7,576	8,065
Utility system	1,370	1,445
Booster system	1,406	1,445
Auxiliary system	1,942	1,982

Complete reliability data and the method and logic used in calculation are presented in detail in Section 9 of Volume 4.

Many features are included to improve or reduce maintenance requirements. System reservoirs are provided with drain valves and large filler necks. Elastomeric seals are eliminated from check valves and restrictors, and teflon flexible lines are used to increase service life. System reservoirs, valve panels, and accumulators are grouped closely together and are easily accessible within the cargo area. The two main systems have separate ground test connections accessible from outside the airplane. The utility and auxiliary system have interconnect valves which allow checkout of either system from ground test connections or AC electric power. These valves can only be operated on the ground to prevent possible inflight loss of two fluid systems through a common failure.

Growth Potential

The engine driven pumps are sized for the emergency engine failure condition at take-off. This requirement leaves excess power available during normal cruise. With full system capacity of 44 gpm and retaining 14 gpm for flight controls, the utility system has available at cruise condition 30 gpm for new systems if not operated simultaneously with loads other than flight controls. This capability is available for either the utility or booster system; however, only primary flight control functions would be allowed on the booster system. The auxiliary system has 16 gpm available for operation of loads not simultaneous with present loads.

ELECTRICAL SYSTEM (5.1.5.7.2)

The aircraft has a primary AC power system and a secondary DC system as outlined in Figure 6-2. Four 40-kva ram-air-cooled brushless AC generators, one driven by each main engine through a hydraulic-mechanical constant speed drive, operate in parallel to supply 3-phase 200/115-volt 400-cps power to four load buses. A 5th 40-kva generator driven by an auxiliary gas turbine furnishes auxiliary and emergency power. A frequency and load controller for each constant speed drive electromagnetically trims the drive governor to maintain a steady state frequency of 400 ± 1 cps, and to divide real load in parallel operation within 4 kw of the average. A static voltage regulator for each generator is provided with highest phase take-over. Bus voltage is 200/115 volts ± 2½% and reactive load division in parallel operation is within 4 kvar of the average. A control panel for each generator provides generator field control, auto paralleling, and automatic protection against underfrequency, over and under voltage on each phase, over and under excitation, unbalanced currents among generators, and short circuits. A permanent magnet generator contained in each main generator, supplies control and excitation power independent of any external source. A mechanical failure detector is incorporated.

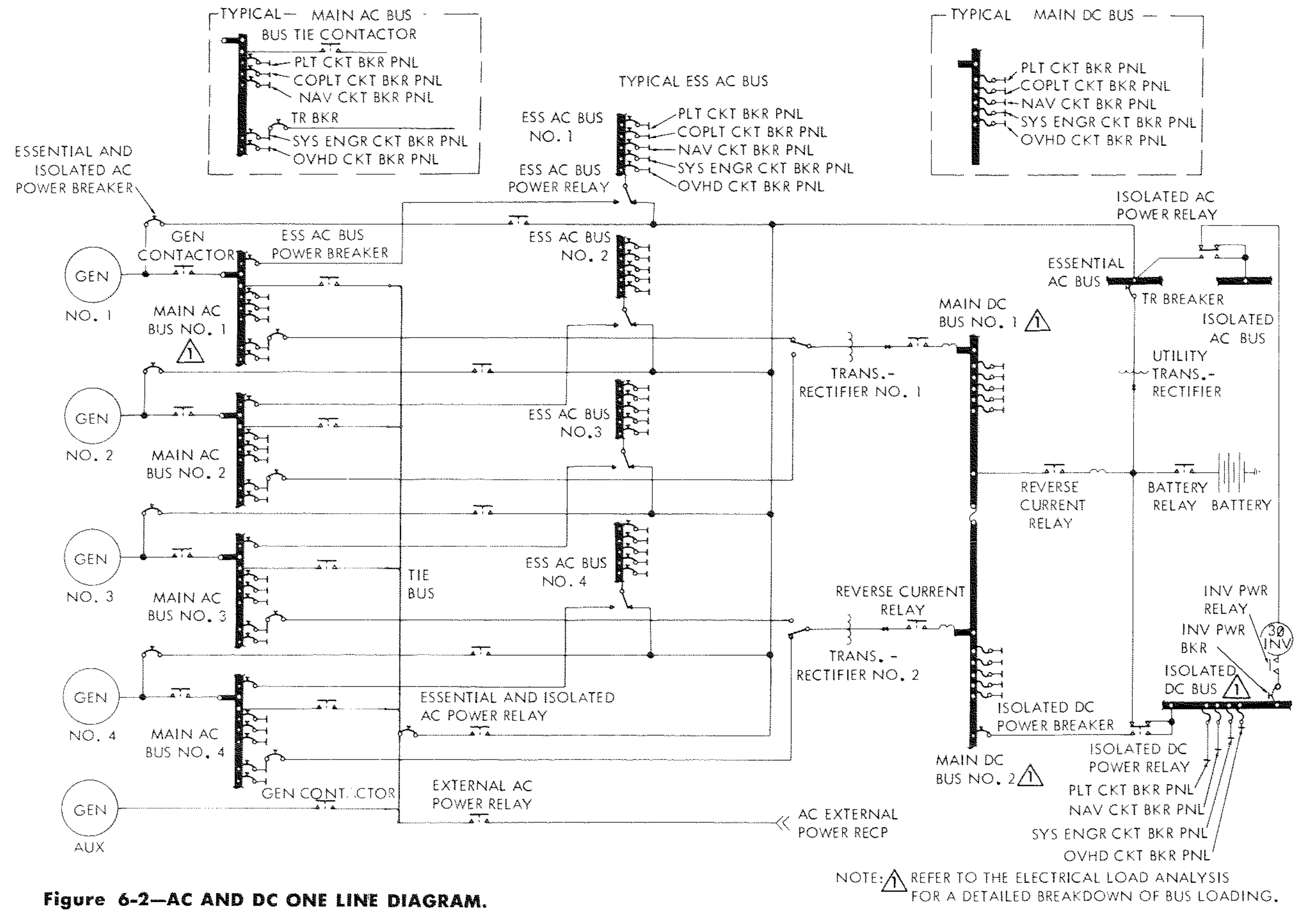


Figure 6-2—AC AND DC ONE LINE DIAGRAM.

The AC output of each main generator is connected through a magnetically held contactor to its load bus. Each load bus is connected through a bus tie contactor to the tie bus for parallel operation. The load buses may also be fed through the tie bus from external power or the auxiliary generator. External AC power can be connected through a standard receptacle and a magnetically held contactor. Protection is provided against reverse phase rotation and low phase voltage. The auxiliary generator furnishes self-contained power for ground maintenance, check-out, and inflight emergency loads.

Figure 6-3 gives excerpts from the load analysis. Adequate power is available for missile transport. The essential loads are distributed among four sub-buses. During normal operation, one essential load sub-bus is connected to each generator main bus. Should a main bus be de-energized, its essential load sub-bus transfers to the essential AC bus. Manual switching is provided so that the essential AC bus may be connected to the tie bus or to the feeders of any main generator. Should all power generator be lost, an isolated AC bus is supplied through an inverter from the battery.

The secondary DC system is supplied by two 200-ampere non-regulated transformer rectifiers with a nominal system voltage of 27 volts. Each receives input power from either of two main generators, and is connected through a reverse current relay to a main DC bus. The two buses are tied together through a current limiter. A 36 ampere-hour nickel-cadmium battery, used to start the auxiliary power unit, receives charging current from a main DC bus through a reverse current relay. The relay opens if the bus is de-energized to prevent discharge of the battery through the main DC bus. A 25-ampere utility transformer rectifier connected to the essential AC bus supplies a topping charge to the battery, and provides back-up power for an isolated DC bus.

Design Features

The electric power system is designed to fulfill the following general design objectives: (1) No single failure or probable combination of failures shall cause complete loss of electric power. (2) System operation and protection shall be as automatic as practicable, requiring only visual monitoring by the flight crew for normal operation. (3) External power shall not be required for normal start and warm-up of the aircraft. (4) The system shall observe all reliability and safety requirements defined by de-

	T. O. & Climb 15 Min. Ave. Watts	Vars	Cruise 30 Min. Ave. Watts	Vars
MAIN AC BUS #1				
H—Heat, Vent				
Ice Detector	200	......	200	......
Window Defog				
Controller Loss	......	......	190	62
Fwd Side Window	......	......	900	......
Clear View Window	......	......	1,500	......
Aft Side Window	......	......	1,500	......
Galley, Flt. Deck				
Oven	......	......	1,333	......
Food Cup	......	......	690	......
Work Light	......	......	40	......
Liquid Cntnr.	220	......	220	......
Windshield De-ice				
Cont Loss—Norm	110	36	110	36
—High	105	22	42	9
Center Pnl.—Norm	1,120	......	1,120	......
—High	1,060	......	424	......
Q—Fuel, Oil				
#1 Tnk Pump—Idle	......	......	200	305
—Run	1,245	1,290	......	......
# 1 Aux. Tnk Pump	......	......	485	692
TOTAL	4,060	1,348	8,954	1,104
ESS AC BUS #1				
E—Eng Inst				
#1 Tnk Fuel Qty	2	3	2	3
#1 Aux. Tnk F Qty	2	3	2	3
#1 Fuel Flow Ind.	10	48	10	48
#1 Fuel Flow Xmtr	18	36	18	36
#1 Press Ratio Ind.	......	1	......	1
#1 Press Ratio Xmtr	16	8	16	8
#1 Inst Xfmr Loss	6	8	6	8
H—Heat, Vent				
Windshld De-ice				
Cont Loss—Norm	130	42	130	42
Cont Loss—High	95	20	38	8
Plt Pnl—Norm	1,310	......	1,310	......
Plt Pnl—High	965	......	386	......
J—Ignition				
Eng #1	135	268	135	268
M—Misc.				
Hyd Boost Pump	2,898	2,956	2,898	2,956
Q—Fuel, Oil				
#1 Mn Tnk Aux Pmp	510	724	510	724
#1 Aux Tnk Aux Pmp	......	......	510	724
TOTAL	6,097	4,117	5,971	4,829
TOTAL GEN #1	**10,157**	**5,465**	**14,925**	**5,933**
MAIN AC BUS #2				
C—Cont Surf	448	307	448	307
H—Heat, Vent	19,000	......	19,000	......
L—Lighting	136	26	136	26
M—Misc.	2,021	1,903	......	......
P—DC Power	2,540	835	2,330	765
Q—Fuel, Oil	1,245	1,290	1,170	1,689
R—Radio	1,904	922	1,883	913
S—Radar	965	520	965	520
TOTAL	28,259	5,803	25,932	4,220
ESS AC BUS #2				
C—Cont Surf	102	156	102	156
E—Eng Inst	56	110	56	110
F—Flt Inst	421	90	421	90
J—Ignition	135	268	135	268
Q—Fuel, Oil	510	724	1,020	1,448
R—Radio	335	162	335	162
TOTAL	1,559	1,510	2,069	2,234
TOTAL GEN #2	**29,818**	**7,313**	**28,001**	**6,454**

	T. O. & Climb 15 Min. Ave. Watts	Vars	Cruise 30 Min. Ave. Watts	Vars
MAIN AC BUS #3				
F—Flt Inst	274	18	274	18
H—Heat, Vent	2,500	62	1,864	50
L—Lighting	2,714	39	2,854	39
M—Misc	2,021	1,903	1,778	1,752
P—DC Power	2,540	835	2,330	765
Q—Fuel, Oil	1,245	1,290	1,170	1,689
R—Radio	918	444	847	435
TOTAL	12,212	4,591	11,117	4,748
ESS AC BUS #3				
E—Eng Inst	75	169	75	169
F—Flt Inst	158	49	158	49
J—Ignition	135	268	135	268
L—Lighting	102	......	102	......
Q—Fuel, Oil	510	724	1,020	1,448
TOTAL	980	1,210	1,490	1,934
TOTAL GEN #3	**13,192**	**5,801**	**12,607**	**6,682**
MAIN AC BUS #4				
H—Heat, Vent	......	......	4,200	......
L—Lighting	545	......	845	......
M—Misc	2,400	......	2,574	130
Q—Fuel, Oil	1,245	1,290	685	997
TOTAL	4,190	1,290	8,304	1,127
ESS AC BUS #4				
E—Eng Inst	38	98	38	98
F—Flt Inst	160	120	160	120
J—Ignition	135	268	135	268
L—Lighting	549	......	549	......
M—Misc	2,898	2,956	2,898	2,956
Q—Fuel, Oil	510	724	1,020	1,448
TOTAL	4,290	4,166	4,800	4,890
TOTAL GEN #4	**8,480**	**5,456**	**13,104**	**6,017**
ISOLATED AC BUS				
F—Flt Inst	127	26	127	26
R—Radio	12	13	12	13
S—Radar	80	39	80	39
TOTAL	219	78	219	78

Ave DC Amps

DC BUS	1 Main TO	1 Main CR	2 Main TO	2 Main CR	Isolated TO	Isolated CR
C—Cont Surf	10.0	8.0	2.0	....	2.0	2.0
D—Inst, Gen	1.4	1.4	0.8	0.8	....	....
E—Eng Inst	1.4	1.4	1.4	1.4	....	....
F—Flt Inst	1.1	1.1	1.0	1.0	0.1	0.1
G—Ldg Gear	0.6	0.6	10.9	10.2	0.8	0.8
H—Heat, Vent	11.9	9.9	17.8	15.8	14.3	14.3
K—Eng Cont	....	....	....	....	....	3.2
L—Lighting	....	....	....	....	1.3	1.3
M—Misc	0.5	0.7	28.7	28.7	....	....
P—DC Power	11.0	11.0	25.0	11.0	2.1	2.1
Q—Fuel, Oil	....	....	....	....	....	0.5
R—Radio	12.0	11.5	2.0	1.9	1.0	1.0
S—Radar	1.8	1.8	....	....	0.2	0.2
W—Warning	0.3	0.3	0.2	0.2	0.1	5.7
TOTAL	52.0	47.7	89.8	71.0	21.9	31.2
TOTAL DC	....	....	....	....	**163.7**	**149.9**

Total AC Load	K1-Loading 5 Sec	K1-Loading 15 Min	K2-Start 5 Sec	K2-Start 15 Min	K3-Taxi 5 Sec	K3-Taxi 15 Min	K4-To, Climb 5 Sec	K4-To, Climb 15 Min	K5-Cruise 5 Sec	K5-Cruise 30 Min	K7-Landing 5 Sec	K7-Landing 5 Min	K8-Emerg 5 Sec	K8-Emerg 30 Min
KVA	88.0	55.9	58.3	49.9	64.7	55.3	92.1	66.4	101.7	64.2	96.4	83.7	15.2	14.0
PF	0.89	0.87	0.89	0.86	0.90	0.89	0.93	0.93	0.95	0.92	0.93	0.93	0.77	0.77

Figure 6-3—EXCERPTS FROM LOAD ANALYSES.

sign and installation specifications and handbooks. (5) System design and equipment selection shall be based on concepts and components proven in military and airline service.

System Control and Protection

The control and protective panel for each generator automatically de-energizes the generator in case of fault or malfunction. Use of magnetically held relays prevents loss of control power from leaving a faulty generator latched to the system. The panel provides the following protection:

1 Differential fault protection for the generator and feeders including the bus tie contactor–The generator is de-energized and the generator contactor opens immediately on a fault. If the fault is in the protected zone beyond the generator contactor, the bus tie contactor is opened after 0.4 seconds.

2 Individual phase overvoltage and selective overexcitation protection—An inverse time delay is employed

3 Individual phase undervoltage and selective underexcitation protection—The bus tie contactors open after 3 seconds delay on a tie bus fault, with a 6-second delay before de-energizing the generator on an underexcitation or isolated open phase.

4 Underfrequency protection—The generator contactor opens when drive output speed drops below the speed corresponding to 380-370 cps for 2 seconds.

5 Unbalanced current protection—The bus tie breaker opens after an 8-second delay on a current difference of 25 amperes or more from the average of the generator currents.

Design, Development, Testing, and Installation

The design, development, testing, and installation of the system and components are in accord with specifications and handbooks: HIAD, CAR4b, MIL-E-25499A, MIL-E-7080A, MIL-W-5088B, MIL-I-6051C, MIL-M-25500, and MIL-STD-704. Detail specifications for the switches, wiring, connectors, circuit protection, lighting, receptacles, indicators, and meters, are set forth in the Model Specification, Volume 5.

All system components are improved versions of equipments that have been developed and have been used in service. A system development schedule is presented in Volume 2 of this proposal. A complete testing program approved by the procuring activity and monitored by the FAA is to be conducted.

Equipment Location

The control switches, selectors, and indicators for the power system are grouped on the systems engineer's electrical control panel shown in Figure 6-4. A master caution light is located on the pilot's panel. A switch in conjunction with failure indicators is provided for operating an emergency disconnect in the input of each constant speed drive. Figure 6-5 shows equipment locations. The main junction box is located at the rear of the flight deck. The generator load buses are located in the circuit breaker panels, adjacent to the pilot, co-pilot, and systems engineer. The external power receptacle and the battery compartment are forward of the crew door, well away from the engine intakes, and readily accessible from the ground. Test points and suitable instrumentation are provided to facilitate system checkout and maintenance.

Design Reliability

Reliability is achieved by utilizing the desirable aspects of service proven systems and making improvements in indicated deficiency areas. Advantage is taken of all available reliability information including manufacturers' test and field reports, operating data, and airline maintenance reports. For example only one 200 amp. convection cooled transformer rectifier has been replaced in 60,000 exposure hours and brushless generators have nearly twice the overhaul period of the brush type with fewer failures between overhauls.

Growth

The power supply system utilizes 2500-hour minimum life components nominally rated at 40 kva. The system and components, however, are designed and installed to allow uprating to 50 kw or 50 kva under Class A temperature conditions with no aircraft installation changes. The usable capacity of each generator is reduced to 44 kva by 6 kva of paralleling and line losses. The continuous load during take-off and climb is 66.4 kva, leaving a total growth capacity of 21.6 kva, allowing for failure of two generators. A growth capacity of 65.6 kva exists, allowing for failure of one generator. Additional capacity could be obtained by use of 60 kva generators and associated constant speed drives which are offered in an alternate cost proposal.

Development progress is being closely monitored on variable speed constant frequency generating systems which promise improved reliability along with reduced maintenance and maintenance costs. The development status, however, is not sufficiently advanced at present for application to this aircraft. The variable speed constant frequency system is discussed in more detail in Volume 2 of this proposal.

AUXILIARY POWER SYSTEM (5.1.5.7.3)

Description

The auxiliary power unit (APU) shown in Figure 6-6 includes a small gas turbine engine which furnishes bleed air for engine starting and ground air conditioning. The engine also drives a standard 40 kva alternator mounted directly to the engine reduction gearbox. The alternator is normally used to

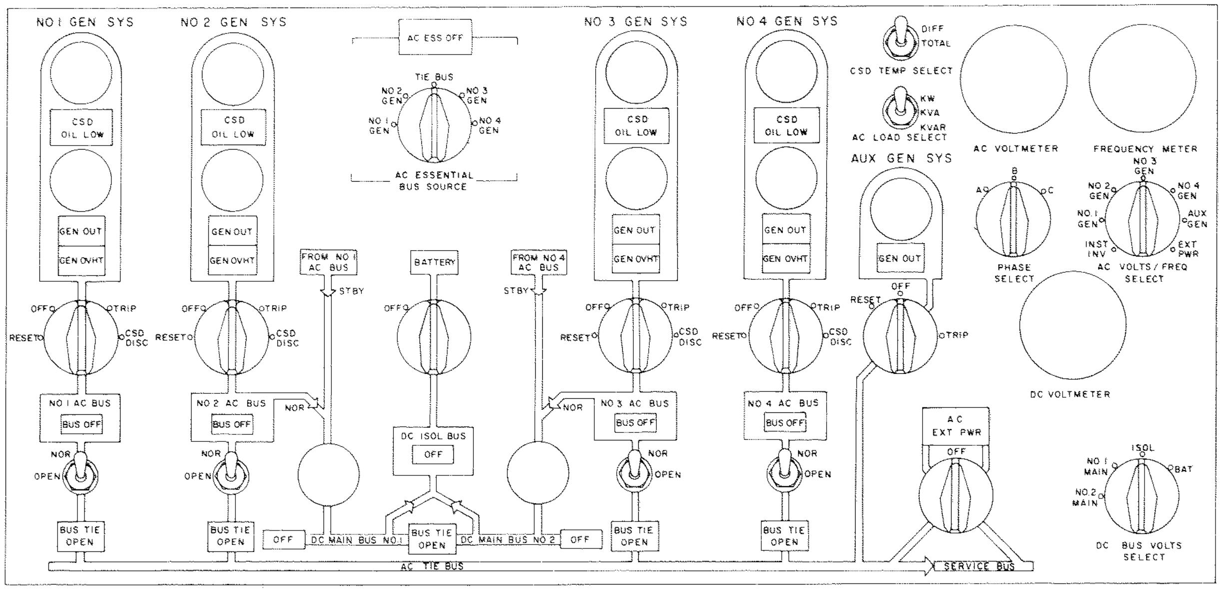


Figure 6-4—ELECTRICAL SYSTEM CONTROL PANEL.

1. WING TIP NAVIGATION LIGHT
2. FORMATION LIGHTS
3. LANDING LIGHT (NARROW BEAM)
4. RIGHT-TAXI LIGHT (NARROW BEAM)
5. ANTI COLLISION LIGHT (BOTTOM)
6. ANTI COLLISION LIGHT (TOP)
7. TAIL NAVIGATION LIGHT
8. AUXILIARY AC GENERATOR
9. TOP FUSELAGE LIGHT
10. CONSTANT SPEED DRIVE
11. AC GENERATOR
12. INBOARD LEADING EDGE LIGHTS (WIDE BEAM)
13. OUTBOARD LEADING EDGE LIGHTS (WIDE BEAM)
14. MAIN POWER JUNCTION BOX
15. LEFT-TAXI LIGHT (NARROW BEAM)
16. ELECTRICAL CONTROL PANEL (PART OF SYSTEM'S ENGINEER'S PANEL)
17. WING TIP AREA TAXI LIGHTS (WIDE BEAM)
18. BATTERY
19. BOTTOM FUSELAGE LIGHT
20. EXTERNAL ELECTRICAL POWER RECEPTACLE
21. GENERATOR VOLTAGE REGULATORS; GENERATOR CONTROL PANELS; TRANSFORMER RECTIFIERS

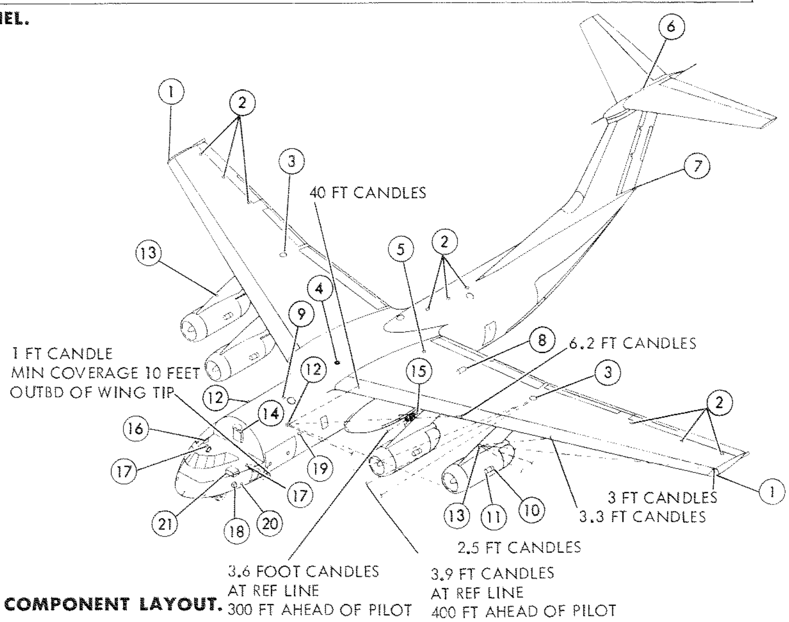


Figure 6-5—EXTERIOR LIGHTING AND ELECTRICAL COMPONENT LAYOUT.

power the airplane electrical system on the ground; however it may be operated during flight below 10,000 ft. altitude, if desired. The APU is installed in the aft portion of the left main alighting gear fairing on resilient mounts with the necessary ducting and electrical controls.

Design Features

The engine is equipped with all accessories required for its operation including a complete oil system, fuel control and constant speed governor. The AC generator is identical to those on the main propulsion engines. Access to the APU is gained through two large quick-opening doors in the alighting gear fairing. The APU can be hoisted from a single point with the cable passing through an access door on top of the fairing. Servicing the oil reservoir is done through a small access door. A remotely actuated door in the upper access door permits air for the APU to enter the fairing. External connections for ground extraction of pneumatic and electrical power are provided.

Starting and air inlet door controls are electrical and are located on the APU panel on the systems engineer's console. The start circuit prevents APU operation when the air inlet door is closed. External openings for generator cooling air and engine exhaust gas are provided. The APU is isolated from adjacent areas by a firewall. Three thermal switches in the compartment are used for fire or overheat detection. A fuel shut-off valve is controlled from the APU control panel. Fire extinguishing is provided from the main propulsion fire extinguishing system shown in Section 8 of this volume.

The APU will start and operate between - 65°F and

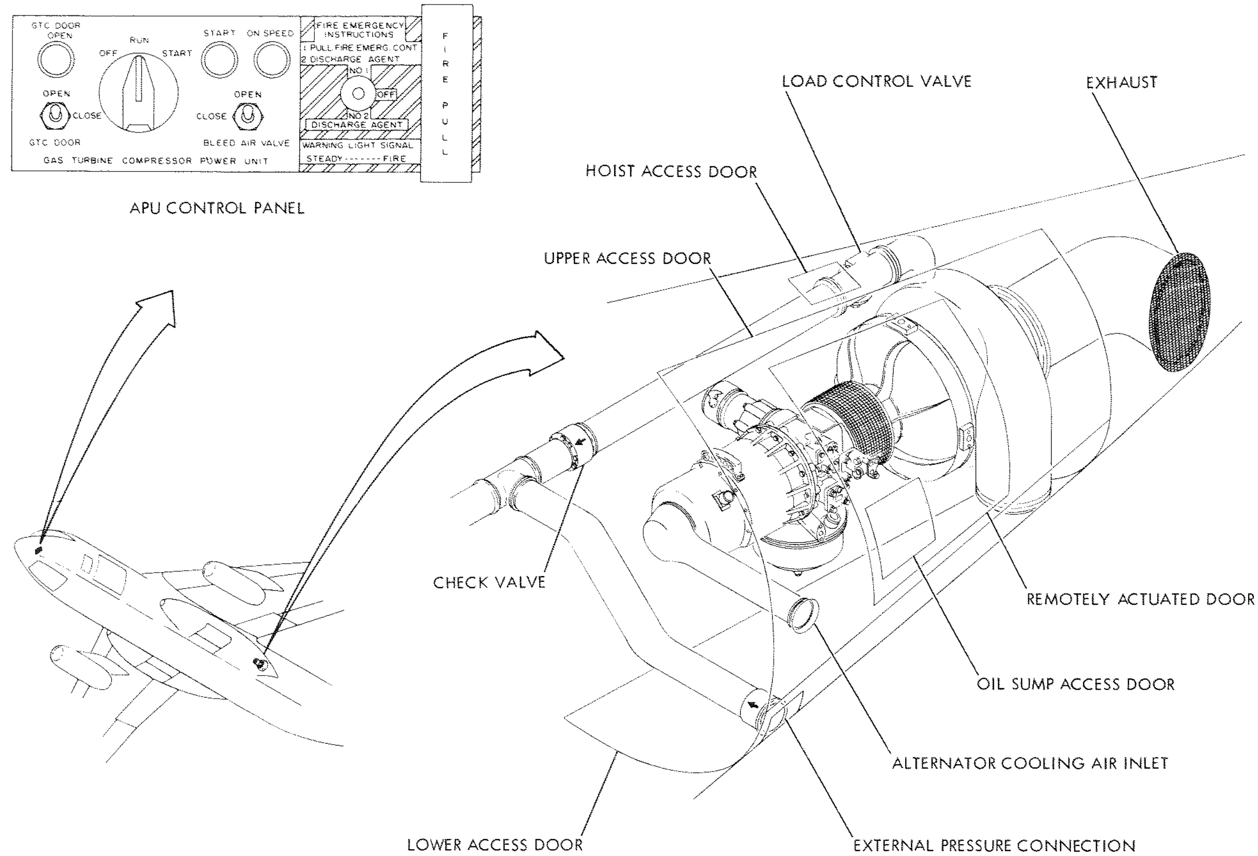


Figure 6-6—AUXILIARY POWER UNIT INSTALLATION.

+160°F up to 10,000 ft. altitude with fuel temperatures up to 135°F and inlet air temperatures up to 130°F. The APU will supply the bleed air required for one engine pneumatic turbine starter while simultaneously furnishing 64 hoursepower for the generator input.

Failure Analysis

No unsafe APU operation can result from any single fuel control part or system failure. No single failure in the fuel or electrical systems can result in unsafe overspeeding. Containment of all rotating elements has been demonstrated in satisfaction of all applicable military and commercial requirements.

Reliability

Two well established sources for the APU are available. Competing units are the Solar T-150 Mark 2 and the AiResearch GTCP 85-106. Both suppliers have production units meeting the system requirements. All components of both units are either fully qualified or capable of qualification by similarity, analysis or by short time proof testing. Both basic units have been in Air Force service for several years.

Growth Potential

A 10% increase in the output capability of the APU is expected before 1964. A universal mounting is provided to accept all presently available and growth units now probable. These units are also capable of accepting larger (60 kva) AC generators.

PNEUMATIC SYSTEM (5.1.5.7.4)

The pneumatic system supplies engine bleed air for engine starting, cabin pressurization, air conditioning, rain removal, and anti-icing. A schematic of the pneumatic system is shown on Figure 6-7. The airplane installation is illustrated on Figure 6-8. Ducting in the engine nacelle is shown on Figure 6-9. Compressor air is bled from the three outer diffuser (O.D.) wall ports and one inner diffuser (I.D.) wall port at the 16th compressor stage of each engine into an engine manifold. The O.D. bleed air manifold has a normally-closed shut-off valve which is opened only when operating the airplane anti-icing or rain removal systems. Two check valves are incorporated in the O.D. manifold, while the I.D. manifold has one check valve. Bleed air flows from the nacelle into the pylon through a flow limiter; through a pressure regulator which limits the pressure to 70 psig; by-passes the pressure relief valve, passes through the pylon isolation valve and enters the cross-ship manifold.

One main duct in each wing extends from the outboard engine to the fuselage. The main ducts are connected together across the cargo compartment but are normally isolated from each other by two valves located outside of the fuselage pressurized area. These valves are controlled from the system engineer's panel and are closed except during engine starting. A branch line from the main ducts to the auxiliary power unit (APU) provides self sufficiency and self-containment for engine starting, and for operation of the pneumatic systems when the main engines are inoperative.

Branch lines in the nacelle supply the engine inlet anti-icing system, the starting system, and the nacelle pre-heat system. Anti-icing systems for engine inlet vanes, the engine bullet nose, and fuel are separate from the airplane bleed system and are provided by the engine manufacturer.

The supply line to the engine inlet anti-icing system, upstream of the O.D. port shut-off valve, isolates each engine anti-icing system and prevents bleed to an inoperative engine during icing conditions.

The nacelle pre-heat system provides for all weather starting capability and consists of a distribution tube and a shut-off valve in each nacelle. On the ground, the compressor bleed system may be supplied with air from four sources; main engine bleed, APU, mobile ground air compressor, or another airplane externally connected. Each of these sources will supply enough air to operate any one of the pneumatic systems.

Two dual pressure gages and two dual flowmeters installed in the system engineer's panel, and an external pressure connection conforming to AF Drawing 54B9301 installed in the APU branch line, provide for rapid checking of the pneumatic system by using an external air source.

Design Features

The bleed ducting system is designed as a tension type with flexible joints installed to facilitate assembly, proper alignment, and to compensate for thermal expansion. The system is fabricated of corrosion resistant steel and uses V-band flanges and couplings. The system and its components are designed for the following operating conditions downstream of the engine relief valves: maximum operating pressure - 85 psig. maximum operating temperature - 810°F, proof pressure - 130 psig, and burst pressure - 213 psig at 810°F.

Switches controlling the pressure regulator/shut-off valves are located on the systems engineers' panel in the flight station. By manipulation of these valves, the entire bleed system can be rapidly checked for leakage and for proper operation prior to flight. Should the need arise, a malfunctioning engine can be detected easily and isolated from the aircraft manifold by operation of its pressure regulator or pylon isolation valve. Each pylon isolation valve is closed automatically by operation of the fire emergency control handle.

Load Analysis

Maximum compressor bleed air demand occurs during icing conditions at a loiter altitude of 20,000 feet and a true air speed of 230 knots. At this condition the thrust is 1860 lbs/engine and the engine primary airflow 62.1 lbs/second per engine. The maximum system requirements are:

	Bleed % (4-engine bleed)	Total Airplane Bleed Flow (lbs./min.)
Wing Anti-icing	6.2	920
Engine Inlet Anti-icing	1.3	200
Air Conditioning/Pressurization	1.1	166
Underfloor Heating	.2	25
	8.8	1311

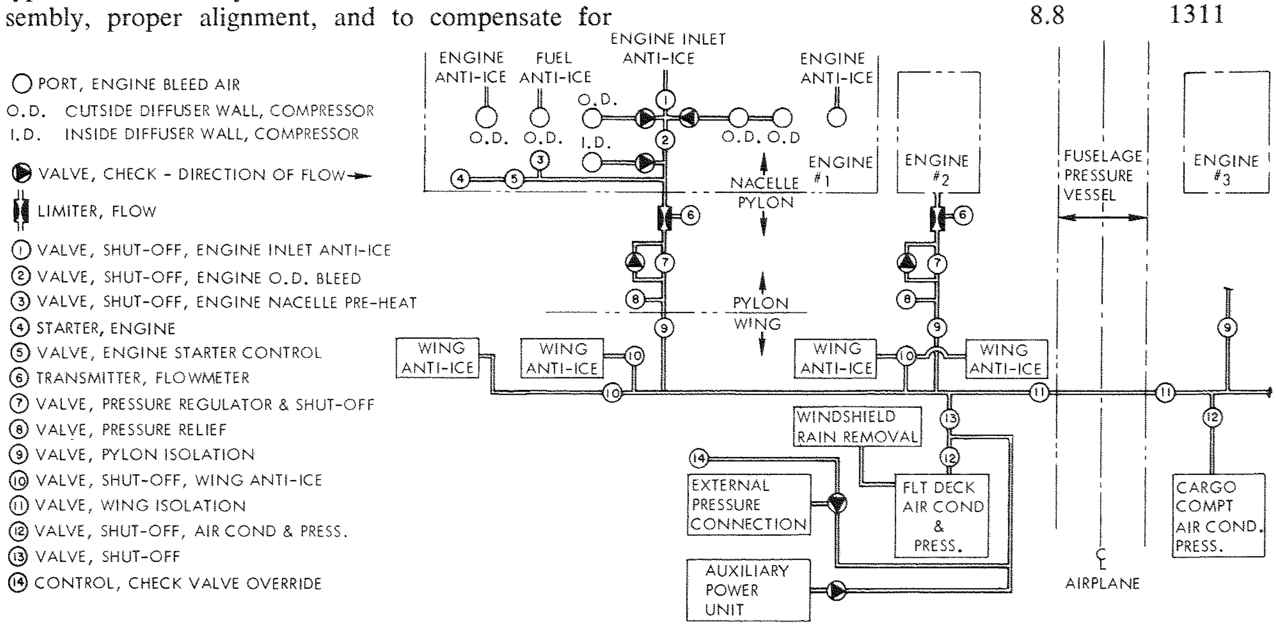


Figure 6-7—COMPRESSOR BLEED SYSTEM DIAGRAM.

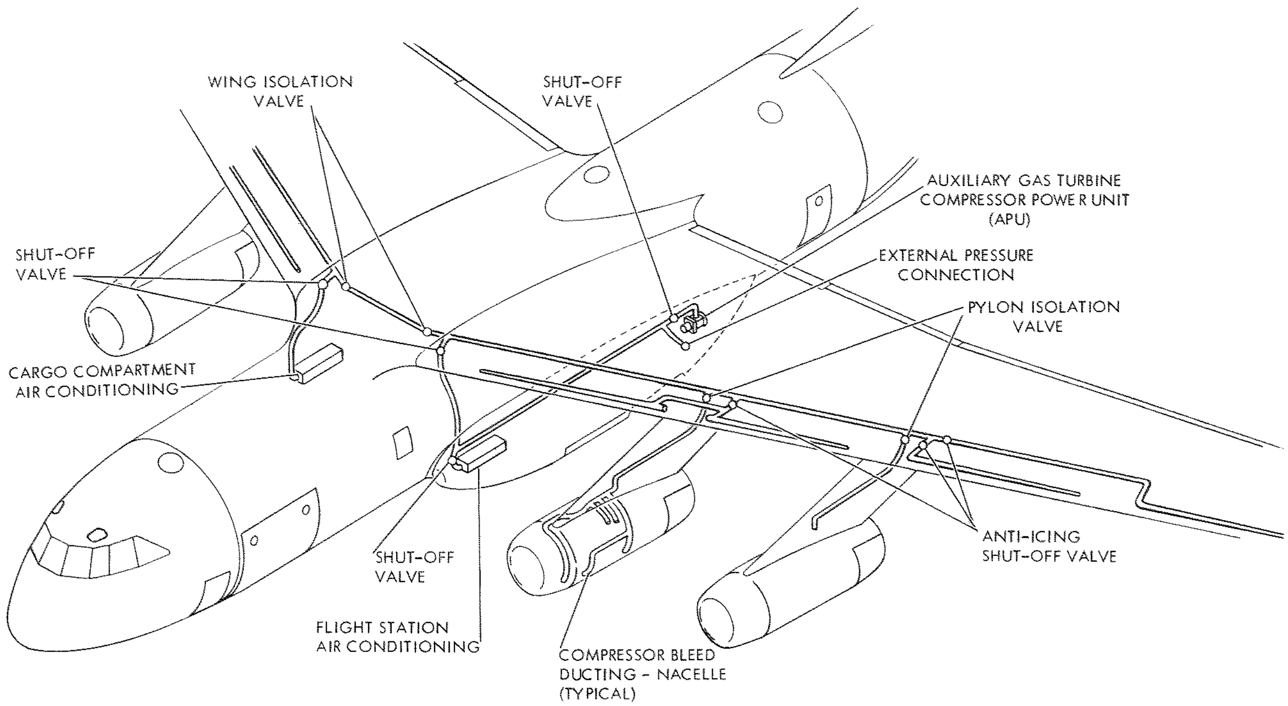


Figure 6-8—COMPRESSOR BLEED SYSTEM.

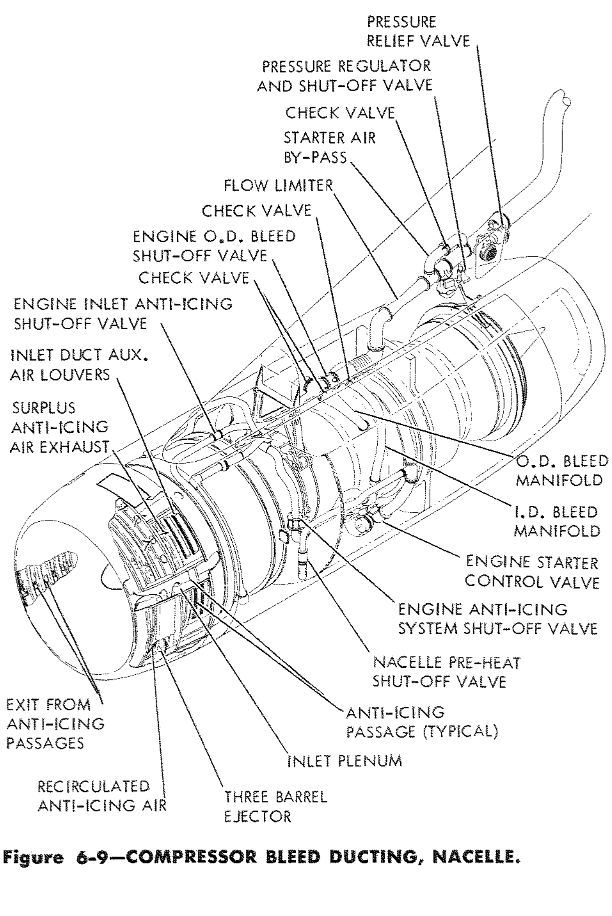


Figure 6-9—COMPRESSOR BLEED DUCTING, NACELLE.

Failure Analysis

In the event two engines malfunction on the same side of the airplane, they can be isolated by operation of the pylon isolation valves or the pressure regulator valves. The wing isolation valves can then be opened to allow normal operation of the pneumatic systems. If a main duct fails, the duct is isolated by closing the pressure regulators or the pylon isolation valves for the two engines supplying the failed duct. All of the pneumatic systems are operable from the remaining main duct except for a portion of the wing anti-icing system and one air conditioning system which are normally fed by the failed main duct.

Design and Development Testing

A full scale functional mockup of the duct systems and components will be constructed. Mockup testing will provide verification of structural integrity and other factors related to safety of flight. The mockup will be fully operational 18 months after go ahead. Test programs will be completed in an additional 12 months.

Growth Potential

All components up to and including the pressure regulator valves are designed on the basis of the maximum bleed air pressure and temperature anticipated from advanced engines. The design requirements for the ducting and equipments located downstream are unaffected by the type of powerplant installed, which is an additional advantage gained from the regulated system design philosophy.

SUPER HERCULES · GL207-45

section 7

MISSION CONTROL SYSTEMS (5.1.5.8)

FLIGHT CONTROLS SYSTEMS (5.1.5.8.1)

Primary Flight Controls Description

The primary flight controls are essentially conventional, hydraulically boosted type subsystems based on those used on the C-130 series aircraft. Only those changes deemed necessary to reduce system friction effects and provide proper feel control characteristics to the pilot have been made. The general arrangement of these subsystems is shown in Figure 7-1.

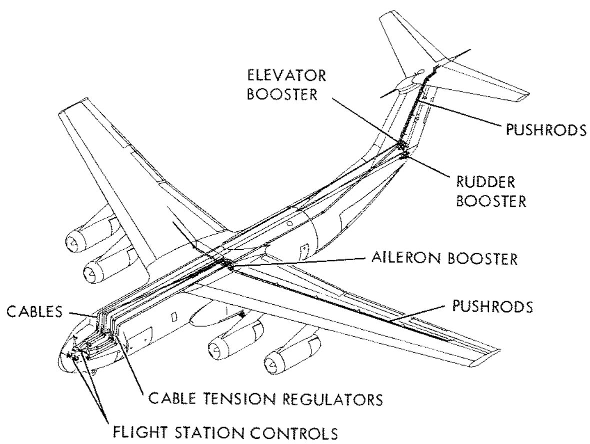


Figure 7-1—FLIGHT CONTROLS, PRIMARY.

The general arrangement of the flight station controls is shown in Figure 7-2. Manual control of the primary flight control surfaces is initiated through the pilot's or co-pilot's conventional wheel, column, and rudder pedals. The two sets of flight station controls are interconnected through cranks and pushrods under the floor.

Control motions are transmitted to the corresponding boosters through cables, cranks, and pushrods. Dual cable systems are provided for aileron and elevator control, and a single cable system is provided for the rudder control. As a design philosophy for these subsystems, the requirements and recommendations of applicable military specifications, and the FAA requirements are used and met in all cases.

The control surface travels are: ailerons, 25 degrees up and 15 degrees down; elevator, 25 degrees up and 15 degrees down; rudder, 35 degrees to either side. The design load surface rate values are 40 degrees per second for the aileron and elevator and 35 degrees per second for the rudder.

Geared tabs on each aileron are used to lighten the hinge moments. A ratio shifter, actuated by a cable from the flight station, is provided at each booster input for improved boost-off manual control. Control motions from the automatic flight control system are fed into the booster input.

Booster Description

Force variable-ratio type boosters are used in each system to improve the control feel force gradients and centering characteristics. The boost ratio is

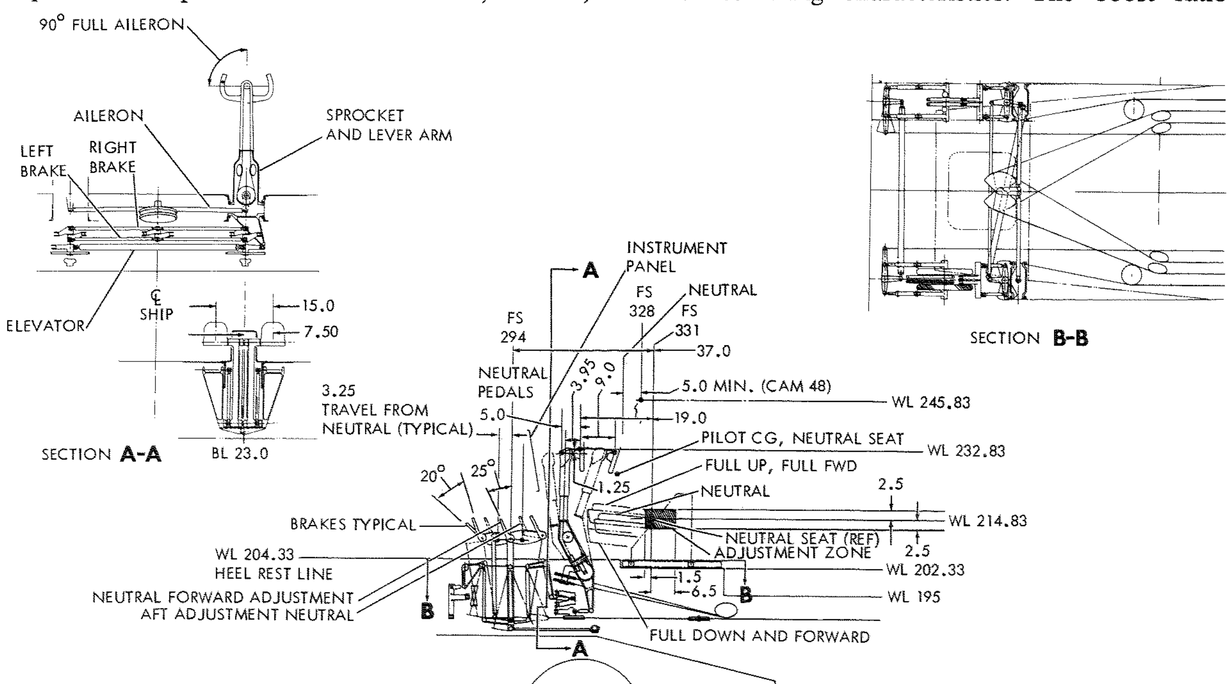


Figure 7-2—FLIGHT STATION CONTROLS AND MOVEMENT.

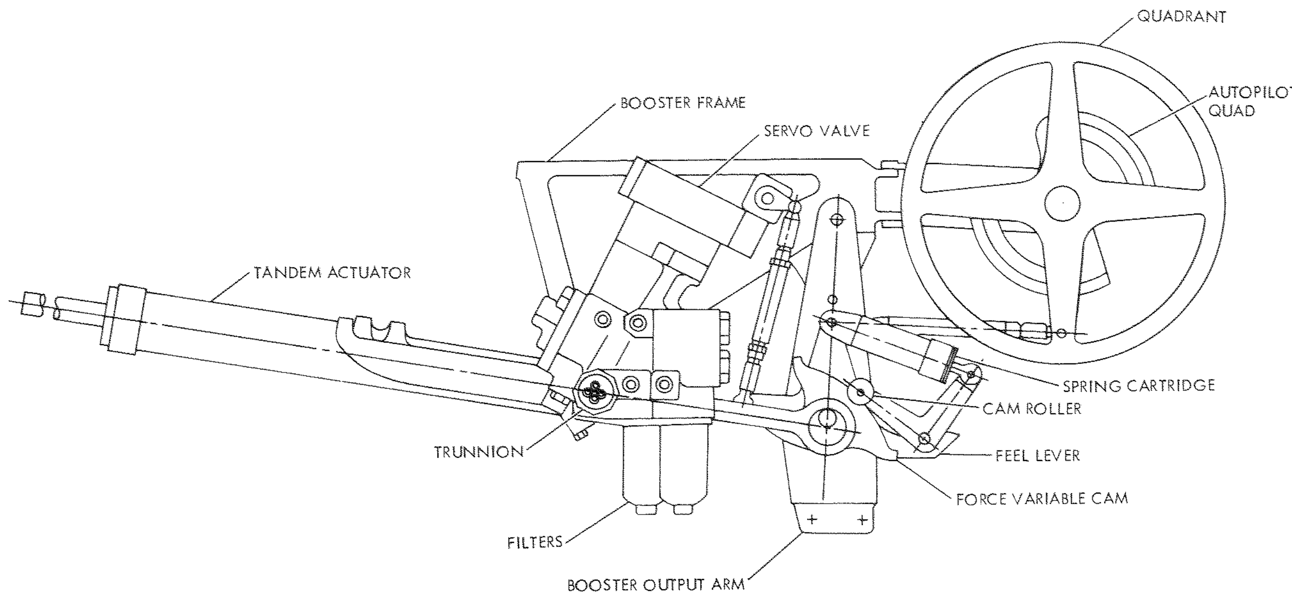


Figure 7-3—FORCE VARIABLE RATIO BOOSTER.

made to vary as a function of actuator force by a cam and roller combination which allows the effective lever arm of the actuator to decrease by rotation as the actuator force increases. In addition, the boost ratios increase slightly with surface deflection from neutral due to rotation of the linkages. A typical booster assembly is shown in Figure 7-3.

The boosters are normally powered by both the boost and utility hydraulic systems with each one providing half the power. Each booster hydraulic assembly consists of the actuator assembly trunnion mounted to a manifold into which the filters, tandem control valve with damper, and shut-off and bypass valves are assembled. A tandem-type actuator assembly, with each piston sized for half the design maximum load, is used in the aileron booster. A dual-type actuator assembly is used in the elevator and rudder boosters. Each elevator actuator piston is sized to provide 70% of the design maximum hinge moment load. Each rudder actuator piston is sized for half the design maximum hinge moment load.

Secondary Flight Controls Description

The secondary flight controls includes the rudder, aileron and stabilizer trim controls as well as the wing flap and spoiler control subsystems. These controls are designed to provide the aerodynamic control required in flight and on the ground in addition to that provided by the primary flight controls. The trim controls are designed to comply with all applicable military and FAA requirements, and the actuators are designed to have high reliability and simple maintenance requirements. Full use of the design and operating experience gained on the C-130 has been made, together with the experience gained while complying with FAA requirements during development of the C-140.

Trim Controls Description

The conventional mechanical rudder and aileron trim tab control subsystems are shown in Figure 7-4. Control knobs with swing-out crank handles and position indicators are located on the rear of the flight station center console. Shafts, gears, torque tubes, and cables transmit motion to the cable-driven, multiple-load-path actuators and mechanisms used to operate both the rudder and the aileron trim tabs. The aileron trim tab actuator is attached to the rear wing structure and produces a geared tab motion when the aileron is moved. The rudder trim tab actuator is attached to the rudder and does not produce a geared tab motion. Both the rudder and aileron trim tabs may be provided with dampers for flutter control if necessary. Pitch trim is accomplished by movement of the horizontal stabilizer independently of the elevator controls.

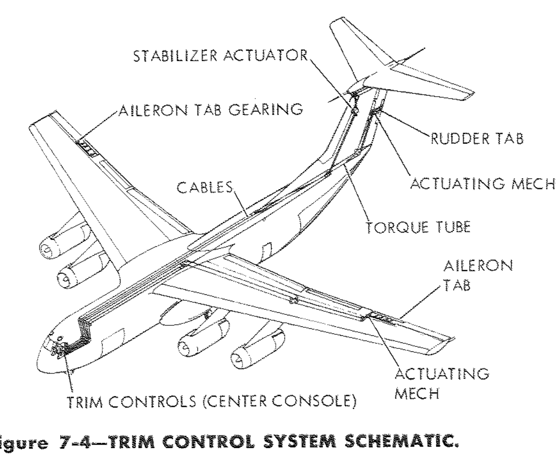


Figure 7-4—TRIM CONTROL SYSTEM SCHEMATIC.

The stabilizer actuator is a dual load path, irreversible jackscrew assembly, which can be controlled by any of three independent means. Primary manual positioning is by the use of handles located on either side of the flight station center console. The pilot and co-pilot stabilizer trim control handles are connected by cables to a spring-centered, modulated-flow type hydraulic valve which controls the rate of the hydraulic motor drive. A spring-loaded brake prevents rotation without hydraulic pressure. Mach trim compensation, autopilot, and switches on the pilot and co-pilot wheels drive the actuator through an electro-mechanical servo having a rate compatible with the automatic control requirements. A wheel and torque tube subsystem enables emergency manual pitch trim. Adequate protection is provided to prevent an electrical malfunction from causing a runaway.

Spoiler Control Description

The wing spoilers, shown in Figure 7-5, are used only for lift destruction on the ground during braking. Actuation is by a hydraulic actuator in each wing. The utility and auxiliary hydraulic subsystem each power one actuator. Both actuators are controlled by a tandem valve which is cable-actuated from a lever on the crew station center console and coupled to all spoiler panels by dual cables. Overcenter linkages lock the spoilers in the retracted position, and hydraulic pressure holds them in the extended position. This subsystem is mechanically interlocked with the nose gear oleo to prevent inadvertent inflight operation. The control lever can be prepositioned such that action of the nose gear strut will open the spoilers. Access to the mechanisms is provided by opening the spoiler surfaces and the doors underneath the actuators in each wing.

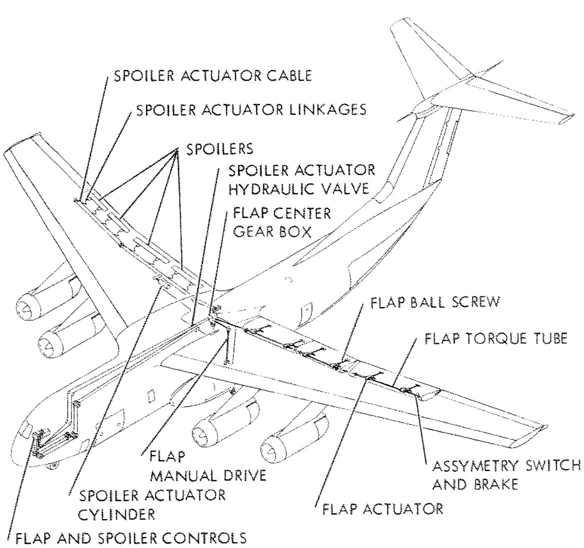


Figure 7-5—FLAP AND SPOILER SYSTEM SCHEMATIC.

Wing Flap Control Description

The wing flap control shown in Figure 7-5 consists of three Fowler flaps on each wing. Each flap rides on three tracks and two ball-screw jacks drive each flap. The jacks are connected through tee-gear boxes to a common torque tube which terminates in the center gear box located on the rear of the wing box section in the fuselage, similar to the Lockheed C-130 and C-140 flap systems. Two hydraulic motors normally drive the flap system; one motor is powered by the utility system and the other by the auxiliary system. The motors are controlled by a tandem servo valve which is mechanically actuated by the preposition flap lever on the flight station center stand. Feedback from the center gear box, operating through the servo valve, terminates system action. Manual flap extension can be accomplished by a hand crank-operated torque tube subsystem from the left aisle space in the cargo compartment.

Protection Features

Design of the primary flight controls is such that no possible single failure will cause loss of control of any axis or result in adverse safety of flight condition. Redundancy of components in the more vital areas is employed to ensure the utmost in reliability where flight safety is involved. Loss of a hydraulic power source does not affect control until the load exceeds half the maximum attainable during normal operations. The structural members of the control subsystems are designed on the basis of minimum deflections; hence, they have large margins in strength. The boosters contain a shut-off and bypass valve for each hydraulic source for use in isolating and reducing the friction during boost-off operation. Adequate filtration, screening, and sharp-edge valve ports provide satisfactory protection against inadvertent operation or jamming of the booster valves or actuator.

To minimize the effects of failures, multiple load path actuating subsystems have been used in all the secondary controls. In this way a single structural failure cannot free a surface. Because of the importance of being able to move and maintain control of the horizontal stabilizer, three independent modes of actuation are utilized. A failure to function of the rudder or aileron trim would not endanger the airplane, and a runaway is impossible. A failure of the flaps or spoilers would not endanger the airplane, but would make a landing more difficult and require a longer ground roll. However, either of the two independent hydraulic-actuating power devices can be used to extend the flaps or spoilers. The manual hand-crank-operated subsystem can also be used to lower the flaps.

A flap assymetry detection system is installed and an assymetry indicator is installed in the cockpit. In the event of an assymetric flap condition, further flap action is stopped automatically.

Reliability and Maintainability

The use of multiple structural load paths throughout, plus dual power sources and input controls for flight critical functions, along with designs taken from or based on operational aircraft such as the C-130, will assure the desired degree of airplane reliability. This is increased by the use of mechanical controls wherever practicable.

The booster designs have been proven through usage on the C-130 and C-140 airplanes. Addition of the force variable ratio shifter feature changes only the feel-lever design and has been developed through laboratory and flight testing. No depreciation of the high reliability and useful service presently attained with boosters is anticipated.

All components of the primary flight controls are readily accessible for removal and installation as well as for inspection and adjustment. This factor, together with simplicity of the controls and use of highly reliable components, minimizes the maintenance required. The cables are easily inspected from inside the fuselage. Maintenance access to those in the tunnel through the wing box is provided by removing the center section of the tunnel from the top of the center wing. The boosters are easily removable assemblies accessible from inside the fuselage. The primary flight control component locations are shown on Figure 7-1.

All components of the secondary flight controls are readily accessible for removal and maintenance as well as for adjustment and inspection. The stabilizer trim actuator is accessible through a door in the horizontal stabilizer and from a ladder installed inside the vertical stabilizer. Rudder and aileron tab actuators are accessible through access doors at their locations. The flap drive, being located on the center section rear beam, is accessible from the cargo compartment. Flap and spoiler actuators are accessible when either the flaps or spoilers are extended. The secondary flight control component locations are shown on Figures 7-4 and 7-5.

Design and Development Testing

Design testing of the boosters and stabilizer trim actuator will assure meeting the requirements of 5,000,000 cycles life specified in MIL-F-9490B. All the subsystems will be incorporated into a full-scale flight control system functional mock-up for systems developmental testing. Each component will also be tested for compliance with the applicable specifications. Phasing of these tests will follow that shown for the automatic flight control system.

AUTOMATIC FLIGHT CONTROL SYSTEM (5.1.5.8.2)

The automatic flight control system (AFCS) consists of the yaw damper, automatic pilot and Mach trim compensator subsystem. The selected equipment will meet the requirements of FAA TSO C9c and MIL-F-9490B except for sealed electronic packaging. Since all the electronic packages are located within the heated fuselage pressure shell, the added cost for military packaging is not considered warranted for this application. This equipment is at least as environment-tolerant as the E-4 autopilot equipment widely used by the Air Force. This assumption has proven valid on the C-130, C-140, B-47, and QB-47 airplanes.

From evaluations of yaw damper and automatic pilot proposals from Sperry, Bendix, Collins, and Lear, in conjunction with Lockheed's experience with automatic flight control systems in the above mentioned airplanes, it has been determined that existing equipment will provide adequate automatic control of the GL 207-45 aircraft. Such equipment, utilizing the latest proven state-of-the-art and designed in accordance with criteria and philosophy compatible with Support System 476L, is to form the basic AFCS; however, final selection of the manufacturer will be negotiated after the airplane contract has been let.

The functions and features discussed herein meet the operational requirements of the statement of work and of the airplane, and meet or better the standard FAA and military functional and safety requirements.

Yaw Damper and Automatic Pilot Subsystems Description

The yaw damper and automatic pilot subsystems are shown in Figure 7-6. Since yaw damping is needed only while flying at high altitudes with light gross weights, the yaw damper is also employed as the rudder channel of the automatic pilot.

Yaw Damper

When engaged, the yaw damper drives the rudder control subsystem in accordance with signals from the yaw rate sensors to oppose and dampen the "Dutch Roll" oscillations. The yaw damper is interlocked with the automatic pilot only to the extent that an additional lateral accelerometer signal is provided for turn coordination whenever the automatic pilot is engaged. Engagement during lateral perturbations cannot result in a biased rudder. Pilot controls consist of a yaw damper engage switch located on the automatic pilot controller, and quick-disconnect pushbuttons on control wheels.

Automatic Pilot

Engagement of the complete automatic pilot by use of a switch on the controller will automatically level

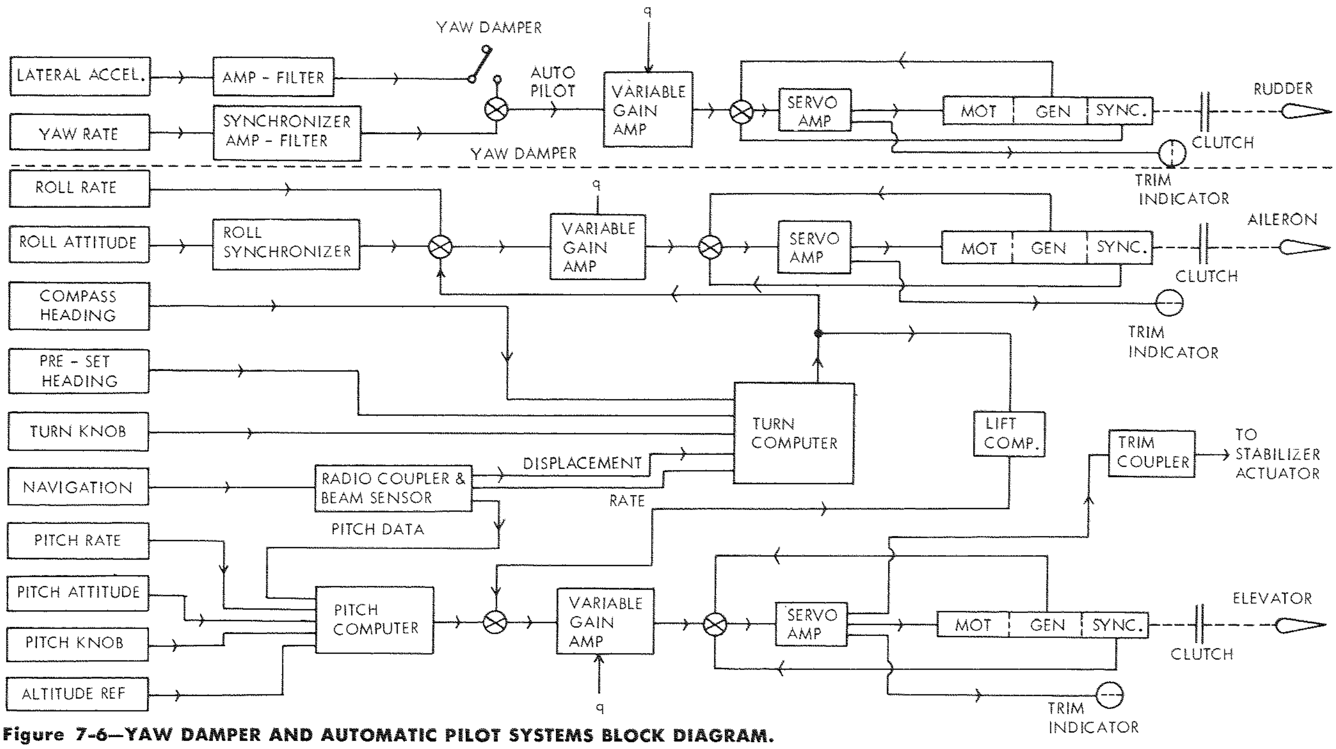


Figure 7-6—YAW DAMPER AND AUTOMATIC PILOT SYSTEMS BLOCK DIAGRAM.

the aircraft wings to within ± 1 degree (trimmed), and maintain the pitch and heading attitudes existing at the time of engagement to within ¼ degree and 1 degree, respectively. Stabilization is accomplished by conventional techniques employing inputs from roll and pitch attitude gyros, roll and pitch rate sensors, and the directional gyro. Automatic wing leveling is accomplished by the roll synchronizer signal at engagement. Heading errors are corrected by commanded bank attitudes. Automatic pitch trim is provided through the trim coupler which smoothly repositions the stabilizer through the electro-mechanical servo to prevent disengage transients. Manual turn and pitch maneuvers, up to ±40 degrees of bank and ±25 degrees of pitch are accomplished through the automatic pilot controller turn and pitch rate knobs. All maneuvers commanded by the automatic pilot are in a smooth fashion. Turns are coordinated to within ± ⅜ fall and steady state turn to within ± ¼ fall.

The conventional operating modes are provided. The Heading Select mode permits presetting the desired heading on the compass repeater. On Altitude Hold mode, barometric altitude is maintained within ±10 ft. at sea level and ±75 ft. at 40,000 ft. VOR or Tacan navigation is obtained when the radio receiver is tuned to the proper station and the respective mode is engaged. Compass heading data, referred to mean range heading, facilitates smooth flight through the cone of confusion directly over the station. ILS range flying is similar to the VOR mode, except that radio range rate data substitutes for compass heading data, and different gains are used. The Glide Path is automatically engaged when the aircraft approaches the center of the glide path beam. When engaged in Doppler Navigation, the doppler computer supplies track displacement and rate information to the heading computer to maneuver the aircraft along the track, and supplies track switching information to automatically program a smooth aircraft turn and entry to a new track.

The control surface servos incorporate rate and displacement feedback. Cockpit trim indicators monitor the servo amplifier output. Automatic synchronization enables engagement of the automatic pilot with no objectionable transients. Since the changes in response of the GL 207-45 are no more severe than encountered in similar aircraft of this type, no difficulty is anticipated in using the simplest optimization techniques such as gain changing with dynamic pressure and lift compensation as a function of bank angle.

The total automatic pilot and yaw damper has a system power requirement of less than 400 watts.

Mach Trim Compensator Subsystem Description

The Mach trim compensator (MTC) automatically compensates for the slight tuck tendency found above 0.75M by adding to the pilot's trim commands stabilizer trim increments as a function of Mach number change above the tuck entry, thus increasing the apparent speed stability of the aircraft. The pilot's MTC controls consist of a push-to-test switch for warning light, and MTC on-off switch.

The MTC installed in the GL207-45 is considered conventional, as it is developed from the one employed on the C-140 aircraft. The primary differences are the Mach number at which compensation is initiated and the incremental stabilizer angle vs. Mach number program characteristic

A functional diagram of this system is shown on Figure 7-7. The output drives the stabilizer through the electro-mechanical servo. It automatically drops into follow-up and sychronizes whenever the pilot commands pitch trim through the primary or secondary trim controls, when the automatic pilot is engaged, or when the airspeed drops below 0.75M.

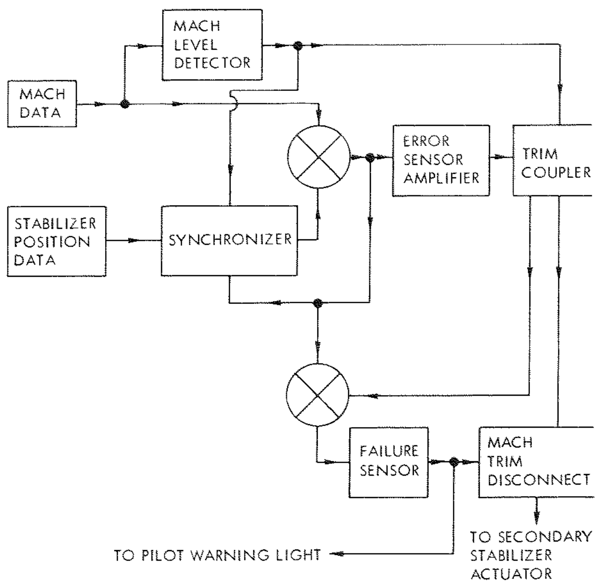


Figure 7-7—MACH TRIM COMPENSATION SYSTEM SCHEMATIC.

Protection Features

The only single malfunction that is capable of causing a two-axis hardover is a mechanical failure of the vertical gyro. Regardless of the particular type of malfunction, all servos are in parallel with the pilot's controls and are torque-limited to prevent aircraft damage and permit the pilot to override the automatic pilot. The use of "g" limiting is not considered necessary at this time. The automatic pilot can be disengaged at any time, by pressing the disengage buttons on the control wheels. Since the yaw damper is completely isolated, failure of the automatic pilot or MTC does not prevent use of the yaw damper.

An MTC failure indicator is provided to warn the pilot of the existence of probable malfunctions, and to automatically disconnect the subsystem from the stabilizer actuator. The automatic pilot provides a backup system for the MTC.

Reliability and Maintainability

The use of conservative semiconductor design and proven components, along with a minimum number of components and system-interconnected wiring, contributes to a high reliability factor. Compliance with the applicable military and FAA requirements, including TSO c9c, is a basic criterion.

Modular-type components located in accessible areas facilitate the application of removal and replacement troubleshooting techniques. The flight computer and coupler assemblies consist of racks into which modules are plugged, and are located in the electronics compartment under the aft crew station floor along with the vertical gyros. The controller is located on the crew station center console. The servos are located adjacent to the primary flight control subsystem boosters.

Field maintenance requires the use of a minimum of standard test equipment. Special go-no-go test equipment permitting faster and simpler test procedures are available.

Design and Developmental Testing

The automatic flight control phasing chart indicating the division of responsibilities is shown in Figure 7-8 The use of proven techniques allows emphasis to be placed on system calibration, system and component testing, and design improvement by both Lockheed and the vendor.

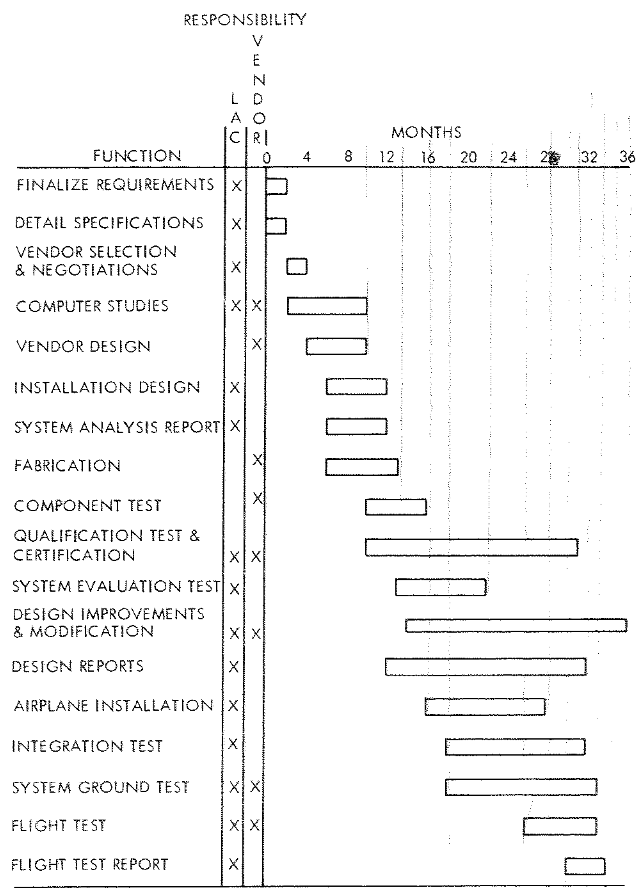


Figure 7-8—AUTOMATIC FLIGHT CONTROLS DEVELOPMENT PHASING CHART.

Growth Potential

The use of modular construction and channelization provides flexibility for the desired future growth in functional capability at minimum costs. Consideration was given to the addition of automatic speed or Mach control, inertial referenced navigation, and landing flare-out (when a particular system is designated by WADD). Space is available on the controller for additional mode selection. The radio coupler is flexible enough to handle the longitudinal and lateral signals used by systems being considered. This concept was applied successfully to the Sperry SP-40 Automatic Pilot installed on the Lockheed C-140 aircraft.

FLIGHT INSTRUMENTS (5.1.5.8.3)

The standard basic advanced flight instruments with conventional direct reading speed, altitude, and rate of climb indicators make up the basic flight group as shown in Figure 7-9. This group is positioned without compromise of its own or outside visibility. Central air data system indicators are provided for outside air temperature and ram air temperature. The combination of the Attitude Director and the Horizontal Situation Indicator with the CPU-27/A Computer and the radio and navigation references offers many possible modes of director-type indication and navigation information display to the pilot. The following modes have been chosen, and are made by the manual rotary switch located on the right of the flight instrument group:

1 Data-link
2 Auto-Nav (sometimes called heading)
3 Navigation steering
4 Tacan
5 VOR/ILS
6 Go-around

Data link and Auto-Nav are conventional modes. Navigator Steering mode is dependent upon the navigator computer selecting the most accurate information available and automatically providing the commands and deviation inputs to the flight director computer, the Attitude Director (ADI), and Horizontal Situation (HSI) Indicators. The along-the-track distance to go is shown on the digital distance indicator. Further details are contained in the Navigation Equipment discussion of Volume 1 and Volume 2. In the Tacan mode, course is selected by the HSI course-set knob and the following is displayed: director steering on the ADI; deviation from course and to-from indication on the HSI bars and mask; station distance on the digital distance indicator.

The VOR portion of VOR/ILS mode provides the same display as Tacan to the pilot, based on the VRO facilities selected on the NAV receiver. Distance is again available if the particular station includes the distance portion of the VOR-TAC system. The ILS mode is automatically engaged when the NAV receiver is tuned to localizer frequencies. Localizer runway magnetic heading must be inserted into the HSI by the course-set knob. The shift to Approach mode from ILS is triggered by the flight director computer beam sensors. Go-around mode provides director steering information for continuing the same localizer heading, intercepting or following a preselected (on one receiver) radio facility, and pitch command for level-off and climb. The horizontal bar of the ADI provides sensitive pitch attitude deviation in the navigation steering, Tacan, and VOR modes. The pilot's and copilot's flight computer, ADI, and HSI are basically independent with independent gyro and radio signal sources. The only exception occurs when the pilot and copilot cross-monitor on approach with one receiver tuned for go-around.

The Radio Magnetic Indicator displays station bearing from any two of the ADF, Tacan or VOR receivers. The choice is made manually through the bearing selector switches to the right of the director mode selector, and is indicated by annuciator lights adjacent to the indicator.

Flight instruments by type number are listed below. Complete panel instrument listing is provided in the Model Specification, Volume 5. The Altimeter, Rate of Climb, Airspeed and Mach indicators are modified to provide MIL-L-27160 white lighting.

	Type	Pilot	Copilot
Flight Director Indicator	ARU-2B/A	X	X
Horizontal Situation Indicator	AQU-2/A	X	X
Altimeter	MB-1	X	X
Rate of Climb Indicator	MS28049-1	X	X
Airspeed Indicator	L-7A	X	X
Mach Indicator	A-1	X	X

ENGINE INSTRUMENTS (5.1.5.8.4)

The pilot's integrated engine instruments display those functions that are necessary for optimum thrust setting and power management for the specific combination of aircraft and engine, as shown in Figure 7-9. The display modules (tape mechanism) and computer techniques now under development for WCLCIP-286 are directly applied to System 476L. Computed command for the chosen operating mode, such as maximum distance cruise control, is displayed for each engine on the engine pressure ratio (EPR) indicator. Supplementary information, including individually-computed "standard" ranges as well as measured values of exhaust gas temperature, rotor speed, and fuel flow are also displayed for "confidence" and for complete monitoring of engine operation. Handbook data can still be used for other conditions than those defined by computer modes.

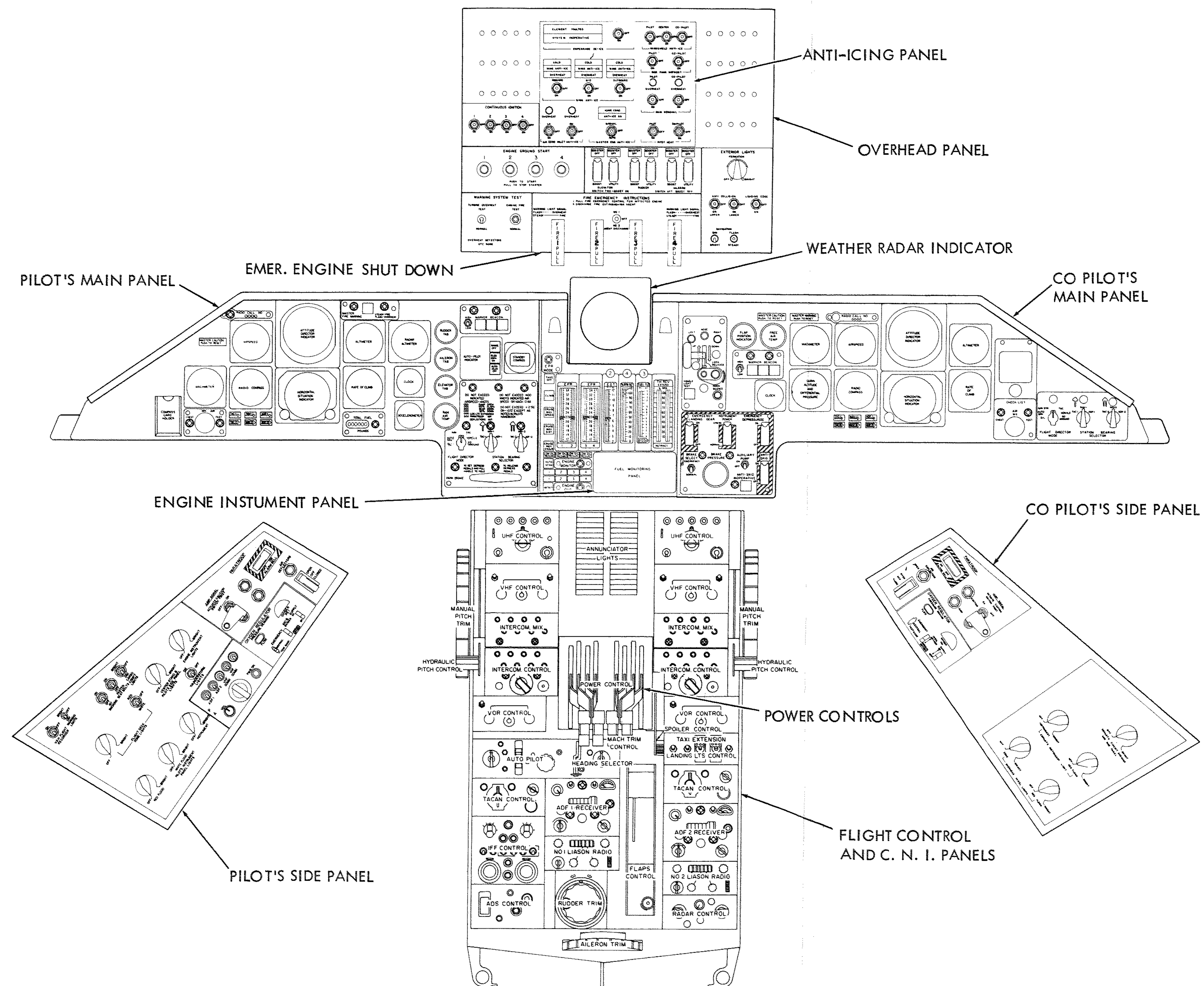


Figure 7-9—FLIGHT STATION DISPLAY.

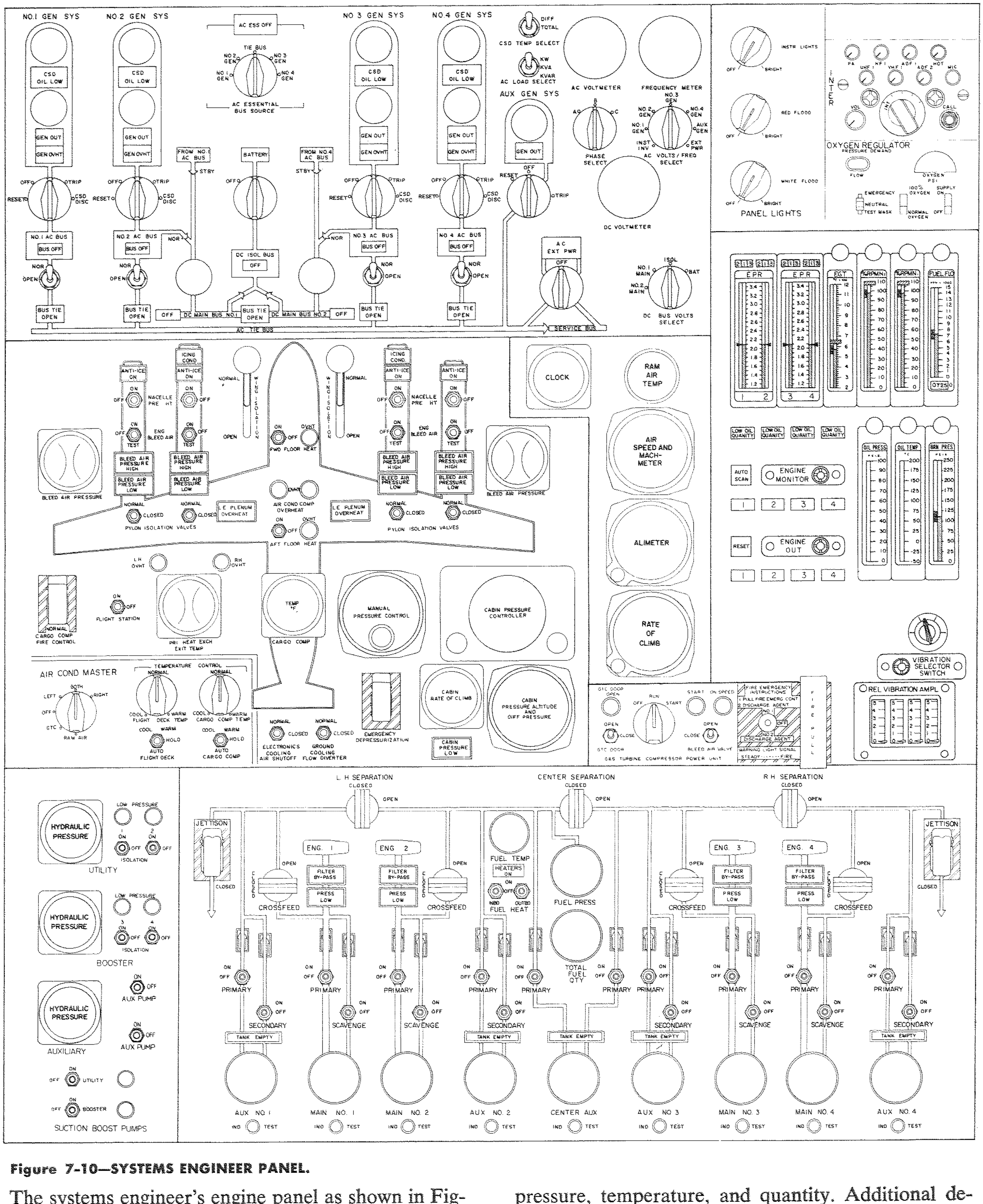


Figure 7-10—SYSTEMS ENGINEER PANEL.

The systems engineer's engine panel as shown in Figure 7-10 contains basic indicator modules that are identical with the pilot's indicators, plus additional indicators required for monitoring and analysis, including N_1 rotor speed, burner pressure, and oil pressure, temperature, and quantity. Additional details are provided in Volume 2 and Volume 5. The basic concepts of integrated engine instrumentation set forth for the C-130B aircraft by Exhibit WCLCIP-286 are retained and enlarged upon. These

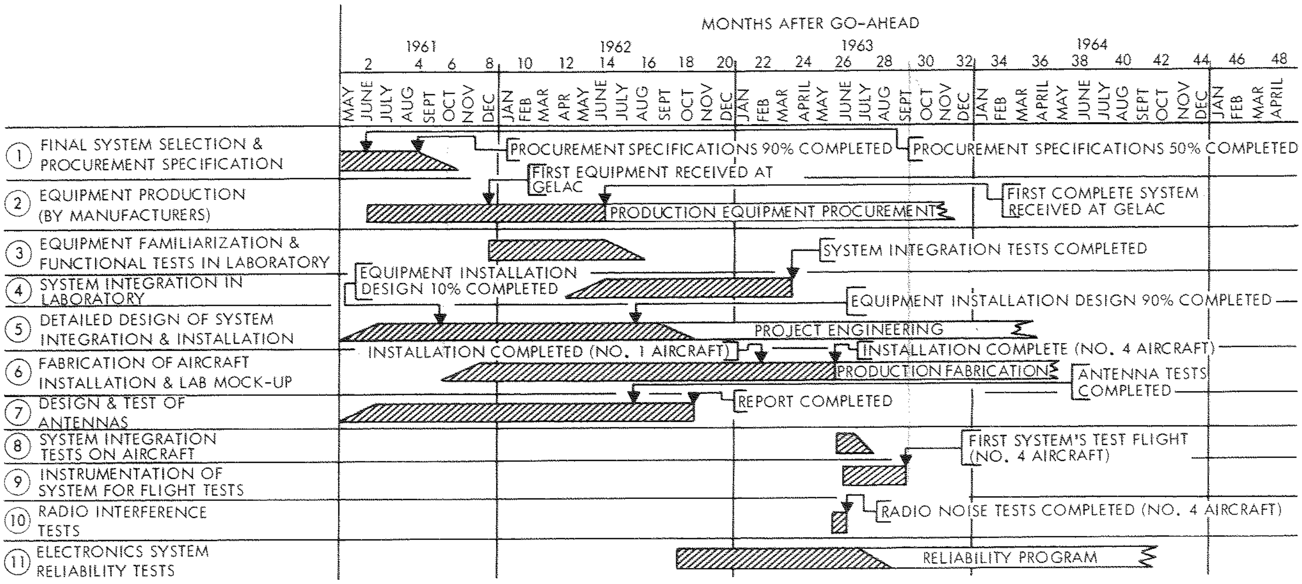


Figure 7-11—ELECTRONICS SYSTEMS DEVELOPMENT SCHEDULE.

concepts are: (1) tape, servo-driven indicators, (2) engine scanning by computer, (3) computed "Command" markers and, where applicable, redline markers, (4) malfunction warning outside acceptable ranges. These acceptable ranges of item (4) are continuously indicated by green areas on separate tapes.

Engine Instrument List	Pilot	Engineer
Pressure ratio—2 dual tape indicators	X	X
Exhaust gas temperature, EGT, tape indicator	X	X
Fuel, flow, tape indicator	X	X
Tachometer N2, tape indicator	X	X
Tachometer N1, tape indicator		X
Oil Pressure, tape indicator		X
Oil temperature, tape indicator		X
Thrust reverse position 1 dual tape indicator	X	
Indicator, vibration		X
Burner pressure, tape indicator		X

NAVIGATION AND COMMUNICATION EQUIPMENT (5.1.5.8.5 and 6)

Operational Requirements

The System 476L is required to have an all-weather global navigation capability. In addition, the airborne system must provide positive position information at all times for domestic and oceanic air traffic control purposes. To ensure flight safety, sufficient redundancy is required for cross-checking and reliability. The manipulative work load of the navigator, due to these multiple data sources, must be kept within reasonable bounds. Accurate position data must be provided to the pilot, especially during local traffic control. In addition to conventional UHF, VHF, and HF communications equipment, the electronics system must include an automatic air-to-ground system to adapt the transmitting and receiving equipment to the next-generation systems for traffic control, and eventually direct control of the aircraft from the ground. The navigation and communication system proposed in the following paragraphs meets the requirements, with adequate provisions for future growth. The system presented here provides maximum state-of-the-art capability for the development and test schedule period shown in Figure 7-11.

Navigation Equipments

The navigation equipments are listed in Figure 7-12. Figure 7-13 is a simplified block diagram showing the integration, control, and display of the system. The navigation system is functionally divided into two parts: the radio aids to navigation equipment, and the global navigation equipment.

The radio aids to navigation, which include the VHF navigation, glide slope, Tacan, automatic direction finder, marker beacon, and radar systems, are controlled from the flight control pedestal shown in Figure 7-9. The global navigation equipment, which includes the inertial platform, doppler radar, digital computer, photoelectric sextant, and dead-reckoning computer are controlled from the navigator's panel shown in Figure 7-14.

Quantity	System	Type	Manufacturer
2	VHF Communications	VHF-101	Collins
2	UHF Communications	AN/ARC-50	Magnavox
2	HF Communications	HF-102	Collins
1	Intercommunications	AN/AIC-18	Andrea
1	Service Interphone	—	Lockheed
1	Public Address	AN/AIC-13	RCA
1	Radar Altimeter	AN/APN-141	Bendix
1	Doppler Radar	AN/APN-501*	Marconi
1	DR Computer	AN/ASN-15* (Simplified)	Waldorf
1	Digital Computer	AN/ASN-24	Libroscope
2	Glide Slope Receiver	51V-3	Collins
2	Gyro-Magnetic Compass	C-11	Sperry
2	VHF Navigation	VOR-101	Collins
1	IFF Transponder	AN/APX-46	Hazeltine
2	Radio Compass, ADF	DF-202	Collins
2	Tacan	AN/ARN-52	ITT
1	Marker Beacon Receiver	51Z-2	Collins
1	Weather-Navigation Radar	RDR-1D	Bendix
1	Inertial Platform	LN-2C*	Litton
1	Astro-Navigation	AN/AVN-1	Kollsman
1	VGH Recorder	A/A24U-3	Emerson
1	AGACS/SELCAL	—	RCA
1	Malfunction Detection and Recording	Madrec	Lockheed

* Or Equivalent

Figure 7-12—ELECTRONICS EQUIPMENT.

Radio Aids to Navigation Equipment

Except for the weather radar, marker beacon receiver, and low-altitude radar altimeter, each pilot operates a complete set of navigation radio aids. A flight director mode selector is provided each pilot for selecting the type of information desired from his equipment. This information is displayed on his horizontal situation and attitude director indicators. The output from either the pilot's or co-pilot's equipment may be coupled to the autopilot at the discretion of the pilot. Each pilot also has a master compass indicator installed on his flight instrument panel for displaying ADF, VOR, Tacan, and compass information from either the pilot's or co-pilot's equipment. Annunicator lamps located adjacent to each of the indicators show what information is displayed on each pointer. The pilots have primary control of the weather-navigation radar. The radar indicator is centrally located on the flight instrument panel as shown in Figure 7-9. The navigator has a repeater indicator and an azimuth rotator control at his station. The azimuth rotator permits the navigator to utilize the full range of the radar when looking abeam of the aircraft. Three-lamp marker beacon displays are installed on the pilot's and co-pilot's instrument panels. The low-altitude radar altimeter display is located on the pilot's instrument panel.

Global Navigation Equipment

The integrated system utilizes the large data-handling and accuracy capabilities of a general-purpose digital computer. The system consists of an AN/ASN-24 digital computer, an analog dead-reckoning computer, a doppler-damped inertial system, and a semi-automatic sextant. Inputs are also accepted from a central air data computer, dual C-11 compasses, and the Tacan. The above sensors provide the computer with multiple values of velocity, heading, and star position and the computer produces true heading, ground velocity vector, wind, and aircraft position. In addition to navigation computation, the computer performs self-checks and credibility checks on the sensors by cross-comparing the input information to stored limits. It also provides weighted averages on the input data. Computer outputs are provided for display and steering. Provisions are also made for displaying equipment malfunction information to the navigator. In case of failure of the AN/ASN-24, automatic changeover is made to the analog dead-reackoning computer. Should the platform fail and the doppler still be operative, the doppler alone is used in the computation.

Data is accepted and manipulated in the digital computer in the following manner. True heading, is obtained from four sources: Compass No. 1 plus digital magnetic variation; compass No. 2 plus analog variation; doppler inertial platform; and the semi-automatic sextant. The ground velocity vector is obtained from the following three sources: the doppler-inertial platform; doppler plus compass No. 1 plus digital variation; and air data plus compass No. 2 plus analog variation plus wind from two fixes. Position is obtained from the following five sources: doppler-inertial dead reckoning; doppler plus compass No. 1 plus digital variation; air data plus compass No. 2 plus analog variation plus wind from two fixes; semi-automatic sextant; and a Tacan fix. Wind is obtained from two sources: two celestial fixes plus TAS plus compass No. 1 plus digital variation; and TAS plus compass No. 2 plus doppler speed and drift angle. A doppler attachment may be added to the navigation radar to provide a third means of measuring wind.

The credibility of the above data is automatically checked by comparing quantities to stored tolerance limits.

The primary output from the navigation system is the steering signal forwarded to the pilot for manual or automatic flight control. This information is supplied to the pilot when his mode selector switch is in the "NAV STR" position. Outputs such as present position, ETA, winds and other data pertinent to position reports are displayed at the navigator's position. The estimated position-keeping accuracies of several navigation modes for an airspeed of 500 mph are: (1) Doppler-Inertial with digital solution- 1 mph. (2) Doppler-Sextant with digital solution - 2 mph. (3) Doppler-Sextant with analog solution - 3.5 mph. (4) Airspeed, wind from two fixes, gyro-compass, with analog solution - 7.5 mph.

Communications Equipment

The communications system provides for complete information flow within the aircraft, from aircraft

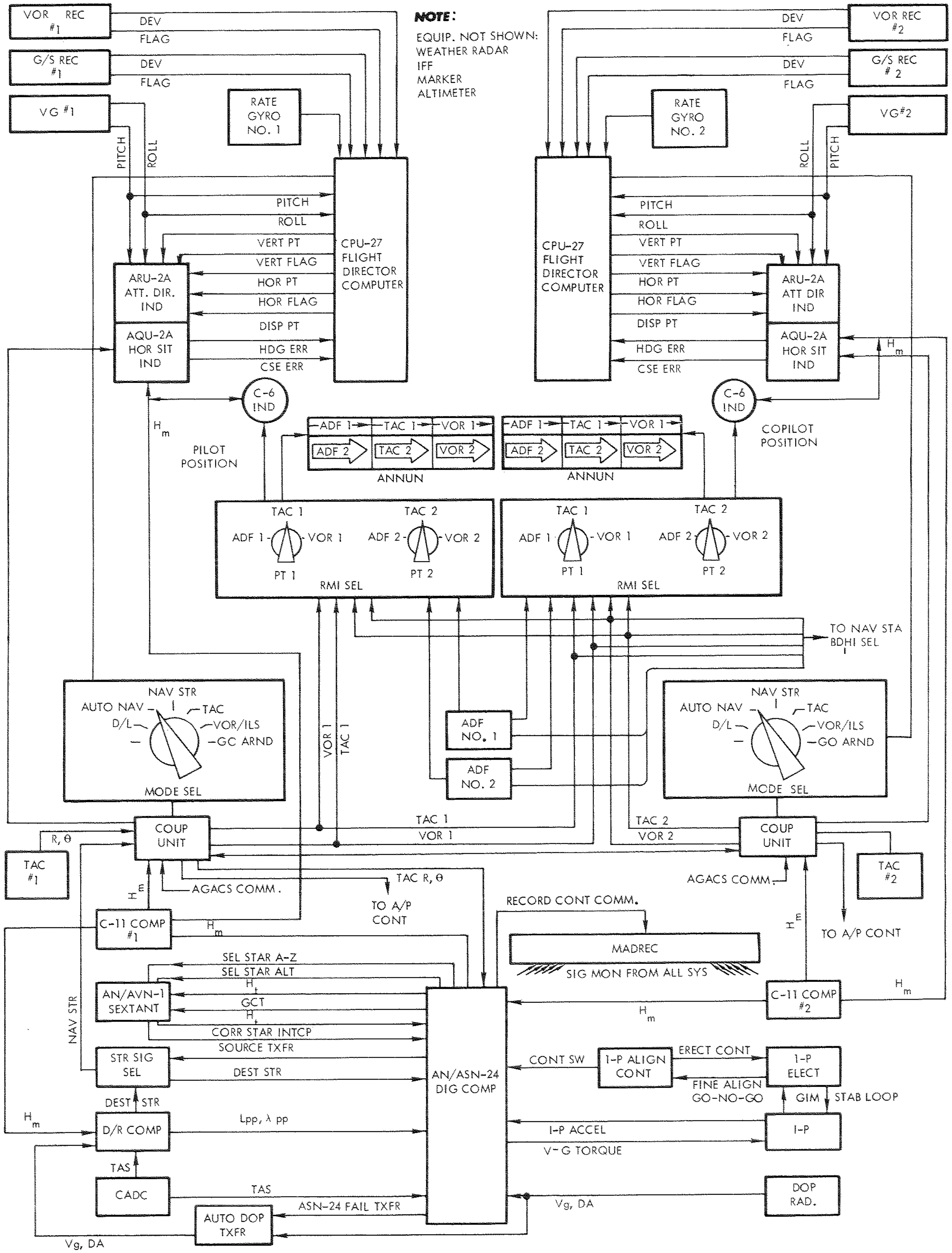


Figure 7-13—NAVIGATION SYSTEM BLOCK DIAGRAM.

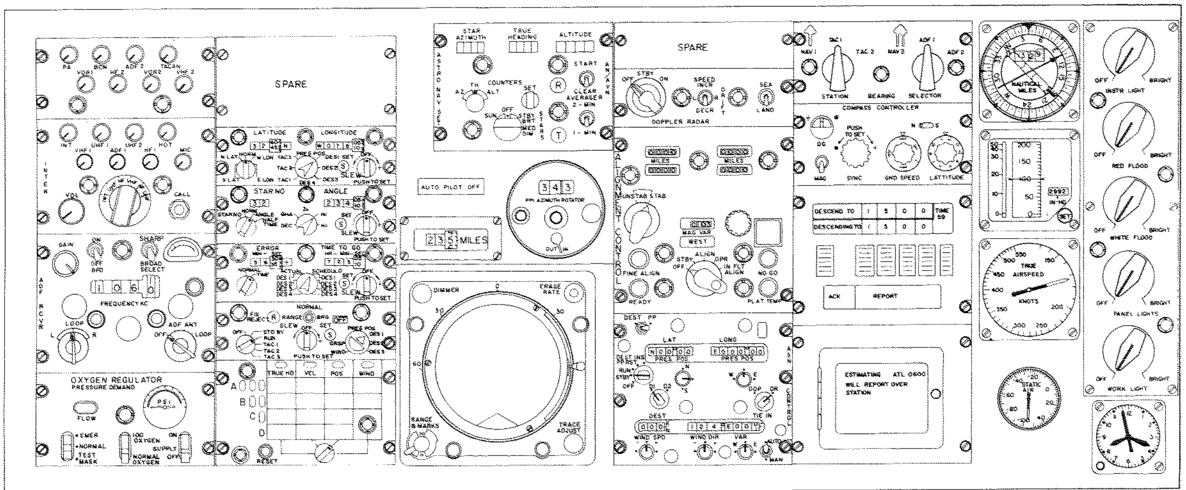


Figure 7-14—NAVIGATION PANEL.

to aircraft, and from aircraft to ground. Figure 7-15 a simplified block diagram, shows how the system is integrated. Communication in the UHF range is accomplished by two AN/ARC-50 transceivers, in the VHF range by two VHF-101 systems, and in the high frequency range by two HF-102 systems. All set controls are located between the pilot and co-pilot on the flight control pedestal. Audio access to and from the equipment is through the AN/AIC-18 intercommunication system. A second, independent interphone system is installed for use solely by ground service and maintenance personnel. This system provides interphone stations in all major service areas and is not operated during flight.

Figure 7-16 shows the flight and service intercommunication station locations and location of the AN/AIC-13 public address system components.

An automatic ground-air communications system (AGACS) is used with the RF equipment to provide a high-speed, two-way, air traffic control data link for handling routine flight information, variable-length messages, and for selective calling. Information such as aircraft identity, altitude, and position are continuously available and are automatically transmitted upon command. The display indicator, message printer, and message composer units for handling "canned" and variable length messages are installed at the navigator's position.

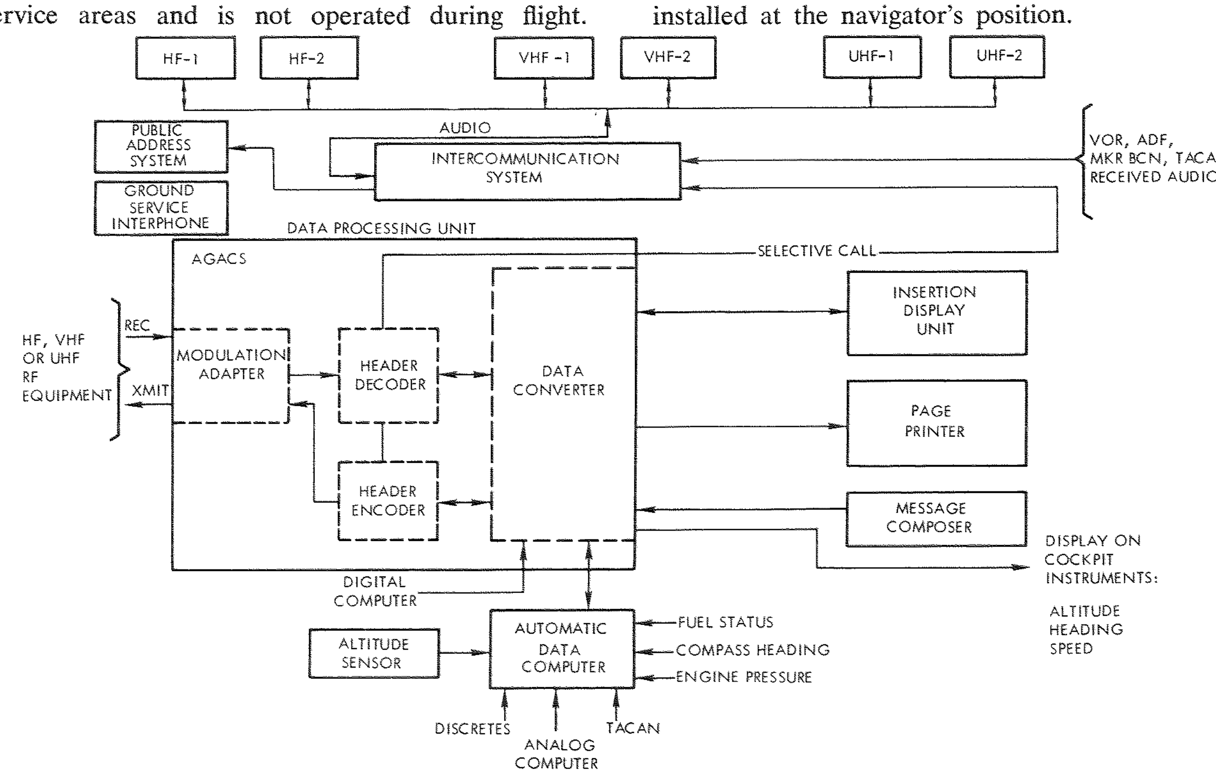
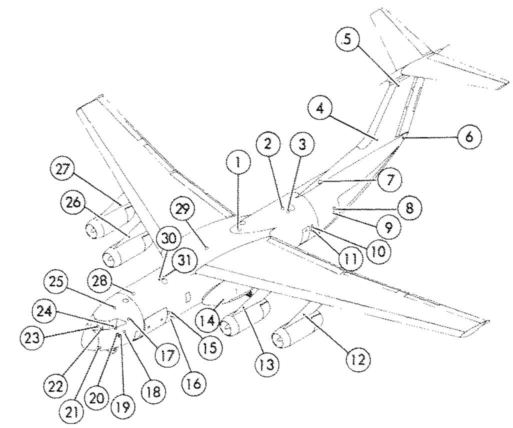


Figure 7-15—COMMUNICATIONS SYSTEM BLOCK DIAGRAM.



1. NO. 4 LOUDSPEAKER
2. RH PARATROOP DOOR LOUDSPEAKER
3. LH PARATROOP DOOR LOUDSPEAKER
4. LOWER VERTICAL STABILIZER JACKBOX
5. UPPER VERTICAL STABILIZER JACKBOX
6. TAIL CONE JACKBOX
7. AFT LOUDSPEAKER
8. AFT CARGO DOOR ICS
9. AFT CARGO DOOR PA AUXILIARY CONTROL PANEL
10. LH PARATROOP DOOR PA AUXILIARY CONTROL PANEL
11. LH PARATROOP DOOR ICS
12. LH OUTBOARD PYLON JACKBOX
13. LH INBOARD PYLON JACKBOX
14. LH WHEEL WELL JACKBOX
15. FWD CARGO DOOR ICS
16. FORWARD CARGO DOOR PA AUXILIARY CONTROL
17. NAVIGATOR'S ICS CONTROL PANELS
18. ELECTRONICS COMPARTMENT AND EXTRA CREW COMPARTMENT ICS
19. SERVICE INTERPHONE AMPLIFIER
20. PA AMPLIFIERS
21. NOSE WHEEL WELL ICS
22. PILOT'S ICS CONTROL PANELS
23. COPILOT'S ICS CONTROL PANELS
24. PILOT'S SIDE SHELF PA MAIN CONTROL
25. SYSTEM ENGINEER'S ICS CONTROL PANELS
26. RH INBOARD PYLON JACKBOX
27. RH OUTBOARD PYLON JACKBOX
28. NO. 1 LOUDSPEAKER
29. NO. 3 LOUDSPEAKER
30. RH WHEEL WELL JACKBOX
31. NO. 2 LOUDSPEAKER

Figure 7-16—INTERCOM AND PUBLIC ADDRESS SYSTEM.

Inflight Malfunction Detection Equipment

In addition to the malfunction display provided by the AN/ASN-24 computer, a malfunction detection and recording system is proposed. This recorder provides operational data for predicting malfunctions and for maintenance troubleshooting on such equipments as the inertial platform, gyro compass, autopilot, doppler radar, astro compass, and the dead reckoning computer. The proposed system is based on the MADREC system designed by Lockheed and currently undergoing operational evaluation by SAC on the B-52 Bomb/Nav system.

Military-ARINC Equipment Compatibility

The selected equipment provides maximum compatibility between military and commercial requirements. The commercial equipments include many items already in military inventory such as the VHF navigation VOR-101, VHF communications VHF-101, marker beacon receiver 51Z2, glideslope receiver 51V3, and automatic direction finder DF-202. The C-11 compass also compares favorably with the N-1 military compass.

Commercial equipment is environmentally qualified to RTCA Paper 87-54/DO-57 for minimum performance standards. These requirements are comparable to MIL-E-5400 for Class 1A equipment.

All commercial equipment is designed for operation in pressurized areas at aircraft altitudes of 20,000 to 30,000 feet. This airplane maintains an 8000-ft. cabin to 50,000-ft. altitude with an environment essentially the same as commercial jets. The RDR-1D radar antenna is designed for a maximum altitude of 40,000 ft.; therefore, the nose area has a small amount of pressure so as not to exceed the altitude limits of the antenna.

Antenna and Radome Installations

Most of the antennas required for the GL 207-45 aircraft are production items. Custom antennas are required for HF and UHF communications, ADF sensing, and VOR. Antenna pattern tests were conducted at Lockheed to verify most of the antenna locations, which are shown in Figure 7-17. Nose radome lightning protection is provided by external conductors similar to those employed on the Lockheed JetStar and C-140 aircraft. Lightning tests conducted on the JetStar nose radome have proven the effectiveness of these conductors. Similar tests will be conducted on the GL 207-45 aircraft nose radome. Nose radome anti-icing provisions are not proposed. Since the GL 207-45 aircraft will normally fly above 20,000 feet altitude, icing will be very infrequent. Below 20,000 feet altitude, the weather avoidance capability can be utilized to minimize icing.

Equipment Installation and Environment Control

The electronic system installation provides an effectively controlled equipment environment with maximum maintainability in compliance with the "quick equipment change" philosophy. Equipments are installed in pressurized areas on the flight deck and in the electronic compartment as shown in Figure 7-18. In this compartment, the two racks are rigidly mounted between the flight deck floor and cargo floor. Each shelf is mounted on the racks with shock mounts or vibration isolators and the equipments are rigidly mounted on the shelf. Adequate lighting, test equipment power outlets, and space between the racks for two men are provided.

The equipment cooling system provides both cooling by free air convection and by forced air in accordance with ARINC Specification 404. Equipments cooled by free air convection are installed on the forward rack with the electrical and autopilot

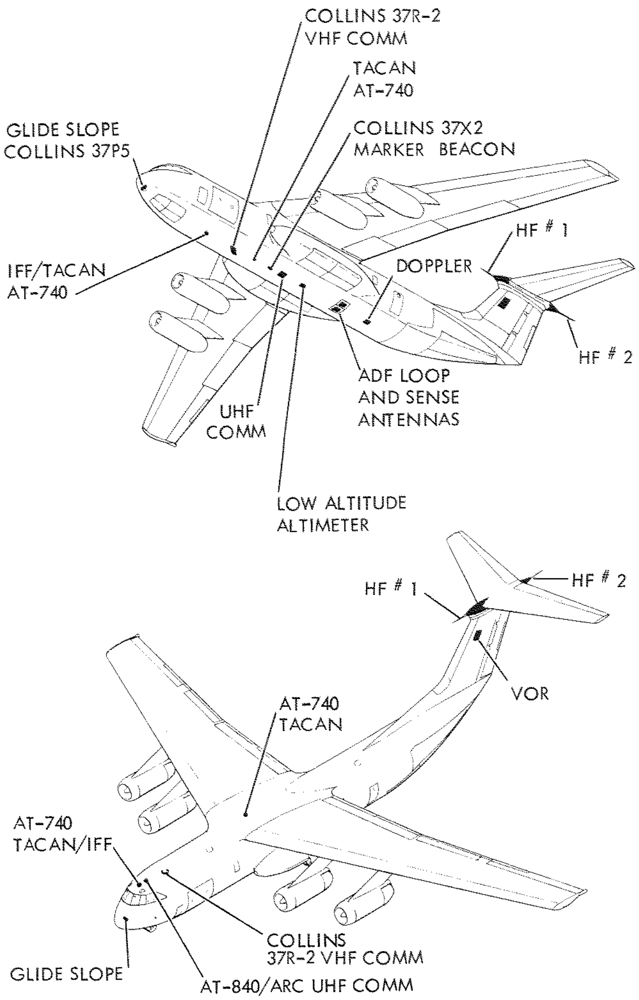


Figure 7-17—ANTENNA LOCATION.

components. Equipments requiring ARINC cooling are mounted on the aft rack. During normal pressurized flight, cabin air is pulled through the equipment and exhausted overboard through the flow regulator. A fan and a shut-off valve are located in the duct, down-stream of the rack, to pull air through the equipment during ground operation. A differential pressure switch opens the valve and starts the fan whenever the cabin pressure is insufficient to supply the required air flow. An emergency shut-off valve is also provided in the exhaust duct to seal this opening in the event of a cargo-compartment

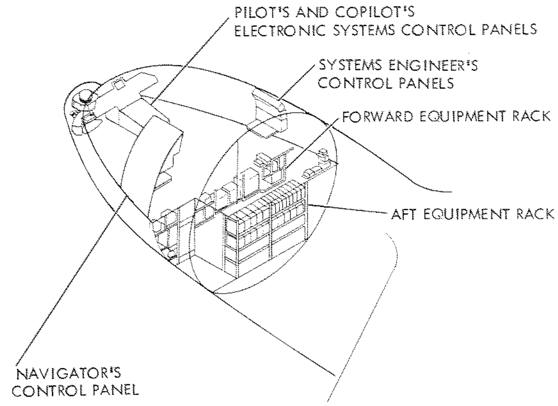


Figure 7-18—ELECTRONIC EQUIPMENT LOCATION.

fire or to prevent depressurization due to an abnormal fuselage leak.

If possible in addition to the environmental factors of cooling, pressurization, and shock isolation, the control of interference between equipment is required. To reduce the effort necessary to achieve an acceptable interference level in a system of this complexity, potential problem areas will be determined and minimized prior to the complete interference tests. Within 90 days after Air Force approval of the system the proposed interference control program will be submitted in accordance with MIL-E-6051C. Precipitation static is minimized by the use of Null Field P-Static dischargers. A technical discussion of this is included in Volume 2.

Space and power provisions are adequate to accommodate any future system requirements presently envisioned. Developments which warrant further consideration but which were not included in the proposed configuration include: (1) High resolution radar with terrain avoidance capability, (2) Equipment for taking position fixes on transit satellites, (3) Equipment for communications with Army ground forces, (4) A new line of commercial avionics equipment which exploit recent advances in solid state physics, and (5) A simple, reliable navigation system developed by Computing Devices of Canada.

SUPER HERCULES · GL207-45

section 8

ENVIRONMENTAL CONTROL SYSTEMS (5.1.5.9)

PRESSURIZATION AND AIR CONDITIONING (5.1.5.9.1)

System Description

The fuselage is pressurized and air conditioned with an engine bleed air system as shown in Figure 8-1. Conventional air cycle refrigeration units, valves, controls, and duct components are used. The all-pneumatic cabin pressure control system, shown in Figure 8-2, is designed to utilize existing outflow valves and control components. The maximum controllable differential pressure is 9.3 psi, which provides an 8,000-ft. cabin altitude at 50,000 ft. and a sea level cabin up to 25,000 ft. The positive pressure differential relief point is 9.7 psi and negative relief occurs at 0.37 psi. Cooling and heating capacity is adequate to maintain the crew and cargo compartment temperatures between 75 and 80°F under all climb and cruise power conditions. The system is designed to provide a cruise ventilation rate of 80 cfm for each crew member and 18.5 cfm per person for 95 troops. The system airflow varies from 175 lb/min. at sea level to 120 lb/min. at 50,000 feet on a design hot day. The cargo compartment floor is heated to 60°F by a jet pump system, similar to that used successfully in the C-130B airplane. When the extra crew compartment is installed, it is maintained at essentially the same thermal conditions which exist in the cargo compartment. Openings and small fans are provided to ensure proper air circulation within the enclosure.

Ground heating and cooling is accomplished with bleed air from the auxiliary power unit. An external duct connection is also provided to utilize conditioned air from a ground cart. The APU is capable of heating the airplane to 70°F or cooling to an 80°F crew compartment and a 95°F cargo compartment under the design conditions, as outlined in Section 7 of Vol. 2. The two air conditioning systems normally operate in parallel. However, in the event of equipment failure or duct rupture, each system can function independently to maintain full pressurization up to 47,000 ft. During normal system operation, bleed air is extracted from the inner surface of the engine compressor. The wing isolation

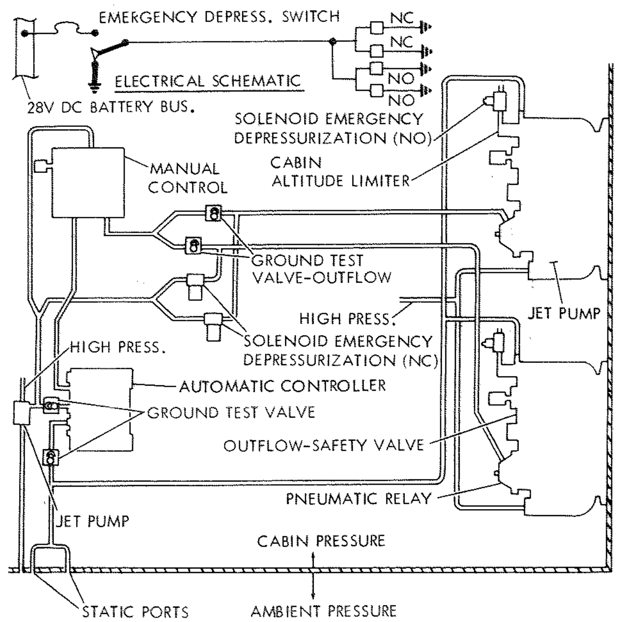


Figure 8-2—CABIN PRESSURE SYSTEM SCHEMATIC.

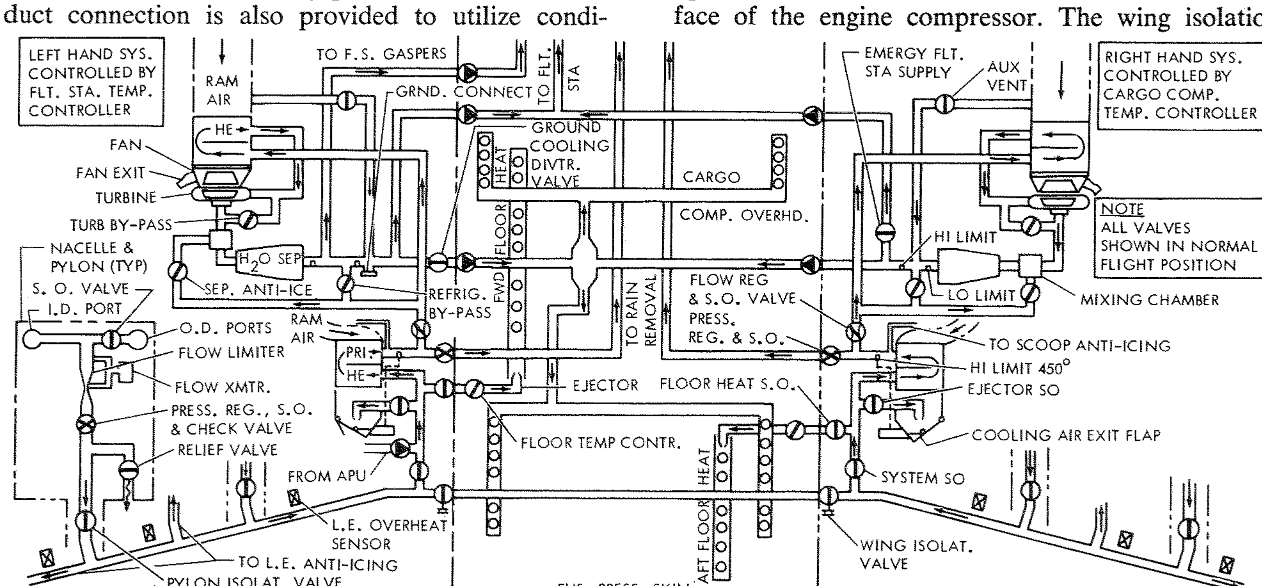


Figure 8-1—AIR CONDITIONING SYSTEM SCHEMATIC.

valves are closed, thus providing two completely separate air sources. Cabin air is extracted from the inside diameter of the engine because it is the cleanest air available. Due to the limited quantity of ID bleed furnished by the engine manufacturer, additional air must be extracted from the OD ports for rain removal and wing anti-icing. The possibility of contamination during these limited periods is recognized, and the detail design of the engine will dictate the amount of contamination obtained. Sufficient space exists for the installation of qualified catalytic filters, if desired or needed in the cross-ship manifold just outboard of the wing isolation valves.

The pressure in the bleed air ducting is limited to 70 psig by regulator valves installed in each pylon duct of the pneumatic system. The relief valves open at 80 psig in case of a regulator malfunction. The bleed air temperature entering the refrigeration units is limited to 450°F by modulating primary heat exchanger cooling air flow. An ejector is used to pump cooling air across the primary heat exchanger during ground operation. Temperature control and bleed airflow regulation are automatic. Operation of the left-hand system is governed by the crew compartment temperature controls and the right-hand system is controlled by the cargo compartment temperature requirements. Approximately 42% of the air from the left hand system is supplied to the crew compartment and the remainder is mixed with the air from the right hand system before being distributed to the cargo compartment via the overhead duct outlets. The air cycle unit temperature control valves are sequenced electrically. The turbine bypass valve is opened first to obtain an increase in supply air temperature. The water separator anti-ice control valve is thermostatically modulated to maintain the duct air temperature above freezing. The underfloor heating control valve is regulated in response to the jet pump secondary air temperature. The controls and indicators for air conditioning and pressurization are located on the systems engineer's panel, which is shown in Figure 7-10, Section 9, of this volume.

The cabin pressure and rate-of-change are controlled automatically by the action of the two combination outflow safety valves. A "reference" pressure is supplied to the outflow valves by the controller to maintain a constant cabin altitude or a constant differential pressure. Positive and negative pressure relief are provided by separate mechanisms inside the outflow valves. A cabin limiter control is incorporated in each valve to prevent the cabin altitude from exceeding 12,000 ft. in the event of equipment malfunction or misuse of the manual pressure control. Emergency depressurization is accomplished by opening the outflow valves and a remotely controlled hatch in the top of the fuselage. The dump time using the valves is approximately two minutes. Simultaneous operation of the valves and the hatch reduces the time to about 18 seconds. Ground test valves are provided to verify that both outflow valves are functioning and to check isobaric and differential calibration.

Electronic Equipment Cooling

The majority of the aircraft electronic equipment is located in a pressurized area under the crew compartment floor and is cooled by cabin exhaust air as shown in Figure 8-3. During normal pressurized flight a portion of the cabin air is allowed to flow through the rack to cool the equipment and is then dumped overboard through a flow control venturi. In this manner the provisions for electronic cooling prevent any smoke or noxious gases from entering the occupied area of the airplane. Ground cooling is accomplished by a fan. The fan and shut-off valve are controlled by a differential pressure switch. The switch opens the valve and starts the fan when the cabin pressure level is insufficient to supply the required cooling air flow. An emergency shutoff valve is installed in the overboard discharge duct for use in the event of a cargo compartment fire or to prevent depressurization because of abnormal fuselage leakage. The electronics cooling flow rates are in accordance with industry standards recommended by the SAE and ARINC. The fan and flow control venturi are sized so that the discharge air temperatures do not exceed 130°F except during hot-day ground operation with no APU cooling. The maximum heat rejection of electronic and electrical equipment is estimated at 6000 watts, which requires an overboard flow of approximately 30 lb/min. Proper flow division to individual boxes is controlled by orifices in the supporting shelf. Maximum system reliability is obtained by the use of a simple venturi for flow control during flight.

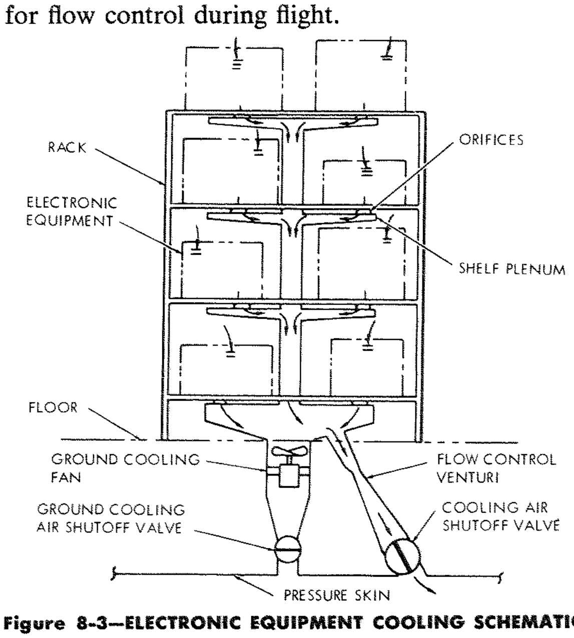


Figure 8-3—ELECTRONIC EQUIPMENT COOLING SCHEMATIC.

Design Features

Special features of the air conditioning and pressurization system are as follows:

1 Mechanical simplicity, maximum air pressure source reliability, light weight, minimum airplane performance penalty, low cost, and interchangeable equipment.

2 Maximum reliability of the cooling turbines is obtained by limiting operating speed to 40,000 rpm and requiring positive bearing cooling provisions

3 Maximum ground cooling capability from the APU. Also the diverter valve permits increased flow to the crew compartment for rapid "pull-down" and optimum comfort conditions

4 Service-proven method of heating the cargo compartment floor

5 Reduction of bleed air pressure to decrease duct system weight and obtain compatibility between ground and flight air cycle design parameters

6 Separate temperature control system for the crew compartment and main cabin

7 Combination outflow and safety valves for maximum reliability

Safety features incorporated in the system are as follows:

1 Cooling turbine hub burst containment provisions

2 Pylon and wing isolation valves

3 Firewall shutoff valves for engine isolation

4 Bleed air pressure-relief valves to protect against a regulator malfunction

5 Automatic system shutdown to protect the refrigeration units against a malfunction of the primary heat exchanger control.

6 Check valves in the supply ducts to prevent loss of cabin pressure in the event of duct failure

7 Cabin altitude limit control

Emergency Operation

Emergency provisions include an alternate source of ram air for ventilation, emergency air supply for the crew compartment in case of failure of the left hand system, manual override for temperature and pressure control, emergency depressurization control and special shutoff provisions for a cargo compartment fire. Warning devices include overheat indicators in the wing leading edge and equipment compartments, over-temperature at the primary heat exchanger exit, overheat in the underfloor area, excessive bleed air pressure downstream of the regulator, low duct pressure due to a rupture in the pylon or nacelle, and low cabin pressure.

System Test Plan

The test plan for pressurization and air conditioning includes component qualification tests to be conducted by the equipment manufacturers in accordance with Lockheed specifications, special reliability tests on critical components, and system mockup and flight tests. Information to be obtained from component tests will include verification of performance requirements and demonstration of satisfactory service life characteristics; demonstration of satisfactory strength characteristics, including wheel containment provisions; and capability to operate satisfactorily under various environmental conditions.

An operational mockup of the bleed air ducting, mechanical equipment and compartment air distribution ducting is to be constructed to demonstrate structural integrity and proper system operation.

Flight Testing

Flight tests will be conducted to demonstrate the safety and performance of the complete system. This phase of testing will involve air conditioning system capacity, cabin pressure regulation, temperature and velocity surveys, noise surveys, cabin air contamination analysis, smoke removal techniques, and emergency operating procedures.

Reliability and Maintenance

Reliability of the proposed air conditioning and pressurization system is predicted to exceed the requirements by incorporating system redundancy, duct isolation features, and the use of existing equipment designs. The primary reliability objective is to conduct extensive environmental and endurance tests, above the normal level of qualification, in order to establish safety margins and reliability trends on such critical components as the bleed air pressure regulator and relief valves, flow control valve, duct compensation devices, isolation valves, and the primary heat exchanger flap actuator and control. The advantages of system redundancy will be verified by mockup and flight tests. The location of the air conditioning equipment in the landing gear fairings provides excellent accessibility for maintenance purposes.

Growth Potential

The air conditioning system capacity is sufficient to handle the maximum personnel loading of 151 troops, and therefore growth potential needs only to be considered on the basis of advanced engines and increased electronics cooling airflow requirements. As explained in Section 7 of Volume 2, provisions have been made for a growth of approximately 20% in the electronics cooling load. This factor can be increased further by simply re-sizing the flow control venturi. The installation of advanced engines would not affect design structural requirements for the air conditioning system because the pressure is limited by the regulator valves and the bleed air temperature would not be significantly higher.

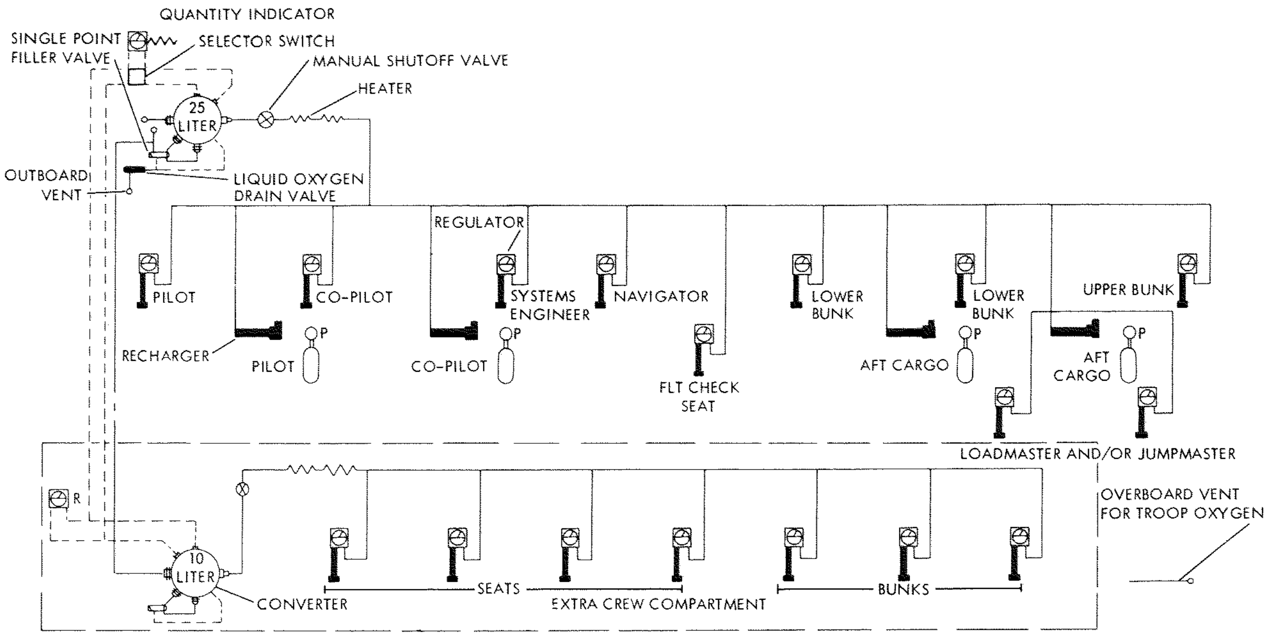


Figure 8-4—AIRCRAFT OXYGEN SYSTEM SCHEMATIC.

SOUND PROOFING (5.1.5.9.2)

Approximately 880 lbs. of insulation will be used for thermal and soundproofing requirements. The aft fuselage, which will be the least quiet area under all flight conditions, employs damping foam in conjunction with fiberglas batts and blankets. The forward and mid-fuselage sections use only the fiiberglas material.

Predicted sound levels are discussed in detail in Section 4 of this volume.

OXYGEN SYSTEM (5.1.5.9.3)

Basic System

The aircraft oxygen system is shown schematically in Figure 8-4. Oxygen is provided for a normal flight crew of five through a permanently-installed aircraft system, which contains provisions for these crewmen and up to five others as standby crew or passengers. System capacity is sufficient to allow an eleven-hour, 30,000 feet altitude, unpressurized flight, should such an extreme condition become necessary. The removable extra-crew compartment is supplied by an independent system installed within it, and troops, when carried, are provided oxygen from a completely portable system.

Design Features

For the crew a 25-liter liquid oxygen converter is supplied with a single point, externally-accessible filler valve, and is suitably vented overboard. The converter, which delivers gaseous oxygen at 300 psi, is located to the right of the nose wheel in an unpressurized area in order to take advantage of the lower ambient temperatures to reduce "boil off" loss. The oxygen converter is adequately protected from wheel-thrown foreign objects by a suitable enclosure. A readily accessible manual shut-off valve and warming plates are located under the flight stations. Four portable unit rechargers also available to the crew are located at the pilots co-pilots and two loadmaster/jumpmaster stations. A portable cylinder, type MA-1, is located adjacent to each recharger. Figure 8-4 also portrays the 10-liter system in the extra crew compartment. All system outlets permit the use of the standard issue USAF masks, Type A-13A.

Pressure build-up in the converter is automatic, and the operation of the oxygen system involves only the setting of the MD-1 automatic pressure breathing, diluter demand regulator control as desired, and coupling of the mask hose to the mask-to-regulator tubing. At maximum flow, the warming plate output is no more than 25°F below ambient. The characteristics of the MD-1 automatic pressure breathing, diluter demand regulator automatically provide the proper mixture of oxygen and ambient air, based on cabin air pressure. An in-flight oxygen supply quantity gage is provided. Operation of the extra crew compartment oxygen system is identical except that its converter is filled while out of the airplane and is readily installed or replaced.

Reliability and Maintenance

The oxygen system for the GL 207-45 airplane is practically identical to that installed in the C-130E, and all components other than the quantity gage are the same and are qualified. Reliability objectives will be fulfilled with the establishment of failure trends during evaluation tests and in Category I and II flight testing. All components of the oxygen system are located in easily accessible areas, and are covered

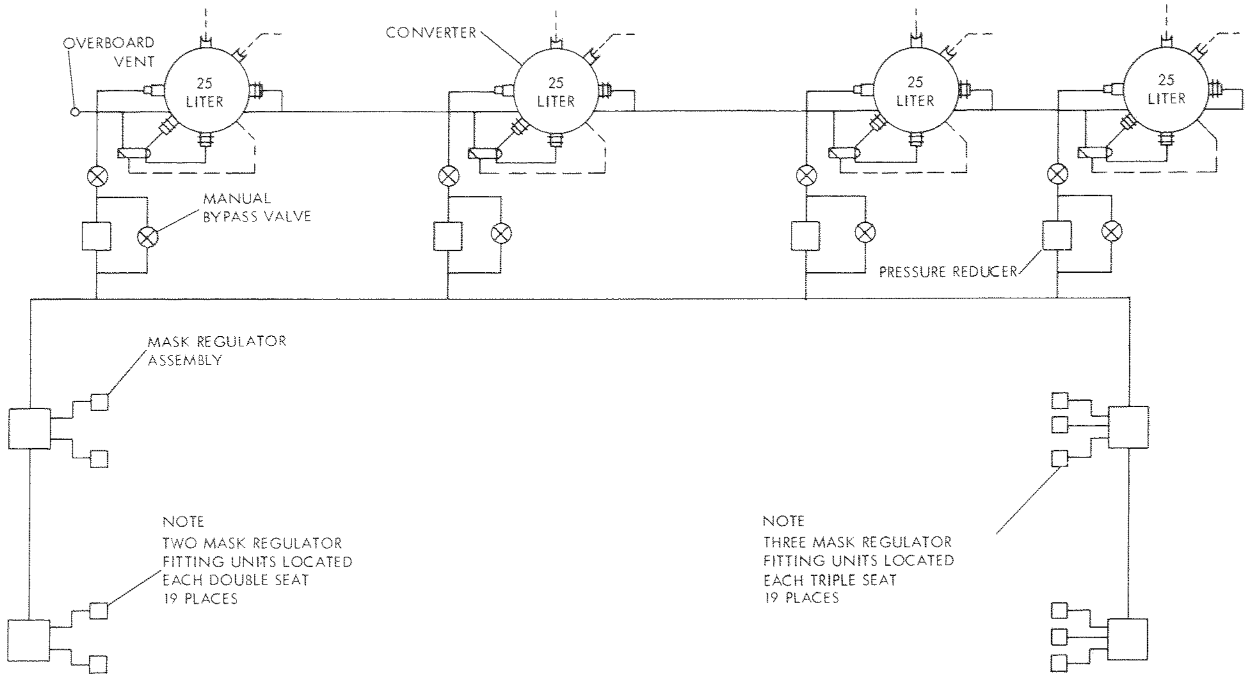


Figure 8-5—TROOP OXYGEN SUPPLY SCHEMATIC.

by existing technical orders and tool complements for USAF field-level maintenance.

Design and Development Testing

Evaluation tests of a limited nature will be conducted to verify the suitability of the line size and their associated pressure drops.

Portable System

A portable oxygen supply system can be installed on the airplane for missions on which troops or litter patients are to be transported. Oxygen for this system is supplied by 25-liter liquid oxygen converters placed on the ramp in the aft end of the cargo compartment. Four converters normally installed for the troop compliment are sufficient for over four hours of unpressurized flight at 30,000 ft., with 95 troops. This system is installed along with the troop seats, and its flexible distribution lines are attached to the fuselage frames with clips affixed to the lines. The liquid oxygen converters for this installation are filled prior to being placed in the airplane, and are connected to an overboard vent with flexible lines. Connection to the quantity indicator in the aircraft completes the installation. A schematic of this system is shown in Figure 8-5. The pressure reducers shown are provided to permit the use of simple mask-regulator assemblies per MIL-R-19121.

The litter patient installation is also in portable form and is installed along with the litter stanchions. The mask-regulator assemblies used are the same as those for the troops.

RAIN REMOVAL (5.1.5.9.4)

The windshield panels in front of the pilot and copilot are provided with a jetblast rain removal system, as shown in Figure 8-6. A continuous-slot nozzle, 16 inches in length, is mounted at the base of each panel to clear an area which is adequate for forward visibility during taxi, take-off and landing. Temperature of the bleed air supplied to the nozzle is limited to 450°F by the primary heat exchangers. To obtain maximum system reliability, each windshield panel is supplied by a separate duct, with a pressure regulator and shut-off valve located adjacent to the point where it joins the air conditioning system ducting. The glass is protected from overheat damage by a temperature sensor and control unit which closes the shutoff valve. The controls and indicators for the rain removal system are located on the pilot's anti-ice panel.

The system is designed for heavy rain conditions and on the basis of data presented in WADD TR 58-444. The pressure regulator is set at 25 psig, and the nozzle is sized to flow 4.5 lb/min. per inch at this pressure level during take-off and approach. At ground-idle power on an 85°F day the engine bleed pressure drops to 14 psig and the flow reduces to 3.75 lb/min per inch. A visibility index of at least 6.2 is obtained during the approach, which is above the minimum acceptable level of 4.4 mentioned in TR 58-444.

ANTI-ICING (5.1.5.9.5)

Ice protection systems of sufficient capacity are provided to assure all-weather capability in accordance with the requirements of CAR 4b.

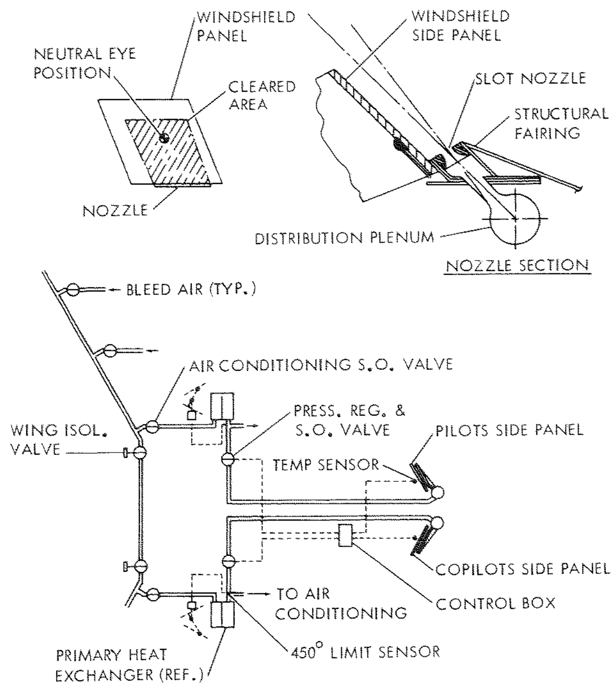


Figure 8-6—RAIN REMOVAL SYSTEM SCHEMATIC.

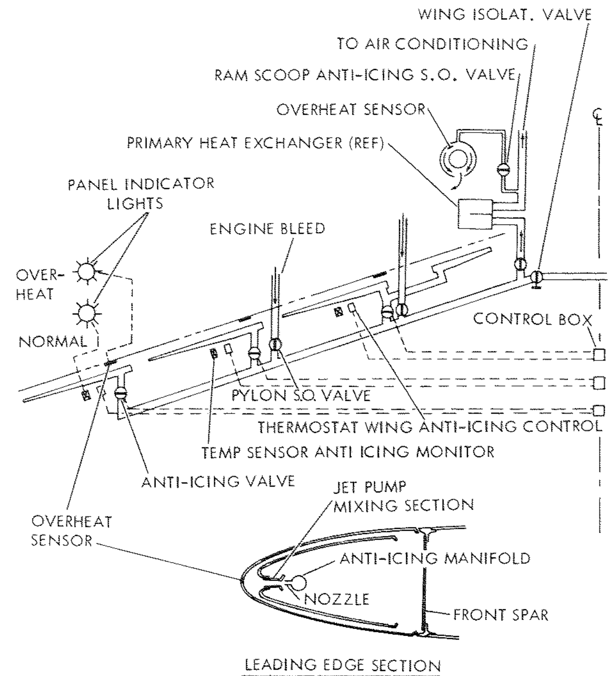


Figure 8-7—WING AND RAM AIR SCOOP ANTI-ICING SYSTEM SCHEMATIC.

Wing Anti-Icing

The wing leading edge is anti-iced with engine bleed air, as shown in Figure 8-7. The ejector method of diluting the hot bleed air with recirculated air from the leading edge double-skin passages is identical to that used in the C-130 airplanes. The airflow to the six wing sections is regulated by thermostatically-controlled, motor-actuated valves. Three switches turn the wing sections on or off in pairs, as shown in Figure 8-8. The double-skin exit temperature is maintained at a constant value by the control thermostats which vary the valve opening in accordance with the thermal load. Temperature sensors are installed to monitor system operation and to provide overheat warning. Pressure-relief doors are installed to protect the leading edge structure in case of a duct rupture. The wing anti-icing system is designed to be 100% evaporative under all climb and level flight conditions, using the meteorological requirements outlined in Specification MIL-A-9482. The system also meets the requirements of CAR 4b. Approximately 6.2% of the engine compressor airflow is required for wing anti-icing at the design condition.

Empennage De-Icing

The empennage is protected by metal-clad electrical heating elements which are recessed and bonded to form an integral part of the leading edge structure. Electrical de-icing has been selected because it is lighter and more efficient than a bleed air system, and eliminates the hazards involved in locating a long run of high-temperature ducting inside the cargo compartment. The arrangement and construction of the de-icer elements, and the electrical power required, are shown in Figure 8-9. The bonded laminate type of construction affords maximum protection for the heater element, and the steel cladding prevents damage from abrasion and hail. The cycling sequence is indicated by numerical order, and is established on the basis of providing symmetrical ice removal. Each de-icer section is energized for 8 seconds every cycle, resulting in a total cycle time of just over three minutes. The cycled areas are divided to obtain a nearly constant power load. Continuously-heated, chordwise parting strips are located at the ends of each cycled section to insure positive ice shedding. The total power requirement is 18.7 kw. The wiring diagram for the empennage de-icing system is shown in Figure 8-10. The controller performs all timing and switching functions necessary to carry out the de-icing cycle. A warning light illuminates if the timer motor fails to start or stops during the cycle. A fault-indicator light is used for overload and open circuit detection. Operation of the timer can be checked on the ground by placing the control switch in the "TEST" position. Overheat protection is provided by temperature sensors located in one parting strip and one cycled section. The proposed electrical de-icing system has a high degree of reliability through the use of qualified components.

Engine Anti-Icing

The inlet duct and the engine, including the nose dome and guide vanes, are fully anti-iced. The

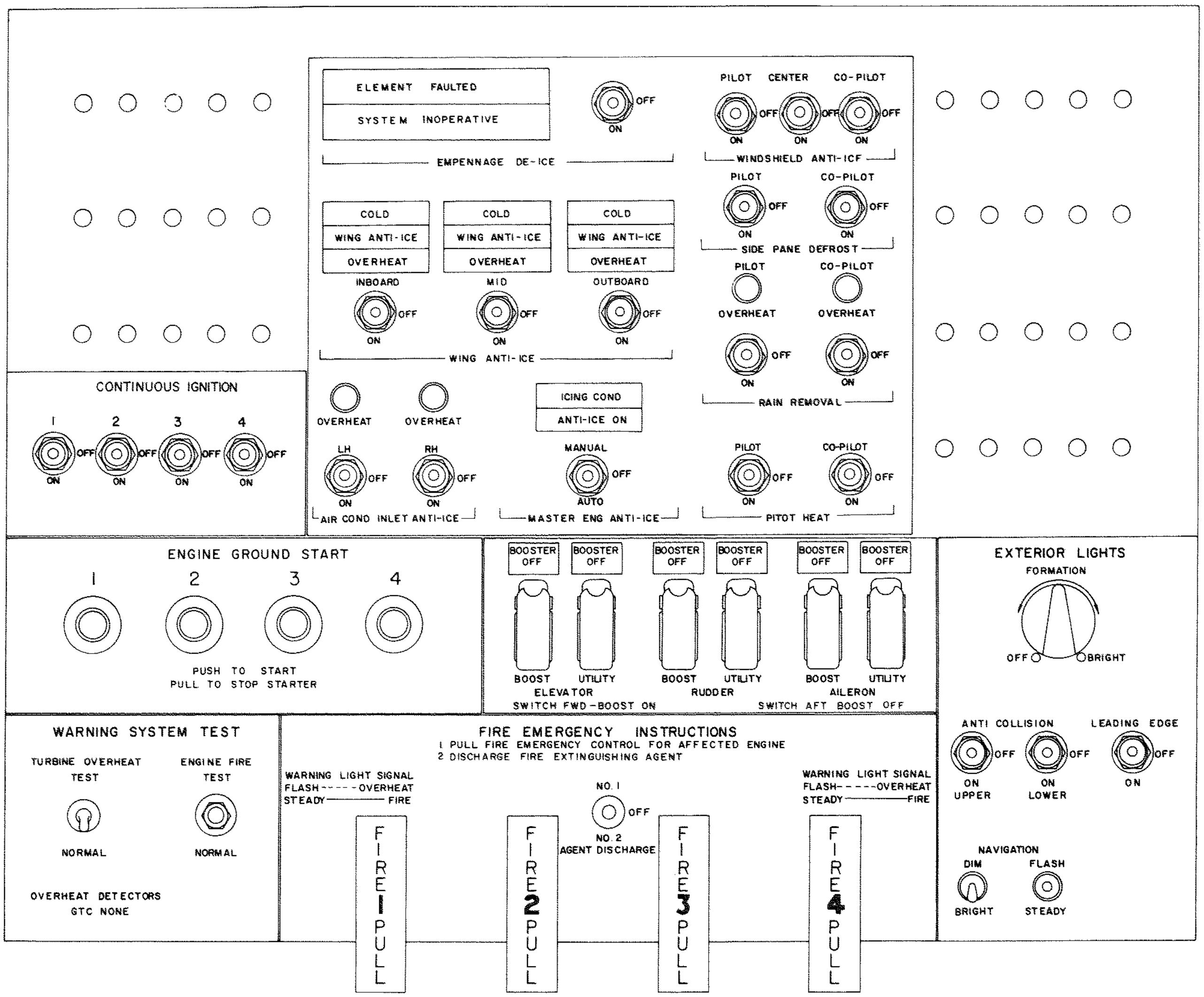
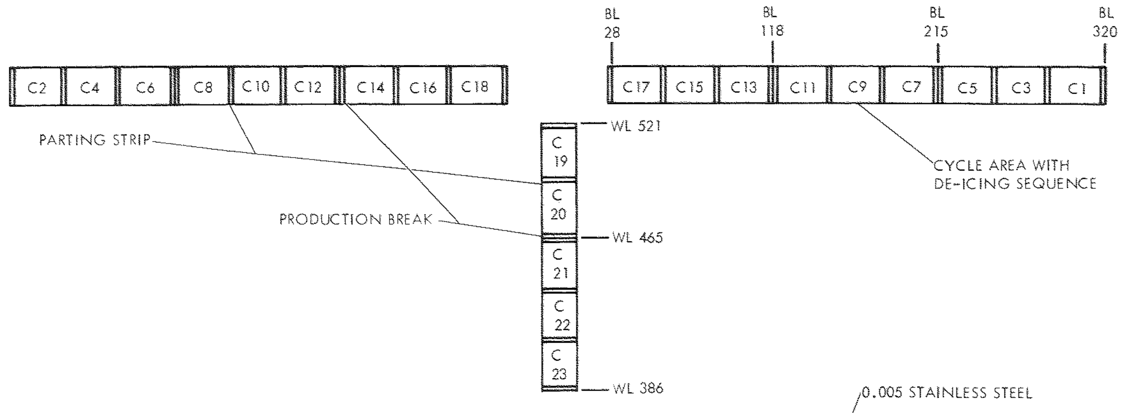


Figure 8-8—OVERHEAD PANEL.

system for the guide vanes is engine-supplied but is actuated by the airframe manufacturer's anti-icing control arrangement as shown in Figure 8-8. Bleed air in the amount of 1.3% of the engine compressor airflow is mixed with recirculated air in a "three-barrel" ejector which supplies an inlet plenum. The mixed air then flows around the inlet in circumferential passages, with the ejector supplying the required pressure. The coverage extends 24 inches back from the inlet lip. The multiple-ejector-and-passage principle is also employed in the JetStar engine inlet and the C-130 wing. It provides positive heat input to the surfaces, low temperatures that allow aluminum to be used, and extreme reliability. Structural damage from overheat will not occur, even in the event of inadvertent operation at high ambient temperature, as a result of another more critical design condition. The duct is designed by its maximum collapsing load, which occurs at sea level static take-off power on a cold day.

Operation may be either automatic or manual. Automatic on-off operation is initiated by an ice-detector located on the fuselage. Manual operation of the system whenever icing conditions are known or predicted is recommended by most of the commercial airlines. The system is designed with fail-safe features; e.g., a dead engine does not penalize other engine bleed systems, valves fail in the safe direction, and an engine isolated from the main aircraft bleed system continues to furnish its own anti-icing.

The system is designed to be fully evaporative in respect to catch inside the inlet duct at all climb and level flight conditions, including loiter, as discussed in Section 7 of Volume 2. Exterior icing has little effect and is not removed. The use of loiter as a design condition poses a difficult problem because of the very low bleed temperature, but it has nonetheless been adhered to because of the operational importance of the ability to "hold" for extended periods, especially in the bad weather associated with icing conditions.



ELECTRICAL POWER REQUIRED FOR PARTING STRIPS AND CYCLED SECTIONS							
LEADING EDGE SECTION	PROTECTED SPAN (IN)	TOTAL PROTECTED AREA (FT^2)	PARTING STRIPS AREA (IN^2)	PARTING STRIPS POWER (KW)	CYCLED AREAS AVERAGE AREA (IN^2)	CYCLED AREAS AVERAGE POWER (KW)	TOTAL POWER (KW)
INBOARD HORIZ.	90	12.6	80.7	0.97	557	11.15	
CENTER HORIZ.	97	12.4	73.5	0.88	570	11.40	
OUTBOARD HORIZ.	105	12.1	66.3	0.80	577	11.55	
TOTAL HORIZ. (PER SIDE)	292	37.1	220.5	2.65	568	11.36	
LOWER VERTICAL	79	13.0	95.0	1.15	592	11.85	
UPPER VERTICAL	56	8.7	66.5	0.80	587	11.75	
TOTAL VERTICAL	135	21.7	161.5	1.95	590	11.80	
AIRPLANE TOTAL	719	95.9	602.5	7.25	573	11.45	18.7

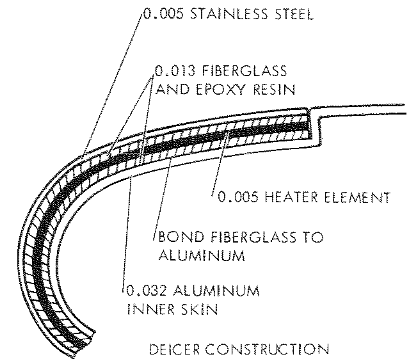


Figure 8-9—EMPENNAGE ELECTRICAL DE-ICER LAYOUT.

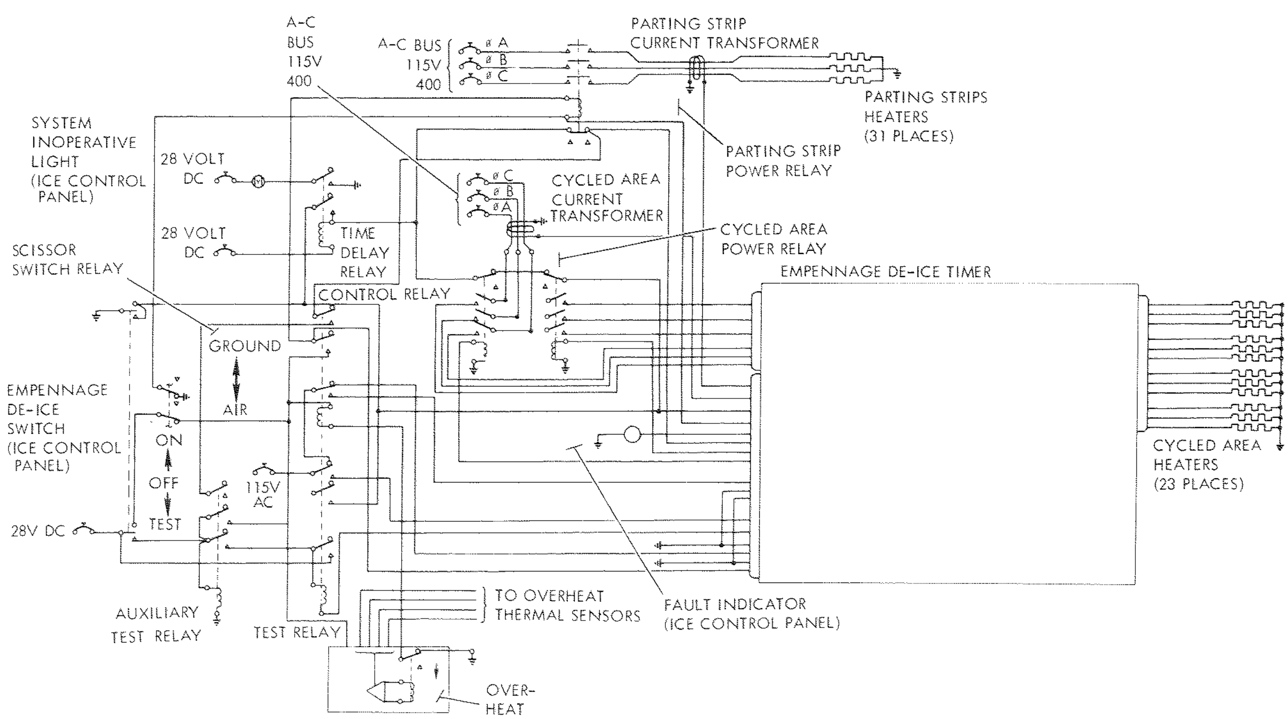


Figure 8-10—EMPENNAGE DE-ICER SYSTEM WIRING DIAGRAM.

Ram Air Scoop Anti-Icing

The lip area of each air conditioning ram air scoop is anti-iced by heating the inner and outer surfaces to a point three inches aft of the leading edge. Bleed air at a maximum temperature of 450°F is used as the heating medium, as shown in Figure 8-7. A running-wet surface is maintained at all operating conditions.

System Test Plan

The test program for the ice protection system is similar to that outlined under pressurization and air conditioning. The bleed air ducting in the wing and engine nacelles will be included in the pneumatic mockup and subjected to the same type of tests. A flow calibration curve will also be obtained for the various ejector sections. It is planned to conduct preliminary tests on the empennage de-icers in an icing tunnel. The wing and engine anti-icing systems will be flight tested in dry air to determine skin temperature profiles and to check temperature control system operation. All of the ice protection systems will be flight tested in measured natural or artificial icing conditions to demonstrate compliance with CAR 4b.

TRANSPARENT AREA DEFOGGING, DEFROSTING AND DE-ICING (5.1.5.9.6)

The front three panels of the windshield are provided with a resistance film which is electrically heated to prevent icing of the outer glass surface and fogging or frosting of the inner surface. The remaining windshield panels are electrically heated on the inner surface only for defogging purposes. The film resistance on the anti-iced panels is established on the basis of supplying 2100 Btu/hr per square foot at a 35°F external surface temperature, which is the requirement of Specification MIL-T-5842. The heat required for defogging is approximately 540 Btu/hr per square foot. Based on a constant power density over the entire glass area, the maximum power required for anti-icing and defogging is 12.5 kw. The initial design consideration is to apply the coating to the entire glass area in order to minimize the thermal stresses induced by cold edges. Heating is accomplished by five separate electrical systems. A typical wiring diagram is shown in Figure 8-11. Each of the three front panels operate from a separate power control unit. The six side panels are operated by the two remaining controllers. The control unit is basically a magnetic amplifier which varies the power input to the heated panel in proportion to the temperature rate of change as sensed by a thermal element imbedded in the plastic inner-layer. A "bridge" circuit, using the sensor as a variable resistor, furnishes the input signal for the control amplifier. The proportional-type control provides panel preheat, close temperature regulation, power limiting and cool-down control to reduce thermal shock.

The panels in front of the pilot and co-pilot can be anti-iced from the emergency bus in the event of normal power failure.

FIRE PROTECTION (5.1.5.9.7)

Rigid fire protection criteria have been applied to preserve the four-engine-reliability concept and to comply with the requirements and intent of HIAD and CAR 4b. Maximum isolation of flammables and ignition sources provide the most effective means of fire prevention. Particular care has been exercised to confine engine fire and prevent its spread to the pylon or wing. A service-proven surveillance fire-detection system is used. The fire extinguishing system utilizes components of proven reliability which are currently in USAF inventory.

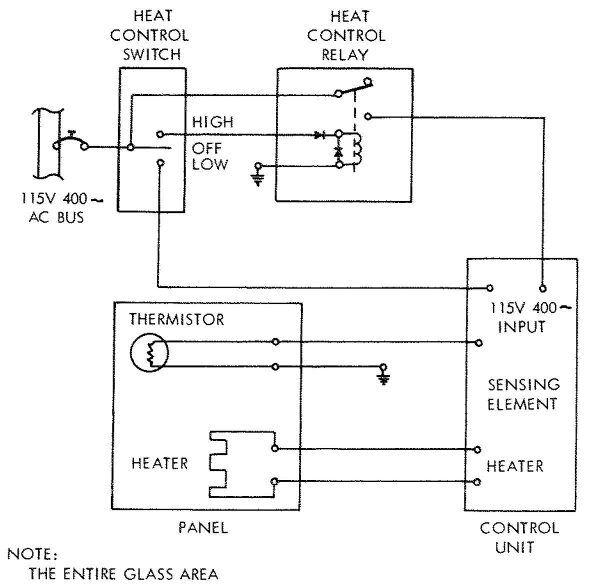


Figure 8-11—WINDSHIELD ANTI-ICING AND DEFOGGING SYSTEM WIRING DIAGRAM.

Figure 5-1 shows the features in the engine installation for preventing the spread of fire beyond the originating area. These principles employed have been established from full scale fire tests on, and service experience with, current jet transport airplanes. A firewall on the pylon base within the nacelle contour and a nacelle shoulder skin prevent flame damage to the pylon or wing. A fireseal between Zones I and II and a fireproof bulkhead on the nose cowl prevent spread of fire beyond Zone II. Structural damage and loss of the engine from the aircraft by fire are prevented by high-strength alloy steel engine mountings. Excessive pressure within the nacelle due to fire damage of the fan discharge ducts is prevented by a titanium shield.

Engine Fire and Ovenheat Detecting System

Four pyrotector detectors are located in the base of the pylon as illustrated in Figure 8-12. They scan the hemisphere below them except as obstructed by the engine, ducts and components, which will reflect the flame radiation to the detectors. This location protects the detectors and their wiring from mechanical damage and high ambient temperatures, and eliminates the need for flexible quick-disconnect wiring in the fire zone. Verification of this location is required, and tests are to be conducted with flames at various locations in the bottom of a simulated nacelle. Overheat thermoswitches located near the top of the combustor-tailpipe section will preclude prolonged hot gas impingement upon the pylon firewall. Other thermoswitches are mounted on the bottom of the nacelle doors. The auxiliary power unit fire-detecting system thermoswitches are located throughout the APU compartment.

Each engine fire and overheat-detecting system is electrically independent. Fire-detector units are connected in parallel to the amplifiers located in the respective pylons. The engine and APU overheat thermoswitches are connected with fireproof wiring in a closed-loop circuit. A nacelle fire energizes a steady warning light in the fire emergency control handle and also energizes the master warning light with a steady light. The overheat circuit includes a keyer or flasher which gives a blinking signal on the same warning lights in the fire emergency control handle and master warning light.

Engine Fire-Extinguishing System

The engine fire-extinguishing system utilizes a central supply of two containers of chlorobromomethane (CB), or bromotrifluoromethane (DB). They are located in the forward section of the left main landing gear fairing. This location provides ready access and visual reference to the container pressure gages. The quantity supplied exceeds that required by USAF and FAA standards. The system delivers two discharges of agent to any engine or to the APU, or one discharge to any two locations. Agent is conducted through thin wall stainless steel tubing and directed by continuous-duty, solenoid-operated directional control valves. These valves are operated when a Fire Emergency Control handle is operated. An external position indicator on each valve facilitates ground checking. A manifold located below the pylon firewall distributes the agent within only the compressor-accessory section of the nacelle as shown in Figure 8-12.

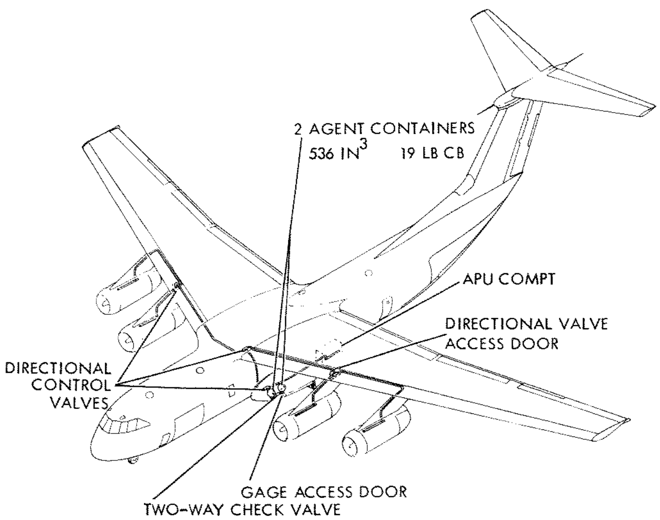


Figure 8-12—AIRCRAFT FIRE EXTINGUISHING SYSTEM.

Flight Deck and Cargo Compartment Fire Protection

The fire protection of the crew compartment and cargo compartment complies with Civil Air Regulations 46.380 through 4b.385. The cargo compartment is a Class A type as defined in CAR 4b.383. Detection of a cargo compartment fire is provided by a window in the bulkhead between the cargo compartment and the flight deck allowing the crew to view the cargo compartment from their normal stations. Control of cargo compartment fire and smoke is provided by operating a switch on the air-conditioning panel at the Systems Engineer Station which shuts off the incoming pressurizing and ventilating air into the cargo compartment and the flight deck, and closes the louvered opening in the bulkhead to exclude smoke from the flight deck.

All parts of the cargo compartment are readily accessible for combating fire with conveniently located portable extinguishers. Portable extinguishers consist of one CO^2 bottle on the flight deck, and one CO_2 and two water extinguishers in the cargo compartment.

SUPER HERCULES · GL207-45

section 9

INTERIOR PROVISIONS AND ARRANGEMENTS

SAFETY AND COMFORT PROVISIONS (5.1.5.10)

The comfort provisions for the crew and cargo compartments are discussed in separate sections. These sections are followed by a description of the safety and escape facilities provided.

Crew Compartment

Efficient operation of the crew station is ensured by a design which recognizes human factor requirements. To satisfy these requirements, such things as comfortable surroundings and easy access to properly located control components must be provided. The carpeted duty station floor is on two levels to provide maximum head room for both the seated and standing positions of the crews and to provide ready seated access from the co-pilot's position to the system engineer's station. Normal and emergency movement is aided by an overhead handrail and by conveniently located hand grips.

All projecting edges and corners which could cause crew injury are rounded. General flight station lighting is provided, as well as integral adjustable instrument and indirect panel lighting. In addition, each crew station has panel flood lights and portable units. Daylight glare is counteracted by tinted sun visors at the forward windshields and overhead windows. Glare shields are also installed to aid instrument readability and to prevent reflection from the windshield. Each crew station has a four-way adjustable seat with arm rests to ensure individual comfort and efficient performance of duties. A seat belt and shoulder harness, required for high "g" load safety, accompanies each seat.

Each station is provided with a coffee cup holder, an ash tray, and an electric lighter. The navigator and systems engineer are supplied with large tables, book and map stowage areas. The pilot and co-pilot side panels and the aft end of the pedestal afford additional map stowage. An oxygen and intercom connection and long lines are provided at the navigator's station so that no interruption of these systems occurs while using the sextant. Provisions for detecting fire or smoke in the cargo compartment from the crew compartment through a window is described in Paragraph 5.1.5.9.7.

The rest area includes the clothes closet aft of the system engineer's station; the galley, which consists of an oven, a refrigerator, hot cups, drinking water, storage and disposal space; the bunks; and the sanitary facilities. The clothes closet affords space for cap, overcoat, and jacket storage for each crew member. The two bunks re 28 in. wide and 78 in. long and are provided with curtains. The upper bunk folds at the end nearest the steps to permit access to the emergency ladder. Oxygen and intercom provisions and seat belts are furnished at the bunks. Anti-exposure suits are stowed under the lower bunk. The sanitary facilities consist of a chemical toilet, a urinal and a lavatory. These items are stowed behind doors and are moved into the crew entrance area for use. Privacy is afforded by a modesty curtain across the flight deck access steps. The access steps to the flight deck are provided with a handrail and anti-skid treads. The comfort of the crew is considered in the careful selection of pleasing colors for the crew compartment.

In addition to the safety and comfort provisions on the flight deck, a portable extra crew compartment can be installed on a WS 463L standard pallet in the forward portion of the cargo compartment to provide for a relief crew on long missions. The compartment is enclosed on all 4 sides and has a door in the forward left corner for easy access to and from the flight deck and the sanitary facilities. The completely portable compartment has a separate floor, to which the walls are attached. The design permits removal of the compartment and its contents from the pallet. The contents of the compartment as shown by Figure 9-1 include 3 bunks, four 16"g" reclining seats, a garbage receptacle, refrigerator, liquid containers, food storage compartment, and equipment storage space for the entire crew. The storage space is provided under the lower bunks, in storage closets and in wall racks above the reclining seats. Oxygen regulators are provided at each bunk and at each seat location. Both general and selective lighting are provided as well as an intercom panel. Ventilation is provided by forced circulation of the conditioned cabin air through louvers in the walls. An alternate permanent extra crew compartment containing 3 bunks and 4 reclining seats requires an 80 inch extension of the flight deck and is described in Section 8 of Volume 2. The requested weight and cost data of a 2 bunk and 3 section seat arrangement requiring only a 45 inch extension are presented in Section 7 of Volume 4.

Cargo Compartment

The airplane is designed primarily as a cargo airplane but it can be quickly and readily converted to carry troops, paratroops, or litter patients for emergency requirements and peacetime training considerations. These alternate modes of operation have not compromised the design of the airplane as a basic cargo carrier.

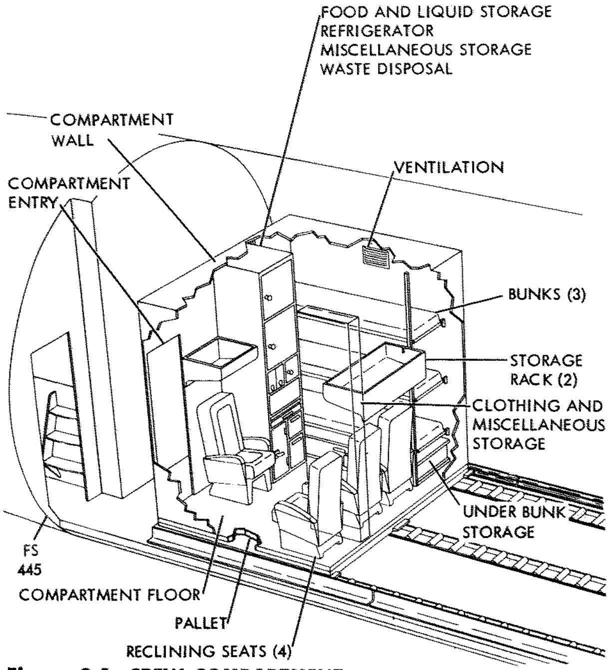


Figure 9-1—CREW COMPARTMENT.

Oxygen regulator and intercom panels are provided, forward of each rear personnel door, for a jumpmaster and/or a loadmaster. When not actively engaged with their duties, seating space is provided on the lower bunk on the flight deck. Passenger equipment provisions in the cargo compartment arrangements are as follows:

1 Aft facing, 19 inch wide, 16"g" troop seats with Brownline seat fittings may be readily mounted directly on the 20-inch grid of the cargo floor tiedown fittings. As shown in Figure 9-2 this arrangement provides for 95 troops arranged with a two-seat cluster on the left side and a three-seat cluster on the right side with a 20-inch aisle between. Two separate sets of removable sanitary facilities, portable oxygen equipment attaching to permanently installed tubing and outlets, a removable galley with food provisions for 95 hot and 95 frozen flight box meals, drinking water, first aid kits, and three additional 20-man life rafts are provided.

2 Troop seating mounted on pallets, shown in Figure 9-3, accommodates 82 troops and provides the same equipment and escape items as arrangement 1.

3 Paratroop seating, shown in Figure 9-4, has a seating capacity of 74 and has equipment necessary for paratroop evacuation. In addition, the same equipment and escape items noted in arrangement 1 are carried except provisions for storing frozen food and heating meals are not required. Paratroop spoilers are also installed by kit for this arrangement. The spoilers are attached within the fuselage forward of the paratroop doors. The spoilers are actuated to the desired position for protection during bailout of paratroops. The spoiler is powered into the airstream by a hydraulic actuator.

An alternate possibility for a paratroop arrangement is shown in Figure 9-5. This arrangement shows the usual side facing seats required for airborne troops. This version has a capacity for 151 troops at a 20-inch spacing and approximately 128 paratroops at 24-inch spacing.

4 The cargo compartment is also capable of housing 72 litters in a triple tiered arrangement and seating 8 attendants, as shown on Figure 9-6, together with the equipment and escape items of seating arrangement 1.

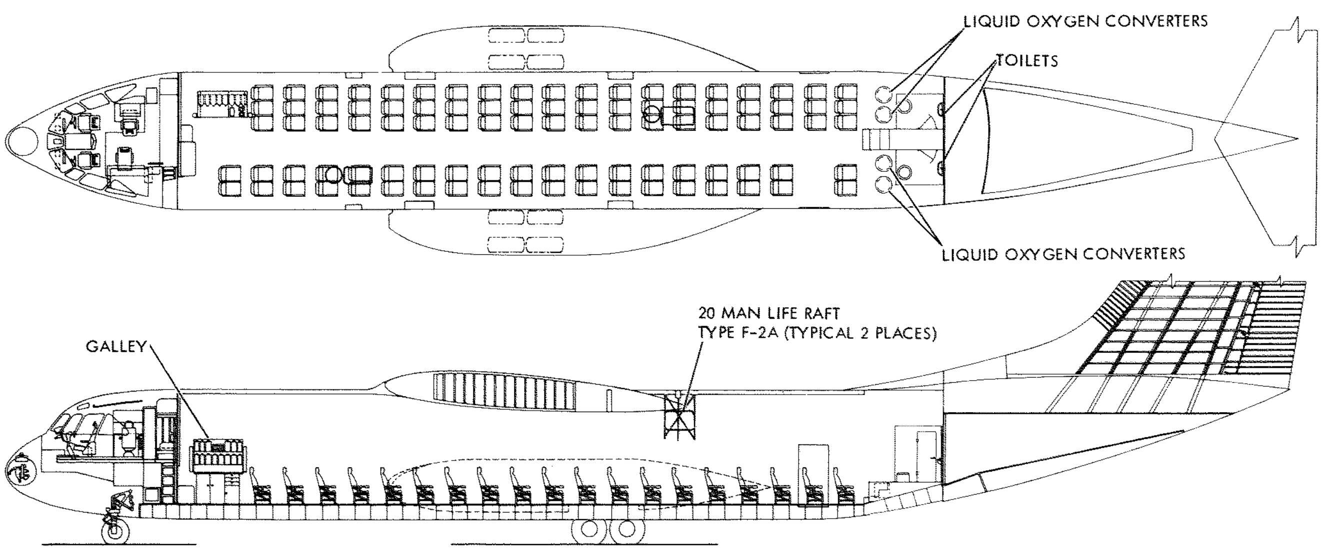


Figure 9-2—INBOARD PROFILE, MAXIMUM TROOP SEATING ARRANGEMENT ON CARGO FLOOR, 19 INCH SEAT WIDTH, 5 ABREAST, CAPACITY 95 SEATS.

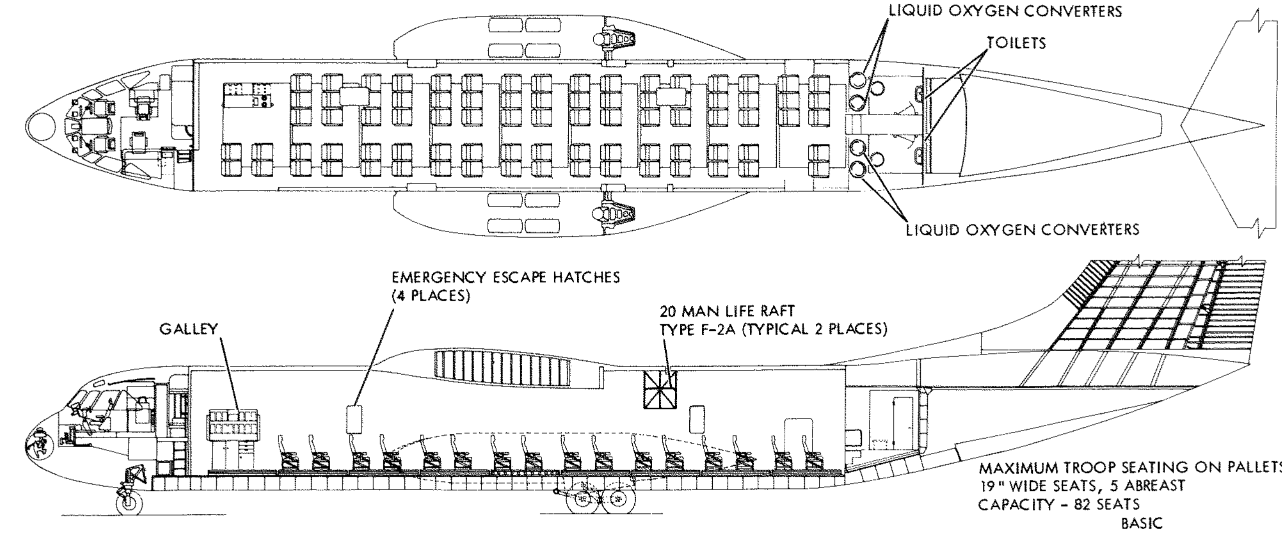


Figure 9-3—INBOARD PROFILE, MAXIMUM TROOP SEATING ARRANGEMENT ON PALLETS, 19 INCH SEAT WIDTH, 5 ABREAST, CAPACITY 82 SEATS.

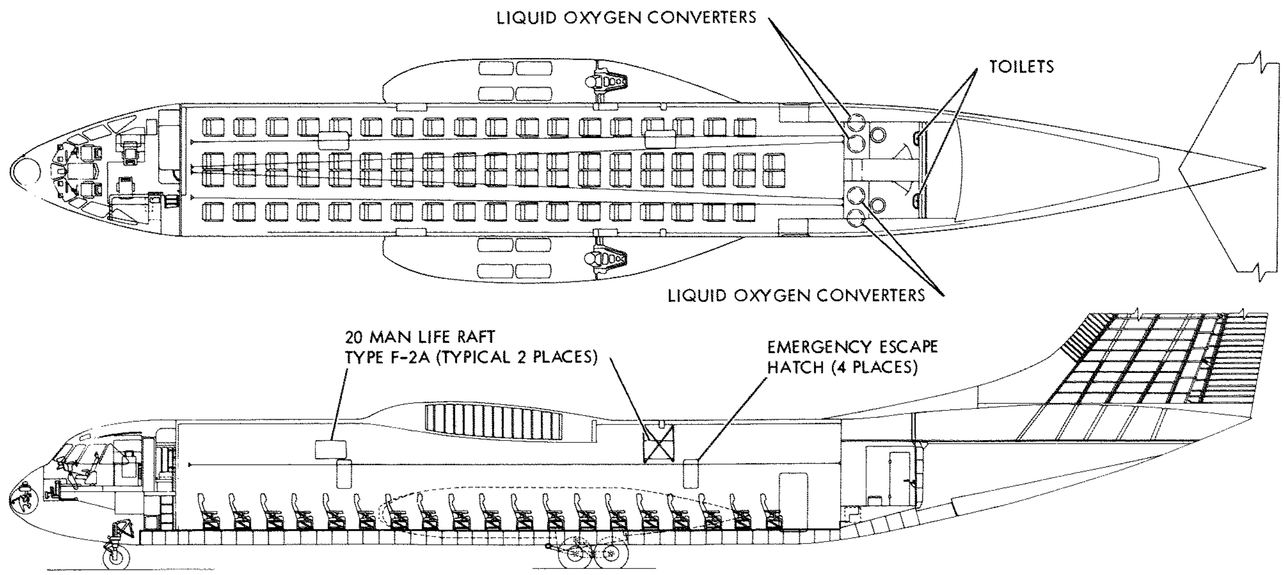


Figure 9-4—INBOARD PROFILE, MAXIMUM PARATROOP SEATING ARRANGEMENT ON CARGO FLOOR, 19 INCH SEAT WIDTH, 4 ABREAST, CAPACITY 74 SEATS.

Safety and Escape Facilities

The behavior of the aircraft during crash landing or ditching operations has been examined and is discussed below. This is followed by a description of the equipment and facilities provided to assist the crew and other personnel aboard the airplane under these emergency conditions as well as in-flight emergencies.

The design and construction characteristics of the airplane combine to enhance the safety of the crew and occupants in a controlled crash landing. Actual experience in the wheels-up landing of a C-130 which has the same general rugged structure in the bottom fuselage and cargo floor indicates that a successful wheels-up landing can be accomplished with only minor damage to the aircraft and with minimum hazard to the occupants.

Using data from NACA model ditching tests of aircraft of similar fuselage configuration (C-123, C-133) and the NACA evaluation of the C-130B ditching characteristics, it is concluded that the airplane will meet the requirements set forth in specification MIL-S-5705. Further analysis in Section 8, Volume 2 supports this view. Nevertheless, NASA will be consulted regarding the requirement for a model test.

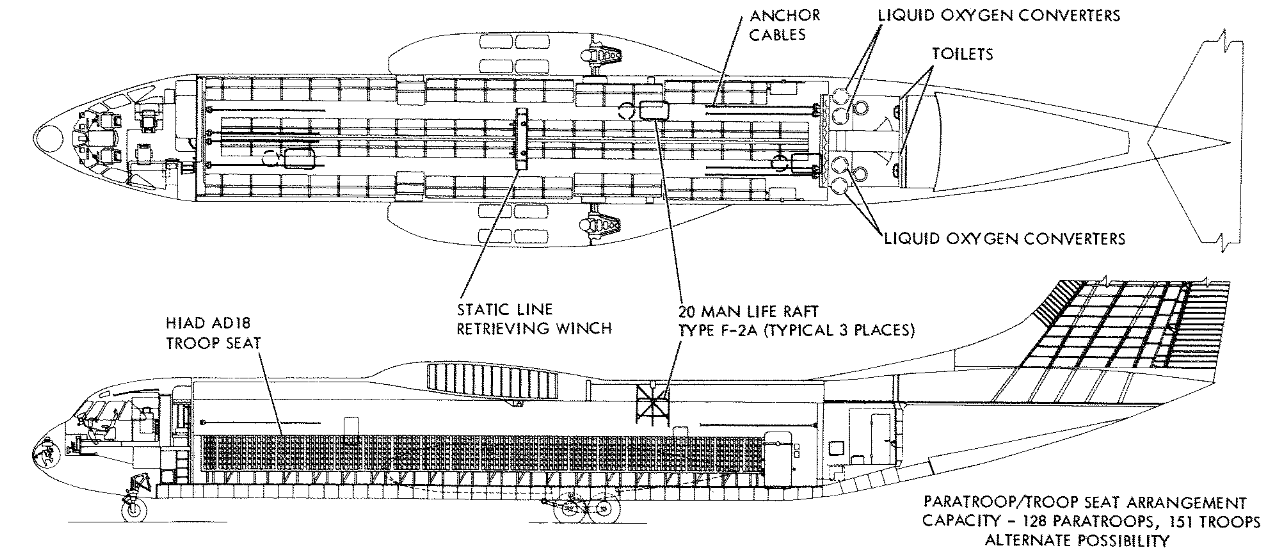


Figure 9-5—INBOARD PROFILE — PARATROOP/TROOP SEATING ARRANGEMENT, ALTERNATE POSSIBILITIES, CAPACITY 128 PARATROOPERS, 151 TROOPS.

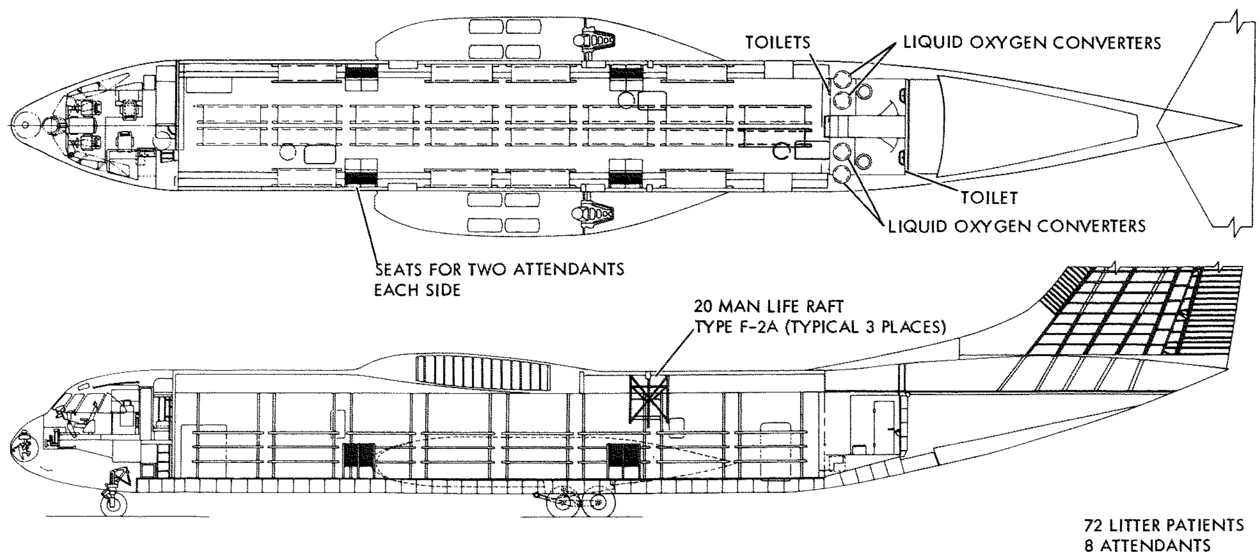
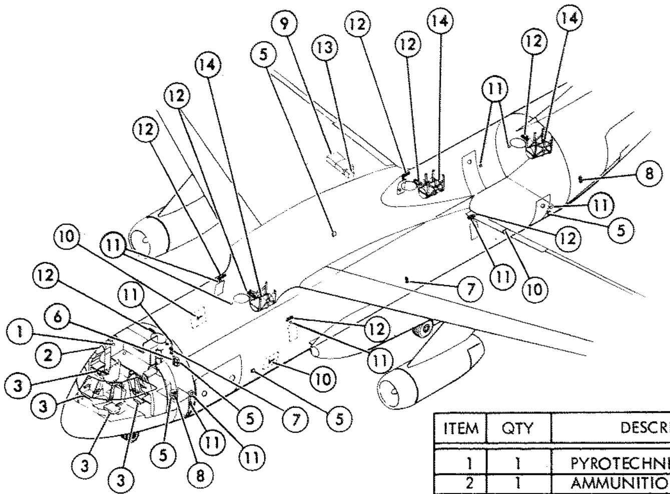


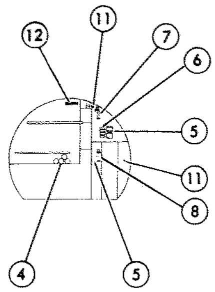
Figure 9-6—INBOARD PROFILE, LITTER ARRANGEMENT, CAPACITY 72 LITTER PATIENTS, 8 ATTENDANTS.

Emergency Equipment

Figure 9-7 shows the location of the emergency equipment in both the crew and cargo compartments. These provisions have been developed in part through fabrication of a full sized and very complete mockup.

Life vests for each crew member, an escape rope, a fire extinguisher, and two first aid kits are located in the crew compartment near the escape hatch. A pyrotechnic pistol is mounted in the ceiling at the system engineer's station. One CO_2 and two water fire extinguishers are located in the cargo compartment for use in fighting interior fires. Emergency lights are installed in each of the eight escape hatches as well as one at the crew door and one on the forward bulkhead of the cargo compartment. The lights are removable and may be carried with personnel escaping from the aircraft. An 11/16-in. nylon escape rope is installed at each of the eight escape hatches to aid in climbing from the fuselage after emergency exit through the escape hatches. There are provisions in the upper surface of the wing trailing edge for four 20-man life rafts and an emergency radio transmitter. Release and inflation of the life raft is accomplished by pulling release handles located (1) at the rear bulkhead of the crew station, (2) forward of the right cargo compartment personnel door, (3) at the wing trailing edge upper surface at the side of the fuselage body and, (4) at the life raft compartments. For passenger, litter, or troop configurations, one 20-man life raft may be stowed in portable storage racks located at each of the three cargo compartment overhead escape hatches. Each





ITEM	QTY	DESCRIPTION	IDENTIFICATION	UNIT WT
1	1	PYROTECHNIC PISTOL	TYPE AN-M8	2.2 LB.
2	1	AMMUNITION KIT (20 FLARES)	TYPE A-8	10.5 LB.
3	4	SURVIVAL KIT	MIL-C-25570	45 LB.
4	4	ANTI-EXPOSURE SUIT	MIL-C-005808F	
5	6*	FIRST AID KIT	FEDERAL CATALOG STOCK NO. 6549-919-6650	2.2 LB.
6	4	LIFE VEST		
7	2**	FIRE EXTINGUISHER (CO_2)	AN 6045-147	12.1 LB.
8	2**	FIRE EXTINGUISHER (H_2O)		
9	2***	LIFE RAFT	MIL-L-009131D	
10	4	CRASH AXE	PER DWG. NO. 56D6221	3.5 LB.
11	12	EMERGENCY LIGHT	GRIMES MFG. CO. # 44910 MIL-L-25866	
12	8	ESCAPE ROPE	LAC # 388576-1	4.2 LB.
13	1	EMERGENCY TRANSMITTER	AN/CRT-3	44.0 LB.
14	3	LIFE RAFTS	TYPE F-2	

* (2) LOCATED ON FLIGHT DECK, (4) IN CARGO COMPARTMENT WITH STOWAGE PROVISION FOR (20) ADDITIONAL IN CARGO COMPARTMENT.

** (1) CO_2 EXTINGUISHER LOCATED ON FLIGHT DECK, (1) CO_2 AND (2) H_2O EXTINGUISHERS LOCATED IN CARGO COMPARTMENT.

*** PROVISIONS FOR (4) TO BE STOWED IN WING COMPARTMENTS AND (3) ADDITIONAL IN CARGO COMPARTMENT WHEN TROOPS ARE CARRIED.

Figure 9-7 EMERGENCY EQUIPMENT LIST AND LOCATION.

life raft contains a survival kit and each of the crew seat cushions contains survival equipment kits.

Escape Hatches and Escape Routes

Provisions are made for emergency exit from the aircraft in flight, on the ground, or in the water. Escape hatches which are provided in addition to the normal entrance and loading doors are shown in Figure 9-8. Four ground emergency escape hatches, two on each side of the fuselage, are located at fuselage stations 658.0 and 1098.0.

These hatches are plug-in type and are operable from either inside or outside of the fuselage. The hatches afford a clear opening 36 in. high by 20 in. wide. Except for their larger size, these hatches are the same as those used successfully on the C-130 airplane. For ditching, there are emergency escape hatches located along the top of the fuselage at F.S. 424.0, 598.0, 1018.0, and 1218.0. The one at F.S. 424.0 is in the aft portion of the crew compartment while the other three are in the cargo compartment. The one at 1018.0 has a "T" handle, bell crank cable release mechanism operable from the crew compartment so that this hatch may also be used for emergency depressurization of the aircraft. This arrangement is similar to that on the C-130 aircraft. Alternate escape openings are made through four chop-out areas in the cargo compartment, with axes stowed in these areas, and through the large side clear view windows in the crew compartment. Each of the escape hatches is held in place by a latch and may be removed by the simple movement of a release handle. The hatches are removable from either inside or outside the airplane. All latching handles are painted red for quick identification. Escape is made from the crew entrance door, the cargo compartment personnel doors, the cargo ramp and the eight emergency hatches as shown in Figure 9-9—depending upon the nature of the emergency. In-flight escape from the aircraft is made through the normal airplane openings: the crew entrance door, cargo compartment personnel doors and cargo ramp. Ground escape from the aircraft is made through the cargo compartment personnel doors, the crew entrance door, the eight escape hatches, the pilots side windows, or the chop-out areas. To escape after ditching, the crew exits through the overhead escape hatch in the crew compartment by climbing the ladder on the compartment rear bulkhead. Exit from the cargo compartment is made by climbing the folding ladders attached to the portable life raft racks. Automatic release and in-

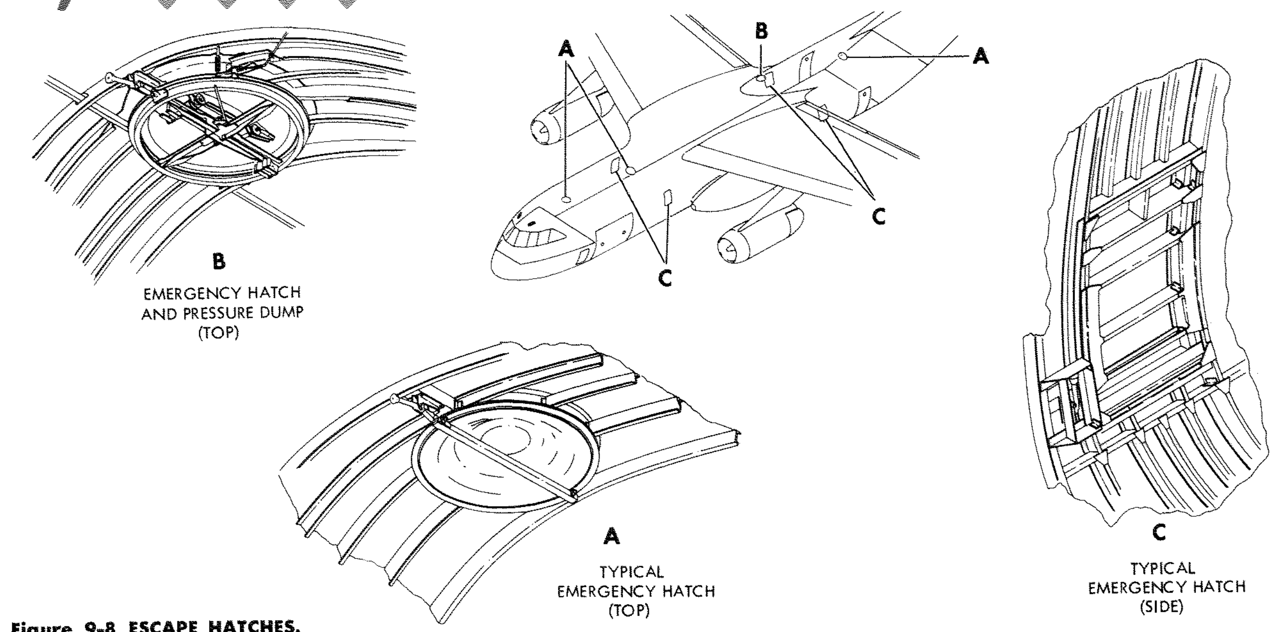


Figure 9-8 ESCAPE HATCHES.

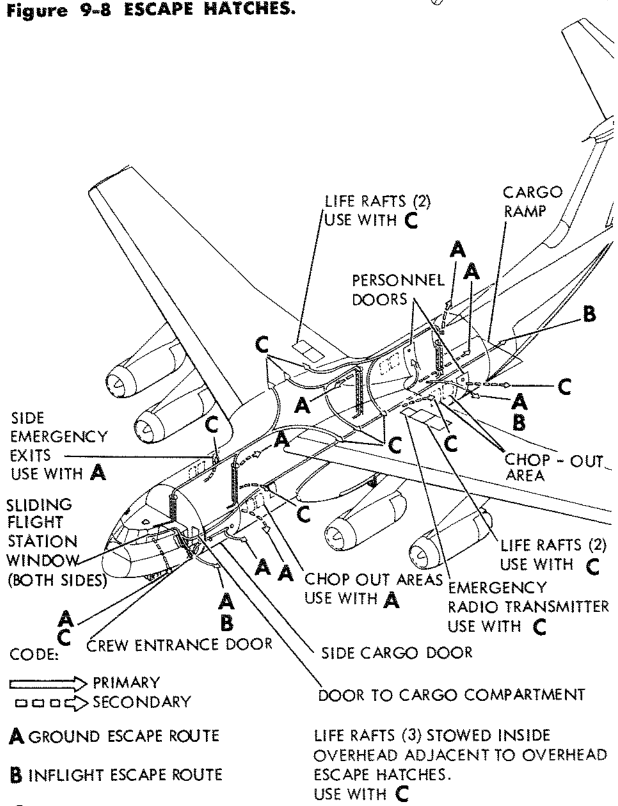


Figure 9-9 ESCAPE ROUTES.

flation of the life rafts in the wing is made by pulling the release handles at time of exit as described earlier.

Flight Deck Arrangement (5.1.5.11)

The flight deck design is based on extensive operation experience with the C-130 and JetStar aircraft. To provide optimum aircrew efficiency, this operational experience is combined with the principles of human engineering to produce a systems design displaying optimum man-machine capability. Every effort has been made to conform to all military and commercial aircrew station standards including HIAD, HIGED, MIL-STD-203C, MIL-STD-411, SAE-S-7 Standards, and CAR 4b. In this manner, transition times and the possibility of pilot error are minimized. Bread board, scale, and full size mock-ups have been constructed in order to permit continuing analysis of the operational procedures and design details.

The general arrangement of the flight deck shown by Figures 9-10 and 9-11 contains carefully planned work stations for a pilot and co-pilot located in the conventional manner, a systems engineer's station and a navigator's station. The navigator and systems engineer face in an outboard direction— the systems engineer on the right side aft of the co-pilot and the navigator on the left side aft of the pilot. A flight check seat, designed for flight loads, is located immediately aft of the pedestal between the pilot and co-pilot. The seat folds and is stowed in a compartment forward of the navigator's table. For take-off and landing or when the navigator's position is unoccupied, the navigator's seat may be moved into position behind the pedestal and utilized by the check pilot. A rest area located aft of the work stations includes a complete galley, and sleeping facilities for two men. A chemical toilet, a wash basin and a urinal are located on the lower deck forward of the crew entrance door.

The arrangement selected is considered optimal in that it provides clear delineations of responsibility, direct and easy communication among the crew members, and an unrestricted view of the systems

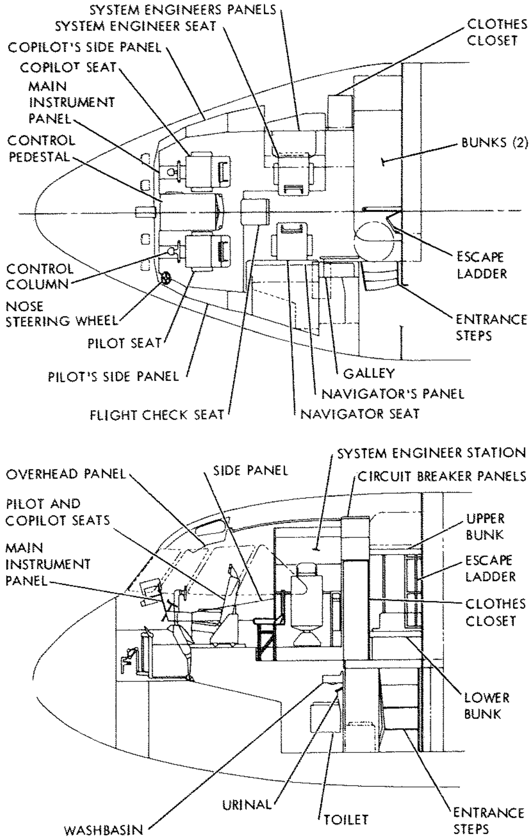


Figure 9-10—FLIGHT STATION ARRANGEMENT.

engineer's panels from the pilot's station. The co-pilot has accessibility to the systems engineer's control by moving his seat aft to the forward part of the system engineer's station. Optimum visibility, both internal and external, meeting all military and civil requirements is provided for all crew members at their respective stations. Lighting details in the flight deck area is described in a following section. The design details of the various work stations have evolved within the framework of a systematic human engineering program described in Section 8, Volume 2, and during development of a full size, very complete fuselage mockup.

The pilot's and co-pilot's stations include five basic panel areas; (a) the primary instrument panel, (b) the engine instrument panel, (c) the center pedestal, (d) the overhead panel and (e) the side panels. The general locations of these panels with respect to the pilots is conventional as illustrated in Figure 9-11. The details of the pilot's panels are shown in Figures 7-9. The layout of the systems engineer's and navigator's panels are shown in Figures 7-10 and 7-14. The controls and displays associated with the various panels are discussed in Section 8, Volume 2.

Direct entrance into the lower level of the air-crew station from ground level is provided by a 30-inch wide door identical to that in the C-130. Access up to the flight deck level is by a set of three steps. A flame resistant folding door immediately aft of the main entrance door connects the lower flight deck and the cargo compartment. Emergency exits include a large ditching hatch in the upper fuselage at the aft end of the flight deck and the large sliding windows on the sides of the pilot and co-pilot. All exits, passageways and walkway clearances are in accordance with HIAD provisions.

The pilot's and co-pilot's seats are located so as to provide maximum outside visibility and a dimensional relationship to the flight and engine controls in accordance with the requirements of HIAD and CAR 4b. The seating dimensions are shown in Figure 9-12. The Neutral SRP (seat reference point) is established as a point 12.5 inches above the floor level (10.5 inches above the heel rest line). The SRP conforms to both HIAD and CAR 4b and is the basic consideration, in the determination of the total work area available and the basic work areas. The outside vision diagram shown in Figure 9-13 illustrates the excellent visibility afforded by the large windshield and window panels provided at the crew station. Emphasis has been placed on meeting or exceeding all the requirements of the HIAD, FAA and SAE standards. The resultant configuration is based upon detailed studies conducted on this area involving inputs from Lockheed human engineering specialist, flight test pilots, airline pilots, and FAA contacts.

The airplane is normally operated by a crew of four; a pilot, a co-pilot, a systems engineer, and a navigator. However, the arrangement is such that the pilot and co-pilot can safely operate the aircraft over short range missions or under emergency conditions. This is accomplished by four design features: (a) a careful assignment of control functions and locations, (b) provision for the co-pilot's seat to slide aft to the systems engineer's station in order to provide accessibility to controls at this station, (c) location of the systems engineer's panel in direct view of the pilot and (d) a comprehensive warning and caution system located at the pilot's stations to provide immediate indication of malfunction with any system controlled at the systems engineer's station. A careful functional analysis has been made to obtain an equal distribution of work loads. Every effort has been made to assign functions in accordance with conventional operating procedures and the requirements of pertinent standards. Lockheed has employed a systems manager concept in defining the functions assigned to the systems engineer. This concept, which is in accordance with HIAD, assigns to the systems engineer the control of only those systems which will not affect the immediate safety of flight but pro-

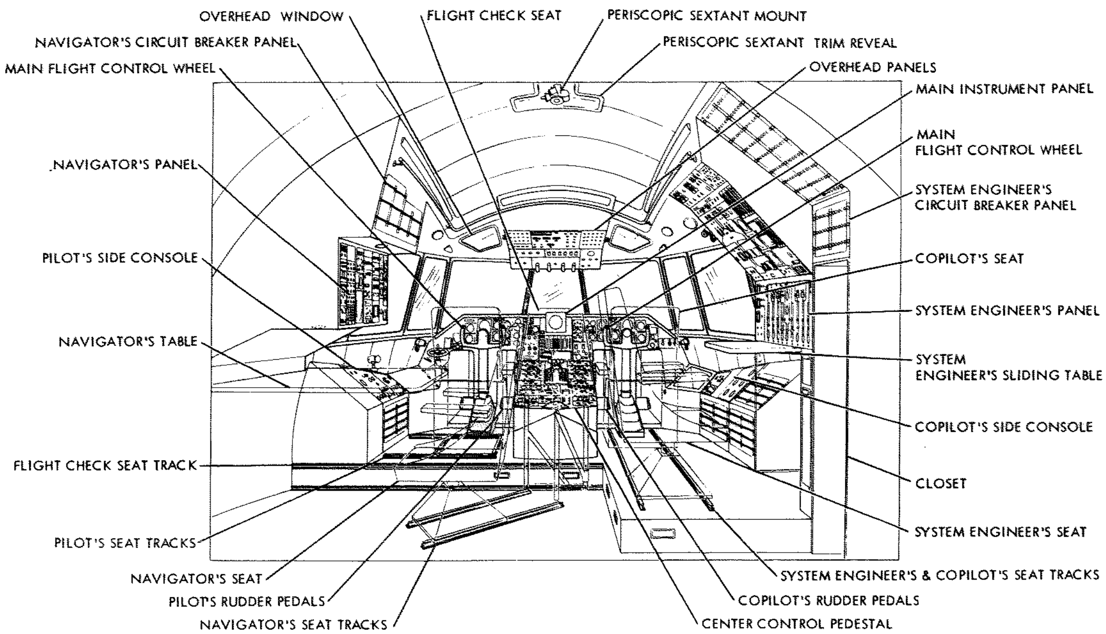
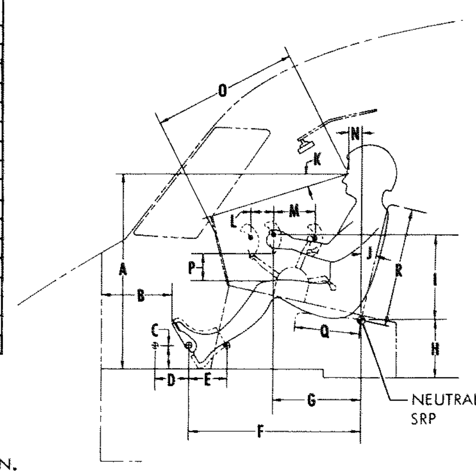


Figure 9-11—FLIGHT STATION, LOOKING FORWARD.

ALL DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED

CODE	SUPER HERCULES	HIAD	CAR 4b	SAE S-7	
A	41.50	41.50	(2)	41.00	HORIZONTAL TO HEEL REST LINE
B	6.75 (MIN)	1.00	NR	NR	RUDDER PEDAL TO FWD BULKHEAD
C	5.00	5.00	NR	NR	RUDDER PEDAL PIVOT TO HEEL REST LINE
D	7.25	7.25	NR (3)	NR	MAX FWD RUDDER MOVEMENT FROM NEUT.
E	8.25	8.25	NR (3)	NR	MAX AFT RUDDER MOVEMENT FROM NEUT.
F	37.00	37.00	NR (3)	NR	NEUT RUDDER PEDAL TO NEUT SRP
G	19.00	19.00	NR (3)	NR	NEUTRAL WHEEL TO NEUTRAL SRP
H	12.50	12.50	NR	11.50	NEUTRAL SRP TO PILOT'S FLOOR
I	18.00	18.00	NR	NR	NEUTRAL SRP TO NEUTRAL WHEEL
J	13° - 33°	13°	NR	14° - 42°	SEAT ANGLE WITH VERTICAL
K	17°	17°	15°	15°	FWD AND DOWN VISION (OVER THE NOSE)
L	5.00	5.00	NR	NR	MAX FWD WHEEL MOVEMENT FROM NEUT
M	9.00	9.00	NR (3)	NR	MAX AFT WHEEL MOVEMENT FROM NEUT
N	3.00	3.00	NR	NR	NEUT EYE TO NEUT SRP (13° INCLINATION)
O	31.25	NR	NR	NR	DIST FROM NEUT EYE TO CTR OF FLT INST
P	2.50 (MIN)	1.50 (MIN)	NR	NR	WHEEL-THIGH CLEARANCE (1)
Q	14.00	NR	NR	16.00 - 17.50	SEAT BOTTOM LENGTH
R	26.5	26.5	NR	23.00 - 25.00	SEAT BACK LENGTH



NOTES:

(1) WHEEL-THIGH CLEARANCE OF AVERAGE (50 PERCENTILE) WITH SEAT AT MAX.FWD AND UP POSITION.
(2) THE SUPER HERCULES EYE POSITION CONFORMS TO CAR AND HIAD STANDARDS.
(3) SEAT ADJUSTMENT AND CONTROL RELATIONSHIPS ACCOMMODATES INDIVIDUALS RANGING FROM 5'2" TO 6'0" IN HEIGHT AS SPECIFIED BY CAR 4b.

NR - NO REQUIREMENT

Figure 9-12—DIMENSIONS OF PILOT SEATING.

vides a monitoring capability of all of the aircraft systems. This concept is consistent with current commercial trends concerning the responsibilities of the Flight Engineer. The specific assignment of controls and their locations except for several minor deviations is in accordance with all applicable standards including HIAD, MIL-STD-203C, CL B1, CAR 4b, and SAE S-7 ARP 268B.

A portable extra crew compartment can be installed on the forward pallet in the cargo compartment and is described earlier in this section. A permanent extra crew compartment shown as an extension of the flight deck is an alternate arrangement and is described in Section 8, Volume 2.

CARGO COMPARTMENT (5.1.5.12)

General Arrangement

The cargo compartment is shown in Figure 9-14. The configuration presented not only meets or betters all requirements for Support System 476L, but

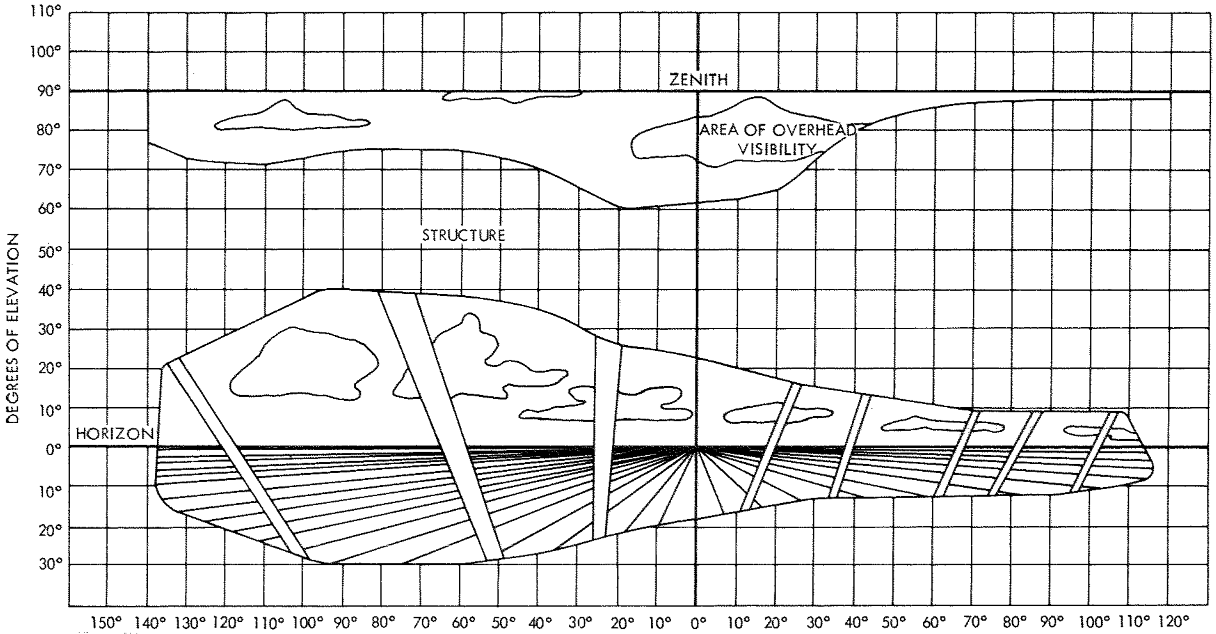


Figure 9-13—VISION DIAGRAM.

it also contains many additional features which contribute to versatility, flexibility, and greater utilization of the cargo compartment. The airplane is basically designed for cargo transport; however, it can be quickly and readily converted to carry troops, paratroops, or litter patients for emergency requirements and peacetime training considerations. These alternate modes of operation have not compromised the design of the airplane as a cargo carrier.

Volume

The constant cargo compartment envelope is 109.0 in. high, 123.25 in. wide, and 70 ft. long. Eight ft. of additional floor space is included on the ramp which is also 123.25 in. wide, but varying in height from 109.0 in. to 73.5 in. This envelope results in a clear cube volume of 6531.0 cu. ft. in the constant area and 625.0 cu. ft. on the ramp for a total of 7156 cu. ft.

The available volumes for bulk and palletized loads in this cargo compartment are shown in Figures 9-15 and 9-16. When loading cargo on the 88 x 108 in. 463L pallets, the compartment can accommodate 5049 cu. ft. on the normal nine pallets or 5484 cu. ft. when a tenth is loaded on the ramp.

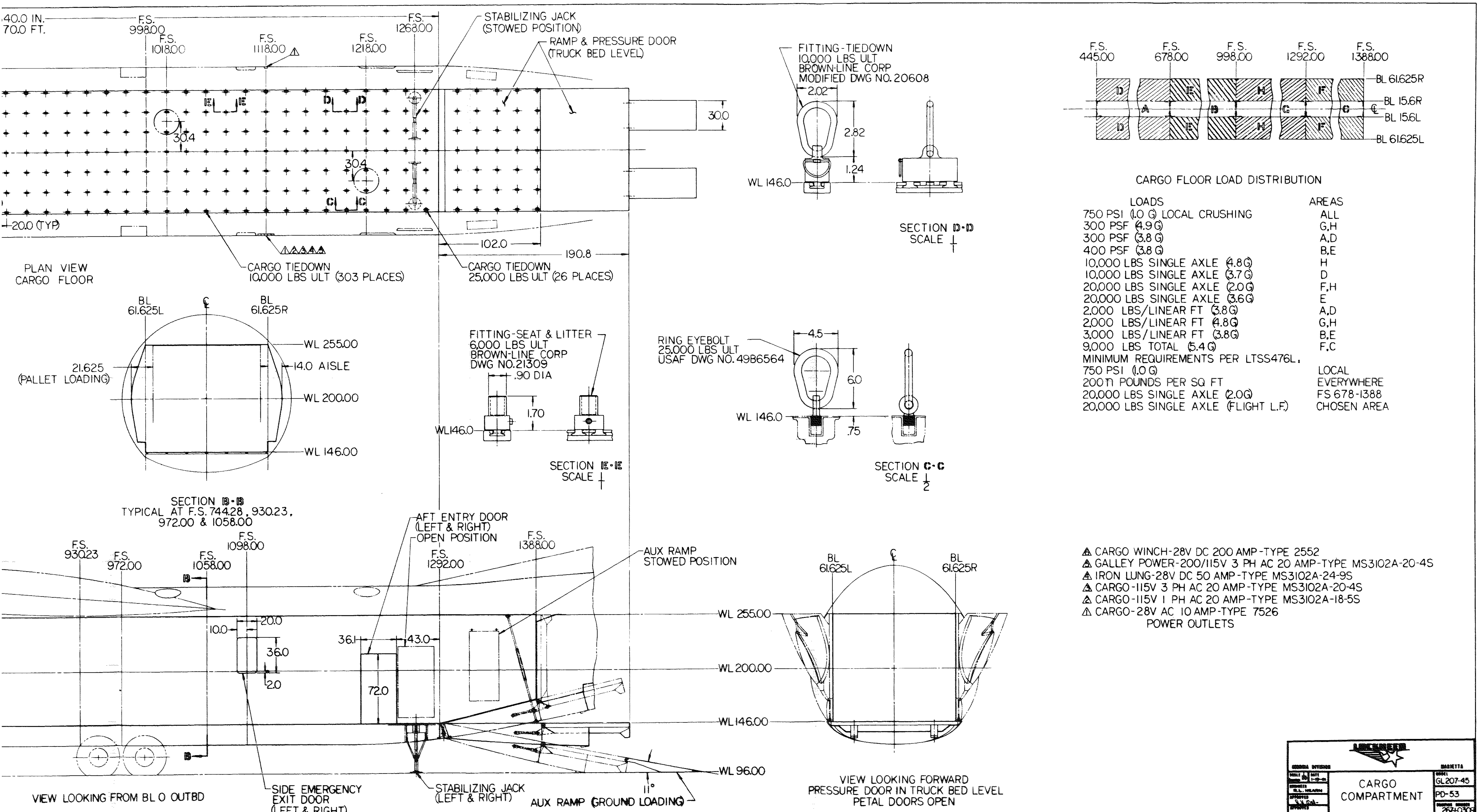
A full length unobstructed scanning/safety aisle is located along both sides of the cargo compartment to provide easy passage from the crew compartment to the rear of the cargo compartment. It in no way compromises the 10 ft. wide and 9 ft. high cargo envelope required by 476L. The aisleway takes advantage of the curbed sides of the fuselage and requires no additional fuselage cross sectional area or weight increase except for a walk-away that is installed. The aisleway is 14 in. wide from the extreme edge of the cargo floor and presents a clearance of 21.6 in. from the 463L palletized cargo which is 108 in. wide. These clearances are shown in Section BB of Figure 9-14. Electrical power outlets are also indicated on this figure.

Doors

The aft cargo door provides for straight-in tail loading. A combination ramp/pressure-door forms a platform which lowers to either a 50 in. truck-bed height for horizontal loading or to an inclination of 11 degrees for vehicular loading operations.

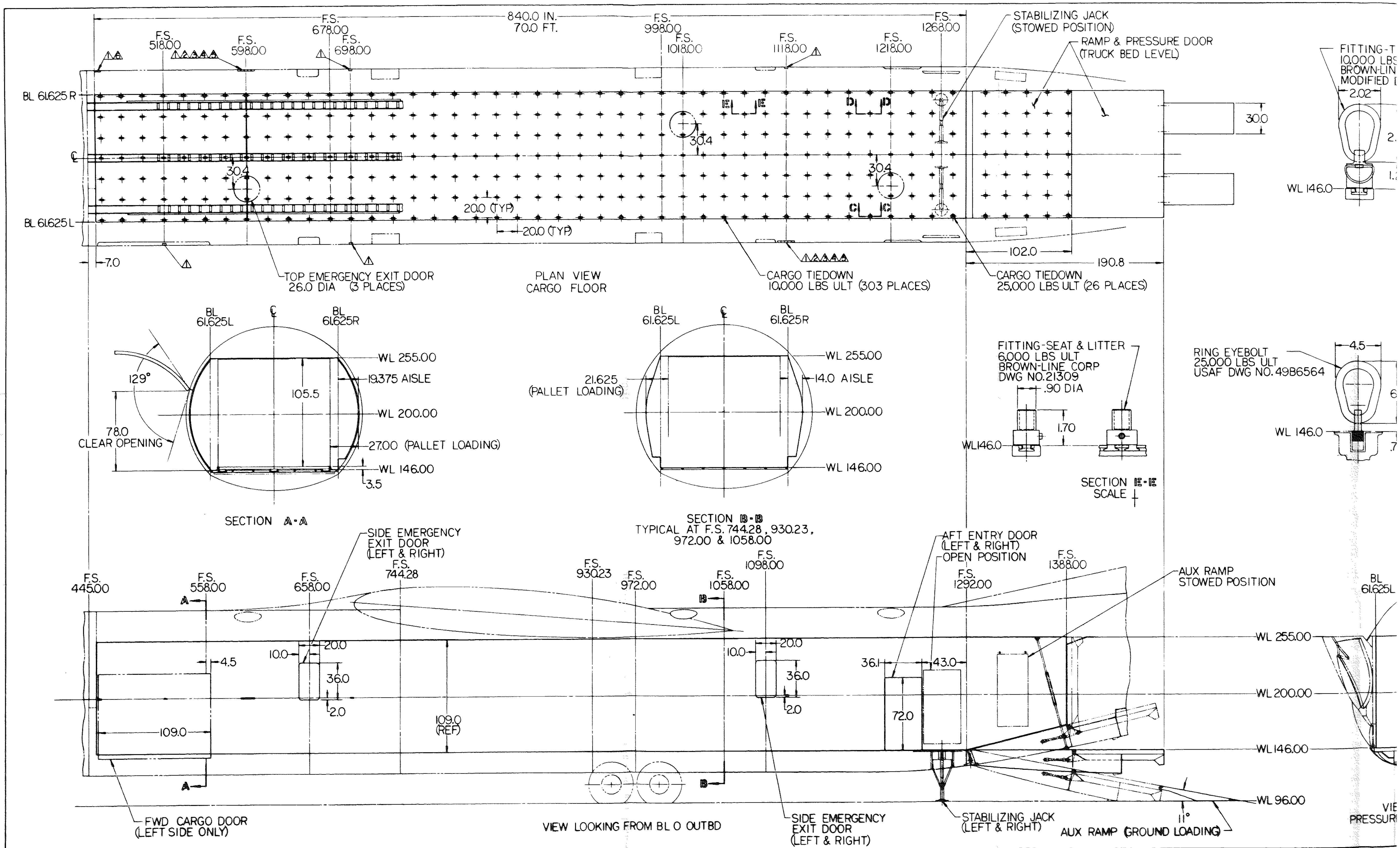
A forward cargo loading door with a clear opening 78 in. and 109 in. wide is provided on the left side of the airplane. Except for the greater width required, the door installation is identical to the military door used successfully on the C-130. The door is hinged at the top and powered by an independent hydraulic system actuated by a hand pump. The door moves outward and up to give full access to the clear opening dimensions.

Aft entry/paratroop doors are located at Fuselage Station 1213.0 on both the right and left sides of the fuselage. These doors provide a clear opening 36 inches wide and 72 inches high. The doors are inward opening plug-type equipped with four locks. The locks are operable from either inside or outside the airplane by rotating handles. When opened the door is raised inboard and upward by a spring loaded device. A system of arms and tracks permits rolling the door to a stowed area aft of the opening, about five inches above the floor. Emergency escape hatches are described under "Safety and Comfort Provisions" earlier in this section.



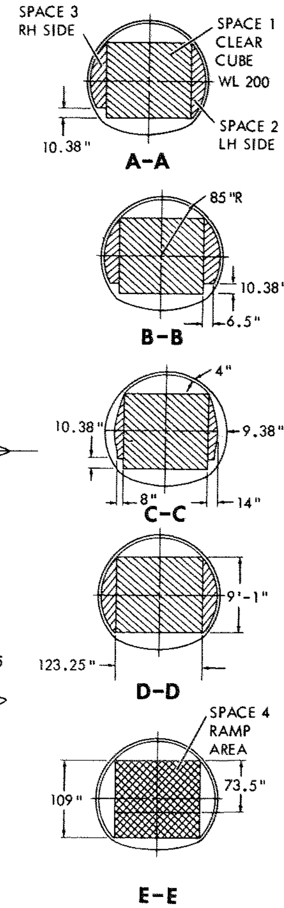
40.0 IN.
70.0 FT.
F.S. 998.00
F.S. 1018.00
F.S. 1118.00
F.S. 1218.00
F.S. 1268.00
STABILIZING JACK (STOWED POSITION)
RAMP & PRESSURE DOOR (TRUCK BED LEVEL)
30.0
30.4
30.4
20.0 (TYP)
102.0
190.8
PLAN VIEW CARGO FLOOR
CARGO TIEDOWN 10,000 LBS ULT (303 PLACES)
CARGO TIEDOWN 25,000 LBS ULT (26 PLACES)
FITTING-TIEDOWN 10,000 LBS ULT BROWN-LINE CORP MODIFIED DWG NO. 20608
2.02
2.82
1.24
WL 146.0
SECTION D-D SCALE 1/1
F.S. 445.00
F.S. 678.00
F.S. 998.00
F.S. 1292.00
F.S. 1388.00
BL 61.625R
BL 15.6R
BL 15.6L
BL 61.625L
CARGO FLOOR LOAD DISTRIBUTION
LOADS | AREAS
750 PSI (1.0 G) LOCAL CRUSHING | ALL
300 PSF (4.9 G) | G,H
300 PSF (3.8 G) | A,D
400 PSF (3.8 G) | B,E
10,000 LBS SINGLE AXLE (4.8G) | H
10,000 LBS SINGLE AXLE (3.7 G) | D
20,000 LBS SINGLE AXLE (2.0G) | F,H
20,000 LBS SINGLE AXLE (3.6G) | E
2,000 LBS/LINEAR FT (3.8G) | A,D
2,000 LBS/LINEAR FT (4.8G) | G,H
3,000 LBS/LINEAR FT (3.8G) | B,E
9,000 LBS TOTAL (5.4 G) | F,C
MINIMUM REQUIREMENTS PER LTSS476L,
750 PSI (1.0 G) | LOCAL
200 Π POUNDS PER SQ FT | EVERYWHERE
20,000 LBS SINGLE AXLE (2.0G) | FS 678-1388
20,000 LBS SINGLE AXLE (FLIGHT L.F.) | CHOSEN AREA
BL 61.625L
℄
BL 61.625R
WL 255.00
21.625 (PALLET LOADING)
14.0 AISLE
WL 200.00
WL 146.00
SECTION B-B TYPICAL AT F.S. 744.28, 930.23, 972.00 & 1058.00
FITTING-SEAT & LITTER 6,000 LBS ULT BROWN-LINE CORP DWG NO. 21309
.90 DIA
1.70
WL146.0
SECTION E-E SCALE 1/1
RING EYEBOLT 25,000 LBS ULT USAF DWG NO. 49B6564
4.5
6.0
WL 146.0
.75
SECTION C-C SCALE 1/2
1 CARGO WINCH-28V DC 200 AMP-TYPE 2552
2 GALLEY POWER-200/115V 3 PH AC 20 AMP-TYPE MS3102A-20-4S
3 IRON LUNG-28V DC 50 AMP-TYPE MS3102A-24-9S
4 CARGO-115V 3 PH AC 20 AMP-TYPE MS3102A-20-4S
5 CARGO-115V 1 PH AC 20 AMP-TYPE MS3102A-18-5S
6 CARGO-28V AC 10 AMP-TYPE 7526
POWER OUTLETS
F.S. 930.23
F.S. 972.00
F.S. 1058.00
F.S. 1098.00
AFT ENTRY DOOR (LEFT & RIGHT) OPEN POSITION
F.S. 1292.00
F.S. 1388.00
AUX RAMP STOWED POSITION
10.0
20.0
36.0
2.0
36.1
43.0
72.0
WL 255.00
WL 200.00
WL 146.00
WL 96.00
11°
VIEW LOOKING FROM BL 0 OUTBD
SIDE EMERGENCY EXIT DOOR (LEFT & RIGHT)
STABILIZING JACK (LEFT & RIGHT)
AUX RAMP (GROUND LOADING)
BL 61.625L
℄
BL 61.625R
VIEW LOOKING FORWARD PRESSURE DOOR IN TRUCK BED LEVEL PETAL DOORS OPEN
LOCKHEED
GEORGIA DIVISION
MARIETTA
CARGO COMPARTMENT
GL207-45
PD-53
2674-0309

figure 9-14


840.0 IN.
70.0 FT.
F.S. 518.00
F.S. 598.00
F.S. 678.00
F.S. 698.00
F.S. 998.00
F.S. 1018.00
F.S. 1118.00
F.S. 1218.00
F.S. 1268.00
STABILIZING JACK (STOWED POSITION)
RAMP & PRESSURE DOOR (TRUCK BED LEVEL)
BL 61.625 R
BL 61.625 L
30.4
20.0 (TYP)
30.0
102.0
190.8
7.0
TOP EMERGENCY EXIT DOOR 26.0 DIA (3 PLACES)
PLAN VIEW CARGO FLOOR
CARGO TIEDOWN 10,000 LBS ULT (303 PLACES)
CARGO TIEDOWN 25,000 LBS ULT (26 PLACES)
FITTING-T
10,000 LBS
BROWN-LIN
MODIFIED
2.02
WL 146.0
BL 61.625L
BL 61.625R
129°
78.0 CLEAR OPENING
105.5
WL 255.00
19.375 AISLE
WL 200.00
27.00 (PALLET LOADING)
WL 146.00
3.5
SECTION A-A
21.625 (PALLET LOADING)
14.0 AISLE
SECTION B-B TYPICAL AT F.S. 744.28, 930.23, 972.00 & 1058.00
FITTING-SEAT & LITTER 6,000 LBS ULT BROWN-LINE CORP DWG NO. 21309
.90 DIA
1.70
WL146.0
SECTION E-E SCALE 1
RING EYEBOLT 25,000 LBS ULT USAF DWG NO. 49B6564
4.5
SIDE EMERGENCY EXIT DOOR (LEFT & RIGHT)
F.S. 445.00
F.S. 558.00
F.S. 658.00
F.S. 744.28
F.S. 930.23
F.S. 972.00
F.S. 1058.00
F.S. 1098.00
F.S. 1292.00
F.S. 1388.00
AFT ENTRY DOOR (LEFT & RIGHT) OPEN POSITION
AUX RAMP STOWED POSITION
10.0
20.0
36.0
2.0
109.0
109.0 (REF)
36.1
43.0
72.0
WL 96.00
11°
FWD CARGO DOOR (LEFT SIDE ONLY)
VIEW LOOKING FROM BL 0 OUTBD
SIDE EMERGENCY EXIT DOOR (LEFT & RIGHT)
STABILIZING JACK (LEFT & RIGHT)
AUX RAMP (GROUND LOADING)

VOLUMES AND DENSITIES

SPACE	VOLUME CU. FT.	50,000 LB PAYLOAD DENSITY CU FT	60,000 LB PAYLOAD DENSITY CU FT	70,000 LB PAYLOAD DENSITY CU FT
1 (CLEAR CUBE)	6531.0	7.66	9.19	10.72
2 LH (CHEEK)	662.0	—	—	—
3 RH (CHEEK)	658.0	—	—	—
4 (RAMP)	625.0	—	—	—
TOTAL (GROSS)	8476.0	5.90	7.08	8.26
1 + 2 + 3	7851.0	6.37	7.64	8.92
1 + 4	7156.0	6.99	8.38	9.78



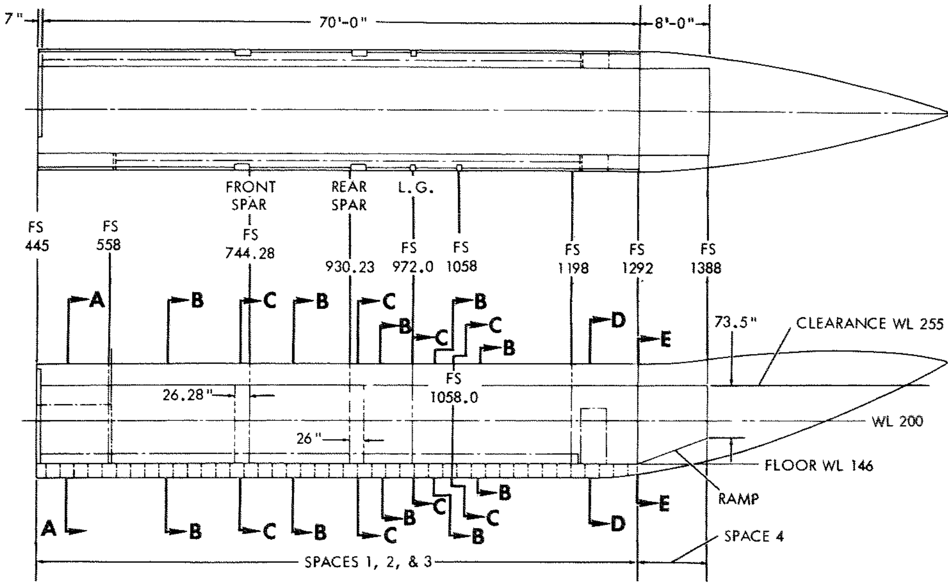
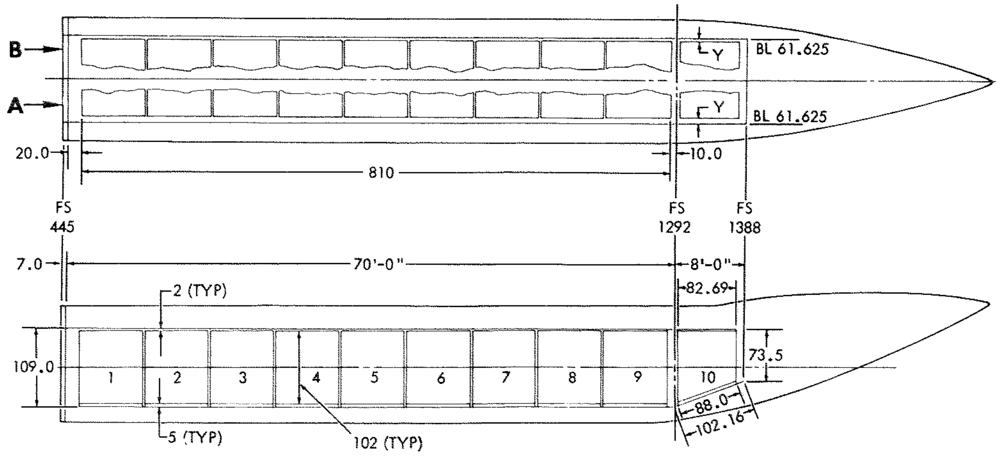


Figure 9-15—CARGO COMPARTMENT SIZES, DENSITIES AND VOLUMES — GROSS.



	PALLETS	Y	OVERALL DIMENSIONS	MAIN CABIN ONLY - NO RAMP: NO. OF PALLETS IN 70' LGTH.	VOL PER PALLET - CU. FT.	TOTAL VOL CU. FT.	WITH RAMP: RAMP PAL. VOL. CU. FT.	TOTAL VOL CU. FT.	DENSITY LB/CU FT 70,000 LB P.L.: NO RAMP	WITH RAMP	50,000 LB P.L.: NO RAMP	WITH RAMP
A	88 X 108 (WS-463L)	7.63	90 X 110	9	561.0	5049	435	5484	13.86	12.76	9.90	9.12
B	88 X 118 MAX CAPACITY	2.63	90 X 120	9	612.9	5516	480	5996	12.69	11.67	9.06	8.33

Figure 9-16—CARGO COMPARTMENT SIZES AND VOLUMES PALLETIZED.

Floor

The universal floor selected for the cargo compartment is shown in Figure 9-14. The design is based on the concept of providing a simple and rugged floor that is readily adaptable to all types of military and commercial loading requirements. Materiel handling equipment is an integral part of the aircraft, and provisions are made for handling both 463L pallets and System 476L airdrop requirements. This system can be quickly converted to form a flat smooth cargo floor to receive bulk loading, rolling stock, or the troop seating and litter arrangements required by System 476L.

The floor is completely flush, and constructed of integrally stiffened 24ST aluminum extrusions riveted into interchangeable panel assemblies. This construction permits damaged panels to be easily removed for repair or replacement. The panel assemblies are installed longitudinally over 20-in. spaced transverse floor beams. Recesses in the floor surface permit a flush installation of the 20-by 20-in. grid of 75ST aluminum tiedown points made from No. 20864 tracks, manufactured by the Brownline Corporation. The tiedown points are designed to receive 10,000 lb. rated quick disconnect tiedown rings of a Brownline type, or to provide floor attachment for litter stanchions and seat fitting No. 21309 (Brownline Corporation). A 25,000 lb. tiedown point is provided at every fourth grid point on the extreme sides of the floor. The 25,000 lb. tiedown points are designed to receive the standard 25,000 lb. eyebolt rings defined by USAF Drawing No. 49B6564. In all, 303 10,000-lb. tiedown points and 26 25,000-lb. tiedown points are installed over the entire cargo floor, including the ramp area.

The extruded cargo floor is liquid-sealed to permit cleaning without the creation of a corrosion hazard to the structure below the floor surface. The floor panel assemblies are sealed during fabrication by applying a 0.010 thickness of Thiokol sealing tape, SF50, to all faying surfaces of splices and joints. Liquid-tight rivet techniques are used throughout. The sills of the aft personnel doors and the cargo ramp area are similarly sealed to prevent liquids from entering the bilge.

The floor is stressed for 300 lbs. per sq. ft. and a crushing strength of 750 lbs. per sq. in. In addition, it is designed to receive 20,000 lb. single axle loads over treadways located between Buttock Lines 15.6 and 61.6 on both the left hand and right hand sides of the floor. When converted to a flat floor, it will accept, for example, the rolling loads imposed by the 31,750-lg. type MB-2 aircraft tow tractor, as shown in Section DD of the inboard profile. In the cargo jettison /airdrop configuration, the floor can accommodate the armored reconnaissance airborne assault vehicle, having a delivery weight of 35,000 lbs., as a unit load. The cargo floor load distribution by sections and per lineal foot is shown in Figure 9-11.

As shown in Figure 9-17, the floor is equipped with three roller conveyors running parallel to the centerline of the floor, with the 10-in. pitch rollers spaced 5 in. forward and aft of the transverse floor beams. Sections are made up of channels comprising rollers 2 in. in diameter by 6 in. long, located on 10 in. centers. The roller conveyors are supported by the floor substructure, and project 1 in. above the floor level. For vehicle and bulk loading the roller conveyor sections are rotated 180 degrees about their longitudinal centerline and secured in place, thus forming a smooth cargo compartment floor. The centerline rollers contain cutouts to clear the tiedown points, which are attached directly to the floor substructure, as shown by View C of the inboard profile drawing. Fiberglass drip pans are installed beneath the roller conveyor sections for sealing as shown on the floor drawing. The above features are continuous through the ramp door and pressure ramp door.

Two restraint rails run parallel to the centerline on either side of the floor. The rails are fastened to the floor substructure by quick-disconnect fittings. The forward and aft restraint mechanism and control cables are mounted on the outboard side of the rails, 40 inches on center. Hinge straps are attached to the rail sections at 40 in. intervals to allow quick stowing by swinging the rails up under the walkway. Rail sections on the ramp door, the pressure ramp door, and in front of the forward cargo door and aft personnel doors are taken up and secured to the side of the fuselage. The aft-most section on the pressure ramp door has the end flared out for the acceptance of cargo pallets. An alternate floor with the pallets as the principal load surface is described in section 8 of Volume 2.

Jacks

Stabilizing jacks are incorporated as an integral part of the airframe to ensure that the cargo compartment will remain stable and horizontal (± 1.5 degrees) during loading and unloading operations. When retracted, the jacks are positioned within fuselage compartments located on the L. H. and R. H. sides at Fuselage Station 1268.0. The jacks are hinged at their trunnion points, which allows them to be extended and locked by hand to approximate ground level position. The jacks are manifolded and are actuated to ground level by a hand operated wobble pump. The design includes a feature which will not allow the aft ramp/pressure doors to be actuated until the jacks are retracted and locked within the fuselage.

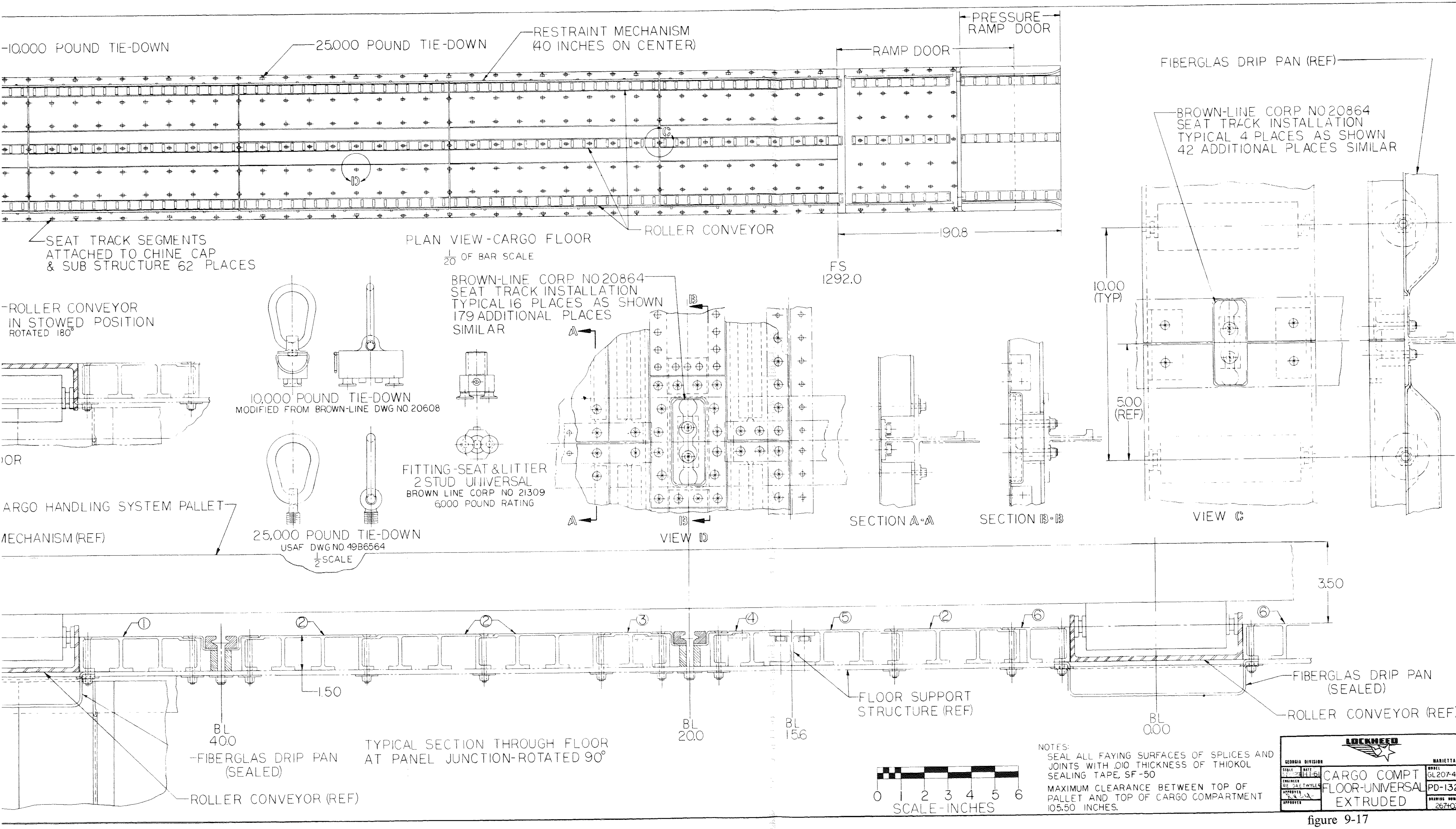
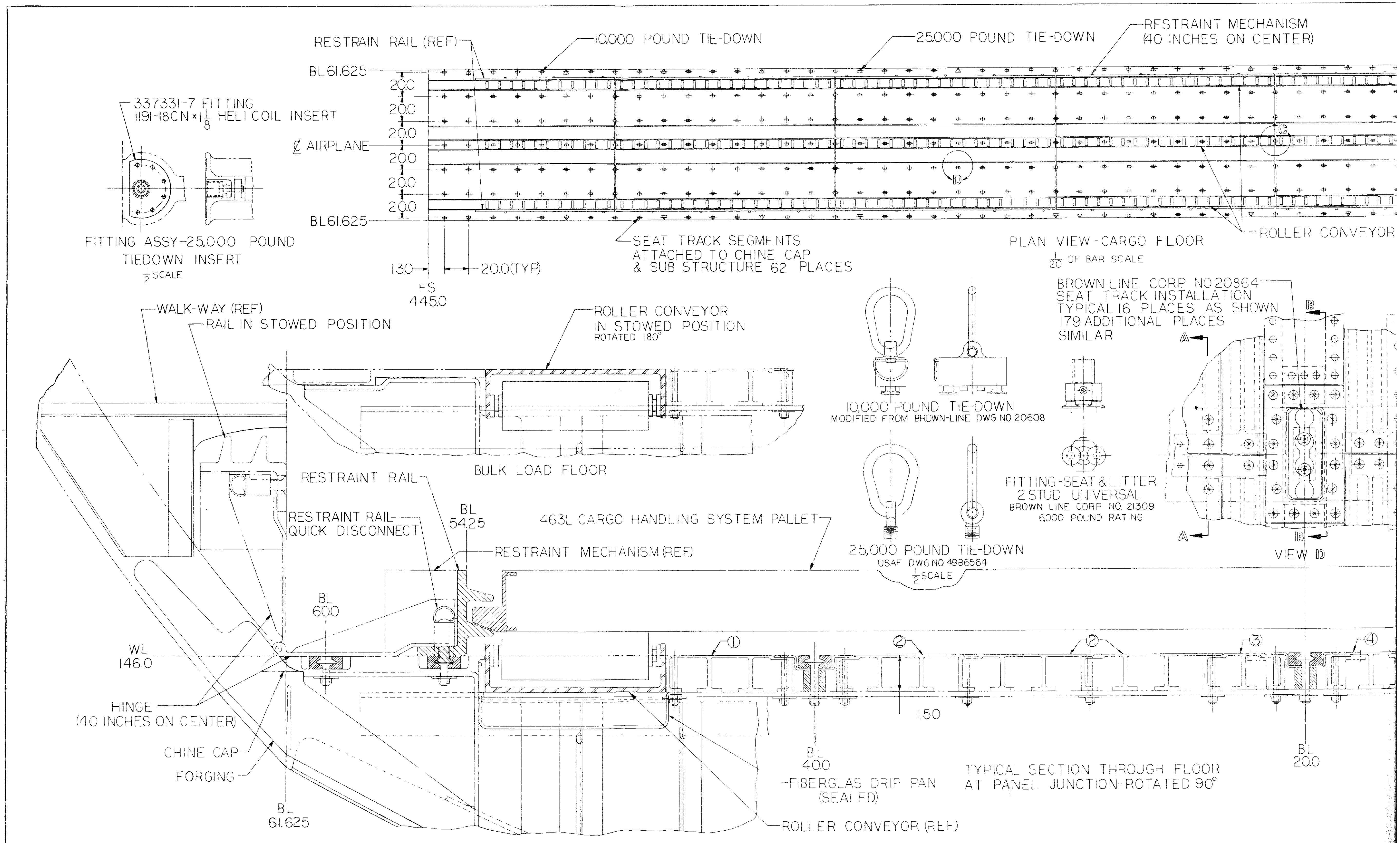
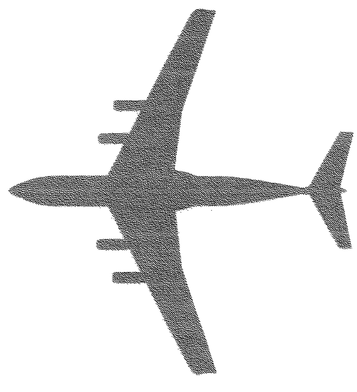

10,000 POUND TIE-DOWN
25,000 POUND TIE-DOWN
RESTRAINT MECHANISM (40 INCHES ON CENTER)
PRESSURE RAMP DOOR
RAMP DOOR
FIBERGLAS DRIP PAN (REF)
SEAT TRACK SEGMENTS ATTACHED TO CHINE CAP & SUB STRUCTURE 62 PLACES
PLAN VIEW-CARGO FLOOR
1/20 OF BAR SCALE
ROLLER CONVEYOR
190.8
FS 1292.0
BROWN-LINE CORP NO 20864 SEAT TRACK INSTALLATION TYPICAL 4 PLACES AS SHOWN 42 ADDITIONAL PLACES SIMILAR
ROLLER CONVEYOR IN STOWED POSITION ROTATED 180°
10,000 POUND TIE-DOWN
MODIFIED FROM BROWN-LINE DWG NO 20608
BROWN-LINE CORP NO 20864 SEAT TRACK INSTALLATION TYPICAL 16 PLACES AS SHOWN 179 ADDITIONAL PLACES SIMILAR
FITTING-SEAT & LITTER 2 STUD UNIVERSAL
BROWN LINE CORP NO 21309
6000 POUND RATING
10.00 (TYP)
5.00 (REF)
ARGO HANDLING SYSTEM PALLET
MECHANISM (REF)
25,000 POUND TIE-DOWN
USAF DWG NO 49B6564
1/2 SCALE
VIEW D
SECTION A-A
SECTION B-B
VIEW C
3.50
1.50
BL 40.0
BL 20.0
BL 15.6
BL 0.00
FLOOR SUPPORT STRUCTURE (REF)
FIBERGLAS DRIP PAN (SEALED)
ROLLER CONVEYOR (REF)
TYPICAL SECTION THROUGH FLOOR AT PANEL JUNCTION-ROTATED 90°
0 1 2 3 4 5 6
SCALE-INCHES
NOTES:
SEAL ALL FAYING SURFACES OF SPLICES AND JOINTS WITH .010 THICKNESS OF THIOKOL SEALING TAPE, SF-50
MAXIMUM CLEARANCE BETWEEN TOP OF PALLET AND TOP OF CARGO COMPARTMENT 105.50 INCHES.
LOCKHEED
GEORGIA DIVISION
MARIETTA
CARGO COMPT FLOOR-UNIVERSAL EXTRUDED
PD-132

figure 9-17



RESTRAIN RAIL (REF)
10,000 POUND TIE-DOWN
25,000 POUND TIE-DOWN
RESTRAINT MECHANISM (40 INCHES ON CENTER)
BL 61.625
20.0
℄ AIRPLANE
337331-7 FITTING
1191-18CN x 1 1/8 HELI COIL INSERT
FITTING ASSY-25,000 POUND TIEDOWN INSERT
1/2 SCALE
SEAT TRACK SEGMENTS ATTACHED TO CHINE CAP & SUB STRUCTURE 62 PLACES
13.0
20.0 (TYP)
FS 445.0
PLAN VIEW-CARGO FLOOR
1/20 OF BAR SCALE
ROLLER CONVEYOR
WALK-WAY (REF)
RAIL IN STOWED POSITION
ROLLER CONVEYOR IN STOWED POSITION
ROTATED 180°
BULK LOAD FLOOR
10,000 POUND TIE-DOWN
MODIFIED FROM BROWN-LINE DWG NO 20608
25,000 POUND TIE-DOWN
USAF DWG NO 49B6564
1/2 SCALE
BROWN-LINE CORP NO 20864 SEAT TRACK INSTALLATION TYPICAL 16 PLACES AS SHOWN 179 ADDITIONAL PLACES SIMILAR
FITTING-SEAT & LITTER 2 STUD UNIVERSAL
BROWN LINE CORP NO. 21309
6000 POUND RATING
VIEW B
RESTRAINT RAIL
RESTRAINT RAIL QUICK DISCONNECT
BL 54.25
463L CARGO HANDLING SYSTEM PALLET
RESTRAINT MECHANISM (REF)
BL 60.0
WL 146.0
HINGE (40 INCHES ON CENTER)
CHINE CAP
FORGING
BL 61.625
1.50
BL 40.0
FIBERGLAS DRIP PAN (SEALED)
ROLLER CONVEYOR (REF)
TYPICAL SECTION THROUGH FLOOR AT PANEL JUNCTION-ROTATED 90°
BL 20.0

section 10



PERSONNEL SUBSYSTEMS AND GENERAL DATA

PERSONNEL SUBSYSTEMS (5.1.5.13)

Requirements (5.1.5.13.1)

Data in accordance with Specifications MIL-H-25946, MIL-M-5474, and Exhibit AFBM 58-18C will be supplied. The human factors work has commenced in development of the proposed airplane, and will continue in accordance with these specifications.

Human Engineering

The application of the principles of human engineering to the airplane design was initiated at the onset of design developmental efforts. This program will continue as scheduled in accordance with MIL-H-25946. Preliminary design of the airplane required the determination of operator functions; the description of operator performance (time base); the analysis and delineation of crew station work areas; the assignment of controls; and the selection, design, and placement of displays and controls at each work station. Major emphasis has been placed on the aircrew station design; however, human engineering efforts are also reflected in other personnel areas such as troop accommodations and maintainability.

Additional analyses and evaluations proposed constitute a continuation of the above efforts and include a concerted human engineering analysis and evaluation of the full scale mock-up of the airplane. Specific areas to be systematically investigated with the aid of the mock-up include control accessibility, display readout, egress and ingress, escape and emergency procedures, lighting efficiency, ground support, maintenance, and cargo handling. The above analyses will be orientated toward the objective determination of operator efficiency with respect to the variables associated with each of the areas in question. Experimental programs will be established as required. Details of the human factors program and Lockheed's qualifications for this work are contained in Section 9 of Volume 2.

Technical Orders and Technical Manuals

Technical data in support of System 476L will be supplied in accordance with MIL-M-5474 by manuals engineers and technical illustrators thoroughly experienced in the preparation of technical data for high-performance military aircraft. During ten years of operation, the Lockheed Service Manuals Organization has consistently prepared quality technical manuals in accordance with MIL-H-5474 and has delivered them on schedule. The organization has approximately one hundred specialized personnel including writers, illustrators, editors, and supervisory personnel intimately familiar with MIL-H-5474, its derivatives, and the many allied handbook specifications listed in MCMSP Exhibits 1 and 1A. The organization has prepared many basic manuals, supplements, revisions, time compliance technical orders, and other publications in support of B-29, B-47, C-130, and GV-1 aircraft and equipment.

Preliminary manuals will be supplied at the time the first airplane is delivered for flight testing. Although these manuals will not be prepared to military specification, later publications will comply with specification requirements. Basic manuals will be developed from preliminary manuals and will be expanded and updated during the revision program. Revisions will be supplied at ninety-day intervals to cover production changes and to incorporate additional information.

Qualitative Personnel Requirements Information (QPRI)

Lockheed will fulfill the requirements for preparation and submission of personnel planning data as specified in AFBM Exhibit 58-18C. The similarity of systems and components used on this airplane to those of the C-130 will enable Lockheed to prepare a factual estimate of personnel planning requirements. Lockheed has maintenance records covering 80% of the C-130 fleet. Planning data will be obtained from these records, from analysis of aircraft design and equipment function, from observation of the aircraft in various stages of production, and from information secured during category tests. These data will be combined with a comprehensive knowledge of Air Force and airline maintenance procedures to produce a realistic QPRI document.

Training (5.1.5.13.2)

Type I factory training for maintenance and flight personnel is recommended in accordance with AFR 50-9 and ATCM 52-9. Training equipment is proposed in accordance with MIL-T-27382. It is anticipated that a Training Program Conference and a Training Support Conference to finalize training plans will be necessary. A guidance meeting to assist Lockheed in the development of the Training Equipment Planning Information (TEPI), a Training Parts Pre-Provisioning Conference, and a Training Equipment Engineering Approval Conference, will also be required. To indicate program milestones, a Training Timetable is included as Figure 10-1.

Maintenance Training

Support system orientation training used to famil-

TRAINING TIME TABLE	MONTHS AFTER CONTRACT AWARD
GL 207-45 CONTRACT AWARD	0
GUIDANCE MEETING TEPI AND QPRI	1
TEPI - COMPLETE	6
TRAINING PROGRAM CONFERENCE	9
TRAINING PARTS PRE-PROVISIONING CONFERENCE	11
TRAINING SUPPORT CONFERENCE	14
PERFORMANCE SPECIFICATION FOR TRAINING EQUIPMENT - COMPLETE	12
TRAINING EQUIPMENT ENGINEERING APPROVAL CONFERENCE	16
TYPE 1 TRAINING CONTRACT	18
TRAINING MANUAL - COMPLETE	27
TRAINING EQUIPMENT DELIVERY	27 (2 UNITS); 42 (1 UNIT)
TYPE 1 FLIGHT TRAINING FOR AIR FORCE TEST PERSONNEL -COMPLETE (GND. SCHOOL ONLY)	29
TYPE 1 MAINTENANCE TRAINING FOR AIR FORCE TEST PERSONNEL - COMPLETE	36
TYPE 1 FLIGHT TRAINING FOR INSTRUCTOR PERSONNEL (AF) - COMPLETE	35
TYPE 1 MAINTENANCE TRAINING FOR INSTRUCTOR PERSONNEL (AF) - COMPLETE	28
TYPE 1 MAINT. TRAINING FOR AIR FORCE OPERATING SQUADRON - COMPLETE	32
FLIGHT SIMULATOR DELIVERY	30 (1 UNIT); 39 (1 UNIT); 42 (1 UNIT)
FIRST OPERATIONAL AIRCRAFT	33

Figure 10-1—TRAINING TIME TABLE.

iarize staff and supervisory personnel with the operation, maintenance, and general characteristics of the airplane will be available nine months following contractual go-ahead. This training should be utilized by Air Force and FAA planning personnel whose jobs require a basic knowledge of the aircraft.

Two maintenance training programs for Air Force personnel are provided: one for instructors and one for a nucleus of skilled technicians from test activities, operating squadrons, and support activities. Separate programs permit emphasis on specific job requirements and will insure training completion at the optimum time.

In accordance with AFR 50-9, the following Type I factory training programs for maintenance personnel are proposed:

1. Maintenance Training Program for Instructors

Course Title	*Course Duration hrs.*
Aircraft Radio Maintenance Repairman (AFSC 30150/70)	160
Aircraft Electronics Navigation Equipment Repairman (AFSC 30151/71)	200
Aircraft Pneudraulic Repairman (AFSC 42152/72)	240
Aricraft Ground Support Equipment Repairman (AFSC 42153/73)	80
Instrument Repairman (AFSC 42250/70)	120
Aircraft Electrical Repairman (AFSC 52350/70)	160
Auto Pilot/Compass System Repairman (AFSC 42353/73)	120
Aircraft Mechanic-Instructor (AFSC 43151E/71E)	240
Aircraft Fuel System Mechanic (AFSC 43155/75 — 43151/71E)	80
Jet Engine Mechanic (AFSC 43250/70)	160

2 Maintenance Training Program for Operating Squadron and Test Personnel

Course Title	*Course Duration hrs.*
Supervisors and Planners	40
Aircraft Radio Maintenance Repairman (AFSC 30150/70)	160
Aircraft Electronics Navigation Equipment Repairman (AFSC 30151/71)	200
Malfunction Detection and Recording Equipment — MADREC (AFSC 30151/71)	80
Aircraft Pneudraulic Repairman (AFSC 42152/72)	240
Aircraft Ground Support Equipment Repairman (AFSC 42153/73)	40
Instrument Repairman (AFSC 42250/70)	120
Aircraft Electrical Repairman (AFSC 42350/70)	160
Auto Pilot/Compass System Repairman (AFSC 42353/73)	80
Aircraft Mechanic (AFSC 43151E/71E)	240
Aircraft Fuel System Mechanic (AFSC 43155/75)	80
Jet Engine Mechanic (AFSC 43250/70)	160
Airframe Repairman (AFSC 53450/70)	80

Special maintenance training will be available for FAA personnel whose job responsibilities encompass the certification and commercial use of the airplane. Courses planned include aircraft orientation for management personnel, maintenance courses for inspector personnel, and special courses for FAA instructors.

Flight Training

The proposed program provides training for Air Force flight test aircrews, Air Force Plant Representative acceptance crews, and Transport Training Unit instructor crews. Flight training will be available for FAA personnel as required.

It is recommended that Air Force flight test aircrews receive ground instruction and flight transition training at the factory. Production Flight Operations will conduct the ground school phase and Flight Test Engineering will conduct the flight transition phase of this training. It is also recommended that Air Force Plant Representative flight acceptance crews receive ground school instruction and twenty hours of flight transition training prior to the first production acceptance flight.

A program for training five Air Force instructor aircrews is proposed. This program will be conducted by Production Flight Operations and will include ground school instruction and twenty hours of flight transition training for each crew.

The flight crew ground school is designed to provide the student with a thorough knowledge of the aircraft and its systems. These systems will be discussed and analyzed individually and collectively so that normal and emergency procedures are clearly understood. The following ground school courses are planned for individual aircrew members:

Pilot	120 Hours	(3 weeks)
Systems Engineer	240 Hours	(6 weeks)
Navigator	120 Hours	(3 weeks)

Training Equipment

Training aids packages are proposed to support Type I, Type II, Type III, and Type IV training. Each package will include a mobile training unit, a mission flight simulator, transparencies, and maintenance training manuals. A minimum of three complete packages is essential to cover anticipated deployment of the aircraft.

1. Mobile Training Unit—Twenty-seven trainers covering all major systems will be included in each mobile training unit. The following trainers are proposed:

Auto-pilot System	Engine Fuel System
Compass System	Engine Rigging & QEC
Command Radio System	Engine Simulator
Liaison Radio System	Aircraft Fuel System
IFF System	Hydraulic Power System
Loran System	Flight Control System
Radar Altimeter System	Landing Gear System
Search Radar System	Cargo Ramp & Ramp Door System
Radio Navigation System	Fire Detection & Extinguishing System
Doppler Radar System	Air Conditioning System
Radio Compass System	Pressurization System
Flight Director System	Ice Control Electrical System
Gas Turbine Compressor (GTC) and Air Turbine Motor	Aircraft Electrical System
GTC Electrical System	

2. Mission Flight Simulator—A mission flight simulator is required to provide aircrew personnel with transition and flight proficiency training. The simulator incorporates provisions for training the pilot, co-pilot, systems engineer, and navigator. The unit reflects a physical duplicate of the aircraft's visual operational equipment and a functional duplicate of all systems and sub-systems necessary to accomplish crew training. Closed circuit television and simulated aircraft motion are included. Provisions for land-sea mass radar mapping, grid and pressure pattern navigation, doppler radar and celestial navigation training are required. Lockheed's Field Service School is responsible for flight simulator program management.

3. Transparencies—One set of photographic transparencies of aircraft systems and components will be furnished with each training aids package. Developed in conjunction with the training manual, they constitute complete graphic coverage of the airplane and provide essential visual support for instruction.

4 Maintenance Training Manual—Three hundred maintenance training manuals will be provided in each training package. Each manual will cover the description and operation of all aircraft systems and is to be used as an instructional text in conjunction with applicable technical orders. This manual will be used in Type I training and will be particularly useful when the aircraft is first deployed.

Qualifications to Support Proposed Training Program

Lockheed's qualifications to design training equipment and to conduct training programs in support of System 476L include a qualified staff, the most modern training facilities in the aircraft industry, and a reputation for conducting successful training programs. Advanced instructional methods and techniques are utilized. Lockheed's Georgia Division has extensive experience in the design of training equipment and the implementation of training programs. Since the proposed airplane is a derivative of the C-130, experience gained on the C-130 has provided a guideline for developing the proposed training plan. Lockheed's personnel will work closely with the Air Force to finalize a program that is practical and economical.

AIRCRAFT LIGHTING (5.1.5.14)

The lighting is generally in accordance with CAR4b and specification MIL-L-6503D, with instrument lighting per MIL-L-5667A and MIL-L-27160 and emergency exit lighting per MIL-L-26866A. Figure 6-5 shows the exterior lighting proposed. One red anti-collision light is located on top of the horizontal stabilizer and a second under the fuselage. Two 1000-watt landing lights and six taxi lights provide illumination for the area outboard of the wing tips, the area ahead of the wings, and forward of the pilot. Wing scanning lights are provided as are standard navigation and formation lights. Exterior illumination levels are greater than those required by the specifications.

Interior red and white illumination is provided in the flight station and cargo compartment ceiling, with dimming as applicable. Floor level and walkway lighting is provided for cargo loading. Flood, integral insstrument, and thunderstorm lighting are provided. Figure 9-11 illustrates the locations of cockpit lights. The aircraft Model Specification, Volume 5, provides further details of the equipment used. The final evaluation of lighting coverage and illumination levels shall be accomplished in an aircraft lighting mock-up.

AERIAL DELIVERY (5.1.5.15)

The airplane is well suited for delivery of airborne troops and various types of air-droppable cargo by parachutes at any desired drop speed from 115 to 200 knots. A unit drop load of 35,000 lbs. can be dropped at 115 to 200 knots, 2000 nautical miles from a take-off point and return with military reserves, per MIL-C-5011A. The aircraft cross-sectional dimensions are identical to those of the C-130 series aircraft, and personnel and cargo-type drop equipment compatible with present airborne operations can be employed with little or no change. The aircraft is not limited to existing techniques and equipment. Later techniques and equipment considered include heavier palletized loads, simultaneous delivery of personnel and combat equipment in quantity, and remote area supply. Like the C-130 series aircraft, the airplane has been determined to be readily adaptable to recovery in the air of dropping objects such as parachute-supported capsules and to airborne recovery using snatch techniques of objects from the ground. The investigation of recovery-in-the-air potential, also applicable to high speed drops or snatches, has shown that rear-doors-open speeds could be raised from 200 to 250 knots with a weight increase of 580 lbs.

Personnel Delivery

The airplane will deliver 74 paratroops from the two side paratroop doors, or optionally over the ramp at speeds as low as 115 knots. The 74 standard 19 in. MIL-S-26688 16 "g" troop seats will be in two single seat runs and one row of two seats abreast spaced fore-and-aft at 40 inches, for paratroops. Attachment provisions for 128 paratroops seated in variable-width-type side-facing seats with seat belt attachment points at 24-inch intervals could be provided. Hydraulically actuated spoilers minimize airload interference with exit from the paratroop doors. All personnel airdrop provisions, including the spoilers, are in kit form and are designed so as to be readily attachable and detachable.

Cargo Delivery

The airplane can not only deliver system 463L palletized loads up to 108 in. wide and in variable lengths, but can also deliver pallet loads as wide as 120 in. in variable lengths. The single drop load capacity of the airplane exceeds 35,000 lbs., including the armored reconnaissance airborne assault vehicle referred to in Paragraph 3.1.10 of the Work Statement. The structural integrity of the ramp doors provide for teeter loads imposed by emergency gravity ejection of loads to 35,000 lbs. The aircraft will accommodate known cargo delivery systems such as the interim conveyor system and rail system for skid boards, stressed metal platforms, combat-expendable platforms, and others. Gravity ejection of A-22 containers can be accomplished using existing techniques.

Aerodynamic Considerations

Positive speed stability exists for the full range of drop speeds from 115 to 200 knots and higher, and provides the desirable characteristics for satisfactory formation airdrops. Experience has shown that C-130 handling qualities at drop speeds of about $1.3V_S$ or above are quite satisfactory. Since the GL 207-45 is twice the weight and has three times the pitching moment of inertia of the C-130, it should have the same satisfactory characteristics when dropping a payload up to 40,000 pounds as the C-130 when dropping 20,000 lbs. The thrust required and the thrust available over the speed range is shown in Figures 10-2 and 10-3 for partial flap settings of 35 and 50 degrees respectively. Also shown on these figures are cargo floor inclination angles. The range of floor angles shown provides the operator a choice of angles depending upon his selection of flap setting and speed, appropriate to mission requirements for payload and circumstances of drop.

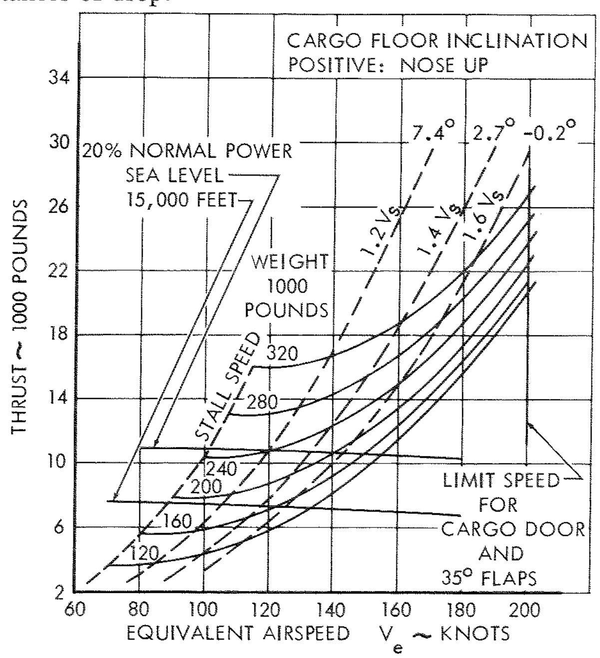


Figure 10-2—AIRDROP CONFIGURATION, GEAR UP, FLAPS 35 DEGREES, PRATT & WHITNEY JT3D-4 ENGINE, CARGO DROP DOOR OPEN ($\Delta C_{D_{Door}}$ = 0.016).

The impact on overall airplane performance of the air drop capability is limited to effects of weight increments only as no drag penalties are associated with the aft end configuration. Many different aft ends were tested in the wind tunnel program and the configuration chosen has no more drag than a symmetrical streamlined body of revolution, and thus is a minimum drag configuration.

Structural Considerations

Two operating flight regimes are of importance. The first is when the cargo or personnel are in the fuselage, and covers the time span prior to drop. This time governs the aft fuselage strength, particularly in the fuselage box above the doors and in the doors. The second regime is that during the actual drop or extraction. This covers a nominal

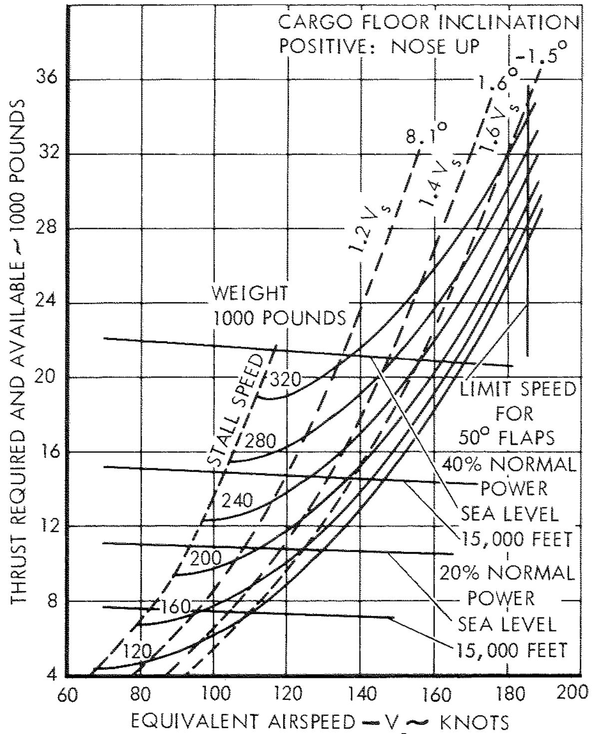


Figure 10-3—AIRDROP CONFIGURATION, GEAR UP, FLAPS 50 DEGREES, PRATT & WHITNEY JT3D-4 ENGINE, CARGO DROP DOOR OPEN ($\Delta C_{D_{Door}} = 0.016$).

time span of less than two seconds and governs the ramp structure. A 2.0 "g" maneuver load factor is considered satisfactory for both regimes as well as reduced equivalent gust intensities of 25-feet-per-second prior to drop and 10-feet-per-second during drop. This is the same criterion that has been applied to the C-130 and which has proven satisfactory during the airdropping of unit pallets slightly in excess of 40,000 lbs. A 1.25 "g" vertical factor combined with a 0.25 "g" side load factor at the ramp have been satisfactory for ramp door design and recognizes the pitch characteristics during the drop, extraction chute misalignment and airplane yaw.

Airdropping of personnel provides no structural problems. Since the delivery of paratroops has generally been done at 150 knots or less on the C-130, the 200 knot provision for strength in the removable air deflector doors and attachments is considered ample.

FLIGHT TEST (5.1.5.16)

Presented herein is a brief description of the developmental and military and civil qualification flight test programs required to establish the ac-

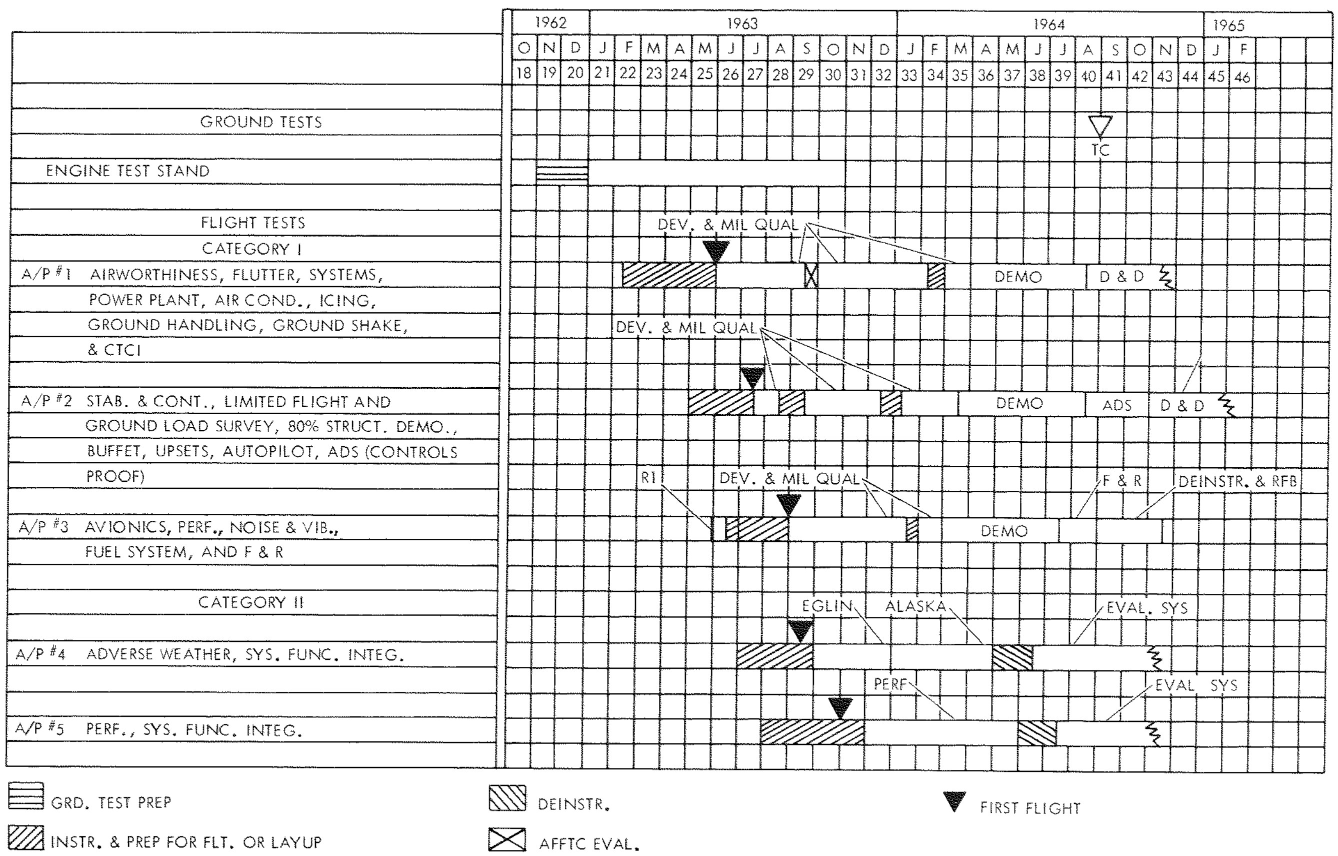


Figure 10-4—FLIGHT TEST PROGRAM SCHEDULE FIVE AIRPLANES.

ceptability of the Model GL 207-45 airplanes for effective USAF operational utilization.

The Category I program is separated into two phase as shown in Figure 10-4. The first phase is concerned with developmental and military qualification testing, and the second with the flight test demonstrations required to obtain an FAA Type Certificate. It is anticipated that a Type Certificate will be issued the Model GL 207-45 airplanes on 31 August 1964, fifteen months after first flight.

The Category II program, as shown in Figure 10-4, includes environmental tests in the Eglin Cold Hangar and Alaska, flight tests to obtain Performance Handbook data, and the flight and ground tests necessary to satisfy the System Functional Integration requirements.

A more detailed discussion of the Category I and II programs is presented in Section 9 of Volume 2.

DEVELOPMENT TEST PROGRAMS

Tests will be conducted at the component and subsystem level early in the development program. As shown in Figure 10-5, these tests will be planned and programmed based on a structural, functional, and environmental analysis of the system. The purpose of these test programs will be to evaluate the design concept at an early stage in the design effort so that corrective action relative to any design deficiencies may be incorporated into the design, thus minimizing retrofits. The information obtained in these tests will be used to establish reliability and maintenance criteria.

The various development test programs will permit the evaluation and qualification of all structure, systems, and sub-systems in accordance with HIAD, applicable military specifications, and with all FAA requirements. Individual test programs are discussed in more detail in Section 9 of Volume 2.

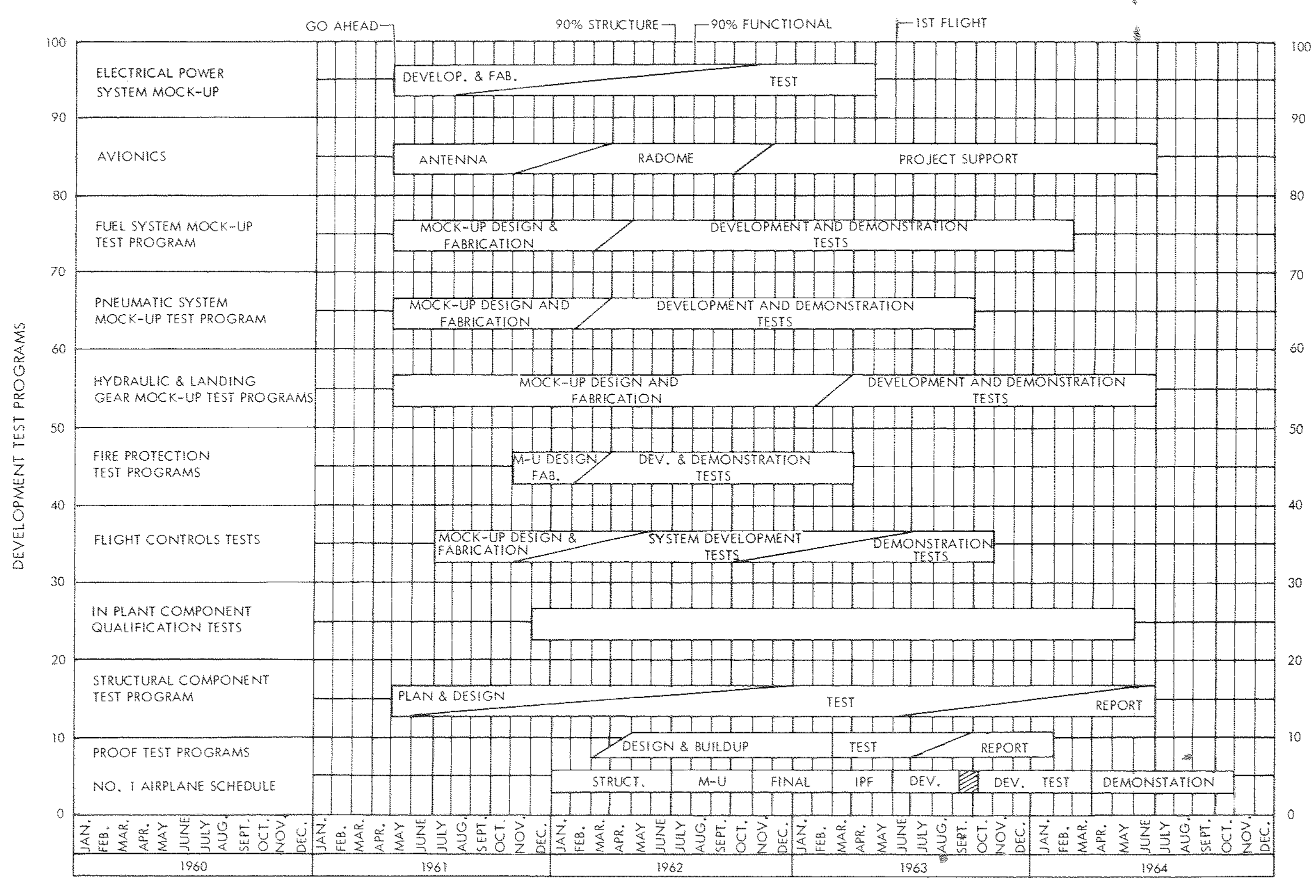


Figure 10-5—DEVELOPMENT TEST PROGRAMS.

SUPER HERCULES · GL207-45

section 11

MASTER PROGRAM PLAN (5.2.1)

In development of the System 476L Master Program Plan, experience gained from similar programs permitted establishment of a realistic schedule and phasing plan that assures earliest possible operational aircraft availability. In this connection, a substantial portion of Lockheed experience on the Air Force C-130 program has been directly applicable.

There are five primary assumptions, specified in the Statement of Work, upon which the Master Plan is predicated. They are:

1. Program go-ahead is 1 May 1961
2. Total contract quantity of aircraft including flight test articles is 132
3. Five aircraft are to be used for flight test
4. FAA type certificate will be obtained
5. Maximum military production rate will be four per month

The Master Program Plan for the System 476L is summarized in Figure 11-1. The major milestones associated with the development, production, and support are indicated and time-phased. This constitutes the general overall plan, and permits assessment of primary aspects of schedule.

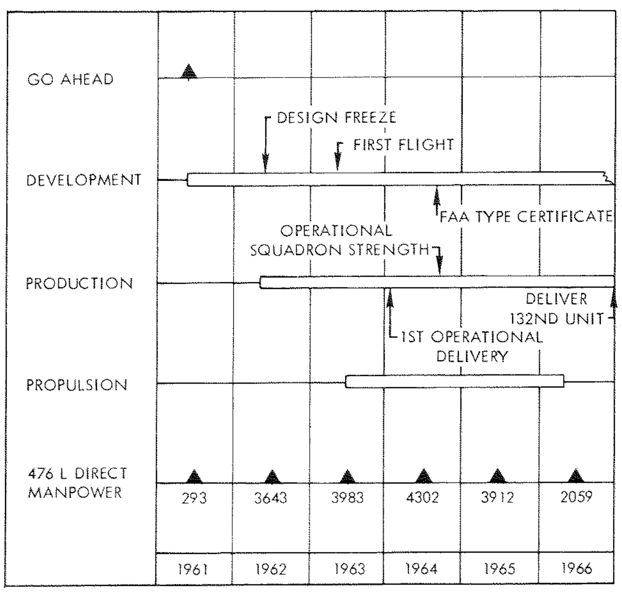


Figure 11-1—MASTER PROGRAM PLAN.

This Master Program Plan is derived from detailed analysis of every activity contributing to the System 476L. The supporting data are provided in three categories which are (1) activity phasing, (2) development and production phasing, and (3) detailed time-phasing.

Activity phasing support information, shown in Figure 11-2 considers the major functional areas of activity required for the program, and their time relationship.

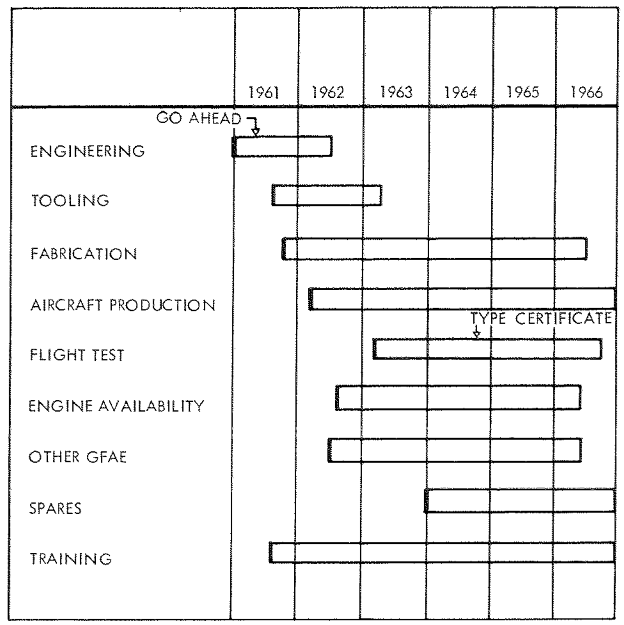


Figure 11-2—SUPPORT CHART, ACTIVITY PHASING.

Development and production phasing support data is provided in Figure 11-3. This gives more detailed information on activity areas, flight test, production, and their interrelationship. The most significant milestones are:

	Time from Go-Ahead
Complete airplane design	11½ months
First flight-1st test aircraft	25
First operational delivery	33
FAA type certificate	40
Operational squadron strength	41
Delivery of total contract quantity	68

Detailed time-phasing control points associated with major program milestones are specified in Figure 11-4. The indicated line items are the primary factors used in monitoring and control. There are 154 factors shown, further detailed by 463 measurable time intervals. The primary consideration upon which these detailed control points are established is emphasis on the relationship between the flight test programs and production deliveries while incorporating the advantages and substantial economic savings gained by maintaining a continuous production line. The scheduled input of air-

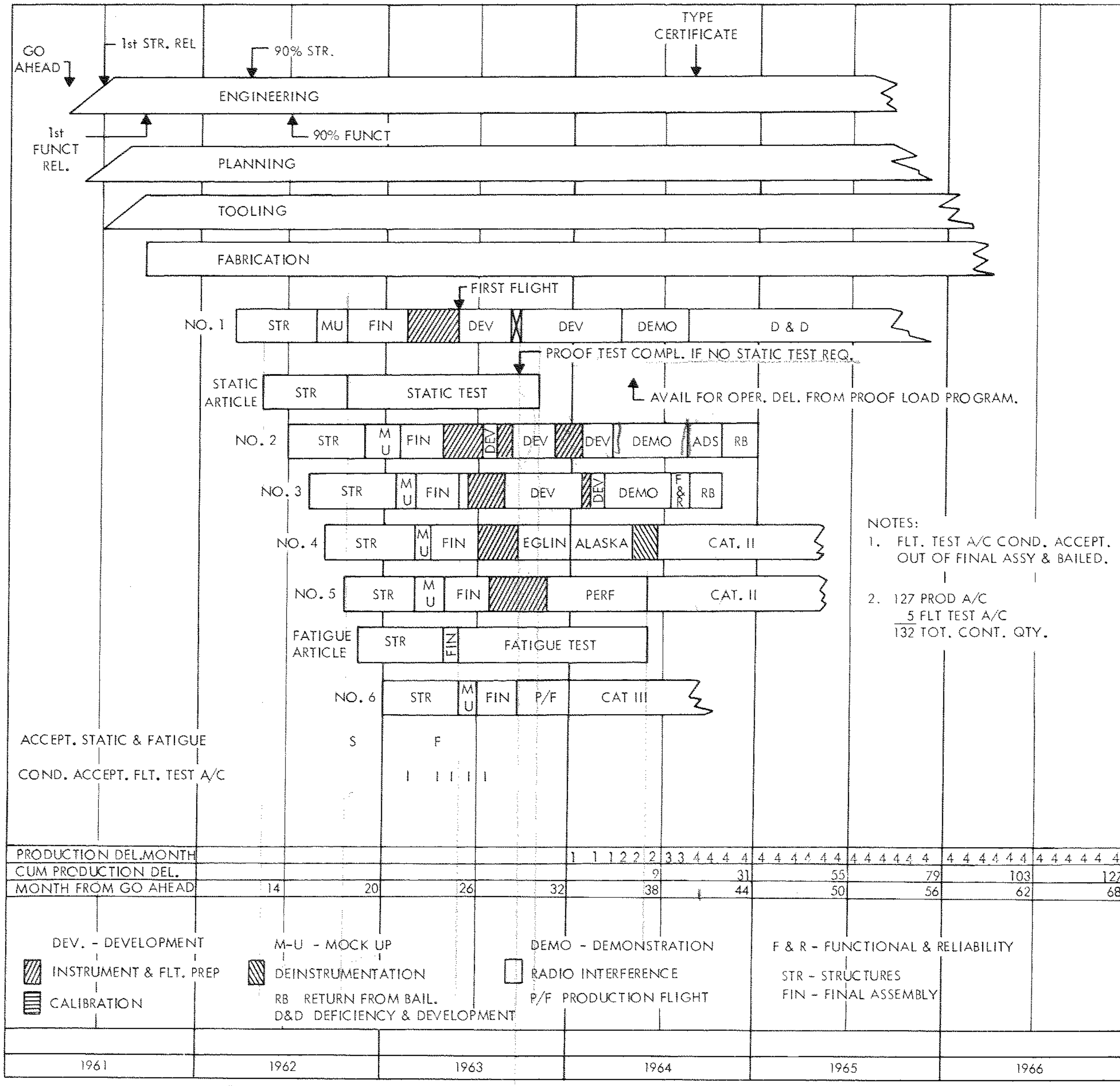


Figure 11-3—SUPPORT CHART, DEVELOPMENT AND PRODUCTION PHASING.

planes into production assembly provides the recommended five flight test aircraft and static and fatigue test articles at the required time and still permits build-up to the maximum military rate of four aircraft per month at the desired schedule time.

To facilitate surveillance of these and other program activities, Lockheed employs Program Evaluation Procedure (PEP). A typical PEP network, encompassing 177 events, complete with critical path and supporting data is submitted in Volume 7. Network events are compatible with control points included in the detailed time-phasing charts and include major milestones and major decision milestones as described by AMCR 375-4, 31 August 1960.

The detailed time-phasing charts include five areas that are of special interest and importance to the conduct of System 476L program. These are:

Development test program—structural & functional test

Engineering flight test programs

FAA Certification

Subcontracts

Supply (spares and AGE)

Lockheed's specific programs in these areas merit individual description.

Structural and Functional Test Programs

Lockheed is stressing the importance of structural and functional test programs. To ensure quality

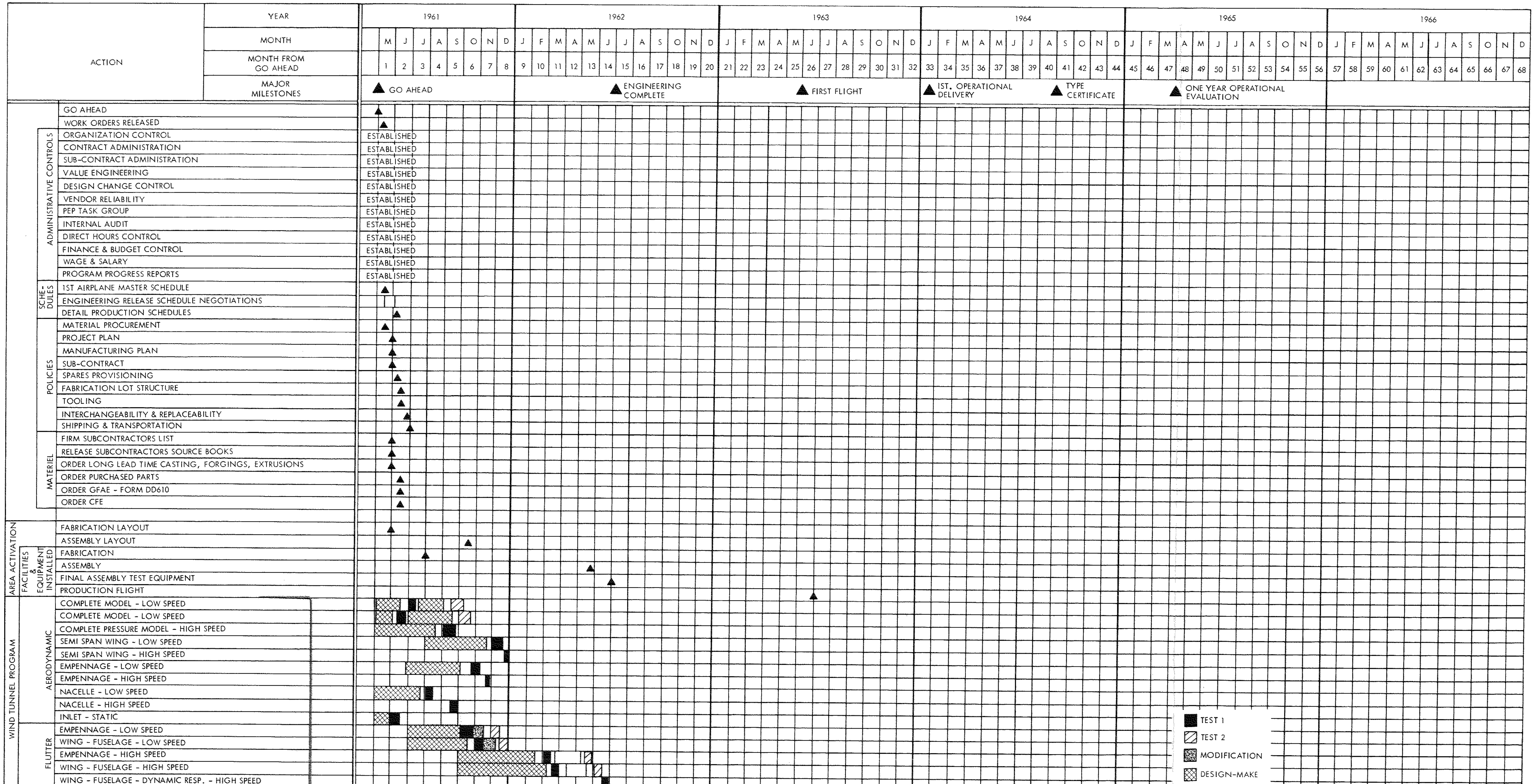


Figure 11-4—SUPPORT CHART, DETAIL TIME PHASING. (1 of 3)

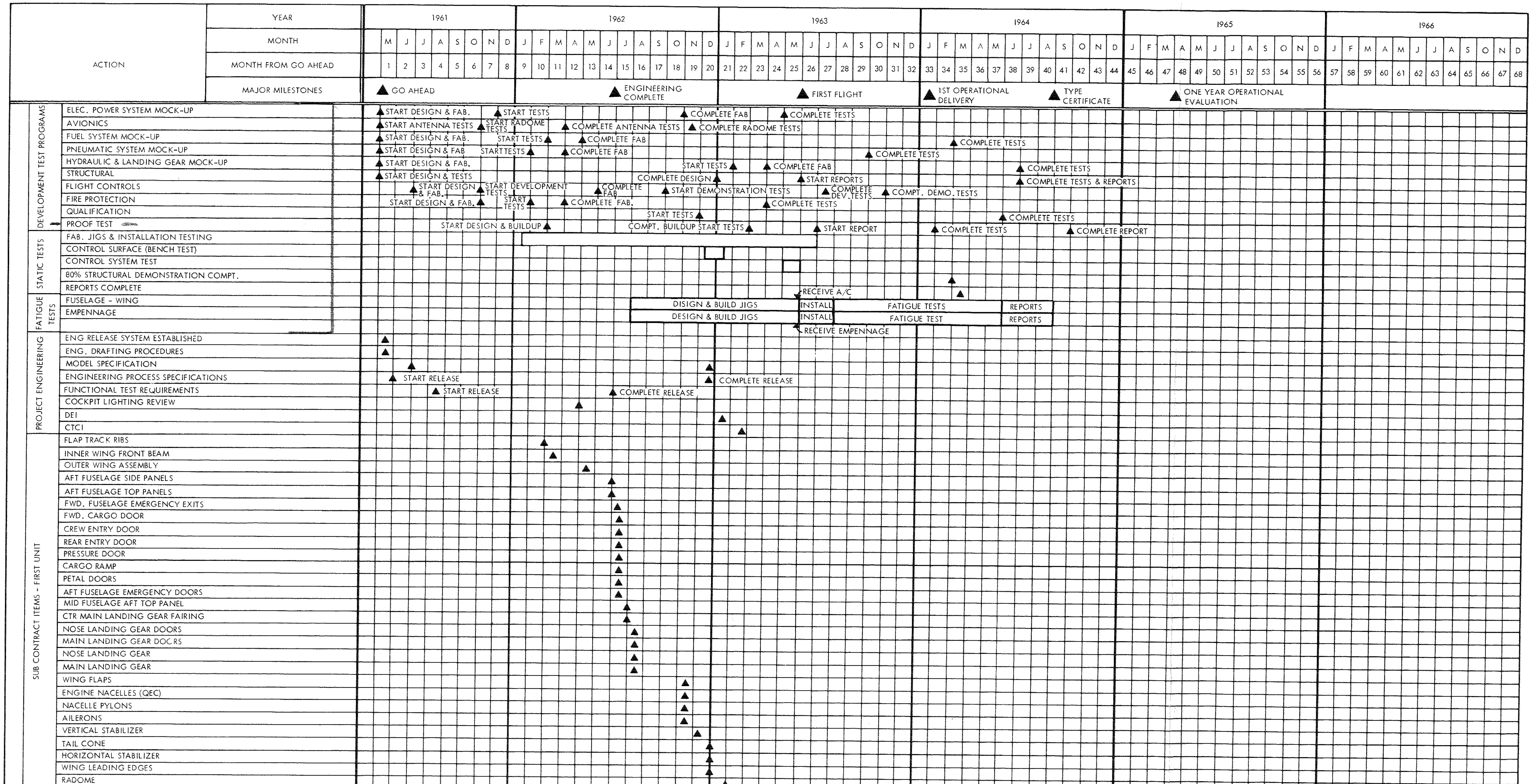


Figure 11-4—SUPPORT CHART, DETAIL TIME PHASING. (2 of 3)

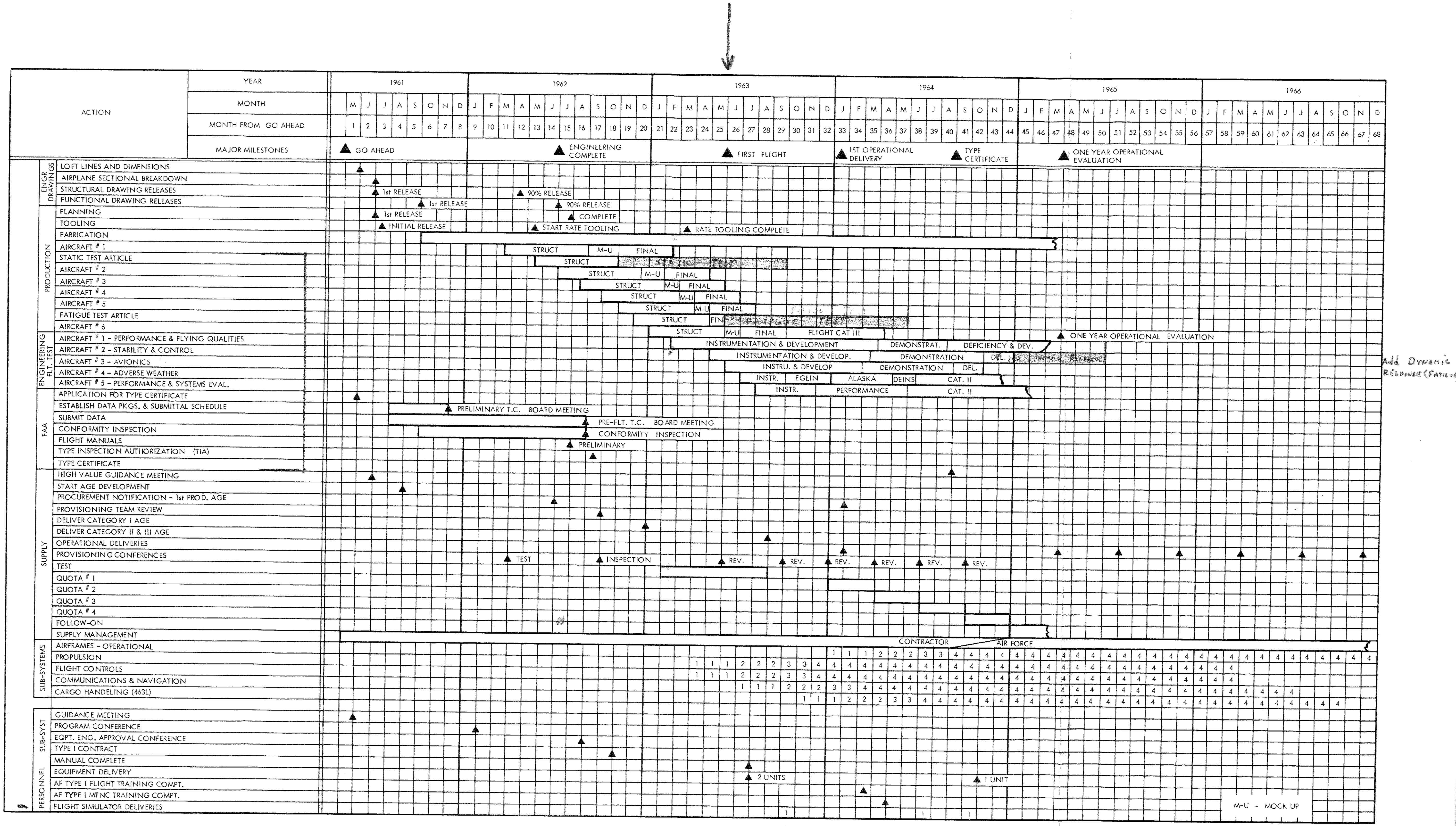


Figure 11-4—SUPPORT CHART, DETAIL TIME PHASING. (3 of 3)

and reliability of all materials, components, assemblies, subsystems, and integrated systems, extensive testing is planned and is programmed for early completion. Significant tests are:

Continuation of wind tunnel testing, which Lockheed began in September, 1960. Aerodynamic tests and a large portion of flutter test will be complete by late 1961, four months ahead of release of 90% of initial structural engineering drawings; last flutter test will be complete approximately one year ahead of first flight of the first aircraft.

Extensive fatigue tests, utilizing major aircraft structural sections.

Completion of development tests, including structural, qualification, and proof tests, and complete testing of electrical power, avionics, fuel, pneumatic, hydraulic, landing gear, flight control, and fire protection systems.

A proof loads ground test, limited air and ground load survey and an 80% limit load structural demonstration, proposed as a minimum program to substantiate structural design on the basis of operational use of airplanes in the normal MATS or civil transport category. Lockheed proposes the second airframe structure as the static test article. This assignment permits the earliest possible first flight date for the first aircraft. Moreover, utilizing the second airframe for test reduces in-line manufacturing and engineering changes to the static test structure.

Lockheed also proposes, in the structural and functional test program, a minimum structural test program that includes a static test to ultimate design load and an air load survey and flight structural demonstration to 100% of design limit load. This additional test is considered essential to military transport operations.

Engineering Flight Test Programs

Lockheed agrees that the use of five aircraft as recommended by the Air Force forms the base for an optimum flight test program. The static test article and the five aircraft to complete production are scheduled for utilization in Air Force and Lockheed engineering test programs and all are available to Lockheed's Engineering Flight Test Division six to ten month before delivery of the first operational aircraft. At the time the first operational aircraft is delivered, in January 1964, the three Category I aircraft will have been assigned to Engineering Flight Test for an accumulative 25 equivalent airplane months for instrumentation, development, and testing, largely in flight status. The two Category II aircraft will have been in use by Air Force and Lockheed flight test groups for an accumulative 11 equivalent airplane months before the first operational aircraft is delivered. Active participation of military and FAA test personnel during development test phases is anticipated.

An alternate test program using seven aircraft and resulting in earlier certification is described in Volume 2.

Timely review of the results of the flight test programs at Lockheed is given special emphasis. Daily review of flight test results and decisions of appropriate action are expedited by a committee of key representatives of the engineering, reliability, and manufacturing branches. Conditions requiring correction are teletyped from the test site by Lockheed's field service representatives for committee review and action. Results of this committee action in effecting expeditious incorporation of design changes and quality fixes were realized in the delivery of C-130B aircraft to operational bases and are presently being used in the Navy test program for GV-1 aircraft. Similar committee activity is planned during GL 207-45 engineering flight test programs at Lockheed and can be utilized during Air Force testing at other sites.

FAA Certification

Immediately following Air Force contractual go-ahead, Lockheed will apply for an FAA Type Certificate. for the GL 207-45. FAA requirements are embodied in the design concepts and released through engineering drawings and test programs and through reliability processes. FAA personnel will actively participate throughout the production program, beginning with conformity inspection of aircraft parts fabrication in early October 1961. Type Inspection Authorization (TIA) is available sixteen months after program contractual go-ahead.

Attainment of a Type Certificate 15 months after first flight in a combined military and civil qualification program is the result of a coordinated and cooperative effort on the part of the Air Force, FAA, and Lockheed. The engineering flight test program is critically analyzed to phase military and FAA requirements into common effort and to prevent duplication of instrumentation and testing. Active participation by Air Force and FAA personnel beginning with the development test phase of the engineering flight test program assures orderly completion of both military and FAA requisites.

Subcontracts

Lockheed's subcontract policy is reflected throughout the System 476L program and results in the company's most extensive subcontract program. More than 60% of the GL 207-45 by AMPR weight is produced by subcontractors. Results of the policy are evident in the extensive listing in Figure 11-4.

Included in the broad subcontract base are airframe and components manufacturers from widely varied geographic sections of the United States and Canada. Preliminary selection of subcontractors and tentative schedule reviews indicate capabilities to produce the many critical GL 207-45 components reflected in required schedules.

A detailed description of the subcontractor program is presented in Paragraph 5.2.3.3.

Supply (Spares and AGE)

Scheduling of supply activities has been developed to provide effective support for the System 476L. Provisioning and review conferences are scheduled to ensure orderly procurement and disbursement of spare parts and AGE, not only for initial aircraft deliveries but throughout the program. Lockheed's supply management organization is responsible for comprehensive supply coverage for test sites and using agencies. Direct communication between operational units and Lockheed results in maximum efficiency for solution of support problems and acquisition of needed spares and AGE. At the appropriate time, following initial aircraft deliveries, management is phased into the Air Force supply system.

SUPER HERCULES · GL207-45

section 12

MANAGEMENT AND ORGANIZATION (5.2.2)

POLICIES AND PROCEDURES (5.2.2.1)

Lockheed's basic policies and procedures are formulated by the corporate policy committee consisting of four senior officers. These men formed the Corporation in 1932 and have directed the company continuously since that time. Specialized corporate policy staffs assist the operating divisions in applying corporate policies and procedures; these staffs include legal, finance, industrial relations, and others. The Georgia Division operates as an autonomous unit having all the functions and facilities necessary to support its assigned product lines. A Vice President-General Manager heads the Georgia Division and implements basic corporate policies with Division policies and procedures as necessary. Although the General Manager is held fully responsible for Division accomplishments, he receives continuous, valuable support from corporate officers on matters of policy and inter-divisional coordination. Corporate officers thus can and often do resolve problems that are beyond Division control but within the powers of the company as a whole. This provides the advantages of a strong, autonomous division organization strengthened by the stability and breadth of experience of the corporate officers. The Georgia Division has produced large cargo type aircraft for the past eight years, and its policies are geared to meet Air Force requirements.

The policies and procedures which directly affect the System 476L program are reviewed here. They cover program planning and control, cost, quality control, reliability, maintainability, supportability, and purchasing and subcontracting.

Program Planning and Control

Lockheed's system of program planning and control is designed to ensure a sound, consistent approach toward attaining the objectives of the Air Force and the Corporation. The corporate office determines the feasibility of undertaking a new task in one of the operating divisions by evaluating program requirements and the division's capabilities, facilities, past performance, and work load. Such an evaluation led to the selection of the Georgia Division to design, manufacture, test, and support System 476L. This Division has an established, experienced, and integrated team which can fulfill effectively all System 476L requirements.

Policies and procedures established for a program are implemented by a project plan produced by the master scheduling organization. This plan provides operating organizations with overall program policy plus specific operating directions, schedules, and procedures for attainment of the program objectives. The project plan for System 476L is based on using to the greatest advantage the experience, facilities, and skills of the Georgia Division. Responsibility for successful execution of each function required to design and produce the system is assigned to fully qualified organizations. With Lockheed's basic concept of management by line organization, authority is granted and responsibility is clearly assigned to specific individuals to carry out these functions.

Techniques for the control of activities of all organizational units are established; many of these controls are monitored by large-scale IBM electronic computers. Each operating organization is required to report periodically on such items as quality, schedule performance, design change, subcontracts, budget, organization, and wage and salary. These program planning and control techniques developed by Lockheed over many years lend themselves readily to the PEP format proposed for System 476L.

Project meetings with the General Manager and his staff are held at least once each week to review program status. Potential problem areas receive the attention of all staff members; this assures close coordination in planning corrective action which is the responsibility of an individual manager. Management receives daily reports showing the status of every aircraft throughout its manufacture from subassembly through delivery. Continuous review of the System 476L program performance will be accomplished by daily contacts between the System 476L Assistant General Manager and the General Manager, by the representation of the System 476L Assistant General Manager on all standing committees, and by a comprehensive system of management reports.

Cost Control

All elements of program cost are subjected to stringent control and are reviewed continuously throughout the duration of the program. Cost control systems are described in detail in Section 5.2.5.

Quality Control

The Lockheed Quality Control system meets or exceeds all requirements of MIL-Q-9858, Quality Control System Requirements, and has been thoroughly proven by use on C-130 contracts. Complete familiarity with military specifications, CAR Part 4b, and other applicable regulations as demonstrated on current production programs assures compliance with the quality specifications that are mandatory for the System 476L program.

The quality control system, as it applies to System 476L, has three primary objectives: (1) to ensure that each part, assembly, and the end product conforms to the engineering specification established by Air Force requirements, (2) to ensure that the intent of design is achieved, and that component compatibility with system requirements is obtained throughout the manufacturing cycle, and (3) to place particular emphasis on the prevention of defects by application of uniform acceptance criteria and by utilizing established process inspection capabilities.

Quality control objectives are achieved through proper implementation of a balanced quality plan. The plan will encompass all quality control policies necessary for attainment of the desired product quality level as defined by the engineering and manufacturing plans. Details of the quality plan and its implementation are contained in Volume 2, paragraph 5.2.3.2.3.

Reliability

Lockheed Georgia Division has in operation a reliability program capable of meeting the requirements of MIL-R-26674 and other applicable military specifications. The System 476L program is a continuation and extension of the existing program which has been so successful on the C-130. In recognition of the importance of reliability, Lockheed has established a Reliability Branch organization which ensures that responsibility for reliability is placed within an organization that is independent of other branches over which they exercise reliability control.

The Lockheed reliability program encompasses capabilities including collection, processing, and maintenance of complete and detailed historical records; electronic computer programs such as actuarial analyses, failure model analyses, and inspection evaluation analyses based upon these historical data; and advanced reliability control techniques developed for using the data and electronic computer programs.

The complete reliability program is presented in Volume 4, Section 5.4.8.

Maintainability

Lockheed recognizes that maintainability must be inherent in original design to enable the operator to meet operational requirements with minimum expenditures of maintenance time, material, and personnel. Lockheed fully appreciates the Air Force emphasis on maintainability and was one of the first aircraft manufacturers to establish a group of experienced, specialized engineers whose function is solely to ensure superior design from the maintenance viewpoint.

The maintenance design group, under the chief systems engineer, participates in the design and development of the airplane and related support systems from the earliest design work. The background of practical engineering and maintenance experience in the maintenance design group is continuously supplemented by input from such organizations as field service, engineering flight test, production, and flight line maintenance, and by personal contact with military and commercial operators. The maintenance design group promotes maintainability through design surveillance, design evaluation, and educational programs. Maintainability in vendor and subcontractor products is achieved through stringent specification requirements and design evaluation.

Supportability

Lockheed recognizes the requirements for technical and logistic support of System 476L as long as these aircraft are actively carried in Air Force inventory. Lockheed will maintain manufacturing and procurement capabilities in accordance with existing Air Force requirements established by MCP 71-650 and 71-373 and other related specifications. Mechanically prepared and maintained records are provided to show application and history of all CFE-type spare parts.

Technical data and modification or change tech orders are engineered, programmed, and released to ensure that the Air Force can maintain the airplanes in accordance with latest improvements.

Lockheed offers continuous training for Air Force technical support purposes. Factory school training is provided for Air Force personnel on a continuing basis with refresher courses to up-date previous training. Training is provided in the field by qualified field service representatives. These representatives also provide a constant flow of field maintenance data back to Lockheed. These data are charted, coded, analyzed, and channeled to responsible departments for necessary action to support the continuous product improvement plan. All publications are developed and supplied in strict accordance with Air Force specifications.

Subcontracting and Purchasing

Determination of items to be subcontracted is made by the Georgia Division make-or-buy policy committee based on in-plant capabilities, schedules, facilities utilization, transportability, cost reliability factors, and on the interests of the Air Force. Full consideration is given to Government desires with respect to small business, depressed labor areas, and Canadian production sharing, and to the placing of major sections with other air frame manufacturers.

Lockheed's procurement practices conform to ASPR and AFPI requirements and have been performed under Air Force, Army, NASA, and Navy, contracts. The methods of the procurement organization are streamlined and mechanized by use of electronic data processing equipment. Program Evaluation Procedures (PEP) for subcontractor coordination are utilized, and a value analysis engineer assists buying personnel in researching uses and costs of materials and equipment.

Buying personnel are assisted by staff specialists in such fields as auditing, tooling, warranty, and termination claims. Complete manuals on all policies and procedures are furnished to every buyer to provide assistance and to ensure compliance with the customer and buying requirements. A small-business coordinator maintains liaison with the small business administration and with those small business concerns which have capabilities which can be utilized. Lockheed has a consistent and vigorous program of encouraging qualified small firms to participate in the defense work being performed at the Georgia Division.

ORGANIZATION (5.2.2.2)

The Lockheed Aircraft Corporation consists of a number of autonomous operating divisions including the Georgia, Missiles and Space, and California Divisions. Each division is headed by a Vice President-General Manager who reports through a Group Vice President to the Executive Vice President to the President and Board of Directors. These General Managers exercise basic line control over the activities of their divisions, having a corresponding basic responsibility for division accomplishments. Also reporting to the President is a group of officers, each with a small staff, which gives general guidance and counsel to the operating divisions in specialized areas such as accounting, legal matters, taxes, insurance, and industrial relations.

As an example of the close corporate support that the Georgia Division receives, the Group Vice President spends fully 25% of his time on Georgia Division affiairs. Corporate management keeps fully apprised of the status, progress and problems on all significant projects by conventional reporting systems and frequent visits.

The Georgia Division is organized on a functional basis as shown in Figure 12-1. This figure also shows the positions of key management control organizations within the functional organization, although these control organizations do not, in every case, report directly to the functional branch head. Each major functional organization such as engineering, manufacturing, and finance, reports directly to the general management level. This sytem is more flexible and economical for the production of a wide range of similar aircraft products than the alternative, a project system. It assures common techniques and principles between production programs, provides employees with experience on more than one project, and minimizes employee turnover as programs phase in and out.

Within most functional organizations there must still be certain individuals and organizations devoting full time to specific projects. For example, the assembly function is normally organized on a project basis. Figures 12-2 thru 12-7 identify those organizations which will be established specifically for the System 476L program. In general, this follows the organizational system so successfully used in producing the many versions of the C-130 Hercules; it provides a highly responsive coordination team, maintaining constant control over critical areas and having a direct channel of communication to top management.

The scope and importance of the System 476L program warrants the constant attention of Lockheed's top management. Accordingly, Assistant General Manager W. B. Rieke will be assigned full time to this program. The Vice President and General Manager has delegated authority to the System 476L Assistant General Manager to provide complete administration over this program and to speak for the Georgia Division on all matters relative to this program.

The System 476L Assistant General Manager in exercising his full authority over this program will ensure that: all essential activities are programmed and controlled; potential problems are anticipated and resolved in a timely manner, through his control over the functional organizations; and Lockheed and USAF management are kept apprised of the cost, quality and delivery status of the program. In carrying out this responsibility, he will be assisted by the System 476L management control organizations shown in Figure 12-1.

Figure 12-8 illustrates those functions within the engineering, materiel, manufacturing, finance, sales, reliability, and master scheduling organizations which are to be performed by people assigned full time to the System 476L program and those functions performed by other units which, directly or indirectly, will support the program. Figure 12-9 lists the education, years of experience, present position and a few related aircraft programs worked on by the persons assigned to the System 476L program and by the persons in other key management positions supporting this program. It is significant to note that virtually all individuals have experience on both turbine powered aircraft and swept-wing jet aircraft.

Management Controls

Figure 12-1 indicates 13 key management control organizations, as differentiated from product control organizations such as quality control, which have as their common purpose the furnishing of

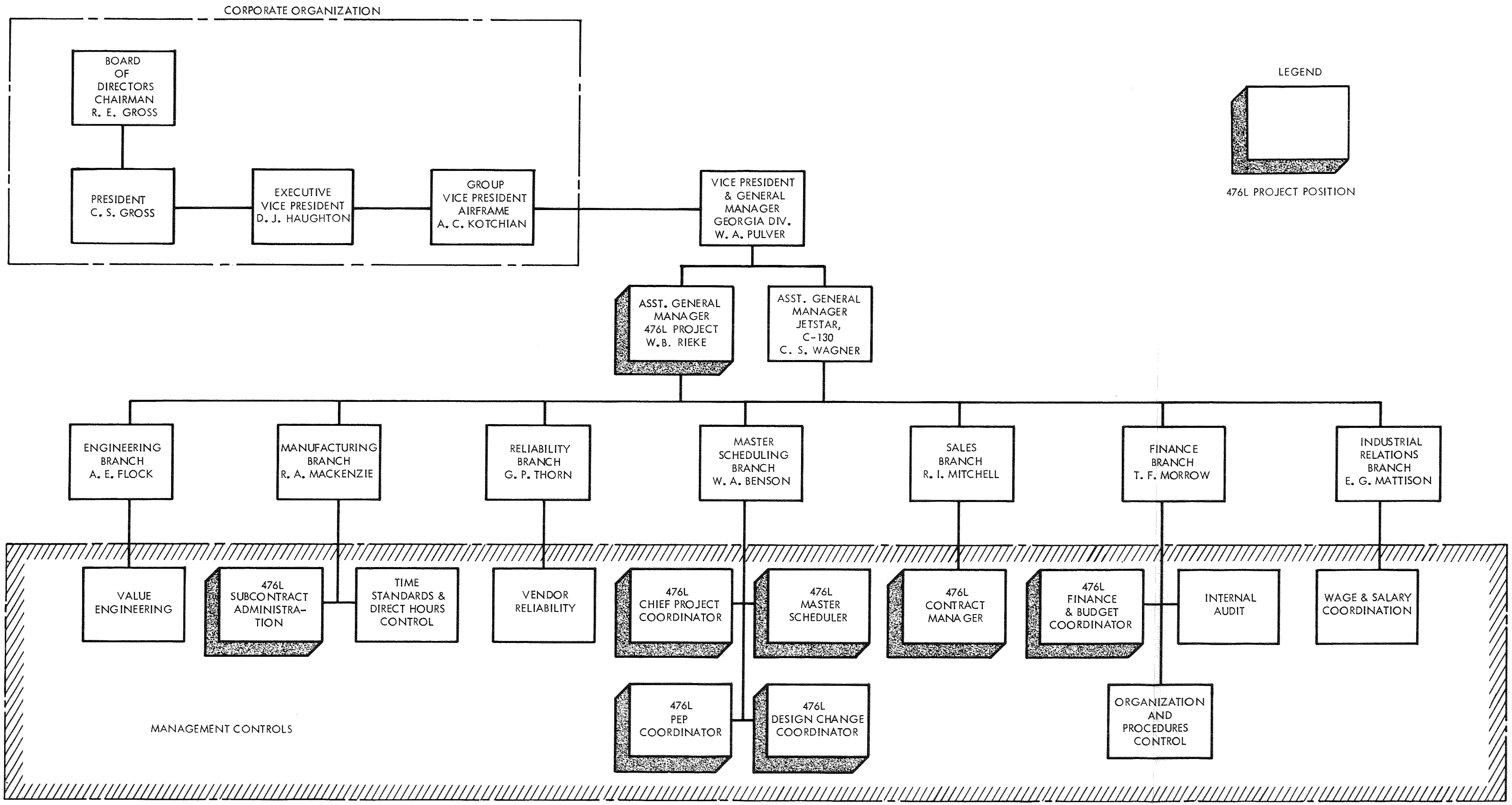


Figure 12-1—SYSTEM 476L ORGANIZATION.

information to management concerning the existence of possible problems to be resolved. This information, whether in regard to detailed project cost performance, internal schedule performance, or subcontractor performance, is reviewed by general management and corporate management as early as possible so significant problems can be anticipated and settled. A brief report on the basic responsibilities of these 13 control organizations follows:

Value Engineering

For the past six years, the essential principles of value engineering have been performed at the Georgia Division. The Georgia Division has established a Value Engineering Department whose functions are to (1) perform evaluation of initial product design and advise engineering design organizations so these designs may achieve required quality at a minimum cost, (2) review specification control documents and vendor equipment proposals in coordination with Equipment and Standards Engineering, (3) conduct value analysis studies on existing equipment and designs and assist purchasing by applying value analysis techniques to procurement, (4) publish information bulletins to interested organizations regarding applications of value engineering, and (5) conduct training seminars to influence other organizations to seek full value in their operations.

Subcontract Administration

This department is responsible for (1) procuring subcontracted items from outside sources in ac-

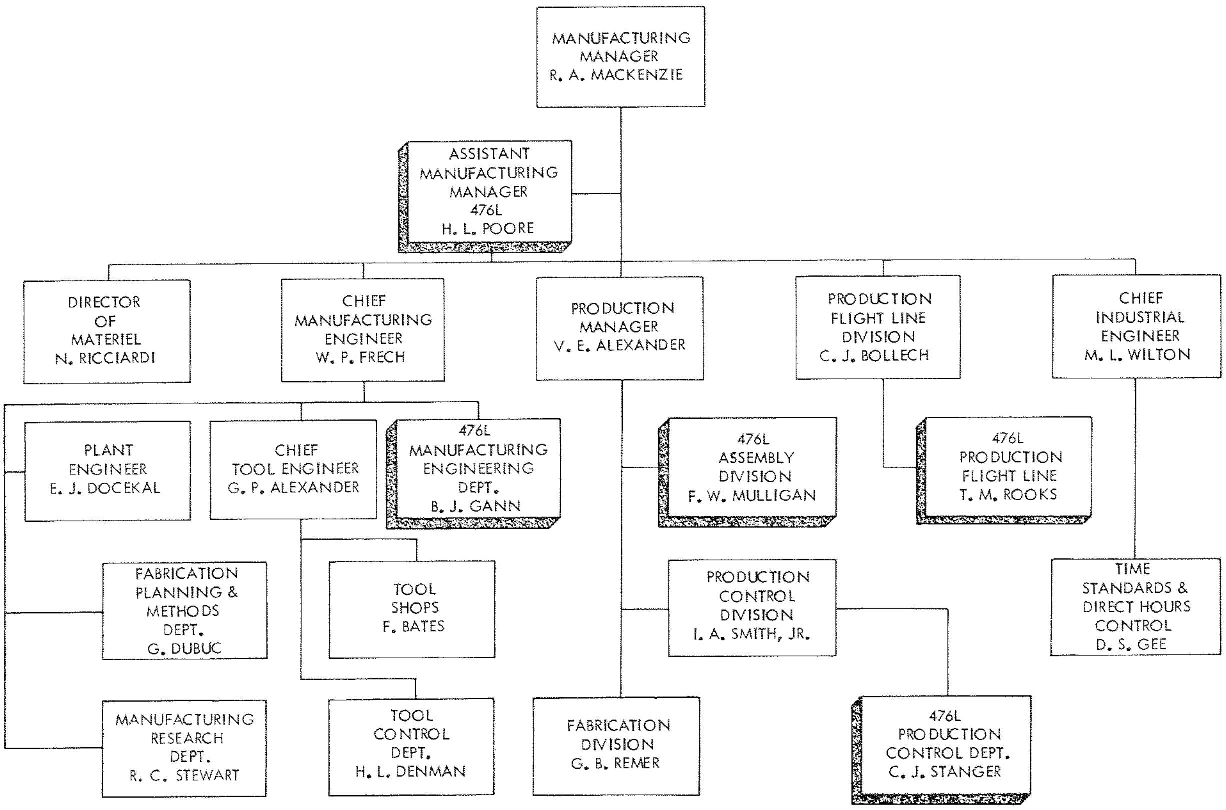


Figure 12-2—MANUFACTURING ORGANIZATION.

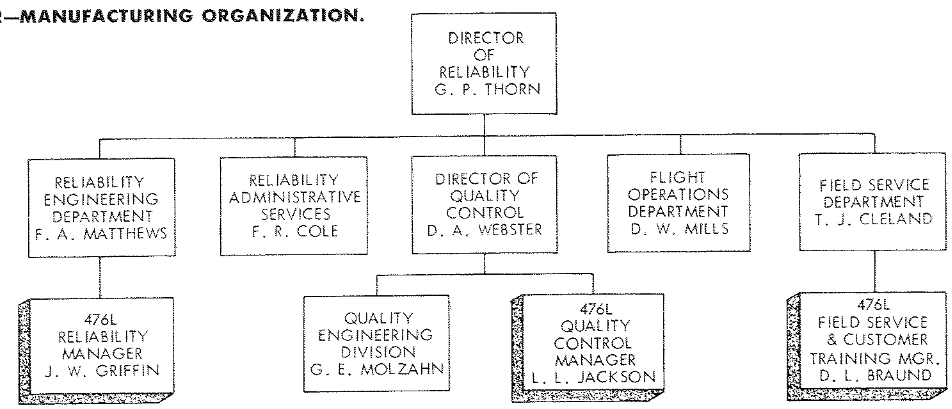


Figure 12-3—RELIABILITY ORGANIZATION.

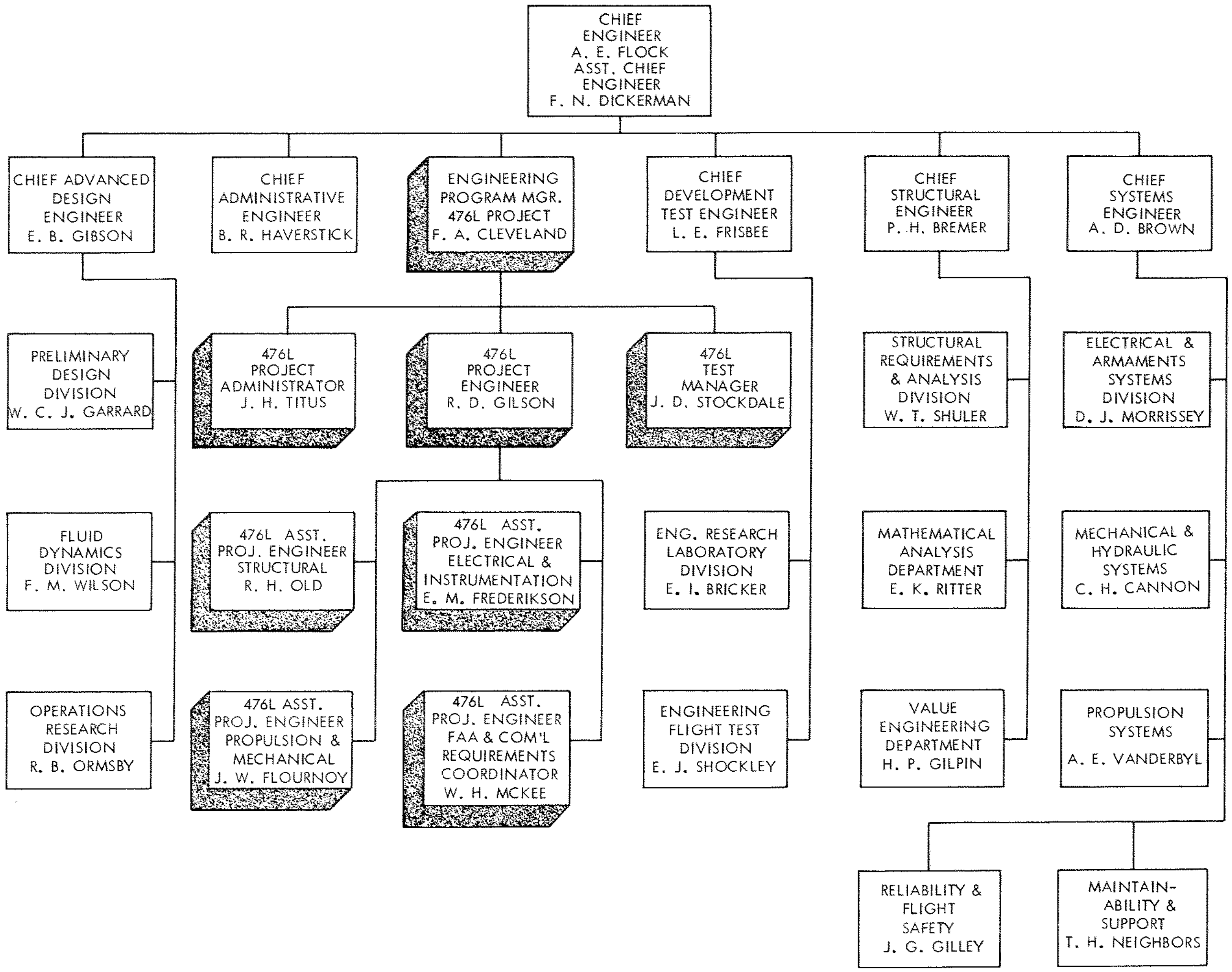


Figure 12-4—ENGINEERING ORGANIZATION.

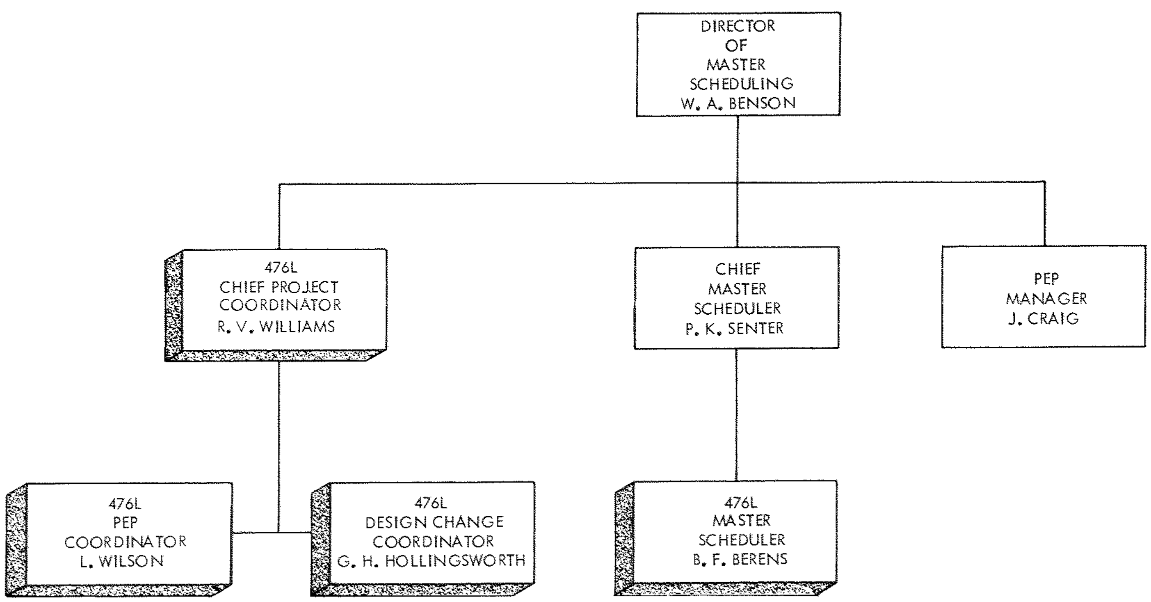


Figure 12-5—MASTER SCHEDULING ORGANIZATION.

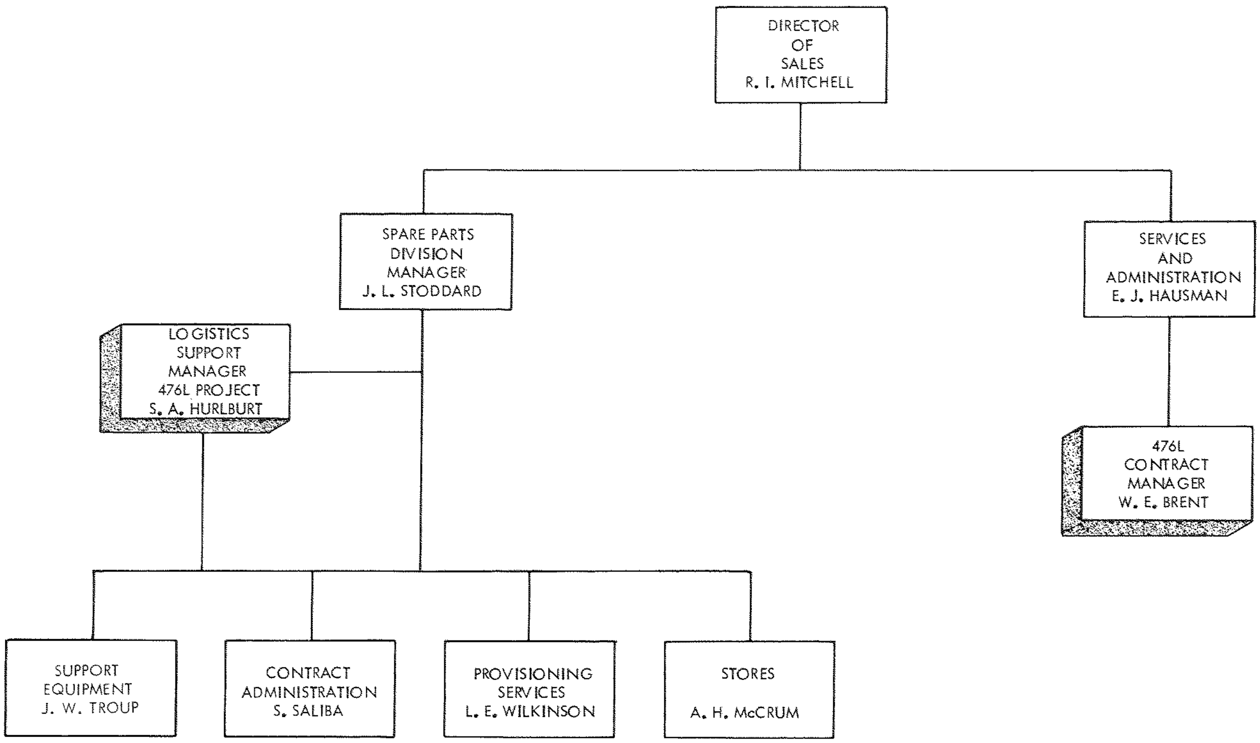


Figure 12-6—SALES ORGANIZATION.

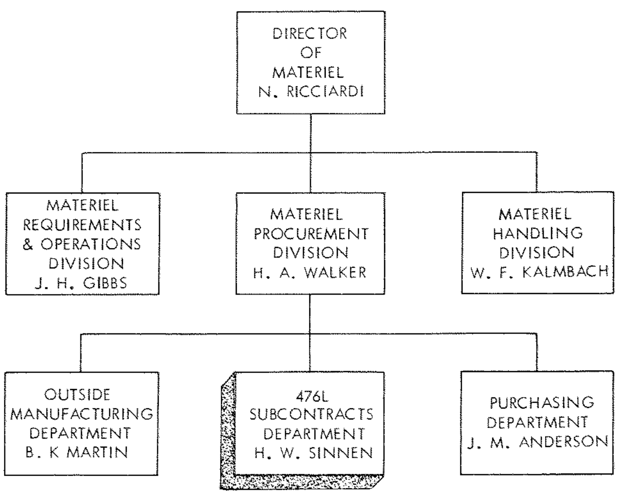


Figure 12-7—MATERIEL ORGANIZATION.

cordance with applicable Government procurement regulations, Air Force policies and requirements, and authorized procurement documents; (2) ensuring establishment of fair and reasonable prices; (3) furnishing vendors and subcontractors with required drawings, technical data, technical assistance, and tools and aids, (4) negotiating and ensuring compliance with all schedule and design changes with the subcontractors or vendors, and coordinating subcontractor's manufacturing programs with Lockheed's design change activity, and (5) maintaining liaison, surveillance and control of subcontractor activity through the program evaluation procedure (PEP) program.

Engineering liaison, PEP coordination, and other coordination with the associate contractors is performed by the System 476L subcontractors organization.

Time Standards and Direct Hours Control

This department: (1) develops and maintains work measurement programs for fabrication, assembly, and flight line operations; (2) recommends and evaluates methods improvements; (3) develops and maintains budgets for direct manhour expenditures; and (4) conducts special manpower studies and prepares manpower estimates for price quotation purposes.

Vendor and Subcontractor Reliability Control

The Reliability Branch maintains a comprehensive vendor and subcontractor reliability control program, in conformance to the Statement of Work and its appended documents; this is incorporated as an integral part of the basic reliability program for System 476L. The vendor control program includes all aspects of vendor selection, training, monitoring and performance evaluation and is designed to ensure that the reliability of vendor and subcontractor components is commensurate with the reliability requirements of the overall system.

System 476L Chief Project Coordinator

The System 476L Chief Project Coordinator: (1) negotiates details of the System 476L program with affected organizations for subcontracts, flight tests, service tests, etc., and develops and publishes "milestone" schedules that are commensurate with

ORGANIZATION OF BASIC SYSTEM 476L FUNCTIONS

System 476L Project Organizations within these branches will perform the following:

Engineering

1. Design GL207-45 aircraft and components.
2. Develop project engineering for release to manufacturing.
3. Control qualification, ground, flight evaluation and other required tests.
4. Provide technical data and liaison to vendors, subcontractors, and associate contractors.
5. Develop improvements and variations in aircraft use.
6. Provide assistance to USAF on airplane service.

Materiel

1. Propose subcontractors and negotiate subcontracts.
2. Exchange technical data with subcontractors and associate contractors.
3. Provide subcontractors with liaison, tools, and other aid.
4. Monitor performance by subcontractors and associate contractors on schedules and standards.
5. Audit subcontractors and assure proper cost control and performance.

Manufacturing

1. Plan production and tool operations, except fabrication.
2. Design tooling.
3. Order project materials; schedule detailed production.
4. Assemble GL207-45 aircraft.
5. Control production material flow.

Reliability

1. Review initial designs for reliability.
2. Establish detailed reliability standards.
3. Review performance against standards by Lockheed, vendors, and subcontractors.
4. Inspect System 476L manufacturing to ensure adequate quality control.
5. Ensure that no products are delivered without meeting established engineering standards.
6. Provide USAF training.
7. Provide field support for delivered aircraft.

Master Scheduling

1. Develop System 476L Master Schedule and detailed schedules.
2. Develop System 476L Project Plan.
3. Approve design changes; serialize, and schedule incorporation.
4. Develop and monitor PEP and milestone schedules.
5. Report schedule performance to management.
6. Negotiate corrective action with organizations having schedule difficulties.
7. Conduct project meetings.
8. Monitor all System 476L control data requirements.

Finance

1. Develop System 476L manhour and material budgets.
2. Prepare project performance reports.
3. Assist in price negotiations.
4. Review contracts for financial requirements and reporting.
5. Ensure cost accumulation system meets contract needs.
6. Conduct weekly cost performance meetings.
7. Report cost performance to management.

Sales

1. Negotiate contract terms and conditions.
2. Administer contract.
3. Submit engineering changes to USAF.
4. Maintain liaison with customer.
5. Develop proposed spares requirements and negotiate with USAF.
6. Order the production of spare parts and assure timely receipt.
7. Deliver spares to USAF in accordance with contract schedules.

Existing functional organizations will support the System 476L project by performing the following:

Engineering

1. Structural weights, loads, dynamics and strength analysis support.
2. Electronic, mechanical, propulsion and hydraulics systems support.
3. Fluid dynamics development.
4. Mathematical analysis.
5. Producibility engineering analysis.
6. Value engineering analysis.
7. Wind tunnel and experimental shop.
8. Engineering flight testing systems and analysis.
9. Manual and bulletins preparation.
10. Research laboratory development and testing.
11. Lofting and drafting practices.
12. Operations research.

Material

1. Purchase parts and supplies from vendors, and monitor performance.
2. Provide clerical and procurement support functions.
3. Order standard raw material and standard part items.
4. Receive shipments, store, and disburse to using organizations.
5. Ship material outside the division.
6. Transport material within the division.
7. Provide traffic instructions to vendors and division personnel.
8. Carry out the division's conservation program.

Manufacturing

1. Manufacture tools.
2. Fabricate parts.
3. Perform plant maintenance and layout functions.
4. Perform industrial engineering operations, including setting time standards and work measurement.
5. Control facility equipment ordering.

Reliability

1. Production flight testing.
2. Provide reliability performance data on existing systems and aircraft.
3. Establish process controls and quality standards.
4. Provide experience on existing field service programs.

Master Scheduling

1. Develop long range plans and schedules.
2. Coordinate other program schedules, changes and performance.
3. Implement and monitor overall PEP program.

Finance

1. Perform electronic data processing services.
2. Price contracts.
3. Establish divisional budgets and forecasts.
4. Accumulate costs.
5. Maintain property accounting control.
6. Maintain books of accounts and prepare financial reports.
7. Control organization and procedures.
8. Coordinate finance matters with corporation.
9. Provide photographic, motion picture, and office services.

Sales

1. Maintain liaison offices.
2. Suggest new uses for aircraft.
3. Promote the aircraft and its uses.
4. Seek commercial customers for the System 476L.

NOTE: The above include only the basic functions performed by the above seven organizations. Further details concerning the method by which these functions are carried out is shown throughout the applicable sections of this proposal. In addition to the above, the following functions are performed by other organizations: employment, personnel, security, training, public relations, and legal.

KEY PERSONNEL—SYSTEM 476L PROJECT POSITIONS

Effective Date	Name	Present Position	Higher Education: Years	Higher Education: Degrees or Major	Years Experience: Total Lockheed	Years Experience: Total Applicable	Related Product Experience	% Time System 476L
May 1961	W. Rieke	Assistant General Manager	1	Bus. Adm.	20	30	C130, JetStar, B47, Connie, P2V	100
May 1961	F. A. Cleveland	Chief Advanced Design Engineer	6	MA AE	15	17	C130, JetStar, ANP, P2V	100
May 1961	J. H. Titus	C-130 Project Administrator	3	AE	6	18	C130, B47, C46	100
May 1961	R. D. Gilson	Project Engineer—Preliminary Design Division	4	BS AE	5	25	C130, C119, XB48	100
May 1961	R. H. Old	Group Engineer—Preliminary Design Division	3	AE	12	22	C130, B47, Connie	100
May 1961	J. W. Flournoy	Asst. P.E.—C-130	4	BS AE	5	19	C130, B47	100
May 1961	E. M. Frederickson	Asst. P.E.—C-130	5	BS ME	9	18	C130, B47	100
May 1961	W. H. McKee	LASA 60 Project Manager	4	MS AE	7	20	C130, JetStar, LASA 60, DC7	100
May 1961	J. D. Stockdale	Assistant Division Engineer—Flight Test	4	BS AE	18	21	C130, JetStar, Electra, Connie	100
May 1961	H. L. Poore	Production Manager	1	Aero	22	25	C130, JetStar, B47, Connie, P2V	100
May 1961	B. J. Gann	Fabrication Planning and Methods Dept. Manager	2	IE	20	20	C130, B47, Connie, P2V	100
Nov. 1961	F. W. Mulligan	Fabrication Division Superintendent	1	ChE	23	24	C130, JetStar, B47, Connie, P2V	100
May 1961	C. J. Stanger	JetStar Production Control Department Manager	—	—	16	21	C130, JetStar, B47, DC3, DC4	100
Aug. 1963	T. M. Rooks	B-47 Production Flight Line Department Foreman	1	Arts	10	16	B47, B29, DC3, B26	100
May 1961	H. W. Sinnen	Materiel Project Manager—JetStar	—	—	19	19	C130, JetStar, B47, B34	100
May 1961	J. W. Griffin	Engineering Analysis Group Supervisor	9	MA Math.	6	6	C130, JetStar	100
May 1961	L. L. Jackson	Mfg. Q. C. Division Manager—C-130 and B-47	2	Engrg.	8	26	C130, JetStar, B47, B29	100
May 1961	D. L. Braund	Training Section Supervisor	1	Bus. Adm.	10	15	C130, JetStar, B47	100
May 1961	R. V. Williams	Chief Project Coordinator—C-130	2	IM	9	9	C130, B47, B29	100
May 1961	G. H. Hollingsworth	Design Change Coordinator—C-130	3	I. Rel	9	9	C130, B29	100
May 1961	B. F. Berens	Project Coordinator	2	Math	9	18	C130, JetStar, B47, B29, C76	100
May 1961	L. Wilson	Project Coordinator	5	BBA	21	21	C130, B47, Connie	100
May 1961	S. A. Hurlburt	Commercial Spares Department Manager	6	MBA	10	10	C130, JetStar, B-47	100
May 1961	W. E. Brent	Contracts Manager	5	BS	23	23	C130, JetStar, Connie, P2V	100

Figure 12-9—KEY PERSONNEL, SYSTEM 476L PROJECT AND EXISTING FUNCTIONAL POSITIONS.

KEY PERSONNEL—SYSTEM 476L PROJECT POSITIONS

Planned Position	Effective Date	Name	Present Position	Higher Education: Years	Higher Education: Degrees or Major
Asst. General Manager—S476L	May 1961	W. Rieke	Assistant General Manager	1	Bus. Adm.
Engineering					
Program Manager	May 1961	F. A. Cleveland	Chief Advanced Design Engineer	6	MA AE
Project Administrator	May 1961	J. H. Titus	C-130 Project Administrator	3	AE
Project Engineer	May 1961	R. D. Gilson	Project Engineer—Preliminary Design Division	4	BS AE
Asst. P.E.—Structural	May 1961	R. H. Old	Group Engineer—Preliminary Design Division	3	AE
Asst. P.E.—Propulsion and Mechanical	May 1961	J. W. Flournoy	Asst. P.E.—C-130	4	BS AE
Asst. P.E.—Electrical and Instrumentation	May 1961	E. M. Frederickson	Asst. P.E.—C-130	5	BS ME
Asst. P.E.—FAA and Commercial Requirements	May 1961	W. H. McKee	LASA 60 Project Manager	4	MS AE
Test Manager	May 1961	J. D. Stockdale	Assistant Division Engineer—Flight Test	4	BS AE
Manufacturing					
Asst. Manufacturing Manager	May 1961	H. L. Poore	Production Manager	1	Aero
Manufacturing Engineering Department	May 1961	B. J. Gann	Fabrication Planning and Methods Dept. Manager	2	IE
Assembly Division	Nov. 1961	F. W. Mulligan	Fabrication Division Superintendent	1	ChE
Production Control Department	May 1961	C. J. Stanger	JetStar Production Control Department Manager	—	—
Production Flight Line	Aug. 1963	T. M. Rooks	B-47 Production Flight Line Department Foreman	1	Arts
Subcontracts Department	May 1961	H. W. Sinnen	Materiel Project Manager—JetStar	—	—
Reliability					
Reliability Manager	May 1961	J. W. Griffin	Engineering Analysis Group Supervisor	9	MA Math.
Quality Control Manager	May 1961	L. L. Jackson	Mfg. Q. C. Division Manager—C-130 and B-47	2	Engrg.
Field Service and Customer Training Manager	May 1961	D. L. Braund	Training Section Supervisor	1	Bus. Adm.
Master Scheduling					
Chief Project Coordinator	May 1961	R. V. Williams	Chief Project Coordinator—C-130	2	IM
Design Change Coordinator	May 1961	G. H. Hollingsworth	Design Change Coordinator—C-130	3	I. Rel
Master Scheduler	May 1961	B. F. Berens	Project Coordinator	2	Math
PEP Coordinator	May 1961	L. Wilson	Project Coordinator	5	BBA
Sales					
Logistics Support Manager	May 1961	S. A. Hurlburt	Commercial Spares Department Manager	6	MBA
Contract Manager	May 1961	W. E. Brent	Contracts Manager	5	BS

the project plan for the activities of the major organizations of the Georgia Division; (2) evaluates overall division performance against the project schedule, negotiating corrective action with affected organizations; and (3) conducts weekly project meetings for Georgia Division management to review schedule performance on the project.

System 476L Master Scheduler

The Master Scheduler: (1) develops schedules establishing start and completion dates for engineering design, material procurement, manufacturing planning, tooling, fabrication, and assembly; (2) develops schedules for airplane deliveries and major airplane component manufacture and publishes assembly line position; (3) negotiates, developes and issue the System 476L project plan outlining the type of engineering release, type of tooling, the facilities and area to be used, and the general plan for accomplishing all objectives of the program; and (4) monitors all contract data requirements.

System 476L PEP Coordinator

The System 476L PEP Coordinator will implement and monitor the PEP program, reporting to management on program schedule performance, forecast trouble spots, and use of resources applicable to the System 476L project. Overall Georgia Division PEP programming and reporting is the responsibility of the PEP manager, who reports directly to the director of master scheduling.

The Lockheed Missiles and Space Division in conjunction with the military services had the opportunity to pioneer in the development of the PERT/PEP concept. The Georgia Division has been able to draw on their extensive experience in establishing a PEP network and reporting system for the System 476L program. Application of trial PEP programs has already commenced at the Georgia Division for existing C-130 contracts, under the guidance of Missiles and Space Division representatives utilizing their experience to train Georgia Division employees.

The detailed PEP network which has been developed for the System 476L program is described in Volume 7. An IBM 7090 computer to perform this reporting is scheduled for delivery in mid-1961; the Missiles and Space Division IBM 7090 computer has been made available for use until this delivery. The Georgia Division has IBM 704 and 705 III computers on hand to meet other needs on the System 476L program.

System 476L Design Change Coordinator

The System 476L Design Change Coordinator: (1) approves or disapproves all design changes, except safety changes on products over which the Georgia Division has proprietery control; (2) serializes and schedules the incorporation of product design changes, technical orders, service kits, service bulletins, and specifications; (3) specifies the type of engineering release to be employed, type of manufacturing planning to be furnished, and type of facility to be used in accomplishing individual design changes; (4) coordinates the compiling of data for design change quotations, including required manhours, schedule variations, probable redundancies, and vendor cancellation charges; (5) assists sales and engineering organizations in negotiating design changes with the customer; and (6) reviews progress of design change incorporation into the finished airplane or product.

System 476L Contract Manager

The prime function of the System 476L Contract Manager is to determine that contractual obligations are being satisfactorily fulfilled and to advise management immediately of any imminent deviation from such obligations. The Contract manager also: (1) submits engineering change proposals and other requests for contract change or amendment to the Air Force for authorization; (2) receives similar requests from the Air Force and determines company position regarding incorporation of such requests; and (3) maintains constant liaison with the Air Force to keep abreast of new developments.

By its nature, the function of the System 476L Contract Manager requires extensive experience in the administration of government contracts, and cognizance of all applicable rules and regulations pertaining to such contracts. As the key man in the flow of correspondence between Lockheed and USAF, the System 476L Contract Manager will coordinate with virtually all Lockheed organizations. The lines of formal communication between the Air Force and Lockheed, with the System 476L contract manager serving as the prime point of contact, are illustrated in Figure 11-1 in Volume 2.

System 476L Finance and Budget Coordinator

The System 476L Finance and Budget Coordinator: (1) assists in negotiation of prices with the Air Force after audit and evaluation of price proposals from Price Estimating; (2) reviews contracts for financial requirements and reporting, and helps establish a cost accumulation structure to meet contract requirements; (3) reviews proposed manhour budgets and proposed bills of material, and develops approved manhour and material budgets for management; (4) prepares project performance reports for general and corporate management; (5) conducts weekly cost performance meetings; and (6) furnishes management with continuing information on all phases of the project.

To the Air Force, this coordinator is a single, specialized source of both schedules and interim financial reports and information regarding the project; to all operating levels of the Georgia Division, he is a continuing source of specialized financial counsel for the System 476L project.

Organization and Procedures Control

Financial operations staff department, reporting directly to the director of financial operations: (1) provides liaison with the corporate office regarding matters pretaining to corporate Management policy statements and other corporate policies; (2) prepares, coordinates, and issues Georgia Division management directives; (3) publishes and maintains functions and responsibilities statements, listing in detail the duties of each Georgia Division department; (4) coordinates requests for changes in any organization and its duties; and (5) publishes charts which show the entire divisional organization structure.

Internal Audit

Lockheed uses its internal audit function as a managerial control. The field of audit activity extends to all organizations in the entire Georgia Division operation. The objective of such audit examinations is to determine if the planning, accounting, control, and custodial activities of the organization are being performed in accordance with Air Force requirements, management instructions, the applicable statement of policy and procedure, and in a manner consistent with Air Force and company objectives and high standards of administrative practices. In cases where corrective action is required, a report of the action to be taken, and another report of the action taken, must be made to the corporate vice president Finance.

The internal audit function for the System 476L program will be performed by the staff of experienced auditors maintained at the Georgia Division to make periodic examinations of the various organizational units.

Wage and Salary Coordination

The functions of wage and salary coordination for the System 476L program are performed by the labor relations department of the industrial relations branch.

This department: (1) prepares descriptions and evaluations of all jobs; and (2) establishes rate ranges for the jobs, submitting those for non-represented jobs to a top management salary board for final determination, and submitting those for represented jobs to the appropriate bargaining agent for negotiation. This department will authorize job classifications to be used in each System 476L department and assist line supervision in the solution of problems involving application of job descriptions and proper classification of employees.

Electronic Data Processing Capabilities

As mentioned earlier in reference to the System 476L PEP coordinator, the Georgia Division has IBM 704 and 705-III equipment and will have an IBM 7090 in mid-1961. This Division has had an electronic data processing program in operation for over four years and is utilizing such equipment extensively in its ordering, pricing, scheduling and budgeting operations as well as in its engineering mathematical analysis operations. Significant manpower and cost savings as well as improved management data have resulted from this program to date.

Currently a total systems concept study, project "Inter-Loc," is underway to achieve even better performance. "Inter-Loc" is being jointly sponsored by Lockheed and International Business Machines. It has as its objectives: (1) the designing of an integrated total production and management control processing system from program inception; (2) the definition of additional data collection and processing requirements to attain this total concept system; and (3) the achievement of immediate cost reduction benefits through installation of interim systems.

Organizational Flexibility

The Georgia Division, in addition to its earlier B-47 production program and its continuing C-130 and JetStar programs, has accomplished extensive modification and repair programs on the B-47, C-130, and other aircraft.

By their nature, modification programs often develop on short notice and demand rapid fluctuations in manpower requirements beyond the control of management. A critical B-47 modification program will serve to illustrate Lockheed's organizational flexibility. A buildup to accomplish this program during 1956 raised the total employment to nearly 20,000 people, approximately one quarter of whom were required directly or indirectly for the B-47 modification activities. This was accomplished rapidly, with only a few departments being added to the organizational structure. As this program phased out, these departments were eliminated without affecting normal production operations. During the past several years, after completion of the B-47 production program and as a result of smaller C-130 orders, manpower fell off to the present level of approximately 10,000 employees. This contraction was accomplished smoothly and efficiently as attested by the fact that certain management ratios, such as indirect/direct manpower, improved during this total manpower decline.

The success achieved in accommodating such wide fluctuations in manpower levels is largely attributable to the flexibility of the organization type now established and proposed for the 476L program. This basically functional type of organization, embodying only carefully selected project units, provides all the advantages of a specialized project organization without overlapping of functions and duplication of facilities and personnel.

MANPOWER (5.2.2.3)

History of Labor-Management Relationships

Aeronautical Industrial District Lodge 33 of the International Association of Machinists, AF of L—CIO, is a recognized bargaining agent for office clerical, factory, and maintenance hourly employees. Plant Protection Lodge 615, although affiliated with Aeronautical Industrial District Lodge 33, is a separate bargaining unit with a separate agreement covering the plant protection employees.

There has been only one strike in the history of the Georgia Division. The strike commenced May 7, 1958, following a prolonged period of contract negotiation. By May 19, 1958, all employees had returned to work and acceptance of contract items had been voted. No subsequent major problems have arisen, and a two-year contract was successfully negotiated in 1960. A two-year agreement was also negotiated in 1960 with Plant Protection Lodge 615. The expiration dates of the present agreements are July 10, 1962 for the major agreement, and July 24, 1962 for the Plant Protection Lodge agreement.

Company-Union relationship is considered both normal and satisfactory. Marked and consistent improvement in this relationship has been achieved since the 1958 contract negotiations with the grievance volume currently reduced to a record low.

The Lockheed Nuclear Products facility located in Dawsonville, Georgia, was activated early in 1958, and the I.A.M. was granted representation. In an NLRB election on February 12, 1959, however, the employees voted against Union representation. The Lockheed Nuclear Products organization is still non-represented, and the employer-employee relationship has remained excellent.

Manpower Availability

Manpower requirements of the System 476L program present no problem for the Georgia Division. The skills required to produce System 476L are those which have been developed over the Georgia Division's many years of design and production of the C-130 and the C-140 JetStar, and production of the B-47.

The Georgia Division has experienced a decline from approximately 20,000 to 10,000 employees, primarily in office and shop classifications, during the past several years. This decline in number of employees has elevated the overall caliber of employees to a peak, with 86 per cent of present employees having from 5 to 25 years experience. Projection of firm and anticipated business other than the System 476L program indicates that total employment will continue to decline to an average level of approximately 5,000 employees during the period of System 476L production.

Manning the System 476L program will be accomplished largely by reassignment of personnel from other projects. Replacement of personnel on those projects will in turn be accomplished by recall of personnel on lay-off. Approximately 3,000 direct and 1,500 indirect employees presently on lay-off are actively maintaining their recall rights and are available in the immediate area for this purpose. According to recent labor statistics for Cobb County, where the Georgia Division is located and where the majority of employees reside, the level of unemployment is 8.3 percent. The area is described by the Georgia State Employment Office as one of "substantial labor surplus."

Exclusive of mandatory lay-off of personnel consistent with declining business volume, the Georgia Division has a very low employee turn-over rate. This factor, coupled with the normal retention of senior employees during manpower reductions, has produced a nucleus of high seniority workers experienced and skilled in the production of military cargo and swept wing jet aircraft. Additionally, the other divisions and subsidiaries of Lockheed provide excellent and readily available sources of critical or highly specialized skills.

The time phasing of the System 467L engineering workload in relation to other Georgia Division programs is fortunate. Planned reductions in engineering personnel now assigned to the JetStar, C-130E, and GV-I programs coincide with the increase required for System 476L.

The net result of this program phasing is a practically level engineering manpower requirement which obviates the need for an engineering hiring program. Assurance of an adequate supply of engineering manpower will be strengthened by the selection of subcontractors fully qualified to perform combined engineering and manufacturing subcontracts.

Final selection of subcontractors will be based on availability of sufficient manpower having appropriate skills along with normal considerations such as price and quality. Preliminary subcontractor investigation has shown that many highly qualified sources having ample manpower are available to supply all System 476L items planned for subcontract or purchase.

Manpower requirements of the System 476L are shown in Figure 11-2, Paragraph 5.2.2.3 in Volume 2.

SUPER HERCULES · GL207-45

section 13

PRODUCTION (5.2.3)

This section presents the production plan encompassing materials, components, assembly plan, manufacturing layout, tooling, production testing, subcontracting and facility requirements.

Production of System 476L requires a large facility equipped with a wide range of manufacturing equipment and staffed by experienced personnel.

Lockheed's Georgia Division very adequately satisfies these requirements and, in addition, is geographically well situated to administer a heavy subcontract program using subcontractors in any part of the United States or Canada.

The design requirements of the GL 207-45 provide a basis for effective use of C-130 techniques in materials, manufacturing, tooling, interchangeability, testing, and subcontracting.

The production plan for manufacture of the GL 207-45 is based on use of proved materials, methods, and techniques and employs to the best advantage the excellent facilities of Air Force Plant No. 6. Use of materials is limited to present state-of-the-art applications, thus assuring that production or performance is not endangered by the failure of new materials to fulfill their promised function.

The production breakdown of the airplane into its component parts is based on the fulfillment of all the requirements of manufacturing, subcontracting, service, and spares. Subassemblies can be completely assembled as separate units, including the installation of all functional items, thus permitting a smooth line flow leading to a simple, minimum station, final assembly line. Full consideration is given to the interchangeability requirements and to the need for flexibility in order that each major component may be produced by qualified subcontractors.

Lockheed employs a system of concurrent engineering-manufacturing release of drawings. For subcontracted airplane sections engineered in-plant, this method provides the close control required to assemble the airplane on schedule.

The tooling policy is to attain the optimum level of economy consistent with quality in the overall manufacturing effort. Generally, initial tooling will be minimum but designed for expansion or supplementation.

All component parts of the airplane are designed to be manufactured on existing equipment. Design of the aircraft will not necessitate special manufacturing facilities. Manufacture of the highest quality aircraft at the lowest possible cost consistent with functional performance requirements is the goal of the production plan.

Assembly efficiency is assured by this plan which takes full advantage of proved assembly and tooling techniques and assures a smooth minimum station assembly line permitting maximum use of subcontractor facilities.

Lockheed has the tool design and tool manufacturing capability to produce aerospace ground equipment and training equipment related to the 476L System. This capability is demonstrated by successful manufacture of support equipment for the C-130.

Materials (5.2.3.1.1)

Materials are selected on the basis of cost, structural integrity, weight, ease of fabrication, maintenance requirements, and conformance to military specifications. New or untried materials are not used in the GL 207-45. Materials reliability and producibility have been proven in evaluation tests and in service experience on other Lockheed aircraft.

The aircraft structure is made primarily of standard aluminum aircraft alloys 2024 and 7075. Pressure skins and other applications requiring high fatigue strength are generally 2024; 7075 is used for high static strength. 7079 aluminum alloy is used for forgings over 2½ inches in section. AM 350 stainless steel is used in applications where great strength is needed for concentrated loads in thin sheet. AISI 4340 and 4130 steels are used for heavy steel fittings. The use of ultra-high heat treat in steel has been kept to a minimum to reduce costs and maintenance. Titanium is used in applications showing a design advantage based on strength and density versus cost.

Material forms such as castings, forgings, and extrusions are employed to render structural integrity and maximum reliability. Special emphasis is placed on material forms which reduce fabrication costs.

Finishing materials and processes are generally those specified by MIL-F-7179 and its referenced specifications, supplemented by additional requirements to provide superior corrosion resistance. Resistance to Skydrol corrosive action is attained by the use of Nylon, epoxide, and epoxide-acrylic paint. Materials not covered by government specifications are controlled by contractor originated, Air Force approved, material specifications.

Polysulfide materials for sealing integral fuel tanks provide maximum fuel resistance and trouble-free service life. The entire interior surfaces of the tanks are coated with a Buna-N overcoat by a fill-and-drain method. These materials exceed the requirements of MIL-S-8802. Low-density polysulfide compounds are used for sealing seams, joints and fasteners; regular polysulfides are used for filling voids and joggles. MIL-S-7502 sealants are used when faying surface seals are required. Galley and toilet areas are protected from acids by using a sprayable two-part polysulfide compound. Engine firewalls are treated with a firewall sealant meeting Air Force requirements. When required, aerodynamic smoothness of exterior surfaces is achieved by appropriate polysulfide materials.

For the radome and antennas, epoxy resin is used in place of conventional polyester resin to provide superior physical characteristics. The nose radome is a solid laminate of uniform electronic thickness. It is protected from the erosive effects of rain by a conventional elastomeric coating. Flush antennas are of solid laminate construction composed of glass cloth, epoxy resins, and suitable metallic materials.

Tempered, laminated glass is used for flat and curved windshields and windows because of superior optical characteristics and serviceability. For compound curvatures, stretched acrylic sheet is employed. Craze-resistant acrylic sheet as an inner, separate pane is used for the unheated glass windows.

Windshields, flat and curved, are a five layer laminate using an extended plastic edge for attaching directly to the airframe. The outer glass of the windshield is tempered to provide birdproofing characteristics and is electrically heated to provide anti-icing. Inner plastic and tempered glass layers prevent spalling of the center tempered glass layer. The plastic layer between center and outer glass layers, which will not rupture in the event of total glass failure, provides fail-safe characteristics.

The materials listed in the following table are not "off-the-shelf" items and require special lead-time.

Material	Kind	Cross Sec. Area	Qty. per Ship	Projected Area	Gross Wt. per unit	Net Wt. per unit	Lead Time
Extrsn	Al	18 in.^{2}	2880 Ft.		21.6 lbs/ft	8.7 lbs/ft	12 wks.
Forging	Al		2	2550 in.^{2}	90 lbs.	65 lbs.	22 wks.
Forging	Al		2	3600 in.^{2}	330 lbs.	285 lbs.	22 wks.
Forging	Al		2	4130 in.^{2}	265 lbs.	240 lbs.	22 wks.
Forging	Al		2	2760 in.^{2}	175 lbs.	160 lbs.	22 wks.
Forging	Al		2	1125 in.^{2}	1150 lbs.	300 lbs.	22 wks.
Forging	St		2	510 in.^{2}	1300 lbs.	385 lbs.	22 wks.
Forging	St		2	970 in.^{2}	375 lbs.	340 lbs.	22 wks.

Components (5.2.3.1.2)

Standard, proved and readily-available vendor-supplied components are used to the greatest extent possible consistent with system design and operational requirements. Every effort is made to use compatible C-130 components.

New component requirements not common with the C-130 are selected from equipment that has been used and proved on other aircraft. Where no equipment exists that meets design parameters of the GL 207-45, off-the-shelf vendor items, modified to meet requirements, are considered. Components designed especially for the GL 207-45 are held at the minimum.

Where component requirement cannot be matched with existing standard or off-the-shelf items, engineering issues specification documents and drawings which define all design parameters and test requirements. Potential vendors are furnished with Lockheed specifications and requested to submit design proposals for technical evaluation.

Vendor design proposals are evaluated against Lockheed requirements for engineering concept and design feasibility. Vendors whose proposals are acceptable to engineering are listed on applicable specification control drawings as approved sources.

Where the equipment components are of a high-value or critical nature, a Vendor Proposal Point Evaluation system is employed and a Proposal Evaluation Committee, composed of representatives from Engineering, Reliability, and Material, performs a systematic and documented vendor proposal evaluation.

Listed below are the longer lead-time major procured items.

Description	Qty. Per Airplane	Probable Source	Availability	Cost	Qualif. Span	Prod. Span
Transformer-Rectifier, 25 Amp.	1	Westinghouse	*	$1,500	6 mo.	5 mo.
Transformer-Rectifier, 5 Amp.	1	Westinghouse Chatham Electronics	*	1,500	6 mo.	5 mo.
Regulation, Press, APU Fuel	1	AiResearch	*	620	6 mo.	5 mo.
Pump, Hyd. (QEC)	4	Vickers New York Air Brake	*	2,000	6 mo.	6 mo.
Mech. MLG, Extend & Retract	2	Western Gear Foote Bros.	*	10,000	6 mo.	6 mo.
Mech. NLG, Extend & Retract	1	Menasco	*	7,500	6 mo.	6 mo.
Refrigeration Unit	2	AiResearch Hamilton Std.	*	3,500	6 mo.	8 mo.
Water Separator	2	AiResearch	*	1,000	6 mo.	7 mo.
Valve, Check, 2" dia.	1	Whittaker	*	550	6 mo.	6 mo.
Galley	1	DK Mfg.	**	2,655	6 mo.	6 mo.

* It is anticipated that design and manufacture of this item will involve only already-demonstrated capabilities within the existing state of the art.

** Specification-controlled item previously tested and used on other Lockheed aircraft.

MANUFACTURING (5.2.3.2)

The GL 207-45 is designed for optimum producibility and requires no advancements in use of materials or manufacturing processes. The production breakdown assures unit sizes and arrangements that are most adaptable to the facilities of Lockheed and those of established subcontractors. Further discussion of producibility design considerations is found in Paragraph 5.1.5.4. A major assembly breakdown, shown in Figure 13-1 was

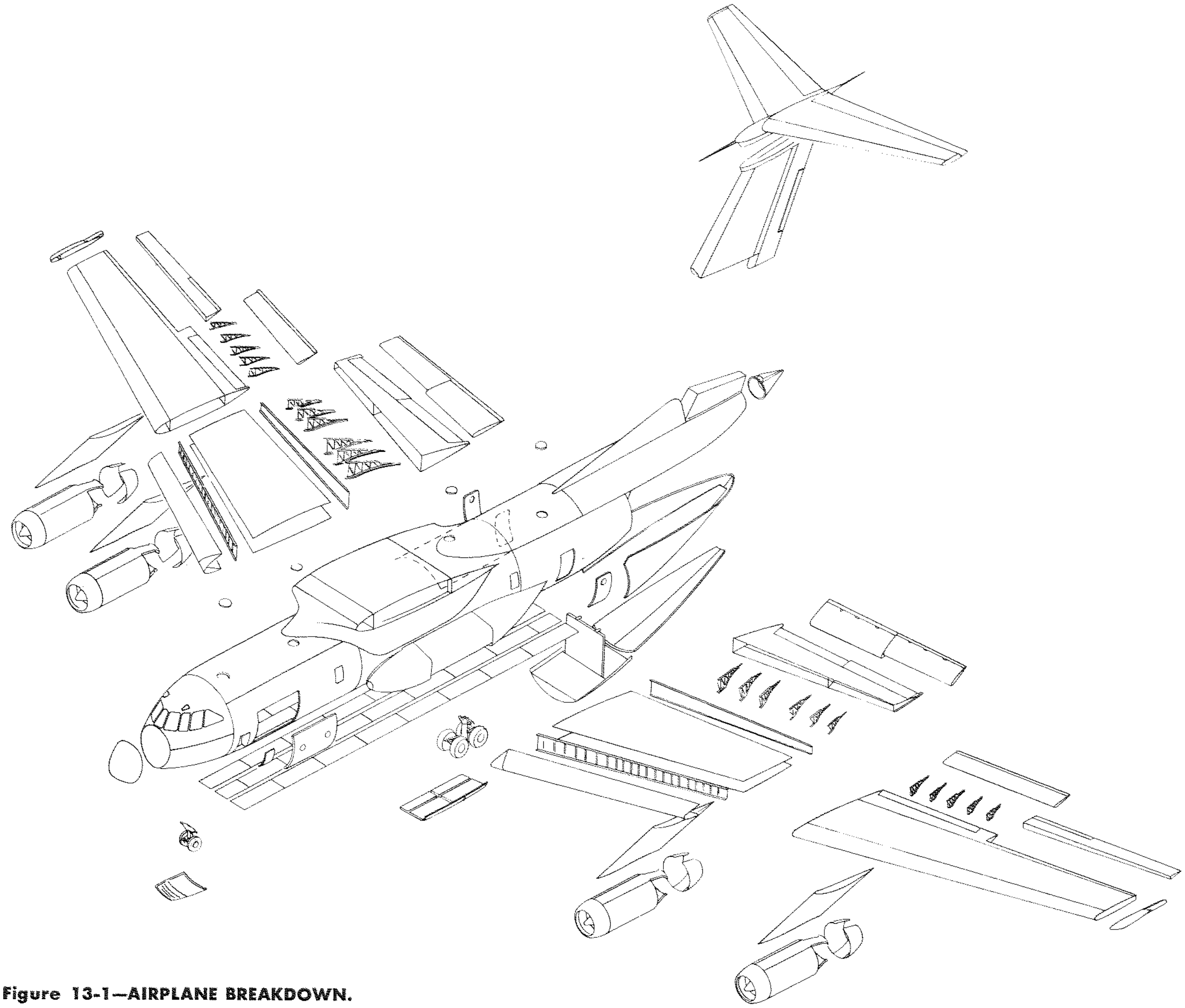


Figure 13-1—AIRPLANE BREAKDOWN.

developed jointly by design, production, and manufacturing engineers to meet requirements of strength, weight, and ease of assembly.

The production breakdown of the airplane is based on the fulfillment of all requirements of manufacturing, subcontracts, service, and spares. The components can be completely assembled into separate units including the installation of functional items where practical. Every consideration is given to the interchangeability requirements and to the need for flexibility to produce assemblies by qualified subcontractors and with minimum tooling.

Careful selection of production breaks and subassembly components result in economical and easily tooled assemblies. This concept is followed in all sections of the GL 207-45.

GL 207-45 structures are basically of conventional design comprising body frames, angles, stiffeners, brackets, stringers, skins, ribs, and webs of aluminum alloy, magnesium alloy, and other conventional metals used in modern airframe manufacture. Other structural members consist of steel or aluminum fittings used for attaching major assemblies. Protective coatings and treatments for the various airframe parts follow methods conforming to accepted aircraft standards. For additional information on types of materials used, see Paragraph 5.2.3.1.1

Design of the systems and subsystems for manufacture of the airplane is based on these ground rules: Subcontractors provide their own tools for building and mastering their assemblies; Lockheed provides master tools to control mate points between subcontractor and in-plant sections. Proved manufacturing techniques and tools used successfully on the C-130 are employed. A concurrent engineering-manufacturing paperwork release system is used. Development of functional systems is accomplished concurrently with manufacture of the production airplanes.

Advanced manufacturing and assembly techniques used to produce the GL 207-45 employ only thoroughly demonstrated state-of-the-art applications. Tooling is planned, designed, and manufactured to make use of numerically controlled machinery, plastics, optics, and photographic reproductions in order to reduce cost and to increase accuracy and improve performance. Fabrication applications include machining of large integrally stiffened wing skins, close tolerance fusion welded large sections, metal bond, honeycomb panel manufacture, and chemical milling. Assembly techniques include automatic riveting, wing tank sealing, and advanced methods of mock-up development.

A typical set of assembly tools and their assembly sequence is depicted in Figure 13-2. Figure 13-3 illustrates the planned flow sequence of the major assemblies. For additional information supporting the illustrations, see the step by step plan for building GL 207-45 subassemblies and assemblies in Paragraph 5.2.3.2 of Volume 2, and Figures 13-4 and 13-5 which show the plant and flight line layout through which the manufacturing process flows.

Manufacturing Layout (5.2.3.2.1)

The manufacturing layouts show the GL 207-45 as a single-phase program. Costly tool and facility rearrangements involved in multi-phase layouts are avoided by this approach. This plan is made possible by the ample production area available.

Structures assembly, final assembly, and flight line operations require 607,000 square feet of area for the manufacture of the GL 207-45 at a four-per-month rate.

Tabulation of the space requirements is summarized below:

Four-Per-Month Spare Requirements

Name	Area (Square Feet)	Remarks
Structure Assembly	265,000	Main Bldg. (B-1)
Final Assembly	192,000	Main Bldg. (B-1)
Flight Line	150,000	Flight Line Bldg.
TOTAL	607,000	

Final assembly space requirements increase progressively from a minimum of 32,000 square feet at the outset of the program to a maximum of 192,000 square feet for rate production.

The C-130 and C-140 (JetStar) series, and the B-70 (major subcontract portion) program run

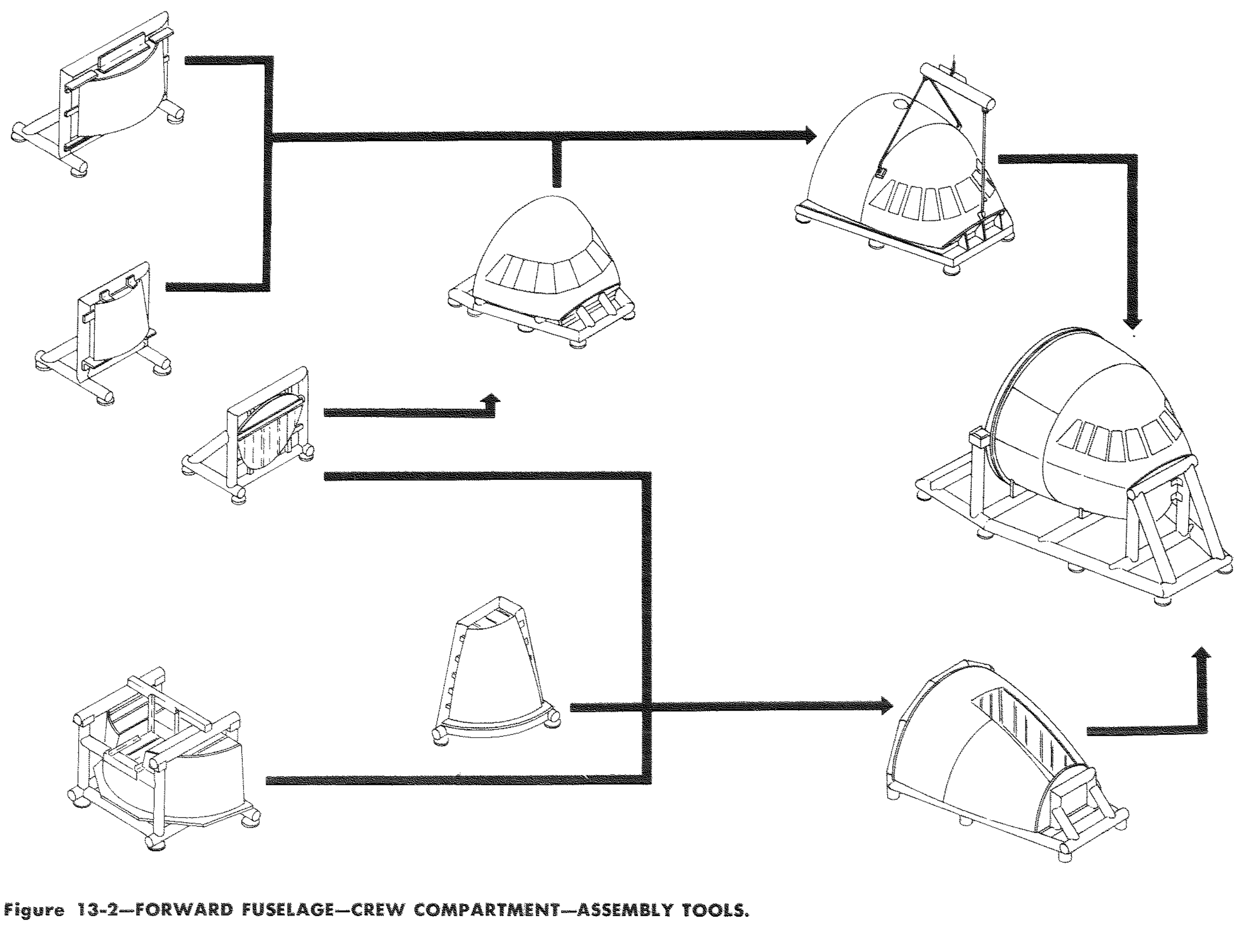


Figure 13-2—FORWARD FUSELAGE—CREW COMPARTMENT—ASSEMBLY TOOLS.

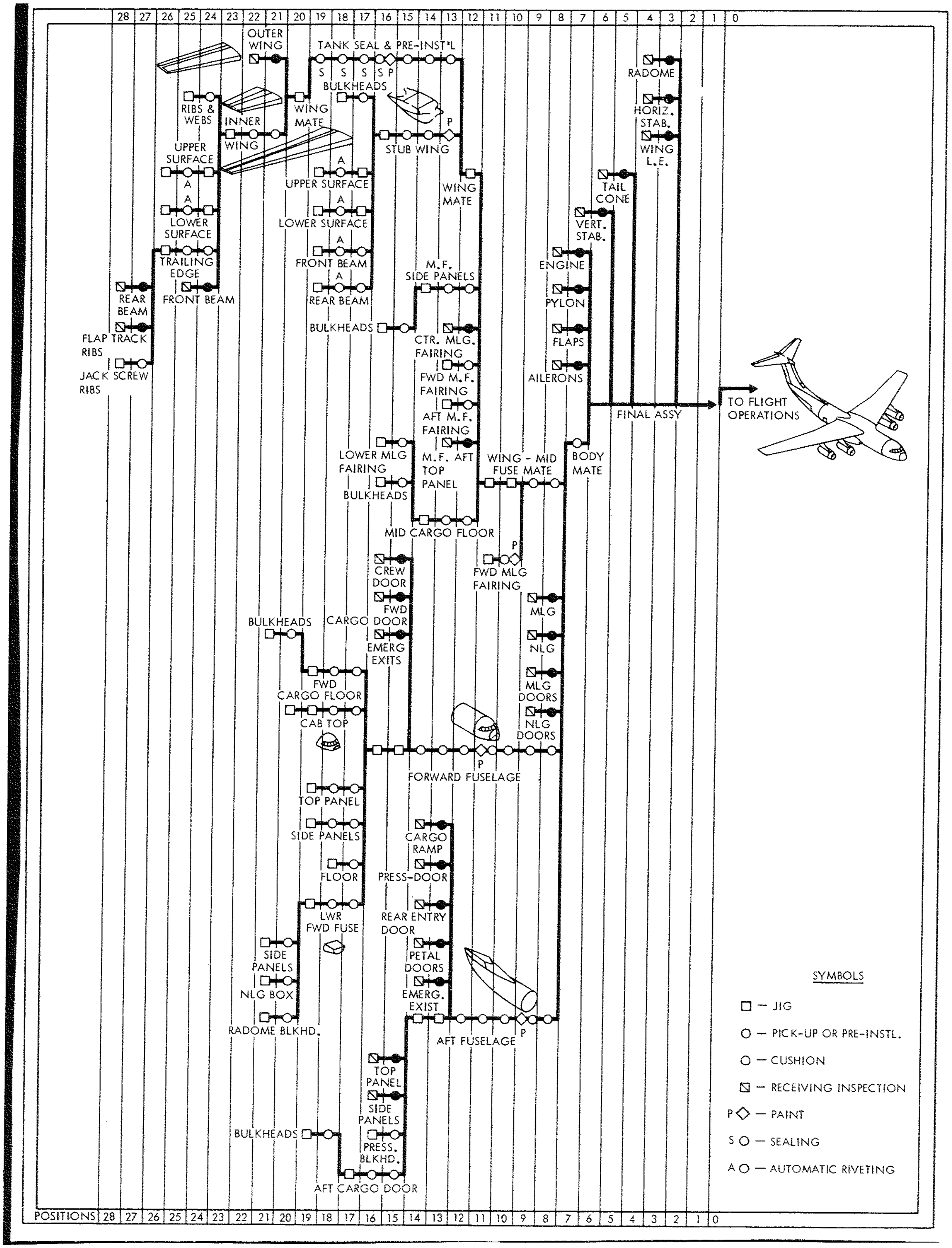


Figure 13-3—MAJOR ASSEMBLY SEQUENCE FLOW CHART.

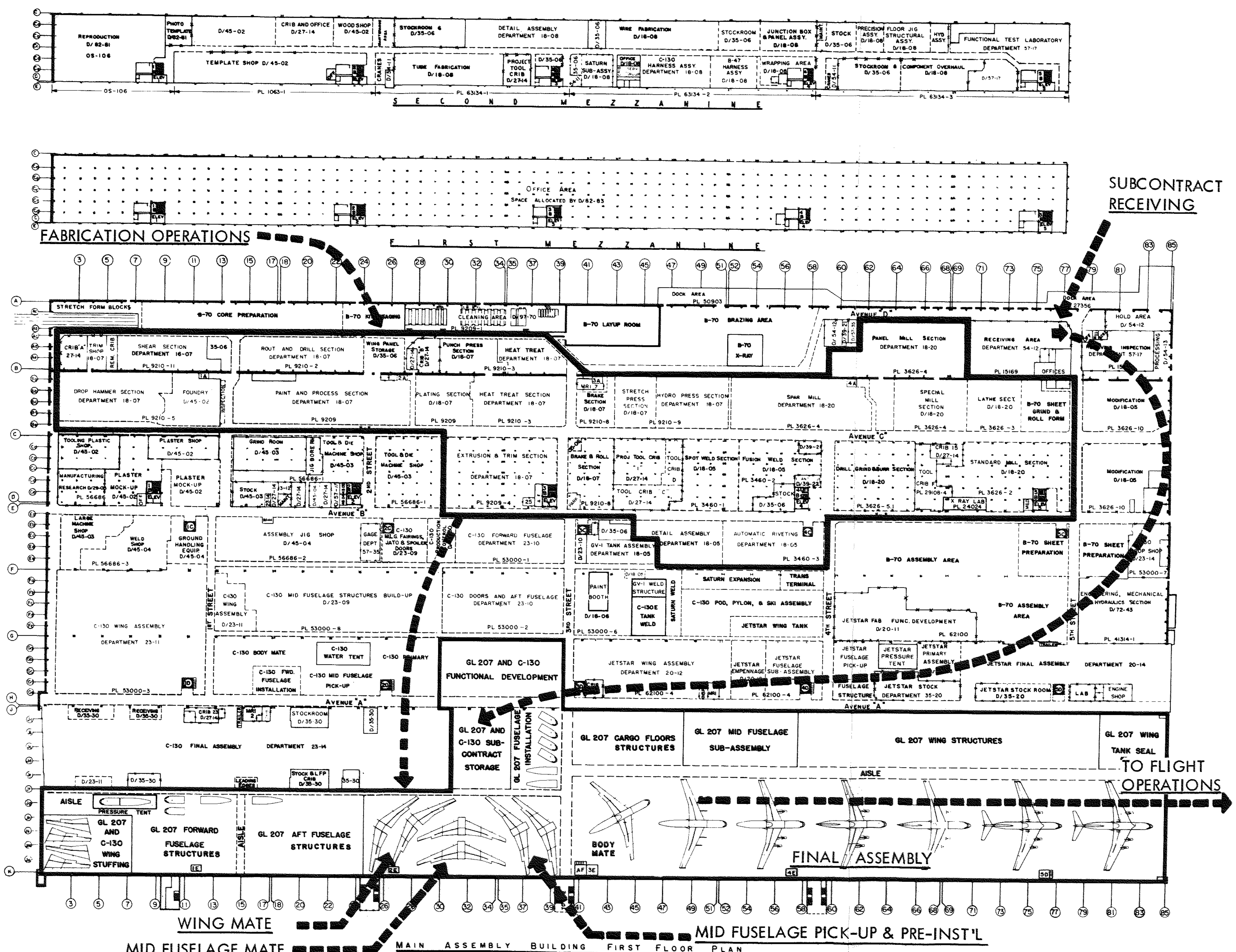


Figure 13-4—MAIN ASSEMBLY BUILDING LAYOUT.

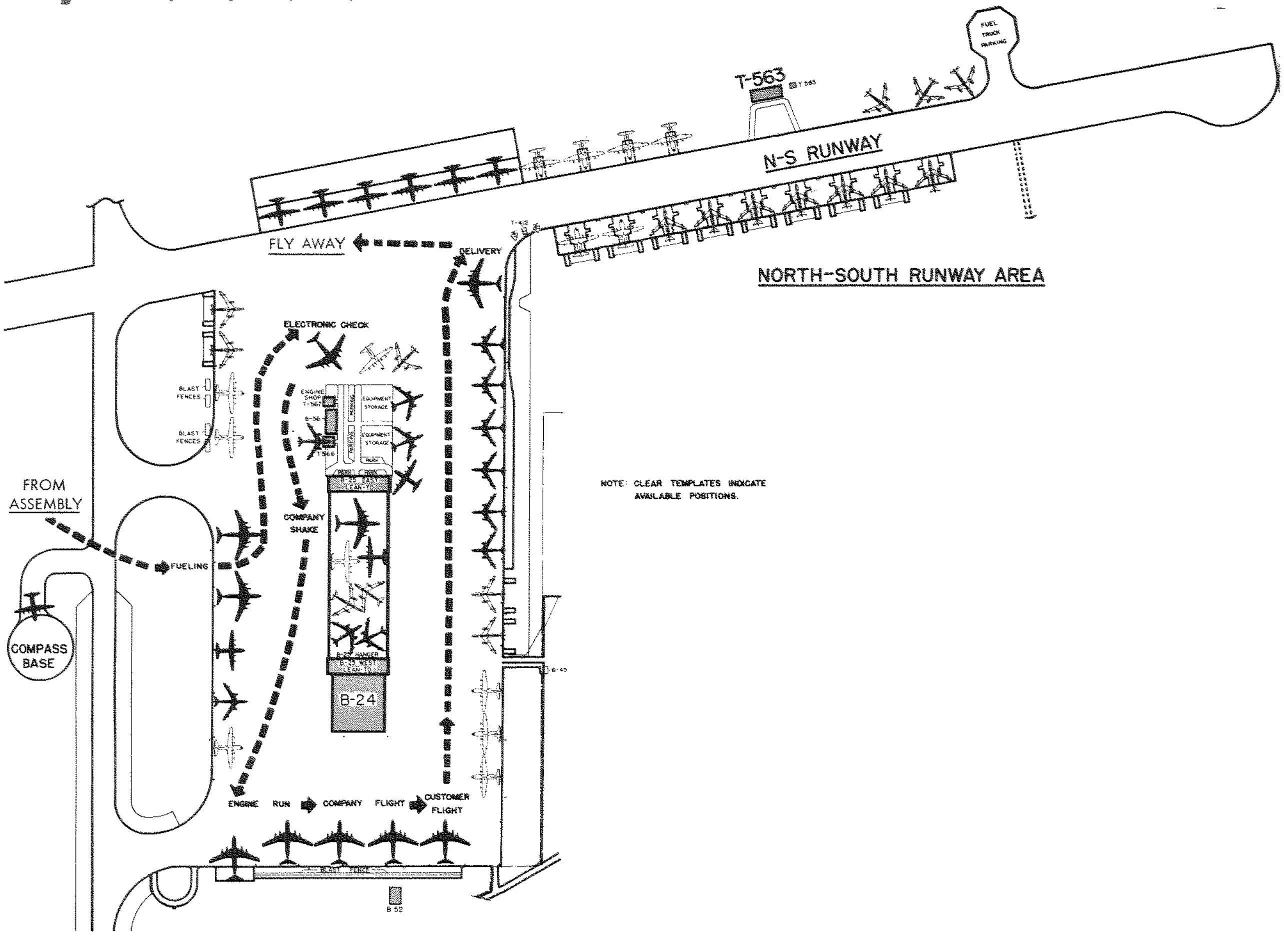


Figure 13-5—PRODUCTION FLIGHT LINE.

concurrently with the GL 207-45 production program; therefore, fabrication, functional test lab, paint, and process areas are not shown in the tabulation above since they are used jointly. For total fabrication area, see Facilities Area Chart in Paragraph 5.2.3.4.

Tooling (5.2.3.2.2)

A tooling development program is utilized which permits smooth advancement from beginning initial tooling to final production tooling. This program minimizes tooling costs and avoids building final tools for initial production. However, all tools required to assure interchangeability are provided for the first airplane and no prototype or soft tooling is to be used. Line-of-sight master tooling is used wherever possible. Minimum use is made of subassembly tooling by completing assemblies in the final or mating jigs. The GL 207-45 structures are similar to the C-130 structures and the tooling is of the same basic type.

A tooling plan is reflected in the following major categories:

Interchangeability

Lockheed's policy for interchangeability control of airplane parts and assemblies utilizes coordination of engineering, production design, spares, planning, and tool manufacturing during the concurrent design and preplanning stage.

Master Gages

Master gages are provided as necessary to physically establish control points. Dimensional control is used in place of master gages wherever interchangeability can be achieved without gages. Optical techniques are also used in place of master gages where interchangeability can be accomplished by this method. Control gages are to be built after the first five airplanes. Supplementary features on the master gages are eliminated for the first five airplanes.

Master Models

Permanent master models are made as initial tooling for all necessary multiple-contoured areas. Contour template components of master models are numerically milled from mathematical loft data and optically set by master line-of-sight plates, as shown in Figure 13-6. These plates are used to build master models, subsequent control tool media, and assembly tools.

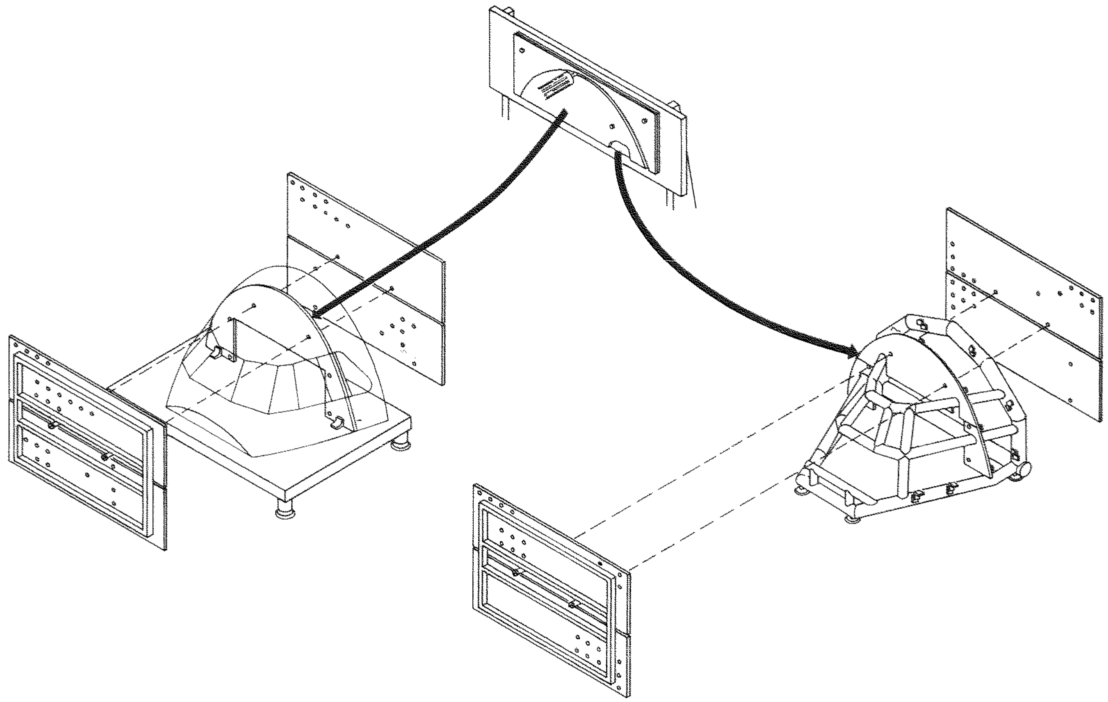


Figure 13-6—OPTICAL TOOLING.

Fabrication Tooling

Fabrication tooling is planned, designed, and built to manufacturing standards manual requirements. Full use is made of skilled labor, standard machine set-ups, Tooling Master Layouts, and standard tooling. Extensive use is made of numerically controlled milling machines.

Tooling Master Layouts are full scale, superimposed, precision engineering layouts of assembled parts, including flat pattern developments, hole patterns, and trim lines. They are photographed directly onto tooling material. This photographic system assures that the drawing structure is compatible at manufactured joints, contributes to accuracy, reduces the need for highly skilled layout personnel in tool shops, broadens the scope for subcontracted detail parts, and reduces subsequent tool maintenance costs.

Limited fabrication tooling is ordered for the first five airplanes; however, throw-away tooling is not used. Tooling Master Layouts are used extensively to replace detail tooling. Final families of machine parts tooling will be preceded by machine tool set-ups for the first five ships.

Assembly Tooling

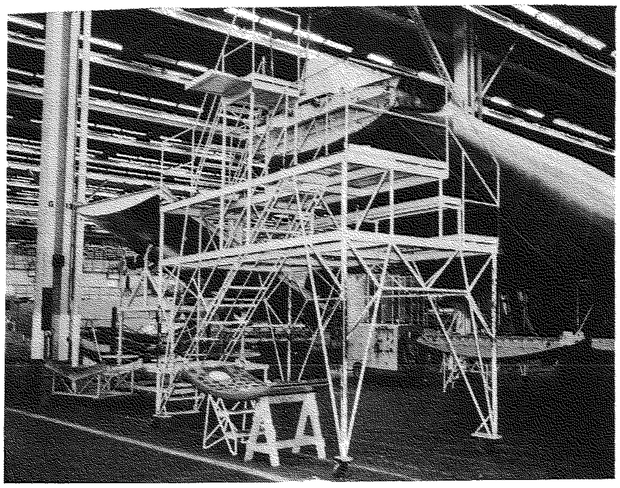
Assembly tooling is designed to add additional features during subsequent development with a minimum of interruption of production. Contour locators on assembly tools are positioned by the use of optically-set, numerical-milled master-tooling templates. Tools are coordinated to master gages, or to other production tools designed for direct setting. Typical assembly tools are shown in Figure 13-4.

Manufacturing Aids

Numerous existing manufacturing aids are used jointly for the GL 207-45 and the C-130. Scaffolding is initially simple wooden work platforms. Utilities are supplied by extension cords and drop lights. Cradles and pick-up stands are of limited-life wood construction. As the program progresses, and after the fifth unit, this wood scaffolding with its temporary utilities is replaced with permanent units. Liaison between the Tools Design and Field Service Departments enables many manufacturing aids to meet the requirements of aerospace ground equipment. Typical manufacturing aid applications are shown in Figure 13-7.

Functional Test Tooling

Functional test tools, including test jigs, fixtures, panels, and benches are constructed and maintained in a special tool shop. New tools required for testing the Model GL 207-45 are to be checked in a routine basis for accuracy in the same manner under which the C-130 tools are checked. The airplane components and systems are similar to those in-



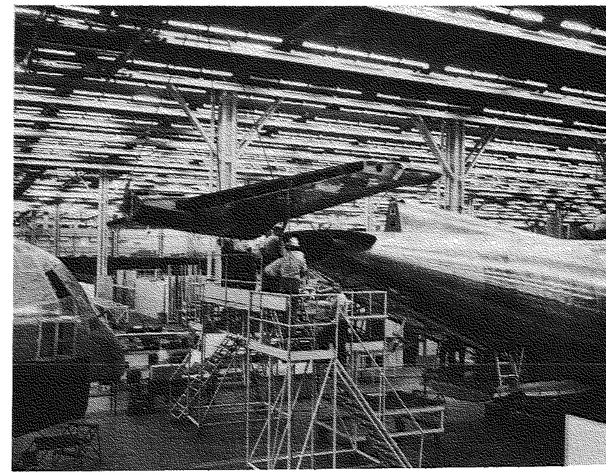


Figure 13-7—MANUFACTURING AIDS.

stalled in the C-130 airplane; new tools are required for checking systems peculiar to the GL 207-45.

Tooling manpower curves are shown in Figure 13-8.

Production Testing (5.2.3.2.3)

Lockheed utilizes an integrated plan for the testing and inspection of production raw materials, aircraft components and systems. Production testing capability integrates both production and inspection skills, combining them in several ways during different phases of the production cycle, to achieve optimum control of quality over the entire manufacturing process.

A quality control laboratory performs required functional tests on all vendor components except electronic black boxes. Another laboratory performs the non-destructive tests necessary for structural integrity of the required product. A third laboratory performs the necessary surveillance over the precision measuring devices used in the production and tooling shops. The Electronic Laboratory, operated by production personnel, performs tests prior to and after installation of electronic systems and components. These tests and installations are monitored by quality control.

The aircraft is functionally and operationally checked by production and verified by quality control. In-process inspection from fabrication through final assembly is performed at planned installation points; functional systems tests and proof runs are conducted at shop completion points.

Material specifications and functional test requirements, as defined by Lockheed's engineering department, are incorporated by manufacturing into the applicable production paper.

The vendors chosen to participate in the extensive subcontract program adhere to the same rigid production test requirements, when applicable, as those specified in-plant.

Lockheed's reliability program for the GL 207-45 is implemented at the outset by personnel and techniques which have proved to be successful on the C-130. The data computer program for the C-130, now encompassing over one million items of reliability data, is expanded to include the GL 207-45. This program supplies summary reports, actuarial reports, assignable causes analyses, inspection record reports, and reliability demonstration reports.

Lockheed is thoroughly familiar with both military and FAA specifications and can assure complete compliance on the GL 207-45 program. This is based on the current Georgia Division production of the C-130 Hercules to military specifications and the C-140 JetStar to FAA specifications.

Continuous surveillance is provided for all processes and skills related to design and manufacture of the complete System 476L. A government-approved certification program for production and quality control personnel is used to assure compliance with applicable specifications. The listing of additional test facilities required for the GL 207-45 program is shown under the facility section, Paragraph 5.2.3.4, Vol. 2. These will be Lockheed funded.

Additional information on Quality Control is provided in Vol. 2, Paragraph 5.2.3.2.3.

SUBCONTRACTING—MAKE-OR-BUY (5.2.3.3.)

It is Lockheed policy to buy quality materials and services at a fair price and to insist on delivery and performance at the time required. A recent survey by Government procurement specialists reaffirmed that the Georgia Division procurement operation meets the criteria of Air Force concepts and ASPR requirements.

The subcontract program utilizes the existing talents and facilities of the aircraft industry to the

CHECK

CODE MP 91S

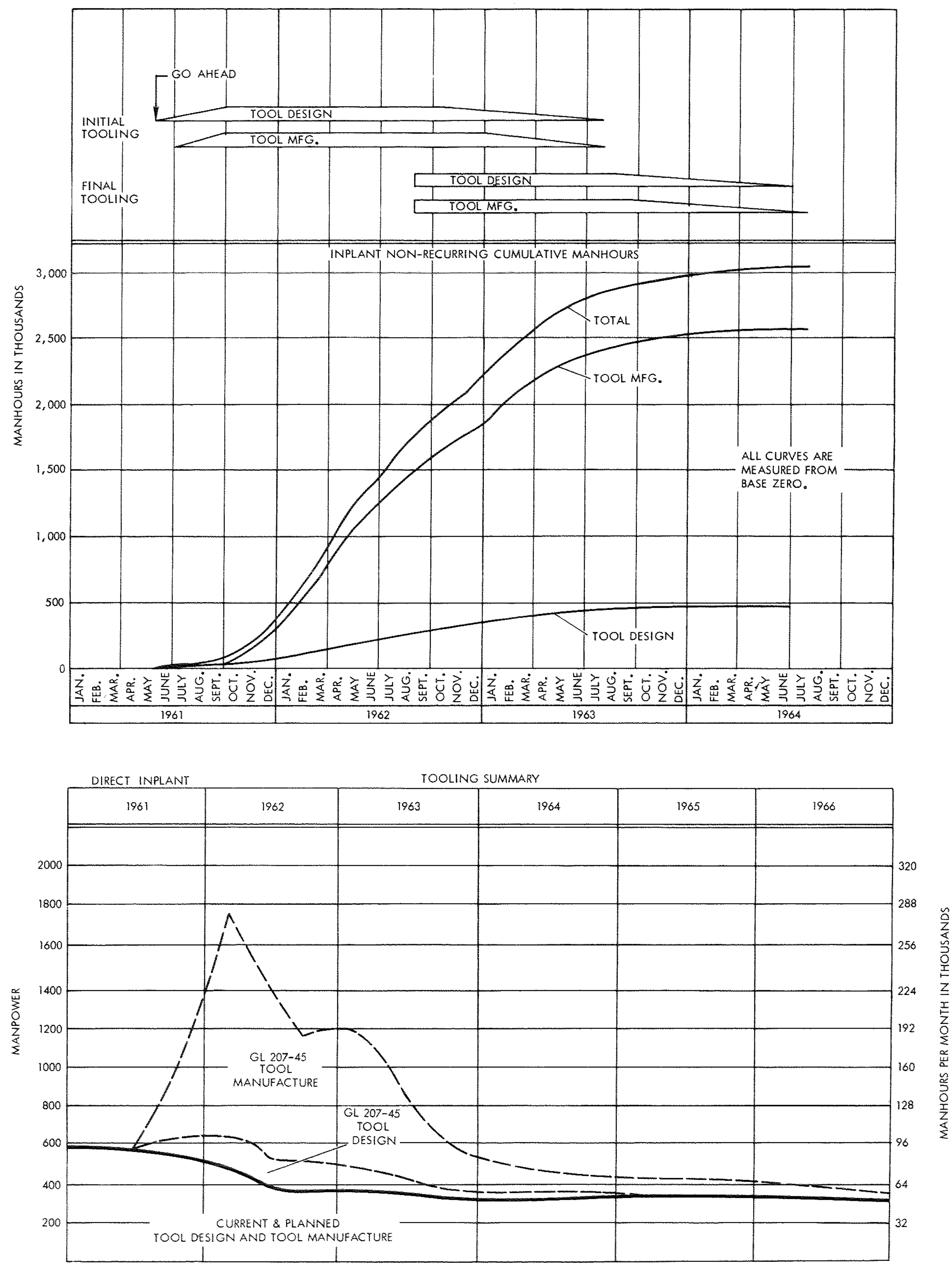


Figure 13-8—TOOLING PHASE CHART.

greatest possible extent. Subcontracts are contemplated in areas where labor surpluses coincide with technical ability and manufacturing know-how. In addition to utilizing the facilities of the small business community, the participation of other major airframe contractors is taken into consideration.

It is planned that 61.6% of the AMPR weight will be subcontracted, as shown in Figure 13-9. More than ⅔ of the total program cost will be spread among subcontractors, equipment suppliers, associate contractors, and other participants in the program. The System 476L subcontracts department has been formed to exercise the most effective control over subcontractors' schedules and cost, and to ensure that the coordination problems are efficiently handled. As a primary managerial tool. program evaluation procedures (PEP) will be installed at the major subcontractors and utilized by the System 476L Subcontracts Manager.

The scope of the subcontract structure is worthy of note. See Figure 13-9. For comparison purposes the assemblies which are asterisked indicate the type and kind of assemblies subcontracted on the C-130 program. The other "buy" items, although well within the capabilities of the Georgia Division of Lockheed, represent the increase in subcontracting for System 476L. The last grouping indicates the assemblies which will be manufactured in-plant. The groupings of prospective bidders set out in Figure 13-10 are not final, but represent what a typical bidders grouping might look like when finally established. Careful consideration will be given to other qualified sources desiring to participate.

The make-or-buy policy as established for the System 476L program is based on two major premises: (1) provide a large subcontract base; (2) use existing facilities and capabilities without attempting to create new capabilities in-plant or for subcontractors. These decisions were arrived at by the Lockheed Make-or-Buy Policy Committee comprised of the Manufacturing Manager (chairman), the Vice President and General Manager, the Assistant General Manager—System 476L program, the System 476L Subcontracts Manager, and executive level representation from all other affected organizations.

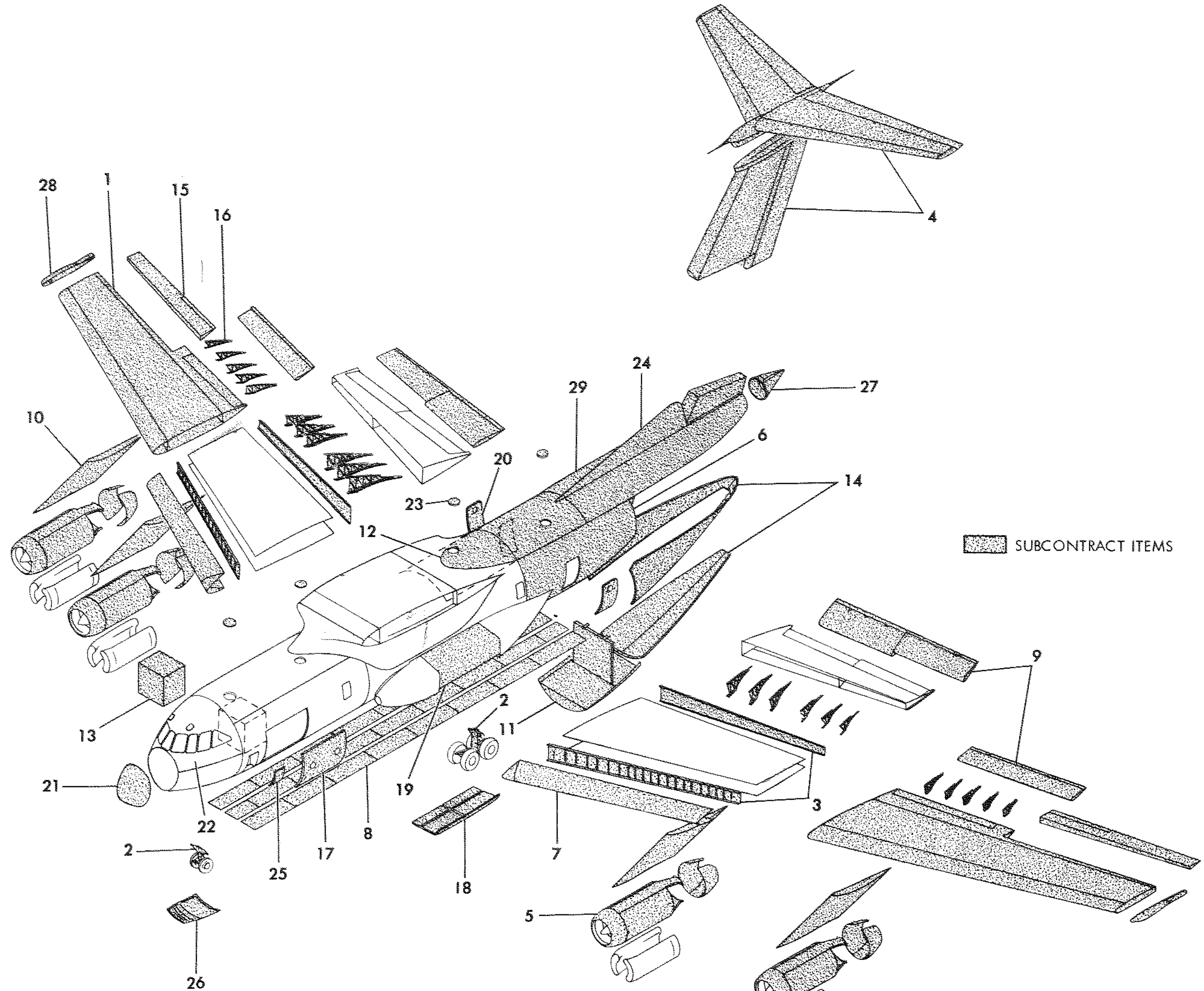
Considerations taken into account by this committee are those enumerated in ASPR 3-902 (c) and include in-plant capabilities, facilities utilization, cost, transportability, special techniques, processes, and the capability of small business concerns. The Committee participates in all phases of the establishment of the policy and subcontract structure, thereby ensuring that the interest of the Government and Lockheed are best served.

In the past decade the Georgia Division of Lockheed has placed six hundred million dollars in subcontracts for airframe structures and equipment, ground support equipment, training devices, and research and development projects. In the course of these activities, Lockheed has developed a highly-trained procurement team with a broad knowledge of subcontractors and their potentialities. From this information, plus the information and knowledge available from the other divisions of Lockheed, certain selections of prospective bidders have been made and preliminary surveys conducted. Figure 13-11 indicates the geographical distribution of these companies. The program's impact on the industry and the national economy has been taken into account in establishing this list of prospective bidders, which includes major airframe manufacturers, major subcontractors, and every major geographic section. The special knowledge and capabilities of the other participants in the System 476L competition obviously qualify them for special consideration in the subcontract program.

Before requests for proposals are forwarded to any of the potential airframe subcontractors, a complete facilities evaluation review will have taken place. This procedure follows certain definite steps. They are: (1) company contacted and indication of interest and a current facilities brochure is requested; (2) when a company is selected for bid participation, a Lockheed team will make a detailed survey of the subcontractor's facility and technical competence. (This team will be chairmanned by a Subcontracts representative, and will include members from at least the following: Engineering, Finance, Manufacturing, Quality Control, and Reliability); and (3) each member of the team, after an independent analysis of his particular area, will submit a written report. The chairman will compile these reports and present them to the System 476L Subcontracts Manager for review.

A Request for Proposal will be supplied to all prospective bidders which will include (1) invitation to make a proposal; (2) definition of scope of work; (3) technical data and management and controls data requirements based on Program Evaluation Procedures (PEP), including organization structure and liaison provisions, financial data with respect to the company's overall position and method of financing the proposed subcontract, manpower projection, cost projections in detail, subcontracting and purchasing plan, facilities utilization, small business program; and (4) complete support program.

Bidders conferences will be held and all bidders will be given equal opportunity to ask questions and seek any necessary clarification. A summary of the proceedings of each conference will be distributed to all participants. Questions asked after the conference must be submitted in writing; questions and answers will be given to all bidders.



NO. DESCRIPTION

1. OUTER WING (BL415-OUTBD)
2. LANDING GEAR (NOSE & MAIN)
3. INNER WING BEAMS
4. EMPENNAGE
5. NACELLES (LESS PYLONS)
6. AFT SIDE PANEL
7. WING LEADING EDGES
8. CARGO FLOOR PLATES
9. FLAPS
10. QEC PYLONS
11. RAMP (INCL. PRESS. DOOR)
12. MID FUSE TOP PANEL, AFT
13. CREW CAPSULE
14. AFT FUSE. PETAL DOORS

NO. DESCRIPTION

15. AILERONS
16. FLAP TRACK RIBS
17. FWD CARGO DOOR
18. MLG DOORS
19. MLG CTR. FAIRINGS
20. REAR ENTRY DOORS
21. RADOME
22. CREW SEATS
23. EMERGENCY EXITS
24. DORSAL FIN
25. CREW DOOR
26. NLG DOORS
27. TAILCONE
28. WING TIPS
29. AFT FUSE TOP PANEL, DORSAL, AND STUB

Figure 13-9—SUBCONTRACT ITEMS.

SYSTEM 476L MAKE OR BUY PLAN

ITEM	Qty. (Per Ship)	Make or Buy	Est. Cost Per S/S (132 Ships)	Unit AMPR Weight	Percent AMPR Weight	Eng. Sub-contract-able**	PROSPECTIVE SUBCONTRACTORS (Alphabetically)				
Outer Wing (WS 415-Outboard)	2	Buy	$ 186,079	12,539	14.09	No	Convair	Douglas	Northrop	North American	Republic
Wing Leading Edges	10	Buy	17,229	1,161	1.30	No					
Wing Beams	4	Buy	76,367	5,146	5.78	No	(Wing subassemblies would provide an integrated subcontract of major proportions.)				
Wing Tips	2	Buy	1,068	72	.08	No					
*Ailerons	2	Buy	16,918	1,140	1.28	Yes	Aeronca	Bell	Grumman	Temco	
*Flaps	6	Buy	47,889	3,227	3.63	Yes	Bristol	Douglas	Fairchild	Rohr	Temco
*Flap Track Ribs	14	Buy	13,950	940	1.06	No	Chance-Vought	Detroit-Kellering	Fairchild	Research Designing	Wheland
QEC Pylons	4	Buy	101,352	2,530	2.84	Yes	Beech	Convair	Rohr	Ryan	
Nacelles (including long ducts)	4	Buy	101,135	3,529	3.96	Yes	Bell	Convair	Rohr	Ryan	
*Empennage	1	Buy	81,843	5,515	6.20	Yes	Avco	Boeing	DeHavilland	Douglas	Rohr
*Tail Cone	1	Buy	594	40	.04	Yes	Avco	Boeing	DeHavilland	Douglas	Rohr
*Landing Gear (Nose and Main)	3	Buy	79,957	3,527	3.96	Yes	Bendix	Cleveland Pneumatic	Menasco		
Aft. Fuse. Top Panel (w/Fin Stub)	1	Buy	66,231	4,463	5.01	No	Douglas/Tulsa	McDonnell	No. Amer./Columbus	Republic	
Aft Side Panels (FS 1078-Aft)	2	Buy	22,408	1,510	1.70	No	Convair	Fairchild	Goodyear	No. Amer./Columbus	
Mid Fuse Top Panel (FS 972-1078	1	Buy	31,906	2,150	2.42	No	Chance-Vought	Fairchild	Grumman	Kaman	
Petal Doors—Aft Fuselage	4	Buy	21,444	1,445	1.62	No	Chance-Vought	Fairchild	Grumman	McDonnell	
Forward Cargo Door	1	Buy	4,823	325	.37	Yes	A. V. Roe	Rohr	Schweizer	Temco	
Rear Entry Door	2	Buy	3,710	250	.28	Yes	Beech	Cessna	Colonial	Temco	
Emergency Exits	8	Buy	4,244	286	.32	No	Bristol	DeHavilland	Doman	Twin Coach	
Crew Door	1	Buy	1,261	85	.10	Yes	Benson	Bristol	Helio	Kaman	
Nose Landing Gear Doors	2	Buy	1,113	75	.08	No	Beech	Cessna	Solar	Temco	
Main Landing Gear Doors	8	Buy	4,675	315	.35	Yes	Beech	Brooks & Perkins	Cessna	Hayes	
MLG Center Fairing	2	Buy	4,452	300	.34	Yes	Fairchild	Iron Fireman	Ryan	Solar	
*Randome	1	Buy	3,116	210	.24	Yes	Brunswick	Douglas	Goodyear		
*Crew Seats	5	Buy	4,304	290	.33	Yes	Aircraft Mechanics	Burns	Stanley	Weber	
*Ramp (incl. Pressure Door)	1	Buy	30,600	2,062	2.32	No	Continental Can	Fairchild	McDonnell	Republic	
Cargo Floor Plates	9	Buy	24,486	1,650	1.85	No	Bell	Chance-Vought	Convair	Douglas	Republic
SUB TOTAL			953,154								
Aux. Crew Capsule	1	Buy	25,000	800	Not AMPR	No	Amer. Airmotive	Benson	Hayes	REF	L. B. Smith
Thrust Reversers	4	Buy	65,000	1,980	Not AMPR	Yes	Boeing	Convair	Douglas	Rohr	
TOTAL			$1,043,154								

* Comparable C-130 Subcontracts.
** Engineering could be, but will not necessarily be, subcontracted on the assemblies indicated; tooling except for masters, will be provided by subcontractors for all "buy" items.
NOTE: The subcontract items shown plus other subcontract items as defined by ASPR represent 60% of the 132 S/S production program cost.

Aft MLG Fairing	2	Make	5,620	280	.31
Fwd. MLG Fairing	2	Make	4,014	200	.22
Fwd. Mid Fuselage Fairing	1	Make	1,004	50	.06
Aft. Mid Fuselage Fairing	1	Make	1,505	75	.08
Mid Fuselage Side Panels	2	Make	19,287	961	1.08
Mid Cargo Floor	1	Make	46,763	2,330	2.62
Lower Main Landing Gear Fairing	2	Make	903	45	.05
Fwd. Cargo Floor	1	Make	31,309	1,560	1.75
Fwd. Fuselage Top Panel	1	Make	8,730	435	.49
Fwd. Fuselage Side Panels	2	Make	15,053	750	.84
Cab Top	1	Make	18,665	930	1.04
Flight Deck Floor	1	Make	8,028	400	.45
Lower Fwd. Fuselage Side Panels	2	Make	9,292	463	.52
Nose Landing Gear Box	1	Make	2,107	105	.12
Radome Bulkhead	1	Make	1,405	70	.08
Aft Cargo Floor	1	Make	26,292	1,310	1.48
Pressure Bulkhead	1	Make	5,018	250	.28
Inner Wing Upper Surface	2	Make	20,271	1,010	1.13
Inner Wing Lower Surface	2	Make	20,331	1,013	1.14
Inner Wing Trailing Edge	2	Make	14,049	700	.79
Inner Wing Jack Screw Ribs	8	Make	9,634	480	.54
Stub Wing Upper Surface	1	Make	29,764	1,483	1.67
Stub Wing Lower Surface	1	Make	29,704	1,480	1.67
Stub Wing Front Beam	1	Make	2,408	120	.13
Stub Wing Rear Beam	1	Make	2,408	120	.13

NOTE: The "make" portion represents 40% of the 132 S/S production program cost.

Figure 13-10—SYSTEM 476L MAKE OR BUY PLAN.

Figure 13-11—SUBCONTRACT SOURCE LOCATION.

A rating system will be utilized for each proposal. Such evaluations will include all of the items covered in Lockheed's request for proposal, reasonableness of cost projections, reliability, cost control system, and use of depressed labor areas.

After evaluation of bids by procurement personnel, evaluation sheets and bid packages will be forwarded to the System 476L Subcontracts Manager for review. Specific recommendations will then be sent to the Make-or-Buy Policy Committee for review and ratification. Upon direction by this Committee, a formal proposal will be presented to the cognizant Air Force contracting officer for his approval, prior to making the award. Upon approval by the cognizant Air Force contracting officer, a definitive subcontract will be negotiated and purchase orders issued.

The System 476L subcontracts manager will have appropriate buying personnel reporting to him through subcontracts administrators. Assistance in specialized fields will be provided by a staff group which includes a tooling engineer, an experienced price analyst and CPA, and an attorney. Field representatives will be stationed at major subcontractors' facilities as necessary during the preliminary stages of the program.

Preliminary personnel assignments have already been made; there will be no time lag whatsoever in expediting tooling, outside production and selection of subcontract sources. The supervisory personnel who are involved have worked closely with engineering and production personnel in the design planning stages of this program and are fully prepared to begin the procurement activity at once. As this will be the major project at the Georgia Division, the most experienced personnel will be placed on the program from the outset.

The material control function and the purchasing functions have been combined in the purchasing organization. Purchasing agents are thus responsible not only for the buying activity, but also for the inventory control aspects of all material assigned to their sections.

The purchasing department has achieved in this manner, marked advancement toward the ultimate goal of complete material management. This broad scope of responsibility, with commensurate authority, enables the buyer to ascertain the actual cost of possession of any given item, and determines the optimum point in sound and effective inventory control. Source selection by the purchasing department is in compliance with ASPR, AFPI, and AMC Manual NR70-3. Assigned to the purchasing department in a staff capacity is an auditor responsible for assuring compliance with ASPR and AFPI as well as Lockheed policies and procedures.

Inventory and procurement functions have been mechanized through application of advanced electronic data-processing methods. Reports are received which assist the buyer and management in control functions. Typical of information derived from these reports is the total amount of material received and disbursed to production, the per cent disbursed to spares, and average expected usage rate and dollar-volume forcasts for coming months. Another report furnishes an analysis of behind-schedule orders.

Other special procurement approaches include Lockheed's improved version of the "economic order quantity" concept and use of blanket purchase orders in order to reduce costly inventory and long lead time problems.

The purchasing department maintains a comprehensive reporting system to assure that Lockheed buyers give careful consideration to small business concerns and sources of supply in depressed labor areas. Through a series of meetings and correspondence with Canadian defense production authorities, Lockheed buyers maintain a current knowledge of Canadian sources of supply.

Insistence on competitive bidding, exhaustive audit of follow-on pricing, and overall analysis of all variable factors are followed through in thorough negotiation of cost factors. In addition to the scrutiny of bid prices by buying and audit personnel, competitive price estimates are secured, when appropriate, from Lockheed's price estimating department. Moreover, Lockheed buying personnel make use of U. S. Government audit facilities to the full extent available.

Many specific areas of control are given special attention. Pricing is never allowed to be delayed so as to become an after-the-fact matter. Material pricing techniques and bills of material are closely scrutinized. Cost reduction effects of similar work are always analyzed, and in nogotiations with subcontractors, Lockheed insists on a projection of work load at the subcontractor's facility. Future estimated costs are weighed more heavily than past cost data in price negotiations. Cost breakdowns and analysis thereof are submitted to the AF contracting officer.

Consolidation of requirements to secure volume discounts is assured through use of Lockheed's corporate interdivisional Central Procurement Agency, annual usage contracts for MSP and raw stock, and dollar volume contracts for maintenance. Our electronic data processing systems automatically accumulate and consolidate requirements, including spares.

High dollar value subcontracts are naturally subjected to the most thorough-going system of cost review. Approval of at least two supervisory levels is required on any procurement above $10,000. Three levels of supervision meet weekly to analyze major procurement action and make certain that the most stringent pricing policies are consistently adhered to.

The value analysis approach is inherent in the Lockheed procurement system and procedures. A value analyst reports directly to the materiel division manager. Procurement personnel working closely with production engineering, design engineering, manufacturing, and the value engineering department thoroughly investigate possible material substitutions and other traditional methods of cost reduction. Continuous efforts of the value analyst, advanced material pickup activities, and the buyers are asserted to avoid establishment of unusual and exotic material, parts or equipment.

In addition to the traditional approach, buyers and the value analyst work closely with design and using organizations to investigate the actual function of required items, especially new items. Elaborate solutions to a functional requirement can often be simplified. By participating in the design phase, buying personnel and the value analyst become familiar with the functions to be performed by all equipment and subcontract items, and are thus in a position to apply effectively the value analysis approach and techniques. They question the need for each item, whether its cost is reasonable for the function performed, whether every feature is necessary, and whether an existing similar item can accomplish the same function.

Regarding Government Furnished Equipment, Lockheed has assumed that the items to be furnished by the Government will be typical, e.g., engines and accessories, wheels tires and brakes, and certain communications and navigational devices. If it should be desired by the USAF, Lockheed stands fully prepared to supply such units on a contractor furnished basis for the development program.

INDUSTRIAL FACILITIES (5.2.3.4)

The Georgia Division of the Lockheed Aircraft Corporation operates Air Force Plant No. 6 at Marietta, Georgia. This industrial site covers 670 acres and is serviced by a railroad spur off the main line of the North Carolina and St. Louis Railway, a four lane access road connecting the nearby U. S. Highway 41, and the B-52 class, 10,000 ft. runway of Dobbins Air Force Base. Primary manufacturing activities for the GL 207-45 program are within the B-1 main production building. The paint hangar, ramp, and production flight facilities are also used. An aerial view and plot plan of the facility are shown in Figures 13-12 and 13-13 respectively. The production layouts of the main assembly building and flight line are included in Section 12, Volume 2.

The main manufacturing building, B-1, 2,050 feet long and 1,000 feet wide, has more than two million square feet of space on the ground floor and an additional 840,000 square feet of area is provided by two mezzanines and a partial basement. Overhead clearance of 45 feet exists throughout the ground floor. The main floor area and the loading dock are served by a bridge crane network of 10-ton capacity which can be increased to handle greater loads by use of multiple hoists.

The production flight division is equipped to perform ground operation and flight checks of all Model GL 207-45 aircraft and systems. The flight line hangars, adjacent to the runway and taxiways of Dobbins Air Force Base, provide space for machine shop, battery shop, maintenance shop, certification laboratory, blueprint, and standard tool cribs.

The ramp and apron surrounding the flight line hangar, including streets, taxiways, space for parking, storage, and production service, have a total paved area of 2,336,383 square feet. Some 1,007,000 square feet are suitable for production service of aircraft in flight status.

The GL 207-45 production program within the B-1 building is shown on the layout, Figure 13-4. Activation of this program is accomplished with a minimum of rearrangement costs; no relocation of large machines, tools, jigs, or equipment is necessary.

Lockheed requires the additional Industrial Facilities as listed in the following tabulation to produce the GL 207-45 at the maximum proposed rate of four per month. Lockheed intends to obtain these additional facilities with corporate funds; however, a request will be made for permission to screen Government surplus sources for some of the required items. No additional Government funds for facilities are required for any subcontractor in this program.

An estimated $26,250,000, or approximately 34%, of the total of $77,750,000 of Government-owned facilities now in place are utilized in the production of the GL 207-45 airplane. Of the Contractor-owned portion of AFP No. 6 facilities, amounting to over $15,250,000, a total of almost $6,000,000, or 39% of these facilities are required.

As a direct result of the increased envelope size of the GL 207-45 over that of the C-130, some modifications to existing leasehold facilities are required. The present tank seal facility is expanded to contain the GL 207-45 wings. Some of the engineering test

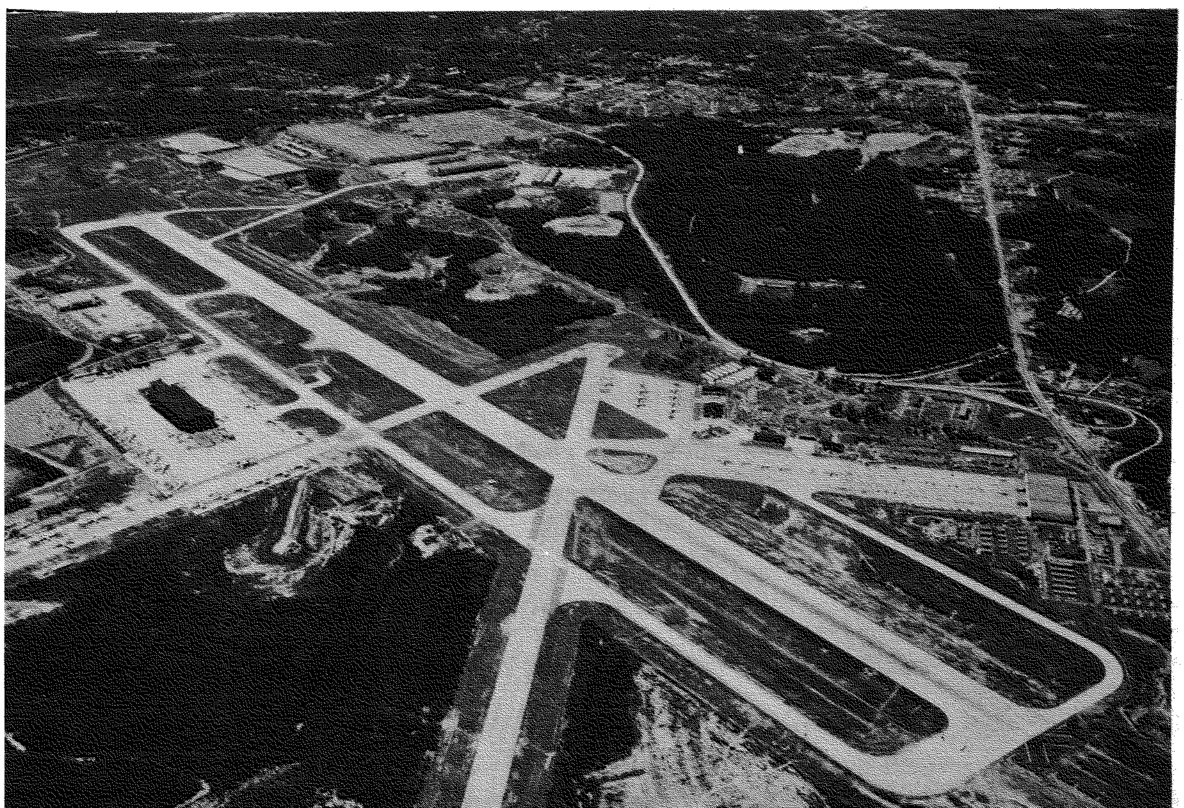


Figure 13-12—AERIAL VIEW OF TOTAL FACILITY.

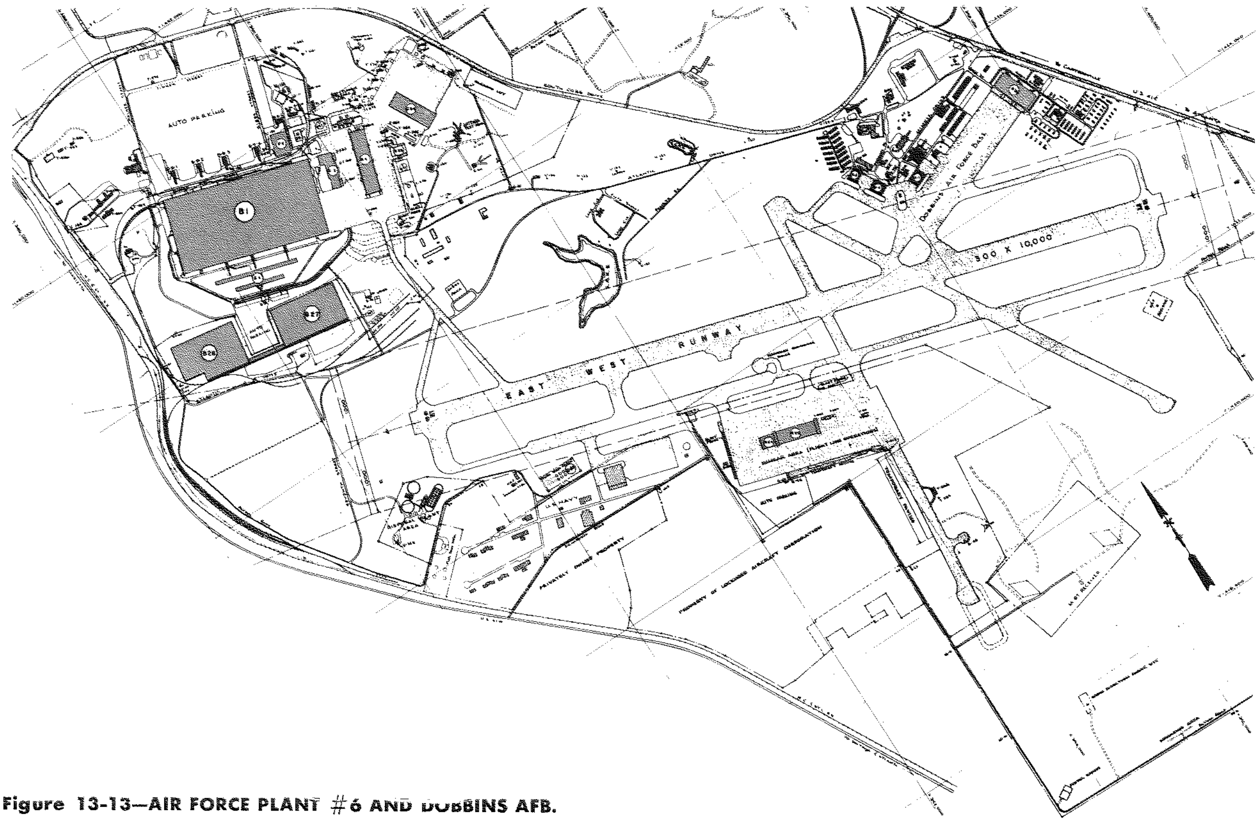


Figure 13-13—AIR FORCE PLANT #6 AND DOBBINS AFB.

equipment is relocated to provide sufficient area for testing Super Hercules components, and a special hoisting method and access means is added in the overhead truss members of the main assembly building for installation and checkout of the horizontal stabilizer. Lockheed will accomplish these leasehold improvements with corporate funds.

The Facilities Area Summary Chart depicts area utilization and availability at the Georgia Division. Approximately one-third of the million square feet of high-bay assembly area with overhead crane service is presently available. Existing tooling and fabrication areas support a production rate of four GL 207-45's in addition to present contracts; only minor rearrangements to the assembly area are required.

Facilities Area Summary Chart

Total Existing
Direct and Indirect Floor Space: 4,453,924 sq. ft.

Total Existing Engineering
and Laboratory Area: 199,617 ft.

Total Existing Occupied Assembly Area: 741,624 sq. ft. Ceiling Height 45 ft.

Total Existing Unoccupied Assembly Area: 337,580 sq. ft. Ceiling Height 45 ft.

Total Existing Machine Shop Area: 113,702 sq. ft.

Total Existing Sheet Metal Fabrication Area: 175,707 sq. ft.

Total Existing Tooling Shop Area: 166,301 sq. ft.

Storage Area—Total Indoor: 378,037 sq. ft.

Storage Area—Total Outdoor: 200,000 sq. ft.

Planned Expansion (if any): Completion Date:

No sq. ft. Additional Assembly Area

No sq. ft. Additional Machine Shop Area

No sq. ft. Additional Sheet Metal Fab. Area.

No sq. ft. Additional Tool Shop Area

Other

Extent that assembly area planned for this program would require preparation? Minor Rearrangement

Lockheed has a continuing program for replacement and modernization of equipment; therefore, no specific modernization requirements are anticipated for the GL 207-45 program. A program is now underway to further update and automate existing production machinery at AFP No. 6.

section 14

LOGISTICS (5.2.4)

Lockheed is acutely aware of the emphasis the Military Air Transport Service places on safety, reliability, rapid turn-around capability, self-sufficiency, and responsiveness for instant deployment. These essential system requirements set the pattern for System 476L logistic support. Accordingly, it is imperative that the functional elements of logistics support be integrated and responsive, one to the other, to satisfy these requirements and assure a minimum AOCP/ANFE rate throughout the lifetime of the airplane. Meticulous attention to maintenance design considerations in terms of simplicity, accessibility, and maintainability serves to minimize maintenance requirements for manpower, skill levels, special tools, and test equipment. Standard, proved AGE is selected to simplify maintenance support. Supply support is organized to be immediately responsive to requirements. Transportation is programmed carefully to meet the need.

Since Lockheed C-130 airplanes have been performing missions similar to those planned for System 476L aircraft, proved concepts of supply maintainability-accessibility, and support systems can be applied. Validity of the C-130 logistic support approach has been demonstrated in the unmatched record of safety and reliability of the C-130's in that not a single major accident due to mechanical malfunction has occurred since the C-130 became operational in December, 1956. At the present time there are more than 300 C-130 aircraft in operation throughout the world. Their support has been successfully programmed through the coordinated efforts of Air Force, Coast Guard, Marine Corps, Navy, and Lockheed personnel. The valuable experience gained in these programs, and the forthcoming opportunity to apply knowledge gained supporting the MATS C130E squadrons assure Lockheed's ability to implement effectively the logistic support program for System 476L.

Supply (5.2.4.1)

The System 476L Logistics Support Manager will be the single point of contact within Lockheed for internal control and Air Force liaison relative to System 476L. He will deal directly with the spare parts division functional departments: contract administration, provisioning services, support equipment, and stores. This functional organization provides the necessary flexibility to adjust to changing work loads and permits realization of the inherent benefits of function specialization.

The problems inherent in a new aircraft program must be dealt with directly and responsively with a minimum commitment of financial, facility, and manpower resources. Lockheed proposes the following plan for supply support of Category I and II Test Programs:

1 Staff and operate a central supply center. Manage supply at selected test sites.

2 Develop test support requirements per MIL-S-26799 through review of progressively released design information and utilization of reliability data from other programs.

3 Provision on an incremental or phased basis, all items except lo-valu items as shown in Figure 14-1.

4 Defer procurement of insurance items. Provide production line back-up.

5 Maintain base and supply-center stock levels below normal pipeline quantities if it is determined that production inventories are adequate, and emergency transportation costs do not exceed anticipated savings.

6 Develop special mission supply mobility packages.

7 Manage equipment overhaul activities for items not currently overhauled at an Air Force facility.

8 Relate actual versus planned time-between-overhaul rates. Take corrective action as required.

9 Collect and evaluate usage data concerning parts required for the overhaul of equipment items. Provision these parts at minimum levels until experience is gained.

10 Coordinate activities with the Air Force Logistic Support Manager.

The above plan permits the Air Force to minimize initial supply funding; to optimize support through a single source of supply; and to conserve its manpower and material resources through the use of Lockheed's services and facilities. Specifically, the direct advantages to the Air Force from a Lockheed-managed supply support program are as follows:

1 Direct communication between using activity and the factory facilitates instant response to supply needs.

2 Design changes are incorporated into Spares and AGE concurrent with the production articles, thereby substantially reducing the cost of retrofit and modification normally incurred during this period of design progression.

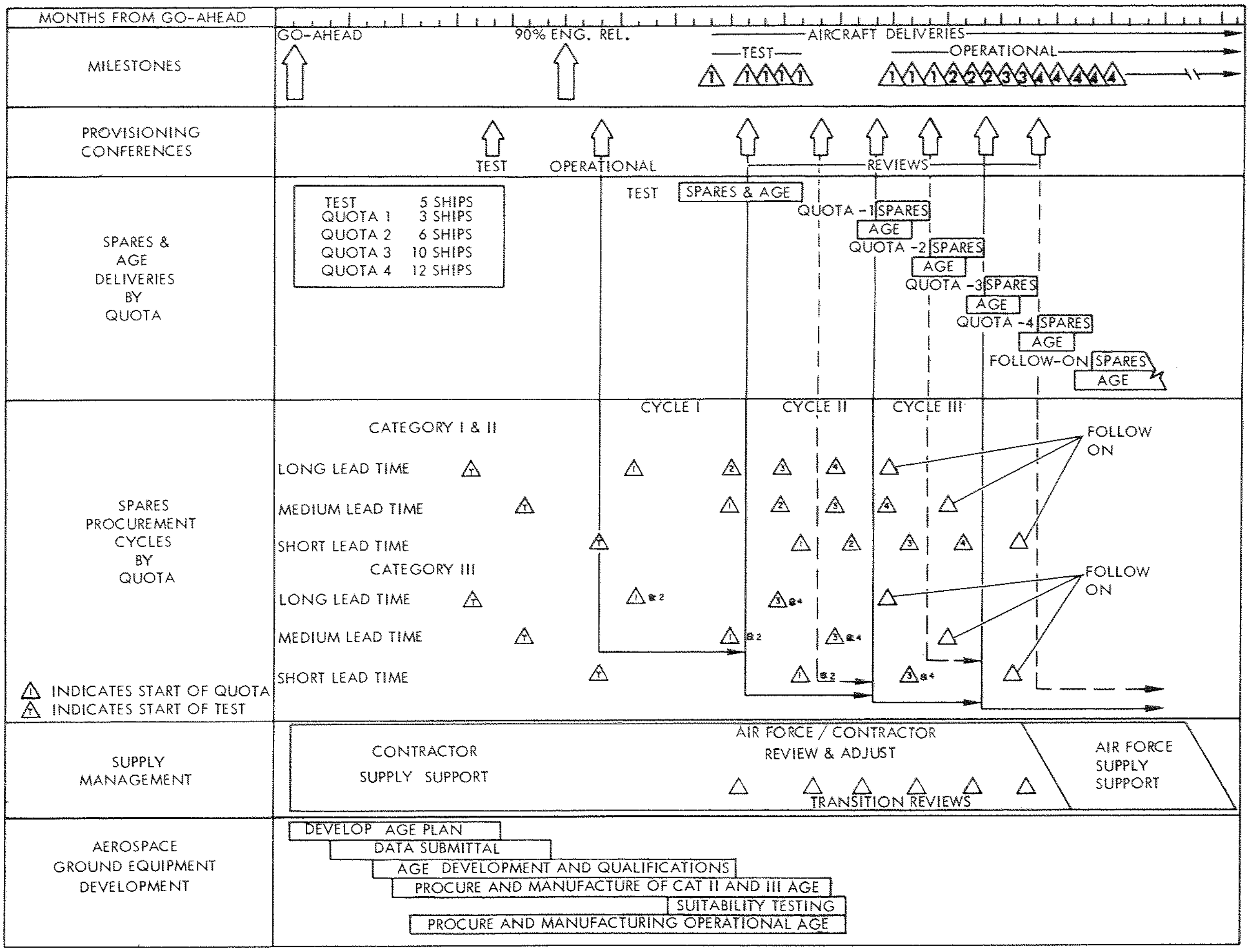


Figure 14-1—TIME PHASING CHART—SUPPLY.

3 Excess materials are identified at a much earlier date, and can be profitably diverted to the production line.

4 Supply funding is minimized through the continuance of phased provisioning and adjustment of supply requirements.

5 Development of accurate overhaul instructions, parts requirements, and AGE for the overhaul of reparable equipment items is possible.

6 Trans-shipment costs are eliminated.

Air Force supply support is based upon the applicable portions of AFM 67-1 and other Air Force supply regulations. Lockheed is presently working under the Logistic Support Manager concept, and is applying the Forward Supply Support concept in support of MATS. Lockheed will have no problem in relating its functions to Air Force procedures. After a thorough examination of all the problems normally encountered during early operational supply support, it is Lockheed's recommendation that consideration be given to extending Contractor supply support through the delivery of the sixteenth inventory aircraft. This approach is consistent with the reasons for applying Contractor support.

Transition from the Lockheed program to the Air Force program will be coordinated with the Air Force Logistic Support Manager. In anticipation of the phase-out of the Lockheed program, only those spare parts and AGE required to support category testing and the first operational squadron will be delivered to the Lockheed supply center. Phasing-out of the support center inventory will be accomplished concurrently with the delivery of supply items provisioned for activation of the second squadron as shown in Figure 14-1. To facilitate transfer of the supply responsibilities to the Air Force system, Lockheed's procedures and reports will be established to be generally compatible with Air Force requirements. At least three Air Force/Lockheed review conferences are recommended prior to the transfer period to assure that delivery schedules and quantities of spares and AGE provisions for the second operational squadron are compatible with requirements as shown in Figure 14-1.

Lockheed currently controls provisioning, procurement, production, receipt, and shipment of spares and AGE through an integrated system of electronic data processing as shown in Figure 14-2. Upon receipt of a punched card procurement order, the system prepares mechanically the documentation necessary to record, release, control, and deliver on schedule the items ordered. The use of integrated data processing has increased administrative performance at reduced cost.

Typical provisioning concepts and controls are:

1. Projection of supply requirements based on the planned flying hour program; life expectancy; time between overhaul; rate of return to serviceable inventory; overhaul, maintenance and wear-out factors; failure rates; and mean time to failure data.
2. Development of special mission and in-flight maintenance packages capable of satisfying instantaneous mobility requirements.
3. Identification of items which are economically reparable and recommendations as to the range and quantity of components required.
4. Selection with the Air Force of all items for which provisioning will be deferred and/or procured on a phased basis.
5. Recommend optimum provisioning levels for all Category II and III items in accordance with the Air Force buying programs—"Economic Orders and Stockage Program" and the new "Blue Chip Item Program" for low-cost, hi-volume items.
6. Compliance with Hi-Valu concepts contained in AMCM 400-1, AFM 65-3, MIL-H-8729, AMC Form 263's, and other applicable documents. Prepare and maintain Hi-Valu application summary data; provision incrementally based on progressive accumulation of operational flying hours; adjust provisioning criteria in keeping with Air Force regulations; motivate design changes; and actively participate in Air Force Hi-Valu Review Board meetings.

Configuration control is accomplished through liaison representatives to engineering, manufacturing, vendors, and subcontractors to monitor spares and AGE design and production in terms of standardization, feasibility, interchangeability and cost.

Maintenance (5.2.4.2)

Lockheed's maintainability philosophy provides features and characteristics that will enable the Air Force to meet operational and maintenance require-

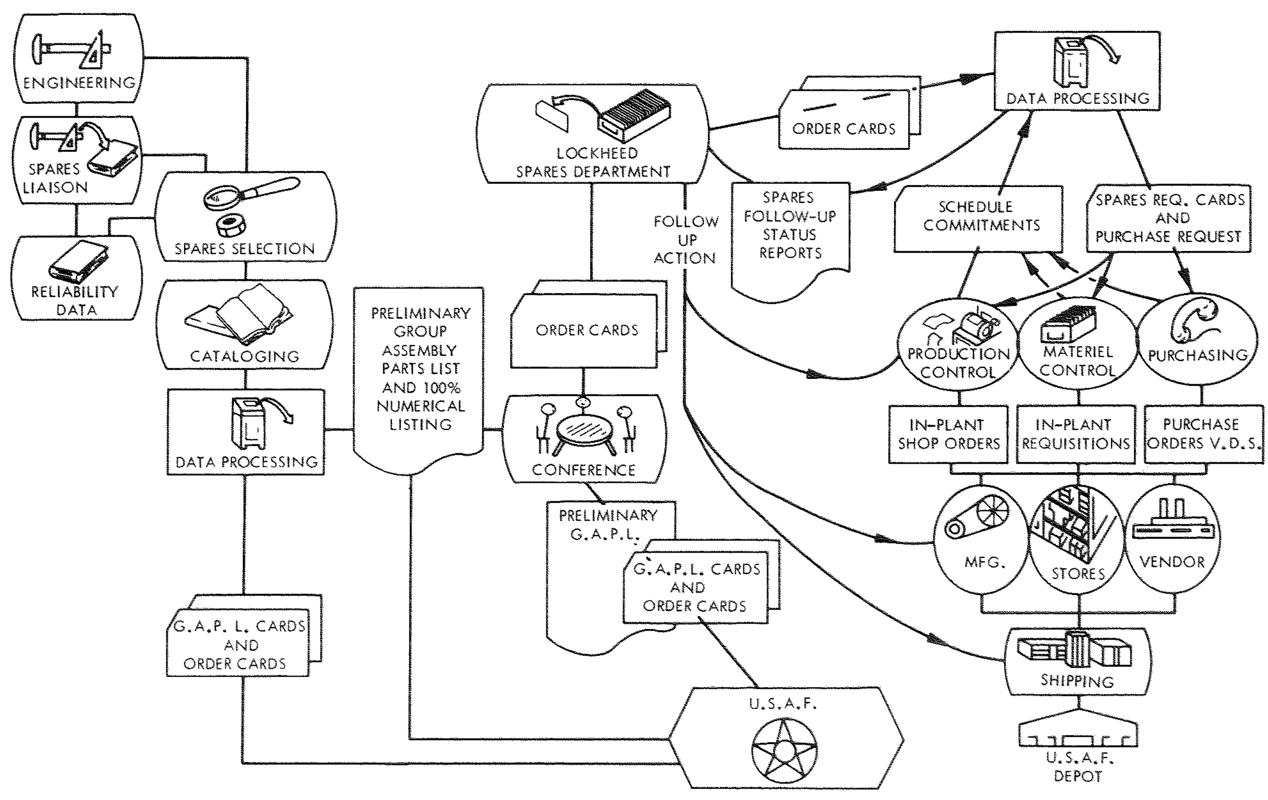


Figure 14-2—SUPPLY SUPPORT INTEGRATED DATA PROCESSING.

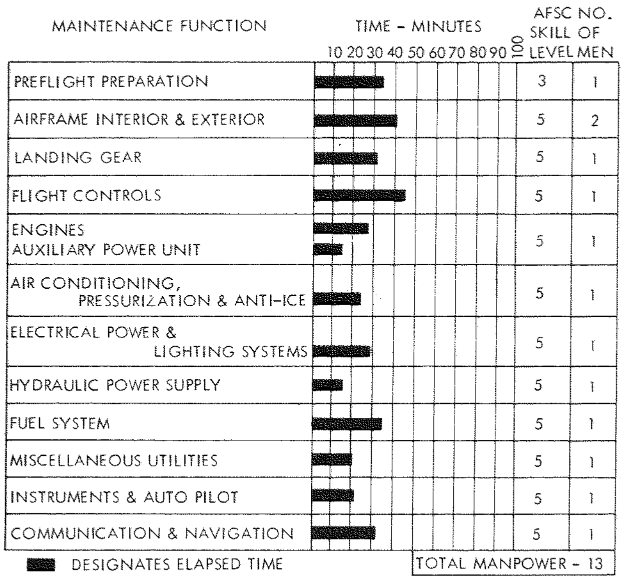


Figure 14-3—PREFLIGHT INSPECTION TIME CHART.

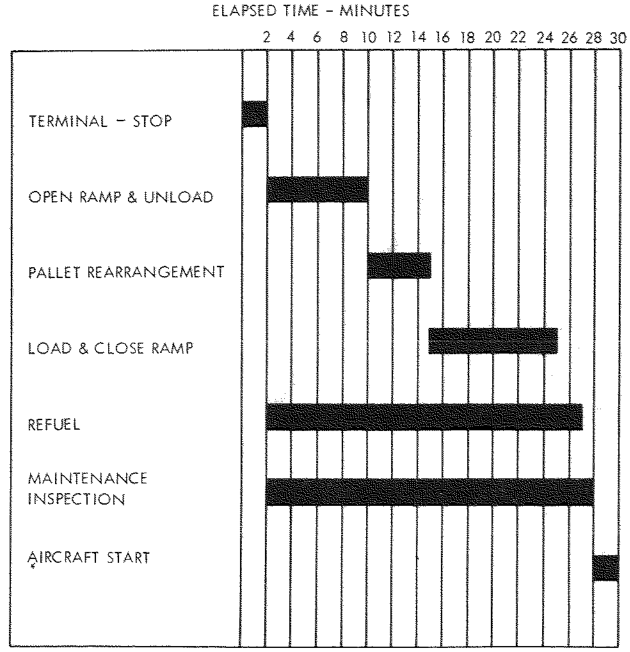


Figure 14-4—TURNAROUND TIME CHART.

ments with minimum manpower, skill levels, and AGE. The fundamental factors of this philosophy are simplicity, accessibility, interchangeability, and reliability.

The following maintenance plan will ensure aircraft readiness and mission accomplishment.

Preflight Inspection

Visual inspections and operational checks are performed prior to the first flight of the day. Areas to be inspected, required manpower, and skill levels are shown in Figure 14-3. Preflight inspection will be accomplished by 13 men in 45 minutes, with an expenditure of 6.9 manhours.

Thruflight/Turnaround Inspection

A 'walk-around' inspection prior to take-off at enroute and turnaround stations, requiring 1.3 maintenance manhours, performed by 3 men in 26 minutes. See Figure 14-4.

Hourly Postflight Inspection

A comprehensive check of aircraft components, areas and systems after 75 flying hours is accomplished by 20 men in one hour. As shown in Figure 14-5, 14.6 manhours are required. Unscheduled maintenance and TCTO's will require one additional elapsed hour.

Periodic Inspection

A detailed inspection of the entire aircraft, systems and components after 300 flying hours is performed by 32 men in a 5-hour span; 106 man hours are required as shown in Figure 14-6. Unscheduled and post-dock maintenance, including functional check-out, will be accomplished in 9 additional elapsed hours.

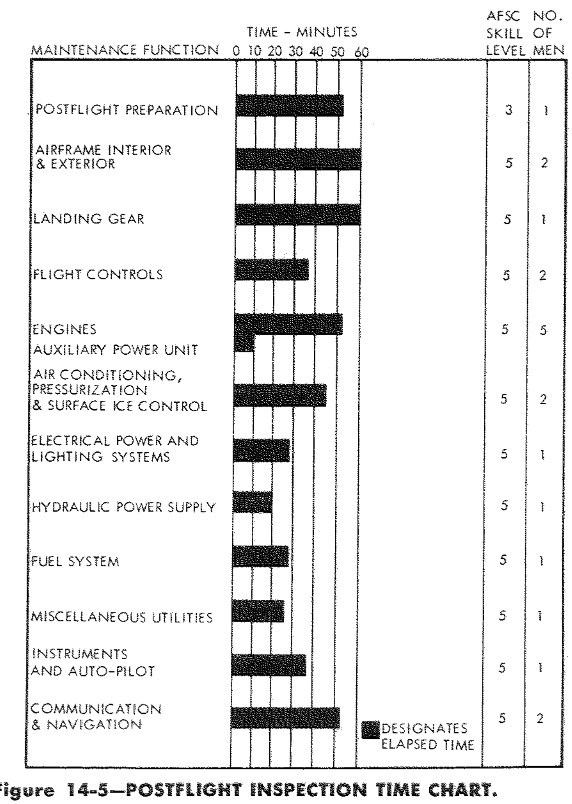


Figure 14-5—POSTFLIGHT INSPECTION TIME CHART.

Progressive Aircraft Reconditioning Cycle

PARC is completed every 2400 hours. Four cycles constitute a complete program. Each cycle contains maintenance and overhaul operations required at specific total times, as well as repetitive functions common to all cycles. 45.00 manhours is the estimate for completion of scheduled and unscheduled

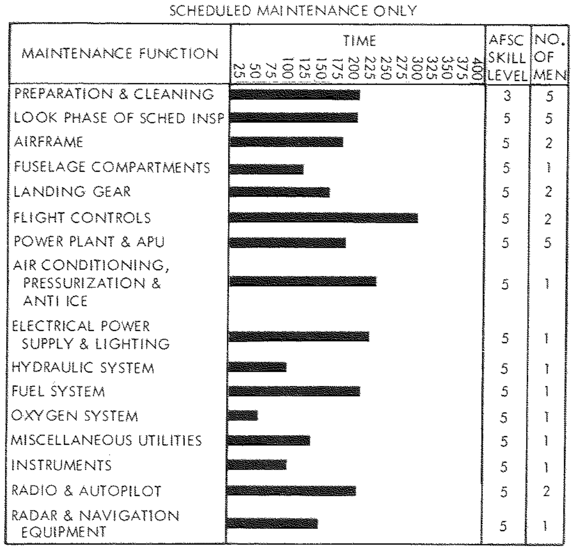


Figure 14-6—PERIODIC INSPECTION.

maintenance and TCTO's. A work schedule of 2 shifts a day, 5 days a week, will complete the PARC program in 7 working days. This plan is compatible with Air Force Organizational and Field Maintenance methods contained in T.O. 00-20A-1 and AFM 66-1.

Inspection/Personnel Skills

Skill levels required are: "skilled" (5 level) and "semi-skilled" (3 level) under supervision of "advanced skills" (7 level), defined in AFM 35-1.

Repair/Replace

The maintenance design used in the installation details of accessories and components permits replacement of units without disassembly or removal of adjoining units. Attachments conducive to rapid replacement are used where possible.

Servicing

The GL 207-45 is designed to permit rapid servicing, by equipment presently in Air Force inventory. A detailed discussion appears in Paragraph 5.3.7.2, Volume 3.

Facilities

Most MATS maintenance facilities are compatible with the servicing requirements of the GL 207-45. Facilities are discussed in detail in Paragraph 5.3.7.4, Volume 3.

Training

Technical training requirements and recommendations appear in Paragraph 5.1.5.1.3.2.

Transportation

A complete transportation plan is detailed in Paragraph 5.2.4.3.

Reliability

The maintenance plan utilizes Lockheed's data collection system for preparation of actuarial analyses to predict scheduled replacement rates and to pinpoint high failure rate items. See Paragraph 5.3.7.5.5,Volume 3 for details.

Technical Data

Preliminary flight, maintenance and inspection manuals, and a weight and balance handbook will be provided for the first test airplane. These manuals will conform to MCMSP Exhibit 1-1. Lockheed will supply revisions to the preliminary manuals. Basic manuals, a list of publications, and negatives will be delivered 30 days prior to first operational aircraft delivery. Changes will be supplied in accordance with MCMSP Exhibit 1-1. Lockheed will prepare a flight manual for FAA approval during type certification proceedings. Lockheed will submit contractor and vendor engineering drawings and associated lists in accordance with MCP 71-77. Initial submittals will be 30 days prior to first operational aircraft delivery. Final delivery will be 30 days subsequent to delivery of the last aircraft. Revision intervals will be 30 days with the exception of decals and Type II undimensioned drawings, which will be 120 days.

Technical Services

Upon operational deployment, on-site representation is the responsibility of the field service department, supplemented as required by engineering, reliability, and supply support personnel. The field service representatives will prepare Service Trouble Reports on maintenance discrepancies which are forwarded to the maintainability and ground support systems organization for coordination. Weekly activity reports will summarize the maintenance problems at the various bases. The maintainability and reliability data collected will provide statistical information for analyzing a specific problem and instituting the required corrective action. Data affecting supply support provisioning will be forwarded to the Lockheed logistics support manager.

Technical Representatives

Cost for contract technical services to support the GL 207-45 are based on the following allocation of CTS personnel and have been included in the program cost estimates of this proposal:

Location	Number CTS Personnel	*Time Span (Mos. from Go-ahead)
Test Sites	6–12	26–44
Travis AFB	6	32–68
Dover AFB	6	36–68
Overseas Turn-around Bases	12 (3 per base)	32–68
En Route Stops	6 (1 per base)	35–**59

*For cost estimate purposes.

**Fifty-nine months after go-ahead, technical support will be provided at en route stops on a TDY basis.

Lockheed's contract technical representatives are available on a twenty-four hour basis. Requests for assistance from the field are received by direct communication and are processed by a specialized in-plant group. This group, through liaison with other departments, provides the representatives with support from the entire Lockheed organization.

Service Life Expectancy

The GL 207-45 aircraft is designed to comply with the fatigue and fail-safe requirements of CAR 4b. Service life of the airframe is a function of design methods which, in practice, have achieved 50,000 flight hours and 25,000 take-offs and landings. Subsystem components are designed for a service life goal of 2400 flying/operating hours.

Aerospace Ground Equipment

The GL 207-45 airplane system and subsystems are designed to use standard Air Force and commercial aerospace ground equipment where possible. See paragraph 5.3.7.8.1 in Volume 3 for details.

Maintainability Program

The maintainability program established for System 476L will minimize out-of-service time for scheduled maintenance, optimize accessibility to components and systems most vulnerable to unscheduled maintenance, and provide immediate technical service response to recurring and unanticipated maintenance problems. The program will comply with all the requirements of MIL-M-26512A and other applicable specifications. The preliminary design phase covers maintenance and support concepts, maintainability parameters, AGE requirements, and the maintenance plan. The development and test phase covers establishment and verification of system maintainability as measured in terms of repairability and serviceability as shown in Figure 14-7. The production and Operational Phase covers surveillance of the system throughout Lockheed's tenure and system responsibility.

Field reports of system deficiencies reported during Category I, II, and III test programs will be systematically processed to minimize delay in the test and FAA certification programs, and to produce required solutions that can be incorporated with early effectivity in production aircraft. A problem evaluation committee under the chairmanship of the System 476L logistics support manager will review the field reports of systems and support deficiencies, define the action to be taken, establish a schedule, assign the responsibility, and ensure compliance of the assigned action and schedule. Field representatives will be notified of action taken.

Transportation (5.2.4.3)

Optimum logistics support demands a transportation plan which implements supply in terms of both routine and emergency activities. Adequate planning, scheduling, and traffic control minimize problems associated with emergency transportation requirements and eliminate problems associated with routine requirements.

To satisfy routine and emergency requirements at minimum cost, Lockheed observes applicable military specifications and uses the following plan. After routine supply requirements are set, materials are delivered to a staging area at least 60 days in advance of shipment. An even flow of materials through inspection, packaging, and shipping permits

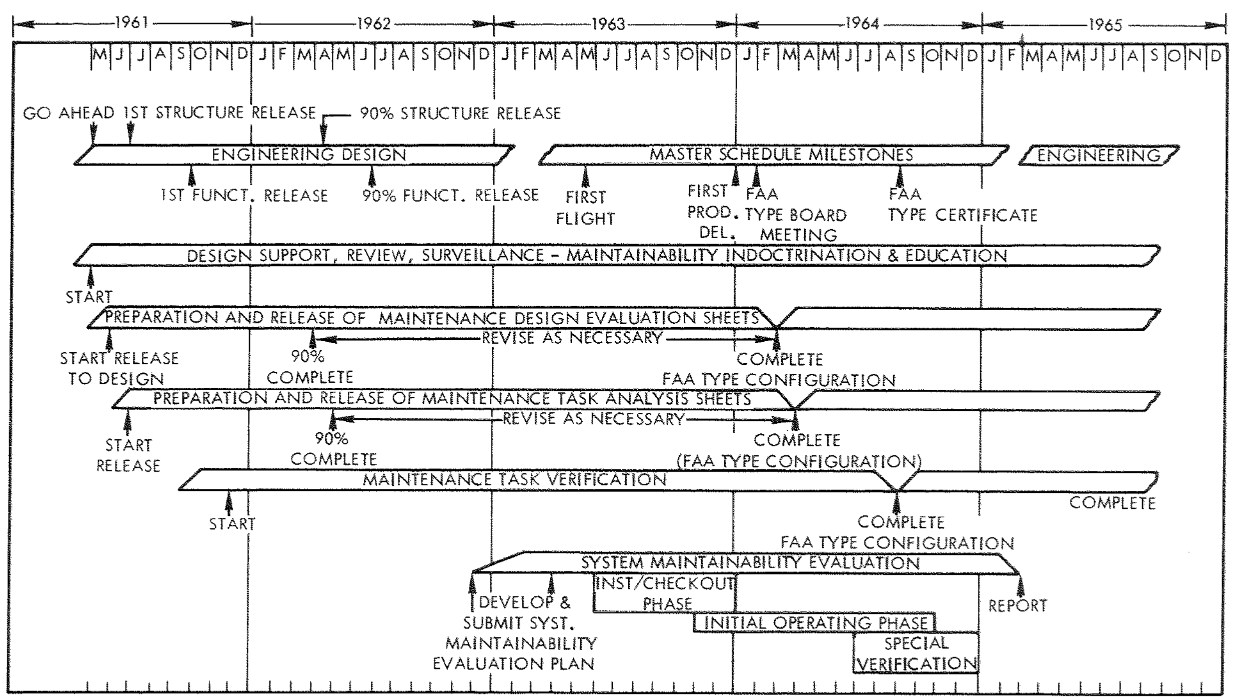


Figure 14-7—MAINTAINABILITY PROGRAM SCHEDULE.

maximum use of unit load packaging techniques, and allows traffic management to select the optimum mode of transportation for schedule compliance at minimum cost. To insure positive schedule compliance, all shipping activities are integrated into the Lockheed data processing supply system. Detailed status reports flag trouble areas well in advance of schedule requirements.

To facilitate in-position readiness, test support materials are delivered to test sites sixty days in advance of aircraft arrival, and operational support materials are delivered thirty days in advance. Supply materials to be delivered with the aircraft are packaged and staged well in advance of scheduled departure. Fly-away mission support packages are packed and identified to facilitate rapid use of the contents.

High cost-to-weight ratio items are reviewed with the Air Force Logistics Support Manager to reduce the Air Force inventory through high-speed transportation services. At the time of shipment, Due-in Assets Reports and shipping data, if desired, are relayed to the destination.

The Air Force and Lockheed successfully supported the C-130 during the Lebanon emergency airlift by minimizing process time for emergency supply requirements. Emergency requirements are processed in the manner dictated by the individual situation. High priority requirements receive maximum personal handling. Immediately following receipt of the requirement, all sources of supply are alerted and responsive action is initiated. Traffic management takes the necessary action to prefabricate shipping containers and reserve high-speed transportation service while the required materials are being delivered to the packaging and shipping area. Supply materials for high-priority requirements are hand-delivered to the carrier.

If transportation service is not adequate to meet required need, Lockheed immediately notifies the affected Air Force organization. Military airlift has been utilized when warranted. No transportation problems are anticipated on the System 476L program in view of experience on the many C-130 programs. Transportation services available in this area are: seven major railroads, 76 general-commodity common carrier truck lines, and seven major airlines. Four-day delivery service to the West Coast is available by five common carrier truck lines, 13 commercial all-cargo airlifts depart from this area daily, and additional airfreight capacity is available on the recently-installed commercial jet service. LogAir service is available at Warner Robins AFB, and could be made available at Dobbins AFB if required.

The only aircraft components, sub-assemblies and AGE which are not transportable by the GL 207-45 are two major insurance items: the horizontal stabilizer and the outer wing section.

Support Systems (AGE) (5.2.4.4)

A resume of Lockheed's support equipment plan is presented in this section. The preliminary Ground Support Equipment Specification Plan is included in Volume 2 of this proposal.

AGE requirements are established concurrently with release of aircraft design information. All requirements are compared with Air Force inventory items contained in MIL-HD8K-300, and with commercial sources. Data required for compliance with MIL-D-9412C are submitted to the Air Force progressively.

All items which have an application at the Georgia Division and at Air Force depots and operational units are reviewed to standardize the design to the maximum possible extent. All designs incorporate standard commercial/Air Force components and are compatible with commercial airline equipment where possible. Necessary design and procurement data are submitted progressively.

Items requiring qualification and suitablity testing are designed and manufactured sufficiently early to permit testing during the manufacturing and flight test spans of the first aircraft. Design changes are incorporated during and immediately following equipment testing. With approval of the Air Force Logistics Support Manager, AGE for aircraft category testing is designed, manufactured, and qualified at a date which ensures delivery to the test sites 60 days in advance of aircraft delivery. Provisioning conferences and reviews are recommended sufficiently in advance of AGE needs to provide adequate spans for manufacturing, testing, and delivery. The Supply Time Phasing Chart, Figure 14-1, contains recommended time phasing for AGE development.

With Air Force approval, AGE required for operational aircraft support is designed, manufactured, and tested to ensure delivery 30 days in advance of aircraft delivery. Vendors and subcontractors are to submit all AGE development data to Lockheed for review and submittal to the Air Force. Design, development, and manufacturing data comply with all requirements of applicable military specifications, and observe the same overall Lockheed objectives stated above. Suitability testing is performed at Lockheed or under Lockheed supervision at the vendor or subcontractor's facility. An incremental break-out and identification of total AGE requirements is contained in paragraph 5.2.4.4, Volume 2. Lockheed will continue to develop and support AGE throughout the life span of the GL 207-45. Design improvements and support will be responsive to changes in airplane design and to changes in mission concepts.

SUPER HERCULES · GL207-45

section 15

COST (5.2.5)

METHODS AND TECHNIQUES

Development of Estimates

Lockheed's estimating procedures are designed to secure the maximum benefit from all available information sources. Full use is made of the various statistical estimating techniques available and of historical data, including government and industry statistics, together with actual performance on prior Lockheed programs. The approach employed is one in which detailed estimates of the cost of a planned program are made by those who will be responsible for performing the work. After review by successively higher levels of management, these estimates are submitted to the Division's estimating organization. This organization carefully compares the estimates with all available historical data, reviews the methods employed, and compares the results with those obtained from using other techniques. Finally, the overall proposal is reviewed by a Proposal Review Committee composed of the top management of the Division. The cost estimates for this proposal were developed in the above described manner.

Budget Procedure

The Lockheed budget program is built around a philosophy of responsibility budgeting, beginning with a Division-wide budget which is successively broken down into specific cost objectives for all levels of management. The budget philosophy also dictates that the goals established must always reflect an improvement over previous performance. To ensure realistic objectives, the individual responsible for meeting the budget is given a voice in setting his goals.

Methods of Cost Recording and Reporting

Lockheed's method of cost recording has been developed over a long period of time using the latest techniques and equipment available. This system is designed to provide an accurate determination of contract costs and to make all cost information available to management and appropriate governmental representatives on the most current basis possible.

Methods of Cost Control

Lockheed's cost control system is based upon an integrated series of reports which are correlated with responsibility goals at all levels of management. Regularly scheduled meetings are held to review performance against objectives and to ensure prompt corrective action if required.

The Air Force Industrial Survey Report of a survey conducted at Lockheed's Georgia Division 21 March through 1 April 1960 is quoted in part as follows:

> "SUMMARY—The Contractor with few exceptions, as pointed out by items included in this report, has satisfactory management controls and is using them. The Air Force aims and the Contractor's policy and approach toward contractual obligations appear to be in harmony."

METHODS OF INJECTION OF COST ELEMENT INTO DESIGN, TOOLING, AND MATERIAL

Design

Lockheed's basic design philosophy is to achieve an optimum balance between program costs and performance, reliability and maintainability. All statements of design policy and procedure reflect this philosophy. In addition, Value Engineering is employed to evaluate all elements of a system to achieve this basic design objective.

Tooling

Lockheed's basic policy is to build tools only to the extent that such tooling will produce ultimate cost savings in direct labor with proper consideration given to reliability, interchangeability and production rate. To implement this policy the head of Lockheed's manufacturing branch issues a statement of tooling policy for each program. This policy is then interpreted in detail for all affected personnel by use of a project tooling plan.

Improvements in tooling methods and manufacturing techniques are sought and incorporated. During the past year this effort has resulted in the continued development of the uses of numerical controlled machine tools, development of standard setup data sheets for machine tools, the use of a new plastic called Metalfoam for dies, and the expanded use of ceramic tooling. All of these improvements in production methods have resulted in substantial savings.

Production

Intensive control of production direct labor through maximum use of time standards, group, and individual performance reports has produced the following results during 1960:

The 40th C-130B aircraft was completed at a production hour level representing a 60% reduction in hours from the first unit.

The 12th QB-47 modification aircraft was produced with a reduction in labor hours of 68% of the first unit hours.

The 104th B-47 FY-60 modification aircraft was produced at a reduction of 33% of the first unit.

The average number of C-130 production test and acceptance flights was reduced to a level 35% less than that required previously.

Overhead

Lockheed's concept of responsibility budgeting is applied to overhead as well as to direct costs. Control efforts have produced significant results as follows during 1960:

Indirect employees which represent the major part of overhead costs have been reduced by a total of 842, representing an annualized cost savings of over $7,500,000. This was accomplished during a period of relatively stable volume.

Electronic data processing applications made possible a significant part of the personnel reductions. Work measurement of clerical and other support personnel has also contributed to the savings.

Equally notable savings have been made in other expenses.

Material

A letter from the Air Force Plant Representative, 1 December 1960, is quoted in part as follows:

"An Air Force Panel has reviewed and evaluated the survey report (of Lockheed's Procurement System) and was favorably impressed with many phases of your Procurement Operation. Where Lockheed's policies and procedures and practices were questioned and recommendations made during the survey, prompt consideration was taken to bring about conformity with Air Force policies."

Lockheed has always strongly emphasized the importance of its procurement organization. All procurement functions are centralized under a director of materiel, whose organization is responsible for determining requirements, scheduling, procuring, receiving, storing and issuing all material including subcontracted items. Accomplishments during 1960 have included the following:

Savings of $1,325,000 have resulted from reductions accomplished by thorough cost analysis of suppliers' quotations and effective negotiation of subcontractors' quoted prices.

An Economical Material Procurement program has been adopted which seeks scientifically to balance all of the pertinent factors to be considered in determining the amount and frequency of purchasing cycles. Results to date indicate an annual savings of $1,700,000.

Value analysis efforts have been intensified and it is estimated that an annual savings of $2,000,000 will be realized.

A reprogramming of the "first cut" operation on metal plate, sheet, and tubing to provide better control and usage of fractional pieces of standard sizes of material has also produced significant annual savings.

CURRENT EFFORTS TO IMPROVE ESTIMATING, BUDGET AND CONTROL PROCEDURES

Lockheed is acutely aware that it must continue to be highly cost-conscious and that cost reduction programs must be aggressively pursued if the scheduled further improvement of its competitive position is to be attained. Described below are some of the cost control objectives for 1961.

"Project Inter-Loc"

Project Inter-Loc is a study initiated late in 1960 on a cooperative cost sharing arrangement between IBM and Lockheed. The object of the study is to develop a total concept of management reporting and control. Over the past several years, through the use of electronic data processing, Lockheed has been able to provide its management with control information earlier and in greater detail than would have been economically feasible using mechanical processing equipment. However, these advances were accomplished a-step-at-a-time and necessarily without consideration of the total requirements of management reporting and control. Project Inter-Loc seeks to integrate all data presently stored in the memory sections of the equipment, evaluate the need for additional data, and determine the complete potential for providing management control information. This potential will then be reconciled with management requirements. It is anticipated that all levels of management can be supplied control data in any form and at any time a need exists.

Functional Analysis and Work Measurement

Lockheed believes there is considerable cost saving potential in continuing the application of its functional analysis and work measurement programs. A "Functional Analysis of the Engineering Branch" will be undertaken early in 1961. This study is designed to increase engineering efficiency by identifying and analyzing each function performed, reviewing individual and group performance, and evaluating distribution of functional responsibilities. This study will also incorporate work measurement where applicable and particular emphasis will be placed on simplifying the complex functional relationships that exist between engineering organizations.

Check Book Budgeting

Lockheed developed late in 1960 a program whereby operating organizations were given total dollar authorizations for overhead expenses. Through use of electronic data processing equipment, deductions are made each week from a total expenditure authorization, representing costs incurred during that week. A new balance together with an analysis of over or under expenditures for the week is given to the organization head. The speed with which this information is provided enables the organization head to take immediate corrective action if required and to continually plan his future expenditures. During 1961 it is anticipated that this program will be applied to several major operating organizations of the Division.

Value Engineering

Considerable emphasis will be placed on the expanded use of Value Engineering.

Manufacturing Research

A small but effective group of research engineers is expected to make significant advances in the state-of-the-art in manufacturing methods and processes. Primary fields of interest in which immediate applications may be anticipated are electrical discharge high explosive forming, compound contoured full depth honeycomb airfoil surfaces, chemical milling and ceramic tooling for high temperature forming.

Procurement Lead Time

Procurement lead time will be the object of intensive study during 1961. New techniques, made possible by electronic data processing equipment, offer new approaches to the problem and clear opportunities to make substantial reductions in total airframe manufacturing lead time.

Mechanization

A number of functions will be converted from manual to mechanized performance during 1961. Included therein will be spare parts pricing, maintenance of GFP records, and preparation of shipping documents.

In summary, the philosophy which Lockheed has followed in establishing management objectives and measuring achievement of those objectives has produced highly significant cost savings in a broad spectrum of operations. Extension of this same management philosophy will produce comparable achievements in future years.

COST AND PRICING DATA (5.2.5.1–5.2.5.4)

The cost and pricing data contained in this proposal have been prepared in accordance with established methods used by Lockheed in submitting proposals for negotiating firm prices with government agencies.

Inasmuch as the GL-207-45 incorporates many features of the C-130 series airplanes, it is Lockheed's opinion that the cost history of that series provides a completely reliable and logical base from which to project costs for this program. Not only does the C-130 experience provide a reliable base for projection, but in certain cost areas such as production manhours the effect of substantial uninterrupted learning is realized and must be reflected in the estimate. In every cost area the extensive actual experience realized in the manufacture of more than 300 units of the C-130 aircraft must also be considered.

The data have been prepared and are submitted on the premise that the initial procurement program, incrementally funded, will cover the development, test and evaluation of 5 aircraft, with 3 follow-on quantities of 31, 48, and 48 aircraft, to be funded respectively from appropriations for fiscal years 1963, 1964, and 1965, thus completing a total program of 132 aircraft.

In presenting the cost and pricing data in this proposal, Lockheed has adhered strictly to the terms, conditions, and instructions contained in the Request for Proposal. Lockheed proposes a fixed price incentive type contract as contemplated in the Request for Proposal. However, Lockheed is willing to consider any alternate method of contracting which the Air Force might subsequently propose. Further, the commercial considerations set forth in Paragraph 4.2.2 of the Statement of Work are acknowledged and Lockheed will be pleased to negotiate appropriate contractual provisions with respect thereto.

Lockheed market research studies indicate that a strong market potential exists for a commercial cargo aircraft. The GL 207-45 is perfectly compatible with both military and civil aviation requirements. The commercial aircraft production program resulting from civil application of the GL 207-45 will substantially reduce the cost of the military program.

Each element of the price is discussed in this volume of the proposal. This discussion describes the methods and techniques employed in developing the estimates and does not attempt to substantiate the method or the results. All substantiating data are contained in Section 5 of Volume 2.

Engineering Manhours

Manhours of engineering effort were estimated by the several line organizations of the engineering branch based on the anticipated work requirements of this program. The various estimates were then consolidated and reviewed to detect any possible duplications or omissions before submittal to the price estimating organization for furthur review. Detailed comparisons with engineering experience on other Lockheed aircraft models verified the reliability of the estimate.

Tooling Manhours

Tooling manhour requirements were estimated by manufacturing engineering based on C-130 experience for planning, tool design, and tool manufacturing activities. The tooling manhours are apportioned between in-plant and subcontract on the basis of the AMPR weight allocated to in-plant and subcontract structures, with due consideration being given to the tooling requirements for master gages, final assembly, check-out and production flight operations which will be performed at Lockheed.

It should be noted that non-recurring tooling costs appear in the cost estimates for both the 5 aircraft test program and the 31 aircraft production program. Lockheed plans to provide for the 5 airplane program the minimum number and class of tools consistent with schedule and interchangeability requirements. Under the 31-ship program this basic tooling will be expanded and augmented to meet the increasing schedule and production cost objectives which are inherent in the total proposal. This course of action will reduce the cost of incorporating those changes which are a normal result of test programs.

Manufacturing (Production) Manhours

This element of cost is directly related to C-130 production and is, in fact, an extension of C-130 experience. The historical data relative to the change from the model C-130A to the C-130B are of particular value inasmuch as the change from the C-130B to the GL 207-45 is similar in many respects. Actual C-130B experience was plotted and then projected through 199 airplanes, assuming the 200th unit to be a GL 207-45. The manhours required for the new work, represented by the weight increase of the GL 207-45 over the C-130B, were determined by applying the hours per pound experienced on the first C-130B to the increased weight. The resulting manhours required for new work on the first unit of the GL 207-45 were then projected on a 73% curve for 134 units. A composite or spliced curve was then constructed from the basic C-130B curve representing old work and the GL 207-45 curve representing new work.

The manhours projected by this method were then verified by using the hours per pound experience on the first C-130A, applying them to the GL 207-45, and projecting the resulting first unit time on a 75% slope, representing the industry average curve for cargo aircraft.

The total production hours are allocated between in-plant and subcontract based on C-130A experience. Although 61.6% of the AMPR weight is subcontracted, approximately 59% of the total production hours are expended in-plant because of the effect of mating, assembly, functional check-out and production flight operations.

Quality Assurance Manhours

Quality assurance as used in this basic proposal includes the functions of quality control and that increment of reliability engineering necessary to support the basic program. Cost data for the balance of reliability engineering effort required to comply with MIL-R-26674 are presented in Section 5.4.8 of Volume 4. Estimates for the reliability engineering function were based on detailed manpower assignments. The quality control functions were estimated using historical relationships between quality control and the affected organization. Thus, quality control estimates are based on the relationship between hours spent by production inspectors to production workers, tooling inspectors to tool manufacturing workers, etc.

Material and Direct Charges

Engineering and tooling requirements are estimated on a rate per direct labor hour basis. Actual rates per hour incurred on the C-130 program have been used as the basis for these estimates. Tooling material and direct charge rates are applied only to tool manufacturing hours. Production material and direct charges and purchased equipment are also based on C-130 experience related to the total AMPR airplane weight.

Although the above methods do not provide for increased costs which might result from economic trends, it is believed that the effect of economic trends will be offset by two factors. First, since this airplane is closely related to the C-130, most of the raw materials and much of the CFE are common to both airplanes, thus eliminating the need for vendors to incur development, tooling, or start-up costs on such items. Second, it is anticipated that the larger size of the GL 207-45 aircraft will allow greater quantity procurement with resultant lower unit prices.

Subcontracting

Aircraft components have been selected for subcontracting on the basis of make-or-buy analyses that were reviewed and approved by the Make-or-Buy Committee composed of top management personnel. Engineering and tooling subcontract requirements have been estimated as an allocation of total manhours proposed by those organizations and were based on programs developed by engineering and manufacturing branches.

Production airframe subcontracting allocations are estimated based on C-130 experience. The actual dollar cost of C-130 subcontracted airframe items was divided by the AMPR weight of those items. The rate per AMPR pound thus developed was applied to AMPR pounds of the GL 207-45 airframe items that will be subcontracted. This method has been cross-checked by comparison with tentative price quotations submitted by some of the larger proposed subcontractors and found to be reasonable.

Direct Labor Rates

Average direct labor rates are estimated for engineering, tooling, production and quality assurance on the basis of current direct labor rates, using step-type projections of known and anticipated increases.

Overhead

Estimated overhead rates are expressed as a percentage of direct labor dollars. The direct labor dollar volume was forecast on the basis of firm and anticipated business, including this program. To account for the effect of business volume fluctuations on overhead expense, 1958 was selected as a base year, it being the most recent year of experience consistent with the average volume level anticipated for the period of this program. Overhead expenditures in 1958 were adjusted to reflect known and anticipated increases and decreases in overhead expenses.

Spares and Aerospace Ground Equipment

The estimate for spares support of the GL 207-45 is based on the percentage relationship between spares cost and airframe cost on the first 159 C-130A airplanes. This percentage is applied to the estimated GL 207-45 airframe cost and then adjusted to compensate for the higher aircraft utilization anticipated for MATS as compared to TAC. Amounts are included for additional specific items, such as en route and way-station spares, and fly-away mobility packages. Peculiar AGE costs are estimated on the basis of analyzing the specific requirements for non-standard equipment items.

Training

This estimate was developed by Lockheed's specialists in this area who have broad experience in meeting customers' training needs. A comprehensive knowledge of all aspects of training required on System 476L was made possible through extensive experience with similar type aircraft and discussions with the Military Air Transport Service regarding its specific requirements. Cost estimates include mobile training units and flight simulators, as well as the personnel and equipment required to support the training program.

Field Service

Costs for technical representatives were based on the allocation of CTS personnel in the number and for the period of times shown in paragraph 5.2.4.2. To the man days reflected in the assignment schedule, a daily rate has been applied which includes salary, fringe benefits, subsistence and travel allowances.

"Other" GFAE

Price of these items was established through contact with probable vendors of such equipment. No Lockheed profit is included in this category.

For substantiating data in support of the foregoing, see Section 5 of Volume 2.

Aerospace Ground Equipment (5.2.5.4.4)

Estimates for peculiar aerospace ground equipment, developed in accordance with this paragraph of the Statement of Work, are included in the preceding pricing data.

AMC Form 271A (5.2.5.4.4.1)

Time phased AGE funding data are included in Volume 4, Section 10.

AMC Form 217 (5.2.5.4.4.2)

These listings of peculiar AGE are included in Volume 4, Section 10.

PRICING INFORMATION

DEVELOPMENT, TEST AND EVALUATION OF ONE (1) AIRCRAFT

	Hours[1]	Rate	Amount[1]
		No Year / Contractor's Proposal	Qty 1
Engineering			
D.L.–Basic	2,711	$4.20	$11,386
D.L.–Sustaining	1,843	3.22	5,934
Overhead		69.55%	12,046
Material & Direct Charges		.56	2,550
Technical Data & Handbooks			1,199
Subcontracting			935
Total Engineering			$34,050
Tooling			
D.L. Planning–Basic			
D.L. Planning–Sustaining			
D.L. Tool Design–Basic			
D.L. Tool Design–Sustaining			
D.L. Tool Mfg.–Basic			
D.L. Tool Mfg.–Sustaining			
Overhead			
Material & Direct Charges			
Subcontract Tooling			
Total Tooling			
Manufacturing–(Production)			
Direct Labor	-0-		-0-
Overhead			-0-
Material and Direct Charges			$ 2,355
Purchased Equipment			-0-
Subcontracting			-0-
Total Manufacturing			$ 2,355
Quality Assurance			
Direct Labor	-0-		-0-
Overhead			-0-
Total Quality Assurance			-0-
G & A Expense		23.99%	$ 4,155
Total Cost			$40,560
Profit		8%	3,245
Price			**$43,805**

[1]Thousands

FORMAT "A"

DEVELOPMENT, TEST AND EVALUATION OF FIVE (5) AIRCRAFT

	Hours[1]	Rate	Amount[1]
		No Year — **Contractor's Proposal**	**Qty 5**
Engineering			
D.L.–Basic	4,230	$4.11	$ 17,385
D.L.–Sustaining	172	4.11	707
Overhead		69.55% DL	12,583
Material & Direct Charges		.56	2,465
Technical Data & Handbooks			664
Subcontracting			3,957
Total Engineering			$ 37,761
Tooling			
D.L. Planning–Basic	547	$3.59	$ 1,964
D.L. Planning–Sustaining	66	3.59	237
D.L. Tool Design–Basic	312	3.59	1,120
D.L. Tool Design–Sustaining	10	3.59	36
D.L. Tool Mfg.–Basic	1,703	3.59	6,114
D.L. Tool Mfg.–Sustaining	49	3.59	176
Overhead		115.62% DL	11,154
Material & Direct Charges		1.26 TMH	2,208
Subcontract Tooling			17,841
Total Tooling			$ 40,850
Manufacturing–(Production)			
Direct Labor	2,372	$2.82	$ 6,689
Overhead		115.62% DL	7,734
Material & Direct Charges			1,269
Purchased Equipment			1,632
Subcontracting			4,766
Total Manufacturing			$ 22,090
Quality Assurance			
Direct Labor	441	$3.39	$ 1,495
Overhead		115.62% DL	1,729
Total Quality Assurance			$ 3,224
G & A Expense		23.99% DL	$ 8,618
Total Cost			$112,543
Profit		8%	9,003
Price			**$121,546**

[1]Thousands

FORMAT "A"

PRICING INFORMATION

PRODUCTION OF THIRTY-ONE (31) AIRCRAFT

	Hours[1]	Rate	Amount[1]
		FY '63 Contractor's Proposal	Qty 31
Engineering			
D.L.–Basic	-0-		-0-
D.L.–Sustaining	784	$4.33	$ 3,395
Overhead		68.31% DL	2,319
Material & Direct Charges		.56	439
Technical Data & Handbooks			2,396
Subcontracting			-0-
Total Engineering			$ 8,549
Tooling			
D.L. Planning–Basic	123	$3.73	$ 459
D.L. Planning–Sustaining	200	3.73	746
D.L. Tool Design–Basic	149	3.73	556
D.L. Tool Design–Sustaining	34	3.73	127
D.L. Tool Mfg.–Basic	864	3.73	3,223
D.L. Tool Mfg.–Sustaining	164	3.73	612
Overhead		111.04% DL	6,355
Material & Direct Charges		1.26 TMH	1,295
Subcontract Tooling			10,710
Total Tooling			$ 24,083
Manufacturing–(Production)			
Direct Labor	6,459	$2.92	$ 18,860
Overhead		111.04% DL	20,942
Material & Direct Charges			7,870
Purchased Equipment			10,125
Subcontracting			29,548
Total Manufacturing			$ 87,345
Quality Assurance			
Direct Labor	625	$3.49	$ 2,181
Overhead		111.04% DL	2,422
Total Quality Assurance			$ 4,603
G & A Expense		23.00% DL	$ 6,935
Total Cost			$131,515
Profit		8%	10,521
Price			**$142,036**

[1]Thousands

FORMAT "A"

PRICING INFORMATION

PRODUCTION OF FORTY-EIGHT (48) AIRCRAFT

	Hours[1]	Rate	Amount[1]
		FY '64 Contractor's Proposal	Qty 48
Engineering			
D.L.–Basic	-0-		-0-
D.L.–Sustaining	493	$4.53	$ 2,233
Overhead		71.28% DL	1,592
Material & Direct Charges		.56	276
Technical Data & Handbooks			954
Subcontracting			-0-
Total Engineering			$ 5,055
Tooling			
D.L. Planning–Basic	-0-		-0-
D.L. Planning–Sustaining	219	$3.87	$ 848
D.L. Tool Design–Basic	-0-		-0-
D.L. Tool Design–Sustaining	32	3.87	124
D.L. Tool Mfg.–Basic	-0-		-0-
D.L. Tool Mfg.–Sustaining	159	3.87	615
Overhead		109.10% DL	1,731
Material & Direct Charges		1.26 TMH	200
Subcontract Tooling			-0-
Total Tooling			$ 3,518
Manufacturing–(Production)			
Direct Labor	6,608	$3.01	$ 19,890
Overhead		109.10% DL	21,700
Material & Direct Charges			12,187
Purchased Equipment			15,678
Subcontracting			45,751
Total Manufacturing			$115,206
Quality Assurance			
Direct Labor	610	$3.62	$ 2,208
Overhead		109.10% DL	2,409
Total Quality Assurance			$ 4,617
G & A Expense		22.88% DL	$ 5,930
Total Cost			$134,326
Profit		8%	10,746
Price			**$145,072**

[1]Thousands

FORMAT "A"

PRICING INFORMATION

PRODUCTION OF FORTY-EIGHT (48) AIRCRAFT

	Hours[1]	FY '65 Contractor's Proposal Rate	Qty 48 Amount[1]
Engineering			
D.L.–Basic	-0-		-0-
D.L.–Sustaining	442	$4.70	$ 2,077
Overhead		72.76% DL	1,511
Material & Direct Charges		.56	248
Technical Data & Handbooks			747
Subcontracting			-0-
Total Engineering			$ 4,583
Tooling			
D.L. Planning–Basic	-0-		-0-
D.L. Planning–Sustaining	210	$3.99	$ 838
D.L. Tool Design–Basic	-0-		-0-
D.L. Tool Design–Sustaining	26	3.99	104
D.L. Tool Mfg.–Basic	-0-		-0-
D.L. Tool Mfg.–Sustaining	152	3.99	606
Overhead		115.12% DL	1,782
Material & Direct Charges		1.26 TMH	192
Subcontract Tooling			-0-
Total Tooling			$ 3,522
Manufacturing–(Production)			
Direct Labor	5,409	$3.10	$ 16,768
Overhead		115.12% DL	19,303
Material & Direct Charges			12,187
Purchased Equipment			15,678
Subcontracting			45,751
Total Manufacturing			$109,687
Quality Assurance			
Direct Labor	511	$3.73	$ 1,906
Overhead		115.12% DL	2,194
Total Quality Assurance			$ 4,100
G & A Expense		24.40% DL	$ 5,441
Total Cost			$127,333
Profit		8%	10,187
Price			**$137,520**

[1]Thousands

FORMAT "A"

DEVELOPMENT, TEST, EVALUATION AND PRODUCTION OF ONE-HUNDRED THIRTY-TWO (132) AIRCRAFT

PROGRAM SUMMARY
Contractor's Proposal

	Hours[1]	Rate	Amount[1]
Engineering			
D.L.—Basic	4,230	$4.11	$17,385
D.L.—Sustaining	1,891	4.45	8,412
Overhead		69.79% DL	18,005
Material & Direct Charges			3,428
Technical Data & Handbooks			4,761
Subcontracting			3,957
Total Engineering			$55,948
Tooling			
D.L. Planning—Basic	670	$3.62	$ 2,423
D.L. Planning—Sustaining	695	3.84	2,669
D.L. Tool Design—Basic	461	3.64	1,676
D.L. Tool Design—Sustaining	102	3.83	391
D.L. Tool Mfg.—Basic	2,567	3.64	9,337
D.L. Tool Mfg.—Sustaining	524	3.83	2,009
Overhead		113.60% DL	21,022
Material & Direct Charges		1.26 TMH	3,895
Subcontract Tooling			28,551
Total Tooling			$ 71,973
Manufacturing—(Production)			
Direct Labor	20,848	$2.98	$ 62,207
Overhead		112.01% DL	69,679
Material & Direct Charges			33,513
Purchased Equipment			43,113
Subcontracting			125,816
Total Manufacturing			$334,328
Quality Assurance			
Direct Labor	2,187	$3.56	$ 7,790
Overhead		112.37% DL	8,754
Total Quality Assurance			$ 16,544
G & A Expense		23.56% DL	$ 26,924
Total Cost			$505,717
Profit		8%	40,457
Price			**$546,174**

[1]Thousands

FORMAT "A"

PROGRAM FUNDING SUMMARY (COST IN THOUSANDS $)

RDT&E and
PRODUCTION PROGRAM

FUNDING ITEM	**FY 61**	**FY 62**	**FY 63**	**FY 64**	**FY 65**	**Total**
Airframe & CFE	$1,141	$21,434	$135,227	$139,006	$127,920	$424,728
Systems Reliability	41	1,623	7,227	5,936	5,018	19,845
Test Items	340	2,386	3,777	5,350	2,156	14,009
Tooling	1,250	33,712	38,984	4,292	4,212	82,450
Technical Data & Handbooks	—0—	144	2,946	1,232	820	5,142
System Planning & Management	.....	......	Included in Overhead		....	....
Program Evaluation Procedures	.....	......	Included in Overhead		....	....
Sub-Total	**$2,772**	**$59,299**	**$188,161**	**$155,816**	**$140,126**	**$546,174**
Contractor's Technical Representation and Training	—0—	$ 178	$ 1,403	$ 1,516	$ 1,789	$ 4,886
Initial Spares						
Airframe & CFE	—0—	8,048	22,403	26,090	24,528	81,069
Other GFAE	—0—	120	2,041	2,882	2,882	7,925
Peculiar AGE	—0—	251	1,970	2,584	2,610	7,415
Training Equipment	—0—	—0—	3,732	2,245	1,296	7,273
Industrial Facilities	.....	..... No Air Force Funding Requested ...				....
Other GFAE	—0—	600	10,207	14,409	14,409	39,625
Total	**$2,772**	**$68,496**	**$229,917**	**$205,542**	**$187,640**	**$694,367**
Advance Buy Requirements (Identify Items)	.....	..... No Air Force Funding Requested ...				....

FORMAT "C"

(COST IN THOUSANDS $)

DT&E Qty 1

PROGRAM FUNDING ITEM	**FY 61**		**FY 62**		**FY 63**		**FY 64**		**FY 65**		
	Recurring	**Non-Recurring**	**Recurring**	**Non-Recurring**	**Recurring**	**Non-Recurring**	**Recurring**	**Non-Recurring**	**Recurring**	**Non-Recurring**	**Total**
Design/Development Eng.											
Mock-up Article	-0-	$ 50	-0-	$ 72	-0-	-0-	-0-	-0-	-0-	-0	$ 122
Airframe & CFE	-0-	1,462	-0-	11,029	-0-	$ 5,239	-0-	$1,063	-0-	$ 190	18,983
Manufacturing											
Airframe & CFE	-0-	370	-0-	11,484	-0-	4,208	-0-	-0-	-0-	-0	16,062
Systems Reliability	-0-	150	-0-	850	-0-	400	-0-	90	-0-	1	1,491
Test Items											
Wind Tunnel Model & Test	-0-	$ 357	-0-	$ 778	-0-	$ 197	-0-	$ 75	-0-	-0	$ 1,407
Category I—Flight Test	-0-	3	-0-	207	-0-	946	-0-	1,423	-0-	$ 762	3,341
Instrumentation	.... Included in Category I – Flight Test										
System/Sub-System Integration	.... Included in Overhead										
Sub-Total Test	-0-	$ 360	-0-	$ 985	-0-	$ 1,143	-0-	$1,498	-0-	$ 762	$ 4,748
System Planning & Management	.... Included in Overhead										
Tooling	-0-	$ 300	-0-	$ 804	-0-	-0-	-0-	-0-	-0-	-0-	$ 1,104
Tech Data & Handbooks	-0-	462	-0-	831	-0-	$ 2	-0-	-0-	-0-	-0-	1,295
Program Evaluation Procedures	.... Included in Overhead										
Sub-Total	**-0-**	**3,154**	**-0-**	**$26,055**	**-0-**	**$10,992**	**-0-**	**02,651**	**-0-**	**$ 953**	**$43,805**
Other GFAE	-0-	-0-	-0-	$ 100	-0-	$ 200	-0-	-0-	-0-	-0-	$ 300
Contractor Technical Representatives & Training	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-	-0-
Initial Spares											
Airframe & CFE	-0-	$1,468	-0-	2,112	-0-	-0-	-0-	-0-	-0-	-0-	3,580
Other GFAE	-0-	-0-	-0-	20	-0-	40	-0-	-0-	-0-	-0-	60
Peculiar AGE											
Airframe	-0-	-0-	-0-	251	-0-	455		$ 4	-0-	-0-	710
Training Equipment											
Operation Trainers											-0-
Maintenance Trainers											-0-
Training Parts (ATC)											-0-
Industrial Facilities & Equipment	.... No Air Force Funding Requested										
Total	**-0-**	**$4,622**	**-0-**	**$28,538**	**-0-**	**$11,687**	**-0-**	**$2,655**	**-0-**	**$ 953**	**$48,455**
Advance Buy Requirements (Identify)	.... No Air Force Funding Requested										

FORMAT "D"

(COST IN THOUSANDS)

DT&E **Qty 5**

PROGRAM FUNDING ITEM	FY 61 Recurring	FY 61 Non-Recurring	FY 62 Recurring	FY 62 Non-Recurring	FY 63 Recurring	FY 63 Non-Recurring	FY 64 Recurring	FY 64 Non-Recurring	FY 65 Recurring	FY 65 Non-Recurring	FY Summary Recurring	FY Summary Non-Recurring	Total
Design/Development Eng.													
Mock-up Article	—0—	$ 51	—0—	$ 179	—0—	$ 44	—0—	—0—	—0—	—0—	—0—	$ 274	$ 274
Airframe & CFE	—0—	590	—0—	11,732	—0—	11,478	—0—	$ 4,570	—0—	$ 349	—0—	28,719	28,719
Manufacturing													
Airframe & CFE	$ 500	—0—	$ 9,523	—0—	$17,201	—0—	$ 117	—0—	—0—	—0—	$27,341	—0—	$ 27,341
System Reliability	—0—	41	667	956	1,248	466	112	292	$ 4	84	2,031	1,839	3,870
Test Items													
Wind Tunnel Model & Test	—0—	$ 313	—0—	$ 1,329	—0—	$ 235	—0—	$ 227	—0—	—0—	—0—	$ 2,104	2,104
Category I —Flight Test	—0—	—0—	—0—	37	—0—	1,799	—0—	3,420	—0—	$ 254	—0—	5,510	5,510
Category II—Flight Test	—0—	—0—	—0—	—0—	—0—	189	—0—	751	—0—	26	—0—	966	966
FAA Test (Reqmts for FAA certification not included in AF testing)	—0—	—0—	—0—	—0—	—0—	—0—	—0—	556	—0—	1,843	—0—	2,399	2,399
Qualification	—0—	3	—0—	404	—0—	921	—0—	347	—0—	33	—0—	1,708	1,708
Instrumentation	Included in Flight Test												
System/Sub-system Integration	—0—	24	—0—	616	—0—	633	—0—	49	—0—	—0—	—0—	1,322	1,322
Sub-Total Test	—0—	$ 340	—0—	$ 2,386	—0—	$ 3,777	—0—	$ 5,350	—0—	$2,156	—0—	$14,009	$ 14,009
System Planning & Management	Included in Overhead												
Tooling	—0—	$1,250	$ 725	$32,987	$ 1,487	$10,066	$ 57	$ 44	—0—	—0—	$ 2,269	$44,347	$ 46,616
Tech Data & Handbooks	—0—	—0—	—0—	144	—0—	358	—0—	202	—0—	$ 13	—0—	717	717
Program Evaluation Procedures	Included in Overhead												
Sub-Total	**$ 500**	**$2,272**	**$10,915**	**$48,384**	**$19,936**	**$26,189**	**$ 286**	**$10,458**	**$ 4**	**$2,602**	**$31,641**	**$89,905**	**$121,546**
Other GFAE	—0—	—0—	$ 600	—0—	$ 901	—0—	—0—	—0—	—0—	—0—	$ 1,501	—0—	$ 1,501
Contractor Technical Representatives & Training	—0—	—0—	91	$ 87	262	$ 205	$ 237	$ 16	—0—	—0—	590	$ 308	898
Initial Spares													
Airframe & CFE	—0—	—0—	4,348	—0—	7,851	—0—	49	—0—	—0—	—0—	12,248	—0—	12,248
Other GFAE	—0—	—0—	120	—0—	180	—0—	—0—	—0—	—0—	—0—	300	—0—	300
Peculiar AGE													
Airframe	—0—	—0—	251	—0—	455	—0—	4	—0—	—0—	—0—	710	—0—	710
Training Equipment													
Operation Trainers													—0—
Maintenance Trainers													—0—
Training Parts (ATC)													—0—
Industrial Facilities & Equipment	No Air Force Funding Requested												
Others (Identify)													—0—
Total	**$ 500**	**$2,272**	**$16,325**	**$48,471**	**$29,585**	**$26,394**	**$ 576**	**$10,474**	**$ 4**	**$2,602**	**$46,990**	**$90,213**	**$137,203**
Advance Buy Requirements (Identify)	No Air Force Funding Requested												

FORMAT "D"

(COST IN THOUSANDS $)

PRODUCTION

Program Funding Item	Recurring Cost	Non-Recurring Cost (FY 1963)	Total (Qty 31)
Manufacturing Airframe & CFE	$106,504	—0—	$106,504
System Planning & Management	....	Included in Overhead	....
Tooling	4,516	22,915	27,431
System Reliability	5,081	432	5,513
Tech Data & Handbooks	2,588	—0—	2,588
Program Eval. Procedures	....	Included in Overhead	....
Sub-Total	**$118,689**	**$23,347**	**$142,036**
Other GFAE	$ 9,306	—0—	$ 9,306
Contractor Technical Representatives & Training	936	—0—	936
Initial Spares			
Airframe & CFE	18,252	—0—	18,252
Other GFAE	1,861	—0—	1,861
Peculiar AGE Airframe	1,515	—0—	1,515
Training Equipment			
Operator Trainers (Type & Qty)	—0—	1,620	1,620
Maintenance Trainers (Type & Qty)	—0—	1,896	1,896
Training Parts (ATC)	—0—	216	216
Industrial Facilities & Equipment	....	No Air Force Funding Requested	....
Total	**$150,559**	**$27,079**	**$177,638**
Advance Buy Requirements	....	No Air Force Funding Requested	....

FORMAT "E"

(COST IN THOUSANDS $)

PRODUCTION

Program Funding Item	Recurring Cost	FY 1964 Non-Recurring Cost	Qty 48 Total
Manufacturing Airframe & CFE	$134,319	—0—	$134,319
System Planning & Management	....	Included in Overhead	....
Tooling	4,191	—0—	4,191
System Reliability	5,532	—0—	5,532
Tech Data & Handbooks	1,030	—0—	1,030
Program Eval. Procedures	....	Included in Overhead	....
Sub-Total	**$145,072**	**—0—**	**$145,072**
Other GFAE	$ 14,409	—0—	$ 14,409
Contractor Technical Representatives & Training	1,263	—0—	1,263
Initial Spare			
Airframe & CFE	26,041	—0—	26,041
Other GFAE	2,882	—0—	2,882
Peculiar AGE Airframe	2,580	—0—	2,580
Training Equipment			
Operator Trainers (Type & Qty)	—0—	$1,296	1,296
Maintenance Trainers (Type & Qty)	—0—	949	949
Training Parts (ATC)	—0—	—0—	—0—
Industrial Facilities & Equipment	....	No Air Force Funding Requested	....
Total	**$192,247**	**$2,245**	**$194,492**
Advance Buy Requirements	....	No Air Force Funding Requested	....

FORMAT "E"

(COST IN THOUSANDS $)

PRODUCTION

Program Funding Item	Recurring Cost	FY 1965 Non-Recurring Cost	Qty 48 Total
Manufacturing			
Airframe & CFE	$127,571	—0—	$127,571
System Planning & Management	....	Included in Overhead	....
Tooling	4,212	—0—	4,212
System Reliability	4,930	—0—	4,930
Tech Data & Handbooks	807	—0—	807
Program Eval. Procedures	....	Included in Overhead	....
Sub-Total	**$137,520**	**—0—**	**$137,520**
Other GFAE	$ 14,409	—0—	$ 14,409
Contractor Technical Representatives & Training	1,789	—0—	1,789
Initial Spares			
Airframe & CFE	24,528	—0—	24,528
Other GFAE	2,882	—0—	2,882
Peculiar AGE			
Airframe	2,610	—0—	2,610
Training Equipment			
Operator Trainers (Type & Qty)	—0—	$1,296	1,296
Maintenance Trainers (Type & Qty)	—0—	—0—	—0—
Training Parts (ATC)	—0—	—0—	—0—
Industrial Facilities & Equipment	....	No Air Force Funding Requested	....
Total	**$183,738**	**$1,296**	**$185,034**
Advance Buy Requirements	....	No Air Force Funding Requested	....

FORMAT "E"

(COST IN THOUSANDS $)

PRODUCTION

Program Funding Item	Recurring Cost	SUMMARY Non-Recurring Cost	QTY 127 Amount
Manufacturing Airframe & CFE	$368,394	—0—	$368,394
System Planning & Management	....	Included in Overhead	....
Tooling	12,919	$22,915	35,834
System Reliability	15,543	432	15,975
Tech Data & Handbooks	4,425	—0—	4,425
Program Eval. Procedures	....	Included in Overhead	....
Sub-Total	**$401,281**	**$23,347**	**$424,628**
Other GFAE	$ 38,124	—0—	$ 38,124
Contractor Technical Representatives & Training	3,988	—0—	3,988
Initial Spares			
Airframe & CFE	68,821	—0—	68,821
Other GFAE	7,625	—0—	7,625
Peculiar AGE			
Airframe	6,705	—0—	6,705
Training Equipment			
Operator Trainers (Type & Qty)	—0—	$ 4,212	4,212
Maintenance Trainers (Type & Qty)	—0—	2,845	2,845
Training Parts (ATC)	—0—	216	21
Industrial Facilities & Equipment	....	No Air Force Funding Requested	....
Total	**$526,544**	**$30,620**	**$557**
Advance Buy Requirements	....	No Air Force Funding Requested	..

FORMAT "E"

FISCAL YEAR EXPENDITURE (AIR FORCE) REQUIREMENTS (IN THOUSANDS)

	A/C Qty.	FY 61	FY 62	FY 63	FY 64	FY 65	FY 66	FY 67	Total
DT & E (No Year)	5	$2,697	$65,921	$ 55,352	$ 10,724	$ 2,509	—0—	—0—	$137,203
Production Programs									
FY 63	31	—0—	100	58,801	102,649	16,022	$ 66	—0—	177,638
FY 64	48	—0—	—0—	—0—	23,207	148,029	23,168	$ 88	194,492
FY 65	48	—0—	—0—	—0—	—0—	19,665	143,114	22,255	185,034
Total	**132**	**$2,697**	**$66,021**	**$114,153**	**$136,580**	**$186,225**	**$166,348**	**$22,343**	**$694,367**

FORMAT "F"

PROGRAM QUANTITY SUMMARY

	Aircraft Quantity	Program Fiscal Year
DT & E	5	No Year
Production Program #1	31	1963
Production Program #2	48	1964
Production Program #3	48	1965
Total	**132**	

FORMAT "B"

OPERATING COST DATA (5.2.5.5)

General

The GL 207-45 in commercial operation will achieve a direct operating cost of 3.8¢/TSM for transcontinental ranges of 2200 n.m. The importance of determining an accurate direct operating cost in advance of actual operations cannot be over-emphasized. It is necessary to evaluate carefully operating cost data to prevent misinterpretation of cost comparisons between various transport airplanes. The variance of input data to any one major factor (fuel price, utilization, etc) within any acceptable method can result in a substantial change in the final direct operating cost.

The cost data presented in this section have been computed in accordance with the 1960 ATA "Standard Method of Estimating Comparative Direct Operating Costs" for commercial operations. A more stringent set of rules, provided in detail by the Air Force, was used to compute military and comparative commercial operating costs. The actual operating costs of an aircraft with a conventional configuration reflecting normal state-of-the-art advances, such as the GL 207-45, could be even lower than the costs obtained from the ATA method, since this method is developed from CAB statistics compiled for the early passenger jet transports now in operation. On the other hand, operating costs for an advanced state-of-the-art airplane may, in actuality, exceed the predicted values.

A comprehensive analysis of "normal" versus "advanced" fleet operating costs is presented in Volume 1, Section 3.

Commercial Operating Cost

The commercial GL 207-45 completely fulfills all of the known requirements for a low cost airfreighter. The operating cost of 3.8¢/TSM over transcontinental routes of 2200 N.M. rises to only 3.9¢/TSM over intermediate routes of 1000 N.M., remains at 3.9¢/TSM over international routes of 3150 N.M. Even over short routes of 500 N.M., on which direct operating costs are normally disproportionately high, the DOC of the Super Hercules is 4.3¢/TSM.

Figure 15-1 presents the operating costs of the commercial GL 207-45 (computed in accordance with both ATA and System 476L methods) in dollars/block hour, and cents/ton mile (statute and nautical) for two gross takeoff weights. The basic values used and the breakdown of the costing equation are presented in Figure 15-2. A comparative cost tabulation for distances requested in the Statement of Work for System 476L is shown in Figure 15-3. The commercial (domestic) costs shown reflect the use of ATA domestic fuel prices, and less sophisticated communications and navigational aids systems for civil operations.

The payload ranges shown for the Super Hercules in Figure 15-4 confirm its excellent capability over a wide range of operations. Payloads of 86,000 lbs. can be carried for transcontinental distances of 2200 N.M., and 83,000 lbs. for international routes of 3150 N.M. The palletized cube densities shown at selected points are based on the Lockheed commercial airfreight loading system. This system can be replaced quickly by 463L without airplane alteration or time loss in the event of a national emergency.

The commercial GL 207-45 is completely interchangeable with the military airplane and can be used in military operational assignment except for minimum removable equipment additions or substitutions.

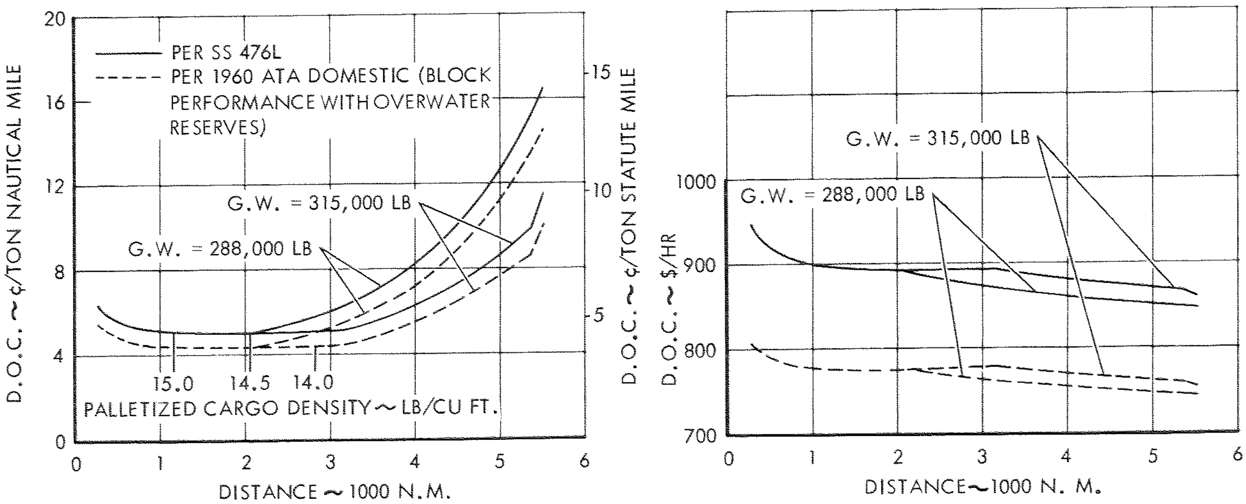


Figure 15-1—COMMERCIAL DIRECT OPERATING COST.

			GL 207-45		
			Commercial		Military
			1960 ATA Domestic	System 476L	System 476L
Basic Values for Cost Equation					
Weight					
Manufacturer's empty		lb	115,875	115,875	118,075
One engine (dry)	(W_e)	lb	4,170	4,170	4,170
Airplane less engines	(W_a)	lb	99,195	99,195	101,395
Cost					
Total airplane	(C_t)	$	5,355,000	5,655,000	5,655,000
One engine	(C_e)	$	225,000	250,000	250,000
Airplane less engines	(C_{spa})	$	4,455,000	4,655,000	4,655,000
Radio	(C_r)	$	100,000	300,000	300,000
Airplane less eng & radio	(C_a)	$	4,355,000	4,355,000	4,355,000
Fuel	(A)	$/gal	.110	.144	.098
Oil	(B)	$/gal	6.00	6.00	3.90
Engine Thrust Rating	(T)	lb	18,000	18,000	18,000
Utilization	(U)	hr/yr	3650	3650	1825
Breakdown of Cost Equation					
Flying Operations					
Crew		$/hr	76.08	131.60	59.50
Crew		$/nm	.0997	—	—
Fuel		$/lb	.0169	.02282	.01553
Oil		$/hr	2.06	2.06	1.29
Insurance—airframe		$/hr	58.68	61.97	—
Insurance—liability		$/nm	.001	.001	—
Maintenance					
Labor—aircraft & other		$/hr	29.80	29.80	30.26
Labor—engines		$/hr	17.18	17.18	17.18
Material—aircraft & other		$/hr	38.84	40.47	40.47
Material—engines		$/hr	75.49	81.94	81.94
Applied burden		$/hr	68.46	70.34	70.74
Depreciation					
Airframe		$/hr	101.43	101.43	202.86
Engine		$/hr	29.93	33.27	66.54
Radio		$/hr	5.48	16.44	32.88
Airframe		$/hr	10.37	11.84	21.68
Engine spares		$/hr	22.44	24.96	49.92

Cost Equations

Commercial–ATA (Domestic–\$/hr $= \$536 + (\$.0169)\ (F_B/T_B + \$.100\ (V_B)$
–SS 476L – \$/hr $= \$622 + (\$.0228)\ (F_B/T_B) + \$.001\ (V_B)$

Military –SS 476L – \$/hr $= \$675 + (\$.0155)\ (F_B/T_B)$

NOTES: 1. F_B = Block Fuel (lb)
2. T_B = Block Time (hr)
3. V_B = Block Speed (knots)

Figure 15-2—SUMMARY OF OPERATING COST DERIVATION.

Military Operating Costs

The military operating costs shown in Figures 15-5 and 15-3 are computed in accordance with the System 476L method and are expressed in cents per ton nautical mile. Conversion to ton statute miles is also provided in these figures. The excellent design and performance characteristics of the GL 207-45 are reflected in a 4.9¢/TNM cost at a range of 2000 N.M. This cost rises to only 5.0¢/TNM at 1000 N.M. range, and 5.4¢/TNM at 3450 N.M. range. A second DOC curve is shown in Figure 15-5 reflecting the operating cost of the GL 207-45 when operated from a 6000 ft. (or less) runway carrying only 70,000 lbs. of payload.

Operating costs in dollars/hour are also shown in Figure 15-5. A curve for "zero" payload is included to permit interpolation of operating costs for less-than-maximum payloads.

The block performance data, presented in Figure 15-6, are based on military procedures including cruise climb, fuel flows increased 5% over engine specification values, and reserves as specified in MIL-C-5011A. Ground and air maneuver fuel and time allowances and block speeds have been computed in accordance with the 1960 ATA costing method. The payload capability increases as range decreases from the "full-load maximum-range point" as shown in this figure. Explanation is provided in Figure 15-5. This excellent weight payload flexibility permits the fulfillment of high density cargo missions at lower ton mile costs with insignificant operational penalties. The palletized payload cube densities shown at selected range points are based on the 463L loading system.

The basic values used and the breakdown of the costing equation are presented in Figure 15-2.

Effect of Growth Power Plants on Military Operating Costs

The effect on *performance* of using several growth power plants in the GL 207-45 airframe is presented in Section 3, Volume 1. The operating cost changes of these growth engines are shown in Figures 15-5 and 15-9, Paragraph 5.2.5.5, Volume 2. Minimum cost changes result from the use of the growth engines versus the JT3D-4, at short and medium ranges. However, at ranges beyond the "full-load maximum-range point" of the JT3D-4, the growth engines create ton-mile cost improvements since their increased power will permit higher payloads for these distances. Basic values and details of the costing equation for each version of the airplane are presented in Paragraph 5.2.5.5, Volume 2. Block performance data for the power growth versions of the airplane, presented in Figure 15-6, were computed as stated previously under "Military Operating Costs".

Aircraft	Distance	Block Time	Block Fuel	Fuel Costs	Other Costs	Total Cost	Block Speed	Payload	Total Cost	Total Cost
	(n.m.)	(hr.)	(lb)	($/hr)	($/hr)	($/hr)	(knots)	(tons)	(¢/tnm)	(¢/tsm)
Commercial										
1960 ATA	1000	2.60	31,400	204	575	779	385	45.4	4.46	3.88
(Domestic)	2000	4.93	58,000	199	577	776	406	43.6	4.38	3.80
	3000	7.23	85,500	200	578	778	415	41.8	4.49	3.90
	3150	7.56	90,000	201	578	779	416	41.5	4.51	3.92
	4000	9.52	108,000	192	578	770	420	33.0	5.56	4.84
	5350	12.53	134,000	181	579	760	426	20.5	8.70	7.55
	5500	12.90	134,500	176	579	755	426	17.5	10.10	8.77
Commercial										
System 476L	1000	2.60	31,400	276	623	899	385	45.4	5.15	4.48
	2000	4.93	58,000	268	623	891	406	43.6	5.03	4.37
	3000	7.23	85,500	270	623	893	415	41.8	5.15	4.48
	3150	7.56	90,000	271	623	894	416	41.5	5.16	4.50
	4000	9.52	108,000	258	623	881	420	33.0	6.36	5.54
	5500	12.90	134,500	238	623	861	426	17.5	11.55	10.00
Military										
System 476L	1000	2.60	30,500	182	675	857	385	44.8	4.96	4.31
	2000	4.93	57,000	179	675	854	406	42.8	4.90	4.26
	3000	7.23	84,500	181	675	856	415	41.0	5.04	4.38
	3440	8.24	97,000	183	675	858	417	40.0	5.15	4.48
	4000	9.52	109,000	178	675	853	420	34.0	5.97	5.19
	5500	12.90	138,000	166	675	841	426	19.0	10.40	9.04

Figure 15-3—TYPICAL OPERATING COST CALCULATIONS.

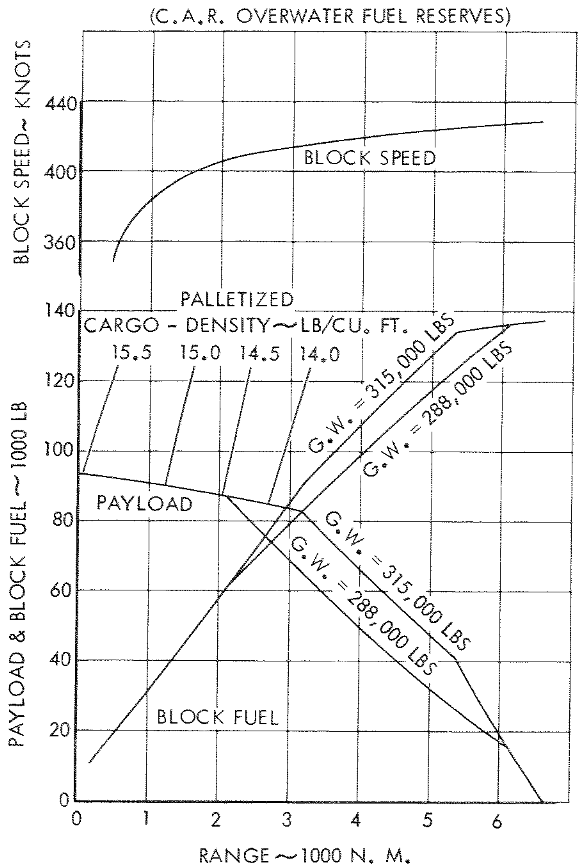


Figure 15-4—COMMERCIAL BLOCK PERFORMANCE SUMMARY.

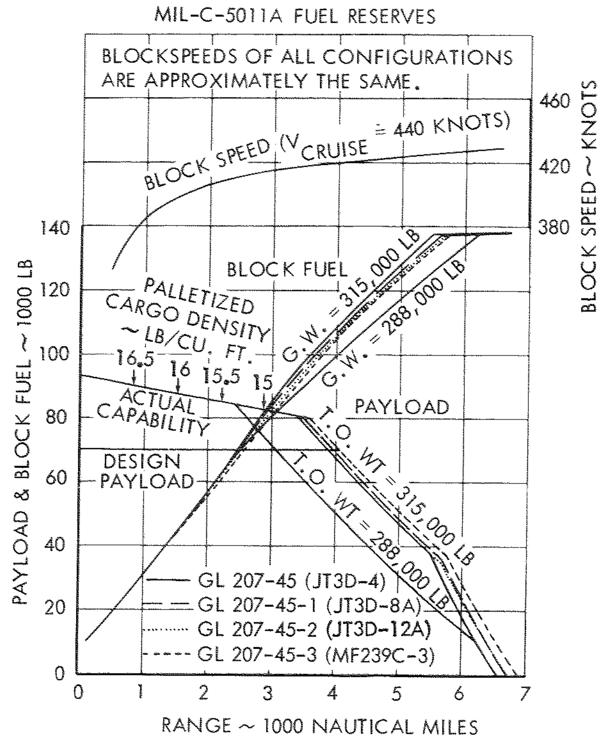


Figure 15-6—MILITARY BLOCK PERFORMANCE SUMMARY.

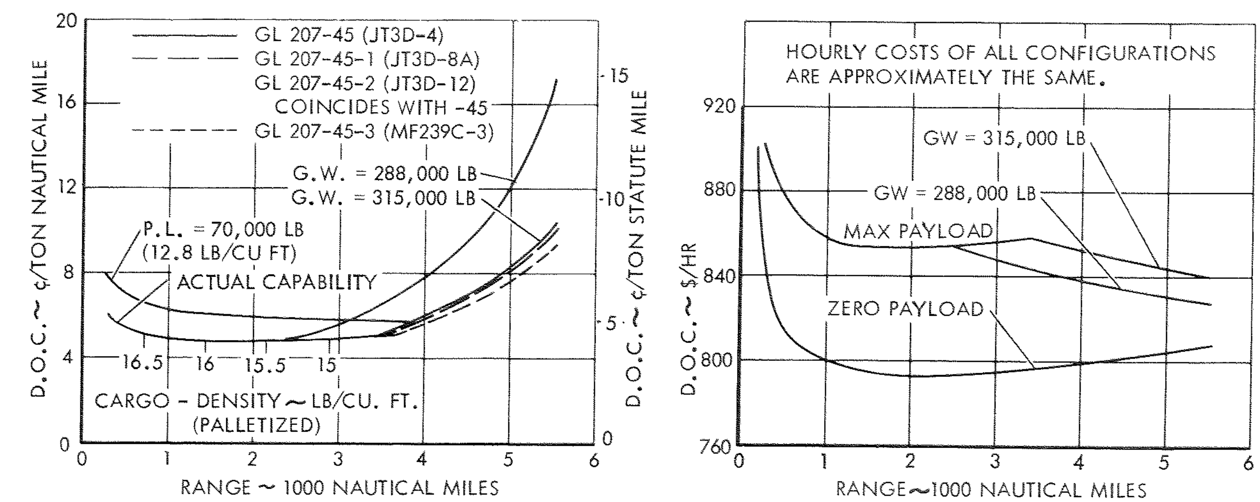


Figure 15-5—MILITARY DIRECT OPERATING COST.

SUPER HERCULES · GL207-45

section 16

REFERENCES

Page

1 Civil Aeronautics Manual 4b.

2 Military Specification—Flying Qualities of Piloted Airplanes MIL-F-8785.

3 Civil Aeronautics Manual 4b.

4 British Aeronautical Research Council Report No. R & M 1910 dated 1953, "The Calculation of Aerodynamic Loading on Surfaces of any Shape," V. N. Faulkner.

5 "A Method for the Determination of the Spanwise Load Distribution of a Flexible Swept Wing at Subsonic Speeds," Richard B. Skoog and Harvey H. Brown.

6 Journal of the Aeronautical Sciences, dated August 1951, LAS Paper, "A Superposition Method for Calculating the Aerolastic Behavior of Swept Wings," R. B. Brown, K. F. Holtby and H. G. Martin.

7 Nelson, W. J. and Popp, E. G., "Performance Characteristics of Two 6-degree and Two 12-degree Diffusers at High Flow Rates," NACA RM L9H09, 1949.

8 Baals, D. D., Smith, N. F., and Wright, J. B., "The Development and Application of High-Critical-Speed Nose Inlets," NACA TR 920, 1948.

9 Blackaby, J. R. and Watson, E. C., "An Experimental Investigation at Low Speeds of the Effects of Lip Shape on the Drag and Pressure Recovery of a Nose Inlet in a Body of Revolution," NACA TN 3170, April, 1954.