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Lockheed Aircraft Corporation

ADVANCED DEVELOPMENT PROJECTS

BURBANK, CALIFORNIA

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DATE 6 Nov. 1963

COPY NO. 2

MODEL D-21

TITLE MANUFACTURER'S MODEL SPECIFICATION

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Development Projects

REVISIONS

DATE	PAGES AFFECTED
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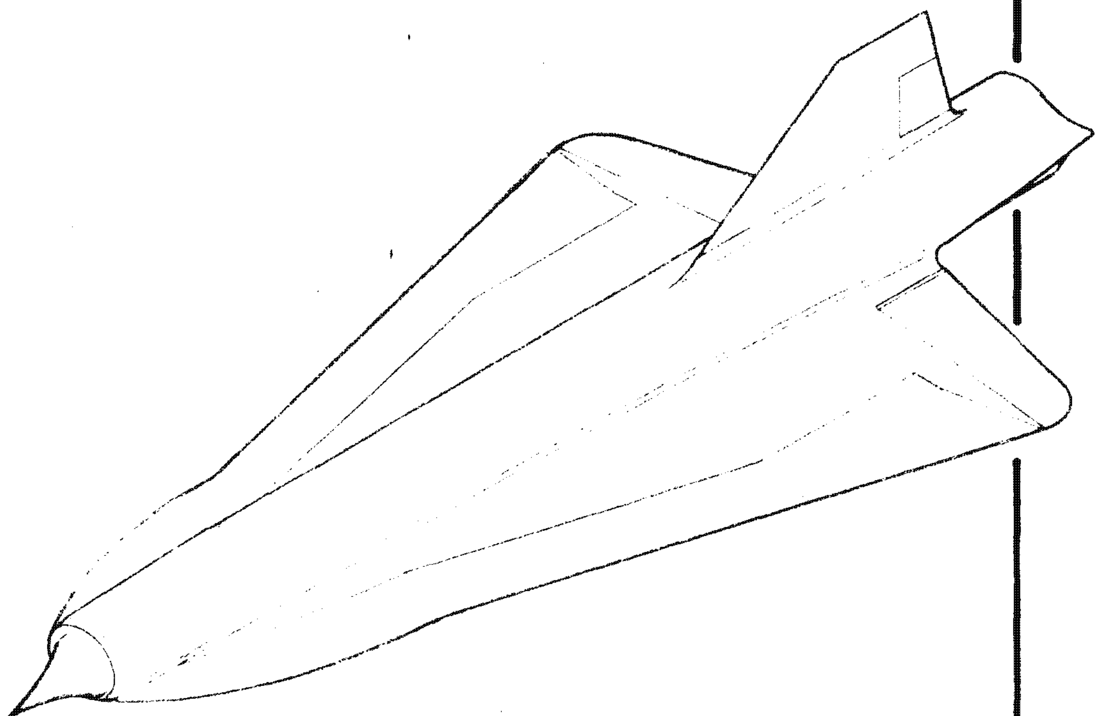


D-21

TABLE OF CONTENTS

TABLE OF CONTENTS
(Contd)

TABLE OF CONTENTS
(Contd)

TABLE OF CONTENTS
(Contd)

TABLE OF CONTENTS
(Contd)

TABLE OF CONTENTS
(Contd)

WING

AREA (ACTUAL)	398.5 SQ FT
AREA (WIND-TUNNEL REFERENCE)	280.0 SQ FT
ASPECT RATIO	.937
ROOT CHORD (PROJECTED)	40.00 FEET (480.00 INS)
TIP CHORD	0
SPAN	19.08 FEET (228.90 INS.)
DIHEDRAL (NEGATIVE)	-7°
INCIDENCE	0°
AIRFOIL - MODIFIED BI-CONVEX	2.5% (MAX THICKNESS @ .63 C)
SWEEP @ .250 C	70°-16'-33"
M.A.C. @ WING STA 45.0	25.00 FEET (300.00 INS)

ELEVON

AREA (EACH)	12.9 SQ. FEET.
TRAVEL	UP 17°, DOWN 18°

VERTICAL TAIL

AREA (TOTAL)	49.0 SQ FT
AREA (EXPOSED)	30.7 SQ FT.
ASPECT RATIO	.694
ROOT CHORD (PROJECTED)	13.50 FEET. (162.00 INS)
TIP CHORD	3.28 FEET. (39.40 INS)
SPAN (PROJECTED)	5.83 FEET (70.00 INS.)
AIRFOIL - MODIFIED BI-CONVEX	2½% @ W.L. 170; 4% @ W.L. 125. (MAX THICKNESS @ .70 C)
SWEEP @ .250 C	46°-48'-05"
M.A.C. @ W.L. 127.9	9.45 FEET (113.14 INS)

RUDDER

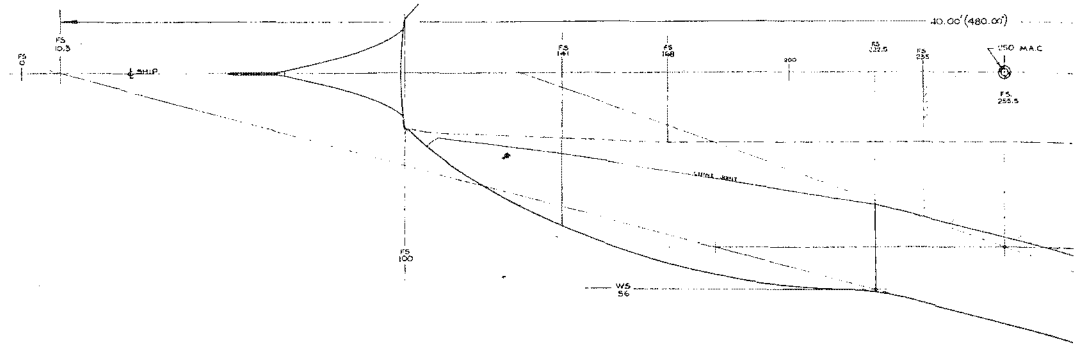
AREA	8.77 SQ FT
TRAVEL	±10°

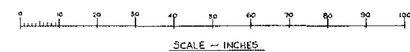
FUSELAGE

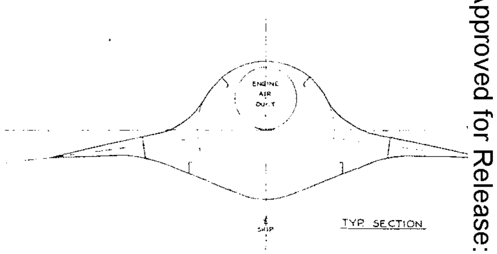
DIAMETER	3.00 FEET (36.00 INS)
OVERALL LENGTH	42.85 FEET (514.20 INS)

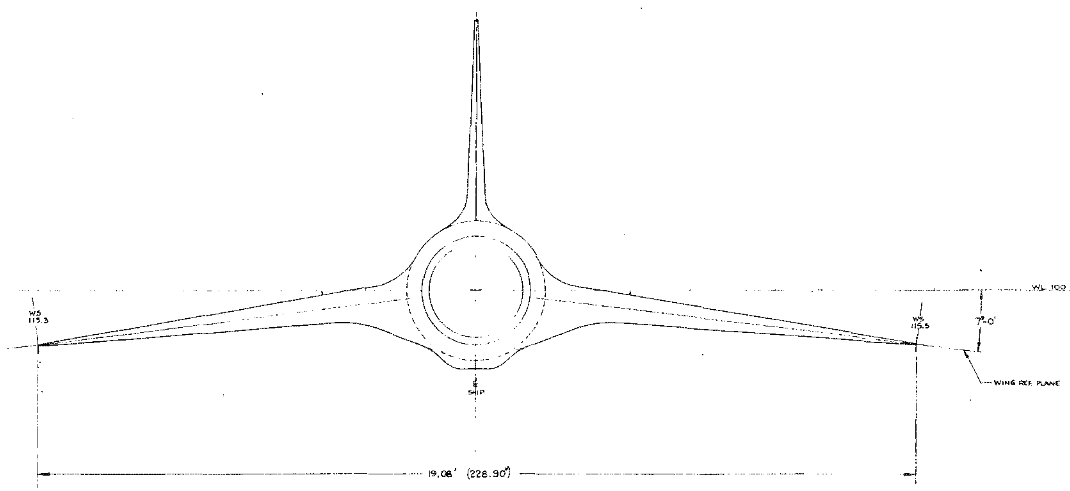
WEIGHT

LAUNCH WEIGHT	11,000 LBS.
ZERO FUEL WEIGHT	5,800 LBS
FUEL WEIGHT	5,200 LBS.
PAYLOAD WEIGHT - RECOVERABLE	880 LBS









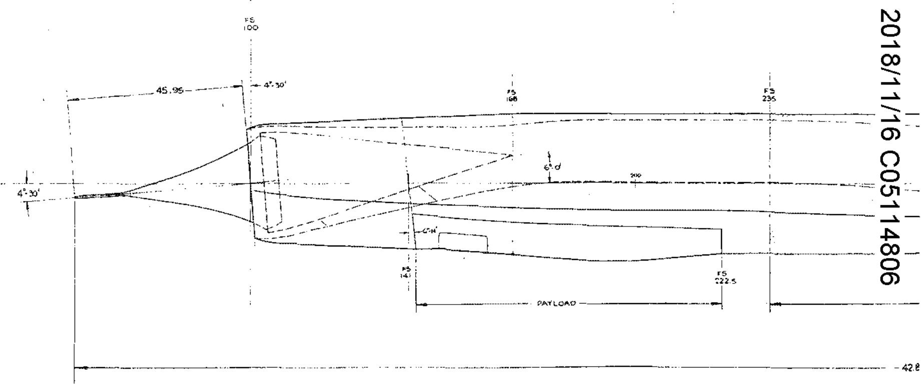
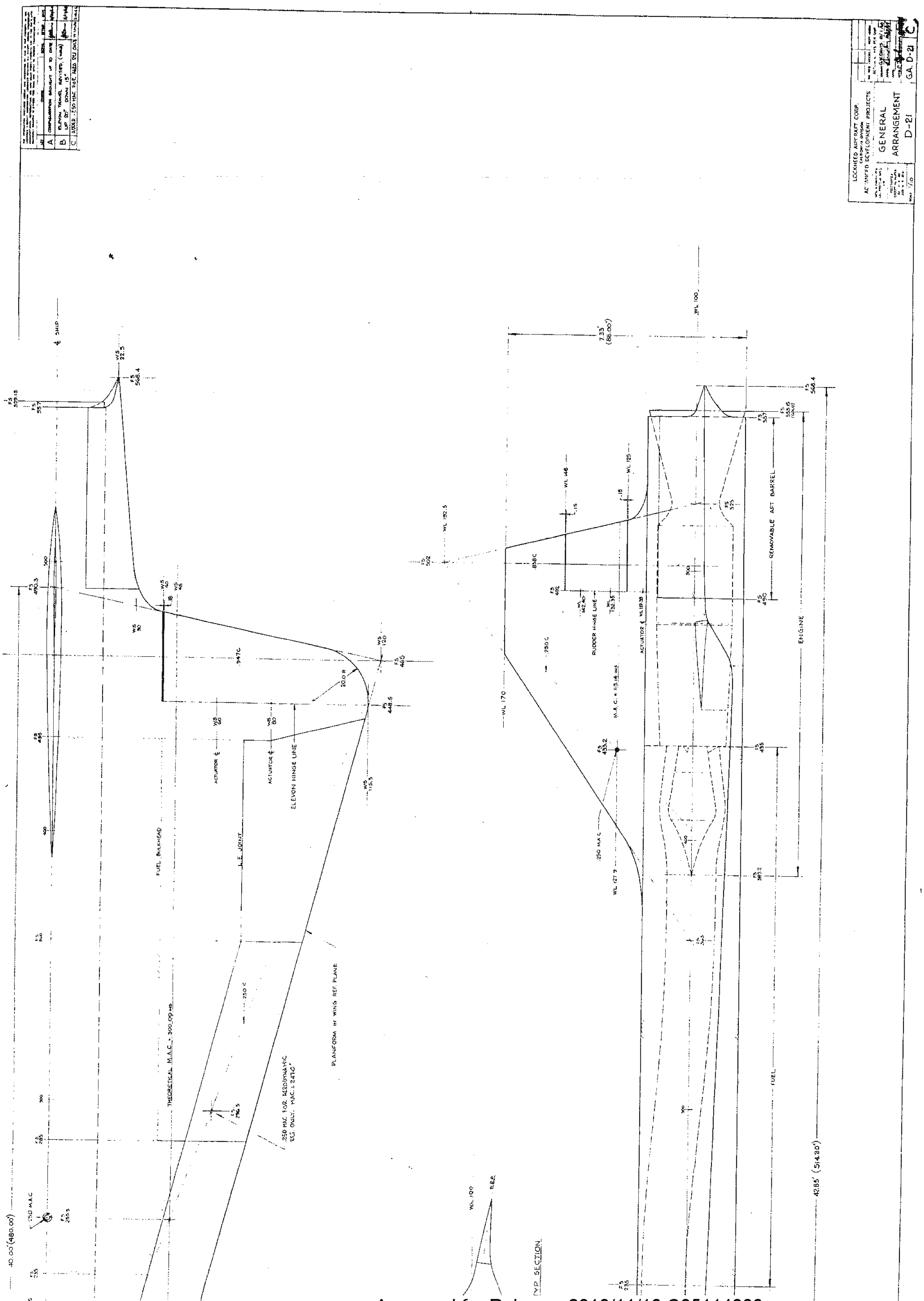
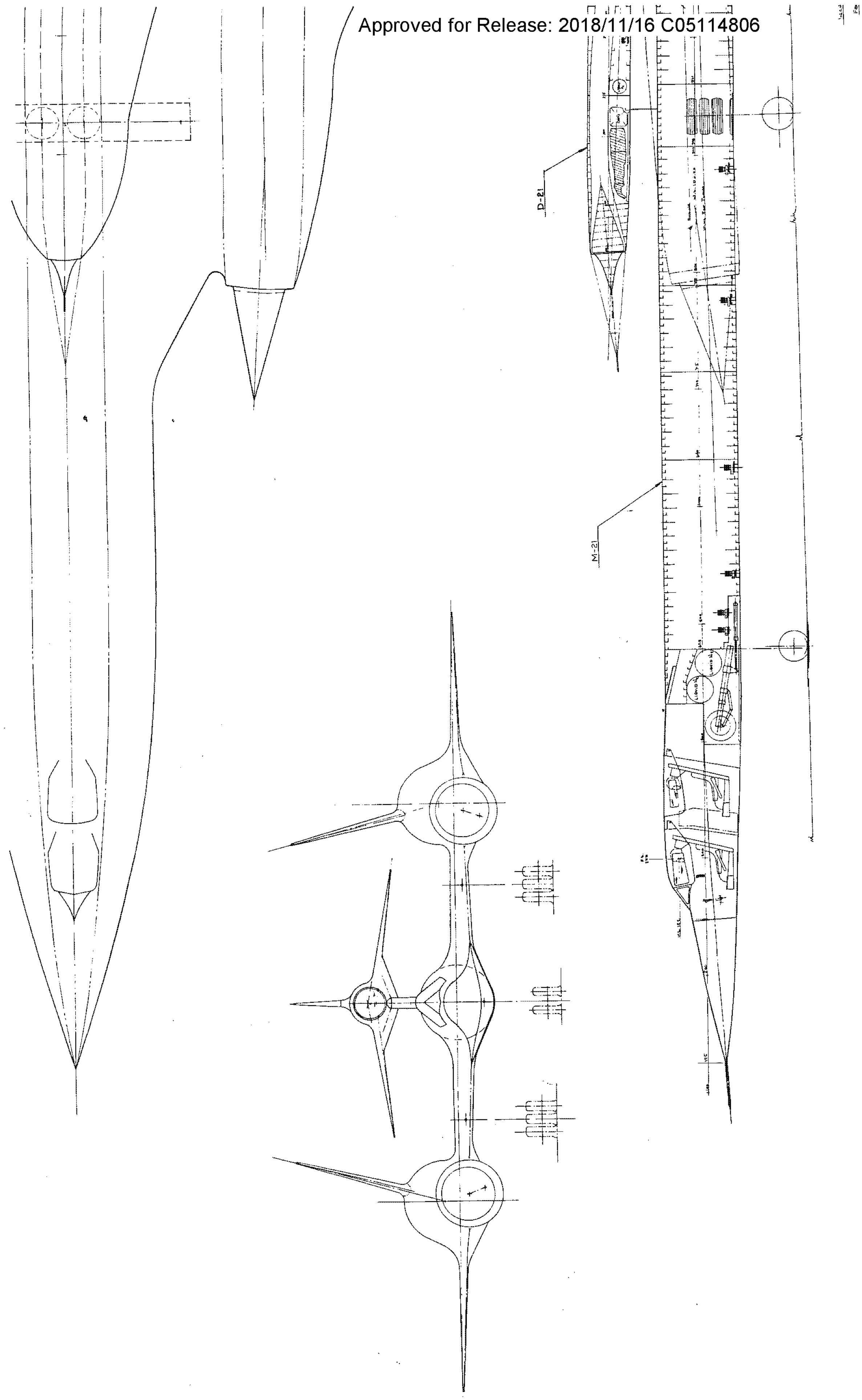
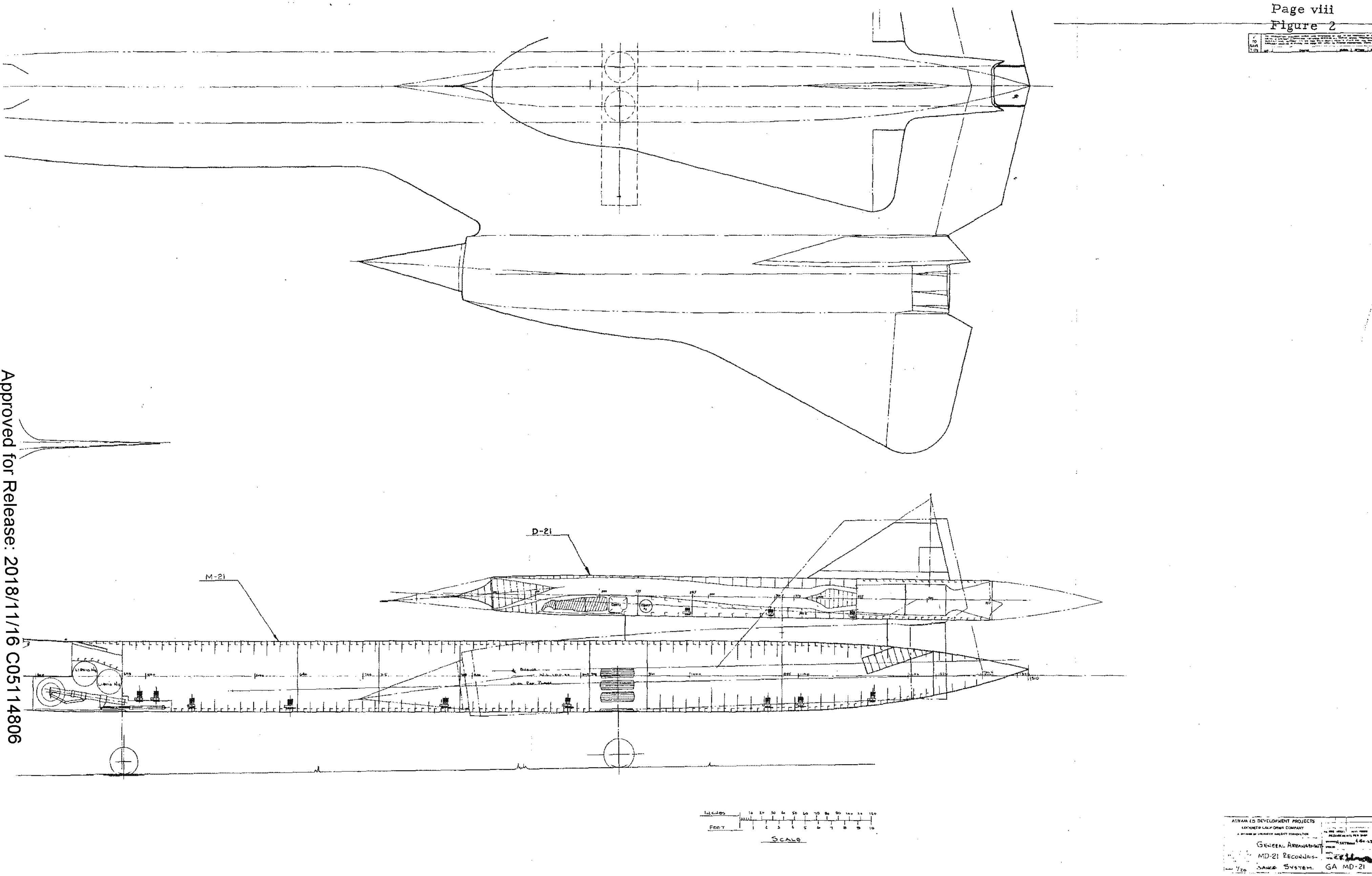


Figure 1


LOCKHEED AIRCRAFT CORP.
ADVANCED DEVELOPMENT PROJECTS
GENERAL
ARRANGEMENT
D-21
GA D-21
C
REMOVABLE AFT BARREL
ENGINE
FUEL
RUDDER HINGE LINE
ACTUATOR ℄
ELEVON HINGE LINE
FUEL BULKHEAD
L.E. JOINT
THEORETICAL M.A.C. = 300.00 in.
PLANFORM IN WING REF PLANE
TYP SECTION
℄ SHIP
WL 100
WL 170
7.33' (88.00")
42.85' (514.20")
20.00' (480.00")


D-21
M-21

SP-582
Page viii
Figure 2



AIRCRAFT - RAMJET - HIGH ALTITUDE - RECONNAISSANCE

1.0 SCOPE AND CLASSIFICATION

1.1 This specification covers the following aircraft:

Service Model Designation	-	Reconnaissance
Designers Name	-	Lockheed Aircraft Corporation
Model Designation	-	D-21
Number and Places for Crew	-	None
Number and Kind of Engines	-	One; RJ-43 Ramjet Model MA20S-4 (Modification of MA-11)
Ramjet Applicable Spec	-	MIL-E-8219

2.0 APPLICABLE SPECIFICATIONS, OTHER PUBLICATIONS, AND DRAWINGS

2.1 The following publications, with dates as listed below, form a part of the Specification.

2.1.1 Specifications*

"Airplane Strength and Rigidity", MIL-A-8860

2.1.2 Other Publications*

"Handbook of Instructions for Airplane Designers" - HIAD Tenth Edition

3.0 REQUIREMENTS

3.1 Characteristics

3.1.1 Configuration - (See General Arrangement drawing)

3.1.2 Performance -

3.1.2.1 Guaranteed Performance -

Performance data are guaranteed for the design mission.

*These documents are made part of this Specification and are complied with to the extent permitted by the radical nature of this vehicle and its intended mission.

3.1.2.2 Performance Curves (To be furnished)

3.1.2.3 The performance specified herein is based on the following atmospheric, fuel, and engine characteristics.

Atmosphere:	ARDC Model Atmosphere defined in AFCRC TR 59 267
Fuel:	PWA 523B Hydrocarbon Fuel Heating Value - 18,900 BTU/Lb. Weight at 50°F 6.6 Lbs./Gal.
Engine:	Engine Manufacturer's Specification ASD R 63-1 forms a part of this specification. Maximum thrust at 85,000 feet altitude at Mach 3.3 at 76% inlet recovery = 1,706 lbs. Specific fuel consumption at 85,000 feet altitude at Mach 3.3 at 76% inlet recovery = 2.08 lb./hr./lb. thrust.

3.1.3 Mission Requirement

Launch:	The D-21 is capable of being launched from an M-21 carrier aircraft.
Free Flight:	Launch (initial)altitude - 75,000 Ft. (max.) Initial Cruise Altitude - 80,000 Ft. Final Cruise Altitude - 95,000 Ft. Speed (Constant) - Mach 3.3 Range - 3,000 N.M.
Recovery:	The payload is jettisonable, and is capable of being recovered by modification to existing "parachute and snatch" systems, using a JC-130B as the recovery aircraft. The payload parachute will be installed in a suitable compartment adjacent to the payload.

3.1.4 Life - The operational life of each D-21 aircraft is approximately five hours. Therefore the airframe and its installed equipment is designed to have an operational life at maximum temperature, of twenty-five hours. This twenty-five hours is predicated on four mated flights of five hours each and one operational flight of five hours duration.

Minor components (such as "O" rings) of engine, servos, hydraulic and fuel systems may require replacement as a result of tethered flights at elevated temperatures.

3.1.5 Weights - (See following tabulations)

3.1.5.1	Design Gross Weight	-	11,000 Lbs.
3.1.5.2	Design Zero Fuel Weight	-	5,800 Lbs.
3.1.5.3	Actual Gross Weight	-	10,330 Lbs.
3.1.5.4	Actual Zero Fuel Weight	-	5,130 Lbs.

[redacted]

3.1.6 Center of Gravity Location -

Forward Limit	-	F.S. 300
Aft Limit	-	F.S. 316

3.1.7 Areas -

Wing area including elevons	-	388.5 sq. ft.
Elevon area each	-	12.9 sq. ft.
Vertical tail area including rudder at W.L. 100	-	49.0 sq. ft.
Rudder Area	-	3.77 sq. ft.
Flap area	-	None
Dive flap area	-	None

3.1.8 Dimensions and General Data -

Wing

Span	-	19.08 ft. (228.90")
Aspect Ratio	-	0.937
Chord		
Theoretical Root (Centerline aircraft)	-	40.0 ft. (480")
Reference MAC	-	20.6 ft. (247")
Location of 25% MAC	-	F.S. 296.5
Airfoil Section	-	Modified Bi-convex
Airfoil Thickness (constant)	-	2.3% (Max. thickness at .63C)

3.1.8 Dimensions and General Data - (Contd)

Sweepback at 25% Chord	-	70° 16' 33"
Cathedral	-	7°
Incidence	-	0
Elevons		
Span	-	6.26 ft. (75.1")
Chord		
Root (WS 40)	-	2.77 ft. (33.3")
Actual Tip (WS 115.30)	-	0
Average	-	2.076 ft. (24.912")
Hinge Line	-	F.S. 448.5
Vertical Tail		
Span (From WL 100)	-	5.83 ft. (70.0")
Aspect Ratio	-	0.694
Chord		
Root (WL 100)	-	13.5 ft. (162")
Tip	-	3.28 ft. (39.4")
MAC (WL 127.9)	-	9.425 ft. (113.1")
Airfoil Section	-	Modified Bi-convex
Airfoil Thickness	-	2-1/2% at WL 170 4% at WL 125 (Max. thickness at .70C)
Sweepback at 25% Chord	-	46° 48'
Rudder		
Span	-	1.89 ft. (22.7")

3.1.8 Dimensions and General Data - (Contd)

Rudder (Contd)

Chord		
Root	-	2.225 ft. (26.7")
Tip	-	1.758 ft. (21.1)
Average	-	1.992 ft. (23.9")
Hinge Line	-	F.S. 492

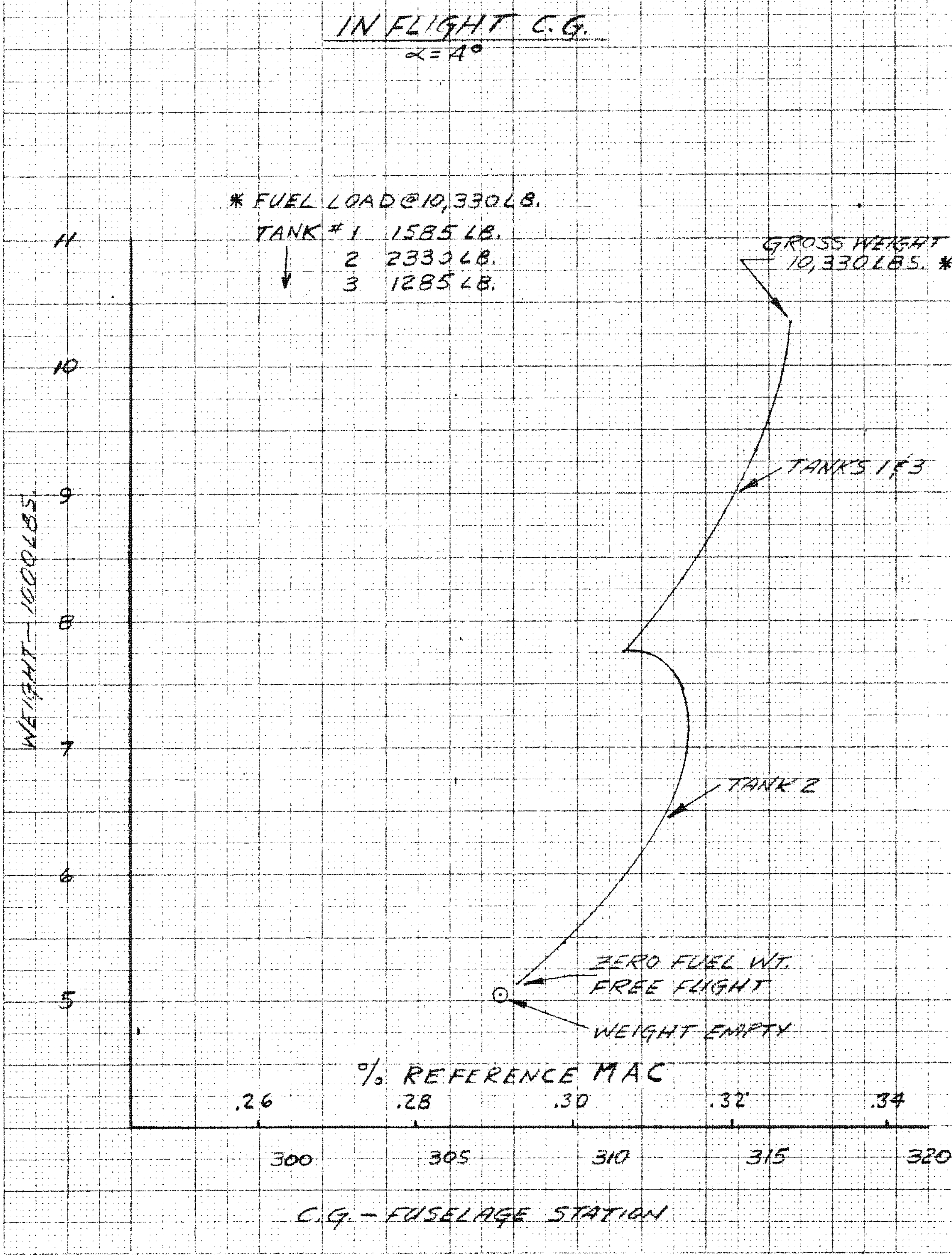
General

Over-all Height (FRL Horizontal)	-	7.333 ft (88")
Over-all Length	-	42.85 ft. (514.20")
Launch Angle (angle between wing reference planes of the D-21 and the M-21)	-	+ 2°

WEIGHT STATEMENT

	Lbs.
Wing	626
Tail	104
Fuselage	1,648
Surface Controls	145
* Propulsion	1,324
Auxiliary Power Plant	90
Hydraulics	105
Electrical	183
Electronics	224
Air Conditioning	63
Recovery System	135
Furnishings (Interior Insulation)	84
Payload	319
Unusable Fuel	80
Zero Fuel Weight	5,130
Fuel	5,200
Launch Weight	10,330

* Includes Engine Weight 490 Lbs.


IN FLIGHT C.G.
α = 4°
* FUEL LOAD @ 10,330 LB.
TANK #1 1585 LB.
2 2330 LB.
3 1285 LB.
GROSS WEIGHT 10,330 LBS. *
TANKS 1 & 3
TANK 2
ZERO FUEL WT. FREE FLIGHT
WEIGHT EMPTY
WEIGHT - 1000 LBS.
% REFERENCE MAC
.26
.28
.30
.32
.34
300
305
310
315
320
C.G. - FUSELAGE STATION

FORM 537

3.2 General

The aircraft is a midwing monoplane type, of metal and plastic construction. Design is as simple as possible consistent with the necessary operational, maintenance, and checkout characteristics. The basic aircraft with its power unit is expendable.

3.2.1 General Interior Arrangement - The interior arrangement is essentially divided into four sections located in a fore to aft relationship. The first section is the circular engine air inlet with the appropriate fixed spike and by-pass installations to control air flow and boundary layer removal.

The second section is the equipment installation bay, which houses the payload, recovery parachute, and major electronic gear. This compartment is suitably cooled.

The third section extending for 200 inches comprises three fuel tanks, suitably interconnected to provide the entire fuel supply for the engine.

The fourth section is devoted to the installation of the engine with its integral tail pipe and nozzle.

3.2.2 Materials - The main structural material is titanium alloy, except for those areas where temperature requirements dictate the use of stainless steel and/or other high temperature alloys. Non-metallic materials are used in areas found to be suitable or as required for mission accomplishment.

The design procedures, material properties, and material processes conform to the standards established in Contractor's Reports, LAD-105, LAD-108, SP-153D, SP-156B, SP-154C, and SP-377. Standard parts and usage are as described in Report LAD-109.

3.2.3 Workmanship - Construction of the aircraft, including such operations as detail fabrication, assembly, and equipment installation is accomplished in a thorough and workmanlike manner consistent with high-grade aircraft manufacturing practices.

3.2.4 Production, Maintenance and Repair - The first considerations in the design and construction of the aircraft are performance and reliability. Secondary considerations are ease of access, maintenance and repair. All factors leading to rapid producibility are given careful consideration, but are not incorporated at the expense of performance, reliability or ease of maintenance. The design, while utilizing high strength titanium alloys and high temperature plastic materials, employs conventional fabrication and assembly techniques to the maximum degree possible. precautions are observed in the handling, processing, and installation of titanium alloys to inhibit corrosion and fatigue. Such design practices and production procedures as defined in the documents outlined in Paragraph 3.2.2.

The design policy affecting the flight control system; and hydraulic, fuel, and electrical systems, is to eliminate insofar as possible, any incorrect installation or re-installation of components or assemblies. Fluid lines, linkages and wire, etc., are so designed that incorrect installation is not possible by inadvertent action, where such error would involve damage, malfunction, or safety of flight.

The design of the vehicle permits effective inspection, maintenance, and repair procedures to be utilized in production and service. Accessibility is provided to permit scheduled maintenance and preflight check-outs as required for mission accomplishment. Emphasis is placed on ease of replacement of major units such as engine, subsystem components, electronic equipment, and payload.

3.2.5 Interchangeability and Replaceability - The following components are interchangeable substantially in accordance with MIL-I-8500.

Rudder
Equipment Bay Hatch and Installed Components
Elevons

The following components are considered to be replaceable with minor trim and hole transfer.

Miscellaneous Doors
Vertical Fin
Wing Leading Edge

3.2.6 Finish - The standards used for the finish of the vehicle, both interior and exterior surfaces, are defined in the documents listed in Paragraph 3.2.2 of this specification.

3.2.7 Identification and Marking - No exterior markings other than the Manufacturer's serial number are applied to the aircraft.

3.2.8 Extreme Temperature Operation - The aircraft as a whole, with its equipment and accessories, is designed to meet the requirement for satisfactory function throughout the extreme environmental operation ambient flight temperature range of -90°F to +110°F. The ARDC temperature variation with altitude (Ref. AFCRC TR-59-267, #115, dated August 1959) is assumed for performance determination.

3.2.9 Ground Climatic Requirements - A ground ambient temperature range of -65°F to +160°F is assumed for the basic design of the aircraft. Special deviations to this temperature range must be given for the type of fuel, hydraulic oil and over-all cooling systems used. It is assumed that ground shelter will be provided so that normal ground environment is + 35°F to + 100°F.

3.2.10 Lubrication - Provisions made for lubricating the aircraft and its equipment and accessories are generally in accordance with the requirements of Specification MIL-L-6880B. However, due to unusual environmental conditions, some lubricants are selected as a result of Contractor's tests and are not necessarily in compliance with this Specification.

3.2.11 Standard Parts - Standard parts are as listed in the Lockheed Engineering Standards Manual, selection to be made in accordance with the requirements of MIL-STD-143.

3.2.12 Crew - Not Applicable.

3.2.13 Equipment Installation - The aircraft incorporates major items of equipment, or provisions therefore, as noted, listed in the following sub-paragraphs.

3.2.13.1 Armament - Not Applicable.

3.2.13.2 Inertial Navigation System

A Honeywell MH-390(D) Inertial Navigation System is installed on the equipment bay hatch. Output signals from the INS will be used as steering signals in the autopilot, and information signals in the payload. The system will provide point to point steering signals for up to 16 pre-determined destinations. The system position error may be updated to the accuracy of the M-21 immediately prior to launch. Maximum position error at launch, employing the stellar tracker installed in the M-21 will be $\pm$ 1.7 nautical miles. During free flight the maximum rate of error build up will be $\pm$ 2 nautical miles/hour.

[redacted]

The computer section is also used in conjunction with the In-flight Check-out System.

3.2.13.3 Instruments - Not Applicable.

3.2.13.4 Pyrotechnic Devices

[redacted]

3.2.13.4.1 Destruct System - A destructor system capable of destroying the aircraft and its payload is provided. The system shall conform to the intent of USAF Spec X-28663. The destruct system is armed by time/command after launch, and is actuated by: (1) altitude during free flight phase, or by (2) altitude command during the terminal phase after payload ejection. There is no provision for destroying the payload and electronic equipment after hatch ejection.

3.2.13.4.2 Payload Pyrotechnic devices, (Gas Generator, Initiator, and Thrusters), are utilized to release and eject the payload (including beacon) from the vehicle at the termination of the flight. Payload recovery is accomplished by a drogue gun deployed stabilization and recovery parachute system having cartridge actuated release pins.

3.2.13.4.3 Protective Covers - Window covers are secured with cartridge-actuated latches for in-flight jettisoning prior to launch.

3.2.13.5 In-Flight Check-out (IFCO) -

In order to insure a safe launch and successful mission completion, an in-flight check-out system is installed in the MD-21. The following D-21 systems are tested prior to launch from the M-21 (Launch Control Officer station):

1. Automatic Flight Control System
2. Inertial Navigation System
3. Payload
4. Engine
5. Electrical System
6. Command Receiver System

3.2.13.6 In-Flight Monitor (IFM) -

The following systems of the D-21 are monitored continuously at the LCO station:

1. Destruct System Temperature
2. Altitude Switches
3. Command System
4. Hydraulic System
5. Fuel System
6. APU Speed
7. Battery
8. APU Overspeed Lockout
9. Launch Sensing System
10. INS Position Error

Note: The M-21 launch system pressure is also continuously monitored by the LCO.

3.2.13.7 In-flight Subsystem Control -

During mated flight the following D-21 Systems are controlled from the LCO station:

1. Fuel System
2. Hydraulic System (Pressure Only)
3. Electrical System
4. INS Position Up-date

3.2.13.8 Launch Control -

The following launch functions are controlled from the LCO station:

1. Ejection of nose and tail fairings
2. Engine Fuel
3. Engine Ignition
4. APU Air Transfer

Note: Functional Systems transfer from mated to free flight occurs automatically on electrical umbilical separation.

3.2.13.9 Payload Hatch -

The payload hatch is located between Stations 141 and 222.5, on the underside of the fuselage.

The following equipment is mounted on the hatch and is ejected with the hatch:

1. Camera
2. Camera Electronics
3. AFCS Air Data Computer
4. INS Power Supply
5. INS Computer
6. INS Gimbal Control Electronics (GCE)
7. Inertial Electronics Unit (IEU)
8. INS Platform
9. Electronic Components Assembly
10. Recovery Beacon
11. Beacon Antenna Transfer Relay
12. Beacon Antennas
13. Generator Control Box
14. Command Receiver
15. Electrical Breakaway Couplings
16. Air System Breakaway Couplings

[redacted]

All of the above components are enclosed by a housing comprised of the hatch and hatch cover so as to provide a water tight and bouyant unit.

3.2.13.9 Payload Hatch (Contd)

In addition, the aerodynamic decelerator system is mounted on the hatch, but not within the water tight housing.

3.2.13.10 Removable Fairings -

Nose cone and tail fairings are provided for streamlining during mated flight. Both fairings are jettisoned prior to engine ignition and launch.

3.3 Aerodynamics

3.3.1 General - The external configuration of the aircraft is based on a modified delta wing planform. The body incorporates the circular air inlet with its spike in the extreme forward nose. The forebody incorporates chines which act as a canard-like surface. The engine is in the afterbody, and because of its completely internal installation, results in a smooth streamlined appearance for the entire aircraft. In general, all external surfaces are flush, utilizing butt joints and flush attachments.

3.3.2 Stability and Control - The aircraft is aerodynamically stable. The low aerodynamic damping at high altitudes requires artificial stability augmentation. Special effort is made to obtain the most stable platform at high altitude that the state of the art allows.

3.3.3 Jettison - The D-21 may be jettisoned, with no engine power, and with no "on board" electrical or normal hydraulic power available.

3.4 Structural Design Criteria

3.4.1 General - The structural design criteria is based on the intent of the requirements of specification MIL-A-8860 (ASG), dated 18 May 1960.

3.4.2 Maximum Flight Design Gross Weight - The maximum flight design gross weight is 11,000 pounds for captive flight, launch, and free flight.

3.4.3 Landing Design Gross Weight - Not applicable.

3.4.4 Limit Flight Load Factors - Limit flight load factors are positive 2.0g and zero g for captive flight. Free flight maneuver load factors are positive 5.0g and negative 2.0g.

The maximum free flight gust load factor is based on an empty weight and a gust velocity of 27.5 ft./sec. (rough air). Critical altitude and speed are 60,000 ft. and 400 keas respectively.

Δn_z (gust) = 2.00g

$\therefore n_z$ (total) = 3.00g

Maximum captive flight gust load factor is based on an MD-21 gross weight of 62,700 pounds and gust velocity of 45.8 ft./sec., and altitude of 25,000 ft. and V_H = 400 keas.

Δn_z (gust) = 2.32g

$\therefore n_z$ (total) = 3.32g

3.4.5 Limit Landing Load Factor - Not Applicable.

3.4.6 Limit Dive Speed - The limit dive speed is 450 knots EAS, both for captive flight and free flight. Above 69,500 feet captive flight is limited to Mach 3.2 and free flight to Mach 3.3.

3.4.7 Limit Taxi and Ground Handling Load Factors

3.4.7.1 Taxi Loads -

Taxi of the towable transporter cart does not generate load factors within the aircraft, greater than those listed for ground handling conditions.

3.4.7.2 Ground Handling Loads

For the 11,000 pounds gross weight condition the ground handling load factors are:

3.4.7.2 Ground Handling Loads - (Contd)

Vertical:	± 2.0g
Lateral:	± 0.5g
Fore & Aft:	± 0.5g

3.4.7.3 Air Transport Loads -

For the 5,800 pounds gross weight condition (no fuel) the following combinations are applied:

Vertical:	± 2.0g
Lateral:	± 2.0g
Fore & Aft:	± 0.5g

3.4.7.4 Jacking Loads -

Structural strength is provided for hoisting the vehicle at appropriate points and for transporting the vehicle on a towable cart.

3.4.7.5 Crash Loads -

For a crash condition wherein the D-21 is mated to the M-21, strength is provided to withstand a forward load factor of 3.0g(ult.) at a D-21 gross weight of 11,000 pounds. Under this condition, the D-21 fuel is retained in its mated position, D-21 fuel is retained, and all components aboard the D-21 remain fixed in their normal locations. Strength is further provided to withstand a 6.0g (ult.) forward acting load factor at a D-21 gross weight of 11,000 pounds. Under this condition, the D-21 is retained in its mated position and major D-21 components are retained aboard the D-21. Loss of D-21 fuel can occur under this condition, however.

3.5. Wing Group

3.5.1 [redacted]

3.5.2 [redacted]

3.5.3 [redacted] Elevon travel is 17° up and 18° down.

There are no provisions for balance weights or trim tabs.

3.6 Tail Group

3.6.1 Description and Components - The tail group consists of a vertical stabilizer mounted on the centerline of the upper aft fuselage, containing a hinged rudder. Rudder travel is 10° each side of neutral.

3.6.2 Construction - The vertical stabilizer and rudder are titanium throughout and are of conventional skin and rib construction.

3.6.3 Rudder - The rudder is operated by a torque tube mounted in the stub fin. The rudder servo unit is connected to the torque tube, and is mounted on the upper surface of the fuselage within the stub fin.

3.7 Body

3.7.1 Fuselage -

3.7.1.1 Essentially, the fuselage is a cylindrical shape extending from the engine air inlet to the engine tail pipe. The general configuration contains the major elements necessary for the aircraft mission. The smooth streamlined form is the result of aerodynamic and functional considerations.

3.7.1.2 Construction -

The prime fuselage structure is a titanium alloy, semi-monocoque construction, employing smooth skin attached to formed frames.

Two major openings are provided in the fuselage:

One, in the forward lower body between Stations 141 and 222.5, and approximately 40 inches wide. This opening accommodates the equipment compartment hatch which is ejectable.

The second opening is on the top centerline of the mid-fuselage over the fuel tank area; approximately 22 inches wide, it extends from Station 235 to Station 385. This opening provides access for servicing and inspecting the fuel tanks.

Suitable insulation is applied to the outside of the fuselage in the vicinity of the fuel tanks.

3.7.1.3 Equipment Compartment -

The equipment compartment is constructed in the forward section of the fuselage between Station 141 and Station 235. Titanium structure is designed to provide the necessary space and mounting provisions for the auxiliary power unit and other subsystem equipment.

3.7.1.3 Equipment Compartment - (Contd)

The major electronic equipment, the payload, and the recovery parachutes are all mounted on the compartment hatch in the opening provided in the fuselage. The hatch is ejectable to serve as a platform for the payload and electronic gear in their recovery descent.

3.7.1.4 Dive Flaps - None

3.8 Alighting Gear

None

3.9 Surface Control System

3.9.1 Primary Flight Control - The basic flight control system consists of an autopilot, servo control valves, hydraulic actuating cylinders and the surfaces. The prime motivation will be the signals derived in the autopilot and stability augmentation system. These signals will in turn control the positioning of the servo valves, thus establishing the flow of oil to the hydraulic cylinders located at the surfaces. Two sets of two cylinders actuate the elevon and one cylinder actuates the rudder. Automatic spring-loaded locks are provided to prevent flutter in the event of complete loss of hydraulic system during mated flight. Emergency jettison control valves actuated and powered by the emergency jettison hydraulic system meter oil directly to the primary cylinders to position the surfaces for jettison. The major components of the flight control system are designed as subassemblies where practicable to facilitate bench assembly and check-out. The autopilot is located in the equipment compartment hatch and the servos and cylinders in the tail group. Accessibility is provided for inspection, removal, and replacement.

3.9.2 Secondary Flight Controls - None

3.9.3 Lift and Drag Increasing Devices - None

3.9.4 Trim Control System - None

3.9.5 Automatic Flight Control System - The automatic flight control system consists of the air data computer, the stability augmentation system and the autopilot. The air data computer provides a source of data for the stability autmentation system, the guidance system, and the payload. The stability augmentation system incorporates logic circuitry to insure maximum reliability. Stability augmentation is provided on three axes. The autopilot modes are launch, cruise or Mach hold, and recovery mode.

3.10 Engine Section

3.10.1 Description and Components - The engine is contained in the aft portion of the fuselage.

3.10.2 Construction - The fuselage structure in this area is all metal, semi-monocoque structure utilizing titanium alloy as the prime material.

3.10.3 Engine Mounts - The engine is mounted by means of spherical ball fittings located in two fuselage planes. At Station 435.93 a single ball fitting attaches to the bulkhead on the top centerline. This fitting is designed to take full engine thrust loads. At Station 468.13 the mounting consists of three spherical ball fittings located at 120 degree intervals around the engine. These fittings are attached to the fuselage frame at this station through suitable linkages designed to take engine radial loads.

3.10.4 Vibration Isolators - None

3.10.5 Firewall - Fuselage Station 435 bulkhead serves as an aft tank bulkhead as well as a firewall.

3.10.6 Cowling and Cowl Flaps - Not applicable.

3.10.7 Access for Inspection and Maintenance - Access to the engine is by removal of the aft fuselage structural shell.

3.11 Propulsion

3.11.1 General Description and Components - One Marquardt, RJ-43, Model MA-20-S-4 Ramjet engine constitutes the propulsion system for the aircraft.

3.11.2 Auxiliary Propulsion Units - None

3.11.3 Engine-Driven Accessories - None

3.11.4 Air Induction System - The air induction system consists of a circular inlet located in the extreme forward portion of the fuselage. A duct, circular in cross section, connects the air inlet to the engine. An inlet fixed spike and by-pass vent installations are provided to control inlet shock position and boundary layer removal.

3.11.5 Exhaust System - The exhaust system is supplied with the engine and consists of a tailpipe and a nozzle.

3.11.6 Engine Compartment Cooling - The engine compartment is cooled by bleed air taken from the main air inlet duct through a fixed annulus ring located at fuselage Station 435. The gap in the engine tailpipe is calibrated to provide a cooling air flow around the engine.

3.11.7 Lubrication System - The lubrication system is integral with the engine.

3.11.8 Fuel System -

3.11.8.1 Description and Components -

The fuel is contained in three integral tanks, with the center tank as the sump tank feeding the engine. The fuel transfer system consists of an AC electrically driven fuel pump, one each in the forward and aft tanks, pumping to the center sump feed tank for C.G. control. The center feed tank has an AC electrically driven booster pump to maintain adequate pressure and flow to the engine.

A nitrogen inerting system is installed to pressurize the fuel to 1.5 ± 0.5 psi. The nitrogen is carried in liquid form in a Dewar flask. The quantity of nitrogen is sufficient for the maximum mission duration, or for a return to base in case of an abort at the launch point.

3.11.8.2 Fuel System Management -

The fuel in the D-21 is used as the heat sink for the electronic equipment and hydraulic fluid cooling system. In order to insure relatively cool fuel in the D-21 during the free flight portion of the mission the following system is employed.

3.11.8.2 Fuel System Management - (Contd)

Take-off to refueling point - D-21 fuel is pumped into the M-21 engine feed line. During the descent to refuel the auxiliary M-21 fuel dump valve is opened and any fuel remaining in the D-21 is pumped overboard.

Refuel point to launch point - The D-21 is filled with fuel from the M-21 during the M-21 aerial refueling operation.

During the climb-out and cruise the D-21 again supplies fuel to the M-21 engines. Just prior to launch the D-21 tanks are "topped off" with fuel pumped from the M-21.

Fuel management is performed by the Launch Control Officer.

3.11.8.3 Pumps -

All pumps are the submerged centrifugal type, three phase, 200 volts, 400 cps AC, induction wet motors, which are able to operate at 230/520 cps.

3.11.8.4 Tanks -

The fuel is contained in three tanks integral with fuselage and inner wing structure. Total usable fuel is 5,200 pounds at 6.6 pounds per gallon. A 3% air space is utilized for fuel expansion.

3.11.8.5 Vent System -

All tanks vent into a common manifold line and relieve through a pressure relief valve set at a nominal 3 psi $\pm^{.25}_{0}$, and vacuum relief set at 2 to 4 inches of water.

3.11.8.6 Piping and Fittings -

Aluminum alloy piping and fittings are utilized for fuel, the nitrogen, and vent systems.

3.11.8.7 Valves -

Electrically operated solenoid shut-off valves are installed on the engine fuel feedline and on the defuel and refuel lines to the M-21 aircraft. Dual float-operated shut-off valves are installed on the fueling lines in each tank. Pressure fueling from the M-21 aircraft is utilized for ground fueling and aerial refueling. Self-sealing breakaway fittings are utilized between the two aircraft. Suitable check valves are used as required.

3.11.8.8 Strainers and Filters -

A 200 mesh fuel filter is installed in the engine feedline.

3.11.8.9 Quantity Gages -

No quantity gages are installed.

3.11.8.10 Fuel Vapor Inerting -

The quantity of nitrogen aboard is sufficient to inert the tanks for two aerial refuelings and a final MD-21 descent. The quantity of nitrogen aboard is determined by overfilling the system.

3.11.8.11 Drainage Provisions -

Each fuel tank has adequate provisions for draining sediments and water at low tank points.

3.11.8.12 Fuel Evaporation Control -

Fuel evaporation is controlled by use of low vapor-pressure fuel and by tank pressurization in excess of the fuel vapor pressure.

3.11.8.13 Refueling Provisions -

The vehicle has a pressure refueling breakaway fitting in the bottom of the fuselage. This connects to a trunk line leading to all tanks.

3.11.8.13 Refueling Provisions - (Contd)

Dual shut-off valves in each tank are controlled by dual pilot valves which are located at a point which gives approximately 3% air space when the MD-21 aircraft is either ground fueling or air refueling. All pressure refueling shall be from the M-21 aircraft.

3.11.8.14 Defueling Provisions -

The vehicle is defueled through a breakaway fitting to the M-21 aircraft. The AC booster pump in Tank No. 2 is used for defueling.

3.11.9 Ignition System - A triethylborane ignition/re-ignition system is provided, and is an integral part of the engine.

3.12 Auxiliary Power Unit

3.12.1 Description and Components - An auxiliary power unit is provided to drive the hydraulic pump, the AC/DC generator, and to furnish cooling air for the electronic units and the payload. This unit consists of a variable area nozzle air turbine, gear box and power pads, lubricating system, speed control system, and an outlet air temperature control system. Turbine exhaust temperature is sensed by thermistors connected through the temperature control system to the fuel flow by-pass valve which meters heat exchanger inlet fuel as required to regulate cooling air within set limits. Up to 20,000 ft. altitude, because of the possibility of freezing, exhaust air is controlled to a minimum temperature of 40°F. Above this altitude a control temperature of 0°F is maintained to provide greater cooling capacity where moisture is not a problem.

3.12.2 Power Source - During free flight the air for driving the auxiliary power unit is obtained from the engine inlet duct. On the ground and during mated flight, air for driving the unit is obtained from the M-21 engine air bleed system. This air is pre-cooled by the existing M-21 heat exchanger system and further cooled as required by the D-21 heat exchanger. For ground operation with the M-21 engines off, the auxiliary power unit may also be operated by a ground truck (such as MA-1A) through a ground connector in the wheelwell of the M-21.

3.13 Electric System

3.13.1 Description - Power Source - The prime power source for the electric system is a 4 kva 120/208V, 400 cps AC brushless generator, combined with a 100 amp, 28V DC brushless generator in the same housing, which is driven at 12,000 $\pm$ 5% rpm by the auxiliary power unit.

AC and DC power are supplied to utilization equipments via simple distribution systems.

A 600 VA solid state inverter is supplied to provide 400 cps $\pm$ 2%, 115/200 VAC power to the Inertial Navigation System and the Autopilot.

3.13.1.1 General Conformance -

The electrical system conforms to the intent of MIL-E-25366.

3.13.2 Batteries -

3.13.2.1 Aircraft -

A 28V, 25 ampere hour silver-zinc battery is provided to supply power for the inverter, command receiver, the destruct system, and the recovery system after engine shut-down and prior to package separation.

The battery is connected to the remainder of a direct current system via a blocking diode which allows the battery to receive power, but prevents the battery from discharging into any other than the above specified loads.

3.13.2.2 Package -

A smaller battery is provided for the recovery system beacon and is installed inside the beacon package.

3.13.3 Receptacles - An umbilical receptacle is located on the bottom centerline of the vehicle and mates with its counterpart installed in the pylon on the M-21 vehicle. Wires connected to this receptacle are used to supply power and for check-out of the vehicle when mated with the M-21 and for ground check-out. The use of plugs and receptacles on equipment is avoided as far as practicable and terminal blocks and/or permanent splices are used instead.

3.13.4 Equipment Installation - All equipment, except those items required for the fuel system, engine control, and the auto-pilot gyros, are located in the equipment compartment, or are an integral part of the recovery package.

3.13.5 Wiring - The electrical wiring installation is in accordance with applicable requirements of specification MIL-W-8160 as interpreted by approved Lockheed Process Specification. MIL-W-8777 wire (300°F ambient) is installed in the equipment compartment. Wire installed in uncooled areas is MIL-C-25038 nickel clad copper wire suitable for 650° F ambient temperatures. MIL-W-16878C, Type E Teflon wire (329°F ambient) is installed in the fuel tanks. Spec LAC 1-140 wire is installed in the payload package.

3.13.6 Bonding - Bonding is accomplished in accordance with the requirements of specification MIL-B-5087.

3.13.7 Controls - (Refer to 3.2.13.7)

3.13.8 Lighting - Not applicable.

3.13.9 Ignition System - (See 3.11.9)

3.13.10 Indicators - Not applicable.

3.13.11 Electric Drives - Not applicable.

3.13.12 Relays - The utilization and installation of relays is based upon the requirements of the aircraft system. Relays conform to MIL-R-6106 or their applicable detail specifications and MS drawings.

3.13.13 Booster Coil - Not applicable.

3.13.14 Filters - Radio interference filters are installed as required in conformance with the requirements of MIL-I-6051.

3.14 Hydraulic System

3.14.1 Description and Components - A single hydraulic system is provided to actuate the flight control surfaces only. The system consists of an APU driven variable delivery pump, a pressurized reservoir, filters, valves, fittings and tubing as required. Components conform to MIL-H-8775, except where deviations are necessary to provide satisfactory operation throughout the intended ground and flight envelope.

3.14.1 Description and Components - (Contd)

Dual operating pressures are provided in the system. The basic system pressure used for free flight operation is 3300 psi at zero flow and 3200 psi at the full flow condition.

To prevent structural damage during certain mated flight regimes, the hydraulic system pressure is reduced to 900 psi. Pressure control is effected by solenoid operation of a pressure reducing valve via a switch at the LCO station.

The hydraulic fluid used in the system is SP-302, a high temperature de-waxed mineral oil. An oil-to-fuel heat exchanger is provided to prevent fluid temperature at the pump from exceeding 500°F. The hydraulic system is designed to conform to the intent of MIL-H-25475, except where deviations are necessary to provide satisfactory operation throughout the intended ground and flight envelope.

3.14.2 Emergency Hydraulic System -

3.14.2.1 Emergency hydraulic power is supplied by a cold gas blow-down accumulator which directs reserve fluid through mechanical servo valves into the primary actuators to position the control surfaces for jettison.

3.15 Pneumatic System

3.15.1 Adequate cooling for the electronic equipment and payload installed in the equipment compartment is provided by the auxiliary power unit (see Paragraph 3.12.1). Cool air is ducted directly to electronic units to provide suitable air circulation within the units as specified by the manufacturer, and air is also supplied for externally cooling the payload and other equipment not internally cooled. At low altitude when there may be free water in the air leaving the auxiliary power unit, the air passes through a water separator, which removes approximately 70% of the free moisture.

3.15.2 Ground Cooling - For cooling when the D-21 is mated to the M-21, a ground connection is provided in the wheelwell of the M-21 through which either high pressure air may be supplied to operate the auxiliary power unit under load and provide cool air, or low pressure cool air may be provided for cooling only.

3.15.2 Ground Cooling - (Contd)

For operation when the D-21 is not mated, the same air sources as above may be connected directly to the bleed air coupling nipple on the D-21.

3.15.3 Anti-Icing Provisions - None

3.16 Utilities and Equipment Subsystems

3.16.1 Instruments - None

3.16.2 Furnishings - None

3.16.3 Oxygen System - None

3.16.4 Emergency Rescue - None

3.17 Communications, Navigation, and Guidance

The following Equipment is installed, placed in normal operating condition, and tested in accordance with the intent of MIL-E-25366.

The equipment conforms to MIL-E-8189 where possible.

Inertial Guidance System
Autopilot with Stability Augmentation System
Command Receiver
Recovery Beacon

This equipment is located in a cooled compartment.

3.17.1 Communication Equipment - A five channel command receiver is provided, for remote control of the beacon, fuel shut-off, package eject, destruct arm, and destruct disable.

3.17.2 Navigation Equipment - A Honeywell MH-390 (D) Inertial Navigation System is installed to provide steering information to the Autopilot and present position for programming operating commands.

3.17.3 Autopilot - (See 3.9.1)

3.17.4 Antenna Installations - Two antennae will be installed in the forebody of the fuselage. These antennae installations will conform to MIL-A-7772 where possible.

3.18 Reconnaissance System

Provisions for installation of a GFAE camera (Hycon HR-335) and accessories, are made.

3.19 Fire Control System - None

3.20 Armament System - None

3.21 Ground Handling and Servicing Provisions

3.21.1 Towing Provisions - None

3.21.2 Jacking Provisions - None

3.21.3 Mooring Provisions - None

3.21.4 Hoisting Provisions - Hoisting fittings are provided at appropriate points for raising and lowering the vehicle off and on the towable transporter cart, and the M-21 aircraft.

3.21.5 Measuring and Leveling Provisions - Are installed at Stations 222.5 and 444.5.

3.22 Aerial Refueling System

(See Paragraph 3.11.8.2)

4.0 QUALITY ASSURANCE PROVISIONS

The method of inspection and tests are in accordance with Lockheed Aircraft Corporation, Advanced Development Projects Division standard procedure.

5.0 PREPARATION FOR DELIVERY

Vehicle will be prepared and delivered in accordance with the terms of the contract.

6.0 NOTES

6.1 Intended Use

This specification is intended to describe the vehicle configuration at time of delivery as complete, assembled and flyable unit produced by Lockheed Aircraft Corporation under terms of the contract.

6.2 Revisions

The Contractor will take suitable action to maintain this specification current by issuance of revised pages as necessary and appropriate, through delivery of the last vehicle described by this specification.

14 00050818D

Dear Leo: 12 April 1966

Subj: D-21 Manufacturer's Model Specification, SP-582

The subject ~~manual~~ Spec has been brought up-to-date. Significant changes made under Revision "B" are as follows:

Page viii - General arrangement. Elevon travel angle changed from up 20° and down 15° to up 17° and down 18°. The aerodynamic reference MAC quarter chord was added.

Note lower vets

Page 3 - Actual gross weight and actual zero fuel weight added. C.G. aft limit changed from F.S. 315 to F.S. 316.

Page 6 - Weight statement; completely revised.

Page 7 - Center of gravity curve; completely revised.

Page 11 - Paragraph 3.2.13.2; number of INS pre-determined destinations changed from 8 to 16. Paragraph 3.2.13.4.1; deleted.

Page 13 - Paragraph 3.2.13.9; reidentification of some of the hatch equipment.

Page 27 - Paragraph 3.14.2.1; Hot Gas changed to Cold Gas.

Other changes to the ~~manual~~ spec involve phrasing and verb tense, and are of a minor nature.

Regards,

Kelly

cc: Col. F. Hartley