TABLE OF CONTENTS

FIGURE INDEX

INTRODUCTION

This report presents a study of a lightweight reconnaissance aircraft designed for flight at very high altitude and speed. Previous studies on larger aircraft known as Archangel I and II resulted in types having a gross weight of 100,000 pounds to 135,000 pounds, which were considered too large for the purpose intended.

The small aircraft described in this study (and called A-3 hereafter) has a gross weight of approximately 32,000 pounds. Its construction at this weight calls for extreme weight control and ingenuity of design in order to obtain satisfactory performance and range.

DESIGN AIMS

The conception of the aircraft included the following major considerations:

1. The aircraft had to be a "self-contained" unit, requiring no launching assistance from other aircraft.
2. The turbojet engines used must be an adaptation of a type already in existence.
3. The fuel used initially should be of a petroleum type not requiring large new facilities for its production.
4. The aircraft should be capable of exploiting the more advanced boron fuels.
5. The radar cross section of the aircraft should be minimized in every way feasible.
6. The minimum initial cruise altitude should not be less than 90,000 feet. Target altitude should be 95,000 feet or more.
7. Radius of action, including a 180° turn, should be no less than 1500 nautical miles at a cruising speed of $M = 3.0$ to 3.2 on petroleum fuel. With borane fuels, the radius should be approximately 2000 nautical miles at the same or higher altitude and speed.
8. The minimum weight and cost should be achieved for the system.

DESCRIPTION OF AIRCRAFT

The A-3 aircraft has a wing area of 500 square feet, span of 33.6 feet and length of 62.5 feet.

It is powered by two afterburning Pratt and Whitney JT-12 engines assisted by two 40-inch diameter ram-jets. The turbojets are located above the wing, which is shaped around the bottom of the engines to reduce the frontal area. The ram-jets are located on the tips of the wing. Figure 1 shows the general arrangement of the aircraft.

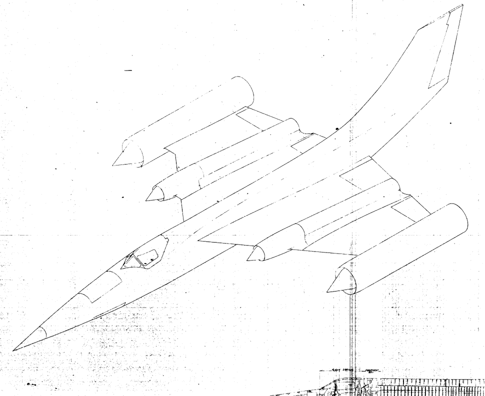
The nose of the aircraft holds the equipment bay, cockpit and nose gear. Aft of the cockpit, the whole fuselage contains a series of integral fuel tanks until the tail structure is reached. The 3 percent thick wing also holds fuel which is burned in climb to avoid high temperature effects at high speeds. Each ram-jet carries 1100 pounds of fuel in its center section. This fuel is the first to be used.

The use of a horizontal tail is subject to wind tunnel tests. It is desirable to delete it from a radar cross section point of view, if possible. An alternative design incorporating a horizontal tail is being carried forward, in case stability and drag tests show it to be necessary.

POWER PLANTS

The turbojet power plants used are two Pratt & Whitney JT-12 engines having a take-off sea level rating of 4,000 pounds. Afterburners are used on the engines, and it is necessary to provide for Mach 3.2 operation by material changes at several points in the engine. We have been told that major aerodynamic design changes are not required. The basic JT-12 engines have run and passed an unofficial 50-hour test at their current design rating. Discussions with the engine manufacturer indicate that the adaption of the engine to the A-3 is not considered to be a difficult task. This engine was chosen because it has an excellent thrust/weight ratio and a low compression ratio, which adapt it to high speed. Figure 2 shows the thrust variations with altitude used in this report, based on data received from Pratt & Whitney.

The tip ram-jets have been studied based on data from Marquardt and Pratt & Whitney, and thrust output is also shown in Figure 2. It will be seen that at high altitude the ram-jets provide by far the major portion of the required thrust. The specific fuel consumption of the ram-jets is as good as, or better than, that of the turbojet engines, when operating above Mach 3.0. Final figures on the weight breakdown are not available but are believed to be about 600 pounds to 800 pounds each, which



WING -

AREA	500.00 SQ. FT.
ASPECT RATIO	1.800
TAPER RATIO	.333
ROOT CHORD	25.00 FT. (300.0 IN.)
TIP CHORD	8.33 FT. (100.0 IN.)
SPAN	30.00 FT. (360.0 IN.)
DIHEDRAL	0°
INCIDENCE	4°
AIRFOIL — MOD. BI-CONVEX	3%
SWEEPBACK AT .25C	31½°
M.A.C. AT WING STA. 75.0	216.67 IN.

ELEVONS -

AREA (EACH)	23.10 SQ. FT.
TRAVEL	±20°

VERTICAL TAIL -

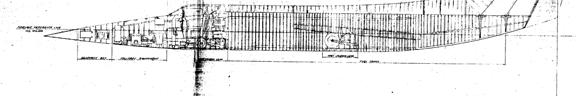
AREA	75.00 SQ. FT.
ASPECT RATIO	.853
TAPER RATIO	.500
ROOT CHORD	12.50 FT. (150.0 IN.)
TIP CHORD	6.25 FT. (75.0 IN.)
SPAN	8.00 FT. (96.0 IN.)
AIRFOIL — MOD. BI-CONVEX	4%
SWEEPBACK AT .25C	40½°
M.A.C. AT FIN STA. 42.67	166.67 IN.

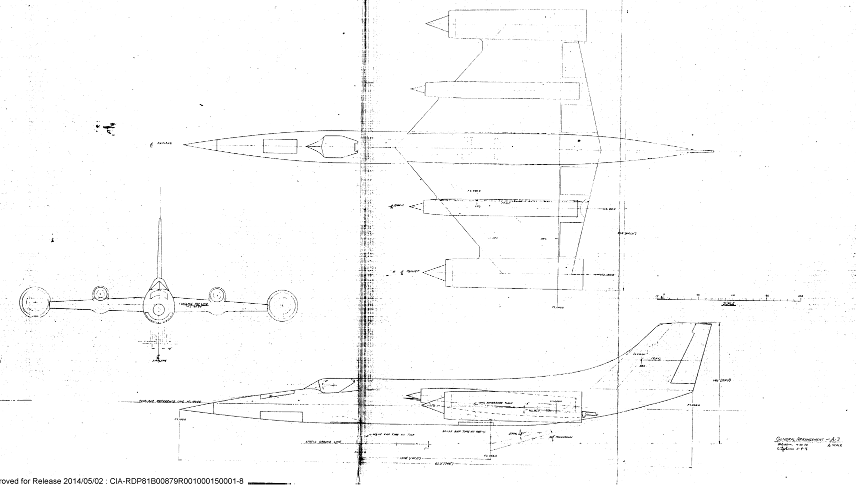
RUDDER -

AREA	16.45 SQ. FT.
TRAVEL	25° R

FUSELAGE -

MAXIMUM WIDTH	47.00 IN.
MAXIMUM DEPTH	65.00 IN.
OVERALL LENGTH	64.33 FT. (748.0 IN.)
FRONTAL AREA	15.25 SQ. FT.





STAT

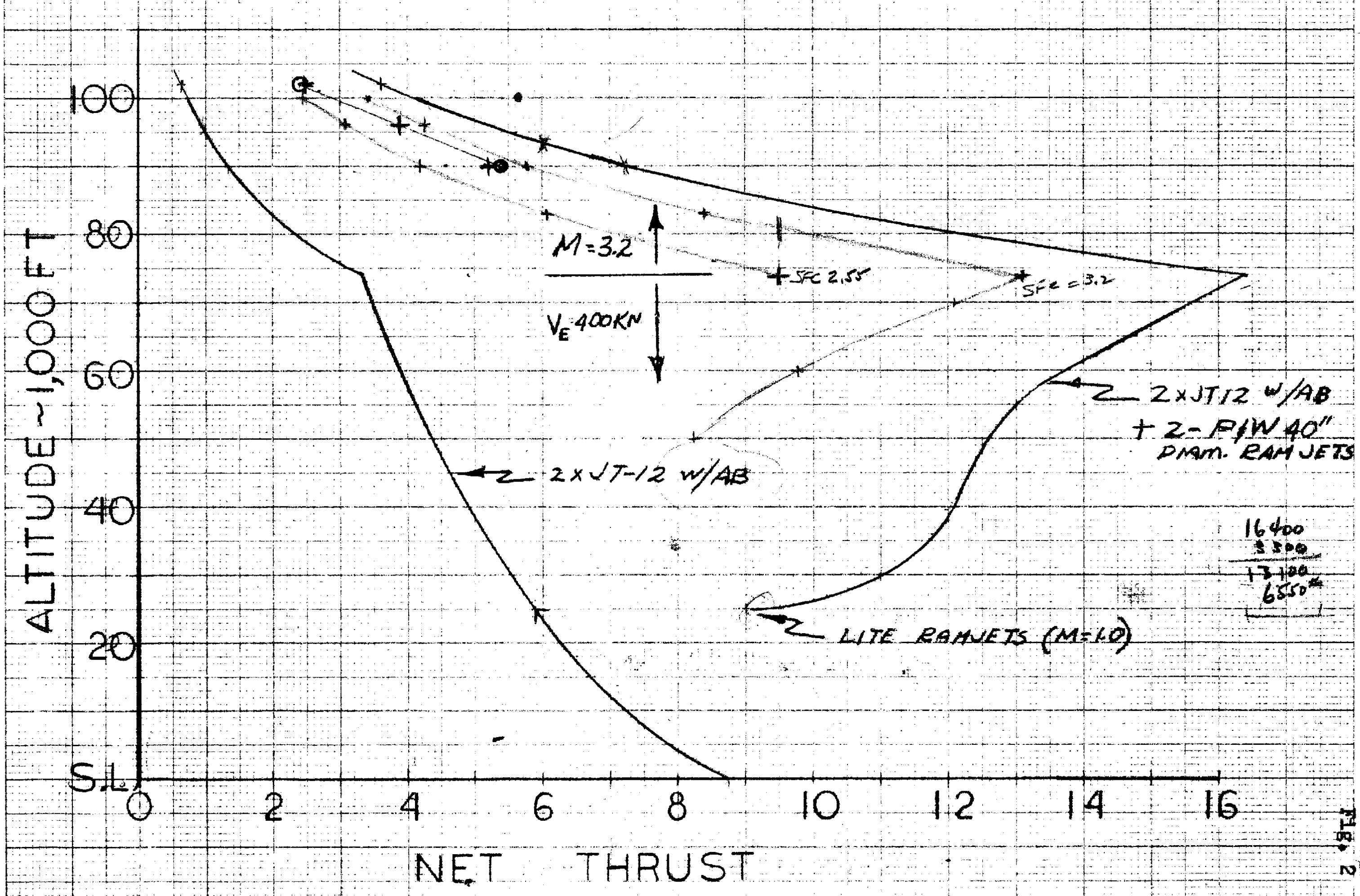
Page Denied

Declassified in Part - Sanitized Copy Approved for Release 2014/05/02 : CIA-RDP81B00879R001000150001-8

FORM 527R

PREPARED BY
DATE
CHECKED BY

AVAILABLE THRUST VS ALTITUDE



is substantially the same as the turbojets. The ram-jets are configured to include provisions for carrying 1400 pounds of fuel as a tip tank during the early part of the climb. It may be necessary to fair over the aft end of the ram-jet, using a Mylar pressurized sack, to reduce the drag in climb. For operation between Mach 1.0 and 1.6, it will probably be necessary to use a hood in conjunction with a movable spike on the nose of the ram-jet to obtain optimum thrust. Such hoods have been used on test ram-jets in the past.

EQUIPMENT

The equipment volume provided for the reconnaissance gear is less than that used in the U-2 aircraft. It is assumed that re-packaging can lighten the gear and reduce its size. The weight of the reconnaissance gear, the pilot and his equipment has been set at a total of 500 pounds. Under normal conditions, this would leave between 250 and 300 pounds for the equipment. The problems of temperature control in the equipment bay, the rate of heat conduction, and the effect of a turbulent boundary layer at high Mach number on photography have not yet been investigated.

COCKPIT

The cockpit dimensions have been reduced from the U-2 in the interests of reducing aircraft drag. It should be borne in mind that the mission time for this aircraft is approximately one-fifth of that for the U-2, so reduced room for the pilot is in order. The number of instruments has been reduced to the minimum, because of space and weight considerations. Their places have been taken by warning lights, when feasible. The rate of climb instrument has been totally deleted, as the very high performance of the airplane would keep it at an extremely high reading at practically all times, and it is not considered necessary for blind flight, as the aircraft is not intended to hold in a normal type of traffic pattern for any important length of time.

It is necessary to redesign such standard items as control sticks, rudder pedals, brake valves, etc., in order to save weight. Behind the pilot's seat are located a number of the aircraft system complements. These must be kept in a cooled and pressurized area for satisfactory operation at altitude. The pilot's seat will be a rocket type designed for escape at zero velocity, as well as for the flight conditions during training and ferrying flights. It will be replaced with a lightweight seat for the tactical missions.

It is intended that the pilot use an adaptation of the Navy full pressure suit, rather than the present Air Force partial pressure suit. The great advantages of being able to cool and ventilate the pilot separately from the cockpit itself, the lack of shock from high altitude decompression, and the greater mobility when pressurized make this suit a desirable improvement.

The cockpit pressurization is intended to be by nitrogen bottles for high altitude, with standby air bleed pressurization at low altitudes. Cooling of the cockpit and possibly the equipment bay will most likely be done by water boil-off from a radiator type construction built directly into the fuselage skin.

LANDING GEAR

The landing gear is a lightweight type designed to U-2 criteria, but a normal tricycle gear geometry, with regards to the CG position, is used in the fore and aft vertical plane of the aircraft. Tip pogos for lateral stabilization will be used on take-off and dropped, as on the U-2. The problem of lateral control on landing should be much less than with the U-2 aircraft, and there is a good possibility that enough stability can be obtained with the main gear that the airplane could be balanced down to very low velocities without tipping over on the ram-jets. The question of wheel braking for a rejected take-off is not yet solved. It is not desired to carry the conventional amount of brake steel to absorb the required amount of energy. The best solution is probably to lock the main gear wheels in such an emergency, blow the tires, and skid along on the wheels themselves. An alternative to this would be a simple anchor chain type of barrier.

CONSTRUCTION MATERIAL

The aircraft is constructed mainly of high strength titanium alloy. Light gauges down to .010 inches will be used, but the most probable minimum gauges in stressed areas will be .016 inches. Using such material requires a large number of supporting elements, which add to the tooling and material costs. The wing construction is such that the beams (not the wing skins) run through the fuselage tanks. Their strength helps maintain fuselage shape when the fuel is pressurized for altitude operation. This type of construction requires building a section of the fuselage as an integral part of the wing. It is the lightest conceivable design for this particular aircraft concept.

It is not planned to insulate the wing or fuselage fuel sections, as current indications are that the mission would be completed prior to heating up the fuel beyond 250°F, which is an acceptable value for the engines. It may be necessary to keep reserve fuel in a small insulated tank, however.

It is not planned at this time to build any large elements of the aircraft from plastic. If particular problems show up radar-wise, such items as inlets to the engines, and possibly a vertical tail, would be studied for whatever reduction in cross section could be obtained.

CONTROLS

The aircraft is flown by powered controls. The trailing edge of the wing acts both as elevators and ailerons. It is necessary to use a power rudder to provide ample directional control should a ram-jet blow out at high speed. Directional control is ample to restrict the aircraft to less than 3° angle under this condition.

(8° if no pilot reaction)

FUEL TYPES

Several different fuels have been studied for the turbojets and the ram-jets. It is proposed that the initial operation start with JP-150, a petroleum-based fuel of reasonable availability and cost.

The following table compares JP-150 to decalin:

	Decalin	JP-150
Heating value/pound	18,400	19,100
Specific Gravity	.872	.733
Cost/Gallon	$2.60	$0.55
Burning Characteristics	Same as JP-4	Same as JP-4

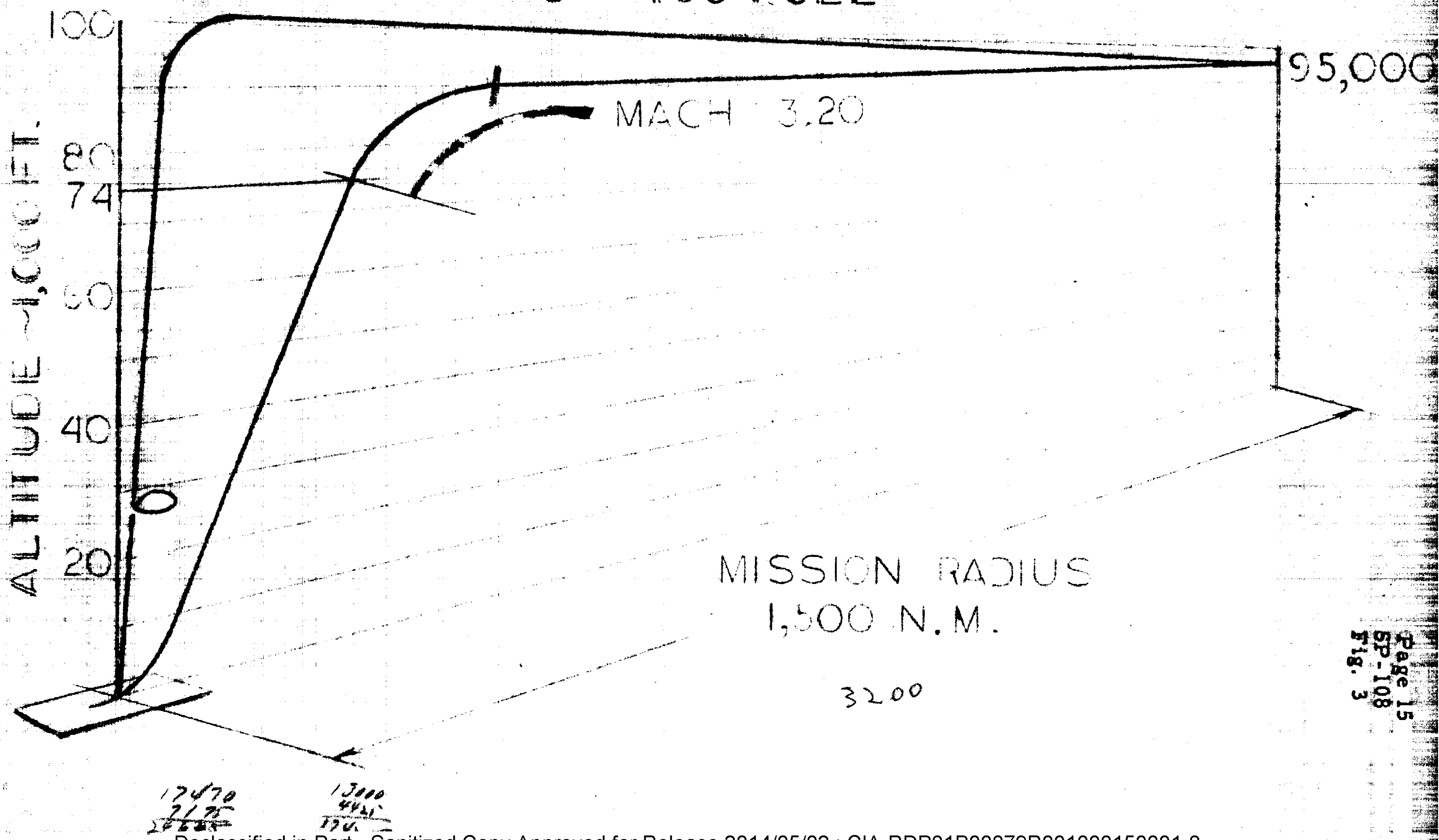
It will be seen from the table that the use of JP-150, at its lower specific gravity, penalizes the aircraft volume by about 14 percent. This, however, provides stretch in the aircraft design for obtaining greater range with heavier fuels, such as HEF-3, at a later date. The use of the borane fuels would provide from 15 to 30 percent more radius of operation at a given weight. However, because of their better burning characteristics, there may also be an improvement in power at altitude, which would allow the use of more total fuel and thereby give it a further gain in range. Figures 3, 4, and 5 show various mission capabilities.

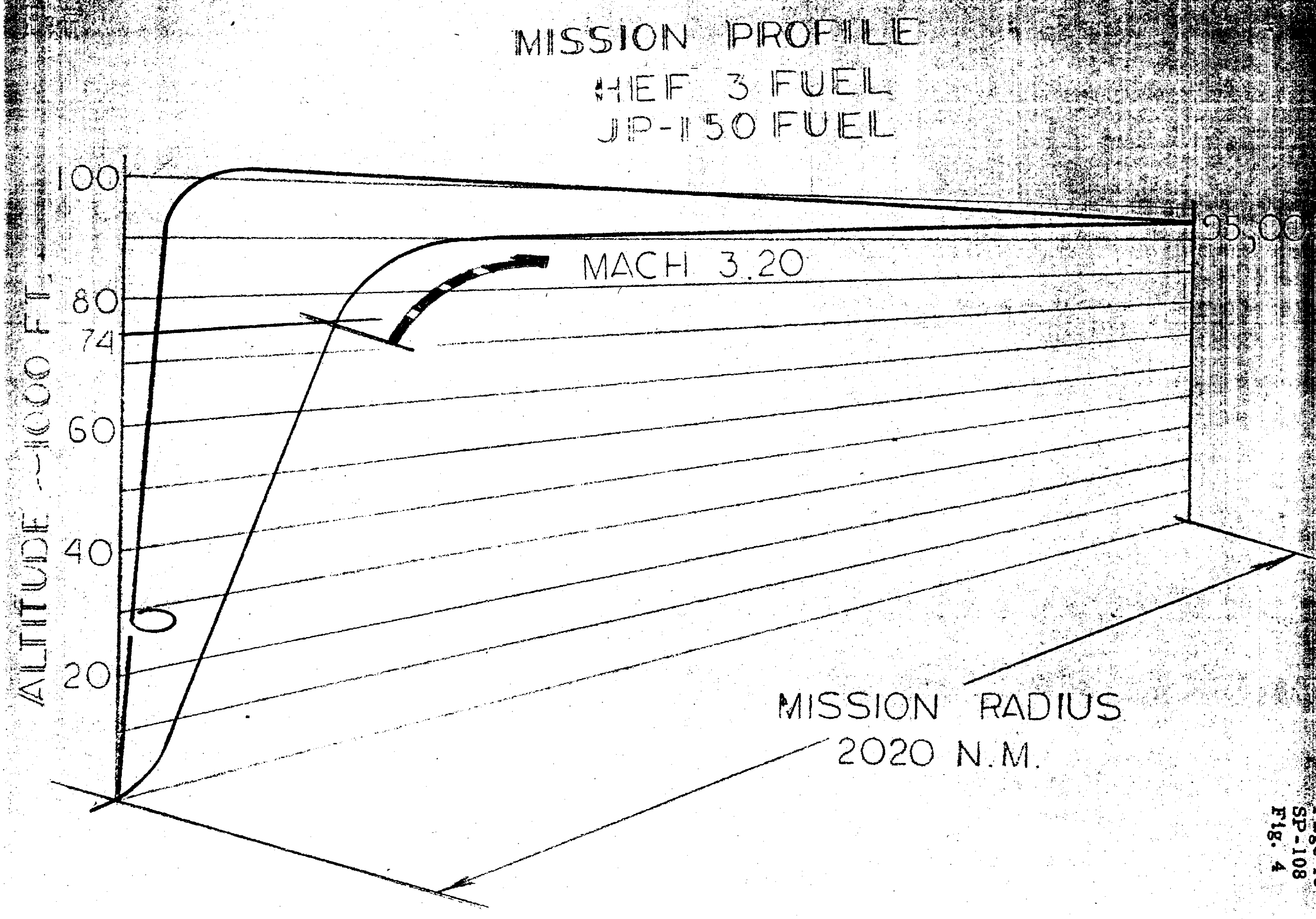
STAT

Page Denied

Declassified in Part - Sanitized Copy Approved for Release 2014/05/02 : CIA-RDP81B00879R001000150001-8

MISSION PROFILE
JP-150 FUEL

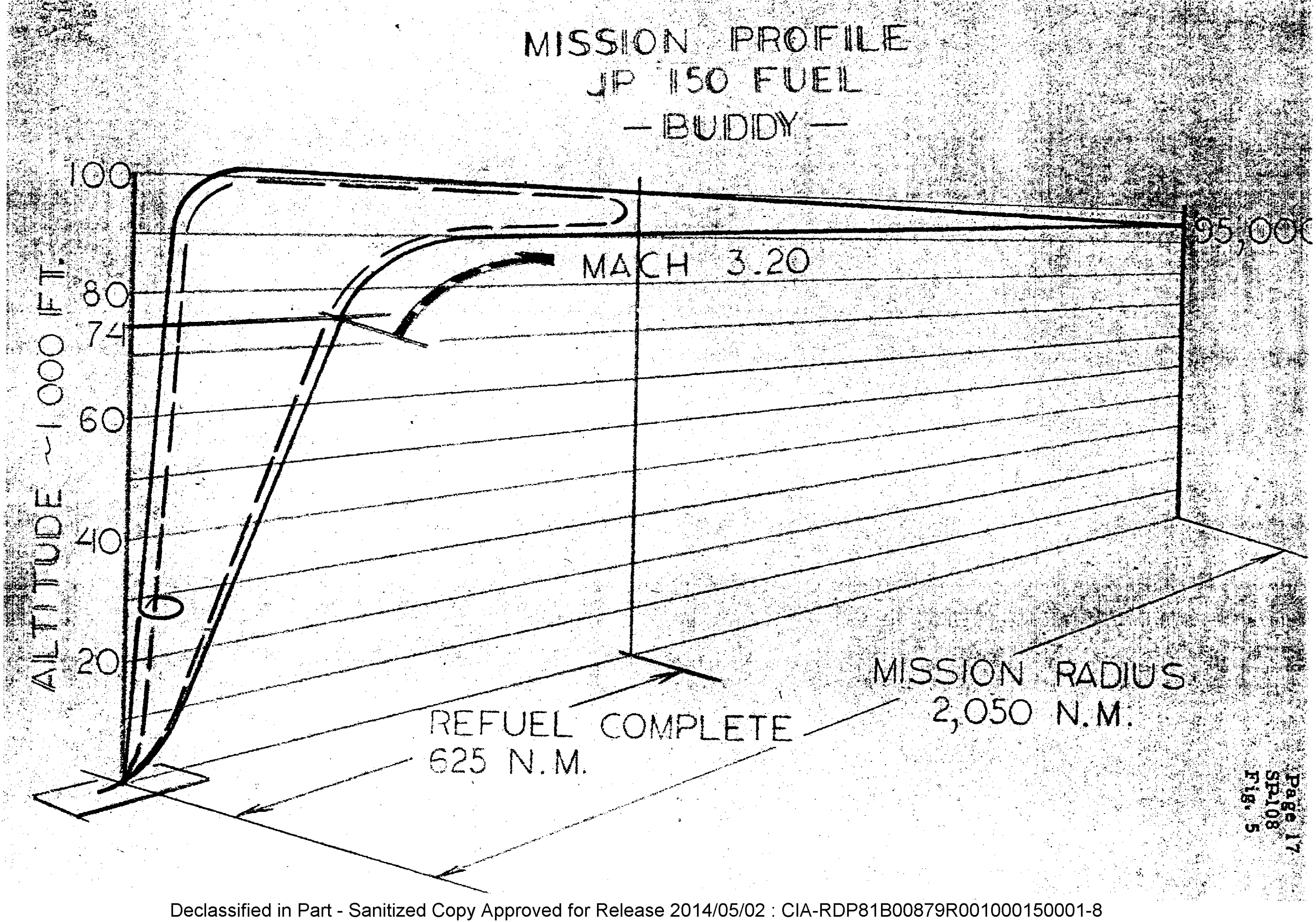




Page 16
SP-108
Fig. 4

Page Denied

Declassified in Part - Sanitized Copy Approved for Release 2014/05/02 : CIA-RDP81B00879R001000150001-8



Page 17
SP-108
Fig. 5

MISSION CAPABILITIES

Using JP-150 fuel (similar to JP-4), take-off is made on turbojet power at a gross weight of 32,000 pounds. The aircraft is climbed to 25,000 feet at a speed of 400 knots E.A.S. At this altitude, the ram-jets are ignited to assist in climb. Using a constant indicated airspeed, climb is continued to 75,000 feet, where Mach 3.2 is reached. This speed is held and climb continued to 90,000 feet. At this height, the fuel/air ratio of the ram-jets is reduced and cruising flight ensues. A target altitude of 95,000 feet is reached, where a 180° turn is made. Returning to base, higher altitudes are reached.

The advisability of refueling the A-3 from a U-2 aircraft was studied. This did not improve the A-3 penetration capabilities, as it was assumed that all refueling was done prior to penetration. The added distance on the return leg, therefore, reduced the penetration. The situation is different if the aircraft could be refueled at altitude from another A-3. It is assumed that this could be done at any point on its basic mission. Figure 4 shows the gain obtainable in actual combat radius for the "Buddy" mission. The use of HEF provides the best capability for the A-3, considering all factors.

Page Denied

Next 1 Page(s) In Document Denied

WEIGHT CONTROL

A breakdown of the aircraft weight elements is shown on Figure 6. These weights are predicated upon most extreme weight control procedures, including many static tests run both at normal and elevated temperatures. The adiabatic temperature rise for the speed is roughly 875°F, resulting in actual temperatures of roughly 800°F inside of ducts and certain other stagnation areas. By making proper treatment to obtain maximum emissivity, skin temperatures can probably be held to values between 300 and 500°F. There must be few or no compromises made for weight, because the power of the turbojets to accelerate the aircraft to a speed where the ram-jets can be lighted is critical. Should the wind tunnel tests show more favorable transonic drag characteristics than expected, there could be some relaxation in providing more weight for the equipment and aircraft systems.

Page Denied

Declassified in Part - Sanitized Copy Approved for Release 2014/05/02 : CIA-RDP81B00879R001000150001-8

WEIGHT ESTIMATE

WING	2,715
VERTICAL	375
FUSELAGE	1,780
LANDING GEAR	375
SURFACE CONTROLS	450
JT-12 DUCTS & FAIRING	605
JT-12 ENGINES	1,685
RAM JETS	1,600
ENGINE CONTROLS	80
FUEL SYSTEM	505
INSTRUMENTS	120
HYDRAULICS	250
ELECTRICS	250
ELECTRONICS	100
FURNISHINGS	100
AIR CONDITIONING	350
WEIGHT EMPTY	11,340
OXYGEN	40
OIL	20
UNUSABLE FUEL	100
PILOT	285
PAYLOAD	215
ZERO FUEL	12,000
WING FUEL	3,120
FUSELAGE FUEL	14,880
TAKE-OFF WEIGHT	30,000

5850

100
3120
14880
2800
20900

(Ramjets carry 1,400 lb. each in addition to above)

PERFORMANCE

Figure 7 shows a summary of the aircraft performance. It will be noted that rather excellent performance is available, even at take-off weight, on the turbojets alone. Peak performance is obtained at 75,000 feet, where a Mach number of 3.2 is reached at a rate of climb of 76,000 feet per minute.

The aircraft is designed to use a 400 knot E.A.S. For design safety purposes, a margin of about 30 knots would be provided over this figure. Limitations on the rolling velocity would have to be accepted at this speed, however. The aircraft can make a 180° turn at target weight and altitude of 55 miles radius. Because of the ability to richen the fuel/air ratio, this turn can be made without loss of altitude.

It should also be pointed out that at a sacrifice of range, higher penetration and cruising altitudes can be obtained, by increasing the power output from the ram-jets by the same means.

Time Schedule:

1. Need go ahead now to line up preliminary ground work.
2. "Number of aircraft to be purchased" decision must be made by Feb 59.
3. Approximately 18 months to first flight with unqualified engine
4. Approximately 2½ years to be operational

Engines may well pace program

1. Need to complete development on ram jets (Marq. say ok - P&W ??)
2. Need to develope afterburner on JT-12.
3. Need new external hardware on JT-12 (P&W says no problem here)

Cost:

12 aircraft [redacted] (does not include engine) STAT

$4,100,000 needed between 1 Dec 58 and 1 July 59 for:

a) design engineering
b) wind tunnel studies
c) mock up
d) sub contracting
e) limited tooling and manufacturing

PERFORMANCE SUMMARY

MISSION		SOLO	SOLO	BUDDY REFUEL
FUEL - Turbojet		JP-150	JP-150	JP-150
- Ramjet		JP-150	HEF-3	JP-150
TARGET - Radius	(N.M.)	1500	2020	2050
- Altitude	(Ft.)	95,000	95,000	93,000
WEIGHTS - Takeoff Gross	(Lbs.)	32,800 4	34,600	32,800
- Target	"	18,000	18,200	20,300
- Zero Fuel	"	12,000	12,000	12,000
- Fuel	"	20,800	22,600	20,800
BEGIN CRUISE - Altitude	(Ft.)	90,000	90,000	90,000
- Distance	(N.M.)	162	168	162
FINAL ALTITUDE	(Ft.)	102,000	102,000	102,000
REFUEL POINT - Distance	(N.M.)			625
-Altitude	(Ft.)			90,000
- Mach No.				3.2
TAKE-OFF GROUND ROLL				
Engines Only	(Ft.)	6100	7500	6100
Engine + 8000 lbs.15 sec.Jato	(Ft.)	4000	5400	4000
Takeoff Speed	(Kts)	177	185	177
RATE OF CLIMB -				
Sea Level	(Ft./Min)	5400	4820	5400
Mach 3.2 @74,000 Ft.	(")	76,000	74,000	76,000
TURN RADIUS	(N.M.)	55	55	60
LANDING - Ground Roll	(Ft.)	1840	1840	1840
- Speed	(Kts.)	108	108	108

is should be heavy after IFR

PAYLOAD 215#
MACH 3.2
SPAN 33.8'
LENGTH 62.3'
WING AREA 500 sq ft
W/S 65.6→24

L/D START CR 5.0
POWERPLANT 2/RAMJETS
2/J7-10 w/ AFTERBURNER
FUEL JP-150

SECRET

Dated: 10 Nov. 1958

10-11-58
10-11-58

15.

50X1

DOC ____ REV DATE 16/2540 BY 064540
ORIG COMP ____ OPI 56 TYPE 11
ORIG CLASS S PAGES 30 REV CLASS S
JUST 22 NEXT REV 2012 AUTH: HR 70-2

PROPOSAL FOR A LIGHTWEIGHT RECONNAISSANCE AIRCRAFT

By Clarence L. Johnson

STAT

227636

SECRET

227636