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Report #1

Proposal for a High Speed Reconnaissance Aircraft.

Introduction:

After a substantial amount of studying the basic problem of advanced aerial reconnaissance an aircraft design has been developed which in the opinion of the writer, warrants development by the U.S.A. Over several years aircraft powered by advanced engines utilizing liquid hydrogen fuel, boron, water plus petroleum and petroleum fuels have been evaluated for the basic mission by LAC.

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Basic approach & Design of U-3.

April 21, 1958

CZJ

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Design of U-3:

Requirements:

High Altitude Cruise — 90,000'
Design Cruise Mach No. — 3.0
Engines — Two
Crew — Basic - one Two in future
L/D ratio — 7 to 8.
Range — 2000 K. mi. Radius
Payload — 500 #

Basic Data:

90,000' — $\frac{\delta}{\delta_{sl}} = \frac{.0166}{.07648}$ #/cu. ft. = .0217 (.0225 old std.)

T = −48° F (New. Std.)

f for M = 1 = 25.5 #/□'

M = 1 = 678 mph. (588 Kts)

1770 Kts. f for M = 3 = 9 × 25.5 = 230 #/□'

E.A.S. = 3[illegible]

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Engine Data

Thrust of J-58 at 90,000' M = 3.0 — 4000 #

SFC = 2.4 $W_{dry\ J58}$ = 5900 #

$\frac{I}{\#W} = \frac{4000}{5900\ \#} = .677$

Thrust of J-93 (Same cond.) = 2800 #

W = 4370 $\frac{I}{W} = .64$

SFC = 2.80

With 2 - J-58's (8000 # thrust.)

$\frac{L}{D} = 7.5$ Wtotal = 7.5 x 8000 # or 60,000 #

Cruise Fuel Reqd for 4000 Kn. miles =

$\frac{4000}{1770} \times 8000 \times 2.4 = 43{,}400\ \#$!!

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Engine + fuel wt. = 43,400# + 12,000# = 55,400#

Airplane would have to weigh 5000# or 80% of U-2.

If $\frac{L}{D} = 8$, airplane could weigh 9000#.

at $C_L = .2$, $\frac{L}{A} = 230\#/\square'$ $\frac{W}{A} = 46\#/\square'$

$\frac{64000}{46} = 1400\ \square'$

Wing wt. = 2800# A.R. = 1

Span = 37.5'

If S.F.C. = 2.0 to 2.4, fuel wt. = 36,100#

airplane wt. could be 64000 − 36,100 − 12000 = 16000#.

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Estimate airplane criteria:

Consider wing made up of stainless steel waffle. — 2 sheets of .010

1 Sq. Ft. = .020 x 144 x .30 x 1.25 factor for wt
= 1.08 #

For 2 sides — wt. = 2.16 #

Use 3 #/□' for wing & tail.

Wing area = 1400 □' = 5200 #

Tail area = 700 □' = 2100 #

Fuselage = a cyl. 48" in aver. dia. x 80' long.
★ = 960 □' area ≅ 3000 #

Gear =	=	1000 #
Missiles =		3000 #
Systems =		1000 #
Payload + Crew =		1000 #
Engines =		12000 #
		28,300 # empty.

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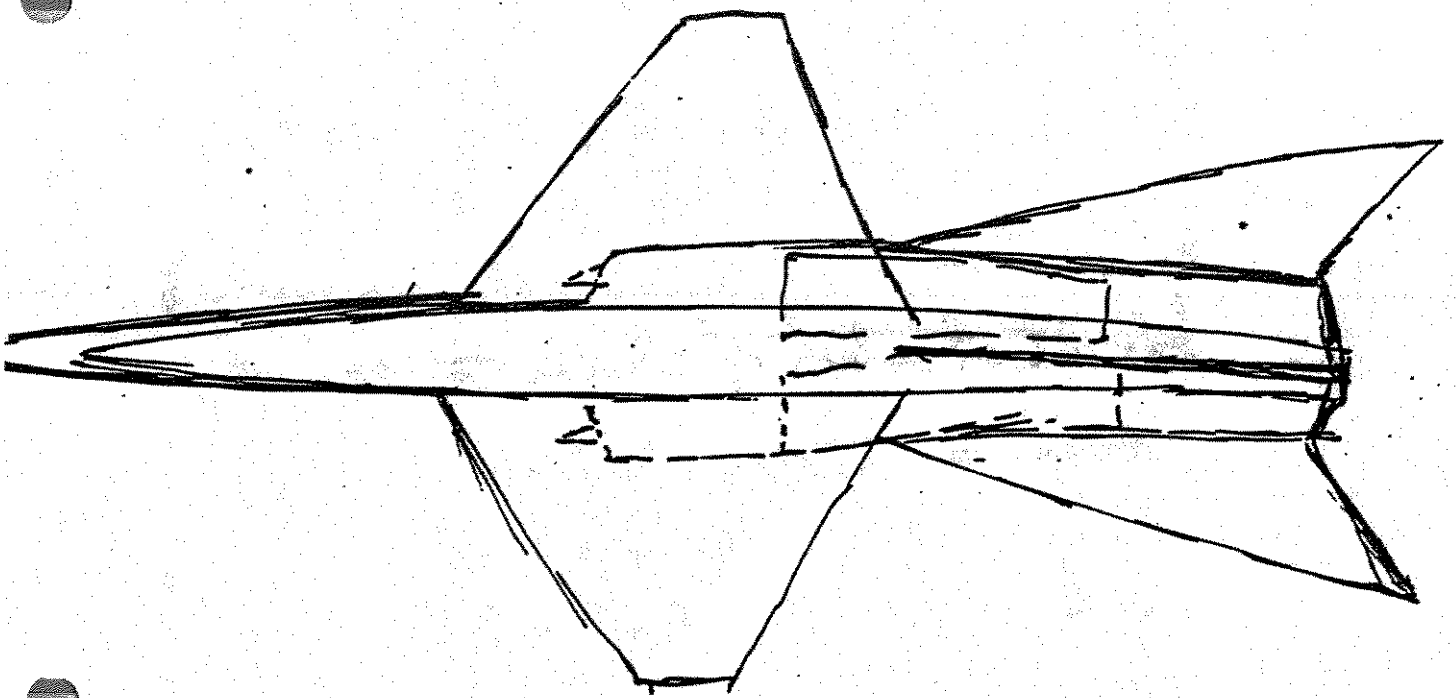
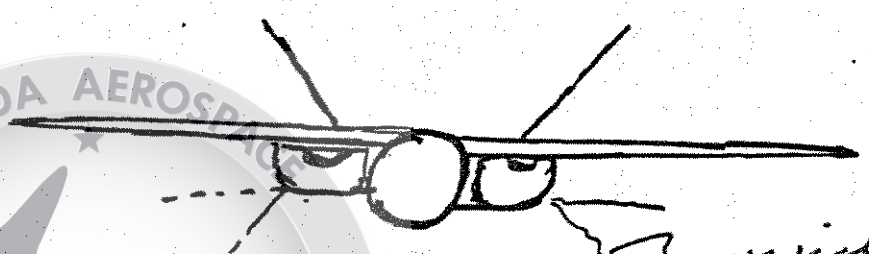
Page 3.

April 23





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June 19, 1958 — Study of configuration C-3.

Basic wing loading at alt. ≐ 45 #/□'

If we have a 41,000 # E.E.W., 100,000 # gross wt.
the wt at start of cruise ≐ 88,000 #

Area = $\frac{88000}{45}$ = 1950 □'

A.R. = 2.0 — Span = 62.2'

A.R. = 1.8 — Span = 59.0'

Use 60' span — A.R. = 1.84

Aver. chord = 32.5'

Taper 3:1 — Tip chord = 16.25' Root 48.75'

Engine is 26' x 5½'

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Engineering Cost Status

A-3

June 30, 1958 to Oct 15, 1958

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Prepared June 26, 1954 — LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION — Dept. — Sheet 1.

Approved

Interim Eng. Situation

Boehme has — 40 men with Kennel & Hess

40 x $200/week = $8000/week

$20 hr x 40 hr week = $800/week

40 x 400 = $16,000

Nick profit — $16,500/week

4½ x 16500 = $74,200/month.

3 months = $222,600

for $225,000 can go full steam for 3 months.

Tunnel testing — $200,000 more,

Mock up — $100,000

$525,000

−355

$170,000

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We have $808,355,000 for Proj. "G".

We will have spent (to July 15) — $453,000

Have left. — $355,000

Get $175,000 July 15 & Oct. 15, 1958.

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Shop - 6/26 to 7/15/58

Specimens

500 hrs. per week x 3 wks x $6.50 = $ 9,750.

Mac - 6/26 to 7/15/58

Spec. & Study

500 hrs. per week x 3 wks x $8.00 = 12,000.

Dick Boehme - 6/26 to 7/15/58

800 hrs. per week x 3 wks x $10.00 = 24,000.

Cost Est. - 6/26 to 7/15/58 $ 45,750.

Approx. Cost to 6/26/58 375,000.

Total Cost to 7/15/58 $ 420,750.

Profit @ 9.5% 50,000.

Anticipated Price to 7/15/58 $ 460,750.

Cost for 3 months - 7/15/58 Forward (to 10/15/58)

Boehme	$225,000.	
W.T.	200,000.	
Shop	100,000.	525,000.

Study - Cost Est. $ 985,750.

Allocated to (G) 808,965.

Additional Funds Required $ 176,785.

RLAdair/inr
7/1/58

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Evaluation of A.B. vs Dry J-58.

&

Weight Breakdown — A-3

June 26, 58

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June 26, 58 Evaluate Dry vs A.B. versions of J-58 !

Use P & W specs - #3912 A.B.
1457 non A.B.

Data plotted on attached curve.

Airplane A weighs 100,000 # - L/D = 6.5

Engine Thrust Reqd = $\frac{100,000}{6.5 \times 2}$ = 7700 #

at altitude W = 85000 #, Thrust would be 6550 #/engine

alt. = 83,500' start of cruise.

Engine + fuel wt. = (6000 x 2) + 50,000 #
= 62,000 #

On Non A.B. type - Engine weighs 4680 #

S.F.C. at M = 3.0 @ 1.55.

Ratio of fuel wts = $\frac{6.5}{2.08}$ x 50,000 = 37,200 #

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Engine + fuel wt. = (2 x 4680) + 37,200

= 9360 + 37,200

= 46,560 #

Ratio of E+Fuel = $\frac{46560}{62000}$ = 75%

Airplane would weigh ~ 80,000 #

L/D = 6.25

Thrust/engine = $\frac{80,000}{6.25 \times 2}$ = 6400 #

alt. at ~~start of cruise~~ ~~mid point~~ wt of

70,000 wt. — 5600 #/eng.

alt. = 66,500 '

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With one half fuel on airplane "A"

$$T/eng = \frac{75{,}000\#}{2 \times 6.5} = 5760\#$$

alt. = 86,000'

On airplane "B" at ½ fuel.

$$\frac{62{,}000}{2 \times 6.25} = 4960\#$$

alt. = 68,000'.

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Check Range with Equipped empty of 45,000 #

Gross Wt. = 100,000 #

Fuel wt. = 54000 #

Climb fuel = 14000 # Distance = 200 mi

Cruise fuel = 54000 − 14000 − 2000 # reserve =
38,000 #

Range at M = 3.0:

$$R = 575 \times 6.5 \times \log_e \frac{86000}{\cancel{56}48,000} \times \frac{3}{2.08}$$

$$R = 5400 \times \log_e 1.71$$

$$= 5400 \times .537$$

$$= 2900 \text{ miles}$$

$$R_{Tot} = 2900 + 200 + \frac{\text{Descent}}{(100)}$$

Radius = 1600 nautical miles.

Wt. at Target = 86,000 #

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If we can do 41000 # - equip. empty
100,000 # gross.
59,000 # fuel.
2000 # reserve.
14000 # to get to M = 3.0

Cruise fuel = 43000 #

$R_c = 5400 \times \log_e \frac{86000}{43000}$

R_c 5400 × .695 = 3750 naut. mi.

Climb dist. = 268 mi. (Fuller)

Radius = 2000 nautical.

Percent + 2000 # = reserve.

Our only chance

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Weight Study.

Heal & Boehme – cd June 26, 58.

From 150,000		From 100,000
5340	Gear – 2% gross wt.	2000 #
100	Instruments – [illegible].	100
1500	Surface controls + Auto Pilot.	1200
2000	Hydraulics & electric –	1000
471	Electronics –	470
450	Furnishings –	150
450 (typed)	Air Conditioning –	350
	Tail chute –	100
300	~~Residual~~ fuel, oil, O2 –	315
7900	Wing – 1550 ft² –	9200
3,800	Fuselage –	5800
310	Tail –	4000
		21,0
3620 in 4100	Airplane less Propulsion group –	24,685
	Payload + crew –	800
	W.E. minus propulsion	25,485 #
890	For design W.E. of 41,000# – Prop. group cannot be over	15,515#

(Ms BLC ... 0.01)

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Weight Study –

Pylon type metall. = 20,000 #

Tail pipe = 25 #/ ft.

∴ Put engines in fuselage —

Engines —	12,000 #
Fuel system — (includes ¼" insul)	1,400 #
	13,400 #
Starters, controls	,300
	13,700 #

This leaves about 1800 # for cowling, spikes, etc.

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Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION		
Checked	June 26		Fuel in Fins		8
Approved					

$$\frac{400'' \times 50'' \times 12^{6}}{8} = 120{,}000 \text{ cu in}$$

$$\frac{120{,}000}{231} = 520 \text{ gals} \; @ \; 6.25$$

$$= 3250\#$$

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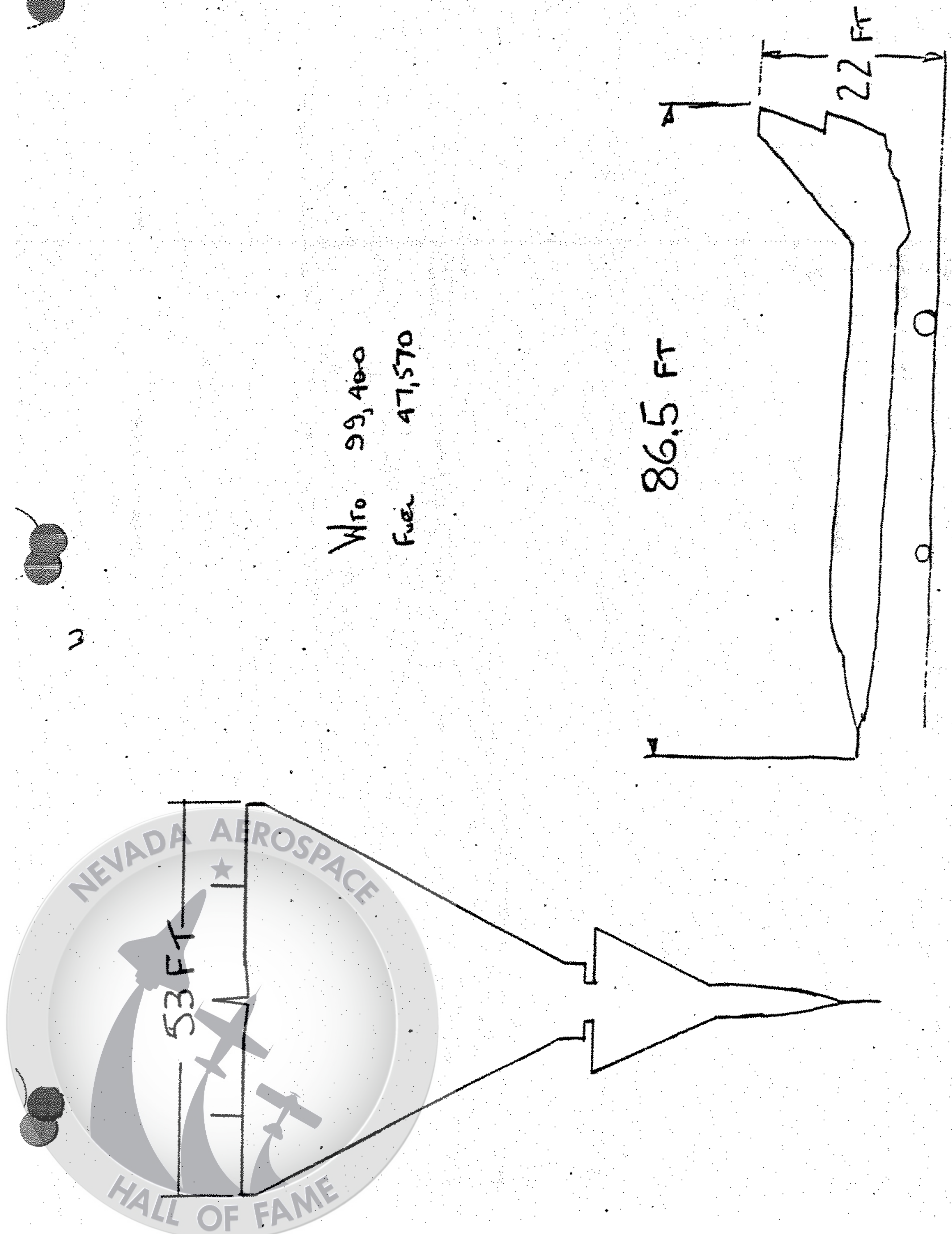

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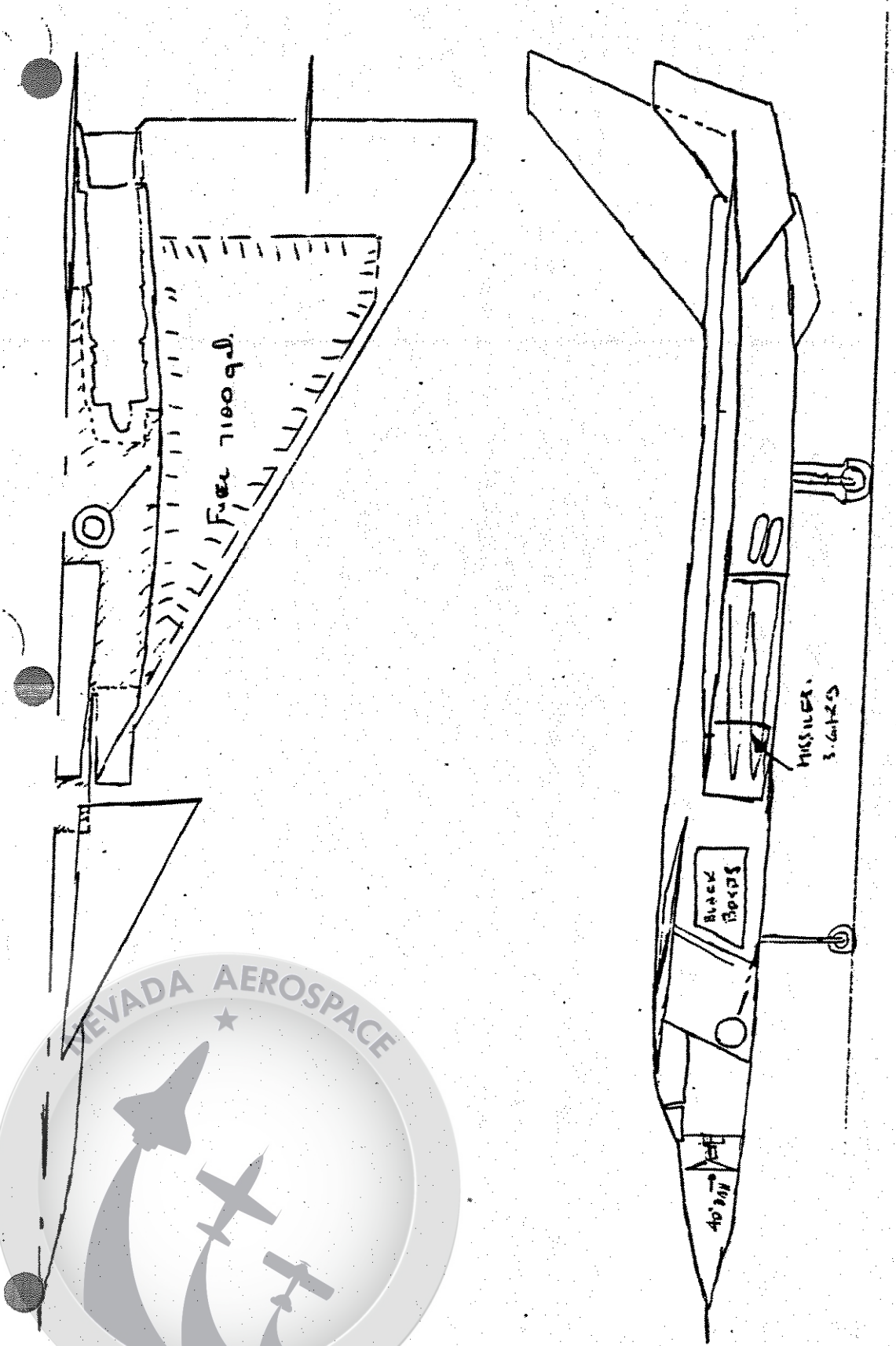

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Cost Study —

Project - G-Z

CZJ June 30, 1957

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NAME | DATE | LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION | PAGE NO. 1

June 30, '58.

Cost Estimate –
Project G.

AMPR wt = 28,000 #

Guess that – 15000 # stainless
5000 # titanium
8000 # Dural.

Quote on 6 & 12 airplanes.

On Flt. test status – 3 for 1 year.
Production tests on all.
Haul to [redacted] & Reassemble.

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June 30, 58

Cost Estimate

Basic Cost – 3 aps.

Engineering – average 90 men – 2 yrs. (Sept. 2 '58 – Sept 2, 60)

10^{00}/hr. = $20,800 man yr.

180 man yrs × 20,800 = $3,750,000

$1800 man/mo.

Tooling:

50 men – 2 years

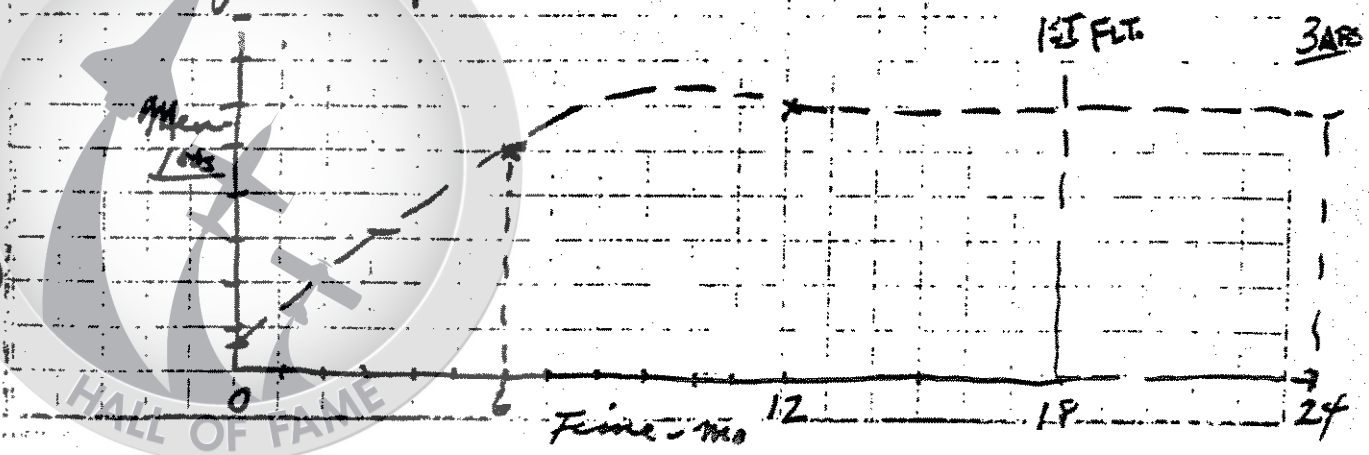
7^{00}/hr. = $14,600/man yr.

Total = $730,000/yr

Material = $100,000/yr

$830,000/yr or $1,660,000

Manufacturing: (Ex tooling)



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Prepared June 30, 58 — LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION — Task 78

Checked

Approved

Manufacturing:

600 X 18 mo. = 10800 man months

275 x 6 = 1625 man months.

For 24 months = 12,425 man months

$700/hr. X 180 hrs/mo. = $1260 man mo.

Manufacturing = 12,425 x $1260 = $15,700,000

Materials — $45/# plus increment for titanium.

3 airplanes x 30,000# x $45/# = $4,050,000

Because of high cost of developed item titanium — add $1.5 x 10^6

Materials — $5,550,000

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LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION

Originator June 30, 58 CJ

Checked

Approved

(42)

Cost of 'X'

Cost of 24 months operations — 3 airplanes:

Basic Engineering - Design -	$ 3,750,000
Tunnel tests —	500,000
Static tests — (150 man months)	225,000
Research Job —	200,000
Mock-up —	150,000
Tooling —	1,660,000
Materials —	5,550,000
Manufacturing - 3 ops. -	15,700,000
Spares — 20% of Mat. & Manuf. =	4,000,000
	$ 31,735,000
Profit - 9½% =	3,265,000
	$ 35,000,000

Add 6 months of flt. testing:

50 men at [redacted] x $/hr. = cost/hr.

180 hrs/mo. x 13 = = $ 2,350 man/mo

50 x 2350 = $ 117,500/mo. — 6 mo. = $ 710,000

Bonuses, etc. — about $ 1,000,000

Cost of Program = $ 36,500,000

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June 30, 58.

GJ

Cost of 'X'

Cost of next 3 airplanes: (3 more months)

Engineering — 50 men — 3 mos. =	$260,000
Materials & spares	5,000,000
Manufacturing —	8,000,000
Jet. Cost. — $120,000/mo. x 6 = Quote	720,000
	$13,980,000
Profit — 9½% =	1,340,000
Cost — plus 3	$15,320,000
Total cost for 6 —	36,000,000
	$51,320,000

Cost for next 6: —

Engineering — 30 men — 6 mos. —	$325,000
Materials & spares —	9,000,000
Manufacturing —	12,000,000
Jet. Cost —	720,000
	$22,045,000
Profit — 9½%	2,100,000
Cost for 6 more =	$24,145,000

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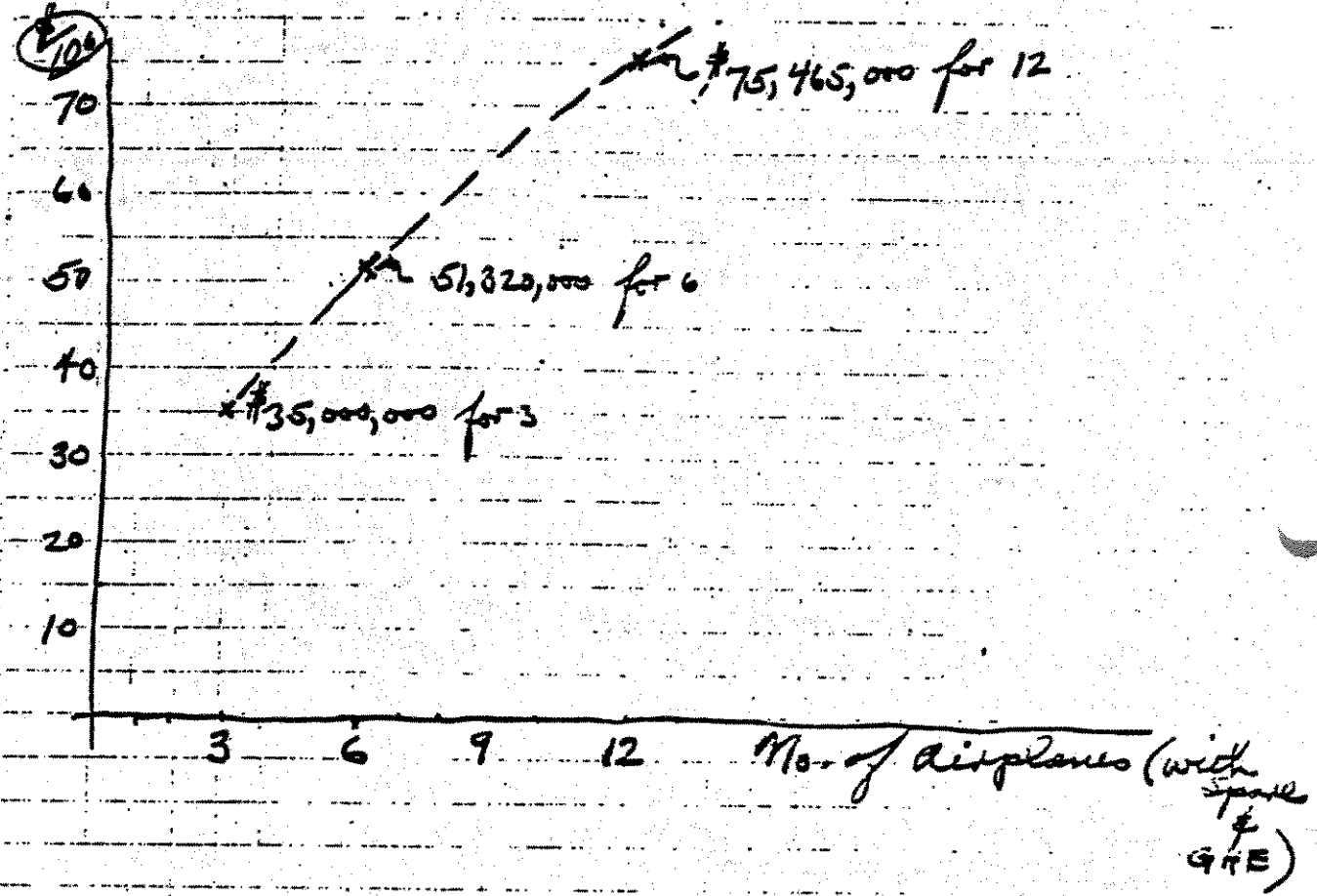
June 30 '58 (6)

Cost of "X"

Total Price for 3, 6 & 12 "X"s.



Price for 20 A-2's – about $23,000,000 for 20 at 6000# airframe wt.

$$\frac{\$23,000,000}{6000 \times 20} = \$191/\text{\# airframe.}$$

On above Model 'X':

$$\frac{75,465,000}{29,000\text{\#} \times 12} = \$216/\text{\# airframe.}$$

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CLJ
Aug. 18, 58

On first study:

Items to be investigated.

a. Launching
b. Structure
c. Performance.

Call General Mills
See Marquardt (call Kiefer first.)
Call Perry Pratt.

Assume a configuration.

W = 20,000 #
R = 4000 miles
P.L. = 800 #
L/D = 5.0

at 40 psi & 60° Fairing we have 1500 # of air in a 60 ft wing)

V_D = 120 Kt I.A.C
H = 150,000'

Derive the following:

Wing weight including air.
Size of Ramjet. No of Ramjets.
Size of Balloon

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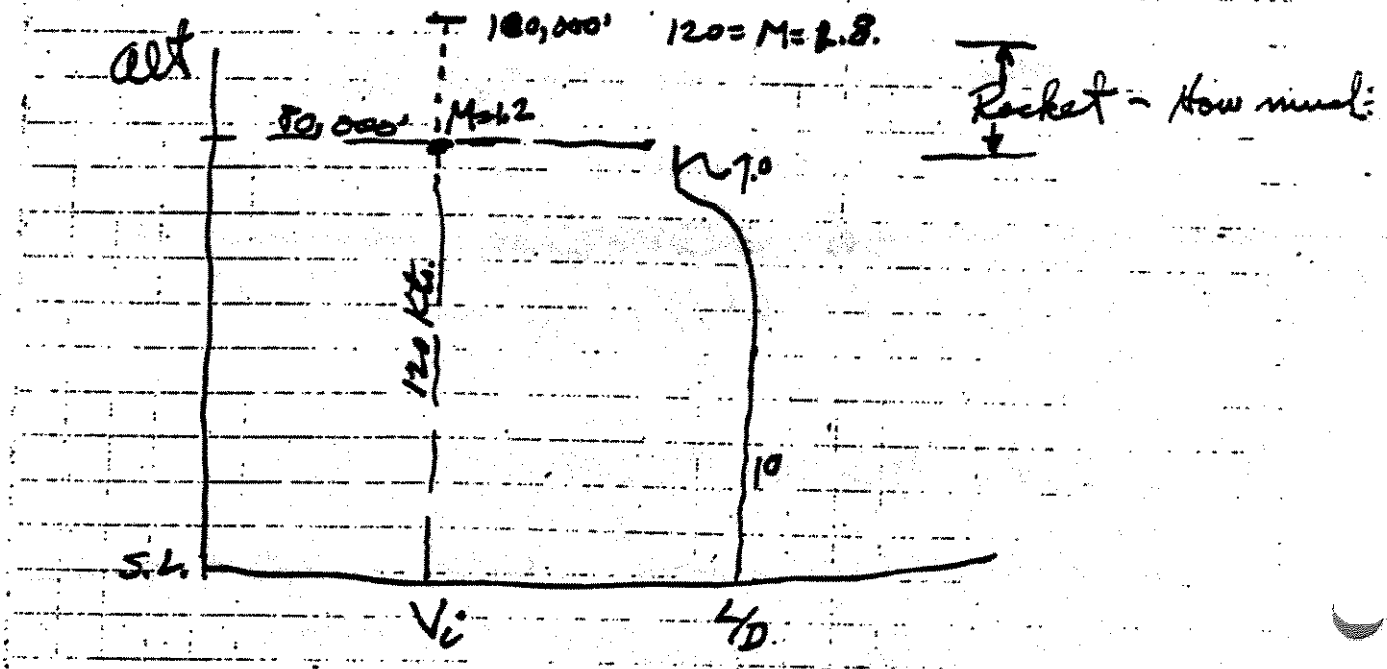
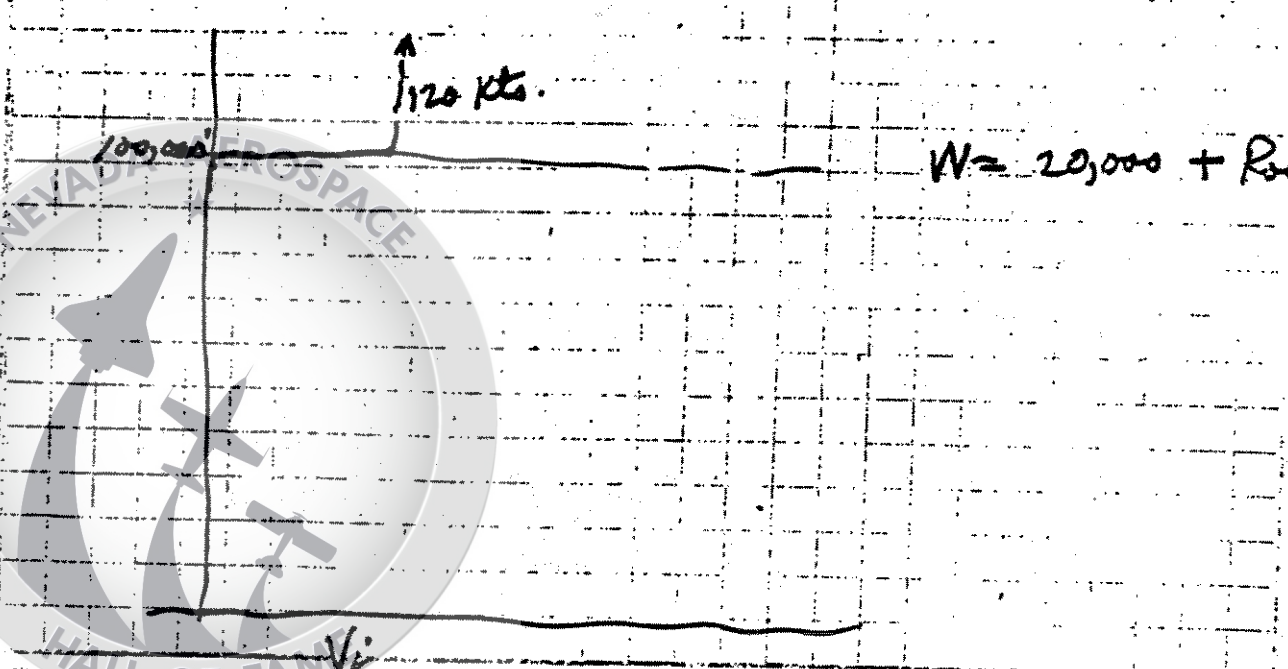
CLJ
Aug 18, 58.

A. Tow to Launch:



B. Balloon Launch.



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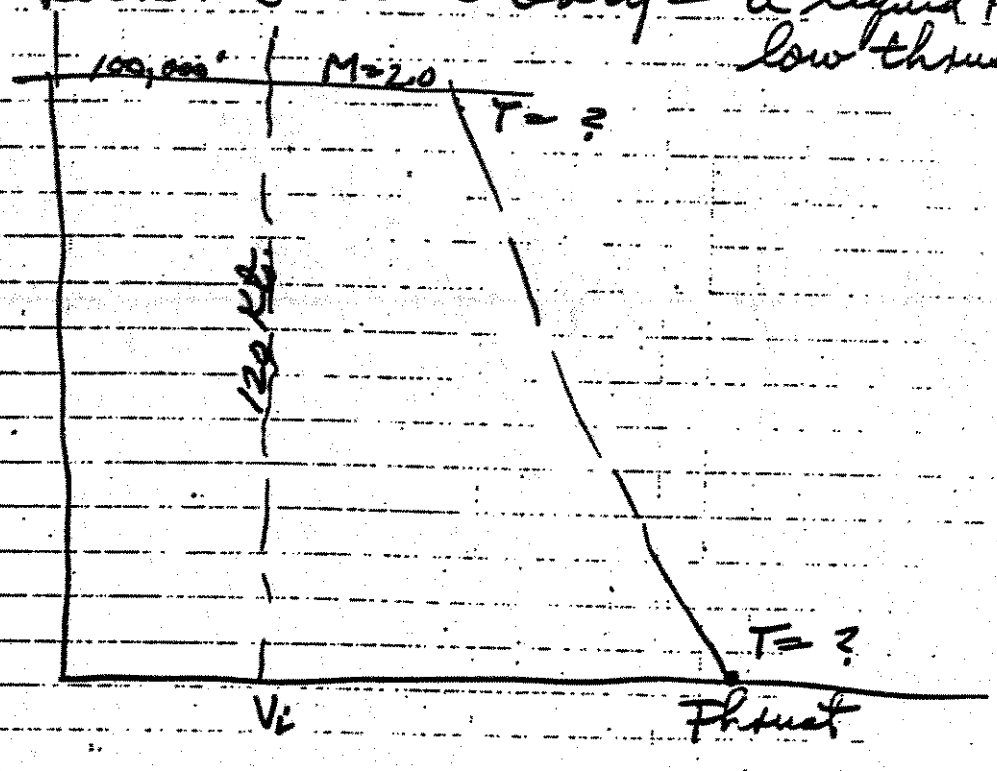
c. Rocket Launch Only — a liquid Rocket of low thrust



V_{climb} = M of .5 or 500'/sec — average

to go to 100,000' = 200 seconds.

Average Thrust = 20,000# + Drag + Rocket W_t + acceleration M=0 to M_2

Guess this to be 50,000#

I_{sp} = 260 #/sec/# (Solid)

50,000 x 200 sec = 10,000,000 # sec.

Rocket propellant Wt. = $\frac{10 \times 10^6}{260}$ = 38,400#

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Aug 18, 58.

On Archangel:

a. Put on Ram-jet tip tanks for 5000' alt

b. In general terms — what does staging do? Consider lower design wt. by amt. of climb fuel.

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~~E~~ 35#. C= .6-.7

2000 Δ' — 50,000#

6000 x 4 — 28,000 engs. — 4

Wing — 7000#
Fuselage — 3000#
Tail — 3000
Engs — 28,000#
~~Ctl~~ — 2000

43,000

Fuel 7000#

Thrust = 1800 x 4 = 7200# / 25

L/D = 20 — Drag = 2500#

Excess T. = 4700#

~~#~~ Fuel wt = 7000#

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Joe Shirley

LOCKHEED AIRCRAFT CORP.
CALIFORNIA DIVISION

Project
Checked
Approved

Page

X-7 Reliability 95% Stat Thy. - Developed engine.

20 @ 70,000

Carrying people — can't get beyond 2 to 3.5

±5° α.

Design 2.7 — 2 @ 3.5 low eff.

Fuel JP-4

I.2 OK for reliability.

~~Start~~ Procedure.

Overtime — 100 times — (3 hrs.) max.

Boeing + Talos + LAC = 10 hrs.

Vibration — Rough as a cat.

Up to 50g on attach. (2 to 3 in X-7 fus.)

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CLW

Aug. 17, 57

Phone — Ray — State - 12121

M_{SFC} — $\frac{4.0}{1.4} = 2.86$

$\frac{3.0}{2.08} = 1.44$

Sept. 3, 1958. — Ray Marquardt.

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CW
Aug. 25, 58 — Data from Marquardt

1. at 393° Rankine air temp. — Variable geometry — does pay off.

(100,000")

3000# — 65" x 260" long — 1500# — (Circle Vert. pr.

Cruising at net force coef of .95 —

SFC of 1.65 with HEF

Max thrust coef. of .9 at 80,000 & 2
1.6 at 180 at 3.

SFC during accel. of 3.5 to 3.2 at 90 @ 2.5

Initial thrust in # — ?

2 eng each tip — lighter, 46" dia
Sand thrust — 200" long — 1300#

Within 2 years — o.k. — $\frac{M}{SFC}$ = 1.82

2.

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Data from Marquardt:

g line from 35000 — 300 K.A.S.

22:4 ∆' engine — Rich — Max

SFC at 35,000	M_{10} .95	Thrust 1035
40	1.05	1690
45	1.18	2240
50	1.32	2900
55	1.48	3760
60	1.67	4650
65	1.88	5585
70	2.15	6200
75	2.43	8270

Do a little better:

Look at

Can up thrust engs. to double thrust case.

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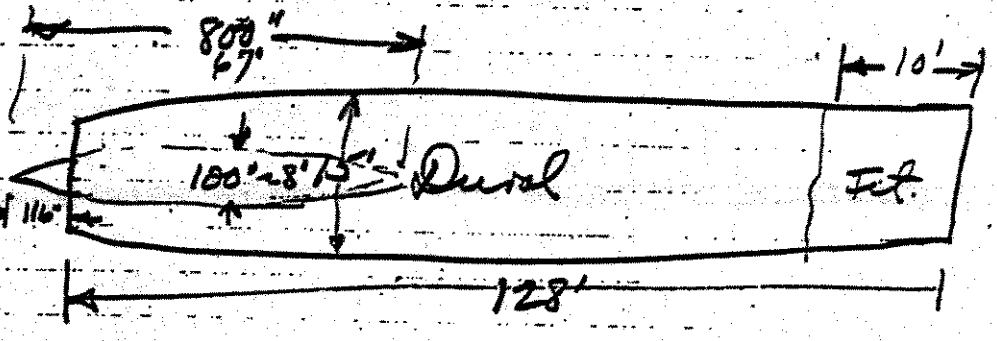
150,000' Ramjet.

Engine is 128' long (+inlet)



Outer area in Diesel $\pi \times 15 \times 118 = 5620\square'$

Inner area in diesel $\pi \times 14' \times 118 = 5250'$

Area of island is $1670\square'$

Assume an island - 8' dia x 67' long.

$W_o = 5620 \times .032 \times 144 \times .10 = 2590^{\#}$

$W_i = 5250 \times .025 \times 144 \times .10 = 1890$

$W_{island} = 1670\square' \times .025 \times 144 \times .10 = 600$

On rings — 12" spacing — 4" deep + 2" in flanges,

45' in circumference x $\frac{1}{2}$' wide — .025

118 rings @ 8.1# = 950#

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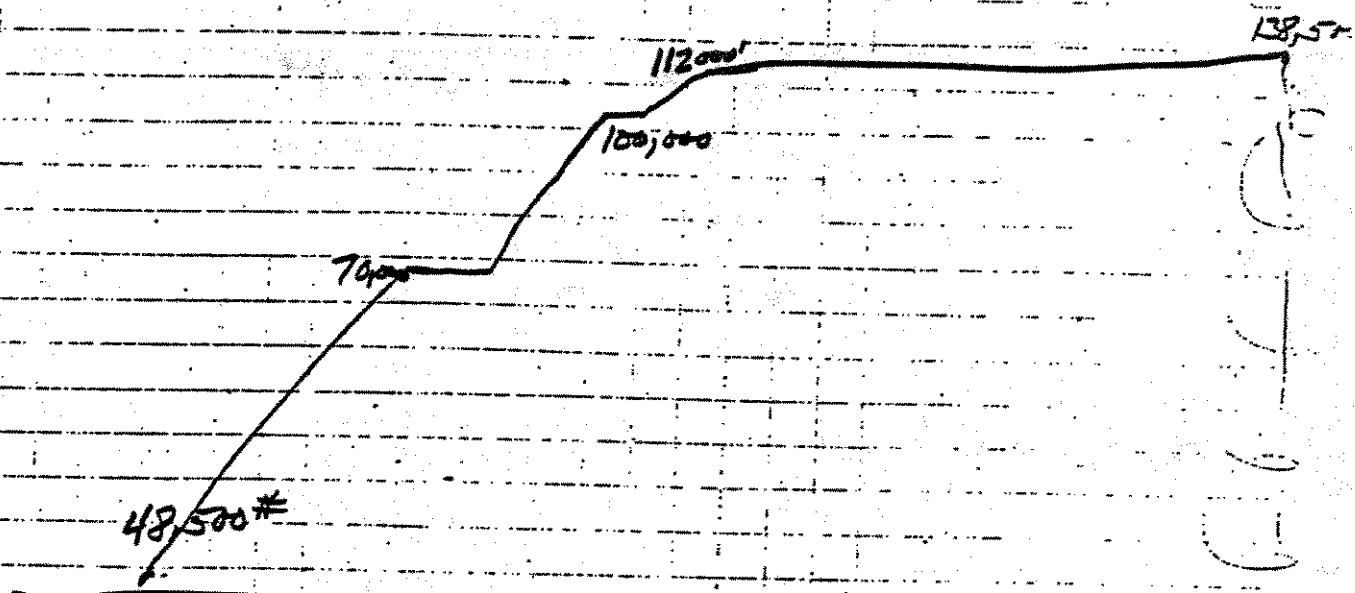
Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION	DEPT.	PERM.
Checked					
Approved					

To get range of 4000 mi. —

Wt gd. = 48,500 ±

Initial alt. would be about 112 000'



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Aug. 25, 58. Wt. on Roc

Wt. of aircraft — assumed 20,000#

Area @ 3#/□' loading — 1#/□' structure

Wing =	6700#
Wvert @ 12% =	800#
Engine =	8625
Cockpit =	500#
Controls, in. =	560
Gear	0
Other items	2320 (500# cameras)
Equip empty =	19,505

Fuel left = 495# !!

Radius = 52 miles

If this is taken to be end pt. of flight — alt. = 138,500'

L/D = 7.0 Thrust of 2860# at 138,500'.

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Without any extraneous elements.

2590
1890.
600.
950
6030 #

To here —

On rear end of engine — use titanium

Use 10' long 15' dia use 2 gages of .025

$\pi \times 15 \times 10 \times 2 = 942$ total □'

$942 \times .025 \times 144 \times .175 =$ 595 #

For flame holders, other things, accessories turbines, pumps etc. — add — 2000 #

Minimum possible tanjet wt — is to

6030
2000
595
8625 #

Revise this to make up for shorter Range & drag 29. See Report

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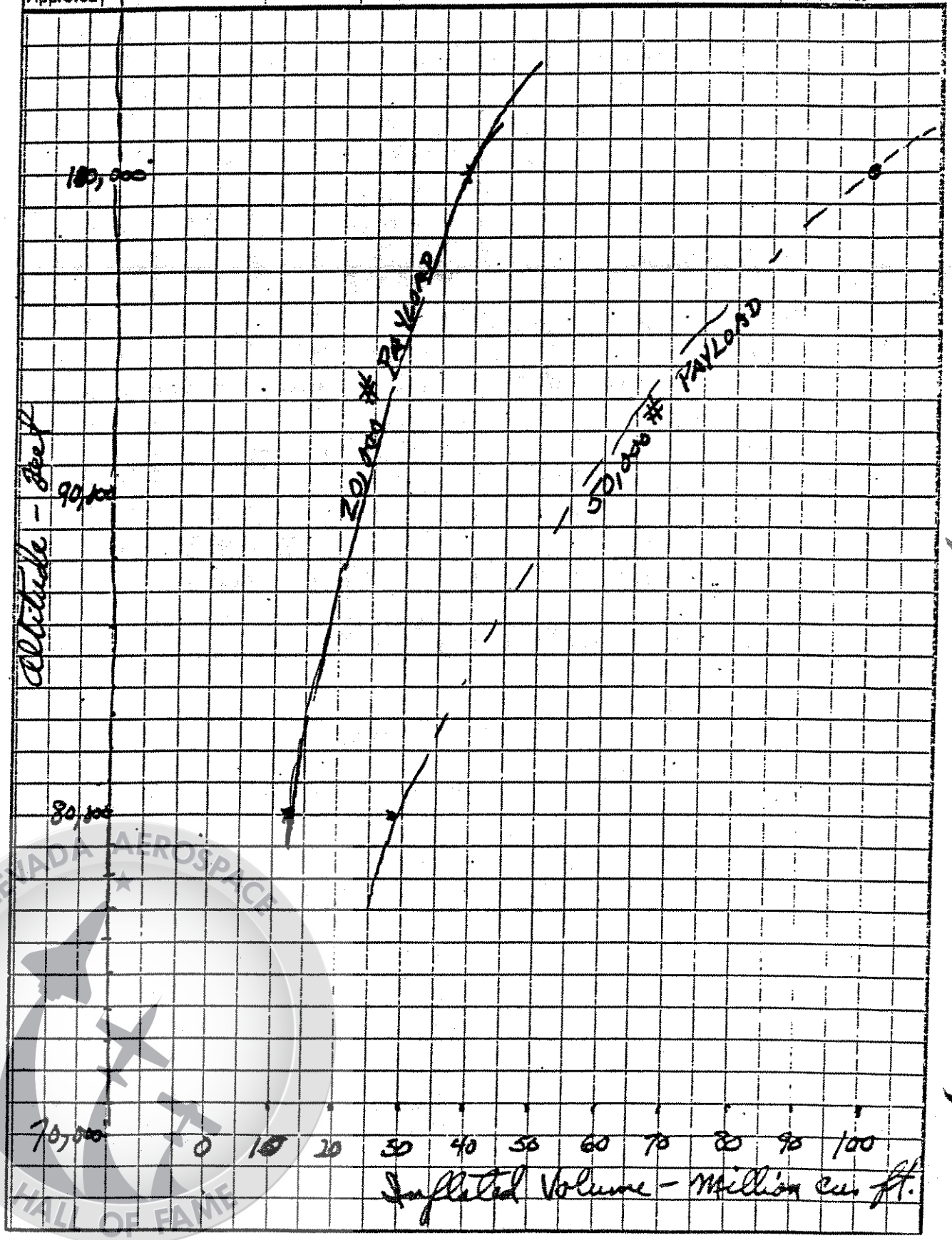
Checked			TITLE Balloon Data	Model		
Approved				Report No.		

Sept. 9, 1958
CW



NEVADA AEROSPACE HALL OF FAME

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George Schenk - in Gen Mills

1. 20,000# — 80,000' — Vol. — 11.2 X 10^6
Inflated 301' -

Uninflated 439.

Scotch Mylar + Poly 6530#

100,000 37.8 X 10^6
Dia 457' [illegible]

20,000

654'

Wt - 14 ?0#

$\sqrt[3]{2.5} = 1.36$

2. 50,000# 80,000' — Vol. 27 X 10^6

400' dia

500' [illegible].

Stronger Material. 13,000#

1/10 100,000' — 95 & 100 X 10^6
820' long
550' dia

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Target Town 4 X 10°

. If they can pick launch

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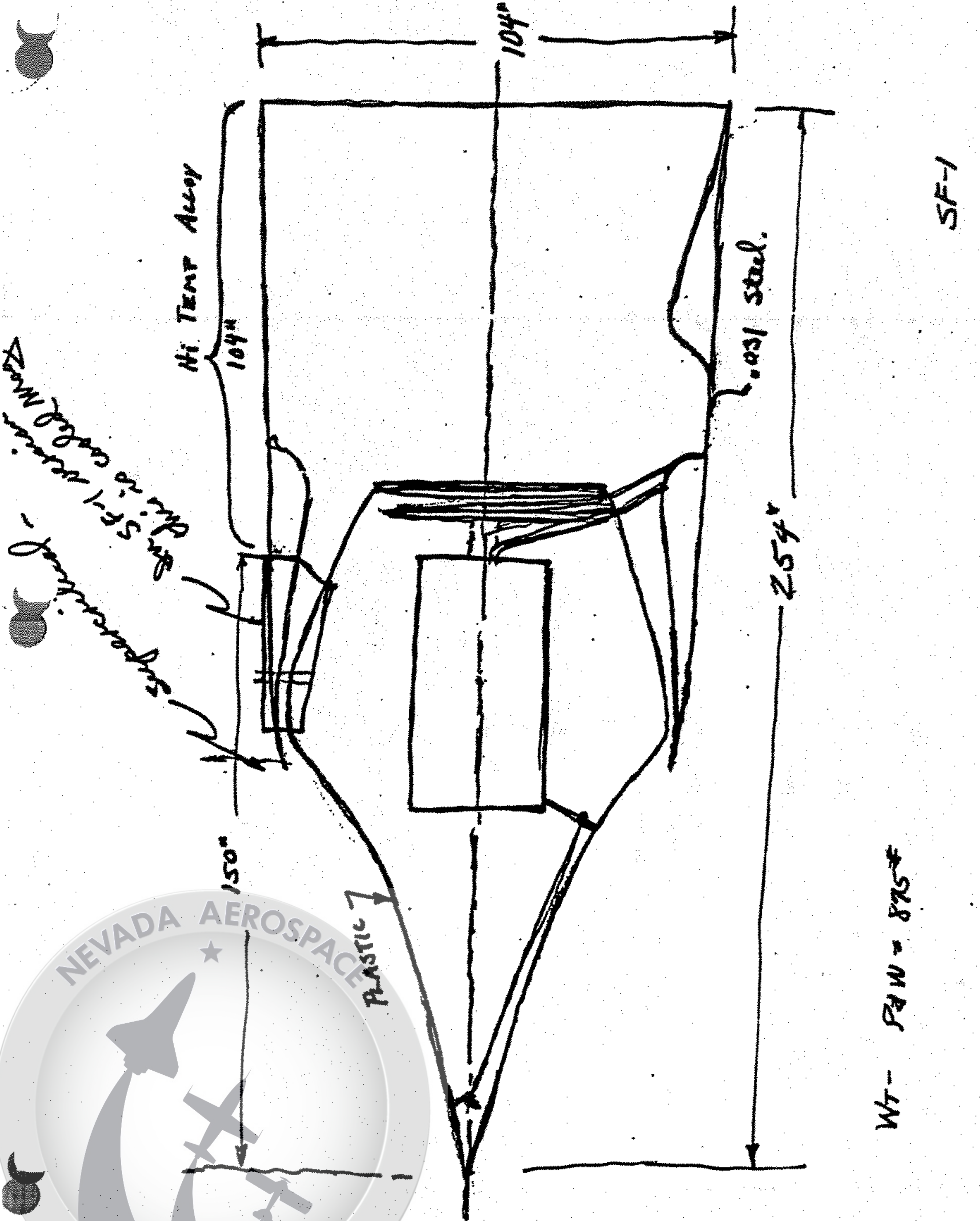

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PREPARED BY Clark
DATE SEPT 20, 58
CHECKED BY

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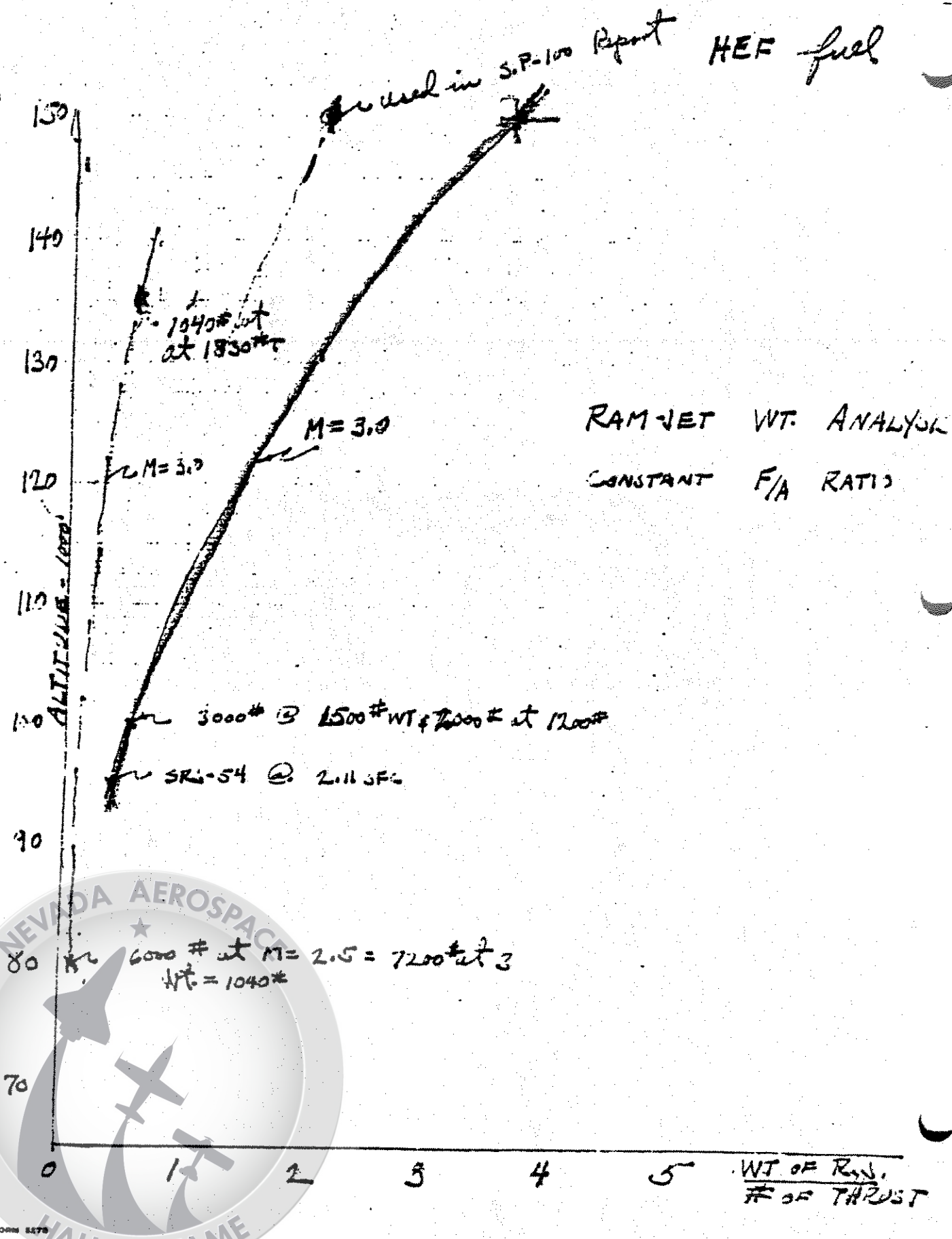
CALIFORNIA DIVISION

MODEL
REPORT NO.



NEVADA AEROSPACE HALL OF FAME

FORM 5175

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Estimate fuselage wt. – 100' long – 6' dia.

Skin area = 100' × 6 × π = 1885 □'

Assume it is .020 titanium skin

It weighs .020 × 144 × .175 = .50 #/□' –

Skin would weigh – 950#

Rings " " 900 #

Cockpit & equip bay – 500 #

Min. wt. fuselage – 2350 #

Horizontal flying tail – 2 #/□' × 400 □' = 800 #

absolute minimum wt. – no SFI fuel system

	2350
	800
	6235
	9385 #
If A-2 gear is provided	+ 265
	9650 #

Max useful range is available at this wt.

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Checked	Sept. 20, 58		TITLE			10
Approved				Model		
				Report No.		

Assume a 10,000 # equip empty wt. —

Add = 5000 # of SF-1 & SF1 system

at same Up (and structural wt.) —

a thrust of 1400 # is req'd.

This could be done at 125,000' with same ram jets.

Cruise EAS for M=3.0 = 120 Kt.

To insulate 4000 # SF-1 for mission (6700 gallons) would take about 700 # of insulation. This leaves 300 # for system.

6700 gallons is about 900 cu. ft. volume.

1000 cu. ft. needed with expansion space.

~~cu ft~~ at 5½' aver. dia. — 42' long tank is required

All the CL-400 problems come up — Tank expansion etc. Logistics.

Hypothetical Range — $\frac{575 \times 6.3 \times 3.0}{1.0} \log \frac{15000\#}{11,000\#}$? 31

— 3360 n. miles.

at Up of 5.7 — 2960 n. mi

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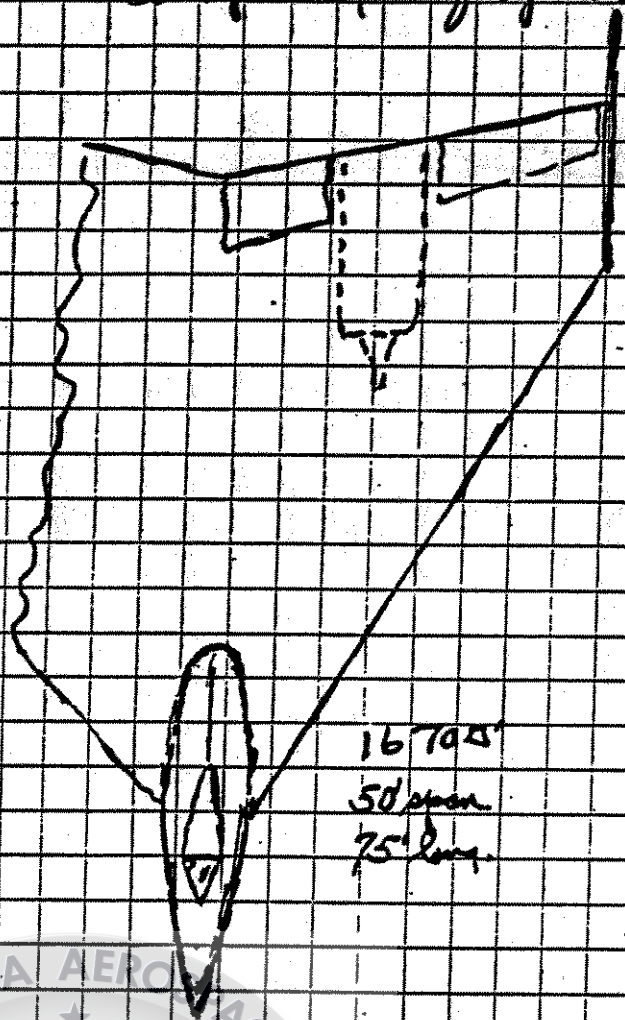
Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION	Page	TEMP.	PERM.
	Sept. 20, 58					11
Checked	CLS		TITLE Try a Bomber Job.	Model		
Approved				Report No.		

Use 10,000# airplane at 135,000# —

Try to eliminate fuselage except for cockpit & equip. bay.

L/D = 6.0 to 5.5



Wing @ 1.32#	2200#
Tail (minimum)	600
Engine - 2 @ 800#	1600
Gear (required min)	400
Instruments	60
Surface controls	300
Power supply	200
Electronics	150
Air Cond.	250
Oxygen	50
Subtotal =	5810
Cockpit & Bay =	1000
Ejector seat & fuse. =	150
Payload =	500
Subtotal =	7460
Fuel system - tanks =	500
	7960

Fuel load = 2000#

Range = $575 \times 6.0 \times \frac{3.0}{2.10} \times \log \frac{10,000}{5000} = 1090$ n. miles

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FORM 362

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Prepared	NAME ewj	DATE	LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION	Page	TEMP.	PERM. 12
Checked	Sept. 20, 58		TITLE Borane job.	Modal		
Approved				Report No.		

By dropping to 125,000' — Going to 15,000#
(5000# more fuel)

$$R = 575 \times 6.0 \times \frac{3}{2.11} \times \log_{51} \frac{15000}{9000}$$

$R = 2520$ n. miles.

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Prepared	Name: Sept. 21, 58	Date	LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION	Page	Temp.	Perm. 13
Checked	CW		Title: Try U-2 for tow job.	Model		
Approved				Report No.		

Consider basic U-2 airframe modified to tow a 15000# vehicle + 2/3 (90,000)# booster

Must tow 29,000# at 135 kts.

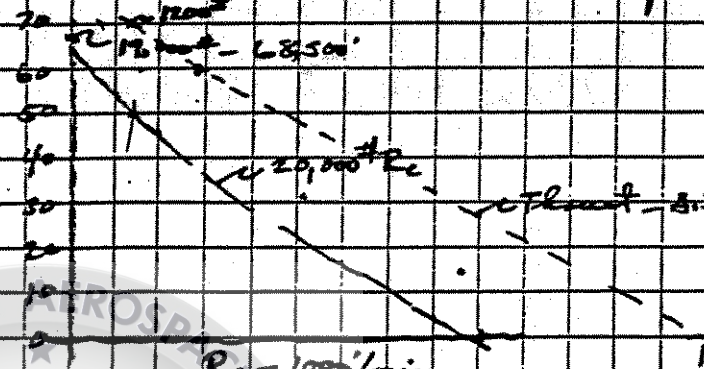
L/D vehicle = 17.4 # q = 62 #/ft² C_L = .2

L/D clean = $\frac{.28}{.015 + \frac{.28}{\pi \times 1.6}}$ = 9.1

Use 8 to account for Rocket.

$\frac{29000\#}{8}$ = 3630 # tow required.

At 50,000' today at .75 M — U-2 has about 1000# excess thrust at full wt.



at 60,000', an A.B. J-57 would give about 28,200# thrust

Two A.B. J-57's would add 5600# total thrust or 5000# net thrust to U-2 at 60,000'

Each nacelle would weigh 5000# — too much use up all U-2 fuel wt. —

Equipped empty wt. = 20,000#

Overload to 24000# perfectly feasible to 40000# [illegible]

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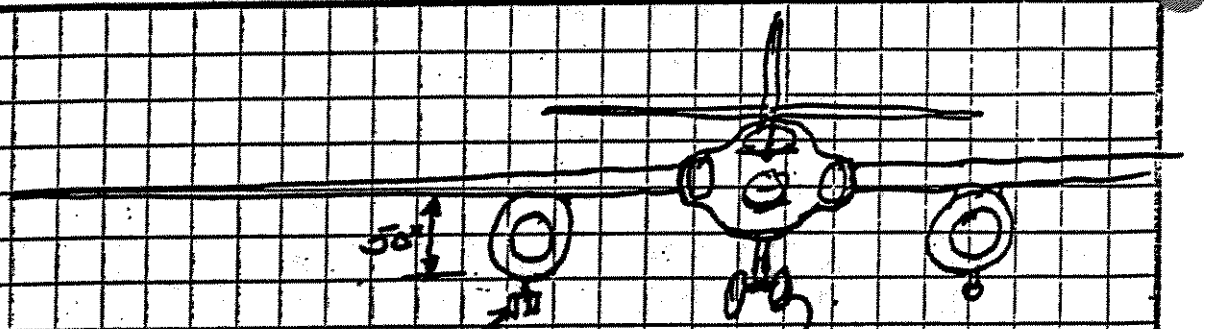
Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION	Page	TEMP.	PERM. 14
Checked	Sept 21, 58		TITLE U-2 as a towing aircraft	Model		
Approved				Report No.		



2 Longer gear — to or delete existing gear + carry all on fixed nacelles

Proposed U-2 is perfectly feasible and cheapest aircraft available to provide tow at low speeds and with sufficient excess thrust to get ram-jet vehicle to 60,000' or more at M = .80

Fuel Reqd — Mom A-B to 30,000' in 10 min.

SFC = 1.2 — Thrust = 3 x 8000 = 24000 (very conservative)

Fuel used = $\frac{10}{60}$ x 1.2 x 24000 = 4800# (with Taxi etc)

20 min to get 30 to 60,000'

One eng. mom A-B — 2500# thrust at 1.2

$\frac{1}{3}$ x 2500 x 1.2 = 1000# fuel

Other engines — $\frac{1}{3}$ x 5000 x 1.9 = 3200 mph at 6400'

Reserve fuel replaces equipment.

Gross wt = 20,000 + 4800 + 6400 = 31,200

Need heavier wing skins 200#

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A.

Report Outline - SP-100

A.- Introduction -

1. This Report presents an invest. of a highly specialized ---

2. Basically a feasibility study

B. Basic Approach to prob.

1. Fixed gross wt.
2. Fixed Range.
3. Design lightest possible wing of each type.
4. Various launching means.

C. Power plants

1. Experience to date
2. Low g - high alt.
3. Some outputs. # wts.
4. Curves vs wt.

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B.

Report SP-100.

* - Figures

D. The General Design

* 1. 3 view.
* 2. Wing — Gusts, pressures, $A/A = 3.0$ air vol. $\frac{1}{\Delta P}$ wt., helium. high & low.
* 3. Construction — wing weight Miles of thread.
* 4. Competitive metal wing.
* 5. Leading edge & trailing edge.
6. Ramjet — wt. — performance
7. Outline skin gages. REF
8. Gear.

E. The Weight Estimate.

a. 20,000 # — T.O.
b. wt. Breakdown.
c. 48,500 #

F. Performance parameters.

1. Design Speeds.
2. Range
3. Climb
4. Descent and landing.

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Report SP-100

* Figure.

G. Launching
- *1. Balloon — size
- 2. Rockets.
- *3. Fly-Tow.
  - a. Design of Fly
  - b. Tow Mission
  - c. Boost to 116,000

H. Special Problems
- a. How to build.
- b. Vulnerability
- c. Radar cross section
- d. Logistics.
- e. Wind grad. for balloons.
- f. Design time. —
- g. Aeroelastic effect.
- Radar

I. Conclusions:
- a. Wing wt.
- b. Launch
- c. Performance
- d. Usefulness

} ?

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Aug. 28, 58
CWS

D.

Airspeed reading at alt.

Compute the reading of the airspeed instrument at M=3.2 at 100,000'

$$\text{Impact press.} = \frac{\rho V^2}{2}\left(1 + \frac{M^2}{4} + \frac{M^4}{16} + \cdots\right)$$

V = 595 Kts at M=1 or 687 mph. (-45°F)

$$\text{Impact Press.} = \delta\left(\frac{\rho_0 V^2}{2}\right)\left(1 + \frac{M^2}{4} \text{ etc}\right)$$

$\delta = .0132$

$$I.P. = .0132 \times \frac{.00256 \times 687^2}{\quad} \quad (F)$$

$$= 80 \times 2 = 160\left(1 + \frac{3.2^2}{4} + \frac{3.2^4}{16} + .3.2\right)$$

3.2 = 1900 Kts or 2200 mph.

$$= 160\,(1 + 2.64 + 6.60 +$$

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Sept. 3, 1958.

Bill Sens – Pt W

J-58 data.

On turbojet 3.2 M – A.B. for Hi alt.

Run RPM up

Wt. is up 140# each (No allowance for T.P. ext.)

100,000	90,000
2850#	5240#
2.30	TSFC 2.22
40.1 #/sec.	Airflow 71.9 #/sec.

75% ram – new Spx.

Partial A.B.

	% TSFC
100 % Thrust	100
90	96
80	93
70	91

On Ramjet at 100,000 – 75% ram E.B.

2000#/thrust

wt.	TSFC	Length-Max	Max Dia	F/A
810#	2.30	134"	41"	.058
880#	2.17	141"	42.5	.05
990#	1.97	150	45	.04
1160#	1.74	161"	49.5	.03

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Bill Sens –

Inlet dia. is 85% of nozzle –

2000# at 3.2 – 100,000.

Question to Sens:

At 35 to 45,000' – V_i = 300 to 330 – Inlet is adaptable. Site R-to – appears feasible –

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FIGURES

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Sept. 4, 58
C.J.

~~Dyna chart 6~~
~~Ramjet wt vs~~ Mach No.

Ram-jet Weight Estimate:

Consider 100,000' altitude.

P. & W data for 3.2 M at .03 F/A. - gives
2000# thrust for 1160# wt or .58#/#th.

Marquardt data - 3000# thrust - 1500# or
.50 #/# thrust - SFC = 1.65

at 150,000' - $P = 2.9395$ #/□" $\delta = .001436$
at 100,000' - $P_1 = 22.598$ $\delta = .0132$

$\frac{P_{150}}{P_{100}} = 13\%$ $\frac{\delta_{150}}{\delta_{100}} = 10.8\%$

Marquardt thrust data - at M = 2.5 $\frac{10\#/A'_{150}}{70\#_{100}} = 14.3\%$

Taking 14% of ~~weight~~ thrust to wt. ratios shown -

$\frac{1}{.14} \times .50$ #wt/#thrust = ~~.070~~ 3.57 #wt/#thrust

But this does not correct for lower E.A.S.

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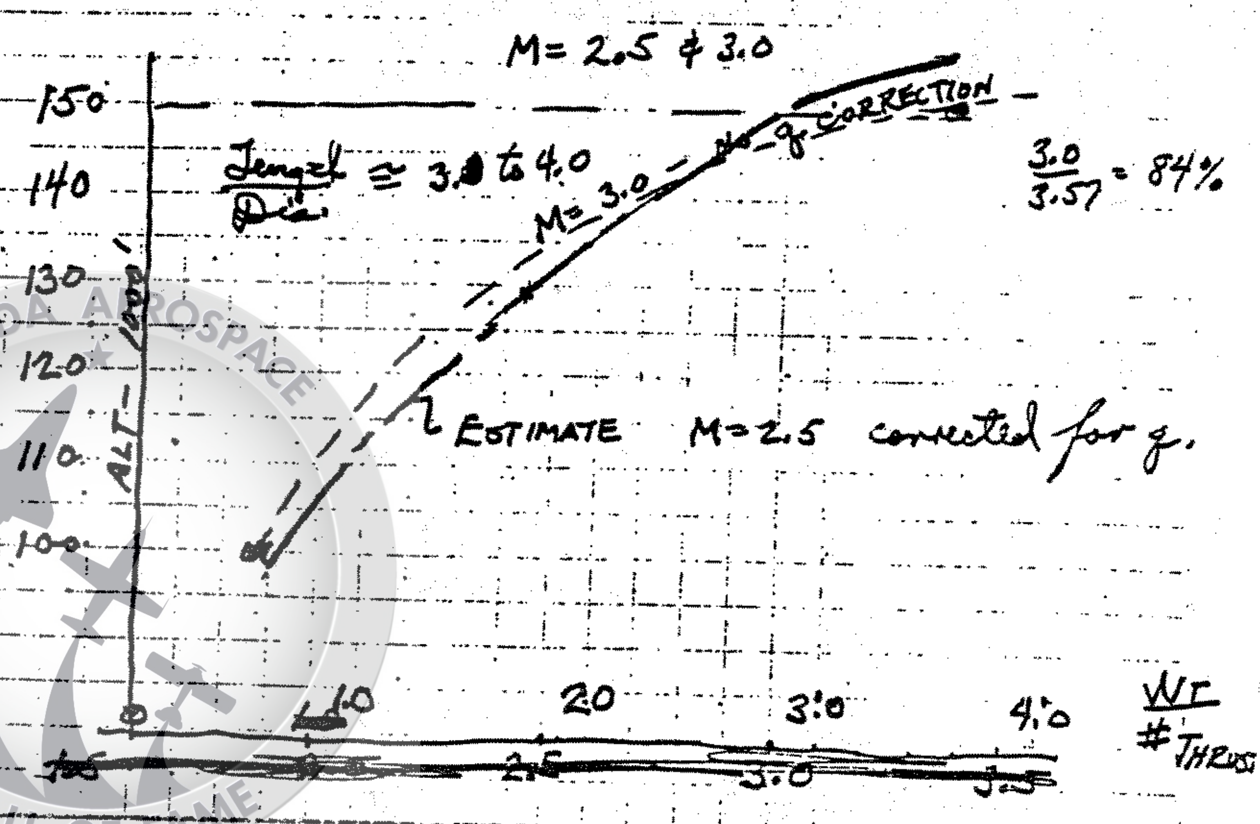
Sept. 4, 59
CLJ.

The values derived are for 150,000' operation of ram jets designed for M= 3.0 adjusted approx. for density changes so the data is only a first approximation. The high design Mach no. is favorable to a low value of ram jet weight to thrust but is partly compensated for by the need for a variable inlet required for Mach 3 but perhaps not needed for M= 2.5. The lower EAS values at 150,000' would lower the weight for higher altitude. As a rough estimate then, Fig 5 can be drawn.



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at 130,000', a wt. of 2# per pound of thrust might be feasible except that size influence the ramjet adversely.

For a 20,000# weight airplane at an L/D of 7.0 (for wing + tails + drag due to lift) — 2840# of thrust is required.

Minimum Ramjet wt. = 2 x 2840 = 5680#

This is for a minimum length ramjet

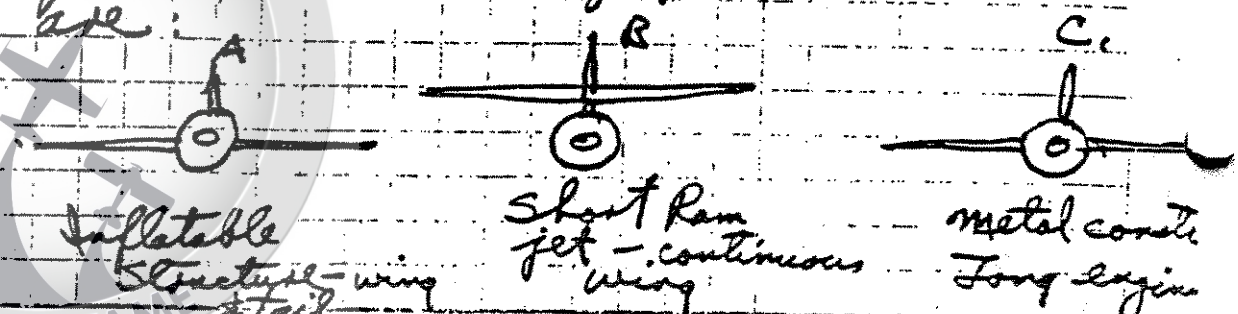
~~(Check this against recent skin gage data)~~

To make another estimate of the ramjet wt. — assumptions were made of skin gages for the design shown in Fig 6.

This engine-fuselage combination has a length to diameter ratio of 8.7 while the engine data above assumes 3.3.

Basic Weight Data:

The equipped empty wt. is estimated for three configurations. (Fig 7) They are:



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Sept 4, 1958
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Item –	Airplane A Inflatable Long Engine	Airplane B ~~[illegible]~~ Inflatable Short Engine	Airplane C Metal Long Eng
Wing weight –	7500	10,050	6000
Tail wt. –	1210	1,210	970
* Landing Gear	265	265	265
Ram jet	10,835	5680	10,835
Ram jet Pylon	0	750	0
Surface Controls	500	600	500
* Instruments	60	60	60
Hydraulic & Electric Power Supply	500	500	500
* Electronics	170 ~~[illegible]~~	170 ~~[illegible]~~	170 ~~[illegible]~~
* Ejection Seat & furnishing	150	150	150
Air Conditioning	250	250	250
Unusable Fuel	100	100	100
* Oxygen	50	50	50
* Structural Provision for crew, equipment etc.	500	500	500
Equipped Empty Wt.	22,090	20,335	20,350
* Wt. allowances			

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ITEM	AIRPLANE A INFLATABLE LONG ENGINE	AIRPLANE B INFLATABLE SHORT ENGINE	AIRPLANE C METAL LONG ENGINE
Wing Weight	7500	10,050	6,000
Tail Weight	1210	1,210	970
*Landing Gear	265	265	265
Ramjet	10,835	5,680	10,835
Ramjet Pylon	0	750	0
Surface Controls	500	600	500
*Instruments	60	60	60
Hydraulic & Electric Power Supply	500	500	500
*Electronics	170	170	170
*Ejection & Furnishing	150	150	150
Air Conditioning	250	250	250
Unusable Fuel	100	100	100
*Oxygen	50	50	50
*Structural Provision for Crew, Equipment, etc.	500	500	500
Equipped Empty Wt.	22,090	20,335	20,350
*Pilot	285	285	285
*Military Load	500	500	500
Zero Fuel Wt.	22,875#	21,120#	21,135#

*U-2 allowances

The U-2 weight allowances are felt to be the minimum practical for the items starred (*). It can be seen therefore that the assumption of a gross weight of 20,000# to do the mission is fantastically optimistic. No range at all is possible at this weight. While Airplane B has a lighter ramjet than Airplanes A and C, the wing weight is higher. In the latter two cases, the wing area displaced by the ramjet provides enough weight allowance to account for the carry-through structure.

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4

Equipped Empty Wt. ~	22090	20,335	20,3
*Pilot	285	285	28
*Military load	500	500	50
Zero fuel wt.	22,875#	21,120#	21,13

The A-2 weight allowances are felt to be the minimum practical for the items starred (*). It can be seen therefore that the assumption of a gross wt. of 20,000# to do the mission is fantastically optimistic. No range at all is possible at this weight. While airplane B has a lighter ramjet than airplanes A and C, the wing weight is higher. In the latter two cases, the wing area displaced by the ramjet provides enough weight allowance to account for the carry-through structure.

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Configuration B is so unwieldy and probably high in drag, that A or C should be considered from this point forward.

If a smaller aircraft would be built, keeping a constant 500 # payload it is not to be expected that a more favorable weight picture would be obtained. Fixed weight items such as pilot, radio, instruments & system would no doubt worsen the trend keeping the same wing loading.

Landing Gear:

In spite of the low stalling speed of the airplane on landing, a gear is considered mandatory. The U-2 gear weight is assumed - namely 265#. This weight might be obtained for a 20,000 # gross weight but it is

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only 10% of that necessary for the heavy weights considered ~~under~~ later in this report.

The use of ~~a~~ a gear configuration makes towing practical for launching. A 7° angle of attack is used on take-off and landing. This requires a wing-to-fuselage angle of incidence (4°) which however is beneficial for cruising.

Recapitulation:

Although it has been shown ~~that~~ that a 20,000# gross weight would have no fuel in the aircraft being evaluated, this basic weight will be used with no structural weight changes to continue the study of launching and performance problems. Later in the report, a zero fuel weight of 23,000# (Airplane A) is used and fuel added to get a ~~total~~ range of 4000 n. miles.

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In this case, the gross weight at the point of ram-jet ignition is 56,000 #. To all of the weight used, the rocket booster weight must be added.

Launching: Vena - A major title

Three methods of launching were considered. Because ram-jets must be ignited at pressures or speed reasonably close to their design value it is necessary to provide a rocket boost to get up to M = 2.5 at about 114,000' for the aircraft considered. At this condition, the rocket cases are jettisoned and the ram-jet provide enough thrust to fly the aircraft in a gradual climb.

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Record | Sept 8, 58 CLS | ACCELERATED AIRCRAFT CORP. | 8.

The use of rockets only to launch the aircraft was rejected at once due to the large units required, the low design speed of the vehicle (120K and the problems of accurate thrust control required.

The second means considered was the use of a large balloon to lift the aircraft with its accelerating rocket to 100,000 feet and then cutting it loose.

Deleted rest of it

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The most feasible launching system seems to be a combination of towing by a subsonic tow aircraft to an altitude of about 60,000' and then rocket boosting the vehicle to 114,000' and M = 2.5 for ram-jet ignition. Towing vehicles were designed for meeting these requirements (Fig - - -)

The following data (expanded in appendix 'B') applies:

Item.	Case I	Case II
Vehicle ~~Equipped~~ empty wt.	20,000 #	23,000 #
Ramjet fuel wt.	0	33,000 #
Vehicle range	Negative	4000 n. mi
Rocket Boost Spec. Impulse	5.1×10^6 Pound sec.	15.6×10^6 Pound sec.
Rocket Spec. Impulse - #/sec	250	250
Vehicle wt. with Rockets -	41,000 #	125,000 #

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Item.	Case I	Case II
Tug gross wt.	60,000#	94,000#
No. of J-75 engines	4	6
Release altitude	60,000'	55,000'
Release Mach No.	.68	.60
Ram jet Ignition	116,000'	114,000'

It is interesting that the equivalent rocket of the Polaris missile is required to launch airplane A (Case I) after towing to altitude, while three Polaris are required if the actual mission is to be accomplished (Case II).

The complexity of the whole system, the problem of disposing large rocket cases, 3' in diameter and 40' long and the danger involved to the pilot and tug crew make even this, the best launching means, a very considerable problem.

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Note that when Airplane A is loaded up for a range of 4000 n. mi. it takes off at 125,000 # or 5½ times its design weight. Obviously a 26 # landing gear or a wing designed for a 3 #/sq. ft. wing loading and carrying 18.7 #/sq. ft. are somewhat over-

Performance

Redone when decided actual performance data is presented in appendix 'B'. Briefly, using supported weights, the aircraft cruises at M=2.5 at an initial altitude of 114,000' and reaches 125,000' at one half range. It gradually climbs to 134,000' over home base when it descends and lands.

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Prepared	Sept. 9, 1958	DATE	LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION	Page	TEMP.	PERM. L
Checked	CW		TITLE What factors are required to make a 20,000 # airplane Work			
Approved						

$$R = 575 \times \frac{L}{D} \times \frac{M}{C} \times \log_e \frac{W_a}{W_{EE}}$$

$$4000 = 575 \times 7.0 \times \frac{2.5}{2.46} \times \log_e \frac{20,000}{W_{EE}}$$

$$\log_e = .978 \qquad \frac{W_a}{W_{EE}} = 2.66$$

$$W_{EE} = \frac{20,000}{2.66} = 7530\ \#$$

at 115,000' — M = 2.5 = EAS of ~ 131 Kts

$$q = 44.6\ \#/ft^2$$

or $C_L = .45$ $\quad \frac{L}{A} = 607\ \#/ft^2$

at 120,000' — M = 2.5 EAS = 110 $q = 31$

$C_L = .45$

$L/A = 4.65$

Using this value — what kind of airplane results? —

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Checked			TITLE	Model		
Approved				Report No.		

W_{EE} = 7530 #

Wing area = $\frac{20,000}{4.65}$ = 4300 □'

Tail area = 500 □'

at 1 #/□' — 4800 # wt. of wing + tail

Weight Breakdown

Wing Weight @ 1.2 #/□' =	5160 #
Tail Wt. @ 1.2 =	600
Gear —	0
Instruments	60
Surface Controls —	300
Power supply (No gear, flaps, booster)	200
Electronics	150
Cockpit seat, furnishings	150
Air Conditioning	250
Oxygen	60
Subtotal —	6920
Man & suit — (Should him for his weight	200
Payload —	500
	7620
Neat 15' dia. engine —	5680
Equipped Empty Wt =	13,300

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$$\text{Range} = 575 \times \left(\frac{L}{D}\right)_{\text{cruise}} \times \frac{M}{SFC} \times \log_e \frac{W_G}{W_G - \text{Fuel}}$$

$$\text{Range} = 575 \times 7.0 \times \frac{2.5}{2.46} \times \log_e \frac{20{,}000}{13{,}300}$$

$$\text{Range} = 4100 \log_e 1.51 = 1690 \text{ miles}$$

If $SFC = 1.65$, $R = \frac{2.46}{1.65} \times 1690 = 2520$ mi.

$\therefore \frac{L}{D}$ to get 4000 mi $= \frac{4000}{2520} \times 7.0 = 11.10$

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4000 nautical mile range completed at an altitude near 150,000 feet. To do this would require an equipped empty weight of 7530 #. With a wing loading of 3 pounds per square foot and a wing weight of one pound per square foot, the weight of wing plus tail alone is 7500 # so it can be seen that these values are not consistent. Dideb.

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Radar Cross Section:

While the inflatable aircraft does ~~have~~ have certain characteristics favorable ~~to~~ for reducing radar reflection in certain frequency bands, a careful examination of actual construction does not necessarily substantiate this. The large 15' diameter metal ram-jet is just as bad as worse than a comparable fuselage. Metal or thick fiberglass control rods, links and hinges on the wing and tail will partially nullify the good basic wing design from a reflectivity point of view.

Overall, the aircraft will probably have a rather large return at search frequencies.

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REPT. C

System Cost

No cost estimates have been made for the whole weapon system. It is obvious that a great expense will be incurred in the solving of the many unique design problems. Jets complete aircraft and new rocket boosters must be developed. It can be stated that the cost and risk per flight will be many times greater than those incurred with existing reconnaissance systems.

Developement Time.

No estimate has been made on required developement time. In the experience of the writer, it would take no less than six years to get an operational system.

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Conclusions

Based on the studies made in this report, the following conclusions are reached:

1. Inflatable wing and tail surfaces for the proposed design cannot be built for one pound of weight per square foot for the speeds and altitudes proposed.

2. A metal surface can be built for 80% of the weight of the inflatable surface for the same speed, altitudes, planform and thickness. It would however still be 20% over the desired unit weight.

3. Ram-jet power plants will operate at the speeds and altitudes proposed when run on Borane fuels.

~~4. Overall aircraft weights of 50 to 60 per cent of the gross weight of the power plant are required~~

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4. Even using the most optimistic design criteria in terms of speeds, gust loads, structure, drag and propulsion, no aircraft system having any reasonable degree of feasibility could be devised to fly the desired mission previously outlined.

5. The best launching means for the aircraft studied was a combination of towing by another aircraft and then boosting to speed and altitude by rockets.

6. The great technical risks involved, high cost, great vulnerability, and overall lack of feasibility for the mission proposed indicate that other approaches to the problem should be considered more fruitful.

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Checked	CH		TITLE Report on Archangel I & II	Model		
Approved				Part No.		

Report SP-101

Introduction

Basic problem

Two aircraft I & II

Ram Jet — 10#

Archangel I

1650 a' — Span — Length —

2 - J-58 Titanium

Wts Performance on pages — — —

85,000 target act.

Archangel II

To get more alt — use 75" R.I.

Use HEF. Go 1/2 M = 3.2

3 view — Dimensions.

Wt — Breakdown

J-58 — engine wt 1450# each

Lite R.I. — Low —

Performance section — Drag — R/C

Recommendations —

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Checked	CW		TITLE Report on Archangel	Model		
Approved				Report No.		

Report List:

Fig.	Title.	Where is it
1	Archangel I - 3 View -	Done - CW (Typed on Spec, a with it)
2.	Wt. Summary - A-1	Typed on Spec
3	Performance Summary - A-1	"
4.	Mission Profile - A-1	"
5.	Archangel II - 3 View	
6.	Weight Breakdown	CW
7	Mission Profile	

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FORM 362

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Checked			TITLE	Model		
Approved				Report No. 4E333		

Col. John Hancock - AFDAP - ~~4A348~~

Dammler + Swofford. See Him

Hal Watson -

Is in P. a request for 3 A/c. $850,000 fund reqd.

Col Fred Moore - AFDRDER

Col Finton - aircraft assignment - Wilson's office - has request for 3 aircraft.

Aspa Very Early Warning Panel -

~~Dave Fuck~~

Ward Low - Dr Dave Fuck

Sylvania - RCA

4 approaches - GM - $10x10^6 - ordered closed ~~& tactical use~~

GE Redeye Bamboo -

B-ins - V Low F + UHF + R + Opt. - Fat Lin.

AMEWS - Possible claims

+ 87A Bams

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Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION	Page	TEMP.	PERM.
	Sept. 2, 58					6
Checked	Wash. D.C.		TITLE Evaluate Nt. of P&W Lit-wt. Power Plant.	Model		
Approved	CW			Report No.		

Basic Data on P&W Ramjet.

	SF-1		PENTAB.
Dia - inches	104"	104"	104"
Length - "	256"	254"	254
Wt. —	875#	875#	1040
Thrust - M = 3.0 - 135000'	1600#	1960#	1830#
TSEC - " "	.89	.97	2.10
Thrust - M = 2.5 - 80,000'	4500	6660	6000
SFC " "	1.13	1.00 (?)	1.91

See P-2 for Drawing of Engine

At 80,000' — M = 2.5 + Spec. wt. = $\frac{875\#}{6660}$ = .1325 !

On Pentaborane — $\frac{1040\#}{6000}$ = .173

Take this to 100,000' on density ratio only:

$\frac{\delta_{100}}{\delta_{80}} = \frac{.0132}{.036} = .366$

Weight Ratio would then be about $\frac{.1325}{.366}$ = .362

$\frac{.173}{.366} = .472$

Compare .472 with .58 given me by Sam before

$\frac{.58}{.472} = 1.23$

~~Thrust - 54"~~ But this engine weighs about the same as RJ-54-#2 (P.I. of report, which puts out same thrust on same fuel at same SFC 40,000' lower!

FORM 362

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Prepared	NAME Sept. 20, 1957	DATE	LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION	Page	TEMP.	PERM. 44
Checked	Work. DC		TITLE	Model		
Approved	CW			Report No.		

I called Perry — he cannot explain differences. Will call me back.

Mach 2.5 at 80,000' is about 270 Kts. E.A.S. Engine is designed for 6600# of thrust there so this is about 1/2 the same I asked for in SR-54. There is then essentially two g. diff. in design. Also — a variable inlet design is absolutely mandatory above M = 2.5 from our experience.

Why does SF1 engine weigh less than HEF?

Mach 3.0 at 135,000' is 100 Kts. E.A.S.

At 12 45 I talked to Bill Sens. He could not explain above except to say it was very optimistic. He did not know of our CL-400 inlet tests. He agreed that the reliability was low. He could not explain satisfactorily the difference in wt. in SF-1 & HEF engine.

I conclude at this point:

(a) My original wt. estimate used in SR-160 is sound for 150,000' alt.

(b) P & W optimistic by about 50 to 100% at 135,000'.

(c) P & W design won't work because of inlet conditions.

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Prepared	NAME Sept. 24, 1958	DATE	LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION	Page	TEMP.	PERM. 5.
Checked	Wash. DC		TITLE Evaluate a 10,000#—	Model		
Approved	CLJ		135,000' M=3.0 Aircraft No.			

Let us see what a metal surface, ramjet powered SF-1 fueled aircraft can do at M= 3.0 at 135,000' altitude.

Design variables:

Wt. at R-J ignition = 10,000 #

Design C_L = .17

M_{ct} = 3.0 E.A.S. = 100 Kts

Design dive speed = that to ignite R-J at M= 2.5 at 80,000' — This is 275 Kts. —

Unalterable

M = 2.5 at 110,000' at E.A.S. = 135 Kts

For this

Cruise $\frac{L}{D}$ = 34 #/D. $\frac{L}{A}$ = 5.8 #—

Use 6# wing loading.

Wing area = $\frac{10,000}{6}$ = 1670 ft²

Titanium plus fabric to be used.

Ultimate load factor is 3.75 Design

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Checked	CW		TITLE	Model		
Approved				Report No.		

Gust load factor = $1 + \frac{K_g V_e a C_{L_\alpha}}{500 \left(\frac{W}{S}\right)}$

$K = \frac{1}{2}\left(\frac{1}{A}\right)^2 = .78$

applied factor = $1 + \frac{.78 \times 30 \times 1.35 \times 2.9}{500 \times 6}$

$= 1 + 3.06 = 4.06$

Design factor = $1.5 \times 4.06 = 6.1$

(Compare this to 8.4 @ 3#/ft²)

However, torsion will design the wing.

Estimate wing wt. as follows:

Assume we can do 1.1 #/ft² in metal + fabric at M = 2.5

To go to titanium would raise wt. about ½ difference of material wts. —

$\left(\frac{.175}{.100} - 1\right)\frac{1}{2} = 37.5\%$ There is some saving, though little due to load factor. Wing torsions are worse due to design speed increasing.

Assume, optimistically, that only a 20% (not 37½%) wing wt increase takes place:

Unit wt. = $1.1 \times 1.20 = 1.32$ #/ft².

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Checked	Sept. 20, 58		Title	Model		
Approved				Report No.		

Power Plant:

Assume L/D of 6.3 — Thrust req'd. =

$\frac{10,000}{6.3} = 1600\#$

Use engine spec. wt. of 1.0 #/# thrust.

(This compares to 2.25 in my orig. estimate

Weight analysis:

Wing — 1670 □' at 1.32 #/□' =	2200 #
Vertical tail — 300 □' @ ~ —	400
Engines (2 @ 800 #)	1600 #
Gear (reinforcements only)	150 #
Instruments	60
Surface controls —	300
Power supply —	200
Electronics —	150
Air conditioning —	250
Oxygen —	50
Subtotal —	5360
Pilot —	225
Eject seat, insulation	150
Payload —	500
Subtotal —	6235

(No fuselage or fuel to here)
(No [illegible] Hor. tail)

Draw up airplane:

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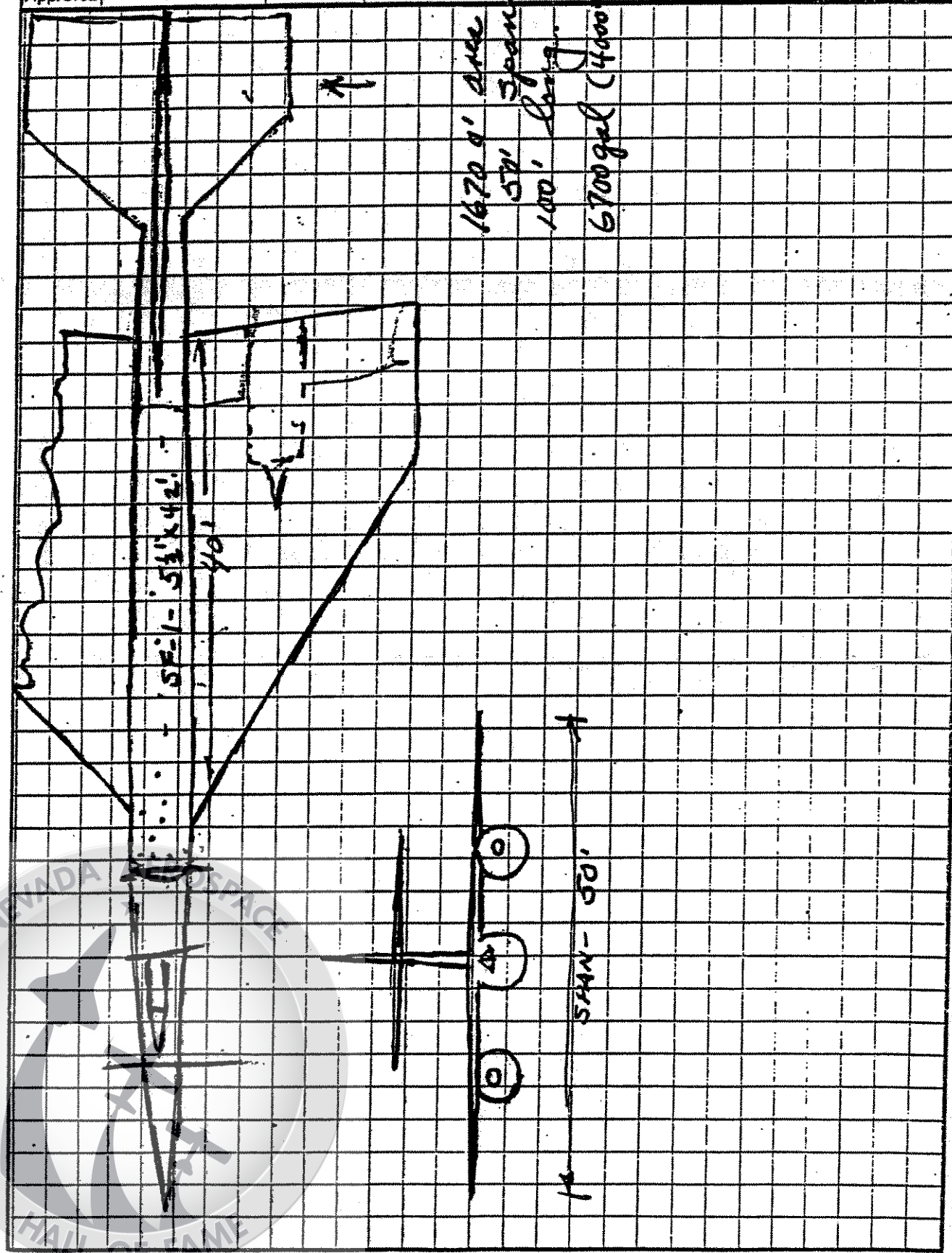
Checked	Sept 29, 58		TITLE	Model		
Approved				Report No.		



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Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION	Page	TEMP.	PERM.
Checked	Aug 27, 58 CLJ		TITLE	Model		
Approved				Report No.		

A Study on Getting Archangel II
to 100,000' Cruise Altitude
by Going to M = 3.2
plus
Ram-jets on Tip.

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Aug. 27, 1958 — 1

Revise Archangel to Higher Speed & alt.

By use of ram jets plus turbo jets we can fly about 10,000' higher than Archangel #1.

Assume a target altitude of 100,000'.

$M = 3.2$ $V_{EAS} = 220$ δ at 100 = .0132

$\delta^{\frac{1}{2}} = .115$

$q = 162$ #/sq. ft.

$C_{L\ design} = .17$ $\frac{L}{A} = C_L \times q = .17 \times 162$

Wing loading = 27.6 #/ft²

at 90,000' — $M = 3.2$ is 274 E.A.S.

Choose 300 E.A.S. design dive speed.

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Aug 27, 58

Revised Archangel.

Estimate new zero fuel wt.

A-1 was 41000#.

Add wing area - 1650□' to 2500

Δ Area = 850□'

Due to difference in design speed:

Wing wt. = $\left(\frac{4.8\#/\square' \times 2500}{\cancel{1650}}\right) - 9100$

= 12,000 − 9100 = 3000#

Tail area must increase to 1200□' from 780 Δ area = 420□'

Δ W = 4 × 420 = 1680#

Archangel #1 - E.E.W. =	41,000
Add wing =	3000
Add tail =	1680
Add Ramjets =	3500
Add misc. =	1000
A-2 =	50,180 ≈ 50,000#

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Aug. 27, 58

Revise Archangel 1.

Gross wt = 100,000#

Fuel wt. = 50,000#

Average SFC. at 3.2 at 100,000 is 1.88

Use JP-x in engine
HEF in Ramjet.

$$R = 575 \times 6.5 \times \frac{3.2}{1.88} \times \log_e^{(.692)} 2.0$$

R = 4400 n. mi. or 4000 mi. plus climb.

at 70,000# gross $\frac{L}{A}$ = 28# - C_L = .172

Thrust Rqd = $\frac{70,000}{6.5}$ = 10,750#

Ramjets = 6000# net.

Engines Aguin $\frac{4750}{2}$ = 2375#

Spec shows — 2400 to 3000 — therefor — config. works.

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Checked:

Approved:

Archangel #2

At 100000' — R.N/ft. = MX 100,000 per ft.

R.N. = 320,100 x mean chord.

AR = 1.5 Span = $\sqrt{2500 \times 1.5}$ = 50 x 1.22

$AR = \frac{S^2}{A}$

Span = 61.2'

Average Chord = $\frac{2500}{61.2}$ = 40.8

RN - average = 13,000,000

C_f for wing = .0019

C_D = .0038 compared to A, of .0030

Tail = C_{D_T} = .0048 " " "

or

$C_{D\,Tail\,(wing\,area)}$ = .0023, or .0018

Nacelles were .0009 on 1650 ft² or .0006 on 2500 ft²

Fuselage was .0010 — at RN = 19 x 10⁶

New RN. 16 x 10⁶ — call $C_{D_{FW}}$ = .0007

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Aug 27, 58

Archangel #2 –

Summary – 2500 ft²

Skin friction – (correct wing for 400 ft² inf.

Wing – C_D =	.0032
Tail –	.0023
Nacelles –	.0006
Fuselage –	.0007
C_{D_F} =	.0068

Pressure Drag – M = 3.2 –

Fuselage Nose .00085 ∴ $\frac{1650}{2500}$ x .00085 = .00056

Canopy =	.00020
Wing – =	.00125
Tail – =	.00080
Nacelles – =	.00033
Press. Drag Coeff. =	.00314
Drag due to Wing Lift – C_L = .17 (Include Trim) =	.0088e

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Archangel 2.

Total Drag at 100,000' at $C_L = .17$
$M = 3.2$

Skin Friction	.00680
Pressure Drag	.00314
Due to lift	.01880
Total =	.02874

$$L/D = \frac{.17}{.02874} = 5.9$$

$$\text{Regd Thrust} = \frac{70,000}{5.9} = 11,850\#$$

$$\text{Range} = \frac{5.9}{6.5} \times 4400 = 4000 \text{ miles}$$

at $M = 1.0 = 575$ n. mi.

Actually at 100,000' $\rightarrow$ $M = 1.0 = 595$

$$R = \frac{595}{575} \times 4000 = 4170 \text{ n. mi.}$$

(Done with RenRich, Fuller, Nelson)

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Checked	Aug 26, 58		Call from P & W - Mr [redacted]		
Approved					

Sena

1. On JT-11 eng - M=4.0 - 350#/eng thrust

2. The HEF - 180# more (thrust)

3. at M-4.0 @ 100000' 62% ram -
Either fuel - 2010#/eng.

4. HEF is ~~2.0~~ 1.96 SFC.
2.4 with new JP (20

5. Airflow 37½#/sec.

6. Corrected thrust constant to 79,000'

On turbo ramjet JT 11-7a -
wt. - (HEF) - 6990#
Thrust - 3500# - 4.0 M. (100,
Thrust SFC - 2.26 JP
1.75 HEF.
Airflow 62#/sec.

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Report No. SP-101
Dated: 11 Sept. 1958

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DESIGN STUDY

ARCHANGEL AIRCRAFT

By Clarence L. Johnson
Clarence L. Johnson

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ARCHANGEL I

Figures 1 through 4 show the important characteristics of Archangel I. The airplane is a single-place, twin-engine type having an equipped empty weight of 41,000 pounds. Titanium alloy B120CVA is used for the major portion of the structure. The aircraft is powered by two afterburning Pratt & Whitney J58 turbojets. At half maximum range, an altitude of 85,000 feet is obtained, as shown in Figure 4. This altitude performance was considered to be unsatisfactory for the time period at which the airplane could be operational. Additional studies were made leading to the design described herewith.

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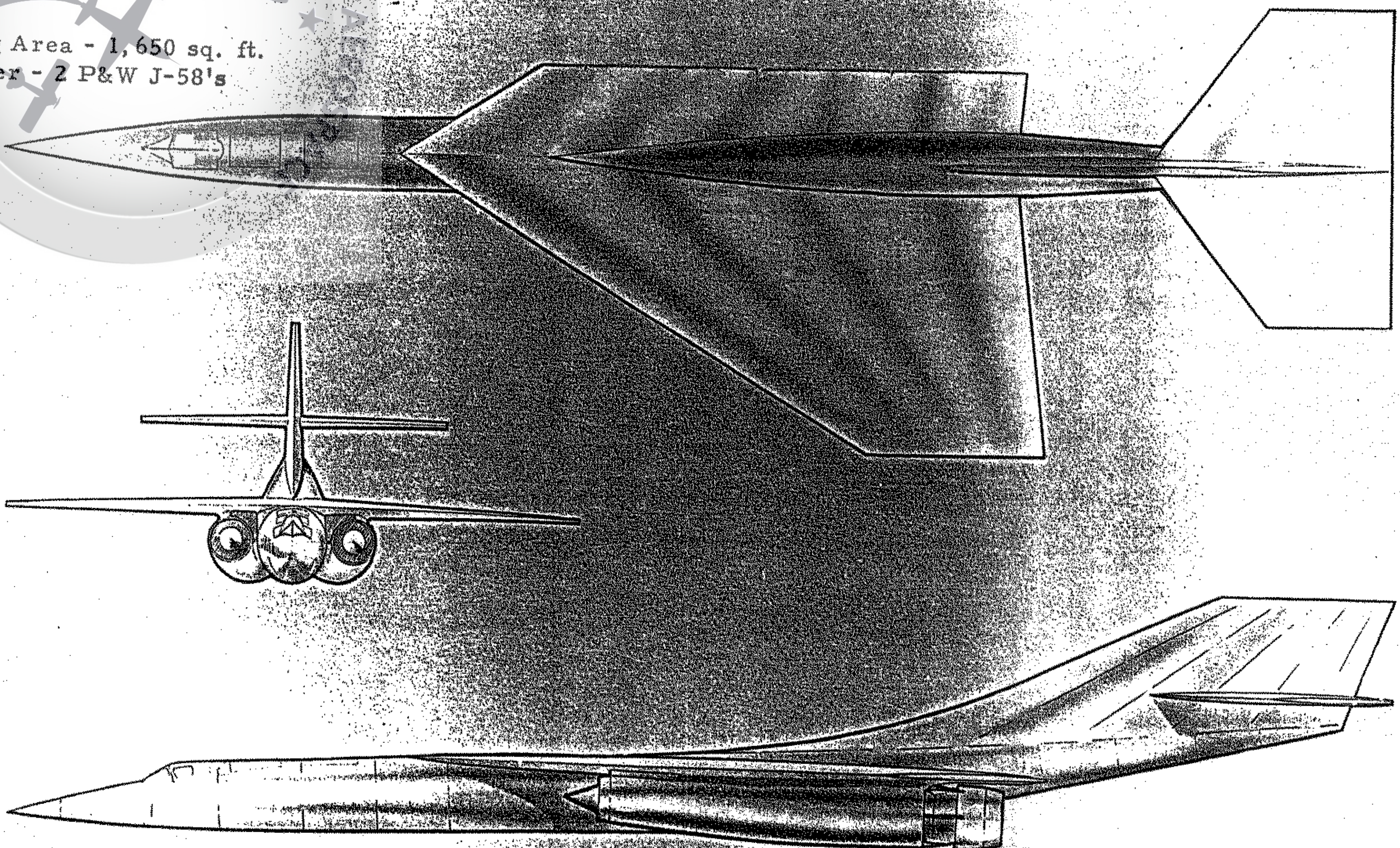
ARCHANGEL I

Span - 48.8'
Length - 116.7'
Height - 23.6'

Wing Area - 1,650 sq. ft.
Power - 2 P&W J-58's



Equipped Empty Wt. - 41,000 lbs
Gross Wt. - 102,000 lbs.

FIGURE 1

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WEIGHT SUMMARY

ARCHANGEL I

WEIGHT EMPTY		39,910 Lb.
NON-DISPOSABLE USEFUL LOAD		
Residual Fuel	150	
Oil	100	
Oxygen	55	
Pilot	285	
Payload	500	1,090 Lb.
ZERO FUEL WEIGHT		41,000 Lb.
FUEL		61,000 Lb.
TAKE-OFF WEIGHT		102,000 Lb.

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PERFORMANCE SUMMARY

Supersonic Airplane

ARCHANGEL I

TAKE-OFF WEIGHT	lb.	102,640
ZERO FUEL WEIGHT	lb.	41,000
RANGE	n. mi.	4022
CRUISE MACH NO.		3.0
CRUISE ALTITUDE	ft.	83,000/ 93,000
RATE OF CLIMB - S.L. - T.O. Wt.	ft/min	17,100
TAKE-OFF GROUND ROLL	ft.	3,330
LANDING GROUND ROLL	ft.	3,390

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ARCHANGEL II

In order to get higher altitude, the wing loading must be reduced and the power output increased by approximately 100%. Archangel II data is shown in Figures 5 through 8. 75 inch diameter ram-jets are provided on the wing tips, while two Pratt & Whitney J58 engines are located in outboard nacelles. The added wing area has now allowed the engine installations to move outboard from their positions on the Archangel I. The design cruise speed of the airplane has been raised from Mach 3 to Mach 3.2. The J58 engine weights have increased 140 pounds to obtain this performance. In order to obtain transonic acceleration while still staying within the design speed (300 knots E.A.S.), the ram-jets are lighted at Mach .95 at about 36,000 feet. Their S.F.C. is high during this low Mach number operation, and it is necessary to use an expendable nose cowl to get reasonable thrusts at the Mach number range of from .95 to 1.6. HEF is used for the ram-jets, while the J58's burn a hydrocarbon fuel, known as JP150, having slightly greater heating values than JP4.

The airplane performance is excellent, as shown on Figure 7. Using combined power plants, it is feasible to use ram-jets without encountering major launching problems. There is no safety problem on landing, which would have to be done power-off on an aircraft powered by ram-jets only. The average SFC of the ram-jets during the cruise

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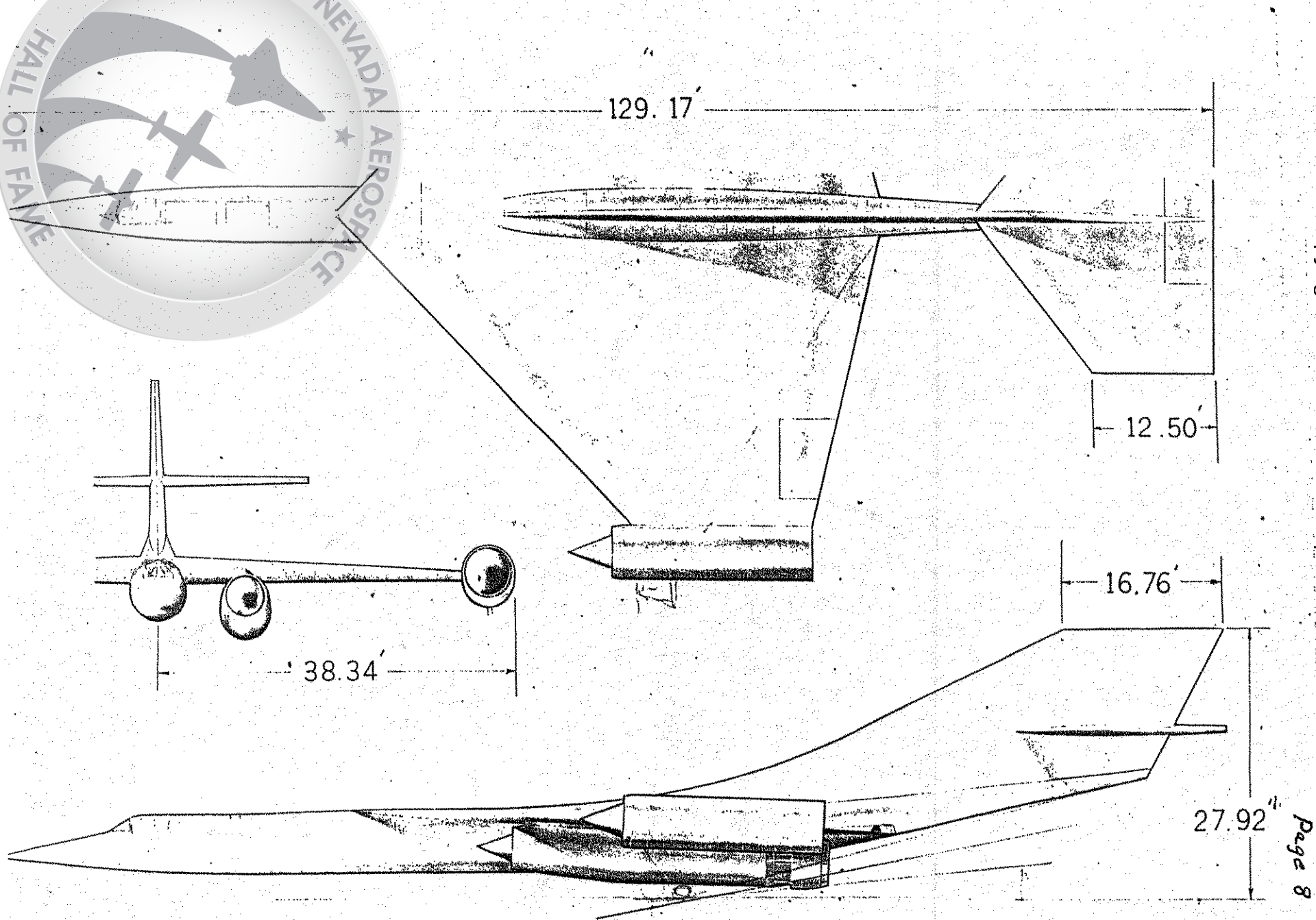

ARCHANGEL II

FIGURE 5

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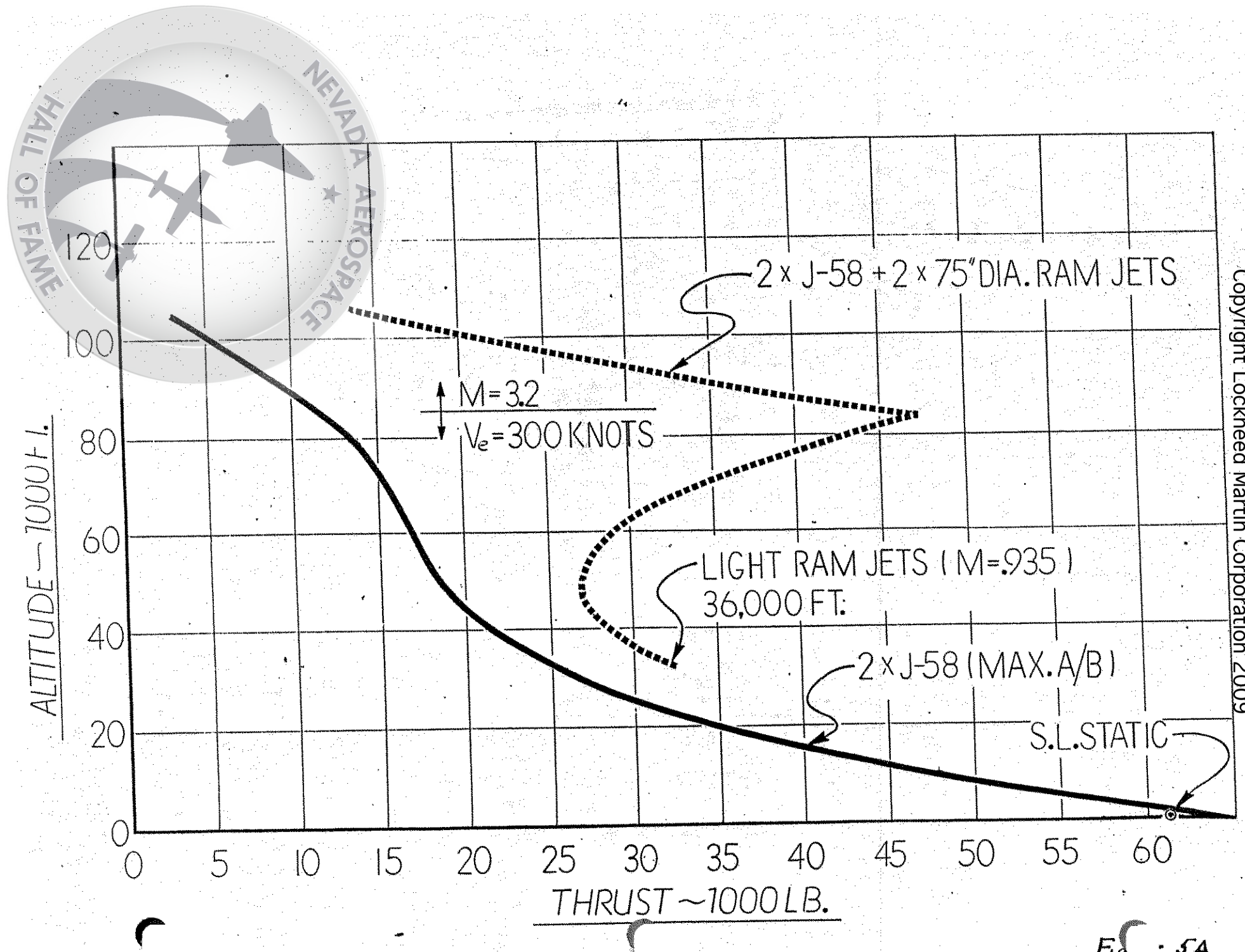

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Fig 5A

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ARCHANGEL II

WEIGHT ESTIMATE

WING	13,760
TAIL	5,940
FUSELAGE	6,350
GEAR	2,070
SURFACE CONTROLS	1,500
NACELLES	2,800
PROPULSION GROUP	14,290
RAM JETS	4,000
INSTRUMENTS	130
HYDRAULICS & ELECT.	1,000
ELECTRONICS	470
FURNISHINGS	150
AIR CONDITIONING	350
TAIL PARACHUTE	100
UNUSABLE FUEL	150
OIL	100
OXYGEN	55
EQUIPPED WT. EMPTY	53,215 LBS.
PILOT	285
PAYLOAD	500
ZERO FUEL WEIGHT	54,000 LBS.
FUEL	81,000
TAKE-OFF WEIGHT	135,000 LBS.

FIGURE 6

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ARCHANGEL II

MISSION PROFILE	A	B
TAKE-OFF WEIGHT	135,000 LBS.	135,000 LBS.
TAKE-OFF FUEL	3,000 LBS.	3,000 LBS.
INITIAL PENETRATION		
ALTITUDE	94,000 FT.	100,000 FT.
DISTANCE FROM BASE	280 N.MI.	300 N.MI.
MACH NUMBER	3.2	3.2
WEIGHT	102,200 LBS.	101,100 LBS.
TARGET		
ALTITUDE	100,000 FT.	100,000 FT.
DISTANCE FROM BASE	2,000 N.MI.	1,800 N.MI.
MACH NUMBER	3.2	3.2
WEIGHT	77,000 LBS.	74,500 LBS.

MISSION PROFILE	A	B
END CRUISE		
ALTITUDE	105,000 FT.	105,000 FT.
DISTANCE FROM BASE	3,750 N.MI.	3,350 N.MI.
MACH NUMBER	3.2	3.2
WEIGHT	58,500 LBS.	58,500 LBS.
DESCENT DISTANCE	250 N.MI.	250 N.MI.
LANDING WEIGHT	56,000 LBS.	56,000 LBS.
RESERVE FUEL	2,000 LBS.	2,000 LBS.
ZERO FUEL WEIGHT	54,000 LBS.	54,000 LBS.
RANGE	4,000 N.MI.	3,600 N.MI.
TAKE-OFF DISTANCE OVER 50 FT.	4,260 FT.	4,260 FT.
LANDING DISTANCE OVER 50 FT.	3,650 FT.	3,650 FT.

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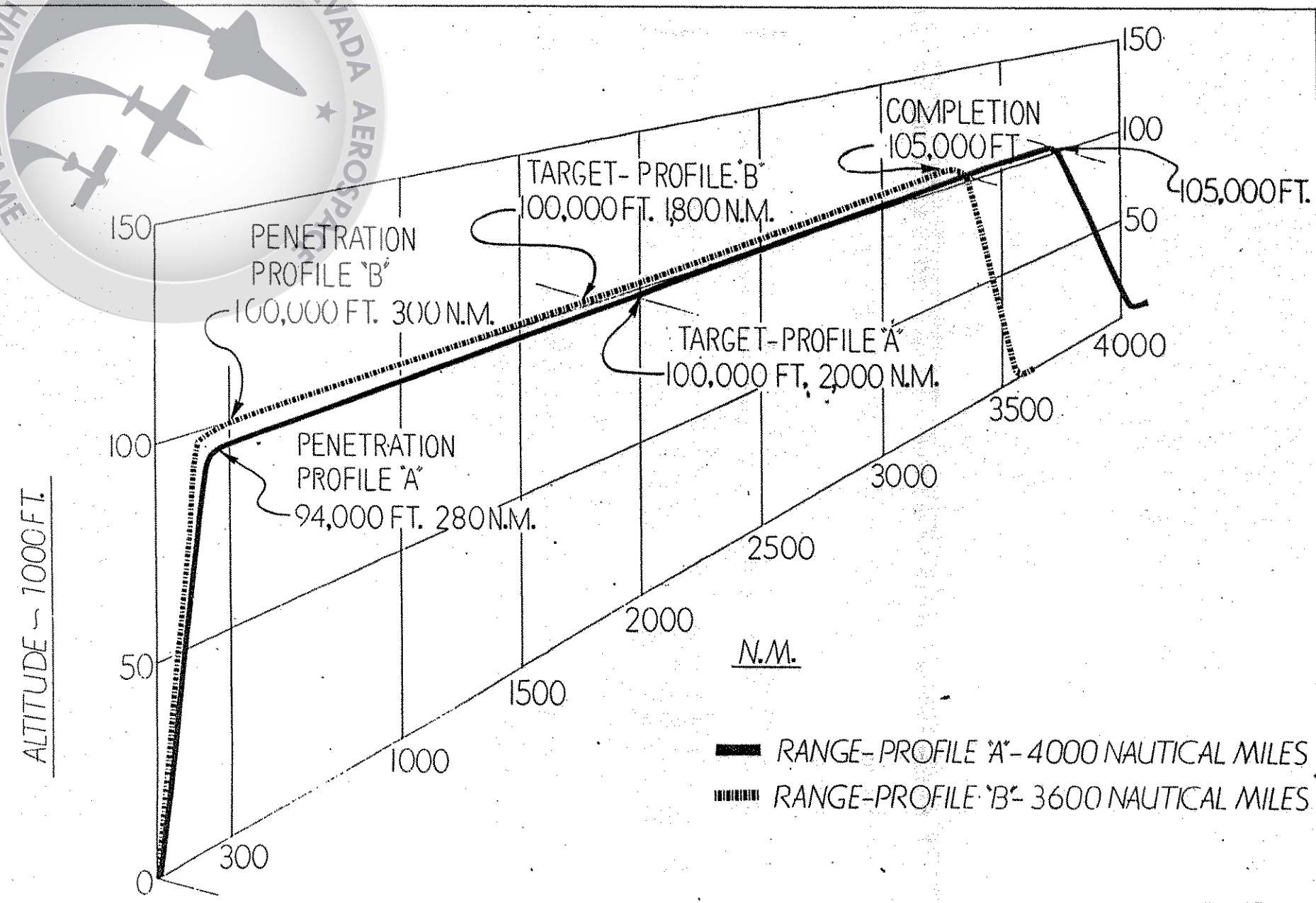

FIGURE 8

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portion of the mission is approximately equal to that of the afterburning turbojet. The fact that the ram-jets can be leaned out allows the use of high power at the start of cruise and best range fuel consumption when the airplane is light. The SFC for the ram-jets proposed varies from 7.7 pounds of fuel per pound of thrust per hour at Mach .95 at 36,000 feet to 3.2 pounds of fuel per pound of thrust per hour at Mach 3.2 at 100,000 feet, reducing to 1.69 at the same speed at 105,000 feet near the end of the mission.

For this reason, two missions are shown in the performance data. On Mission A, the cruise climb starts at 94,000 feet and a target altitude of 100,000 feet is obtained 2,000 miles from base. Cruise climb is continued to 105,000 feet near the base. If it is desired to have a mission altitude no lower than 100,000 feet, Mission B can be accomplished by the use of higher ram-jet power for a short period of time. In Mission B, the target altitude is also 100,000 feet, and 105,000 feet is reached, but the total range has dropped from 4,000 nautical miles in Mission A to 3,600 nautical miles for Mission B.

In spite of not having wing flaps, the airplane can take-off over 50 feet in 4,260 feet, and can land over 50 feet in 3,650 feet.

In the derivation of this performance, a maximum L/D ratio of 6.2 is used and proper consideration given to the actual Reynolds number

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obtained at high altitude. It should be noted that the advantage of using HEF-3 in the engine afterburner has not been included in obtaining the performance and range noted. This provides a possible further extension of range, if used.

The structure of Archangel II is proposed to be of the same titanium alloy used in Archangel I. A unit wing weight of 5.54 pounds per square foot has been used and full allowance is made for electronics system, a 500 pound payload, and the normal air conditioning and other allowances. It may be possible and desirable to use a liquid hydrogen heat sink for cabin air cooling, in that this could provide added fuel for the afterburner, while simplifying the cabin cooling problems. The weight allowances made, however, cover only an air system including the use of water evaporation.

It should be noted that the ram-jet weights proposed are 2,000 pounds apiece, which is in keeping with our experience to date, so that essentially no important advances in ram-jet design are required. This ram-jet is less than half the diameter of one studied in an accompanying proposal and is not felt to be out of the realm of experience to date. It can be tested in facilities already existing. One ram-jet manufacturer has stated that these power plants could be in service within two years from a go-ahead date.

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RECOMMENDATIONS

After very considerable study of the basic reconnaissance mission, the Archangel II aircraft is considered to be the most feasible to do the mission and to involve the least cost and development risk. It is recommended that actual development work for the type be undertaken at once.

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A-1

PERFORMANCE SUMMARY

Supersonic Airplane

TAKE-OFF WEIGHT	lb.	102,640
ZERO FUEL WEIGHT	lb.	41,000
RANGE	n. mi.	4022
CRUISE MACH NO.		3.0
CRUISE ALTITUDE	ft.	83,000/ 93,000
RATE OF CLIMB - S.L. - T.O. Wt.	ft/min	17,100
TAKE-OFF GROUND ROLL	ft.	3,330
LANDING GROUND ROLL	ft.	3,390

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A-1

WEIGHT SUMMARY

WEIGHT EMPTY		39,910 Lb.
NON-DISPOSABLE USEFUL LOAD		
Residual Fuel	150	
Oil	100	
Oxygen	55	
Pilot	285	
Payload	500	1,090 Lb.
ZERO FUEL WEIGHT		41,000 Lb.
FUEL		61,000 Lb.
TAKE-OFF WEIGHT		102,000 Lb.

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3 bod?

PERFORMANCE SUMMARY

Subsonic Airplane

TAKE-OFF WEIGHT	lb.	38,000
ZERO FUEL WEIGHT	lb.	21,600
RANGE	n. mi.	4000
CRUISE MACH NO.		.78
CRUISE ALTITUDE	ft.	61,000/ 75,500
RATE OF CLIMB - S. L. - T.O. Wt.	ft/min	5750
TAKE-OFF GROUND ROLL	ft.	2350
LANDING GROUND ROLL	FT.	2530

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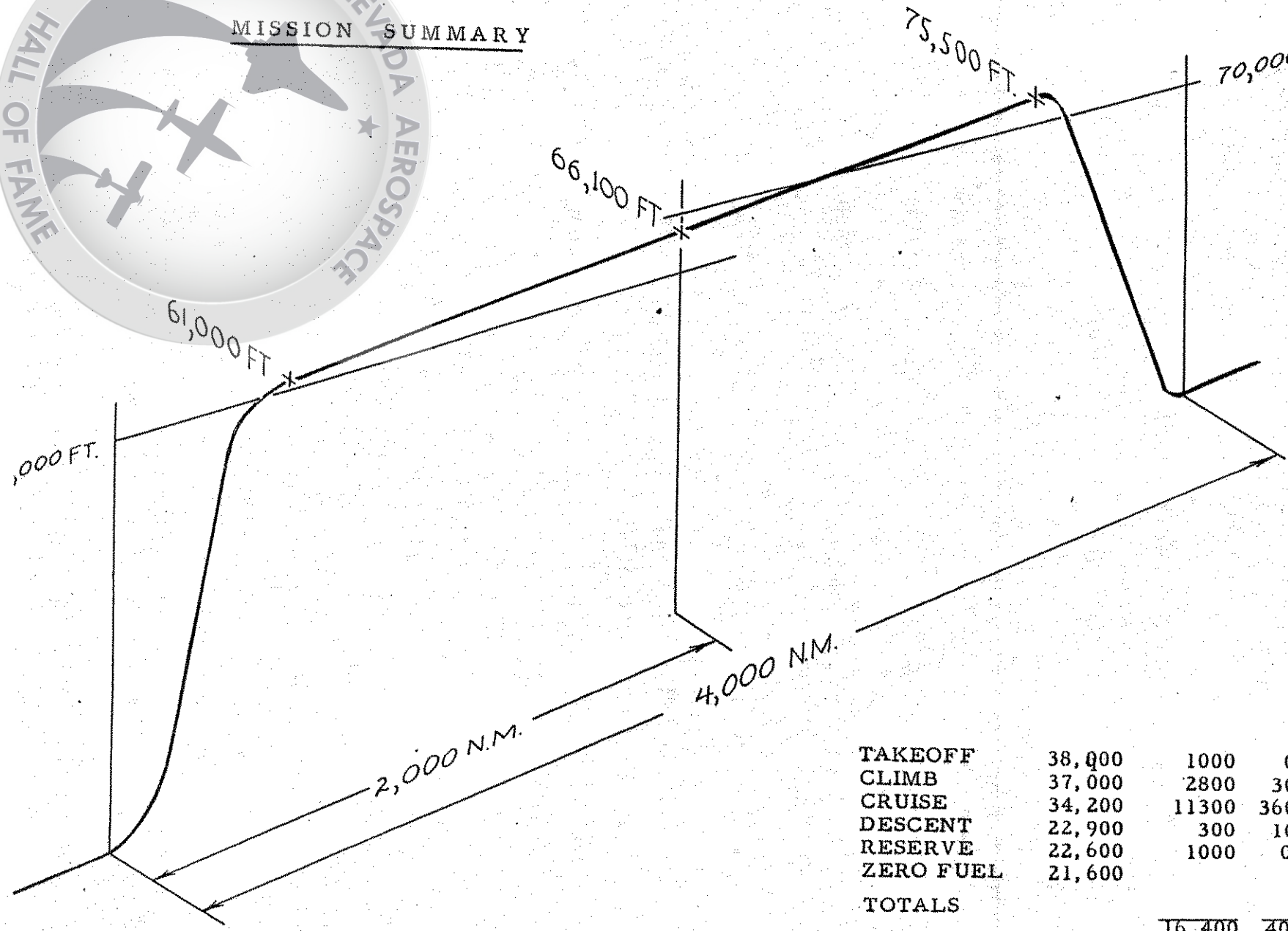
MISSION SUMMARY



TAKEOFF	38,000	1000	0
CLIMB	37,000	2800	300
CRUISE	34,200	11300	3600
DESCENT	22,900	300	100
RESERVE	22,600	1000	0
ZERO FUEL	21,600		
TOTALS		16,400	4000

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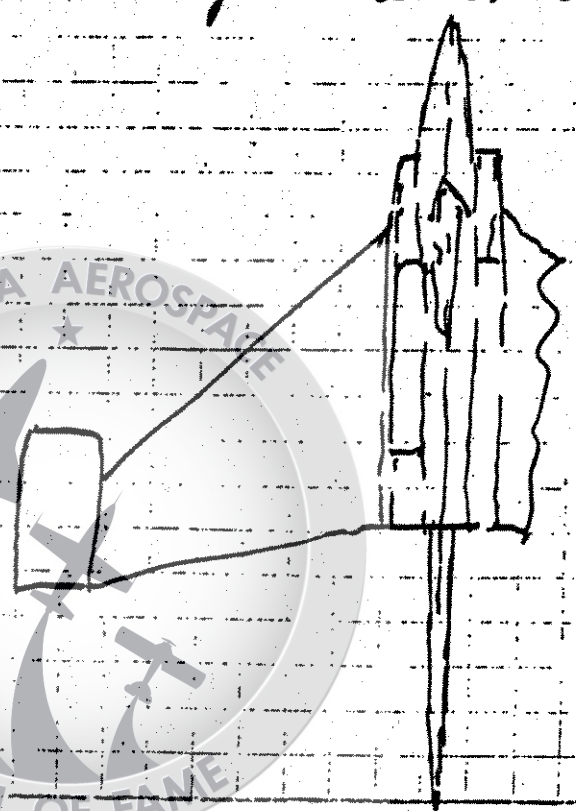
Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION	E. O.	PERM.
Checked	Sept. 29 '58 CW		TITLE Design of A-3.		1
Approved					

From previous work — a basic design of the following characteristics was derived (AAL trip - 5 page)

Area — 500 ft²
Gross wt. — 17,000 #
Wt. at 100,000' — 13,200
2 — A.B. JT-12A
2 — 30" Ram jets.
300 # payload.
M = 3.0 @ 100,000' (3.2?)
Basic concept — reduce radar C.S.
Data given to SP on Thurs. — Sept. 25, '58



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Prepared: Oct. 1, 51. DATE
Checked: Sept. 29, 51
Approved: CW

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CALIFORNIA DIVISION

Design of A-3.

TEMP. PERM. Page 2

Consider an airplane 50% larger. Use 3 J T-12s.

Area = 750 ft² Gross Wt. = 25,400.#

Fuel — 15,000 # empty wt. 10,400 #

Span = 47.5' A.R. = 3.0

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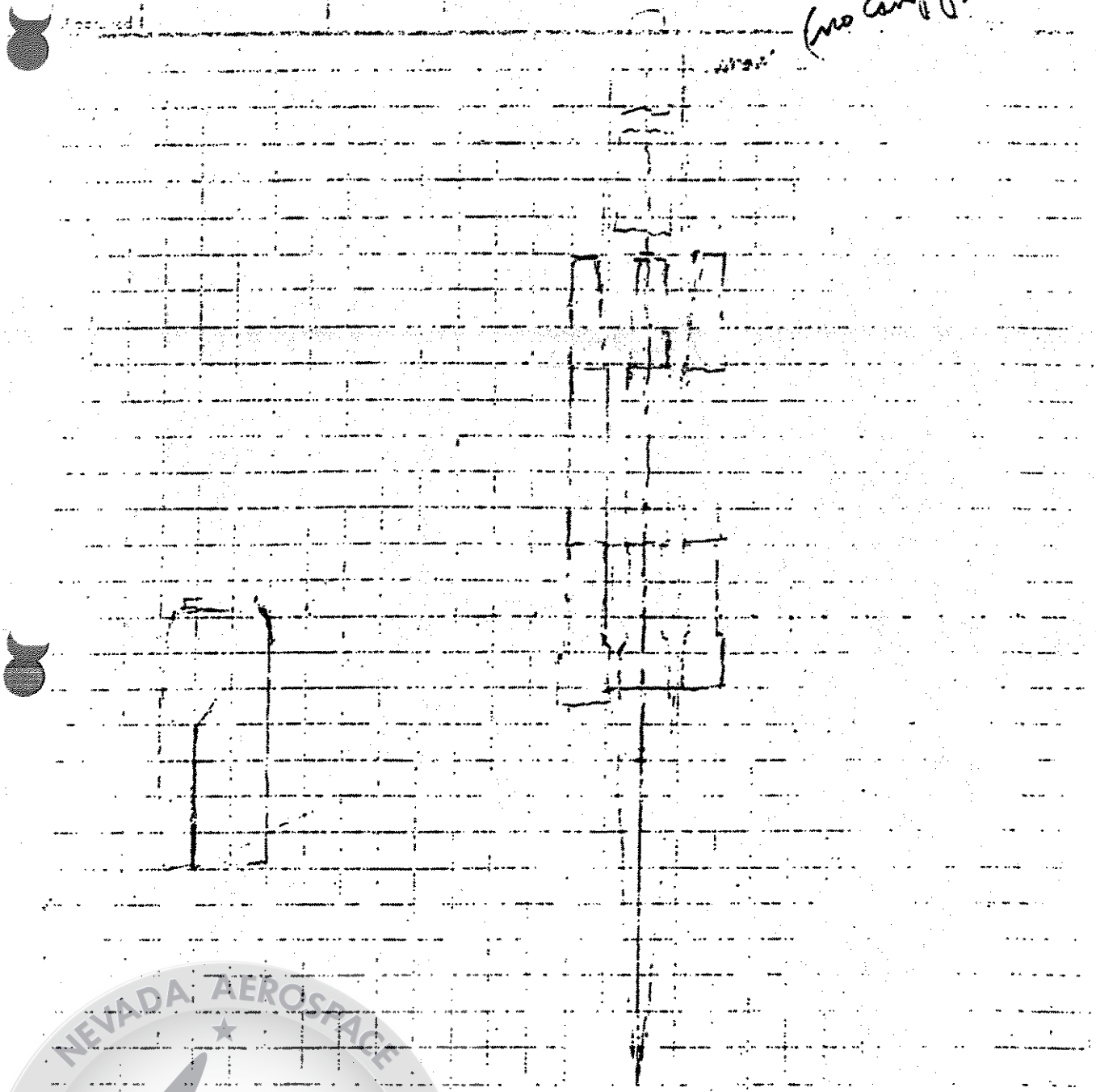
	NAME	DATE	LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION	TEMP.	PERM.
Prepared					3
Checked					
Approved					

(no canopy)



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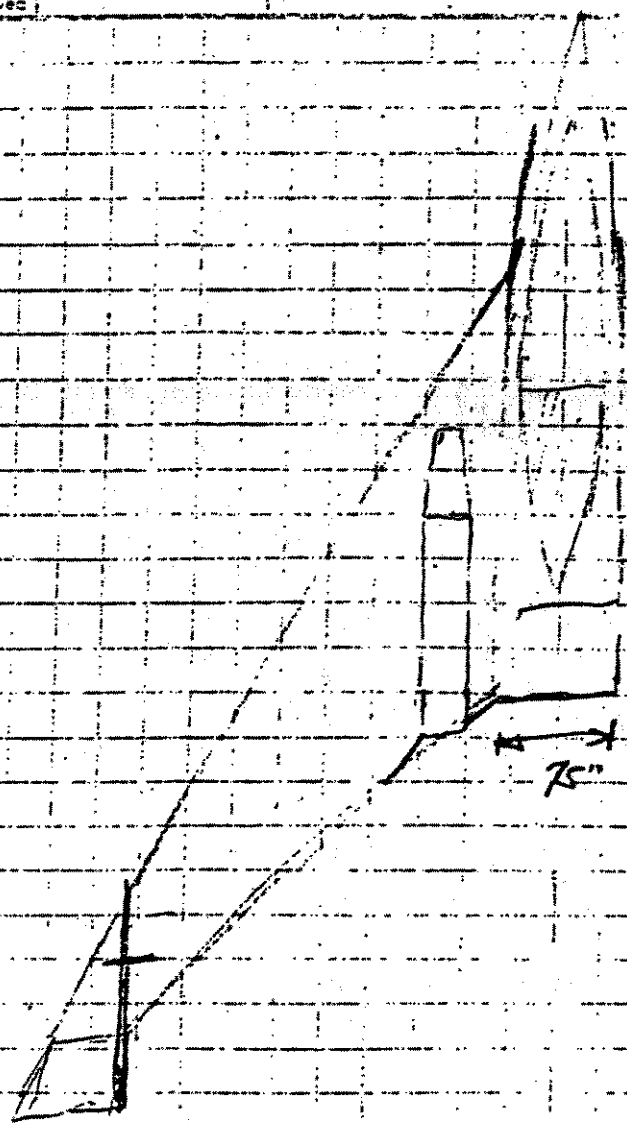
TITLE

4



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Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION		PAGE
	Oct. 2, 58				5.
Checked	ehs		Design of A-3		
Approved					

Our studies to date show great benefit in going to 400 Kt. design speed vs 300

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New P. & W. Ram Jet data.

Basic size 440# – 121" long Inlet 29.2
Exit 32.9"

Alt	M	Q	Thrust	SFC
58,000	1.2	330	640	8.5
	1.5		880	5.0
	2.0		1150	3.35
	2.5	"	1540	2.72
	3.0		1950	2.41
80	3.2	"	2100	2.33
100	3.2	220 lb	1000	2.41

Below 1.7 different fuel or additive.

Scaling factor:

% base thrust — 120 140 160 1..

Wts # 510# 570 635 700 770 #

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	Pounds
Payload & Pilot	500
Air Conditioning Cane	250
Electronics Sanbol	100
Furnishings & Insulation	100
Wing 500 sq. ft. (with R.J.) 400 sq. ft. with C.S. - no R.J. - @ 6.75#/ft.^{2} Warren Bissell	2,700
Tail Weight - 100 sq. ft. - @ 4.0#/ft.^{2} Nystrom	400
Fuselage - includes canopy, bay, etc.)	1,000
Gear (Drop Pogos) Kaiser	300
Surface Controls (includes A.P.) Sorenson	350
Powerplants - JT 12A @ 700# (complete starter & oil) GaTh	1,400
Ramjets GaTh	800
Controls (engine) GaTh	80
Fuel System - Robertson	200
Instruments - Zuck & Wc	60
Hydraulic - Bramberg & Bell	70
Electrical - Rockel	250
Oxygen -	40
Unused Fuel - Robertson	100
Reserve over base -	300
Empty Weight	9,000
Gross Takeoff Weight	20,000
Arrive at start of cruise	17,000

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10/3/58 Weight breakdown given project to aim for

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Prepared	Oct 9, 58	
Checked		
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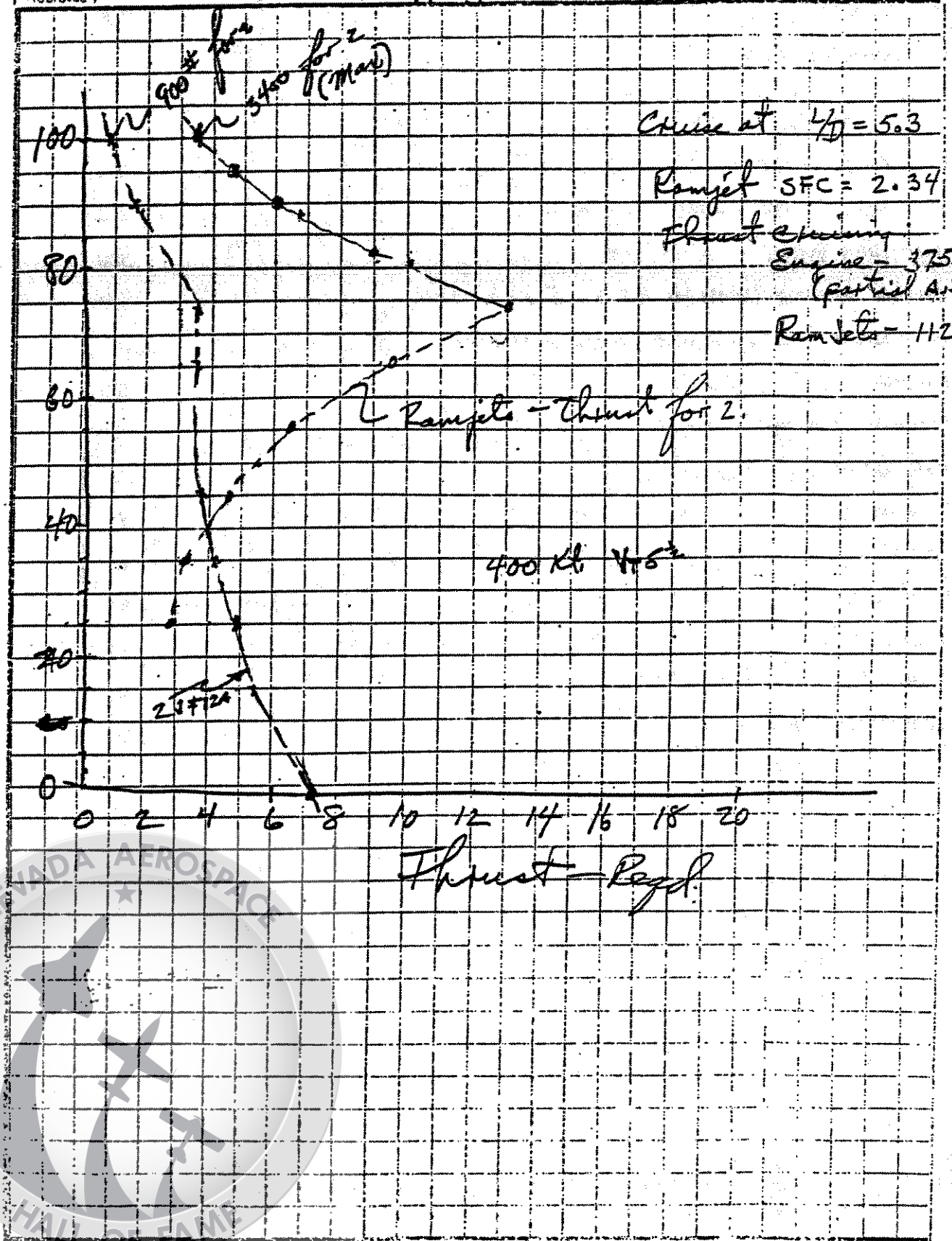
TEMP. | PERM.

Page:
Model:
Report No.

TITLE: Thrust Values Req'd for A-3



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	NAME	DATE
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Title: Perry Pratt.
Ram Jet.

By increasing Back end with regard to exit

Can do thrusts. Variable inlet ... compress.

Wt. — 900 to 1000# each. (no 755 ...

Fuel consumpt. cruise — 2.34 at 3.2 M
max — 2.55 at 3.2 M

Regard. 95 to 100,000' —
75,000 — 2.35 vs 2.55.

Exit dia. 53" Inlet 39.4 ~~Length~~ 17 (+ ...
46" ...

→ One pt 1.78 @ 50,000' — 2900# get 415

at 1.2 at 400 EAS — 3100#

Unchoke below to 1640 at 1.0 at 25000'

Higher volatility — gasoline.

4" on dia at 4 places

Margin of 6% overall.

1.7 — 85% 1.0 — 89%

Ram at 3.2 — 74% R. Vonby

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Oct 17 58

Pratt & Whitney —
JT-12A

On JT-12 — (No interference)

100,000 — 310# initial — 2.8
365# later — 2.65 fins

95,000# — by density

Weight — 700 # 500 # quick
Heavy

Will have check soon.

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Data to Ray M. — Oct. 9, 1958.

Altitude:	Net Thrust	E.A.S
25,000'	1500 #	400 Kt.
50,000'	2900 #	400
75,000'	6500 #	400
100,000'	1700 #	220
105,000'	?	M = 3.2
100,000'	1125 #	220

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Prepared NAME Oct 21, 58 DATE — LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION — Page 1

Checked CJ

Approved

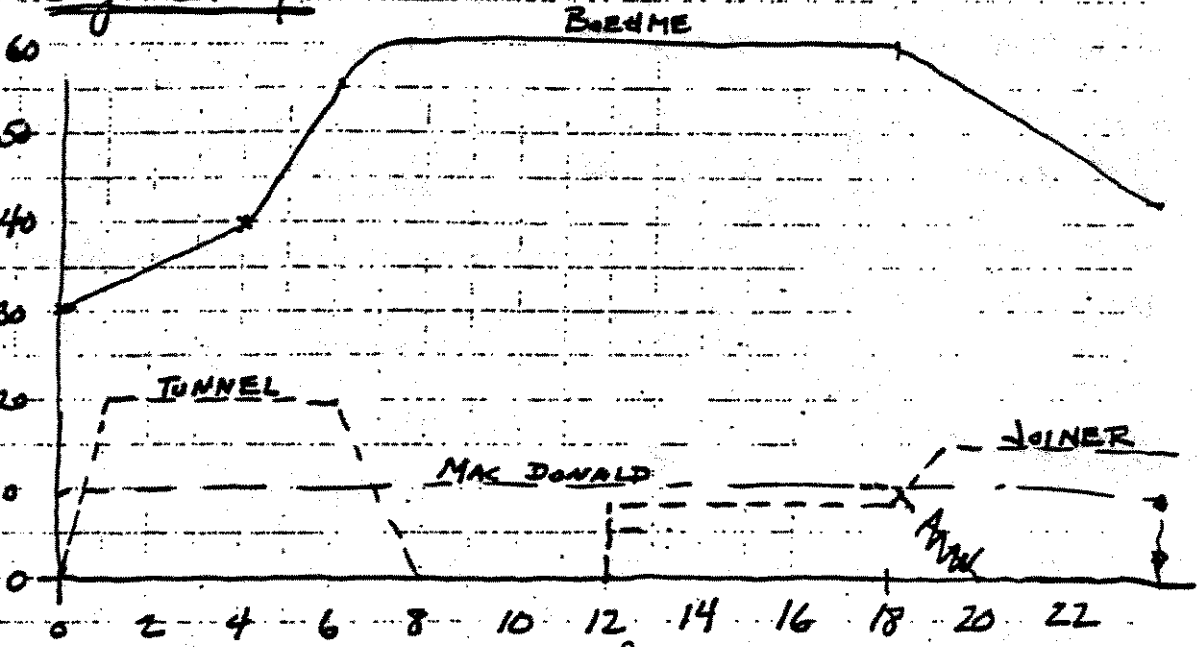
Developement Plan - A-3

Schedule and Cost estimate for A-3 ~~Plan~~

Consider 12 airplanes to 36 airplanes.

18 months to 1st flight.

Engineering:



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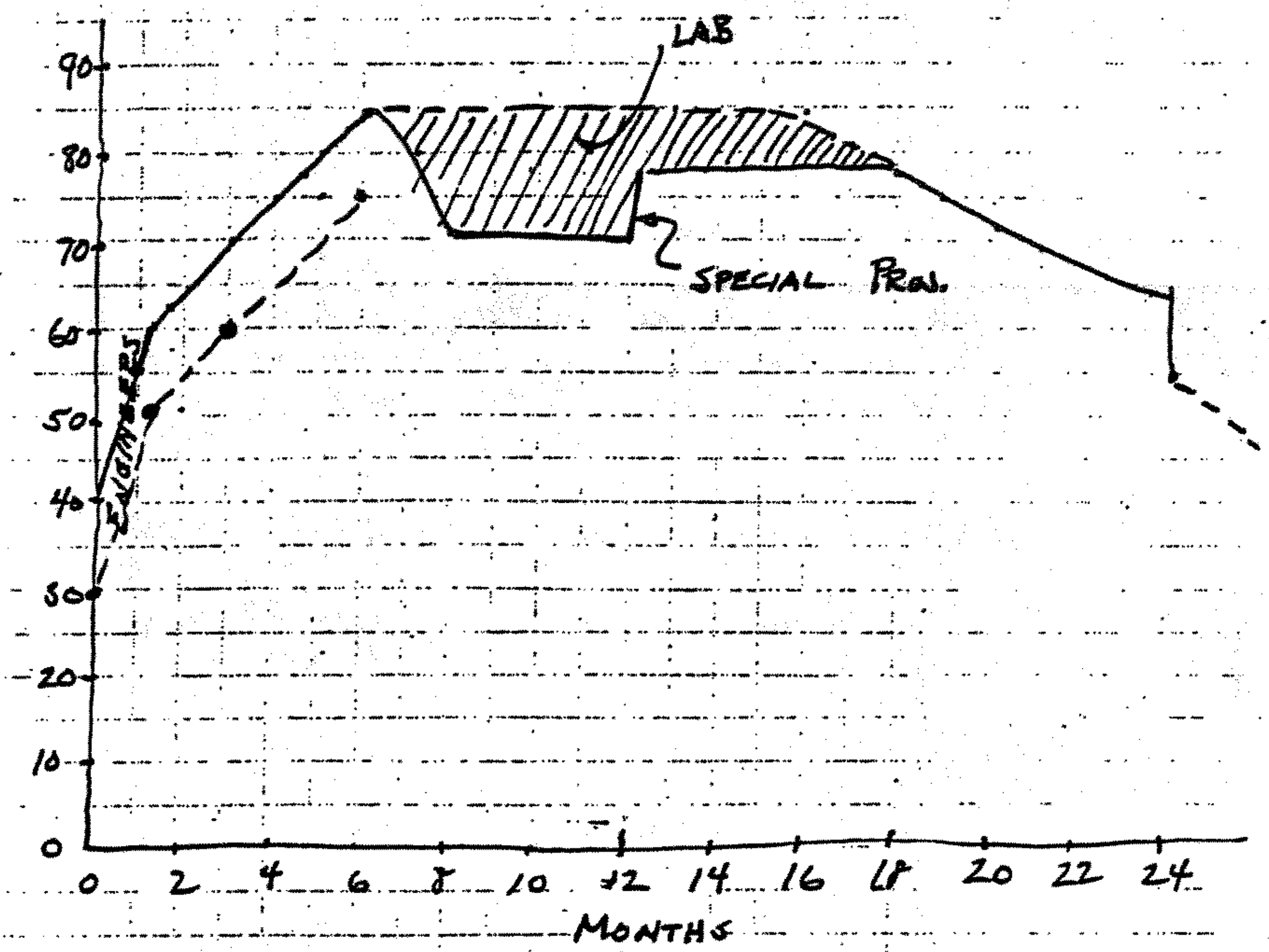
Prepared	Oct 21, 58	DATE	LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION	TEMP.	PERM. 2
Checked	CLJ		TITLE Development Plan – A3.		
Approved					



Cost – Engineering + overhead – $10.00/hr. or

22 days × 8 hrs × 10.00/hr × 1.10 (profit) ≅ $2000 man/mo

Expenditures/Mo.

Month No	$	Month #		#	$	#	$
#1	$94,000	5	154,000	10	170,000	16	164,0
#2	124,000	6	164,000	11	170,000	17	162,0
#3	140,000	7	170,000	12	170,000	18	160,0
#4	150,000	8	170,000	13	170,000	19	152,0
		9	170,000	14	170,000	20	146,0
				15	170,000		

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Prepared	Oct. 21, 58	
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CALIFORNIA DIVISION

Dept. | Perm. 3

Developement Plan – A-3

Engineering Cost:

For 6 months – $826,000

For 6 more – 1,020,000

For 6 more – $996,000

To first flight – $2842,000

For 6 more months – 836,000 (Total – 24 mo.)

For 6 mos to 30 mos – 12 ops – $450,000

Airplane Schedule:

#1 – 18th month
#2 – 20
#3 – 22
4 – 23
5 – 24
6 – 25
7
8/9 – 26
10 – 27
11
12 – 28

Total Engineering including tunnel, design, tools, radio & flight tests for 30 months = $4,128,000

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Prepared NAME Oct. 21, 58 DATE — LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION — REPT. 4

Checked CDJ

Approved

Developement Plan – A-3

Viereck Operation:

Base on $750 /hr with profit.

Mock-up:

Build in 5 months. – Cost $100,000

Material:

Empty wt. – 11,000 #
Engines – (2X700) + (2X600) = 2600 #
Wheels, tires, instruments – 200 #
Payload – etc. – 500 #
AMPR wt. ≅ 7700 #

Assume 5500 # of titanium in airplane.
Utility factor 60% –
∴ Buy $\frac{5500}{60}$ or 9150 #/airplane

About 90% is sheet at #22 – 10% bar at #10
Titanium cost 181,000 + 10,000 = #191,000/airp

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	NAME	DATE
Prepared	Oct 21, 58	
Checked		
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Development of A-3.

Material Cost:

2200 # of other equip. in airplane. This very expensive due to development. Average it out at $100/# for 1200 # + $60/# for 1000 #.

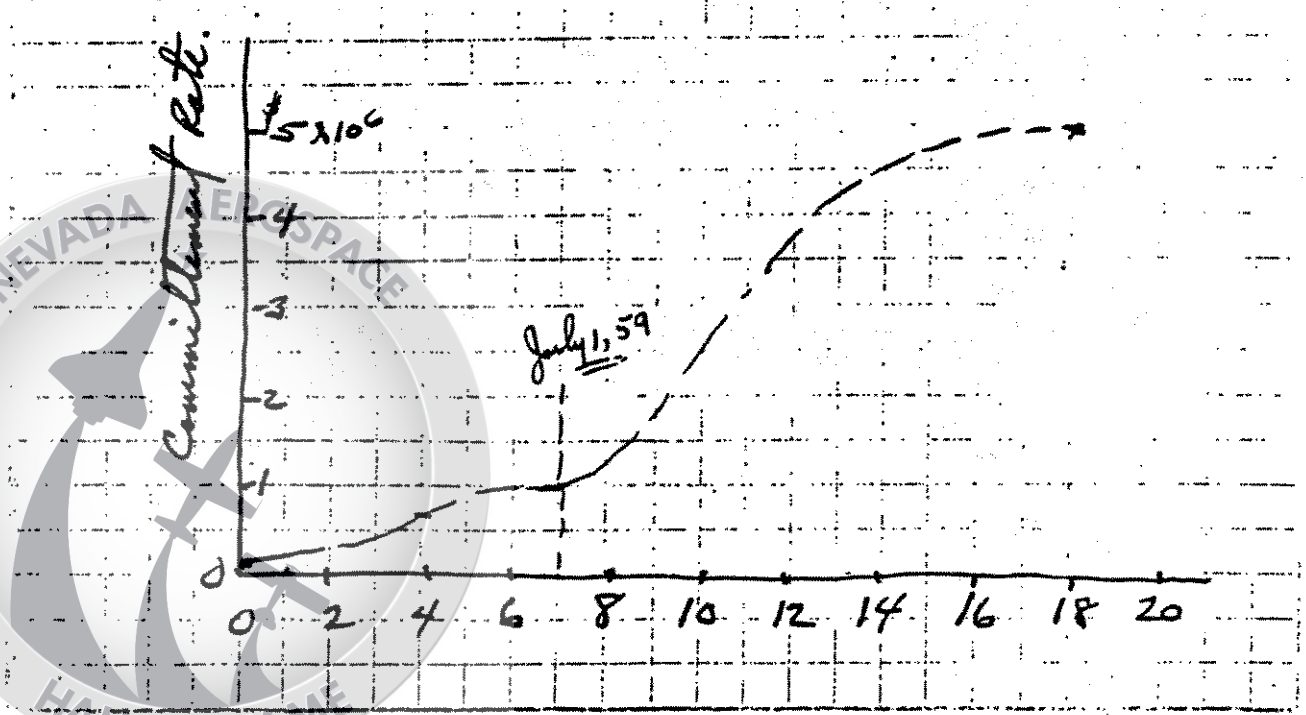
This cost is then $120,000 plus $60,000 or $180,000

Airplane material cost (LAC) — $371,000

For 12 airplanes — $4,450,000

With static tests — $5 x 10^6

Cost/airplane — $416,000



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Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION	TEMP.	PERM.
	Oct 21, 45			Page 6	
Checked	Carl		"Development Plan – A-3	Model	
Approved				Report No.	

Tooling –

Rate per man hr with Tooling material = $11.00 / hr (includes profit)

300,000 man hrs = $3,300,000

Manufacturing of Assembly:

AMPR wt. – 7700# Use 50 $/# for #1 etc

#1 = 50 × 7700 = $385,000 hours @ 75¢ (includes profit)

#2 = 385,000 @ 75¢

Use a 90% learning curve –

Airplane No.	Hrs	Cost
1	385,000	$ 2,900,000
2	385,000	2,900,000
3	346,000	2,590,000
4	310,000	2,320,000
5	279,000	2,080,000
6	250,000	1,870,000
7	224,000	1,680,000
8	202,000	1,510,000
9	181,000	1,360,000
10	163,000	1,220,000
11	146,000	1,100,000
12	131,000	980,000

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FORM 562

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	NAME	DATE	LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION	TEMP.	PERM.
Prepared	Oct. 21, 58		TITLE Developement of A-3	Page	7
Checked	CWL			Model	
Approved				Report No.	

Pilot Bonus — $250,000

Static Test — $250,000

Spares & GHE — $4,000,000

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Prepared Oct 22, 58 | Checked | Approved | DATE

TITLE: Cost Summary - A-3

TEMP. | Page 8 | Model | Report No.

Cost for 30 months operation — Mock-up + spare flite test, GHE.

		CL	adjust
Engineering	—	$ 4,128,000	4,535,000
Mock-up	—	100,000	178,000
Material	—	5,000,000	6,118,000
Tooling	—	2,200,000	2,209,000
Man. & Assemb.	—	22,510,000	15,828,000
P.B.	—	250,000	[illegible]
Static test (model in above)	—	250,000	250,000
Spares & GHE	—	4,000,000	5,220,000
Total	—	$ 38,438,000	$ 34,130,000

Difference is primarily in Manufacturing
used 90% learning curve slope on #2 to account for problems of weight saving and titanium.

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Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION	TEMP.	PERM.
	Oct. 22, 58			Page	1.
Checked	ecl		TITLE: Data from Bill Sens	Model	
Approved				Report No.	

All data ARDC atmosphere.

1 On JT-12 – Many engine changes.

airflow - 59# 365#/engine at 100,000' SFC 2.68

385-# 2.72

EAS	alt.	Thrust	TSFC	airflow
400	10			
	15	3510	2.45	
400	0	4680	2.56	59#/sec.
	25	3030	2.35	34
	35	2720	2.24	29
	45	2330	2.28	25
	55	2050	2.22	22.5
	65	1820	2.24	21.7
3.2	74.4	1620	2.44	23.0
400	50	2190	2.26	23.7

Raw 2.5 – 85% 3.0 - 78% 3.2 - 75%

At 95000' SFC - 2.62 max thrust & 480# thrust

Use 2 position A.B. – no thrust

Wt. – 645 fixed ejector + 50# for Hi. Mach.
+100 moveable ejector

Stoic S.L. – 4000#.

JP-150 – used 3% more BTU/# than JP4. – S.G. = 7.3

Fuel temp. -? – Boiling 300°F end pt. 391°F

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Prepared		Oct 22, 58
Checked	CS	
Approved		

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- CALIFORNIA DIVISION

TITLE: Data from Bill Sams

	TEMP.	PERM.
Page		2
Model		
Report No.		

Can probably take 250° F fuel inlet temp.

Our engine characteristics:

Top mounted accessories

Our Ram jets:

3.2 Max thrust — 95000' — 2300# TSFC - 2.44

At max thrust — 2.36

1500# " — 2.27

1360# " 2.26

At 1700# at 100,000' — SFC — 2.55 at 1100# — 2.34

At 1445 — " — " 2.41

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FORM 382

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Prepared	Name: Oct 28, 58	Date	LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION	Temp.	Perm. 9
Checked	cbl.		Subject: Developement Plan - A-3		
Approved				Report No.	

Estimate "Zero Time Tests" Program from Dec. 1, 1958 to July 1, 1959.

	$	CU
Engineering & Tunnel tests —	1,000,000	
Mock-up —	100,000	137
Material Commitments —	1,000,000	
Tooling —	440,000	
Fab. & other tests	340,000	
Manufacturing	290,000	
	3,170,000	

Ask for $4,000,000 for insurance to cover other studies, more material, Tunnel tests — etc.

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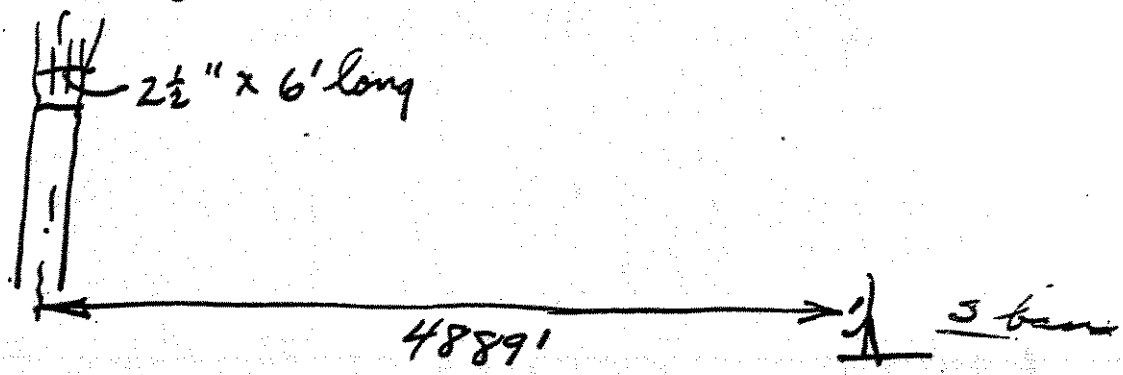
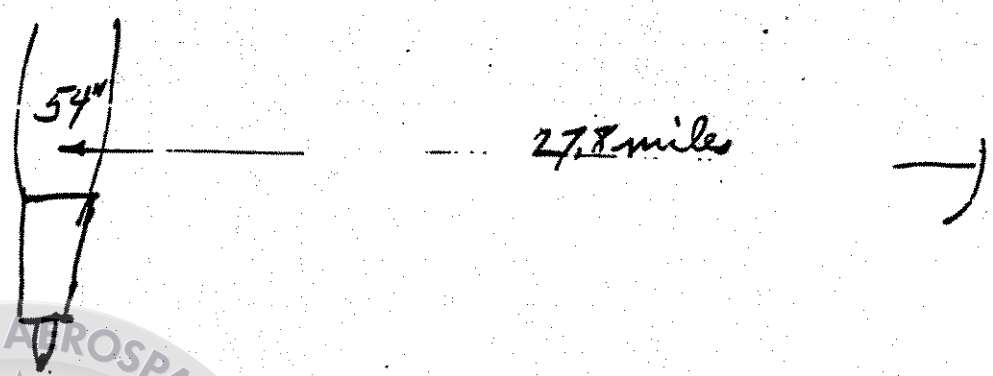
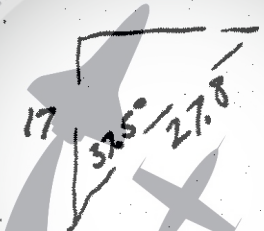
On HEF — tests



No difference — either polarization.

Full scale:





Ratio of jet diameters — 216:1

With jet expansion — take 30:1

Scale distance = $\frac{30 \times 4889}{5280}$ = 27.8 miles

90,000' is 17 miles.

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Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION	TEMP.	PERM.
Checked			TITLE Call on Wkl. Nov. 26, 50	Page	
Approved				Report No.	

Gen B. on new proposal:

1. Have written panel report from on Convair 1-st Choice K. talked to 2 members.
Choice conditioned on Radar

Other characteristics — seem to comply.

Only thing not said — Worry tech. on deflections.

Gen B. view very close choice except for R. effect.

2. Will soon have report — Don't regard issues as closed — Have not told Conv.

3. Timing — Basic decision on one or other be done.

4. Elaborate schedule to go thru — A.F. Quarles & Pres. — about 2 weeks

5. Norm & 2 colleagues looking at two proposals — Finish by next week — Comments only.

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Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION	TEMP.	PERM.
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Approved				Model	
				Report No.	

6. Ulsega — think out scheme immediately better.

7. Frank Rogers — coming down. Have questions on techniques.

8. In two weeks — a program summed up may. Urgency basis — 3 mos. Given decision — one or two ? ops.

9. During 3 months — desireability of full scale iron maiden.

10. Would like a figure for 3 mos. No manufacturing. within 10 to 15% — firmly spend.

Section Mgr Mann

11. I talked to Gene — o.k. to use other engines. Would be interested.

12. Call at 1pm today.

1/20/00

NEVADA AEROSPACE HALL OF FAME

FORM 532

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	NAME	DATE	LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION	Page	TEMP.	FORM.
Prepared	CLC	11/26/55	Cost Estimate A-3	Model		
Checked			tunnel tests & Radar test	Part No.		
Approved						

High speed tunnel model -

Total eng. & shop — 12000 hrs (Confirmed by Paul Tinkham)

1.10 (12000 hrs X 10.00 (aver. shop & eng))

= $132,000

Material — $1500

Low speed model — 6000 hrs —

$66,000

Material negligible.

To take care of variations wing, etc.

add $50,000 (includes travel expense $10,000)

Total — $250,000 for

tunnel program.

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FORM 352

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Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORP. CALIFORNIA DIVISION	Page 2	TEMP.	PERM.
Checked			TITLE Cost Estimate -4-3	Model		
Approved				Report No.		

Radar Tooling —

MacDonald — 12 men — 4 mo. —

1.10(12 x 4 x $1700/mo) = $91,000

Build a Full scale Model & test at Wind Springs

$150,000 — model.

25,000 — test.

Total Price 110(175,000) = $91,500

Boeing Work —

25 people — 4 mo. — @ 10¢/hr.

110 (25 x $1700 x 4) = $187,000

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Checked	Nov. 26, 52		TITLE Concept of A-4	Model		
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Design Ground Rules:

1. Basic non-refueled range on JP-150 is 400 n mi.
2. Do not use JT-12As.
3. Radar Cross section vital consideration
4. Cruise alt can be reduced 3 or 4 M
   (93 to 91,000 target)
5. Basic self contained system.
6. Basic cruise Mach No. — 3.2
7. No honeycomb.
8. O.K. to use rocket assist.

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Start of cruise L/A — C_L = .17 — E.A.S. = 220 kts. — q = 160 (100,000') Will go up as wt. changes.

$L/A = .17 \times 160 = 27$ #/ft²

Fly gross wt. of 50,000 # at start of cruise.

Use 2 A.B. J-57 — 43A water-inj. engines.

T.O. thrust = 16,500 #

Total T.O. thrust — no inj. = 33000 #

Use J-57's M = 2.15

Wing area = $\frac{50,000}{27} = 1860$ ft²

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At L/D of 6.0 at $C_L = .17$ — Thrust req'd at 90,000' is about 10,000 #.

(This is for 60,000 # wt.) This means our jet area is $\frac{10,000}{6000}$ # or 67% larger than in A-3. Dia = $1.29 \times 40'' \doteq 52''$.

Length/Dia ratio can be $3\frac{1}{2}$:1 or 182"

Outlet dia = $\frac{52}{40} \times 53 = 69''$

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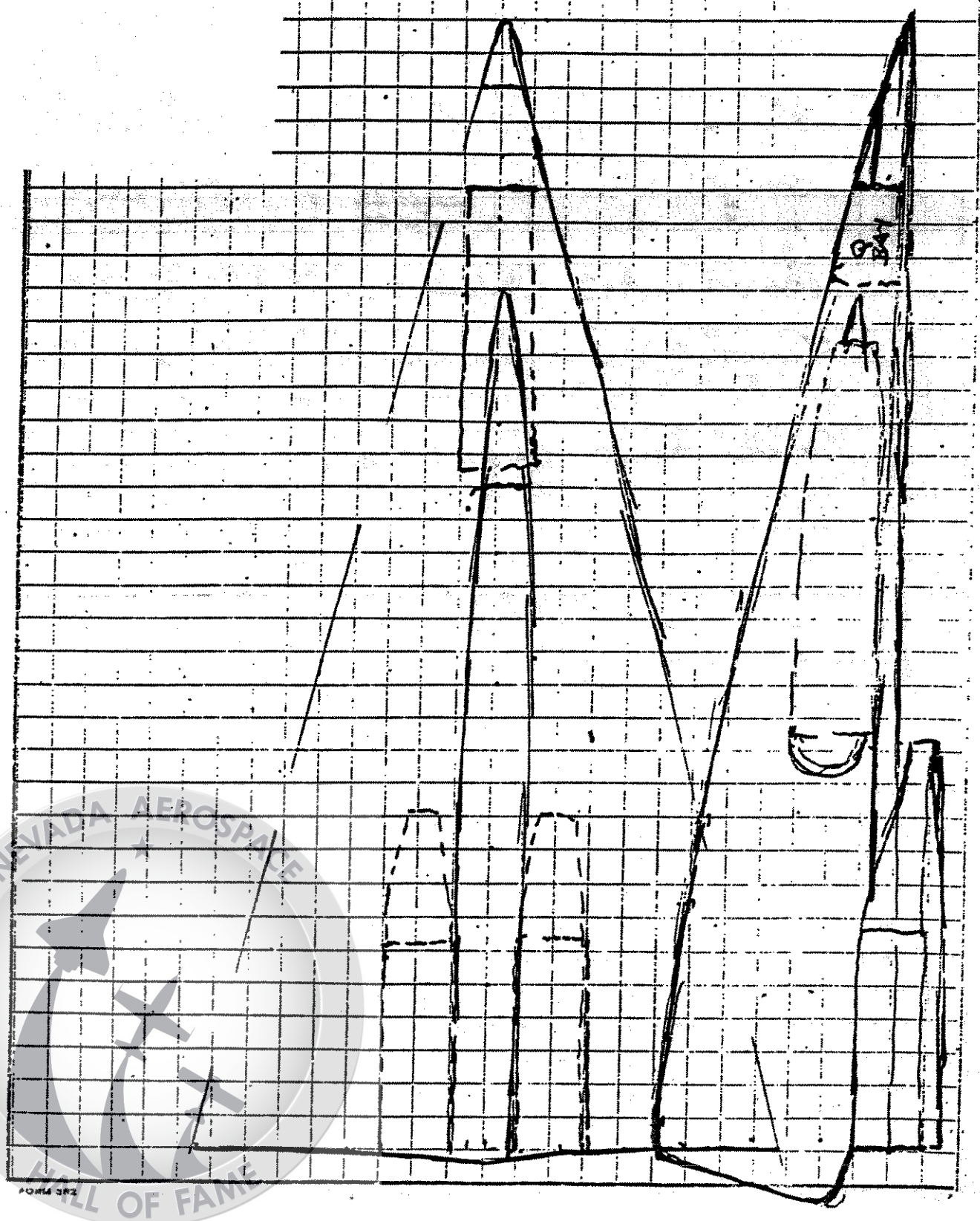
TITLE

A-4

Model

Report No.



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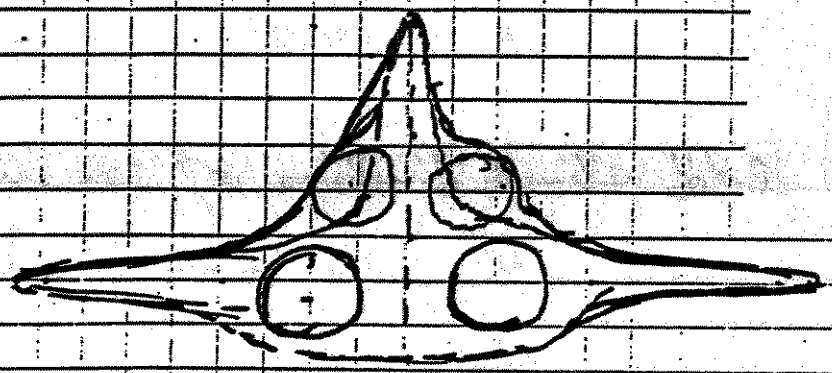

Engine Wt. –

2 J-57 = 11,000 #

2 Ramjets = 4000 #

15,000 #

20,200
1.5

Wing – 1860 x 6 = 11,200

Fuselage – tail = 4000 #

Gear = 1000 #

Systems = 3000

Payload, pilot cockpit – 1000 #

Equipped empty – 35,200 #

T.O. at 72,000 # – Sea lvl at 60,000 #

4-2-

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$$\text{Range} = 590 \times 6.0 \times \frac{3.2}{2.3} \times \log_e \frac{60{,}000}{35{,}200}$$

$$= .543 \times 4940 = 2700 \text{ miles.}$$

Add climb distance of 300 mi.

Range = 3000 miles

Need 2.1 wt. Ratio. — or for this

empty wt. — gross at 90,000' = 74,000

Climb fuel = 15000 # T.O. = 90,000 #

~~90,000~~ $\frac{74{,}000}{1860} = 39.7$ #/ft²

q at 90,000 at 3.2 = $\left(\frac{270}{220}\right)^2 \times 160 = 241$ #/ft²

$C_L = \frac{39.7}{241} = .165.$

But Rad Thrust is $\frac{74000}{6} = 12{,}400$ #

Ram jets must be 58" dia.

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Consider a revision to A-4 Can we use 1 ram jet of large size and two turbo jets? The airplane would be about as large as indicated previously (35,000# empty) but might layout better.

Also, can we use JT-12's with A.B. with no costly development problem to M=2.0?

Let us use a ram-jet of this size:

A-3 had 1300# thrust at 90,000' from 2-J71

" + 7400# " " " " " 2-40 K

A-3 " 8700# " " " "

One Ram-jet to develope 9000# is

40" = 3700#

$\sqrt{\frac{9000}{3700}} \times 40" = 63"$ dia.

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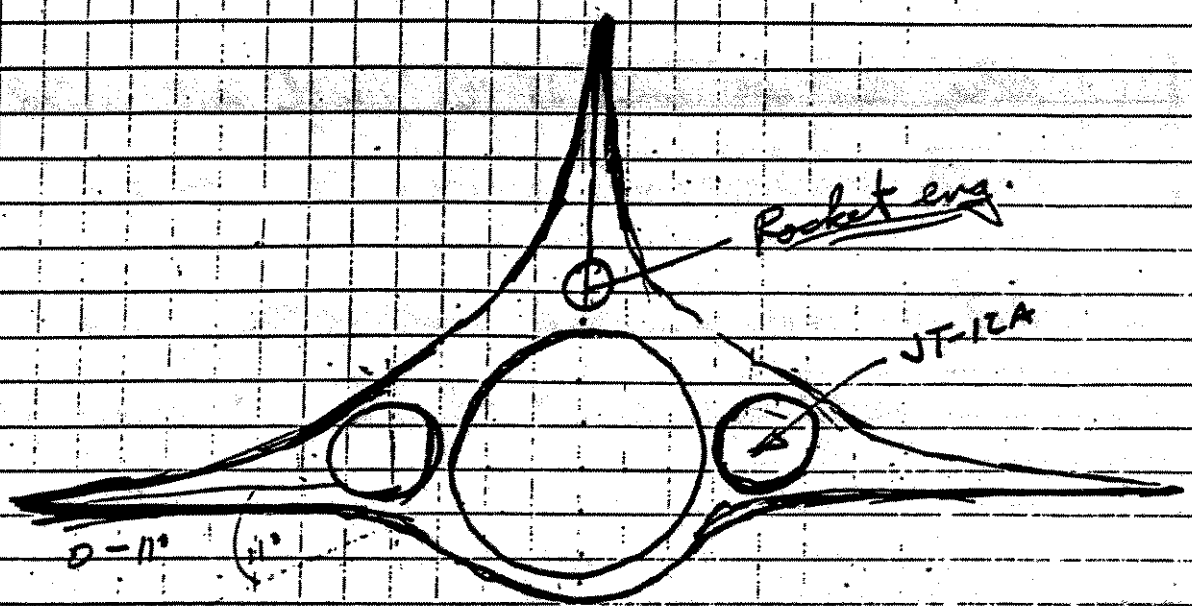

Use 750 sq ft. area — 35,000 # gross wt.
at altitude —

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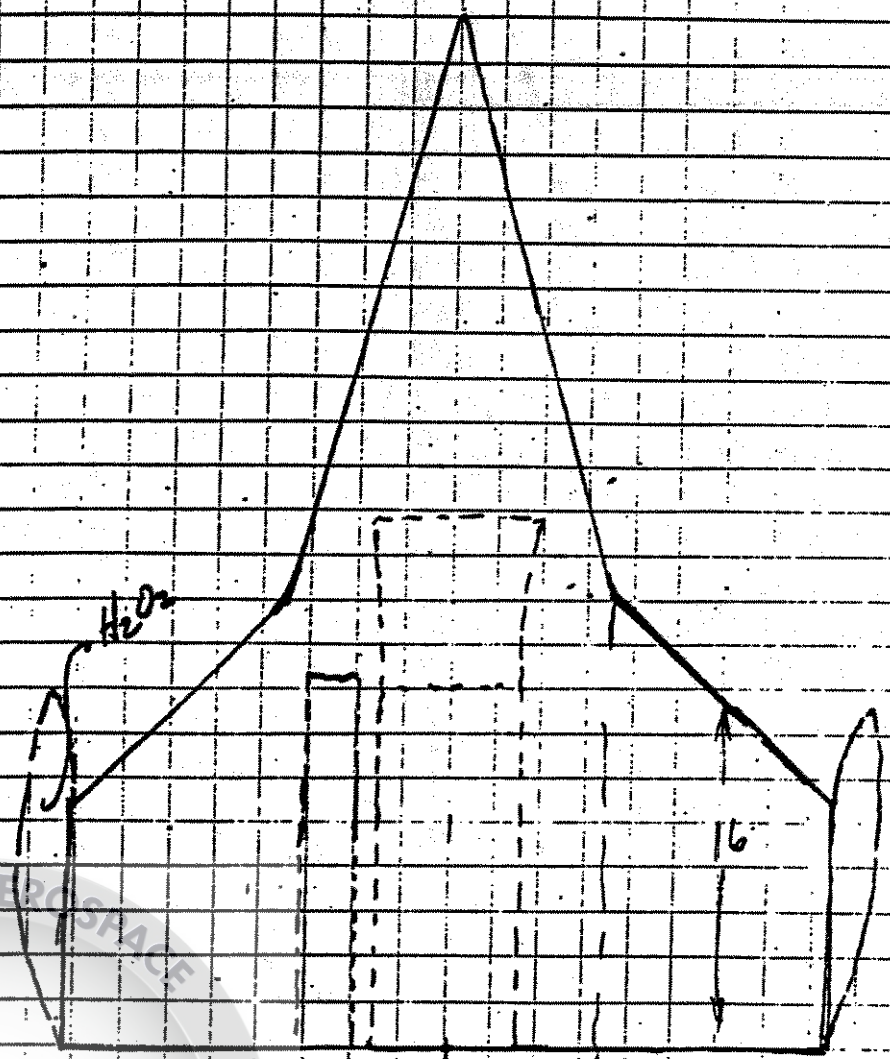
At an A.R. of 6.42 — Span = 32.6'



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Checked			Title: A-4	Page:	10
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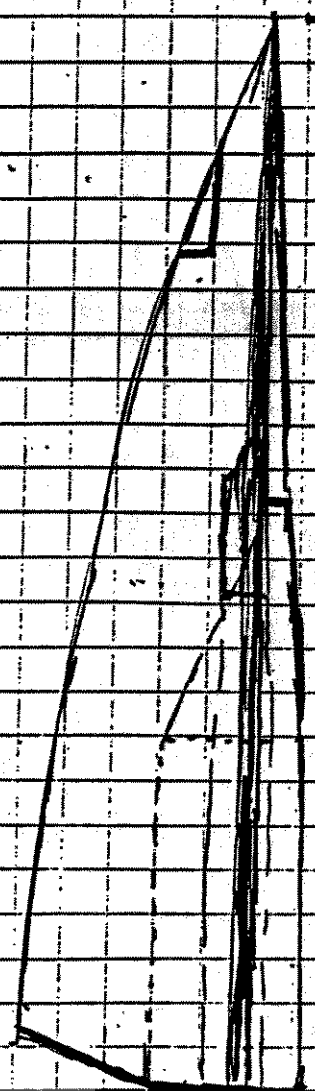

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FORM 302

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At 90,000' $M = 3.2$ = EAS of 275 Kt

$q = 246$ at 35000 #, $C_L/C_A = 46.5$

$C_L = .189$

Required range = 4000 n. mi. (3700 over climb)

at 15,000 # zero fuel wt. -

$$R = 590 \times \frac{3.2}{2.4} \times 5.8 \times \log_e \frac{W_G}{W_{EE}}$$

$$3700 = 4560 \log_e \frac{W_G}{W_{EE}}$$

$$\log_e = \frac{3700}{4560} = .812$$

$$\frac{W_G}{W_{EE}} = 2.26$$

$$W_{EE} = \frac{35000}{2.26} = 15,500\ \#$$

at 15,000 # L/D could be 5.55

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Check 25000' acceleration:

Mach 1 = 400 kts EAS @ 25,000'

$q = 542\ \#/ft^2$

at 45,000 # $L/D = 6.0$, $C_L = .111$

Thrust of JT-12 - 2550 each.

5100 # total

Need $\frac{L}{D}$ of $\frac{45000}{5100} = 9.0$ or.

If we use Aerojet Super Perform. Rocket:

We get - 10,000# T.O. thrust.

S.I. = 245 30" long 13" x 24" wide

Use H_2O_2 + JP-5

Use drop tank for H_2O_2. (S. Grav = 1.44 or 12 #/gal)

at $\frac{10,000\ \#}{245} = 40.6\ \#/sec$. This is 2440 #/min

For 1 min T.O. & 1 min accel — 4880 # + eng.

Take-off at $C_L = .50$ at 45000 # is 190 kts

Land at 127 kts at 29,000 #

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Weight Factors.

A-3 — Zero fuel wt. — 12,000 #

Addwing — ?

Electronics — +150

Rocket + system — +500

Save on JT-12's — −285

Ramjet — 0

Payload up — 300

Cockpit cooling — +400

Tail chute — +60

Insulation — +200

Gear — +400

+1710

+12000

13,710

Margin 290

Equipped empty — 14,000 #

Use 15000 #

NAVARRA AEROSPACE HALL OF FAME

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JT-12 – No gov. fin. program.
4000# OK

Bill Gore – Jim Ryan. –
3 to 10,000 throttle
225# dry
90% H_2O_2 –
385 gals. for 2 to 5 min
7 H_2O_2 – 1 JP-5
wt. wt.
No time limit on oper. 30 m O.K.
Test next summer.
Sept. or Oct. 1959
Can we get ser. units in 14 months.
24 ST tanks O.K. – no coating
20 psia at eng.
Nepier – Havecon.

32 – 24 x 13
48" 18" wide 15" high.

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Big prob. is soaking. — Keep compt. cool — around 300°. Eng. would be 645#. Prototype in 0/14 mo. Wt. of Ref. as JT-12-20 spec. 3900#

Prod. version — 24 mo. — 4025#

Fuel & oil system — prob. in soaking. Have to cool ignition system. Require some airflow & windmill. Some fuel circulated thru engine.

645# based on Al. & steel in back

This engine could go 2.0 to 2.1 M.

Level. Cost 10 to 15 X10⁶.

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Considering that T.O. wt. is upto 53000# to get 45000# @ 25000', consider getting equivalent thrust by other means.

2 - JT-12 + 10,000# rocket = 18,000#

1 - J-58 non AB = 24,600#

Wt. of 2-JT-12 = 1400#

1 Rocket + tp = 500

1900#

If we consider fuel wt. - 1 min SL.
12 sec. 25000'

$5000\# \times \frac{2.0}{60} \cong 270\#$

Rocket - ~~tp~~ 40.6 #/sec x 60 = 2440#

at 25000'

JT-12's - $2 \times 250 \times \frac{2.0}{3600} \times 12 =$ 34#

Rocket - 40.6 x 12 = 490#

Total for JT-12 + Rocket

1900#
270
2440
34
490
5134 #

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Wt. of J-58 – non-AB — 4680

for 1 min on T.O. –

$21{,}600\# \times \frac{10}{60} = 360\#$

for 12 sec at 25,000'

$13{,}200 * \frac{1.17}{3600} \times 12 = 52\#$

Total — 4680.
360
52
5092 vs 5134#

Advantages:

1. Lighter overall wt
2. Runs thru out flite & solves a difficult ackcessory prob.
3. Overall better performance on turbo-jet only
4. Is designed for 3.2 mach.
5. Smaller ram jets
6. 3 eng vs 1 eng perform at alt.

Disadvantages:

1. One eng on landing.

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Estimate thrust at 95000' —

$\frac{\delta_{95}}{\delta_{65}} = \frac{.0169}{.074}$

Thrust at M = 3.0 — 6000# at 65,000

at 95,000' — 1370 (say 1200#)

SFC on JP-150 — 1.60 —

fuel/hr = 1920#

Total Req'd thrust — 95000' — ~~6000#~~ 5400#

Ram jets = 4200#

SFC = ~~2.30~~ 2.30

4200 X ~~2.30~~ 2.30 = 9640 #/hr.
1120

Total fuel/hr = 11,560

Average SFC = 2.14

Compare this to 2.35 with one R.J.

$\frac{2.14}{2.35} = 91\%$

Considering climb, this figure may reduce to 85%. Top of bottle is 87%

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of JT-12A job. ∴ Range is about even for

850 sq ft. wing
16000 lb end cruise for JT12
18500 " " " " J-57

Which is best airplane?

If we have zero velocity escape system it is probably J-58 type with 2 ram jets

Base this on overall safety, performance, simplicity & accessibility

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Prepared Dec 29 58 | Checked | Approved | Title: Quote on 3-mo. Engineering on A-5. | Page | TEMP. | PERM. | Model | Report No.

With Boeing –

40 engineers for 3 months –

175 hrs/mo. @ 11.00 = $1925 man/mo.

With 9% profit – $2100 man/mo.

40 x 2100 = $84000/mo.

3 x 84000 = $252,000

Quoted $575,000 before with 191,000 for a full scale rotor model – $384,000. This included some high speed tunnel work –

Mac Donald – 12 men – ½ time –

12 x $2,00 x 1½ = $38000

252000
+ 38000
$290,000

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FORM 283

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