ARROW 72/PERF/22

~~SECRET~~ UNCLASSIFIED

ARROW PERFORMANCE WITH P AND W JT2B-23 ENGINES

PERFORMANCE GROUP JULY 1958

UNCLASSIFIED

SECRET

Aircraft:- Arrow

Report No. 72/PERF/22

File No. 72/PERF/22
72/PERF/24

No. of Sheets:- 23

Title: ARROW PERFORMANCE WITH P AND W JT4B-23 ENGINES

Classification cancelled/changed to.....

by authority of.....(date).....

Signature.....Rank F/L

Prepared by:- Performance Group
Performance Group

Supervised by:- R.G. Rose
Senior Aerodynamicist

Recommended for Approval by:-
Chief of Performance Evaluation

Approved by:-
Chief of Technical Design

JULY 1958

UNCLASSIFIED

FORM 1749 A-2

SECRET

ARROW PERFORMANCE WITH P AND W JT4B-23 ENGINES

SUMMARY

A comparison has been made between the Arrow performance when fitted with P and W JT4B-23 engines and the present performance of the Iroquois powered version.

The time available limited the accuracy of this comparison, in that the JT4B-23 installed performance had to be ratioed from available J75 data.

$$\text{i.e. } (\text{JT4B-23 Performance})_{\text{installed}} = (\text{J75})_{\text{installed}} \times \frac{(\text{JT4B-23})_{\text{Brochure}}}{(\text{J75})_{\text{Brochure}}}$$

Thus although the performance of the P and W JT4B-23 version is of the right order, the accuracy of small differences between it and the Iroquois version cannot be guaranteed.

Both versions of the Arrow were at compatible weights, with suitable allowances being made for the weight changes due to the installation of the JT4B-23 engines. The Iroquois version was based on weight report 7-0400-34 Issue 21, and the JT4B-23 version was based on weight report 7-0400-76 Issue 2.

Both version are comparable, from a performance viewpoint, when operating subsonically with afterburners unlit; but at supersonic speeds with afterburner lit it is evident that the JT4B-23 engine has a much greater fuel consumption than the Iroquois.

TABLE 1 - LOADING AND PERFORMANCE

UNDER ICAO STANDARD ATMOSPHERIC CONDITIONS

(Clean aircraft, i.e. no ventral tank, unless otherwise stated)

		J 75 (P6)	Iroquois
Weight			
Operational weight empty	lb.	49,239	46,650
Maximum useable internal fuel	lb.	19,443	19,443
Gross Take-off weight (max.internal fuel)	lb.	68,682	66,093
Combat weight ($\frac{1}{2}$ max.internal fuel wt.)	lb.	58,961	56,372
Maximum external fuel and tank (500 gall. at 7.8 lb/gall. and drop tank)	lb.	4,242	4,242
Maximum gross take-off weight	lb.	72,924	70,335
Normal design landing gross weight	lb.	52,372	49,783
Maximum landing gross weight	lb.	68,682	66,093
Wing loading at gross take-off weight	lb/sq.ft.	56.1	54.0
Power loading at gross take-off weight	lb/lb thrust	1.62	1.52
Speed			
True airspeed in level flight at combat weight			
Sea Level (i) Maximum thrust, A/B Lit	kts.	700 *	700 *
(ii) Maximum thrust, A/B unlit	kts.	648	670
50,000 ft. (i) Maximum thrust, A/B lit	kts.	1,098	1,147 *
Ceiling			
Ceiling at combat weight, rate of climb 500 ft/min. with maximum thrust at optimum Mach number A/B lit	ft.	55,500 (1.50M)	59,500 (1.80M)
Rate of Climb			
Steady state rate of climb at combat weight			
Sea Level (i) Maximum thrust, A/B lit, at 0.92M	ft/min.	42,700	42,500
(ii) Maximum thrust, A/B unlit at 527 kts. TAS	ft/min.	15,700	19,400
50,000 ft. (i) Max Thrust, A/B lit at 1.80M	ft/min.	4,260	9,740 ?

* Placard Speed

Cont'd...../2

		J 75 (P6)	Iroquois
Time to Height			
Time to reach 50,000 ft. and 1.5M from engine start at gross take-off weight, maximum thrust A/B lit	min.	5.2	5.3
Manoeuvrability			
Load factor at combat weight			
1) Maximum thrust A/B lit 1.5M at 50,000 ft.		1.40	1.50
2) Maximum thrust A/B lit 1.8M at 50,000 ft.		1.19	1.58
Take-off Distance			
Take-off distance over 50 ft. obstacle at sea level at gross take-off weight			
1) Maximum thrust A/B lit, standard day	ft.	4,120	3,850
2) Maximum thrust A/B unlit, standard day	ft.	6,350	4,750
3) Maximum thrust A/B lit, hot day	ft.	5,040	4,640
Landing Distance			
Landing distance over 50 ft. obstacle at sea level at normal design landing gross weight	ft.	4,980	4,800
Stalling Speed			
True stalling speed in landing configuration at combat weight at sea level	kts.	119	117
Missions			
Combat radius of action on internal fuel, see mission profile for detail breakdown			
1) Supersonic high altitude mission - supersonic combat	n.m	169	238
2) Subsonic high altitude mission - supersonic combat	n.m.	310	347
3) MIL-C-5011A Area Mission - subsonic combat	n.m.	248	277
a) Ferry Mission (armament carried throughout) - tank jettisoned when empty	Range n.m.	1,310	1,300

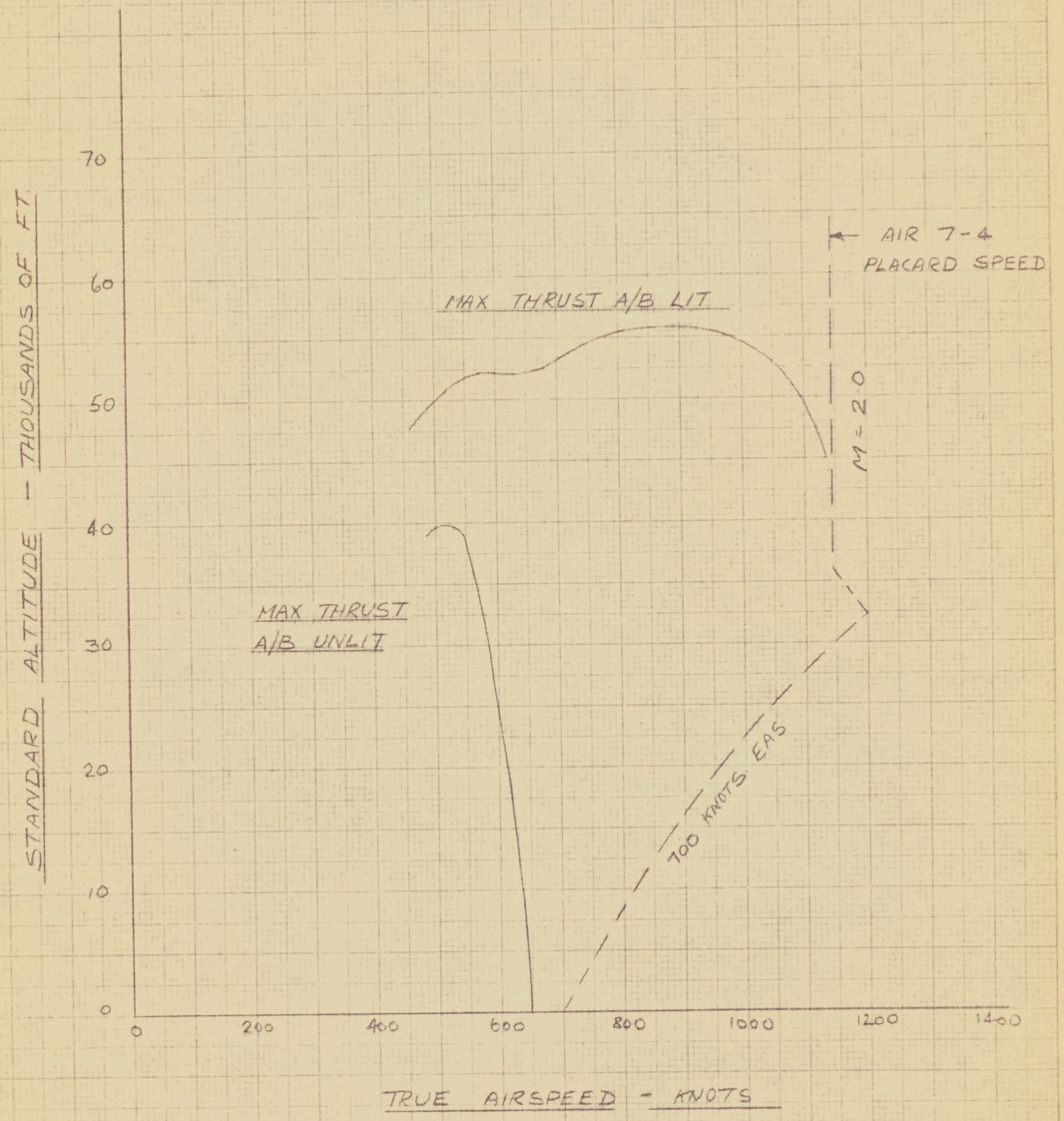
UNCLASSIFIED

72/PERF/22

ARROW 2 WITH UPRATED J 75-P6 ENGINES

MAXIMUM LEVEL SPEED

AT COMBAT WEIGHT = 58,961 LB



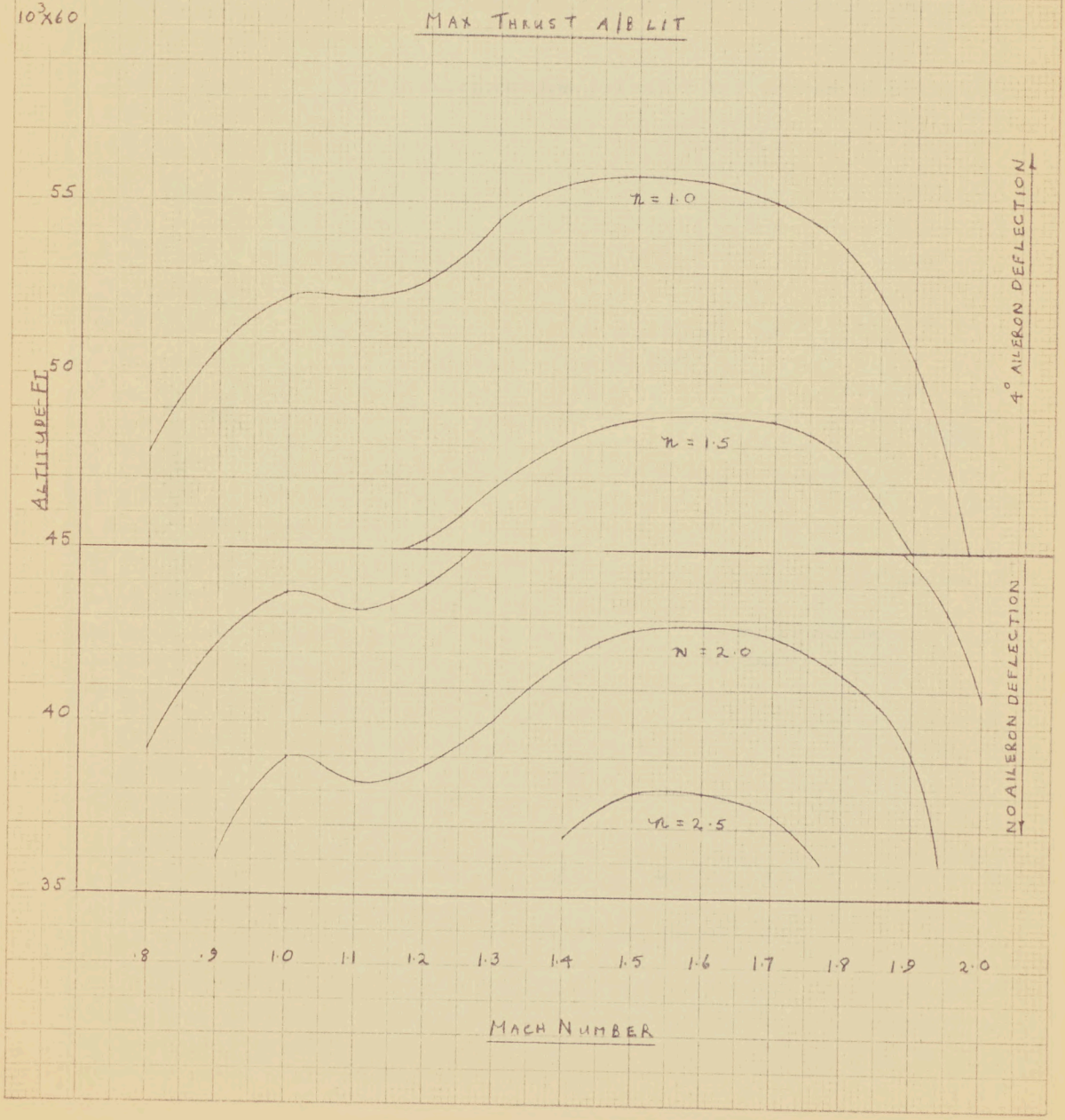
ARROW 2

J75-P6 UPRATED ENGINES

MANOEUVRABILITY

AVAILABLE STEADY $G^{'S}$ AT COMBAT WEIGHT (58961#)

MAX THRUST A/B LIT



ARROW 2

J75-P6 UPRATED ENGINE

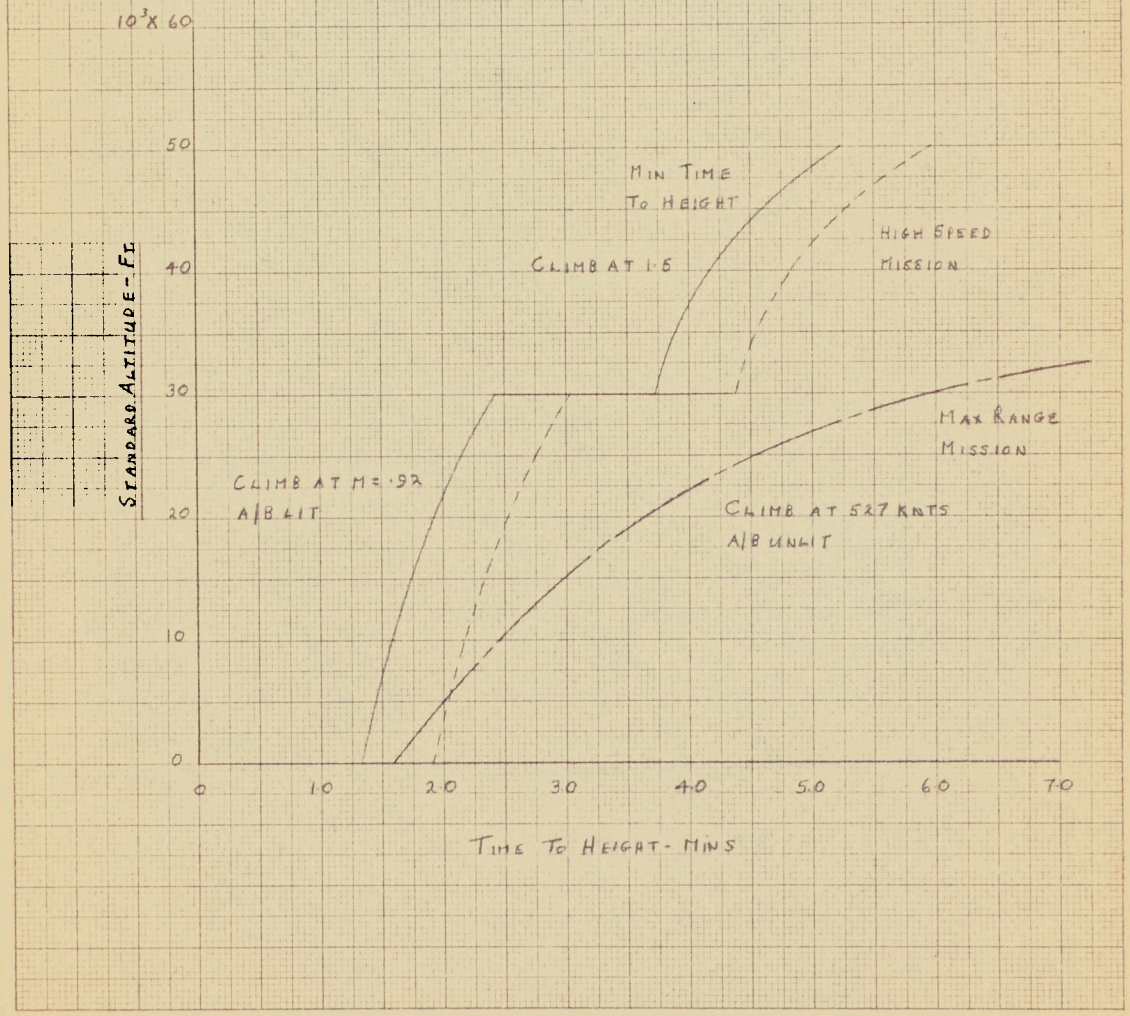
TIME TO HEIGHT

——— MIN TIME TO HEIGHT A/B LIT THRO'OUT FLIGHT PLAN

– – – – HIGH SPEED MISSION A/B LIT AT THE BEGINNING OF M=0.92 CLIMB

——— MAX RANGE MISSION A/B UNLIT THRO'OUT FLIGHT PLAN

NOTE :- ½ MIN ALLOWED FROM ENGINE START TO MAX THRUST.

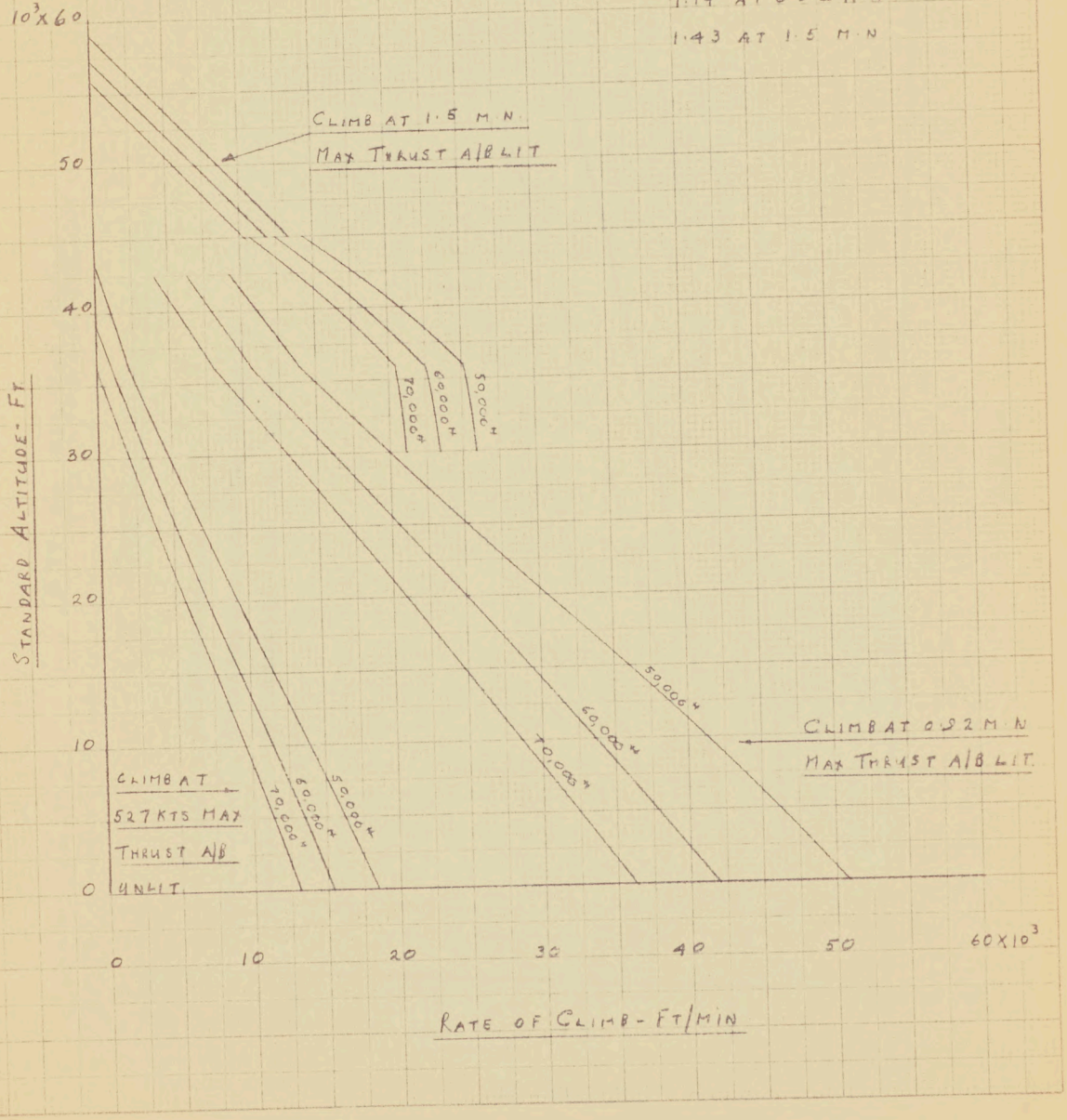


ARROW 2

J75-P6 UPRATED ENGINE

STEADY STATE RATE OF CLIMB

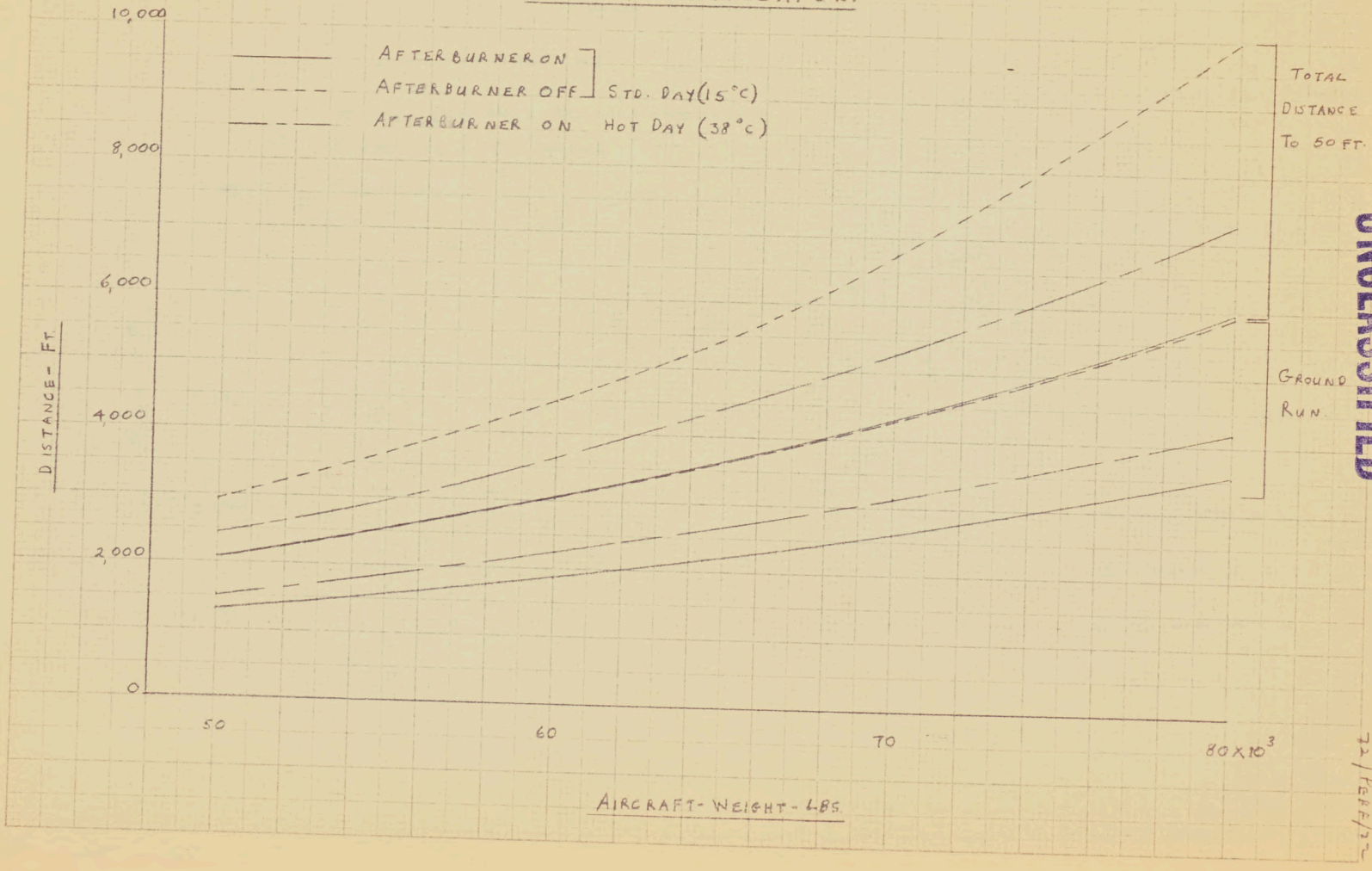
FOR K·E EFFECT INCREASE
R/C BELOW 36,089 FT. BY,
1·14 AT 0·92 M·N
1·43 AT 1·5 M·N



ARROW 2

J 75- P6 UPRATED ENGINE

TAKE-OFF DISTANCE AT S.L.



72/PERF/17

ARROW 2

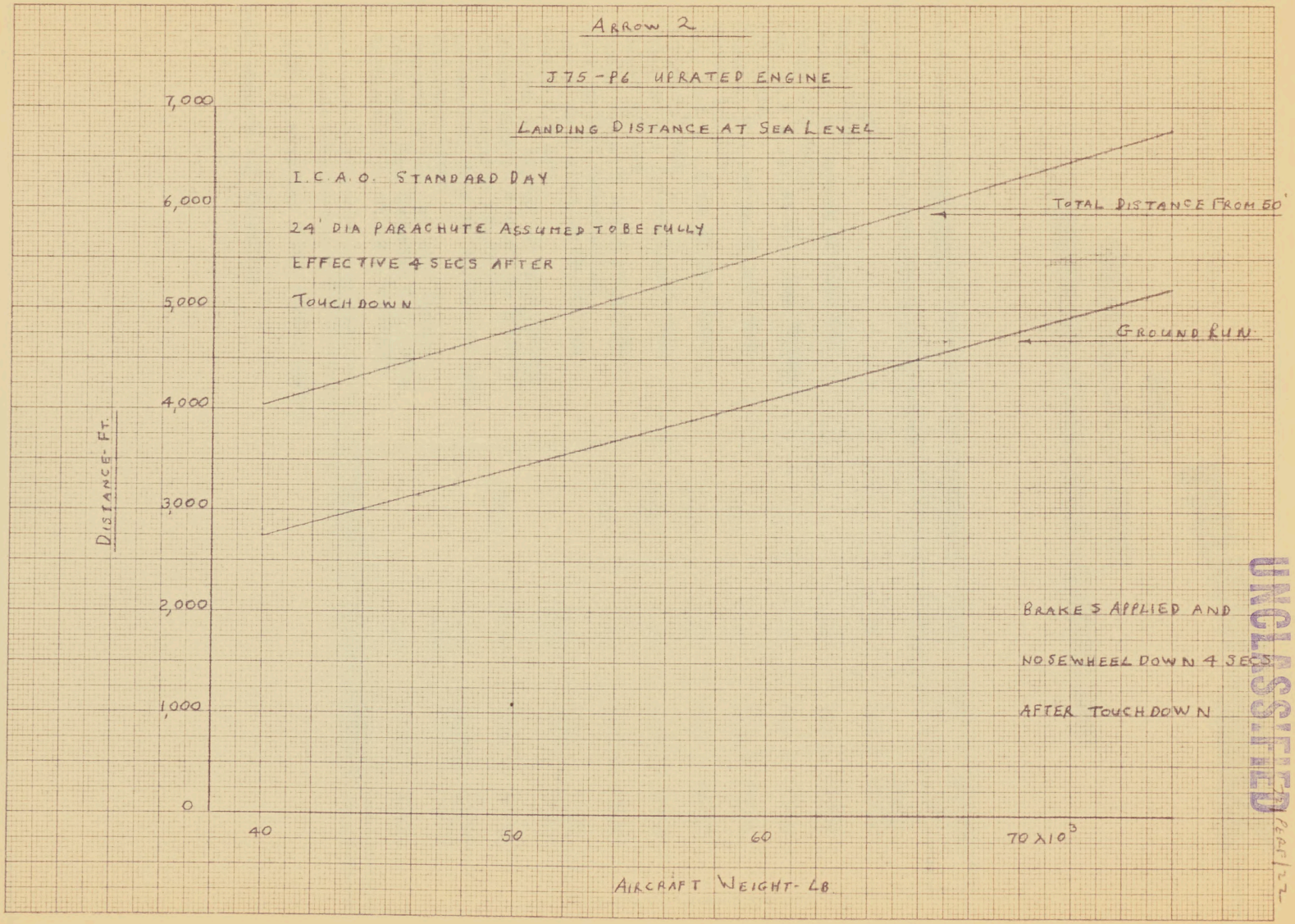
J75-P6 UPRATED ENGINE

LANDING DISTANCE AT SEA LEVEL

I.C.A.O. STANDARD DAY

24' DIA PARACHUTE ASSUMED TO BE FULLY EFFECTIVE 4 SECS AFTER TOUCHDOWN

BRAKES APPLIED AND NOSEWHEEL DOWN 4 SECS AFTER TOUCHDOWN



ARROW 2

WITH UPRATED J 75 - P6 ENGINES

SUPERSONIC HIGH ALTITUDE MISSION - SUPERSONIC COMBAT

CONDITION	DISTANCE N.M.	TIME MIN.	FUEL LB	A/C WT. LB
Start Weight	-	-	-	68682
Engine Start	-	.50	100	68582
Take-off to Unstick at S.L. Max Thrust A/B Unlit	-	.38	192	68390
Acc. to M = .92 at S.L. Max Thrust A/B Unlit	7.2	1.02	540	67850
Climb at M = .92 to 30,000' Max Thrust A/B Lit	9.3	1.12	1880	65970
Acc. to M = 1.5 at 30,000' Max Thrust A/B Lit	16.5	1.35	1880	64090
Climb at M = 1.5 to 50,000' Max Thrust A/B Lit	22.5	1.58	1650	62440
Cruise Out at M = 1.5 at 50,000' with Partial Afterburning	113.5	7.93	4550	57890
Combat at M = 1.5 at 50,000 Max Thrust A/B Lit	-	5.00	3800	52362 *
Descent to 34,000' at Idle Thrust	-	2.82	213	52149
Cruise Back at M = .90 at Optimum Cruise Altitude (34,000')	169.0	19.50	2034	50115
Loiter Over Base at 34,000' at Max Endurance Speed	-	15.00	1515	48600
Descend to S.L. at Idle Thrust	-	5.90	307	48293
Land with Fuel Reserves for 5 min Loiter at S.L. at max. Endurance	-	5.00	782	47511
TOTAL	338.0	67.10	19443	

* 1728 lb missiles fired during combat

Fuel density 7.8 lb/gallon

AVRO AIRCRAFT

ARROW 2

WITH UPRATED J 75 - P6 ENGINES

SUBSONIC HIGH ALTITUDE MISSION - SUPERSONIC COMBAT

CONDITION	DISTANCE N.M.	TIME MIN.	FUEL LB.	A/C WT. LB.
Start Weight	-	-	-	68682
Engine Start	-	.50	100	68582
Take-off to Unstick at S.L. Max Thrust A/B Unlit	-	.38	192	68390
Acc. to 527 Kts at S.L. Max Thrust A/B Unlit	4.16	.70	351	68039
Climb at 527 kts to 28,000' Max thrust A/B Unlit	32.40	3.75	1360	66679
Cruise Out at M = .90 at Optimum Cruise Altitude (28,000')	238.34	26.70	3721	62958
Acc. to M = 1.5 at 28,000' Max Thrust A/B Lit	14.40	1.18	1774	61184
Climb at M = 1.5 to 50,000' Max Thrust A/B Lit	20.40	1.48	1540	59644
Combat at M = 1.5 at 50,000 Max Thrust A/B Lit	-	5.00	3800	54116 *
Descend to 34,000' at Idle Thrust	-	2.82	213	53903
Cruise Back at M = .90 at Optimum Cruise Altitude (34,000')	310.00	35.60	3788	50115
Loiter Over Base at 34,000' at Max Endurance Speed	-	15.00	1515	48600
Descend to S.L. at Idle Thrust	-	5.90	307	48293
Loiter at S.L. at Max Endurance Speed	-	5.00	782	47511
TOTAL	620.0	104.01	19443	

* 1728 lb. missiles fired during combat

Fuel density 7.8 lb/gallon

AVRO AIRCRAFT

ARROW 2

WITH UPRATED J 7 5 - P6 ENGINES

MIL - C-5011A AREA MISSION - SUBSONIC COMBAT

CONDITION	DISTANCE N.M.	TIME MIN.	FUEL LB.	A/C WT. LB.
Start Weight	-	-	-	68682
Allowance for Engine Start, Take-off and Accelerate to 527 kts at S.L. (a) 2 min. with Normal Power (max Continuous) at S.L. Static plus (b) 1 min. Max Power (A/B Lit) at S.L. Static.		3.0	2686	65996
Climb to Cruising ceiling (35,000 ft) at 527 kts Max Thrust A/B Unlit	60.0	7.0	2153	63843
Cruise at M = .915 at Cruise Ceiling	163.0	18.6	2820	61023
Climb to Combat Ceiling at M = .92 Max Thrust A/B Lit	25.4	2.92	1607	59416
Combat at M = .92 at 50,000' Max Thrust A/B Lit		5.0	2100	57316
Cruise Back at M = .90 at optimum altitude (32,000 ft.)	248.4	28.30	3782	53534
Land with 5% of Initial Fuel + 20 mins. Loiter at Max Endurance Speed at S.L.		20.0	4295	49239
TOTAL	496.8	84.82	19443	

1728 lb. missiles held during flight

Density of Fuel = 7.8 lb/gallon.

All fuel allowances increased by 5%

ARROW 2

J 75 - P6 UPRATED ENGINES

FERRY MISSION (ARMAMENT CARRIED THROUGHOUT)

EXTERNAL TANK JETTISONED WHEN EMPTY

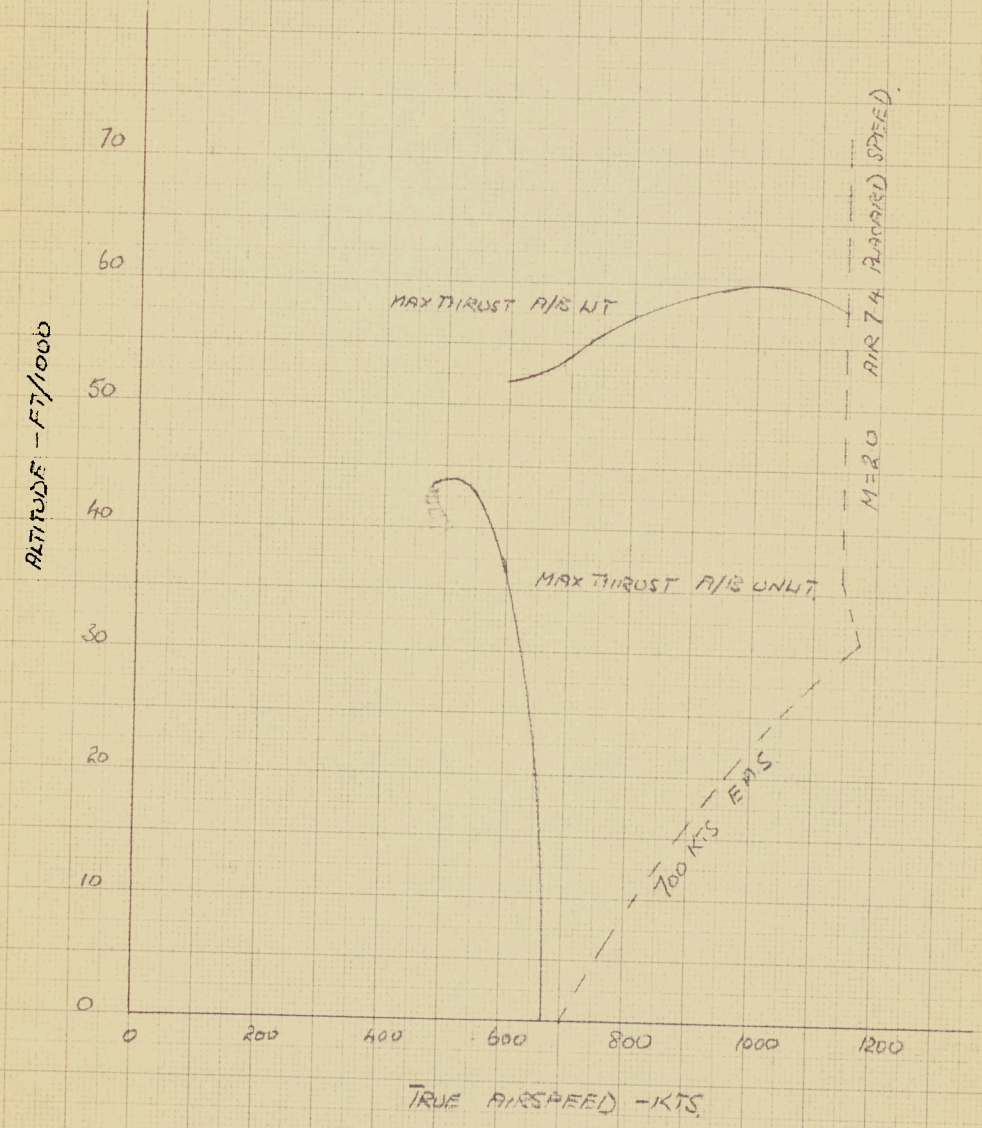
CONDITION	DISTANCE N.M.	TIME MIN.	FUEL LB.	A/C WT. LB.
Start Weight	-	-	-	72924
Engine Start	-	.5	100	72824
Take-off to Unstick Max Thrust A/B Unlit	-	.44	193	72631
Acc. to 527 kts. at S.L. Max Thrust A/B Unlit	4.61	.76	383	72248
Climb to 27,500' Max Thrust A/B Unlit at 527 kts.	38.50	4.45	1610	70638
Cruise Climb to 34,500' at M = .90	1267.3	145.0	18347	51949
Loiter Over Base at 34,500' at Max Endurance Speed	-	15.0	1620	50329
Descend to S.L. at Idle Thrust	-	5.95	310	50019
Land with Reserves for 5 min. Loiter at S.L.	-	5.0	780	49239
TOTAL	1310.4	176.6	23343	

Fuel density 7.8 lb/gallon.

72/PERF/124.

ARROW 2.

MAX LEVEL SPEED AT [illegible] WEIGHT (56,372 LB)

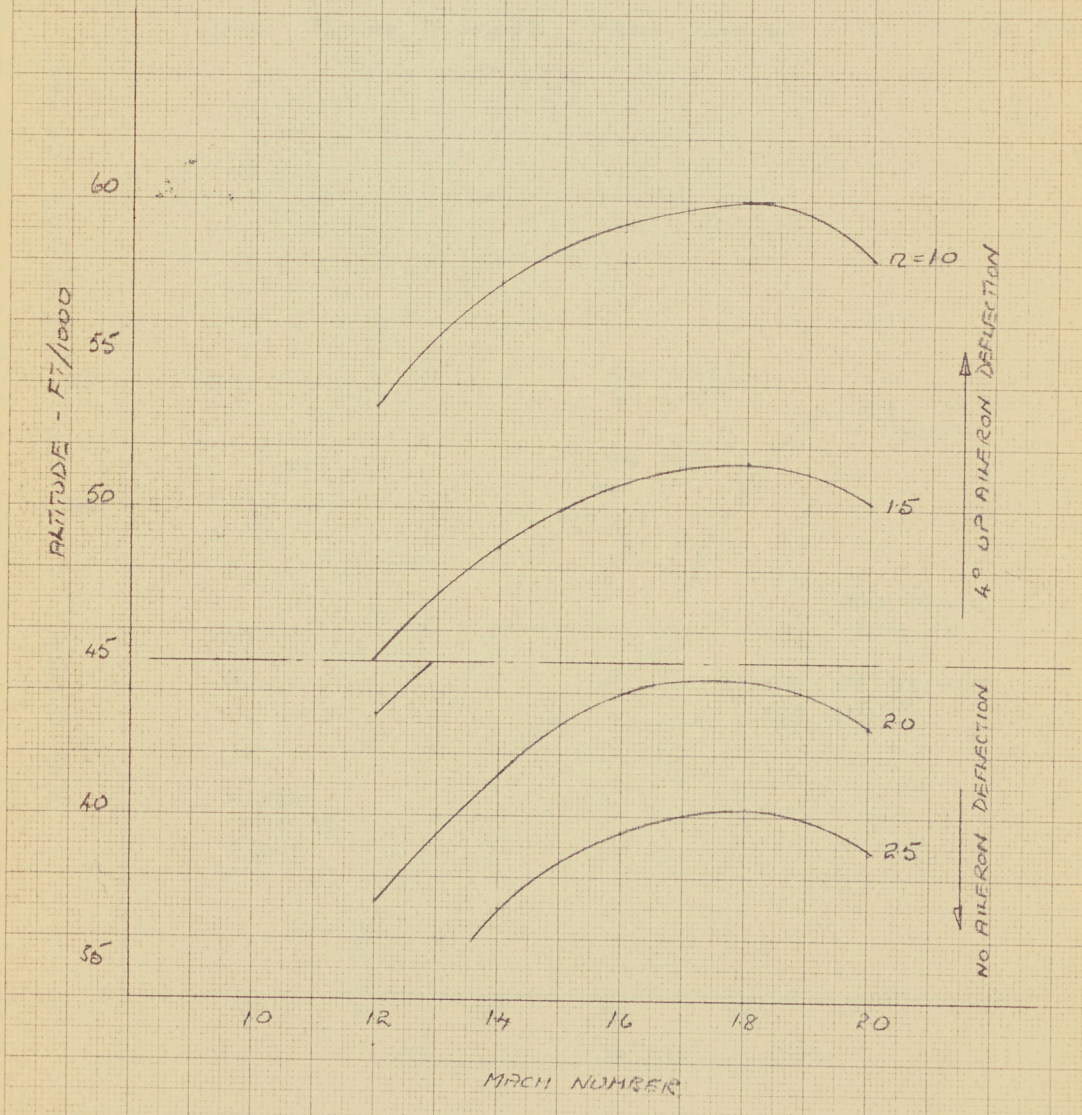


ARROW 2.

MANOEUVRABILITY - STEADY G'S AVAILABLE

AT COMBAT WEIGHT MAX THRUST A/B LIT.

COMBAT WEIGHT = 56,372 LB



ARROW 2

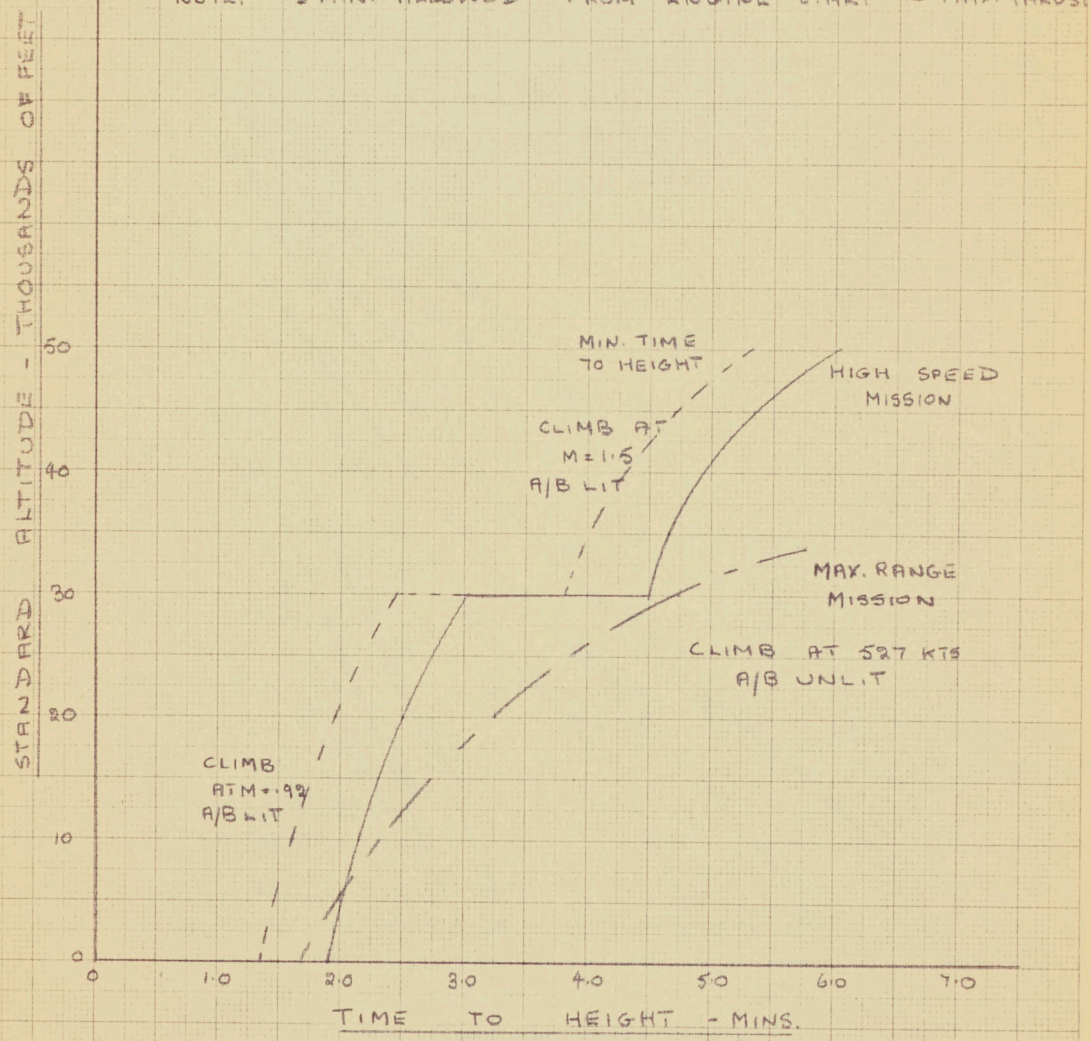
TIME TO HEIGHT

– – – – MIN. TIME TO HEIGHT A/B LIT THROUGHOUT FLIGHT PLAN

——— HIGH SPEED MISSION A/B LIT AT BEGINNING OF M = 1.92 CLIMB

— – — – MAX. RANGE MISSION A/B UNLIT THROUGHOUT FLIGHT PLAN

NOTE: ½ MIN. ALLOWED FROM ENGINE START TO MAX. THRUST



N.W. JULY '58

SECRET

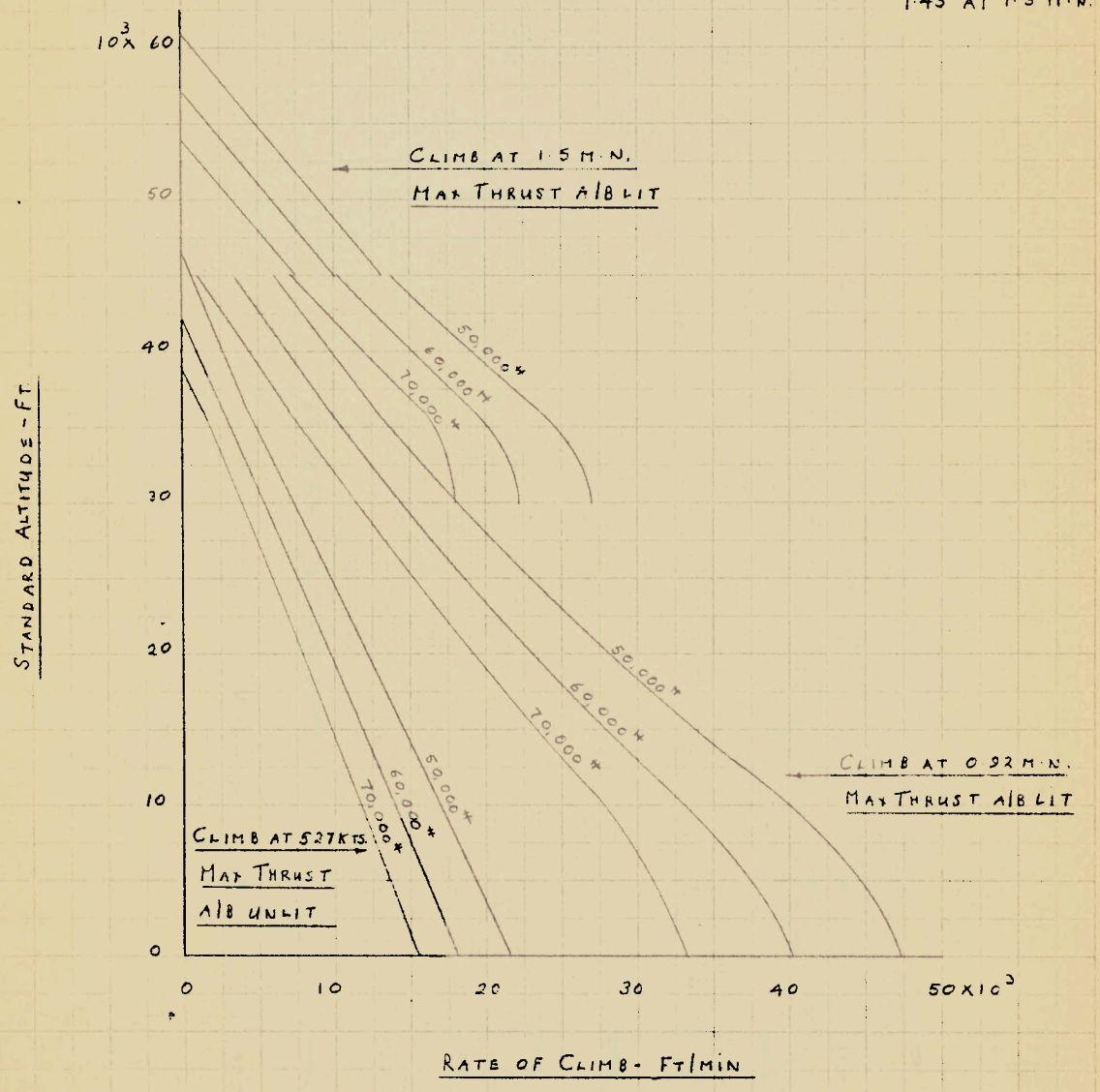
72/FER/24

ARROW 2

STEADY STATE RATE OF CLIMB

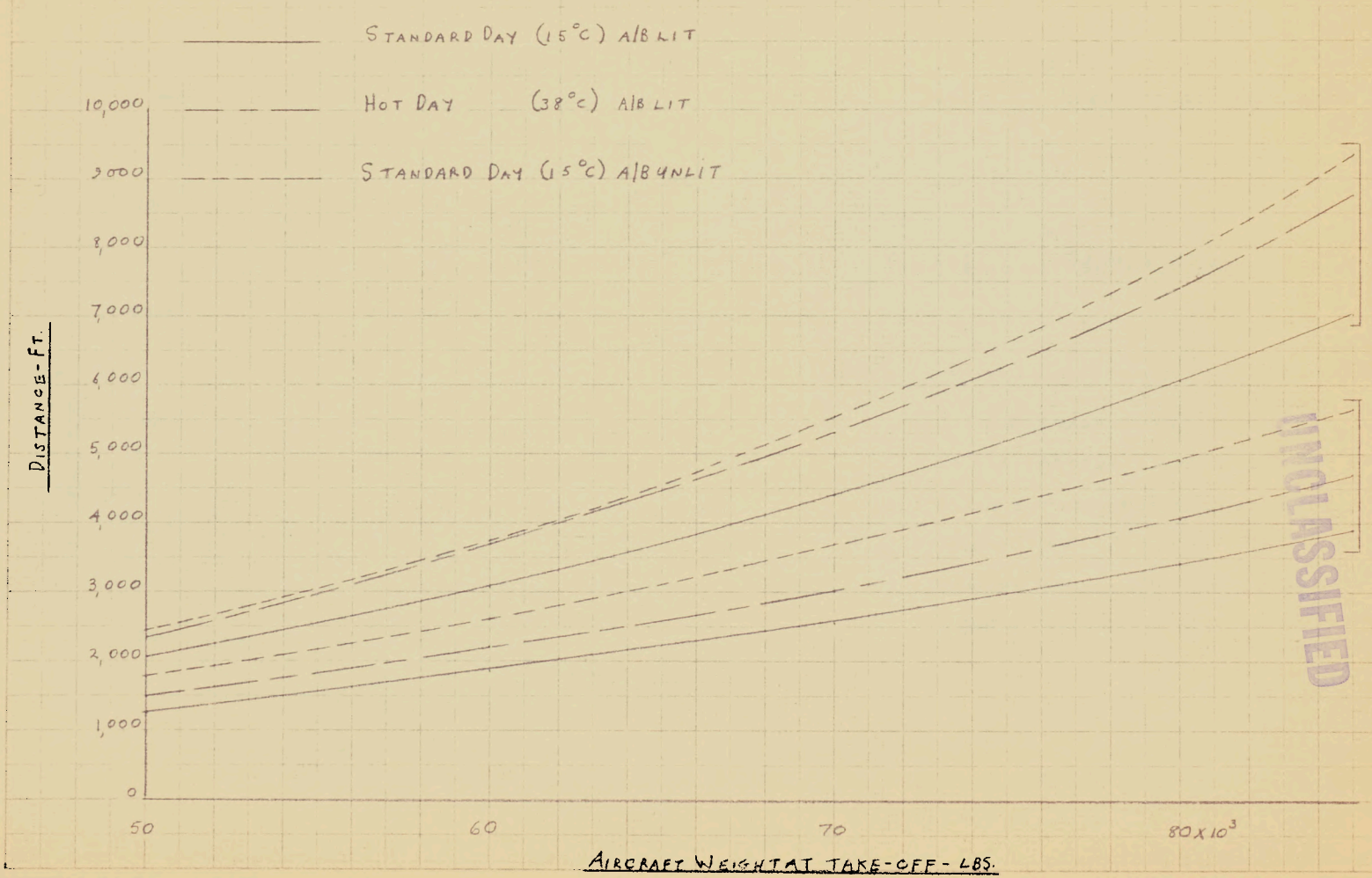
FOR K.E. EFFECT INCREASE R/C

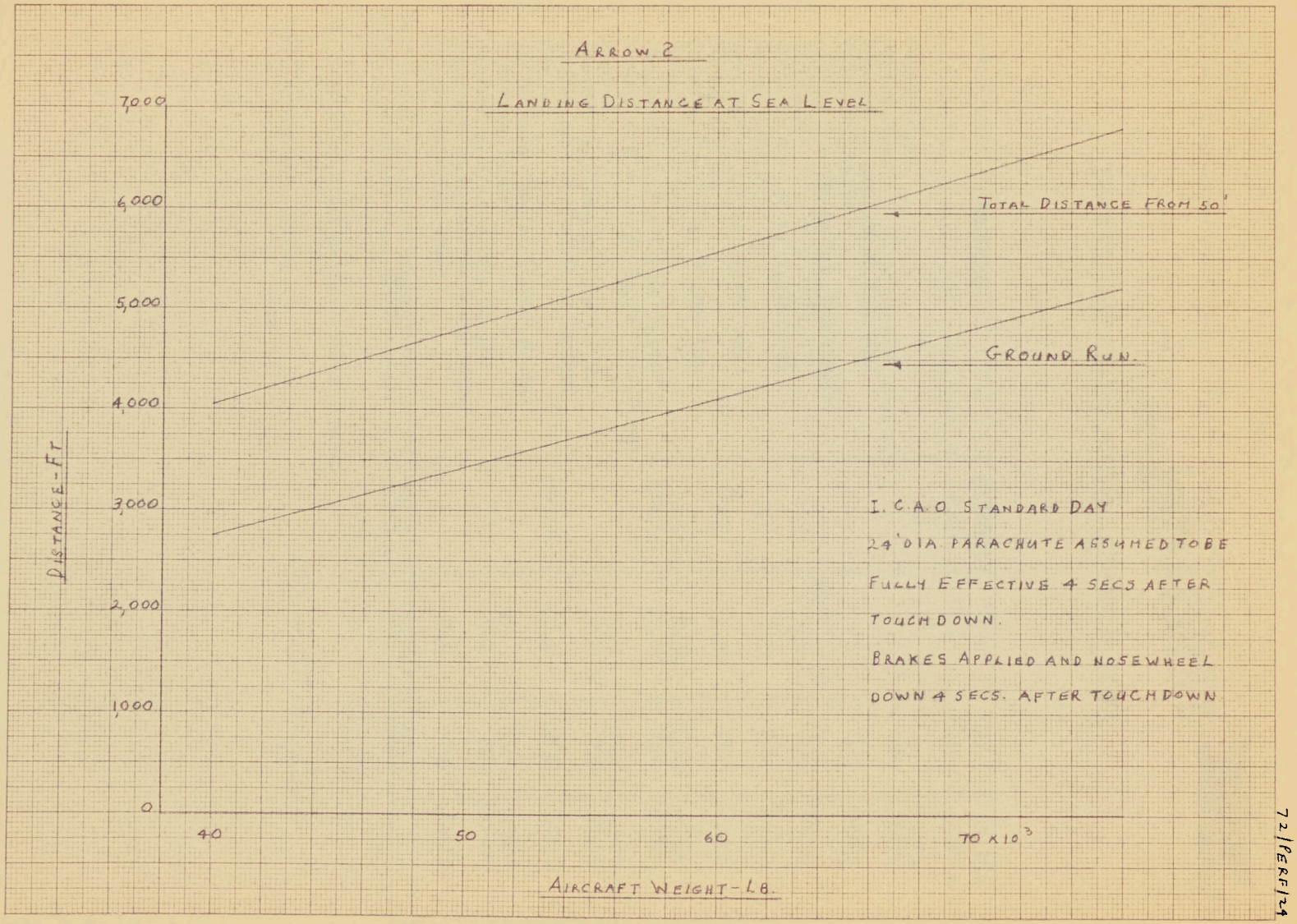
BELOW 36,089 FT BY 1·14 AT 0·92 M·N.
1·43 AT 1·5 M·N.



ARROW 2

TAKE-OFF DISTANCE AT S.L.





SECRET

72/PERF/24

ARROW 2 UNCLASSIFIED

SUPERSONIC HIGH ALTITUDE MISSION - SUPERSONIC COMBAT

CONDITION	DISTANCE N.M.	TIME MIN.	FUEL LB.	A/C Wt. Lb.
Start Weight	-	-	-	66093
Engine Start	-	.5	100	65993
Take-off to unstick at S.L. Max Thrust A/B Unlit	-	.3	185	65808
Acc. to M = .92 at S.L. Max Thrust A/B Unlit	7.0	* 1.1 ?	810	64998
Climb at M = .92 to 30,000' Max Thrust A/B lit	9.4	1.12	1560	63438
Acc. to M = 1.5 at 30,000' max Thrust A/B Lit	17.8	1.48	1680	61758
Climb at M = 1.5 to 50,000' Max Thrust A/B Lit	21.5	1.53	1360	60398
Cruise out at M = 1.5 at 50,000'	182.15	12.67	5068	55330
Combat at M = 1.5 at 50,000' Max Thrust A/B Lit	-	5.0	3042	50560 *
Descend to 30,000'at idle thrust		2.8	210	50350
Cruise back at M = .91 at optimum Alt.	237.85	27.2	2834	47516
Loiter over Base at 36,000' at Max Endurance Speed		15	1530	45986
Descend to S.L. at Idle Thrust		6.2	324	45662
Land with reserves for 5 min Loiter at Max Endurance Speed		5.0	740	44922
TOTAL	475.7	79.9	19443	

* 1728 lb of Missiles fired during combat

Fuel Density 7.8 lb/gal.

Avro to confirm.

ARROW 2

SUBSONIC HIGH ALTITUDE MISSION - SUPERSONIC COMBAT

CONDITION	DISTANCE N.M.	TIME MIN.	FUEL LB.	A/C WT. LB.
Start Weight	-	-	-	66093
Engine Start	-	.5	100	65993
Take-off to Unstick at S.L. Max Thrust A/B Unlit	-	.3	185	65808
Acc. to 527 kts. at S.L. Max Thrust A/B Unlit	5.0	.88	634	65174
Climb at 527 kts. to 34,000' Max Thrust A/B Unlit	35.5	4.1	1765	63409
Cruise Out at M = .91 at 34,000'	269.5	30.68	4055.	59354
Acc. to M = 1.5 at 34,000' Max Thrust A/B Lit	19.0	1.65	1560	57794
Climb to 50,000' at M = 1.5 Max Thrust A/B Lit	18.0	1.25	1080	56714
Combat at M = 1.5 at 50,000' Max Thrust A/B Lit	-	5.0	3042	51944 *
Descend to 36,000' at Idle Thrust	-	2.8	210	51734
Cruise Back at M = .91 at Optimum Altitude	347.0	39.62	4218	47516
Loiter Over Base at 36,000' at Max Endurance Speed	-	15.0	1530	45986
Descend to S.L. at Idle Thrust	-	6.2	324	45662
Land with Reserves for 5 min. Loiter at S.L. at Max Endurance Speed	-	5.0	740	44922
TOTAL	694.0	112.98	19443	

Fuel density 7.8 lb/gallon.

* 1728 lb. of missiles fired during combat.

ARROW 2

WITH IROQUOIS SERIES 2 ENGINES

MIL - C - 5011A AREA MISSION - SUBSONIC COMBAT

CONDITION	DISTANCE N.M.	TIME MIN.	FUEL LB.	A/C WT. LB.
Start Weight	-	-	-	66093
Allowance for Engine Start, Take-off and Accelerate to 527 kts. at Sea Level a) 2 min. with Normal Power (Max Continuous) at S.L. Static plus b) 1 min. Max Power (A/B Lit) at S.L. Static	-	3.0	2790	63303
Climb to Cruising Ceiling (41,000 ft.) at 527 kts. Max Thrust A/B Unlit	67.5	7.27	2457	60846
Cruise at M = .93 at Cruise Ceiling	192.0	21.60	3190	57605
Climb to Combat Ceiling at M = .92 Max Thrust A/B Lit	17.0	1.82	903	56702
Combat at M = .92 at 50,000' Max Thrust A/B Lit	-	5.0	1922	53052
Cruise Back at M = .91 at Optimum Cruise Altitude (36,000 ft.)	276.5	31.7	4081	50750
Land with 5°/o of Initial Fuel + 20 mins. Loiter at Max Endurance Speed at S.L.	-	20.0	4100	46650
TOTAL	553.0	90.39	19,443	

1728 lb. missiles carried throughout flight

Fuel density 7.8 lb/gallon.

All fuel allowances increased by 5°/o

ARROW 2

FERRY MISSION (ARMAMENT CARRIED THROUGHOUT)

EXTERNAL TANK JETTISONED WHEN EMPTY

CONDITION	DISTANCE N.M.	TIME MIN.	FUEL LB	A/C WT. LB.
Start Weight	-	-	-	70335
Engine Start	-	.50	100	70235
Take-off to Unstick Max Thrust A/B Unlit	-	.34	209	70026
Acc. to 527 kts Max Thrust A/B Unlit	5.4	.94	677	69349
Climb to 30,000' Max Thrust A/B Unlit 527 kts.	30.1	~~31.8~~ 3.48	1690	67659
Cruise Climb to 36,000' at M = .91	1265.	144.	18098	49219
Loiter Over Base 15 mins at 36,000'	-	15.0	1485	47734
Descend to S.L. at Idling Thrust	-	6.2	324	47410
Land with reserves for 5 min. Loiter at S.L. at Max Endurance Speed	-	5.0	760	46650
TOTAL	1300.5	~~206.78~~ 175.46	23343	

Tank jettisoned approx. 8 mins. after start of cruise.

Missiles carried throughout mission.

Fuel density 7.8 lb/gallon.