LONG RANGE ARROW

P.R.7-1 Appendix 2

PROJECT RESEARCH GROUP

Prepared by [signature] Approved by [signature]

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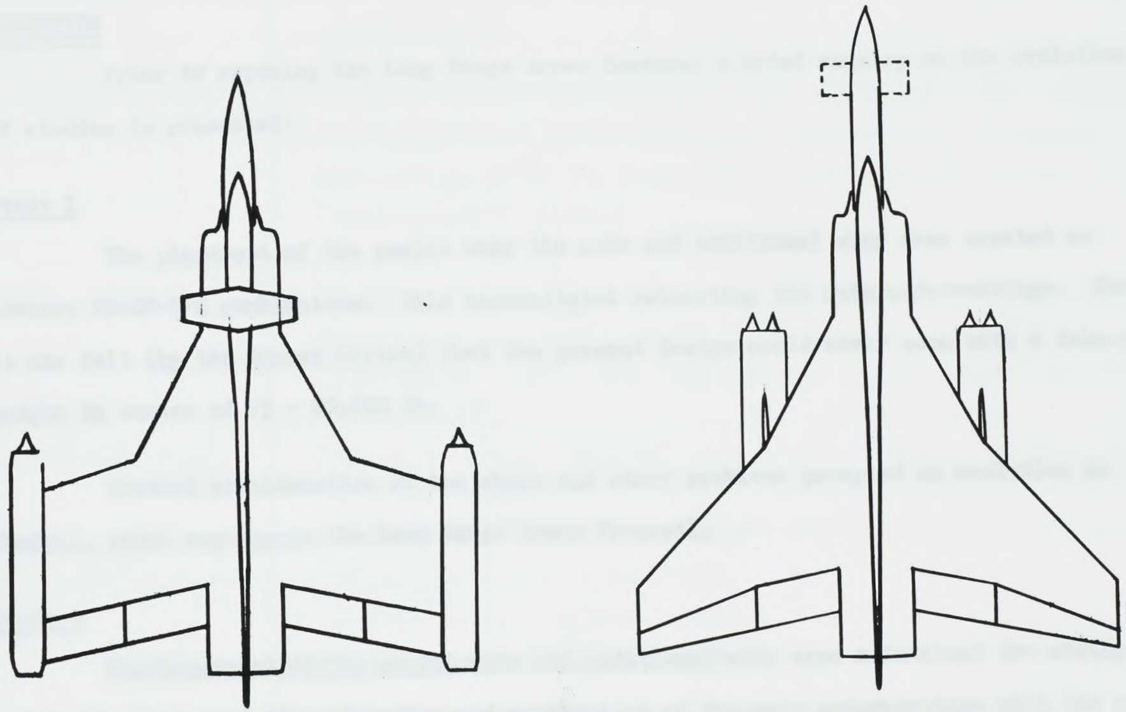
EVOLUTION



STUDY 1 -
ADVERSE C.G., C.P., & MAIN U/C CONDITIONS

STUDY 2 -
STATIC MARGIN MAINTAINED AND MAIN UNDERCARRIAGE ACCOMODATING

FIG. 1

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EVOLUTION

Prior to exposing the Long Range Arrow features a brief summary on the evolution of studies is presented:

Study 1

The placement of the ramjet wing tip pods and additional wing area created an adverse CG-CP-U/C combination. This necessitated relocating the main undercarriage. Further it was felt (by the Stress Office) that the present design could never cope with a take-off weight in excess of 75 - 80,000 lb.

Careful consideration of the above and other problems prompted an evolution to Study 2, which represents the Long Range Arrow Proposal.

Study 2

The placement of the ramjet pods and additional wing area maintained the static margin the same, and the relocation and combination of the main undercarriage with the ramjet pylons resulted in the removal of the main disadvantages of Study 1. Thus we now have the same relative CG-CP-U/C placements as on the Arrow 2.

BASIC MODIFICATIONS FOR LONG RANGE ARROW

ITEM	REMARKS
UNDERCARRIAGE	(1) UNDERCARRIAGE REMOVED AND SPACE USED FOR FUEL ~2000 LBS (2) UNDERCARRIAGE INTEGRATED WITH RAMJET PYLONS, AND RELOCATED TO THE INNER AND OUTER WING TRANSPORT JOINT.
MIXED POWER	COMBINATION OF TURBOJET AND RAMJET POWER PROVIDES A LIGHT AND EFFICIENT SYSTEM CAPABLE OF EXTREMELY HIGH PERFORMANCE
INCREASED FUEL	RAMJET PODS SERVE AS FUEL PODS DURING CRUISE - OUT.
DRAG REDUCTION	(1) ADDITION OF CANARD (2) INCREASED WING AREA (3) INCREASED ASPECT RATIO

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BASIC MODIFICATIONS OF LONG RANGE ARROW

UNDERCARRIAGE

It has been established that the take-off weight of a Long Range Arrow is of the order of **105,000 lb.** and it is very unlikely that the present main undercarriage scheme can be developed to cope with these loads. Further the redesign should be capable of a potential take-off weight of much more than the immediate 105,000 lb. requirement.

A plausible solution would be to:

(1) **Remove the existing undercarriage and utilize the space for fuel storage.**

(2) **Integrate the main undercarriage with the pylons which support twin ramjets and are located at the transport joints of the inner and outer wing. The bulk of the increased weight would be concentrated at the undercarriage thus keeping other structural changes to a minimum.**

MIXED POWER

A high supersonic performance may be achieved without sacrifice of subsonic capability by the utilization of mixed power plants. This principle when applied to the Avro Arrow results in increased performance at altitude. It is therefore recommended that:

(1) A pair of 36" diameter ramjets straddle each pylon-undercarriage structure.

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The preceding three basic modifications would in effect reduce the drag at M 2.5, 90,000 ft. altitude to:

Profile Drag - 4900 lb.

Induced Drag - 6950 lb.

Trim Drag - 1230 lb., totalling 13,080 lb. and reduction of over 9,000 lb.

It should be noted, however, that the subsonic drag, at M = .92, 40,000 ft. and $\frac{W}{P}$ = 22,000, increases approximately from 6,660 to 7,000 lb., a small subsonic penalty to pay for attainment of a 90,000 ft. ceiling.

(1) CANARD

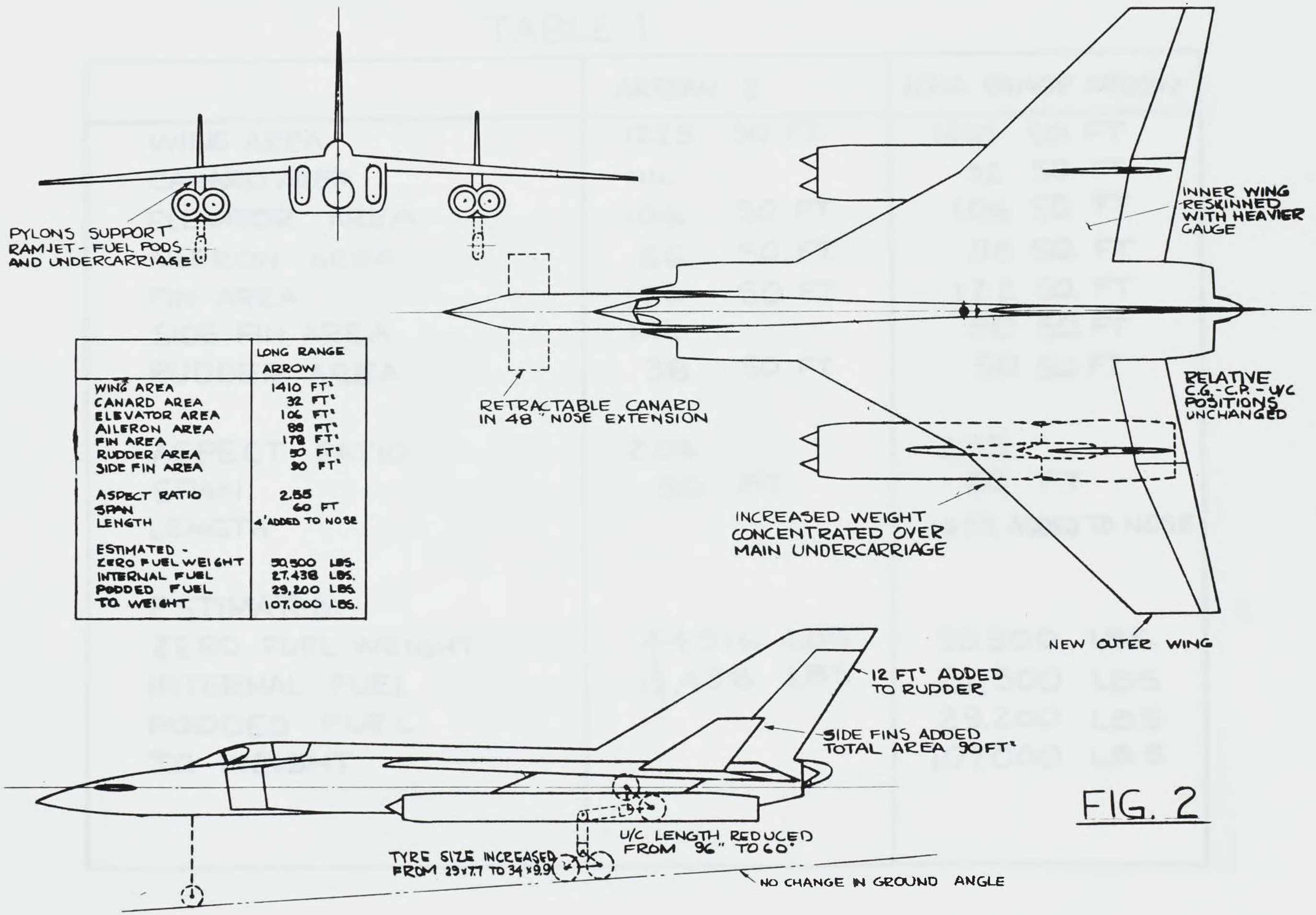
It is intended that the canard be used as an additional trim control at supersonic speeds only. At subsonic speeds it would be retracted into the 4 ft. nose extension. The aircraft controls in all other respects could function essentially the same. It is felt that the additional canard air loads induced into the fuselage can be adequately catered for by increasing the skin thickness.

(2) WING AREA

The increased wing area may be obtained by utilizing an entirely new outer wing of a lesser sweepback angle. The resulting increased tip chord (from 52.085 to 102 in.) also provides for a much stiffer wing. It is however anticipated that some re-vamping of the aileron and aileron control may be necessary.

(3) The addition of 10 ft. to the existing span increases the aspect ratio from 2.04 to 2.55 thereby resulting in a substantial reduction in induced drag.

LONG RANGE ARROW PROPOSAL



	LONG RANGE ARROW
WING AREA	1410 FT²
CANARD AREA	32 FT²
ELEVATOR AREA	106 FT²
AILERON AREA	88 FT²
FIN AREA	178 FT²
RUDDER AREA	50 FT²
SIDE FIN AREA	90 FT²
ASPECT RATIO	2.55
SPAN	60 FT
LENGTH	4' ADDED TO NOSE
ESTIMATED -	
ZERO FUEL WEIGHT	50,500 LBS.
INTERNAL FUEL	27,438 LBS.
PODDED FUEL	29,200 LBS.
T.O. WEIGHT	107,000 LBS.

FIG. 2

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LONG RANGE AVRO ARROW PROPOSAL

TABLE 1

	ARROW 2	LONG RANGE ARROW
WING AREA	1225 SQ FT.	1410 SQ. FT
CANARD AREA	NIL	32 SQ. FT
ELEVATOR AREA	106 SQ. FT.	106 SQ. FT
AILERON AREA	66 SQ. FT.	88 SQ. FT
FIN AREA	170 SQ. FT	172 SQ. FT
SIDE FIN AREA	NIL	90 SQ. FT
RUDDER AREA	38 SQ. FT.	50 SQ. FT
ASPECT RATIO	2.04	2.55
SPAN	50 FT.	60 FT
LENGTH		4 FT. ADDED TO NOSE
ESTIMATED:-		
ZERO FUEL WEIGHT	44,516 LBS.	50,500 LBS.
INTERNAL FUEL	19,438 LBS	27,500 LBS
PODDED FUEL		29,200 LBS
T.O. WEIGHT		107,000 LBS

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LONG RANGE AVRO ARROW

PRELIMINARY PERFORMANCE ESTIMATES

TABLE 2

1. ASSUMPTIONS $\Sigma C_{D_0} = C_{D_0\,ARROW} + \Delta C_{D_0\,PODS} = .023 + .00338$

2. CLIMB DATA

ALTITUDE	WEIGHT	M_c	R/C FT/MIN	POWER	ΔX_N - LB
41,000	78,520	1.5	20,000	TJ+AB+RJ	17,450
50,000	77,650	1.5	10,000	"	8,770
60,000	79,650	1.5	7,300	"	6,670
41,000	80,000	2.5	130,500	"	70,400
50,000	79,000	2.5	105,300	"	56,400
60,000	79,000	2.5	42,500	"	22,800
70,000	79,000	2.5	27,300	"	14,600
80,000	79,000	2.5	6,400	"	3,430

3. CRUISE DATA

ALTITUDE	WEIGHT	M	G	NOTE
70,000	79,000	2.5	1	
70,000	70,000	2.5	1.5	SUSTAINED
80,000	80,000	2.5	1	
80,000	70,000	3.0	1.5	SUSTAINED
90,000	60,000	3.0	1	

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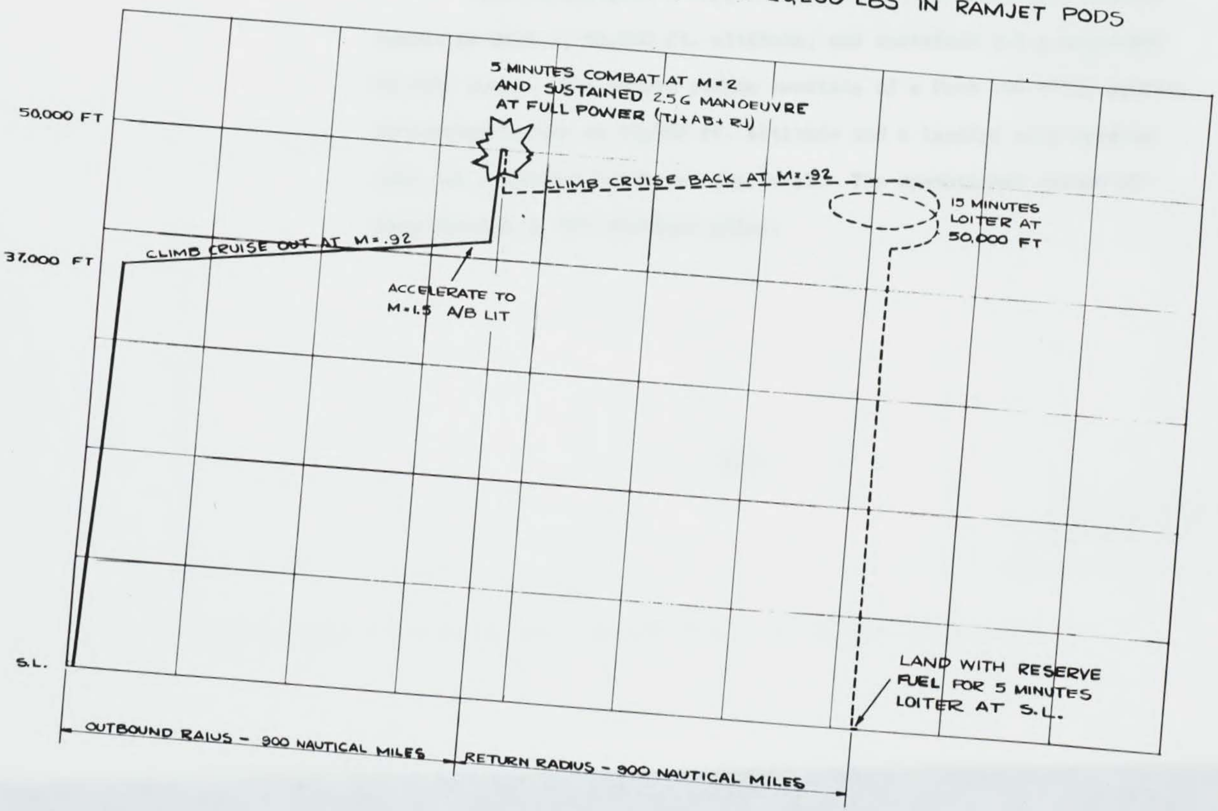
LONG RANGE ARROW MISSION #1

SUBSONIC CRUISE OUT

INTERNAL FUEL 25,400 LBS, PLUS 29,200 LBS IN RAMJET PODS



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MISSION NO. 1 - LONG RANGE INTERCEPTION

This constitutes a subsonic cruise-out followed by 5 minutes combat at Mach 2, 50,000 ft. altitude, and sustained 2.5 g manoeuvre at full power. The return radius consists of a Mach .92 climb cruise, 15 minutes loiter at 50,000 ft. altitude and a landing with reserve fuel for 5 minutes loiter at sea level. The operational radius of this mission is 900 nautical miles.

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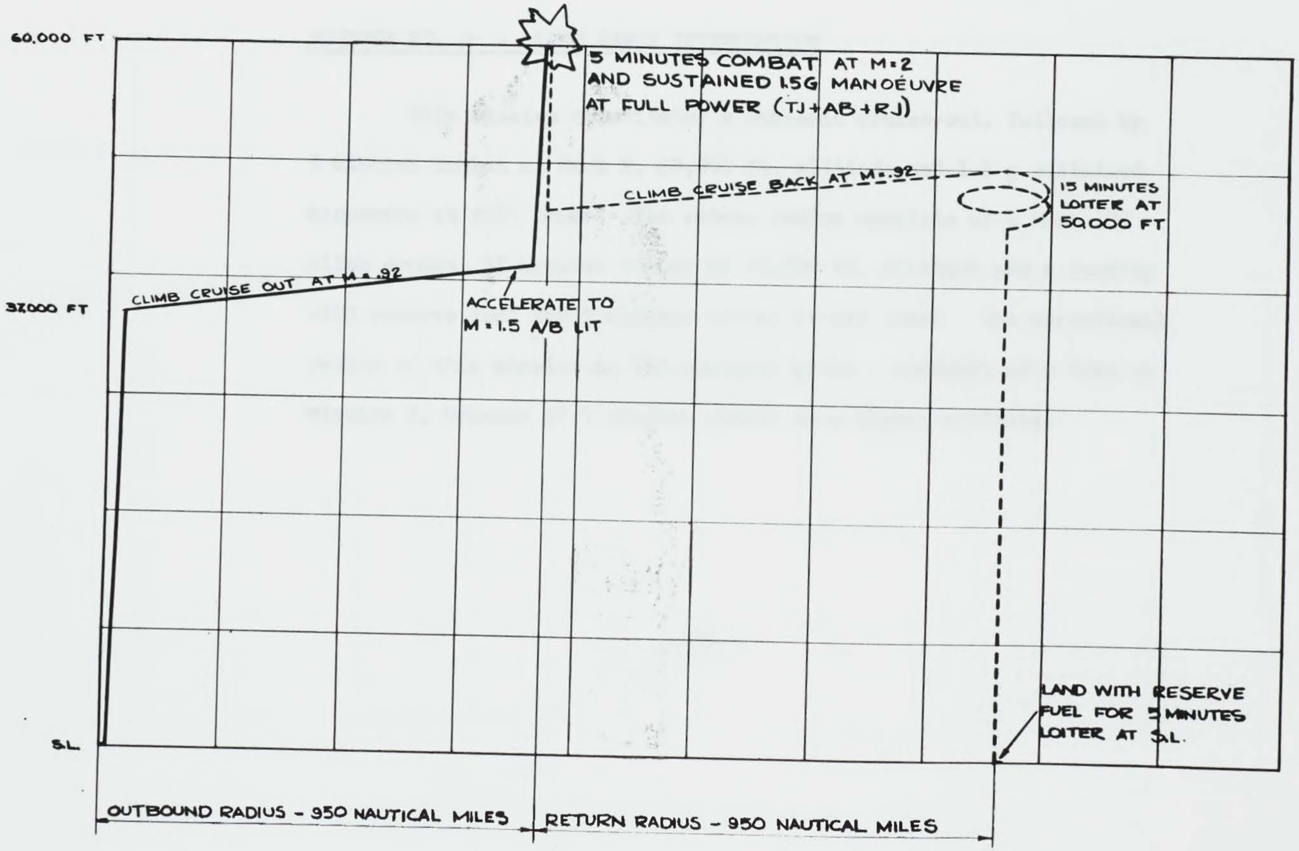
LONG RANGE ARROW MISSION #2

SUBSONIC CRUISE OUT

INTERNAL FUEL 25,400 LBS, PLUS 29,200 LBS IN RAMJET PODS



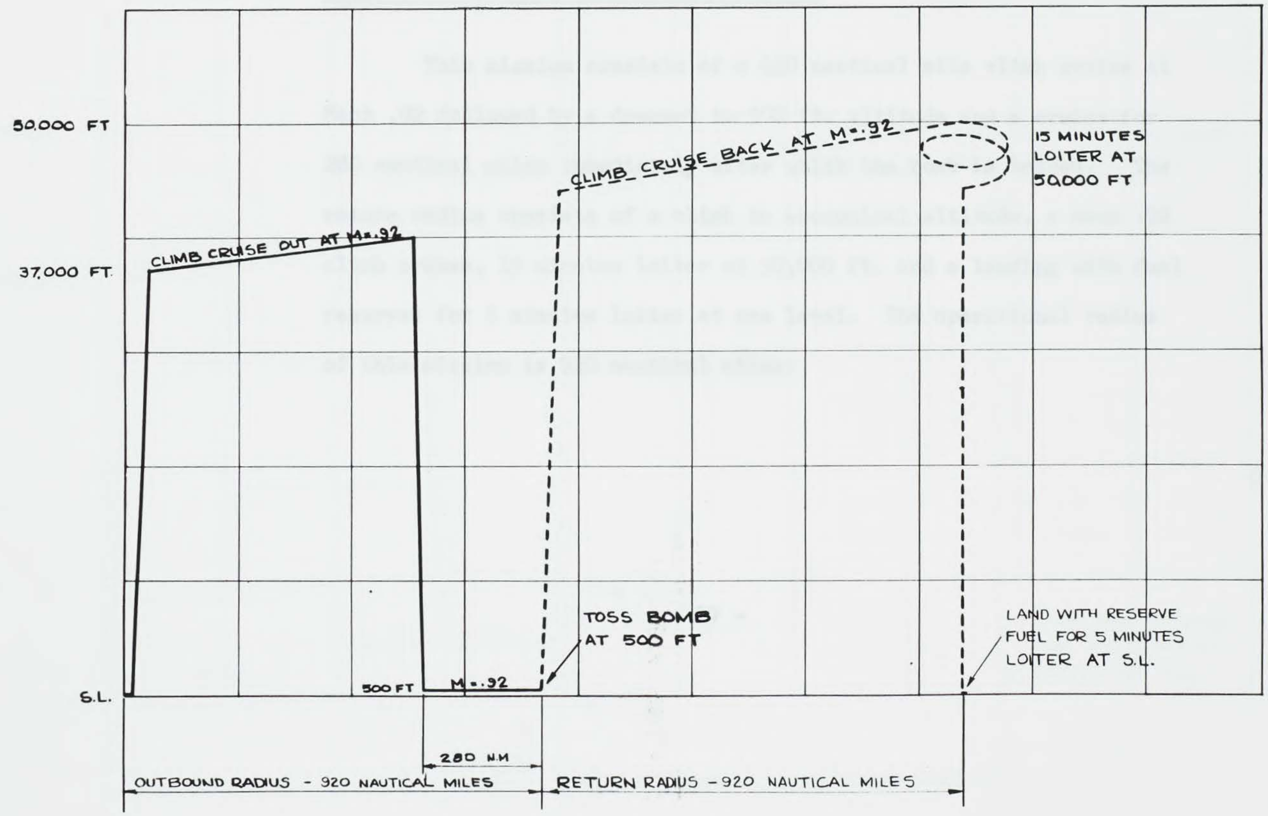
MISSION NO. 2 - LONG RANGE INTERCEPTION

This mission constitutes a subsonic cruise-out, followed by 5 minutes combat at Mach 2, 60,000 ft. altitude and 1.5 g sustained manoeuvre at full power. The return radius consists of a Mach .92 climb cruise, 15 minutes loiter at 50,000 ft. altitude and a landing with reserve fuel for 5 minutes loiter at sea level. The operational radius of this mission is 950 nautical miles - somewhat more than on Mission 1, because of 5 minutes combat at a higher altitude.

LONG RANGE ARROW MISSION #3

SUBSONIC CRUISE OUT

INTERNAL FUEL 25,400 LBS, PLUS 29,200 LBS IN RAMJET PODS



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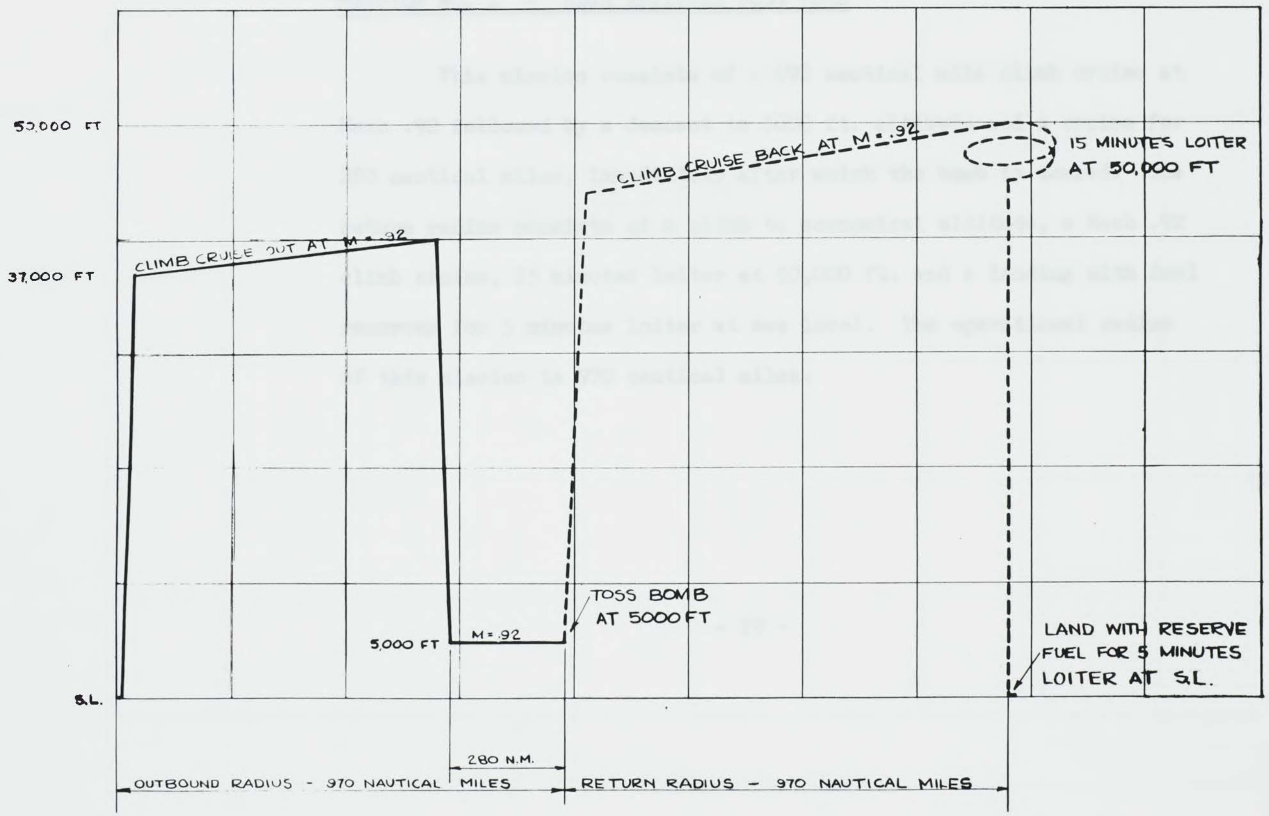
LONG RANGE ARROW MISSION # 4

SUBSONIC CRUISE OUT

INTERNAL FUEL 25,400 LBS, PLUS 29,200 LBS IN RAMJET PODS



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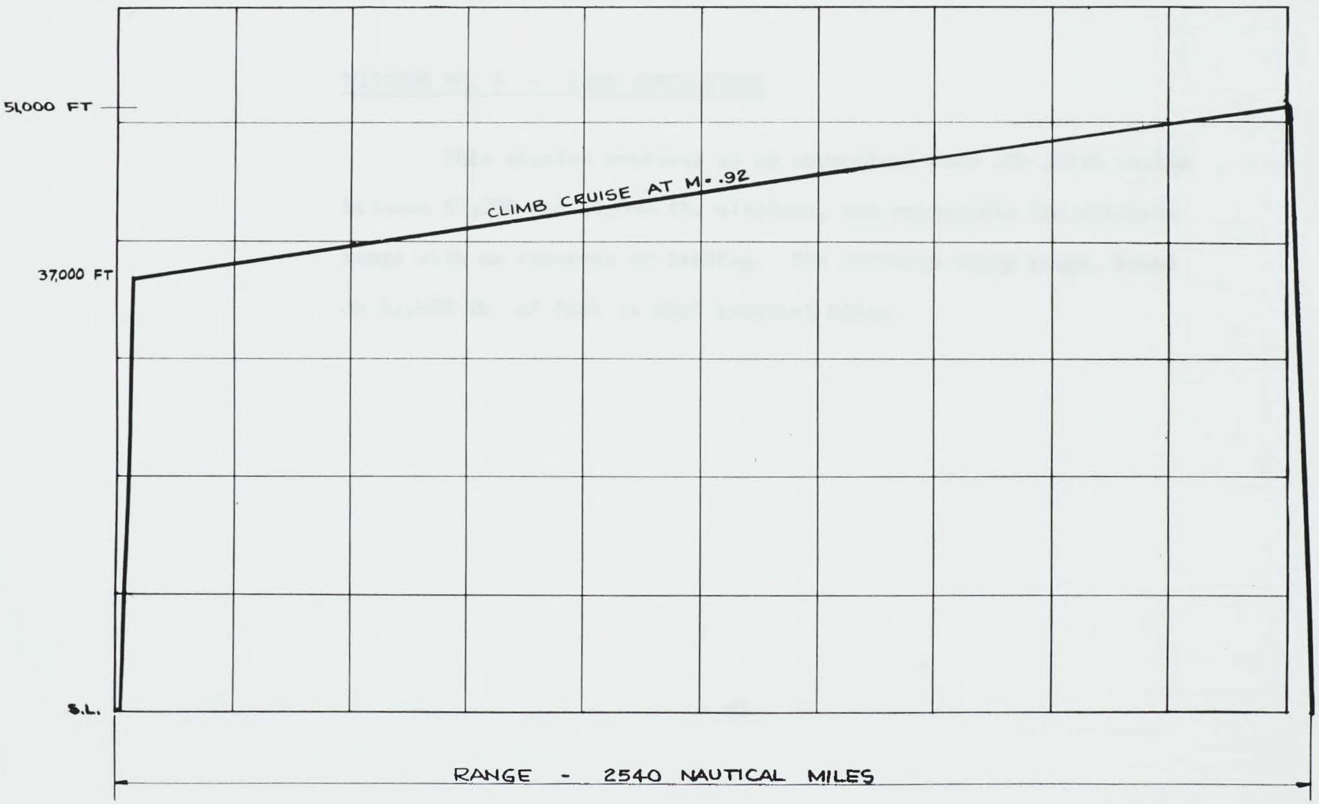
MISSION NO. 4 - HIGH ALTITUDE TOSS BOMB

This mission consists of a 690 nautical mile climb cruise at Mach .92 followed by a descent to 5000 ft. altitude and a cruise for 280 nautical miles, immediately after which the bomb is tossed. The return radius consists of a climb to economical altitude, a Mach .92 climb cruise, 15 minutes loiter at 50,000 ft. and a landing with fuel reserves for 5 minutes loiter at sea level. The operational radius of this mission is 970 nautical miles.

LONG RANGE ARROW MISSION # 5

SUBSONIC CRUISE

INTERNAL FUEL 25,400 LBS, PLUS 29,200 LBS IN RAMJET PODS



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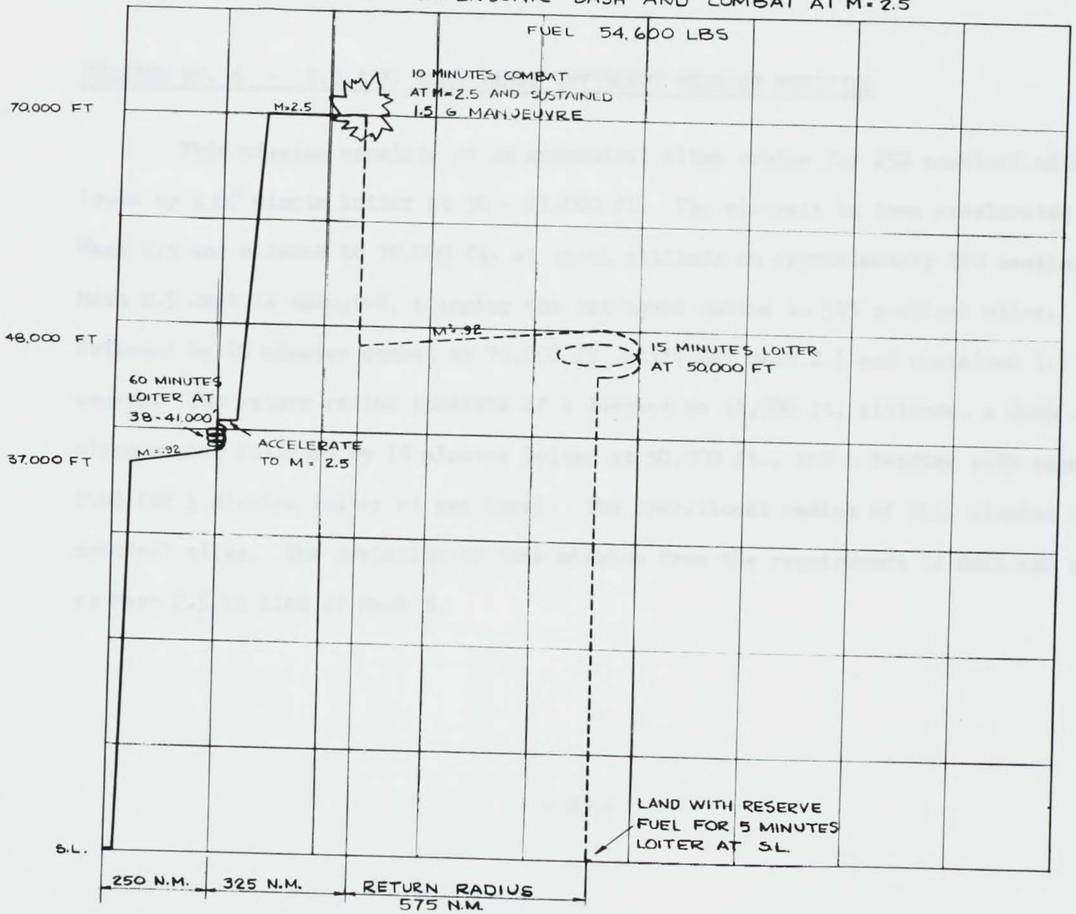
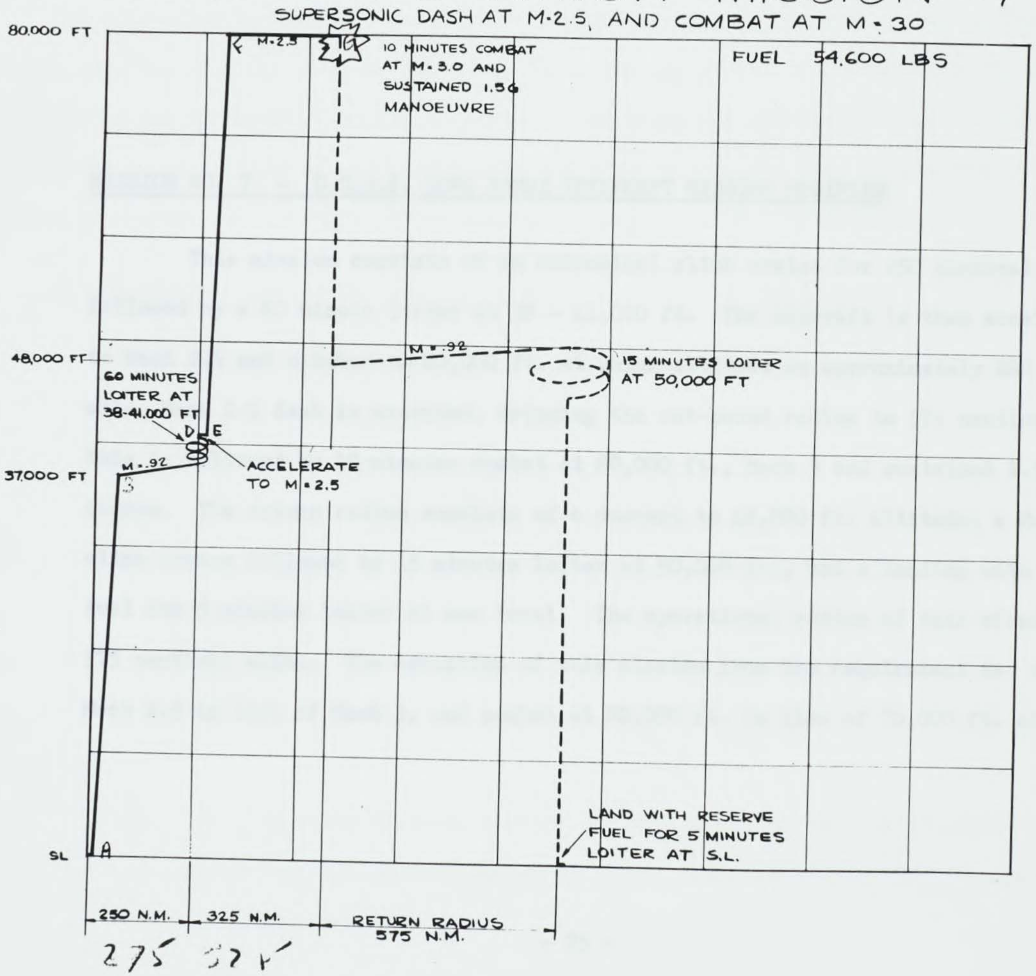
LONG RANGE ARROW MISSION # 6

SUPERSONIC DASH AND COMBAT AT M = 2.5



LONG RANGE ARROW MISSION #7



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SUMMARY

The philosophy behind this proposal is to make every possible use of the engineering that has gone into the Avro Arrow I, II and III. One might argue that the proposal calls for substantial redesign and it would be better to start at the beginning and design a new aeroplane. However, in the consideration of overall economy and time, it is felt that utilization of the present engineering systems and airframe center portions would indeed be worthwhile.

In conclusion, some of the highlights of this study are listed below,

(a) Avro Arrow hardware and systems used with minimum modification commensurate with M = 3 capability.

(b) Most of Mk. III development would be utilized.

(c) Provision for installing mixed fuel operation.

(d) Most of added weight concentrated over redesigned and relocated main undercarriage capable of development for higher T.O. weights.

(e) Jet pods capable of containing much more than 29,200 lb. of fuel.

(f) Area rule application could reduce parasitic drag.

and finally,

(g) The Long Range Arrow is a means of prolonging the life of the Avro Arrow and extracting the maximum amount of return from the current and immediate future Arrow investment.