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APO

ARROW WEAPON SYSTEM
CO-ORDINATING CONTRACTOR
REPORT No. 7
CAPABILITY OF THE ARROW WEAPON SYSTEM

AVRO AIRCRAFT LIMITED

APPENDIX B

CAPABILITIES OF THE MARK 1A SYSTEM

September 17, 1958

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Electronic Projects

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ASTRA System Integration

CAPABILITIES OF THE MARK 1A SYSTEM

The MK 1A System was described in the Arrow Weapon System Coordinating Contractor Reports 1 and 3, and was termed the "Minimum Astra System."

The basic subsystems of the Mk 1A System are:

1. Aircraft Instruments (Attitude Indicator and Mach Meter)
2. Navigation [Dead-Reckoning Computer, Low and Medium Frequency Automatic Direction Finder (ARN-6) UHF Automatic Direction Finder (ARA25)] .
3. AI Radar (Antenna, Transmitter, Receiver, Synchronizer, Power Supplies, Search Computer and Programmer, AMTI Signal Processor, Range and Angle Track).
4. Fire Control Computer and Sparrow II Missile Auxiliaries.
5. Automatic Flight Control (Hold Modes).
6. Air Data Computer
7. Vertical and Heading Reference [Vertical Gyro (GG48), Directional Gyro (LDG-1), Flux Valve, and 3-axis Repeater]
8. Identification [Ground-to-Air Transponder (APX 25A)]
9. Communications [UHF Command Set (ARC 552), Intercomm (AIC 10 A)]
10. Ground Support Equipment

The MK 1B System, or "Full System" differs from the MK 1A by the addition of the following:

1. Doppler Navigational Radar
2. Data Link Receiver and Coupler
3. Infra Red Seeker
4. Air-to-Air IFF Interrogator
5. Air-to-Air IFF Transponder
6. AFCS Integrated Coupler
7. Increased Power Magnetron

The following modes are not available in the MK 1A due to the lack of a portion of the equipment required for the mode.

1. Beacon Reception (Since the a-a IFF interrogator receiver is used in this function)
2. Quasi-Passive Ranging (Since this mode depends on IR for angle tracking)

The capability of the MK 1A System is different from MK 1B in the following basic areas due to lack of equipment, data, or flight evaluation time:

1. Manual insertion of GCI data, rather than automatic.
2. Manual control of the aircraft, rather than automatic.
3. Decreased detection range by 10 per cent.
4. Manual insertion of meteorological wind data, rather than automatic doppler radar inputs.
5. IR and QPR ECM capabilities.

6. Air-to-Air Identification.

7. Genie capability.

The following presentation is intended to show the overall capability and accuracy of the MK 1A System by function and mode.

1.0 Aircraft Instruments (ASTRA Only)

1.1 Aircraft attitude is presented on a moving horizon type display of aircraft elevation and roll angles from 0 to 360° to an accuracy of 1.7°. Elevation trim is adjustable from 20 degrees dive to 10 degrees climb.

1.2 The mach indicator displays aircraft mach and limit mach. Aircraft mach is displayed from M 0.65 to 2.2 accurate to M 0.028.

2.0 Navigation to Intercept and Return-to-Base

2.1 Broadcast Control

2.1.1 The navigation subsystem provides the following displays and manual entry equipment.

a. Pilot and Observer Destination Indicators:

PDI

Mode of Operation	Interceptor Heading Card	Bearing Pointer	Command Bug	Distance Counter
Broadcast Control	Magnetic Heading	Relative Target Bearing	Heading Error when read against Lubber Line	Distance to Target
Close Control	Magnetic Heading	Relative Target Bearing	Heading Error	Distance to Target
Return to Base	Magnetic Heading	Relative Error	Heading Error	Distance to Base

2. 1. 1 (a) Cont'd. PDI (Cont'd)

Function Selector Switch in ADF Position				
Mode of Operation	Interceptor Heading Card	Bearing Pointer	Command Bug	Distance Counter
ADF	Magnetic Heading	Relative Bearing of Radio Station	Heading Error	Flag Covers Distance Counter

ODI

All of the signal inputs to the ODI are the same as those listed in the previous table except that grid heading is shown rather than magnetic, and for the Set Indicator position which follows:

Mode of Operation	Aircraft Heading Card	Bearing Pointer	Command Bug	Distance Counter
All Modes	Aircraft Grid	Relative Bearing of Fix Point	Same as PDI	Distance to Fix Point

b. Target Data Display -- Target data is presented in rho-theta coordinates on two dial and counter type displays. The following information may be manually inserted:

Function	Range	Increments	Type of Display	Relative to:
Target Range	0 - 999 N. miles	1 mile	Counter	Interceptor or GCI
Target Bearing	0 - 360 degrees	2 degrees	Dial	Interceptor or GCI
Target Speed	0 - 1,500 knots	1 knot	Counter	Interceptor or Grid

c. Wind Data Display -- Meteorological wind speed (0 - 200 knots) and direction (0 - 360^{o}) is inserted manually.

2.1.1 Cont'd

d. Time-to-go to destination continuously presented.

e. Five Ground Control Interceptor Reference Stations are selectable including "grid zero" for target data entry and display.

f. Five bases are selectable for return-to-base.

g. Command heading to the pilot is held while data is being inserted until "Heading Hold - Off" is selected.

h. Check points received from the LF/MF ADF, UHF ADF, GCI, or ground map are manually inserted.

2.1.2 Check Point Facilities

ARN-6	--	LF/MF ADF
ARA-25	--	UHF ADF
ARC-552	--	Communications Set (GCI fix)
Ground Map	--	AI Radar

2.2 Close Control

The same dead-reckoning facilities are available with the pilot receiving steering instructions directly by voice from GCI.

2.3 Performance

For the standard high speed mission profile the expected error in computed position and heading is 2 miles (1σ) and 0.75 degrees (1σ) at AI radar acquisition and 5 miles (1σ) after return-to-base exclusive of wind errors, with no check point insertion.

3.0 Fire Control

3.1 Detection

3.1.1 Clear Environment

The probability of detection for a 5 m^2 target closing at M 4 is 80% at a range of 29 nm. The basic parameters of the MK 1A System pertinent to the detection range are:

Pulse Width	2.35 μ s
Pulse Repetition Frequency	330 cps ±0.8% FM
Transmitter Power	750 KW ±0.4 db
Transmit Insertion Loss	0.8 db
IFF Injection Loss	0 db
Antenna Gain (9,400 mc)	34 db
Beamwidth (9,400 mc)	2.9^{o}
Side Lobes	-22 db
Polarization	Horizontal, Vertical, Left and Right Circular
Overall Receiver Noise Figure	9.5 db
IF Bandwidth	1.5 mc
Minimum Discernible Signal	-103 dbm
Assumed Field Degradation	7 db
Range Scales	200 nm, (ground map and beacon, 80, 40, 16 nm AI search, 8,000 yd. VIP
Indicator Resolution	300 lines

The 16 nm and 8,000 yard ranges are operated with the radar in the short pulse mode (0.5 μ sec., 1 KC PRF).

3.1.1 Cont'd.

The operating point of the transmitter is magnetically regulated for optimum performance.

Scan Pattern:

Central axis controlled by navigation computer output with manual trimming or full manual control.	Narrow -- 40^{o} x 13.5^{o} 3 Bar Palmer with center bar retraced. Wide -- 140^{o} x 13.5^{o} 3 Bar Palmer with center bar retraced. Searchlight - 5^{o} conical scan

Scan Pattern Stabilization:

$\pm 2^{o}$ for all aircraft attitude within antenna gimbal limits.

Antenna Gimbal Limits:

$+75^{o}$, -50^{o} elevation, $\pm 75^{o}$ azimuth

Look Angle Limits:

(Excluding Beamwidth)

With respect to A/C Datum Line.

$+70^{o}$, -45^{o} elevation, $\pm 70^{o}$ azimuth

GCI Target Designator:

Circle presented on B scan at predicted azimuth and range.

3.1.2 AMTI Performance

The parameters of the radar are the same as 3.1.1 with the exception of the following:

Pulse Width	0.5 μ sec.
Pulse Repetition Frequency	4,000 cps

3.1.2 Cont'd

Transmitter Frequency	9,200 mc/sec.
Transmitter Power	375 KW ±0.4 db
IF Bandwidth	4.0 mc
Range Scale	16 nm

Double delay line cancellation is used. Cancellation of ground clutter is 30 db along the ground track.

3.1.3 Detection of Barrage Jammer

A 2 watt per megacycle barrage jammer may be detected at a range of 200 nm. The criterion for detection is a 6db jamming signal to noise ratio.

3.1.4 Display

The B scan display provides 4.5" x 4.2" effective area with the GCI target designator, elevation marker, and local target designator superimposed.

3.1.5 Counter-countermeasures Capability for Search

a. Magnetron tuning at 70 mc/sec.^{2} for avoidance of "friendly" jamming or interference.

b. Random magnetron tuning at rates up to 200 mc/sec.^{2} to avoid spot jamming.

3.2 Local Target Designation and Acquisition

The target designation in range and azimuth is by two dots on the B scope used to bracket the target. The designators are 1 mile apart in range, positioned by the radar hand control, and are heading stabilized.

3.2 Cont'd.

On depressing the acquisition trigger, acquisition is automatic with the antenna slewing to the designated azimuth and the range gate sweeping over the one mile interval designated.

Target reject-in range only overrides the automatic lock-on circuitry to reinitiate range sweeping at the designated range and azimuth.

The radar parameters are the same as during track with a minimum acquisition sensitivity of -92 dbm for a 2,400 knot closing rate.

3.3 Track

3.3.1 Clear Environment

The tracking parameters of the AI Radar are as follows:

Pulse Width	0.5μ sec.
Pulse Repetition Frequency	1,000 cps ±1.5% FM
Transmitter Power	750 KW ±0.4 db
Transmit Insertion Loss	0.8 db
IFF Injection Loss	0 db
Antenna Gain (9,400 mc)	34 db
Beamwidth (9,400 mc)	2.9°
Conical Scan Offset	1.05°
Conical Scan Frequency	66 2/3 cps
Beam Crossover (one way)	-1.5 db
Side Lobes	-22 db
Polarization	Horizontal, Vertical, Right and Left circular

3.3.1 Cont'd.

Overall Receiver Noise Figure	9.5 db
IF Bandwidth	4.0 db
AGC Threshold	-82 dbm
AGC Dynamic Range	110 db
Range Track Limits:	
Range	25 nm max., 150 yds. min.
Range Track Error	$\frac{\ddot{R}}{3/sec^2} + \frac{\dot{R}}{1,000\ sec}$ $\pm \frac{R}{100} \pm 20$ yds.
Angle Track Limits:	
Angle	$+70^{o}$, -45^{o} Elevation $\pm 70^{o}$ Azimuth
Target Angular Rate	0.5 rad./sec.
Angle Track Error	$\frac{\ddot{\theta}}{28/sec.^2} + \frac{\dot{\theta}}{85/sec.}$ ± 1.0 mr +6 mr (Radome & Boresight)
Base Motion Attenuation	$\frac{\ddot{\theta}}{340/sec.^2} + \frac{\dot{\theta}}{340/sec.}$

Pre-gated video and nose tail tracking are both approaches to the chaff and ground clutter problem. Analysis shows that these modes will be effective to within $\pm 15^{o}$ of the beam aspect angle for continuously dispensed chaff and less than 5^{o} for bundles.

Continuous random magnetron tuning is available with a maximum rate of 200 mc/sec.^{2}.

3.3.1 Cont'd.

Antenna polarization selection of right circular, left circular, horizontal and vertical provides 3 to 20 db rejection of jamming power depending on jammer sophistication.

ECM homing is provided as a range-denied tracking mode for barrage or spot jamming.

In the event of completely effective countermeasures, the optical mode provides capability under clear weather conditions in tail attacks.

In the design of the radar many of the parameters chosen increase the effectiveness of the Astra System against jamming. Servo dynamics have been selected to provide both range rate and angular rate memory. The microwave AGC extends the dynamic range of allowable signal levels to +28 dbm.

An aural presentation of the angle track error signal is used to alert the operator to ECM and, with the B scope, provide identification of the type being used.

3.4 Attack

The fire control computer and missile auxiliaries provide steering signals and preparation for the following armament and courses.

3.4 Cont'd

Armament	Environment	Courses
Four Sparrow II, fired in the order of lock-on; in pairs, or all.	Clear	Lead Collision Lead Collision Snap-up Lead Pursuit Optical
	ECM (Range denied)	Home on Jam Fixed-Range Lead Pursuit Collision
	ECM (Completely effective)	Optical

The pilot's attack display is composed of the following elements:

Element	Mode	Range
Steering Dot	All Except Optical	20°/in. to 25° of steering error
Ref. Circle	Lead Collision, Lead Collision, Snap-up,	5° of steering error
	Collision Lead Pursuit, Fixed Range Lead Pursuit	Variable diameter to indicate allowable steering error as a function of altitude. Scale 20°/inch.
Artificial Horizon	All Attacks Except Optical	Roll: 1°/1° Vertical Translation: Corresponds to sine of pitch angle, one inch translation corresponds to 25°.
Range or Time Arc		Range to Rmin. and Rmax. minus Rmin. 222 yds./deg.

3.4 Cont'd

The system provides data readout for a non-firing visual identification pass.

Azimuth and elevation angles are read from the observer's scope; range and range rate are read from a meter located beside the scope.

4.0 Communication and Identification

Air-to-air and air-to-ground communications are provided by the ARC-552 command set. Intercomm facilities are provided by the AIC 10 A.

The ground-to-air IFF transponder is the APX 25A.

5.0 Automatic Flight Control

The AFCS provides the following pilot assist modes:

Mode	Range	Accuracy
Mach Hold	0.2 to 0.98 and 1.06 to 2.2 M	±.0015 M
Altitude Hold	-1,000 ft. to 65,000 ft. (pressure alt.)	±25 ft.
Pitch Attitude	±60°	±0.5°
Heading Hold	0 - 360°	±0.5°
Bank Hold	±60°	±0.5°

6.0 Installation Requirements

6.1 Electric Power Requirements

The power requirements shown are for the MK 1B Astra System and

6.1 Cont'd.

four Sparrow II Missiles. For MB-1 the power consumption is lower. Flight Instrumentation is not included.

6.1.1 Power Consumption

	115V/200V - 400 cps-3Ø	27.5 VDC
Normal with all missiles	KVA	Watts
Normal with all missiles at steady state.	28.0	1,250
Max. generator load at a-c peak (last missile starting).	40.0	1,250
Max. generator load at d-c peak (first missile starting).	26.5	1,950
Emergency	1.0	200
Emergency during UHF channel change (3 sec.)	1.0	325
Maximum transient (Missile start)	12.0	700
Power Factor	0.75 to 1.0	
6.1.2 Tolerance		
Steady State voltage	±1.5%	±1.0 volt
Voltage Transient	±8%	±5.0 volts
Voltage Transient Recovery Time Constant	0.2 sec.	0.2 sec.
Harmonic Content	2%	
Steady State Frequency	±1%	
Frequency Transient	±1.5%	
Frequency transient recovery time constant	0.5 sec.	
Min. Frequency for load connected	380 cps	
Ripple		1.0 V p - p
Min. voltage (emergency)		20.0 V

6.2 Air-Conditioning Requirements

87#/min. at 70°F. -- This does not include the cooling air requirements of the missiles.

6.3 Hydraulic Power Requirements

3.5 gallons per minutes at 4,000 psi.

6.4 Pressurization Requirements

126 cubic inches/min. (STP) supplied at 14 to 74 psia.

6.5 Total Weight

The following figures are for a MK 1B System, the MK 1A is somewhat lighter.

Electronic System	--	2,220 pounds
Racks and Cabling	--	440 pounds
TOTAL	--	2,640 pounds

6.6 Reliability

90% probability of remaining operational standard missions of 80 to 130 minute duration.

6.7 Availability

18 missions during a 30 day period. Six 30 minute periods of "Standby", with three operational missions per 24 hour period.

6.8 Standards

RCA ASTRA I Standards Handbook.

6.9 Environmental Conditions

RCA ASTRA I Environmental Specification.

6.10 Sensor Requirements

6.10.1 Indicated Temperature

6.10.2 Pitot - Static Pressures

6.10.3 Angle of Attack

6.11 Radome Requirements

RCA Drawing #8940240-A Type B

7.0 Ground Support

The maintenance concept is based on semi-automatic flight line test sets to minimize aircraft down time and in-aircraft repairs, complemented by second-line test, alignment, and repair consoles in the maintenance shops.

The semi-automatic fire control test set generates a target return which is detected and tracked utilizing 85% of the fire control system, checking the system for miss resulting from alignment errors or failures.

The navigation system is also checked by the insertion of a typical problem which in this case is done by the manual data entry controls.

The communication system is checked by means of a test set which operates through the ARC 552, AIC 10A, and ARA 25.

The AFCS, Air Data Computer, Attitude Indicator, and Mach Indicator are checked by the flight control semi-automatic test set.

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ARROW WEAPON SYSTEM

CO-ORDINATING CONTRACTOR

REPORT NO. 7

22 SEPTEMBER 1958

CAPABILITY OF THE ARROW WEAPON SYSTEM

ISSUED: W. R. Stephens
Arrow Weapon System
Co-Ordinator

APPROVED: J. C. Morley
Vice-President
Sales and Service

AVRO AIRCRAFT LIMITED

AVRO AIRCRAFT

CAPABILITY OF THE ARROW WEAPON SYSTEM

Paragraph 21(c) of the minutes of the Second Programming Committee Meeting required the Co-ordinating Contrator, in conjunction with the Associate Contractors, to define the complete capability of the minimum weapon system possible by January 1961.

The method of satisfying this requirement was discussed with W/C Londeau of AAWS during a meeting at Malton on 18 July 1958. It was decided that the requirement should be met by a report comprising a section on Arrow performance and a section on Astra capability.

Appendix A deals with performance of the Arrow aircraft and is identical to Avro Aircraft Performance Report #14. The performance quoted is applicable to both the 1961 and the 1962 weapon system capability.

Appendix B, which was prepared by RCA, Camden, deals with the capability of the Astra 1A system. Capability of the Astra 1B system is covered by inference.

AVRO AIRCRAFT LIMITED

MALTON – ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

APPENDIX 'A'

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SECRET

AIRCRAFT: ARROW 2

REPORT NO: Periodic Performance Report 14

FILE NO: 72/PERF/26

NO. OF SHEETS 25

TITLE: PERFORMANCE OF THE ARROW 2

PREPARED BY Performance Group RGB DATE August 1958

RECOMMENDED FOR APPROVAL [signature] DATE Aug/58

APPROVED [signature] DATE Aug/58.

APPROVED FOR RELEASE [signature] DATE Aug/58

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ARROW PERIODIC PERFORMANCE REPORT 14

PERFORMANCE OF THE ARROW 2

(C.G. at 29.5% MAC)

SUMMARY

The performance data given in this report are based on the drag and engine data given in Periodic Performance Reports 12 and 13. They represent the best estimate of the ultimate performance of the Arrow 2 as at present evisaged, with nominal engine performance of the Iroquois assumed as in EMS 8 Issue 2.

The operational weight empty used in this report is 557 lb. lighter than the figure quoted in the August 1 weight report No. 7-0400-34 Issue 22. The principal reason for this difference is that, in this performance report, no allowance has been made for the increase in engine weight included in the current weight report.

The main differences between this report and Periodic Performance Report No. 12 are:-

1. Revised mission profiles and combat weight definition.
2. The inclusion of a Thermodynamic envelope.
3. The inclusion of Flight envelope limitation curves.
4. The inclusion of acceleration performance.
5. An increase in operational weight empty of 1,489 lb.
6. Revised input data - based on flight test - for take-off and landing distances.

The loading and performance data and flight envelopes are given in Figs. 1 to 9(b) and in Tables 1 to 8 inclusive.

The Thermodynamic envelope is based on a recovery factor of 0.90. The Flight envelope limitations are based on strength and control considerations only, and do not necessarily represent the steady performance capabilities of the aircraft.

It should be noted that the mission format is as agreed to at an informal meeting with the R.C.A.F. (S/L Landry, F/L Hall) but has not yet been formally approved. In the ferry mission, no consideration has been given to tail plugs, or to fuel in the weapon pack, since neither of these schemes have had formal approval for operational use. However the performance achievable with these schemes will be covered in Addenda.

This report should be considered as a draft for R.C.A.F. approval as to data presentation and mission format. If approved, it is anticipated that this format would comprise the basis for the WSC 1-2 performance requirements, to which subsequent Periodic Performance Reports would be prepared.

TABLE 1 - LOADING AND PERFORMANCE

UNDER ICAO STANDARD ATMOSPHERE CONDITIONS

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

Weight

Operation weight empty		lb.	46,650
Maximum useable internal fuel		lb.	19,443
Gross Take-off weight (max.internal fuel)		lb.	66,093
Combat weight ($\frac{1}{2}$ max.internal fuel weight)		lb.	56,372
Maximum external fuel and tank (500 gallons at 7.8 lb/gall. and drop tank)		lb.	4,242
Maximum gross take-off weight (Combat mission)		lb.	70,335
† Maximum gross take-off weight (Ferry mission)		lb.	68,607
Normal design landing gross weight		lb.	49,783
Maximum landing gross weight (Combat mission)		lb.	66,093
Wing loading at gross take-off weight	lb/sq.ft.		54.0
Power loading at gross take-off weight	lb/lb thrust		1.52

Speed

True airspeed in level flight at combat weight

Sea Level (i) Maximum thrust, A/B lit	kts.	700	*
(ii) Maximum thrust, A/B unlit	kts.	665	
50,000 ft. (i) Maximum thrust, A/B lit	kts.	1,147	*

* Placard Speed

Ceiling

Ceiling at combat weight, rate of climb 500 ft/min. with maximum thrust at optimum Mach number (1.8 M)

A/B lit	ft.	59,500

Rate of Climb

Steady state rate of climb at combat weight

Sea Level (i) Maximum thrust, A/B lit, at c.92 M	ft/min.	42,500
(ii) Maximum thrust, A/B unlit at 527 kts. TAS	ft/min.	19,400
50,000 ft. (i) Maximum Thrust, A/B lit at 1.80 M	ft/min.	9,740

† Maximum gross take-off weight (Combat mission) less 1728 lb. missiles.

Time to Height

Time to reach 50,000 ft. and 1.5 M from engine start at gross take-off weight, maximum thrust A/B lit	min.	5.4

Manoeuvrability

Load factor at combat weight

1) Maximum thrust A/B lit 1.5 M at 50,000 ft.	1.50
2) Maximum thrust A/B lit 1.8 M at 50,000 ft.	1.60

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.	3,850
2) Maximum thrust A/B unlit, standard day	ft.	4,750
3) Maximum thrust A/B lit, hot day	ft.	4,640

Landing Distance

Landing distance over 50 ft. obstacle at sea level at normal design landing gross weight	ft.	4,800

Stalling Speed

True stalling speed in landing configuration at combat weight at sea level	kts.	117

Missions

Combat radius of action, see mission profile for detail breakdown

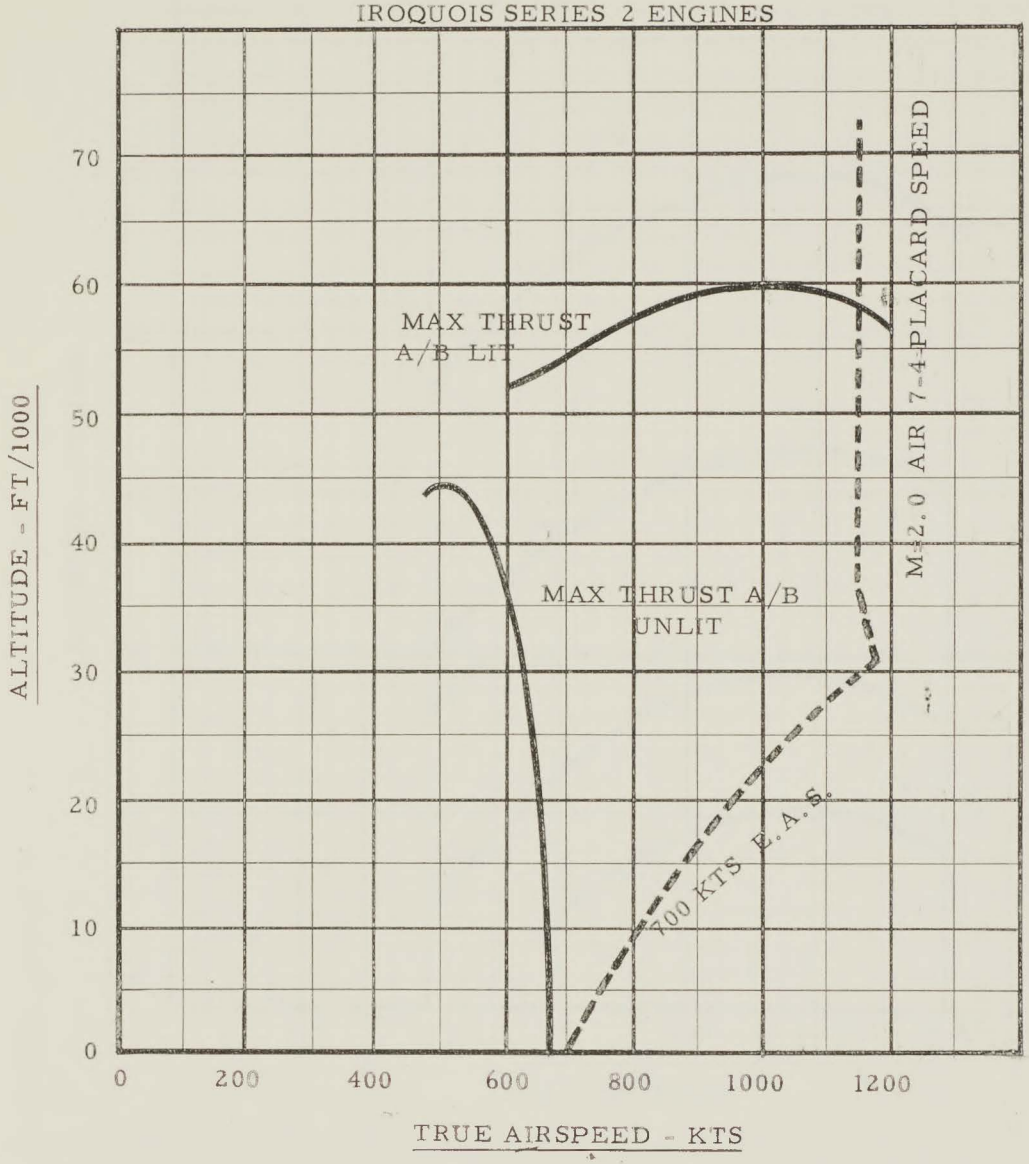
1) Subsonic high altitude mission - subsonic combat	n.m.	442
2) Subsonic high altitude mission - supersonic combat	n.m.	347
3) Supersonic high altitude mission- supersonic combat	n.m.	238
4) Combat air patrol - supersonic combat	n.m.	467
5) Subsonic low level mission (10,000 ft.) - subsonic combat	n.m.	349
6) Ferry Mission (no armament)		
a) ventral tank carried throughout	Range n.m.	1,306
b) ventral tank jettisoned when empty	Range n.m.	1,357

AVRO AIRCRAFT

ARROW 2

MAX LEVEL SPEED AT COMBAT WEIGHT (56,372 LB)

IROQUOIS SERIES 2 ENGINES



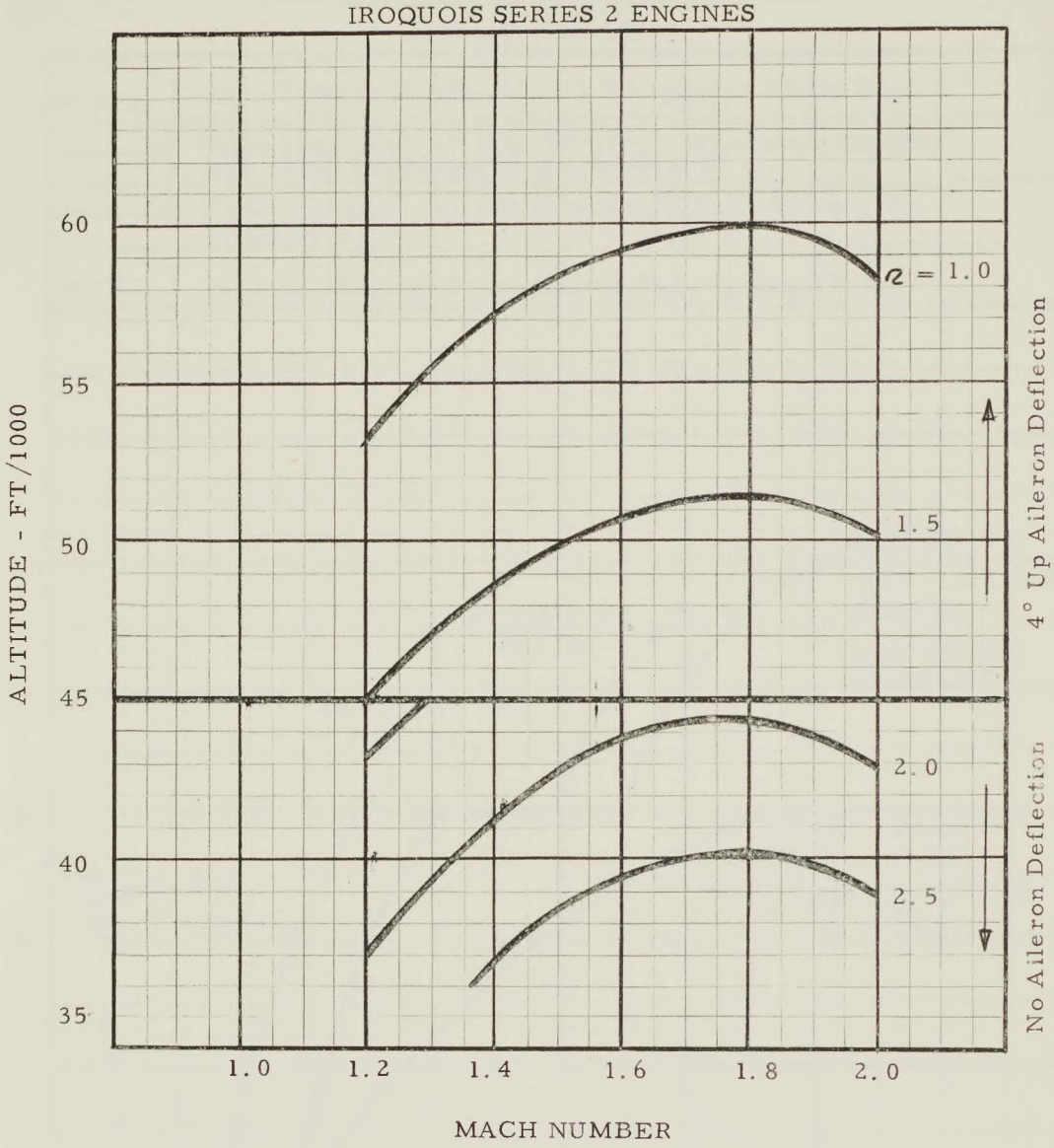
72/PERF/24

FIG. 1

FORM 1749 A-2

COMBAT WEIGHT - 56,372 LB

IROQUOIS SERIES 2 ENGINES



ARROW 2 MANOEUVRABILITY - STEADY G's AVAILABLE

AT COMBAT WEIGHT MAX THRUST A/B LIT

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FIG. 2

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ARROW 2 - IROQUOIS SERIES 2 ENGINES
TIME TO HEIGHT

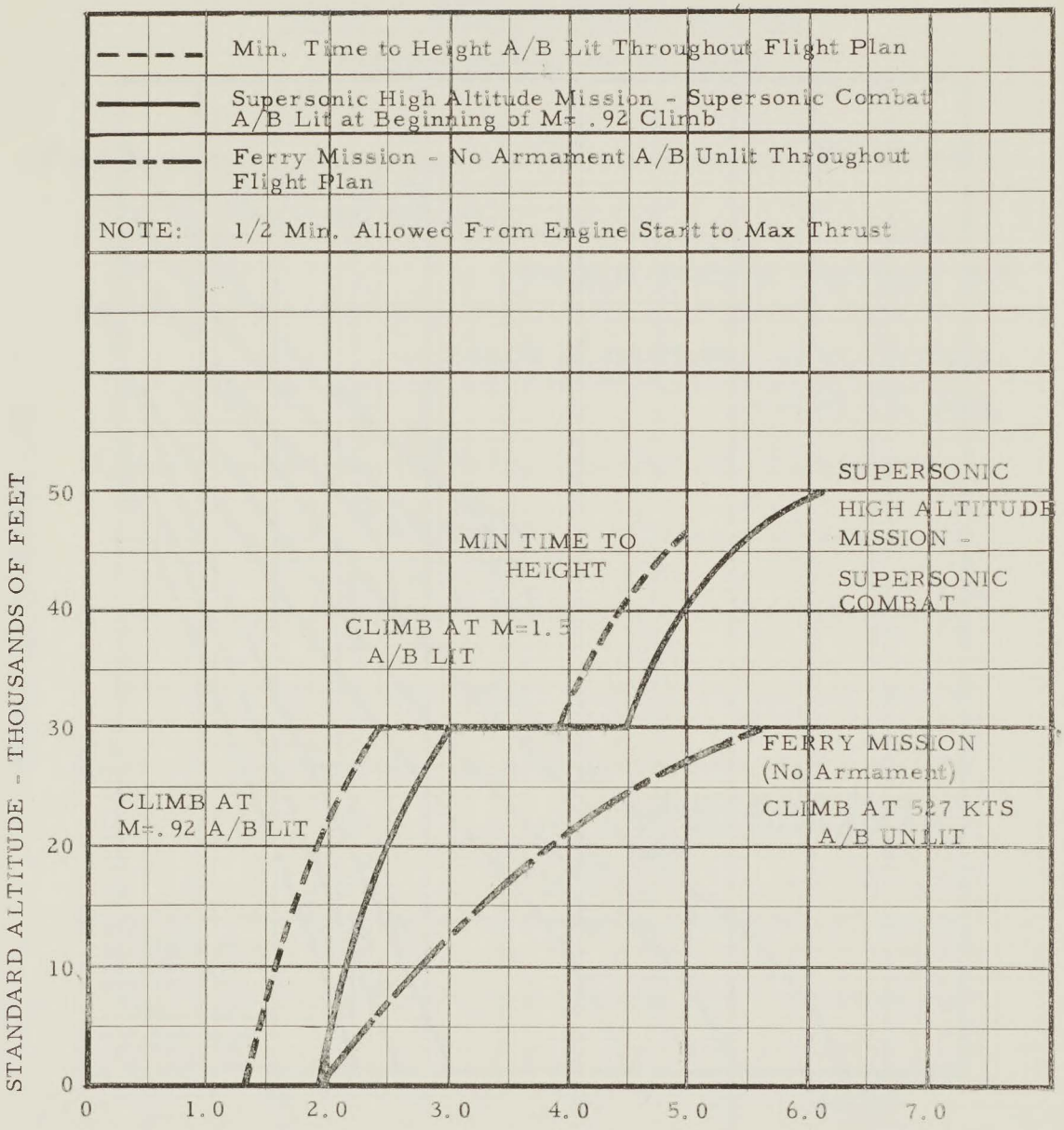

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FIG. 3

FORM 1749 A-2

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ARROW 2 IROQUOIS SERIES 2 ENGINE

STEADY STATE RATE OF CLIMB

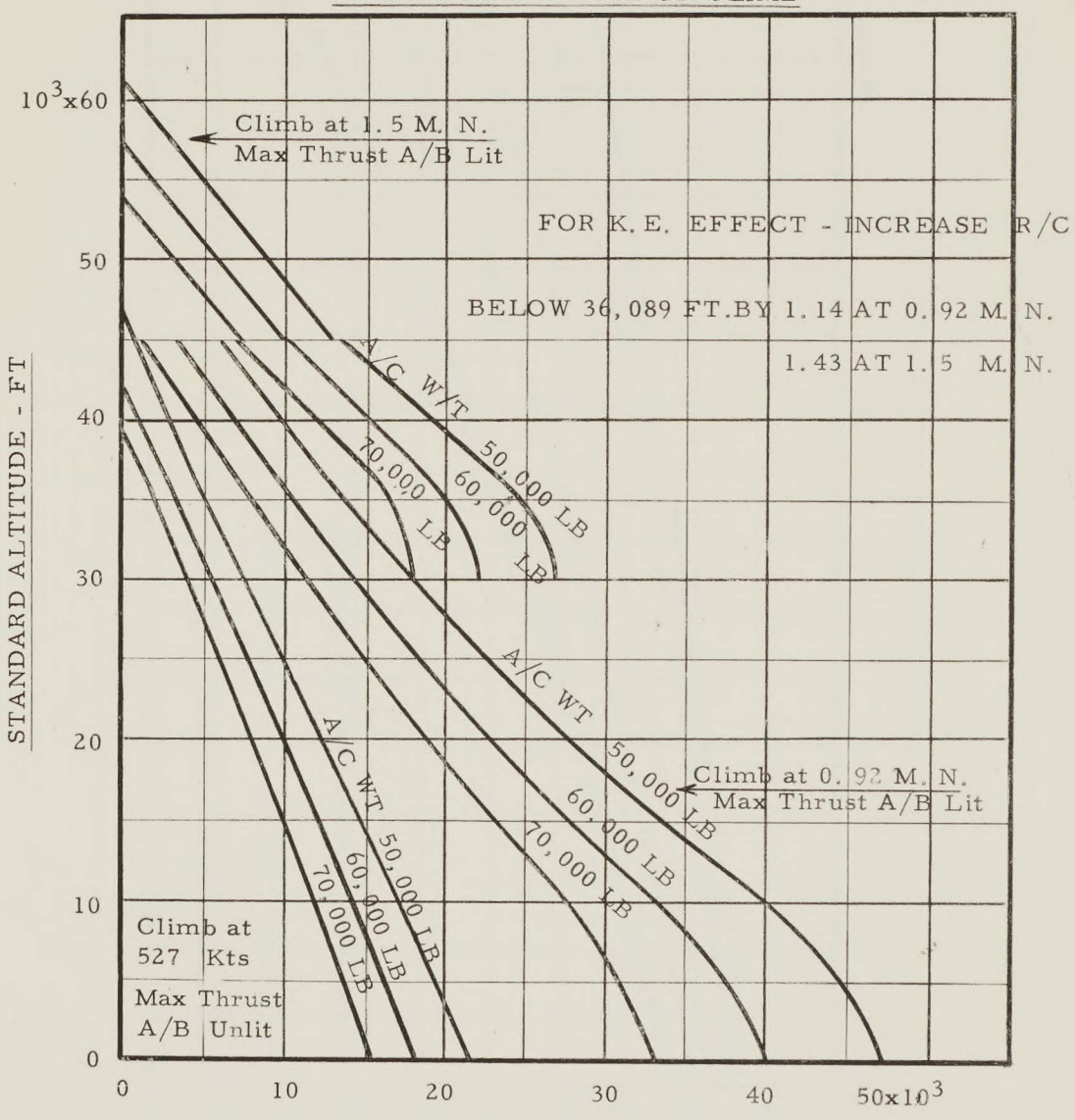

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FIG. 4

FORM 1749 A-2

ARROW 2 IROQUOIS SERIES 2 ENGINE

LANDING DISTANCE AT SEA LEVEL

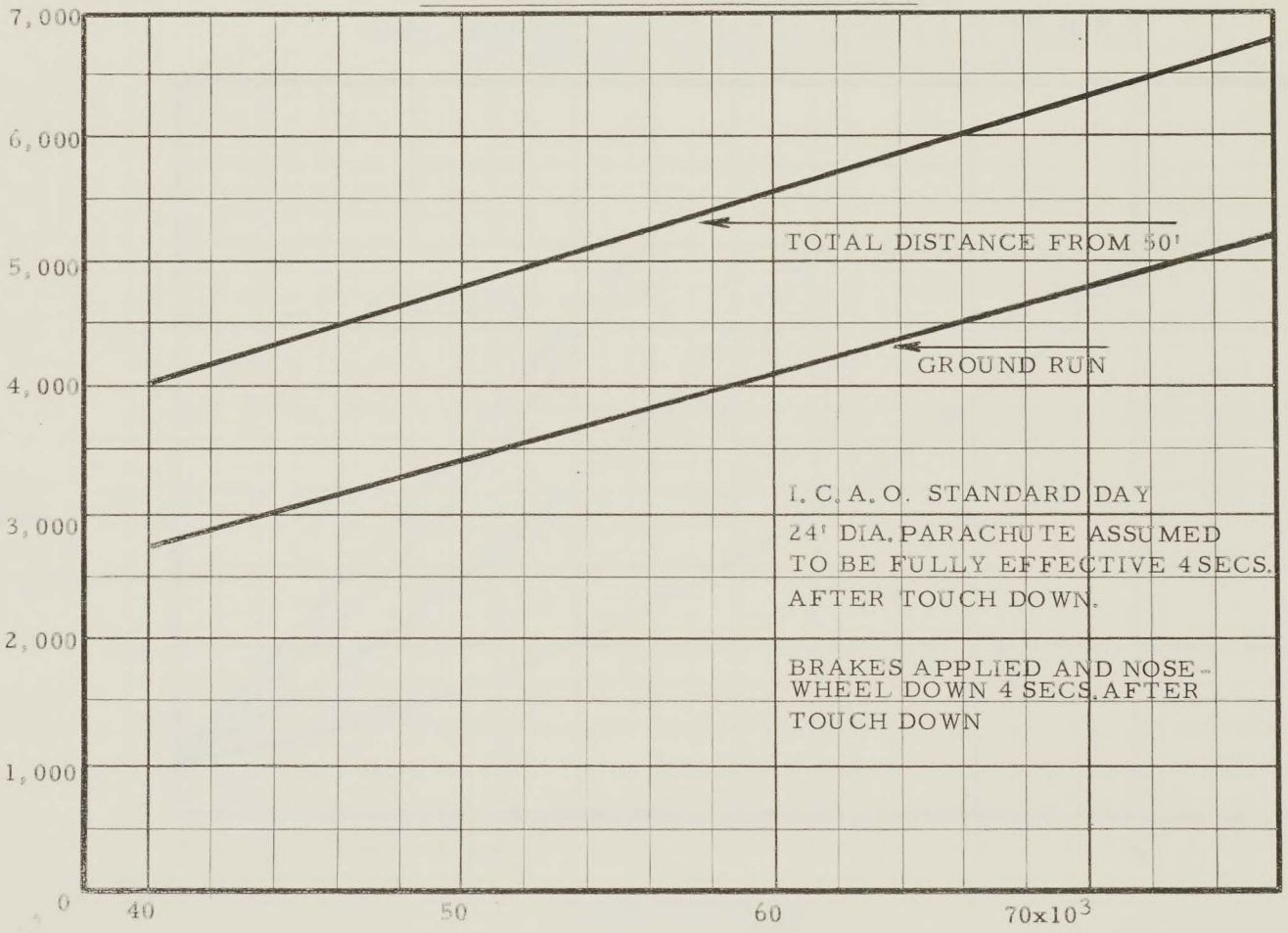

FIG. 6

ARROW 2 IROQUOIS 2 - A/B LIT

DISTANCE TAKEN TO ACCELERATE FROM M=.92 TO M=2.0

A/C WEIGHT=56,372 LB (Combat Weight)

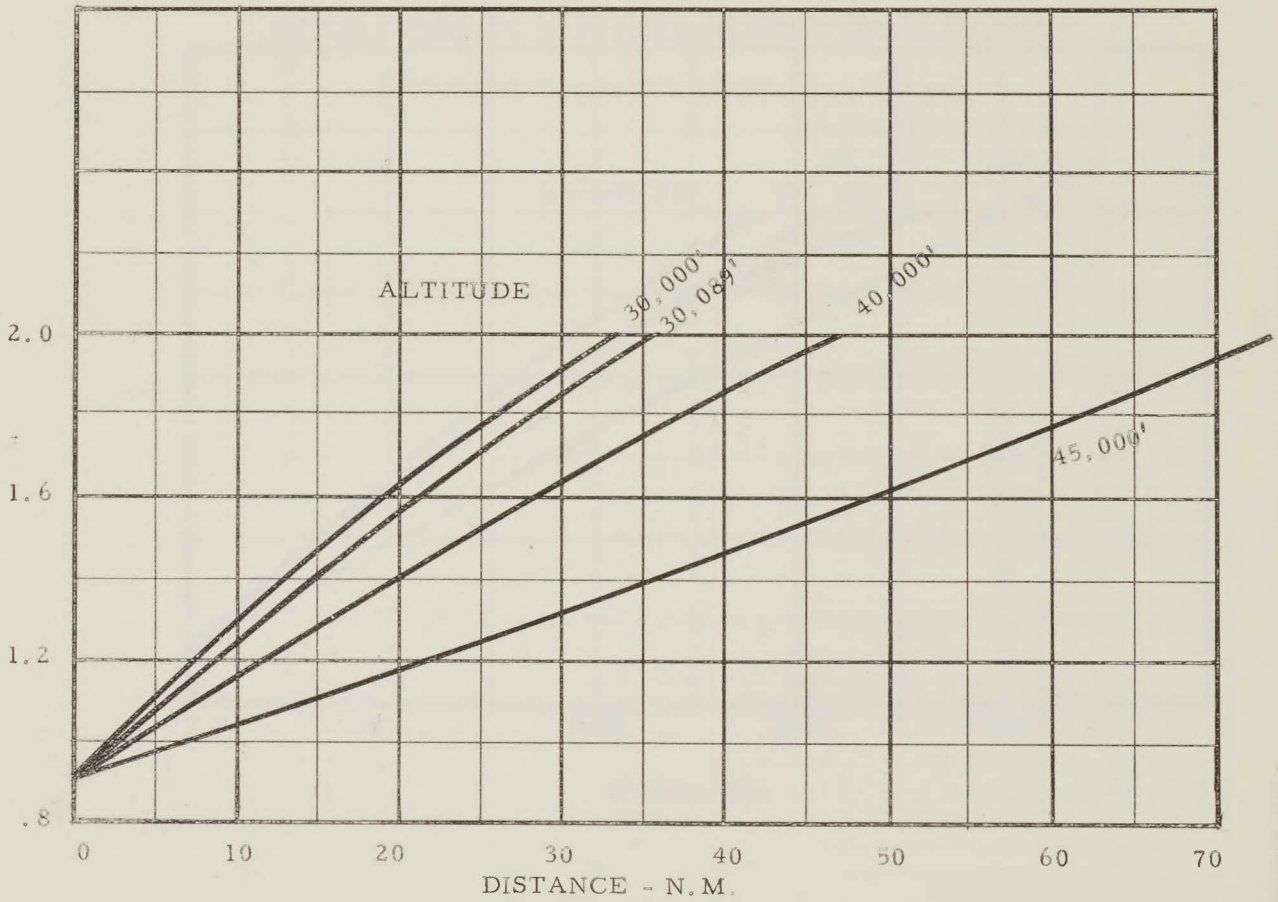

FIG.7(a)

ARROW 2 - IROQUOIS 2 - A/B LIT

FUEL TAKEN TO ACCELERATE FROM M=.92 TO M=2.0

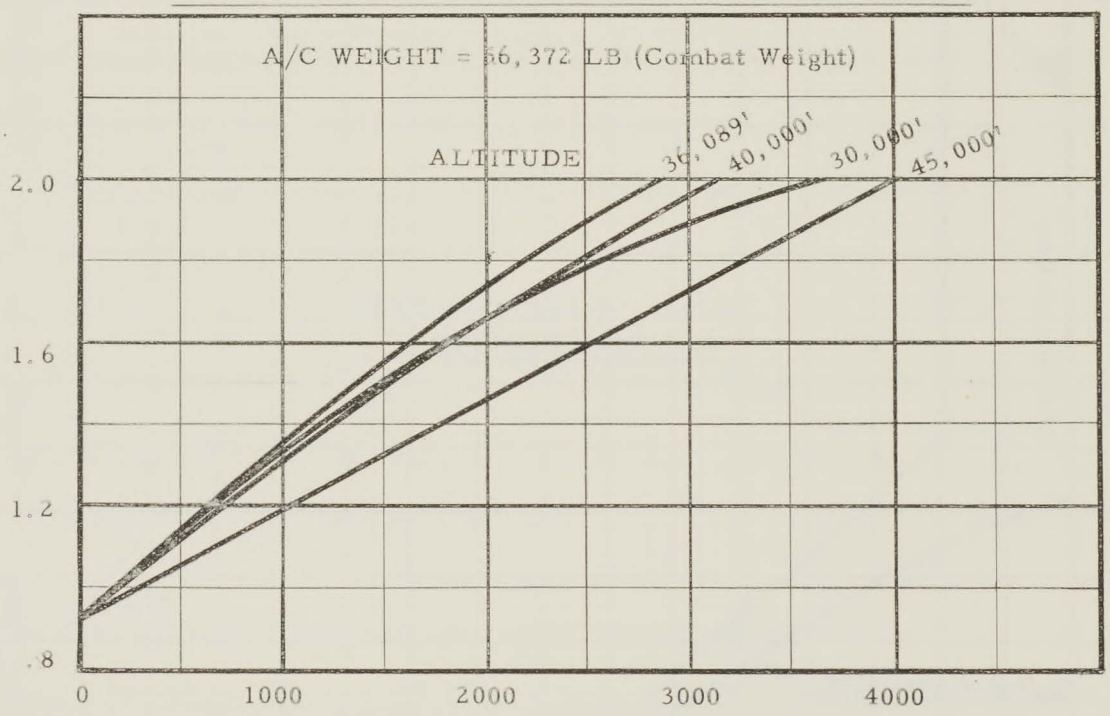

FIG. 7(c)

THERMODYNAMIC ENVELOPE

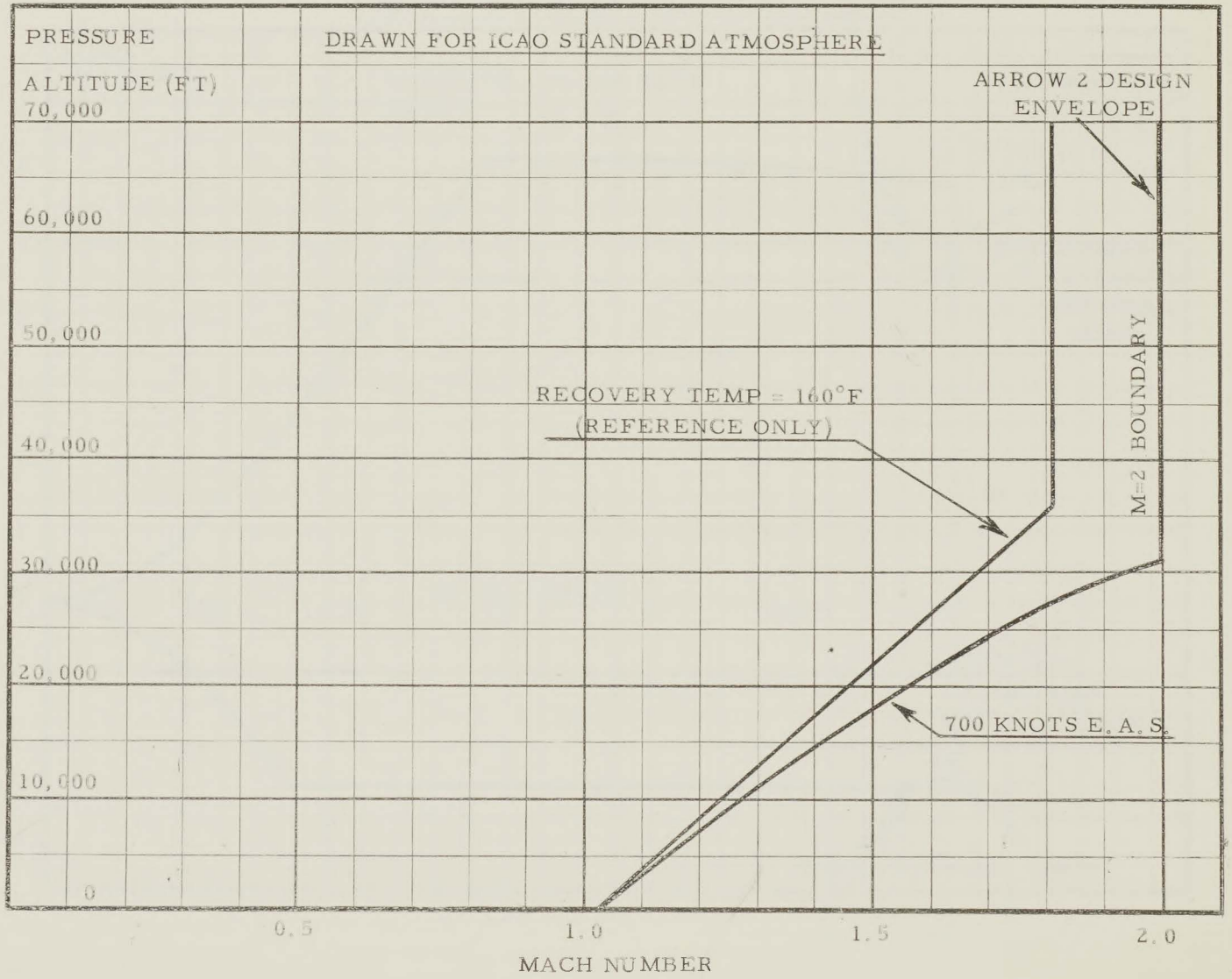

FIG. 8

FORM 1749 A-2

ARROW 2 FLIGHT ENVELOPE LIMITATIONS

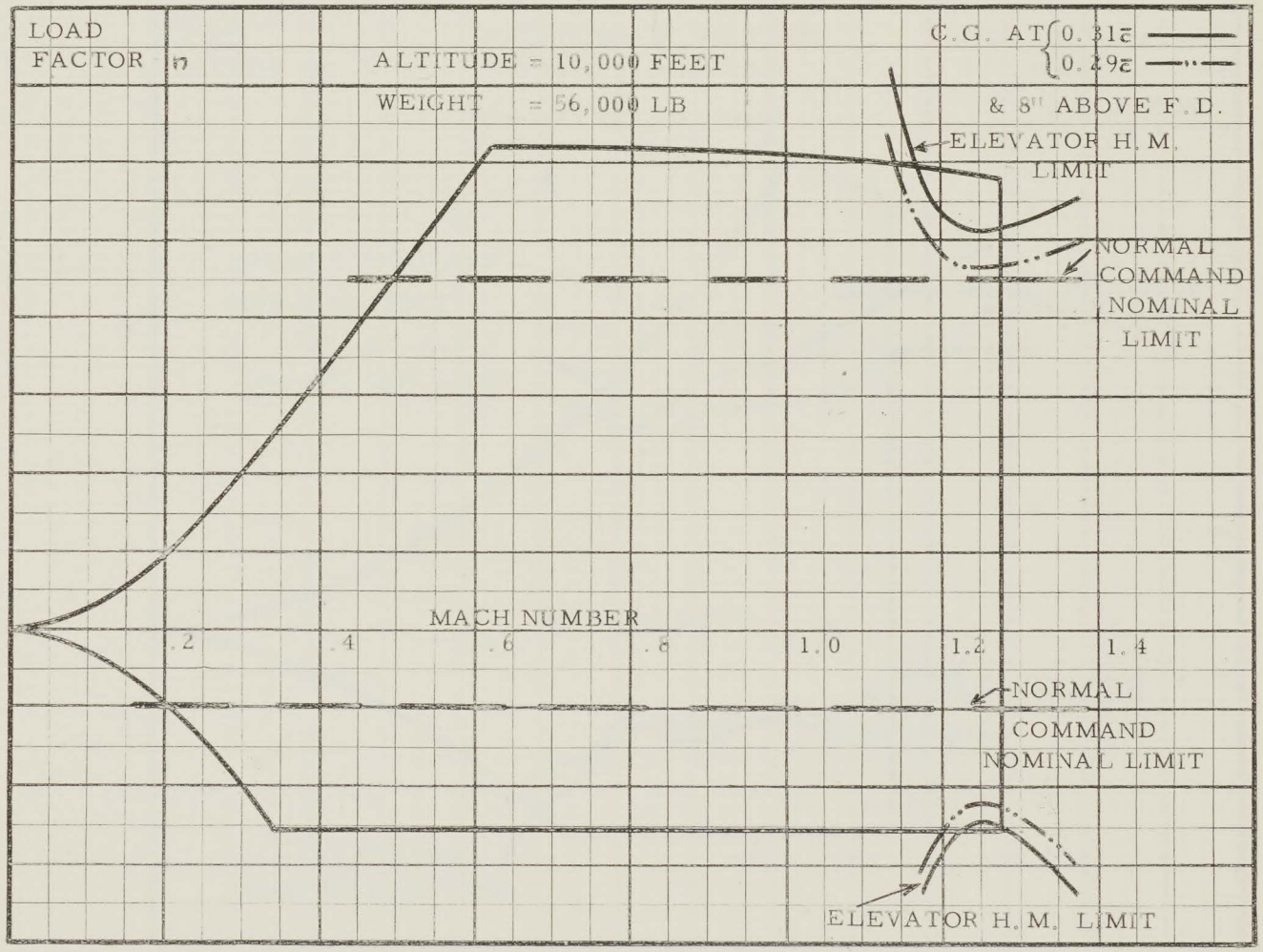

FIG. 9(a)

AVRO AIRCRAFT

ARROW 2 FLIGHT ENVELOPE LIMITATIONS

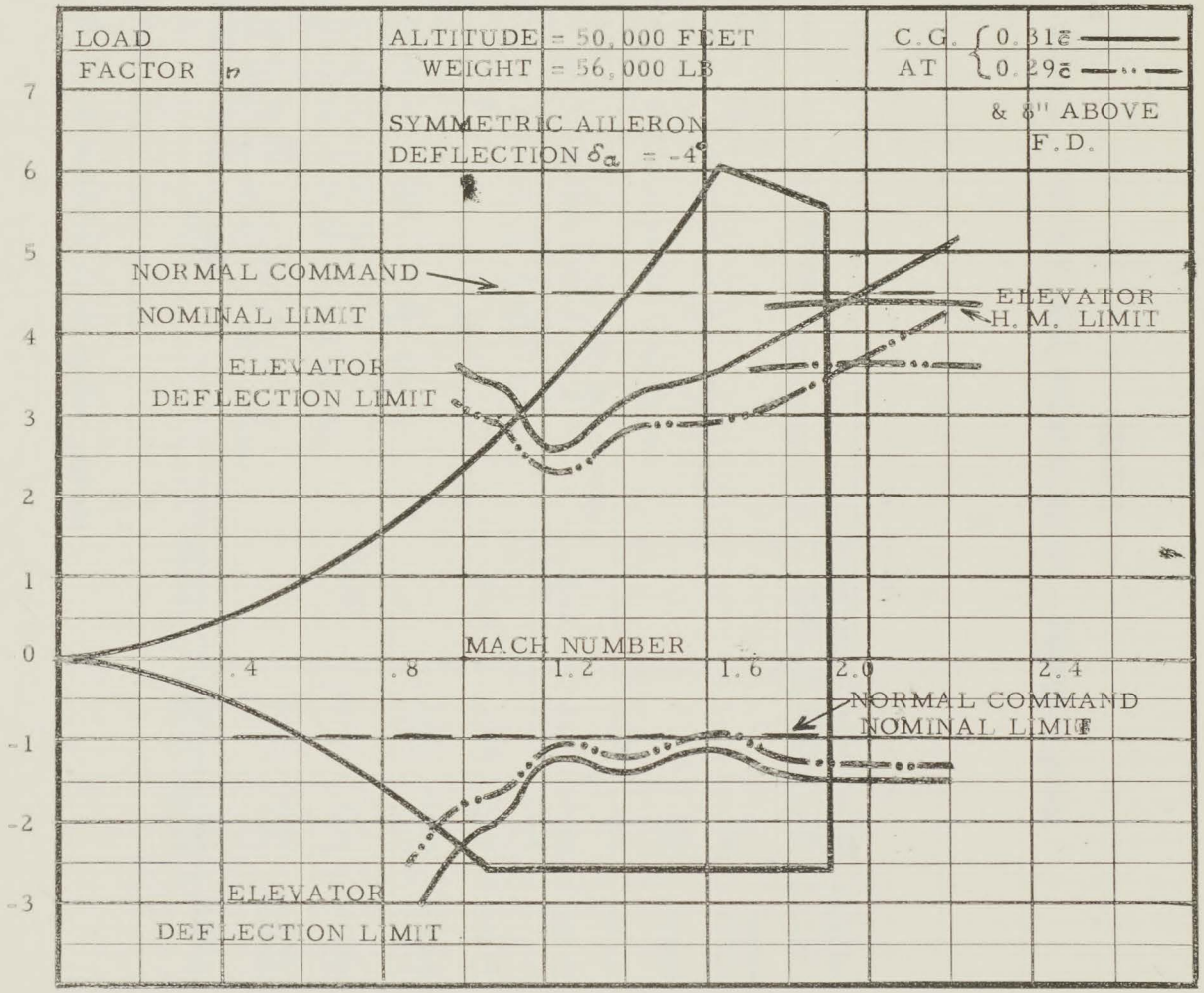

FIG. 9(b)

ARROW 2

TABLE 2 SUBSONIC HIGH ALTITUDE MISSION - SUBSONIC 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 (Optimum Cruise Out Alt.)	35.5	4.1	1765	63409
Cruise Out at M = .91 at 34,000'	378.5	42.9	5646	57763
Climb at M = .92 to 50,000' A/B Lit Max Thrust	23.0	2.65	1330	56433
Combat at M = .92 at 50,000' Max Thrust A/B Lit	-	5.0	1620	53085 *
Descend to 36,000' at Idle Thrust	-	2.8	210	52875
Cruise Back at M = .91 at Optimum Altitude (36,000 ft.)	442.0	50.8	5359	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 Max Endurance Speed		5.0	740	44922
TOTAL	884.0	136.13	19443	

7.8 lb/gallon fuel density.

* 1728 lb. of missiles fired during combat.

TABLE 4 - ARROW 2 WITH IROQUOIS SERIES 2 ENGINES

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(Optimum Cruise Out Alt.)	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 36,000'at idle thrust		2.8	210	50350
Cruise back at M = .91 at optimum Alt. (36,000 ft.)	237.85	27.2	2834	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 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.

ARROW 2

TABLE 5 - COMBAT AIR PATROL - SUPERSONIC COMBAT

WITH VENTRAL TANK JETTISONED AT FUEL EXHAUSTION

CONDITION	DISTANCE N.M.	TIME MIN.	FUEL LB.	A/C WT. LB.
Start Weight	-	-	-	70335
Engine Start	-	.5	100	70235
Take-off to Unstick at S.L. Max Thrust A/B Unlit	-	.33	200	70035
Acc. to 527 kts. at S.L. Max Thrust A/B Unlit	5.4	.93	680	69355
Climb at 527 kts. to 32,000' Max Thrust A/B Unlit (Optimum Cruise Out Alt.)	34.0	3.9	1820	67535
Cruise Out at M = .91 at 32,000'	390.0	44.1	6194	60999
Acc. to M = 1.5 at 32,000' Max Thrust A/B Lit	18.0	1.5	1610	59389
Climb to 50,000' at M = 1.5 Max Thrust A/B Lit	19.5	1.38	1210	58179
Combat at M = 1.5 at 50,000' Max Thrust A/B Lit	-	5.0	3042	53049 *
Descend to 36,000' at Idle Thrust	-	2.8	210	53199
Cruise Back at M = .91 at Optimum Altitude (36,000 ft.)	466.9	53.8	5683	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	933.8	140.44	23343	

*1728 lb. missiles fired during combat

Fuel density 7.8 lb/gallon.

ARROW 2

TABLE 6 - SUBSONIC LOW LEVEL MISSION (10,000') - SUBSONIC 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 to 10,000' at 527 kts. Max Thrust A/B Unlit	5.7	.7	480	64694
Cruise at M = .6 at 10,000'(Opt.Cruise Speed)	335.3	52.6	7050	57644
Acc. to M = .92 at 10,000' A/B Unlit	3.1	.39	220	57424
Combat at M = .92 at 10,000' Max Thrust A/B Unlit	-	5.0	3220	52476 *
Climb to 36,000' at 527 kts. A/B Unlit	24.5	2.8	1010	51466
Cruise Back at M = .91 at Optimum Altitude (36,000 ft.)	324.6	37.3	3950	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	698.2	126.7	19443	

* 1728 lb. missiles fired during combat

Fuel density 7.8 lb/gallon.

ARROW 2 - IROQUOIS SERIES 2 ENGINES

TABLE 7 - FERRY MISSION (NO ARMAMENT)

VENTRAL TANK CARRIED THROUGHOUT

CONDITION	DISTANCE N.M.	TIME MIN.	FUEL LB.	A/C WT. LB.
Start Weight	-	-	-	68,607
Engine Start	-	.50	100	68,507
Take-off to Unstick Max Thrust A/B Unlit	-	.33	198	68,309
Accelerate to 527 kts. at S.L. A/B Unlit	5.2	.92	662	67,647
Climb to 30,000' Max Thrust A/B Unlit at 527 kts. TAS	29.0	3.37	1640	66,007
Cruise Climb to 36,000' at M = .91	1271.8	145.5	18129	47,878
Loiter Over Base 15 mins. at 36,000'	-	15.0	1530	46,348
Descend to S.L. at Idle Thrust	-	6.2	324	46,024
Land with Reserves for 5 mins. Loiter at S.L. at Max Endurance Speed	-	5.0	760	45,264
TOTAL	1306.0	176.82	23343	

Fuel density 7.8 lb/gallon.

ARROW 2 - IROQUOIS SERIES 2 ENGINES

TABLE 8 - FERRY MISSION (NO ARMAMENT)

VENTRAL TANK JETTISONED WHEN EMPTY

CONDITION	DISTANCE N.M.	TIME MIN.	FUEL LB.	A/C WT. LB.
Start Weight	-	-	-	68,607
Engine Start	-	.50	100	68,507
Take-off to Unstick Max Thrust A/B Unlit	-	.33	198	68,309
Accelerate to 527 kts. A/B Unlit at S.L.	5.2	.92	662	67,647
Climb to 30,000' Max Thrust A/B Unlit 527 kts. TAS	29.0	3.37	1640	66,007
Cruise Climb to 36,000' at M = .91	1322.6	151.13	18129	47,536
Loiter Over Base 15 mins. at 36,000'	-	15.0	1530	46,006
Descend to S.L. at Idle Thrust	-	6.2	324	45,682
Land with Reserves for 5 mins. Loiter at S.L. at Max Endurance Speed	-	5.0	760	44,922
TOTAL	1356.8	182.4	23343	

Fuel density 7.8 lb/gallon.