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S E C R E T

REPORT NO. 21 - ISSUE 2
DATE: 12 JAN 59.

ROYAL CANADIAN AIR FORCE
AIR MEMBER FOR TECHNICAL SERVICES
CHIEF OF AERONAUTICAL ENGINEERING

GENERAL POLICY AND PROGRAMME
FOR THE DEVELOPMENT, DEMONSTRATION AND EVALUATION
OF THE ARROW WEAPON SYSTEM

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File No. S1038CN-180 (AMTS/CAE)

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P R E F A C E

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(i)

SUMMARY

This report has been compiled as a result of joint planning by the staffs of AFHQ, ADC, AMC and AVRO. The Flight Test Programme has of necessity been divided into two stages, Stage I consisting of the first twenty aircraft and with the object of delivery to the Squadron in Oct 60 a fully reliable weapon system with a proven capability. Stage 2 cannot at this time be fully defined but the main objective will be to evaluate the Weapon System through the complete combat envelope. The report, therefore, defines in detail the objectives and methods of achieving Stage I and in much less detail, the probable nature of the Stage 2 programmes. A subsequent report detailing the Stage 2 programme will be written when sufficient information is available to allow a realistic plan to be drawn up.

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GENERAL POLICY AND PROGRAMME FOR
THE DEVELOPMENT, DEMONSTRATION, EVALUATION OF THE
ARROW WEAPON SYSTEM

1. INTRODUCTION

1.1 This report supersedes Issue 1 since it has been necessary to revise the Arrow programme as a result of the Cabinet decision to cancel the Astra/Sparrow combination and to install a developed FCS/Missile system in the Arrow i.e. MA-1C/Falcon 3A, 4A and MB-1.

1.2 The Flight Test Programme has been planned in two stages as follows:

(a) STAGE 1 - Weapon System Proving

This stage includes the contractor and/or RCAF managed programme on aircraft 201-220 inclusive, as described in this report. The programme covers aerodynamic, structural and systems testing of the aircraft and engine, plus testing and proving of the FCS/Missile system as installed in the Arrow.

(b) STAGE 2 - Stage 2 will overlap the latter part of Stage I and will complete the weapon system testing required to define the complete operational envelope.

1.3 To maintain economy throughout the programme the Stage I Flight Test Programme presented in this report is the minimum that will meet the contractor's and RCAF requirements within the time scale and aircraft available.

1.4 Aircraft 25221 is scheduled for delivery to the Squadron in Oct 60. This delivery takes place prior to the completion of the Stage I programme. Therefore, throughout this report there are some areas which must be cleared to a specified minimum before delivery. These areas include stability, control, handling, structural, strength and performance.

2. CONDITIONS AND ASSUMPTIONS

2.1 The basic conditions and assumptions that dictated the programme as described in this report are:

(a) STAGE 1 of the Flight Test Programme will be achieved using the first 20 aircraft and will be completed by March 62.

(b) There should be no discontinuity as the emphasis shifts from the contractor's managed to the RCAF managed programme, in order to achieve maximum results in the minimum time.

(c) The MA-1C/Missile installation in the Arrow will compare satisfactorily with the installation in the F106 with respect to the quality of signals from the FCS to the missile and to the launch errors defined for the F106.

3. OBJECTIVES

3.1 STAGE 1

The overall Flight Test Programme objectives for Stage I listed in this paragraph are expanded in the Appendices.

- (a) The Stage I programme to be completed by March 62, will constitute proof testing of the weapon system including the following:
 - (i) The aircraft to be cleared to the minimum acceptable stability and control, and structural envelopes described in Appendix "D" and "E" by Oct 60.
 - (ii) The aircraft to be cleared to the full envelopes as described in the Arrow 2 Model Specification by March 62.
 - (iii) The aircraft to have an MB-1 and MB-1/GAR capability by Oct 60 and Jun 61 respectively.
 - (iv) The complete weapon system to be cleared and its effectiveness assessed in its predominant combat envelope by March 62.
 - (v) Adequate Pilot Operating Instructions (P.O.I.'s) based on flight test results by Jan 61.
 - (vi) During the contractor's programme to establish a plan for logistic support of the RCAF managed portion of the Flight Test Programme.
 - (vii) 1000 hours of flight test time should be achieved by Oct 60 and approximately 2500 hours by the end of Stage I in March 62.

3.2 STAGE 2

The primary objective of Stage 2 will be to complete the Arrow Weapon System evaluation throughout the operational flight envelope. Target dates for detail planning of Stage 2 are as follows:

- (a) Planning complete and directives issued by Jun 61.
- (b) Programme to commence early 62.

4. FLIGHT TEST PROGRAMME

4.1 STAGE 1

Stage I utilizing the first 20 aircraft will be done at Malton using Pt. Petre and the RCAF Lake Ontario Range for as much of the firing programme as possible. Firing of active missile against targets will be carried out at the Cold Lake Range. The detailed objectives of the various phases of Stage I are contained in the Appendices listed below:

<u>Stage</u>	<u>Test</u>	<u>Manager</u>	<u>Appendix</u>
1 A I	Aircraft Systems Normal Environment	Contractor	A: I

- 3 -

1 A II	Aircraft System Cold Weather	RCAF	A: II
1 A III	Aircraft System Intensive Flying	Contractor Initially RCAF	A: III
1 B	Engine and Engine Systems	Contractor	B:
1 C	Performance	RCAF	C:
1 D	Stability and Control	Contractor	D:
1 E	Structural Integrity	Contractor	E:
1 F	Handling	Contractor and RCAF	F:
1 G	Electronic System	Contractor	G: I
1 H	Operational Weapon System	RCAF	H: I

4.2 AIRCRAFT ALLOCATION

Appendix "K" is the aircraft allocation of the first twenty aircraft to meet the objectives of the Stage I programme. It should be appreciated that the aircraft, as allocated, is subject to change as priorities or emphasis in certain areas change.

4.3 STAGE 2

4.3.1 Stage 2 will encompass those areas not adequately covered in Stage I so as to complete the Weapon System Testing. Although it is not possible to define the objectives of this Stage at this time, in general, the following are the probable areas of concern:

- (a) Aircraft and FCS performance.
- (b) Structural Integrity.
- (c) Missile maintenance and ground handling.
- (d) Weapon system envelope with respect to:
 - (i) various altitudes and speeds
 - (ii) all aspect attacks
 - (iii) multiple firing
 - (iv) snap-up
 - (v) "g" loading envelope
 - (vi) warhead lethality
 - (vii) continuing ECM testing.

As the GAR 3A, GAR 4A and MB-1 are semi-active, passive and unguided respectively, the three systems must be proven independently. The tentative estimate of the programme involved is shown in Appendix "N", Stage 2 Weapon System Testing.

5. FACILITIES

- 5.1 It is planned to make maximum use of the Malton facility during the Stage I programme. It is planned to fire EVA's and dummy missiles of both types at Pt. Petre. Fully active missile firings against targets will be done at Cold Lake. Appendix "M" gives in general terms the facilities required to support Stage I of the Flight Test Programme.

6. ORGANIZATION

- 6.1 In order to meet the objectives of the Stage I programme with the aircraft allocated and in the time scale specified some changes in the present organization of the RCAF will be necessary. Appendix "L" is a suggested organization that could be set up at the contractor's to ensure that all the requirements and objectives of the Stage I Flight Test Programme are achieved. The whole or part of this organization could be re-located at an RCAF base at a later date to implement the Stage 2 programme.

7. FLIGHT TEST PROGRAMME SUPPORT

- 7.1 In order to avoid the discontinuity that could exist as the emphasis shifts from contractor to RCAF managed programmes during Stage I, aircrew and ground crew training must be phased into the contractor's programme as soon as possible. Appendix "J" details the manpower and training requirements to enable the RCAF to participate in the contractor's programme and to implement the RCAF portion of the Stage I programme.

7.2 Logistic Support

Appendix "I" is a plan whereby the Logistic Support required for the RCAF portion of the Stage I programme will be achieved. This plan will form the basis by which the Logistic Support requirements for squadrons will be established.

8. CONCLUSIONS

- (a) The limited time, aircraft and funds available for the revised Arrow programme makes it imperative that all existing facilities, manpower and experience of both the RCAF and the contractor be concentrated to achieve the aims of the programme.
- (b) To ensure a day-to-day appreciation of the Flight Test Programme status and progress it will be necessary to complement the existing test organization at the contractor's plant with personnel from AMC and ADC.
- (c) RCAF participation in the contractor managed programme will be invaluable when the emphasis shifts to an RCAF managed programme.

9. RECOMMENDATIONS

- (a) Stage I and Stage 2 programmes as outlined be approved as the Flight Test Programme for the Arrow Weapon System.
- (b) Consideration and/or approval be given to establish a Test Organization at the contractor's plant to monitor and participate in the contractor's portion of Stage I.

AIRFRAME SYSTEMS TESTINGI. AIRCRAFT SYSTEMS

- (a) Philosophy: Systems and components have been qualified by bench tests to various AVROCAN specs. Therefore, systems will be assumed to function until proved otherwise. Basic instrumentation will pick off key parameters of any systems to determine functioning - sufficient instrumentation points will be available for concentration of instrumentation, as required, to isolate and diagnose problems. This avoids carrying excessive instrumentation. In addition, where possible, ground test rigs will be used as development tools and to correct systems deficiencies.
- (b) Systems Affected: All basic airframe systems except weapons, fire control and those aspects of the flying controls systems directly associated with the stability and control programme. Prime Systems - electric, hydraulic, air conditioning, fuel, pneumatic oxygen and escape.
- (c) Objectives:
- (i) Determine that the systems, as installed, will function safely and satisfactorily under a realistic environment, emphasizing compatibility with airframe, engine and interrelated systems.
 - (ii) To prove that the qualification standard established by the manufacturer is achieved.
 - (iii) To determine reliability in terms of life, overhaul periods and servicing and maintenance schedules.
 - (iv) To develop the system to the standards set by qualification test or, if remaining deficient, to that required by the Arrow Weapon System.
 - (v) To determine and investigate any operational limitations inherent in the systems.
 - (vi) To determine single engine capabilities and establish modes of operation under such conditions.
 - (vii) To determine systems operation under emergency conditions, e.g. both engines windmilling.
 - (viii) To investigate drop fuel tank operation with reference to fuel flows, range and endurance checks, separation, handling and stability under various conditions, including one tank released and hang-up possibilities.
- (d) Programme
- (i) Arrow I aircraft will be employed for 85-100 hours of systems testing on systems common to Arrow 2. Aircraft to be allocated as expedient.
 - (ii) A development programme will proceed to achieve the objectives outlined in III below with particular attention to the characteristics and

compatibility of the aerodynamics, damping and flying control systems.

- (iii) Aircraft 206 to be used for testing of prime systems backed up by 208: - 40 to 50 flight test hours should be sufficient.
- (iv) Aircraft 208 fitted for drop tank evaluation.
- (v) Trial installations will be conducted on Arrow I where appropriate - i.e., nose wheel steering and anti-skid brakes.
- (vi) Aircraft 215 to be retained by AVRO indefinitely for trial installations and to be maintained as closely as possible to squadron standard.
- (vii) The present programme should be completed by the 31 Dec 60. Beyond this date one aircraft (206 or 208) will be required for systems development.

(e) Instrumentation:

Aircraft 206 and 208 to carry full instrumentation connections; 208 to be fitted, additionally, for drop tank evaluation.

(f) Location:

Malton.

(g) RCAF Participation:

Flying by the RCAF on this programme will be on an equal basis with the contractor.

II. AIRCRAFT SYSTEM - COLD WEATHER

- (a) Philosophy: Since all components and systems are qualified at low temperatures prior to installation the main purpose of testing the aircraft lies in the effect of prolonged cold soak periods on the actual installation. Since a long period of cold soak prior to operation is likely to be an unrealistic requirement, the cold weather operational capability can be evaluated, to reasonable limits, at a characteristic squadron base. The inherent weaknesses can be reported by the normal defect report or UCR and should be implemented at least as rapidly as if originating from the normal climatic testing programme. Recognizing that this approach is something less than ideal the pre-dominant factor is the lack of available aircraft for this purpose.
- (b) Objectives:
 - (i) A qualitative analysis conducted with modification recommendations submitted to the contractor.
- (c) Programme:
 - (i) The tests can be carried out on aircraft 216 which is scheduled for employment at Cold Lake for firing

trials during the winter of 1960/61.

- (ii) A two month period during winter 1960/61 should be sufficient and trials are to be conducted in combination, with the firing trials.

(d) Instrumentation:

No special instrumentation to be embodied by the contractor during production as CEPE will instrument as required during test period.

(e) Location:

Cold Lake.

(f) RCAF Participation:

The RCAF will handle this programme.

III. AIRCRAFT SYSTEMS - INTENSIVE FLYING

(a) Objectives:

- (i) Intensive flying on a "fly and fix" basis should commence as early in the programme as possible and proceed at a rate of two flights per day building up to 20 - 25 hours per month.
- (ii) Changes and modifications, found to be necessary, are to be embodied on less active aircraft.

(b) Programme:

- (i) Although the first priority on use of aircraft 209 will be Iroquois testing the majority of flight time on 209 can be devoted to intensive flying.
- (ii) Aircraft 208 and others to be added to the programme when available.
- (iii) The programme, as presently envisaged, will continue indefinitely.

(c) Instrumentation - None contemplated.

(d) Location:

Malton.

(e) RCAF Participation:

Approximately 50%.

ENGINE TESTINGI. OBJECTIVES

- (a) The various engine control systems to be evaluated with regard to functioning and reliability. Problems are to be investigated and development carried out as required.
- (b) The engine performance to be evaluated against that specified in EMS 8 issue 2 using average readings of key parameters at each engine plane. No performance development beyond the Model Specification standard is contemplated.
- (c) The intake duct and ejector to be evaluated with regard to distortion and turbulence effects, intake losses and compatibility, etc..
- (d) Handling characteristics, with emphasis on engine acceleration, deceleration and A/B light up and shut down, to be assessed, as required by the RCAF, to determine the effect upon the aircraft performance and handling envelope.
- (e) The engine and installation to be tested with respect to functioning, vibration analysis (blades and engine), and airframe and intake compatibility. Mechanical development is to be carried out to improve reliability.

II. PROGRAMME

- (a) Aircraft 207 will be fully instrumented to accommodate a fully instrumented engine in the starboard nacelle, and will be employed for the majority of the tests. This should involve approximately 130 hours test flying including 30 hours data acquisition and be completed by October 1960.
- (b) Aircraft 209, containing instrumentation pick-ups for engine control system testing only, will be complementary to 207 for engine controls testing, and also for flight proving of components. Providing 207 operates satisfactorily 209 is planned for limited use here.
- (c) Engines 118, 119, and 121 carry basic instrumentation, so that, although the engine installation is handed, full instrumentation can be applied to any engine as required for the starboard the starboard nacelle of 207. Although the programme will start with two instrumented engines, installed in 207, the availability of more flight engines will permit one instrumented engine in each of aircraft 207 and 209 and one in Orenda for modification.
- (d) It is planned that on aircraft will be required indefinitely for engine development. Since the complex nature of the instrumentation of 207 precludes use in other capacities, it will be retained in this role.

III. INSTRUMENTATION

- (a) Pressure and temperature logs.
- (b) Oscillograph recorder.

(c) Telemetering for desired engine parameters.

IV. LOCATION

Malton.

V. RCAF PARTICIPTION

It is estimated that the RCAF can contribute 25% - 50% flight time as negotiated by the RCAF and OEL.

PERFORMANCE TESTING

I. OBJECTIVES

- (a) Conduct a performance flight test programme to verify the performance parameters used in compiling the POIs.
- (b) The POI's to be delivered ADC by Jan 61.
- (c) The data used to compile the contents of POI's must be sufficiently accurate to allow printing of POI's containing flight test performance figures.

II. PROGRAMME

- (a) 40 hour programme on the Mk 1 aircraft. This will result in final POI's for the Arrow 1 and preliminary POI's for the Arrow 2.
- (b) 40 hour programme on the Mk 2 aircraft which will result in the issue of POI's for Arrow 2 by Jan 61.
- (c) Programme (a) to be carried out on 204.
- (d) Programme (b) to commence early 1960 on 214.

III. INSTRUMENTATION

- (a) Photo panel.
- (b) Oscillograph.

IV. SPECIAL REQUIREMENTS

- (a) Two calibrated engines.

V. LOCATION

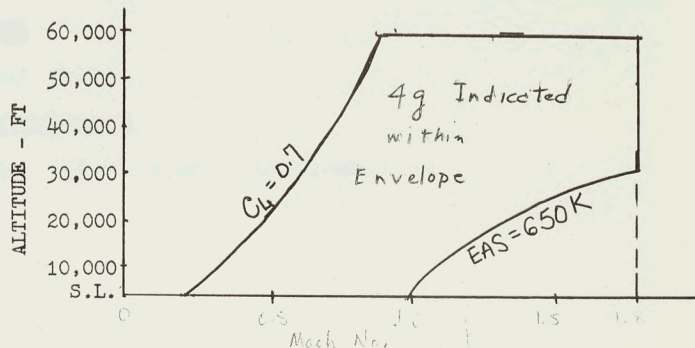
- (a) Malton.

VI. RCAF PARTICIPATION

- (a) 100% of flying.

STABILITY AND CONTROL TESTINGI. OBJECTIVES

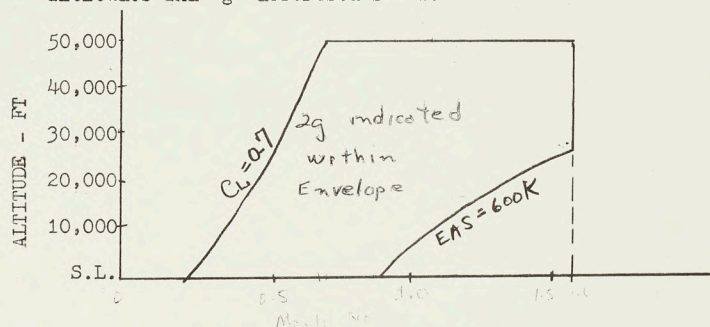
- (a) To provide a safe and useable aircraft within the envelope described below by Oct 60. This envelope must be safe for all envisaged manoeuvres within the limits of the normal damping system and recovery from such manoeuvres must be possible with emergency yaw dampers only. In addition a limited exploration of zoom climb and recovery technique will be checked prior to squadron delivery.



- (b) To provide a safe and useable aircraft within the operational envelope described in the Model Specification by Mar 62.

II. PROGRAMME

- (a) The aircraft flying characteristics will be investigated, with all dampers disengaged over the speed range, altitudes and 'g' described below:



- (b) The low speed programme will be restricted to a Cl of approximately 0.7.
- (c) Spin characteristics to be investigated especially in spin entry area. A limited qualitative investigation in the air down to approximately 130 Knots will be carried out.
- (d) The aircraft will be checked to MIL 8785 as the criteria with deviations as negotiated between the RCAF and the contractor. This is not intended to be a discrete programme but will be achieved throughout the Flight Test programme.
- (e) The programme will be scheduled as follows:

- (i) Contractor/RCAF Programme .200 hours.
- (ii) MIL Spec compliance during contractor/RCAF programme but the majority will be checked during the RCAF Handling Programme..

III. INSTRUMENTATION

- (a) Telemetry.
- (b) Oscillograph.
- (c) Magnetic tape.

IV. LOCATION

- (a) Malton.

V. RCAF PARTICIPATION

- (a) 10% of flying by RCAF crews.

STRUCTURAL INTEGRITY TESTING

I. OBJECTIVES

- (a) To establish the strength of the structure up to full design limits on the static test aircraft.
- (b) To demonstrate by flight test the structural integrity of the Arrow 1 within the envelope as described in AVRO Report 71/FAR/54 and approved by the RCAF.
- (c) To demonstrate by flight test the structural integrity of the Arrow 2 within the envelope as described in AVRO Report 71/FAR/54 by Oct 60. The extent to which this programme duplicates the Arrow 1 will be determined by negotiation between AVRO and the RCAF.
- (d) If considered necessary by the RCAF, a programme may be planned beyond the 20 aircraft programme to explore in greater detail the Flight Envelope corresponding to the design structural envelope for the aircraft.

II. PROGRAMME

The majority of the flight test for this programme will be achieved in parallel with the stability and control programme.

III. INSTRUMENTATION

- (a) Telemetry.
- (b) Oscillographs and/or data tape.

IV. LOCATION

- (a) Malton.

V. RCAF PARTICIPATION

- (a) 10% of flying by RCAF crews.

HANDLINGI. OBJECTIVES

- (a) To obtain qualitative data for inclusion in POI's in the following areas:
 - (i) T.O. and landing data.
 - (ii) Stability and Control in all damper modes.
 - (iii) Manoeuvre boundaries i.e. determination of buffet boundaries, etc.
 - (iv) Engine handling.
 - (v) Instrument flying.
 - (vi) Night flying.
 - (vii) Emergency procedures.

II. PROGRAMME

The handling programme will be achieved during other portions of the programme particularly the Performance Programme. The majority of the flying in this programme will be by RCAF aircrew.

III. INSTRUMENTATION

- (a) Photo Panel.
- (b) Oscillograph.

IV. LOCATION

- (a) Malton.

V. RCAF PARTICIPATION

- (a) It is intended that the RCAF will do the majority of the flying for this programme.

MA-1C/MB-1/GAR PROGRAMMEI. OBJECTIVES

- (a) MB-1 capability in squadron aircraft by Oct 60.
- (b) GAR capability in squadron aircraft by Jun 61.
- (c) To establish that the MA-1C including missile auxiliaries, and missile launching systems, function such that the GAR and MB-1 missiles are launched within the system tolerances established by the USAF for the F-106 (including F106 snap-up and snap-down capability). This objective to include the design of a satisfactory radome and power supply.
- (d) To confine as much of the programme to Malton as possible viz:
 - (i) Separation and launching firings at Pt. Petre.
 - (ii) Captive missile trials.
 - (iii) FCS proving - ECM conditions.
- (e) Instrumentation reduced to a minimum.
- (f) As a successful result of (c), to enable the F-106 evaluation data to be applied to the Arrow.
- (g) To allow for the incorporation of modifications into the Arrow system originating from USAF development and test programmes on the MA-1C/GAR/MB-1 system.
- (h) To allocate priority to the area of the Arrow 2 flight envelope where it is assumed the majority of intercepts will take place. Initially this area will limit the combat envelope for missile launchings between approximately:
 - (i) Altitudes of 30,000 ft. to 50,000 ft.
 - (ii) Speeds of Mach 1.2 to Mach 1.5.
 - (iii) "g" loadings of 0.8 g to 2.0 g indicated.

The extent of this combat envelope will depend upon the results of the tactical and operational studies on the use of the Arrow 2 which are proceeding parallel to the flight test programme. A few firings will be done at Mach 2.0 and subsonic to prove general safety considerations.

- (i) To assess the effects of rocket blast on engine handling and airframe. This objective will be accomplished as a by-product of air firings.
- (j) To assess and optimize the Arrow 2 escape manoeuvre such that the aircraft is within the acceptable safety limits when under the effects of the warhead of the MB-1 rocket.
- (k) To install and/or develop antennas for the MA-1C and other equipment such that all installed equipment

functions to the F-106 standard as a minimum or to an acceptable RCAF standard where AVRO development is required (the ARA 25 antennas, although to a Hughes design for the F-106 is to be modified such that a comparable performance is obtained in the Arrow).

- (1) To establish the requirement for the necessary maps for the Horizontal Tactical Display (HTD) scope.

II. PROGRAMME

(a) MB-1 Installation

<u>Purpose</u>	<u>Missile Req.</u>	<u>Facilities</u>
(i) To check the MB-1 ejection system as installed in the interim weapon pack.	1 Dummy MB-1 (Local Manufacturer)	
(ii) MB-1 firings to determine launch errors and comparison to F-106 results - modify or adjust to approach F-106 results (incl. snap-up and snap-down).	30 MB-1 ⁽¹⁾ (Inert Warhead)	Malton Range (Pt. Petre) Photographic Chase A/C Launch Cameras
(iii) MB-1 ejection tests	6 Dummy MB-1	Malton Range (Pt. Petre) Photographic Chase A/C

(b) GAR 3A and 4A Installation

<u>Purpose</u>	<u>Missile Req.</u>	<u>Facilities</u>
(i) Ground Test installation to check proper launch mechanism operation.	4 GAR 3A or 4A (Any type or dummy).	Malton
(ii) Airborne test of launch mechanism operation and aerodynamic performance of missile on launcher.	3 GAR ETV (1 ea air loads dynamics, temp).	Malton and Pt. Petre Photographic Chase A/C Cameras.
(iii) Air firings of individual missiles from front and rear launchers to determine separation and launch errors - compare and modify to F-106 standard as minimum.	20 GAR EVA ⁽¹⁾	Pt. Petre Range Photographic Chase A/C Launch Cameras

(1) Telemetry missiles may be required.

- | | | | |
|------------------------------|---|--------------------------------|--|
| (iv) | Air firings to determine physical interference of ripple firings viz. 2's and 4's - Compare and modify to F-106 standard. | 30 GAR EVA ⁽²⁾ | Pt. Petre Range

Photo Chase A/C

Launch Cameras |
| (v) | Captive missile flight test to evaluate quality of signal fed to GAR - compare to F-106 installation. | 4 GAR 3A WSEM
4 GAR 4A WSEM | Malton |
| (vi) | Qualitative proving to FCS/GAR system to show that radar loop is closed by air firing of missiles against drone target - proof of installation to F-106 standard. | 4 GAR 3A + TM
4 GAR 4A + TM | Cold Lake Range

Limited telemetry

Launch Cameras

Photo Chase A/C

Drones. |
| (c) <u>MA-1 Installation</u> | | | |
| <u>Purpose</u> | | | |
| (i) | Install MA-1C to Hughes and AVRO Model Specs in Arrow 1. | Nil | Malton |
| (ii) | Install communication and nav. equipment including antennas not included in MA-1C system. | Nil | Malton |
| (iii) | Flight Test MA-1C FCS against target aircraft - modify or adjust to approach F-106 standard as minimum. This is to include radome assessment. | Nil | Malton

Target A/C

MA-1C telemetry pack

Limited telemetry (ground) |
| (iv) | Develop antennas for equipment not part of MA-1C system or where Hughes antenna not acceptable in Arrow installation. | Nil | Malton

Adequate ground/air facilities for antenna pattern development. |

(2) Telemetry missiles may be required.

- (v) Flight test MA-1C and other nav. and com. equipment to F-106 or RCAF standard where equipment part of MA-1C system. Malton
- (vi) Flight Test MA-1C FCS/GAR system in conjunction with Item 2(e) and 2(f). Refer item 2(e) and 2(f) Malton
Cold Lake Range
MA-1 telemetry pack
Limited telemetry (ground)
- (vii) Flight test MA-1C FCS/MB-1 system to check proper firing signal operation. Nil Malton
Adequate instrumentation
- (viii) Install MA-1C in Arrow 2 and prove Arrow 2 changes over Arrow 1 installation - general MA-1C/Arrow 2 debugging. Captive missiles if required Malton
- (ix) Install AFCS - pilot assist modes only - develop over flight envelope. Nil Malton

(d)

- (i) Weapon Pack and missile separation will be carried out in aircraft 2, 4, 5.
- (ii) MA-1C Missile development and compatability programme will be carried out on Aircraft 10, 11, 12 and 13. The amount of RCAF flying in this programme to be negotiated with the contractor.

IV. MISSILE REQUIREMENTS SUMMARY

Purpose	MB-1		FALCON				Date Rq'd	
	Dummy	Inert Warhead	ETV	EVA	GAR 3A	GAR 4A		Target
Ground Ejection	1		-	-	4(Dummy)	-	-	Apr 59
Separation and Launch Errors	6	30 (1)	-	20 (1)	-	-	-	Jun 59 MB-1 Jan 60 Falcon

Physical Inter- ference Ripple Firing	-	-	-	30 ⁽¹⁾	-	-	-	Dec 59
Aerodynamic Performance Missile on Launcher and Ejection	6	-	3	-	-	-	-	Dec 59
Captive Missile programme	-	-	-	-	4	4	Arrow	Jun 60 (WSEM)* (WSEM)
FCS/GAR system Active Firing	-	-	-	-	4 TM*	4 TM	Drones	Jan 60
Limited Stage I Weapon System Assess- ment	-	6	-	-	12	12	Drones	Jul 61
Development Contingency	-	10	-	30	8	8	Drones	Sep 59
<hr/>								
TOTAL	13	46	3	80	4 dummy	4 WSEM	4 WSEM	
					4 TM	4 TM		
					20 Active	20 Active		

WSEM - Weapon System Evaluation Missiles

TM - Telemetered Missile

Drones - Number and Type to be determined.

(1) Telemetry missiles/units may be required.

OPERATIONAL WEAPON SYSTEM TESTING

I. OBJECTIVES

- (a) The contractor to demonstrate during the MA-1C/Genie/Falcon compatibility programme reference Appendix "G", the probability of placement for successful launching of missiles.
- (b) The RCAF with RCAF maintained aircraft to develop and/or determine the optimum tactics for launching Falcons and/or Genie.
- (c) In conjunction with the above to compile statistical data for logistical and operational planning for the Squadrons.
- (d) The Flight Test plan should, where possible, simulate operational employment as envisaged by ADC based on the standard mission contained Air 7-4 Issue 5.
- (e) Data gathered in this programme should include information required for the design of a suitable OFTT.

II. PROGRAMME

- (a) ADC Air and Ground Crew to be introduced to the Flight Test Programme in the schedule as detailed in Appendix "J".
- (b) The RCAF programme to include Aircraft 16-20.
- (c) Details of this programme to be planned by the Test Organization at Malton.

III. LOCATION

- (a) Malton and Cold Lake.

IV. RCAF PARTICIPATION

- (a) This programme will be under the management of the RCAF with assistance from AVRO as required.

LOGISTIC SUPPORTI. GSE AND TEST EQUIPMENT(a) Objectives:

- (i) To establish the equipment requirement for the Flight Test Programme.
- (ii) Develop or otherwise obtain programme support equipment by Oct 60.
- (iii) To establish the equipment requirement and implement procurement to support isolated RCAF testing operations.

(b) Programme:

- (i) Retain AVRO monitoring of the full scale programme requirement by appropriate re-issuing of a GSE list which will be continually reviewed by AFHQ and AMC staffs.
- (ii) AFHQ to direct AMC on effecting appropriate procurement action.

II. SPARES, GSE AND TEST EQUIPMENT(a) Objectives:

- (i) To have available a range, depth and configuration of spares appropriate to the support of the GSE employed in the programme.

(b) Programme:

- (i) Items of equipment being procured by the RCAF on source to be supported by routine AMC procurement.
- (ii) Items being purchased by reason of development/evaluation on prime contractor to be supported by RCAF procurement of spares listed by such contractor.

III. AIRCRAFT AND GSM SPARES(a) Objectives:

- (i) To sustain the operation of five Arrow 1 aircraft and Arrow 2 aircraft, increasing in number to fifteen by Oct 60, throughout the Flight Test programme.
- (ii) To provide, by Oct 60, a confirmed spares support, in range and depth, to sustain RCAF operation of 12 to 17 aircraft.

(b) Programme:

- (i) Prime contractor to recommend listings to RCAF for appraisal by AMC and preparation of CD's or AL's.
- (ii) For R & O spares Avro and Orenda will assume responsibility for establishing and procuring back-up

spares for the aircraft and engine.

- (iii) Selected R & O contractors for MA-1C and various missiles will be authorized to meet the appropriate spares requirement.

IV. SPARES CONTROL

(a) Objectives:

- (i) To achieve full machine accounting of maintenance spares holdings and movements through AMC by Oct 60.

(b) Programme:

- (i) To be discussed with prime contractor to resolve a system compatible with AMC planned control accounting methods.
- (ii) To exercise the proposed system at an RCAF facility at an early date.

V. DEFECT REPORTING

(a) Objectives:

- (i) RCAF/AMC to assume, by Oct 60, responsibility for receiving, analyzing and utilizing defect reports on the Arrow Weapons System.

(b) Programme:

- (i) The contractor to collect and analyze defect reports, providing AMC with run-offs appropriate to phasing AMC's analysis centre into effective operation.

VI. MATERIAL MOVEMENT

(a) Objectives:

- (i) To establish and employ, by Oct 60, a procedure for rapid movement of material compatible with machine accounting and defect reporting methods in service.

(b) Programme:

- (i) Material pipe lines to be reduced to the minimum value by utilizing transport aircraft, either located at the Arrow base or suitably dispatched from ATC base.
- (ii) Employment of machine accounting to hold all repair lines under continuous review.

VII. TECHNICAL DATA

(a) Objectives:

- (i) To make available, by Oct 60, or in phase with earlier RCAF operations, a full range of EO's informat, optimized in regard to expenditure, maintenance instructions, service bulletins and modification leaflets to support a weapon system

configuration exhibited at that time.

(b) Programme:

- (i) All major equipment EO's, from -1 to -9 inclusive, to be available in draft form, timed to be in phase with the equipment requirement date.
- (ii) With regard to components of major equipment the minimum requirement commensurate with the maintenance requirement will be obtained.
- (iii) A procedure to be established for amending EO's to retain compatibility with equipment configuration changes.

VIII. TECHNICAL ASSISTANCE

(a) Objectives:

- (i) To create and verify, through exercise, a working complex of men, tools, instructions and methods on all aspects of the Arrow weapons system pertinent to an RCAF operation and base by Oct 60.

(b) Programme:

- (i) To be accomplished by the Maintenance Advisory Committee, on a continuing basis, by review of technical data, R & O support, maintenance procedures, personnel training, technical problems, etc..
- (ii) R & O type contracts to be termed, if possible, to include purchase of this range of function.

IX. OPERATING POINT AS RCAF EXERCISE

(a) Objectives:

- (i) Logistically, to have available a complete range of support appropriate to the weapon system configuration extent by Oct 60.

(b) Programme:

- (i) A modest RCAF facility to be created at Malton, as soon as possible, to operate a limited number of aircraft, including intensive flying, in order to exercise logistic support in relation to operating problems.

X. BASE FACILITIES

(a) Objectives:

- (i) To determine and provide, by Oct 60 at the point in question, the support installation of material, exclusive of GSE, required to support RCAF squadron operation.

(b) Programme:

- (i) AFHQ and AMC to study and resolve the design, development and installation of the total range

of support requirement for the Arrow Weapon System.

XI. REPAIR AND OVERHAUL

(a) Objectives:

(i) R & O for the Arrow Weapon System to be accomplished as far as possible within existing Canadian industrial facilities.

(b) Programme:

(i) AMC recognizes Orenda and Avro as the major overhaul points for Iroquois engines and Arrow airframes and will discuss with these contractors suitable overhaul selections for the component parts of their product.

(ii) R & O facilities for the electronics system, missiles and GSE to be resolved later by AMC.

XII. CONTRACTUAL ASPECTS

(a) Objectives:

(i) To provide by Oct 60 a full range of required contractual authorities to achieve the logistic support planned.

(b) Programme:

(i) AFHQ and AMC to resolve the administrative and financial problems associated with procurement, R & O and technical assistance contracts cognizant with Proc-Spec.

TRAINING REQUIREMENTSI. AIRCREW(a) Objectives:

- (i) Aircrew must be introduced to the programme sufficiently early to avoid any discontinuity when the emphasis shifts from contractor participation to RCAF participation.
- (ii) Early RCAF assessment and especially ADC input in the Flight Test Programme.

(b) Programme:

- (i) No. 1 RCAF (CEPE) pilot actively engaged.
- (ii) No. 2 RCAF (CEPE) pilot undergoing training as back-up.
- (iii) No. 3 RCAF (CEPE) pilot to be introduced by April 59.
- (iv) No. 1 RCAF (ADC) crew in Aug 59.
- (v) No. 2 RCAF (ADC) crew in Feb 60.
- (vi) No. 3 and No. 4 crew to be determined.
- (vii) No. 5 and No. 6 crew to replace 1 and 2 who will form nucleus of O.T.U..

(c) Training Requirements:

- (i) Simulator at least 2 hours.
- (ii) 2 taxi, high and low speed runs.
- (iii) At least 2 hour familiarization.
- (iv) Minimum of 4 hour/month/crew during Flight Test Programme to be increased as RCAF participation increases.

II. GROUND CREW TRAINING(a) Objectives:

- (i) The training of Arrow ground crews to maintain six Arrow a/c coincident with the introduction of aircraft 25215 into the flight test programme.
- (ii) Apart from the primary objective in (a) above, the RCAF maintenance crews must be of sufficient strength to support the detached operation of up to three Arrow a/c employed on weapon firing trials for a maximum period of six months. These trials may proceed simultaneous with the RCAF trials in (a).
- (iii) It is intended that the RCAF maintenance crews employed in support of the RCAF managed programme i.e. a/c 15-20 will form a reservoir of trained personnel to support the introduction of

Arrow a/c to early squadrons and the conversion unit. (The overall strength of the RCAF ground crew participation in the RCAF programme will be maintained uniform by the addition of personnel from the Ground Conversion Training Unit).

(b) Manpower Requirements:

The numbers of RCAF technicians required to support the RCAF programme is predicted on the basis of the following:

- (i) Technicians will be to Group 3 standard and will be experienced on the operation of jet aircraft (preferably CF-100).
- (ii) The RCAF technicians will be required to maintain six Arrow a/c on an accelerated flying basis. (This may necessitate a limited second shift operation).
- (iii) Support of three Arrow a/c on detached operations.
- (iv) The RCAF technicians allocated to the RCAF Programme will form a reservoir of trained personnel to support early squadron formation.

<u>TRADE</u>	<u>AC & CPL'S</u>	<u>SUPERVISORY NCO'S</u>
AF Tech	42	WOI, F/S, SGT.
AE Tech	24	F/S, SGT.
I Tech	11	F/S, SGT.
E Tech (A)	11	SGT.
Comm Tech (A)	6	SGT.
Radar Tech (A)	9	SGT.
SE Tech	6	SGT.
M&W Tech	12	SGT.
Arm't Sys. (a/c)	30	WOI, F/S, 2 SGTs.
Arm't Sys. (Missiles)	<u>11</u>	F/S, <u>SGT.</u>
Sub-Totals	162	18

Total-180

III. TRAINING PROGRAMME

The timing of the training programme is dictated by the relative phasing of aircraft to be maintained by the RCAF technicians and the duration of contractors' training courses. The following relative phasing of Arrow a/c appears applicable:

- (i) The contractor has indicated that an early Arrow Mk I a/c can be made available for RCAF ground crew training in conjunction with its employment as a target aircraft in Jan 60.
- (ii) There is a possibility of a second aircraft being made

available for RCAF maintenance crews in Apr 60.

- (iii) The RCAF technicians must support a build-up to a maximum of six Arrow a/c commencing in Jun 60.

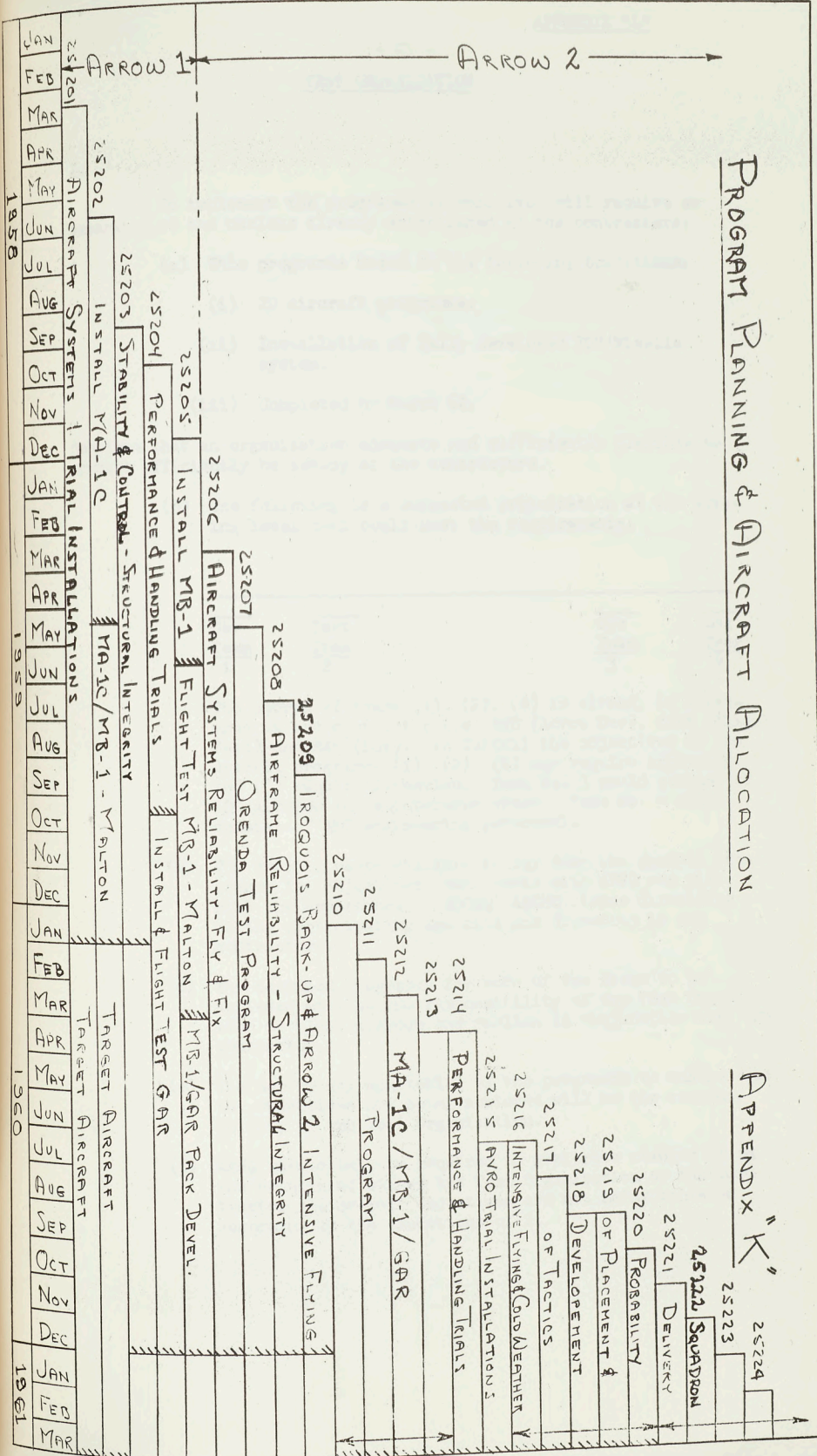
From the foregoing, it is possible to generalize that electronic system training must commence in Aug 59 with all training finished prior to 1 Jun 60. Training of AF Techs, AE Tech, E Tech (A)'s and some I Techs can commence as late as Oct 59, however, the exact scheduling must be determined in conjunction with AVRO. In any event all training must be accomplished prior to 1 Jun 60.

IV. AVAILABILITY OF PERSONNEL

Once exact course commencement dates are determined, ADC will be approached to ascertain if they can supply the 180 personnel detailed in para 2 above.

PROGRAM PLANNING & AIRCRAFT ALLOCATION

APPENDIX "K"



JAN	1958	1959	1960	1961
FEB				
MAR				
APR				
MAY				
JUN				
JUL				
AUG				
SEP				
OCT				
NOV				
DEC				
JAN				
FEB				
MAR				
APR				
MAY				
JUN				
JUL				
AUG				
SEP				
OCT				
NOV				
DEC				
JAN				
FEB				
MAR				

TEST ORGANIZATION

I.

To implement the programme as conceived will require an expansion of the nucleus already established at the contractors;

- (a) This programme based on the following conditions:
- (i) 20 aircraft programme.
 - (ii) Installation of fully developed FCS/Missile system.
 - (iii) Completed by March 62.

Requires that an organization adequate and sufficiently flexible to operate efficiently be set-up at the contractors.

- (b) The following is a suggested organization at the working level that could meet the requirements.

Dev	Test	Ops	Log
Team	Team	Team	Team
1	2	3	4

The embryo of Teams (1), (2), (4) is already in existence at the contractor i.e. TSD (Arrow Dev), CEPE (Flight Test) and MAT (Log). To fulfill the objectives of the overall programme (1), (2), (4) may require expansion and (3) require formation. Team No. 3 would consist of ADC aircrew and maintenance crews. Team No. 4 would consist of AMC engineering personnel.

- (c) The overall responsibility to lay down the general programme ie. objectives, etc. rests with AFHQ who will, with the assistance of ADCHQ, AMCHQ, issue directives to the participating agencies and direction to the contractors.
- (d) The detailed programme for each of the tasks to be achieved will be the responsibility of the Test Organization to plan, approve and publish in conjunction with the contractor.
- (e) The day to day monitoring of the programme to ensure that the objectives are being achieved will be the responsibility of the Test Organization.
- (f) AFHQ should only be required to arbitrate changes if in the opinion of either the Test Organization or the Contractor the overall objectives are not being achieved according to the conditions of 2.

FACILITIESI. STAGE 1

- (a) To accomplish the objectives detailed in Appendices A - G the following facilities are required:

- (i) Aircraft Maintenance - Existing Contractors Facility.
- (ii) FCS Programme - GCI facility for vectoring target and interceptor.
- (iii) Firing Range - Pt. Petre for all unguided missile firings.

- Cold Lake for guided missile firing at drones.

Pt Petre Range Requirements

Tracking Radar C/W plotting Board Surveillance Radar Adequate Range Area.

Cold Lake Range Requirements

Tracking Radar c/w plotting Board, Drone Flight c/w MD.I, Existing Telemetry Station, Data Reduction for MD I and Missile Telemetry. Hangars for up to 3 Arrow a/c + 2 Chase and or Target a/c.

The portion of the programme at Cold Lake will be of a detached nature where the a/c complete with GSE spares proceed to Cold Lake for a limited period. The Cold Lake facility will be required in early 60 for active Missile Firing.

- (b) To accomplish the objectives detailed in Appendix "H" Operational Weapon System Programme the following facilities will be required at Malton:
- (i) Aircraft Maintenance - Similar to existing Facility at Malton i.e. Hangar Office Space GSE spare etc..
 - (ii) GCI Facility for vectoring a/c targets and interceptor.
 - (iii) Target a/c complete with ECM equipment.

II. STAGE 2

Stage 2 of the Flight Test Programme will be an RCAF supported Programme at Cold Lake as detailed in Appendix "N".

STAGE 2 WEAPON SYSTEM TESTINGI. OBJECTIVE

The complete objectives of Stage 2 cannot be defined at this time but the overall objective is to complete the weapon system testing so as to define completely its operational capability.

II. PROGRAMME

- (a) Falcon missile requirements for RCAF evaluation are considered to be:
 - (i) 16 EVA (Evaluation Vehicle Aerodynamic).
 - (ii) 4 EVA (Inert).
 - (iii) 84 Radar Falcons (76 telemetry, 8 warhead).
 - (iv) 84 IR Falcons (76 telemetry, 8 warhead).
- (b) Genie requirements for RCAF Cold Lake evaluation of the Arrow Weapon System will be analogous to a Project "K" type of evaluation. The requirements are estimated to be:
 - (i) 80 MB-1 Genies (Inert warhead).
 - (ii) Unknown quantities of ground handling and test equipment.

III. TARGETS

- (a) Two target systems are considered for use on the Genie/Falcon evaluation programme:
 - (i) Del Mar Towed Target (RADOP).
 - (ii) Drone targets - Jindivik type (available KDA drones will be used for lower altitude firings).
- (b) The basis for calculations of the target requirements is:
 - (i) For towed targets a life of 3 flights per target is assumed.
 - (ii) For drone aircraft operation a life of 6 flights per drone is assumed.
 - (iii) Since all drone flights or tow target flights will not be completely successful for missile firing it is necessary to assume a factor of success for such flights as follows:
 - (A) 60% of all drone launchings will be completely successful for missile firing.
 - (B) 75% of all towed target flights will be completely successful for missile firing.
- (c) Firing Programme - Target Requirements
 - (i) Towed Targets. The total number of flights requiring targets is as follows:

(A) Falcon	-	150 flights
(B) Genie	-	<u>94</u> flights
Total		244.

Towed targets are considered to be suitable for captive flights and live firings only of Falcon missiles. It is estimated that approximately 40 captive flights will be required and that 50 of the Falcon firings can be carried out against a towed target. This represents a total of 90 successful tow-target missions. Target requirements are as follows:

Required Successful Missions	=	90
Total flights necessary (25% failure rate)	=	120
Targets necessary (at 3 flts/target)	=	40

(ii) Drone Targets. Drone targets are required for $(244 - 50) = 194$ firing flights. Assuming 40 captive flights against drones the total requirements is as follows:

Required successful missions	=	$194 + 40 =$	234
Total flights necessary (at 40% failure rate)	=		390
Drone targets necessary (at 6 flights/drone)	=		65

IV. INSTRUMENTATION

(a) To be determined.

V. LOCATION

(a) Cold Lake.

VI. RCAF PARTICIPATION

(a) 100%.

