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NO. 1079

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ROBOT-X DEVELOPMENT REVIEW (U)

by

A.B. Markov

PCN No. 21V10

June 1983

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ABSTRACT

Progress in the development of proof-of-concept prototypes of a winged, rocket-boosted target (ROBOT-X) simulating low altitude, high subsonic speed invader aircraft and antiship missiles is summarized. The development program is described in detail. Expenditure summaries to the present stage and anticipated future funding requirements are included, with emphasis on R & D contract funding requirements. A detailed breakdown of past, present and future R & D contracts is given.

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PREFACE

This report is an expanded version of a paper presented at the twenty-fifth TTCP HTP-1 (Aerial Targets and Drones Panel) in London, U.K. on September 17, 1982. This report contains more detailed R & D contract breakdowns with associated funding levels.

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TABLE OF CONTENTS

Page No.

ABSTRACT
PREFACE
TABLE OF CONTENTS
LIST OF TABLES
LIST OF FIGURES

1. INTRODUCTION 1

2. ROBOT-X DEVELOPMENT PROGRAM 3

   2.1 Phase I — Preliminary Design and Feasibility Assessment 4
   2.2 Phase II — Detailed Configuration Design 5
   2.3 Phase III — Detailed Design and Prototype Construction 6
   2.4 Phase IV — Flight Testing 6
   2.5 Phase V — Advanced Development 7

3. PROGRAM SCHEDULE AND CURRENT STATUS 7

4. DEVELOPMENT PHILOSOPHY AND FUNDING BASIS 8

5. ROBOT-X R & D CONTRACT REVIEW 10

   5.1 Structural Design and Construction of Wind Tunnel ROBOT-X Models 11
   5.2 ROBOT-X Control Law Synthesis 12
   5.3 ROBOT-X Detailed Airframe Design and Construction 13
   5.4 Autopilot Development 14
   5.5 R & D Contract Funding Summary 15

6. ROBOT-X TTCP BRIEFING 16

7. ROBOT-X ESTIMATED UNIT COSTS 16

8. SUMMARY 16

REFERENCES 18

TABLES

FIGURES

[redacted]

[redacted]

LIST OF TABLES

1. Revised ROBOT-X Development Program Milestones

2. ROBOT-X Direct and Related R & D Contract Funding Requirements

LIST OF FIGURES

1. ROBOT-X Navy Scenario

2. ROBOT-X Typical Velocity Profile

3. ROBOT-X Boom Configuration

4. ROBOT-X Original Canard Configuration

5. ROBOT-X Wind Tunnel Conventional Configuration

6. ROBOT-X Wind Tunnel Canard Configuration

7. ROBOT-X Development Program

8. ROBOT-X Development Program Schedule

9. ROBOT-X Conventional Wind Tunnel Model

10. ROBOT-X Canard Wind Tunnel Model

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1. INTRODUCTION

The Canadian Forces (N) currently have a need for a target simulating a low altitude, high subsonic velocity threat (e.g. an antiship missile or a low flying invader aircraft). The low level air defence (LLAD) project office anticipates a similar requirement. Such targets are required both for training purposes and for evaluating point defence missile systems.

Current practice by the navy has been to obtain the use of high performance targets (e.g. MQM-34 and Chukkar) and the required range facilities through contract. This practice is both inconvenient and expensive (fuel costs, range availability, and so forth). The targets are high cost, complex vehicles that require extensive maintenance between flights by a trained, dedicated support group. They are particularly susceptible to corrosion problems resulting from the salt water recovery.

There is thus an urgent Canadian requirement for a low-cost target suitable for exercising and evaluating point defence systems, and satisfying the following requirements:

[redacted]

a) High subsonic speed.

b) Sustained low altitude flight capability.

c) Over-the-radar-horizon attack profile.

d) Maneuvering capability.

e) Altitude and direction hold, and homing capability.

f) Recoverable avionics package (minimum).

g) Low cost.

The Defence Research Establishment Suffield's (DRES) involvement in the development of two rocket-boosted ballistic targets (CRV7/BATS and ROBOT-9, see Reference 1) and associated equipment for rapid deployment off navy ships in heavy seas has provided a substantial experience and technology base from which to proceed with the development of a target that meets the more ambitious requirements defined above. In particular the use of 2.75 inch rocket motors, such as the Canadian developed CRV7 or improved MK IV motors, as the basic propulsion unit provide a method of reducing the cost of the target by eliminating the need for a turbine motor. This not only reduces procurement cost, but also minimizes operational cost by reducing the amount of between flight maintenance as well as the level of skill required of the support group. The latter is particularly advantageous for occasional users of such targets (such as the Canadian Forces) for which it is not cost effective to maintain a dedicated, highly trained target support group. There also appears to be the possibility of substantially reducing avionics cost through the development of a low-cost three axis automatic pilot system.

Preliminary work carried out at DRES in the summer of 1981 and reported in Reference 2 has indicated that the performance requirements are met by a winged rocket-boosted target (ROBOT-X) that is based on a 19 CRV7 or equivalent rocket motor propulsion system. The vehicle requires a 5 motor initial boost followed by 7 stages of 2 motors each. The timing between stages is adjustable so that operation within a desired velocity-range envelope is achieved. The latter capability will, for example, allow a high speed terminal portion of the mission.

The ROBOT-X navy mission scenario is summarized in Figure 1. As indicated in this figure, there is nothing to preclude the use of this target as a look-down, shoot-down target for the CF (Air), or for that matter, as a low level air defence target for the CF (Land) element.

Figure 2 gives a typical mission velocity profile for the target. Figures 3, 4, 5 and 6 show a number of configurations that have been or are currently under consideration.

Since the initial, favourable performance assessment of Reference 2, considerable effort has been expended towards formulating a detailed development program for the vehicle. The resulting program is a five phase program that is described in detail in Section 2, and includes both direct DRES research and development involvement and private sector involvement.

Section 2 describes this development program in detail. Section 3 describes the evolution of the ROBOT-X vehicle through this program, its current status and anticipated future developments. Section 4 considers development philosophy and funding basis. Section 5 reviews past, present and future R & D contract requirements. Section 6 considers the possibility of international cooperation for flight testing ROBOT-X, and Section 7 provides estimates of ROBOT-X unit costs.

This work was carried out under PCN 21V10 between August, 1981 and October, 1982 inclusive.

2. ROBOT-X DEVELOPMENT PROGRAM

The development program is conveniently divided into five phases, as follows:

I — Preliminary design and feasibility assessment.
II — Detailed configuration design.
III — Detailed design and prototype construction.
IV — Flight testing.
V — Advanced development.

The intent of the program is to flight test a number of proof-of-concept vehicles. Phase V is included for completeness and is intended to indicate an eventual transfer of the technology base to a production version of the vehicle. Currently the program is moving into Phase III, as will be discussed further in Section 3.

As will become apparent from the program description to follow, the vehicle's development requires facilities, expertise and manpower which are not all resident at

DRES, thus implying a need for extensive contractor support. Such support is also desirable in the long term in anticipation of the eventual transfer of ROBOT-X technology and production to the private sector.

Despite the need for contractor support, it is felt to be in the best interests of a successful ROBOT-X program to maintain significant DRES inputs into the design and development of the vehicle. This was particularly desirable during the more conceptual first two phases of the program, i.e. during the feasibility assessment and configuration design, and during the flight testing phase. Such an approach is also more conducive to developing inhouse expertise in the area of high speed, winged, maneuvering targets.

The role adopted by DRES is thus somewhat analogous to that of a prime contractor. Key conceptual elements of the design and development will continue to proceed inhouse; otherwise contractor support has been and will continue to be solicited. Vehicle prototypes will be manufactured under contract. Flight testing and operational evaluation will be carried out by DRES with CF and contractor support.

Five major areas of contractor support have been and will be required for the ROBOT-X program. These are:

a) autopilot control law synthesis,
b) wind tunnel model detailed structural design, fabrication and testing,
c) detailed airframe structural design and prototype construction,
d) detailed autopilot hardware design and prototype construction, and
e) DRES range facility development.

The program phases are discussed in detail in the following sections, and summarized in Figure 7.

2.1 Phase I — Preliminary Design and Feasibility Assessment

The overall purpose of this phase was to demonstrate feasibility of the ROBOT-X concept. This involved a number of steps as follows:

a) preliminary design to establish one or two nominal configurations (NC's) for the purposes of the feasibility study;

Phase II is essentially complete with the major outstanding item being the control law synthesis contractor's report. It is anticipated that this report will be delivered to DRES on schedule in December, 1982.

2.3 Phase III — Detailed Design and Prototype Construction

The overall purpose of Phase III is to carry out the detailed design and construction of a number of ROBOT-X prototypes. This will involve a number of steps as follows:

a) estimation of structural design loads including loads during boost and nonboost phases, aerodynamic loads, maneuvering loads, recovery loads and vibration and temperature environments;

b) detailed airframe design compatible with low-cost production;

c) recovery system design for the flight testing phase;

d) mock-up construction (if necessary);

e) assessment of radar augmentation requirements;

f) avionics package detailed design and implementation of autopilot control laws;

g) prototype construction and integration of different subsystems;

h) static testing of vehicle structure and subsystems.

2.4 Phase IV — Flight Testing

The overall purpose of this phase is to evaluate the ROBOT-X vehicle in flight. This will involve a number of steps as follows:

a) preparation of required DRES range facilities (e.g. tracking and telemetry stations);

b) subsystem testing (e.g. independent autopilot and recovery system flight testing);

c) static firings;

d) glide tests (e.g. drop from helicopter) if deemed necessary;

e) one stage firings to test recovery, tracking and telemetry systems, and for performance evaluation;

f) two-stage firings with performance evaluation;

g) multistage firings with performance evaluation including evaluation of attack profile capabilities;

h) navy trials.

2.5 Phase V — Advanced Development

If the flight test program is completed successfully and a decision is made by CF to proceed with ROBOT-X advanced development the following steps will be taken:

a) modification of the ROBOT-X vehicle to an advanced development version including the implementation of construction techniques compatible with anticipated usage rates;

b) evaluation of ROBOT-X for suitability for use as a look-down, shoot-down target, and as an air launched target;

c) advise advanced development prime contractor and armed forces as required on any technical problems that arise in connection with advanced development models;

d) transfer ROBOT-X technology to the private sector for target production.

In addition, further testing and modification of ROBOT-X may be undertaken to extend its performance capabilities (e.g. to improve range and increase average velocity).

3. PROGRAM SCHEDULE AND CURRENT STATUS

The original program schedule proposed in September, 1981 is given in Figure 8. Since this schedule was proposed, a considerable amount of progress has been made and a number of schedule adjustments have been incorporated. The revised schedule is also given in Figure 8. As may be seen from this figure, these changes have resulted in significantly more overlap among Phases I, II and III, and a somewhat later start to the flight testing and advanced development.

Currently ROBOT-X development activities are transitioning between Phases II and III. The feasibility assessment of Phase I has been completed with the conclusion that the ROBOT-X concept is a technically valid concept. A written feasibility report is

still pending and will be completed in the fall of 1982. This report will also incorporate some of the Phase II data currently available (e.g. wind tunnel test data). All Phase I work has been carried out on an inhouse DRES basis.

Phase II of the program is currently nearing completion. Two wind tunnel configurations (Figures 4 and 5) were designed as an inhouse activity, and tested in the National Aeronautical Establishment's transonic wind tunnel in June 1982, six months ahead of the orignal schedule. The wind tunnel models' (Figures 9 and 10) detailed structural design and fabrication were carried out under contract with private industry.

Also as part of Phase II, an R & D contract has been let for the ROBOT-X control law synthesis. This contract will result in the control laws and control logic for the vehicle, based on the estimated aerodynamic character istics, by December, 1982, and will close out Phase II of the development program.

Concurrently with these Phase II developments, Requests for Proposals were prepared for the ROBOT-X detailed prototype airframe design and construction and detailed prototype autopilot design and construction. These multiphase contracts were awarded in November, 1982 and will gradually transition the program to Phase III developments with the prototype airframe and autopilot deliveries scheduled for early 1984 for static and flight testing. The autopilot development is additionally intended for general use with other RPV and drone vehicles under investigation at DRES.

Currently the program is approximately four to six months ahead of the original schedule. However, it appears that the time alloted in the original schedule for detailed design and prototype construction was underestimated, and thus in all likelihood the flight testing will begin in the second half of 1984, somewhat later than originally planned.

The current program status and revised milestones are summarized in Table 1.

4. DEVELOPMENT PHILOSOPHY AND FUNDING BASIS

The ROBOT-X vehicle development is proceeding with the objective of flight testing a number of proof-of-concept vehicles in 1984 and 1985. This will allow the development of a substantial inhouse Canadian industry expertise in highspeed RPV's and drones. The development is proceeding with CRAD R & D funding under the technical base program 21V. This development will also allow a more accurate assessment of the cost of an advanced development version of ROBOT-X.

In parallel with this proof-of-concept development, both the Canadian Forces and Canadian industry have been briefed on the objectives of the ROBOT-X program.

The CF (N) have a high level of interest in the target as a missile target for the DDH-280 class destroyers, as a radar tracking exercise target, and as a potential exercise target for the surface-to-air weapon systems of the upcoming Canadian Patrol Frigate (CPF) ships. As well, the CF (N) recognize the potential of ROBOT-X as a target usable by the CPF contractors for weapon system development and evaluation during the commissioning of the ships.

The navy's interest is a continuation of their interest in and tasking support of the ROBOT-9 ballistic target (Reference 1), and focuses on the low-cost features of the rocket-boosted systems. ROBOT-9 has been accepted as an interim Sea Sparrow and radar tracking training target while a more sophisticated system is acquired. The initial estimates of ROBOT-9 usage rates were for 10 vehicles per year, but now it appears that at least twice that number will be used. Similar usage increase may also occur for a ROBOT-X type vehicle once it is available.

Because of this high level of interest within the CF (N), efforts are currently under way to establish a tasking arrangement between the Canadian navy and DRES for evaluating a navy version of ROBOT-X.

The ROBOT-X vehicle is also potentially usable by both the CF (Land) as a low level air defence target and the CF (Air) as a look-down, shoot-down target. The level of interest of these elements will be determined largely by the success of the proof-of-concept program in keeping unit costs relatively low.

A number of Canadian companies (Bristol Aerospace Ltd., Boeing of Canada Ltd., Field Aviation West Ltd. and Northwest Industries Ltd.) were briefed in early 1982 on the DRES rocket-boosted programs. Emphasis was placed on realistic appraisals of CF ROBOT-X usage rates, i.e. that the navy will use 10 vehicles per year from 1986 onwards with this number increasing with the arrival of the CPF ships. Industry was made aware of the potential use of ROBOT-X by CF (Land) and CF (Air). Emphasis was also placed on the need for market assessment of sales potential offshore. Finally, usage by the Canadian navy well into the 1990's was stressed.

A high level of interest has been expressed by Boeing of Canada Ltd. This corporate interest is due to DRES's interest in composite material airframes and may also

be due in part to a renewed interest within parent company Boeing Military Airplane Co. (Wichita) in RPV and drone technology, e.g., as in the Pave Tiger harassment drone program.

Boeing appears to have carried out preliminary research into the marketability of ROBOT-9 and ROBOT-X type vehicles. The results of this research are not currently available to DRES, but do not appear to have reduced the company's level of interest.

5. ROBOT-X R & D CONTRACT REVIEW

While conceptual control of the program has remained with DRES, and will continue to do so, much of the development work has been and will continue to be put out to industry. In particular, five major areas that have and/or will require contractor support are as follows:

a) Autopilot control law synthesis.

b) Wind tunnel model detailed structural design, fabrication and testing.

c) Detailed airframe structural design and prototype construction.

d) Detailed autopilot hardware design and prototype construction.

e) DRES range facility development.

Of these areas, (d) and (e) are relevant to all DRES RPV and drone research. Contract activities in these areas will thus be of benefit to several ongoing programs and will not be directed solely to the ROBOT-X development.

Every effort has been made to cooperate with contract bidders, and to carry out the bidding process in accordance with DSS guidelines and regulations. For one request for proposal (RFP), the ROBOT-X detailed airframe design and construction, a bidders' conference was held. Also, bidders suggested by DSS on the basis of DSS company files have been added to the DRES suggested list of bidders for a number of the RFP's.

Past, present and future related and direct ROBOT-X contracts, and the funding involved, are now reviewed. For the R & D contracts that are pending and for which bids have not yet been received, funding estimates and timing are only approximate. In some cases the R & D contracts have intentionally been phased in a way that will allow for more precise, intermediate assessments of the cost and scope of the program. This

will permit tailoring to reduce R & D expenditures to an acceptable level. If such tailoring is found to produce unacceptable reduction of the scope of the program, then the viability of the program will be reassessed and a decision made on whether to proceed with PDP/PCP action.

The contract summary follows.

5.1 Structural Design and Construction of Wind Tunnel ROBOT-X Models

The intent of the RFP was to determine a company with the capability to design and construct ROBOT-X wind tunnel models (two configurations, see Figures 9 and 10) based on DRES supplied external configurations, within the National Aeronautical Establishment's (NAE) model criteria, and to be available for use by June 1, 1982.

The RFP was sent out to bidders on April 11, 1982. The companies invited to bid were:

1) Advanced Dynamics Corp Ltd.,
2) Bristol Aerospace Ltd.,
3) Hatch Associates Ltd.,
4) Marshall Macklin Monaghan Ltd.,
5) Phoenix Trading Co.,
6) Precision Machine Engineering Ltd.

DRES estimated cost to complete the work was $40K. Bids were received from (1) and (5), with (1) winning because of a stronger commitment to the required completion date and a substantially lower cost bid at $37.5K. The contract was awarded on April 13, 1982.

The ROBOT-X wind tunnel models were completed on schedule and within budget and accepted by DRES on June 4, 1982. Wind tunnel testing (5 testing days) was carried out in late June and early July, 1982 of both configurations in the NAE trisonic facility in Ottawa. The funding for the wind tunnel testing came from a general research FE made available by CRAD to the NAE for use by the research establishments for aerodynamic testing (Memorandum 3622-1 (DST(OV)-7), March, 1982), and did not come from DRES R & D funds. Testing cost in terms of equivalent NAE charges to the private sector were estimated to be $30K.

Tentative booking for future wind tunnel testing of ROBOT-X has been made with the NAE for the fall of 1983, although this testing may not be required. $10K has been allocated from TP21V R & D funds for wind tunnel model modification in Fiscal Year 1983.

5.2 ROBOT-X Control Law Synthesis

The objective of this contract was to determine the ROBOT-X automatic pilot control laws and control logic for both stability augmentation system (SAS) functions and outer-loop guidance functions, e.g. altitude hold, given DRES supplied estimates of the aerodynamic characteristics. The RFP was directed to the University of Toronto Institute for Aerospace Studies (UTIAS) because of the highly specialized nature of the analysis involved and their resident expertise.

The contract was estimated to cost $25K. It was awarded to UTIAS on April 20, 1982 for $28K. The contract work is on schedule and will be completed in December, 1982 as originally planned. UTIAS requests for an additional $3K for computer simulation funds were justified and have been approved, bringing the total cost of this contract to $31K.

Provision has been made for an additional $20K for a follow-on contract in Fiscal Year 1983. The intent of the follow-on contract, if required, will be to update the control laws based on the wind tunnel aerodynamic data, and to check for sensitivity to changes in vehicle characteristics.

5.3 ROBOT-X Detailed Airframe Design and Construction

The intent of this multiphase contract is to examine low-cost composite material fabrication techniques for use in the construction of the ROBOT-X airframe, to carry out the detailed ROBOT-X airframe design, and to construct up to twenty prototype ROBOT-X airframes for use in flight testing. The RFP was sent out to bidders August 11, 1982, and has four phases:

1) **Design Review** — This phase is intended to provide the contractor with all data that is available to DRES, including feasibility assessment data, wind tunnel data, and a detailed specification of airframe design loadings, requirements and external configuration from which a detailed airframe design and construction program

may be formulated. Consideration will be given to composite fabrication techniques and materials.

Phase 1 is nominally scheduled to end in March 1983, and was estimated to cost $40K.

2) **Analysis and Design** — The intent of this phase is to produce engineering drawings, stress reports and prototype production cost estimates (10 and 20 units) for the ROBOT-X airframes. The airframe contractor will also be responsible for designing and/or acquiring a parachute recovery system.

   Phase 2 is nominally scheduled to end in September, 1983.

3) **Prototype Fabrication** — The intent of this phase is to have the contractor fabricate 10 – 20 prototype airframes of ROBOT-X, and perform inhouse structural tests on subcomponent assemblies as required.

   Phase 3 is nominally scheduled to end in June, 1984.

4) **Flight Testing** — The intent of this phase is to have the contractor provide technical support to DRES during the flight testing of ROBOT-X.

   Phase 4 is nominally scheduled to end in June, 1985.

It is impossible at this point in time to reasonably establish individual funding levels for Phases 2, 3 and 4. $200K has been allocated to these phases over Fiscal Years 1983 and 1984, for a total of $240K for the airframe contract.

The companies invited to bid were:

1) Boeing of Canada Ltd.,
2) Bristol Aerospace Ltd.,
3) Uniroyal Ltd.,
4) Field Aviation West Ltd.,
5) Northwest Industries Ltd.,
6) DeHavilland of Canada Ltd.,
7) Canadair Ltd.

[redacted]

Because of the need for clarification in the intent of the phasing of the RFP, a bidders' conference was called and held on August 30, 1982, at DRES. The closing date was extended from September 8, 1982 to October 1, and then to October 15, 1982. Attending the bidders' conference were DRES and DSS representatives, and representatives from companies (1), (2), (4) and (7) above.

Bidders were requested to provide fixed price bids for the first phase and rough order of magnitude (ROM) bids (± 20%) for the second phase.

Only one bid was received, a technically acceptable proposal from Boeing of Canada Ltd., with a Phase 1 price bid at $34,707.00 and a ROM Phase 2 bid at $81,430.00. Contract award is expected to occur in November, 1982.

5.4 Autopilot Development

The intent of this multiphase contract is to examine both conceptually and with detailed hardware design and fabrication, low-cost three-axis automatic pilot systems.

While the RFP is presented in terms of ROBOT-X requirements, the automatic pilot is intended to be digitally programmable and will thus be suitable for use with most DRES RPV and drone systems.

The RFP was sent out to bidders August 18, 1982 and has been phased as follows:

1) **Review of Autopilot Requirements** — This phase is intended to provide the contractor with all required data that is available to DRES, including feasiblilty assessment data, wind tunnel data, control law synthesis data, and a detailed specification of autopilot operating environment and requirements from which a detailed airframe design and construction program may be formulated.

   Phase 1 is nominally scheduled to end in March, 1983 and was estimated to cost $25K.

2) **Design of Autopilot** — The intent of this phase is to produce a detailed design with design drawings for the three-axis autopilot. Breadboarded design units may also be required.

   Phase 2 is nominally scheduled to end in January, 1984.

3) **Prototype Fabrication and Test** — The intent of this phase is to have the contractor fabricate 10 to 20 autopilot units as designed in Phase 2, complete inhouse bench testing as required, and provide flight testing support for the autopilot system as deemed necessary by DRES.

   Phase 3, including flight testing of the system, is nominally scheduled to end in June of 1985.

It is impossible at this point in time to reasonably establish individual funding levels for Phases 2 and 3. $125K has been allocated to these phases over Fiscal Years 1983 and 1984, for a total of $150K for the autopilot development.

The companies invited to bid were:

1) Bristol Aerospace Ltd.,
2) Canadian Astronautics Ltd.,
3) Boeing of Canada Ltd.,
4) Spar Aerospace Ltd.,
5) Field Aviation West Ltd.,
6) SED Systems Inc.,
7) Atlantis Flight Research Inc.

At the request of a number of bidders, the original closing date for the RFP, September 17, 1982, was extended to October 15, 1982. As well, a bidders' conference was scheduled for September 19, 1982, but later cancelled due to only one bidder making a firm commitment to attend.

Bidders were requested to provide fixed price bids for the first phase and ROM bids (± 25%) for the second phase.

Only one bid was received, a technically acceptable proposal from Atlantis Flight Research Inc. with a Phase 1 price bid at $32257.20 and a ROM Phase 2 bid at $56050.81. Contract award is expected to occur in November, 1982.

5.5 R & D Contract Funding Summary

A number of direct ROBOT-X flight testing support requirements are

incorporated in the R & D contracts described in the previous sections. Range preparation and instrumentation requirements are part of a general range improvement intended for all DRES RPV and drone activities, and will not be discussed further in this report other than to summarize funding levels in Table 2.

Table 2 summarizies current best estimates of ROBOT-X direct and related R & D contract funding requirements. Data is also incorporated summarizing expenditures to date.

Fiscal Year 1983 funding for items 1 and 2 may prove to be unnecessary, and autopilot funding is only a related cost and not specifically directed to ROBOT-X. The R & D funds were anticipated and included in RDPIS requests.

6. ROBOT-X TTCP BRIEFING

A condensed version of this report, deleting funding estimates, was presented to TTCP panel HTP-1 (aerial targets and drones) in September, 1982, and was well received by both U.S. and U.K. delegates. Subsequent discussion with U.K. delegates considered the possibity of ROBOT-X naval evaluation and flight testing using British instrumented range facilities at Aberporth. This possibility will be investigated further.

7. ROBOT-X ESTIMATED UNIT COSTS

Better estimates of ROBOT-X unit costs will be available after the Phase 3 bids for the airframe and autopilot contracts are submitted. Current estimates suggest unit costs of $35K in 1982 Canadian dollars are achievable. This estimate does not include the cost of the rocket motors.

8. SUMMARY

The ROBOT-X concept with its use of a staged 2.75 inch rocket motor propulsion system promises to be a low-cost approach to providing the CF (N) with an antiship missile target. A four year program has been described that will result in a number of proof-of-concept engineering ROBOT-X prototypes, and may eventually lead to an advanced version of the vehicle for use by the Canadian Forces.

The development program requires extensive DRES inputs towards the vehicle design. Contractor support has been stressed in the detailed airframe and avionics design

and construction areas. This is intended to facilitate the ultimate transfer of the technology to private industry.

Development work is currently entering the detailed prototype design and fabrication stage (Phase III). It is anticipated that the first prototypes will be ready for flight testing by the middle of 1984.

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2. Schilling, K. **A Winged Rocket Boosted Target (ROBOT-X) (U).** Suffield Memorandum No. 1062, Defence Research Establishment Suffield, September 1981. RESTRICTED.

[redacted]

TABLE 1. REVISED ROBOT-X DEVELOPMENT PROGRAM MILESTONES

PHASE	MILESTONE	STATUS	DATE
I FEASIBILITY ASSESSMENT	Preliminary Performace Assessment (DRES)	Complete	September, 1981
	Preliminary Configuration Design (DRES)	Complete	October, 1981
	Development Program Formulation (DRES)	Complete	October, 1981
	Aerodynamic Characteristic Prediction Software (DRES)	Complete	January, 1981
	Natural Mode Prediction Software (DRES)	Complete	January, 1982
	Feasibility Assessment (DRES)	Complete	July, 1982
	Feasibility Assessment Report (DRES)	Draft in Preparation	December, 1982
II CONFIGURATION DESIGN	Wind Tunnel Models' Configuration Design (DRES)	Complete	March, 1982
	Wind Tunnel Models Detailed Structural Design and Construction Contract Award (ADCL)	Awarded	April 2, 1982
	Control Law Synthesis Contract Award (UTIAS)	Awarded	April 20, 1982
	Wind Tunnel Model Delivery to National Aeronautical Establishment	Complete	June 4, 1982
	Wind Tunnel Testing (NAE, DRES planned and supervised test program)	Complete	June 28 – July 7 1982
	Six Degree-of-Freedom Simulation Software	In Preparation	September, 1982
	Evaluation of Wind Tunnel Data (DRES)	In Progress	December, 1982
	Sizing of Aerodynamic Control Surfaces and Estimation of Hinge Moments (DRES)	In Progress	December, 1982
	Preliminary Structural Design (DRES)	In Progress	December, 1982
	Preliminary Autopilot Configuration Assessment (DRES)	In Progress	December, 1982
	Prototype Configuration Specification (DRES)	In Progress	January, 1983
	Phase II Completion		February, 1983

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TABLE 1. REVISED ROBOT-X DEVELOPMENT PROGRAM MILESTONES
(Continued)

PHASE	MILESTONE	STATUS	DATE
III PROTOTYPE DESIGN AND CONSTRUCTION	Prototype Airframe Detailed Design and Construction Contract Award	To Bidders	October, 1982
	Prototype Autopilot Detailed and Construction Contract Award	To Bidders	October, 1982
	Subsystem Testing (DRES)		June 1983 to June 1984
	Prototype Airframe Delivery		January, 1984
	Prototype Autopilot Delivery		January, 1984
IV FLIGHT TESTING	Range Preparation (DRES + Contract)	In Progress	
	First Flight (DRES Range with Contractor Support as Required)		June, 1984
	Navy Trials (CF, DRES)		
V ADVANCED DEVELOPMENT	Bidding and Negotiation for Contract (DSS)		December 1984 to June, 1985
	Advanced Vehicle Contract Award (DSS)		June, 1985
	Technical Support to Contract (DRES)	As Required	June, 1985

[redacted]

[redacted]

TABLE 2. ROBOT-X DIRECT AND RELATED R & D CONTRACT FUNDING REQUIREMENTS

ACTIVITY		EXPENDITURE BY FY (Thousands of $) (E = Estimate)		
Direct Activities		**1982/83**	**1983/84**	**1984/85**
A.1	Wind Tunnel Model — Design and Fabrication	37.5	10.0 (E)	0
	— Testing at NAE	30.0	20.0 (E)	0
A.2	Control Law Synthesis	31.0	20.0 (E)	0
A.3	ROBOT-X Detailed Airframe Design and Prototype Construction	40.0 (E)	125.0 (E)	75.0 (E)
A.4	Flight Testing	0	0	50.0 (E)
TOTAL DIRECT COSTS		**138.5**	**175.0 (E)**	**125.0 (E)**
Technology Base Activities Related to ROBOT-X		**1982/83**	**1983/84**	**1984/85**
B.1	Autopilot	25.0 (E)	80.0 (E)	45.0 (E)
B.2	Range Development			
	— Instrumentation	370.0	80.0 (E)	0
	— Tracking Radar	60.0	0	0
	— Tracking Cameras	0	90.0 (E)	30.0 (E)
TOTAL RELATED COSTS		**455.0 (E)**	**250.0 (E)**	**75.0 (E)**

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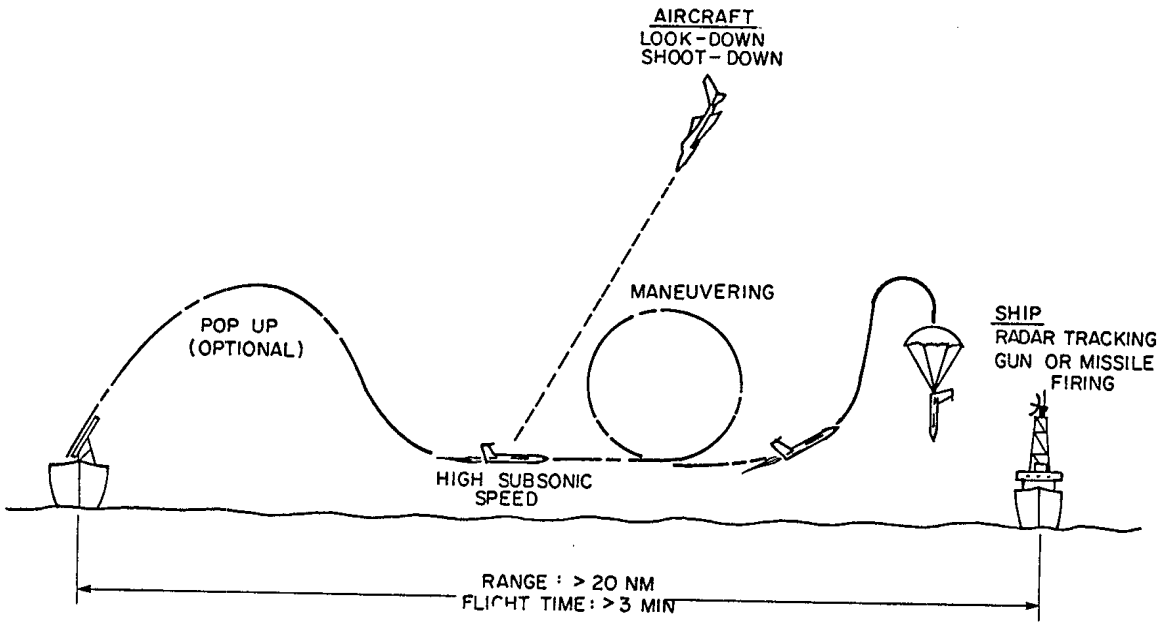

FIGURE 1: ROBOT-X NAVY SCENARIO

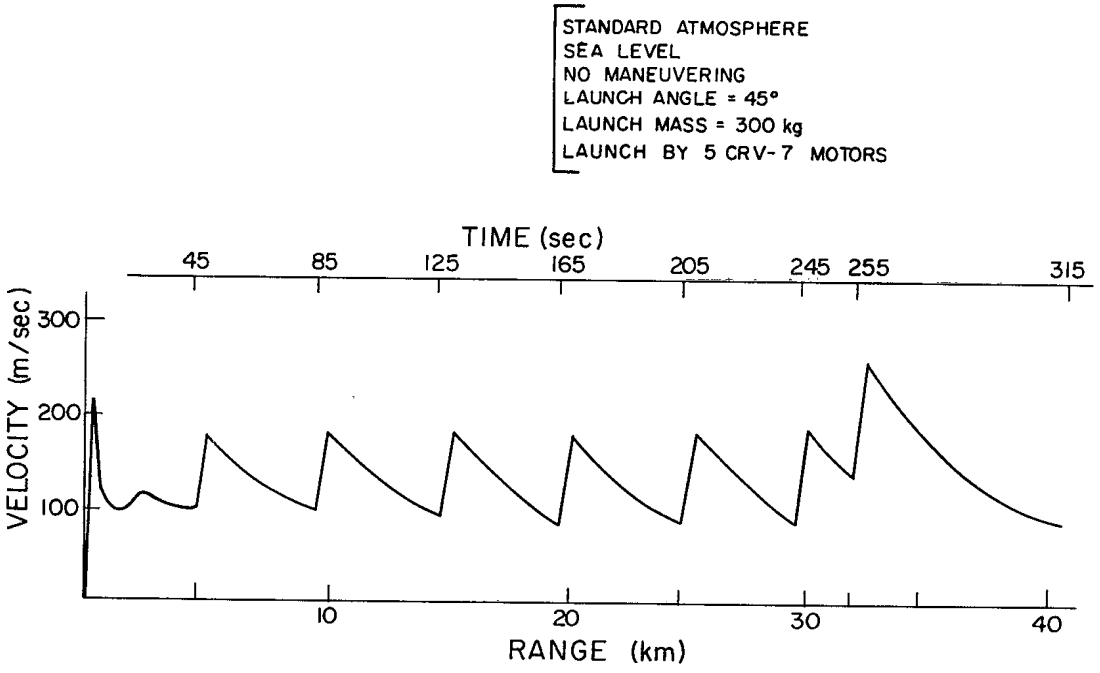

FIGURE 2: ROBOT-X TYPICAL VELOCITY PROFILE

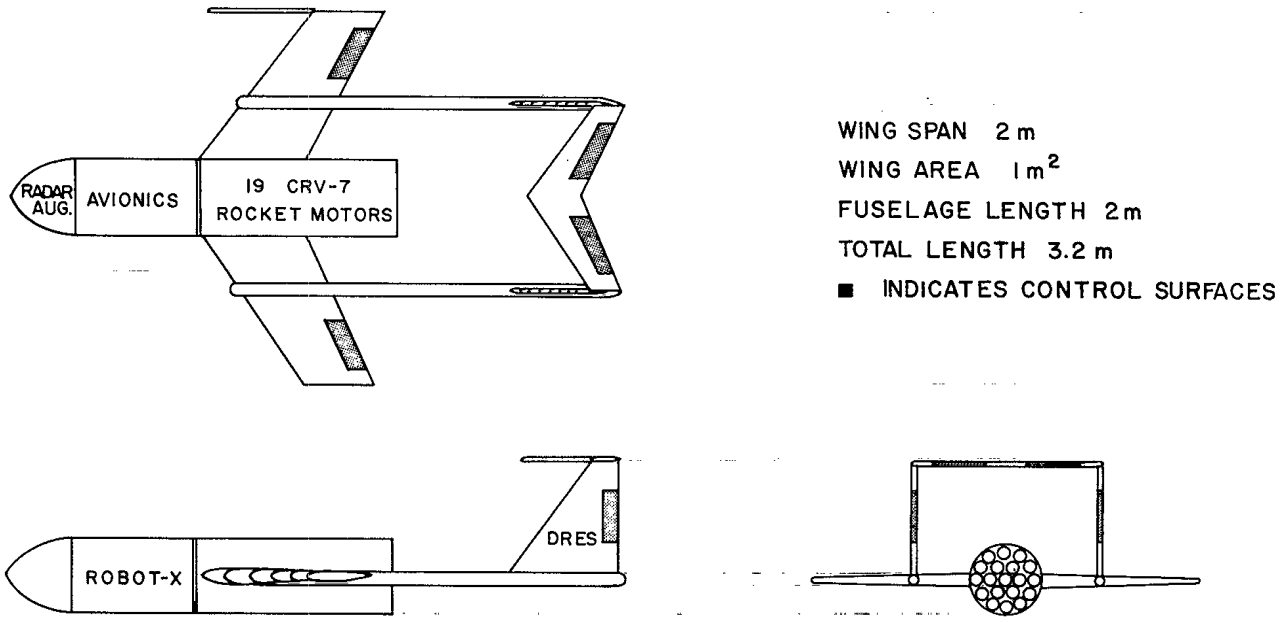

FIGURE 3: ROBOT-X BOOM CONFIGURATION

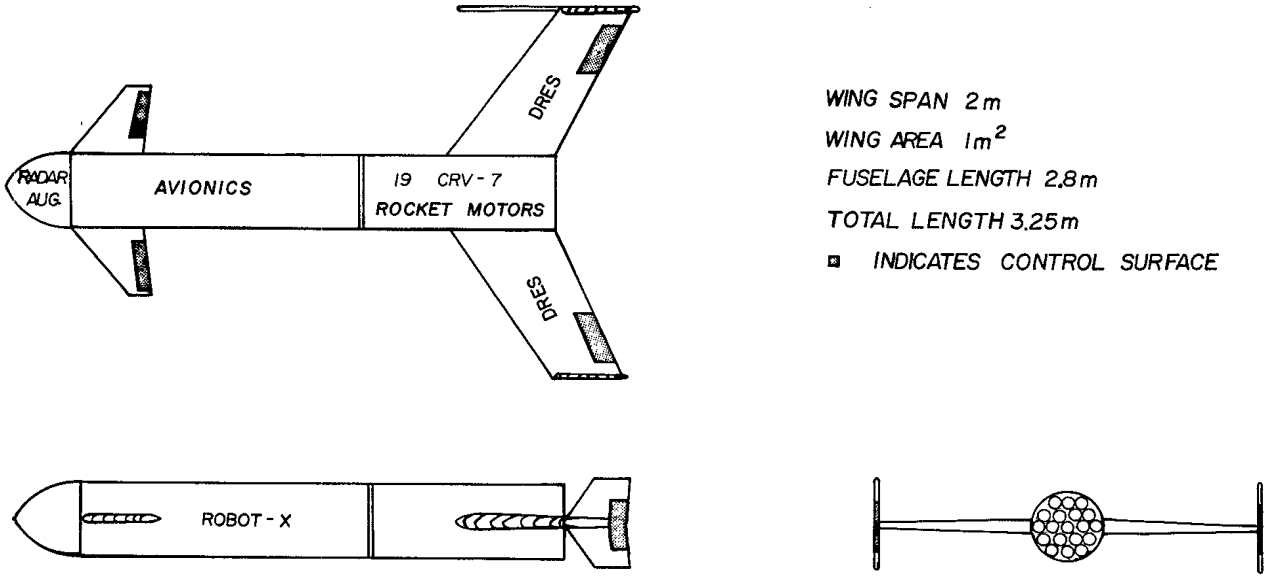

FIGURE 4: ROBOT-X ORIGINAL CANARD CONFIGURATION

[redacted]

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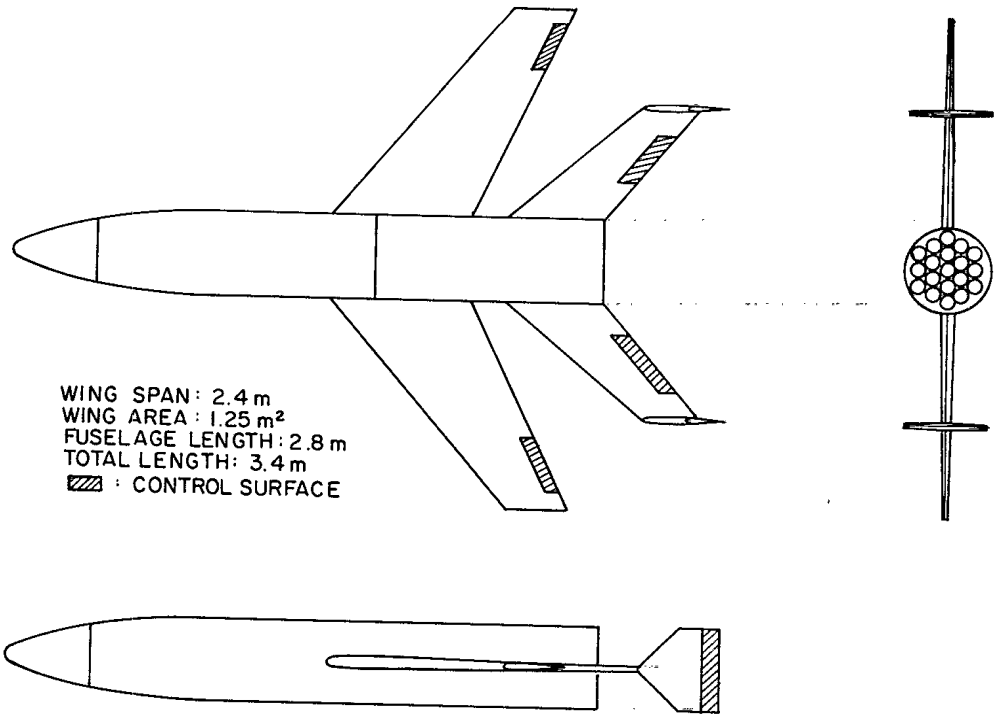

FIGURE 5: ROBOT-X WIND TUNNEL CONVENTIONAL CONFIGURATION

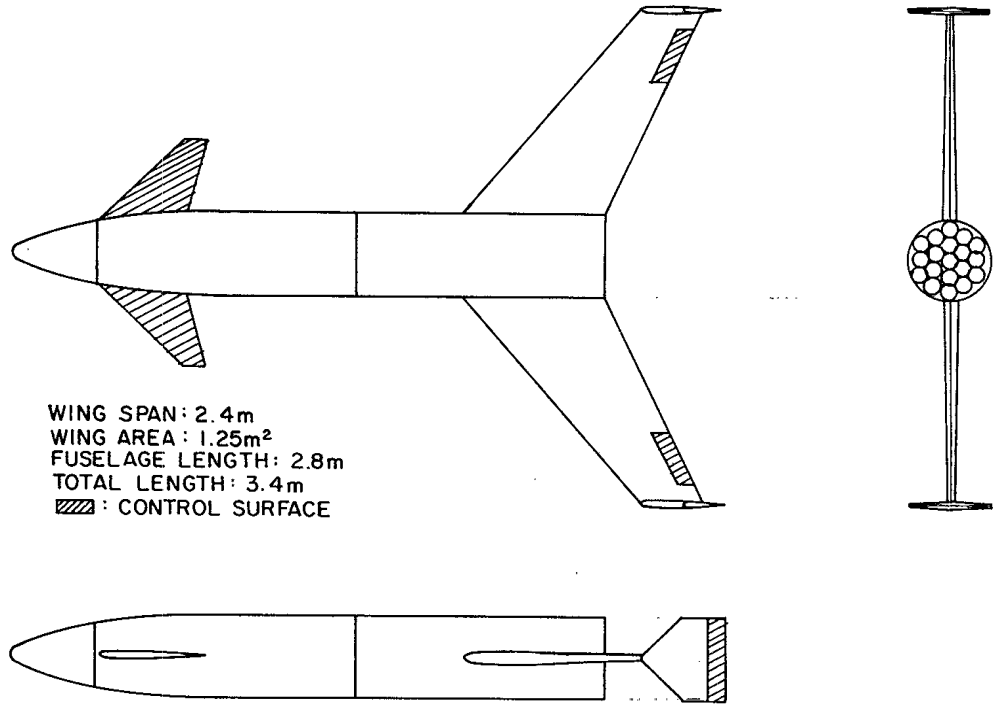

FIGURE 6: ROBOT-X WIND TUNNEL CANARD CONFIGURATION

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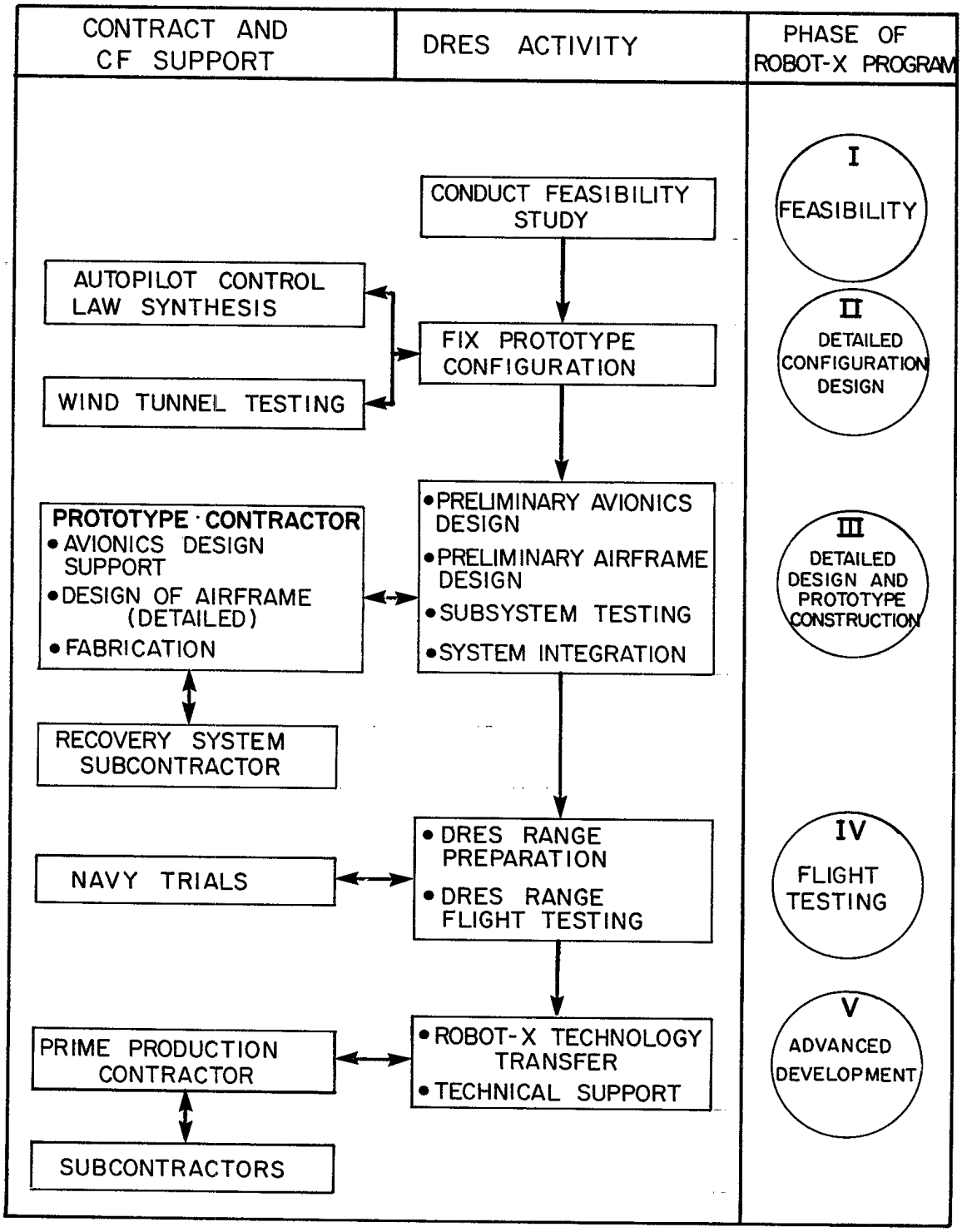

FIGURE 7: ROBOT-X DEVELOPMENT PROGRAM

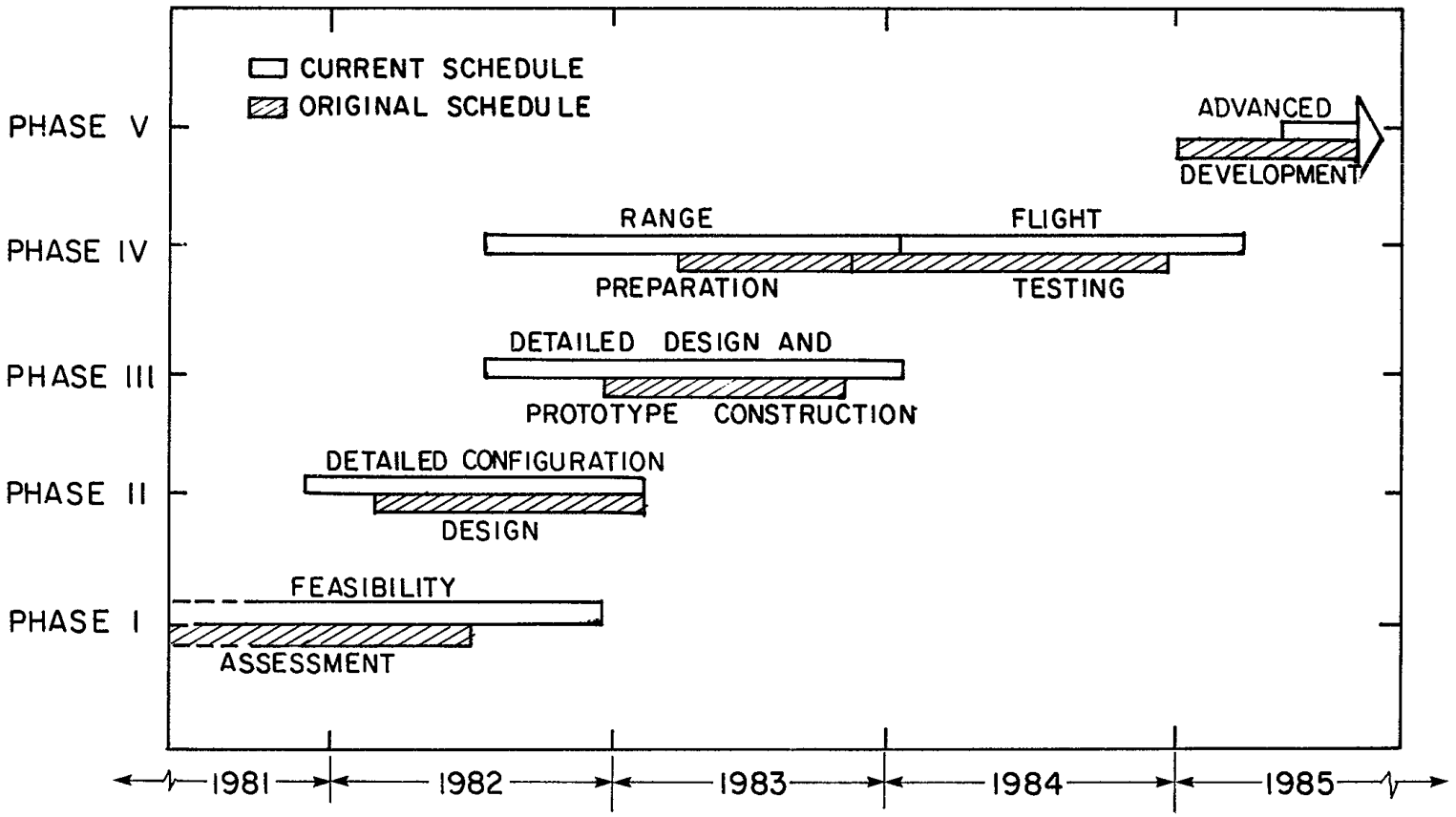

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FIGURE 8: ROBOT-X DEVELOPMENT PROGRAM SCHEDULE

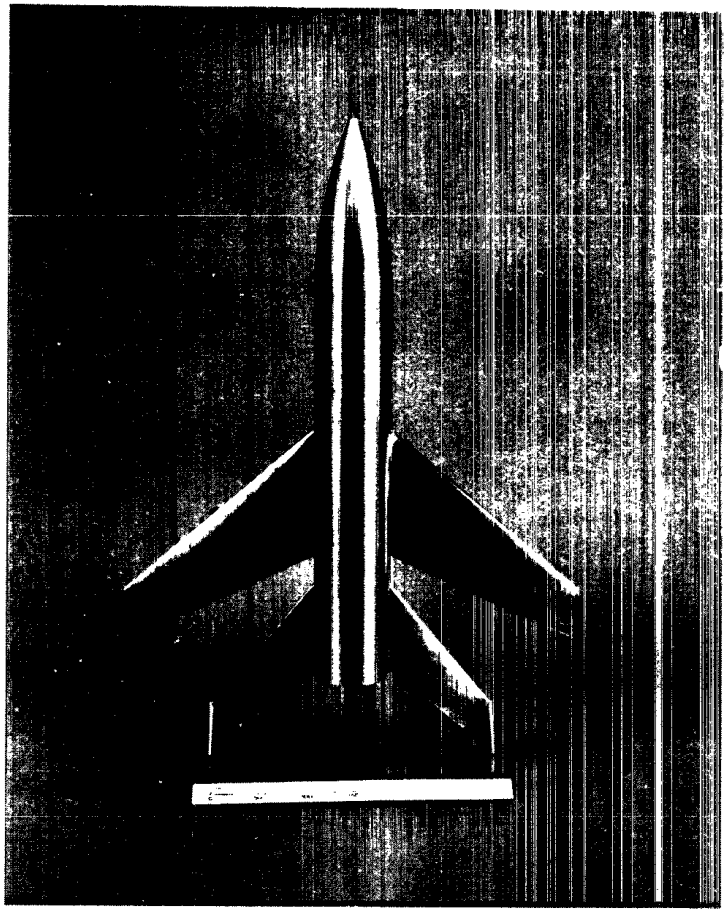

FIGURE 9: ROBOT X CONVENTIONAL
WIND TUNNEL MODEL

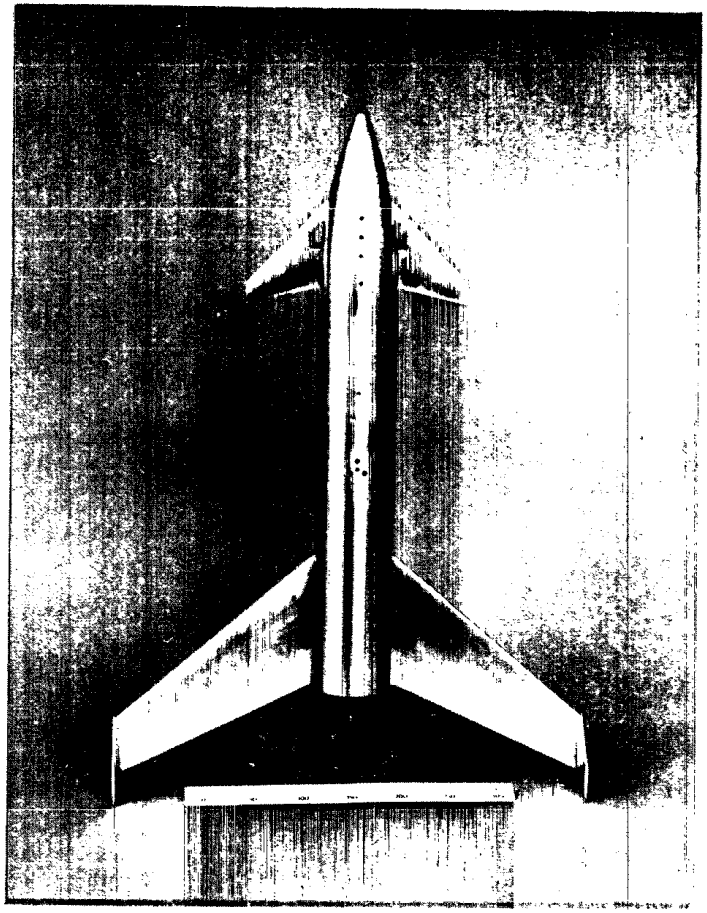

FIGURE 10: ROBOT X CANARD
WIND TUNNEL MODEL

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13. ABSTRACT

Progress in the development of proof-of-concept prototypes of a winged, rocket-boosted target (ROBOT-X) simulating low altitude, high subsonic speed invader aircraft and antiship missiles is summarized. The development program is described in detail. Expenditure summaries to the present stage and anticipated future funding requirements are included, with emphasis on R&D contract funding requirements. A detailed breadkown of past, present and future R&D contracts is given. (U)

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KEY WORDS

Aerial Target
Antiship Missile Target
ROBOT System
ROBOT-X
Rocket-Boosted Target

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