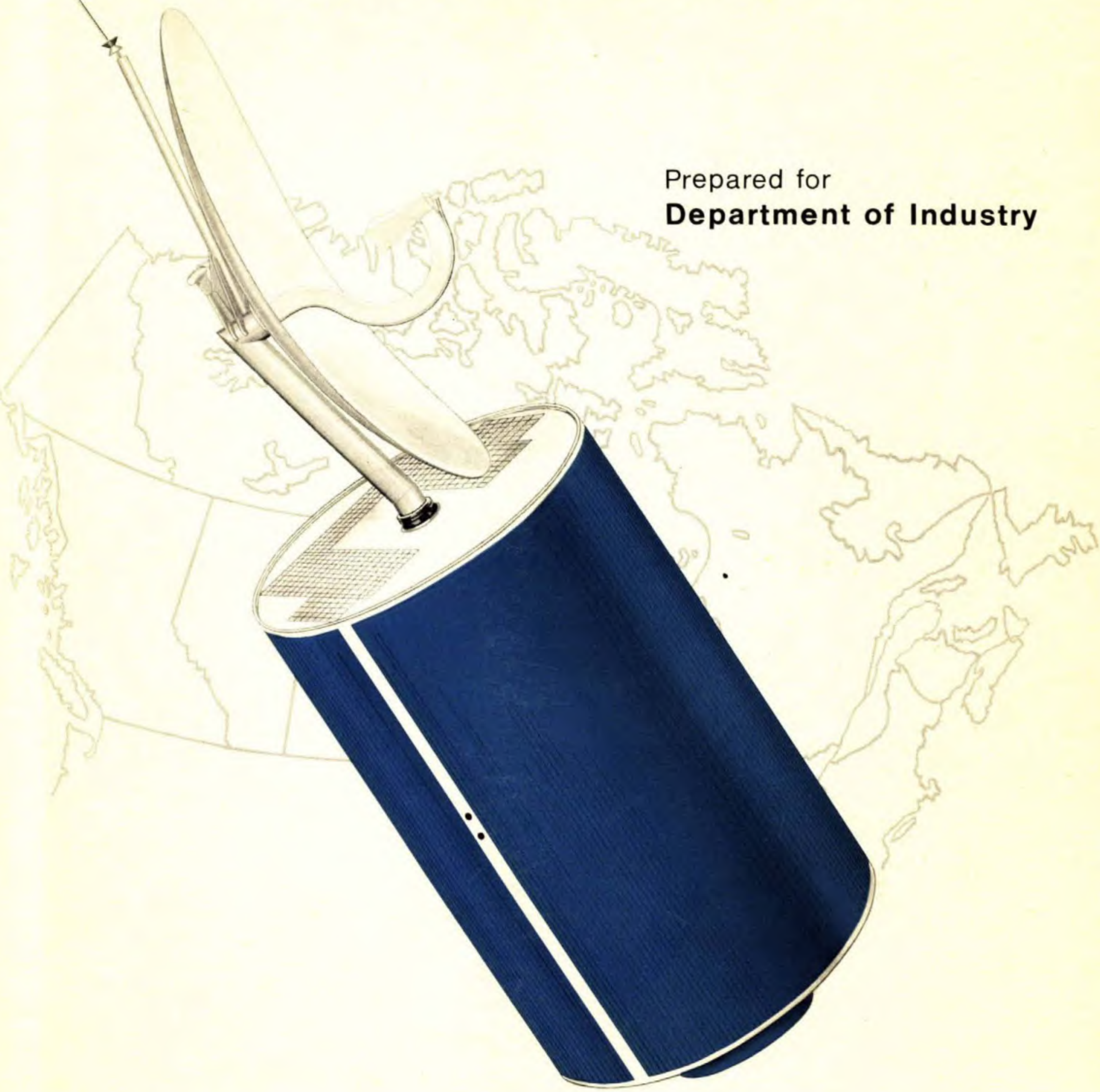
Study Program for
Canadian Domestic Communications Satellite



Prepared for
Department of Industry

Final Report
Volume Four - Program Plan

RCA Space Systems

Copy No. 4

STUDY PROGRAM

for the

DESIGN, DEVELOPMENT AND SUPPLY

of a

DOMESTIC SATELLITE COMMUNICATIONS SYSTEM

FINAL REPORT
VOLUME 4, PROGRAM PLAN

Prepared for

DEPARTMENT OF INDUSTRY

by

RCA LIMITED, Space Systems
1001 Lenoir Street, Montreal

PROPOSITION No. 2220-1

NOVEMBER 25th, 1968

PREFACE

This report is submitted by RCA Limited to the Department of Industry in compliance with Section 4.2 of the Statement of Work forming part of D.O.I. Contract, File No. IRA. 9122-03-4.

The report is in six volumes, namely:

Volume 1	Design Considerations
Volume 2(a)	Spacecraft Design - Electrical
Volume 2(b)	Spacecraft Design - Mechanical
Volume 3	Technical Appendices
Volume 4	Program Plan
Volume 5	Program Costs

The information contained in the report is supplied to Her Majesty for use solely in connection with the design, development, manufacture, operation, repair, maintenance and testing of a Canadian Domestic Satellite Communication System.

IV 1
INTRODUCTION
& SCHEDULE

1. INTRODUCTION AND SCHEDULE

1.1 INTRODUCTION

This volume of the report constitutes the Program Plan as specified in the Study Program work statement. Immediately following, within the Introduction, are the Task Breakdown Structure and the Program Master Schedule, followed by a listing of the major milestones.

The Introduction to the second section of this volume includes some comments in respect to the generation of Canadian content and the trade-offs which have been considered. The proposed development plan covering the major program phases is then discussed, including the pertinent schedules.

Section three of this volume discusses the proposed Organizational Structure and the various subcontractor arrangements. This section also summarizes the distribution of work between the subcontractors.

Section three also presents the proposed Management Plan including that of the prime contractor's program office, and the major management plans.

The final section of this volume outlines the resources and facilities of the major companies which might be included in such a program.

1.2 TASK BREAKDOWN STRUCTURE

The task breakdown for the Canadian Domestic Communications Satellite Program is based on a study of the program requirements (output) against the work (input) necessary to produce the various spacecraft and ancillary equipments. The output of the program is systems and equipment development, an engineering model, a prototype model and three flight model spacecraft.

Each of these outputs in turn can be broken into subsystems such as communication, power, structure and so on. The subsystems themselves consist of units such as tunnel diode amplifiers, power converters, telemetry transmitters and filters to name a few. It is possible at a later stage of design to further analyse the units into sub units and their respective electronic and mechanical components. With the work that has been completed in this study it has been possible to identify the major units that make up each subsystem and of course the subsystems that make up each spacecraft.

The input side of the task breakdown has its own hierarchy in the activities (labour) and material that are expended in the production of the spacecraft.

The activity hierarchy starts with the major activities of engineering, manufacturing, integration and launch. Activities related to the implementation of the program such as program management, system engineering, reliability and quality assurance are covered in a separate category. Within the major activities one finds minor activities such as design and development, fabrication, assembly, test, etc.

The relationship between the program inputs and outputs is summarized in a task breakdown matrix, a sample page of which appears in Figure 1-1. The total matrix covering all spacecraft models and subsystems broken down to one unit level, consists of 23 pages with the program inputs (activities and material) appearing as column headings in the matrix. The task breakdown matrix row headings are the subsystems with their associated units which are the program outputs.

Where a task occurs the matrix crosspoint is marked with a dot. The requirement for a task is determined by the model, whether it be development, engineering, prototype of flight and the sourcing (RCA or subcontract) of the particular unit. It can be seen that each subcontracted unit requires a task in subcontract follow-up.

In summary, the task breakdown structure employed in analysing this program is based on an anlysis of two separate vectors; the program outputs (spacecraft), and the program inputs (activities and material). These vectors are combined in a task breakdown matrix which in turn indicates the specific tasks to be performed. The task breakdown structure is related to the diagram shown as Figure 1-2.

1.3 PROJECT SCHEDULE

1.3.1 Introduction

The project schedule displayed in this report is designed to focus on the project phases. The Project Master Schedule (Figure 1-3) follows while the various secondary schedules may be found in the section of the development program to which they refer. Table 1.1 lists the major milestones. The schedule presentation is as follows:-

Figure 1-3	Project Master Schedule
Figure 2-1	Subsystem Development Schedule
Figure 2-12	Spacecraft Integration and Environmental Test
Figure 2-14	Launch Operations Schedule

TASK BREAKDOWN

MATRIX

Project : CDCS 2220/I

Date : October 21, 1968

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ENGINEERING MODEL

		PROGRAM						ENGINEERING							MFR.				INTEGRATION				LAUNCH		
		Project Management	System Engineering	Reliability Engineering	Q.A. Engineering	Q.C. Support	Subcontract Material	Design and Development	Test Design	Unit Testing	Factory Follow-up	Subcontract Follow-up				Fabrication	Assembly			Subsystem Integration & Test	Spacecraft Integration & Test	Spacecraft Qualification/Acceptance	Range/Launch Operations	Post Launch Operations	
CODE	EQUIPMENT	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
20.00	Engineering Model					●															●				
21.00	Communications Subsystem		●	●																●					
21.01	Command Suppress Filter							●		●															
21.02	Comb Filter							●		●															
21.03	Coax Switch Spdt					●						●													
21.04	6 GHZ TDA					●				●		●													
21.05	Mixer							●		●															
21.06	Local Oscillator							●		●															
21.07	4 GHZ TDA					●				●		●													
21.08	Driver TWT					●				●		●													
21.09	I/P Multiplexer/Equalizer							●		●															
21.10	PIN Diode Attenuator							●		●															
21.11	Output TWT					●				●		●													
21.12	Isolator 4 GHZ					●						●													

Figure 1-1
Sample Page of Task Breakdown Matrix

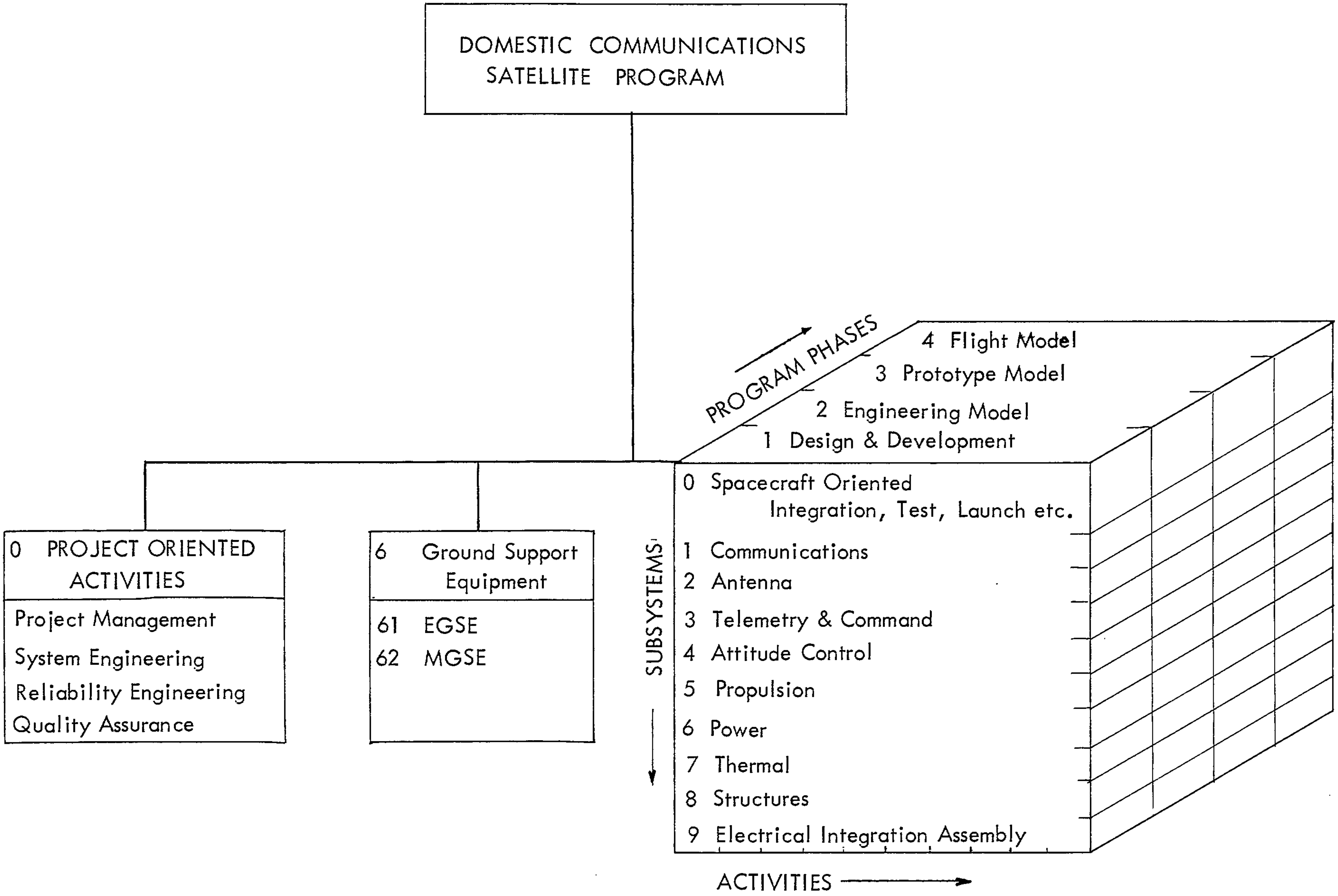


Figure 1-2(a)

Pictorial Representation of Matrix developed for Program and Cost Analysis

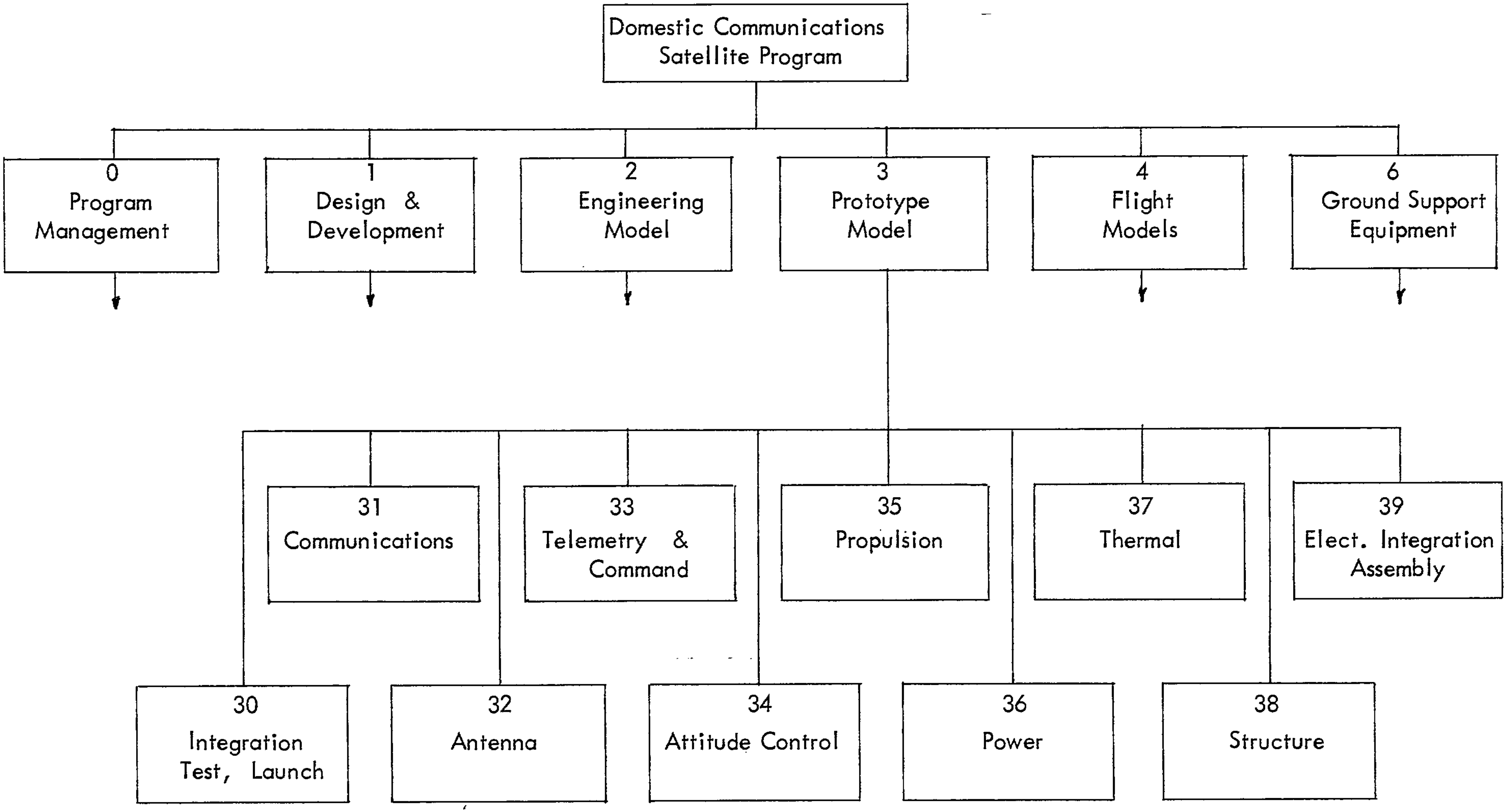


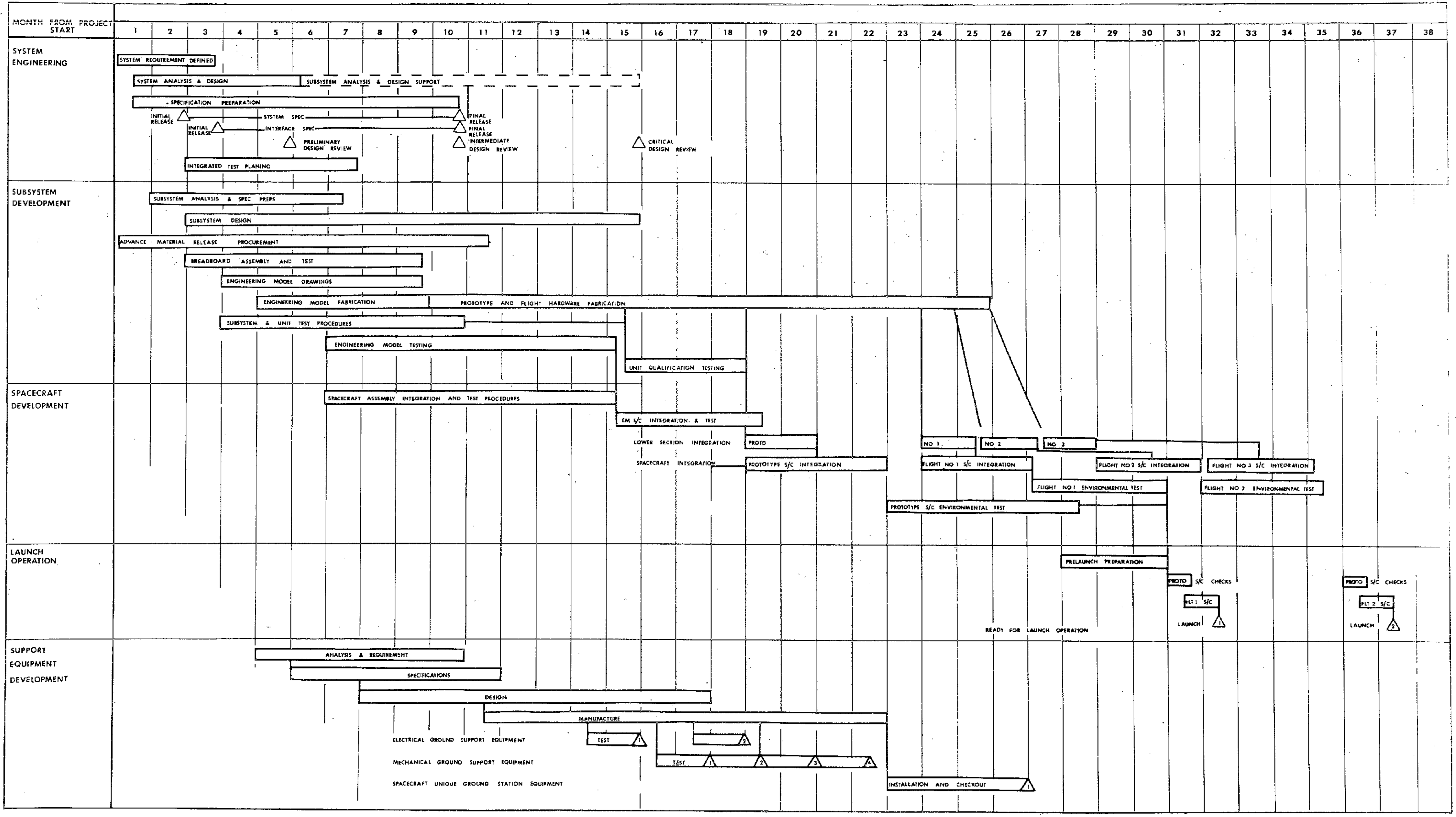
Figure 1-2(b)

Representation of Task Matrix in Tree Form

1.3.2 Schedule Assumptions

The following assumptions were made in preparing these schedules to allow for both implementing technical policy and the optimum allocation of resources to the Program.

- The unit qualification testing is completed prior to the start of prototype spacecraft qualification and prior to the start of flight spacecraft integration. This procedure will ensure that any modifications to units resulting from qualification will be incorporated before the flight spacecraft is started thus preventing repetition and lost time.
- The desirable schedule objective is 31.5 weeks to Flight 1 launch with a continuous work cycle to the end of flight 3 integration and system testing. Flight 3 will not be environmentally tested until required. The optimum application of Ground Support resources, including test crews, to meet this program is two complete test crews and system test sets.
- The lower deck sections and upper sections of the spacecraft will be integrated simultaneously at two locations and integrated as a spacecraft at Montreal. Environmental testing will be carried out in California after which the spacecraft will be shipped to the range.
- The prototype will be used at the range for initial testing and mechanical fit prior to the start of launch operations on flight spacecraft. This will ensure that the Flight 1 Spacecraft is exposed to a minimum of ground handling operations.
- A two week contingency is developed between the arrival of flight spacecraft at the range and the beginning of launch operations on the Flight spacecraft. This contingency time allows for unforeseen difficulties at the launch site as well as prior to shipment to the range.


MONTH FROM PROJECT START
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2
3
4
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37
38
SYSTEM ENGINEERING
SYSTEM REQUIREMENT DEFINED
SYSTEM ANALYSIS & DESIGN
SUBSYSTEM ANALYSIS & DESIGN SUPPORT
SPECIFICATION PREPARATION
INITIAL RELEASE
SYSTEM SPEC
FINAL RELEASE
INITIAL RELEASE
INTERFACE SPEC
FINAL RELEASE
PRELIMINARY DESIGN REVIEW
INTERMEDIATE DESIGN REVIEW
CRITICAL DESIGN REVIEW
INTEGRATED TEST PLANING
SUBSYSTEM DEVELOPMENT
SUBSYSTEM ANALYSIS & SPEC PREPS
SUBSYSTEM DESIGN
ADVANCE MATERIAL RELEASE PROCUREMENT
BREADBOARD ASSEMBLY AND TEST
ENGINEERING MODEL DRAWINGS
ENGINEERING MODEL FABRICATION
PROTOTYPE AND FLIGHT HARDWARE FABRICATION
SUBSYSTEM & UNIT TEST PROCEDURES
ENGINEERING MODEL TESTING
UNIT QUALIFICATION TESTING
SPACECRAFT DEVELOPMENT
SPACECRAFT ASSEMBLY INTEGRATION AND TEST PROCEDURES
EM S/C INTEGRATION. & TEST
LOWER SECTION INTEGRATION
PROTO
NO 1
NO 2
NO 3
SPACECRAFT INTEGRATION
PROTOTYPE S/C INTEGRATION
FLIGHT NO 1 S/C INTEGRATION
FLIGHT NO 2 S/C INTEGRATION
FLIGHT NO 3 S/C INTEGRATION
FLIGHT NO 1 ENVIRONMENTAL TEST
FLIGHT NO 2 ENVIRONMENTAL TEST
PROTOTYPE S/C ENVIRONMENTAL TEST
LAUNCH OPERATION
PRELAUNCH PREPARATION
PROTO S/C CHECKS
FLT 1 S/C
LAUNCH
1
PROTO S/C CHECKS
FLT 2 S/C
LAUNCH
2
READY FOR LAUNCH OPERATION
SUPPORT EQUIPMENT DEVELOPMENT
ANALYSIS & REQUIREMENT
SPECIFICATIONS
DESIGN
MANUFACTURE
ELECTRICAL GROUND SUPPORT EQUIPMENT
TEST
1
2
MECHANICAL GROUND SUPPORT EQUIPMENT
TEST
1
2
3
4
SPACECRAFT UNIQUE GROUND STATION EQUIPMENT
INSTALLATION AND CHECKOUT
1

Figure 1-3

TABLE 1.1
MAJOR MILESTONES

The following events are related to significant points on the project schedule. They indicate and allow management measurement of program progress.

ITEM	DESCRIPTION	MONTH ARO
1	System Requirements defined	3
2	Preliminary System Design Review	5
3	System specification released	10
4	Interface Specification released	10
5	Subsystem and Unit Test Procedures released	10
6	Intermediate Design Review	10
7	Engineering Model Subsystems Tested	15
8	Spacecraft Integration and Test Procedures released	15
9	Electrical Ground Support Number 1 tested	15
10	Critical Design Review	15
11	Unit Qualification Tests complete	19
12	Electrical Ground Support Number 2 tested	19
13	Engineering S/C Tested	19
14	Prototype integrated	22
15	Flight 1 integrated	27
16	Prototype qualified	28
17	Flight 1 accepted	30
18	Flight 2 integrated	31
19	Flight 1 launched	32
20	Flight 2 accepted	35
21	Flight 3 integrated	35
22	Flight 2 launched	37

IV 2

DEVELOPMENT PLAN

2. DEVELOPMENT PLAN

2.1 INTRODUCTION

In this section the project plan is discussed with reference to the project phases and subsystems, including the proposed levels of Canadian participation in each activity. Because of the short study period it has not been possible to explore fully all areas where Canadian companies could generate capability or the costs of such possibilities. However, where possible, indications of additional areas are given and the arrangements which would be involved.

From the technical and preliminary design discussion of Volume II, it is apparent that the realization of a spacecraft such as proposed here involves a wide variety of technology as well as the appropriate managerial and manufacturing capabilites. Further, the demands on the spacecraft performance and capability, as well as the inherent complexity means that many or most of the required technologies are "state of the art". Thus a project such as this inevitably involves many specialized groups. Before developing the plan proposed here, it is desirable to discuss the basic philosophy and ground rules which have been followed, particularly in respect to Canadian content.

2.1.1 Program Optimization

The work statement pertaining to this study requires an optimization of participation by Canadian industry allowing the maximum benefit from technological development, and a design and implementation plan which provides the minimum overall program cost. There are of course other trade-offs involved and implicit in the work statement, such as a schedule management, and, although not called out explicitly, - program risk.

Canadian Content

Fundamentally any component, unit, subsystem or activity associated with the program can be classified with reference to Canadian capability as being within one of the following areas:

a) A Canadian capability exists and can be made available. It is assumed that the program itself, the continuity, profit and other benefits will be such that, where the capability exists, it will be made available.

b) The nucleous of a capability exists and a desire to extend it can be developed. The extension may be in regard to size or depth, as for example the up-grading of a facility to flight hardware standards.

c) Little or no Canadian capability exists, but involves areas wherein the program benefits can be shown in terms of broad spin-off.

d) Areas where little or no Canadian capability exists nor can an entry be justified (in business terms) by other than those associated with the program itself.

Broadly speaking, in moving from (a) to (d) there will be increased resistance on the part of industry to taking part in the program, generally coupled with an increased cost to the program. For example, in an (a) or (b) area, industry would require only normal business motivation to enter the program, and incidently probably produce a lower cost to the program than a comparable U.S. bidder; industry might bid a (c) area if a reasonable portion of the training and/or capitalization can be recovered from the program; industry would bid a (d) activity only if all costs plus a profit could be recovered directly on the program or by other financial arrangements. There are of course finer distinctions possible because any area offers its own mix of engineering, manufacturing, capitalization and spin-off.

Schedule

Although the proposed schedule is "slack" by present practice, it is relatively tight for extensive Canadian Industrial training. It is apparent that excessive easing of the schedule, while allowing for somewhat greater Canadian participation, would also start to increase the overall cost on the management side and also defer the availability of an operational system and the associated revenue.

Management

From the program management point of view, a totally internal program run on a project organization is the simplest and cheapest but is clearly impossible in this case. The next degree of complication is to have subcontracts at the subsystem level, which would be quite possible in this program, but would exclude smaller Canadian companies or potential splits. As the size of the work packages decreases, the management control becomes more difficult and costs increase, through additional management and quality assurance requirements, but significant benefits can accrue. Similarly, subcontracts by a subsystem subcontractor can increase costs, but the arrangement can also minimize program risk by having "built-in" backup capability.

Program Risk

It is axiomatic that in a program as complex as this, using capabilities less than the best available, introduces an element of risk both in program schedule and spacecraft performance. The problem is to judge the extent of the risk compatible with the overall objectives and develop a program plan and program control to minimize the jeopardy.

2.1.2 Program Ground Rules

In establishing the program plan, a subjective evaluation was made of the various factors discussed previously and a tentative assignment made for each area of activity. The following rules were generally followed throughout, although specific alternatives are mentioned in respect to some subsystems.

- All aspects of program management and control must be in Canadian hands.
- Where a clear Canadian capability exists it will be used.
- The schedule will be as long as possible to enable maximum Canadian build-up of capability, but must be in accordance with the customer's wishes.
- The dominent desire is to obtain new technologies for Canada for growth of Canadian capability in space or other fields (directly or as spin off), and particularly those areas potentially contributing to export activities.
- Black-box manufacturing (i.e. to other designs) is of secondary interest but should not be neglected, particularly when it may act as an "entré" to a more comprehensive program.
- Schedule and managerial simplicity must be maintained through efficient and careful designation of work packages and responsibility.
- Major start-ups or generation of new Canadian capability for this program must be carefully evaluated in terms of schedule, cost and program risk. Where such new activities are considered beneficial, backup capability and/or sourcing should be identified.

- Major capitalization (beyond the scope of a typical spacecraft program) cannot be paid for by this program, but presumably could be the subject of separate negotiation between the appropriate companies and the government.

- Minor facility build up would be an acceptable program change i.e. where the total subsystem price would not significantly exceed the probable foreign quotation.

- Available designs or hardware should be considered as a minimum cost approach especially where Canadian sources are involved.

2.1.3 Program Stages

In the optimization of a program, careful consideration must be given to the number of models to be developed. Broadly, the possibilities range from a minimum of models e.g. Engineering plus Flight, to a full series of models scheduled sequentially. Additional models of course involve higher costs, but also permit "fixes" to be evolved without jeopardizing the final product or schedule. As the schedule is tightened, rarely is it possible to have fully sequential models, and overlap occurs. As the overlap becomes greater, the values of the respective models decrease, the program risk increases, without attendant cost savings. If the schedule is further shortened, the overlap becomes so great that the opportunity is lost to make effective use of the model data, so the model and its associated costs may be removed without a further major increase of risk.

The previous remarks tend to suggest the generation of a minimum number of models as a minimum cost solution. However, there is little doubt that the judicious use of the models can ease the learning process by reducing the risks. The reasoning behind the selected phases and models for the present program is discussed next.

Development Phase

This really refers to the subsystems or units thereof, and development models are required for any new types under design. This phase also includes the development of a structure for the structural and thermal design verifications.

Engineering Models

Several different articles fall into this area. First of all, it is not proposed to produce an engineering model of the spacecraft as such. However, it is proposed to have an engineering model of the upper deck with single channels of the Transponder, and, Telemetry and Command subsystems, plus dummies of the remainder of the units.

This partial model will be used to verify configuration interfaces and to design the upper deck harness, rf cables, etc. Similarly the lower deck will have a model for the same purposes but involving the despin electronics, P & O, and power subsystems. Where new subsystems are being developed, the engineering models of the units will be deliverable and used on the model. Where no engineering units are available but are required, as is the case for previously qualified subsystems, prototype units would be used.

Prototype Model

The prototype model will be the first complete spacecraft built to flight standards. All units will be qualified separately previous to this model. This model will be the qualification model in respect to all testing of the complete spacecraft and will also be used in any tests of launch procedures, etc. The model will be a flight model in all respects except that, for economy, only one flight solar panel will be used, with the remainder accurately simulated.

This model is one which could be considered as a possible option. It is feasible to consider this as a candidate for flight, but it appears preferable not to attempt launch of a spacecraft which has been subjected to very long periods of testing and to stress levels above those of flight test.

Flight Models

These are the actual spacecrafts to be launched and would be tested to flight standards. Flight three is the only spacecraft which may be distinguished by special procedures. If flight one and two are successfully launched and operational, then the space segment of the communications system is essentially complete. Flight three is intended to provide replacement for first failure and/or orbital development. If flight three were to be launched immediately (assuming no failures), then unless the space segment loading develops very rapidly, its fuel and lifetime is being expended without any great return. If, however, it is held on the ground for an extended period, say four years, it will require a substantial time to replace an early failure and will itself deteriorate on the shelf. It is suggested that launch at about 18 months is a desirable compromise.

The problem is to determine at what stage of completion is a most desirable hold point for flight 3. It is possible to hold the model as a series of units available as backups against 1 and 2, and to some extent this will be done. However, the integration costs will be high because of the restart learning. In the other limit, with a long hold of a completed and tested spacecraft, retesting before launch would be a necessity and the corresponding costs incurred twice. It is therefore proposed to integrate flight three and perform the integrated system tests, then store it. When required for launch it would be put through the environmental flight tests and delivered to the launch site.

2.2 ADVANCED DEVELOPMENT

Prior to the award of any contract in regard to this satellite, RCA Limited proposes to carry out certain advanced development programs related to the satellite design. In early November programs were initiated in the following areas:

a) Transponder design - A detailed design and realization of the transponder proposed in this report with particular reference to three areas viz:

   i) Multi carrier operation in a TWT driver
   ii) Channel filtering techniques
   iii) Evaluation of experimental solid-state devices for application as TWT driver stages.

b) Antenna design - Detailed theoretical and modeling studies of spacecraft antennas suitable for Canadian coverage.

Additional discussion of these programs is found in section 1 and 2 of Volume II (a)

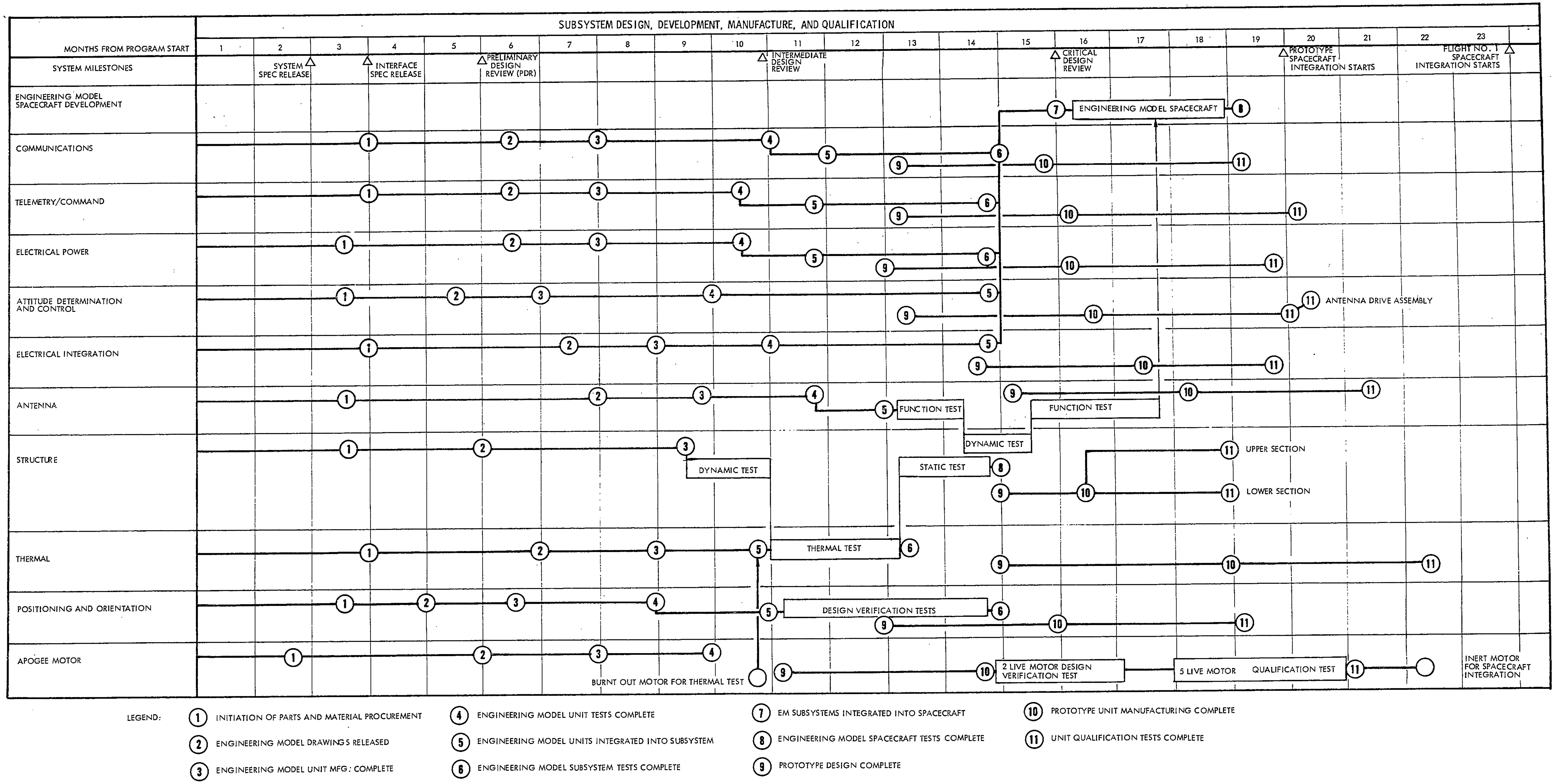
2.3 SYSTEM ENGINEERING

This is a function that is carried on at various levels of effort for the duration of the program. Initially it consists of the finalization of all trade-offs and the establishment of detailed spacecraft and subsystem specifications. During this period the group will consist of a relatively large number of engineers working in close contact within the project office. At the end of this phase many of the group will go back to their respective skill centers to supervise the detailed design and execution of the subsystems.

During the development and integration phases the system engineering function is one of orderly technical coordination and liaison between spacecraft hardware engineering constraints and overall systems requirements as given by the customer. It also includes the coordination of inputs from Earth Station System Engineering, other agencies such as Comsat and NASA, and international bodies such as CCIR. It will also be responsible for special tests and preparation of reports not specifically related to the integration and test of the spacecraft. The overall system engineering function will be a responsibility of RCA.

2.4 SUBSYSTEM DEVELOPMENT

Figure 2.1 illustrates the various subsystem schedules proposed for this program. Under each subsystem the respective subsystem activities are shown as tentatively defined. It will be noted that these activity charts include data regarding the unit level, and, in some cases,the preliminary


SUBSYSTEM DESIGN, DEVELOPMENT, MANUFACTURE, AND QUALIFICATION
MONTHS FROM PROGRAM START
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SYSTEM MILESTONES
SYSTEM SPEC RELEASE
INTERFACE SPEC RELEASE
PRELIMINARY DESIGN REVIEW (PDR)
INTERMEDIATE DESIGN REVIEW
CRITICAL DESIGN REVIEW
PROTOTYPE SPACECRAFT INTEGRATION STARTS
FLIGHT NO. 1 SPACECRAFT INTEGRATION STARTS
ENGINEERING MODEL SPACECRAFT DEVELOPMENT
ENGINEERING MODEL SPACECRAFT
COMMUNICATIONS
TELEMETRY/COMMAND
ELECTRICAL POWER
ATTITUDE DETERMINATION AND CONTROL
ANTENNA DRIVE ASSEMBLY
ELECTRICAL INTEGRATION
ANTENNA
FUNCTION TEST
FUNCTION TEST
DYNAMIC TEST
STRUCTURE
DYNAMIC TEST
STATIC TEST
UPPER SECTION
LOWER SECTION
THERMAL
THERMAL TEST
POSITIONING AND ORIENTATION
DESIGN VERIFICATION TESTS
APOGEE MOTOR
BURNT OUT MOTOR FOR THERMAL TEST
2 LIVE MOTOR DESIGN VERIFICATION TEST
5 LIVE MOTOR QUALIFICATION TEST
INERT MOTOR FOR SPACECRAFT INTEGRATION
LEGEND:
① INITIATION OF PARTS AND MATERIAL PROCUREMENT
② ENGINEERING MODEL DRAWINGS RELEASED
③ ENGINEERING MODEL UNIT MFG. COMPLETE
④ ENGINEERING MODEL UNIT TESTS COMPLETE
⑤ ENGINEERING MODEL UNITS INTEGRATED INTO SUBSYSTEM
⑥ ENGINEERING MODEL SUBSYSTEM TESTS COMPLETE
⑦ EM SUBSYSTEMS INTEGRATED INTO SPACECRAFT
⑧ ENGINEERING MODEL SPACECRAFT TESTS COMPLETE
⑨ PROTOTYPE DESIGN COMPLETE
⑩ PROTOTYPE UNIT MANUFACTURING COMPLETE
⑪ UNIT QUALIFICATION TESTS COMPLETE

Figure 2-1

make or buy decisions, available qualified units, etc. It may also be noted in some cases the charts are not up to date re companies involved because of art work lead time.

2.4.1 Transponder Subsystem (Figure 2-2)

The development plan for the transponder will be carried out in four stages. Most of the subsystems in the transponder will be chosen from modified existing designs or from designs based on microwave radio relay experience. Only the passive components, mostly filters and the equalizer, will be totally new designs.

Advanced development on a company funded program is being carried out to prove the validity of the design concepts and to acquire quanitative data necessary to specify each subsystem. Design principles for all new development items will be laid during this stage. A breadboard transponder, utilizing only partial subsystems, will be put together and thorough electrical and systems tests performed to narrow down any regions of specification uncertainty.

An engineering model, specified on the basis of data gathered previously, will then be assembled and put through further tests. During the breadboard and engineering model stage close liaison will be maintained with component suppliers to assure that the overall system requirements get translated into meaningful and achievable component specifications.

Electrical testing at the engineering model stage will include baseband to baseband simulation of the communication system as well as RF to RF simulation. Appropriate environmental tests would be performed to assure system performance under operating environmental conditions.

The test results will be analysed and condensed to pinpoint the necessary and sufficient number of RF tests required on the actual flight model. This phase should be looked upon as an exercise in the design of experiments to discover the parameters which define the overall system performance. A reduction in the electrical tests to be performed on the spacecraft transponder subsystem would be the goal.

For the prototype and spacecraft models, space qualified units will be supplied by vendors to the appropriate specifications. All units designed and fabricated in house by RCA Limited will be tested and qualified separately. At module level functional tests will be performed before and after each environmental exposure. Qualification level testing, for the prototype, will include vibration, temperature, thermal vacuum and electrical interference tests whereas Acceptance Level testing for the flight models, will cover vibration and thermal vacuum.

DEVELOPMENT PHASES

DESIGN

COMMUNICATIONS SUBSYSTEM	QUANTITY PER SPACECRAFT	DESIGN BASED ON MICROWAVE AND TELEMETRY EXPERIENCE	DESIGN BASED ON SIMILAR PREVIOUS EXPERIENCE	SIMPLIFICATION OF EXISTING DESIGN	MODIFICATION OF EXISTING DESIGN	CONVENTIONAL DESIGN	PROCURED EXISTING DESIGN
SUBSYSTEM FUNCTIONS							
COMMAND SUPRESS FILTER	1	X					
COMB FILTER	1	X					
INPUT BANDPASS FILTER (6gHz)	1	X					
SWITCH-COAX SPDT	10						X
6 gHz TDA	2				X		
FREQUENCY TRANSLATOR	2				X		
LO HYBRID	1				X		
LOCAL OSCILLATORS	2				X		
4 gHz TDA	2				X		
(SWITCH-COAX SPDT)							
DRIVER TWTA	2						X
TWTA CONVERTER	2						X
(SWITCH-COAX SPDT)							
INPUT MULTIPLIER AND EQUALIZER	1		X				
PIN DIODE ATTENUATOR	6					X	
SWITCH-COAX TRANSFER (SWITCH-COAX SPDT)	8						X
TWT CONVERTER	9						X
OUTPUT TWT	9						X
(SWITCHES, COAX SPDT AND TRANSFER DPDT)							
ISOLATOR (4 gHz)	6		X				
OUTPUT MULTIPLEXER	1	X					
HARMONIC ABSORBER FILTER	1	X					
OUTPUT FILTER (4 gHz)	1	X					
TELEMETRY SUPPRESSION FILTER	1	X					

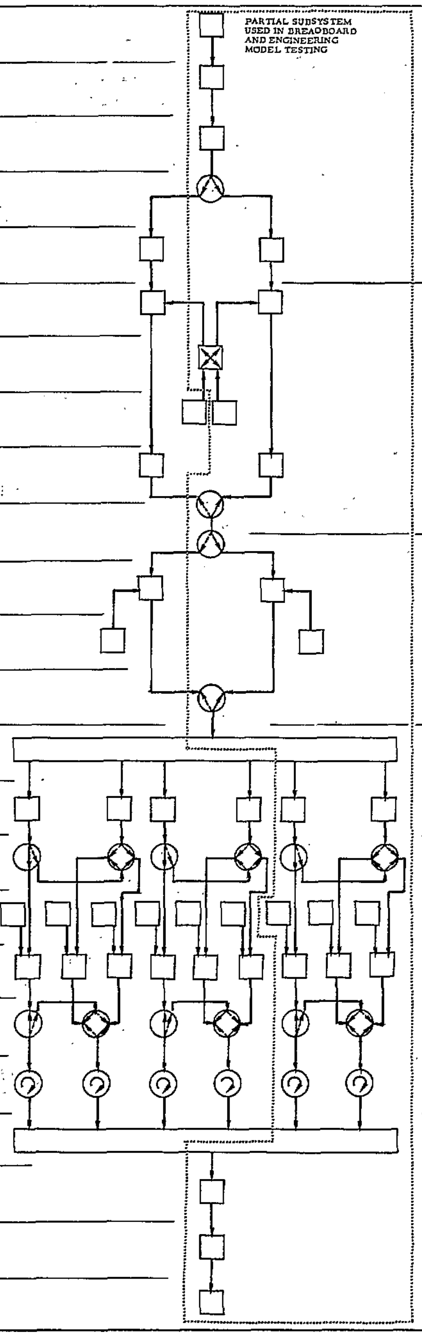
SUBSYSTEM ANALYSIS AND PRELIMINARY DESIGN FOR STUDY WILL BE AUGMENTED WITH UPDATED SPACECRAFT REQUIREMENTS AND A FINAL DEFINITION OF SUBSYSTEM PARAMETER BUDGETS.

ELECTRICAL, THERMAL, AND MECHANICAL INTERFACES WILL BE DEFINED.

UNIT AND SUBUNIT SPECIFICATIONS ARE REQUIRED.

DETAIL CIRCUIT AND PACKAGING DESIGN IS REQUIRED ON ALL NON-PROCURED ITEMS.

UNIT AND MODULE TEST SET DESIGN IS REQUIRED.


PARTIAL SUBSYSTEM USED IN BREADBOARD AND ENGINEERING MODEL TESTING

DEVELOPMENT TESTING

- ALL PERFORMANCE PARAMETERS ARE MEASURED AT NOMINAL DRIVE LEVELS ON BREADBOARD AND ENGINEERING MODELSSUBSYSTEMS.
- ON THE ENGINEERING MODEL ONLY THE TRANSPONOERS WILL BE OVER DRIVEN AND ALL THE NOTED PARAMETERS WILL BE MEASURED AGAIN.

	ELECTRICAL POWER REQUIREMENT	BALANCE	GAIN	LINEARITY	PHASE AND GROUP DELAY	GROUP DELAY	INPUT-OUTPUT IMPEDANCE	INPUT-OUTPUT VSWR	NOISE TEMPERATURE	INPUT FILTER RESPONSE	HIGH AND LOW TEMPERATURE (Qualification Level)	VIBRATION (Qualification Level)	THERMAL VACUUM	INTERMODULATION	OUTPUT FREQUENCY STABILITY	OUTPUT POWER STABILITY	OUTPUT POWER LEVEL	SPURIOUS FREQUENCIES	INSERTION LOSS	BANDPASS CHARACTERISTICS	CONVERSION EFFICIENCY	REFLECTION FACTOR DETERMINATION	ELECTROMAGNETIC INTERFERENCE	DISTORTION	TRANSPONDER GAIN	GAIN SLOPE	SENSITIVITY	BANDWIDTH	FREQUENCY RESPONSE	AM TO PM TRANSFER COEFFICIENT	INTELLIGIBLE CROSSTALK	FREQUENCY CONVERSION
ENGINEERING MODEL PARTING SUBSYSTEM	X			X		X		X			X			X		X	X	X	X				X	X	X	X	X	X	X	X	X	X
BREADBOARD MODEL PARTIAL SUBSYSTEM	X			X		X		X						X		X	X	X	X					X	X	X	X	X	X	X	X	X
ENGINEERING MODELS		X	X	X		X		X	X	X		X	X										X									
BREADBOARDS		X	X	X		X		X	X	X	X																					
ENGINEERING MODELS			X	X	X			X	X			X	X	X	X	X		X					X									
BREADBOARDS			X	X	X			X	X		X			X	X	X		^						X								
ENGINEERING MODELS	X		X	X		X		X	X			X	X	X							X		X									
BREADBOARDS	X		X	X		X		X	X		X			X							X											
ENGINEERING MODELS					X		X					X	X	X					X	X			X									
BREADBOARDS					X		X				X			X					X	X												
ENGINEERING MODELS	X		X	X								X	X				X						X									
BREADBOARDS	X		X	X							X						X															
ENGINEERING MODELS												X	X							X		X	X									
BREADBOARDS											X									X		X										
ENGINEERING MODELS					X							X	X						X			X	X									
BREADBOARDS					X							X							X			X										

COMMUNICATIONS SUBSYSTEM	PROCUREMENT	MANUFACTURING: PLANNING	PROCESSES AND VISUAL AIDS	TOOLING	UNIT TEST SET	TEST FIXTURES	QUANTITY REQUIRED	FUNCTIONAL TEST BEFORE AND AFTER EACH ENVIRONMENTAL EXPOSURE	VIBRATION	TEMPERATURE	THERMAL VACUUM	ELECTROMAGNETIC INTERFERENCE	VIBRATION	THERMAL VACUUM	PROTOTYPE	FLIGHT	SPARES
	PROCUREMENT	MANUFACTURING						FORMAL TESTING: UNIT LEVEL	QUALIFICATION				ACCEPTANCE		HARDWARE REQUIRED		
COMMAND SUPRESS FILTER		RCA MAKE					1	X	X	X	X	X			1		
							3	X					X	X		3	
COMB FILTER		RCA MAKE					1	X	X	X	X	X			1		
							3	X					X	X		3	
INPUT BANDPASS FILTER (6gHz)							1	X	X	X	X	X			1		
							3	X					X	X		3	
SWITCH-COAX SPDT	BUY LEADTIME IS NO PROBLEM						44	ADDITIONAL UNITS QUALIFIED BY VENDOR X					X	X	10	30	4
6 gHz TDA	BUY LEADTIME IS ADEQUATE						8	PREVIOUSLY QUALIFIED X					X	X	2	6	
FREQUENCY TRANSLATOR		RCA MAKE					1	X	X	X	X	X			1		
							8	X					X	X	1	6	1
LO HYBRID	BUY LEADTIME IS ADEQUATE						4	PREVIOUSLY QUALIFIED X					X	X	1	3	
LOCAL OSCILLATORS		RCA MAKE					1	X	X	X	X	X			1		
							8	X					X	X	1	6	1
4 gHz TDA							1	X	X	X	X	X			1		
							8	X					X	X	1	6	1
(SWITCH-COAX SPDT)																	
DRIVER TWTA	BUY LEADTIME IS ADEQUATE						1	X	X	X	X	X			1		
							8	X					X	X	1	6	1
TWTA CONVERTER	BUY LEADTIME IS ADEQUATE						1	X	X	X	X	X			1		
							8	X					X	X	1	6	1
(SWITCH-COAX SPDT)																	
INPUT MULTIPLIER AND EQUALIZER	SOME COMPONENTS ARE LONGLEAD TIME	RCA MAKE					1	X	X	X	X	X			1		
							4	X					X	X		3	
PIN DIODE ATTENUATOR	BUY LEADTIME IS ADEQUATE						1	X	X	X	X	X			1		SPARE DI-ODES ONLY
							23	X					X	X	5	18	
SWITCH-COAX TRANSFER (SWITCH-COAX SPDT)							26	ADDITIONAL UNITS QUALIFIED BY VENDOR X					X	X	6	18	2
TWT CONVERTER	BUY LEADTIME IS ADEQUATE						1	X	X	X	X	X			1		
							37	X					X	X	8	27	2
OUTPUT TWT	BUY LEADTIME IS ADEQUATE						1	X	X	X	X	X			1		
							37	X					X	X	8	27	2
(SWITCHES, COAX SPDT AND TRANSFER DPDT)																	
ISOLATOR (4 gHz)	BUY LEADTIME IS ADEQUATE						24	PREVIOUSLY QUALIFIED X					X	X	6	18	
OUTPUT MULTIPLEXER	SOME COMPONENTS ARE LONGLEAD TIME	RCA MAKE					1	X	X	X	X	X			1		
							3	X					X	X		3	
HARMONIC ABSORBER FILTER	BUY LEADTIME IS ADEQUATE						4	PREVIOUSLY QUALIFIED X					X	X	1	3	
OUTPUT FILTER (4 gHz)		RCA MAKE					1	X	X	X	X				1		
							3	X					X	X		3	
TELEMETRY SUPPRESSION FILTER		RCA MAKE					1	X	X	X	X	X			1		
							3	X					X	X		3	

SPACECRAFT LEVEL

	INTERFACE CHECKS	TRANSPONDER GAIN	GAIN SLOPE	SENSITIVITY	BANDWIDTH	FREQUENCY RESPONSE	POWER OUTPUT	AM TO PM TRANSFER COEFFICIENT	INTELLIGIBLE CROSSTALK	LINEARITY	GROUP DELAY	FREQUENCY CONVERSION	SPURIOUS OUTPUT	INTEGRATED SYSTEMS TEST (IST) BEFORE AND AFTER ENVIRONMENTAL EXPOSURES	VIBRATION	ACOUSTIC	SPACE SIMULATION	ELECTROMAGNETIC INTERFERENCE	VIBRATION	SPACE SIMULATION
	SUBSYSTEM INTEGRATION TESTS														QUALIFICATION				ACCEPTANCE	
1 PROTOTYPE SPACECRAFT	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
3 FLIGHT SPACECRAFT	X	X	X	X	X	X	X	X	X	X	X	X	X	X					X	X

Figure 2-2

The prototype and spacecraft transponder will be integrated on the upper deck of the satellite within the RCA Limited facility. This preliminary integration will include the full range of electrical tests. After the upper deck has been integrated with the rest of the Satellite, the prototype will be put through the full qualification for environmental routine and the integrated transponder system tested before and after each exposure. The flight models will be tested for vibration and space simulation only.

The transponder subsystem will be the responsibility of RCA Limited, based on both the broadwide band communications experience and that specific to communications spacecraft. RCA Limited proposes to design and fabricate the passive components and the L.O. source. The amplifiers within the transponder will be purchased to RCA Limited specifications from vendors having experience in similar space qualified components. The TWT's being a major item of procurement have received considerable attention. Both Hughes Aircraft Company of Los Angeles and Varian Associates of Palo Alto have basic designs available and with minor modification, suitable for this program. Varian of Canada is examining the possibility of participation in the program through (as a minimum) final packaging and testing of the TWT's.

2.4.2 Antenna Subsystem (Figure 2-3)

The initial design and development of the antenna subsystem will be primarily concerned with the electrical specification of the configuration required for the selected coverage. This phase will include the development models required to verify the electrical properties. The resulting mechanical specifications will then be given to a structural group for the "flight" mechanical design and fabrication. Each model, engineering (dynamic), prototype and flight will be tested for boresight, pattern and efficiency as well as under the appropriate environmental conditions.

The design and development phase of the antenna subsystem will be the responsibility of RCA Limited, as will be the design and fabrication of the feeds and polarizers for the two types of spacecraft (for the two channel plans). The mechanical design of the antenna structural elements, the main reflector, as well as all environmental testing will be subcontracted with the spacecraft structure (Section 2.4.10) because of the strong interface in this area.

All electrical testing will be the responsibility of RCA Limited.

2.4.3 Telemetry and Command (Figure 2-4)

The Telemetry and Command subsystem development will use, where possible, existing techniques, and components, although the subsystem would be developed into units optimized for this application. Throughout the unit development program, the development would be continuously monitored and analysed on a subsystem basis to ensure interface compatibility.

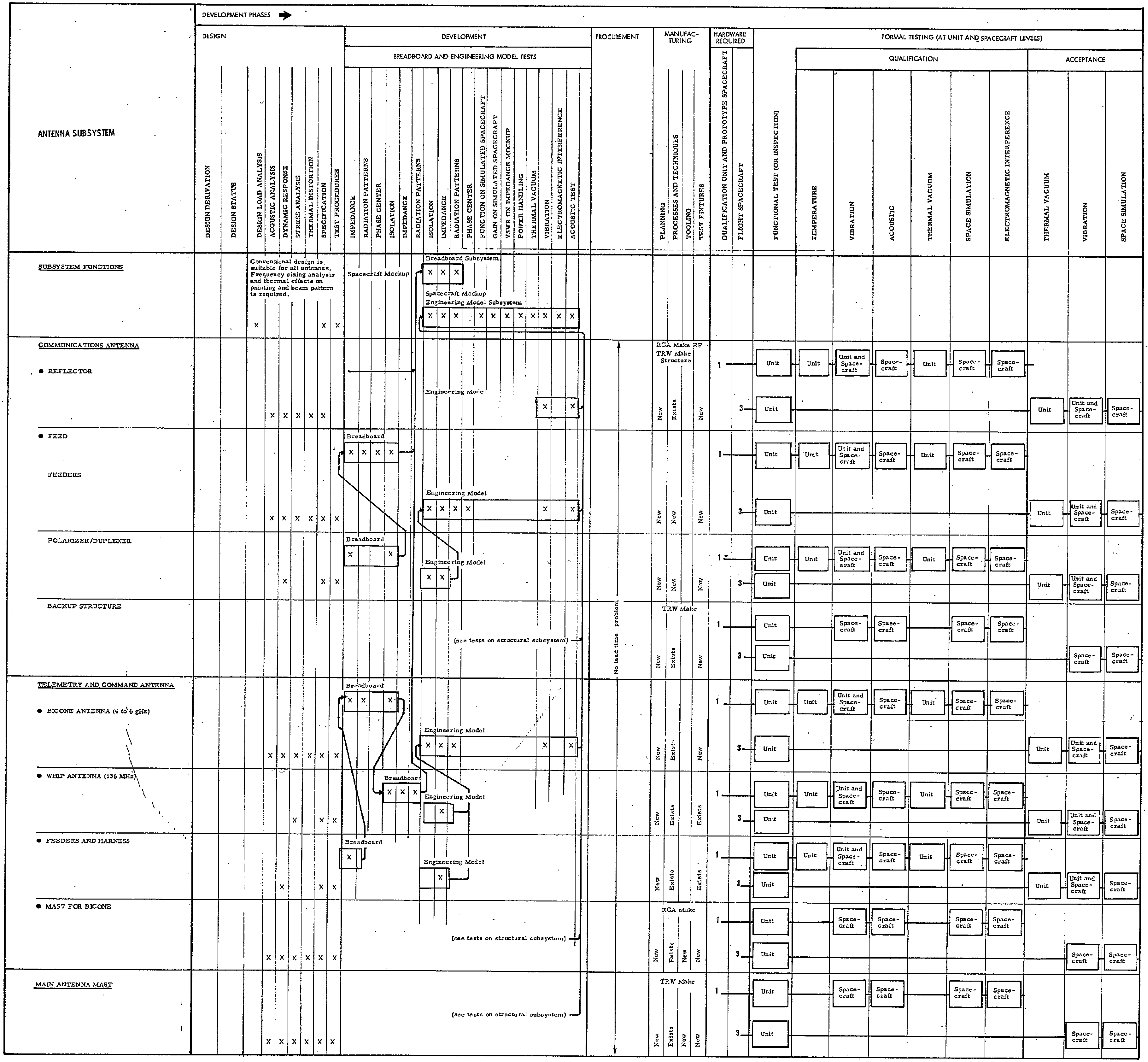

ANTENNA SUBSYSTEM
DEVELOPMENT PHASES
DESIGN
DESIGN DERIVATION
DESIGN STATUS
DESIGN LOAD ANALYSIS
ACOUSTIC ANALYSIS
DYNAMIC RESPONSE
STRESS ANALYSIS
THERMAL DISTORTION
SPECIFICATION
TEST PROCEDURES
DEVELOPMENT
BREADBOARD AND ENGINEERING MODEL TESTS
IMPEDANCE
RADIATION PATTERNS
PHASE CENTER
ISOLATION
IMPEDANCE
RADIATION PATTERNS
ISOLATION
IMPEDANCE
RADIATION PATTERNS
PHASE CENTER
FUNCTION ON SIMULATED SPACECRAFT
GAIN ON SIMULATED SPACECRAFT
VSWR ON IMPEDANCE MOCKUP
POWER HANDLING
THERMAL VACUUM
VIBRATION
ELECTROMAGNETIC INTERFERENCE
ACOUSTIC TEST
PROCUREMENT
MANUFAC-TURING
PLANNING
PROCESSES AND TECHNIQUES
TOOLING
TEST FIXTURES
HARDWARE REQUIRED
QUALIFICATION UNIT AND PROTOTYPE SPACECRAFT
FLIGHT SPACECRAFT
FORMAL TESTING (AT UNIT AND SPACECRAFT LEVELS)
FUNCTIONAL TEST (OR INSPECTION)
QUALIFICATION
TEMPERATURE
VIBRATION
ACOUSTIC
THERMAL VACUUM
SPACE SIMULATION
ELECTROMAGNETIC INTERFERENCE
ACCEPTANCE
THERMAL VACUUM
VIBRATION
SPACE SIMULATION
SUBSYSTEM FUNCTIONS
Conventional design is suitable for all antennas. Frequency sizing analysis and thermal effects on pointing and beam pattern is required.
Spacecraft Mockup
Breadboard Subsystem
Spacecraft Mockup
Engineering Model Subsystem
COMMUNICATIONS ANTENNA
• REFLECTOR
Engineering Model
RCA Make RF
TRW Make Structure
New
Exists
New
• FEED
FEEDERS
Breadboard
Engineering Model
POLARIZER/DUPLEXER
BACKUP STRUCTURE
TRW Make
(see tests on structural subsystem)
No lead time problem
TELEMETRY AND COMMAND ANTENNA
• BICONE ANTENNA (4 to 6 gHz)
• WHIP ANTENNA (136 MHz)
• FEEDERS AND HARNESS
• MAST FOR BICONE
RCA Make
MAIN ANTENNA MAST
TRW Make
1
3
Unit
Unit and Space-craft
Space-craft
X

Figure 2-3

DEVELOPMENT PHASES →

TELEMETRY AND COMMAND SUBSYSTEM	ANALYSIS AND DESIGN												BREADBOARD AND ENGINEERING MODEL TESTING																		PROCUREMENT	MANUFACTURING				HARDWARE REQUIRED		FORMAL TESTING									
																																							QUALIFICATION						ACCEPTANCE		
	DESIGN DERIVATION	DESIGN STATUS	SPECIFICATIONS	INTERFACE ANALYSIS	PRELIMINARY MATERIAL LIST	PARTS LIST	DEFINITION OF CRITICAL CIRCUITS	CIRCUIT DESIGN	MOCKUP DESIGN	PRODUCTION DESIGN	TEST PROCEDURES	UNIT TESTER DESIGN		PERFORMANCE SURVEY	ELECTRICAL POWER REQUIREMENTS	INPUT SENSITIVITY	GAIN SELECTIVITY	SPURIOUS SIGNAL SENSITIVITY	SIGNAL OUTPUT POWER	LOSSES	GAINS	SIGNAL DISTORTION	STABILITY	BANDWIDTH	SPURIOUS SIGNAL OUTPUT	WORST CASE LOADING	TEMPERATURE	VIBRATION	THERMAL VACUUM	ELECTROMAGNETIC INTERFERENCE		PLANNING	PROCESSES AND TECHNIQUES	TOOLING	UNIT TEST SET	UNIT QUALIFICATION AND PROTOTYPE SPACECRAFT	FLIGHT SPACECRAFT	FUNCTIONAL TEST BEFORE AND AFTER EACH ENVIRONMENTAL TEST	TEMPERATURE	THERMAL VACUUM	VIBRATION	ACOUSTIC	SPACE SIMULATION	ELECTROMAGNETIC INTERFERENCE	TEMPERATURE	VIBRATION	SPACE SIMULATION
SUBSYSTEM FUNCTIONS													Engineering Model Antenna Subsystem and Simulated Spacecraft																																		
			New	X	X		X		X		X		Engineering Model Subsystem	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X																	
TELEMETRY/COMMAND DIPLEXER (1 per spacecraft)		New											Breadboard	X		X		X	X	X	X		X	X		X	X				Some components are long lead items	RCA				1		Unit	Unit	Unit	Unit and Space-craft	Space-craft	Space-craft	Unit and Space-craft			
			New	X	X	X		X	X	X	X	X	Engineering Model	X		X		X	X	X	X		X	X		X	X					New	New	New	New		3	Unit							Unit	Unit and Space-craft	Space-craft
TELEMETRY/COMMAND HARNESS (1 per spacecraft)		New											Engineering Model							X						X	X				Some components are long lead items	RCA				1		Unit	Unit	Unit	Unit and Space-craft	Space-craft	Space-craft	Unit and Space-craft			
			New		X	X		X	X	X	X	X																				New	New	New	New		3	Unit							Unit	Unit and Space-craft	Space-craft
POWER DIVIDER (1 per spacecraft)		New											Breadboard	X		X	X	X	X	X			X	X		X	X				Some components are long lead items	RCA				1		Unit	Unit	Unit	Unit and Space-craft	Space-craft	Space-craft	Unit and Space-craft			
			Update		X	X		X	X	X	X	X	Engineering Model	X		X	X	X	X	X			X	X		X	X					New	New	New	New		3	Unit							Unit	Unit and Space-craft	Space-craft
RECEIVER AND DEMODULATOR (6 gHz) (2 per spacecraft)		New											Breadboard	X	X	X	X	X	X	X	X	X	X	X	X		X				Some components are long lead items	RCA				1		Unit	Unit	Unit	Unit and Space-craft	Space craft	Space-craft	Unit and Space-craft			
			New		X	X		X	X	X	X	X	Engineering Model	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X		New	Exists	New	New	1	6	Unit							Unit	Unit and Space-craft	Space-craft
DECODER (2 per spacecraft)		New											Breadboard	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	Some components are long lead items	RCA				1		Unit	Unit	Unit	Unit and Space-craft	Space-craft	Space-craft	Unit and Space-craft			
			New		X	X	X	X	X	X	X	X	Engineering Model	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X		New	New	New	New	1	6	Unit							Unit	Unit and Space-craft	Space-craft
136 MHz BEACON TRANSMITTER (1 per spacecraft)		Com-plete as is with minor modi-fica-tion																													Some components are long lead items	RCA				1		Unit	Unit	Unit	Unit and Space-craft	Space-craft	Space-craft	Unit and Space-craft			
			Update		Update	Update		Update		Update	Update	Exists																				Exists	Exists	Exists	Exists		3	Unit							Unit	Unit and Space-craft	Space-craft
ENCODER (2 per spacecraft)		New											Breadboard	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	Some components are long lead items	RCA				1		Unit	Unit	Unit	Unit and Space-craft	Space-craft	Space-craft	Unit and Space-craft			
			New		X	X	X	X	X	X	X	X	Engineering Model	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X		New	Exists	New	New	1	6	Unit							Unit	Unit and Space-craft	Space-craft
TRANSMITTER AND MODULATOR (4 gHz) (2 per spacecraft)		New											Breadboard	X	X	X	X	X	X	X	X	X	X	X	X		X				Some components are long lead items	RCA				1		Unit	Unit	Unit	Unit and Space-craft	Space-craft	Space-craft	Unit and Space-craft			
			New		X	X		X	X	X	X	X	Engineering Model	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		New	Exists	New	New	1	6	Unit							Unit	Unit and Space-craft	Space-craft
POWER COMBINER (1 per spacecraft)		New											Breadboard	X	X				X	X		X	X	X	X	X	X			X	Some components are long lead items	RCA				1		Unit	Unit	Unit	Unit and Space-craft	Space-craft	Space-craft	Unit and Space-craft			
			New		X	X		X	X	X	X	X	Engineering Model	X	X				X	X		X	X	X	X	X	X			X		New	New	New	New		3	Unit							Unit	Unit and Space-craft	Space-craft

Figure 2-4

Since no known "off-the-shelf" equipment is available for the 6 GHz command receiver, the decoder, the encoder or the 4 GHz telemetry transmitter, these units would have to be developed specifically for this project. First in the development would be a detailed equipment performance review within the framework of the overall system requirements to apportion permissible performance deviations, to establish interface characteristics and to prepare the equipment specifications. At the same time, breadboard studies would be initiated to check out predictions and to provide test beds from which the most promising of the several alternative methods for achieving a desired result can be selected. Following this the detailed development of the engineering model units can be initiated.

Development of the antenna system would begin with construction of a full scale model of the bicone antenna from which pattern and other measurements to verify predicted performance would be made. Development of the duplexer, power splitter and power combiner as separate units would begin shortly after starting construction of the bicone antenna, and these units would be checked out. Following the basic measurements the engineering model units of the complete antenna system would be begun and the complete system would be checked out. Measurements of the integrated telemetry/command system would also be performed to verify integrated performance.

No specific development is required for the beacon transmitter since this is essentially an "off-the-shelf" unit that was developed for the Alouette/ISIS Space program.

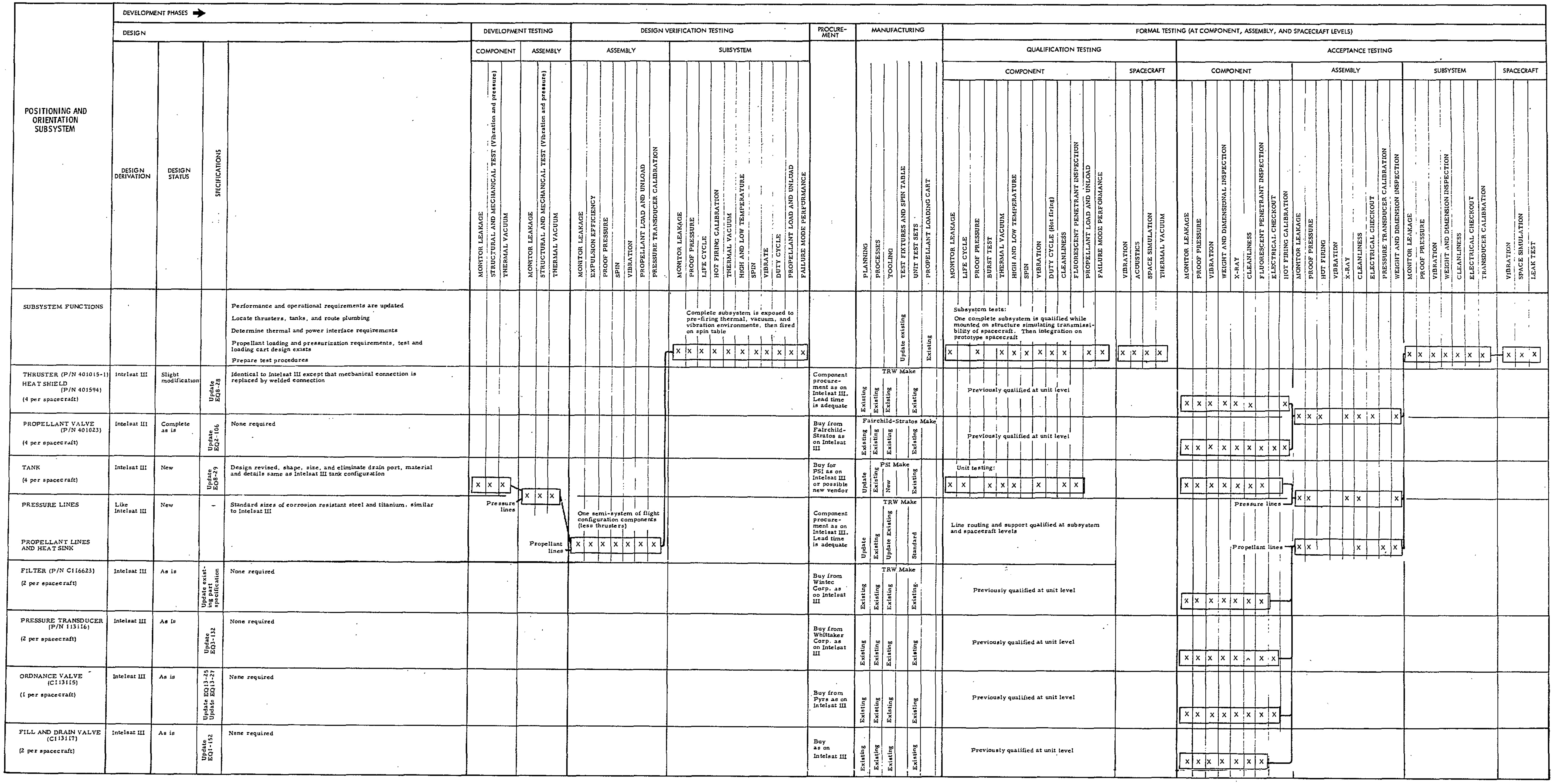
Following development of the engineering model units, a complete engineering model telemetry and command subsystem would be set up "on the bench" and given an exhaustive checkout for performance characteristics and protection capability. Any necessary modifications can, at this point, be introduced and the release made to manufacturing for flight quality units.

The prototype and flight units, should at this point, be conceptually correct and should require only testing to verify this. The prototype units would be qualified before integration on the spacecraft.

The telemetry and command subsystem activities would be the responsibility of RCA Limited.

2.4.4 Position and Orientation System (Figure 2-5)

The Position and Orientation subsystem design is based upon the subsystem developed for Intelsat III and, in most cases, uses identical components.



	DEVELOPMENT PHASES ➔ DESIGN				DEVELOPMENT TESTING		DESIGN VERIFICATION TESTING		PROCUREMENT	MANUFACTURING	FORMAL TESTING (AT COMPONENT, ASSEMBLY, AND SPACECRAFT LEVELS)					
					COMPONENT	ASSEMBLY	ASSEMBLY	SUBSYSTEM			QUALIFICATION TESTING		ACCEPTANCE TESTING			
											COMPONENT	SPACECRAFT	COMPONENT	ASSEMBLY	SUBSYSTEM	SPACECRAFT
POSITIONING AND ORIENTATION SUBSYSTEM	DESIGN DERIVATION	DESIGN STATUS	SPECIFICATIONS		MONITOR LEAKAGE STRUCTURAL AND MECHANICAL TEST (Vibration and pressure) THERMAL VACUUM	MONITOR LEAKAGE STRUCTURAL AND MECHANICAL TEST (Vibration and pressure) THERMAL VACUUM	MONITOR LEAKAGE EXPULSION EFFICIENCY PROOF PRESSURE SPIN VIBRATION PROPELLANT LOAD AND UNLOAD PRESSURE TRANSDUCER CALIBRATION	MONITOR LEAKAGE PROOF PRESSURE LIFE CYCLE HOT FIRING CALIBRATION THERMAL VACUUM HIGH AND LOW TEMPERATURE SPIN VIBRATE DUTY CYCLE PROPELLANT LOAD AND UNLOAD FAILURE MODE PERFORMANCE		PLANNING PROCESSES TOOLING TEST FIXTURES AND SPIN TABLE UNIT TEST SETS PROPELLANT LOADING CART	MONITOR LEAKAGE LIFE CYCLE PROOF PRESSURE BURST TEST THERMAL VACUUM HIGH AND LOW TEMPERATURE SPIN VIBRATION DUTY CYCLE (Hot firing) CLEANLINESS FLUORESCENT PENETRANT INSPECTION PROPELLANT LOAD AND UNLOAD FAILURE MODE PERFORMANCE	VIBRATION ACOUSTICS SPACE SIMULATION THERMAL VACUUM	MONITOR LEAKAGE PROOF PRESSURE VIBRATION WEIGHT AND DIMENSIONAL INSPECTION X-RAY CLEANLINESS FLUORESCENT PENETRANT INSPECTION ELECTRICAL CHECKOUT HOT FIRING CALIBRATION	MONITOR LEAKAGE PROOF PRESSURE HOT FIRING VIBRATIDN X-RAY CLEANLINESS ELECTRICAL CHECKOUT PRESSURE TRANSDUCER CALIBRATION WEIGHT AND DIMENSION INSPECTION	MONITOR LEAKAGE PROOF PRESSURE VIBRATION WEIGHT AND DIMENSION INSPECTION CLEANLINESS ELECTRICAL CHECKOUT TRANSDUCER CALIBRATION	VIBRATION SPACE SIMULATION LEAK TEST
SUBSYSTEM FUNCTIONS				Performance and operational requirements are updated Locate thrusters, tanks, and route plumbing Determine thermal and power interface requirements Propellant loading and pressurization requirements, test and loading cart design exists Prepare test procedures				Complete subsystem is exposed to pre-firing thermal, vacuum, and vibration environments, then fired on spin table X X X X X X X X X X X		Update existing Existing	Subsystem tests: One complete subsystem is qualified while mounted on structure simulating transmissibility of spacecraft. Then integration on prototype spacecraft X X X X X X X X X X	X X X X			X X X X X X X	X X X
THRUSTER (P/N 401015-1) HEAT SHIELD (P/N 401594) (4 per spacecraft)	Intrlsat III	Slight modification	Update EQ8-28	Identical to Intelsat III except that mechanical connection is replaced by welded connection					Component procurement as on Intelsat III. Lead time is adequate	TRW Make Existing Existing Existing Existing	Previously qualified at unit level		X X X X X X X	X X X X X X X		
PROPELLANT VALVE (P/N 401023) (4 per spacecraft)	Intelsat III	Complete as is	Update EQ2-106	None required					Buy from Fairchild-Stratos as on Intelsat III	Fairchild-Stratos Make Existing Existing Existing Existing	Previously qualified at unit level		X X X X X X X X X			
TANK (4 per spacecraft)	Intelsat III	New	Update EQ8-29	Design revised, shape, size, and eliminate drain port, material and details same as Intelsat III tank configuration	X X X	X X X			Buy for PSI as on Intelsat III or possible new vendor	PSI Make Update Existing New Existing	Unit testing: X X X X X X X X		X X X X X X X			
PRESSURE LINES	Like Intelsat III	New	–	Standard sizes of corrosion resistant steel and titanium, similar to Intelsat III	Pressure lines		One semi-system of flight configuration components (less thrusters)		Component procurement as on Intelsat III. Lead time is adequate	TRW Make Update Existing Update Existing Standard	Line routing and support qualified at subsystem and spacecraft levels		Pressure lines	X X X X X		
PROPELLANT LINES AND HEAT SINK						Propellant lines	X X X X X X X						Propellant lines	X X X X X		
FILTER (P/N C116623) (2 per spacecraft)	Intelsat III	As is	Update existing part specification	None required					Buy from Wintec Corp. as oo Intelsat III	TRW Make Existing Existing Existing Existing.	Previously qualified at unit level		X X X X X X X			
PRESSURE TRANSDUCER (P/N 113116) (2 per spacecraft)	Intelsat III	As Is	Update EQ3-132	None required					Buy from Whittaker Corp. as on Intelsat III	Existing Existing Existing Existing	Previously qualified at unit level		X X X X X ^ X X			
ORDNANCE VALVE (C113115) (1 per spacecraft)	Intelsat III	As is	Update EQ13-25 Update EQ13-27	Nane required					Buy from Pyrs as on Intelsat III	Existing Existing Existing Existing	Previously qualified at unit level		X X X X X X X X			
FILL AND DRAIN VALVE (C113117) (2 per spacecraft)	Intelsat III	As is	Update EQ1-152	Nane required					Buy as on Intelsat III	Existing Existing Existing Existing	Previously qualified at unit level		X X X X X X X			

Figure 2-5

At the program start, the Position and Orientation subsystem performance and operational requirements will be updated. This includes a final estimate of propellant requirements for a typical duty cycle taking into account such effects as cold catalyst bed starts, feed pressure-performance effects, and cosine losses for radial thrusting.

Development testing will be required for the tanks and the assembled subsystem (less thrusters) to verify functional and structural adequacy of the design after exposure to qualification level environmental conditions. The assembly will also be subjected to propellant and pressurant loading and unloading test, after which the tanks are reloaded and the expulsion efficiency is determined with the tank and line assembly on a spin table. The final development test consists of subjecting the entire subsystem to a prefiring thermal vacuum and vibration environmental, and then conducting spin firings simulating the life cycle. At the conclusion of these test, final production drawings are released for the prototype hardware.

The qualification test consists of life cycling of tanks, burst tests of tanks, high and low temperature thermal vacuum, environmental vibration and hot firing spin tests.

Acceptance tests consist of proof pressure tests, leakage tests, hot firing, pressure transducer calibration and electrical checkout. This entire subsystem will be subcontracted to TRW Systems on the basis that it is largely an existing system and offers a minimum cost solution in an area requiring a great deal of background knowledge not only in regard to hardware design, but also in handling, purging, etc. However, it is anticipated that in this, as in other subsystems, units or components may be further subcontracted. For example, TRW have discussed manufacture of tanks with Bristol Manufacturing Co. of Winnipeg.

2.4.5 Attitude Determination and Control Subsystem (Figure 2-6)

The Attitude Determination and Control subsystem is based upon designs developed for Intelsat III and IDCSP/A (a U.K. military satellite).

The earth sensors, sun sensors and valve driver electronics are identical to Intelsat III components and will not require redesign or requalification. The despin control electronics and antenna drive mechanism are similar in concept to that developed for IDCSP/A, but will require substantial redesign to achieve the required accuracy.

An engineering model of the nutation damper has been built and tested, so that only flight packaging and qualification is required.

DEVELOPMENT PHASES →

ATTITUDE DETERMINATION AND CONTROL SUBSYSTEM	DESIGN								
	DESIGN DERIVATION	DESIGN STATUS	SPECIFICATIONS		ANALYSIS	CIRCUIT DESIGN	PACKAGING DESIGN	TEST PROCEDURES	UNIT TEST SET DESIGN
SUBSYSTEM FUNCTIONS			Modify SS7-4 to include despin control and antenna drive assy	Subsystem interfaces identified. Requirements for commands, telemetry, and test points refined and released. Analysis in accuracy of attitude, despin control, alignment, reliability					
EARTH SENSORS	Int.III	Complete as is	Update CIR-015 Update EQ4-193	None	Complete	Complete	Complete	Update as required	Existing
SUN SENSORS	Int. III	Complete as is	Update CIR-016 Update EQ4-338	None	Complete	Complete	Complete	Update as req	Existing
DESPIN CONTROL ELECTRONICS	IDCSP /A	Circuit design complete	New	Circuit diagrams, packaging, parts selection, specification to be based upon work already accomplished	X	Exists	Exists	New	None
ANTENNA DRIVE ASSEMBLY	IDCSP /A	Resize basic design	New	Types of bearings, lubricant, and shaft assembly similar to IDCSP unit (Ball Bros.). Resize required. Rotary joint is similar to ComSat Corp. development contract design. Modify to CanSat requirements	X		Exists	New	None
NUTATION DAMPER	Current TRW development	Resize existing tested design	New	Complete subsystem test not required (see despin units below)	X	None	Resize	Update	Exists
VALVE DRIVER ASSEMBLY	Int.III	Complete as is	Update CIR-046 Update EQ4-346	None					

ATTITUDE DETERMINATION AND CONTROL SUBSYSTEM	DEVELOPMENT							
	BREADBOARDS							
			TESTING					
	PART PROCUREMENT	FABRICATION AND ASSEMBLY	EVALUATE PRELIMINARY CIRCUIT DESIGN	STABILITY DATA	THERMAL PERFORMANCE	POWER CONSUMPTION	IMPEDANCE MEASUREMENTS	GROSS SUBSYSTEM INTERACTIONS
SUBSYSTEM FUNCTIONS								
EARTH SENSORS	None required							
SUN SENSORS	None required							
DESPIN CONTROL ELECTRONICS	Existing breadboard to be updated As required	Updating only	X	X	X	X	X	X
ANTENNA DRIVE ASSEMBLY	Not applicable							
NUTATION DAMPER	Not applicable							
VALVE DRIVER ASSEMBLY	None required							

ATTITUDE DETERMINATION AND CONTROL SUBSYSTEM	ENGINEERING MODELS													
	UNITS													
				TESTING										
				STRESS UNDER ENVIRONMENT										
	EM UNIT DRAWINGS	PART PROCUREMENT	FABRICATION AND ASSEMBLY	TEMPERATURE	THERMAL VACUUM	VIBRATION	RADIATED INTERFERENCE SUSCEPTIBILITY	CONDUCTED INTERFERENCE SUSCEPTIBILITY	POWER CONSUMPTION	THERMAL PERFORMANCE	VOLTAGE STRESS (Over and under)	MINIMUM DRIVE	MAXIMUM LOAD	FAILURE CHARACTERISTICS
SUBSYSTEM FUNCTIONS														
EARTH SENSORS	None required													
SUN SENSORS	None required													
DESPIN CONTROL ELECTRONICS	Monitors pulse interval words, output voltage, input power, motor voltage and phasing, antenna reference pulses, etc. New	Use avail. rel. level	X	X	X	X	X	X	X	X	X	X	X	X
ANTENNA DRIVE ASSEMBLY	Motor drive assembly: bearing drag torque, motor resolvers, speed torque variations, loading, balance, alignment New	X	X	X	X	X	X	X	X	X	X	X	X	
	Rotary couplers: evaluate insertion loss, impedance, wow, isolation between channels, mechanical tolerances New	X	X				X	X						
NUTATION DAMPER	Use existing TRW test model to determine best performance for minimum weight. Parameters varied are cantilever blade properties, ball size, fluid viscosity, impact material and case gap. Using existing torsional pendulum test rig frequency is varied over range of spacecraft lifetime nutation frequencies. New	X	X	X	X	X				X				
VALVE DRIVER ASSEMBLY	None required													

ATTITUDE DETERMINATION AND CONTROL SUBSYSTEM	SUBSYSTEM		PROCUREMENT	MANUFACTURING			
	TESTING						
	GROSS SUBSYSTEM INTERACTION	FUNCTIONAL COMPATIBILITY		PLANNING	PROCESSES AND VISUAL AIDS	TOOLING	UNIT TEST SET
SUBSYSTEM FUNCTIONS	Complete subsystem test not required (see despin units below)						
EARTH SENSORS			Components procured as for Intel. III. Lead time is adequate	Lockheed Make Update	Exists	Exists	Exists
SUN SENSORS			Procurement by subcontract (similar to Intel. III, Lockheed). Lead time is adequate	TRW Make Update	Exists	Exists	Exists
DESPIN CONTROL ELECTRONICS	Integrate engineering models, mount on rate table with inertia simulation of antenna. Using artificial sensor and command inputs measure despin position, rate mode accuracies at various spin rates, command values of position, and rate bias		Procurement by subcontract. Philco-Ford	Philco-Ford Make Update	Update	As req'd to existing design	Build to existing design
ANTENNA DRIVE ASSEMBLY				Ball Bros. Make Update Philco-Ford Make Update	Update Update	Update Update	None None
NUTATION DAMPER			Component procurement lead time is adequate	TRW Make New	New	New	Exists
VALVE DRIVER ASSEMBLY			Component procurement as for Intel. III. Lead time is adequate	TRW Make Update	Exists	Exists	Exists

ATTITUDE DETERMINATION AND CONTROL SUBSYSTEM		FORMAL TESTING (AT UNIT, ASSEMBLY, AND SPACECRAFT LEVELS)										
			QUALIFICATION						ACCEPTANCE			
	QUANTITY REQUIRED	FUNCTIONAL PERFORMANCE	TEMPERATURE	THERMAL VACUUM	SPACE SIMULATION	VIBRATION	ACOUSTIC	ELECTROMAGNETIC INTERFERENCE	VIBRATION	THERMAL VACUUM	SOLAR SIMULATION	
SUBSYSTEM FUNCTIONS												
EARTH SENSORS	2	Unit and Assembly	Previously qualified at unit level		Spacecraft	Spacecraft	Spacecraft	Unit and Spacecraft				2 to prototype
	9	Unit and Assembly							Unit and Spacecraft	Unit	Spacecraft	9 to flight
SUN SENSORS	1	Unit and Assembly	Previously qualified at unit level		Spacecraft	Spacecraft	Spacecraft	Spacecraft				1 to prototype
	4	Unit and Assembly							Unit and Spacecraft	Unit	Spacecraft	4 to flight
DESPIN CONTROL ELECTRONICS	1	Unit	Unit	Unit	Spacecraft	Unit and Spacecraft	Spacecraft	Unit and Spacecraft				2 to prototype
	8	Unit							Unit and Spacecraft	Unit	Spacecraft	7 to flight
ANTENNA DRIVE ASSEMBLY	1	Assembly	Assembly	Assembly	Spacecraft	Assembly and Spacecraft	Spacecraft	Spacecraft				1 to prototype
	4	Assembly							Assembly and Spacecraft	Assembly	Spacecraft	4 to flight
NUTATION DAMPER	1	Unit	Unit	Unit	Spacecraft	Unit and Spacecraft	Spacecraft	Spacecraft				1 to prototype
	4	Unit							Unit and Spacecraft	Unit	Spacecraft	4 to flight
VALVE DRIVER ASSEMBLY	1	Unit	Previously qualified at unit level		Spacecraft	Spacecraft	Spacecraft	Spacecraft				1 to prototype
	4	Unit							Unit and Spacecraft	Unit	Spacecraft	4 to flight

Figure 2-6

The first phase of the development program consists of analysis of the total subsystem requirements to determine despin control dynamic performance, vehicle stability analysis, attitude determination accuracy, antenna pointing accuracy, reliability optimization and mechanical analysis of the antenna drive assembly.

Engineering models are then built of all the components and an integrated subsystem test is performed. Environmental tests are performed on new designs. At the conclusion of these tests, qualification units are built and a qualification test is performed on elements not previously qualified. A total subsystem qualification test is performed. The subsystem is then ready for flight unit production and acceptance testing.

This subsystem is being examined with regard to a subdivision of effort. Four separate areas have been identified, namely the earth sensors, the despin motor, the attitude determination electronics and the rotary joint. Discussions are under way between SPAR and Lockeed Aircraft in regard to a licensing arrangement for manufacture in Canada of the earth sensors. The despin motor based on the IDCSP/A design would be subcontracted to Philco-Ford. The rotary joint would be either Philco-Ford if their recent COMSAT design is directly adaptable; or possibly TRW Systems if a new design is required. The electronics portion of this subsystem is the subject of intense discussion between Philco-Ford and RCA Limited. If accordance is reached, this portion of the subsystem would be redesigned for Canadian packaging and built by RCA Limited.

It may be noted that the system is a critical item in terms of spacecraft performance as well as state-of-the-ant. Whereas the electronics is certainly within existing Canadian capabilities, it is felt that a new design to the required specifications would be available only late in the program, whereas the proposed Philco-Ford/RCA Limited agreement would form an excellent basis for a broader Canadian capability for this and other space programs.

2.4.6 Electrical Power Subsystem (Figure 2-7)

The first phase of the program will consist of finalizing the spacecraft power requirements in terms of total power, regulated voltage, limits of ripple peak demand, failure modes, and reliability.

Breadboard and engineering models will then be constructed and development testing will start. The primary new engineering development required will be the testing of batteries utilizing a third electrode for charge control. Detailed tests will be run on the batteries for charge and discharge characteristics, load cycles, storage capacity, overcharge and thermal characteristics.

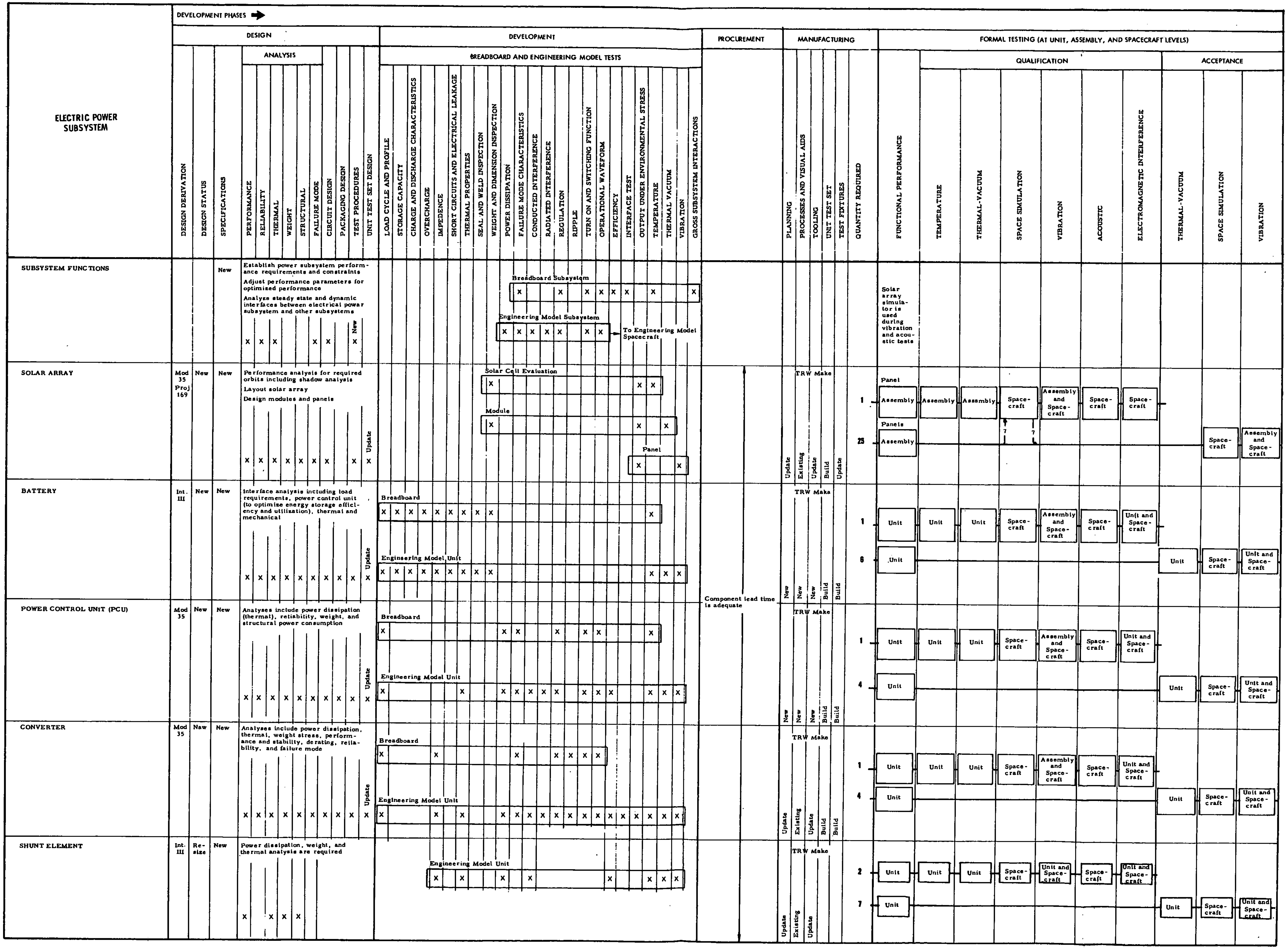

DEVELOPMENT PHASES
DESIGN
ANALYSIS
DEVELOPMENT
BREADBOARD AND ENGINEERING MODEL TESTS
PROCUREMENT
MANUFACTURING
FORMAL TESTING (AT UNIT, ASSEMBLY, AND SPACECRAFT LEVELS)
QUALIFICATION
ACCEPTANCE
ELECTRIC POWER SUBSYSTEM
DESIGN DERIVATION
DESIGN STATUS
SPECIFICATIONS
PERFORMANCE
RELIABILITY
THERMAL
WEIGHT
STRUCTURAL
FAILURE MODE
CIRCUIT DESIGN
PACKAGING DESIGN
TEST PROCEDURES
UNIT TEST SET DESIGN
LOAD CYCLE AND PROFILE
STORAGE CAPACITY
CHARGE AND DISCHARGE CHARACTERISTICS
OVERCHARGE
IMPEDENCE
SHORT CIRCUITS AND ELECTRICAL LEAKAGE
THERMAL PROPERTIES
SEAL AND WELD INSPECTION
WEIGHT AND DIMENSION INSPECTION
POWER DISSIPATION
FAILURE MODE CHARACTERISTICS
CONDUCTED INTERFERENCE
RADIATED INTERFERENCE
REGULATION
RIPPLE
TURN ON AND SWITCHING FUNCTION
OPERATIONAL WAVEFORM
EFFICIENCY
INTERFACE TEST
OUTPUT UNDER ENVIRONMENTAL STRESS
TEMPERATURE
THERMAL VACUUM
VIBRATION
GROSS SUBSYSTEM INTERACTIONS
PLANNING
PROCESSES AND VISUAL AIDS
TOOLING
UNIT TEST SET
TEST FIXTURES
QUANTITY REQUIRED
FUNCTIONAL PERFORMANCE
TEMPERATURE
THERMAL-VACUUM
SPACE SIMULATION
VIBRATION
ACOUSTIC
ELECTROMAGNETIC INTERFERENCE
THERMAL-VACUUM
SPACE SIMULATION
VIBRATION
SUBSYSTEM FUNCTIONS
New
Establish power subsystem performance requirements and constraints
Adjust performance parameters for optimized performance
Analyze steady state and dynamic interfaces between electrical powar subsystem and other subsystems
New
Breadboard Subsystem
Engineering Model Subsystem
To Engineering Model Spacecraft
Solar array simulator is used during vibration and acoustic tests
SOLAR ARRAY
Mod 35 Proj 169
New
New
Performance analysis for required orbits including shadow analysis
Layout solar array
Design modules and panels
Update
Solar Cell Evaluation
Module
Panel
TRW Make
Update
Existing
Update
Build
Update
Panel
1
Assembly
Assembly
Assembly
Space-craft
Assembly and Space-craft
Space-craft
Space-craft
Panels
25
Assembly
7
7
Space-craft
Assembly and Space-craft
BATTERY
Int. III
New
New
Interface analysis including load requirements, power control unit (to optimize energy storage efficiency and utilization), thermal and mechanical
Update
Breadboard
Engineering Model Unit
TRW Make
New
New
New
Build
Build
1
Unit
Unit
Unit
Space-craft
Assembly and Space-craft
Space-craft
Unit and Space-craft
6
Unit
Unit
Space-craft
Unit and Space-craft
Component lead time is adequate
POWER CONTROL UNIT (PCU)
Mod 35
New
New
Analyses include power dissipation (thermal), reliability, weight, and structural power consumption
Update
Breadboard
Engineering Model Unit
TRW Make
New
New
New
Build
Build
1
Unit
Unit
Unit
Space-craft
Assembly and Space-craft
Space-craft
Unit and Space-craft
4
Unit
Unit
Space-craft
Unit and Space-craft
CONVERTER
Mod 35
Naw
New
Analyses include power dissipation, thermal, weight stress, performance and stability, derating, reliability, and failure mode
Update
Breadboard
Engineering Model Unit
TRW Make
Update
Existing
Update
Build
Build
1
Unit
Unit
Unit
Space-craft
Assembly and Space-craft
Space-craft
Unit and Space-craft
4
Unit
Unit
Space-craft
Unit and Space-craft
SHUNT ELEMENT
Int. III
Re-size
New
Power dissipation, weight, and thermal analysis are required
Engineering Model Unit
TRW Make
Update
Existing
Update
2
Unit
Unit
Unit
Space-craft
Unit and Space-craft
Space-craft
Unit and Space-craft
7
Unit
Unit
Space-craft
Unit and Space-craft

Figure 2-7

Thermal vacuum and vibration environmental tests will be run on all engineering units. "Worst case" tests are conducted for open and short circuits, the extremes of input and output voltage and loads, and for the extreme transient conditions. A selected number of solar cell modules are mounted to a substrate panel and subjected to qualification level environmental for verification of design and fabrication process.

After the engineering development phase is completed, the prototype units will be fabricated and submitted to qualification testing, including both functional and environmental testing. The flight units are then constructed and acceptance tested.

This subsystem is considered a candidate for a broad split. As presently contemplated, RCA Limited or appropriate (Canadian) subcontractors to them would provide the battery, power conditioning and converter portion of the subsystem. In addition, efforts are now underway to ascertain the probability of a Canadian manufacturer being able to provide the battery cells.

The solar cell array would be subcontracted to TRW. Particularly in the design phase, the extensive TRW experience and available optimization software programs are highly desirable. At the present time TRW Systems are initiating studies in regard to the possibility of subcontracting to SPAR the assembly of the cell modules on the substrates and the requisite testing. These studies are detailing the controls required, required training programs and the capital requirements. Should this arrangement porve feasible and beneficial to the program, it appears that about 65% of the cost of the array fabrication would be subcontracted back to Canada. The possibility of Canadian production of solar cells is also being explored - notably with National Semiconductors Limited of Montreal.

2.4.7 Apogee Motor Subsystem (Figure 2-8)

The apogee motor now under consideration is a new motor design, based upon existing design capabilities but optimized for this program. Therefore, the motor will undergo an extensive development program consisting of seven development and qualification firings. Two firings will be design verification tests and conducted at the contractor's facilities and the remaining 5 firings will be qualification tests at Arnold Engineering Development Center (AEDC) in Tennessee. Included in these tests will be the firing of a spinning motor while in an altitude chamber. The Thiokol Chemical Corp., Elkton, Maryland has been tentatively selected as the supplier for the apogee motor. However, preliminary discussions have been held with Bristol Manufacturing Ltd. of Winnipeg as to the possibility of their manufacturing these motors.

APOGEE MOTOR SUBSYSTEM	DEVELOPMENT PHASES →																								
	DESIGN			MANUFACTURING					TESTING																
									PRE-MFG		ACCEPTANCE									DESIGN VERIFICATION			QUALIFICATION		
																				THIOKOL			AEDC		
	DERIVATION	TASKS	PROCUREMENT	PLANNING	PROCESSING	TOOLING	TEST FIXTURES	BALANCE FIXTURES (Wallops Island-NASA)	TEST PROCEDURE PREPARATION	HYDRO BURST	INSPECTION	LONGITUDINAL CENTER OF GRAVITY	STATIC AND DYNAMIC BALANCE	NOZZLE ALIGNMENT	ELECTRICAL INSPECTION AND SAFETY	CASE PROOF PRESSURE	LEAK CHECK	RADIOGRAPHIC INSPECTION	MOTOR WEIGHT	VIBRATION TEST	TEMPERATURE CYCLE	FIRING (Sea Level)	VIBRATION TEST	TEMPERATURE CYCLE	SPIN FIRING (Altitude)
SUBSYSTEM FUNCTIONS		Review overall requirements to confirm analysis Thermal and structure analysis of case and nozzle Ballistic performance analysis Preparation of production drawings and specifications Structure installation and alignment. Thermal interface to spacecraft. Electrical interface to ignition and safe-and-arm, telemetry requirements, pre-fire temperature																							
PROPELLANT	Surveyor main retro, Burner II improved Delta, TAT second stage Scout, Athena	Grain design and stress analysis review	Lead time is adequate for all components	Update	Update	New	-	-																	
FORGING AND CASE	Sandia Strypie IV Surveyor, Burner II improved Delta	Case stress analysis		Update	New	New	New	-	Update	X (1)															
IGNITOR SYSTEM AND	Delta and Surveyor TE-P-358	Reliability analysis		Update	Update	Update	Existing	-																	
INSULATION AND NOZZLE	Surveyor retro, Burner II improved Delta	Postfire time-temperature analysis		Update	Update	New	New	-																	
MOTOR ATTACHMENT STRUCTURE		Vibration analysis, compatibility with satellite structure and installation requirements		Update	Update	New	-	-																	
INERT TEST MOTOR (1)							Update Existing	Update Existing	Update		X	X	X	X					X						
LIVE TEST MOTORS (2 for pre-AEDC test)	→	Design Verification Motors →									X	X			X	X	X	X	X	X	X	X			
(5 for AEDC test)	→	Qualification Motors →									X	X	X	X	X	X	X	X	X	→	→	→	X	X	X
FLIGHT MOTORS (3 flight and 1 spare)									Update		X	X	X	X	X	X	X	X							

AEDC: Arnold Engineering Development Center

Figure 2-8

2.4.8 Electrical Integration Subsystem (Figure 2-9)

The electrical integration subsystem includes the harnesses as well as the electrical integration assembly and thus forms the interface function between most of the other subsystems. During the design phase most of the emphasis is on interface control and the requirements for electromagnetic compatibility, particularly with regard to the various items of ordanance within the spacecraft.

The major interfaces involved are:-

- Telemetry and Command
- Power
- Communications
- Positioning and Orientation
- Apogee Motor

The Electrical Integration Assembly will be developed specifically for this spacecraft and thus will have the usual breadboard stages.

The harness will be computer developed and the flight configuration developed from the engineering model of the two decks. After full testing for electromagnetic compatibility as well as system operations and unit qualifications, the flight designs will be released for production.

As presently proposed, the Electrical Integration subsystem would be partially devided between the companies. The EI Assembly would be the responsibility of RCA Limited as would the harness for the upper deck. A small portion of this subsystem would be subcontracted to TRW Systems so as to simplify interfaces between those subsystems on the lower deck which would be their responsibility.

ELECTRICAL INTEGRATION SUBSYSTEM

DEVELOPMENT PHASES ➔

ELECTRICAL INTEGRATION SUBSYSTEM	DESIGN							
	DESIGN DERIVATION	DESIGN STATUS	SPECIFICATIONS	ANALYSIS	CIRCUIT DESIGN	PACKAGING DESIGN	TEST PROCEDURES	UNIT TEST SET DESIGN
SUBSYSTEM FUNCTIONS			New	Established routine requires extreme emphasis on interface control and EMC requirements				
ELECTRICAL INTEGRATION ASSEMBLY (EIA)	Mod 35 Int. III	New	New	Design requires interpretation of overall spacecraft input-output into specific design X	New	Adapted	Update	Existing (semi-auto)
• COMMAND CIRCUITS								
• TIMING CIRCUITS								
• ORDNANCE CIRCUITS								
LOWER SECTION HARNESS	Mod 35 Int. III OGO Vela	New	New	Wiring Integration Design Engineering (WIDE) uses computer to control interconnections, and for error detection. WIDE used as input data to Flexible Automatic Circuit Tester (FACT) WIDE	WIDE		Update	Existing (semi-auto)

ELECTRICAL INTEGRATION SUBSYSTEM	DEVELOPMENT									
	BREADBOARDS									
	PART PROCUREMENT	FABRICATION AND ASSEMBLY	EVALUATE PRELIMINARY CIRCUIT DESIGN	MINIMUM DRIVE	MAXIMUM LOAD	INTERMODULE COMPATIBILITY	TIMING ACCURACY AND STABILITY	ORDNANCE CIRCUIT POWER CAPABILITY	EXTREME TEMPERATURES	GROSS SUBSYSTEM INTERACTIONS
SUBSYSTEM FUNCTIONS										
ELECTRICAL INTEGRATION ASSEMBLY (EIA)	Assemble from modules below X	X	X	X	X	X	X		X	X
• COMMAND CIRCUITS	New Breadboard Module X	X	X	X	X	X	X		X	X
• TIMING CIRCUITS	New Breadboard Module X	X	X	X	X		X			
• ORDNANCE CIRCUITS	New Breadboard Module X	X	X	X	X	X		X	X	X
LOWER SECTION HARNESS										

ELECTRICAL INTEGRATION SUBSYSTEM	DEVELOPMENT							
	ENGINEERING MODELS							
	UNIT LEVEL							
	ENGINEERING MODEL UNIT DRAWING	PART PROCUREMENT	FABRICATION AND ASSEMBLY	ACCURACY AND STABILITY PERFORMANCE	VIBRATION	THERMAL VACUUM	SWITCHING CIRCUIT SUPPRESSIBILITY	FUNCTIONAL CHECK
SUBSYSTEM FUNCTIONS								
ELECTRICAL INTEGRATION ASSEMBLY (EIA)	Monitor accuracy and stability of each function X	X	X	X	X	X	X	X
• COMMAND CIRCUITS								
• TIMING CIRCUITS								
• ORDNANCE CIRCUITS								
LOWER SECTION HARNESS	Develop flight configuration harness on 3-dimensional fixture then transfer to engineering model spacecraft for final verification X	X	X					X

ELECTRICAL INTEGRATION SUBSYSTEM	DEVELOPMENT					
	ENGINEERING MODELS					
	SPACECRAFT LEVEL					
	PERFORMANCE WORST CASE	CONDUCTED INTERFERENCE SUSCEPTIBILITY	RADIATED INTERFERENCE SUSCEPTIBILITY	POWER QUALITY	EIA INTEGRATION TEST	EIA PERFORMANCE AND COMPATIBILITY
SUBSYSTEM FUNCTIONS	Integrate engineering models onto EM spacecraft. Perform same operations and testing for prototype and flight spacecraft X	X	X	X	X	X
ELECTRICAL INTEGRATION ASSEMBLY (EIA)						
• COMMAND CIRCUITS						
• TIMING CIRCUITS						
• ORDNANCE CIRCUITS						
LOWER SECTION HARNESS						

ELECTRICAL INTEGRATION SUBSYSTEM	PROCUREMENT	MANUFACTURING				
		PLANNING	PROCESSES AND VISUAL AIDS	TOOLING	UNIT TEST SET	QUANTITY REQUIRED
SUBSYSTEM FUNCTIONS						
ELECTRICAL INTEGRATION ASSEMBLY (EIA)	Component lead time is adequate	TRW Make New	Update	Update	New Make	1 4
• COMMAND CIRCUITS						
• TIMING CIRCUITS						
• ORDNANCE CIRCUITS						
LOWER SECTION HARNESS	Component lead time is adequate	TRW Make New	Update	New	Update "FACT"	1 3

ELECTRICAL INTEGRATION SUBSYSTEM	QUANTITY REQUIRED	FORMAL TESTING (AT UNIT AND SPACECRAFT LEVELS)									
			QUALIFICATION						ACCEPTANCE		
		FUNCTIONAL PERFORMANCE	TEMPERATURE	THERMAL VACUUM	SPACE SIMULATION	VIBRATION	ACOUSTIC	ELECTROMAGNETIC INTERFERENCE	VIBRATION	THERMAL VACUUM	SPACE SIMULATION
SUBSYSTEM FUNCTIONS											
ELECTRICAL INTEGRATION ASSEMBLY (EIA)	1	Unit	Unit	Unit	Spacecraft	Unit and Spacecraft	Spacecraft	Unit and Spacecraft			
	4	Unit							Unit and Spacecraft	Unit	Spacecraft
• COMMAND CIRCUITS											
• TIMING CIRCUITS											
• ORDNANCE CIRCUITS											
LOWER SECTION HARNESS	1	Assembly			Spacecraft	Spacecraft	Spacecraft	Spacecraft			
	3	Assembly							Spacecraft		Spacecraft

Figure 2-9

2.4.9 Thermal Subsystem (Figure 2-10)

The development of this subsystem is an iterative process of analysis and testing. An extensive computer analysis will first be performed. At the same time, testing of individual subunits or thermal control techniques will take place to furnish data for the computer program. After the thermal design analysis is completed, a full scale thermal model will be tested in a thermal vacuum environment. This model will be adapted from the structural model and includes thermal simulation models of all the components. The results obtained from this test will be used to produce the final production design.

The qualification and acceptance tests of the Thermal Subsystem will be accomplished in conjunction with the tests for the completely assembled vehicle. The Thermal Subsystem will be supplied by TRW Systems. This choice is based on the proven capability, as well as the subsystem relationship to the structural subsystem. It may be noted that a synchronous satellite has very specific thermal problems associated with the apogee motors and the hydrozine thrusters. Further the partial operation of the satellite when in eclipse aggravates the design problems.

2.4.10 Structure Subsystem (Figure 2-11)

The initial design phase will include structural and mechnical design layouts, analysis and required structural development testing. The analytical work includes an analysis of the structural design load criteria,dynamic and acoustic response analysis, material and processes analysis,and a detailed stress analysis.

A structural test model will be fabricated which consists of basic flight type structure and mass simulated components. This structural model will be used to determine fundamental structural integrity when subjected to limit static loads.

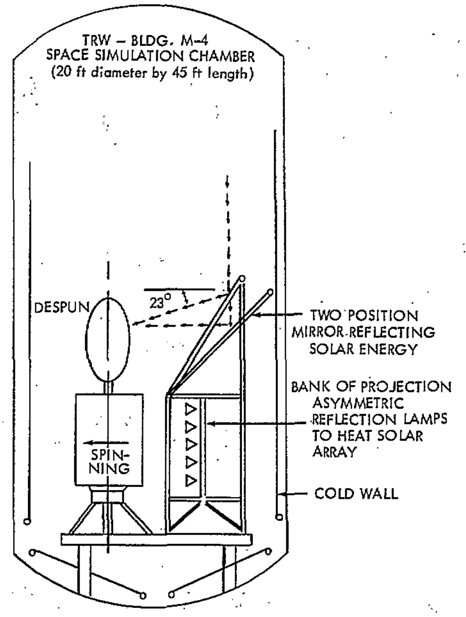
After completion of these tests, the prototype and flight units are fabricated. The qualification and acceptance test of this subsystem shall take place in conjunction with the assembled spacecraft.

The structural subsystem will be subcontracted to TRW Systems with a requirement that SPAR participate to the greatest extent possible. Discussions between RCA Limited and the other parties have concluded that a feasible division of work may be based on the following:-

Up to 25% of the subsystem design and detailed analysis would be carried out by SPAR personnel at TRW, with concentration by SPAR on their specific areas of fabrication capability. In the fabrication phase, it is

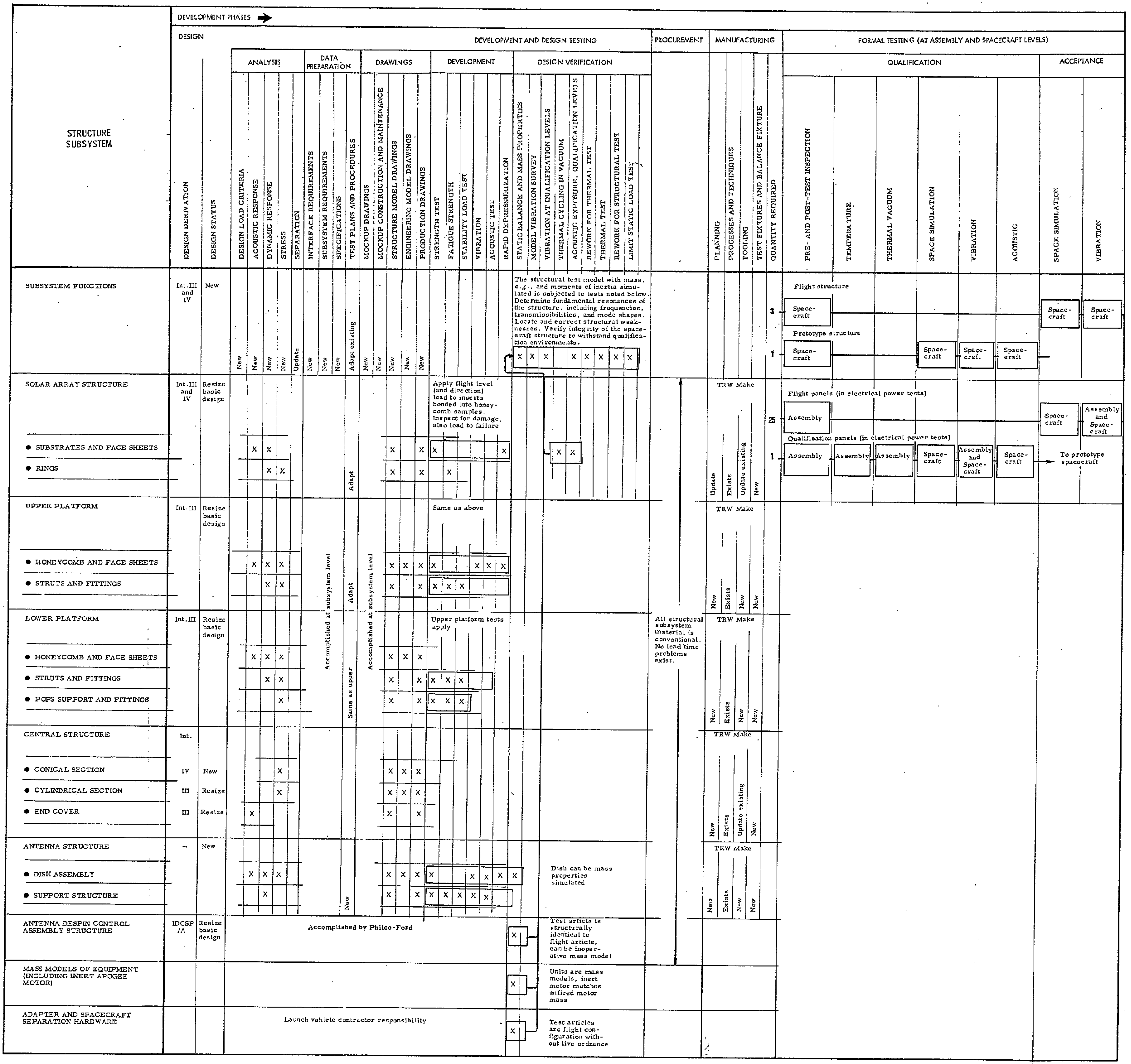
THERMAL CONTROL SUBSYSTEM	DEVELOPMENT PHASES →																						
	ITERATIVE ANALYSIS, DESIGN, AND TESTING																						
				ANALYSES USING TRW THERMAL ANALYZER PROGRAM																			
							DEVELOPMENT TESTING																
	DESIGN DERIVATION	DESIGN STATUS	DEFINE DESIGN CRITERIA	PRELIMINARY ANALYSIS	PREPARE DESIGN SPECIFICATIONS	INITIATE DETAILED DESIGN	ABSORBTIVITY AND EMISSIVITY	EFFECTIVE EMITTANCE AND CONDUCTIVITY	EFFECTIVE THERMAL CONDUCTANCE	HEAT LOSS DETERMINATION	TEMPERATURE EXTREMES	TEMPERATURE CYCLING	VACUUM, ULTRAVIOLET, CHARGED PARTICLES	FINAL ABSORBTIVITY AND EMISSIVITY	THERMAL INTERFACE REPORT	DETAILED ANALYSIS	UPDATE DESIGN	TEMPERATURE EXTREMES AND CYCLING	VACUUM CONDITIONS	+23-DEGREE SUN ANGLE	0-DEGREE SUN ANGLE	UPDATE ANALYSIS	FINAL DESIGN
SUBSYSTEM FUNCTIONS	Int. III Mod 35 Pioneer VI (Int. IV proposed)	New	X	X	X										X			A full scale model of the spacecraft including heat source, thermal mass, thermal footprint of all units and inert apogee motors is tested (see sketch below) X	X	X	X		
SURFACES (FORWARD, CENTER CONTROL, AND AFT CLOSURES, SUBSTRATE BARRIERS, INTERIOR SURFACES)		New				X	Determination of properties required only where reliable data does not exist X				X	X	X	X		X	X					X	X
INSULATION BLANKETS (HYDRAZINE SECTION, APOGEE MOTOR, NUTATION DAMPER)		New				X	Measurements made of particular insulation blanket arrangements: only required where data does not exist.	X								X	X					X	X
SECOND SURFACE MIRRORS		New				X	X				X	X	X	X		X	X					X	X
ISOLATORS (STRUCTURAL JOINTS AND UNIT MOUNTING INSULATORS)		Update				X	Uses representative structure sections and isolators over range of predicted conditions		X							X	X					X	X
SOLAR ARRAY (PANELS AND MODULES)		New				X	Uses section of solar array with cell modules and back insulation installed X	X					X			X	X					X	X
ANTENNA		New				X	Uses maximum length section. Thermal distortion is measured over range of predicted conditions X	X					X			X	X					X	X

THERMAL CONTROL SUBSYSTEM	PROCUREMENT	MANUFAC-TURING			FORMAL TESTING (AT SPACECRAFT LEVEL)					
						QUALIFICATION			ACCEPTANCE	
		PLANNING	PROCESSES AND TECHNIQUES	TOOLING	PRE- AND POST-TEST INSPECTION	VIBRATION	ACOUSTIC	SPACE SIMULATION	VIBRATION	SPACE SIMULATION
SUBSYSTEM FUNCTIONS	All thermal subsystem material is off the shelf. No lead time problems exist.				1 Prototype Subsystem Spacecraft 3 Flight Subsystems Spacecraft	Spacecraft	Spacecraft	Spacecraft	Spacecraft	Spacecraft
SURFACES (FORWARD, CENTER CONTROL, AND AFT CLOSURES, SUBSTRATE BARRIERS, INTERIOR SURFACES)		TRW Make New	Existing	New						
INSULATION BLANKETS (HYDRAZINE SECTION, APOGEE MOTOR, NUTATION DAMPER)		TRW Make New	Existing	New						
SECOND SURFACE MIRRORS		Buy Item New	Existing	New						
ISOLATORS (STRUCTURAL JOINTS AND UNIT MOUNTING INSULATORS)		TRW Make New	Existing	Update						
SOLAR ARRAY (PANELS AND MODULES)		TRW Make New	Existing	Update						
ANTENNA		TRW Make New	Existing	Update						



A full-scale model of the spacecraft, including heat source and thermal mass/foot-print of all units and the inert apogee motor is tested under conditions simulating orbit transfer, summer solstice, equinox and eclipse conditions to verify performance of the thermal control system.

Figure 2-10



SUBSYSTEM FUNCTIONS — Int. III and IV — New

The structural test model with mass, c.g., and moments of inertia simulated is subjected to tests noted below. Determine fundamental resonances of the structure, including frequencies, transmissibilities, and mode shapes. Locate and correct structural weaknesses. Verify integrity of the spacecraft structure to withstand qualification environments.

SOLAR ARRAY STRUCTURE — Int. III and IV — Resize basic design
- SUBSTRATES AND FACE SHEETS
- RINGS

Apply flight level (and direction) load to inserts bonded into honeycomb samples. Inspect for damage, also load to failure

UPPER PLATFORM — Int. III — Resize basic design
- HONEYCOMB AND FACE SHEETS
- STRUTS AND FITTINGS

Same as above

LOWER PLATFORM — Int. III — Resize basic design
- HONEYCOMB AND FACE SHEETS
- STRUTS AND FITTINGS
- POPS SUPPORT AND FITTINGS

Upper platform tests apply

All structural subsystem material is conventional. No lead time problems exist.

CENTRAL STRUCTURE — Int.
- CONICAL SECTION — IV — New
- CYLINDRICAL SECTION — III — Resize
- END COVER — III — Resize

ANTENNA STRUCTURE — -- — New
- DISH ASSEMBLY
- SUPPORT STRUCTURE

Dish can be mass properties simulated

ANTENNA DESPIN CONTROL ASSEMBLY STRUCTURE — IDCSP /A — Resize basic design

Accomplished by Philco-Ford

Test article is structurally identical to flight article, can be inoperative mass model

MASS MODELS OF EQUIPMENT (INCLUDING INERT APOGEE MOTOR)

Units are mass models, inert motor matches unfired motor mass

ADAPTER AND SPACECRAFT SEPARATION HARDWARE

Launch vehicle contractor responsibility

Test articles are flight configuration without live ordnance

Figure 2-11

considered that SPAR would lead in the central structure and antenna pedestal. This would produce a total of 40 - 45% SPAR participation in this subsystem (including the design and analysis). In addition, TRW will investigate the possibility of utilizing the capability of Fleet Aircraft Company in honeycomb fabrication, particularly as it might be applied to the substrate panels.

2.4.11 Ground Support Equipment

It may be noted that the Ground Support subsystem here refers to items associated with integration tasks and does not include the items peculiar to subsystem programs e.g., jigs and subsystem test sets, except where these are common to the integrated system test sets. The major subcontractors in this study have agreed that, where possible, subsystem units will be in turn subcontracted in Canada as directed by the prime contractor, if, in his opinion, such action benefits the program objectives without excessive penalty.

The mechanical support equipment is capable of relatively few steps in realization. Based on the preliminary specifications, the equipments are designed and fabricated. It may be noted that several sets of equipments are required as a consequence of the schedule and various models involved. Major portions of the mechnical ground support equipment will be subcontracted to SPAR.

In the case of Electrical Ground Support Equipment, again the realization is fairly direct. Based on the ISIS and INTELSAT III findings, automated checkout appears highly desirable, and the proposed system is essentially derived from these programs. The Electrical Ground Support Equipment is of course a highly desirable portion of the contract for smaller Canadian electronics companies because it does not involve flight qualification on special fabrication facilities. Discussions have been held with CAE of Montreal for portions of these equipments. This preliminary choice is based on the ease of liaison and their knowledge of computer interface problems. Program optimization may require competitive bidding by Canadian companies on at least portions of these equipments.

All ground support subsystems will be on the basis of contracts between RCA and the appropriate companies. As indicated some other subsystem support equipments may be subject to other arrangements.

2.5. INTEGRATION AND TESTS (Figures 2-12 and 2-13)

The spacecraft development program leading up to the launch of the first three flight spacecraft consists of the following items:

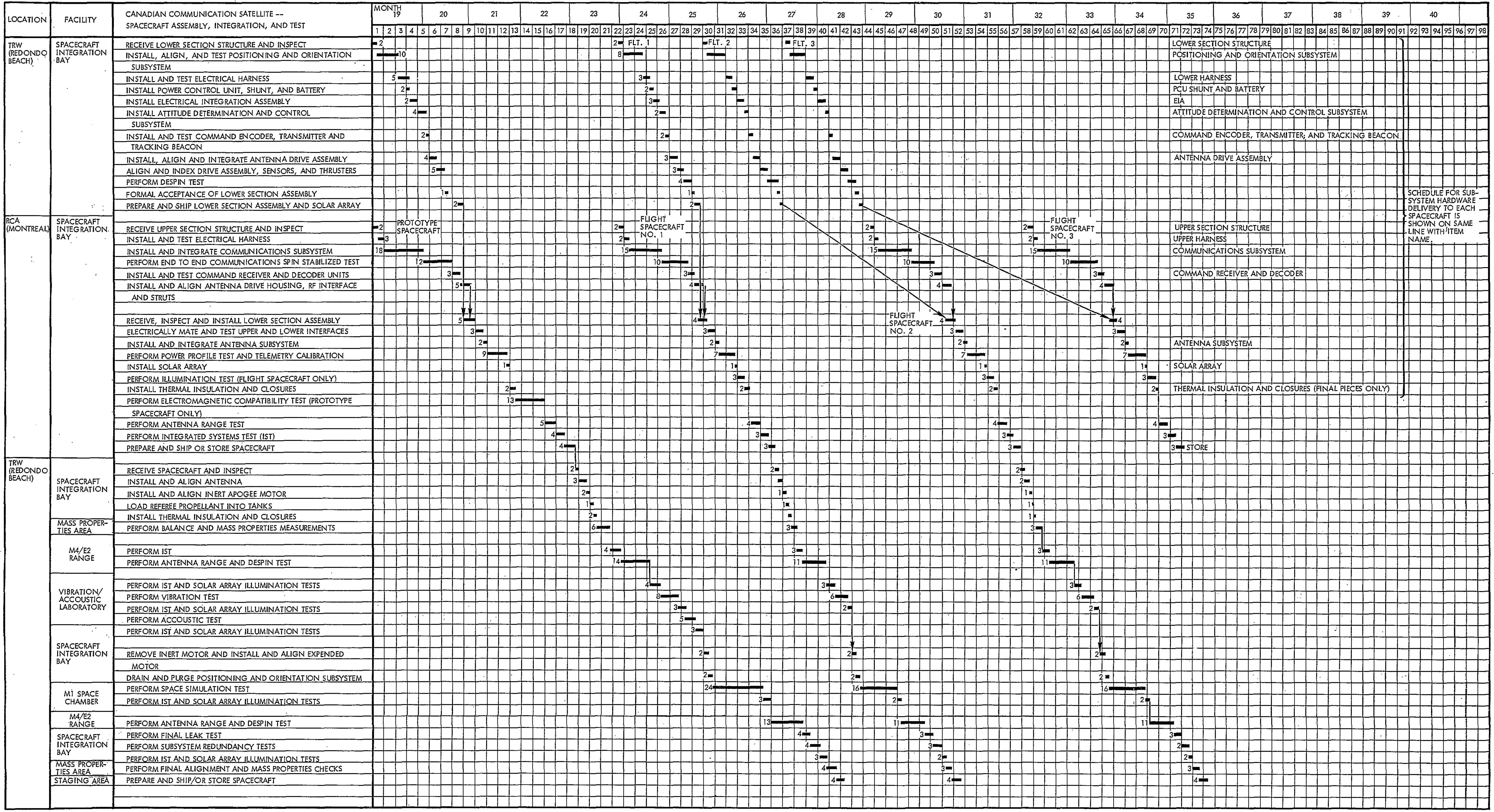
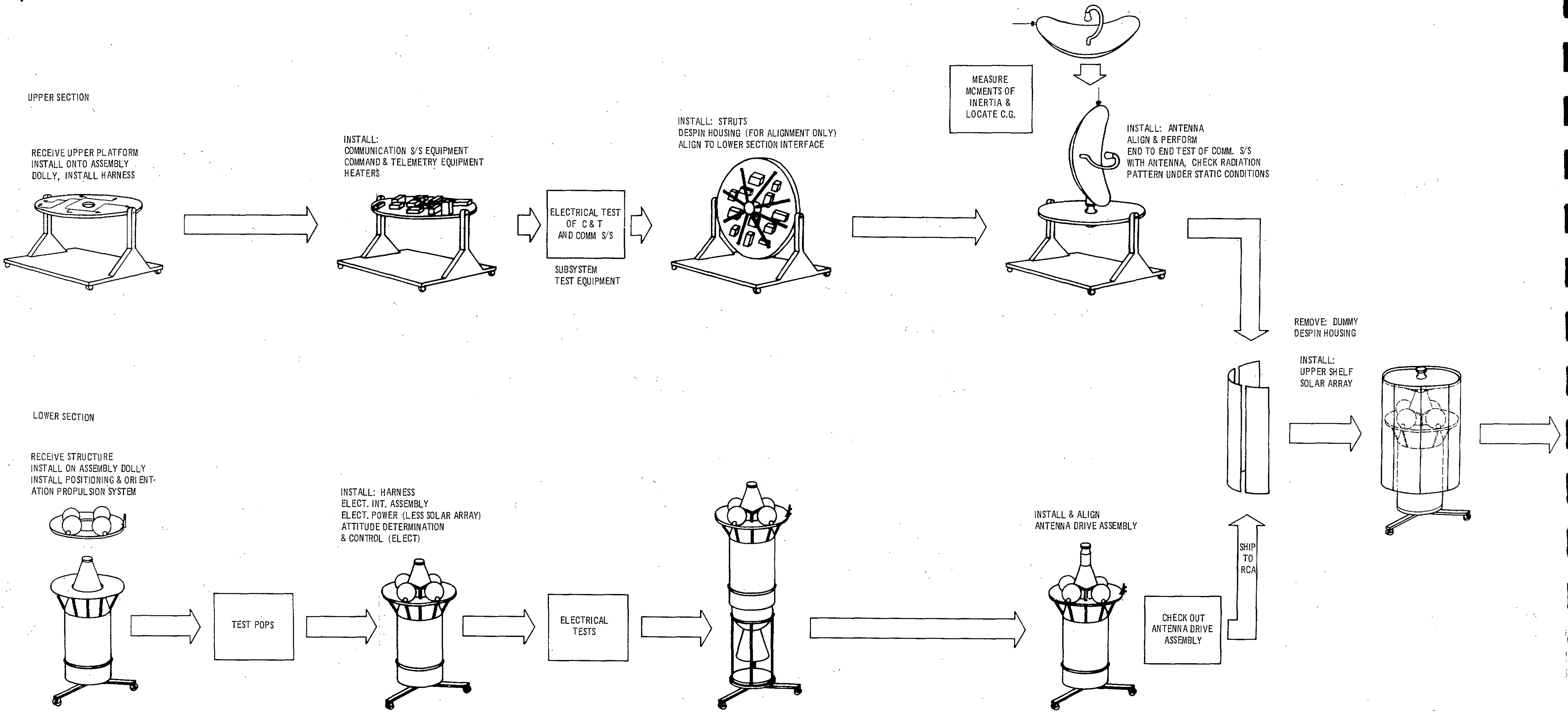

LOCATION
FACILITY
CANADIAN COMMUNICATION SATELLITE -- SPACECRAFT ASSEMBLY, INTEGRATION, AND TEST
MONTH
TRW (REDONDO BEACH)
SPACECRAFT INTEGRATION BAY
RECEIVE LOWER SECTION STRUCTURE AND INSPECT
INSTALL, ALIGN, AND TEST POSITIONING AND ORIENTATION SUBSYSTEM
INSTALL AND TEST ELECTRICAL HARNESS
INSTALL POWER CONTROL UNIT, SHUNT, AND BATTERY
INSTALL ELECTRICAL INTEGRATION ASSEMBLY
INSTALL ATTITUDE DETERMINATION AND CONTROL SUBSYSTEM
INSTALL AND TEST COMMAND ENCODER, TRANSMITTER AND TRACKING BEACON
INSTALL, ALIGN AND INTEGRATE ANTENNA DRIVE ASSEMBLY
ALIGN AND INDEX DRIVE ASSEMBLY, SENSORS, AND THRUSTERS
PERFORM DESPIN TEST
FORMAL ACCEPTANCE OF LOWER SECTION ASSEMBLY
PREPARE AND SHIP LOWER SECTION ASSEMBLY AND SOLAR ARRAY
RCA (MONTREAL)
SPACECRAFT INTEGRATION BAY
RECEIVE UPPER SECTION STRUCTURE AND INSPECT
INSTALL AND TEST ELECTRICAL HARNESS
INSTALL AND INTEGRATE COMMUNICATIONS SUBSYSTEM
PERFORM END TO END COMMUNICATIONS SPIN STABILIZED TEST
INSTALL AND TEST COMMAND RECEIVER AND DECODER UNITS
INSTALL AND ALIGN ANTENNA DRIVE HOUSING, RF INTERFACE AND STRUTS
RECEIVE, INSPECT AND INSTALL LOWER SECTION ASSEMBLY
ELECTRICALLY MATE AND TEST UPPER AND LOWER INTERFACES
INSTALL AND INTEGRATE ANTENNA SUBSYSTEM
PERFORM POWER PROFILE TEST AND TELEMETRY CALIBRATION
INSTALL SOLAR ARRAY
PERFORM ILLUMINATION TEST (FLIGHT SPACECRAFT ONLY)
INSTALL THERMAL INSULATION AND CLOSURES
PERFORM ELECTROMAGNETIC COMPATIBILITY TEST (PROTOTYPE SPACECRAFT ONLY)
PERFORM ANTENNA RANGE TEST
PERFORM INTEGRATED SYSTEMS TEST (IST)
PREPARE AND SHIP OR STORE SPACECRAFT
TRW (REDONDO BEACH)
SPACECRAFT INTEGRATION BAY
RECEIVE SPACECRAFT AND INSPECT
INSTALL AND ALIGN ANTENNA
INSTALL AND ALIGN INERT APOGEE MOTOR
LOAD REFEREE PROPELLANT INTO TANKS
INSTALL THERMAL INSULATION AND CLOSURES
MASS PROPERTIES AREA
PERFORM BALANCE AND MASS PROPERTIES MEASUREMENTS
M4/E2 RANGE
PERFORM IST
PERFORM ANTENNA RANGE AND DESPIN TEST
VIBRATION/ ACCOUSTIC LABORATORY
PERFORM IST AND SOLAR ARRAY ILLUMINATION TESTS
PERFORM VIBRATION TEST
PERFORM IST AND SOLAR ARRAY ILLUMINATION TESTS
PERFORM ACCOUSTIC TEST
SPACECRAFT INTEGRATION BAY
PERFORM IST AND SOLAR ARRAY ILLUMINATION TESTS
REMOVE INERT MOTOR AND INSTALL AND ALIGN EXPENDED MOTOR
DRAIN AND PURGE POSITIONING AND ORIENTATION SUBSYSTEM
M1 SPACE CHAMBER
PERFORM SPACE SIMULATION TEST
PERFORM IST AND SOLAR ARRAY ILLUMINATION TESTS
M4/E2 RANGE
PERFORM ANTENNA RANGE AND DESPIN TEST
SPACECRAFT INTEGRATION BAY
PERFORM FINAL LEAK TEST
PERFORM SUBSYSTEM REDUNDANCY TESTS
PERFORM IST AND SOLAR ARRAY ILLUMINATION TESTS
MASS PROPERTIES AREA
PERFORM FINAL ALIGNMENT AND MASS PROPERTIES CHECKS
STAGING AREA
PREPARE AND SHIP/OR STORE SPACECRAFT
FLT. 1
FLT. 2
FLT. 3
PROTOTYPE SPACECRAFT
FLIGHT SPACECRAFT NO. 1
FLIGHT SPACECRAFT NO. 2
FLIGHT SPACECRAFT NO. 3
STORE
LOWER SECTION STRUCTURE
POSITIONING AND ORIENTATION SUBSYSTEM
LOWER HARNESS
PCU SHUNT AND BATTERY
EIA
ATTITUDE DETERMINATION AND CONTROL SUBSYSTEM
COMMAND ENCODER, TRANSMITTER, AND TRACKING BEACON
ANTENNA DRIVE ASSEMBLY
UPPER SECTION STRUCTURE
UPPER HARNESS
COMMUNICATIONS SUBSYSTEM
COMMAND RECEIVER AND DECODER
ANTENNA SUBSYSTEM
SOLAR ARRAY
THERMAL INSULATION AND CLOSURES (FINAL PIECES ONLY)
SCHEDULE FOR SUBSYSTEM HARDWARE DELIVERY TO EACH SPACECRAFT IS SHOWN ON SAME LINE WITH ITEM NAME.
19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40

Figure 2-12


UPPER SECTION
RECEIVE UPPER PLATFORM
INSTALL ONTO ASSEMBLY
DOLLY, INSTALL HARNESS
INSTALL:
COMMUNICATION S/S EQUIPMENT
COMMAND & TELEMETRY EQUIPMENT
HEATERS
ELECTRICAL TEST
OF C & T
AND COMM S/S
SUBSYSTEM
TEST EQUIPMENT
INSTALL: STRUTS
DESPIN HOUSING (FOR ALIGNMENT ONLY)
ALIGN TO LOWER SECTION INTERFACE
MEASURE
MCMENTS OF
INERTIA &
LOCATE C.G.
INSTALL: ANTENNA
ALIGN & PERFORM
END TO END TEST OF COMM. S/S
WITH ANTENNA, CHECK RADIATION
PATTERN UNDER STATIC CONDITIONS
REMOVE: DUMMY
DESPIN HOUSING
INSTALL:
UPPER SHELF
SOLAR ARRAY
LOWER SECTION
RECEIVE STRUCTURE
INSTALL ON ASSEMBLY DOLLY
INSTALL POSITIONING & ORIENT-
ATION PROPULSION SYSTEM
TEST POPS
INSTALL: HARNESS
ELECT. INT. ASSEMBLY
ELECT. POWER (LESS SOLAR ARRAY)
ATTITUDE DETERMINATION
& CONTROL (ELECT)
ELECTRICAL
TESTS
INSTALL & ALIGN
ANTENNA DRIVE ASSEMBLY
CHECK OUT
ANTENNA DRIVE
ASSEMBLY
SHIP
TO
RCA

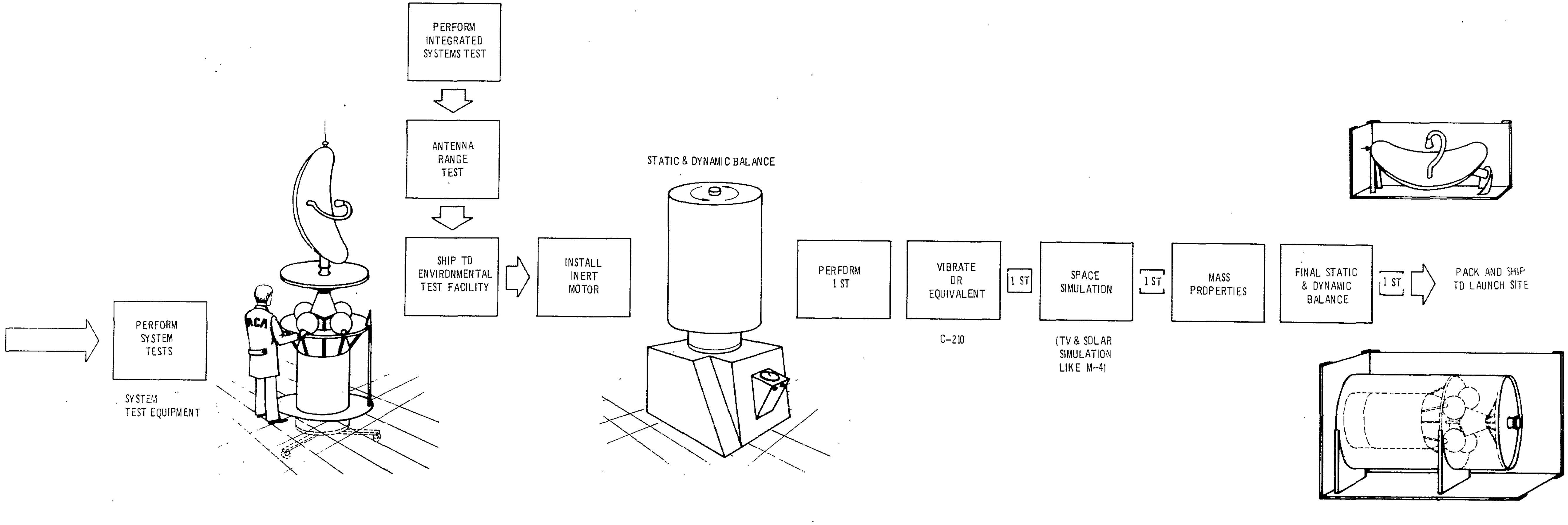


Figure 2-13
Integration and Test Activities

i) An engineering model phase where integration is carried on at the subsystem level on two major sub-assemblies namely the upper and lower equipment decks (but no engineering model spacecraft as such is producted).

ii) A dynamic model used for development and testing of the structural and thermal design.

iii) A Prototype model which is the first electrically and mechanically complete spacecraft made to flight equipment standards with flight standard material. This model is completely integrated and the overall design qualified by comprehensive environmental testing.

iv) 3 Flight spacecraft, two of which are integrated, tested and launched at six month intervals and a third which is integrated, tested as a system (but not for flight) and held as a spare for replacement in case of a failure, or for orbital development.

2.5.1 Upper Deck

The upper deck portion of the structure will contain the Communications and TTC equipment. These two subsystems will be assembled and tested electrically on the deck which will then be integrated with the rotary joint and antenna and despin subsystems. It will be necessary to simulate the remaining interfaces with the rest of the spacecraft. These tasks will be performed by RCA.

2.5.2 Lower Deck

The lower deck portion of the structure will contain the position and orientation, power conditioning, attitude and despin control, and portions of the electrical integration equipment. These subsystems will be assembled onto the deck and tested, simulating the interfaces with the rest of the spacecraft where necessary. This task will be performed by TRW. This solution is suggested because TRW will have the structural, and P & O subsysystem responsibilities which are integrated early on the structure, and interface strongly through mechanical alignment requirements.

2.5.3 Structure

The spacecraft structure is mounted on an assembly dolly and fitted with a dummy apogee motor. The structure is then used to mount the upper and lower equipment decks which in turn carry the solar panels.

2.5.4 Spacecraft Integration

On completion of the lower deck it is joined to the spacecraft structure, which is carried by an assembly dolly, and the antenna drive assembly is next installed. After electrical testing the assembly is shipped to the RCA spacecraft integration area where the upper deck and solar panels are installed. The mounting of the antenna completes mechanical integration of the spacecraft which is then ready for electrical integration tests at RCA followed by environmental tests. These tests consist of balance, vibration, thermal vacuum and solar simulation or variations of these as may be required. These operations will be carried out at TRW but will be the responsibility of and carried out by RCA, with a TRW crew operating the environmental facilities. The spacecraft is then ready for packing and shipping to the launch site.

2.6 LAUNCH AND POST LAUNCH SUPPORT (Figure 2-14)

Launch support consists of all activities leading up to and including the launch phase. In the early phases of the program the activity consists of planning documentations and necessary liaison between range officials, vehicle representatives and the customer. During the launch phase it includes checkout and test by the integration and environmental test team. Following launch, in-orbit checkout will be done in conjunction with the customer at the ground control stations. Reports will be prepared for and assistance given to the customer during the satellite's orbital infancy. These operations will be the responsibility of RCA.

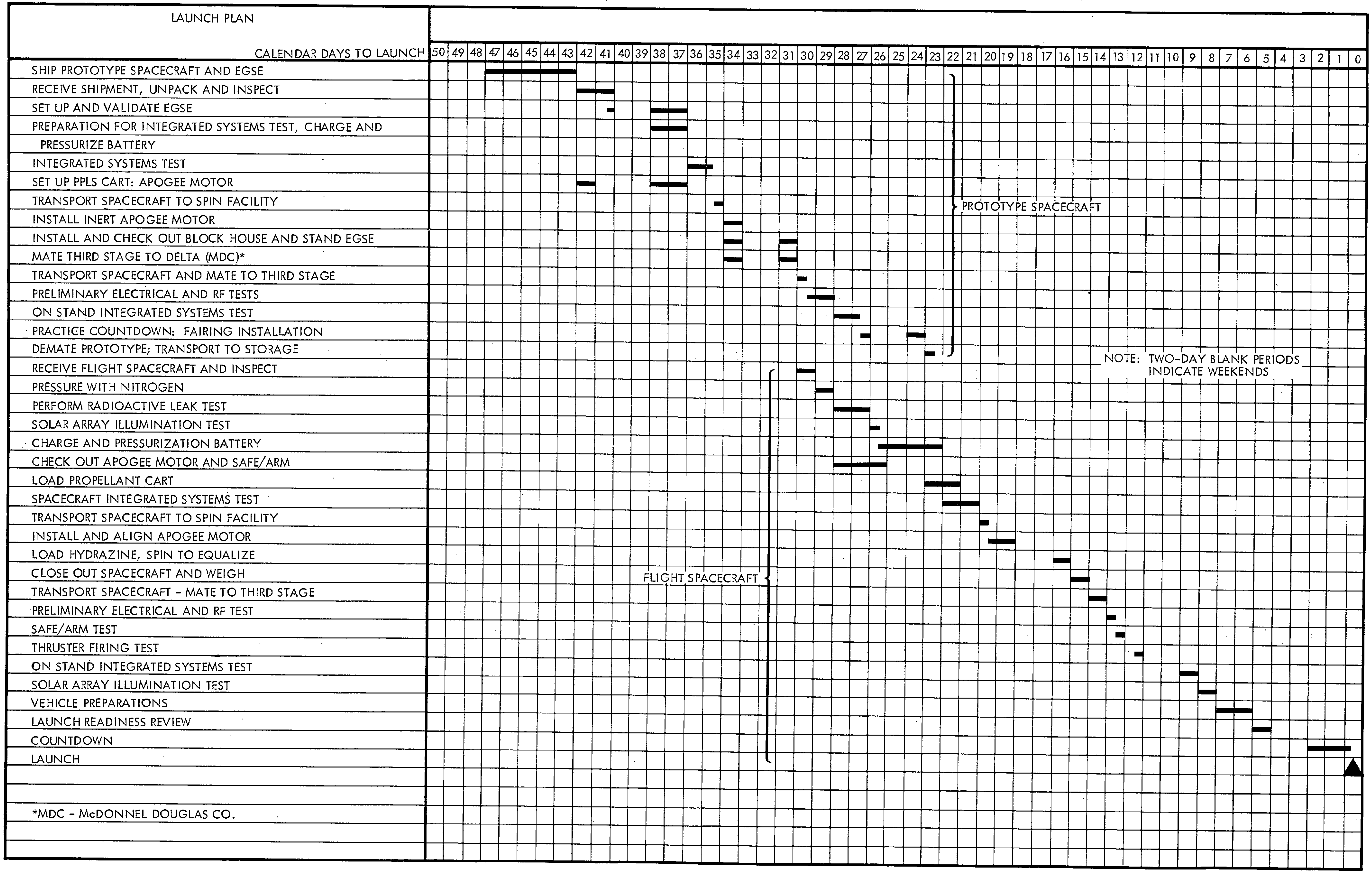

LAUNCH PLAN
CALENDAR DAYS TO LAUNCH
50 49 48 47 46 45 44 43 42 41 40 39 38 37 36 35 34 33 32 31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
SHIP PROTOTYPE SPACECRAFT AND EGSE
RECEIVE SHIPMENT, UNPACK AND INSPECT
SET UP AND VALIDATE EGSE
PREPARATION FOR INTEGRATED SYSTEMS TEST, CHARGE AND PRESSURIZE BATTERY
INTEGRATED SYSTEMS TEST
SET UP PPLS CART: APOGEE MOTOR
TRANSPORT SPACECRAFT TO SPIN FACILITY
INSTALL INERT APOGEE MOTOR
INSTALL AND CHECK OUT BLOCK HOUSE AND STAND EGSE
MATE THIRD STAGE TO DELTA (MDC)*
TRANSPORT SPACECRAFT AND MATE TO THIRD STAGE
PRELIMINARY ELECTRICAL AND RF TESTS
ON STAND INTEGRATED SYSTEMS TEST
PRACTICE COUNTDOWN: FAIRING INSTALLATION
DEMATE PROTOTYPE; TRANSPORT TO STORAGE
RECEIVE FLIGHT SPACECRAFT AND INSPECT
PRESSURE WITH NITROGEN
PERFORM RADIOACTIVE LEAK TEST
SOLAR ARRAY ILLUMINATION TEST
CHARGE AND PRESSURIZATION BATTERY
CHECK OUT APOGEE MOTOR AND SAFE/ARM
LOAD PROPELLANT CART
SPACECRAFT INTEGRATED SYSTEMS TEST
TRANSPORT SPACECRAFT TO SPIN FACILITY
INSTALL AND ALIGN APOGEE MOTOR
LOAD HYDRAZINE, SPIN TO EQUALIZE
CLOSE OUT SPACECRAFT AND WEIGH
TRANSPORT SPACECRAFT - MATE TO THIRD STAGE
PRELIMINARY ELECTRICAL AND RF TEST
SAFE/ARM TEST
THRUSTER FIRING TEST
ON STAND INTEGRATED SYSTEMS TEST
SOLAR ARRAY ILLUMINATION TEST
VEHICLE PREPARATIONS
LAUNCH READINESS REVIEW
COUNTDOWN
LAUNCH
*MDC - McDONNEL DOUGLAS CO.
PROTOTYPE SPACECRAFT
FLIGHT SPACECRAFT
NOTE: TWO-DAY BLANK PERIODS INDICATE WEEKENDS

Figure 2-14

IV 3

ORGANIZATION PLAN

3. PROJECT ORGANIZATION AND MANAGEMENT

3.1 INTRODUCTION

In order to execute successfully a project of the magnitude of the domestic communications satellite project, it is necessary to give careful attention to all aspects of technical and administrative management and control functions. The project must have adequate and continuous managerial and technical supervision and this will be done by drawing on the skills and techniques established on other Company space programs and existing in departments responsible for communications systems. The Management Plan provides the outline of a flexible and yet clearly defined organizational structure which makes the best use of available talent in all company functions and subcontracters and at the same time provides clear cut lines of responsibility.

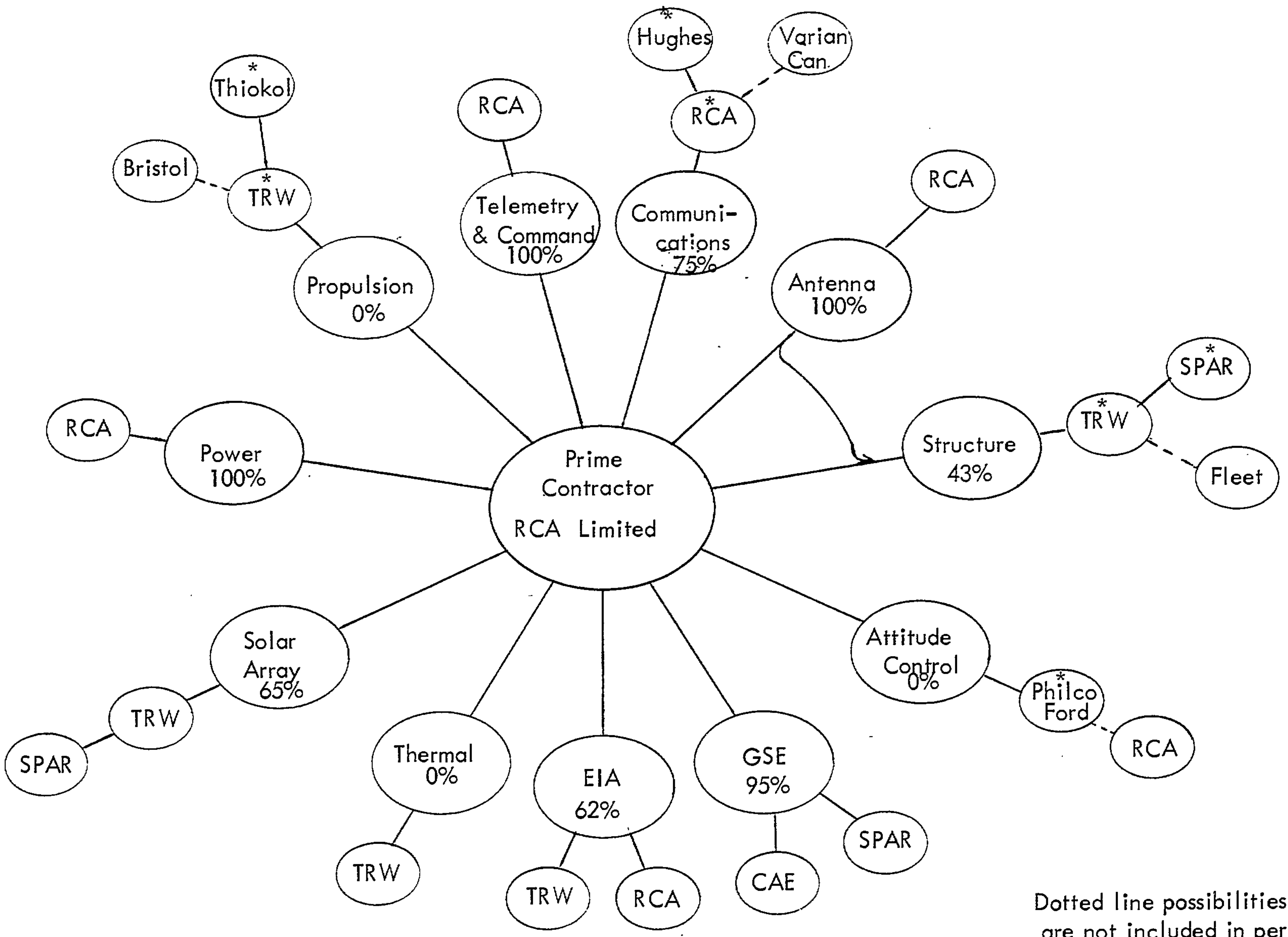
In addition, the best available methods of planning and control will be required over schedule, costs, procurement and material control, engineering, manufacturing operations and subcontracting. Because of the complexity of the project, this planning and control techniques which will allow large masses of data to be handled efficiently and provide timely and accurate information for corrective action by management. The Management Plan must also provide for effective reliability engineering and quality control at all stages of the project.

3.2 INTER-COMPANY RELATIONSHIPS

In the implementation of the program proposed in this report, RCA Limited will be Prime contractor and all other companies involved will be engaged on a subcontract basis. Competitive bids will be sought whereever possible, with preference being given to qualified Canadian companies.

Some assumptions have been made as to allocation of subsystem responsibilities. These we tabled in Figure 3-1, companies which, for costing purposes, have been included in the Program Plan are marked with an asterisk. Discussions have been initiated with potential Canadian alternates to U.S.A. sources. These companies are shown dotted.

In addition, RCA Limited will seek competitive bids in areas for which we have an in-house capability, where overall benefit to the program would result. All subcontracts will be controlled from the Program Management Office which will include subcontract administrators with relevant experience in the work areas affected. Similarly, quality assurance and reliability aspects of subcontract work will be monitored from the Program Management Office by suitable qualified personnel.



Dotted line possibilities are not included in percentages.

Figure 3-1
Subsystem Contracting Relationships
and Canadian Content

3.3 MANAGEMENT PLAN

3.3.1 RCA Limited Organization

Responsibility for the project will be vested in Space Systems of Technical Products, RCA Limited, Montreal, the organizations of the Company, the Technical Products Division and Space Systems are shown in Figures 3-2, 3-3, 3-4.

3.3.2 Project Management

The detailed execution of the program will be the responsibility of a Project Management Office which will be located in the Aerospace Operations Department of Space Systems of RCA Limited, Montreal. The suggested organization of the Project Management Office is shown in Figure 3-5. The Project Management Office will be headed by the Project Manager, who, in turn, will be assisted by Assistant Project Managers in the areas shown in the organization. The concept of the Project Management Office is proposed in order to bring together the best talents available within the Company and from subcontractors for the purpose of designing, building and launching the spacecraft and to focus all project activity into a single business entity charged with the responsibility of producing the spacecraft to specification and on schedule.

The Project Manager will have under his direct control the main administrative, control and systems engineering functions involved in the execution of the project. Personnel will be assigned from Company and subcontractor operating groups into the Project Management Office for the duration of the project. It is planned to undertake all aspects of systems design, systems testing, test and launch planning within the project office; the interface between the Project Office and outside engineering design and procurement functions will be at the detailed unit or component specification level. Detailed project planning, scheduling and quality control will remain the responsibility of the Project Office.

It is anticipated that the number of staff in the Project Office will vary with the particular phase of the project being undertaken at that time and that staff will be transferred between the Project Office and the operating groups as the project dictates.

Present plans are to have a Fabrication and Assembly facility reporting directly to the Space Systems function. This "model shop" type of facility will have sufficient capacity to handle long-term level loads imposed by the project; any excess will be subcontracted to other departments in the Company or to outside vendores.

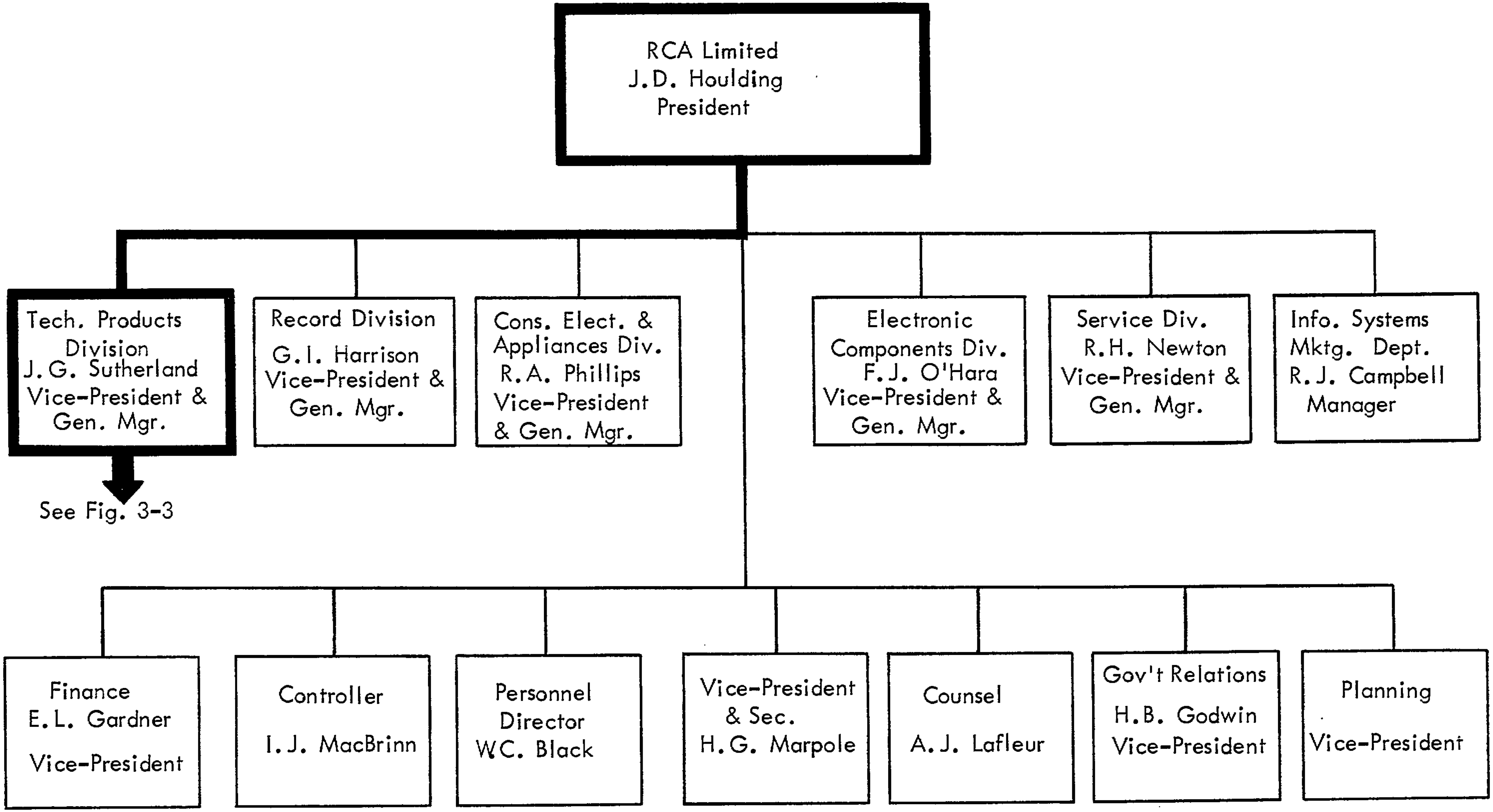


Figure 3-2

Company Organization, RCA Limited

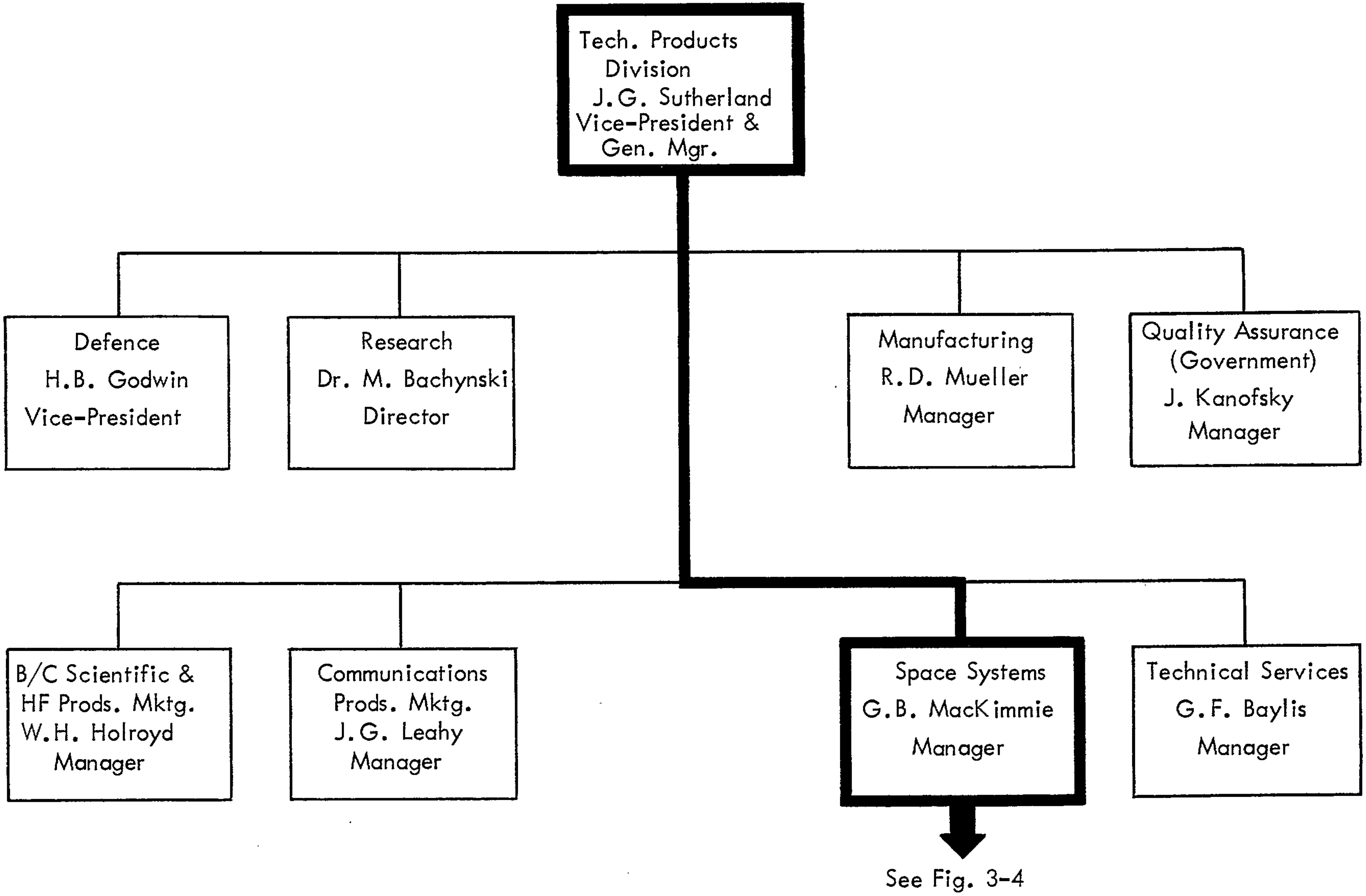


Figure 3-3

Organization Technical Products Division
RCA Limited

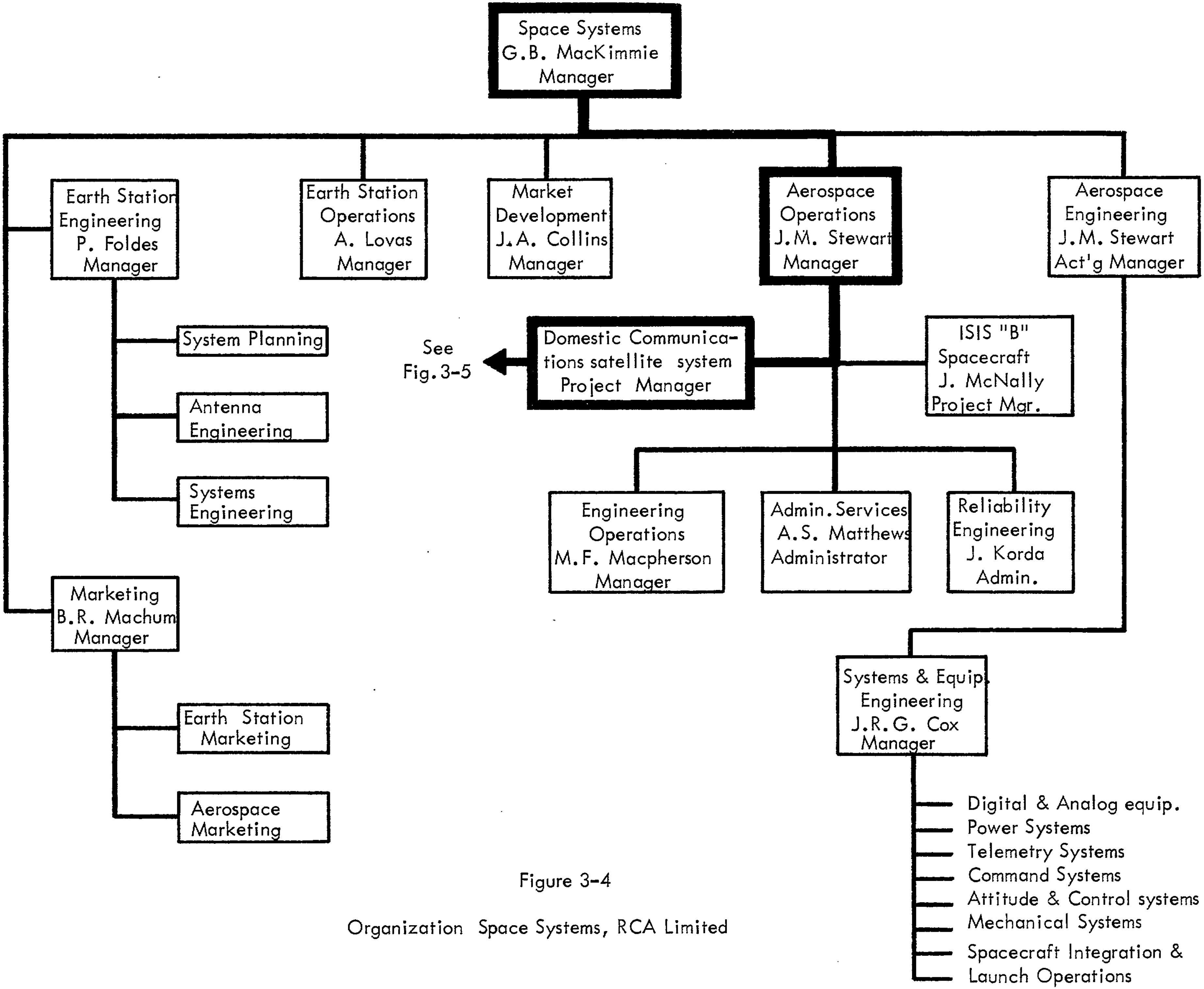


Figure 3-4

Organization Space Systems, RCA Limited

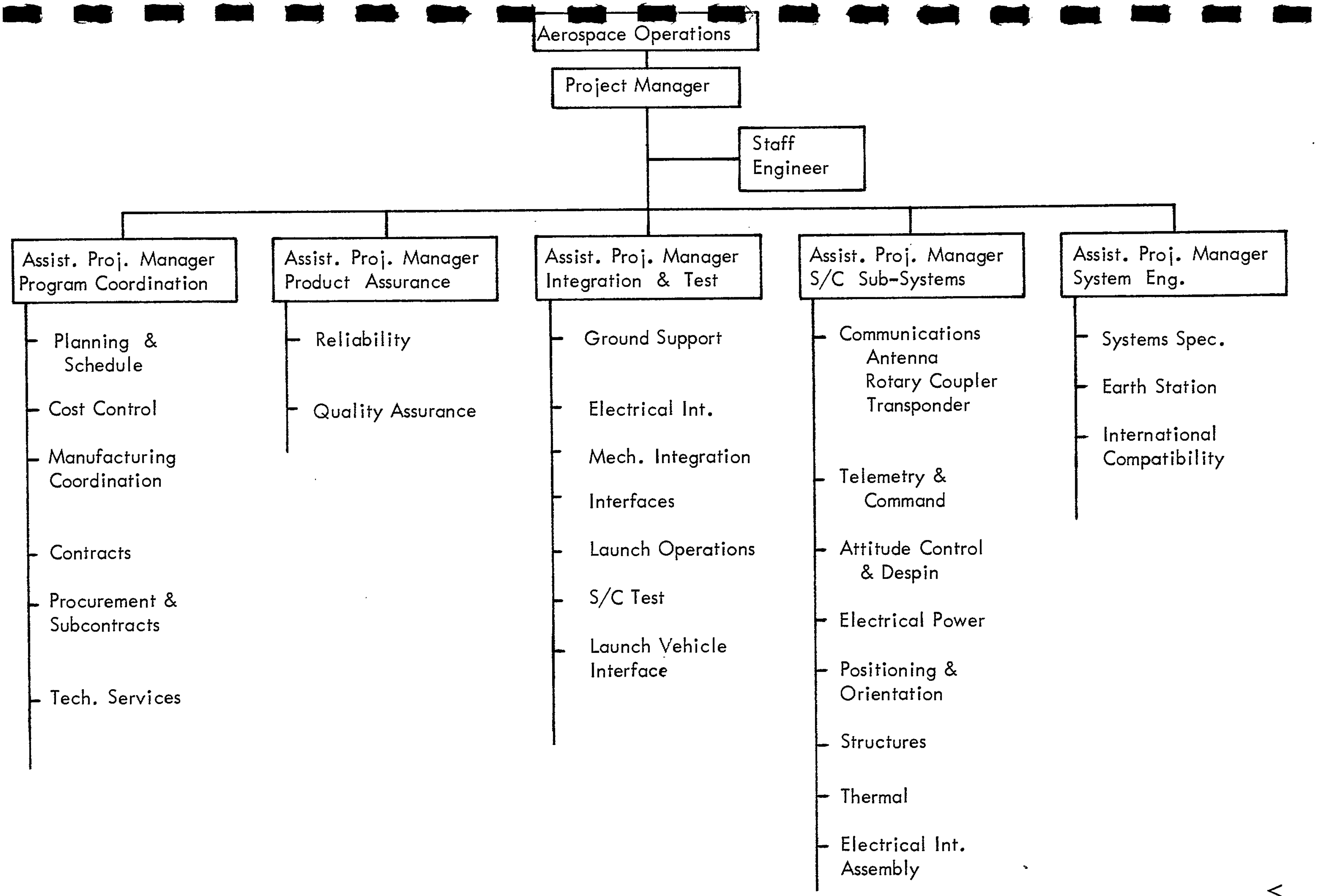


Figure 3-5

Communications Satellite Project Management Office

3.3.3 Interfaces between Project Management Office and other functions

As stated above, overall technical and administrative direction and control of the project, will rest with the Project Manager and his staff in the P.M.O. Detailed activities in areas of engineering design, drafting, test, contracts and subcontracts liaison, procurement manufacturing etc. will be the responsibility of existing Company functions who will be required to complete these activities within time and cost schedules established by the P.M.O. All possible use will be made of the skills established in the engineering groups in Aerospace Engineering as a result of participation in the Alouette - ISIS and other space projects.

3.3.4 Cost and Schedule Control

- Introduction

RCA Limited uses fully mechanized methods for the development of cost and schedule information. The two basic sources of project costs, direct material and direct labour, are accumulated continuously against the task breakdown for the project.

The project task breakdown has a dual function. In addition to providing a framework for the project cost control system, it provides the basis for the project work plan. With the application resources, the project plan becomes the project schedule. As major portion of the costs accumulated against the job result from the expenditure of time by labour, cost control and time control are inter-related.

- Cost Accumulation and Control

The project estimate is analysed into segments which in turn match the project task breakdown. To each segment a code is assigned; this code, in turn, is used to accumulate labour charges against the work expended on the project.

Material charges are accumulated as purchase orders are placed and are in turn continuously compared to the estimates originally prepared for the project. As the original material estimates are directly related to each subsystem through the task breakdown, these form the framework for a material budget for each subsystem. This project material budget is used for measuring the rate of expenditure as the various designs are released to production or to subcontractors for action. Complete project cost actuals and forecasts are prepared and up-dated monthly for review and action by management.

o Time Control

The introduction to this section emphasized that on a project such as a satellite,cost and schedule control are inseparable. This paragraph will be concerned with the methods of data accumulation and reporting of progress against the project schedule.

RCA Limited employs the Critical Path Method for analysing the interrelationships amongst units, subsystems, spacecrafts and other project outputs. The Critical Path system provides the time boundaries for the project plan. With the application of suitable resources, labour, material, machines and test equipment, a project schedule is developed. The project schedule is optimized around normally available resources and the required launch dates. In order to keep the schedule optimized, internal progress reporting on engineering status,material deliveries, manufacturing progress and overall system predictions, provide periodic feedback to allow timely adjustment of network logic and resource applications to maintain the schedule.

Progress reporting to the customer is abstracted from C.P.M. reports which are prepared and updated by computer on a monthly routine. Although the content and format of these reports can be varied to suit customer requirements, it is recommended that a simple format for routine reports be maintained for the program. A summary of Critical Path outputs pertaining to integration, test and launch activities will be provided to produce a brief but cogent indication of progress against the project plan and will indicate in advance the areas in which problems have occurred. In addition to this summary, a pro-forma report will be prepared which provides a summary analysis of the schedule progress for review by management. This report will cover the following subjects.

a) General description of current project phase and progress compared with project plan.

b) Existing problems affecting the schedule and a possible solution in terms of rescheduling of resources.

c) Resolution of problems reported previously.

d) Description of possible future problem areas predicted from current technical difficulties and action that will be taken if necessary.

This proposed time reporting procedure does not preclude special reports, which may be requested from time to time by the customer.

In summary, RCA Limited has the capability for continuous review of project planning and scheduling inputs to relate cost and time expenditures to project plan. The control and reporting system is extensive and detailed enough to ensure that real-time information is available to program management. A monthly summary of the current status will be forwarded to the customer for management review against the program objectives.

3.3.5 Reliability and Quality Control

- Introduction

RCA Limited proposes to control both reliability and quality assurance through the establishment of an integrated Product Assurance group. A brief Product Assurance Plan has been prepared and attached as Appendix A to this section.

The main goal of the Product Assurance Plan will be to ensure a high probability of successful operation of the spacecraft in orbit for a period of at least five years. This will be achieved by RCA Limited establishing procedures and controls for continuous monitoring and analyses of all engineering, manufacturing and procurement activities on the project. These procedures will cover the following as a minimum.

- Reliability Engineering
  - effective sub-contractor surveyance
  - uniform high reliability parts and materials program
  - effective design control through design reviews and design analyses
  - malfunction analyses and control
  - documentation control
- Quality Assurance
  - Incoming Inspection procedures
  - Sub-contractor auditing
  - material traceability

- fabrication and assembly inspection criteria
- equipment test auditing
- test and launch-site quality control

3.4 PROJECT RESPONSIBILITIES

3.4.1 Project Manager

The Project Manager will be responsible for the overall execution of the domestic satellite project. He will be responsible for Project Co-ordination, Product Assurance, Integration and Test, Spacecraft Subsystems Design and overall Systems Engineering and will be supported in this task by five assistant Project Managers, one in each of the areas outlined. In addition, he will have a Senior Staff Engineer appointed to assist him in the overall technical direction of the program. The Project Manager will also be responsible for liaison with senior management within the Company, with subcontractors and with the customer.

3.4.2 Assistant Project Manager - Project Co-ordination

The Assistant Project Manager - Project Co-ordination will be responsible for most business aspects of the project including project planning and scheduling, cost control, contract and subcontract liaison, procurement (including manufacturing) and all support services.

3.4.3 Assistant Project Manager - Product Assurance

The Assistant Project Manager - Product Assurance will be responsible for all aspects of the reliability engineering and quality assurance on the project. His duties and responsibilities are outlined in more detail in the reliability and quality assurance plans contained in later sections of this proposal.

3.4.4 Assistant Project Manager - Systems

The Assistant Project Manager - Systems Engineering will be responsible for all aspects of overall systems design, earth station interfaces, and international participation in the project. In particular, Systems Engineering will be responsible for translating the overall customer requirements into a specific spacecraft configuration and into sub-system specifications and design aims.

In cooperation with design specialists these requirements will be broken down further into unit specifications which are kept up to date during the program. The systems group may carry out studies either internally generated or at the request of the customer, that may involve other groups or areas of concern such as earth station technology or coordination with agencies such as Comsat or CCIR. The group will be responsible for carrying out and reporting on special tests as requested by the customer or as deemed necessary by the prime contractor for the orderly development of the spacecraft. It is not expected that this group will have any hardware responsibilities but that they should provide active overall technical coordination to ensure harmony between subsystems and the achievement of the desired spacecraft purpose.

3.4.5 Assistant Project Manager - Spacecraft Subsystems

The Assistant Project Manager - Spacecraft Subsystems will be responsible for the communications, telemetry and command, attitude control and despin, power, positioning and orientation, structure, thermal design, and the electrical integration assembly of the spacecraft.

The group will be responsible for preliminary designs, detailed specifications and follow up of all subsystems that are the direct responsibility of the prime contractor, such as communications and telemetry, and for specifications, technical co-ordination and follow-up on subsystems that are subcontracted by the prime contractor such as the apogee motor and structure. The prime function of this group will be to translate the overall requirements of the spacecraft, as defined by the system engineering group, into hardware specifications, and to provide orderly channels of two way communications between the equipment development groups and the project office to update or clarify these requirements.

3.4.6 Assistant Project Manager - Integration and Test

The Assistant Project Manager - Integration and Test will be responsible for ground support equipment, electrical and mechanical integration in the spacecraft, spacecraft vehicle interfaces, launch operations, overall spacecraft test and vehicle interface.

The group will be responsible for all technical planning and supervision of operations dealing directly with the complete spacecraft. These will include the initial electrical and mechanical integration of components, subassemblies and subsystems on the spacecraft, and all subsequent environmental tests of the complete spacecraft. The group will be responsible for all test equipment, launch phase technical planning, and supervision of launch and post launch operations.

IV 4

RESOURCES
& FACILITIES

4. FACILITIES & RESOURCES

4.1 INTRODUCTION

RCA Limited's implementation plan is based upon two major subcontractors - TRW Systems of Redondo Beach, California, and SPAR Aerospace Products, Don Mills, Ontario. The proposed work for these companies is described in Sections 2 and 3 of this volume. In addition to TRW and SPAR, RCA Limited has considered several Canadian and European companies for the supply of such products as solar cells, apogee motors, travelling wave tubes, ground check-out equipment, honeycomb structures, precision bearings, and general precision mechanical parts and assemblies.

A summary of the facilities, resources and experience of RCA Limited is given first. This is followed with facility information on TRW and SPAR. Section 5.5 gives a listing of twelve companies in Canada and Europe who have been considered as subcontractors as a part of RCA Limited's total subcontract plan for the spacecraft.

4.2 FACILITIES & RESOURCES OF RCA LIMITED

4.2.1 Background experience in satellite communications

. 1961 start in satellite transponders.

RCA Limited's experience in the space segment aspects of satellite communications began in June of 1961, when NASA approved RCA in Montreal for the major program of development and supply of the transponder system for the RELAY communications satellite. The program, expanded to include beacon transmitters and satellite simulators, provided over $2 million in early Canadian communications satellite experience, involving a team of some 35 engineers. The RELAY satellite, together with Telstar, both launched in 1962, demonstrated the feasibility of communications via satellite.

The experience and organization developed on the RELAY satellite program were successively used to furnish telemetry transmitters for Alouette I, Canada's first satellite, and for two major NASA scientific satellites - Explorer I and Pegasus. In 1963, RCA Limited was the winner of an open Canadian industry competition, organized by Defence Research Board and DDP, for the work of orderly transition from DRTE to industry, of Canada's prime contracting and systems engineering capabilities in scientific satellites, as developed by DRTE on the Alouette I program. This award led to the majority of manufacturing by RCA Limited of the Alouette II satellite, launched in September 1965, and full assumption of prime contractor and design responsibilities for the successive Canadian scientific satellites, the ISIS "A" and ISIS "B".

- RCA Limited's contribution to early considerations for a Canadian domestic satellite system.

Throughout 1966 and 1967, Space Systems of RCA Limited retained at its expense a task force of experts on satellite communications expecially devoted to the problems associated with domestic satellite communications. Two major publications by this task force had appreciable influence in advancing government considerations of a Canadian domestic satellite system and giving technical orientation to the program. One publication entitled "Canadian TV Network Satellite System" of September 1966, formed the basis for considerable material in the Chapman Report of February 1967 on recommendations for a Canadian domestic satellite system, and was also used by Power Corporation of Canada and Niagara Television for a proposed satellite-fed TV distribution service for Canada. The second major publication of the RCA Limited task force, "A Canadian Satellite to Serve Canada's Domestic Communications Requirements" in September 1967, was submitted as a contribution to the Prime Minister's Task Force on Satellites.

The RCA Space Systems task force has carried out extensive information gathering on domestic satellite communications, and satellite communications in general, over the past 3½ years. The members of this task force have been engaged on the Department of Industry satellite study program.

- World-wide ground station experience.

RCA Limited's extensive experience in satellite communications ground stations has enabled the company to conduct sound system trade-off analyses involving the space and ground segments of an overall satellite communications system, and to propose and implement cost-effective measures without compromise to systems performance.

Experience in ground stations began in 1959 with six successive contracts from Jet Propulsion Laboratory for research, development and supply of antenna feed systems for NASA's Deep Space Instrumentation Facility. In the succeeding years, over 20 other satellite ground station assignments have been, or are in process of being performed by RCA Limited in Montreal to a valuation in excess of $24 million. The major of these are the two large stations at Mill Village, N.S., handling Canada's trans-Atlantic telecommunications via Intelsat satellites, India's first communications satellite station at Poona, and supply of major earth station subsystems for large terminals in Panama, USA, Argentina, Brazil, Australia, Philippines, and Kenya.

. <u>Supporting technological strength from RCA Limited's engagement in high capacity, solid state radio relay systems.</u>

The previous paragraphs illustrate the heavy commitment in personnel and planning that RCA Limited has made over the past 8 years in the field of satellites and earth stations. The major technical influences spearheading this Canadian industry success was derived from the company's Research Laboratories providing personnel and concepts for technological innovation, and the company's Microwave Engineering Dept. providing a broad spectrum of techniques in wideband solid state communications at 2, 4, 6 and 7 GHz.

Approximately 90 engineers are engaged in microwave radio relay systems. RCA Limited is Canada's foremost designer and manufacturer of microwave systems, having installed over 30,000 route miles of wideband systems in 13 countries of the world. Recent large scale systems were, an 813 mile system in Mexico, and extensive systems in Colombia, Egypt, Liberia, Turkey, Iran and Pakistan. In Canada, extensive application of RCA Limited microwave communications equipment has been made by CN-CP Telecommunications, Bell Canada, and major telephone companies and public utilities.

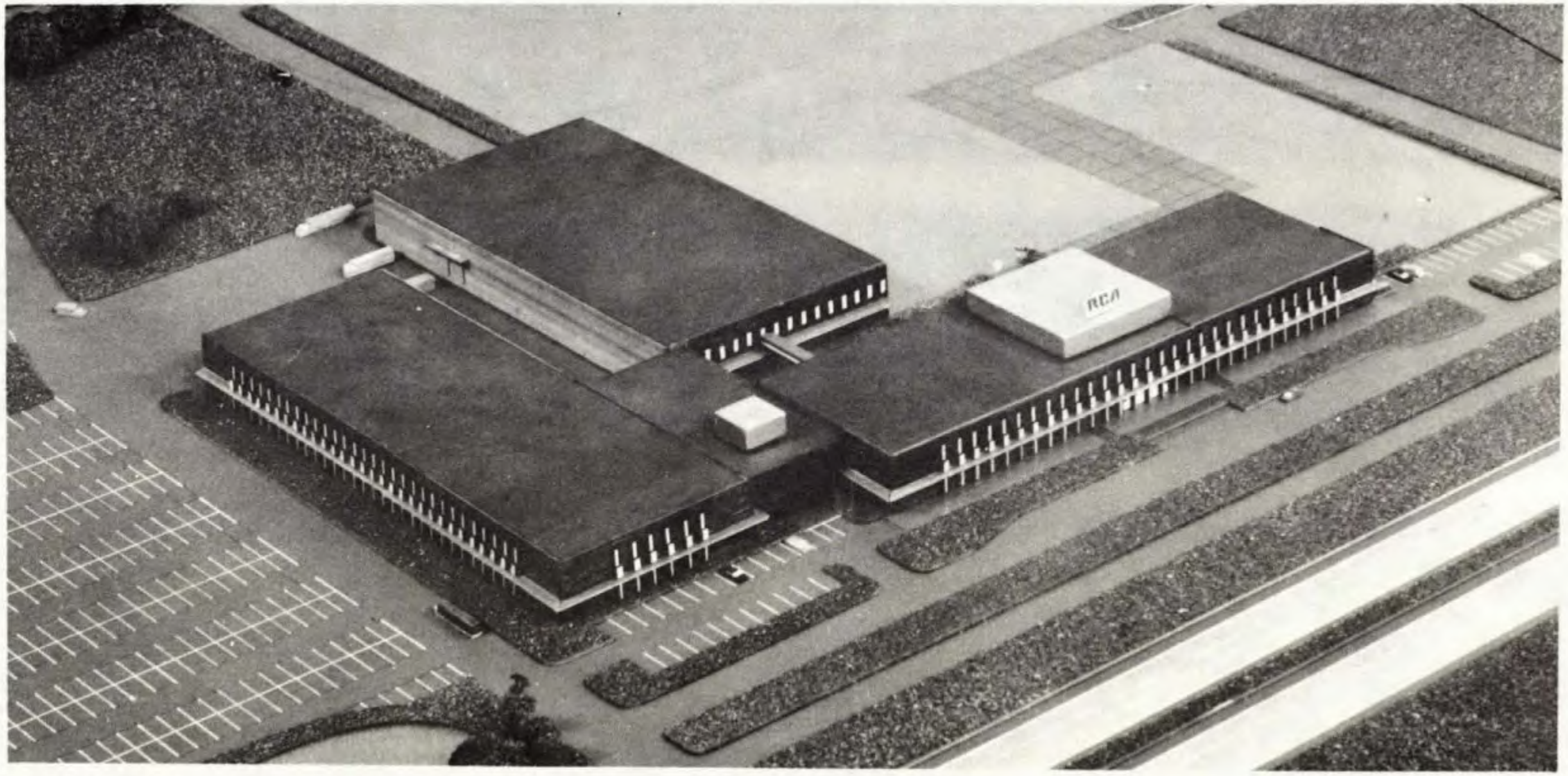
4.2.2 New Aerospace Facility at Senneville, Quebec

Starting in the early Spring of 1969, RCA Limited plans the construction of a modern, 60,000 sq. ft. facility facing the Trans Canada Highway, 20 miles west of Montreal at Senneville, Quebec. The new facility, to be completed by October 1969, will be devoted to research, development, manufacture, integration and test of a complete spacecraft and major satellite subsystems. As such, it will replace the substantial aerospace facility within the Technical Products plant of RCA Limited at 1001 Lenoir Street in Montreal, with increase in space to permit the proposed Canadian domestic satellite to be produced to the prescribed schedule, in addition to other spacecraft commitments. The new RCA aersospace facility is part of a planned $3.6 million RCA Limited plant and office facility at Senneville, comprising 215,000 sq. ft.

Certain specialty manufacturing processes and testing functions associated with spacecraft will continue to be performed at RCA Limited's 365,000 sq. ft. Technical Products plant in Lenoir Street in Montreal. The Lenoir Street facility will beretainedas the engineering and manufacturing centre for expanding requirements in the domestic and international markets for the company's products and services in satellite earth stations, microwave communications systems, digital systems, and broadcast and instructional systems.

NEW AEROSPACE FACILITY FOR RCA LIMITED

RCA Limited of Montreal plans 1969 construction of a $3.6 million 215,000 sq.ft. facility at Senneville, Quebec, 20 miles west of Montreal facing the Trans Canada Highway. The two-story complex will consist of four buildings. One of the buildings is planned expressly for expanded work on research, development, manufacturing, integration and test of spacecraft for scientific explorations, and for domestic satellite communications. Management and Administration functions and support services will be carried out in the other buildings. Building completion is planned for October 1969.



The new 60,000 sq. ft. RCA Aerospace facility will have the following minimum floor space assignments:

. administration offices	5,000 sq. ft.
. research and engineering offices	17,000 " "
. engineering laboratories	12,000 " "
. high-bay spacecraft integration laboratory	8,000 " "
. specialty shop for fabrication of spacecraft parts and assemblies	5,000 " "
. environmental test facility	4,000 " "
. assembly and test of spacecraft subassemblies	5,000 " "

RCA Limited's new satellite facility will be one of the foremost of its kind in the world. In carrying out meticulous design of the facility, RCA management and plant planning experts have drawn from the experience of the RCA Lenoir Street aerospace facility and modern spacecraft plants in the United States and Europe. RCA Limited's expanding scope of satellite activity over the past 8 years, involving 8 separate programs to a valuation of $18 million, and the future requirements for greatly increased sophistication in communications satellites, has been formulated within the design of the new spacecraft centre.

Extensive RCA Limited property surround the Aerospace facility will readily provide for any future expansion that might be required. This land also serves for an ideal antenna test range.

4.2.3 Personnel to Manage the Program

The principal resource that RCA Limited brings to the government as a contender for the prime contractor for the supply of the satellite, is that of highly trained scientists, engineers and technicians who have had experience working together at RCA Limited over the period of a number of years on successful satellite programs. The number of such RCA specialists in satellite electronics now exceed 120.

These personnel now comprise a highly integrated, technical work force of personnel for project management functions; for design, development and systems engineering of various spacecraft subsystems - subsystems such as stabilization, propulsion, power, communications, antenna, etc., for development of ground check-out equipment and for launch arrangements and post launch support.

The group experience of this RCA Limited technical team has yielded efficiency of operation, and organizational stability. The present size and stability of the organization is such that new technical personnel required to discharge the Canadian domestic satellite program will be relatively small in number and can be integrated into the organization and attain optimum contributory efforts in a much shorter period of time than would otherwise be the case.

Additional personnel required to handle the domestic satellite program will be drawn from other technical centres of Technical Products of RCA Limited, Montreal, - e.g., from Microwave Engineering, Earth Station Engineering, Digital System Engineering, or from the Research Laboratories. The total complement of scientists and engineers in these other company activities exceeds 350. It was from the Research Laboratories and Microwave Engineering that the nucleus of the Canadian technical team was obtained for the successful RELAY satellite program in the 1961-1962 period.

The increased acceptance of the products and services of RCA Limited in the domestic and international markets for each of the business areas of satellites, earth stations, microwave systems, and digital systems, is due in most part to forward-looking R & D planning and implementation, and vigilant and sophisticated marketing efforts. This business environment presents challenging assignments that promote considerable job satisfaction to the broad range of skills from scientists, engineers, technicians, and administrators, to various specialists involved in production processes. Accordingly, competent technical personnel of high integrity, the backbone of the company's operations, will continue to be attracted to RCA Limited.

4.2.4 General Manufacturing Facilities & Proposed Procedures

a) Introduction:

The majority of all proposed RCA Limited manufacturing operations for the spacecraft for the domestic satellite program will be performed at the new RCA Aerospace facility at Senneville, 20 miles west of Montreal on the Trans Canada Highway. However, a few RCA manufacturing operations for the spacecraft would be performed at the Lenoir Street plant. This would include electro-forming and numerical control machining, for which extensive facilities have been provided for use on earth station and radio relay programs as well as for spacecraft work. The enlarged facilities for this type of work at the Lenoir Street plant are such as to readily cope with schedule and quality requirements for satellite programs in addition to the requirements for other programs.

The metal working fabrication facilities at RCA Limited's new Aerospace facilities will utilize new high quality machines selected expressly to fulfill the critical tolerance levels attendant with satellite work. The high quality workmanship standards embodied in RCA Limited's satellite fabrication work since 1961 will be retained, with improvement in scheduling and in cost as a result of new machines and procedures.

The new RCA Aerospace facility will include a facility for preparation and manufacture of printed wiring boards. This facility will be similar to that in existence at the Lenoir Street plant.

All of the manufacturing processes that RCA Limited propose to undertake, as distinct from that proposed by subcontractors, will be similar to that on which RCA Limited has had experience on 8 separate satellite programs stemming back to the RELAY program of 1961. The one exception will be the requirement to produce rigid, light weight microwave circuit elements for the antenna subsystem. Electro-forming process will be used for these elements, wherein numerical control machining will be used for machining the formers for the electro-form process. RCA Limited has had considerable experience in electroforming for 4 and 6 GHz circuit elements for earth station feed systems.

b) Industrial Engineering:

The advanced communications techniques described in this proposal will require the employment of equally sophisticated production processes. Many of the units comprising this equipment are cavity types, requiring machining to a high degree of accuracy and the use of certain materials to achieve maximum weight reduction. These materials may present certain difficulties in manufacture.

Industrial Engineering, which embraces Manufacturing Engineering and Methods Engineering, will, during design, obtain assistance from the Materials Engineering Laboratory personnel on such questions as electroforming and plating of units, etc.

Manufacturing Engineers in collaboration with the project design engineers throughout the entire design period will obtain general solutions to the problems facilitating economic production of the required units to the appropriate schedule. They will be mainly concerned with new methods and improved conventional methods of production, including special uses of numerical control. Methods Engineers will, at the earliest opportunity, commence with planning and drawing up of processes of manufacture with regard to the appropriate production schedule.

The approach outlined ensures that the manufacturing processes are available to commence work on the Prototype Model Components as soon as these are released for manufacture.

c) Organization and Control:

The Manufacturing Manager at the new RCA Aerospace facility will exercise overall control of the manufacturing facilities in addition to directing all fabrication and assembly work. He will be directly supported by an Industrial Engineer, a Purchasing Activity, material handling and other support staff. Program management will provide coordination staff to perform the necessary liaison with the parent plant. The fabrication, assembly, and printed wiring facilities at the Aerospace plant will each have supervision to a level determined by the circumstances of their operation.

The control of the manufacturing processes will be by the Production Control System existing in the present organization. This uses data processing methods employing schedule techniques based on the Critical Path Method. This critical path planning will be directly integrated with the overall planning of the project maintained by the Project Management Officer.

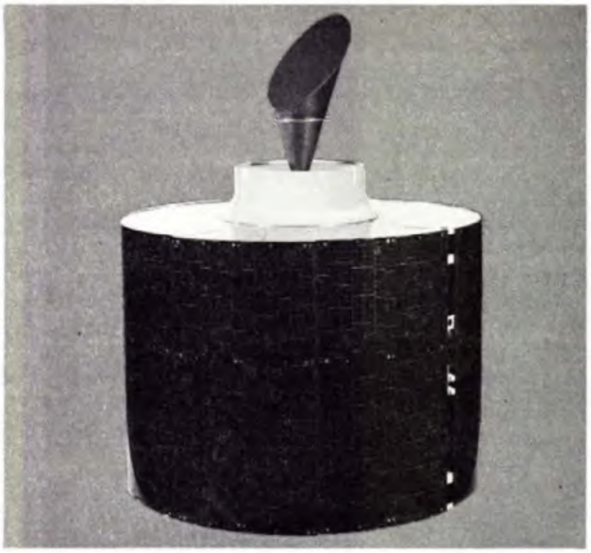
Financial control will be exercised by the continous comparison of estimated and actual costs.

Traceability of materials, components and units, will be carried out in accordance with formalized RCA procedures, refined by application to many spacecraft programs on which RCA Limited has been engaged.

TRW formed the first international space consortium to build INTELSAT III which will handle more information than any other satellite, 1200 voice channels.

INTELSAT III

PERFORMANCE: 3/66 –

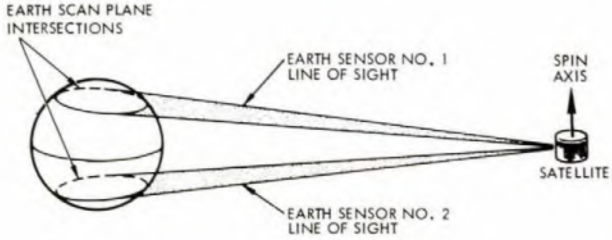


TRW is designing and building INTELSAT III which will be the space link in the first truly global communications system. When three INTELSATS are in synchronous orbit, at any time one will be available as a relay to any point on earth except small polar areas. To the planned ground stations with 85-foot antennas and sensitive receivers they can provide either more than 1200 two-way voice channels of four television channels. The basic configuration can be modified for business, scientific data, or facsimile transmission, television distribution, air traffic communications, or combinations.

The communications system is based on two complete microwave transponders built by ITT Federal Laboratories; each is a linear translater repeater which includes a PAM/FM/PM telemetry encoder, a PAM decoder, two-stage tunnel diode initial amplification, and a travelling wave tube for final amplification. Each transponder bandwidth is 225 mc. Effective radiated power exceeds 22 dbw -- more than 158 watts at synchronous orbit.

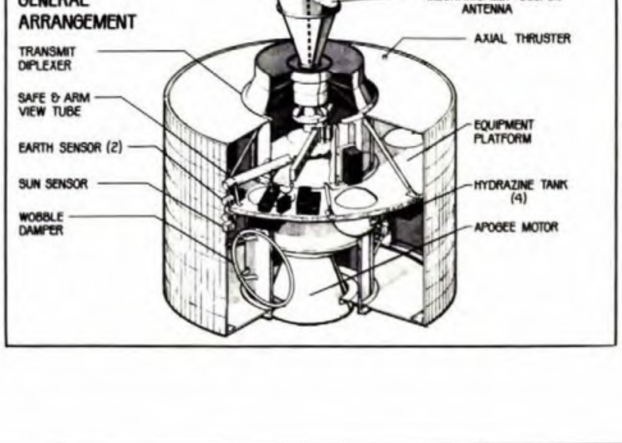
The design features reliability and versatility. The satellites are adaptable with small changes to medium or synchronous orbits at various inclinations. Redundancy and strict quality control make possible a systems reliability assessment of 0.62 for 5 years operation in orbit.

Each satellite weighs about 268 pounds and is 41 inches high. A central magnesium cylinder carries primary loads. Most of the equipment is mounted on an aluminum honeycomb platform which surrounds the central cylinder as in TRW's Vela satellite. Body mounted solar arrays and a storage battery provide more than 130 watts of power for 5 years.



INTELSAT III uses a mechanically despun, circular polarized antenna system built by Sylvania. The high-gain despun antenna is a flat plate reflector illuminated by a single horn. An orthomode transducer is used to feed both 4 gHz and 6 gHz signals. At peak beam the antenna has a maximum of 18.0 db gain and at earth's edge a minimum of 13.5 db. The despin electronics are effectively slaved to an onboard earth sensor or may be controlled by ground command. The earth sensor is also used in conjunction with the Ground Control Station to operate the TRW-pioneered monopropellant hydrazine thruster system which maintains both attitude and position in orbit.

TRW heads an international aerospace consortium to build INTELSAT III. Selection followed completion of million dollar studies by TRW and two competing companies. The first six satellites will be delivered within 27 months after contract go-ahead. Communications Satellite Corporation has an option on 18 more. The first four will be built entirely at TRW's Space Technology Center, but subsequent spacecraft will involve increasing use of subsystems made by non-US members of the consortium.



CUSTOMER: Communications Satellite Corporation (CSC-SA-6)

ENVIRONMENTAL TEST EQUIPMENT

Our environmental test equipment subjects spacecraft and their components to extreme temperature, humidity, vacuum, simulated solar radiation, mechanical shock, vibration, sustained acceleration, and acoustic noise. We have satisfied environmental test requirements on the Lunar Module Descent Engine, Lunar Module Abort Guidance Section, Space Ground Link Subsystem (SGLS), Vela, Orbiting Geophysical Observatories (OGO), Pioneers VI through IX, ESRO I, and INTELSAT III.

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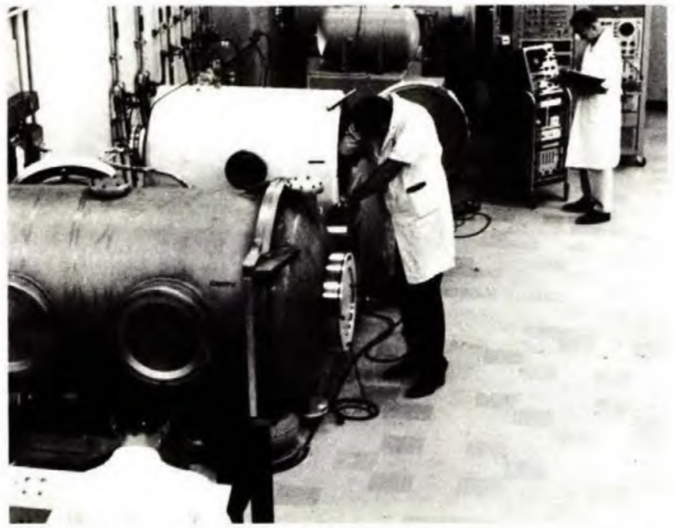
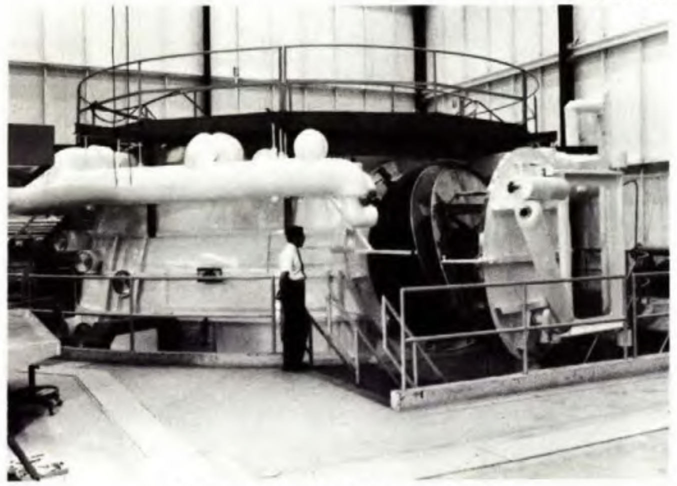


Our space simulation chambers range from a 22- by 46-foot vertical cylinder to a 2- by 3-foot horizontal cylinder. Aerovac Model 610-611 residual gas analyzers monitor contamination from mass 2 to 500.

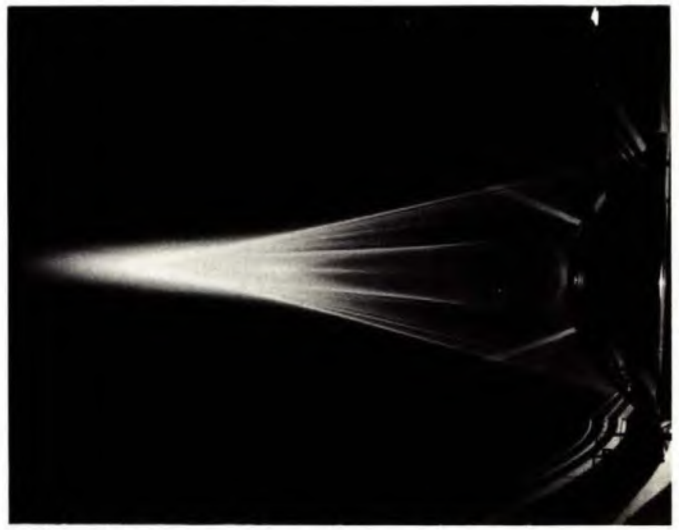
82665-63



30-Foot Spherical Space Chamber

The second largest of our space environment chambers permits thorough evaluation of complete spacecraft (or individual subsystems) prior to flight. Inside diameter is 28 feet, with a 19-foot top entry. Lowest chamber temperature is -300°F; controlled temperature limits are from -30 to +275°F. A simplified console permits either automatic or all manual control.

83865-63



Radiation Beam from TRW Solar Simulator

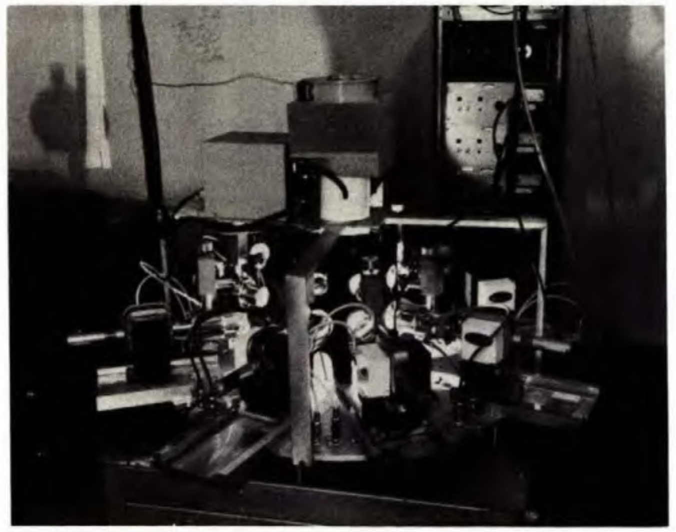
We designed and built solar radiation simulators that deliver 65 to 130 watts per square foot to an 85-inch-diameter target. The units incorporate optical projection elements for off-axis collimated solar simulation.

00810-66

VASP Vibration Test Setup

Our vibration systems simulate mechanical and acoustical coupling with electrodynamic vibration exciters. Each exciter has a horizontal slip table with hydrostatic bearings for testing objects with large mass offsets. Remote control consoles operate the vibration equipment in acoustically isolated rooms. The largest system can test objects over 1000 pounds.

92678-64



5-kW Xenon Ultraviolet Degradation System

We have three degradation systems to determine vacuum and ultraviolet radiation effects on materials in space. Each chamber in the systems has a sputter-ion high-vacuum pump. Irradiance on the sample can be set from less than one to more than 12 "ultraviolet suns."

45143-68

22- by 46-Foot Space Simulation Chamber

TRW's largest space chamber can test a 20,000-pound spacecraft with maximum dimensions of 15 by 15 by 35 feet. Two mechanical roughing pumps and three 95,000-liter/sec oil diffusion pumps evacuate the chamber to 10^{-6} torr. We designed the chamber around a TRW-developed and fabricated solar simulation system which can generate a two-sun solar environment.

92045-64

Integration and Test Laboratory Central Data Acquisition System

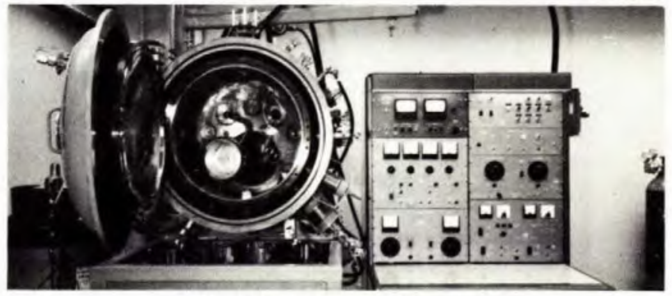
A central data acquisition and reduction facility, linked to all test areas, has over 70 channels of magnetic tape-recording equipment – two tap-loop machines and three 100-channel digital systems with real-time numerical readout and tape punch for recording a total of 300 channels.

38692-67

Pressure Test Facility

For pressure testing deep-sea equipment such as TRW's Air-Droppable Bathythermograph, we modified 16-inch naval gun shells. With walls three and one-half inches thick, the one-ton projectile can withstand pressures up to 25,000 psi. The chamber has a useable volume of over 2400 cubic inches. We added feed-throughs for up to 38 instrumentation monitors.

73709-61



Ultra-High Vacuum Chamber

We have environmental test chambers in most of our laboratories to support research and development. Some chambers can reach 10^{-10} Torr and lower. Nude ionization gages monitor pressure. A residual gas analyzer records partial pressures of 10^{-13} to 10^{-14} Torr from m/e ratios 2 to 50 (minor changes permit m/e ratios up to 200). Temperature control is from -195 to +450°C.

Integration and Test Laboratory Space Simulation Chambers

Quantity	Type	Size (Feet) (Diameter x Length)	Shroud Temperature Control	−300°F Cold Wall	Solar Simulation (One Sun Size)
1	Sphere	30	−30 to +275°F	Yes	84-inch diameter
1	Vertical cylinder	22 x 46	—	Yes	10-feet square †
1	Horizontal cylinder	7 x 12	—	Yes	54-inch diameter
1	Horizontal cylinder	6 x 8	—	Yes	18 inches square
3	Horizontal cylinder	5 x 6	−80 to +200°F°	Yes	16 inches square
2	Horizontal cylinder	4 x 5	−80 to +200°F°	Yes	16 inches square
1	Horizontal cylinder	4 x 4	−80 to +200°F°	Yes	12-inch diameter
1	Horizontal cylinder	3 x 4	−80 to +200°F°	Yes	10-inch diameter
1	Horizontal cylinder	2 x 3½	−80 to +200°F°	No	—
1	Horizontal cylinder	2 x 3	−80 to +200°F°	Yes	—

° Using external heat exchanger

† Two sun size

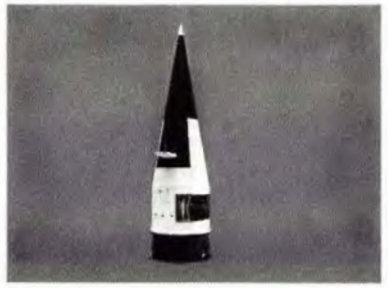
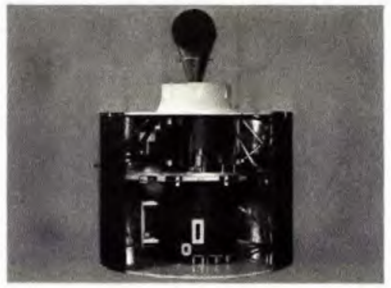
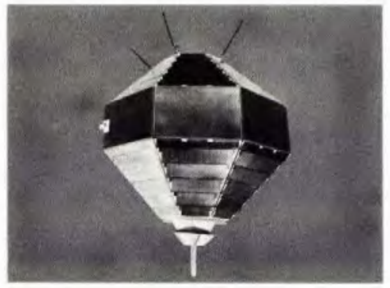
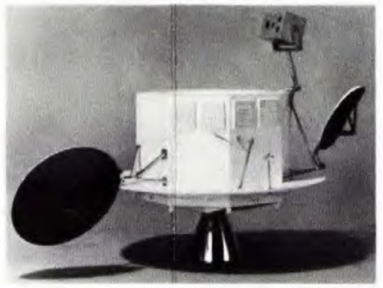
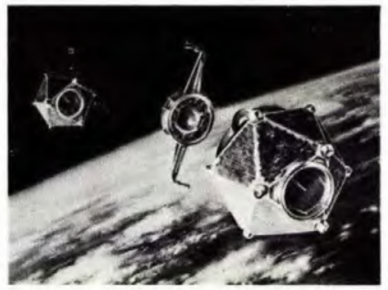
Note: Lowest pressure on all empty chambers is less than 1 x 10^{-6} Torr. Actual test pressures depend on test article gas load.

Integration and Test Laboratory Vibration Systems

System	C-210E	C-150	A300-B	C-125	C-25	Quad C-150	AC 184-6 Hydraulic	C-10E
Force (vector)	28,000 lb	17,500 lb	8000 lb	7800 lb	3500 lb	70,000 lb	18,400 lb	1200 lb
Motion	Sine, random, complex	Sine, random, complex	Sine, random, complex	Sine, random, complex	Sine	Sine, random, complex	Sine	Sine
Frequency range (Hz)	5 to 3000	5 to 3000	5 to 3000	5 to 3000	5 to 3000	5 to 3000	Dc to 200	5 to 3000
Displacement (maximum)	1.0 inch DA	1.0 inch DA	1.0 inch DA	1.0 inch DA	0.5 inch DA	1.0 inch DA	6.0 inch DA	1.0 inch DA
Acceleration (maximum)								
bare table	57 g rms	100 g rms	100 g rms	70 g rms	33 g rms	100 g rms	35 g rms	48 g rms
20 g rms	645-lb load	580-lb load	343-lb load	200-lb load	50-lb load	2320-lb load	3 Gp at 5000-lb load	25-lb load
10 g rms	1635-lb load	1250-lb load	743-lb load	475-lb load	175-lb load	5000-lb load		67-lb load
Random signal band (Hz)	10 to 2000	10 to 2000	10 to 2000	10 to 2000	10 to 2000	10 to 2000	—	10 to 20,000
Equalizer type	Automatic, manual	Automatic, manual	Automatic, manual	Manual	Manual peak notch system	Automatic, manual, phase	—	Automatic, manual
Number of channels	80	40	40	80	—	40 (2)	—	80
Bandwidth (Hz)	25	50	50	25	—	50	—	50

We have many thermal-vacuum chambers and vibration systems of research quality which are not listed in the above tables.

PARTICIPATION IN MAJOR SPACE AND MISSILE PROGRAMS

	PIONEER INTERPLANETARY SPACECRAFT (1963–1969)	POLARIS SPECIAL TEST VEHICLE (1963–1967)	INTELSAT III (1966–)	MILITARY COMMUNICATIONS SATELLITE (1963–1968)	VOYAGER SPACECRAFT (1965–1967)	VELA SATELLITE (1961–1968) VELA ADVANCED SPACECRAFT (VASP) (1965–1968)
						
MISSION	Investigate the sun's influence on the space environment by placing scientific experiments in solar orbits ranging from 0.8 to 1.2 AU.	Test accuracy of inertial platform-mounted star tracker guidance system during boost phase of Polaris missile flight in STAFF program.	Provide global communications coverage with at least 1200 simultaneous two-way voice channels or four television channels.	Demonstrate feasibility and provide operational capability of an active military communications satellite.	Explore Mars with unmanned orbiting spacecraft and landing capsule. Adaptability to 1973, 1975, 1977, and 1979.	Vela: detect nuclear explosions in space; VASP: detect nuclear explosions in the earth's atmosphere. Measure the natural radiation environment. Measure solar and galactic radiation for general scientific use.
TRW RESPONSIBILITY	Prime contractor to NASA/Ames for design, development, and fabrication of five flight spacecraft. Pioneer VI (launched 12/65), Pioneer VII (launched 8/66), and Pioneer VIII (launched 12/67) are performing excellently and are earning orbital incentives.	Subcontractor to General Precision for design, development, fabrication, test, equipment integration, and launch support of five vehicles. All were delivered on schedule.	Prime contractor to Communications Satellite Corporation for design, development, fabrication, test, launch support, ground station telemetry and controls, and supporting equipment for six satellites.	Subcontractor to Philco-Ford for design, development, and fabrication of the structure and power subsystems. Maximum delivery and orbital performance incentives have been realized on 26 subsystems.	Prime contractor to NASA for study of spacecraft design, development, and operation; management and implementation plans; mission sequence; sterilization procedures; and biological contamination control.	Prime contractor to AF/SSD-ARPA for design, development, and fabrication of 14 spacecraft. Six Vela's and two VASP's have been launched to date and are operating satisfactorily. The six Vela's have far exceeded anticipated lifetimes.
INTEGRATION	Assemble components and integrate subsystems into spacecraft.	Integrate vehicle with Polaris launch vehicle. Integrate telemetry with stellar inertial guidance supplied by contractor.	Integrate satellite with launch vehicle. Integrate and test satellite subsystems built by domestic and international subcontractors.	Integrate spacecraft structure; integrate spacecraft with spinup mechanism.	Study spacecraft-capsule integration, planetary vehicle integration with Saturn launch vehicle, and spacecraft system integration with ground support facilities.	Assemble components and integrate subsystems and GFE payload into spacecraft.
STRUCTURE	Design and build spacecraft structure with unusually high payload/structural weight ratio, and active thermal control subsystem.	Design and build aluminum and fiberglass, semi-monocoque structure and thermal control subsystem.	Design and build satellite structure and passive thermal system. An aluminum honeycomb equipment panel rings a central cylinder.	Design and build satellite structure, spinup, and separation systems. A central cylinder carries all primary loads.	Design spacecraft frame, adapter, separation mechanisms, and thermal control equipment.	Design and build polyhedral structure with central cylinder which carries all primary loads and houses the apogee motor. VASP weighs 730 pounds and is 56 inches in diameter.
COMMUNICATIONS	Design and build integrated telemetry, tracking, and command subsystem for the Deep Space Network. Pioneers VI and VII have each received over 5000 commands. The DSN can receive and process data transmitted from Pioneers up to 180 million miles.	Design and build portion of telemetry equipment. Design, integrate, and test tracking and instrumentation subsystems.	Integrate and test transponder and electronically despun antenna supplied by subcontractors.		Design two gimballed antennas and two hemispherical antennas, command link, and telemetry system 50-watt transmitter.	Design and build integrated telemetry, tracking, and command subsystem.
GROUND SUPPORT EQUIPMENT	Design and build electrical and mechanical GSE.	Design and build checkout, handling, and launch support equipment including GSE antenna.	Design and build systems test equipment, and ground station telemetry and command equipment.		Design handling and transportation equipment, test fixtures, checkout equipment, and operations support equipment for the Deep Space Network.	Design and build three system test sets and associated unit test equipment.
SPACECRAFT AND PAYLOAD	Design and build spacecraft and all subsystems except experiments. Special manufacturing techniques make Pioneer one of the magnetically cleanest spacecraft in history.	Design and build vehicles and principal subsystems.	Design and build satellite and all subsystems except communications and apogee motor.		Study photo-imaging systems for mapping Mars and provide spacecraft adaptable to changing complements of experiments.	Design and build spacecraft and subsystems.
PROPULSION	Present planning includes a midcourse correction subsystem using hydrazine fuel and a solid propellant deboost motor.		Specify solid propellant apogee motor.		Perform tradeoff studies of the adaptability of the LM descent stage; incorporate LMDE, Titan, and Minuteman solid engines adapted to Voyager and optimize choice.	Specify, procure, and integrate solid propellant apogee motor. Design and build first electrothermal thrusters in space.
GUIDANCE AND CONTROL	Design and build reorientation control subsystem consisting of sun sensors, electronics, and cold gas jet system. Pioneer is a spin-stabilized spacecraft.	Design special, high-altitude trajectory. Design and build high-thrust, cold gas attitude control subsystem to correct for irregular booster torques.	Design and build monopropellant hydrazine attitude control subsystem for spacecraft positioning and orientation.	Design and build spinup and stabilization systems.	Design sun-Canopus and earth-Canopus reference system and attitude control gas jet and thrust vector control system. Design terminator sensor equipment and inertial reference for maintaining attitude when reference system is not available.	Design and build ACS for VASP. VASP is an earth-oriented, zero-momentum system based on thrusters and reaction wheels.
ELECTRICAL POWER	Design and build power subsystem consisting of solar array, dc/dc converters, and battery.	Design and build power supply and distribution system.	Design and build power supply consisting of solar array, converter, power control unit, and battery.	Design and build power subsystem consisting of solar arrays, power control unit, and radiation termination unit.	Design fixed-array solar cell battery power supply and power control for Voyager.	Design and build spacecraft power supplies and distribution subsystem.
SYSTEM CHECKOUT	Perform complete system checkout with experiments on board.	Support system checkout.	Perform complete system checkout of satellite and install, integrate, and check out ground station equipment.			Design system checkout equipment and perform complete system checkout.
GROUND AND FLIGHT TEST	Provide launch support services and assume responsibility for spacecraft during launch.	Conduct vibration survey of structure and perform acceptance testing. Write computer programs to reduce and analyze flight data.	Perform development, acceptance, and checkout testing of satellite and launch site.			Perform system integration of spacecraft testing. Support launch at ETR. First multiple orbits.
SPACECRAFT EXPERIMENTS	Build Stanford experiment antenna and receivers. Integrate this and all experiments supplied by the scientific community into the spacecraft system.	Specify optically flat window through which a star tracker sights. Analyze data to determine optical effects of aerodynamic flow field.			Design planetary scan platform and fixed-mounted experiment. Design all supporting equipment for spacecraft experiments. Study optimized methods for mapping and reconnaissance.	

4.4 FACILITIES & RESOURCES OF SPAR

4.4.1 Company History

Spar Aerospace Products Ltd. was incorporated on October 27, 1967, under the Canadian Corporations Act as a public company. On December 31, 1967, Spar Aerospace Products Ltd., purchased the Special Products & Applied Research (SPAR) Division of The de Havilland Aircraft of Canada, Limited as a going concern, acquiring all capital equipment, personnel and patent rights.

The SPAR Division of de Havilland was created in 1953 as the "Guided Missile Division" and undertook the development of power supplies and fire control systems for the Velvet Glove missile. Between then and 1959, the Division developed a series of infrared devices for various weapon systems, including IR fuses for nuclear and non-nuclear warheads, solid state power supplies, cryostats, optical distance measuring equipment, airborne recording equipment and radiometers.

In 1959, the Guided Missile Division commenced its true space activity with the design, development, manufacture and test of the Alouette I spacecraft structure and its associated sounder antennas. Alouette I was launched in 1962, and is still functioning today. Alouette II was launched in 1965, and the next in line of this series - ISIS 'A' - is scheduled to be launched this year.

The Guided Missile Division of de Havilland was renamed "Special Products Division" in 1960, in view of its expansion into other fields. The Division was further expanded in 1962 through the acquisition by de Havilland of Canadian Applied Research Ltd., and then became the "Special Products & Applied Research Division" of The de Havilland Aircraft of Canada, Limited.

Spar Aerospace Products Ltd. (Spar) is continuing to operate in the business areas developed under de Havilland Aircraft, with emphasis on product development, and in particular, fixed and extendible structures for spacecraft.

4.4.2 Facilities

Spar Aerospace Products Ltd., occupies some 160,000 square feet of floor space in a plant adjacent to Toronto International Airport. The facilities available include a machine shop, metal fabrication shop, plastics fabrication shop, clean room assembly areas, and various laboratories.

a) Manufacturing:

The company specializes in a high quality, low volume manufacturing operation. It has excellent model shop facilities which enable it to produce prototype and engineering models quickly and economically. The machine and metal fabricating shops are able to manufacture precision metallic and non-metallic components and miniature close tolerance gears. The plastics department is capable of moulding and fabricating thermo-setting materials such as polyesters and epoxies. Experienced personnel working in dust-free, air-conditioned areas carry out intricate assembly of mechanical systems, high precision instruments, electronic assemblies, optical devices and STEM (Storable Tubular Extendible Member) devices.

b) Engineering Facilities:

Spar maintains complete engineering skills and facilities to carry out work in the following areas:

(a) Spacecraft Structural Design.
(b) Spacecraft analysis.
(c) Power conversion systems and aerospace electronics.
(d) Electro-optical systems.
(e) Electro-mechanical devices.
(f) Materials and processes.
(g) Reliability analysis.

To support these activities, Spar has installed at their facility "Quicktran" computer terminals utilizing a central IBM digital computer located in Toronto. Each of these disciplines is further supported by laboratory facilities which are described in broad detail in the following paragraphs.

c) Laboratories:

Laboratory facilities are completely equipped for research and development in mechanical devices, electronics, electro-mechanics, optics and metallurgy and related fields.

The advanced nature of the work undertaken by Spar has required the "in-house" development of specialized equipment to standards not commercially available. The Environmental Laboratory can simulate environments over wide ranges of temperature, pressure, humidity, shock and vibration. It is intended to acquire next year the most up-to-date equipment for thermal vacuum and sine and random vibration testing.

The Standards Laboratory has modern equipment for calibration of electronic, hydraulic and other test equipment used in the laboratory.

The Electro-Optics Laboratory has a screened room (Faraday Cage) and black rooms for the measurement of R.F. and low radiation infrared and ultra violet emission. Black body sources of controlled high accuracy permit absolute calibration of infrared detectors and radiometers. A precision optical bench with a specially desgined collimated light source is available for calibration and alignment of optical equipment. The laboratory has reflectivity and absorption measurement capability and vacuum depostion of aluminum, silicon monoxide, etc. can be carried out on optical surfaces.

4.4.3 Background Experience

a) Mechanical Products Department

Since 1959, Spar Aerospace Products Ltd. has successfully flown over 300 STEM and BI-STEM units on manned and unmanned spacecraft, satellite and sounding rocket payloads. Since it would be impractical to describe all of these units, attention is confined to a brief mention of some of the application.

The principle of a tubular metallix structure which may be opened flat and coiled on a drum for storage purposes was conceived by Canada's National Research Council as a means of erecting a small transmitting antenna. Spar undertook to continue the development of the principle and its many applications, and in 1959 embarked on a comprehensive research and development program aimed initially at providing crossed 75 foot and 150 foot dipole antennas for the Canadian Alouette I Satellite. The structural and mechnical design of this satellite was also carried out by Spar and the satellite was launched and successfully deployed its extendible antennas in 1962. This satellite is still operational. A Javelin rocket carrying two of these antennas was fired in 1961 to prove the deployment mechanism.

From this early work has emerged the existing Mechanical Products organization, comprising the Space Engineering Section, responsible for the structural design and dynamic analysis of all Canadian Satellites to date (Alouette I, Alouette II and ISIS "A") and the STEM Products Department, responsbile for current STEM and BI-STEM devices for both space and ground applications.

b) Satellite Design and Development

When the Alouette program was first conceived in 1959, Spar was awarded the study contract to design the structure and extendible antennas.

This subsequently led to the manufacture by Spar of the Alouette I spacecraft structure and its antennas, as well as a variety of specialized equipment for spacecraft check-out and ground handling equipment.

The success of Alouette I, which is still operating after six years in orbit, led to a continuation of this program with the Alouette II/ISIS series of satellites, with Spar being selected as Associate Prime Contractor with RCA Limited. The inception of this new series was accompanied by the gradual change over of design responsibility from Government laboratories to Industry. This change was accomplished initially on Alouette II (launched in 1965) through the medium of Government sponsored "on the job" training programs. The success of such training programs being evidenced by the successful performance of the spacecraft.

Following Alouette II, Spar, with the benefit of Alouette experience behind it, participated more heavily on ISIS "A", assuming responsibility for the following areas:-

a) Design and fabrication of the spacecraft structure.
b) Design and fabrication of the Sounder Antennas.
c) Mechanical design and fabrication of the magnetic torqueing coils.
d) Design and fabrication of miscellaneous mechanical devices.
e) Design and fabrication of specialized mechanical ground support equipment.

In addition to these hardware oriented responsibilities, Spar utilized their analytical capabilities throughout the ISIS "A" program, assuming responsibility in such areas as:-

a) Dynamics of the spacecraft during initial orbits.
b) Long term dynamics of the spacecraft.
c) Orbital mechanics.
d) Launch window analysis.
e) Stress analysis.
f) Reliability analysis) In conjunction with
g) Thermal analysis) RCA Limited

To support this analytical work, Spar carried out a considerable amount of testing, particularly in the area of thermal properties and structural integrity.

In addition to the analysis carried out in the course of the ISIS "A" program, Spar has carried out analytical studies for a number of U.S. spacecraft programs, prinicipally in the area of spacecraft stability under the influence of long, flexible booms.

4.5 CANADIAN AND EUROPEAN INDUSTRIAL FACILITIES VISITED AND CONSIDERED BY RCA LIMITED FOR SUPPLY OF PARTICULAR PRODUCTS AND SERVICES

Representatives of Space Systems, RCA Limited, have visited the facilities of several Canadian and European contractors as a part of the considerations in the preparation of a subcontract plan for the spacecraft. Details of the proposed subcontract work are given in Sections 2 and 3 of this volume. In addition to the plant visitations, representatives of the companies, in most cases, have carried out detailed technical discussions with design and manufacturing engineers of Aerospace Engineering.

Following is a list of the companies for which subcontract action will be considered in any resulting implementation program by RCA Limited:

	Name of Company	City/Province/ Country	Equipment or services for which subcontract action has been considered
1)	Canadian Aviation Electronics	Montreal, P.Q.	ground check-out equipment
2)	Motorola	Scottsdale, Arizona & Toronto, Ont.	ground check-out equipment
3)	Fleet Mfg. Company	Fort Erie, Ont.	honeycomb structures
4)	Bristol Aerospace	Winnipeg, Man.	apogee motors, P&O tanks
5)	Aviation Electric Limited	Montreal, Que.	general precision mechanical parts and assemblies
6)	Varian Assoc.	Georgetown, Ont.	travelling wave tubes
7)	Siemens	Munich, Germany	parts of the transponder subsystem
8)	AEG Telefunken	Germany	travelling wave tubes
9)	National Semicond.	Montreal, Que.	solar cells
10)	Ferranti	London, England	solar cells
11)	Elliot Bros.	London, England	motors, bearings
12)	United Aircraft of Canada	Longeuil, Que.	apogee motors

APPENDIX I

PRODUCTS ASSURANCE PLAN

A 1 Introduction

The provisions of this preliminary Product Assurance Program Plan are in accordance with the requirements of the Department of Industry's Provisional Work Statement for the Preliminary Study For The Design And Development of a Domestic Communications Satellite, Issue: May 2, 1968.

Recognizing the high reliability requirements and complexity of the program, RCA Ltd. will implement effective reliability and quality programs to assure that the satellites will have a high probability of operating successfully in orbit for 5 years.

To attain this reliability goal, an organized and concentrated reliability and quality effort will be applied early in the design phase, and will be sustained through the procurement, development, manufacturing, integration, test and launch phases of the program.

In addition, the Product Assurance program to be implemented on the program will benefit from RCA Ltd's already demonstrated successful reliability efforts on high reliability projects such as Relay, Pegasus, Alouette, etc.

A 2 Program Management Organization

To exercise the required control an integrated Reliability and Quality program will be established under the direction of the Assistant Program Manager - Product Assurance. This organization will be implemented to make the maximum possible use of all of the Contractor's specialist skills which will be coordinated within the program.

Assistant Program Manager - Product Assurance

The assistant program manager will be responsible directly to the Project Manager for the operation and progress of the overall reliability and quality programs. Additionally he will be responsible for

- Development of plans, schedules, budget and task descriptions on reliability and quality matters.
- Provision of technical support during prime and subcontract negotiations involving reliability and quality questions.
- Representing Project Management Office (PMO) in all reliability and quality matters, including customer interface.
- Planning, scheduling and documenting design reviews and design audits.
- Approval of design review closures.

Project Reliability Engineer

The Project Reliability Engineer will be responsible to the Assistant Program Manager for the operation and progress of the reliability program. In addition he will be responsible for

- Preparing and maintenance of a project reliability program plan
- Conducting design reviews.
- Conducting reliability indoctrination program.
- Maintenance of parts and materials program.
- Maintenance of failure reporting procedures.
- Coordination of the reliability supporting services provided by other specialist facilities of the Contractor.
- Supervision of subcontractors' reliability programs
- Monitoring costs of reliability effort.

Project Quality Engineer

The Project Quality Engineer will be responsible to the Assistant Program Manager - Product Assurance for the operation and progress of the quality program. Additionally he will be responsible for

- Preparation and maintenance of a project quality plan.
- Planning and enforcing project quality requirements and procedures
- Participation in material review board activities.
- Providing for and management of inspection, test surveillance and quality launch operations personnel.
- Reviewing supplier test data to ensure procurement requirements are satisfied.
- Monitoring costs and work performance involving project quality requirements.

A 3 Reliability Assurance Program Control

A 3.1 Contractor Designed Equipment

The Reliability and Quality functions will be responsible for ensuring compliance with the reliability and quality requirements of the project. The functions will monitor the progress of the project and verify the evidence provided for adherence to the reliability and quality requirements.

In general, the Contractor will be required to comply, as a minimum, with the following requirements:

a) Adhere to the approved parts and materials list and to the procedure for obtaining approval for use of non-standard parts and materials.

b) Adhere to the approved mechanical and electrical derating practices.

c) Perform equipment stress analysis, failure mode analysis, and failure effect analyses in support of design reviews.

d) Implement design review procedures and documentations and perform design reviews.

e) Adhere to the approved workmanship standards.

f) Adhere to the approved quality control procedures.

g) Implement design and design change control procedures.

h) Conduct reliability and quality program audits.

i) Maintain effective malfunction report and analyses procedures and practices.

j) Maintain Equipment Log Books.

A 3.2 Sub-Contractors and Suppliers to the Contractor

The Contractor will be responsible for ensuring that electrical and mechanical components, system elements and sub-systems obtained from sub-contractors and suppliers meet the reliability and quality requirements of the project. The Contractor's Reliability Assurance function will monitor the progress of sub-contractors and suppliers and will verify the evidence provided by the sub-contractors and suppliers of adherence to the reliability and quality requirements. In general, all sub-contractors will be required to comply, as a minimum, with the requirements listed in paragraph A 3.1 above.

A 3.2.1 Listing of Sub-Contractors and Suppliers

A list of sub-contractors and suppliers will be provided to the customer for approval. This listing will be updated as required, and submitted concurrently with the progress reports.

A 3.3. Reliability Indoctrination Program

The Reliability Project Engineer will be responsible for the early establishment of a continuing program of personnel indoctrination and training in program reliability concepts and the significance of requirements and tasks specified in this plan.

This training program will be aimed at early indoctrination of design personnel with reliability requirements, procedures and terminology. The program will take the form of lectures, printed notes, group discussions and visual aids.

A 4 Reliability Assurance Engineering During Design and Development

A 4.1 Review of Design Specification

All system and sub-system design and test specifications generated will be reviewed and approved at Design Reviews to ensure that each specification adequately and correctly states performance requirements, environmental requirements, and test criteria for the system element in question. Revisions of these specifications will be provided to the customer for approval.

A 4.2 Reliability Apportionment

A reliability apportionment model will be developed early in the project to establish the reliability goal for each system, sub-system, and component to be consistent with the requirement of 0.7 probability of survival for 5 years of continuous orbital operation. The reliability apportionment model will be revised and updated throughout the development cycle to take into account any changes implemented after the first or subsequent apportionment analysis and as specific engineering data, such as the results of analyses and tests, become available. In this way, the reliability apportionment model will represent an up-to-date measure of reliability growth and progress. Up-to-date information on the reliability apportionment model will be submitted to the customer with progress reports.

A 4.3 Reliability Stress Analyses

In order to ensure that the established derating factors are not violated, stress analyses will be carried out on all circuits down to the component part level.

The derating factors should satisfy the "worst case" specified operational requirements; i.e. maximum specified operational temperature and maximum operational electrical stresses.

The recommended derating factors are specified in RCA's Aerospace Component Application Notes.

A 4.4. Failure Mode and Failure Effects Analysis

As part of the early design process, and in conjunction with the reliability apportionment and stress analyses, system studies will be made to determine possible modes of failure and their effects on mission success.

The primary objectives of these analyses will be to highlight critical failure areas and remove susceptibility to such failures from the system. The analyses will be made starting at the system level and expanding downwards to the component part level. Each potential failure will be considered in the light of probability of occurrence and will be categorized as to the probable effect on mission success.

The results of failure mode and failure effect analyses will be an important consideration in all design reviews and will provide criteria for test planning and checkout procedures.

A. 4 .5 Maintainability Consideration

It is recognized that it may be necessary to replace system elements throughout the testing program and the pre-launch checkout period, and due consideration will therefore be given to facilitate fault location and replacement of all system elements.

A. 5 Design Review Program

A 5.1 Objectives

The design review program will provide a progressive evaluation of design requirements and concepts throughout the design and development phases. Thus assurance will be obtained that factors affecting function, reliability, maintainability, quality and potential degradations have been considered, and that accumulated past experience on similar equipment, parts and processes will benefit the design.

Design Reviews will be organized and conducted according to the principles laid down in RCA's Design Review Guide and Checklist.

A 5.2 Types of Reviews

Concept Reviews

The first design reviews will be held as soon as preliminary design studies have established the preferred concepts.

Major factors to be considered in these design reviews are as follows:

- Review of contractual requirements.
- Preliminary specifications.
- Preliminary design data sheets.
- Block diagrams.
- Interface definitions.
- Preliminary performance analysis, i.e. electrical, thermal, mechanical, etc.
- Preliminary reliability assessment.
- Weight and power considerations.
- Preliminary parts list status.

Intermediate (Breadboard) Test Reviews

These design reviews will be held in the developmental phase, preferably after initial breadboard testing.

Major factors to be considered in these design reviews will be as follows:

- Final design specifications.
- Breadboard test results.
- Reliability analyses (failure mode and effects, stress analyses (electrical and/or mechanical).
- Packaging configuration and mass properties.
- Power requirements.
- Acceptance and Qualification Test Plans.

Final Design Reviews

These design reviews will be conducted to verify the completness and accuracy of engineering data, i.e. drawings, specifications etc. to be released to Manufacturing.

Major factors to be considered in these design reviews are as follows:

- Verify that all action items from previous design reviews have been satisfactorily completed.
- Review the design constraints and standards established to assure compatibility of system hardware.
- Review system and/or sub-system performance under integrated conditions.
- Review final thermal and payload engineering reports.
- Review test results against test specifications.

A 6 Specification, Test and Documentation

A 6.1 Malfunction Reporting and Correction

RCA Victor will implement a controlled system for the reporting, analysis, correction and data feed-fack of all failures and malfunctions, that occur throughout the manufacture, handling, test and checkout on the program.

This malfunction reporting system will be based on the currently existing one to be compatible with other in-house spacecraft projects.

A .6.2 Parts and Materials Program

A program will be carried out covering the selection, specifications, qualification, and application review of parts and materials for all items to be used in the project. Emphasis will be placed on reducing to a minimum the number of different types of components used.

A 6.3 Preferred Parts, Materials and Finishes List

Early in the project a Preferred Parts, Materials and Finishes List will be issued for comment by the participating parties. This document will be based on experience obtained on other spacecraft projects.

A 6.4 Standard Parts, Materials and Finishes List

After comments on the Preferred Parts List have been evaluated a Standard Parts, Materials and Finishes List will be issued and submitted to the customer for approval. All vendors and sub-contractors will be required to comply with this document or will be required to apply for permission to use non-standard parts, etc.

A 6.5 Component Application Notes

These Notes are issued and updated by RCA Aerospace Reliability Engineering and will be utilized to the highest degree possible to assure maximum confidence in attaining the reliability requirements in a cost effective and timely manner.

A .6.6 Procurement Specifications

To ensure that necessary and adequate engineering information is specified to the vendors, the Reliability Assurance function will approve all Procurement Specifications. These specifications will cover electrical, mechanical, reliability and packaging requirements.

A 6.7 Preconditioning and Screening of Parts

Although, in general, preconditioning and screening of parts will be carried out by the part manufacturer as detailed in the Procurement Specification, it may be necessary, in certain instances, to carry out such testing in the Contractor's facility. Preconditioning specifications will be prepared and released by the Reliability and Engineering function.

A 6.8 Parts and Materials Qualification Tests

Where adequate qualification data are not available, the Reliability Engineering function will design and arrange for qualification tests on parts and materials to determine their adequacy in meeting specification requirements and to develop criteria to be used in acceptance testing. Parts or materials requiring this treatment will be regarded as non-standard.

A 6.9 Standardization of Design Practices

It is recognized that the standardization and control of design practices is considered to be one of the major elements affecting reliability, therefore a manual entitled "Aerospace Design Guidelines" has been issued by RCA Victor Aerospace Reliability Engineering.

A 6.10 Equipment Logs

a) Throughout the development, inspection and test phases of the program, and throughout the pre-launch phase, the cognizant engineers will maintain a separate log for each major component, sub-system, and system as a means of documenting the continuous history of the item. Separate log-books will be maintained to cover spacecraft integration and tests.

b) RCA's Laboratory Notebooks, issued by the company's library, will be used to cover development phases.

c) RCA's Equipment Log-books, issued by Aerospace Reliability Engineering, will be used to cover the inspection and test phases.

A 6.11 Evaluation of Test Results

As test information becomes available throughout the program, Reliability Engineering will arrange for the results to be evaluated and reviewed. The test results will be used to assess conformance with theory and to assess the significance of any inconsistency for corrective action.

A 6.12 Reliability Engineering Information Centre

A unified file incorporating all reliability information applicable to the project will be established in the Project Management area. As a minimum, this centralized reliability file will contain:

a) Copies of all reliability correspondence.
b) Copies of all system, unit, component, parts and materials procurement specifications.
c) Documentation on all sub-contracts, including design review meetings, quality audit results, etc.
d) All test specifications and procedures.
e) All procedural notices involving reliability.
f) Test results on all procured items.
g) Component Application Notes.
h) Manual of Workmanship Standards.
i) Documented results of special qualification test programes.
j) Copies of all documents applicable to this plan.

A 7 Quality Assurance Plan

A 7.1 Scope

This Quality Assurance Program Plan for the project outlines the basic Quality Program by which quality conformance of the product to contractual requirements is established and maintained in the design, development, procurement, manufacturing, test, integration and launch plans of all flight standard equipment and also support equipment.

A 7.2 Organization

The RCA Limited organization is described in detail in the Technical Products Quality Control Manual which also describes the responsibilities of the groups within the organization.

Control of quality conformance in RCA Limited is exercised by Quality Assurance. The Quality Assurance organization comprises Quality Control Inspection and Test, Quality Assurance Administration (Engineering Function) and Instrument Services, all of which report administratively to the Manager, Quality Assurance.

To satisfy the requirements of the Project Management Office to be established with RCA Limited, a Quality Assurance engineer will report to the Product Assurance Manager in the P.M.O.

A 7.3 Quality Documents

The documents listed below form a part of this Quality program plan.

- RCA Limited Quality Control Manual.
- RCA Limited Quality Control Manual of Procedures.
- RCA Limited Quality Control Notes (QCN's)
- RCA Limited Aerospace Workmanship Standards.
- NASA NPC 200-4 Quality Requirements for Hand Soldering of Electrical connectors (superceded by NHB 5300.4 (3A)).
- NASA Inspection Documents NPC 200-2, NPC 200-3, if a requirement.

A .8 Material - Procurement and Disposition

Requisitioning

Purchase requisitions, are originated by the appropriate requisitioning group and forwarded to Material Control. Material Traceability requirements are indicated on the Specification Control drawing covering the component.

Vendor Selection and Rating

Evaluation of suppliers and/or sub-contractors will be carried out by Quality Assurance in accordance with the Q.C. Manual of Procedures in order to check quality conformance.

A Vendor rating list, periodically updated, will be maintained by Quality Assurance Administration as a means of checking the delivery and quality performance of suppliers.

Sub-Contractors and Suppliers of critical items or components will be subject to a Quality survey and periodic quality Audits.

Sub-Contractor Quality Control

Following the award of a sub-contract, RCA Limited Quality Assurance in conjunction with Engineering, is responsible for the final acceptance of all items furnished to the customer, so that the same quality standards apply regardless of the source of manufacture.

Quality Audit

In general all suppliers are subject to a quality survey prior to the awarding of a sub-contract. Quality Assurance Administration are represented on the survey team. The team will use the check lists detailed in the RCA procedure "Quality Assurance of Procurement Sources".

Source Inspection by RCA Limited

In the event that inspection at source of a sub-contractor's product is required, this inspection will be carried out on the authority of the Project Manager and by agreement with Quality Assurance.

Incoming Inspection

Requirements for Incoming Inspection and Test of all sub-contracted items will be specified by Quality Control Notices (QCN) issued by Quality Assurance Administration simultaneously with the release of the relevant procurement specifications.

Material Traceability

Material Traceability will be a requirement of the project subject to limits specified in procurement specifications. Traceability requirements will be included in procurement control drawings to be attached to Purchase Order

Postitive Identification requirements will be implemented to provide traceability as follows:

a) Serialization will be provided for all assemblies.
b) Serialization of all electronic parts for prototype and flight equipment as well as spares will be maintained through procurement screening incoming inspection and disbursement. Before installation, piece part serialization will be maintained. After installation in the equipment, electronic parts will be traceable to the manufacturer's lot control number.
c) Traceability for raw material and mechanical parts will be maintained to the physical and chemical analysis. Non-metallic raw material will require a certificate of compliance to the applicable specifications.
d) Traceability below the level of sub-assemblies will be controlled by means of manufacturing records.

A chart showing the flow of documentation and purchased material is attached as Figure 4.

A .9 Inspection and Acceptance Tests

A 9.1 Incoming Inspection

The Project Reliability Engineer will issue specifications for incoming inspection criteria. Incoming Inspection will perform inspection and tests in accordance with the particular specifications and existing departmental procedures.

All electrical parts received for prototype or flight use will be subjected to 100% screening, burn-in and inspection before release to Flight Stores. In addition, all vendor data received, including x-rays, will be analyzed and verified to the purchase order and engineering documentation requirements.

All mechanical parts will be subject to 100% inspection. Certain procured items will require special test and inspection procedures. These may be performed by groups other than Incoming Inspection. In such cases the tests will be witnessed by quality inspection and any acceptance data taken will be maintained by Incoming Inspection.

A 9.2 Fabrication Inspection

- Procedures for in-process fabrication inspection of material will follow the requirements of the Quality Control Manual of Procedures.
- Material Traceability identification of raw material will be confirmed by Quality Control Fabrication Inspection prior to the acceptance of any finished part.

  First Piece inspection is required on all parts.
- Rejected Material will be placed in Quarantine stores and disposal instructions will be obtained from the Material Review Board.

A 9.3 Assembly Inspection

Procedures for in-process assembly inspection will follow the requirements of Technical Products-Manual of Procedures.

Inspection of Equipment will be on a 100% basis and will be carried out at the following inspection stations:

- Mechanical Assembly Inspection
  Inspection of hardware, terminals, feed-thru's, etc.
- Component Mounting Inspection
  Inspection of parts installation, crimping, wire stripping, etc.
- Soldering Inspection

  Inspection of all soldered connections by approved inspectors certified in accordance with the requirements of NASA MPC-200-4, (Superceded by NHB 5300.4 (3A).
- Unit Final Inspection
- System Inspection

- Installation or Prepack Inspection

Appropriate inspection guides such as check lists and pictorial layouts will be used for inspections. Inspection Test Assembly Tags will be used for all equipment inspected. Rejected Material will be placed in Quarantine Stores and disposal instructions will be obtained from the Material Review Board.

A 9.4 Assembly Tests

- Alignment: Upon satisfactory completion of sub-assemblies, and assemblies, these will be submitted as required to Engineering or Quality Control Test.

- Acceptance Test: Following testing, units will be submitted to Quality Control Inspection who will ensure that all drawing requirements, modification status (Engineering Notices and Engineering Change Notices), workmanship standards have been met. On satisfactory completion of the above inspection, Acceptance Testing of Units is carried out by Engineering or Quality Control Test and if tested by Engineering will be witnessed by Quality Control Inspection and Test. Following acceptance, units are placed in the quarantine holding area.

- Environmental Test: Environmental testing may be carried out as required during Acceptance Test. Quality Control Inspection responsibilities during environmental test procedure remain as outlined above.

- Test Repairs: will be carried out in accordance with the instructions of the applicable Quality Control Notice or Engineering Change Notice.

- Equipment Log Books: will be maintained up to date by Engineering or Quality Control Test and monitored by Quality Control personnel throughout the duration of the program, so that a diary of all activities is available.

A 9.5 Systems Integration and Test

- Systems Integration: Only qualified units will be fitted to the spacecraft structure, and prior to integration will pass through Quality Control Inspection and Test. All units will be installed in the spacecraft under Engineering direction.

- Systems Test: Engineering personnel are responsible for the performance of all systems tests in accordance with Systems Test Specifications and Procedures. All tests will be witnessed by Quality Control.

- Environmental Test: Environmental testing may be carried out as required during systems testing. Quality Control Inspection responsibilities during environmental tests remain as described in Acceptance and Systems Test.

- Test Repairs: will be carried out in accordance with the instruction of applicable Quality Control Notices and Engineering Change Notices.

- Potting and Sealing: On satisfactory completion of system test all unsealed units are to be submitted to Quality Control for pre-sealant and pre-pot inspection. Potting and/or sealing will be carried out in accordance with applicable drawings and specifications and units re-submitted to Quality Control Inspection.

- Post Potting Bench Test: Before re-installation of units into the spacecraft, bench testing will be carried out as applicable by Engineering or Quality Control personnel and witnessed by Quality Control for conformance to relevant specifications.

- Final Assembly of Spacecraft: Quality Control will perform a final visual and mechanical inspection on the complete spacecraft models in accordance with applicable drawings, specifications and Quality Control Notices.

- Final Test of Spacecraft: Quality Control will monitor all testings of the complete spacecraft during and after final assembly.

A 10 Preservation, Packaging, Handling, Storage and Shipping

Through all phases of the manufacturing process, Quality Control personnel will monitor and document the handling of articles and deliverable end items. Items will be inspected at predetermined points to ensure that they are adequately protected and that the characteristics of quality are not impaired or degraded through handling.

Quality Control personnel will also verify that articles placed in storage are adequately packaged against damage and deterioration.

When equipment is ready for shipping, Quality Assurance personnel verify that hardware and data packages reflect acceptance and configuration. Also monitor handling and control of shipment to ensure that it is being handled in accordance with contractual requirements.

A 11 Data Reporting and Corrective Action

- Data Collation: Where required Quality Assurance Administration will detail the requirement for sampling plans in accordance with MIL-STD-105. Each stage of inspection documentation is available for analysis and is systematically examined for significant trends.
- Malfunction Reports: All unit failures occurring during any test phase down to and including breadboard stage will be reported on a Malfunction Report form by the function carrying out test.
- Action/Hold Notices: Quality Assurance Administration can initiate corrective action at any phase of the operation by use of the Action/Hold Notice.

A 12 Reliability Assurance Engineering at the Launch Site

o Receiving Inspection

Receiving inspection of spacecrafts, and of all other support items shipped to the launch site, will be performed by quality assurance personnel against shipping documents. Inspectors will verify and document any condition, damage, or deterioration during shipment.

o Launch Operation Test Verification

Tests and launch operations will be monitored by quality assurance personnel to verify adherence to launch test manual and procedures. The quality assurance personnel will generate failure reports, discrepancy reports and at the completion of each test will make entries in the spacecraft logbook.

o Flight Readiness Review

Approval for launch will be given by the Customer Authority. RCA Limited's Reliability Assurance Administrator will participate in the launch readiness decision to launch.

A 13 Documentation

The following tabulation lists the schedule of documentation related to the Product Assurance Plan to be submitted to the customer.

Title	Initial Submitted	Updating
Reliability Assurance Plan	60 days after authorization to proceed	30 days after reviews
Preliminary Parts, Materials, and Finishes List	80 days after authorization to proceed	As changes occur
Minutes of Design Review Meetings	21 days after the review meeting	
Reliability Analysis	14 days before design review	As changes occur
Design Specifications	14 days before design review	As changes occur
List of selected Suppliers and sub-contractors	With Reliability Assurance Plan	In monthly progress reports are required
Reliability Progress Report	30 days after authorization to proceed	Monthly
Quality Plan Reports	30 days after authorization to proceed.	Monthly