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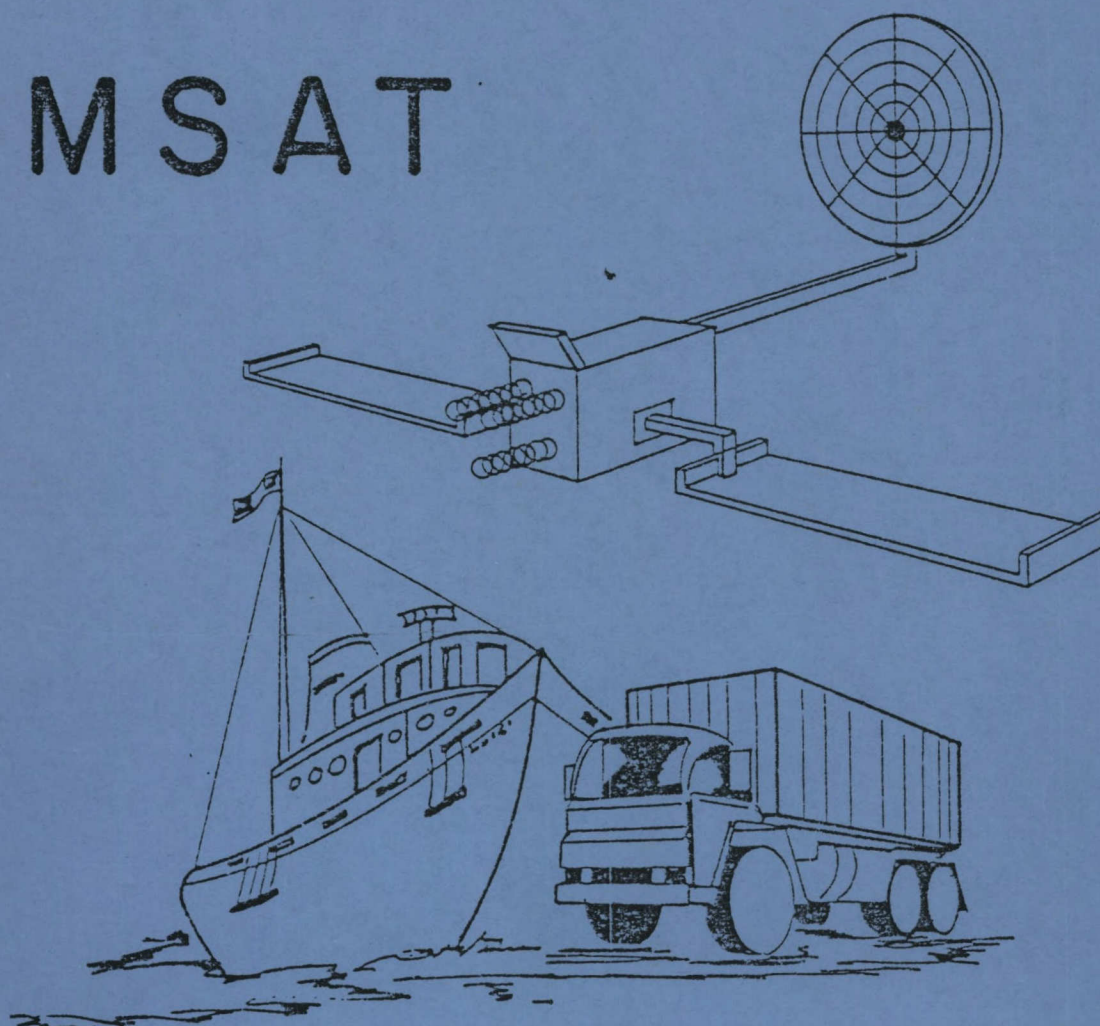


Government of Canada  
Department of Communications

Gouvernement du Canada  
Ministère des Communications

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# MSAT



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## MOBILE COMMUNICATIONS VIA SATELLITE

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v.1

REPORT TO MOSST  
JUNE 1981

D.O.C.  
RESOURCE CENTRE  
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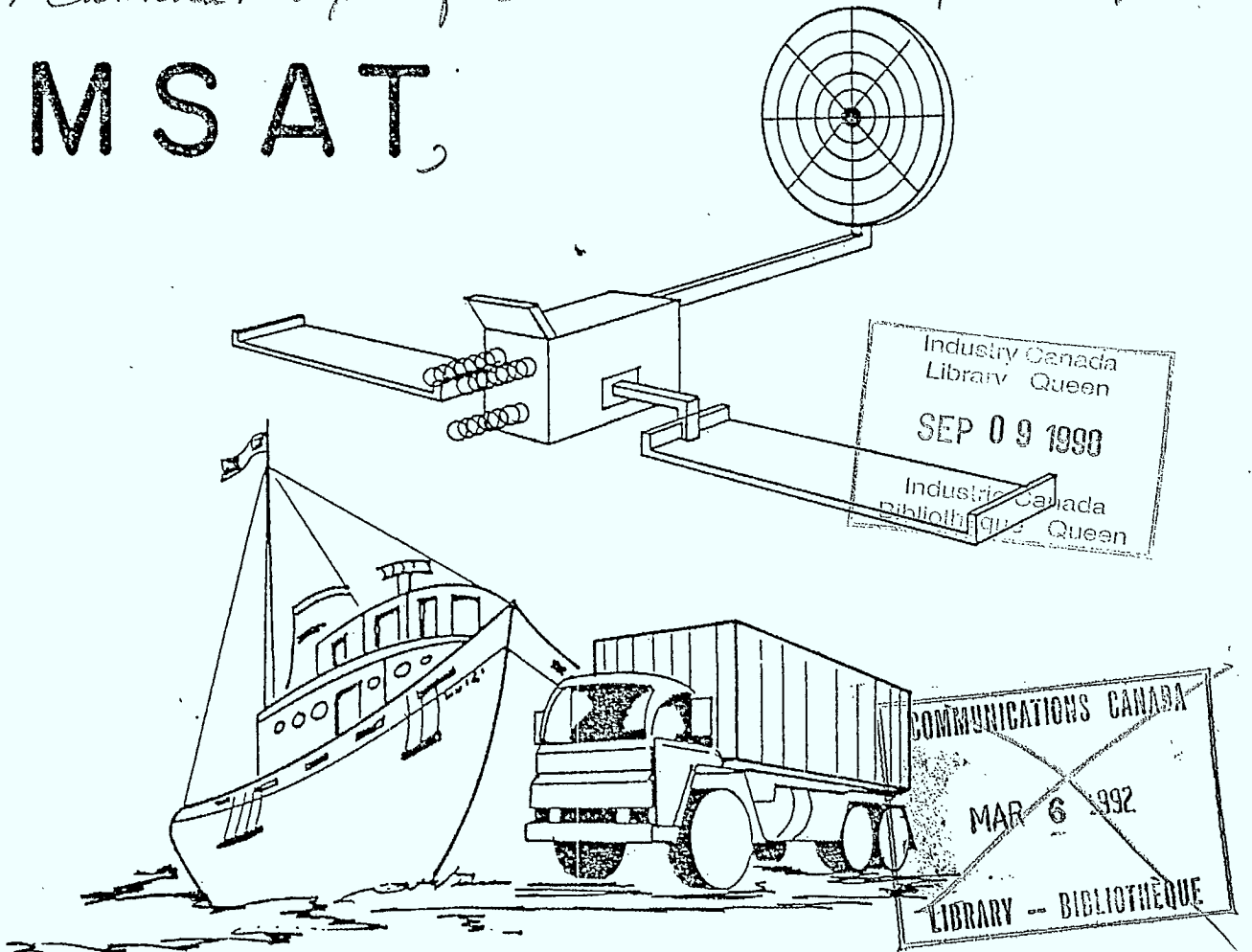
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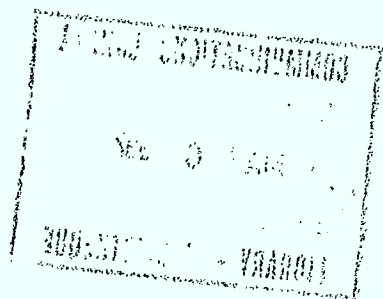
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# MOBILE COMMUNICATIONS VIA SATELLITE

REPORT TO MOSST  
JUNE 1981



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"MSAT WILL DEMONSTRATE THE TECHNICAL AND ECONOMIC FEASIBILITY OF PROVIDING  
EXTENDED COVERAGE TO RURAL AND REMOTE AREAS OF CANADA FOR VEHICULAR MOBILE  
TELEPHONE SERVICE"

REPORT TO MOSST

ON

MOBILE SATELLITE PROGRAM

DEPARTMENT OF COMMUNICATIONS

SPACE PROGRAMS

24 JUNE, 1981

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## 1. INTRODUCTION

The purpose of this report to MOSST is to provide information on the Mobile-Satellite (MSAT) Program necessary for a government decision on the relative timing of this program and the RADARSAT Program. A MOSST Cabinet Submission scheduled for July 1981 is expected to recommend the timing for implementation of these programs consistent with requirements, benefits and industry loading.

The objective of the MSAT Program is to provide a facility to satisfy urgent national needs for improved mobile communications to under-served areas of Canada, including the energy development activities in the North. The program could also provide a satellite communications capability for the Canadian Forces although formal requirement documents have not yet been approved by DND. The MSAT Program will develop, manufacture and launch a UHF mobile communications satellite as required to provide satellite service for mobile terminals in Canada in the most cost-effective and timely manner and to contribute effectively to industrial development. Once in orbit, the MSAT would be used for communications experiments, service development and pre-operational services. The post-launch communications program would be aimed at demonstrating and establishing the viability of mobile-satellite services.\*

The MSAT Program has five major phases:

- Phase A Concept Definition
- Phase B Project Definition and Systems Design
- Phase C Engineering Development and Detail Design
- Phase D Manufacture, Integrate, Test and Launch
- Phase E Post Launch Operations
  - a) DOC MSAT Communications Program
  - b) DND Pre-operational Services (Option)

At the present time DOC is conducting Phase A studies approved by Cabinet at a cost of \$2.2M. These studies were initiated in October 1980 and are scheduled to be completed by December 1981. This report is therefore based on preliminary information. A full program submission will be presented to Cabinet at the completion of the studies.

The following outlines the flow of information contained in this report.

- In Section 2, background information is given relating MSAT to the long-range plan for development of mobile-satellite services and to complementary satellite and terrestrial systems. The two major payloads on MSAT, one for DOC and one as a DND option, are defined and related to program objectives. The user needs and the services that would be provided with these two payloads are described in Section 3. In particular, the results of the

\* Expression meaning satellite service to mobile terminals.



Woods Gordon Market Survey are presented showing a very substantial market with 285,000 mobile terminals to be served via satellite by year 2001 for public and government applications.

- Section 4 outlines the MSAT Phase A studies including objectives, and presents a flow chart of the major activities and a description of the principal contracts.
- Two major program options are presented in Section 5 and recommendations are made to proceed with Phase B in January 1982 with a modest Canadian MSAT which would be launched in 1986.
- In Section 6 three spacecraft bus options (L-SAT, LEASAT and SATCOM) are compared on the basis of capability to satisfy the requirements of the selected MSAT program option. The L-SAT bus has fully-adequate capability while the other two buses have marginal capability to satisfy the MSAT mission requirements.
- The costs and financing options for MSAT are described in Section 7. In particular, the buy versus lease issue is analysed and an alternative scenario comprising both buy and lease activities is proposed to ensure program roles consistent with the mandates of DOC, Telesat and DND and to spread cash flow requirements over the longest period possible.
- In Section 8 the factors ensuring cost effectiveness of the MSAT Program are discussed and results are presented indicating potential commercial viability of a follow-on operational system which is part of the long-range plan for development of mobile-satellite services.
- Benefits of the MSAT Program are described in Section 9. In addition to service development and user benefits, this Section notes the very substantial benefits that will flow to the Canadian manufacturing and telecommunications service industries. In particular, it would have an immediate positive impact on the further development of Spar, as the Canadian spacecraft prime contractor, and Telesat as the Canadian satellite telecommunications carrier.
- In Section 10, the prospects of international cooperation to reduce Canadian program costs are discussed. There are very good chances of cooperation with NASA, and with ESA as well if the L-SAT bus is selected for MSAT.
- Timing considerations are discussed in Section 11 with the main conclusion that the MSAT Phase B should be initiated in early 1982 with the objective of launching the satellite in 1986.

## 2. PROGRAM BACKGROUND

### 2.1 General

This section relates the MSAT Program to the DOC objectives and the long-range plan for the development of mobile-satellite services in Canada. It also defines the major elements of the MSAT system.

### 2.2 Long-Range Plan

The long-range plan for the development and introduction of mobile-satellite services in Canada has two main steps; a) the MSAT Program, and b) the follow-on operational system; and has a time span of 13 years. This plan is in support of the DOC mandate:

"to foster, develop and introduce new communications systems, facilities and resources"; and

"to foster, develop and extend telecommunications services to obtain optimum benefits for Canada in the short and long term".

a) MSAT Program: The first step is an MSAT demonstration program to develop the mobile-satellite services and technology. This step would be funded by the government and undertaken in cooperation with the manufacturing and telecommunications industries and users. It involves the development and launch of a satellite followed by a post-launch program for service development and pre-operational service delivery. The satellite capacity needed on the demonstration satellite is a small percentage of the capacity needed for the follow-on operational satellite. The implementation of a demonstration satellite system takes 6 years (from Phase A start) and requires 7 years of operations following launch (as demonstrated by the HERMES/ANIK-B experience) for service development to allow enough time for planning and implementation of the follow-on operational system and to ensure a smooth transition of services to that system.

b) Follow-on Operational System: The second step is the implementation by telecommunications industry of an operational system operated on a commercial basis for public applications. The satellite is planned with market, economic and technical information obtained from the MSAT demonstration program. A procurement of this operational system would take approximately 4 years and would therefore have to start 3 years after launch of MSAT to ensure no discontinuity of service.

In accordance with this long-range plan, even if the MSAT Phase B is initiated in 1982 and the spacecraft is launched in 1986, the follow-on commercial systems will not be operational until the early 1990's.

Because the MSAT Program is planned within the context of this long-range plan, the Phase A studies and this Submission address not only the MSAT demonstration system but also some issues dealing with a follow-on operational system. Justification for the demonstration system is based among other things, on studies indicating an adequate market for the follow-on operational system and analysis showing potential commercial viability of this follow-on system.

While it is proposed that the MSAT demonstration satellite carry a DOC payload for public and civil government needs and an optional DND payload, it is almost certain that separate follow-on satellite systems will be needed for public/civil government needs and for DND needs. The public and civil government needs, projected to be 285,000 mobile terminals by year 2001, would be satisfied with a commercial follow-on system to MSAT. The smaller military need for several hundred mobile terminals would likely be satisfied with a follow-on system owned by DND. The specialized military needs and the difference of 3 orders of magnitude between military and public terminal needs by the year 2000 are factors that will demand different system concepts and technologies for the follow-on public and military systems.

### 2.3 MSAT Program

The MSAT Program would involve the development of an MSAT system followed by post-launch operations involving a DOC MSAT Communications Program and provision of pre-operational services to DND as an option. The MSAT would consist of one spacecraft in orbit, one spare spacecraft on the ground, satellite ground control facilities, and mobile terminals.

The MSAT spacecraft would have a DOC Communications Payload for public and civil government mobile-satellite service development and, as an option, a DND Communications Payload for pre-operational military mobile-satellite and fixed-satellite services as well as some experimental capabilities. Overall program cost-benefits are optimized with the inclusion of the DND payload. Separate payloads for DOC and DND are necessary as different frequency bands are allocated under Radio Regulations for public and military mobile-satellite services. The DOC Communications Payload would be shared with NASA or augmented by a NASA package through cooperative arrangements as discussed in Section 5.

The DOC Communications Payload would operate at 806-890 MHz, 401-403 MHz and possibly 1.5/1.6 GHz; and the DND Communications Payload would operate at 240-400 MHz, 406.1 MHz, 7/8 GHz and possibly 20/44 GHz.

### 2.3.1 DOC MSAT Communication Program

The DOC Communications Payload would be used following launch for an MSAT Communications Program whose philosophy would be similar to that of the HERMES and the ANIK-B Communications Programs but would fundamentally address the development of mobile services rather than fixed services. Channel capacity and time on the satellite would be allocated for two different purposes:

- a) Experiments, Pilot Projects, Market Trials, and
- b) Pre-operational service delivery

In each case, users could be federal government departments, provincial governments, telecommunications carriers, industry or other Canadian institutions. Experiments, pilot projects and market trials would have limited duration and be selected from proposals submitted on the basis of merit and contribution to program objectives. There would normally be no charge by DOC for use of the satellite for this purpose; however, DOC would not guarantee access to the satellite prior to acceptance of proposals. Part of the satellite capacity would be reserved for those users needing access for pre-operational service. In this case, where there would be commercial benefits to the users, DOC would expect appropriate cost recovery for use of the satellite service. As proposed in Section 7, the pre-operational services could be leased to users by Telesat with some cost offset to the benefit of DOC. The channel capacity needed from the DOC Communications Payload will be determined on the basis of further consultations with experimenters and Telesat.

### 2.3.2 DND Operational Communications Services

The DND Communications Payload is an optional payload that could be added to the satellite at the request of DND prior to the start of Phase B. It would be used by DND for provision of pre-operational communications services for tactical and strategic applications. This capability would be under DND control and would be funded by DND. It would provide all the technical features of an operational system except for the better service availability achievable with a spare satellite in orbit as would be required for a fully operational system.

## 2.4 COMPLEMENTARY SATELLITE AND TERRESTRIAL SYSTEMS

MSAT would be complementary to the ANIK, INTELSAT, INMARSAT and SARSAT satellite systems and the terrestrial mobile radio systems.



#### ANIKS (A, B, C & D)

MSAT differs from current Telesat ANIK satellites in many respects and would develop complementary services. MSAT utilizes primarily frequencies in the 806-890 MHz and 240-400 MHz bands as opposed to present ANIKs which operate in the 4/6 GHz and 12/14 GHz bands; and it provides narrowband services to compact mobile terminals on vehicles, ships and aircraft while the ANIKs provide both narrowband and wideband services to fixed terminals serving cities and small communities. The fixed-satellite services on MSAT at 7/8 GHz being considered as an optional DND capability differ from those on ANIK in that these would provide anti-jam capability, interoperability with satellite systems of allies, and wider area coverage.

In general 4/6 GHz and 12/14 GHz satellites are not suitable for mobile-satellite services for the following reasons:

- Mobile-satellite service is not allowed in these bands under International Radio Regulations;
- Mobile-satellite service is technically impractical and too costly to implement operationally in these SHF bands. Terminal antenna sizes needed to avoid uplink interference with other geostationary satellites are too large for installation in vehicles, aircraft and small vessels.

Under special circumstances, it might be possible to operate ship terminals at 4/6 GHz or 12/14 GHz under an experimental license. Such operation would have to be restricted to areas where this would not interfere with existing terrestrial microwave systems. This might be acceptable for service to a few large ships if no alternatives are possible.

#### FUTURE ANIKS

It does not appear to be technically feasible to integrate the present MSAT payloads with a 4/6 GHz or 12/14 GHz payload meeting a future Telesat requirement on a single spacecraft due to the spacecraft bus problems that would result. No existing spacecraft bus has sufficient payload capability and the technical risk would be too high for a commercial system. It might be feasible, however, to include a 1.5/1.6 GHz maritime mobile-satellite payload on a future ANIK to provide coverage to Arctic waters.

MSAT would, however, represent a new type of ANIK satellite if the program financing option recommended in Section 7 is selected.

### INTELSAT

The INTELSAT satellite system operated in Canada by Teleglobe Canada is used for international fixed-satellite communications mainly over the oceans. This system operates in the 4/6 GHz and 12/14 GHz bands and is unsuitable for mobile communications for the reasons stated above.

### INMARSAT

The INMARSAT organization will introduce a 1.5/1.6 GHz maritime mobile-satellite service over the Atlantic, Pacific and Indian Ocean in 1982 for international shipping. Similar services are now available from the US MARISAT system.

Teleglobe is the Canadian operating entity for the INMARSAT system. The first generation INMARSAT system planned to be operational from 1982 to 1989 will not provide full coverage to the Canadian Arctic waters because the volume of traffic from this area would not justify a dedicated INMARSAT satellite over Canada. For this reason DOC is considering, as an option, a 1.5/1.6 GHz payload on MSAT to provide supplementary coverage to the Arctic waters.

### SARSAT

SARSAT is a joint undertaking of US, Canada and France to implement an experimental polar orbiting satellite system to assist search and rescue operations by detecting and locating emergency locator transmitters (ELTs). SARSAT cannot provide continuous coverage because of the polar orbit. The MSAT 406.1 MHz service will be complementary to SARSAT by providing continuous coverage from a geostationary satellite and therefore immediate notification of a distress signal as well as identification of the party in distress. Unlike SARSAT, MSAT cannot, however, locate the position of ELTs.

### Terrestrial Systems

At the present time there are two principal types of mobile services in Canada:

- a) Mobile telephone service: This is a service offered by the telephone companies as an extension to their normal telephone service. Subscribers with mobile telephones in their vehicles can access subscribers in the telephone network and visa versa.

- b) Mobile radio service: This service consists of voice communications from a mobile radio to a base station without interconnection with the telephone network. Business enterprises and government agencies can either own their system or lease the service from Restricted Common Carriers (RCC).

The main problems with terrestrial mobile systems in Canada are as follows:

- ° There are insufficient frequencies to satisfy the market demand in the cities. As a result, systems are congested and provide a poor grade of service.
- ° There is inadequate coverage in the rural and remote areas in significant parts of Canada due to the technical and economic difficulties of serving these areas with terrestrial systems.
- ° Systems operating in different regions of Canada are frequency incompatible, and as a result roaming mobiles cannot operate outside their home region.

To resolve these problems DOC will allocate additional spectrum at 806-890 MHz to be shared between terrestrial and satellite systems. In particular, new 800 MHz cellular mobile telephone systems and trunked mobile radio systems will remove frequency congestion in the cities. However the 800 MHz systems are not expected to be economically viable to serve the rural and remote areas because the area served by a base station at 800 MHz is limited to an area 10-15 miles in diameter. A mobile-satellite system will complement the terrestrial systems by providing 800 MHz coverage to rural and remote areas and nation-wide compatibility. Following this concept Bell Canada has recently made a submission (1) to the Minister of Communications on the introduction of 800 MHz cellular mobile communications. This submission proposes the introduction of cellular services in three phases. The first two phases involve the development of terrestrial services in major cities. In the third phase, satellite service, as it becomes available, could be integrated with terrestrial systems to achieve province-wide coverage by Bell of both Ontario and Quebec.

### 3. SERVICE REQUIREMENTS

#### 3.1 General

This Section describes the services and user requirements for the DOC and the DND Communications Payloads on MSAT. In the case of the 806-890 MHz mobile-satellite services however, the requirements are projected over the period of 1987-2001 covering both the needs for MSAT demonstration system and the follow-on operational system.

#### 3.2 DOC Communications Payload

It is proposed to design the DOC Communications Payload for development of the following services for public and civil government needs:

- a) Mobile-satellite service at 806-890 MHz;
- b) Sensor data collection service at 401-403 MHz; and
- c) Maritime mobile-satellite service at 1.5/1.6 GHz.

None of these services are presently available from Canadian systems, nor do the Canadian carriers have plans to offer them in the near future. There is, however, a very substantial need, in particular for 806-890 MHz land mobile-satellite service, that could be satisfied in the future on a commercial basis if the MSAT Program is undertaken to develop the technology and the services and to satisfy urgent pre-operational needs.

The 806-890 MHz mobile-satellite market, estimated at 285,000 mobile terminals for 2001, far exceeds the other two services listed above. However, the sensor data collection service can be developed at relatively low cost by extending the bandwidth of the UHF receiver of the DND transponders described in Section 3.3. The 1.5/1.6 GHz service is included as an optional capability pending further assessment of the cost-benefit for this service.

The various services proposed to be developed as well as the user requirements for these services are described in the following sections.

##### 3.2.1 Mobile-Satellite Services at 806-890 MHz

###### 3.2.1.1 Service Description

The 806-890 MHz band was allocated to mobile-satellite services on a shared basis with terrestrial services at the 1979 World Administrative Radio Conference (WARC) to permit the extension of mobile communications to rural and remote areas using satellite technology. Prior to the 1979 WARC, the only band



available for mobile satellite services was the 240-400 MHz band which was, and still is, restricted to government applications and managed by DND.

The 806-890 MHz mobile-satellite service on MSAT will demonstrate the technical and economic feasibility of providing extended coverage to rural and remote areas of Canada for vehicular mobile telephone and private mobile radio terminals used for public and civil government applications. The MSAT mobile telephone service will allow toll quality, and will be compatible with the terrestrial cellular systems which are planned for the large cities. The MSAT mobile radio service will have more freedom to utilize advanced technology, and will probably be a digital system with advanced digitally processed speech and data transmission capability. The system will also provide the capability for operation with airborne, shipborne, transportable, field portable, and personal portable terminals as illustrated in Figure 1.

A few examples of the application areas foreseen for the 806-890 MHz service are as follows:

(a) Private Radio Service (PRS)

- (i) used by private users in resource industries, public utilities, transportation and by restricted common carriers.
- (ii) used by the federal government for law enforcement, Coast Guard services, fisheries management, resource management, emergency disaster services, and emergency health services.
- (iii) used by provincial governments for law enforcement, ambulance services, forest protection, resource management and highway services.

(b) Mobile Telephone Service (MTS)

The MTS would be used mainly by professional and business groups and any of the agencies mentioned in (a) who have a specific requirement to interconnect with the switched telephone network, or have a requirement to be interoperable with the terrestrial MTS system.

3.2.1.2 User Requirements

The public and civil government requirements for the 806-890 MHz mobile-satellite services have been studied in depth by Woods Gordon Management Consultants and by DOC. These studies have addressed the needs for MSAT during the 1986-93 period and for the

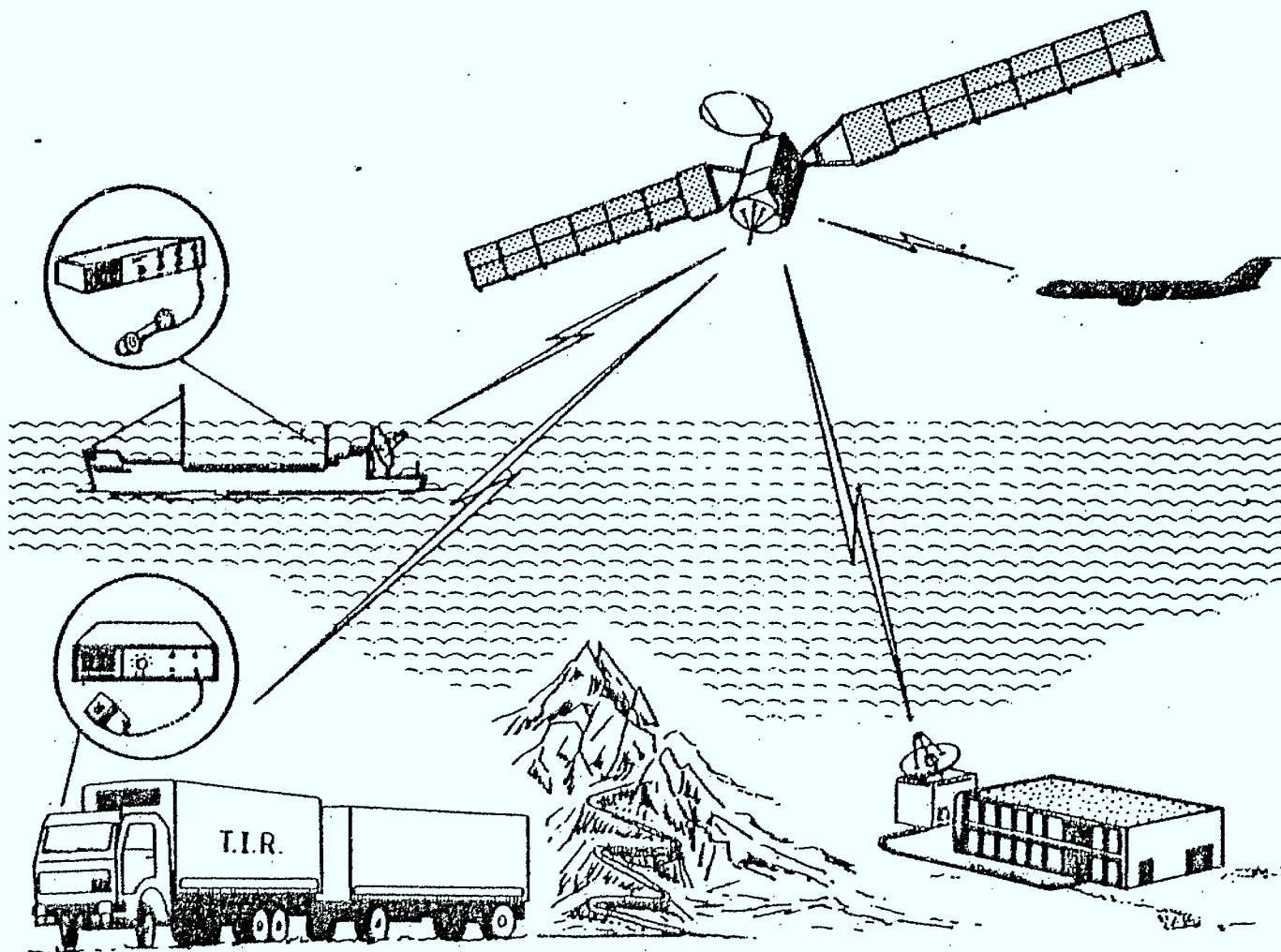


FIGURE 1. SATELLITE SERVICE TO MOBILE TERMINALS

follow-on operational system during the period of 1993-2001. The results presented here indicate a very substantial demand for the services.

#### Results from Woods Gordon

The results of the Woods Gordon study extracted from their report entitled "Provisional Market Projections for MSAT" issued on 12 June 1981 are given in Table 3.1. Woods Gordon have indicated that no significant changes in these projections are anticipated in the final report due in July 1981.

The Woods Gordon projections indicate that the number of mobile terminals in the potential market for MSAT will be 378,000 in 1987 and will increase to 596,000 by 2001. The MSAT market penetration in this potential market will be through new and replacement mobiles operating in non-metropolitan areas. The MSAT share of these will grow from 3% in 1987 to 50% in 1998.

The projections indicate that during the period of operation of MSAT, there is a requirement to serve 48,000 mobile stations. The follow-on operational system would serve 285,000 mobiles by year 2001. This is more than adequate to ensure commercial viability of the follow-on system. Assuming an attractive subscriber charge of \$100 per month per mobile for space segment usage, this market could generate \$342M per year in revenues and could justify the investment of \$500 to \$1000M that would be needed for implementation of a system to serve this market.

The MSAT potential market is further characterized in Table 3.2 which provides the projections by industry sector.

The projections produced by Woods Gordon are based on an extensive market survey and detailed analysis involving the development of mobile radio growth rates by industry sector and by regions of the country. The survey involved over 600 interviews in all regions of Canada with organizations owning in total more than 25% of the mobile radios presently operating in Canada.

#### DOC Consultations with Users

DOC has undertaken consultations with prospective MSAT users independently of Woods Gordon to inform users of the MSAT Program objectives, to involve users in the planning stage and to discuss participation in the post-launch MSAT Communications Program.

Discussions were conducted with federal government departments (EMR, RCMP, MOT, DFO, DOE and Emergency Measures), some provincial governments (B.C., Ontario, Quebec, and with N.S., P.E.I., and N.B. through the Maritime Consultative Committee on Communications),

TABLE 3.1

MSAT MARKET PENETRATION

PROJECTION OF NUMBER OF MOBILES

<u>Year</u>	<u>Number of Mobiles in Potential Market (1) ('000 units)</u>	<u>Number of New and Replacement Mobiles in Year ('000 units)</u>	<u>Projected MSat Share of New Mobiles (%)</u>	<u>Projected MSat Share of New Mobiles ('000 units)</u>	<u>Cumulative MSat Mobile Population ('000 units)</u>
1987	378	47	3%	1.5	1.5
1988	395	49	5%	2.5	4.0
1989	412	52	7%	3.5	7.5
1990	430	54	10%	5.5	13
1991	450	56	15%	8.5	21.5
1992	463	58	20%	11.5	33
1993	477	60	25%	15	48
1994	497	62	30%	18.5	66.5
1995	512	64	35%	22.5	89
1996	532	65	40%	26	115
1997	544	68	45%	31	146
1998	556	70	50%	35	181
1999	571	71	50%	35.5	215
2000	584	73	50%	36.5	250
2001	596	74	50%	37	285

(EXTRACT FROM "PROVISIONAL MARKET PROJECTION FOR MSAT")

BY WOODS GORDON, DATED 12 JUNE 1981



TABLE 3.2

## MSAT POTENTIAL MARKET

PROJECTION OF NUMBER OF MOBILES  
( '000 units)

Industry Sector	1981 Airtime/Mobile (min/month)	Projected Number of Mobiles				
		1981	1986	1991	1996	2001
Ag. & Fish	348	1.2	2.7	4.2	5.4	6.3
Forestry	122	13.4	19.3	27.2	37.1	49.0
Minerals	227	17.0	38.5	67.2	92.5	107.8
Manufacturing	552	15.2	21.8	26.6	29.0	30.2
Construction	192	16.1	18.7	19.7	20.0	20.1
Trucking	340	3.0	4.3	5.7	7.0	8.1
Other Transportation	228	54.4	76.6	102.0	127.7	151.0
Communications	114	3.2	4.6	5.7	6.2	6.5
Utilities	90	18.9	27.0	35.1	41.7	46.3
Trade & Finance	430	1.3	1.7	1.8	1.8	1.8
Services	551	3.4	4.8	6.3	7.8	9.3
Government	416	61.0	82.8	95.1	100.4	102.5
Sub Total	n.a. <i>12.5% 3410</i>	208.1	302.8	396.6	476.6	538.9
Ship	54	24.3	30.8	35.6	38.1	39.3
Air	119	16.8	17.5	17.6	17.6	17.6
Total	n.a.	249.2	351.1	449.8	532.3	595.8

(EXTRACT FROM "PROVISIONAL MARKET PROJECTION FOR MSAT")

BY WOODS GORDON, DATED 12 JUNE 1981

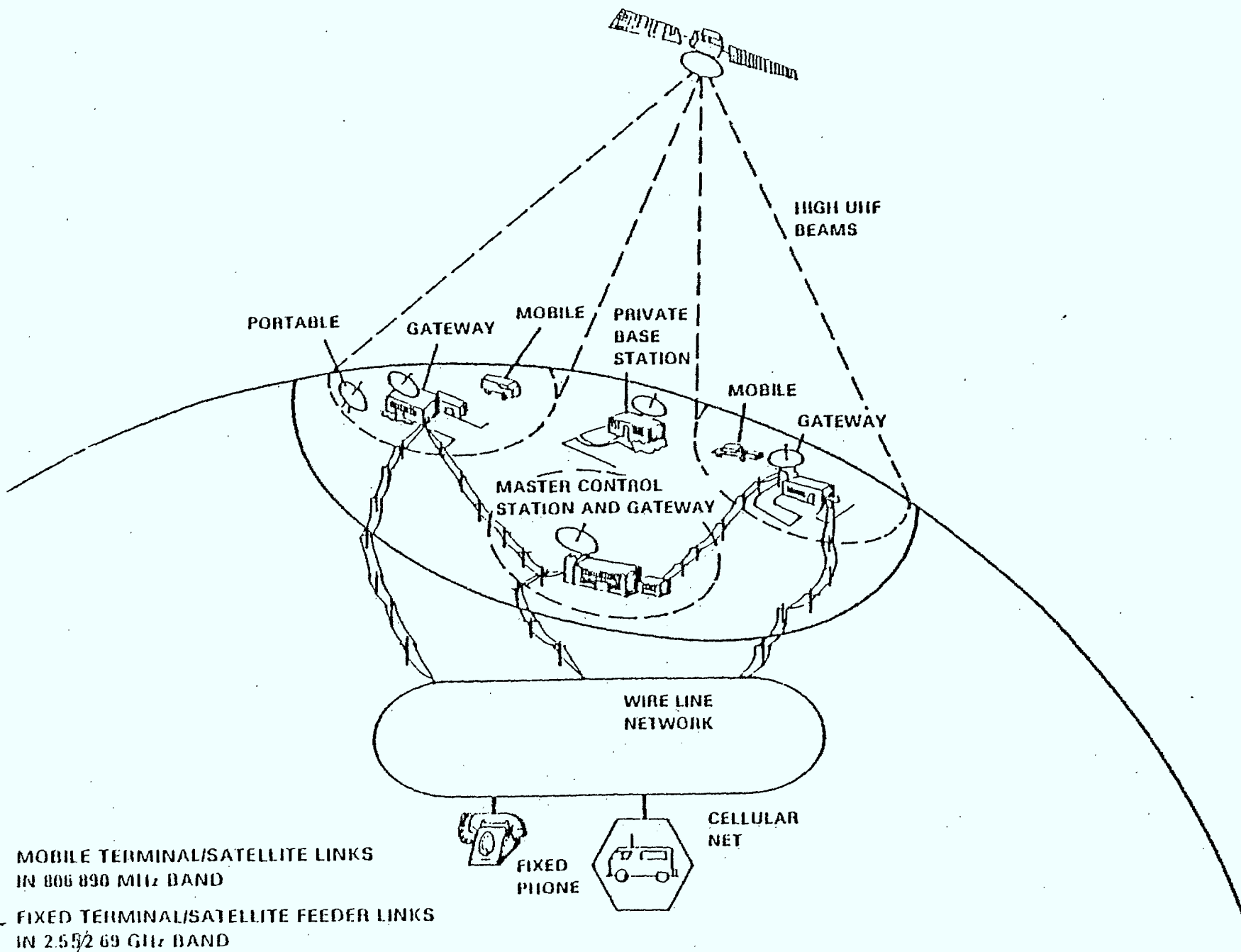
the Canadian Radio Common Carriers Association, the Canadian Petroleum Association Communications Committee (CPACC), and a number of companies that are users of PRS systems. All of these organizations expressed a keen interest in the MSAT Program, and believed there would be an extensive market for the service.

As an example, officials of the Quebec Department of Communications have stated that there is a need now for mobile-satellite services for the development of resources in Northern Quebec and provision of government services. Examples were given of several new hydro electric projects to be developed in the 1980's and 1990's that will require extensive mobile communications support for both the preliminary field work and the construction phases. Any delay in the development of mobile-satellite system beyond 1986 is to the detriment of these and other development activities in Quebec. The Quebec Department of Communications would participate in the MSAT Program and would need 3 or 4 satellite channels and a few hundred mobile stations for experiments and service development for government applications alone.

Several meetings have been held with the members of the CPACC and they have expressed an urgent requirement for a mobile satellite system that will satisfy their communications needs. A survey of MSAT user requirements conducted by CPACC and summarized in Appendix B indicates an urgent need for over 500 mobile terminals for operations of Dome, Esso, Shell, Amoco, Producers Pipeline Ltd. and Hudson's Bay. Petro-Canada also wrote to DOC to offer full cooperation and participation in the MSAT Program in view of the positive impact the program would have on the efficiency of its field operations. CPACC are in the process of employing a consulting organization that will further define their MSAT requirements.

Discussions have been conducted with most of the common carriers (Bell Canada, BC Tel, AGT, CN/CP, TCIS and others). They indicated that they are very interested in the MSAT Program; that they are interested in becoming involved in the service development during the post-launch MSAT Communications Program; and that the user requirements for MSAT could be very significant. They foresee MSAT as a possible means of extending mobile telephone service to areas that cannot be served economically by terrestrial systems. Bell Canada, which is planning to conduct trials on a terrestrial 800 MHz system in 1983, expressed a keen desire to become involved in a joint terrestrial/MSAT demonstration and trial and would require several satellite channels for this purpose. The concept of an integrated satellite-terrestrial mobile telephone system is illustrated in Figure 2.

FIGURE 2. INTEGRATED SATELLITE-TERRESTRIAL MOBILE TELEPHONE SYSTEM



A portion of the Woods Gordon study pertains to determination of users interested in becoming involved in the MSAT demonstration phase. Fifty-eight of the organizations interviewed expressed a desire to participate. The locations of these companies, who presently utilize approximately 47,000 mobiles, are well distributed across Canada. This preliminary information indicates that the various types of users of mobile systems could be adequately represented in the demonstration phase. Extensive consultations with these organizations, and others that have expressed their interest directly to DOC, have been initiated to plan their participation in the MSAT Program. This is essential to ensure that all user needs for the MSAT system are known prior to the start of Phase B and reflected in the system specification.

### 3.2.2 Sensor Data Collection Service at 401-403 MHz

#### 3.2.2.1 Service Description

Operation in this frequency band will provide federal government departments and provincial governments with data collection services using remote data platforms. Meteorological, hydrological, glaciological, oceanographic, and pollution monitoring data can be collected from remote sensors and transmitted via the satellite to a central processor. The processed data would be used by numerous industries (ie. petroleum, shipping, etc.) and by government agencies for flood warning, hydro-electric projects, environmental control, etc.

#### 3.2.2.2 User Requirements

A small requirement exists for collection of environmental data from sensors on unattended remote platforms that can collect and transmit information pertaining to the above application areas. There are presently 231 registered Canadian data collection platforms (DCPs) that operate with the US GOES satellite system. Discussions with EMR, DOE, MOT and others indicate that several hundred more are needed by 1990. At the present time there is no charge to Canadian users for use of the GOES spacecraft. The justifications for inclusion of this service on MSAT is that there is no guarantee that this no-charge policy will continue or that the service will continue to be available to Canadian users up to 1990's. DOC will consult further with DOE and other DCP users on this issue before taking a decision on whether or not to include this capability on MSAT. The impact of including this capability on the MSAT spacecraft is very small if the DND payload is also included.



Telesat has demonstrated through an experiment the technical feasibility of providing DCP service with the ANIK satellite system operating at 4/6 GHz. However, an operational service has not yet been implemented. One of the difficulties is that the 6 GHz DCPs are 2 to 3 times the cost of the 401-403 MHz DCPs.

### 3.2.3 Maritime Mobile-Satellite Service at 1.5/1.6 GHz

#### 3.2.3.1 Service Description

This service will be compatible with the future INMARSAT system, and will provide coverage to vessels in those Canadian Arctic waters that are not covered by the first generation INMARSAT System which will be in operation until the late 1980's. This service could alternatively be provided by the 806-890 MHz payload, but the existing INMARSAT shipborne terminals operating at 1.5/1.6 GHz could not be utilized.

#### 3.2.3.2 User Requirements

The inclusion of this payload on MSAT would provide INMARSAT compatible service to government, shipping industry, and resource industry users.

Discussions with the shipping and petroleum industries, and with the Canadian Coast Guard have indicated a small requirement for satellite coverage in Canadian Arctic waters that is INMARSAT-compatible. It would not be commercially viable for INMARSAT to place a satellite in an orbit position to serve this small market. Compatibility is required because some users have ships fitted with INMARSAT terminals and the majority of users have widespread coverage requirements. It is estimated by the shipping and petroleum industries and the Canadian Coast Guard that at least 100 vessels will require service in the Arctic waters in the 1990's. Further studies are needed to determine what percentage of these need INMARSAT-compatible services.

A study<sup>(2)</sup> has been conducted for the petroleum industry regarding safe passage in the Arctic and Atlantic seaboard for LNG tankers. It is required that ice flow and sea conditions be determined by surveillance satellites and reconnaissance aircraft. The data would be transmitted to a central processing location, analyzed in conjunction with meteorological data, and transmitted to tankers and tanker bases in the form of photographic images, charts, and text. Data transmission from aircraft to the central processor, and from the central processor to the tankers and tanker bases would be via a communications satellite. Depending on the data rates required, this could be accomplished by the 800 MHz or 1.5/1.6 GHz payloads or possibly by the ANIK satellite, although there are serious technical and regulatory problems with this latter approach.

### 3.3 DND Communications Payload

The DND Communications Payload is an option which would be included on the MSAT System at the request of DND prior to start of Phase B of the MSAT Program. DND is seriously considering participation in the MSAT Program and is studying its requirements in order to take a decision by September 1981 on whether to acquire a satellite capability. Formal requirements documents have not yet been approved by DND.

From extensive planning and engineering studies conducted by DOC under the DND recoverable program, and from extensive consultations with DND, it is understood that a DND payload as described in this section would satisfy interim requirements of the 1980's.

The DND Communications Payload would be expected to provide the following capabilities with coverage approximately as shown in Figure 3:

- a) Mobile-satellite services at 240-400 MHz,
- b) Fixed-satellite services at 7/8 GHz,
- c) Experimental mobile and fixed satellite services at 20/44 GHz, and
- d) Experimental emergency beacon monitoring service at 406.1 MHz.

#### 3.3.1 Mobile Satellite Services at 240-400 MHz

##### 3.3.1.1 Service Description

Operation in this frequency band would provide initial National Defence tactical communications via satellite to mobile terminals. This service would be utilized by the Canadian Forces using manpack, land vehicle, shipborne, airborne and transportable terminals. Each terminal would be capable of providing voice, data, teletype, and facsimile services, and would be interoperable with the US military satellite systems. The communications and satellite command links would be secure and ECM protected.

##### 3.3.1.2 User Requirements

Planning studies indicate that potential requirements for tactical communications in the 240-400 MHz band would be in the range of 40-50 duplex voice channels using Demand Assignment Multiple Access (DAMA) operation. There would be a requirement for approximately 50 vehicular and manpack terminals, 24 shipborne terminals, and 100 airborne terminals.

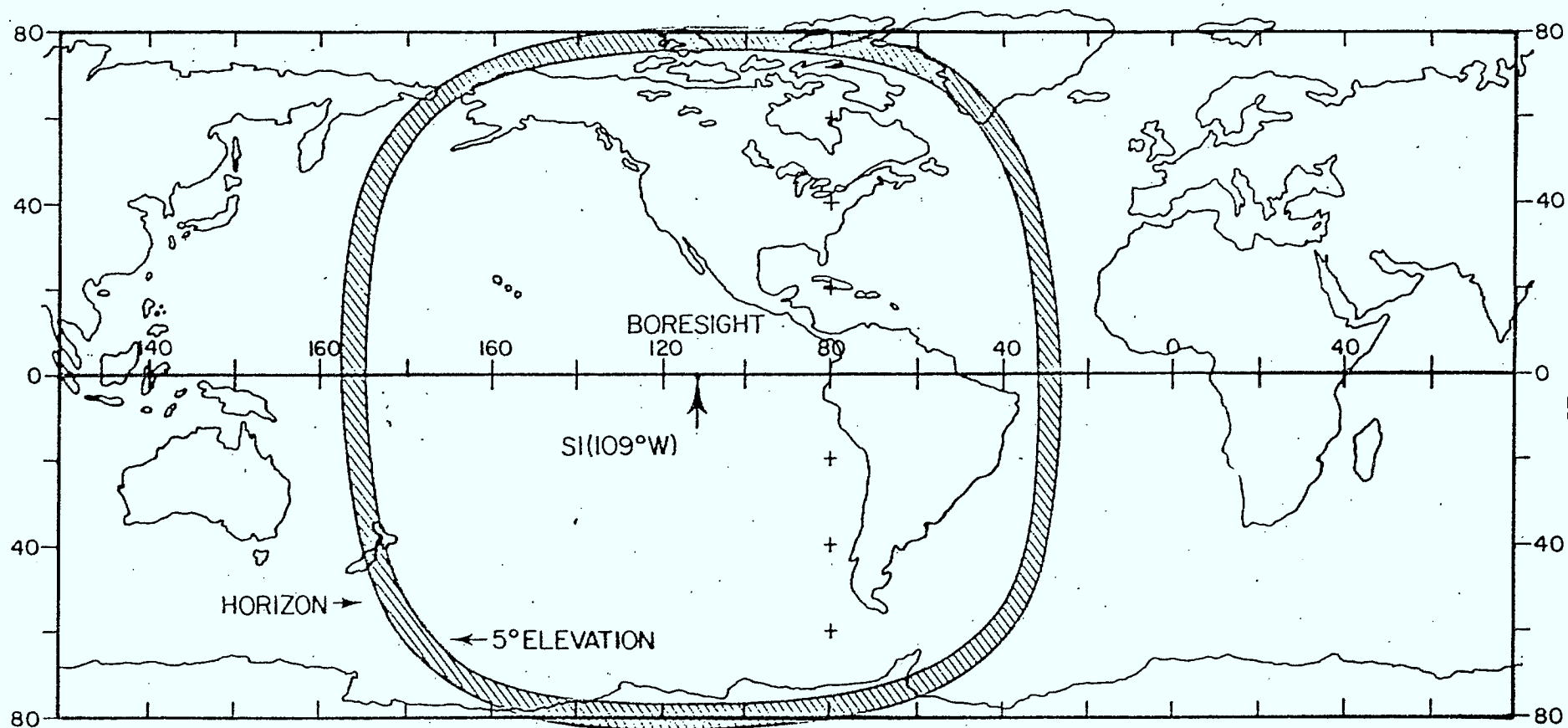


FIGURE 3. SATELLITE COVERAGE AT UHF AND SHF

### 3.3.2 Fixed Satellite Services at 7/8 GHz

#### 3.3.2.1 Service Description

This service would provide National Defence with a strategic communications capability in North America. It would provide secure communications utilizing fixed and transportable terminals which would be interoperable with U.S. military satellite communications systems. The fixed terminals would be used for principal communications nodes across Canada, and would be interfaced with the terrestrial network. The transportable terminals would be used at military bases for voice and data communication purposes, as well as in a contingency role.

#### 3.3.2.2 User Requirements

National Defence have a potential requirement for 8 medium route fixed stations which would be deployed across Canada as communications nodes, for 12 transportable light route stations which would be used at military bases and for contingency purposes, and for 16 tactical SHF terminals which would be used in the NORAD theatre. External Affairs could also be a user of the SHF service for communications requirements between EA in Ottawa and embassies in South American countries.

### 3.3.3 Experimental Mobile and Fixed Services at 20/44 GHz

#### 3.3.3.1 Service Description

The design of this service would be based on the existing US LES 8/9 satellite system, and would be available for demonstration and development of military EHF communications. It could provide a high ECM capability, and operation with fixed terminals as well as land and sea mobile terminals.

#### 3.3.3.2 User Requirements

The US and UK are in the process of developing military EHF satellite communications systems which are planned for extensive operational use in the early 1990 timeperiod. The inclusion of this service on MSAT would permit the Canadian military to gain experience with EHF services, and to maintain a degree of interoperability at EHF with their US and UK allies. With this experience, DND could be in a position to launch a fully operational EHF satellite system in the mid to late 1990s which would provide full interoperability with allies as well as a highly ECM resistant system.

### 3.3.4 Experimental Emergency Beacon Monitoring Service at 406.1 MHz

#### 3.3.4.1 Service Description

This will be an experimental emergency monitoring service that will monitor distress signals transmitted from aircraft, ships, or field parties. The distress signal will be retransmitted via MSAT to a Search and Rescue Center and will provide almost immediate notification of a distress incident with beacon identification. This system will be complementary to SARSAT, which will provide the location of the distress incident, but only on a periodic basis.

#### 3.3.4.2 User Requirements

In 1980 there were 589 Emergency Locator Transmitter alerts which required a DND response. It is essential that the SAR Center be alerted of a distress incident in the shortest possible time so that search and rescue procedures can be implemented expeditiously. The proposed experimental capability is expected to be warranted because of the improved response that could be provided at a low incremental cost in the spacecraft.



#### 4. PHASE A STUDIES

##### 4.1 General

On 27 August 1980 Cabinet gave approval to DOC for studies for definition of an MSAT Program, and approved the expenditure of \$0.5M in FY 80/81 and \$1.7M in FY 81/82, and 3 term person-years in FY 81/82 to supplement available manpower in DOC base resources. These expenditures were approved by Treasury Board on 23 October 1980.

These studies cover concept definition and feasibility of the system (generally known as "Phase A" studies) in sufficient detail to enable a decision to be made on whether or not to proceed with an MSAT Program and to prepare a Cabinet Submission in early 1982. The work includes the development of a program plan and cost estimates necessary for the full program submission, and the preparation of a Memorandum of Understanding (MOU) to be negotiated between DOC and NASA.

The objectives of Phase A are to study the needs, benefits, system concepts, economics, and policy issues of mobile communications satellite systems and to formulate a long-range plan including an appropriate demonstration satellite program for the development of mobile-satellite communications services in Canada. Preliminary technology development studies have also been initiated during Phase A on critical sub-systems to provide the management and technical information necessary to determine technical and system concepts with acceptable technical risk and acceptable impact on schedule and cost.

The Phase A studies involve a combination of in-house and contracted studies which are described in Sections 4.2 and 4.3. To date, a total of \$1.5 M has been committed for contracts out of the budget of \$2.2 M. A total of twenty-seven contracts are being undertaken. A flow chart of the principal Phase A activities is illustrated in Figure 4. The Phase A studies started in October 1980 and are scheduled to be completed by December 1981. The DOC Work Plan for the Phase A studies is attached as Appendix A. Programs and Project organizations have been established at DOC and a level of effort of 15 person-months per month is currently assigned.

##### 4.2 Phase A Contracts

The status of all the Phase A contracts is summarized in Appendix C. The following are descriptions of the six principal contracts:



(i) Mobile Satellite Market Survey

Woods Gordon Management Consultants was awarded a \$195K contract in January 1981 to determine the Canadian user requirements for a mobile-satellite system operating in the 806-890 MHz band. This has been done by identifying the type of services that are needed, estimating the size of the market for these services in the 1985-2000 time frame, and determining the demand for each service as a function of cost to subscribers. The provisional results are reported in Section 3.2.1.2 and the final report is due in July 1981.

(ii) Integrated System Study

A contract for the amount of \$160K was awarded to Intel Consultants Ltd. in May 1981, to assess the commercial viability of a Canada-wide operational mobile-satellite system within an integrated satellite/terrestrial 800 MHz mobile system. This study will make use of the Woods Gordon market survey to construct a traffic model, and will compare the economics of optimized terrestrial and integrated (terrestrial/satellite) system models. Results of related DOC economic studies are presented in Section 7.

(iii) Spacecraft Configuration Study

In January 1981 SPAR was awarded a \$700K contract to examine the technical feasibility and cost of (a) a follow-on operational satellite for 1993 launch, and (b) a demonstration satellite for 1986 launch. In addition to developing conceptual designs and analysing technical performance parameters for these two satellites, the study will identify critical areas of technology and provide a detailed work plan and cost for the Project Definition Phase (Phase B). The Spar contract is scheduled to be completed in September 1981. Results of studies on the follow-on satellite are completed and documented in Reference 3; and concepts for the demonstration system are discussed in Section 6. Figure 5 illustrates a possible spacecraft configuration conceived by Spar for the follow-on systems serving over 200,000 mobile terminals in North America in the mid 1990's.

(iv) Alternative Systems Study

A directed contract to Canadian Astronautics Ltd. was awarded in June 1981 to study a number of alternative spacecraft concepts based on existing bus designs and providing program options at reduced costs. This contract is jointly funded (DOC 120K, DND 125K). Preliminary results are discussed in Section 6.

# M/Sat Conceptual Layout

North American Baseline - Offset fed

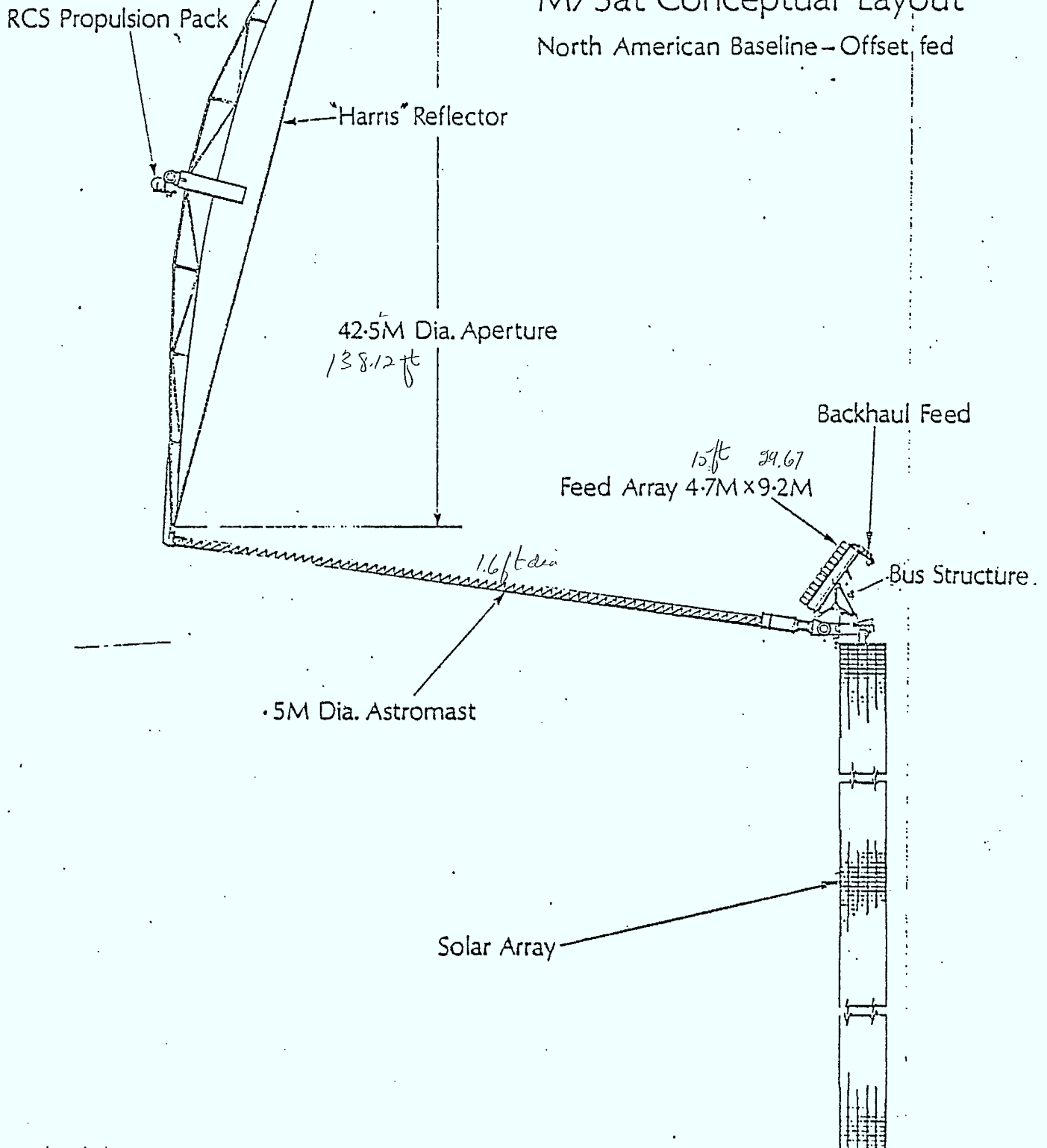


FIGURE 5. SPAR SPACECRAFT CONCEPT  
FOR FOLLOW-ON SYSTEM OF MID 1990'S

(v) User Cost-Benefit Study

A study contract has been initiated that will determine the cost-benefit of a mobile-satellite system to specific user categories. This study will utilize results of the Market Survey and Integrated System Study contracts as inputs. Bidder's proposals are currently being evaluated, and the award of a contract is expected to be made by the end of June. Some preliminary results based on NASA studies are presented in Section 9.

(vi) Program Benefit Study

A study contract is being defined to assess the economic, and industrial benefits to Canada of both a demonstration satellite system and a follow-on commercial system. The study will evaluate benefits to the various manufacturing industries expected to participate (including the potential for developing export markets), to the mobile radio service industry, and to the common carriers. Responsiveness to government policy execution and fulfilment of the DOC mandate will also be addressed. A contract is expected to be awarded in July 1981. The results of a DOC assessment of program benefits are presented in Section 9.

4.3 In-House Activities

In addition to the contracted Phase A studies, various other tasks have been identified and assigned to DOC staff. These are detailed in the Work Plan for the MSAT Phase A Studies (attached as Appendix A). These include tasks which, by their nature, cannot readily be contracted out, such as the preparation of international and interdepartmental agreements, Cabinet and Treasury Board submissions, etc. Approximately twenty-nine such tasks have been defined in the areas of Program/Project Management, Program Development, System Studies, Needs Assessment and User Liaison, Benefit and Economic Studies, and Policy Issues.



## 5. PROGRAM OPTIONS

### 5.1 General

This section describes two major program options under consideration by DOC to implement the MSAT Program.

- i) to proceed in January 1982, at the completion of Phase A, with Phase B project definition activities on a modest Canadian MSAT which would be launched in 1986, with proposed participation by NASA and DND, for maximum program benefits.
- ii) to defer the start of Phase B to 1985 and to then consider joint participation with NASA for development of a larger MSAT for launch in 1990.

DOC recommends the first option based on consideration of the following factors:

- a) Contribution to mobile-satellite service development in Canada for public and government applications in relation to need and timing;
- b) Resulting broad contribution to development of the manufacturing and service industries and technology in Canada;
- c) Program cost and cooperative cost sharing in relation to overall program benefits, and
- d) Program risk and consequence of not proceeding

For each program option, the minimum DOC program requirement is a payload operating at 806-890 MHz for public and civil government mobile-satellite service development as described in Section 2.3. Such a capability would have to provide Canada-coverage and a capability for both FM and digital voice service to vehicular and other types of mobile terminals.

A DOC objective is to achieve maximum program benefit relative to cost through sharing total program cost with NASA and DND by using a common spacecraft bus to carry shared or dedicated payloads. However should cooperation with DND not be feasible due to incompatibility of requirements or timing, DOC will recommend to Cabinet a dedicated program for development of 806-890 MHz mobile satellite services in Canada for public and civil government applications.

### 5.2 Description of Program Options

#### 5.2.1 Large MSAT Program (1990 Launch)

This MSAT option was conceived in April 1980 as a joint undertaking by Canada and the US to develop, manufacture and launch

a UHF mobile-satellite for the demonstration of new technology and for the development and provision of experimental and pre-operational services. SPAR would be the prime contractor, assuming adequate competence and capability within Spar for this very large activity. NASA would provide a 50-ft. diameter deployable antenna, the 800 MHz transponders and a shuttle launch. DND would provide the 240-400 MHz and 7/8 GHz transponders and encryption equipment for its needs. The 800 MHz capability would be shared between Canada and the US.

This MSAT option has adequate capability to fully meet technological and service development objectives, but it is expensive, involves considerable high risk technology, and cannot be scheduled for launch prior to 1990 due to NASA budget considerations. NASA is exploring a reduced MSAT program option at less NASA cost to meet limited objectives as described below.

Canada cannot justify the resources to undertake by itself the necessary technology development for a large multibeam antenna and a large spacecraft structure. The program risks would be high and the project would be beyond the capabilities of Canadian space industry at the present time.

#### 5.2.2 Reduced Canadian-led MSAT Program (1986 launch)

This option involves a small MSAT which would be built in Canada and launched in 1986 with proposed participation by NASA and DND for maximum program benefits.

Because of the difficulties identified in the large MSAT program option described above, and the consequences of a 1990 (or later) launch, DOC has undertaken detailed consideration of options which would enable the earliest practicable launch, reduced technological risk and reduced program cost. Such program options exist which essentially meet all service development objectives and provide excellent industrial and other benefits. The only compromise is that the large-structure spacecraft technology required for large operational mobile satellites is not demonstrated, but this compromise is considered a good one as smaller satellites serving specialized segments of the market are expected to be commercially viable. Eventually, however, the large spacecraft antenna technology will be needed to permit extensive re-use of the frequency spectrum.

In defining this program option the principal consideration relates to the channel capacity, availability, cost and industrial benefits for existing spacecraft buses which have already been developed. Sufficient capacity is necessary to provide DOC, DND and NASA services through adequate payload weight and prime power capability. Availability and cost are important to allow a 1986 launch, reduce program risk, and to size the program to SPAR's

capability. Industrial benefits may vary widely depending on what manufacturing arrangements SPAR has with the major bus suppliers. It is important to require a 7 year mission so that sufficient time exists for the procurement of a follow-on commercial system.

Concepts for a small spacecraft are based on the use of a smaller spacecraft antenna (4.2m to 9m) with lower risk bus designs (e.g. SATCOM, LEASAT, L-SAT). Preliminary studies indicate that adequate channel capacity for service development at 806-890 MHz can be obtained with existing bus designs if the speech signal is digitized for transmission using a residually excited linear predictive (RE-LPC) coder. The RE-LPC transmission occupies a bandwidth of only 3 KHz in comparison with 30 KHz for narrow-band frequency modulation (NBFM) presently used in the terrestrial cellular systems. The studies also show that the small satellite concepts could support NBFM but would require a higher gain antenna on the mobile and portable terminals. NBFM service to mobile terminals with low gain antennas would also be feasible if the L-SAT bus is used. The selection of a spacecraft bus for MSAT is discussed in more detail in Section 6 and the preliminary cost estimates are presented in Section 7 for three spacecraft options.

During recent discussions with NASA three possible levels of Canadian/US cooperation were postulated for further consideration in relation to a reduced program with a 1986 launch.

a) Minimum Level (Canadian Program with NASA as an Experimenter)

DOC would provide limited channel capacity and modest northern US coverage for NASA technical experiments and service demonstration. Figure 6 illustrates the spill-over coverage in the US if an L-SAT bus with a 9 M antenna is selected for MSAT.

NASA would provide favourable fee and arrangements for launch of the Canadian spacecraft.

b) Medium Level (Canadian Program with a NASA package)

DOC would provide more capacity and greater US coverage than in (a), plus provision on the Canadian spacecraft for NASA hardware verification (unit or subsystem), such as a power amplifier and/or feeds for US beams.

NASA would provide more favorable fee for launch services for the Canadian spacecraft.

c) Maximum Level (Joint Canada/US Program)

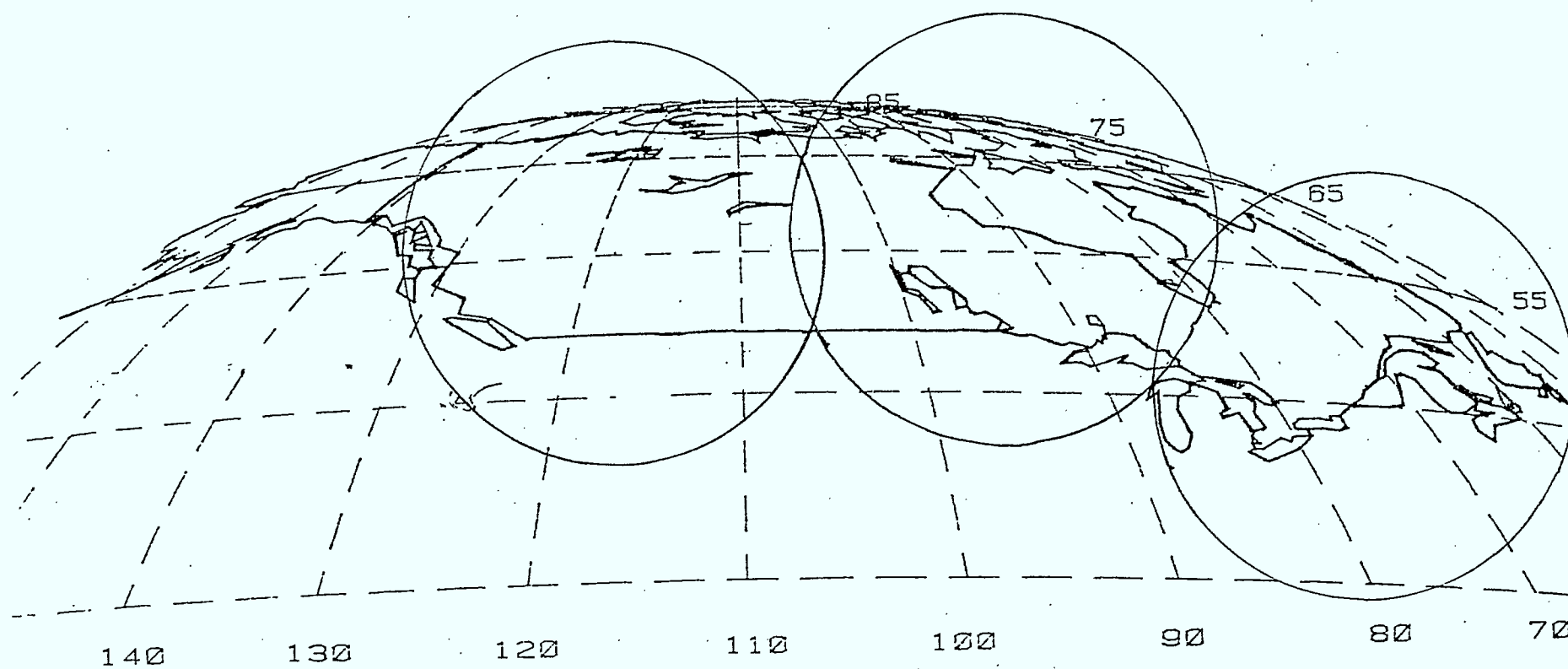
This would involve a joint program with substantial sharing of responsibilities and resources.

Canada would be responsible for the spacecraft bus, part of the communications payload, ground satellite control, spacecraft integration and test, and systems integration.

NASA would provide a communications payload or elements thereof, launch services, and perhaps the upper stage and/or a spacecraft bus subsystem.

Experiment capacity would be shared on the following basis:

- i) 50/50 sharing of 800 MHz payload capability if the DND payload is part of the program.
- ii) 50/50 sharing of complete communications payload capacity if the DND payload is not part of the program.



110°W LONG.

FIGURE 6. MSAT FOOTPRINT FOR 9M ANTENNA



## 6. SYSTEM CONCEPTS AND SPACECRAFT BUS OPTIONS

### 6.1 General

The original MSAT concept with a 15-20M antenna would have required the development of a specialized spacecraft bus. However, alternative payload options now being studied are capable of being carried on several different buses that are either currently in production or planned for the 1986 time frame. This section examines three bus options of differing levels of capacity.

Coupled with the varying capabilities of these buses in terms of power and antenna size is the possibility of trading off voice quality for increased channel capacity by using different modulation techniques. To be compatible with some of the planned 800 MHz terrestrial mobile telephone and mobile radio systems, a mobile-satellite system would require the use of narrow-band FM, with channel spacing 30 KHz and 15 KHz respectively. On the other hand, recent developments in digital voice coding techniques would require as little as 5 KHz of spectrum per channel, and about 8dB less power per channel. This means that for a given spacecraft power and antenna size, the later could support more than six times as many channels in about the same total bandwidth. The penalty would be lower speech quality and incompatibility with the modulation techniques of certain 800 MHz terrestrial mobile systems. Because of these considerations the MSAT system requires operation with FM to serve users who need compatibility with FM terrestrial systems, and digital modulation for the other users needing power and frequency efficient services and compatibility with digital terrestrial systems.

The three buses compared in the following are the L-SAT bus being developed by ESA, the operational RCA SATCOM bus, and the LEASAT bus being developed by Hughes Aircraft. Table 6.1 compares the main characteristics of these three buses. Costs for programs based on these three bus options are presented in Section 7.

### 6.2 L-SAT

L-SAT is a new three-axis-stabilized bus being developed by British Aerospace for the European Space Agency (ESA). It is considerably larger than the other buses considered here, and consequently has substantially greater capacity. It is considered to be the only one of the three that could provide sufficient FM channel capacity for development of MSAT services compatible with 800MHz FM terrestrial mobile systems. Other bus options can develop the satellite services to mobile terminals using more efficient digital modulation techniques, and would be restricted to a smaller demonstration capacity for 800 MHz FM service.

If a 9M diameter antenna is assumed, full Canada coverage would require three beams, thus allowing for possible frequency re-use

in the two outer beams to conserve spectrum. The L-SAT bus is designed to be compatible with the Ariane III and the shuttle. However, a shuttle launch would be expensive as an inertial upper stage (IUS) and the full shuttle bay would be needed. The communications capacity estimates included in Table 6.1 assume the capabilities of the first planned bus. Subsequent buses would have substantially increased payload and solar sail capacity.

This bus is currently the least developed of the three discussed, with the first launch (by Ariane) planned for 1985. The L-SAT bus would provide 800 MHz services to 7,000 FM mobile terminals or 42,000 RE-LPC mobile terminals (or a mixture of these) as well as the DND services. The voice channel capacity is close to the market demand of 48,000 mobile terminals projected by Woods Gordon for the period of operation of the MSAT demonstration system.

Selection of this bus would open the possibility of cooperation with ESA in the sharing of the spare bus of the L-SAT program with the MSAT program at a significant cost saving.

### 6.3 RCA SATCOM

Payload and power capacity of the three-axis-stabilized RCA SATCOM bus (of which ANIK-B was one of the first) have been augmented, providing the possibility of supporting both a DOC and a DND payload but with low channel capacity. The capacity quoted in the table assumes that the main antenna is shared between the DOC and DND payloads, and that the backhaul for the commercial service is provided in the 7/8 GHz band. A 4.8 M diameter main antenna is assumed, requiring two beams for full Canada coverage at 800 MHz.

### 6.4 Hughes LEASAT

The LEASAT bus has been under development by Hughes Aircraft Co. for about 1½ years for the US. Department of Defense as a replacement for FleetSatCom. Development was well advanced when it was halted temporarily in January 1981 due to uncertainties in the space shuttle's launch schedule. This satellite is spin-stabilized, and its power capability can be extended by a "drop-skirt" deployed after launch. Its design has been optimized for shuttle launch, and launch by other vehicles is not practical. The same assumptions were used in calculating channel capacity as for the SATCOM bus (Section 6.3) except that a 4.2M antenna was used. A range of channel capacities is given, corresponding to whether or not a full drop-skirt is used to increase the prime power capability. The LEASAT bus could support a DOC and DND payload providing low channel capacity.

BUS	L-SAT	SATCOM	LEASAT
Developed by:	ESA/BAe	RCA	HUGHES
Description	Large three-axis stabilized.	Three-axis stabilized Augmented Anik-B type	Spin stabilized. Expandable power capacity by adding solar cell skirts
Voice channel capacity at 800 MHz (a) DOC and DND payloads (b) DOC payload	111 FM ch or 692 LPC ch 134 FM ch or 833 LPC ch	6 FM ch or 37 LPC ch 12 FM ch or 79 LPC ch	5-14 FM ch or 31-90 LPC ch 10-19 FM ch or 62-120 ch
No. mobiles served as per (a)	7,000 (using FM) or 42,000 (using LPC)	360 (using FM) or 2,000 (using LPC)	300-800 (using FM), or 2,000-5,000 (using LPC)
Antenna size	9M	4.8M	4.2M
No. beams for Canada-coverage and frequency re-use potential	3 beams, frequency re-use between outer two	2 beams, no frequency re-use	2 beams, no frequency re-use
State of development	Least developed of the three. First launch planned for 1985.	Operational	Development well advanced but "mothballed" at present, pending DOD approval to proceed.
Compatible launch vehicles	Ariane III or STS/IUS (Requires full shuttle bay)	STS/PAM-D, Thor Delta or Ariane	Optimized for STS launch. Others not practical.

TABLE 6.1 Characteristics of Spacecraft Buses

### 6.5 Comparison

It should be noted that the LSAT bus is the only one of the three with the capability of providing an adequately sized mobile-satellite demonstration and service development system using FM modulation, and hence compatible with planned 800 MHz terrestrial FM systems and the switched telephone network. To obtain maximum channel capacity using the SATCOM and LEASAT buses with their smaller size and smaller antennas, it would be necessary to use a highly efficient digital modulation technique (such as LPC), and pay the penalty of incompatibility with certain terrestrial systems.

The use of demand-assignment-multiple-access (DAMA) has been assumed in arriving at the number of mobiles served, based on a loading of about 60 users per channel.

The pros and cons of the three buses are summarized in Table 6.2. The information presented is preliminary and a decision on the bus will not be made until September 1981 when related studies at Spar and CAL are completed.

### 6.6 Spectrum Requirement in 806-890 MHz Allocation

While the 806-890 MHz band has been allocated by the 1979 WARC for shared satellite-terrestrial mobile use, the detail sharing arrangements have not yet been agreed upon. This is an important issue that is currently being studied in Canada and in the U.S.

DOC will issue a discussion paper this summer through the Canada Gazette inviting public comments on issues affecting the introduction of terrestrial cellular mobile telephone services and mobile-satellite services in Canada. One of the principal issues is how the band should be divided between terrestrial and satellite services. In making a decision DOC will have to take into consideration the public need for these two services, image interference with UHF TV and fixed services (if the band has to be extended to 896 MHz), as well as the need for coordination with the U.S.

In the U.S. public consultation has already taken place on the use of the 806-890 MHz band for terrestrial systems. As a result of this process, the FCC has allocated spectrum for cellular and conventional systems and kept in reserve a total of 14 MHz for other systems including mobile-satellite systems. NASA is seriously concerned that this is not adequate for mobile-satellite services and may appeal the FCC decision.

Assuming 30 KHz channels for NBFM and 5 KHz channels for RE-LPC digital transmission, the required spectrum for the MSAT demonstration satellite is estimated to be:

BUS	PROS	CONS
L-SAT	<ul style="list-style-type: none"> <li>- Supports full DOC and DND payloads</li> <li>- Permits development of MSAT FM mobile-telephone</li> <li>- Possibility of sharing of spare bus with ESA</li> <li>- Adequate capacity for NASA participation</li> <li>- Compatible with shuttle and Ariane</li> <li>- Could be used for small follow-on op system</li> </ul>	<ul style="list-style-type: none"> <li>- In early states of development</li> <li>- Higher technical and schedule risk</li> <li>- Shuttle launch requires IUS and costly</li> <li>- Program more costly</li> </ul>
SATCOM	<ul style="list-style-type: none"> <li>- Fully developed operational bus</li> <li>- Lower technical risk and cost</li> <li>- Compatible with shuttle, Delta and probably Ariane launch vehicles</li> </ul>	<ul style="list-style-type: none"> <li>- Will permit technical demonstration only of FM MSAT mobile telephone service</li> <li>- Small channel capacity</li> </ul>
LEASAT	<ul style="list-style-type: none"> <li>- Design optimized for low shuttle launch cost</li> </ul>	<ul style="list-style-type: none"> <li>- Will permit technical demonstration only of FM MSAT mobile telephone service</li> <li>- Development not completed</li> <li>- No back-up to shuttle launch</li> <li>- Small channel capacity</li> </ul>

TABLE 6.2 PROS AND CONS OF BUS OPTIONS FOR MSAT



L-SAT bus option	8.4 MHz	for uplink plus downlink
RCA bus option	.8 MHz	for uplink plus downlink
LEASAT bus option	1.2 MHz	for uplink plus downlink

The spectrum needed for follow-on mobile-satellite systems serving 360,000 mobile terminals is estimated below assuming 15% of the need is mobile telephone service and the balance is mobile radio service. The required spectrum is given for two sizes of spacecraft antenna and for three types of modulation techniques for the mobile radio service.

Modulation Technique		Spectrum Required*	
Mobile Telephone	Mobile Radio	105 ft. dia.	160 ft. dia.
30 KHz NBFM	25 KHz NBFM	69.2 MHz	39.2 MHz
30 KHz NBFM	15 KHz $\Delta$ Mod at 9.6 kbps	46.4 MHz	26.4 MHz
30 KHz NBFM	5 KHz RE-LPC at 2.4 kbps	26.4 MHz	13.6 MHz

\* Total for uplink and downlink

It is clear from the above that a very large spacecraft antenna and spectrum efficient digital speech encoding and modulation techniques will be needed to serve the market of 285,000 mobile terminals projected by Woods Gordon by year 2000. Both DOD and NASA are recommending that 20 MHz of spectrum be allocated for mobile satellite services in 806-890 MHz band.

## 7. COSTS AND FINANCING OPTIONS

### 7.1 Capital Cost

Capital costs have been estimated in 1981 Canadian dollars for the three system options described in Section 6, and are presented in Tables 7.1 to 7.3. These estimates were developed in-house from cost data on other programs. They include the cost to procure two spacecraft, one launch, and a ground segment involving a ground satellite control facility, two gateway stations and 500 mobile terminals. For the MSAT program based on the L-SAT bus, the ground segment includes three gateway stations and 750 mobile terminals, as well as the ground satellite control facility.

The estimates do not include the effect of future inflation, the cost of the DND transponders (estimated at \$45M), the cost of DND ground terminals, or the post-launch operating cost which may be \$3M or \$4M per year.

The estimates do not reflect the expected cost reductions for launch services as a result of NASA participation or the cost-recovery expected from users gaining a commercial benefit from the use of the MSAT system.

In the case of the L-SAT bus, the cost estimates could likely be reduced by \$40M if DOC negotiated with ESA the sharing of a spare bus between the L-SAT Program and the MSAT Program.

The capital cost tables provide the required government cash-flow for an MSAT system procured by the government.

### 7.2 Lease vs Buy

Two basic alternatives for financing the MSAT program exist: "government-buy" and "Telesat-lease". A third, and very attractive alternative, consists of a combination of the two. The cash-flow for the three options are given in Table 7.4.

The government-buy option has the disadvantage of a large peak in capital expenditures during the construction phase of the project, and the need for DOC to institute a cost-recovery charging program for pre-operational services delivery from the system, which could be perceived by Telesat as an encroachment on their mandate. As well as losing a major business opportunity with large potential for growth in investment and profits, Telesat would tend to be largely isolated from involvement in system engineering experience and service development aspects of the program.

The Telesat-lease alternative, on the other hand, would involve Telesat in considerable non-recurring R&D activity and probably

MSAT LESS MUSAT PAYLOAD CASH FLOW M 1981 C\$

RCA SATCOM BUS

Launch  
↓

	FY								
Program Phase	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	Total
A - Concept Definition	1	1							2
B - Project Definition			8	7					15
C - Engineering Development			3	17	12				32
D - Manufacture 2 spacecraft				13	29	31	25		98
1 Launch and Mission Analysis				5	8	9	6		28
Ground Segment			2	8	8	12			30
TOTAL	1	1	13	50	57	52	31		205

TABLE 7.1

MSAT LESS MUSAT PAYLOAD CASH FLOW M 1981 C\$

LEASAT BUS

Launch  
↓

	FY								
Program Phase	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	Total
A - Concept Definition	1	1							2
B - Project Definition			9	8					17
C - Engineering Development			4	17	13				34
D - Manufacture 2 Spacecraft				17	37	39	32	5	125
1 Launch and Mission Analysis				5	11	12	2		30
Ground Segment			2	8	8	12			30
TOTAL	1	1	15	55	69	63	34		238

141

TABLE 7.2

MSAT LESS MUSAT PAYLOAD CASH FLOW M 1981 C\$

LSAT BUS

↓ Launch

	FY								
Program Phase	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	Total
A - Concept Definition	1	1							2
B - Project Definition			13	12					25
C - Engineering Development			10	25	16				51
D - Manufacture 2 spacecraft				22	45	47	31		145
1 Launch and Mission Analysis				14	22	22	17		75
Ground Segment			2	8	12	16			38
TOTAL	1	1	25	81	95	85	48		336

TABLE 7.3

FY	L-SAT			LEASAT			SATCOM		
	Govt-Buy	Telesat-Lease	Hybrid	Govt-Buy	Telesat-Lease	Hybrid	Govt-Buy	Telesat-Lease	Hybrid
80/81	1	-	1	1	-	1	1	-	1
81/82	1	-	1	1	-	1	1	-	1
82/83	25	-	23	15	-	13	13	-	11
83/84	81	-	51	55	-	30	50	-	29
84/85	95	-	38	69	-	24	57	-	20
85/86	85	-	22	63	-	12	52	-	9
86/87	48	99	17	34	-	2	31	-	6
87/88	-	99	54	-	70	45	-	60	38
88/89	-	99	54	-	70	45	-	60	38
89/90	-	99	54	-	70	45	-	60	38
90/91	-	99	54	-	70	45	-	60	38
91/92	-	99	54	-	70	45	-	60	38
92/93	-	99	54	-	70	45	-	60	38
TOTAL	\$336M	\$693M	\$475M	\$238M	\$420M	\$353M	\$205M	\$360M	\$305M

1981 Canadian dollars

Figure 7.4 Comparison of Cash-flow for Financing Options



would create an unacceptable commercial risk even if lease agreements were negotiated in advance with the government. Lease charges would be largely consistent with high commercial risk. In addition, DOC would have no involvement in MSAT technology development (and thus be unable to fulfill this part of its mandate).

The advantages and disadvantages of these two options, for DOC, DND, and Telesat, are summarized in Tables 7.5 and 7.6 as perceived by DOC.

A third option would involve a hybrid approach with government funding of the early (high-risk) phases, and a Telesat purchase of the satellite with lease-back of services to government and private users. Telesat would be involved during the early phases by providing engineering support services to the government. This compromise option would satisfy the mandate of all three entities concerned, as well as take into account their aspirations and limitations. Basically the government would provide funding for Phases A, B, and C up to the testing of the qualification model of the spacecraft, and thus remove from Telesat the large technological risk inherent in the development phases. Also, DOC would procure a launch from NASA at a preferred rate. Telesat would then procure a flight model, a spare spacecraft, and ground satellite control facilities, and lease services to DOC, DND, and others. Such an arrangement would have to minimize problems associated with the government specifying a spacecraft which would then have to be procured, owned, and operated by Telesat. As a variation on the above, which will also be considered, provision would be made on Telesat's satellite for the carriage of agreed Government Furnished Equipment, developed and procured to meet interface specifications (e.g. communications payloads and TT&C encryption equipment).

The hybrid option has the following advantages:

- There is a major role for DOC, Telesat and DND consistent with their mandates. DOC manages the high risk R&D Phases of the project and subsequently leases capacity for service development. Telesat leases services to the government on a commercial basis with a low risk. DND is able to lease services from a Canadian supplier (i.e. Telesat) by 1986.
- The financing arrangements could be attractive to all. DOC and DND only provide capital funding for Phases A, B and C plus the launch in the pre-launch period of 1982-86, thus avoiding high capital peaks that would occur during this period in a government-buy program or the high lease charge of a Telesat-lease program. During the post-launch period, DOC and DND pay service lease charges which would capitalize the flight spacecraft, the ground spare and the ground satellite control facilities and cover operations

G O V T - B U Y

ENTITY	PROS	CONS
DOC	<ul style="list-style-type: none"> <li>- DOC has major involvement in MSAT technology development</li> <li>- Minimum <u>total</u> cash-flow by DOC</li> </ul>	<ul style="list-style-type: none"> <li>- large capital peak during procurement phase</li> <li>- Telesat may not be involved in service development and delivery.</li> <li>- full cost-recovery by DOC from users with commercial benefit stretches DOC mandate.</li> </ul>
DND	<ul style="list-style-type: none"> <li>- DND has maximum control over satellite</li> <li>- minimum total cash-flow by DND</li> <li>- significant involvement in satellite communications systems engineering.</li> </ul>	<ul style="list-style-type: none"> <li>- budgeting problems in early 1980's when funds needed for early phases.</li> <li>- capital peak during construction phase.</li> </ul>
Telesat		<ul style="list-style-type: none"> <li>- Loss of major business opportunity involving growth in investment and profits</li> <li>- Loss of spin-off benefits associated with company development and new procurement project for engineering division.</li> <li>- Transition to follow-on commercial system more difficult than in other options</li> </ul>

TABLE 7.5

# TELESAT - LEASE

ENTITY	PROS	CONS
DOC	<ul style="list-style-type: none"> <li>- Good approach in principle for service development</li> </ul>	<ul style="list-style-type: none"> <li>- Lease charges may be prohibitive</li> <li>- DOC has little or no involvement in MSAT technology development</li> </ul>
DND	<ul style="list-style-type: none"> <li>- May relieve budgeting problem in early 1980's as no funds are needed until 1986 for the space segment lease payments</li> </ul>	<ul style="list-style-type: none"> <li>- Lease charges may be prohibitive</li> <li>- Satellite is not under exclusive DND control</li> <li>- DND gains little experience in satellite communication systems engineering</li> </ul>
Telesat	<ul style="list-style-type: none"> <li>- Very significant growth in investment, and potentially in profit</li> <li>- Engineering staff occupied</li> <li>- New business area</li> </ul>	<ul style="list-style-type: none"> <li>- Technical risk is high</li> <li>- Commercial risk unacceptable unless lease agreements are negotiated in advance.</li> </ul>

TABLE 7.6

and profit. The effect of this arrangement is to spread the government cash flow over the period of 1982-1993. This arrangement is expected to be attractive to Telesat, as the risk and the required capital are less than in a program where Telesat has total procurement responsibility including the R&D Phases and the launch. Yet, Telesat would be involved in these early stages through an Engineering Service Contract with DOC or through capitalizing its costs as part of the future flight model procurement program.

- Telesat would provide services to the oil industry and others who need pre-operational services on a commercial basis.
- This approach appears to match the interest, expertise, and level of manpower resources available at DOC, DND and Telesat.

Discussions are in progress with Telesat to explore the feasibility of the hybrid financing approach.

## 8. COST EFFECTIVENESS

### 8.1 General

Cost effectiveness of the MSAT Program is discussed from two viewpoints in this Section. First, the cost effectiveness of using a single spacecraft to carry dedicated or shared payloads for DOC, DND and NASA is discussed. Secondly, results are presented showing the potential commercial viability of follow-on operational mobile-satellite systems providing service to the public.

### 8.2 Cost Effectiveness of the MSAT Program

In Section 6 three spacecraft bus designs were considered for the MSAT Program. The information presented shows that existing buses can support both the DOC and the optional DND communications payloads, with varying amounts of channel capacity.

A cooperative MSAT Program involving DOC, DND and NASA payloads on a single spacecraft is very cost effective compared with three separate programs involving 3 separate spacecraft, 3 separate launches and 3 separate project management organizations.

In considering the effectiveness of programs to meet the DOC objectives it should be noted that there are no alternatives to a flight program if mobile-satellite services are to be developed in Canada.

The cost effectiveness of the program is not significantly affected by a decision of whether to buy the satellite system or to lease the services from Telesat or elsewhere. As none of the currently planned Telesat spacecraft can provide mobile services, Telesat would itself have to undertake a system procurement to lease the services to the government. Typically the total leasing charges over 7 years would be 2 to 3 times the capital cost the government would incur if the system were procured by the government. The reason for the higher cost is that the leasing charges would include interest on the capital and profit. From an overall government viewpoint however, there is not a large difference in the true costs to the government between the lease and the buy options as the government would also bear the cost of money in a buy program, and in a lease program income tax is paid to the government as well as half of any profits as the government owns 50% of the Telesat shares.

### 8.3 Commercial Viability of Follow-on Operational Systems

A vital question in the development of public mobile-satellite services is whether the follow-on operational systems would be commercially viable. The most important factor in assessing commercial viability is the charge mobile subscribers would have to pay for the

services. The commercial viability of future operational mobile-satellite systems will be studied and compared with the commercial viability of alternative terrestrial systems in the Integrated System Study awarded to Intel Consultants Ltd. Preliminary results of DOC studies reported in Sections 7.3.1 and 7.3.2 show that large spacecraft with antennas in the 100-150 ft. diameter range are expected to be commercially viable for provision of service to FM mobile terminals compatible with terrestrial systems using FM, and that smaller spacecraft (eg. L-SAT size) with antennas in the order of 30 ft. diameter are expected to be commercially viable for provision of lower quality digital voice service to mobile stations or FM voice service to portable stations and mobile stations with higher gain antenna (e.g. 10dB).

### 8.3.1 Commercial Viability of Large Satellite

A preliminary economic analysis of three different size satellites capable of supporting 70,000, 150,000 and 210,000 users has been carried out for an operational system as would be expected to be implemented in the 1990's. The space segment consists of one operational satellite, one flight spare, and a ground spare. The ground segment consists of the central control station and one gateway station per beam. Space segment costs are based on in-house studies at NASA and DOC. These will be adjusted when the results of the spacecraft configuration study are available. Commercial recovery analysis is described in Annex D for the three models, and summarized below:

<u>Number of Users</u>	<u>Ground and Space Segment Costs M \$1980 Can.</u>
210,000	652
150,000	623
70,000	545

Based on a six year development and manufacture cycle and a seven year satellite system life, the per minute user charges in 1980 Canadian dollars as detailed in Annex E are:

<u>Number of Users</u>	<u>Space and Ground Segment Charges</u>	<u>Mobile Radio Leasing Charges</u>	<u>Average Toll Charges</u>	<u>Total User Charges</u>
210,000	\$0.75	\$0.17	\$0.45	\$1.37 per minute
150,000	\$1.00	\$0.17	\$0.45	\$1.62 per minute
70,000	\$1.80	\$0.17	\$0.45	\$2.42 per minute

This would result in a monthly user charge of around \$200 dollars for the system serving 210,000 users. Many users of terrestrial systems are currently paying \$150 per month for service in metropolitan



areas only and are willing to pay more for the extended MSAT coverage. The user charge would of course be less for users willing to accept less than the toll quality voice assumed in this analysis. Also, by the 1990's satellites are expected to have a useful life of at least 10 years as apposed to the 7 years assumed in the cost recovery analysis and the market penetrations of the follow-on system is expected to be larger (285,000 mobile terminals) than that assumed above. Both of these factors suggest even lower charges than indicated above.

#### 8.3.2 Commercial Viability of Small Satellites

A preliminary study has shown that a spacecraft with a deployable antenna of at least 30 ft will be needed for future operational satellites providing field quality digital voice service (2.4 kbps RE-LPC) on a commercial basis with attractive user charges. Spacecraft with smaller antennas could provide commercial service to a limited market willing to pay a premium for the service.

With an antenna diameter of 30 ft. on an L-SAT bus, the space segment capital cost per RE-LPC mobile subscriber is approximately \$4K. Assuming the capital is recovered in 3 years (a common rule of thumb), the annual lease cost per user is \$1,300 or slightly over \$100 per month. This user charge would be very attractive to users.

## 9. MSAT PROGRAM BENEFITS

### 9.1 General

The MSAT Program would provide very substantial benefits to the users of the system, to the Canadian space and electronics manufacturing industries, to the Canadian telecommunications service industry, to the Canadian economy, and to the government.

A User Cost-Benefit Study Contract and a Program Benefit Study Contract are underway to identify and quantify the benefits of the program. This Section provides preliminary information on expected benefits.

### 9.2 User and Public Benefits

The MSAT Communications Program will provide benefits to the public through the following objectives:

- a) To foster the development and introduction of new satellite telecommunications services and systems by supporting demonstrations, experiments, pilot projects and trials designed to develop awareness, knowledge and expertise and assess viability of these new services and systems, and by consolidating the results of these activities.
- b) To facilitate the introduction of new services on commercial satellite systems in Canada by exploring means to aggregate user needs and by providing a vehicle for limited interim service delivery before a follow-on commercial system becomes available.
- c) To support the advancement of Canadian capability in satellite communications technology and service delivery by assisting Canadian user institutions, industry and the carriers to respond to national needs and international market opportunities.
- d) To stimulate telecommunications policy development by identifying issues and providing relevant data.

The use of the satellite by industry, public institutions, provincial governments and federal government will not only result in valuable knowledge on how mobile-satellite service can improve efficiency in industrial activities and public service delivery but it will also result in substantial socio-economic benefits to the public during the course of the program.

A preliminary discussion of user benefits follows, to indicate the type of results expected from the user cost-benefits study contract which has been initiated.

### Oil and Gas Industry

This industry stands to gain significant benefits from the MSAT program. The majority of their operations are in northern latitudes where voice and data communications are difficult. Improved mobile communications in this environment will result in higher efficiencies in operations and large resulting cost savings.

The operating cost of the oil and gas industry is approximately \$1.4 B annually, it is sufficient to say that a small increase in efficiency of operations due to improved mobile communications would result in very significant benefits.

When the industry exploits the far northern reserves, it will become essential to provide navigational support information, eg. sea conditions and meteorological data to ships' masters. MSAT is the most effective and practical method of reliably providing this service. In addition to improved efficiency, the safety aspect is of paramount importance.

### Forest fire fighting

A study<sup>(4)</sup> conducted by Econ Inc. in the U.S. for NASA concluded that the benefit of mobile-satellite services in improving the efficiency of forest fire fighting would be approximately \$28M (1977 U.S. \$) per year. If this is scaled on the basis of forest area protected, the benefit to Canada would be \$19M (1977 CAN. \$) per year.

This estimate may be low due to the difference in the type of forest and type of typical fire. The Canadian forest is mainly boreal which is more prone to fire than the predominately deciduous U.S. forest. The typical Canadian forest fire is of larger dimensions than a typical U.S. fire, with larger fire fighting resources to control. The advantages, and hence the cost benefits derived from enhanced communications should therefore, be greater for Canadian forest fires. The total expenditure in fighting forest fires in Canada is typically \$ 100 M per year: 1980 was a bad year for forest fires with cost of \$198M.

### Law enforcement

A second U.S NASA report<sup>(5)</sup> prepared by the Mitre Corporation estimated the U.S. benefits of mobile-satellite services in federal law enforcements as \$4.7M (1978 US \$) per year.

Relating this type of benefit to Canada is difficult. Canada has a smaller population and hence a smaller police operation, but the police have a more difficult communications requirement. The Canadian

police, especially the RCMP, are spread over a far greater geographic area, and substantial cost savings are expected from the use of a mobile-satellite system instead of terrestrial mobile systems in remote areas.

The RCMP presently operate approximately \$80M of radio communications plant, half of this being mobile and half base stations. Each year an additional \$10M is spent on plant expansion and upgrading. By using a mobile satellite system the fixed plant expenditure would be reduced significantly.

The excellent remote and rural communications possible with a mobile-satellite would improve the overall effectiveness of rural law enforcement, and hence benefit the population being served.

#### Emergency Medical Services

The Econ study(4) concludes that in the U.S. mobile-satellite communications to ambulances serving rural and remote areas will save 60,000 lives per year. This service permits a doctor at a hospital to give instructions to the paramedic following transmission of medical signals from the ambulance. Figure 7 shows an ambulance equipped with a mobile-satellite terminal used to evaluate emergency medical service delivery in the US with the ATS-6 satellite. Presently, there are significant differences between emergency medical services in the U.S. and those in Canada, but by the late 1980s, these differences will most likely disappear, and the same quality of emergency medical services will be available in Canada.

The number of lives saved in Canada can therefore be predicted by population scaling as 6,000 per year from emergency medical services supported by a mobile satellite service.

#### Trucking

The Econ study(4) predicts for the U.S. trucking industry a user benefit of \$25 (US) million per year. The Canadian trucking industry is sufficiently similar to its US counterpart to allow scaling of the result simply on the basis of population; thus the predicted Canadian benefit could be in the order of C \$3 M per year.

### 9.3 Policy Benefit

The MSAT program will strongly support government policy to encourage the development of a spacecraft prime contractor in a progressive fashion, with increasing program size following ANIK-D, and with early timing as required. Through the MSAT program Spar will improve its competitiveness as a prime contractor for Canadian domestic operational systems, as well as strengthening subsystem capability for the export market. Federal-provincial cooperation will be greatly



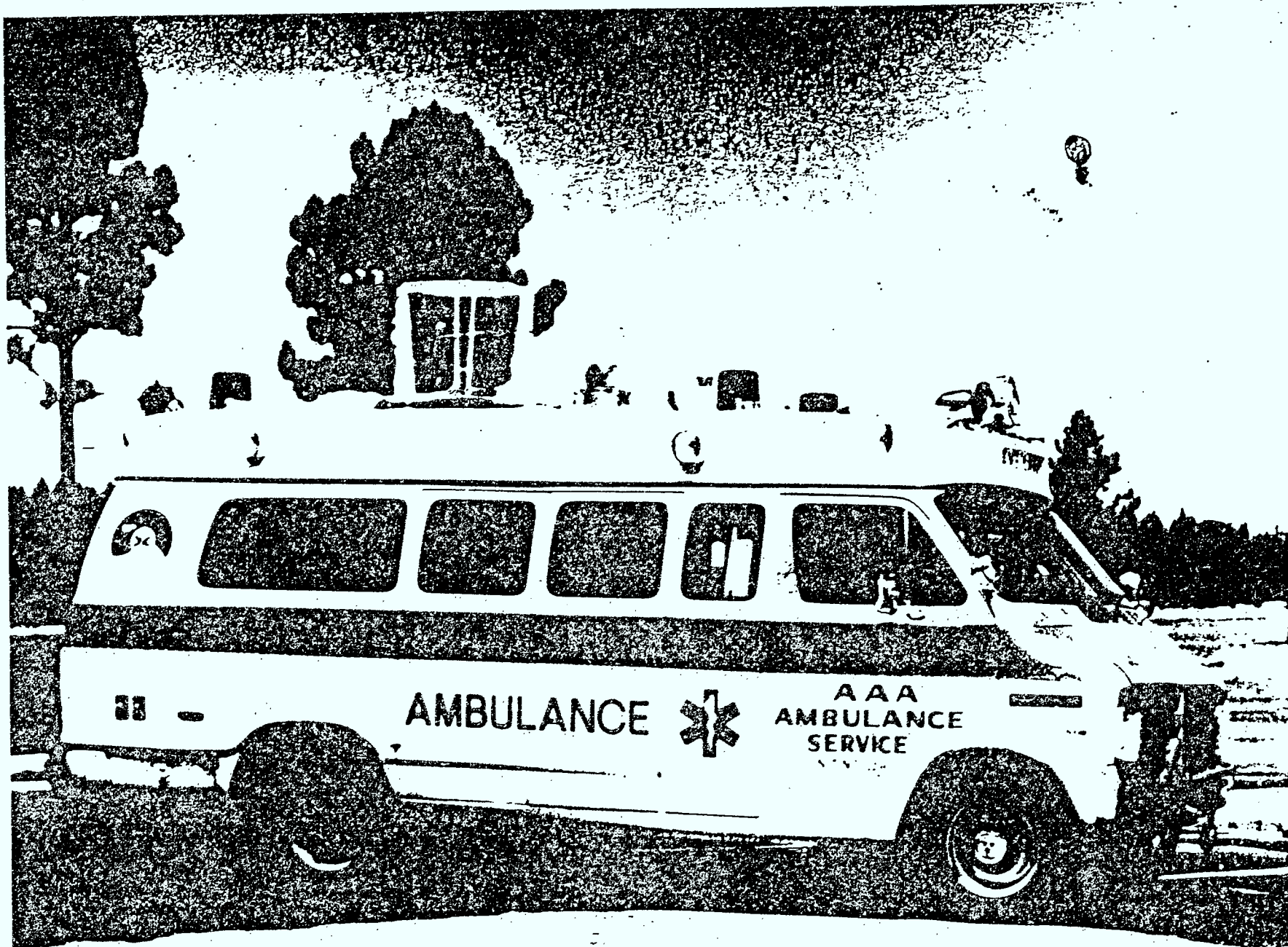


FIGURE 7.

enhanced, much as was possible through the government ANIK-B communications program. Government policy regarding national sovereignty will be observed through control of resource development and national defence.

#### 9.4 Industry Benefit

Both SPAR and other Canadian aerospace subcontractors will benefit from developing public mobile and military payloads, solar arrays and power subsystems, and various other microprocessor-controlled spacecraft bus subsystems. The ground segment requires the development of a family of new civil and military mobile terminals employing new digital, demand assignment, and encryption techniques. These will constitute a substantial domestic market with excellent export potential. Overall stimulation of the high technology industry with consequent job creation in support and service industries will be significant. The present loss of Canadian aerospace talent to the large and strong US market will stop, and Canadian universities will respond to improved domestic demand for aerospace and communications skills.



## 10. INTERNATIONAL COOPERATION

### 10.1 DOC/NASA Cooperation

Collaboration has taken place with NASA since April 1980 in cooperative studies to define a joint program activity to best meet respective national needs.

NASA is considering various degrees of contribution to launch arrangements in exchange for varying amounts of service capacity in the Northern US and some flight hardware verification opportunities (like HERMES).

### 10.2 DOC/ESA Cooperation

ESA is interested in mobile-satellite development and has invested large amounts in the MARECS satellites to be used by INMARSAT. Geographic separation makes it difficult to effectively share a satellite for service development. However, it is possible that ESA could provide some hardware for flight testing on MSAT following arrangement similar to ESA participation in the HERMES program.

DOC is exploring with ESA the feasibility of sharing of partially integrated flight spares between the L-SAT Program and the MSAT Program assuming the L-SAT bus is selected. This could potentially reduce the MSAT Program cost by \$40M.

### 10.3 DND/DOD Cooperation

Extensive cooperation has taken place over the past several years between DND and the US Department of Defense in the area of satellite communications. This has mainly involved cooperation in R&D activities and experiments with US experimental and operational satellites. The DOD has agreed to clear specific frequencies in the 240-400 MHz band needed for the DND payload.

DND could likely provide NORAD coverage to U.S. with the Canadian satellite and obtain in return access to DOD satellites providing services to other areas of the world not covered by the Canadian satellite.

DND may have the option to cooperate exclusively with DOD in acquiring a satellite communications capability. This might be achieved by leasing capacity on a US satellite or by other arrangements.

11. TIMING CONSIDERATIONS

The principal timing considerations affecting a choice between program options for either a 1986 or a 1990 satellite launch are presented in the following Table. The consequence of delay is considered for each of the major factors presented.

A strong recommendation is therefore made to proceed in 1982 with engineering definition (Phase B) of this program for a launch in 1986.

## TIMING CONSIDERATIONS

FACTOR	TIME FRAME	CONSEQUENCE OF DELAY	
User Need	1986-1990 service development start	MODERATE	Gradual loss of revenue due to less efficient operations. Experience in developing fixed services shows about 12 years between government program start and full commercial service. Delay of full commercial service beyond 1994 is serious.
- public and civil gov. mobile, large demonstrated need			
- premium service to resource industry, urgent demonstrated need	1986 experimental service start	SEVERE	Considerable loss of revenue due to inefficient operations, slow-down on exploration and resource development
- military mobile UHF	1986-1988 service start	MODERATE	Allied countries plan to introduce operational EHF service about 1990 and phase out most UHF service about 1995. Delay will mean incompatibility with allies and reduced tactical and strategic capability.
EHF	1990		
Spectrum/Orbit Availability	1986 start of experimental service	CRITICAL	In US only 14 MHz has been reserved for satellite and other use for five years. Great competition is evident for 806-890 MHz spectrum. Delay to 1990 will make adequate spectrum unavailable as it is assigned on first come first served basis. Only one orbit spot is effectively available for the use of this spectrum in North America due to low-gain ground antennas.
- public mobile 806-890 UHF			
Readiness to Proceed	1986 launch	CRITICAL	SPAR will be ready for a Phase B start in early 1982. Delay will cause present staff to be dispersed, and the lack of an early major program start is judged to have severe consequences on SPAR. Phase A studies in SPAR to be completed in September 1981. Some related R&D studies at SPAR will continue to end FY 81/82. Sub-system skills will deteriorate.
- industry			
- government	1986 launch	MODERATE	Telesat seeks MSAT as an opportunity to possible growth, diversity and stability; delay to 1990 launch will interfere with ANIK E, F system procurements.
		CRITICAL	DOC cannot fund mobile program studies beyond January 1982 without a positive program decision. A project team developed over ten years will be disbanded.
		SEVERE	DND will lose a unique opportunity for a soft entry in a funding program to develop military mobile satellite services.
International Cooperation	1986-1990 launch	MODERATE	NASA can contribute more resources to a program having a later (i.e. 1990) launch, although because of severe consequences in such a late service development start, NASA wishes to examine earlier participation in a smaller program.
- NASA			
- ESA		SEVERE	An opportunity to negotiate reduced cost of an LSAT bus will be lost if launch slips beyond 1986.

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APPENDICES TO  
REPORT TO MOSST  
ON MOBILE SATELLITE PROGRAM

DEPARTMENT OF COMMUNICATIONS

JUNE 1981

## APPENDICES

- A. DOC Work Plan for MSAT Phase A Studies.
- B. Results of CPACC Survey of MSAT User Requirements.
- C. Status of Phase A Contracts.
- D. Commercial Viability Analysis of Follow-On  
Operational Satellite.



REVISED  
1 June 1981

ANNEX A

DOC WORK PLAN FOR MSAT PHASE A STUDIES

## MSAT WORK PLAN - PHASE A

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MSAT Work Plan - Phase A

1. BACKGROUND

1.1 Program Approval for Phase A

On 27 August 1980, Cabinet gave approval to DOC for studies directed towards the development of a mobile-satellite program, and approved the expenditure of \$0.5M in FY 80/81 and \$1.7M in FY 81/82, and 3 term person-years in FY 81/82 to supplement available manpower in DOC base resources. These studies would cover Phase A (Concept definition and feasibility) including the development of a program plan and cost estimates necessary to enable a full program submission to be made.

The expenditure of the above funds and person-years for MSAT concept definition studies was approved by Treasury Board on 23 October 1980. The \$2.2M approved for this work will cover concept definition and feasibility in sufficient detail to enable a Cabinet submission for a full program in early 1982. It will also cover preparation of an MOU to be negotiated between DOC and NASA.

In a letter dated 14 October, 1980, DND announced their support for the decision to proceed with MSAT definition studies.

1.2 Objectives of Phase A

The Canadian objectives of Phase A are to study the needs, system concepts, economics, and policy issues of mobile communications satellite systems and to formulate a long-range plan including a demonstration satellite program if appropriate for the development of mobile-satellite communications in Canada. Preliminary technology-development studies will also be initiated during Phase A on critical sub-systems to provide the management and technical information necessary to determine technical and system concepts with acceptable technical risk and acceptable impact on schedule and cost. These studies will be conducted to provide the management and technical information for a government decision on whether or not to proceed with the implementation of a Mobile-Satellite Program called MSAT.

The studies will be conducted in sufficient depth to permit a decision to be made on the basis of the following factors:

- adequate market in Canada,
- cost effectiveness of mobile-satellite technology,
- program benefits in excess of program costs,
- technical feasibility of MSAT concept without undue risk,
- user/Industry support,
- DOC/NASA consensus on MSAT demo concept and MOU items,
- evidence that MSAT is an appropriate technological step to operational systems,
- availability of spectrum,
- favourable policy environment, and
- favourable comparison of MSAT relative to other Canadian mobile satellite/terrestrial program alternatives.

1.3 MSAT Resources

DOC is committed to TB to prepare a submission for the full program within the \$2.2M allocated. This submission will be prepared in FY 1981/82 as indicated in the 5 year space program plan. An interim submission for supporting Research and Technology Development will be prepared in mid 1981 for Cabinet consideration only if it can be proven essential prior to the full program submission.

To conduct the Phase A studies DOC has allocated the following PY from the base resources including 3 term PY approved by TB for FY 81/82.

	<u>FY 80/81</u>	<u>FY 81/82</u>	<u>TOTAL</u>
DOC HQ	2.1	5.0	7.1
CRC	6.0	10.0	16.0
	<hr/>	<hr/>	<hr/>
TOTAL	8.1	15.0	23.1

#### 1.4 Other Supporting Resources

In addition to the resources described in Section 1.5, DOC will apply other resources to support MSAT and foster the development of mobile-satellite technology/services in Canada. In view of the high priority assigned to MSAT by DOC and the ICS, research and technology development activities will be initiated at CRC and in industry on critical areas of technology and sub-systems. These activities will be supported with some A-Budget Base Resources and with resources from the ICF Program, the Augmented R&D Program and the Key Technology Study Program as appropriate.

Other branches of DOC will support the Space Sector to the extent of approximately 1.25 PY, in total. Support will be provided from ADMR for propagation studies in the 806-890 MHz band and consulting services on needs, integrated terrestrial/satellite system studies, and cost-benefit studies.

ADMST will provide support in the examination of radio regulatory issues, negotiation of frequency assignments with the FCC, and study of feasibility of interconnection between MSAT and the GTA network.

From SADM, support will be provided for studies of economic and communications policy issues as well as consideration of international, social, federal/provincial and legal issues associated with the development of mobile-satellite systems in Canada.

Regional offices will provide support in performing liaison with provinces and users in various parts of the country.

#### 1.5 DND Participation during Phase A

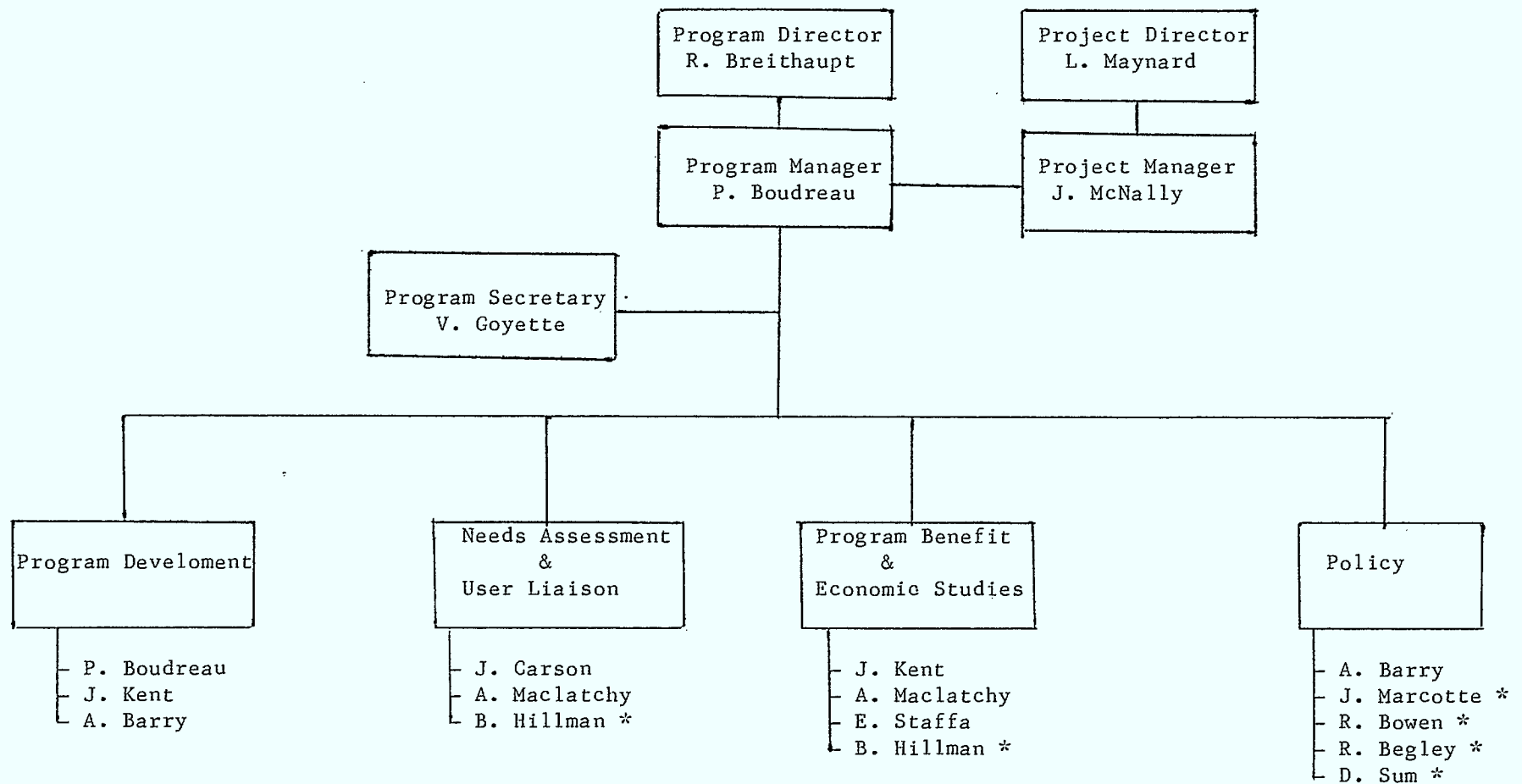
DND will cooperate with DOC in the study of system options to satisfy needs. This study will be jointly funded from MSAT and DND recoverable resources. An MSAT DOC/DND coordinating committee has been set up, with program/project management staff of DOC and DND represented.

#### 1.6 Scope of NASA Phase A Studies

NASA is conducting studies parallel to and coordinated with those of DOC, and results will be exchanged. Discussions are underway to define a co-operative program.

#### 1.7 Project Organization and Schedule

The DOC program organization for MSAT Phase A Program Management is illustrated in fig. 1, and the Project Office organisation in fig. 2. A program schedule leading to a 1986 launch is shown in fig. 3.



\* Advisor

FIGURE 1. MSAT PROGRAM OFFICE ORGANIZATION



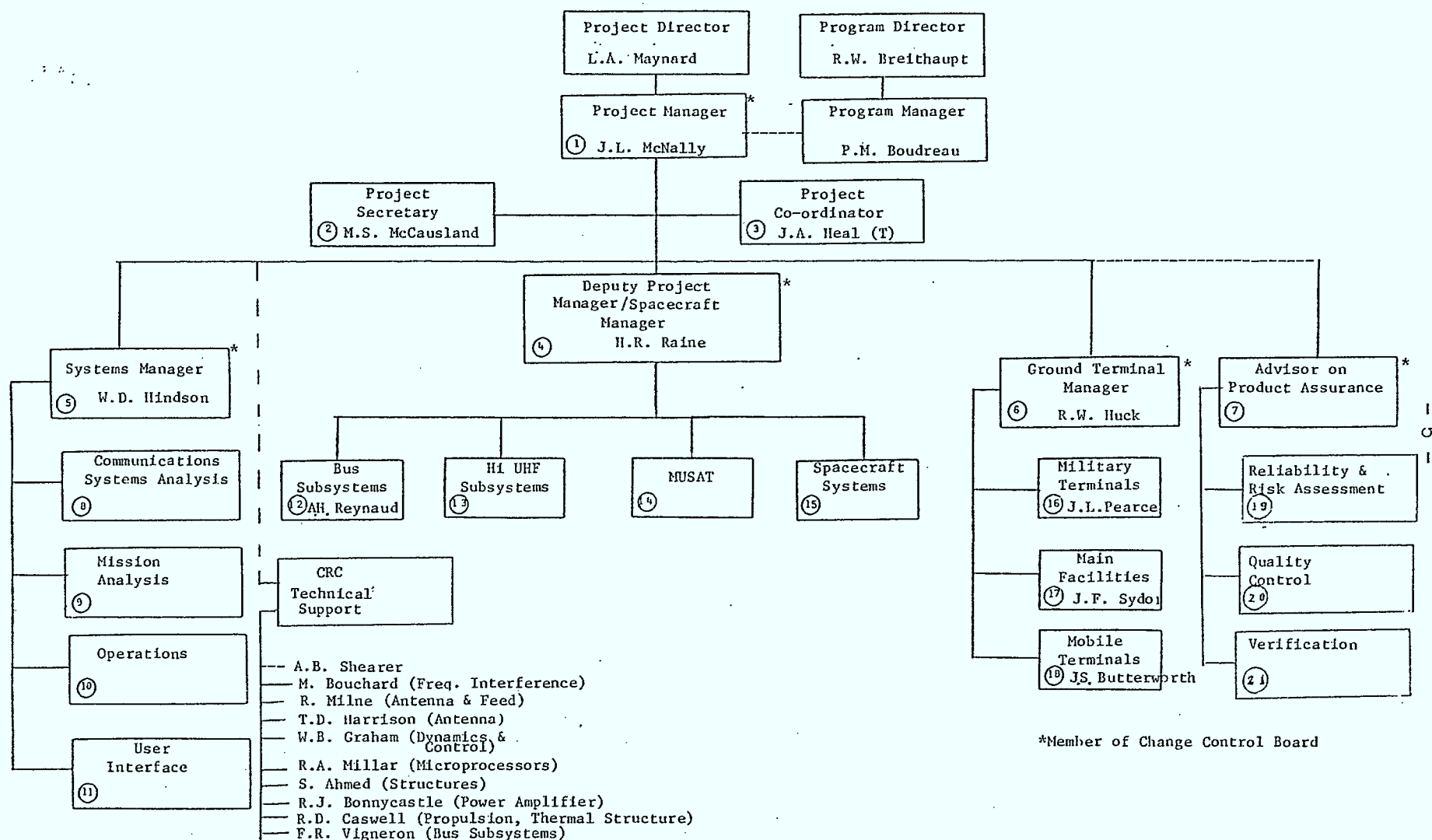
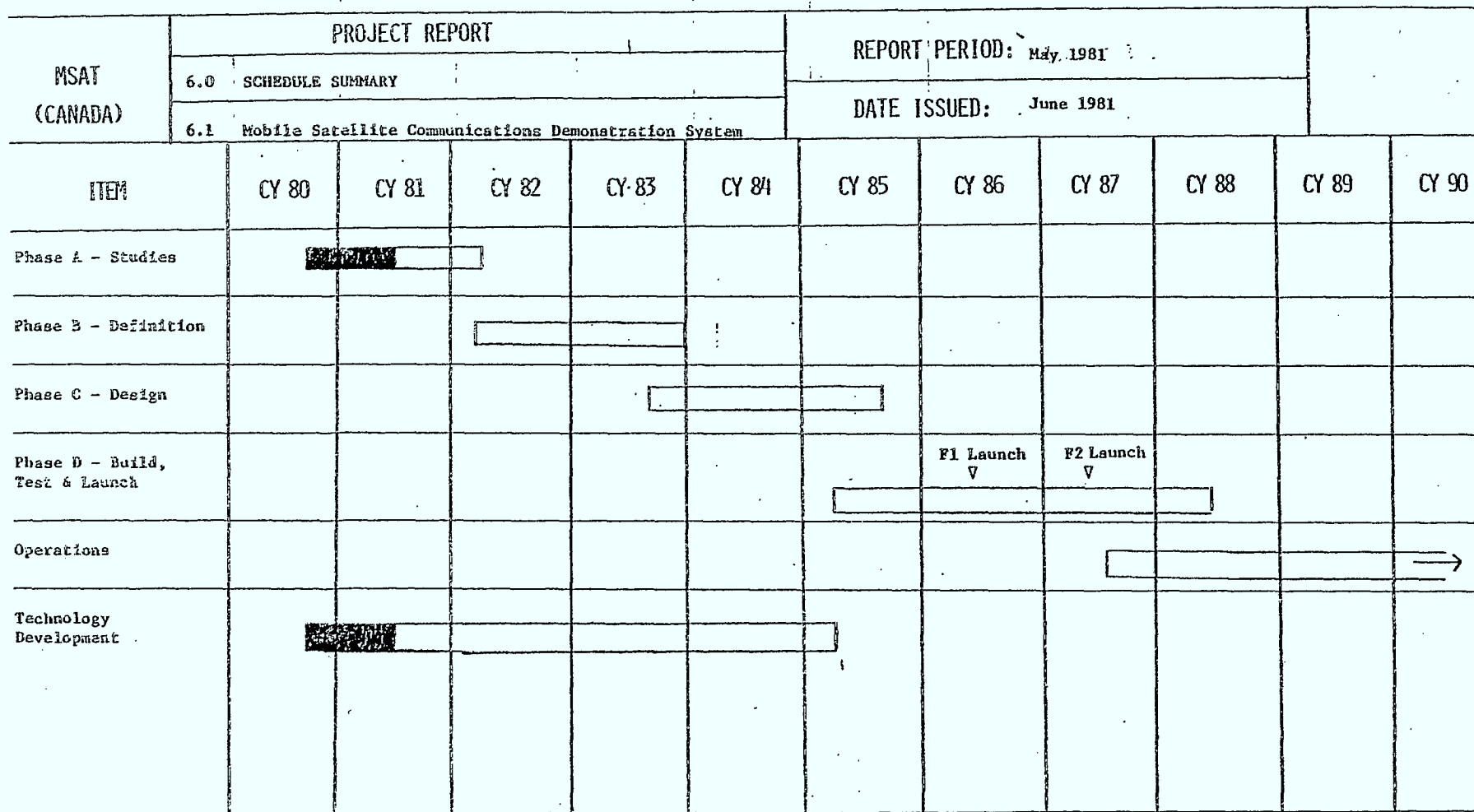


FIGURE 2. MSAT PROJECT OFFICE ORGANIZATION



▽=Estimated, ▼=Actual

FIGURE 3. MSAT PROGRAM SCHEDULE LEADING TO 1986 LAUNCH

2. DOC CONTRACTING PLAN

In August 1980, Cabinet approved the expenditure of \$0.5M in FY 80/81 and \$1.7M in FY 81/82 to cover MSAT Phase A studies. These studies are being carried out largely by industrial contracts, monitored by Scientific Authorities at DOC HQ and CRC. These are summarized in this section, grouped according to functional area. The inter-relation of the various contracts is illustrated in Figure 4, and a summary of contracts and the spending profile is tabulated in Attachment I.

2.1 Program Area

	<u>CONTRACTOR</u>	<u>SCIENTIFIC AUTHORITY</u>
007 User Cost-Benefit Study	TBD	Maclatchy
008 Integrated System Study	Intel	Kent
009 Market Study	Woods Gordon	Carson
012 Program/Project Management Plan	Eastland	McNally/Boudreau
025 Communications Policy	TBD	Barry
026 Program Benefit Study	TBD	Kent

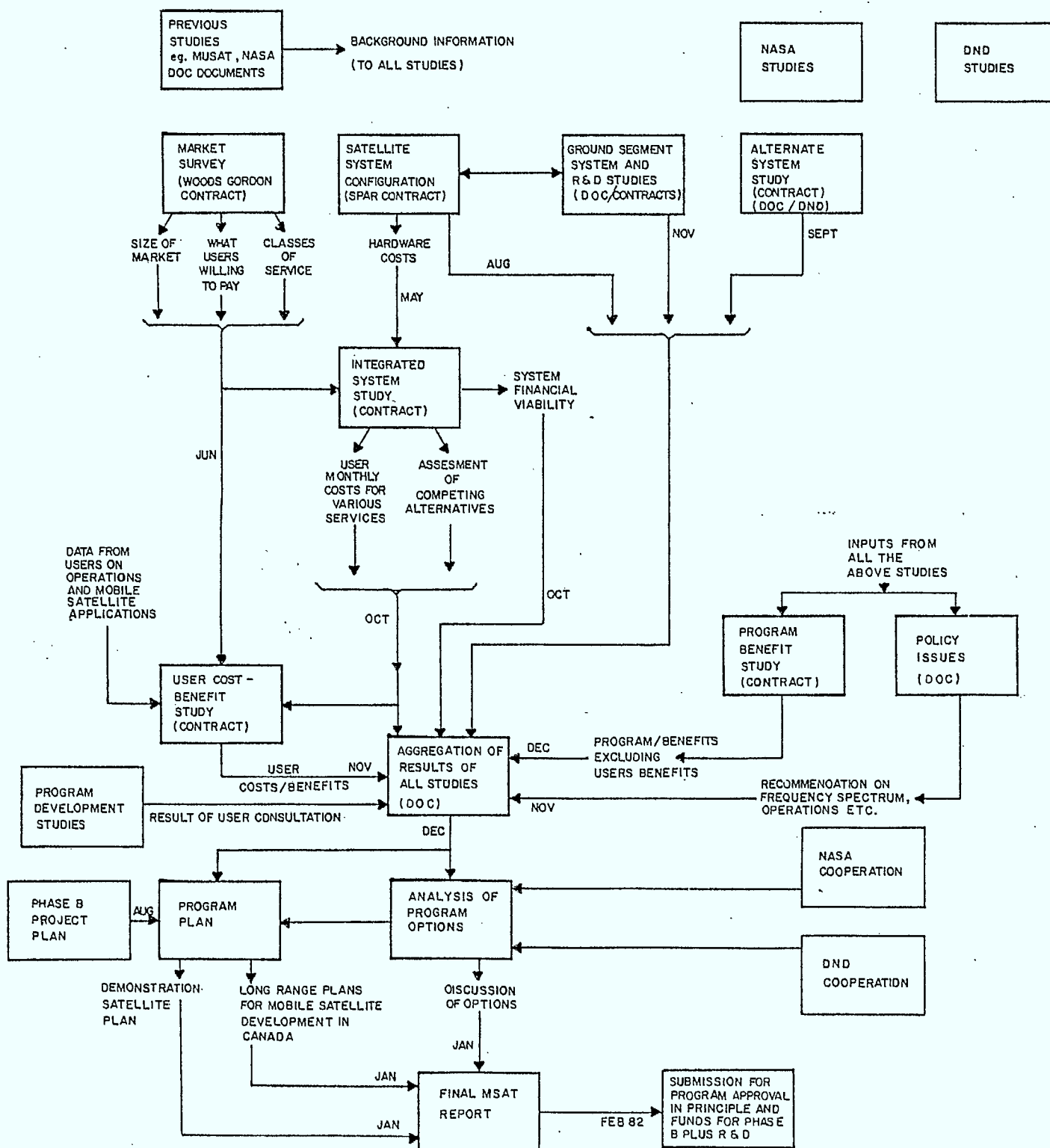


FIGURE 4. FLOW CHART OF MSAT PHASE A STUDIES

USER COST BENEFIT STUDY (007)

OBJECTIVE: To determine the user cost-benefit of a mobile satellite system to specific user populations

LIST OF TASKS:

1. Planning
2. Description of Applications
3. Quantification of costs and benefits
4. Aggregation of results
5. Final Report

MILESTONES:

CRB approval	-	26 March 1981
RFP issued by DSS	-	15 April 1981
Proposals due	-	15 May 1981
Contract award	-	15 June 1981
Interim Report(s)	-	16 September 1981
Final Report	-	1 December 1981

FUNDING:

Source	-	MSAT (4-182-37310)
Total Value	-	Approx. 100K
Spending profile	-	FY 81/82 - 100K

SCIENTIFIC AUTHORITY: A. Maclatchy

ADVISOR(S): Consultants from DGTE, DGSTA and ADMR

CONTRACTOR: TBD

INTEGRATED SYSTEM STUDY (008)

OBJECTIVE: To assess the commercial viability of a Canadian operational mobile satellite system in an integrated satellite/terrestrial system in the 806-890 MHz band and providing Canada-wide coverage.

LIST OF TASKS:

1. Construct traffic model from Woods Gordon market information (Contract 009)
2. Define functional and service performance requirements to satisfy above traffic model
3. Analyse technical and cost information on existing and planned terrestrial systems
4. Develop economic model of mobile satellite system
5. Develop optimized integrated satellite/terrestrial system concept satisfying (1) and (2)
6. Develop optimized alternative terrestrial system
7. Compare the alternatives
8. Estimate spectrum required for (5) and (6)

MILESTONES:

CRB approval	-	29 January 1981
RFP issued by DSS	-	9 March 1981
Proposals due	-	16 April 1981
Contract award	-	16 May 1981
Interim Report(s)	-	17 July and 11 September 1981
Final Report	-	30 October 1981

FUNDING:

Source	-	MSAT (4-182-37310)
Total Value	-	160K
Spending profile	-	FY 81/82 - 160K

SCIENTIFIC AUTHORITY: J.D.B. Kent

ADVISOR(S): M. Estabrooks, R. Fajaros, W. Hindson

CONTRACTOR: Intel Consultants



MARKET STUDY (009)

OBJECTIVE: To determine the Canadian user requirements for a mobile satellite system operating in the 806-890 MHz band.

LIST OF TASKS:

1. Identify services that could potentially be offered by MSAT
2. Determine the projected number of users of an MSAT system in the 1985-2000 time frame
3. Determine the demand for the service by each potential user as a function of cost of the service

<u>MILESTONES:</u>	CRB approval	-	2 September 1980
	RFP issued by DSS	-	3 October 1980
	Proposals due	-	12 November 1981
	Contract award	-	2 January 1981
	Interim Report(s)	-	16 March 1981
	Final Report	-	10 July 1981

<u>FUNDING:</u>	Source	-	DPP (4-197-37230) \$100K
		-	MSAT (4-182-37310) \$95K
	Total Value	-	195K
	Spending profile	-	FY 80/81 - 130K
		-	FY 81/82 - 65K

SCIENTIFIC AUTHORITY: J.A. Carson

ADVISOR(S): B. Hillman, J. Kent

CONTRACTOR: Woods Gordon Management Consultants

MSAT PROGRAM/PROJECT MANAGEMENT (012)

OBJECTIVE: To study DOC program and project management functions, requirements, strategies and arrangements necessary for the effective management of the MSAT program during Phase B/C/D and the post-launch operations.

LIST OF TASKS:

1. Prepare draft project plan for discussion with NASA
2. Prepare draft joint NASA/DOC program/project office documentation
3. Prepare DOC MSAT organization structure plan
4. Describe management interfaces with DND, Users, Telesat, other government departments, etc.
5. Propose procurement management plan
6. Prepare DOC manpower estimate

MILESTONES:

CRB approval	-	29 January 1981
RFP issued by DSS	-	N/A
Proposals due	-	13 February (proposal received)
Contract award	-	16 February 1981
Interim Report	-	Bi-weekly informal progress reviews
Final Report	-	31 August 1981

FUNDING:

Source	-	MSAT (4-182-37310)
Total Value	-	24K
Spending profile	-	FY 80/81 - 9.6K
		FY 81/82 - 14.4K

SCIENTIFIC AUTHORITY: H. Raine

ADVISOR(S): P. Boudreau, as Inspection Authority

CONTRACTOR: T.A. Eastland

MOBILE SATELLITE COMMUNICATIONS POLICY STUDY (025)

OBJECTIVE: To conduct a study on communication policy issues that would be raised by MSAT and follow-on commercial systems.

LIST OF TASKS:

TBD in consultation with DGTN  
(DGTN staff is preparing a discussion paper as a first step.)

<u>MILESTONES:</u>	CRB approval	-	30 June 1981
	RFP issued by DSS	-	15 July 1981
	Proposals due	-	7 August 1981
	Contract award	-	20 August 1981
	Interim Report(s)	-	1 October 1981
	Final Report	-	15 November 1981

<u>FUNDING:</u>	Source	-	MSAT funds (4-182-37310)
	Total Value	-	\$50K
	Spending profile	-	FY 81/82 - 50K

SCIENTIFIC AUTHORITY: A.L. Barry

ADVISOR(S): J. Marcotte

CONTRACTOR: TBD

PROGRAM BENEFIT STUDY (026)

OBJECTIVE: To assess the economic, service, and social benefits to Canada of MSAT and a follow-on commercial mobile satellite system.

LIST OF TASKS:

TBD

<u>MILESTONES:</u>	CRB approval	-	30 June 1981
	RFP issued by DSS	-	15 July 1981
	Proposals due	-	10 August 1981
	Contract award	-	1 September 1981
	Interim Report	-	20 October 1981
	Final Report	-	1 December 1981

<u>FUNDING:</u>	Source	-	MSAT funds (4-182-37310)
	Total Value	-	50K
	Spending profile	-	FY 81/82 - 50K

SCIENTIFIC AUTHORITY: J.D. Kent

ADVISOR(S): to be appointed by DGTE

CONTRACTOR: TBD

2.2      Space Sector

		<u>CONTRACTOR</u>	<u>SCIENTIFIC AUTHORITY</u>
001	Spacecraft Configuration Concept	SPAR	Raine
002A	Multi-band Use of Large Reflector	SPAR	Raine
002B	Multi-band Use of Large Reflector	U. of Man.	Raine
003	Configuration Software	Kendall	Reynaud
013	Integration and Test Plan	SPAR	Raine
020	COMSAT MOD Update	CAL	Raine
021	Program Cost Analysis (Space Sector)	SPAR	Raine
033	MUSAT Payload Definition	TBD	DND

SPACECRAFT CONFIGURATION CONCEPT STUDY (001)

OBJECTIVE: To examine the technical feasibility and cost of a commercial satellite and an interim operational/demonstration satellite of the MSAT class.

LIST OF TASKS:

1. Develop a conceptual design for the Operational Spacecraft;
2. Conduct a parametric analysis of key technical performance parameters;
3. Perform a configuration comparison for the operational baseline spacecraft of Task 1;
4. Identify critical technology areas;
5. Select, develop and recommend a preferred concept for the operational spacecraft;
6. Develop a conceptual design, technical description and cost for a demonstration baseline spacecraft;
7. Conduct a sensitivity analysis for variation of key technical performance parameters and functional requirements;
8. Select and develop the preferred concept design for the demonstration satellite based on information from the previous tasks;
9. Identify and examine key performance parameters that should be monitored during the demonstration mission;
10. Produce a detailed work plan for the project definition phase of the entire space segment which is estimated to take place in CY 1982.

<u>MILESTONES:</u>	CRB approval	-	4 November 1980
	RFP issued by DSS	-	5 November 1980
	Contract award	-	28 January 1981
	Initial Presentation	-	March/April 1981
	Interim Presentation	-	May 1981
	Draft Final Report	-	10 August 1981
	Final Presentation	-	20 August 1981
	Final Report	-	30 September 1981

<u>FUNDING:</u>	Source	-	MSAT Funds (4-261-65605)
	Total Value	-	\$700K
	Spending profile	-	FY 80/81 - \$121K
		-	FY 81/82 - \$579K

SCIENTIFIC AUTHORITY: H.R. Raine

CONTRACTOR: SPAR SSD



MULTIBAND USE OF MSAT LARGE REFLECTOR (002A)

OBJECTIVE: To investigate methods for using the MSAT 800 MHz large reflector to provide a higher gain antenna for MUSAT (250-406 MHz) than can be achieved using the currently proposed MUSAT quad helix antenna.

LIST OF TASKS:

TBD

MILESTONES:

CRB approval Contract A	-	4 November 1980
Contract Award Contract A	-	31 July 1981
Interim Report	-	31 October 1981
Final Report	-	31 December 1981

FUNDING:

Source	-	Accelerated Development Fund
Total Value	-	\$65K
Spending profile	-	FY 81/82 - \$65K

SCIENTIFIC AUTHORITY: H.R. Raine

TECHNICAL ADVISOR: R. Milne

CONTRACTOR: SPAR A&CSD

MULTIBAND USE OF MSAT LARGE REFLECTOR (002B)

OBJECTIVE: To investigate the feasibility of using the large MSAT reflector for both the 200 to 400 MHz and the 800 to 900 MHz bands.

LIST OF TASKS:

1. Carry out conceptual antenna configuration designs and studies for a large deployable MSAT antenna;
2. Investigate and consider theoretically and/or experimentally the complex feed design for this UHF satellite antenna;
3. Recommend preferred or optimized design approaches for the antenna and feed.

<u>MILESTONES:</u>	CRB Approval	-	20 February 1981
	Contract Award	-	2 March 1981
	Interim Report	-	17 April 1981
	Final Report	-	31 May 1981

<u>FUNDING:</u>	Source	-	MSAT Funds (4-261-65605)
	Total Value	-	\$24.5K
	Spending profile	-	FY 80/81 - \$10K
		-	FY 81/82 - \$14.5K

SCIENTIFIC AUTHORITY: H.R. Raine

TECHNICAL ADVISOR: R. Milne

CONTRACTOR: Office of Industrial Research, University of Manitoba  
(Prof. Shafai)

SOFTWARE FOR STRUCTURAL CONFIGURATION DEVELOPMENT (003)

OBJECTIVE: To develop MSAT Configuration Software by upgrading relevant software developed for HERMES program.

LIST OF TASKS:

1. Update the Hermes Configurational Software to make it applicable to MSAT;
2. Review MSAT program requirements for configuration software and displays;
3. Develop functional formulas and generate, debug, test and document software for the demonstration MSAT.

<u>MILESTONES:</u>	CRB Approval	-	29 January 1981
	Contract Award	-	1 April 1981
	Task 1 Report	-	15 May 1981
	Task 2 Report	-	15 June 1981
	Final Report	-	31 July 1981

<u>FUNDING:</u>	Source	-	MSAT Funds (4-261-65605)
	Total Value	-	\$20K
	Spending profile	-	FY 81/82 - \$20K

SCIENTIFIC AUTHORITY: A.H. Reynaud

CONTRACTOR: J.D. Kendall Consultants Limited, Mississauga, Ontario

COMSAT MOD UPDATE (020)

OBJECTIVE: To revise, upgrade and expand a computer program for modelling the mass and cost of communications satellites and produce documents, including users manual and detailed software description.

LIST OF TASKS:

1. Update the mass and cost algorithms of the existing COMSAT MOD software to reflect current technology and costs;
2. Improve certain subsystem models to cover a wider range of spacecraft types and improve the accuracy;
3. Enlarge the selection of technology options and include provision for "black box" additions to the payload;
4. Retain an existing version of the program with its data base for use with existing model studies;
5. Rearrange input and output formats to improve ease of use;
6. Update the Users Manual and Software Description to reflect the modifications made, to correct previous mistakes, to enlarge on the description of the capability and to provide additional user information to more easily utilize the program.

<u>MILESTONES:</u>	CRB Approval	-	9 December 1980
	Contract Award	-	6 January 1981
	Interim Report	-	
	Final Report	-	30 April 1981

<u>FUNDING:</u>	Source	-	MSAT Funds (4-261-65605)
	Total Value	-	\$150K
	Spending Profile	-	FY 80/81 - \$20K
		-	FY 81/82 - \$5K

SCIENTIFIC AUTHORITY:

ADVISOR(S):

CONTRACTOR: Canadian Astronautics Ltd.

PROGRAM COST ANALYSIS - SPACE SECTOR (021)

OBJECTIVE: To perform a cost analysis of the space segment.

LIST OF TASKS:

TBD

<u>MILESTONES:</u>	CRB Approval	-	October 1981
	Contract Award	-	November 1981
	Interim Report	-	February 1982
	Final Report	-	31 March 1982

<u>FUNDING:</u>	Source	-	MSAT Funds (4-261-65605)
	Total Value	-	\$270K
	Spending Profile	-	FY 81/82 - \$270K

SCIENTIFIC AUTHORITY: H.R. Raine

TECHNICAL ADVISOR:

CONTRACTOR: SPAR SSD

DND (MUSAT) PAYLOAD DEFINITION (033)

OBJECTIVE: To define the DND payload requirements for MSAT.

LIST OF TASKS:

TBD

<u>MILESTONES:</u>	CRB Approval	-	October 1981
	Control Award	-	November 1981
	Interim Report	-	February 1982
	Final Report	-	31 March 1982

<u>FUNDING:</u>	Source	-	DND
	Total Value	-	TBD
	Spending Profile	-	TBD

SCIENTIFIC AUTHORITY: DND

TECHNICAL ADVISOR: J.L. Pearce

CONTRACTOR: TBD





2.3 Earth Segment

	<u>CONTRACTOR</u>	<u>SCIENTIFIC AUTHORITY</u>
011A Transportable Antenna (225-400 MHz)	Andrew	Butterworth
011B Transportable Antenna (800 MHz)	Andrew	Butterworth
011C Mobile Antenna (Land Vehicles - 800 MHz)	(In-house)	Butterworth
011D Mobile Antenna (Ship - 800 MHz)	TBD	Butterworth
016A Gateway Stations	SED	Sydor
016B Central Control Station	TBD	Sydor
017 Mobile and Portable Terminals	TBD	Sydor
022 Program Cost Analysis (Earth Segment)	TBD	Huck
034 MUSAT Stations	TBD	DND

TRANSPORTABLE ANTENNA (225-400 MHz) (011A)

OBJECTIVE: To develop and test suitable antennas for operation with DND MUSAT transportable terminals in the 225 to 400 MHz band.

LIST OF TASKS:

1. Design a suitable antenna for MUSAT transportable terminals;
2. Construct and test three prototype antennas for delivery to CRC.

MILESTONES: Contract Award - 13 February 1980  
Contract Complete - 31 March 1981

FUNDING: Source - DND Recoverable  
Total Value - \$30.0K  
Spending Profile - FY 79/80 - \$1.6K  
FY 80/81 - \$28.4K

SCIENTIFIC AUTHORITY: J.S. Butterworth

TECHNICAL ADVISOR:

CONTRACTOR: Andrew Antenna of Canada Ltd.

MOBILE ANTENNA STUDY (TRANSPORTABLE TERMINALS - 800 MHz) (011B)

OBJECTIVE: To perform a study to develop suitable antennas for the MSAT transportable terminals and provide a cost estimate for production quantities.

LIST OF TASKS:

1. Perform a study to determine the most suitable antenna types for a "suitcase type" antenna and for a "rugged" antenna;
2. Construct prototype antennas to demonstrate feasibility;
3. Perform electrical measurements on the prototype antennas;
4. Provide a production cost estimate for the two types of antennas finally selected.

<u>MILESTONES:</u>	CRB Approval	-	29 January 1981
	RFP Issued by DSS	-	18 February 1981
	Proposals Due	-	18 March 1981
	Contract Award	-	15 April 1981
	Interim Reports	-	Three progress review mtgs.
	Final Report	-	30 September 1981

<u>FUNDING:</u>	Source	-	MSAT Funds (4-261-65605)
	Total Value	-	\$25K
	Spending Profile	-	FY 81/82 - \$25K

SCIENTIFIC AUTHORITY: J.S. Butterworth

TECHNICAL ADVISOR:

CONTRACTOR: Andrew Antenna of Canada Ltd.

MOBILE ANTENNA DEVELOPMENT    LAND VEHICULAR 800 MHz    (011C)

OBJECTIVE:    To conduct in-house research and development of antennas  
for land vehicular use in the 800 MHz band.

(See DOC In-House Work Plan for further details)

MOBILE ANTENNA STUDY (SHIP TERMINALS - 800 MHz) (011D)

OBJECTIVE: To study and evaluate suitable antennas for MSAT ship terminals to determine feasibility, specifications and cost.

LIST OF TASKS:

1. Utilize propagation model to determine antenna gain.
2. Determine the most suitable antenna element(s).
3. Recommend the mounting and stabilizing method.
4. Recommend the pointing and tracking method.

<u>MILESTONES:</u>	CRB Approval	-	9 June 1981
	RFP Issued by DSS	-	15 June 1981
	Proposals Due	-	15 July 1981
	Contract Award	-	31 July 1981
	Interim Reports	-	N/A
	Final Report	-	31 January 1982

<u>FUNDING:</u>	Source	-	MSAT Funds (4-261-65605)
	Total Value	-	\$25K
	Spending Profile	-	FY 81/82

SCIENTIFIC AUTHORITY: J.S. Butterworth

TECHNICAL ADVISOR:

CONTRACTOR: TBD by Competitive Tender

GATEWAY STATIONS (016A)

OBJECTIVE: To obtain technical and cost information for the MSAT Gateway Stations.

LIST OF TASKS:

1. Examine the gateway station hardware and software requirements;
2. Document general gateway specifications;
3. Provide non-recurring and recurring cost estimates;
4. Identify major development areas and potential regulatory problems.

<u>MILESTONES:</u>	CRB Approval	-	26 March 1981
	DSS Issue RFP	-	1 April 1981
	Contract Award	-	1 May 1981
	Interim Report	-	TBD
	Final Report	-	31 August 1981

<u>FUNDING:</u>	Source	-	MSAT Funds (4-261-65605)
	Total Value	-	\$30K
	Spending Profile	-	FY 81/82 - \$30K

SCIENTIFIC AUTHORITY: J. Sydor

TECHNICAL ADVISOR: W.D. Hindson

CONTRACTOR: SED



CENTRAL CONTROL STATION (016B)

OBJECTIVE: To extend previous studies in development specifications and costs for the Central Control Station, which provides communication control and land-line interface for the military transponders on MSAT and which supplies TT&C for the satellite.

LIST OF TASKS:

1. Examine the requirements for RF, IF, and channel units; DAMA hardware and software, terrestrial interface, signalling and billing, system monitor, redundancy, availability and maintenance; TT&C and simulation hardware, software and encryption; housing, electrical power (including backup), environmental and operating personnel.
2. Provide details for general CCS specifications, cost estimates, and major development areas and regulatory problems.

<u>MILESTONES:</u>	CRB Approval	-	April 1981
	DSS Issue RFP	-	May 1981
	Contract Award	-	June 1981
	Interim Report	-	August 1981
	Final Report	-	October 1981

<u>FUNDING:</u>	Source	-	MSAT Funds (4-261-65605)
	Total Value	-	\$50K
	Spending Profile	-	FY 81/82 - \$50K

SCIENTIFIC AUTHORITY: J. Sydor

TECHNICAL ADVISOR:

CONTRACTOR: TBD by Competitive Tender

MOBILE AND PORTABLE TERMINALS - 800 MHz (017)

OBJECTIVE: To study the requirements of the mobile and portable terminals for the 800 MHz band, including the impact of compatibility with the AMPS system, the development of preliminary specifications and cost estimates and identification of critical technology development areas.

LIST OF TASKS:

1. Conduct a market survey and determine the cost, availability and technical characteristics of commercially available mobile terminals capable of meeting the MSAT system requirements.
2. Determine the cost, time and level of technical effort required to produce a new mobile terminal capable of meeting the MSAT system requirements.

MILESTONES:

CRB Approval	-	June 1981
CRB Issue RFP	-	July 1981
Contract Award	-	August 1981
Interim Report	-	October 1981
Final Report	-	January 1982

FUNDING:

Source	-	DSS G&S (4-726-65605)
Total Value	-	\$50K
Spending Profile	-	FY 81/82 - \$50K

SCIENTIFIC AUTHORITY: J. Sydor

TECHNICAL ADVISOR: W.D. Hindson

CONTRACTOR: TBD by Competitive Tender

COST ANALYSIS - EARTH SEGMENT (022)

OBJECTIVE: To perform a cost analysis of the Earth segment.

LIST OF TASKS:

TBD

<u>MILESTONES:</u>	CRB Approval	-	October 1981
	CRB Issue RFP	-	
	Contract Award	-	November 1981
	Interim Report	-	February 1982
	Final Report	-	31 March 1982

<u>FUNDING:</u>	Source	-	MSAT Funds (4-261-65605)
	Total Value	-	\$30K
	Spending Profile	-	FY 81/82 - \$30K

SCIENTIFIC AUTHORITY: R.W. Huck

TECHNICAL ADVISOR:

CONTRACTOR: TBD by Competitive Tender

MUSAT STATIONS (034)

OBJECTIVE: To obtain technical and cost information for the MUSAT  
Earth terminals.

LIST OF TASKS:

TBD

MILESTONES:

TBD

<u>FUNDING:</u>	Source	-	DND
	Total Value	-	
	Spending Profile	-	

SCIENTIFIC AUTHORITY: DND

TECHNICAL ADVISOR: J.L. Pearce

CONTRACTOR: TBD

2.4      System Studies

		<u>CONTRACTOR</u>	<u>SCIENTIFIC AUTHORITY</u>
014	Mission Analysis	TBD	Hindson
023	Program Cost Analysis (System Sector)	TBD	Hindson
027	Frequency Interference Study	CAL	Bouchard
031	Computational Requirements	Gas TOPS	Hindson
035	Canadian Options	CAL	Huck

MISSION ANALYSIS (014)

OBJECTIVE: To examine the operations and support required during the period between satellite launch and on-orbit location to identify critical development areas and to cost this phase of the MSAT program.

LIST OF TASKS:

1. Review CTS launch documentation;
2. Review guidelines for allowable launch periods;
3. Identify spacecraft subsystem and communication payload tests from launch to end of life;
4. Establish time phase sequence of operations and determine support required;
5. Determine procedures, facilities and personnel requirements for spacecraft control on orbit;
6. Examine operational system availability;
7. Identify and examine potential failure modes.

<u>MILESTONES:</u>	CRB Approval	-	April 1981
	CRB Issue RFP	-	June 1981
	Contract Award	-	July 1981
	Interim Report	-	
	Final Report	-	31 December 1981

<u>FUNDING:</u>	Source	-	MSAT Funds (4-261-65605)
	Total Value	-	\$50K
	Spending Profile	-	FY 81/82 - \$50K

SCIENTIFIC AUTHORITY: W.D. Hindson

TECHNICAL ADVISOR:

CONTRACTOR: TBD by Competitive Tender

PROGRAM COST ANALYSIS (023)

OBJECTIVE: To perform a program cost analysis of the system sector.

LIST OF TASKS:

TBD

<u>MILESTONES:</u>	CRB Approval	-	October 1981
	Contract Award	-	November 1981
	Interim Report	-	February 1982
	Final Report	-	31 March 1982

<u>FUNDING:</u>	Source	-	MSAT Funds (4-261-65605)
	Total Value	-	\$50K
	Spending Profile	-	FY 81/82 - \$50K

SCIENTIFIC AUTHORITY: W.D. Hindson

TECHNICAL ADVISOR:

CONTRACTOR: TBD



FREQUENCY INTERFERENCE STUDY (027)

OBJECTIVE: To conduct an analysis of interference potential between MSAT and other services in 806-890 MHz band.

LIST OF TASKS:

1. Determine the interference potential between an 800 MHz mobile-satellite and 800 MHz terrestrial systems operating co-channel in two neighbouring countries;
2. Determine the interference potential between two domestic 800 MHz mobile satellite systems operating co-channel in Region 2;
3. Determine the feasibility of serving all Region 2 needs with several satellites operating co-channel and using a maximum of 10 MHz uplinks and 10 MHz downlinks at 800 MHz;
4. Identify and study other types of interference between mobile-satellites and other services in the 800 MHz band.

<u>MILESTONES:</u>	CRB Approval	-	20 March 1981
	Contract Award	-	10 April 1981
	Contract Completion	-	10 June 1981

<u>FUNDING:</u>	Source	-	MSAT Funds (4-261-65605)
	Total Value	-	\$25K
	Spending profile	-	FY 81/82 - \$25K

SCIENTIFIC AUTHORITY: M. Bouchard

ADVISORS: R. Bowen, W. Hindson

CONTRACTOR: CAL

COMPUTATIONAL REQUIREMENTS (031)

OBJECTIVE: To obtain feasibility and cost information on the computational requirements, both hardware and software, for the MSAT project.

LIST OF TASKS:

1. Review the MSAT mission requirements;
2. Examine the functional requirements for the Spacecraft Real Time Computing System (SRICS), Real Time Simulator (RTS) and the Spacecraft Test and Integration Computing System (STICS);
3. Establish hardware and software requirements and costs for the above three systems.

<u>MILESTONES:</u>	CRB Approval	-	29 January 1981
	Contract Award	-	16 February 1981
	Interim Report	-	
	Final Report	-	31 August 1981

<u>FUNDING:</u>	Source	-	MSAT Funds (4-261-65605)
	Total Value	-	\$50K
	Spending Profile	-	FY 81/82 - \$10K
			FY 82/83 - \$40K

SCIENTIFIC AUTHORITY: W.D. Hindson

TECHNICAL ADVISOR:

CONTRACTOR: GasTOPS Limited

CANADIAN OPTION (035)

OBJECTIVE: To determine the technical feasibility and cost estimate for a reasonable combined MUSAT and MSAT satellite demonstration scenario which can provide limited premium 800 MHz service and a somewhat reduced MUSAT capability.

LIST OF TASKS:

TBD

<u>MILESTONES:</u>	CRB Approval	-	April 1981
	Contract Award	-	May 1981
	Interim Report	-	July 1981
	Final Report	-	30 September 1981

<u>FUNDING:</u>	Source	-	DND - 125K
		-	MSAT Funds - \$115K
	Total Value	-	\$240K
	Spending Profile	-	FY 81/82 - \$240K

SCIENTIFIC AUTHORITY: R.W. Huck

TECHNICAL ADVISOR: J.L. Pearce

CONTRACTOR: C.A.L.

2.5      Technology Development

	<u>CONTRACTOR</u>	<u>SCIENTIFIC AUTHORITY</u>
004A    Dynamic Structural Flexibility and Control	Dynacon	Reynaud
004B    Attitude Stabilization - Large S/C	Ancon	Reynaud
004C    Satellite Antenna Control and Pointing	SPAR	Reynaud
005    State-of-the-Art in Reaction Control Systems	SPAR	Reynaud
006    Thermal Control	SPAR	Reynaud
015    Modulation Coding	TBD	Hindson
018A    Application of Microprocessors (General)	SPAR	Millar
018B    Application of Microprocessors (MSAT S/C)	TBD	Reynaud
018C    Microprocessor Architecture	TBD	Millar
019A    Dynamics and Control of Large S/C	Dynacon	Reynaud
019B    Dynamics and Control of Large S/C	SPAR	Reynaud
019C    Dynamics and Control of Large S/C	Dynacon	Reynaud
029    High Efficiency Linear Amplifiers	TBD	TBD
030    L.O. Systems	TBD	TBD
036    Propagation and Interference Measurements	In-House	Huck

DYNAMIC STRUCTURAL FLEXIBILITY AND CONTROL (004A)

OBJECTIVE: To assess the degree of flexibility of a generalized MSAT configuration and the extent to which it is a problem in the attitude control system design.

LIST OF TASKS:

1. State the MSAT attitude control problem in a generic fashion;
2. Identify and describe promising configuration solutions to the problem;
3. Collaborate with ANCON and SPAR in making certain that all available control options have been included;
4. Perform simple analyses to aid in the specification of these configurations;
5. Collaborate with SPAR in the evaluation of the candidate configurations;
6. Conduct a literature review of relevant methods for controlling very large flexible spacecraft.

<u>MILESTONES:</u>	CRB Approval	-	4 November 1980
	Contract Award	-	5 December 1980
	Interim Report	-	5 March 1981
	Final Report	-	31 March 1981

<u>FUNDING:</u>	Source	-	MSAT Funds (4-261-65605)
	Total Value	-	\$20K
	Spending Profile	-	FY 80/81 - \$20K

SCIENTIFIC AUTHORITY: A.H. Reynaud

TECHNICAL ADVISOR: W.S. Graham

CONTRACTOR: Dynacon Enterprises Ltd.

SATELLITE ATTITUDE STABILIZATION SYSTEMS FOR LARGE SPACECRAFT (004B)

OBJECTIVE: To evaluate satellite attitude stabilization systems with particular attention to large spacecraft with large non-symmetrical deployable appendages.

LIST OF TASKS:

1. Conduct a literature review of spacecraft attitude control methods;
2. Determine candidate methods for further study;
3. Assemble functional formulas describing the potential pointing accuracy, fuel consumption rates and other performance factors;
4. Determine methods for placing wheels and thrusters for either based or zero momentum systems for which the sensor, control and principle axes may be skewed relative to each other and where the centre of mass may be outside the spacecraft main body;
5. Identify the influence of high solar and gravity gradient torques;
6. Conduct a hardware review of gimbal and momentum wheel availability, weight and history;
7. Prepare comparative tables and graphs that demonstrate where each control method is optimum;
8. Identify critical areas or topics requiring further development and determine the highest priority items.

<u>MILESTONES:</u>	CRB Approval	-	August 1980
	Contract Award	-	30 September 1980
	Contract Amendment	-	9 February 1981
	Interim Report	-	20 February 1981
	Final Report	-	31 March 1981

<u>FUNDING:</u>	Source	-	DSM G&S (4-285-65227)
	Total Value	-	\$28K
	Spending Profile	-	FY 80/81 - \$28K

SCIENTIFIC AUTHORITY: A.H. Reynaud

TECHNICAL ADVISOR:

CONTRACTOR: ANCON Space Technology Corporation

SATELLITE AND ANTENNA CONTROL AND POINTING (004C)

OBJECTIVE: To study the problems associated with the control of a generic class of very large 3-axis stabilized spacecraft such as MSAT.

LIST OF TASKS:

1. Conduct a literature survey;
2. Define the control problem;
3. Assess various control strategies

MILESTONES:

CRB Approval	-	4 November 1980
Contract Award	-	8 December 1980
Contract Amendment	-	1 March 1981
Interim Report	-	15 March 1981
Final Report	-	31 March 1981

FUNDING:

Source	-	DSM G&S (4-285-65227) \$20K
		MSAT Funds (4-261-65605) \$10K
Total Value	-	\$30K
Spending Profile	-	FY 80/81 - \$30K

SCIENTIFIC AUTHORITY: A.H. Reynaud

TECHNICAL ADVISOR: R.D. Caswell

CONTRACTOR: SPAR RMSD



STATE-OF-ART IN REACTION CONTROL SYSTEMS (005)

OBJECTIVE: To study the state-of-the-art of electric propulsion reaction control systems for MSAT to help upgrade the industrial knowledge level.

LIST OF TASKS:

1. Carry out a literature review;
2. Determine principle characteristics of the basic thrusters and conditioning elements;
3. Determine operational requirements and constraints;
4. Review test results;
5. Discuss potential devices with recognized authorities;
6. Review application considerations and constraints;
7. Propose a preferred system.

<u>MILESTONES:</u>	CRB Approval	-	9 December 1980
	Contract Award	-	12 January 1981
	Interim Report	-	Nil
	Final Report	-	31 March 1981

<u>FUNDING:</u>	Source	-	MSAT Funds (4-261-65605)
	Total Value	-	\$18K
	Spending Profile	-	FY 80/81 - \$18K

SCIENTIFIC AUTHORITY: A.H. Reynaud

TECHNICAL ADVISOR:

CONTRACTOR: SPAR RMSD

MSAT THERMAL CONTROL (006)

OBJECTIVE: To review applicable thermal control systems and develop a conceptual design for thermal control of MSAT.

LIST OF TASKS:

1. Develop a conceptual design for the spacecraft layout and perform a parametric analysis on a bulk model;
2. Calculate temperatures and thermal gradients within deployed appendages other than the solar array;
3. Evaluate the effect of the appendages on the spacecraft thermal design.

MILESTONES:

CRB Approval	-	9 December 1980
Contract Award	-	12 January 1981
Interim Report	-	Nil
Final Report	-	31 March 1981

FUNDING:

Source	-	DSM Funds (4-285-65227)	\$20K
		MSAT Funds (4-261-65605)	\$19.6K
Total Value	-		\$39.6K
Spending Profile	-	FY 80/81	- \$19.6K
		FY 81/82	- \$20K

SCIENTIFIC AUTHORITY: A.H. Reynaud

TECHNICAL ADVISOR: V.A. Wehrle

CONTRACTOR: SPAR RMSD

MODULATION (CODING) (015)

OBJECTIVE: To examine alternative modulation systems to NBFM that require lower resource demands in the satellite, including a study of hardware availability and cost tradeoffs.

(Delete - Now part of 017)

APPLICATION OF MICROPROCESSORS - TECHNOLOGY DEVELOPMENT (018A)

OBJECTIVE: To establish a capability in Canadian industry (Spar) to configure, manipulate and interconnect flight-qualifiable microprocessor components for spacecraft applications.

LIST OF TASKS:

1. Configure, breadboard and test an integrated compatible set of flight-qualifiable microprocessor hardware components;
2. Develop the necessary software and test set to exercise and test the microprocessor system hardware;
3. Conduct failure mode and effect analysis on the breadboard hardware;
4. Specify the type of multiprocessor hardware architectures that could be implemented with an expanded set of compatible microprocessor components.

<u>MILESTONES:</u>	CRB Approval	-	
	RFP	-	
	Contract Award	-	1 June 1981
	Interim Report	-	
	Final Report	-	31 March 1983

<u>FUNDING:</u>	Source	-	UP/DSS Funds - \$225K
			ICF - \$340K
	Total Value	-	\$565K
	Spending Profile	-	FY 81/82 - \$232K
			FY 82/83 - \$283K

SCIENTIFIC AUTHORITY: R.A. Millar

TECHNICAL ADVISOR:

CONTRACTOR: SPAR A&CSD

APPLICATION OF MICROPROCESSORS TO MSAT (018B)

OBJECTIVE: To study the state-of-the-art of onboard microprocessor systems for control of various spacecraft functions, to define the hardware and software requirements for an MSAT class spacecraft, to identify any technology development requirements, and to provide a cost estimate for development of an advanced microprocessor control system for MSAT.

LIST OF TASKS:

TBD

<u>MILESTONES:</u>	CRB Approval	-	
	RFP	-	
	Contract Award	-	
	Interim Report	-	
	Final Report	-	31 March 1982

<u>FUNDING:</u>	Source	-	MSAT Funds (4-261-65605)
	Total Value	-	\$165K
	Spending Profile	-	FY 81/82 - \$165K

SCIENTIFIC AUTHORITY: A.H. Reynaud

TECHNICAL ADVISOR: R.A. Millar

CONTRACTOR: SPAR

MICROPROCESSOR ARCHITECTURE (018C)

OBJECTIVE: To develop software and architecture in microprocessor applications in MSAT class spacecraft.

LIST OF TASKS:

TBD

<u>MILESTONES:</u>	CRB Approval	-	
	RFP	-	
	Contract Award	-	
	Interim Report	-	
	Final Report	-	31 March 1982

<u>FUNDING:</u>	Source	-	ICF
	Total Value	-	\$450K
	Spending Profile	-	TBD

SCIENTIFIC AUTHORITY: R.A. Millar

TECHNICAL ADVISOR:

CONTRACTOR: TBD

DYNAMICS AND CONTROL OF LARGE SPACECRAFT-STUDY (019A)

OBJECTIVE: To develop a dynamics modelling plan for the demonstration MSAT.

LIST OF TASKS:

1. Survey, describe and evaluate methods of structural dynamics modelling for flexible spacecraft;
2. Survey, describe and evaluate available structural dynamics computer codes suitable for modelling flexible spacecraft;
3. Review methods for synthesizing a dynamics model for an entire spacecraft from substructure models;
4. Identify the substructure parameters needed to formulate an overall dynamics model for MSAT;
5. Develop interface specifications to be met by substructure parameters to ensure that acceptable control can be maintained on spacecraft attitude and on reflector attitude and position.

<u>MILESTONES:</u>	CRB Approval	-	29 January 1981
	Contract Award	-	9 February 1981
	Interim Report	-	
	Final Report	-	31 March 1981

<u>FUNDING:</u>	Source	-	MSAT Funds (4-261-65605)
	Total Value	-	\$10.5K
	Spending Profile	-	FY 81/82 - \$10.5K

SCIENTIFIC AUTHORITY: A.H. Reynaud

TECHNICAL ADVISOR:

CONTRACTOR: Dynacon Enterprises Ltd.



DYNAMICS AND CONTROL OF LARGE SPACECRAFT - TECHNOLOGY  
DEVELOPMENT (019B)

OBJECTIVE: To develop software, tools and test facilities for the dynamic control of large flexible spacecraft, including concepts, analysis, sensors, microprocessors, controls laboratory, real time simulation, etc., and to upgrade the Spar capability in this area.

LIST OF TASKS:

1. Develop a design, analysis and simulation plan that addressed all phases of the control system program.
2. Update the system performance requirements and parameters for the spacecraft.
3. Develop an evaluation model for the structural dynamics.
4. Develop a simplified structural dynamics model for control system design.
5. Evaluate the control system design.
6. Identify critical hardware development and system development tests that will be required.

<u>MILESTONES:</u>	CRB Approval	-	30 April 1981
	Contract Award	-	June 1981
	Interim Report	-	
	Final Report	-	31 March 1982

<u>FUNDING:</u>	Source	-	ICF Funds	-	\$200K
	Total Value	-	\$200K		
	Spending Profile	-	FY 81/82	-	\$200K

SCIENTIFIC AUTHORITY: A.H. Reynaud

TECHNICAL ADVISOR:

CONTRACTOR: SPAR RMSD

DYNAMICS AND CONTROL SYSTEM DESIGN DEVELOPMENT (019C)

OBJECTIVE: To develop dynamic models and control system designs for 3rd generation spacecraft.

LIST OF TASKS:

1. Develop, document, code and implement a structural dynamics model for use in simulations associated with control system evaluations.
2. Develop, document, code and implement a structural dynamics model for use in control system design.
3. Study and define the Control System Design.
4. Identify critical hardware

<u>MILESTONES:</u>	CRB Approval	-	May 1981
	Contract Award	-	June 1981
	Final Report	-	March 1982

<u>FUNDING:</u>	Source	-	DSM G&S (4-285-65227 - 2201)
	Total Value	-	\$80K
	Spending Profile	-	FY 81/82 - \$80K

SCIENTIFIC AUTHORITY: A.H. Reynaud

TECHNICAL AUTHORITY:

CONTRACTOR: Dynacon Enterprises Ltd.

SUBCONTRACTOR: ANCON Space Technology Corporation

HIGH EFFICIENCY LINEAR AMPLIFIER DEVELOPMENT (029)

OBJECTIVE: To extend the CRC-developed 200-400 MHz high efficiency linear amplifiers to the 800 MHz band, and to transfer the technology to Canadian industry.

LIST OF TASKS:

TBD

MILESTONES: CRB approval -  
RFP issued by DSS -  
Contract award -  
Interim Report -  
Final Report -

FUNDING: Source - Accelerated Development Funds  
and ICF  
Total Value - \$300K  
Spending profile - FY 81/82 - \$150K  
FY 82/83 - \$150K

SCIENTIFIC AUTHORITY:

TECHNICAL ADVISOR:

CONTRACTOR: TBD by Competitive Tender

LOCAL OSCILLATOR SYSTEMS (030)

OBJECTIVE: To develop conceptual designs for local oscillator systems that can support narrowband data/voice channels for on-board switched transponders.

LIST OF TASKS:

TBD

<u>MILESTONES:</u>	CRB approval	-	
	RFP issued by DSS	-	
	Contract award	-	
	Interim Report	-	
	Final Report	-	31 March 1982

<u>FUNDING:</u>	Source	-	DSS G&S Funds
	Total Value	-	\$75K
	Spending profile	-	FY 81/82 - \$75K

SCIENTIFIC AUTHORITY: TBD

TECHNICAL ADVISOR:

CONTRACTOR: TBD by Competitive Tender

PROPAGATION MEASUREMENTS (036)

OBJECTIVE: To obtain measurements of interference and propagation  
in the 806-890 MHz band, including blockage of the  
signal by physical obstructions.

LIST OF TASKS:

TBD

MILESTONES:

TBD

FUNDING: Source -  
Total Value -  
Spending Profile -

SCIENTIFIC AUTHORITY: R.W. Huck

TECHNICAL ADVISOR: J.S. Strickland

CONTRACTOR: In-House

3. DOC IN-HOUSE WORK PLAN

3.1 IN-HOUSE TASK LIST (HQ)

The following tasks have been identified and assigned to DOC HQ staff, listed under five functional areas, with one sheet prepared for each task:

(A) Program Management

1. Program Management

(B) Program Development

1. DOC/NASA MOU
2. DOC/DND Agreement
3. Post-launch Communications Program
4. Plan for Phases B and C/D
5. ICS Submission
6. Memorandum to Cabinet and Discussion Paper
7. Treasury Board Submission

(C) Needs Assessment and User Liaison

1. Needs Survey and User Liaison for 806-890 MHz Mobile Service
2. Needs Survey and User Liaison for 401-403 MHz DCP Service
3. Needs Survey and User Liaison for 406.1 Emergency Monitoring Service
4. Needs Survey and User Liaison for 1.5/1.6 GHz Maritime Mobile Satellite Service
5. Federal Government User Liaison for 806-890 MHz Service
6. MSAT Services During Demonstration and Interim Phases

(D) Program Benefit and Economic Studies

1. Benefit and Economic Studies

(E) Policy

1. Policy and Regulatory Studies
2. Frequency Allocations

TITLE: Program Management (A-1)

OBJECTIVE: To provide DOC HQ program management functions for the MSAT program during Phase A.

TASK DESCRIPTION:

- perform line management of DOC HQ MSAT tasks
- perform program monitoring, reporting, and MSAT briefings
- organize DOC/NASA MSAT Working Group meetings (every two months)
- provide staff support to Senior DOC/NASA Management Committee (February, June, October meetings)
- conduct liaison with: NASA HQ Study Manager  
CRC Project Manager  
General industry liaison  
Other branches of DOC
- provide staff support to Canadian MSAT Review Committee
- provide staff support to Canadian MSAT Advisory Group

MILESTONES:

Continuing activity

TASK LEADER: P.M. Boudreau

TITLE: DOC/NASA MOU (B-1)

OBJECTIVE: To negotiate a preliminary MOU with NASA to cover a potential joint MSAT development project.

TASK DESCRIPTION:

Prepare a draft MOU for negotiation with NASA, including as main areas:

- the demonstration system architectural concept and functional requirements
- definition of major subsystem interfaces and division of responsibilities
- the management arrangements
- arrangements for joint consideration of a possible follow-on operational satellite system, and
- rights and exchange of information.

MILESTONES:

List of outstanding MOU issues	-	1 April 1981
DOC position paper on outstanding issue	-	1 June 1981
Start of negotiations	-	2 September 1981
Negotiated MOU with NASA	-	1 December 1981

TASK LEADER: P.M. Boudreau



TITLE: DOC/DND Agreement (B-2)

OBJECTIVE: To negotiate a DOC/DND Administrative Agreement for the implementation of the MSAT system.

TASK DESCRIPTION:

Through the DND/DOC MSAT Coordinating Committee to coordinate and monitor DND and DOC activities by:

- identifying program activities that require joint management action, to coordinate their implementation, and to monitor results
- reviewing tasks impacting on DOC/DND cost sharing
- reviewing joint DND/DOC program options
- providing a forum for discussion of overall program timing
- preparing Memorandum of Agreement or Administrative Arrangement outlining responsibilities of DND and DOC

MILESTONES:

Monthly meetings of Coordinating Committee  
DOC Position Paper for Negotiations -  
First Draft of Agreement -  
Final Draft of Agreement - October 1981

TASK LEADER: J.D.B. Kent

TITLE: Post-launch Communications Program (B-3)

OBJECTIVE: To prepare objectives and a plan for an MSAT post-launch communications program.

TASK DESCRIPTION:

A series of pilot projects will be proposed for the post-launch period which:

- determine the viability of pre-operational telecommunications services;
- demonstrate the operational characteristics of an integrated satellite/terrestrial network;
- test the equipment used and identify changes necessary for an operational system;
- identify new service applications; and
- develop expertise and create awareness of potential users of the new service.

<u>MILESTONES:</u>	Draft Work Plan	-	30 March 1981
	Draft Task Plan	-	1 June 1981
	Final Task Plan	-	30 October 1981

TASK LEADER: J.D.B. Kent

TITLE: ICS Submission (B-5)

OBJECTIVE: To prepare submission to the Interdepartmental Committee on Space for incorporation as the MSAT element in their 5-year plan.

TASK DESCRIPTION:

Preparation and staffing of ICS Submission within DOC.

MILESTONES:

Planning and outline prepared	-	30 April 1981
First draft complete	-	31 July 1981
Final draft complete	-	31 August 1981
Submit to ICS	-	11 September 1981

TASK LEADER: A.L. Barry

TITLE: Memorandum to Cabinet and Discussion Paper (B-6)

OBJECTIVE: To obtain Cabinet approval in principle for the MSAT program, and to obtain funding approval for Phase B.

TASK DESCRIPTION:

Preparation and staffing of Cabinet Discussion Paper within DOC, interdepartmental coordination, and preparation of Memorandum to Cabinet.

MILESTONES:

Planning and outline prepared	-	1 April 1981
First draft of D.P. prepared	-	1 August 1981
Second draft of D.P. prepared	-	1 October 1981
Second draft D.P. staffed		
within DOC	-	1 November 1981
Final draft D.P. prepared	-	1 December 1981
Interdepartmental coordination		
and DOC coordination completed	-	1 January 1982
Memorandum to Cabinet prepared	-	1 January 1982
Memorandum submitted to Cabinet	-	31 January 1982

TASK LEADER: P.M. Boudreau (A.L. Barry coordinator for preparation of documents)

TITLE: Treasury Board Submission (B-7)

OBJECTIVE: To obtain Treasury Board approval of the expenditure of funds required for Phase B, including research and technology development.

TASK DESCRIPTION:

- Prepare and staffing of Treasury Board submission, within DOC and interdepartmentally.
- Prepare Project Brief as per TB Directive.

<u>MILESTONES:</u>	Planning and outline prepared	-	1 April 1981
	First draft prepared	-	2 September 1981
	Staffing complete within DOC	-	2 November 1981
	Second draft prepared	-	1 December 1981
	Interdepartmental coordination complete	-	15 January 1982
	Final draft complete	-	15 February 1982
	Submission to Treasury Board	-	22 February 1982

TASK LEADER: P.M. Boudreau (A.L. Barry coordinator for preparation of documents)

TITLE: Needs Survey and Public User Liaison - 806-890 MHz  
Mobile Services (C-1)

OBJECTIVE: To determine the user requirements for a  
mobile-satellite system in the 806-890 MHz band.

TASK DESCRIPTION:

Manage external contract the purpose of which is:

- to determine services required (e.g. voice, fax,  
data, etc.)
- to estimate the number of users (mobile,  
transportable, field portable, personal portable,  
etc.)
- to estimate traffic flow on regional basis in the  
timeframe 1985-2000
- to evaluate costs that users are willing to pay on a  
per-minute or per-channel basis.

Provide contractor with base information and such as  
operational scenarios and ballpark user costs.

MILESTONES:

Contract Start	-	2 January 1981
Contract Completion	-	8 June 1981

TASK LEADER:

J. Carson

TITLE: Needs Survey and User Liaison - 401-403 MHz DCP Service (C-2)

OBJECTIVE: To investigate user needs, technical feasibility cost, and other relevant factors affecting decision to include a 401-403 MHz Data Collection Platform (DCP) service on MSAT.

TASK DESCRIPTION:

- Review past user surveys.
- Prepare service/system description and questionnaire.
- Compile list of users, circulate questionnaire, and interview as required.
- Assess benefit to the Canadian manufacturing industry.
- Contact NOAA to establish state-of-the-art and future projections re DCP technology.
- Comparison of alternate modulation systems.
- Establish feasibility of adding DCP service to MSAT.
- Estimate incremental cost of adding DCP service to MSAT.
- Study compatibility of existing Rx facilities.
- Investigate with DOE their role in the DCP portion of the MSAT program.
- Final report, including recommendations and cost estimates.

MILESTONES:

User Survey Complete	-	15 June 1981
Final report	-	13 July 1981

TASK LEADER: A. Maclatchy

TITLE: Needs Survey and User Liaison - 406.1 MHz Frequency  
Monitoring Service (C-3)

OBJECTIVE: To investigate the merits of including a 401.6 MHz  
emergency beacon monitoring system on MSAT.

TASK DESCRIPTION:

- Determine the practicality of including a 401.6 MHz  
monitoring service on MSAT.
- Evaluate methods of including this subsystem in MSAT.
- Evaluation of ground equipment for the system.
- Compile users list.
- Ensure system compatibility through liaison with DND.
- Prepare operational cost analysis.
- Prepare cost benefit study.
- Prepare program cost estimate.
- Prepare final report.

<u>MILESTONES:</u>	Operational compatibility and	-	6 April 1981
	requirements deferral		
	Benefit and cost studies complete	-	26 June 1981
	Final report issued	-	20 July 1981

TASK LEADER: A. Maclatchy



TITLE: Needs Survey and User Liaison - 1.5/1.6 GHz Maritime  
Mobile Satellite Service (C-4)

OBJECTIVE: To evaluate the merits of adding a maritime  
mobile-satellite package to MSAT.

TASK DESCRIPTION:

- Review existing documentation on maritime  
mobile-satellite systems.
- Investigate coverage and availability of service for  
Canadian Arctic.
- Investigate frequency requirements.
- Coordination with INMARSAT.
- Study of operating agency for Canadian maritime  
satellite system.
- Conduct user study.
- Carry out cost analysis.
- Prepare final draft.

MILESTONES: Coverage and frequency plan reviewed - 20 April 1981  
User study complete - 25 May 1981  
Final report issued - 27 July 1981

TASK LEADER: A. Maclatchy

TITLE: Federal Government User Liaison for 806-890 MHz Service. (C-5)

OBJECTIVE: To liaise with potential federal government users of MSAT through the MSAT Government User Advisory Group.

TASK DESCRIPTION:

- assess the interest of departments in participation in the proposed MSAT demonstration program
- coordinate the assessment of federal government needs in bands other than 806-890 MHz
- coordinate the involvement of interested departments in a contracted cost/benefit study
- consider requirements for a common mobile user station
- invite comments from interested departments on future program submissions to ICS, Cabinet, and Treasury Board

MILESTONES:

Assessment of federal government needs other than 806-890 MHz	- 19 June 1981
Assessment of interest in demo program	- 15 September 1981
Coordination of cost/benefit study	- 15 September 1981
Completion of all tasks	- 1 April 1982

TASK LEADER: A. Maclatchy

TITLE: MSAT Services During Demonstration and Interim Phases (C-6)

OBJECTIVE: To determine the MSAT services required during the demonstration and interim phases.

TASK DESCRIPTION:

- Determine who may be interested in participation in demonstration phase.
- Arrange interviews with users who indicate interest in the demo phase.
- Prepare paper on the program plan and system concept for use as hand-out during interviews.
- Prepare briefing material and questionnaire for interviews.
- Prepare a proposal format that would be used by users to prepare their proposals.
- Conduct interviews.
- Finalize questionnaires and re-interview as required.
- Invite letters of interest to DOC from prospective participants
- Analyze proposals received regarding involvement during demo phase.
- Prepare summary report based on data in questionnaires and analysis of proposals.

MILESTONES:

Briefing material and questionnaire prepared	- 16 May 1981
Interviews complete	- 2 January 1982
Summary report issued	- 12 February 1982

TASK LEADER: J. Carson

TITLE: Benefit and Economic Studies (D-1)

OBJECTIVE: To define and manage contracts for benefit and economic studies and to define tasks and schedule for in-house assistance by Economics Branch.

TASK DESCRIPTION:

Define and manage the Integrated Terrestrial/Satellite System Study Contract

Define and manage the Program Benefit Study Contract

Define and manage the User Cost-Benefit Study Contract

Liaise with SADM sector in their studies of:

- commercial viability of mobile-satellite system
- benefits to Canadian economy
- benefits to telecommunications manufacturing industries
- user cost/benefits associated with introduction of mobile-satellite services

MILESTONES:

Contract award by mid-1981, with completion by November 1981

TASK LEADER: J.D.B. Kent (except for user cost benefit study being managed by A. Maclatchy)

TITLE: Policy and Regulatory Studies (E-1)

OBJECTIVE: To assess the policy implications of the introduction of mobile-satellite services in Canada.

TASK DESCRIPTION:

Examine policy issues raised by MSAT in the following areas of concern to other DOC Sectors:

- National Communications policy
- International implications
- Economics
- Social implications
- Federal/Provincial relations
- Legal implications
- Radio Regulations
- Government telecommunications

MILESTONES:

Specified in agreements with other sectors of DOC.

<u>TASK LEADER:</u>	J. Marcotte	Coordinator for Policy Sector (SADM)
	R. Begley	DGTR
	D. Sum	GTA
	A. Barry	Space Sector Coordinator

TITLE: Frequency Allocations (E-2)

OBJECTIVE: To ensure that frequency are available for MSAT. To conduct analysis and coordination.

TASK DESCRIPTION:

- provide support to DEB in negotiations with the FCC concerning sub-allocations in the 806-890 MHz band
- carry out interference analysis between the DND troposcatter system operating in the 806-890 MHz band and the proposed MSAT mobile system
- coordinate with policy sector the preparation of papers for public comments on use of 800 MHz band

MILESTONES:

- MSAT on agenda of March 1981 meeting of the DOC/FCC Radio Liaison Committee
- negotiations complete by Fall 1981
- bi-monthly meetings will be held with DGTR to review progress

TASK LEADER: R. Bowen

3.2 IN-HOUSE TASK LIST (CRC)

The following tasks have been identified and assigned to CRC staff. A one-page summary of each follows:

1. Project Management
2. Contract Management
3. Concept/Requirement Documents
4. Management Documentation
5. Technology Development Plan
6. Alternate System Options
7. System Design Authority
8. Analysis and Simulation Plan
9. Test Philosophy and Integration Requirements

TITLE: Project Management (F-1)

OBJECTIVE: To provide project management for the MSAT project activities at CRC.

TASK DESCRIPTION:

- line management of project office including planning, staffing and direction of staff.
- Support to DOC/HQ program function
- liaison with NASA including technical matters with LeRC, support of MWG, and support for senior management meetings
- preparation of documents describing mandate, management system, and Canadian position for joint project
- interaction with other DGSTA officers to influence and track direct and indirect project support.
- preparation of cost and other resource predictions.

MILESTONES:

Continuing

TASK LEADER: H.R. Raine (acting)



TITLE: Contract Management (F-2)

OBJECTIVE: To undertake studies in Canadian industry to establish feasibility and scope of MSAT project.

TASK DESCRIPTION:

- preparation of CRB submittals
- assistance to DSS for RFP preparation
- evaluation of proposals
- negotiation of contracts
- monitoring of contract progress
- assessment of accomplishment

MILESTONES:

See contract descriptions and summary attached.

TASK LEADER:

Scientific authority specified on relevant contract summary (Section 2).

TITLE: Concept/Requirement Documents (F-3)

OBJECTIVE: To provide top-tiers of controlled specifications for MSAT project.

TASK DESCRIPTION:

- in response to "Users Requirement Document" preparation "Communication System Concept" in three versions: demonstration system (MSAT), operational system and MUSAT.
- using MSAT Communication Concept prepare performance/ Requirements specifications for:
  - system
  - space segment
  - ground segment
    - Central Control Station
    - gateway
    - mobiles and portables
    - all military terminals

MILESTONES: Draft concept documents - 81-2-1  
Performance Requirement Specifications - TBD

TASK LEADER: H.R. Raine (acting)

TITLE: Management Documentation (F-4)

OBJECTIVE: To prepare Phase B Project Plan  
To describe Joint Project office and its terms of  
reference and procedures.

MILESTONES: First draft Phase B Project Plan 81-4-1  
First draft JPO et al 81-7-1

TASK LEADER: H.R. Raine (acting)

TITLE: Technology Development Plan (F-5)

OBJECTIVE: To establish in Canadian industry the capability required to carry out Canadian responsibilities in MSAT.

TASK DESCRIPTION:

- Determine areas of technology development required based on an assumed Canadian responsibility list and in consultation with industry.
- Prepare an assessment of scope of support required.
- Prepare plans for the technology development including schedules and costing.
- Assist program management in preparation of Cabinet T.B. submissions.
- Generate contractual documentation and monitor contracts.

MILESTONES: Assessment of Technology areas and rough costs 81-4-1

Complete program 83-7-15

TASK LEADER: H.R. Raine (acting)

TITLE: Alternate System Options (F-6)

OBJECTIVE: To prepare alternate project scenarios to MSAT as possible fallback options.

TASK DESCRIPTION:

- Review and update the MUSAT Concept.
  - Prepare 800 MHz concept scaled to smaller aperture and/or smaller total capacity such that the transponder and antenna system together with the MUSAT transponder can be carried on a small bus.
  - Assist DND in re-evaluating the MUSAT payload for a stand-alone satellite system.
  - Develop three options for evaluation:
    - a) MUSAT only (DND funded)
    - b) MUSAT with reduced 800 MHz capability.
    - c) Canadian only smaller 800 MHz system.
- Work to be done by contract with CRC support and direction

MILESTONES:

Initial draft of options 81-7-15

TASK LEADER: R. Huck

TITLE: System Design Authority (F-7)

OBJECTIVE: To conduct system studies and to ensure overall system integrity.

TASK DESCRIPTION:

- Interpret user requirements.
- Develop concept documentation.
- Establish systems parameters.
- Control interfaces.
- Define and allocate margins.
- Maintain technical liaison with user community.
- Undertake preliminary mission analysis.

MILESTONES:

TASK LEADER: W.D. Hindson

TITLE: Analysis and Simulation Plan (F-8)

OBJECTIVE: To provide software tools to designers throughout project ending with such simulations as are needed to support mission.

TASK DESCRIPTION:

- Prepare list of large software systems required for project.
- Make decision as to extent of Canadian responsibility.
- Develop a strategy for software development.
- Prepare plan to carry out strategy.

MILESTONES: Required for phase B work plan 81-10-1

TASK LEADER: H.R. Raine

TITLE: Test Philosophy and Integration Requirements (F-9)

OBJECTIVE: To prepare a strategy of testing and integration acceptable to both DOC and NASA as verification of flight readiness.

TASK DESCRIPTION:

- Using conceptual designs as they evolve consider problems of hardware integration.
- Develop test plan acknowledging the physical restraints of the MSAT spacecraft.
- Evolve a verification plan which can be approved as acceptable proof of Flight Readiness.

MILESTONES: Verification plan needed prior to phase B initiation 81-10-1.

TASK LEADER: AB Shearer.



## MSAT CONTRACT STATUS AND SPENDING PROFILE - CRC

APPENDIX I (1 of 4)

31 May 1981

ITEM NO.	CONTENT	SCIENTIFIC AUTHORITY	SCO NO.	DATE CRB APPROVAL	REQUISITION OR CONTRACT NUMBER	CONTRACTOR	DATE CONTRACT AWARD	DATE CONTRACT COMPLETE	ESTIMATED CONTRACT COST		SPENDING PROFILE				
									MSAT	OTHER	FY 80/81		FY 81/82		LATER
											MSAT	OTHER	MSAT	OTHER	
	<u>SPACE SECTOR</u>														
001	Configuration Study	Raine	--	80/11/4	36100-0-0768H	SPAR SSD	81/1/28	81/8/31 E	700	--	121	--	579	--	--
002A	Multiband Use Large Reflector	Raine	--	80/11/4	36001-0-3350	SPAR A&CSD	81/7/31 E	81/12/31 E		65 <sup>5</sup>	--	--		65 <sup>5</sup>	--
002B	Multiband Use Large Reflector	Raine	750	81/2/20	36001-0-6030	OIR U of M	81/3/2	81/5/31 E	25	--	10	--	15	--	--
003	Configuration Software	Reynaud	709	81/1/29	36001-1-3004	Kendall	81/4/1	81/7/31 E	20	--	--	--	20	--	--
013	Integration and Test Plans	Raine	771	81/4/30	36001-1-0734	SPAR SSD	81/6/5E	81/9/30E		40 <sup>5</sup>	--	--		40	--
020	COMSAT MOD Update	Raine	696	80/12/9	36001-0-3395	CAL	81/1/6	81/3/31E	25	--	17	--	8	--	--
021	Program Cost Analysis	Raine							270	--	--	--	270	--	--
033	MUSAT Payload Definition	Raine		81/6/9 E		SPAR A&CSD	81/7/6 E	81/12/31 E	--	90 <sup>4</sup>	--	--	--	90 <sup>4</sup>	--
	<u>TOTAL - SPACE SECTOR</u>								1040	195	148	--	892	195	--
	<u>GROUND SECTOR</u>														
011A	Transportable Antenna - MUSAT	Butterworth	--	80/1/-	36001-9-6107	Andrews	80/2/13	81/3/31	--	28	--	28	--	--	--
011B	Transportable Antenna (800 MHz)	Butterworth	710	81/1/29	36100-1-3005	Andrews	81/4/10	81/9/30 E	25	--	--	--	25	--	--
011C	Mobile Antenna	Butterworth	--	--	--	In-house	80/12/1	81/6/30	--	--	--	--	--	--	--
011D	Ship Antenna	Butterworth		81/6/15	--	T.B.D.	81/8/1	81/12/31	25	--	--	--	25	--	--
016A	Gateway Stations	Hindson	752	81/3/26		T.B.D.	81/5/15 E	81/9/30 E	30	--	--	--	30	--	--
016B	Central Control Station	Hindson	763	81/4/30		T.B.D.	81/6/15E	81/10/30 E	50	--	--	--	50	--	--
017	Mobile and Portable Stations	Huck				T.B.D.	81/7/15 E	81/12/31 E	--	50 <sup>1</sup>	--	--	--	50 <sup>1</sup>	--
022	Program Cost Analysis	Huck							30	--	--	--	30	--	--
034	Musat Stations	DND							--	--	--	--	--	--	--
	<u>TOTAL - GROUND SECTOR</u>								160	78	--	28	160	50	--
									1200	273	148	28	1052	245	--

NOTES: E - Estimated 1 - DSS G&amp;S 2 - DSS Capital 3 - DND 4 - NIP

TOTAL PAGE 1

## MSAT CONTRACT STATUS AND SPENDING PROFILE - CRC

APPENDIX I (2 of 4)

31 May 1981

ITEM NO.	CONTENT	SCIENTIFIC AUTHORITY	SCO NO.	DATE CRB APPROVAL	REQUISITION OR CONTRACT NUMBER	CONTRACTOR	DATE CONTRACT AWARD	DATE CONTRACT COMPLETE	ESTIMATED CONTRACT COST		SPENDING PROFILE				LATER
									MSAT	OTHER	FY 80/81	OTHER	FY 81/82	OTHER	
014	<u>SYSTEM SECTOR</u> Mission Analysis & Ops Analysis & System Availability	Hindson	774	81/4/30	36001-1-0800	TBD	81/6/15 E		100				100		
023	Program Cost Analysis	Hindson							35				35		
031	Computational Requirements	Hindson	707	81/1/29	36001-8-3435	GasTOPS	81/2/16	81/8/31 E	50		9		41		
035	Canadian Option	Huck	769	81/4/30	36001-1-0703	C.A.L.	81/5/15 E	81/9/30 E	115	125 <sup>3</sup>	--	--	115	125 <sup>3</sup>	
	<u>TOTAL - SYSTEM SECTOR</u>								300	125	9	--	291	125	--
010	<u>SUPPORT SECTOR</u> Telesat									--	--	--	--	--	
032	Word Processor	Heal	--	--	36001-0-2796, 2797, 2820, 2821, 2822, 2827	MICOM Data Terminal Mart, Gandolph	81/3/12	81/3/31	40	27 <sup>2</sup>	22	27 <sup>2</sup>	20	--	--
	Travel & Miscellaneous	McNally							40	--	17	--	20	--	--
	<u>TOTAL - SUPPORT SECTOR</u>								80	27	39	27	40	--	--
TOTAL Page 2									380	152	48	27	331	125	--
TOTAL PAGE 1									1200	273	148	28	105	245	--
TOTAL PAGE 1 & 2									1580	425	196	55	1383	370	--

## NOTES:

E = Estimated

1 - DSS G&amp;S

2 - DSS Capital

3 - DND

## MSAT CONTRACT STATUS AND SPENDING PROFILE - CRC

APPENDIX I (3 of 4)

31 May 1981

ITEM NO.	ITEM	SCIENTIFIC AUTHORITY	SCO NO.	DATE CRB APPROVAL	REQUISITION NO.	CONTRACTOR	DATE CONTRACT AWARD	DATE CONTRACT COMPLETE	ESTIMATED COST		SPENDING PROFILE				
									MSAT	OTHER	FY 80/81		FY 81/82		LATE
	TECHNOLOGY DEVELOPMENT SECTOR														
004A	Flexibility Assessment	Reynaud	--	80/11/4	36001-0-3354	Dynacon	80/12/5	81/3/31	20	--	20	--	--	--	--
004B	Attitude Control	Reynaud	649 & 708	80/8/- 81/1/29	36001-0-3235	Ancon	80/9/30	81/3/31	--	30 <sup>4</sup>	--	30 <sup>4</sup>	--	--	--
004C	Attitude Control	Reynaud	751	80/11/4 81/2/20	36001-0-3355	SPAR RMSD	80/12/8	81/3/31	10	20 <sup>4</sup>	10	20 <sup>4</sup>	--	--	--
005	SOA in RCS	Reynaud	697	80/12/9	36001-0-3393	SPAR RMSD	81/1/12	81/3/31	18	--	18	--	--	--	--
006	Thermal Control	Reynaud	695	80/12/9	36001-0-3394	SPAR RMSD	81/1/12	81/3/31	20	20 <sup>4</sup>	20	--	--	20 <sup>4</sup>	--
015	Modulation Coding														
018A	Application of Microprocessors	Millar				SPAR A&CSD	81/5/1 E	82/12/31 E	--	565 <sup>5</sup>	--	--	--	280 <sup>6</sup>	285 <sup>7</sup>
018B	Application of Microprocessors	Reynaud				SPAR SSD				165 <sup>9</sup>	--	--	--	165 <sup>9</sup>	--
018C	Microprocessor Architecture	Millar				T.B.D.				450 <sup>7</sup>	--	--	--	225 <sup>7</sup>	225 <sup>7</sup>
019A	Dynamics & Control	Reynaud	711	81/1/29	36001-0-3434	Dynacon	81/2/9	81/3/31 E	10.5	--	--	10.5	--	--	--
019B	Dynamics & Control	Reynaud	768	81/4/30		SPAR	81/6/1 E	82/3/31 E	--	200 <sup>7</sup>	--	--	--	200 <sup>7</sup>	--
019C	Dynamics & Control	Reynaud		81/5/27	36001-1-0953	Dynacon	81/6/15	82/3/31 E	--	80 <sup>4</sup>	--	--	--	80 <sup>4</sup>	--
029	Hi Eff'y Linear - Amplifier	May							--	300 <sup>7</sup>	--	--	--	150	150
030	LO Stability	Hindson							--	75 <sup>1</sup>	--	--	--	75 <sup>1</sup>	--
	Parts for In-House Development	Hindson	--	--		Various	81/3/1	81/3/31 E	20.5	--	20.5	--	--	--	--
TOTAL - TECHNOLOGY DEVELOPMENT									100	1905	100	50	--	1195	660
TOTAL PAGE 1 & 2									1580	425	196	55	1383	373	--
TOTAL CRC									1680	2330	296	105	1383	1568	660

## NOTES:

E = Estimated      1 - DSS G&S      5 - UP DSS - 225 + ICF 340      9 - DSA Funds  
 2 - DSS Capital      6 - UP DSS - 225 + ICF 57  
 3 - DND      7 - ICF  
 4 - DSM G&S      8 - DSM G&S - 30 + ICF 150

## MSAT CONTRACT STATUS AND SPENDING PROFILE - DOC/HQ

APPENDIX I (4 of 4)

31 May 1981

ITEM NO.	ITEM	SCIENTIFIC AUTHORITY	SCO NO.	DATE CRB APPROVAL	REQUISITION OR CONTRACT NUMBER	CONTRACTOR	DATE CONTRACT AWARD	DATE CONTRACT COMPLETE	ESTIMATED CONTRACT COST		SPENDING PROFILE				
									MSAT	OTHER	FY 80/81 MSAT	FY 80/81 OTHER	FY 81/8 MSAT	FY 81/8 OTHER	LATER
	<u>PROGRAM SECTOR</u>														
007	Cost Benefit Study	MacLachy	758	81/4/30.		T.B.D.	81/6/30 E	81/11/30 E	100		--	--	100	--	
008	Integrated System	Kent	714	81/1/29.		INTEL	81/5/15 E	81/8/31 E	160		--	--	160	--	
009	Market Study	Carson	--	81/12/9		Woods-Gordon	81/1/2	81/6/2 E	70	125 <sup>1</sup>	70	60 <sup>1</sup>	--	65 <sup>1</sup>	
012	Program/Project Management Plan	Raine/Boudreau		81/1/29		Eastland	81/2/1/	81/7/31 E	25		10	--	15	--	
025	Communications Policy	Barry				T.B.D.				50 <sup>1</sup>	--	--	--	50 <sup>1</sup>	
026	Program Benefit	Kent		81/3/26		T.B.D.	81/6/15 E	81/9/30 E	50		--	--	50	--	
027	Freq. Interference Study	Bouchard	757	81/3/26		CAL	81/5/1 E	81/7/15 E		25 <sup>1</sup>	--	--		25 <sup>1</sup>	--
028	Regulatory Issues	Boudreau				IN-HOUSE				50 <sup>1</sup>	--	--	--	25 <sup>1</sup>	25 <sup>1</sup>
	Misc (Travel, Printing, etc.)									50 <sup>1</sup>	--	--	--	50 <sup>1</sup>	
	Term Manyears								110		--	--	110	--	
	Reserve for Phase B1 Contingency								25				25		
TOTAL - DOC/HQ									540	300	80	60	460	215	25
TOTAL - CRC									1680	2330	296	105	1383	1568	660
TOTAL									2220	2630	376	165	1843	1783	685

## NOTES:

E = Estimated

1 - DOC/HQ G&amp;S

APPENDIX B

RESULT OF CPACC SURVEY

OF MSAT USER REQUIREMENTS

CANADIAN PETROLEUM INDUSTRY  
MSat USER REQUIREMENTS

Requirement	Company					
	Hudson Bay Oil & Gas	Producers Pipelines Ltd.	AMOCO	Shell Canada Resources Ltd.	Esso Resources	Dome Petroleum (?)
a. <u>mobiles</u>	30	Have not determined	50	250	20	50
calls/day		how satel-	250	Did not feel		
mobile-base	20/mobile	lite service	total(?)	that questions	3/mobile	10/mobile
call duration	10 min	could bene- fit them, therefore did not specify requirements at this time	2 min	pertained to their communi- cations requirements	4 min	5 min
b. <u>base stations</u>	3		25		—	20
calls/day base-			100			
mobile	20/mobile		total(?)		—	10/mobile
call duration	10 min		2 min			5 min
calls/day mobile-						
switched network	2/mobile		—		5/mobile	10/mobile
call duration	5 min		—		4 min	5 min
calls/day switched						
network-mobile	2/mobile		—		4/mobile	10/mobile
call duration	5 min		—		4 min	5 min

CANADIAN PETROLEUM INDUSTRY  
MSat USER REQUIREMENTS

Requirement	Company					
	Hudson Bay Oil & Gas	Producers Pipelines Ltd.	AMOCO	Shell Canada Resources Ltd.	Esso Resources	Dome Petroleum (?)
c. <u>portables</u>	4		—		—	50
calls/day						
portable-base	20/portable		—		—	10/portable
call duration	2 min		—		—	3 min
calls/day portable-						
switched network	—		—			10/portable
call duration	—		—			5 min
calls/day switched						
network-portable	—		—			10/portable
call duration	—		—			5 min
d. <u>paggers tone-only</u>	—		—		25	—
messages/day	—		—		10/pager	—
message duration	—		—		—	—
e. <u>paggers tone plus voice</u>	—		—		—	—
messages/day	—		—		—	—
message length	—		—		—	—

CANADIAN PETROLEUM INDUSTRY  
MSat USER REQUIREMENTS

Requirement	Company					
	Hudson Bay Oil & Gas	Producers Pipelines Ltd.	AMOCO	Shell Canada Resources Ltd.	Esso Resources	Dome Petroleum (?)
f. <u>transportables</u>	3		—		20	40
data rate (cont)	600 baud		—		300 baud	2400 bps (burst) 5 Txs/day, 10 min duration each
voice calls/day	20/xportable		—		5/xportable	20/xportable
call duration	10 min		—		4 min	10 min
g. <u>high density</u> <u>E.S.</u>	1		—		2	3
no. channels	3		—		20	40
data rate/ch	800 baud		—		300 baud	2400 bps (burst) 5 Txs/day, 5 min duration
no. voice chs	3		—		20	40
voice calls/day/ch	20		—		4	20
call duration	5 min		—		4 min	10 min



APPENDIX C

STATUS OF PHASE A CONTRACTS

MSAT CONTRACT STATUS

CONTRACT DESIGNATOR	CONTRACT TITLE	CONTRACTOR	CURRENT STATUS
<u>PROGRAM SECTOR</u>			
007	Cost Benefit Study	TBD	Eight bids, received by 9 June closing date. Bids being evaluated and contract award expected by 7 July.
008	Integrated System Study	INTEL	Contract awarded to Intel Consultants on 22 May. Kick-off meeting was held on 3 June. Completion scheduled for 31 Oct., '81.
009	Market Study	Woods Gordon	Preliminary results received June 12. Draft final report expected June 26, and final report scheduled for delivery on 17 July.
012	MSAT Pgm./Project Management	T. Eastland	Draft Project Plan completed on schedule.
026	Program Benefit Study	TBD	Draft Statement of Work in preparation.
028	Mob. Sat. Communications Policy Study	TBD	Meeting to be held with National Branch to determine need for contract.
<u>SPACE SECTOR</u>			
001	Configuration Study	Spar	Operational MSAT phase of study nearing completion, and Demonstration System spacecraft study has commenced with emphasis on Canadian coverage options. Estimated completion date is Sept. 30, 1981.
002A	Multiband Use of Large Reflector	Spar	Directed contract to SPAR expected to be awarded by end of July 1981.

MSAT CONTRACT STATUS (cont'd)

CONTRACT DESIGNATOR	CONTRACT TITLE	CONTRACTOR	CURRENT STATUS
<u>SPACE SECTOR</u> (cont'd)			
002B	Multiband Use of Large Reflector	U. Manitoba	Study is essentially complete, with final report expected to be delivered by mid June.
003	Configuration Software	Kendall	First monthly report received 30 April. Slippage in some tasks is indicated but not serious.
013	Integration and Test Plans	Spar	Submission for directed contract to SPAR using accelerated R&D funds approved by CRB April 30.
020	Comsat Mod. Update	CAL	Contractor granted 60 day extension because of heavy commitment to other MSAT work. Further 30 day slippage now expected, with completion date now estimated as 30 June
021	Program Cost Analysis (Space segment)	Spar	Will be awarded following completion of 001.
033	MUSAT Payload Definition	TBD	(To be managed by DND)
<u>GROUND SEGMENT</u>			
011A	Transportable Antenna (225-400 MHz)	Andrew	Contract completed.
011B	Transportable Antenna (800 MHz)	Andrew	Andrew Antenna awarded contract 2 April to study two types of antenna for 800 MHz transportable terminals.

MSAT CONTRACT STATUS (cont'd)

CONTRACT DESIGNATOR	CONTRACT TITLE	CONTRACTOR	CURRENT STATUS
<u>GROUND SEGMENT</u> (cont'd)			
011C	Mobile Antenna (800 MHz)	(In-house)	Work is continuing in-house.
011D	Ship Mobile Antenna (800 MHz)	TBD	CRB submission being prepared.
016A	Gateway Stations	SED	Contract awarded to SED on 25 May.
016B	Central Control Station	TBD	RFP issued in May.
017	Mobile and Portable Stations	TBD	Submission to be prepared
022	Program Cost Analysis (Ground segment)	TBD	No action yet. This contract will require output from contracts currently underway.
034	MUSAT Stations	TBD	(To be managed by DND)
<u>SYSTEM STUDIES</u>			
014	Mission and Operation Analysis, and System Availability	TBD	Submission for competitive contract approved by CRB April 30, incorporating 024 and 037 into 014. RFP delayed pending further direction on Canadian option requirements.
023	Program Cost Analysis	TBD	No action yet. Scheduled to be awarded later this year.
027	Frequency Interference Study	CAL	Contract awarded 10 April
024	Operations Analysis	Combined with 014 above.	
031	Computational Requirements	GASTOPS	Contract review meeting held April 22 Proceeding satisfactorily, with completion scheduled for 31 August 1981.

MSAT CONTRACT STATUS (cont'd)

CONTRACT DESIGNATOR	CONTRACT TITLE	CONTRACTOR	CURRENT STATUS
<u>SYSTEM STUDIES</u> (cont'd)			
035	Canadian Option	CAL	Contract awarded to CAL in June. Draft final report to be delivered by end Sept. '81.
037	System Availability	Combined with 014 above.	
<u>TECHNOLOGY DEVELOPMENT</u>			
004A	Flexibility Assessment	Dynacon	Study completed 31 March on schedule. Final report received. Closed.
004B	Attitude Control	Ancon	Study completed 31 March on schedule. Final report received. Closed.
004C	Attitude Control	Spar	Study completed 31 March on schedule. Final report still in preparation.
005	State-of-the-art in RCS	Spar	Study completed by 31 March on schedule. Final report received. Closed.
006	Thermal Control	Spar	Study completed by 31 March on schedule. Final report still in preparation. Further work in this area using Accelerated R&D funds is anticipated.
015	Modulation Coding	In-house & contract(?)	Work continuing in-house on modulation techniques. \$25K allocated for future contract.

MSAT CONTRACT STATUS (cont'd)

CONTRACT DESIGNATOR	CONTRACT TITLE	CONTRACTOR	CURRENT STATUS
<u>TECHNOLOGY DEVELOPMENT</u> (cont'd)			
018A	Application of Micro- processors - General	Spar A & CSD	Contract on design of microprocessor-based attitude control system expected to be awarded to SPAR by 31 May. (DSS Bridging funds and ICF).
018B	Application of Micro- processor - Spacecraft	Spar SSD	Contract on microprocessor applications in MSAT class spacecraft has been recommended to be directed to SPAR using DSA funds.
018C	Microprocessor Architecture	TBD	Open tender contract under consideration. To develop software and architecture for microprocessor applications in MSAT spacecraft.
019A	Dynamics and Control	Dynacon	Contract completed on schedule 31 March. Final report received. Closed.
019B	Dynamics and Control	Spar	CRB submission for directed contract to Spar approved April 30. Estimated start of work is June 1.
019C	Dynamics and Control	Dynacon	Directed contract to Dynacon approved by CRB. Contract award expected in mid June.
029	High Efficiency Linear Amplifier	Spar	Approval given for use of ICF funds to transfer CRC-developed technology to Spar.
030	Local Oscillator Stability	TBD	Scope of work under consideration. Possibly to be funded out of Base G&S.
036	Propagation and Interference measurement	In-house	Preliminary results have been obtained on foliage attenuation measurements.

ANNEX D

COMMERCIAL VIABILITY ANALYSIS

OF FOLLOW-ON OPERATIONAL SATELLITE

### PRELIMINARY ESTIMATES OF USER COSTS

Three cost models for a dedicated Canadian satellite have been examined. Common characteristics are:

- a. Traffic intensity - 0.0125 Erlangs per subscriber  
(Two 3 minute calls in the 8 hour busy period)
- b. Grade of service - P.10
- c. STS launch and IUS insertion into GEO
- d. Two in-orbit satellites and one ground spare
- e. Satellite life 7 years

#### Cost Model 1

210,000 subscribers

160 foot Antenna

39 beams

68 Traffic channels and 2 channels for signalling and network management per beam

M 1980 \$CA

Program Year	1	2	3	4	5	6	7	8	Total
Non Recurring Costs	85	100	43						228
Spacecraft X3			30	39	43	50	41	31	234
Launch X2			10	23	32	23	15	3	106
Gateways X39				8	28	35	1		72
Central Control Station				2	3	5	2		12
TOTAL	85	100	83	72	106	113	59	34	652



Cost Model 2

150,000 subscribers

160 foot antenna

39 beams

49 Traffic channels and 1 channel for signalling  
and network management per beam

M 1980 \$CA

Program Year	1	2	3	4	5	6	7	8	Total
Non Recurring Costs	78	92	39						209
Spacecraft X3			29	37	41	48	39	30	224
Launch X2			10	23	32	23	15	3	106
Gateways X39				8	28	35	1		72
Central Control Station				2	3	5	2		12
TOTAL	78	92	78	70	104	111	57	33	623

Cost Model 3

70,000 subscribers

105 foot antenna

20 beams

45 Traffic channels and 1 channel for signalling and  
network management per beam

M 1980 \$CA

Program Year	1	2	3	4	5	6	7	8	Total
Non Recurring Costs	67	79	34						180
Spacecraft X3			27	35	38	45	37	28	210
Launch X2			10	23	32	23	15	3	106
Gateways X20				4	14	18	1		37
Central Control Station				2	3	5	2		12
Total	67	79	71	64	87	91	55	31	545

33.3% Capacity Initial Subscribers, Linear increase  
over five years to system Capacity

Model 1, 210,000 Subscribers

Program Year	1	2	3	4	5	6	7	8	9	10	11	12	13
Cash Required	85	100	83	72	106	113	59	34					
Investment	85	194	296	398	544	711	841	836	775	683	559	398	208
Return on Investment	9	19	30	40	54	71	84	84	78	68	56	40	21
Depreciation							121	120	120	120	120	120	120
Revenue at \$149 per month							150	200	250	300	350	375	375
Taxes							2	25	50	73	98	110	110
Expenses							25	30	30	35	35	35	35
Investment Write Off							123	145	170	192	217	230	230

Model 2, 150,000 Subscribers

Program Year	1	2	3	4	5	6	7	8	9	10	11	12	13
Cash Required	78	92	78	70	104	111	57	33					
Investment	78	178	274	371	512	674	798	795	737	652	534	380	199
Return on Investment	8	18	27	37	51	67	80	80	74	65	53	38	20
Depreciation							114	114	114	114	114	114	114
Revenue at \$200 per month							144	192	240	288	336	360	360
Taxes							3	24	46	70	94	106	106
Expenses							25	30	35	35	35	35	35
Investment Write Off							116	138	159	183	207	219	219

Model 3, 70,000 Subscribers

Program Year	1	2	3	4	5	6	7	8	9	10	11	12	13
Cash Required	67	79	71	64	87	91	55	31					
Investment	67	153	239	327	447	583	696	693	638	560	455	323	167
Return on Investment	7	15	24	33	45	58	70	69	64	56	46	32	17
Depreciation							100	100	100	99	99	99	99
Revenue at \$355 per month							119	159	199	239	278	298	298
Taxes							5	25	42	63	80	90	90
Expenses							10	10	15	15	20	20	20
Investment Write Off							104	124	142	161	178	188	188

Return on Investment 10%

Tax Rate 50%

Taxes = (Revenue - Depreciation - Expenses) X Tax Rate

Investment =  $\sum$  (Cash + Return on Investment - Investment Write Off)

Model 1- 68 Channels per Beam, 39 Beams

Common User Channels Per Beam	67	66	63	50	30	20
Common User Subscribers	209K	206K	197K	155K	88K	55K
Annual Revenue at \$149 Per Month	374M	368M	351M	276M	157M	98M
Required Annual Revenue	375M	375M	375M	375M	375M	375M
Dedicated Channels Per Beam	1	2	5	18	38	48
Required Revenue Dedicated Channels	1M	7M	24M	99M	218M	277
Dedicated Channel Cost Per Month	2.6K	7.3K	10.1K	11.7K	12.3K	12.3K

Model 2 - 49 Channels Per Beam, 39 Beams

Common User Channels Per Beam	48	47	44	40	30	20
Common User Subscribers	148K	145K	134K	121K	88K	55K
Annual Revenue at \$200 Per Month	355M	347M	323M	290M	210M	132M
Required Annual Revenue	360M	360M	360M	360M	360M	360M
Dedicated Channels Per Beam	1	2	5	9	19	29
Required Revenue Dedicated Channels	5M	13M	37M	70M	150M	228M
Dedicated Channel Cost Per Month	10.8K	14.1K	16.0K	16.5K	16.8K	16.8K

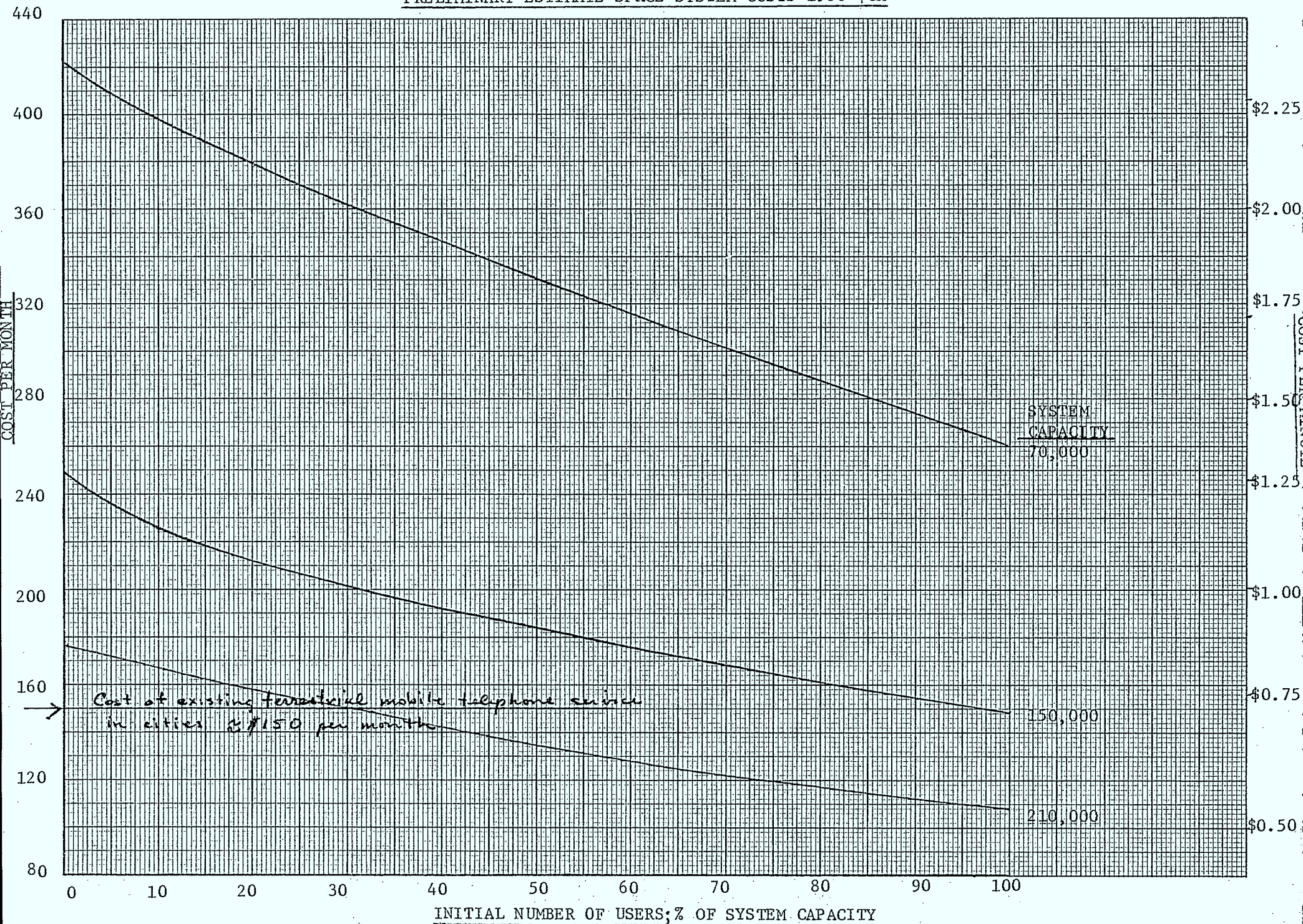
Model 3 - 45 Channels Per Beam, 20 Beams

Common User Channels Per Beam	44	43	40	35	30	20
Common User Subscribers	69K	67K	62K	53K	45K	28K
Annual Revenue at \$355 Per Month	294M	286M	264M	228M	192M	120M
Required Annual Revenue	298M	298M	298M	298M	298M	298M
Dedicated Channels Per Beam	1	2	5	10	15	25
Required Revenue Dedicated Channels	4M	12M	34M	70M	106M	178M
Dedicated Channel Cost Per Month	17.9K	24.3K	28.0K	29.2K	29.6K	29.7K

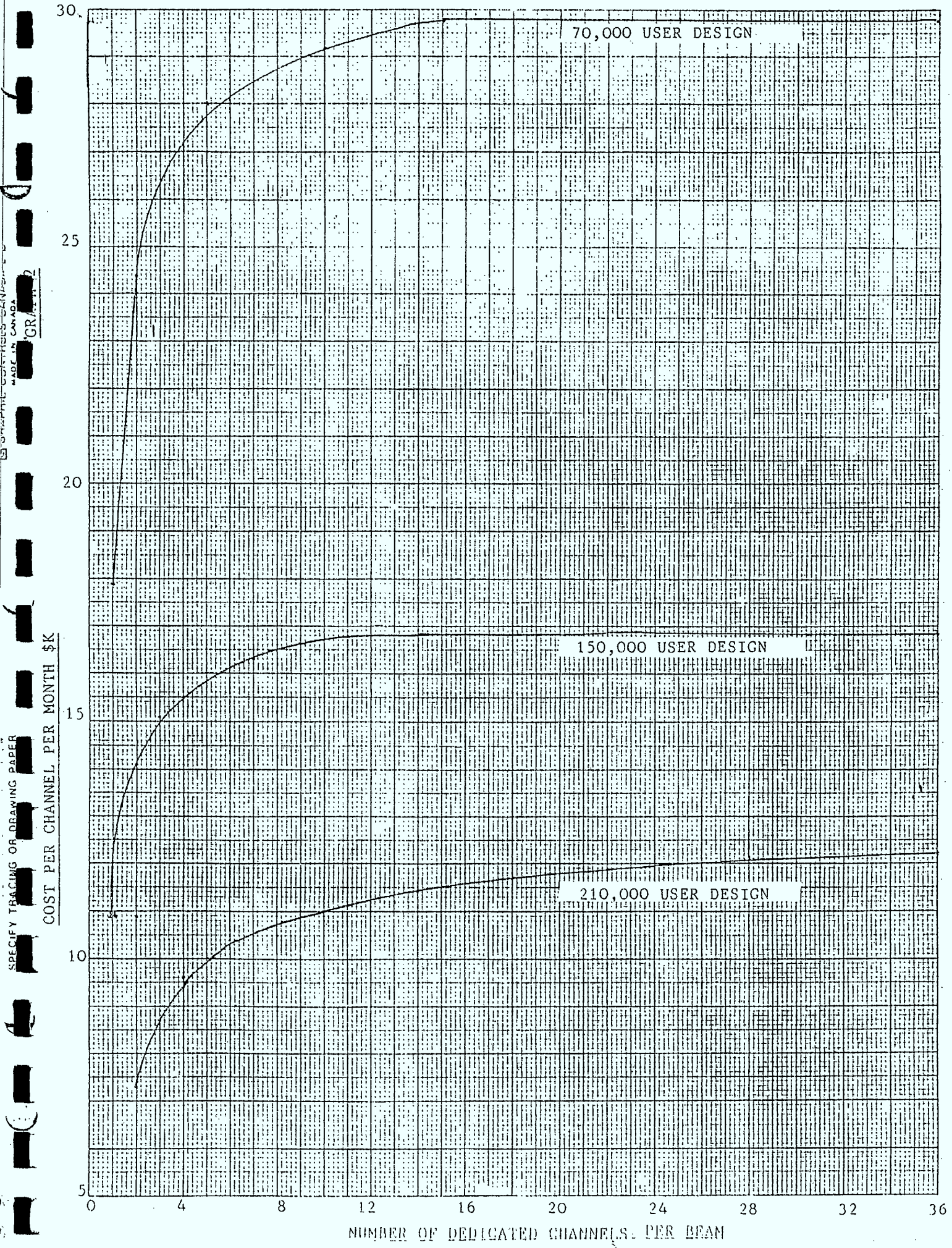


GRAPH 1

PRELIMINARY ESTIMATE SPACE SYSTEM COSTS 1980 \$CA







GRAPHIC COURTESY OF CANADIAN  
MADE IN CANADA  
GR

SPECIFY TRACING OR DRAWING PAPER  
COST PER CHANNEL PER MONTH \$K

NUMBER OF DEDICATED CHANNELS PER BEAM



37005

MSAT, mobile communications...

TK  
6570  
M6  
C3647  
1981  
v.1

DATE DUE

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