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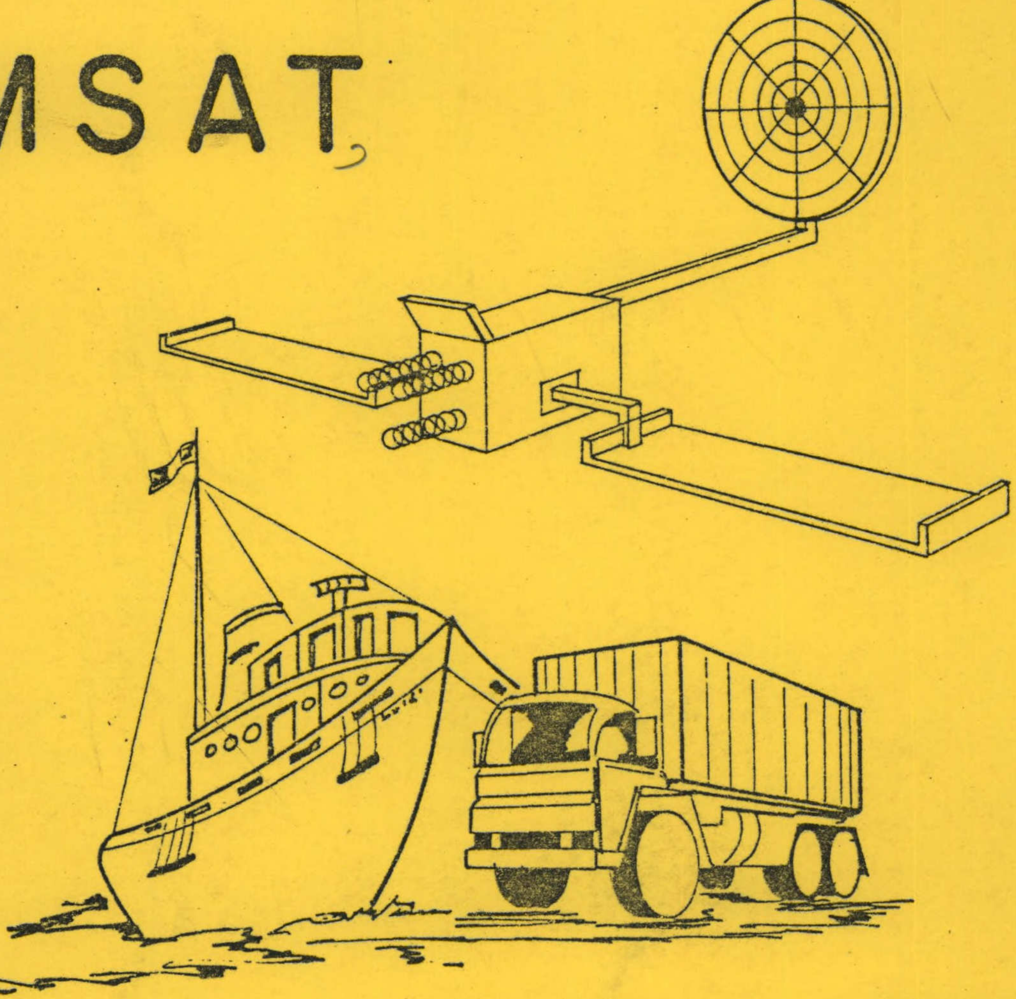

MOBILE COMMUNICATIONS VIA SATELLITE

INTERIM REPORT

JUNE 1981

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INTERIM REPORT
ON
MOBILE SATELLITE PROGRAM

DEPARTMENT OF COMMUNICATIONS

SPACE PROGRAMS

24 JUNE, 1981

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1. INTRODUCTION

The purpose of this interim report is to provide preliminary information on the planning of the Mobile-Satellite (MSAT) Program including factors relevant to the timing of the Program.

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

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* Expression meaning satellite service to mobile terminals.

Woods Gordon Market Survey are presented showing a very substantial market with 140,000 mobile terminals to be served via satellite by year 2001 and 285,000 by the year 2005 - 2010, 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 perecentage 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 140,000 mobile terminals by year 2001, would be satisfied with a commercial follow-on system to MSAT. The smaller military need for several hundred mobile termnals 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 satelllite 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 inferfere 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 provide a comercial maritime-mobile service for international shipping in the Atlantic, Pacific and Indian Oceans from about 1982. The system will operate at 1.5-1.6 GHz, and will provide a continuation of the first-generation maritime-mobile service introduced by Comsat General of the U.S. with its MARISAT system. Teleglobe Canada will be the operating entity for INMARSAT.

INMARSAT's first generation system will not provide full coverage of the Canadian Arctic because the volume of traffic from this area is not expected to be sufficient for an economically viable service. For this reason DOC is considering, as a possible option on MSAT, a payload to provide maritime mobile coverage of Arctic waters on an experimental basis.

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 vice 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. (Bell Canada has recently made a submission(1) to the Minister of Communications on the introduction of 800 MHz cellular mobile systems in Canada.)

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 for Canadian Arctic waters.

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

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

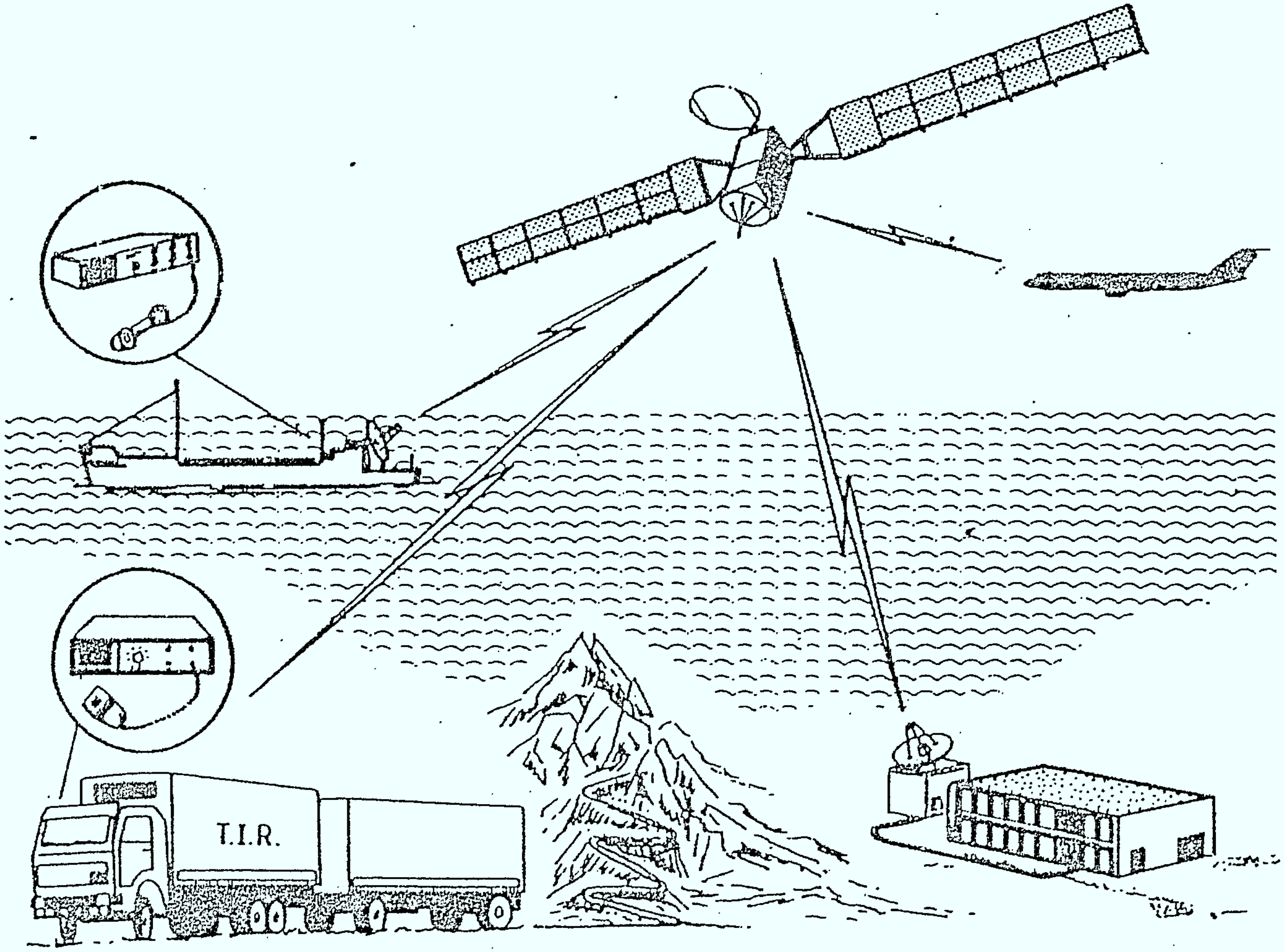


FIGURE 1. SATELLITE SERVICE TO MOBILE TERMINALS

follow-on operational system during the period 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 140,000 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

Year	Number of Mobiles in Potential Market (1) ('000 units)	Number of New and Replacement Mobiles in Year ('000 units)	Projected MSat Share of New Mobiles (%)	Projected MSat Share of New Mobiles ('000 units)	Cumulative MSat Mobile Population ('000 units)
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)

		Projected Number of Mobiles				
Industry Sector	1981 Airtime/Mobile (min/month)	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.	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)

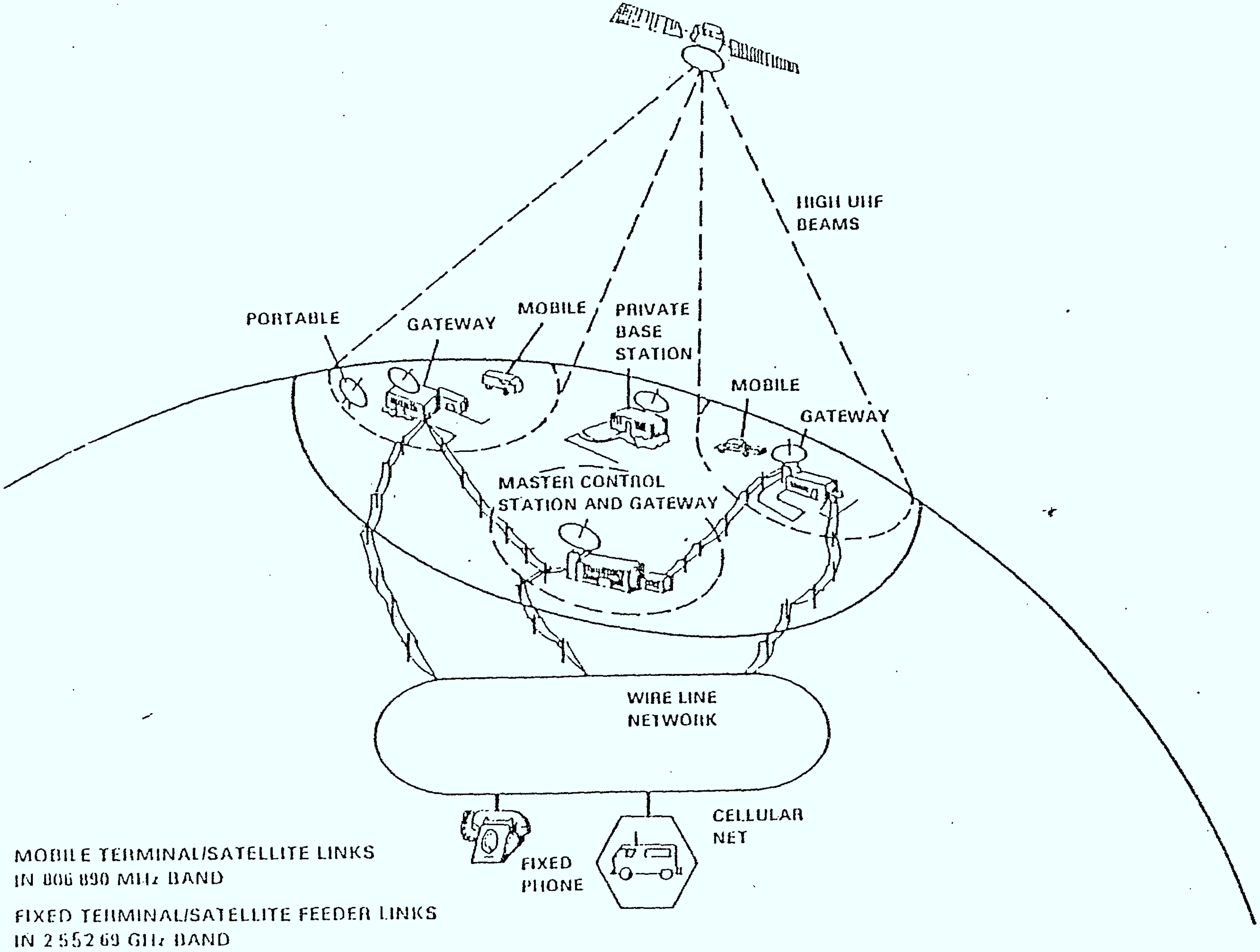
the Canadian Radio Common Carriers Association, the Canadian Petroleum Association Communications Committee (CPACC), and a number of companies that are users of PRS systems. All of these organizations expressed a keen interest in the MSAT Program, and believed there would be an extensive market for the 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(6) 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, TCTS and others). In general, the carriers 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 would operate with INMARSAT-compatible terminals and would provide coverage to vessels in those Canadian Arctic waters that are not covered by the first generation INMARSAT System which will continue 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. Teleglobe is the Canadian operating entity in INMARSAT, and institUttional arrangements would have to take this into consideration.

3.2.3.2 User Requirements

The inclusion of this payload on MSAT would provide a maritime mobile service to government, shipping industry, and resource industry users that would be operationally compatible with INMARSAT.

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.

A study(2) has been conducted for the petroleum industry regarding safe passage in the Arctic and Altantic 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.

3.3.1.1 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.

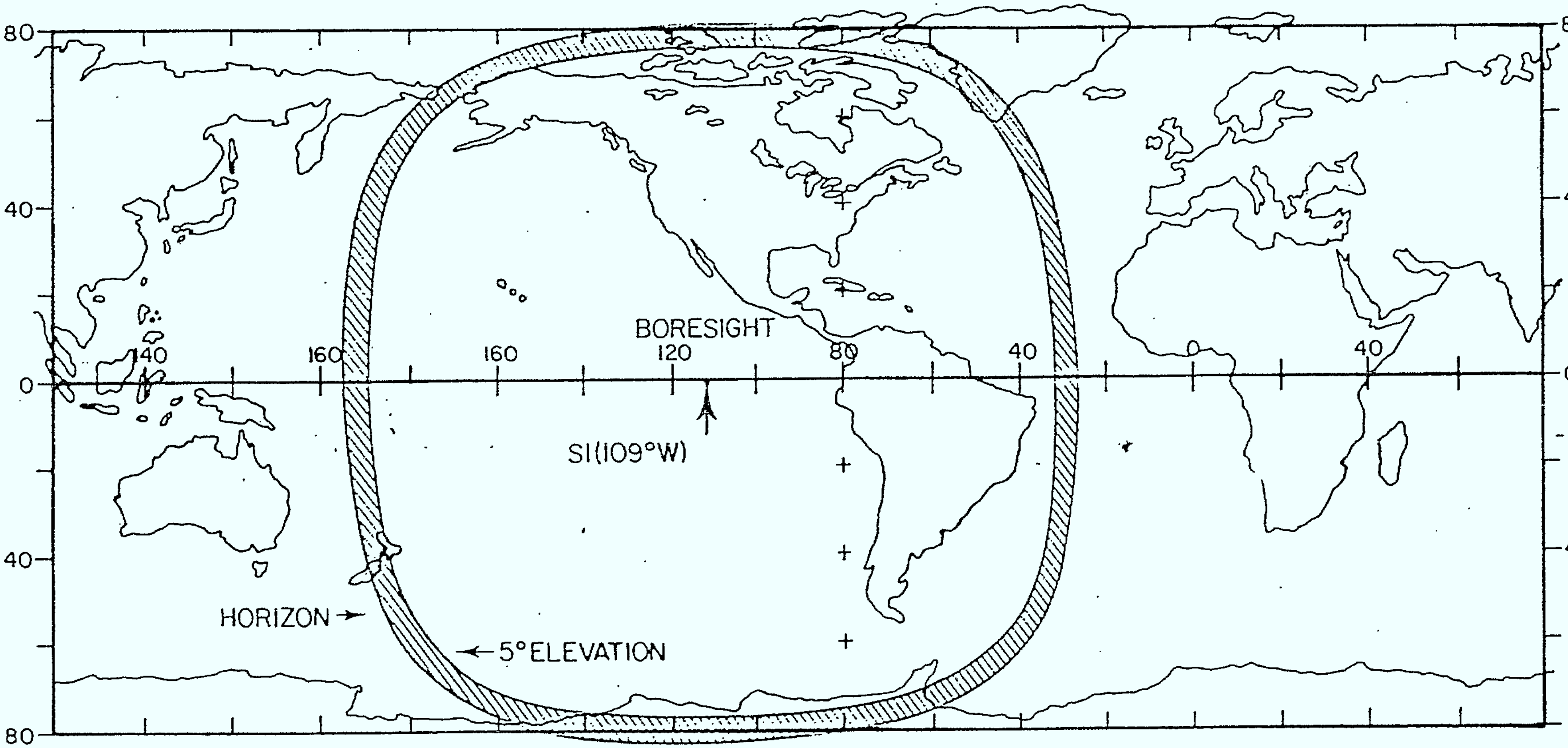


FIGURE 3. SATELLITE COVERAGE AT UHF AND SHF

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 following are descriptions of the six principal contracts:

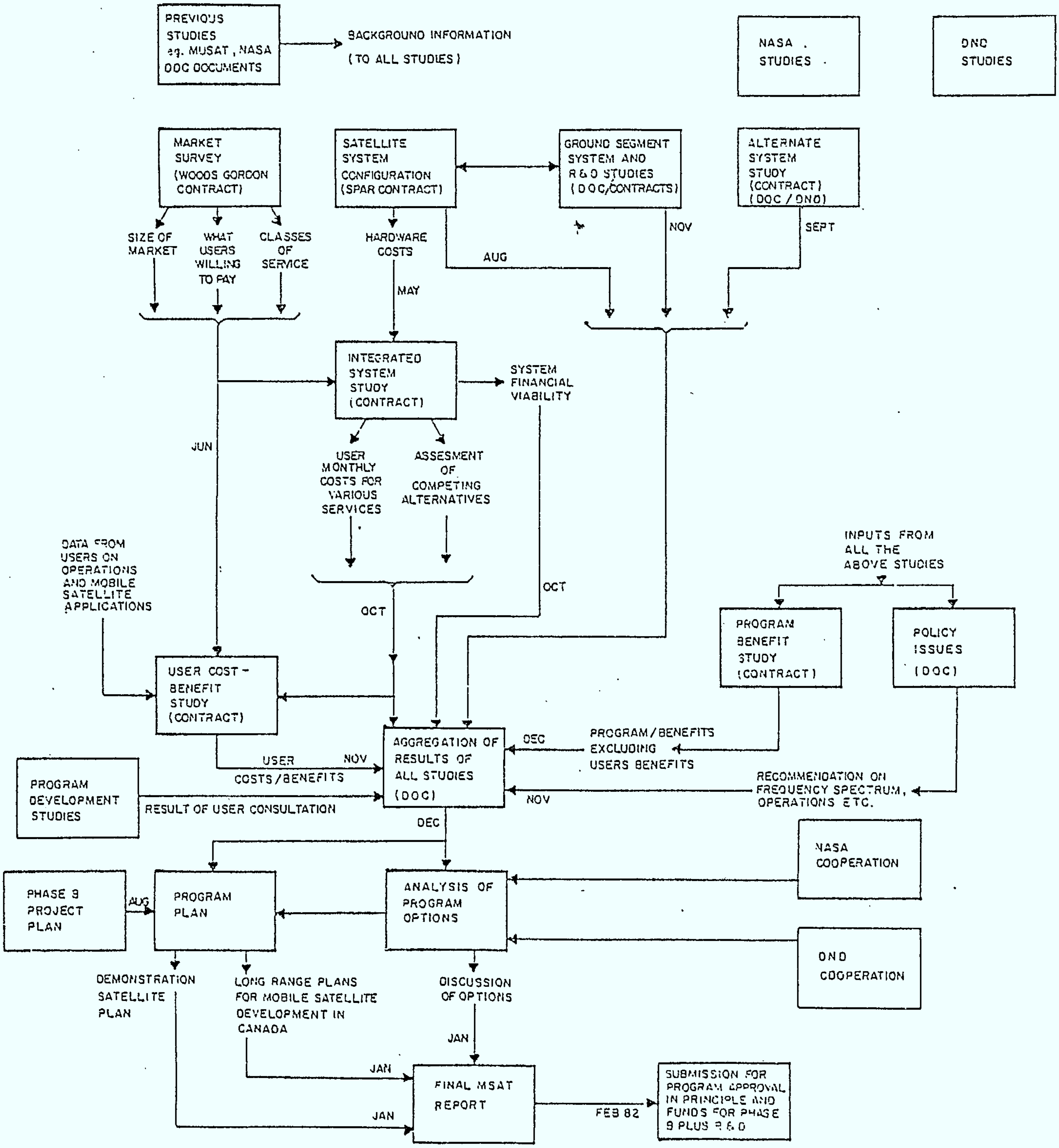


FIGURE 4. FLOW CHART OF MSAT PHASE A STUDIES

(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 Aerospace Ltd. 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. Fiqure 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.

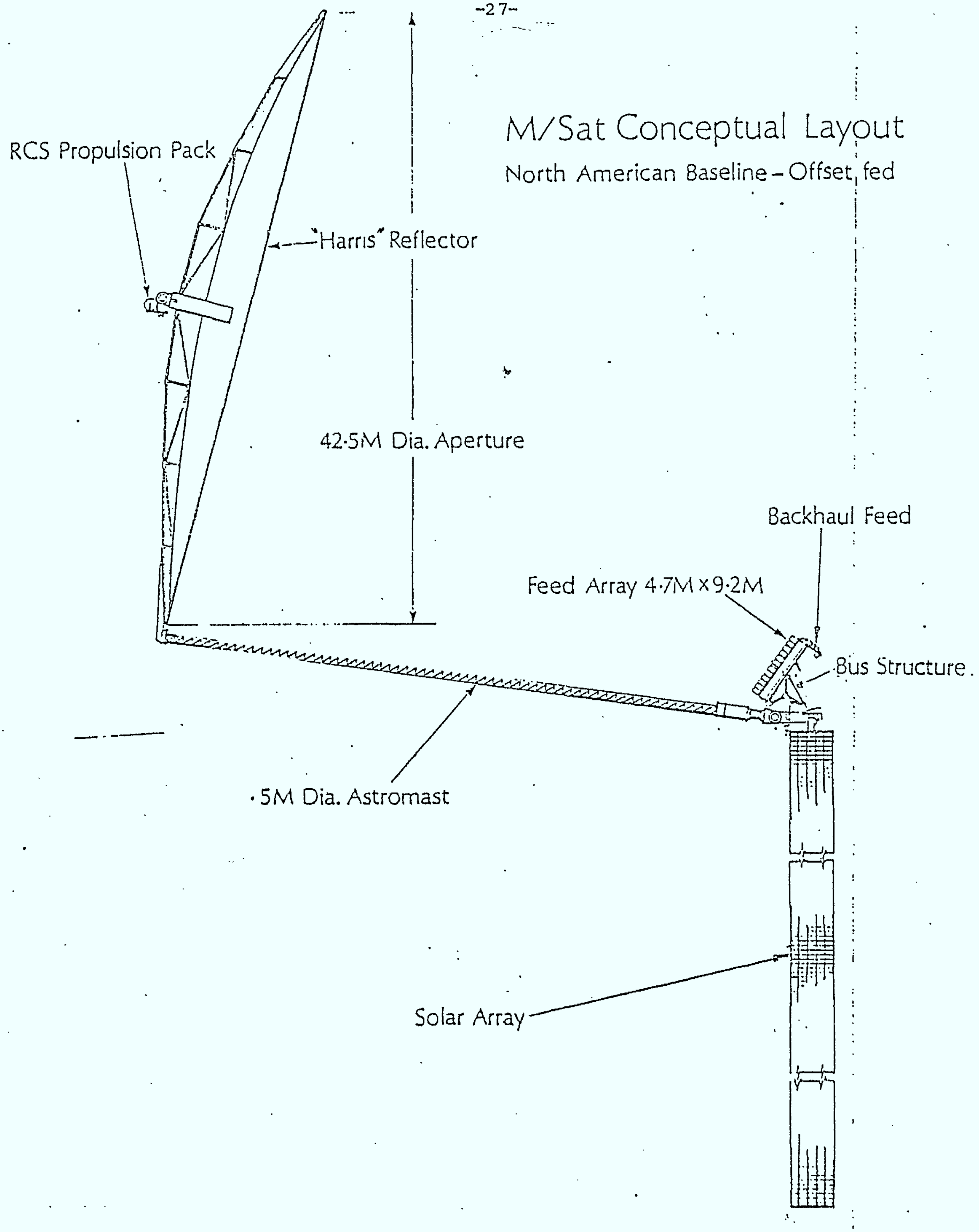


FIGURE 5. SPAR SPACECRAFT CONCEPT FOR FOLLOW-ON SYSTEM OF MID 1990'S

(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. A Canadian prime contractor for the space segment was envisaged. 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 and reduce program risk. 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 comparision 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.

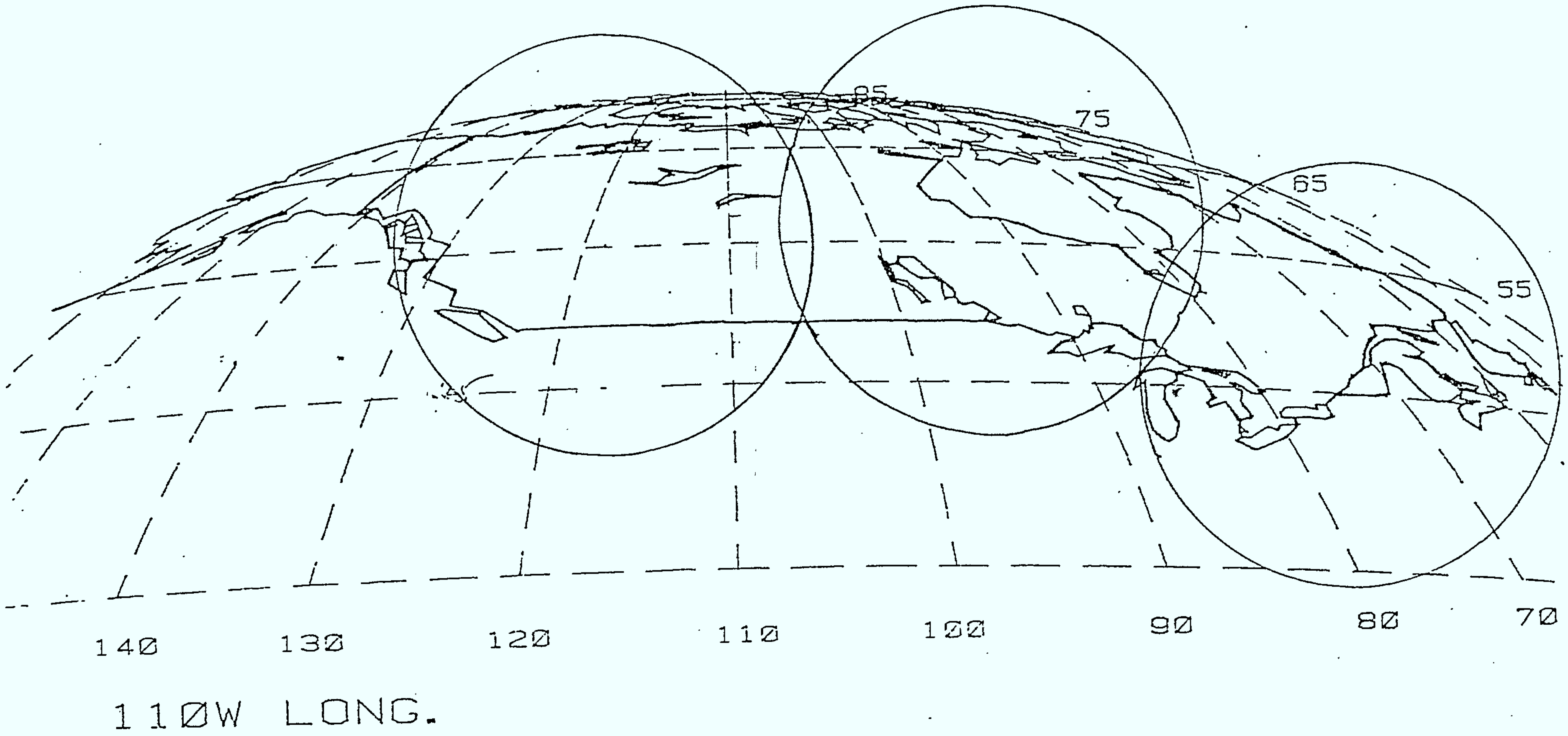


FIGURE 6. MSAT FOOTPRINT FOR 9M ANTENNA

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	111 FM ch or 692 LPC ch	6 FM ch or 37 LPC ch	5-14 FM ch or 31-90 LPC ch
(b) DOC payload	134 FM ch or 833 LPC ch	12 FM ch or 79 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 held in abeyance 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 imcompatability 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 later this year 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 has appealed 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	- Supports full DOC and DND payloads - Permits development of MSAT FM mobile-telephone - Possibility of sharing of spare bus with ESA - Adequate capacity for NASA participation - Compatible with shuttle and Ariane - Could be used for small follow-on op system	- In early states of development - Some schedule uncertainty - Shuttle launch requires IUS and costly - Program more costly
SATCOM	- Fully developed operational bus - Lower technical risk and cost - Compatible with shuttle, Delta and probably Ariane launch vehicles	- Will permit technical demonstration only of FM MSAT mobile telephone service - Small channel capacity
LEASAT	- Design optimized for low shuttle launch cost	- Will permit technical demonstration only of FM MSAT mobile telephone service - Development not completed - No back-up to shuttle launch - Small channel capacity

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 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 DOC 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 possible 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. 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

Program Phase	FY								Total
	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	
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		$205M

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 M

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 M

TABLE 7.3

	L-SAT			LEASAT			SATCOM		
FY	Govt-Buy	Lease	Hybrid	Govt-Buy	Lease	Hybrid	Govt-Buy	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	71	34	70	47	31	60	44
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	$529M	$238M	$490M	$398M	$205M	$420M	$343M

1981 Canadian dollars

(DOC estimates - not based on proposals from industry.)

Figure 7.4 Comparison of Cash-flow for Financing Options (Table revised-9 July 1981) 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 consistant 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

GOVT-BUY

ENTITY	PROS	CONS
DOC	- DOC has major involvement in MSAT technology development - Minimum total cash-flow by DOC	- large capital peak during procurement phase - Telesat may not be involved in service development and delivery - full cost-recovery by DOC from users with commercial benefit stretches DOC mandate.
DND	- DND has maximum control over satellite - Minimum total cash-flow by DND - Significant involvement in satellite communications systems engineering	- budgeting problems in early 1980's when funds needed for early phases. - capital peak during construction phase.
Telesat		- Loss of major business opportunity involving growth in investment and profits - Loss of spin-off benefits associated with company development and new procurement project for engineering division. - Transition to follow-on commercial system more difficult than in other options.

TABLE 7.5

TELESAT-LEASE

ENTITY	PROS	CONS
DOC	- Good approach in principle for service development	- Lease charges may be too high - DOC has little or no involvement in MSAT technology development
DND	- May relieve budgeting problem in early 1980's as no funds are needed until 1986 for the space segment lease payments	- Lease charges may be too high - Satellite is not under exclusive DND control
Telesat	- Very significant growth in investment, and potentially in profit - New business area	- Technical risk is high - Commercial risk may be unacceptable unless lease agreements are negotiated in advance.

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.

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 8.3.1 and 8.3.2 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 has been carried out for the three models(7), and is summarized below:

Number of Users	Ground and Space Segment Costs M $1980 Can.
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 D are:

Number of Users	Space and Ground Segment Charges	Mobile Radio Leasing Charges	Average Toll Charges	Total User Charges
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 meterological 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(4) 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(5) prepared by the Mitre Corporation estimated the U.S. benefits of mobile-satellite services in federal law enforcement 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 equiped 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 progessive 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

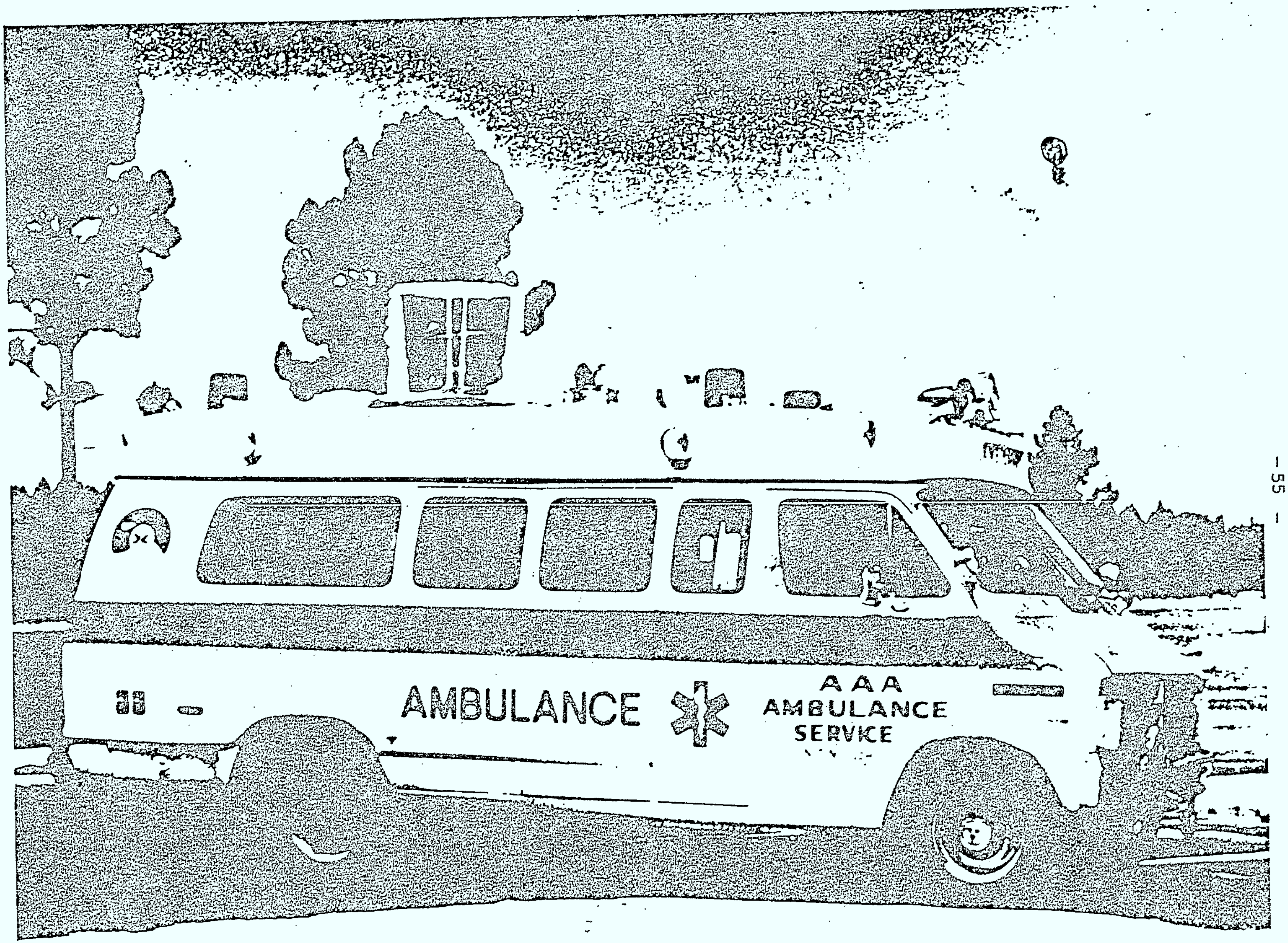


FIGURE 7.

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

The Canadian aerospace industry will benefit from developing public mobile and military payloads, solar arrays and power subsystems, and various other microprocessor-contolled 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 currently assessing several options for possible participation in the mobile-satellite program.

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 if 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 will explore 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 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			
- public and civil gov. mobile, large demonstrated 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.
- premium service to resource industry, urgent demonstrated need	1986 experimental service start	SEVERE	Considerable loss of revenue due to inefficient operations, slow-down of exploration and resource development
- military mobile UHF	1986-1988 service start	MODERATE	Less effective capability for national defence.
EHF	1990		
Spectrum/Orbit Availability			
- public mobile 806-890 UHF	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 the need for low-gain ground antennas.
Readiness to Proceed	1986 launch		
- industry		CRITICAL	Timing of a program such as MSAT would have a major effect on loading of the Canadian Aerospace industry. A Phase B start in 1982 would be optimum, whereas a later start could have severe consequences on the industry. Without a major program start about this time, the resultant slack period would result in the dispersion of a highly trained work force.
		MODERATE	Telesat seeks MSAT as an opportunity to possible growth, diversity and stability; delay to 1990 launch may also interfere with ANIK E, F system procurements.
- government		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			
- NASA	1986-1990 launch	MODERATE	NASA could contribute more resources to a program having a later (i.e. 1990) launch, although because of consequences of such a late service-development start, NASA wishes to examine earlier participation in a smaller program.
- ESA		SEVERE	An opportunity to negotiate reduced cost of an LSAT bus will be lost if launch slips beyond 1986.

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