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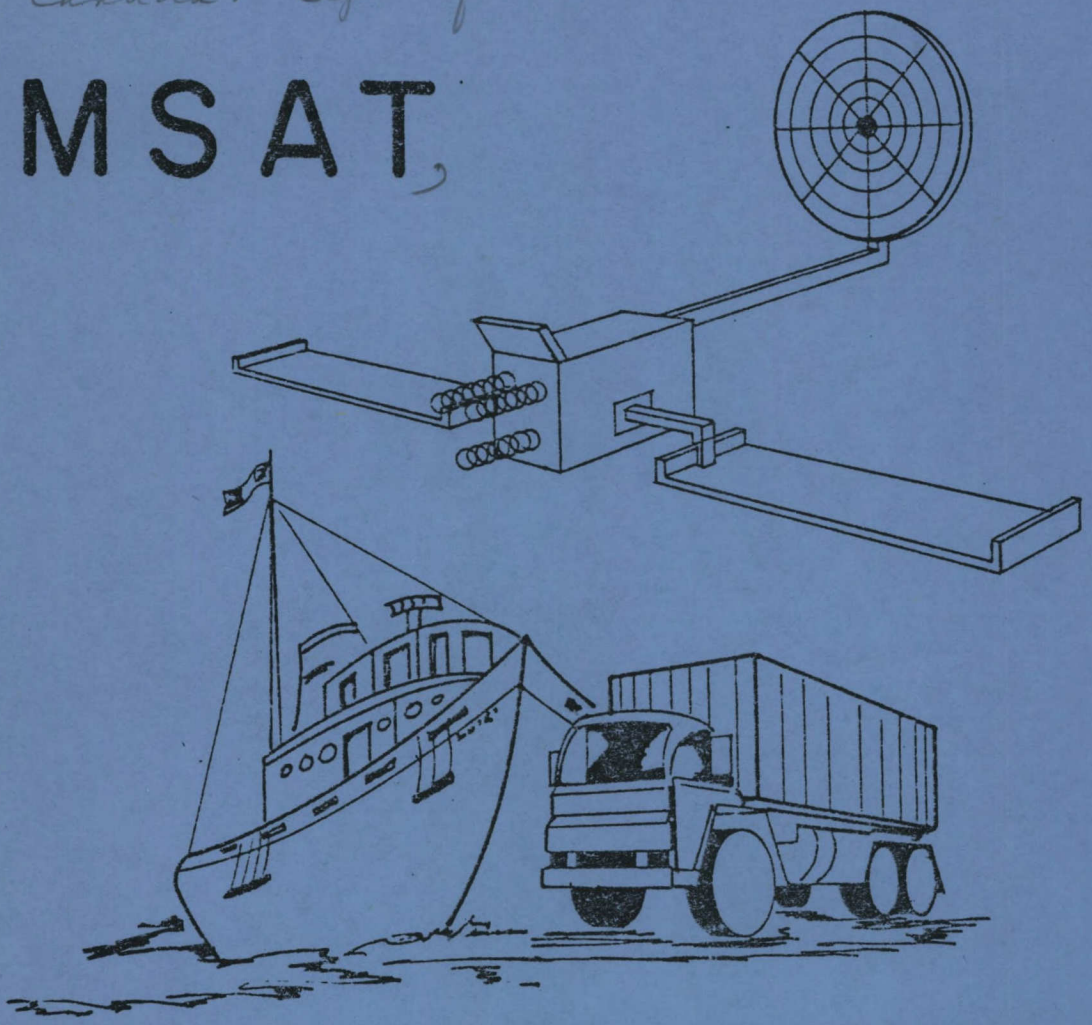

MOBILE COMMUNICATIONS VIA SATELLITE,

EXECUTIVE SUMMARY
REPORT TO MOSST
JUNE 1981

MOBILE SATELLITE PROGRAM SUBMISSION TO MOSST
JUNE 1981
EXECUTIVE SUMMARY

Purpose

This submission is intended to provide information on the Mobile Satellite Program necessary for a government decision on the relative timing of this program and a RADARSAT Program.

Background

The objective of the Mobile Satellite (MSAT) Program is to provide a facility to satisfy urgent national needs for improved mobile communications to under-served areas of Canada, including the resource development activities in the North. The MSAT Program will develop, manufacture and launch a UHF communications satellite as required to introduce satellite service to mobile terminals in Canada in the most cost-effective and timely manner and to contribute effectively to industrial development. This is in direct response to the DOC mandate to foster the development of telecommunications services and obtain optimum benefits for Canada in the short and long term. By year 2000 there is a projected public and civil government need for 285,000 mobile terminals and a military need (to be confirmed) for several hundred mobile terminals.

The public and civil government service capability will be used for communications experiments, trials, pilot projects, and for premium service delivery to the resource industry in remote areas. Service proposed for DND as an optional capability on MSAT will be largely pre-operational in nature, with some experimental capacity. Overall program benefit-cost will be maximized by including separate payloads for both DOC and DND, by including NASA as an international partner, and through a 1986 launch for a 7 year mission.

DOC is presently conducting concept definition studies of a mobile satellite program, as approved by Cabinet on 27 August 1980 at a cost of $2.2M, beginning in October 1980 and scheduled for completion in December 1981.

Requirements

Service development requirements for public mobile and civil government use include:

- mobile satellite service at 806-890 MHz
- sensor data collection service at 401-403 MHz
- maritime mobile service at 1.5-1.6 GHz

a) Public and Civil Government Mobile Satellite Service

Public and civil government mobile satellite service became possible in 1979 with the WARC decision to allocate the 806-890 MHz band for shared satellite-terrestrial mobile use in Region 2. The arrangements for sharing of the 806-890 MHz band between terrestrial and satellite systems is an important issue presently being studied by DOC. The public and civil government mobile satellite service will permit expansion of coverage to rural and remote areas of vehicular mobile telephone systems (MTS) and of private mobile radio systems (PRS). These services will include advanced digital techniques for optimum power and spectrum conservation, and will be capable of operation with aircraft, shipborne, transportable, field-portable and personal-portable terminals. Users of the private radio service will include federal and provincial governments for law enforcement, coast guard service, fisheries and resource management, forest protection, ambulance services, emergency disaster and highway services. Private radio users also include resource industries, public utilities, and fleet transportation. The mobile telephone service will include all those above who require interconnection with the switched telephone network, as well as various professional and business groups. Both an in-house and a major contracted study have been undertaken to ascertain the quantity of demand and acceptable rates for public and civil government mobile service in the 1985-2000 timeframe. The principle findings are:

- MSAT market penetration is projected at 48,000 user terminals by 1993 and 285,000 user terminals by 2001
- All present federal and provincial mobile users keenly interested
- resource industry has an urgent demand for premium service.
- common carriers see large demand and want involvement in developing mobile-satellite services

b) Sensor Data Collection Service

This service involves the collection, by federal and provincial governments, of meteorological, hydrological, glacialogical, oceanographic and pollution data from unattended remote sensor platforms, which is transmitted via satellite for central processing and distribution to various users. At least 230 platforms are presently operated in Canada with the US GOES satellite. Several hundred more platforms are required by 1990.

c) Maritime Mobile Service

This is required to complement INMARSAT system coverage in Canadian Arctic waters, and allow compatible operation with INMARSAT terminals in these areas. It is estimated by the shipping and petroleum industries and the Canadian Coast Guard that more than 100 vessels require mobile service in Canadian Arctic waters in the 1990s.

Formal satellite communications requirement documents have not yet been approved by DND. However, based on consultations wth DND potential service requirements for DND include:

- mobile-satellite service at 240-400 MHz
- fixed-satellite service at 7/8 GHz
- experimental mobile and fixed service at 20/44 GHz
- experimental emergency beacon monitoring service at 406.1 MHz

a) Military Mobile Satellite Service

This will be a fully interoperable service with the US military at 225-400 MHz for voice, data, teletype and FAX, and for land, sea, and air mobile tactical application. Communications and satellite command links will be secure and ECM protected. In the 1995 time frame there is a potential requirement for 40-50 duplex satellite channels, and for 50 vehicular and manpack terminals, 24 shipborne terminals, and for 100 airborne terminals.

b) Military Fixed Satellite Service

This will provide DND with a secure, strategic communications network between military bases in Canada using fixed and transportable terminals. This service will be fully interoperable with the US military system. The potential requirement is for 8 fixed stations in Canada, 12 transportable stations for military bases and 16 tactical terminals for use in the NORAD theatre. External Affairs also wishes secure communications to various embassies.

c) Military Experimental Service

DND wishes to demonstrate and develop a military satellite communications capability at 20/44 GHz, with high anti-jam capability for fixed and mobile service to land and sea terminals. This will allow DND to introduce military EHF operational services in the late 1980s which will be interoperable with those of NATO allies.

d) Experimental Emergency Beacon Monitoring Service

Distress signals from aircraft, ship or field parties will be monitored by the satellite to provide immediate identification and notification of a distress incident. This service will be complementary to SARSAT, which provides the location of an incident, but only on a periodic basis. In 1980 there were 589 Emergency Locator Transmitter (ELT) alerts which required a DND response, and the number of distress beacons is now growing substantially for private vehicle use.

None of these services can be provided by the existing Telesat ANIK satellites which operate at 4/6 GHz and 12/14 GHz. The present ANIK satellites provide services to fixed terminals serving cities and small communities while the MSAT system will develop services for compact mobile terminals in vehicles, aircraft, and ships. Mobile-satellite service is technically impractical and too costly to implement in the 4/6 GHz and 12/14 GHz bands. Terminal antenna size needed to avoid uplink interference with other satellites are too large for installation in vehicles, aircraft and small vessels. 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.

Phase A Studies

On August 27, 1980, Cabinet approved the expenditure of $2.2M in FY 80/81 and 81/82, for DOC studies for definition of a Mobile-Satellite Program. These studies cover concept definition and feasibility in sufficient detail to enable a Cabinet submission for a full program in early 1982. The more specific objectives then, are to study needs, benefits, system concepts, technology, alternatives, costs, policies and to formulate a long-range plan for the development and introduction of mobile satellite services in Canada.

Program and project offices were established and staffed in DOC in October 1980, and a work plan is presently being executed which involves about 15 DOC staff, some part time DND staff, and a package of some 30 contracted studies. This study phase is scheduled for completion in December 1981. Major contracted studies include:

i) mobile satellite market survey (to determine the type and size of market as a function of cost),
ii) integrated system study (to determine the best integrated terrestrial-satellite mobile system in Canada)
iii) spacecraft configuration study (feasibility and cost of demonstration and later operational spacecraft),
iv) alternate systems study (to study alternate spacecraft concepts using proven bus design),
v) user cost-benefit study (for specific user populations) and
vi) program benefit study (economic, industrial and other)
vii) long lead technology development

Program Options

The two major program options presently are:

a) to proceed in January 1982, at the completion of present concept definition studies (Phase A), with Phase B project definition activity on a modest Canadian MSAT which would be

launched in 1986, with proposed NASA and DND participation, for maximum program benefit

OR b) to defer the start of Phase B to 1985, and to then consider joint participation with NASA for development of a large MSAT for launch in 1990.

The first of these options is recommended, based on consideration of:

- need and timing for mobile service development
- broad industrial benefit (service and manufacturing industry)
- maximum benefit-cost
- program risk and consequence of not proceeding

The minimum DOC requirement in each of these options is for an 806-890 MHz payload for service as described earlier, which would provide Canada coverage and allow both FM and digital voice service. Although DOC sees maximum program benefit-cost through inclusion of DND payloads, should this cooperation with DND not be feasible due to requirements or timing, DOC will recommend to Cabinet a dedicated program for service development of public and civil government mobile applications. Ongoing collaboration has taken place with DND over a number of years in the development of satellite systems and program concepts which would respond to DND communications requirements. Collaboration has also taken place with NASA since April 1980 in cooperative studies to define a joint program activity to best meet respective national needs.

Large Mobile Satellite Program (1990 Launch)

This MSAT option was conceived in April 1980 as a joint Canada-US undertaking to develop, manufacture and launch a UHF mobile satellite for the demonstration of new technology, and for the development and provision of experimental and preoperational services. SPAR would be the spacecraft prime contractor, assuming an adequate competence and capability for this very large activity (NASA and DOC must agree). NASA would provide the 50 ft. deployable antenna, 800 MHz payload, and launch. DND would provide a payload involving 225-400 MHz and 7/8 GHz transponders. 800 MHz capacity would be shared between Canada and the US. This mission 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.

Reduced Canadian-led Mobile Satellite Program (1986 launch)

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 capacity, availability, cost and industrial benefits for existing spacecraft buses which have already been developed. Sufficient capacity is necessary to provide DOC, DND and NASA services through adequate payload weight and prime power capability. Availability and cost are important to allow a 1986 launch, reduce program risk, and to size the program to SPAR's capability. Industrial benefits may vary widely depending on what manufacturing arrangements SPAR has with the major bus suppliers. It is important to require a 7 year mission so that sufficient time exists for the procurement of a follow-on commercial system.

The most promising bus options are:

LSAT (ESA) - provides greatest payload capacity, and should optimize industrial benefit.
Can accommodate full DND payload and 9m antenna for 800 MHz (700 voice channels, 3 beams). Full shuttle on Ariane launch.

LEASAT (Hughes) - Can accommodate full DND payload and 4m antenna for 800 MHz (90 voice channels, 2 beams). Optimized for shuttle launch.

SATCOM (RCA) - Can accommodate partial DND payload and 5m antenna for 800 MHz (50 voice channels, 2 beams). Delta, Ariane, or shuttle launch.

The channel capacity above is of field quality only, with six times less capacity for toll quality channels into the telephone switched network. Therefore, only very limited development of mobile telephone service is possible with LEASAT or SATCOM buses, although greater capacity for development of private radio service will be possible. DND is seriously considering participation in this program option (ref - letter Allan to Curran dated 9 June 1981). NASA believes that a specialized mobile market exists, which would pay premium rates for early service, and NASA has undertaken to explore various levels of involvement in an early program option with DOC, as described above.

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

Program Cost and Lease vs Buy

Canadian costs for a demonstration program depend primarily on which spacecraft bus is chosen, on cost sharing with NASA, and on lease vs buy considerations which impact greatly on cash flow considerations.

A comparison of preliminary total program cost estimates (excluding DND payload and terminals) for the various options, in 1981 funds, including 2 spacrcraft, 1 launch, and full ground segment follows:

	$296M	LSAT bus (assume flight spare sharing with ESA)
Canadian MSAT	$238M	LEASAT bus
	$205M	SATCOM bus
Joint Canadian/US MSAT	$700M	new large bus

The Canadian cost is as above less NASA contributions which will reduce launch costs in the first three instances above, and would be approximately 50% of the $700M.

The choice between lease and buy for Canadian MSAT program options is now considered. This choice has a profound influence on the way in which DOC, DND and Telesat carry out their mandates, as well as on the resulting cash flow. Mandates are generally as follows:

DOC - develop services by accepting high risk R&D and sponsoring service trials

DND - buy or lease services under DND control to ensure operational effectiveness

Telesat - procure, own and operate satellite systems to provide domestic commercial satcom services

It is evident that Telest must play a major role in any DOC-sponsored mobile satcom service development in order to best ensure subsequent commercial services and in order to best utilize limited Canadian skills. A hybrid approach is proposed whereby DOC would be responsible for spacecraft development activities up to the test of the engineering and

development models, and Telesat would be responsible for definition and procurement of flight models, and satellite control (DND involvement as required). Launch could be provided as Government Furnished Equipment to permit favorable NASA fee for launch services under a DOC/NASA cooperative agreement. As a variation to the foregoing division of responsibilities, provision would be made on Telesat's flight spacecraft for the carriage of agreed Government Furnished Equipment, developed and procured to meet interface specifications (e.g., TT&C encryption equipment, complete communications payloads). Telesat could contribute to early satellite development through either a service contract to DOC or through capitalizing its costs as part of the future flight model procurement program. DOC and DND would then lease mobile satellite service from Telesat. This approach has the advantage of significantly stretching the cash flow through the mission life, and also allowing industry development through Telesat's earned return on investment. A detailed cost comparison of lease and buy options is provided in the accompanying report.

Cost Effectiveness

There is no effective alternate to a flight program for the development of mobile satellite services in Canada. For the initial program it is most cost effective to share payload capability and costs between DOC, DND and NASA. A lease or buy decision does not materially affect cost-effectiveness on the cost side except for return on investment to Telesat, considering that either the government or private industry must raise capital in the money market.

The commercial viability of follow-on operational mobile satellite systems for public mobile service is a necessity and will be discussed briefly here. Preliminary estimates show that while a large satellite with a 160 ft. antenna, and 210,000 users of FM toll quality voice service will be commercially viable, a smaller satellite with a 30 ft. antenna and 23,000 users of mixed field and toll quality voice service would also be viable.

Benefits

These are divided broadly into user benefit, policy benefit, and industrial benefit.

User Benefit:

Prospective users of MSAT have indicated that they would obtain substantial benefits from mobile-satellite services. These benefits would come from the following areas:

- availability of services in rural and remote areas which cannot be served economically by terrestrial systems.

- improved efficiencies in operations resulting in substantial cost savings.

- large impact is anticipated on efficiency of forest fire fighting, law enforcement, emergency medical services, trucking, oil and gas exploration and exploitation and other applications.

An extensive study of user cost-benefits has been initiated under contract starting in July in cooperation with prospective users of MSAT.

Policy Benefit:

This program will strongly support government policy to encourage the development of a spacecraft prime contractor in a progressive fashion, with increasing program size following ANIK-D, and with early timing as required. Federal-provincial cooperation will be greatly 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.

Industry Benefit:

Both SPAR and other Canadian aerospace subcontractors will benefit from developing public mobile and military payloads, solar arrays and power subsystems, and various other microprocessor-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.

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 on exploration and resource development
- military mobile UHF	1986-1988 service start	MODERATE	Allied countries plan to introduce operational EHF service about 1990 and phase out most UHF service about 1995. Delay will mean incompatibility with allies and reduced tactical and strategic capability.
EHF	1990		
Spectrum/Orbit Availability			
- 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 low-gain ground antennas.
Readiness to Proceed	1986 launch		
- industry		CRITICAL	SPAR will be ready for a Phase B start in early 1982. Delay will cause present staff to be dispersed, and the lack of an early major program start is judged to have severe consequences on SPAR. Phase A studies in SPAR to be completed in September 1981. Some related R&D studies at SPAR will continue to end FY 81/82. Sub-system skills will deteriorate.
		MODERATE	Telesat seeks MSAT as an opportunity to possible growth, diversity and stability; delay to 1990 launch will interfere with ANIK E, F system procurements.
- 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 can contribute more resources to a program having a later (i.e. 1990) launch, although because of severe consequences in such a late service development start, NASA wishes to examine earlier participation in a smaller program.
- ESA		SEVERE	An opportunity to negotiate reduced cost of an LSAT bus will be lost if launch slips beyond 1986.

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