Government of Canada
Department of Communications

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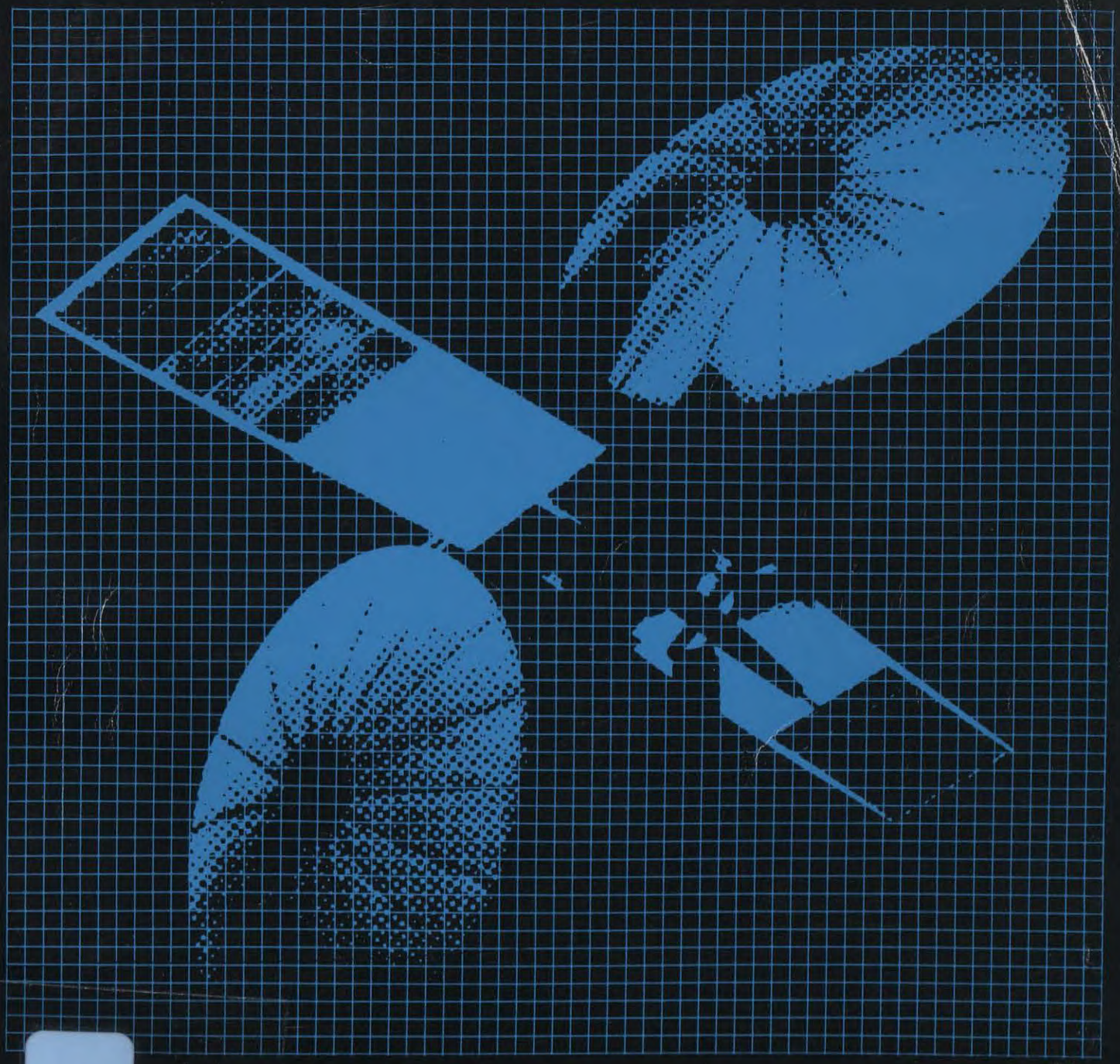

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MSAT PHASE B PROJECT PLAN

DEPARTMENT OF COMMUNICATIONS
SPACE PROGRAM
March 1982

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SECTION 1. INTRODUCTION

On December 3, 1981, Cabinet approved the Project Definition Phase of a Mobile Satellite (MSAT) Program. This document describes the Project Definition Phase known as Phase B and will govern the execution of the MSAT Phase B and constitute the formal Phase B project agreement among the participating organizations.

MSAT would be a demonstration system consisting of a satellite to be launched in 1987, a partially integrated spare spacecraft on the ground, ground control facilities, and a family of terminals for vehicles, ships, aircraft and fixed installations. The system would be used over a seven-year period following launch for experiments and for provision of pre-operational services.

MSAT Phase A studies have indicated a strong market demand for mobile services, and substantial user benefits. It is expected that follow-on systems to serve public needs in the 1990s would be commercially self-sustaining. The Department of Communications would fulfill its mandate to foster the development of new telecommunications services in Canada by developing the needed technology and services with the MSAT demonstration system as there is no viable alternative for providing nationwide mobile services. The Department of National Defence would benefit by placing special military equipment on the satellite to satisfy experimental military communications requirements and to develop technology and services applicable to a follow-on military operational system.

MSAT would benefit users of mobile services, including industry, federal government departments and provincial governments involved in various operations in rural, remote and coastal areas. Spar Aerospace Limited and other manufacturing companies will receive immediate benefits from major contracts for the definition and design of the spacecraft and the mobile terminals. Longer term benefits will flow from the domestic and export sales of MSAT products. The principal critical factors requiring the early development of MSAT are the limited availability of frequency bands and orbital positions, and the urgent need for mobile services in remote areas of Canada for resource exploration and development projects.

Following completion of the Phase B work involving system definition and economic studies, a further submission to Cabinet and Treasury Board would be required prior to the start of Phase C/D. Phase C/D would include engineering development, manufacture and launch of the satellite, and implementation of the ground segment.

This project plan provides background on the MSAT Program, objectives to be achieved and a description of the Phase B work plan. It also details the scheduling, budgeting and project organization. A statement of requirement for the MSAT Program and a selected option paper are attached as Appendices A and B.

SECTION 2. BACKGROUND

MSAT PLANNING

Prior to the 1979 World Administrative Radio Conference (WARC), the Department of Communications (DOC), in co-operation with the Department of National Defence (DND) and other government departments, developed the concept of a Canadian multipurpose UHF satellite communications system called MUSAT. This system was conceived as the most cost effective means of satisfying government needs for voice and data communications with ships, aircraft, vehicles and transportable stations operating in the Canadian north and other areas where conventional terrestrial systems could not provide services for technical and economic reasons. The MUSAT system would have operated in the 240-400 MHz band which is used extensively in both Canada and the United States for military communications.

At the 1979 WARC, a decision was taken to permit shared satellite and terrestrial communications services to mobile radio and telephone users in the 806-890 MHz frequency band in Region 2 (North and South America). This new allocation allows the benefits of mobile-satellite communications to be extended to the general public and non-military government applications in such areas as oil exploration and exploitation, mining, trucking, shipping, business, personal communications, law enforcement, forest fire fighting, ambulance communications and resource management in remote areas. As a result of this new frequency allocation, DOC undertook a re-evaluation of MUSAT program planning. The department then conducted preliminary studies in co-operation with U.S. National Aeronautics and Space Administration (NASA) in early 1980 to explore the use of satellite technology to provide public and government mobile communications services in Canada and in the United States. These studies explored system concepts and gave strong indications that market demand would be sufficient to ensure the future commercial viability of satellite systems providing services to mobile terminals if the required technology and services were developed.

PHASE A: CONCEPT FEASIBILITY

In September 1980, Cabinet approved a program of studies for fiscal years 1980/81 and 1981/82 at a cost of $2.2 million to explore the use of satellites for improved mobile communications in Canada and to define concepts and plans for a demonstration communications satellite (MSAT) for mobile users. During this Phase A study program, completed in March 1982, a total of 23 contracts were awarded to 15 Canadian companies to study the following main areas: market demand for MSAT services, commercial viability, user cost-benefits, spacecraft concepts for an MSAT demonstration system for launch in 1987 and for follow-on commercial satellite systems of the 1990s, ground terminals, overall system concepts, and required technology.

In October 1980 DND informed DOC of its intent to participate in Phase A studies. As a result, possible military mission requirements for MSAT were studied. One of the Phase A contracts awarded to examine alternative spacecraft options was jointly funded by these two departments.

The results of the Phase A studies are documented in final reports (Ref. 6 to 46). The following are the main conclusions of these studies.

- If the MSAT demonstration satellite is launched in 1987, there will be a market penetration of 23 000 MSAT mobile terminals in the domestic market by 1993, increasing to a penetration of 140 000 mobile terminals by the year 2001 with a follow-on commercial system.

- Based on the MSAT market demand forecast for the 1990s, a commercially financed system would be viable in the 1990s with an estimated average subscriber charge of $140 per month (1981 dollars) following the development in the 1980s of technology and services with the MSAT demonstration system. This subscriber charge would include all telecommunications charges except the cost of the mobile terminal.

- Studies carried out with interested users have confirmed extensive benefits from the use of satellites rather than terrestial communications systems in remote areas for forest fire fighting, fisheries, the forest industry, mineral exploration, law enforcement, railway operations, emergency medical services, network construction and maintenance, trucking, and for provision of public mobile telephone service.

- A satellite system is expected to be more cost-effective than terrestrial systems in providing wide-area communications outside metropolitan areas, while terrestrial systems would be more cost-effective in metropolitan areas. Complementary use of satellite and terrestrial systems is expected to be the only viable solution for nationwide coverage and for nationwide compatibility of mobile telephone and radio services.

- The viability of satellite service to mobile terminals will be enhanced by new speech encoding and modulation techniques which will be developed during the MSAT Program to improve efficiency in utilization of frequency spectrum and satellite power.

- Further studies are needed on possible spacecraft platforms for MSAT prior to final selection in Phase B based on performance, cost, schedule, socioeconomic benefits and risk.

- It is technically feasible to include on a satellite an 800 MHz public mobile transponder and a 401-403 MHz environmental data-collection transponder, as well as the optional National Defence experimental EHF transponder studied during Phase A.

The statement of requirement for the MSAT Program is provided in Appendix A and is based on the results of the market study conducted by Woods Gordon Management Consultants and intensive consultation by DOC officials during Phase A with the telecommunications industry, the manufacturing industry, provincial governments, federal government departments and large users of mobile services in the resource and other industries.

PHASE B: PROJECT DEFINITION

In June 1981 DOC reported to the Ministry of State for Science and Technology (MOSST) on the preliminary results of the MSAT Phase A studies; on a proposal for Phase B of the MSAT Program; and on other factors requiring consideration in a government decision on the relative timing of MSAT and RADARSAT (a satellite under study by the Department of Energy, Mines and Resources (EMR) to provide ice information for navigation in arctic waters). Subsequently, in September 1981, MOSST submitted a Discussion Paper to Cabinet on the strategic options for the Canadian space program (Ref. 2). The principal objectives of this paper were to review the spacecraft prime contractor capability objective, to establish optimum planning of the MSAT and the RADARSAT programs, and to review the L-SAT program.

In December 1981, Cabinet approved Phase B of the MSAT Program at a cost of $8 million in fiscal year 1982/83 and $9 million in fiscal year 1983/84. This and other government decisions on future space programs were announced by the Ministers of MOSST and DOC at a press conference held in Montreal on December 9, 1981 (Ref. 3).

The main objectives of the MSAT Phase B are to define and design the MSAT demonstration system, to develop the required technology, to conduct commercial viability studies, and to prepare a proposal, including cost estimates, for Phase C/D. Phase C/D would involve engineering development, manufacture, and launch of the MSAT satellite, implementation of earth terminals, as well as plans and initial cost estimates for a post-launch mobile communications program.

Phase B will be conducted through contracts with Canadian industry. It is proposed that the spacecraft definition and design contract be awarded to Spar Aerospace Ltd. in Montreal, the sole Canadian spacecraft prime contractor. In its capacity as the sole commercial satellite operator for domestic services Telesat Canada will be asked to undertake a major commercial viability study for public mobile services.

On January 21, 1982, DND informed DOC of its qualified support for Phase B of MSAT, and DOC established an MSAT Planning/Implementation Committee with representation from the DND, Department of Supply and Services, Energy Mines and Resources, Department of Transport, Department of Fisheries and Oceans, Department of the Environment, Emergency Planning Canada, Solicitor General Canada, Indian and Northern Affairs, Health and Welfare Canada, Treasury Board Secretariat, Ministry of State for Science and Technology, Canada Employment and Immigration Commission, and Industry, Trade and Commerce, with Telesat as an ex officio member. This committee was established in accordance with the Treasury Board Policy on Management of Major Projects (Ref. 4).

SECTION 3. OBJECTIVES

GENERAL

MSAT is a research and development program whose approval and execution must be carried out in sequential phases, with each of the four major phases defining more precisely the cost and other objectives of the overall program. Class B estimates are provided in this Project Plan for Phase B, and Class B estimates for the complete program will be produced during Phase B. Class B estimates provide for the establishment of a realistic budget and schedule and are sufficiently accurate to permit control of the project. Estimates of the cost of the complete program as presented below are less accurate.

OBJECTIVES OF THE MSAT PROGRAM

Strategic objectives

The primary strategic objective of the MSAT Program is to foster the development of new telecommunications services in Canada. A further objective is to foster the development of Canadian space system technology in the private sector, including the development of the required engineering skills and expertise in the Canadian labour force. In particular, the program is aimed at satisfying urgent national needs for improved public and civil government mobile communications to underserved areas of Canada, including resource development activities in remote areas. The program will also provide a platform for a Department of National Defence (DND) experimental communications package. Finally, the early launch of a demonstration satellite will ensure availability of a geostationary orbit position and adequate spectrum for public, civil government, and military satellite communications services.

Once in orbit, the MSAT demonstration system would be used for communications experiments; service development; and pre-operational services to vehicles, ships, aircraft, compact portable terminals and fixed terminals.

A Department of Communications (DOC) post-launch MSAT communications program would be aimed at demonstrating and establishing the viability of public and private mobile satellite services and providing limited interim operational service pending launch of a follow-on commercial system. The program would have these general objectives:

- to foster the development and introduction of new satellite telecommunications services and systems for mobile users by supporting demonstrations, experiments, pilot projects and trials designed to develop awareness, knowledge and expertise, and to assess viability of these new services and systems

- to facilitate the introduction of new mobile telecommunications services on commercial satellite systems in Canada by providing a means for aggregating user needs and by providing a vehicle for limited interim service delivery before a follow-on commercial system becomes available

- to support the advancement of Canadian capability in space communications technology and service delivery by assisting Canadian user institutions, industry and carriers to respond to national needs and international market opportunities

- to stimulate telecommunications policy development by providing relevant data and by identifying specific policies needed for viable commercial satellite services to mobile terminals

The DND Phase B objective is to determine if an experimental military EHF package on the MSAT would further DND's technological progress towards a dedicated military satellite communications system sufficiently to justify further investment in MSAT. If DND proceeds beyond Phase B there would be an experimental post-launch program aimed at further developments needed for future military operations in the EHF band.

Program benefits

The MSAT Program will provide benefits from both the DOC-sponsored public mobile service and the DND military technology element.

The DOC element of the MSAT Program will provide significant social, economic, technological and policy benefits. The recipients of these benefits would be the user agencies and industries, the public being served, the manufacturing industry, the telecommunications service industry, the government, and the overall Canadian economy. The social benefits would be those obtained through improved mobile communications services to the public and to agencies providing public services such as law enforcement, emergency medical services, and disaster relief. The nature of these program benefits are summarized in Table 1. One objective of Phase B is to define these benefits further and improve confidence in the predictions.

The program strategy for the DOC element of MSAT is to provide an appropriate vehicle or framework in a technical and institutional sense which will allow the flow of social, economic and policy benefits through and beyond the MSAT Program. If the MSAT Program proceeds successfully, there will be transition to a follow-on operational system which would provide public services and which would be financed and operated on a commercial basis. This would result in continuing service and benefits to users and an increase in the economic base of the space manufacturing and telecommunications service industries.

In addition, Canada Employment and Immigration Commission's (CEIC) program objective is to maximize employment and career opportunities for Canadians and ensure that the contractors have the highly skilled work force required for the project. Effective manpower planning by contractors through the management, design, construction, procurement, operational and other aspects of the project will facilitate the acquisition of the required work force, as well as the transfer to the Canadian labour force of technological expertise developed through MSAT. The CEIC will then be in a position to deliver its programs and services (that is, recruitment, training, mobility and foreign worker recruitment) to assist the contractors in obtaining the required work force.

Table 1 General Benefits from DOC Element of MSAT Program

Category of Benefit	Recipient	Quantitative Measure	Objectives (Phase A estimates)
Social (through improved communications and other public services)	MSAT subscribers • governments • industries • businesses • public being served	Market penetration	20 000 MSAT subscribers by 1994 (and 140 000 by year 2001 with further investment by carriers in follow-on commercial system)
		Percentage of Canadians with access to public mobile telephone service	Increase access from 50 per cent to 99 per cent
		Percentage of Canadian territory with public mobile telephone coverage	Increase coverage from 14 per cent to 90 per cent
Economic	Overall Canadian economy	Degree of Canadian content	Greater than 50 per cent Canadian content including all mobile terminals
		Number of jobs created	Person years in high technology and service industry, to be determined in Phase B
		Change in balance of payments	To be determined in Phase B
	Manufacturing industry	Value of MSAT demo sales	$ million, to be determined in Phase B in contracts to Canadian industry
		Value of potential MSAT follow-on sales in Canada	$ million, to be determined in Phase B in contracts to Canadian industry
		Value of potential MSAT export sales	$ million, to be determined in Phase B in contracts to Canadian industry
	Telecommunications industry	Outcome of commercial viability study	Positive decision by industry to implement follow-on system in the 1990s
		Increase in revenues	System to be determined during Phase B
	Users	Gross user benefit	Over $2 billion benefits (1981 dollars) over the period 1990 - 2000
Technological		Number of patents Extent of skill development New manufacturing processes Number of new products and systems Number of spin-offs to terrestrial applications	Technological objectives as listed in Appendix D
Policy	Government	Degree of improvement in mobile communications	Same as social objectives
		Degree of economic development	Same as economic objectives
		Degree of increase R&D	$40 million increase
		National unity	
		Access to frequencies and orbit position	

The definition of a DND experimental EHF package, which could be part of MSAT, would help DND determine the most cost-effective option for acquiring required future military EHF capabilities and would contribute directly to their development. As a result, new technology would be introduced to Canadian industry.

Performance objectives

To implement an MSAT system comprising:

- one spacecraft in geostationary orbit in the vicinity of 109° west longitude
- one spare spacecraft on the ground capable of being integrated and placed in a state of flight readiness within 15 months of a decision to launch
- one satellite ground control station
- ground communications terminals for land vehicles, ships, aircraft, man-pack and fixed installations

The system will be designed to meet the following requirements:

DOC service requirements

- provide mobile radio and telephone services in the 806-890 MHz band
- provide meteorological and earth exploration data collection services in the 401-403 MHz band
- provide back-haul[1] services in a suitable frequency band

DND service requirements

- define a satellite-borne EHF transponder and control link for experimentation with and development of military EHF mobile and fixed communications applications

CEIC requirements

- effective manpower planning by the contractors involved in MSAT to ensure a highly qualified workforce that will successfully perform as required by DOC

Detailed performance requirements will be defined during Phase B.

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1 back-haul - link between a satellite and fixed central control station or gateway station allowing interconnection with terrestrial systems.

Cost objective

The estimated total cost of the DOC-sponsored element of the MSAT Program is $385 million in 1982 dollars. This is expected to be reduced by co-operative arrangements and cost recovery to be investigated during Phase B. The additional cost of the DND payload is to be determined during Phase B, but it is estimated to be not more than $60 million in 1982 dollars, of which $3 million is for Phase B. The actual cost of Phase C/D, if it were to proceed, could be strongly influenced by this design definition phase.

Time objective

The earliest possible spacecraft launch date is November 1987. The program schedule corresponding to this launch date is given in Figure 1.

Certainty of achievement

The MSAT Program is developmental by its very nature and therefore carries a certain measure of risk. The use of a demonstration project, as proposed for MSAT, is the only proven approach for reducing uncertainties in the marketing, technology and economics of a new venture. This approach has been successful in the introduction of 14/12 GHz fixed and broadcast satellite services in Canada through the Hermes and Anik B communications programs, as well as in other capital-intensive areas such as energy development. It is notable that the MSAT mission is intended to do for mobile service development what the Hermes and Anik B programs did for fixed and broadcast service development. DOC therefore has confidence in this proven demonstration concept for the development of new satellite telecommunications services, and in the particular approach proposed for MSAT which builds on previous experience.

The certainty of achieving the objectives of the MSAT Program will be maximized through a phased approach involving the incremental commitment of resources, during which the accuracy of and confidence in the quantified objectives are successively improved with decision points at the completion of each phase. Technical risk will be reduced to an acceptable level through development activity during Phase B and through extensive testing in subsequent phases.

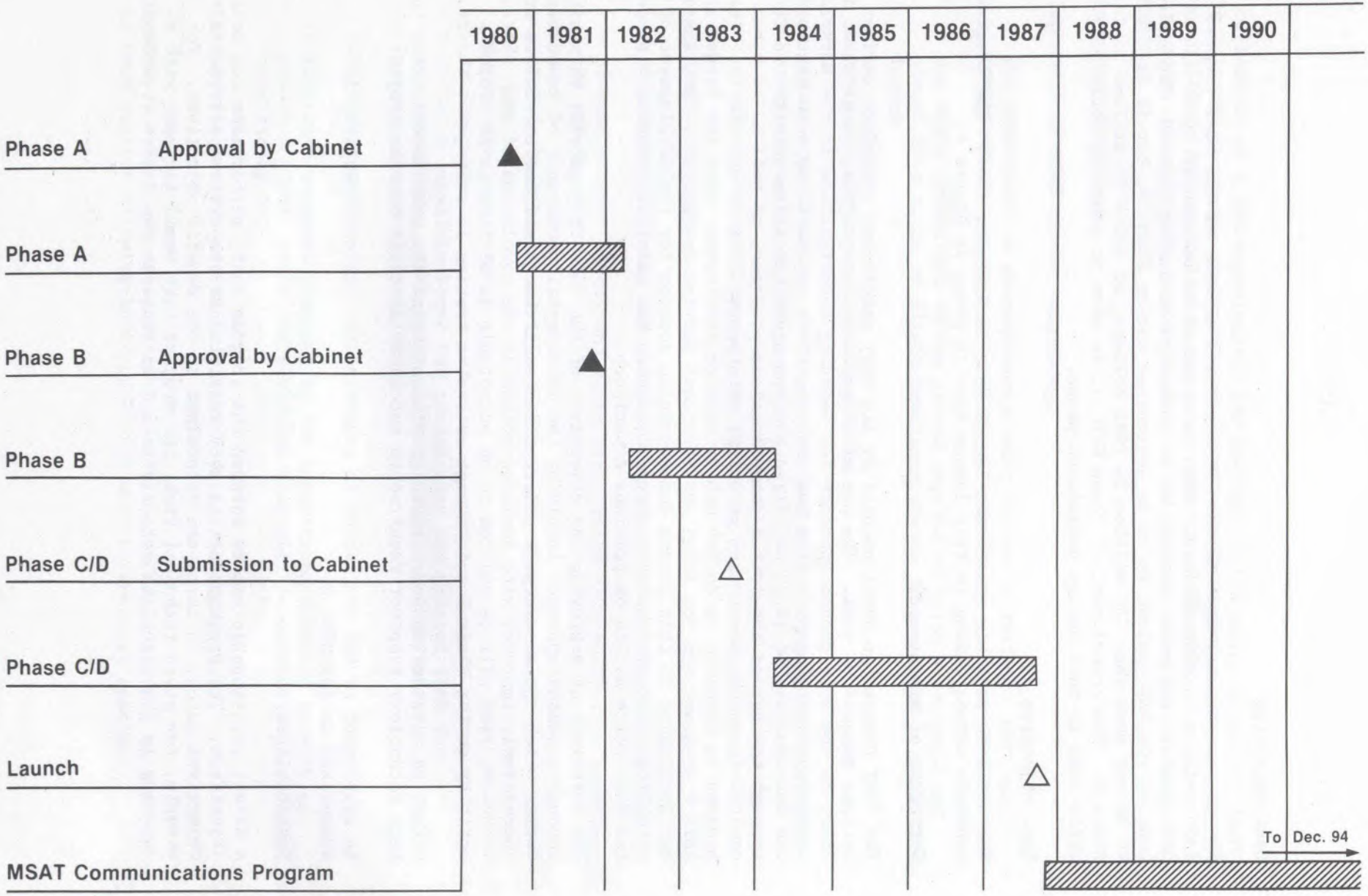
Effective advanced manpower planning will minimize the risk in acquiring the high technology manpower required to successfully carry out the project.

An assessment of the confidence in achieving the stated objectives is summarized in Appendix D.

Sensitivities

A direct relationship exists between the program cost, performance and benefit objectives. The program cost is very sensitive to the system performance objectives which, in turn, are determined by the benefit objectives. For example, for given technical risk, the program cost would increase with an increase in the satellite capacity needed to increase the number of subscribers

Figure 1 MSAT Program Schedule



served. The number of subscribers served is a direct measure of the social and service benefits of the program. This interrelation will be considered fully during Phase B as it is particularly relevant to the selection of the spacecraft platform and other trade-off studies.

There is also an important interrelation between cost and benefits for the MSAT demonstration system and for a subsequent commercial system. For example, the selection of similar spacecraft platform and communications system features for both missions will significantly reduce non-recurring development costs in both the space and ground segments of the commercial system.

The availability of frequency spectrum and an orbital position for MSAT and the follow-on commercial system can affect the success of the program. During Phase B, DOC will notify the International Frequency Registration Board (IFRB) of the Canadian spectrum and orbit position requirements and will undertake co-ordination of these resources. Early implementation of the MSAT system is the best way of ensuring access to these resources which have in the past been allocated on a first-come, first-served basis. The 806-890 MHz frequency issues and other policy issues affecting the introduction of MSAT services in Canada are addressed further in a discussion paper (Ref. 5) released for public comments by the Department of Communications in September 1981.

Revenue

Following the launch, the MSAT system would be used for a seven-year MSAT communications program. The public mobile channel capacity of the satellite would be allocated for experiments, pilot projects, market trials, and for pre-operational services of an interim commercial nature. During Phase B, a policy will be defined for access to the satellite by users and for cost recovery for services provided. This cost recovery would be generally similar to that approved by Treasury Board for the Anik B communications program. Users from federal government departments, provincial governments, telecommunications carriers, industries and other groups would be expected to pay for services received once they have made their commercial viability decision on the use of MSAT. Cost recovery would generate an estimated $50 million in revenues. The revenue-generating potential will depend on the public mobile satellite channel capacity. The Department of National Defence payload would not generate revenue.

OBJECTIVES OF PHASE B

Performance

The performance objectives of the Phase B activities described in Section 4 require the following results from Phase B:

- a detailed proposal for implementation of the MSAT system. This will require Class B cost estimates; a contractual statement of work containing performance requirements and specifications for the spacecraft and the major ground elements; a management plan and schedule; and proposals to minimize the cost to the government of the MSAT Program.

- results of a detailed study of the viability of a commercial follow-on satellite system for mobile services and a marketing plan to promote MSAT services, products and technology

- proof of concept for various key technology items in the MSAT system (for example, antenna feeds, amplifiers, codecs and modulation techniques) through breadboard development

- a proposed post-launch MSAT communications program plan

- an assessment of the socioeconomic benefits to be derived from the MSAT demonstration system and a subsequent operational system

- proposals to resolve regulation, policy, and institutional questions affecting the viability of commercial services

These results will be used for evaluation purposes by DOC and be part of a Cabinet submission for the MSAT implementation phases.

Cost

The total cost of MSAT Phase B is estimated to be $21 million in budget-year dollars including an allowance of 10 per cent a year for inflation. This consists of $17 million for the DOC-sponsored public elements of the program as approved by Cabinet and approximately $3 million for the DND experimental EHF package, and $1 million for modification of the DND EHF earth terminals to the MSAT configuration. This is a significantly reduced package from the option referred to in the MOSST Discussion Paper (Ref. 2). These exclude related R&D carried out under other programs.

Socioeconomic

The MSAT Phase B will have a Canadian content of $19 million. This will create approximately 200 person-years of high technology work in space manufacturing and related industries and also create spin-off benefits to other secondary support and service industries. The MSAT Phase B will support the government policy objective to further develop the Canadian spacecraft prime contracting capability. Quebec will be a major beneficiary of this technology development investment.

Phase B will produce technological benefits in the form of patents, new product concepts, industrial know-how, job creation and the development of high technology manpower.

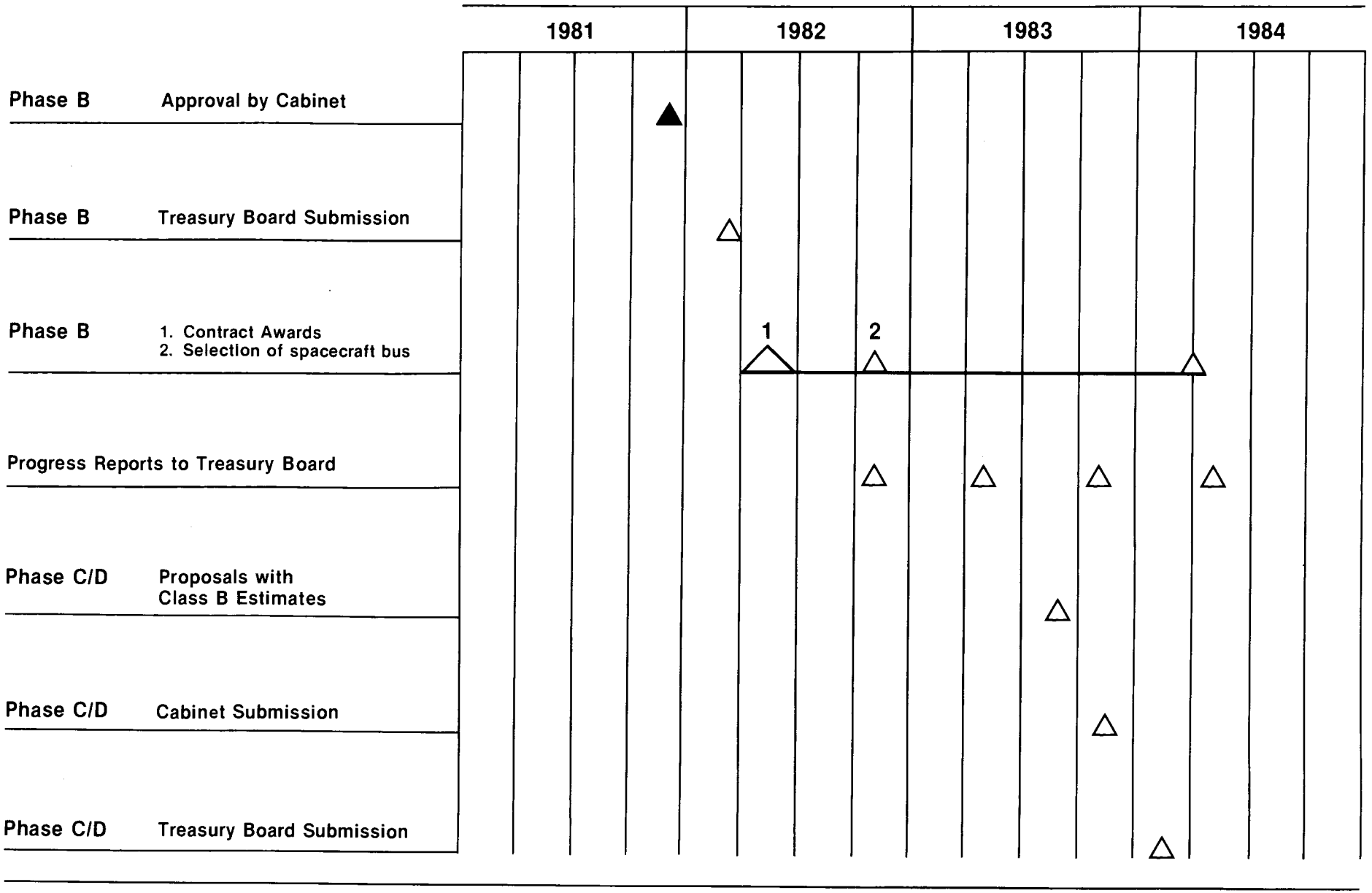
The foreign labour content of Phase B work will also be costed. Foreign labour in this context is defined as those foreign nationals working in Canada under an employment authorization issued by CEIC. In calculating foreign content, contractors will be required to identify and cost the foreign labour to be used.

There will be a total foreign content of approximately $2 million (in Canadian dollars) for the purchase of electronics parts, test equipment and other goods and services not available in Canada. It may also be necessary to advance "earnest money" for launch vehicles.

Time

The MSAT Phase B is proposed to start on April 1, 1982 and will have a duration of two years. The Phase B schedule with the major milestones is given in Figure 2. This schedule is based on the minimum time needed to implement the Phase B work plan as described in Section 4.

Figure 2 MSAT Phase B Schedule



SECTION 4. WORK PLAN

GENERAL

The MSAT Phase B work plan is divided into three main work areas:

Management

This work area includes planning, management and control of all the MSAT activities during Phase B. It includes activities of the MSAT Planning/ Implementation Committee, review of Cabinet and Treasury Board submissions and progress reports.

Program Definition

This includes all Phase B activities conducted under contract and in-house to define the program benefits in the social(service), economic, technological and policy areas and to define and initiate programs which will encourage maximum flow of these benefits. This work area includes studies and resolution of issues dealing with the market, commercial viability, communications policy and definition of a post-launch program to develop service and economic benefits. It also includes the preparation of Cabinet and Treasury Board submissions.

System Definition

This includes all activities conducted under contract and in-house to define and design all elements of the MSAT demonstration system and its operation, and to develop the required technology. This will also involve the preparation of Class B cost estimates, performance specifications, a schedule and other technical information needed for the Phase C/D Project Brief.

The MSAT Phase B work breakdown is given in Table 2 and a description of the work packages in the areas of Management, Program Definition and System Definition follows.

The detailed schedule for this Phase B work is contained in Section 5. The government will provide overall system authority throughout the MSAT Program, and will contract other work to the private sector where practicable. Over the past decade, various ongoing government R&D activities at the Communications Research Centre have been focused on technological problems, sub-systems and trade-offs which affect the MSAT system. Technical consultation and support will be provided from this R&D base to the MSAT project organization, as described in Section 6 under Planning/Implementation Committee. Technological development that pertains critically to MSAT will be funded under the Department of Communications (DOC) MSAT Phase B budget of $17 million. Other resources such as the Industry Contract Fund, the Sub-system Development Program, the Key Technology Program and the Industrial R&D Program (which have their own technology development objectives), will nonetheless provide important spin-off benefits to MSAT. Examples of such technology development benefiting the MSAT

Table 2 MSAT Phase B Work Breakdown Structure

1. Management

2. Program Definition

WP 2.1 Program Management
WP 2.2 Market Definition
WP 2.3 Commercial Viability Studies
WP 2.4 Post-Launch MSAT Communications Program Definition
WP 2.5 Definition of Socioeconomic Benefits
WP 2.6 Communications Policy Analysis & Definition
WP 2.7 Frequency Co-ordination
WP 2.8 Development of Co-operative Arrangements.
WP 2.9 Preparation of Program Submissions
WP 2.10 Data Collection Platform Study
WP 2.11 Working Groups
WP 2.12 Public Information Plan

3. System Definition

WP 3.1 Project Management
WP 3.2 System Definition and Design
WP 3.3 Space Segment Definition and Design
WP 3.4 Space Segment Technology Development
WP 3.5 Launch Definition
WP 3.6 Earth Segment Definition and Design
WP 3.7 Earth Segment Technology Development
WP 3.8 Cost Estimate

Program are given in Appendix E. The MSAT Project Team defined in Section 6 is generally intended to manage and control the MSAT Phase B contracts, and not to personally perform any extensive technical, market or commercial viability studies.

MANAGEMENT

Organization and overall management arrangements for MSAT Phase B activity are described in Section 6. Project control of performance, cost and schedule is described in Section 7, and is achieved generally through the Management Information and Control (or reporting) system of monthly Level II and Level I reports, as well as through bodies such as the MSAT Planning/Implementation Committee, the Configuration Control Board, and liaison or working committees involving Telesat, DOC, the Department of National Defence (DND) and users of the public mobile service. Achievements will be evaluated against Phase B objectives.

MSAT PROGRAM DEFINITION

WP 2.1 Program management

Program management contains activities needed to manage the team of specialists who will be responsible for in-house and contracted studies dealing with the market definition, commercial viability analysis of an operational system, definition of post-launch programs, preparation of program submissions, and other related activities described below.

WP 2.2 Market definition

Further studies will be contracted to refine the market study carried out in Phase A. These studies will involve refinement of market data on a regional and industrial basis and will investigate the market elasticity, the quality of service required, the sensitivity of the market to regulatory and institutional arrangements, HF radio replacement, demand for control and command of automated stations, rural telephone needs of the north, business users of the Citizens Band, data service requirements, and nationwide paging needs. It will also provide an improved data base on current services and deficiencies of present systems. As appropriate, market consultants, manufacturers, users and the telecommunications industry will be involved in the studies. Telesat will contribute to the definition and review of the studies. Users, carriers and manufacturers will also be encouraged to undertake self-financed studies on needs and marketing opportunities (for products or services) in co-operation with the MSAT Program.

WP 2.3 Commercial viability studies

Telesat Canada will be asked to assess the viability of a satellite system for the provision of commercial service to mobile users, and to assess the potential for maximizing commercial exploitation of the technology and products generated during the MSAT Program.

This study will encompass all tasks necessary for the private sector to establish the proper basis for a business investment decision regarding implementation of a satellite system for commercial mobile radio and telephone service. This commercial system would follow the demonstration and pre-operational MSAT system. More specifically, this comprehensive study would include the following tasks: assessment and supplement of a wide base of market data for these services, assessment of relative roles of satellite and terrestrial systems to provide nationwide compatible service, definition of technical system concepts for a commercial system to follow the MSAT demonstration system, assessment of satellite options to meet user needs including lease and joint venture, development of system cost models, definition of an effective marketing approach for these services, performance of a financial investment analysis for these services including consideration of payback of some development costs in subsequent operational systems, risk assessment, investigation of policy and institutional arrangements, and preparation of a strategic plan for transition from the demonstration MSAT to a fully commercial follow-on system.

Telesat will also be asked to assess the potential for exploitation of MSAT technology and products in the follow-on commercial domestic satellite system for mobile radio and telephone services. Other Phase B MSAT studies will assess the potential for general exploitation of MSAT technology and products for both domestic and foreign use in the more general areas of telecommunications and space applications.

These studies will result in a number of reports which will be used as a detailed rational basis for future business decisions regarding the implementation of a commercial system to follow the MSAT demonstration and pre-operational system.

Assuming that commercial service proves viable, the results of these studies will be used by DOC in a submission to Cabinet in late 1983, to seek approval for the implementation of the MSAT demonstration system and subsequently to decide whether or not to implement a follow-on commercial system.

WP 2.4 Post-launch MSAT communications program definition

The post-launch MSAT communications program will be defined during this stage. The intent of this program is to create effective demand, to provide rapid transition from experimental stage to interim commercial service for viable services and to involve the private and quasi-private sectors (telephone companies, manufacturers, Telesat and users) in the design and conduct of the program. This is to ensure that viable services are identified and implemented quickly, thereby realizing the planned social and economic benefits. Some of the prime activities include the definition of a cost recovery policy for use of MSAT services; preparation of criteria for selection of experiments, field trials, market trials and assignment of satellite capacity to users needing continuous pre-operational services of an interim commercial nature; and preparation of cost estimates for this post launch program. Agreements will be developed during Phase B with participants in the post-launch MSAT communications program.

WP 2.5 Definition of socioeconomic benefits

The socioeconomic benefits of the demonstration and the subsequent operational systems will be defined. One or more competitive contracts are proposed to examine benefits to the manufacturing industry, benefits to service industries and subscribers, job creation and manpower development, balance of payments, industrial development, technology spin-offs, industrial offsets, government policy benefits, and other intangibles. It will establish the socioeconomic data base needed to update the program benefit data (See Table 1) prior to the Phase C/D submission.

This work package will also define the major promotion, marketing and related activities necessary to ensure that maximum economic benefits through domestic and export sales are obtained for the Canadian economy from the MSAT Program.

WP 2.6 Communications policy analysis and definition

A DOC position on policy issues related to mobile satellite communications will be defined. This will assist in the formulation of the communications policies necessary for the introduction of MSAT services in Canada. This study will investigate ownership, operation, maintenance, and licensing of the MSAT ground segment; who should market the services to end users; the role of the CRTC and provincial regulatory agencies; interconnections with the switched telephone network; pricing policy for leasing satellite capacity; and compatibility of terrestrial mobile radio and telephone services with the MSAT mobile radio and telephone services. Action plans will also be defined for all department staff and program participants to ensure that the need for change is appreciated by the appropriate agencies and that the results of all MSAT work activities are harnessed fully to effect these changes.

WP 2.7 Frequency co-ordination

Spectrum requirements will be defined and frequency co-ordination will be initiated with other countries through the International Frequency Registration Board.

WP 2.8 Development of co-operative arrangements

Domestic and international co-operative arrangements will be investigated and negotiated at this stage. These would be subject to Cabinet approvals as part of the Phase C/D submission, in order to reduce the MSAT Program cost to the government. As requested by Cabinet, other means of reducing this cost will be explored. DND will be responsible for all dealings with allied military agencies.

WP 2.9 Preparation of program submissions

Submissions to Cabinet and Treasury Board will be prepared at this stage. These will be needed for decisions on the implementation of the MSAT system.

WP 2.10 Data collection platform study

A Data Collection Platform (DCP) study will be undertaken in co-operation with the Department of Environment (DOE) and other DCP users. The objective is to assess the service needs, the options for satisfying these needs, the technical requirements, the cost of a DCP service on MSAT and related information required to reach a decision on the inclusion of a DCP payload on MSAT.

WP 2.11 Working groups

Working groups will be established with DND, Telesat, federal government user departments, provincial governments, carriers and industries to ensure proper involvement of all concerned parties. The terms of reference for the groups will be approved by the MSAT Planning/Implementation Committee. This work package involves all activities needed to establish and support the proper functioning of the working groups.

WP 2.12 Public information plan

A public information plan for the MSAT Program will be implemented during Phase B. The objective is to create awareness among the general public, the news media, the Canadian space and electronics industry, and potential users. Information will be made available on the objectives of the MSAT Program; its possible applications; and the potential benefits for Canadian users, industry and the Canadian economy.

SYSTEM DEFINITION

WP 3.1 Project management

This work package contains the activities required to manage the team of specialists who will be responsible for in-house and contracted activities dealing with the definition and design of the MSAT demonstration system and the development of the needed technology. This involves the establishment of a project office, the implementation of a Management Information System, contract administration and preparation of project management plans for Phase C/D.

WP 3.2 System definition and design

WP 3.2.1 Communication system concept

System engineering studies will be performed in-house and under contract to define the communication system concept for each of the MSAT services, to analyze the link requirements, to define the overall performance and technical requirements as well as the system interface points.

WP 3.2.2 Demand assignment multiple access (DAMA) control concept and switched telephone network (STN) interface definition

Studies will be contracted to define a DAMA concept to be compatible with the various modes of operation of the 800 MHz service as well as with mobile terrestrial systems. The DAMA performance and technical requirements will be specified, as well as the STN interface requirements for the 800 MHz service.

WP 3.2.3 Voice/data system definition

Subsequent to the specification of the system and satellite-terrestrial interface characteristics, terminal characteristics must be specified. This includes the data mode of operation at 800 MHz, both for low speed data with mobile terminals and high speed data from transportable terminals. A competitive contract will be placed to examine the performance requirements for data terminals compatible with the basic voice mode at 800 MHz.

WP 3.2.4 Intermodulation analysis

As an input to transponder specification, studies will be conducted on the intermodulation generated by the various modes and services being carried by the 800 MHz transponders. Constraints on service performance, characteristics of transponder gain control, cross-strap and amplifier linearity will be specified.

WP 3.2.5 Operations analysis and experiments test plan

An operations analysis study will be conducted and will include the development of a post-launch satellite operations plan and a communications test plan.

WP 3.2.6 Frequency interference analysis

Interference analysis studies will be conducted to assist in co-ordinating the frequencies with other countries services.

WP 3.2.7. Product assurance

A product assurance requirement definition will be carried out in-house, supported by contracts with Canadian industry. It will include the development of product assurance plans for the spacecraft central control and gateway stations and for the mobile earth terminals as well as for the spacecraft. Reliability requirements of the overall communications system will be defined. Examination of system availability and reliability will be undertaken.

WP 3.3 Space segment definition and design

The definition of the MSAT spacecraft will be performed mainly by Spar Aerospace Limited, the spacecraft prime contractor. This will involve defining specific performance requirements and developing plans and specifications for the development, test and production phases. The following tasks outline the space segment activity.

WP 3.3.1 Contractor management and control

The spacecraft prime contractor will be responsible for managing and controlling the activities associated with the spacecraft definition and the development of specifications. This will be subject to the overall system requirements identified by the government.

WP 3.3.2 Spacecraft system engineering

The spacecraft system engineering will be performed by Spar and will involve the following activities:

- spacecraft platforms selection studies
- payload system engineering studies
- spacecraft platform definition studies (to be sub-contracted to spacecraft platform supplier)

A spacecraft platform solution paper will be prepared with a discussion of the performance, cost, schedule, socioeconomic and other factors. This paper will be reviewed by the MSAT Planning/Implementation Committee.

WP 3.3.3 Integration and test

Detailed definition of spacecraft integration and test requirements will be performed.

WP 3.3.4 Spacecraft platform

While a platform design available in the 1987 timeframe is proposed for the demonstration MSAT, a number of modifications to accommodate the MSAT payload must be defined. The output of this work package will be integrated into WP 3.3.2.

WP 3.3.4.1 Attitude and orbit control subsystem (AOCS)

The AOCS requires analysis of control margins, fuel consumption, solar torques and related parameters for simulation during testing as well as for launch and operations. Some modification may be required for control of the large MSAT antennas.

WP 3.3.4.2 Thermal subsystem

The thermal subsystem requires study to determine what, if any, modifications are needed to meet the MSAT transponder thermal requirements.

WP 3.3.4.3. Solar array subsystem

The solar array subsystem requires some modification to overcome potential antenna shadowing problems.

WP 3.3.5 Computational requirements

The computational requirements for the demonstration MSAT include the computer hardware and software associated with the telemetry, tracking and control (TT&C) facility in the Central Control Station, plus the requirement for in-house subsystem simulation and analysis.

WP 3.3.5.1 Real time simulator (RTS) for the attitude and orbit control system (AOCS)

Access to computing facilities will be needed during Phase B for initial development of simulation software for the AOCS. Facilities may also be required for additional attitude control system design studies to identify problems in providing performance specifications for the MSAT Program. It is proposed to procure computer services as required, lease or purchase of equipment if alternate cost-effective services are not available.

WP 3.3.5.2 Spacecraft test and integration computer system (STICS)

The hardware and software requirements for the STICS will be defined.

WP 3.3.5.3 Spacecraft real time computing system (SRCTS)

The hardware and software requirements for the SRTCS will be defined.

WP 3.3.5.4 Simulation and control software

Preliminary development of the simulation and control software will be undertaken with the assistance of Canadian industry.

WP 3.4 Space segment technology development

The MSAT payload consists of several types of electronic subsystems and antennas which must be defined, specified and developed.

WP 3.4.1. Transponder subsystem

The transponders associated with the 800 MHz mobile service and the military EHF requirements are the most critical parts of the MSAT spacecraft. In order to reduce costs and schedule risks in the later phases, preliminary designs will be implemented in breadboard fashion for the major types of communications equipment.

WP 3.4.2. Antennas

The required antennas must be defined and specified. Some of the antenna reflectors and feeds will be implemented in breadboard form for proof of concept.

WP 3.4.3. Payload technology development

Payload technology development is critical and includes the design of high efficiency solid state linear amplifiers at 800 MHz, EHF subsystems, electrical power conditioning circuits, duplexers, SAW filters, thermal design and packaging, and antenna feed subsystems.

WP 3.5 Launch definition

WP 3.5.1 Launch requirements plan

This study will review and document the options (including upper stages) for launching the MSAT spacecraft, and will address the following for each:

- launch weight
- cost including range activity as appropriate and upper stages
- payment schedule
- available launch dates
- test requirements
- interface requirements
- insurance
- flight readiness documentation requirements
- range event schedules

WP 3.5.2 Launch vehicle reservations

"Earnest money" to reserve launch options will have to be paid during Phase B.

WP 3.5.3 Mission analysis

This study will develop the appropriate scenarios and perform the mission analysis for each chosen launch option. This will include at least:

- launch window analysis
- launch dispersing effects
- upper stage firing requirements
- telemetry coverage during launch, upperstage firing, transfer orbit, apogee firing and drift to station
- earth station facility requirements
- foreign earth station support
- orbit prediction techniques
- estimate support costs
- develop necessary handover procedure

WP 3.5.4. Upper stage development

Available and proposed upper stage developments, will be examined to determine any modifications or other work required for launch system compatibility with the MSAT mission.

WP 3.6 Earth segment definition and design

WP 3.6.1 Central control station definition

The central control station will be a major facility to provide control both for the satellite and for several of the communications services.

The two primary functions are:

Operations control

The station would provide all telemetry, tracking and control functions, including the reception and analysis of telemetry data, satellite control, ranging, monitoring satellite health and spacecraft flight simulation.

System control

The station would provide appropriate interface and communications control for the 800 MHz mobile service, emergency position indicating radio beacon (EPIRB) reception, and data collection platform reception. It should be noted that the functions of one of the gateway stations for the 800 MHz mobile service would be provided by this terminal.

Many of the individual requirements listed above are addressed in more detail in other contracts. This contract is intended to tie together the overall requirements and to generate an earth station performance specification that can be used for Phase C/D procurement. Prior to start of contract the required control services, and the way in which they should be implemented, will be defined. For example, it may be economically or operationally appropriate to split military payload control and civil payload and spacecraft control into two earth stations.

WP 3.6.2 Gateway station definition

The gateway station provides the back-haul switching centres and interfaces with the switched telephone network for the 800 MHz mobile service. The terminal operates at the back-haul frequencies and will contain modems, Demand Assignment Multiple Access controllers and telephone interface equipment. The contract is required to define overall system requirements and to prepare a performance specification which can be used in Phase C/D procurement.

WP 3.6.3 Mobile terminal definition

Early in the demonstration spacecraft mission, up to three possible schemes for providing services will be thoroughly tested and evaluated. Such testing requires the development and procurement of mobile terminals using three different modulation schemes which have great impact on spectrum and power demands in the spacecraft, that is:

- narrow band FM, a well-proven, widely used technique

- pitch-excited linear predictive coding with differential minimum shift keying modulation, a new efficient digital communications technique

- amplitude-companded single sideband modulation, a technique of some potential for a significant increase in system efficiencies

This contract is required to define in detail the nature of these terminals and to generate an overall performance specification for each type, which could then be used in Phase C/D procurement.

WP 3.6.4 800 MHz base stations

From the Woods Gordon study, it is apparent that there will be a large number of users for the mobile radio service not requiring interconnection with the terrestrial telephone network. Base stations are required to serve as the control centre for organizations operating radio networks. This task will draw results from other tasks, and will develop a system concept and a performance specification which can be used for subsequent procurement.

WP 3.6.5 Communications simulation augmentation

Construction has started on a laboratory communications simulator that is designed to test modulation schemes in a simulated mobile environment. It is intended to augment this facility to adequately represent the MSAT system and allow evaluation of the MSAT system configuration. There are a considerable number of fundamental technical system parameters that require evaluation and optimization. Among these are several modulation schemes being considered for use on MSAT.

WP 3.6.6 Military terminal definition

This activity will be arranged by DND independently.

WP 3.7 Earth segment technology development

Technology development of high efficiency modems, both linear predictive coding and amplitude-companded single sideband modulation, linear and pulse power amplifiers, and frequency agile local oscillators is required as well as laboratory prototypes of other subsystems.

WP 3.8. Cost estimate

Class B cost estimates will be prepared for the implementation of the MSAT system. This will also include estimates of lesser accuracy for the MSAT operations phase.

SECTION 5. SCHEDULING AND BUDGETING

SCHEDULING

The timing of significant activities that will be performed during Phase B of the MSAT program is indicated in Figures 3 and 4. Figure 3 indicates major milestones, progress reviews and progress reports to Treasury Board. Figure 4 is a more detailed schedule for each of the major work packages described in Section 4.

MSAT is a research and development program, with many of the contracts being carried out concurrently and with the interim and final results of some work packages required to be fed into others. The interaction of the major work packages and the flow of results is illustrated in Figure 5.

BUDGETING

An expenditure profile, by month, is provided in Figure 6. This correlates with the funding and scheduling requirements of the work packages. Figure 7 illustrates the cumulative expenditure profile during Phase B. All funds are in budget-year dollars.

The costing of the Phase B work has been carried out by staff of the Space Program Sector of the Department of Communications (DOC), and is based on extensive experience gained in the contracting of studies and R&D in previous satellite projects. The DOC expenditure on Phase B of the MSAT Program will not exceed the budget of $17 million. Apart from an allowance for inflation at 10 per cent a year, no further allowance for uncertainties has been made. Should there be any unforeseen requirements, they will be met within the budget allocation by reducing the scope of lower priority work packages within the technology development area.

Figure 3 Phase B Milestones

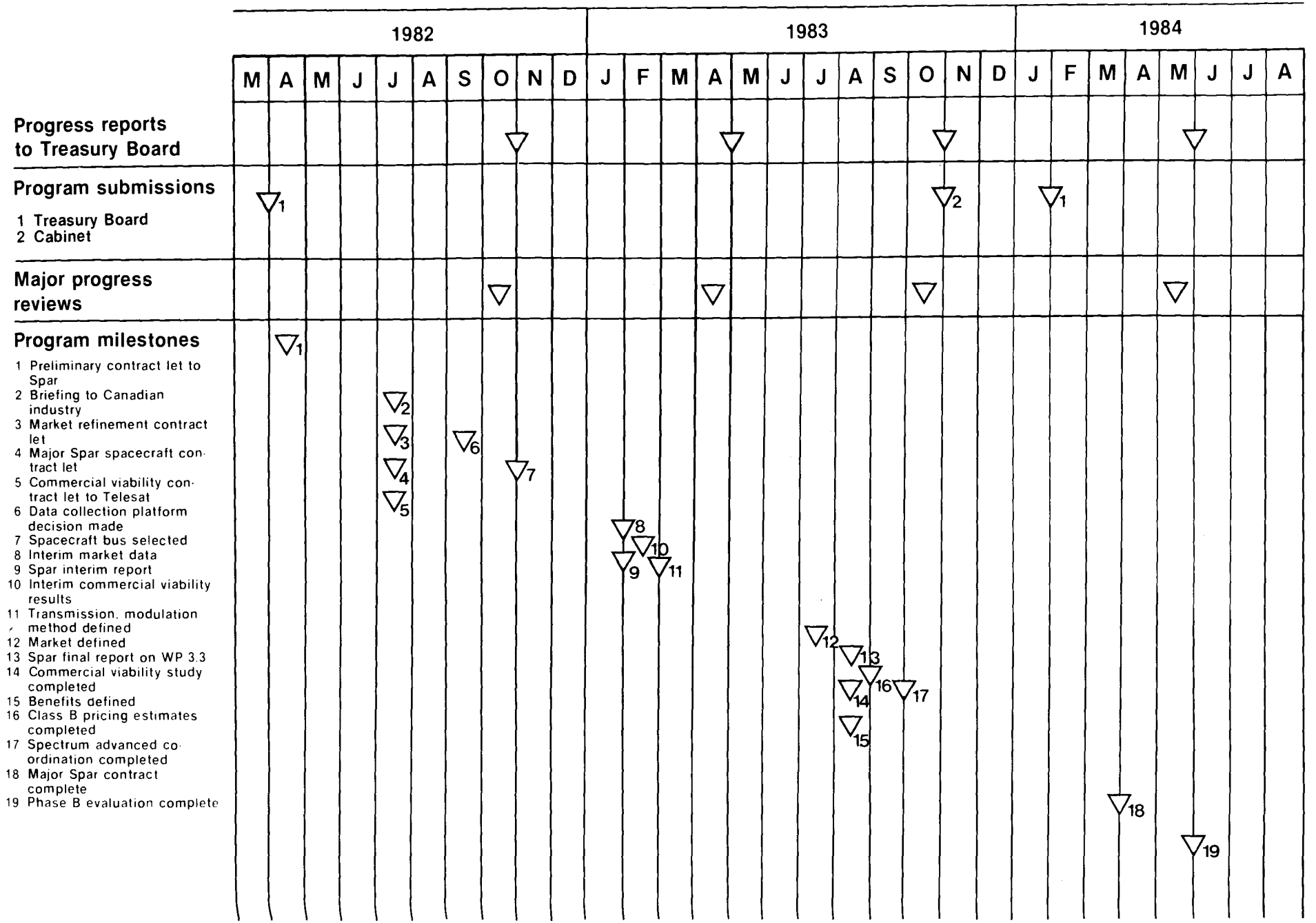


Figure 4 Phase B Schedule

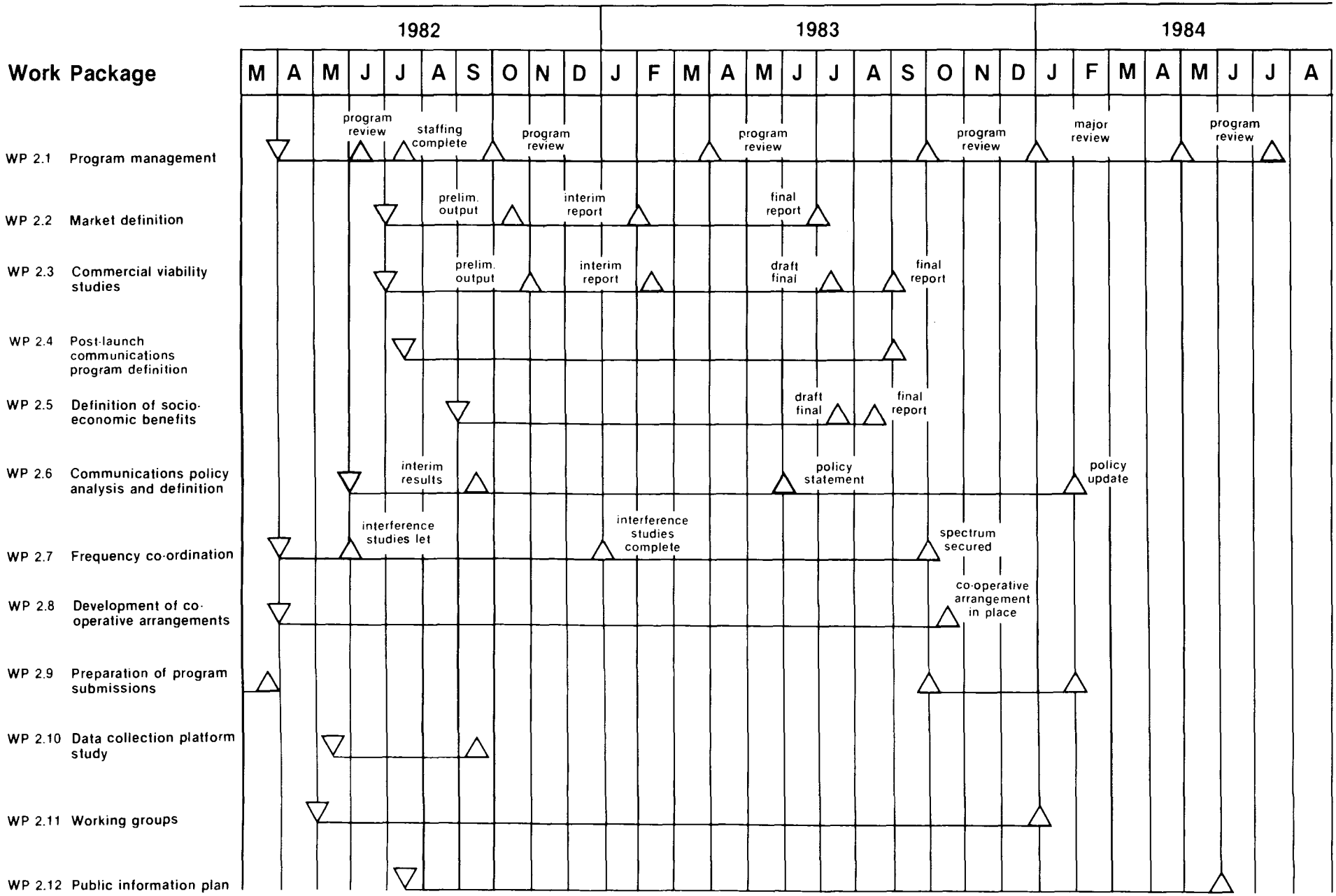


Figure 4 Phase B Schedule (continued)

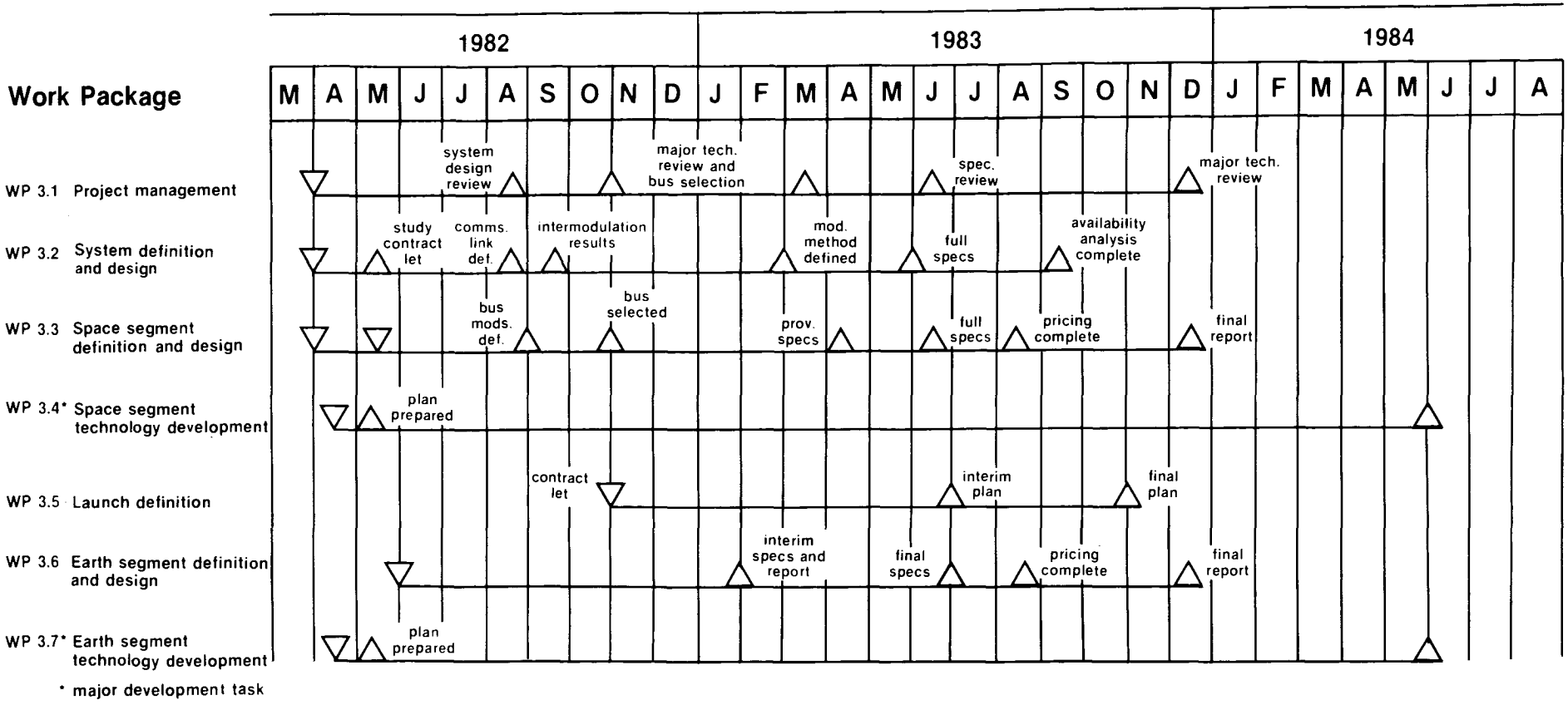


Figure 5 Interaction of Major Phase B Work Packages

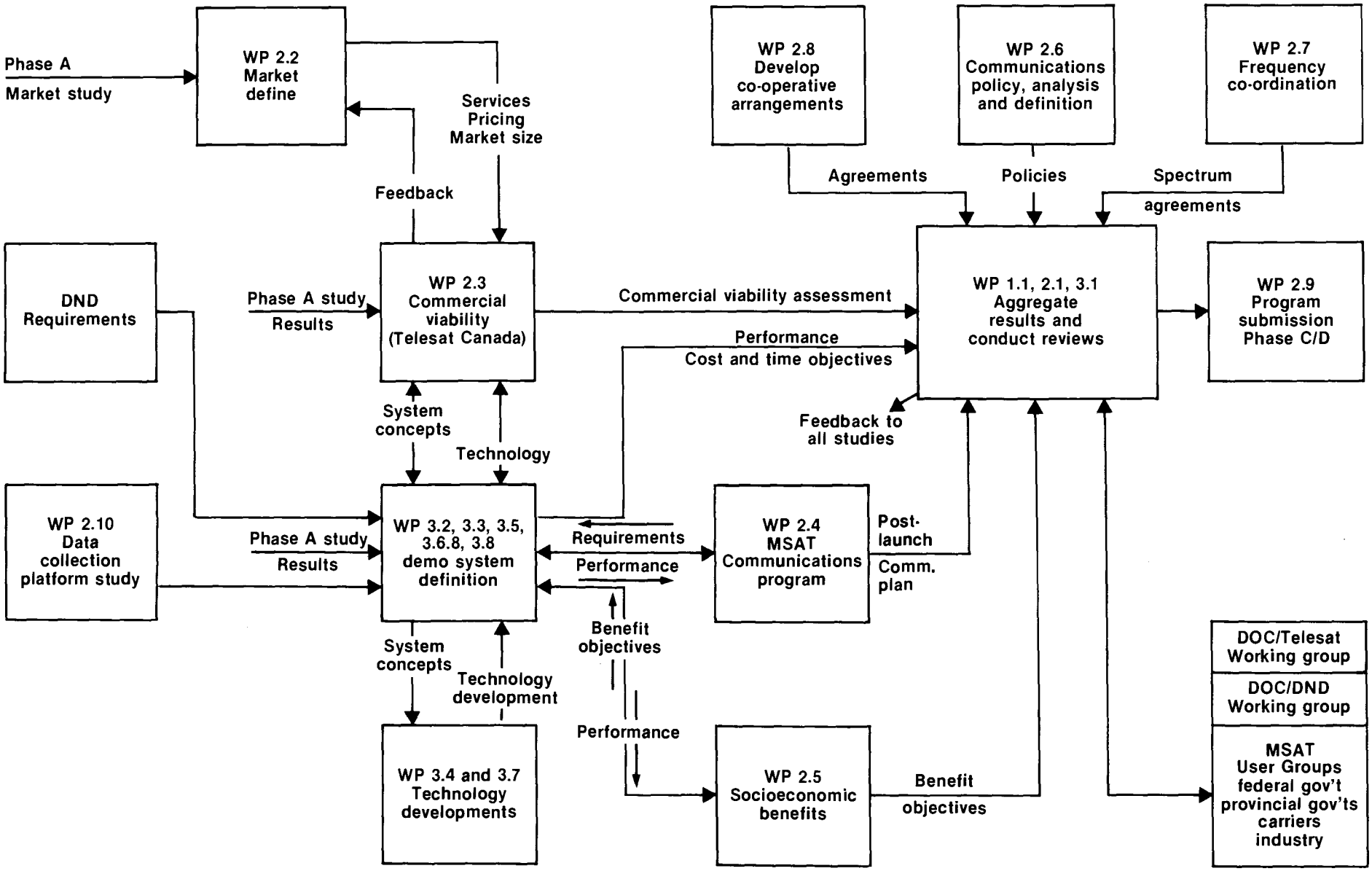


Figure 6

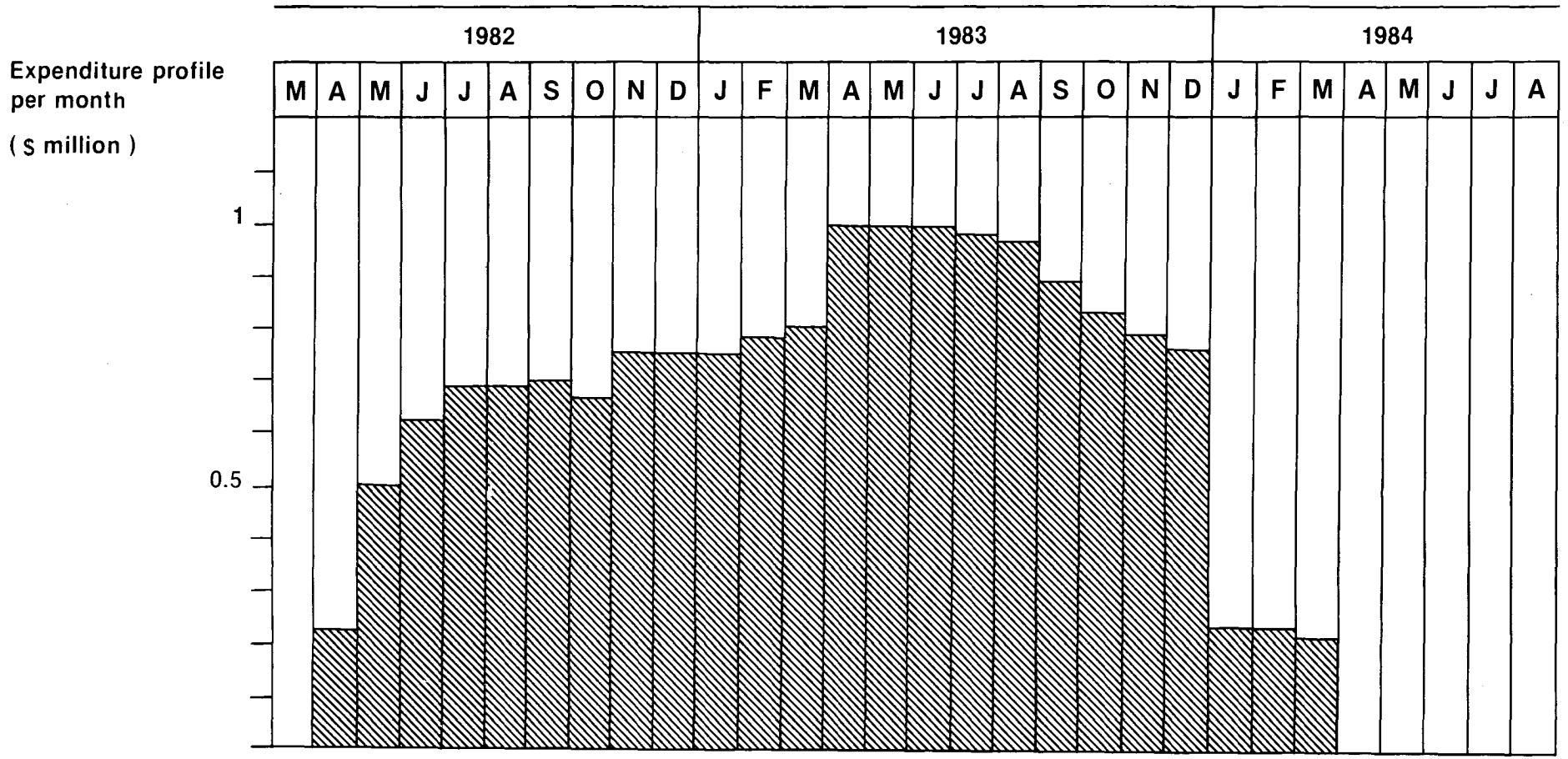
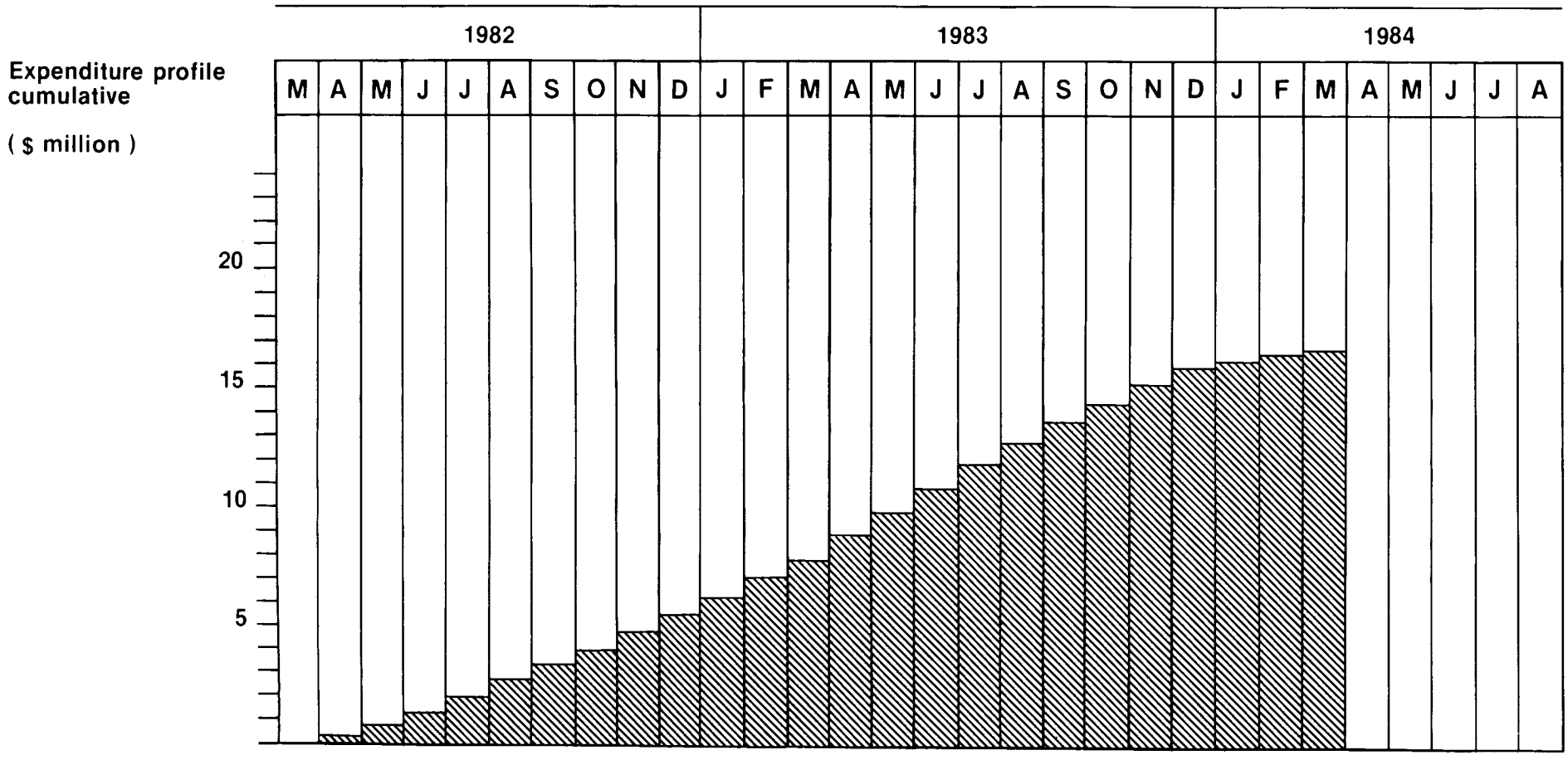

1982
1983
1984
Expenditure profile per month
($ million)
1
0.5
M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A

Figure 7


1982
1983
1984
M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A
Expenditure profile cumulative
($ million)
20
15
10
5

SECTION 6. ORGANIZATION

OVERVIEW

The MSAT Phase B organization will be two-tier organization as shown in Figure 8. It consists of an MSAT Planning/Implementation Committee chaired by the Department of Communications (DOC) as lead department and an MSAT Project Team. The organization and the interdepartmental agreement described here apply only for Phase B of the MSAT Program. The Phase C/D project brief to be prepared at the completion of Phase B will make adjustments to the organization and other arrangements as needed and define the interdepartmental agreements to completion of the project.

PLANNING/IMPLEMENTATION COMMITTEE

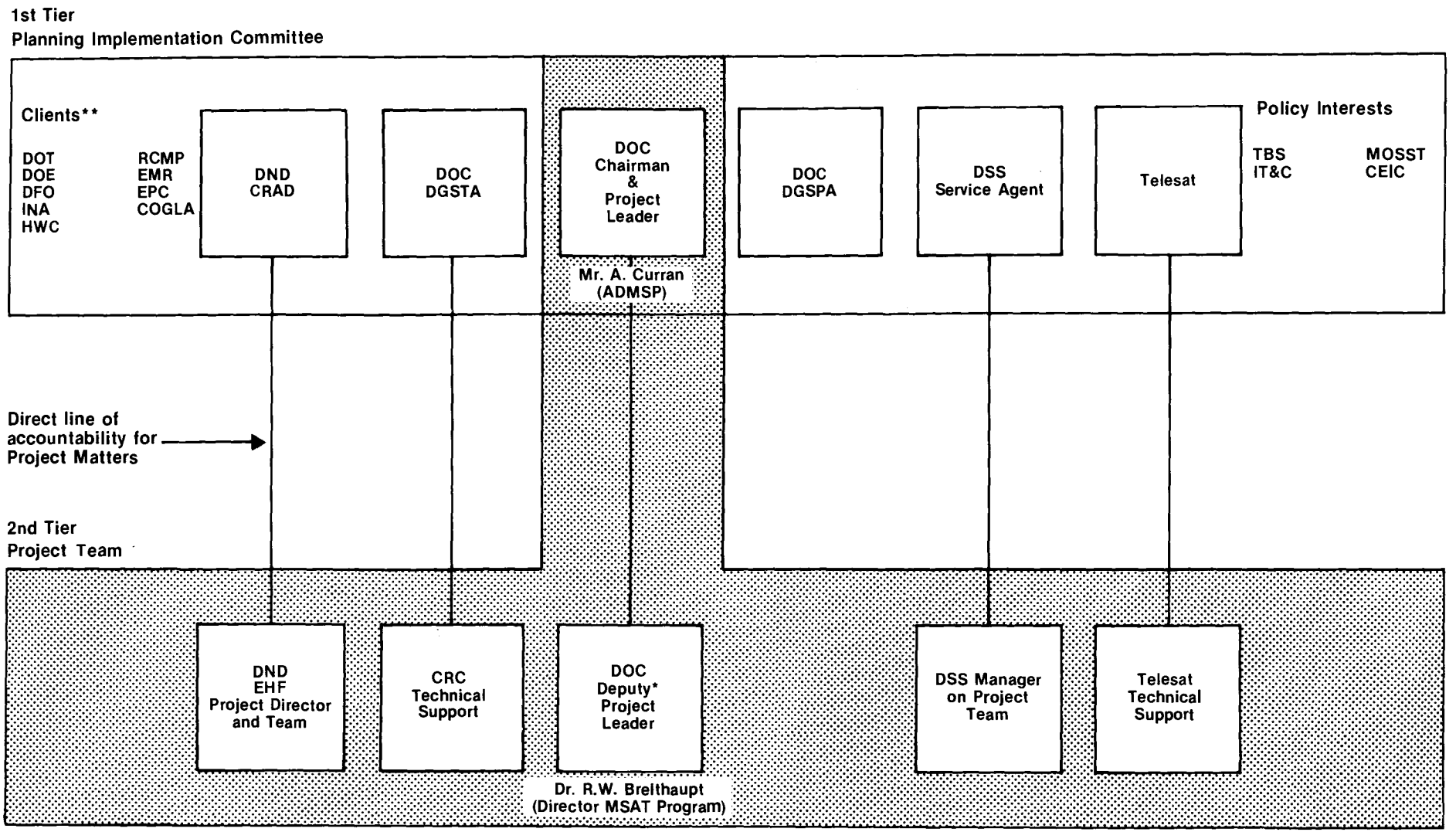
General

The MSAT Planning/Implementation Committee will be led by DOC not only as a major client, but also as the main source of space expertise in the government and as a service agent for other client departments. The committee will have a representative from the Department of National Defence (DND) which is sponsoring the design definition of a military payload for inclusion on the MSAT spacecraft; from the Department of Supply and Services (DSS) which will provide contract adminstration support; from Department of Transport (DOT), Department of Environment (DOE), Indian and Northern Affairs (INA), Health and Welfare Canada (HWC), Royal Canadian Mounted Police (RCMP), Energy Mines and Resources Canada (EMR), Emergency Planning Canada (EPC), and Canadian Oil and Gas Lands Administration (COGLA) which are interested MSAT user departments; and from Treasury Board Secretariat (TBS), Industry Trade and Commerce (IT&C), Ministry of State for Science and Technology (MOSST) and Canada Employment and Immigration Commission (CEIC), which are interested in the implementation of their respective policy objectives through the MSAT Program. Telesat Canada will be an ex officio member of the committee as it will be responsible for decisions regarding a commercial follow-on system for public needs.

The MSAT Planning/Implementation Committee will be chaired by Alex Curran, Assistant Deputy Minister, Space Program (ADMSP) who will also be the MSAT Project Leader as defined by Treasury Board (Ref. 4). Mr. Curran will be accountable to the Deputy Minister of DOC for successful completion of Phase B. The Planning/Implementation Committee will meet regularly to review progress on the MSAT Program.

The Deputy Project Leader will be Dr. R.W. Breithaupt, Director, MSAT Program. He will receive general direction from Mr. Curran and will be accountable to him for successful completion of Phase B. He will have delegated responsibility from Mr. Curran for all MSAT studies and implementation activities except for DND responsibilities. He will be secretary of the Planning/Implementation Committee during Phase B.

Figure 8 MSAT Project Organization Structure



* See subordinate organization in Figure 9

** Major clients will also be represented on the project team through the working groups as shown in Figure 9

Dr. C.A. Franklin, Director General, Space Programs and Industry Development, (DGSPA) will provide functional management and administrative support as well as personnel to the MSAT Project Team.

Dr. B.C. Blevis, Director General, Space Technology and Applications (DGSTA), will also provide manpower to conduct specific technology development activities for the project and to provide specialist consultant services to the project. Both Dr. Franklin and Dr. Blevis will be members of the MSAT Planning/ Implementation Committee.

Overall responsibilities of committee

During Phase B, the MSAT Planning/Implementation Committee will:

- assume overall responsibility for the conduct of Phase B of the MSAT Program as described in the approved Phase B project brief which also constitutes the MSAT Phase B interdepartmental project agreement
- ensure that Phase B activities described in the project agreement are carried out in the most effective manner
- ensure senior level consultation and co-ordination during the contracting process, in instances of special socioeconomic importance, for example, where ministers may wish to endorse a specific contract proposal
- resolve disputes that may arise during the project
- ensure that the information necessary to inform Treasury Board of progress be in proper form, clear and succinct
- ensure that a post-project evaluation report is submitted to Treasury Board

Authority and responsibilities of members

The chairman and committee members will have the necessary authority from their departments to permit effective conduct of the project.

The committee members will be the project focal point within each department, with responsibility for the portion of the project that falls within each department's authority as specified in the project agreement.

The members will marshal within their own departments the resources necessary to support their involvement on the committee. The personnel designated by each department will have the authority and the responsibilities deemed necessary by the department's committee representative in conformity with the project agreement.

Membership and specific responsibilities

The responsibilities of members of the MSAT Planning/Implementation Committee are as follows:

Department of Communications

DOC will be the lead authority for the MSAT Program. As such, the department will integrate all requirements, act as overall system authority, maintain configuration control and define interface requirements. The department will be responsible for the definition and design of the MSAT system except for the Department of National Defence communications terminals.

Department of National Defence

DND will be responsible for specifying its mission requirements to be satisfied by MSAT, and for defining the DND element of MSAT. DND will participate in the definition and design of the DND elements of MSAT. The department's responsibilities during Phase B have been detailed in a DOC/DND administrative arrangement.

Department of Supply and Services

DSS will be responsible for administration of the MSAT Phase B contracts. This responsibility will be carried out by participating on the MSAT Planning/ Implementation Committee and by assigning a DSS contract manager to work for, and be located with, the MSAT Project Team. The department's responsibilities are specified in detail in a DOC/DSS agreement.

Other Interested User Departments

As eventual users of the MSAT system the following departments and organizations will participate on the MSAT Planning/Implementation Committee: DOT, DOE, DFO, INA, HWC, RCMP, EMR, EPC and COGLA. During Phase B they will be responsible for examining how MSAT services could be integrated into their operations, for planning participation in the post-launch MSAT communications program, for advising the Department of Communications on departmental and national needs, for co-operating as appropriate with the MSAT Project Team and MSAT contractors involved in market, commercial viability and user cost-benefit studies, and for reviewing and co-ordinating program submissions. The RCMP has stated that their participation in the MSAT Program must not place any restriction on the development of terrestrial systems, particularly in the areas of spectrum allocation and funding.

Canada Employment and Immigration Commission

CEIC will be responsible for reviewing the manpower required by the contractors involved in the project. Included in the terms and conditions of contracts for MSAT will be a requirement for the contractors to engage in effective manpower planning. CEIC will review the manpower plans submitted and advise DOC as to their overall suitability. CEIC will also assist the contractors in carrying out the manpower plans as required.

Other departments and agencies

The following departments will participate on the MSAT Planning/Implementation Committee to ensure that their policy objectives and concerns are adequately considered:

MOSST: Co-ordination of government space programs
Space industry loading
Spacecraft prime contractor policy

TBS: Resource allocation
Government administrative policy

CEIC: Implications on labour force

IT&C: Industry development
Regional development
Export potential

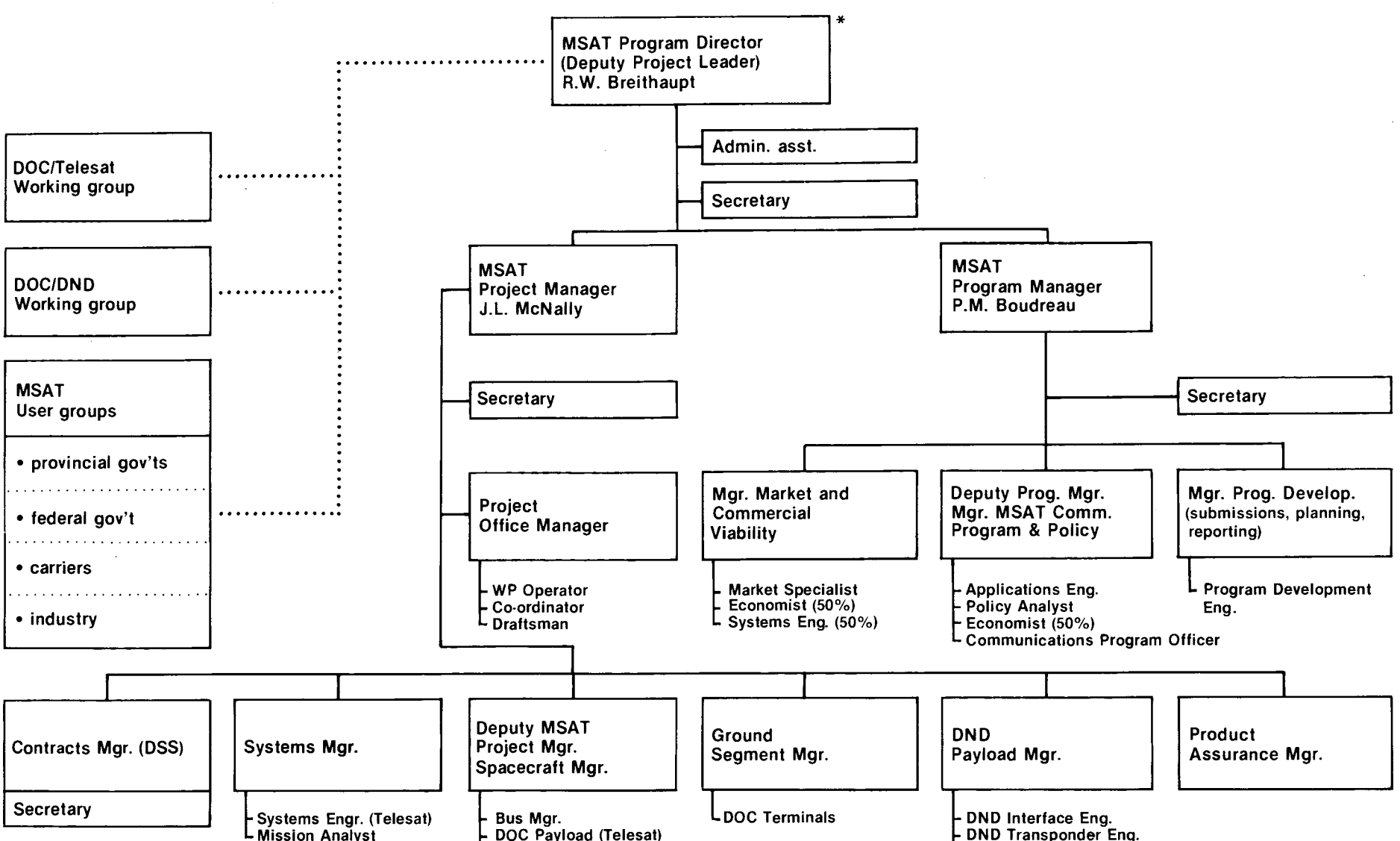
PROJECT TEAM

General

The MSAT organizational structure for Phase B is shown in Figure 9. The MSAT Program Director will be responsible as Deputy Project Leader, for all MSAT studies and implementation activities. The MSAT Program Manager and MSAT Project Manager will report to him. The MSAT Program Manager will be responsible for the market and commercial viability assessment, the definition of MSAT communications program, and for policy, submissions, non-military co-operative arrangements and related areas. The MSAT Project Manager will be responsible for defining and designing the MSAT demonstration system.

The MSAT organization will be located at the Communications Research Centre (CRC) and the positions will be staffed by personnel from DOC, DND, DSS and Telesat Canada.

Figure 9 Phase B Organization



*See MSAT Senior Management Structure Figure 8

Program Manager and Organization

P.M. Boudreau will be the MSAT Program Manager responsible for the work packages described in Section 4 under Program Definition and will have the following key positions in his organization:

- Deputy Program Manager and Manager of MSAT Communications Program and Policy
- Manager, Market and Commercial Viability
- Manager, Program Development

Project Manager and Organization

J.L. McNally, the MSAT Project Manager, will be responsible for the work packages described in Section 4 under System Definition and will have the following key positions in his organization:

- Deputy MSAT Project Manager and Spacecraft Manager
- Systems Manager
- Ground Segment Manager
- Procurement Manager
- Product Assurance Manager
- DND Payload Manager
- Project Office Manager

DOC/DND Working Group

This liaison committee, to be co-chaired at the director level by DOC and DND, will be established to discuss and resolve all matters concerning joint DND/DOC interests or responsibilities in the MSAT Program, as required, except for those matters requiring consideration by the Planning/Implementation Committee.

DOC/Telesat Working Group

This liaison committee, to be co-chaired by DOC and Telesat at the director level, will be established to discuss and resolve all matters concerning joint Telesat/DOC interests or responsibilities in the MSAT Program, as required, except for those matters requiring consideration by the Planning/Implementation Committee. This group will be particularly interested in ensuring that Telesat findings regarding the definition of an operational commercial system properly impact the MSAT demonstration system design and, similarly, that MSAT definition studies properly impact the design of a subsequent operational system.

Configuration Control Board

See Section 7 under Other Control Systems.

User Working Groups

User working groups will be established as described in Section 4 under System Definition WP 2.11. Agreements between DOC and each interested client department and external participant will be prepared during Phase B in the form of a Memorandum of Understanding.

INTERNATIONAL INVOLVEMENT

During Phase B, exploratory discussions and, as appropriate, negotiations will take place with NASA, European Space Agency (ESA), International Maritime Satellite Organization (INMARSAT) and other agencies and countries potentially interested in involvement in the MSAT Program. DND will be responsible for all dealings with allied military agencies. The objective will be to seek co-operative arrangements which would involve sharing of program responsibilities, benefits and costs in subsequent phases of the MSAT Program. International involvement will be accepted only if it can be achieved without unacceptable compromise to the Canadian objectives of the program.

PROVINCIAL INVOLVEMENT

During Phase B it is expected that a number of provinces will participate by: conducting MSAT needs and benefit studies; advising DOC on provincial requirements; co-operating with department officials and MSAT contractors in market, commercial viability and user cost-benefit studies; and by defining plans for their involvement in the post-launch MSAT communications program. During Phase B, DOC will make an announcement of opportunity for participation in the MSAT Program and invite preliminary proposals from provincial governments and others for experiments, field trials and pre-operational services following launch.

PRIVATE SECTOR INVOLVEMENT

Telesat

Telesat Canada will play a special role in Phase B of the MSAT Program as future owner and operator of any commercial follow-on operational system for public needs and will be an ex officio member to the MSAT Planning/Implementation Committee. Also, the establishing of a DOC/Telesat Working Group will facilitate dialogue concerning all aspects of MSAT, as previously described.

Telesat Canada will be asked to undertake a major study regarding the commercial viability of a subsequent satellite system for follow-on service to mobile users. The results of this study will be an important factor in deciding whether to implement the MSAT system.

Telesat Canada will be invited to assign staff to the MSAT Phase B Project Team.

Telesat may also be awarded study contracts during Phase B in support of system definition and design activities described in Section 4 under System Definition.

Other Private Sector Involvement

During Phase B, DOC will consult and co-operate with a wide variety of organizations in the private sector to assess needs and to prepare preliminary plans for the post-launch MSAT communications program. In particular, co-operation is expected from telephone companies, radio common carriers, and firms involved in resource development and other activities requiring mobile communications in rural and remote areas of Canada.

SECTION 7. CONTROL

GENERAL

This section describes the management procedures that will be employed to control, direct and report on MSAT Program activities during Phase B.

CENTRAL CONTROL BY TREASURY BOARD

A Project Identification Sheet (TB350-41E(11/79)) will be submitted to Treasury Board in accordance with Treasury Board Circular No.: 770941 dated May 14, 1980, with the first Project Progress Report (TB350-40E(11/79)) not later than six months after approval of the project brief. Progress reports will be submitted at six-month intervals during Phase B.

DEPARTMENT OF COMMUNICATIONS CONTROL

Reporting

Within the Department of Communications (DOC) a two-tier reporting system involving a monthly Level I report at the ADM level and a monthly Level II report at the MSAT Director level will be implemented to ensure that information is available at the appropriate management level for program control and direction.

The monthly Level I report will be approved by the Director, MSAT Program for release to the MSAT Planning/Implementation Committee and to DOC senior management.

The monthly Level II reports will be prepared by the MSAT Project Manager and the MSAT Program Manager for release by the Director, MSAT Program.

The Level I and Level II reports will provide a summary review and outlook of in-house and contract activities, problems and recommendations, action items and financial status. These reports will be in the standard format required for the department Space Sector Level I and Level II reports.

Progress Reviews

The MSAT Planning/Implementation Committee will hold major progress review meetings at six-month intervals from the start of Phase B, to correspond with the progress reports to be submitted to Treasury Board. This committee will hold other meetings as needed to carry out its other responsibilities described in Section 6.

The Assistant Deputy Minister, Space Program will chair monthly departmental progress review meetings as required to correspond with submission of the monthly Level I Report.

The MSAT Program Director will hold weekly progress review meetings.

Other Control Systems

An MSAT System Configuration Control Board (CCB) will be established during Phase B to review and approve changes to the MSAT system baseline. Prior to the establishment of the board, its terms of reference and proposed representation will be submitted to the MSAT Planning/Implementation Committee for approval. The board is a part of the project activity which deals on its own authority with only those items that do not affect the overall objectives, schedule, cost or performance.

A document control system will be implemented during Phase B to ensure accuracy and flow of information. This is essential for effective system-configuration management.

Both the board and the document control system will be the responsibility of the MSAT Project Manager.

CONTRACTOR CONTROL

Contracts with industry will contain clear statements of work and deliverables; schedules, with key milestones; and planned expenditure profiles tied to the milestones. Contractors will be required to submit monthly progress reports and regular progress-review meetings will be held with contractors to monitor work performance and expenditures. Action will be taken as needed when there are deviations from plans. Contractors will be required to develop and submit a manpower plan confirming that they have the work force necessary to successfully complete the project.

APPENDIX A

STATEMENT OF REQUIREMENT

FOR

MSAT PROGRAM

CONTENTS

STATEMENT OF REQUIREMENT

1. INTRODUCTION

The purpose of this appendix is to provide a statement of the requirements for the MSAT Program. The background on how these requirements arose and their relationship to the mandate of the Department of Communications are provided in Section 2 and Section 3 of the Project Plan. The MSAT requirements are stated in terms of distinct communications service requirements for both the Department of Communications (DOC) and Department of National Defence (DND) sponsored MSAT system.

2. THE DEPARTMENT OF COMMUNICATIONS REQUIREMENTS FOR MSAT

2.1 General

There are three types of civilian requirements for DOC sponsored element of MSAT:

- mobile-satellite services at 806-890 MHz
- meteorological and earth exploration sensor data collection services at 401-403 MHz
- experimental emergency beacon monitoring service at 406.1 MHz

The requirements for mobile-satellite services at 806-890 MHz far exceed the other civilian requirements, and are therefore discussed in much greater detail.

2.2 Requirements for Mobile-satellite services at 806-890 MHz

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

Mobile radio service: This service consists of voice communications between a mobile radio and a base station without interconnection with the switched telephone network. Business enterprises and government agencies can either own their system or lease the service from Radio Common Carriers (RCCs). There are approximately 400 000 mobile radios in Canada today operating in thousands of independent systems.

Mobile telephone service: This is a service offered to the public 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. There are approximately 50 000 mobile telephone subscribers in Canada. Service is generally available only in metropolitan areas except in western Canada

where extensive coverage is provided in rural areas also. Overall, approximately 14 per cent of Canadian territory, and 50 per cent of the population, has access to mobile telephone service.

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

- There are insufficient frequencies to satisfy the market demand in the cities.

- There is inadequate coverage and poor quality of service in extensive rural and remote areas of Canada due to the technical and economic difficulties of serving these areas with terrestrial systems. Wide-area systems needed for essential services to these areas are costly to install and maintain.

- Systems operating in different regions of Canada are incompatible with respect to frequency and signalling protocol, and as a result roaming mobiles cannot operate outside their home region. An exception is the 150 MHz manual systems, but these have inadequate capacity to meet service demand.

New systems and frequency spectrum are needed to improve mobile communications in both metropolitan and non-metropolitan areas Canada. DOC will allocate new spectrum for mobile services at 806-890 MHz to be partitioned between terrestrial and satellite systems. In particular, new 800 MHz terrestrial cellular mobile telephone systems and conventional/trunked mobile radio systems will remove frequency congestion in cities. However, these terrestrial systems are not expected to be economically viable in serving large rural and remote areas because coverage by a base station in the 806-890 MHz band is limited to a radius of 10-15 miles. A mobile-satellite system will complement the terrestrial systems by providing nationwide coverage to rural and remote areas and nationwide compatibility of services, thus greatly improving mobile services in Canada.

The requirement for satellite service to mobile radios and telephones in the 806-890 MHz band was established by Woods Gordon Management Consultants through a market study contracted by the department during Phase A of the MSAT Program. The result of this study constitutes the statement of requirements for the mobile-satellite services at 806-890 MHz. These requirements and the analysis that led to them are documented in detail in Reference 6 and are summarized in the attachment to this appendix.

The requirements were determined from extensive needs analysis that followed more than 600 interviews by Woods Gordon, in all regions of Canada, with organizations owning in total more than 25 per cent of the 450 000 mobile radios and telephones presently operating in the country.

The Woods Gordon projections indicate that the number of mobile terminals constituting a potential market for MSAT will be 372 000 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 per cent in 1987 to 50 per cent in 1998. The projections indicate that during the period of operation of the MSAT demonstration system, there will be a requirement to serve 23 000 mobile terminals. A follow-on operational system would serve 140 000 mobile terminals by the year 2001.

2.3 Requirements for Sensor Data Collection Services at 401-403 MHz

The purpose of this satellite service is to collect meteorological, hydrological, glaciological, oceanographic, and pollution monitoring data from remote sensors and to distribute the information to users in government agencies for flood warning, hydro-electric projects, environmental control, and other applications. This data collection service is also of interest to resource industries and to earth scientists.

This service must be provided by satellite in most cases because there are no terrestrial communications facilities in the remote locations where the platforms must be installed.

In the 1980s a requirement will exist for collection of environmental data from several hundred such sensors on unattended remote platforms. There are presently 159 registered Canadian data collection platforms (DCPs) that operate with the US government GOES satellite system, 38 platforms that opearte with ERTS/LANDSAT, and 35 platforms that operate with the French government ARGOS system. (Table A1) At the present time there is no charge to Canadian users for use of these spacecraft. Users have to provide only their platforms and the communications links from the central data acquisition station to the user address where the data is needed. It is expected that this no-charge policy for use of these foreign satellites will not continue and that the service may not continue to be available to all potential Canadian users.

The Department of Environment (DOE) is extremely interested in pursuing the possible inclusion of a data collection platform payload as part of MSAT. At the present time the department is considering a number of alternative ways of obtaining and maintaining data collection services.

DOE has indicated that it will be in a position to make some formal commitment to a data collection payload on MSAT by the late fall of 1982 and has requested that DOC keep the option of such a payload open until that time.

The Department of Transport (DOT) has indicated that while it can visualize application areas for data collection services (for example monitoring of navigation systems, remote supervision of DOT facilities there are at this time no specific plans or application areas which are specifically set aside for satellite applications. However, since MSAT is an experimental system, DOT indicated that it sees merit in including the data collection service payload in order to evaluate the potential application areas, provided this did not impact on the effectiveness of the primary MSAT service. The Department of Fisheries and Oceans (DFO) and Indian and Northern Affairs (INA) have also indicated their interest in the data collection services. The cost of including a data

TABLE A1 CANADIAN DCP USERS

		B.C.	Alta.	Sask.	Man.	Ont.	Quebec	N.B.	N.S.	Nfld.	YK.	N.W.T.	Totals
Department of Environment	G	3	1	2	4	13	2	5		2	3	17	52
	E	5	1	3	3	4		1		1	3	15	36
	T	20				1			10			4	35
B.C. Hydro and Power Authority	G	18											18
	E												
	T												
Wellsdale Research Ltd.	G		1										1
	E												
	T												
National Research Council	G		1	1	1	1				1			5
	E												
	T												
Alberta Environment	G		10										10
	E												
	T												
Saskatchewan Research Council	G			8									8
	E												
	T												
Canadian Occidental Petroleum Ltd.	G			1									1
	E												
	T												
Ontario Hydro	G					1							1
	E												
	T												
Ministère des Richesses naturelles du Québec	G						54						54
	E						1						1
	T												
Hermes Electronic Ltd.	G								2				2
	E												
	T												
Petro-Canada	G									4			4
	E												
	T												
Aquitaine Company of Canada Ltd.	G									1		1	2
	E												
	T												
Transcanada Pipelines	G											1	1
	E												
	T												

G – GOES
E – ERTS/LANDSAT
T – TIROS/ARGOS

collection payload on MSAT will depend on what other payloads are included, and is of the order of $3 million (1981 dollars).

In view of the need expressed by several departments for data collection services, this payload has been retained for future study during Phase B. DOC has agreed to lead the study of the various technical and cost factors affecting the inclusion of a data collection payload on MSAT. This study will be supported by DOE staff and will involve consultation with other potential Canadian users.

2.4 Requirements for Experimental Emergency Beacon Monitoring at 406.1 MHz

The purpose of this service is to monitor distress signals transmitted from aircraft, ships, or field parties. The distress signal will be retransmitted via MSAT to a Search and Rescue Co-ordination Centre and will provide almost immediate notification of a distress incident and identification of the party in distress. This system will be complementary to SARSAT, which will provide the location of the distress incident, but only on a periodic basis.

In 1980 there were 589 emergency locator transmitter (ELT) alerts which required a DND response. It is essential that the SAR Centre 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 would be used to assess feasibility of improved response.

The DOT supports the SARSAT experimental program and considers an MSAT (406.1 MHz) package would be a desirable back-up and complement to the SARSAT system.

It should be noted that the DOT position on 406.1 MHz ELT/EPIRBs is still subject to international developments in such forums as Inter-govermental Maritime Consultive Organization and International Civil Aviation Organization (neither of which has yet formally endorsed SARSAT or the 406.1 MHz frequency), to an INMARSAT decision on 1.6 GHz emergency transponder, and of course to the results of the upcoming 406.1 MHz SARSAT tests.

The inclusion of the emergency monitoring capability on MSAT is expected to have very small additional impact on the MSAT spacecraft cost and complexity if the data collection package is also included.

DND has no interest or requirement for the inclusion of this payload on MSAT.

3. DND REQUIREMENTS FOR MSAT

The Department of National Defence Phase B objective is to determine if an experimental military EHF package on the DOC MSAT would further DND's technological progress towards a dedicated military satellite communications system sufficiently to justify MSAT investment by DND beyond Phase B. If DND were to proceed beyond Phase B there would be an experimental post launch program aimed at further developments needed for future military operations in the EHF band.

The definition of a DND experimental EHF package which could be part of the MSAT will help the department determine the most cost effective option for acquiring required future military EHF capabilities and contribute directly to their development.

ATTACHMENT TO APPENDIX A

SUMMARY OF USER REQUIREMENTS FOR A MOBILE-SATELLITE SYSTEM OPERATING IN THE 806-890 MHz BAND

(Woods Gordon study
completed in September, 1981)

1. EXECUTIVE SUMMARY

1.1 OBJECTIVES OF THE STUDY

This study of 'User Requirements for a Mobile Satellite System Operating in the 806-890 MHz Band' is the first of a series of studies planned by the federal Department of Communications (DOC) to quantify the market size and potential for MSat and to provide additional technical and commercial data necessary for development of a demonstration satellite to be launched in the late 1980's.

Specific objectives for this study were:

(i) Determination of the Services Required on MSat, such as voice, facsimile, data, teletype, etc.

(ii) Determination of the Projected Number of Users of MSat in the 1985-2000 Timeframe, involving identification of future MSat users and what section(s) of the market the system should be focused on; the degree of market penetration expected; the potential number of service users and the types of mobile communications units required, and potential traffic volume on a regional basis.

(iii) Determination of Potential MSat Service Pricing, that is the amount users are willing to pay on a per-minute basis for the services required.

1.2 THE STUDY METHODOLOGY

The bulk of the data utilized in this study was developed from a user survey carried out with current users of mobile communications systems and services. DOC Mobile licence data were used to define the total existing user population and a sample of these users was selected for interview. The sampling methodology ensured that all large users (i.e. those with 375 mobiles or more within one DOC district) were included in the sample and that a random selection of smaller users was included to provide a representative mix of users.

Personal and supporting telephone interviews were carried out with around 650 users throughout Canada. Additional inputs to this study were obtained from a review of a wide variety of previous mobile communications studies for Canada and the U.S., along with supplementary interviews with other knowledgeable sources such as equipment manufacturers, telephone companies and radio common carriers. The projection methodology for the MSat potential market and the level of market penetration by MSat is based on projecting growth for the relevant segment of the current mobile communications market.

Numerical analysis of the survey data was carried out by computer where possible. Considerable qualitative input was also obtained from the interview program and this has been utilized, where appropriate, throughout the study.

1.3 THE POTENTIAL MARKET FOR MSat

The potential market size for MSat was investigated in two stages. First, we defined the total potential market, representing all mobile communications users who could reasonably make use of MSat. Second, we estimated the proportion of this population that might actually use MSat, i.e. the market share or market penetration for MSat.

The total potential market identified for MSat consists of all those users of mobile communications whose systems have a range of 50 miles radius or more and whose system usage within any one metropolitan area is no more than 25% of total system usage. That is, any user with a wide-area system and more than 75% of usage outside areas with populations of 100,000 or more. This is considered to be a conservative cut-off point for MSat potential, based on the data

currently available about the proposed satellite system and the alternative terrestrial systems.

At the present time, there are just over 410,000 licensed land-based mobile radios in Canada, with a further 41,000 licensed ship and aircraft mobiles. This overall population is expected to grow as follows over the period to 2001:

Growth in Total Licensed Mobile Communications Market

	Actual		Projected			
	1976	1981	1986	1991	1996	2001
Number of Units (000's)	265	451	641	820	970	1,090
		1976-81	1981-86	1986-91	1991-96	1996-2001
5 Year Compound Annual Growth Rate (%)		11.2	7.3	5.1	3.4	2.3

Overall mobile population growth between 1981 and 2001 is projected to be 142%. The growth rates for mobile communications are expected to decline over the next twenty years as penetration of the various industry sectors approaches saturation levels.

The current number of mobiles utilized by users who meet the MSat potential market criteria is estimated at 249,000 or 55% of the present licensed mobile population of 451,000 units. Projected growth in this MSat-potential group is shown in the following table:

Growth in MSat Potential Market

	Estimated	Projected			
	1981	1986	1991	1996	2001
Number of Units (000's)	249	351	450	532	596
Airtime (million minutes per average month)	64	91	115	134	148

These projections show the number of mobile units in the MSat potential population growing by 139% over the period to 2001. In comparison, the total licensed mobile communications market is expected to grow by a similar proportion from 451,000 mobiles to 1,090,000 mobiles over the same period. Average airtime per mobile is expected to remain constant over this period due to the fact that airtime usage per mobile is already at the maximum level likely for most applications. Since revenues and traffic volume would be directly related to the number of mobile units we have treated the number of units and number of users as being synonymous rather than identifying the number of user systems involved.

The traffic volume or airtime associated with these users is expected to increase by 131% (from 64 million to 148 million minutes per average month). Traffic volume is increasing at a slightly lower rate than number of mobiles due to higher projected growth for mobiles in industry sectors with lower than average airtime per mobile.

Traffic volume distribution on a regional basis for the MSat potential market was developed by projecting regional growth trends which result in the following pattern:

Regional Airtime Distribution
(millions of minutes per average month)

Region	1981 Airtime	1981 %	2001 Airtime	2001 %
BC & Yukon	12.8	20	27.9	19
Prairies & NWT	15.2	24	39.7	27
Ontario	20.2	31	51.0	34
Quebec	10.1	16	13.8	9
Atlantic	5.7	9	15.6	11
Total Canada	64.0	100	148.0	100

The results of these regional projections indicate the long term impact that continuance of current regional trends would have on the demand for mobile communications. An alternative projection methodology based on the assumption that there is no change in the regional distribution of mobile communications for each of the main industry sectors is presented in Section 3 of the Report. The degree of uncertainty associated with these regional airtime projection indicates the need to maintain a high enough degree of flexibility in the design and planning of MSat to account for such uncertainties.

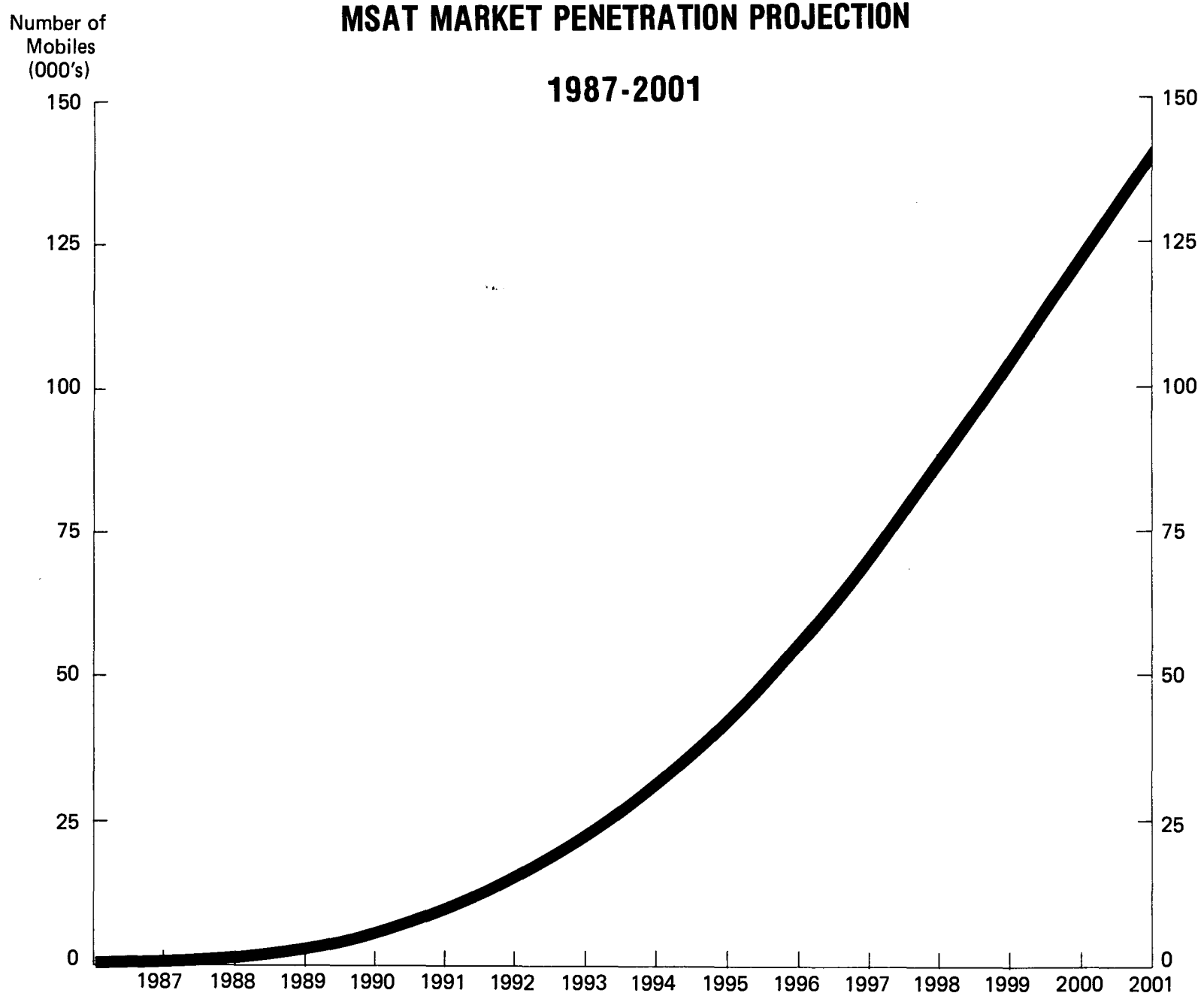
1.4 MSat MARKET PENETRATION

The scenario developed for the market share or market penetration that could be achieved by MSat assumes that, after a period of 15 years from the start of the demonstration phase, a satellite system would capture 50% of the new and replacement market for wide-area, non-metropolitan mobile communications. This will include mobiles associated with system replacements as well as those added to expand an existing MSat system and those purchased by new users. With this scenario, by the year 2001, the MSat units would account for a projected 23% of the installed base of wide-area, non-metropolitan mobiles. On the basis of all the information currently available, this appears to be a reasonable target, provided:

(i) The subscriber costs for MSat are competitive, considering its expected superior performance, with the costs a user would incur if installing a new terrestrial system or replacing an existing one

MSAT MARKET PENETRATION PROJECTION

1987-2001



Woods Gordon

(ii) Pricing policies are flexible enough to allow for fixed monthly charges per mobile rather than pricing the services strictly on a ¢-per-minute-of- airtime-used basis

(iii) No unanticipated new technologies emerge which would provide competition for MSat in terms of winning market share from private and shared (common carrier) radio systems of the types currently in service

(iv) The telephone companies adopt MSat as part of an integrated terrestrial-cellular/satellite mobile communications network

(v) Key potential MSat user industries such as oil and gas do not invest in their own satellite capacity for mobile communications.

Penetration of the market was assumed to follow the profile of a product life cycle curve up to the saturation point (see Appendix G). In the demonstration phase, the number of users will be effectively controlled by DOC rather than being a function of market demand, but for this scenario we have assumed the demonstration phase to be analagous to the development phase of a new product as represented by the product life cycle curve.

On this basis, MSat market penetration would be as follows:

	MSat Market Penetration Projections**			
	1987*	1991	1996	2001
Number of Units (000's)	0.7	10.2	55.8	140
Airtime (million minutes per average month)	0.2	2.8	14.1	34.8

* 1987 is the first year of the demonstration phase for MSat.
** Excludes paging potential which is treated separately.

The airtime projections for MSat make the implicit assumption that all the traffic generated by the MSat mobiles would be

through the satellite. However, if the satellite cannot provide, at a reasonable cost or service level, the metropolitan area service which accounts for up to 25% of traffic volume for the mobile communications systems in the MSat potential market, then not all of the airtime associated with the projected number of mobiles will be through the satellite. This loss of traffic to terrestrial systems would be at least partially offset, and possible exceeded, by MSat traffic from the population of mobile communications users whose metropolitan area requirement is greater than 25% of their traffic volume but who have been entirely excluded from our calculations of the MSat potential market. As a result, we consider the airtime calculated for MSat mobiles to be a reasonable estimate for potential satellite traffic volume.

Under the selected market penetration scenario, the major period of growth in MSat users would be in the late 1990's with a projected 140,000 users requiring 34.8 million minutes per month of airtime by 2001. While, by the year 2001, MSat would have achieved a 50% market penetration in terms of the number of new and replacement mobiles sold in any year, the population of MSat mobiles would still be growing rapidly at that time and the number of mobiles utilizing MSat would be growing by around 20,000 per year based on the market penetration scenario chosen. As a result it would be another 5 to 10 years before MSat achieved a position where it was actually serving 50% of the wide-area mobile communications market, i.e. around 300,000 users with some 80 million minutes of airtime per month.

At the present time, there is no evidence to suggest that the regional distribution of traffic volume for MSat would differ significantly from the distribution expected for the total MSat potential market and presented earlier.

The only significant add-on market we could identify that might reasonably be serviced by MSat and that is not covered in the projections is for wide-area paging. A separate analysis of the potential in this area was carried out, and indicated that, even with a very optimistic projection, paging is unlikely to account for more than 0.9 million minutes per month of MSat airtime in 2001, or 2.5% of the traffic volume projected for MSat. Revenue contribution per minute of airtime however could be higher than for regular voice communications. Due to its small size in relation to the total potential MSat market, pager airtime is excluded from the MSat market penetration projections and treated as a possible add-on market for the purposes of this study.

There is speculation within the communications industry that lack of available bandwidth has inhibited growth in mobile communications. However, analysis of the DOC licence data indicate no significant surges in usage when additional capacity has been made available e.g. 450 MHz service in Toronto or flattening of growth (as capacity ceilings are reached) in cities such as Vancouver and Montreal, where this effect is suspected. In our investigation and analysis of the non-metropolitan mobile communications market applicable to MSat we located no evidence that suggested there were significant suppressed markets for mobile communications that MSat could service. As a result we believe that if any suppressed markets exist they will not be significant enough to have any material impact on the demand for MSat.

TABLE 1

MSat MARKET PENETRATION

PROJECTION OF TYPES OF MOBILE
(000's of Units)

Type of Mobile	1987*	1991	1996	2001
In-Vehicle:				
Mobile Telephone	0.1	1.2	7	20
Mobile Radio	0.4	6.6	35	84
Personal Portable	0.1	2.1	12	32
Field Portable	-	0.1	1	2
Transportable	-	0.1	1	2
Total	0.6	10.1	56	140

* 1987 is the first year of the demonstration phase for MSat.

Source: Developed from Woods Gordon User Survey

The projected mix of types of units required for use with MSat is presented opposite. In-vehicle units are expected to account for 74% of MSat usage in 2001, although demand for voice personal portables would be sizeable.

1.5 TYPES OF SERVICES REQUIRED

Voice communications account for virtually all current mobile communications traffic volume on systems that could potentially convert to MSat. The proportion of total airtime associated with systems the currently have data transmission capability is only 10.6%, based on our survey results. Only a small proportion of this airtime (less than 10% and probably closer to 5%) is actually used for data transmission, the majority being regular voice communications, with the result that data transmission requirements currently account for no more than 1% of mobile communications traffic volume.

Mobile communications systems accounting for a further 14.4% of the current total traffic volume among all the survey respondents with non-metropolitan requirements indicated that lack of data transmission capability was a major problem. Thus, among the mobile communications users covered by the survey, users accounting for 25% of the total airtime (10.6% + 14.4%) either have data transmission capability or regard lack of it as being a major problem.

Based on this information and the expected future usage of mobile communications by sophisticated users, it appears likely that requirements for data transmission will account for no more than 2-3% of overall airtime usage. Of course, the proportion of MSat airtime may well be higher, since we would expect a greater propensity for the

portion of the market with mobile data transmission requirements to switch to MSat. On this basis, the proportion of satellite airtime devoted to data transmission could be as high as 5% in the early 1990's and would grow at a faster rate than voice communications.

The two main technical failings of current mobile radio systems used by those survey respondents with non-metropolitan area communications requirements were noise, interference and distortion in 51% of the systems (206 out of 401) and inadequate range in 41% of the systems (164 out of 401). These proportions clearly indicate potential for a service which will offer improved performance in these two areas, as MSat is intended to do.

The number of system users indicating a requirement for any of the system features investigated in our survey (see Section 10 for full list of features) was generally low. Voice security, connection to the phone system and selective signalling to mobiles were the features with the highest level of respondent-originated (i.e. unprompted) requirement. When prompted about the types of feature that might be available with MSat, much higher numbers of respondents expressed interest. However, it was clear that, at the present time, the lack of these features was not considered to be a major concern for the majority of users. The low quality of voice communications and lack of range were of much greater concern.

We found that there was little awareness among users as to the type of features that could become available in the future (or were currently available) and how these might relate to their operations. Only a few sophisticated users such as the natural resource

industries and the government sector were really aware of potential in this area.

1.6 DETERMINATION OF USER COSTS

In our interviews with mobile communications users we asked what premium they would be prepared to pay for an improved system offering the capabilities that MSat could provide. This implies an increase over their current costs, but most users are not aware of what these costs are. Therefore, in interpreting their responses we have calculated the current replacement cost of their existing system and applied the premium to this figure.

The survey respondents indicated that, as an average for this group, they would be prepared to pay an additional 20% over the cost of their current systems for the improved MSat service.

The mobile radio cost formula indicates that the average airtime cost, based on replacement costs for current systems, is 95¢ per minute of airtime usage. Applying a 20% increase to this suggests that $1.14 per minute of airtime would be an acceptable cost for MSat.

We must point out that the concept of actually paying for airtime used is unfamiliar to the majority of mobile users since their private or shared radio systems do not have a direct airtime charge associated with them. As a result, we consider that it would be a far more effective marketing technique to offer fixed monthly charges per mobile for specified maximum levels of usage, or a reduced airtime charge coupled with an access charge.

Applying the $1.14 per minute airtime charge to the traffic volume projected for the MSat market penetration in 2001

(140,000 mobiles and 34.8 million minutes of airtime per average month) suggests a revenue potential for MSat in the order of $475 million per annum at 1981 price levels.

This $1.14 price level is well above that currently charged for mobile telephone service. As a result, a considerable marketing and user education effort is expected to be required to persuade potential MSat users that this level of pricing is realistic if, in fact, this is the price that MSat would need to charge.

1.7 LEVEL OF CONFIDENCE IN THE STUDY RESULTS

Given the uncertainties that are always associated with making projections 20 years into the future, we have a high degree of confidence that the potential market size estimates resulting from this study are both reasonable and conservative. Factors supporting this level of confidence are:

- The survey on which the study results are based covered 138,000 of the current total licensed mobile population of 450,000 or 30% of the total.
- Growth rates utilized in the projections tail off considerably over the period to 2001 and are in line with expectations for a maturing market. No dramatic changes were assumed, nor were any speculative assumptions made.
- Average monthly airtime per mobile for all wide-area mobiles is 276 minutes per month or 13.8 minutes per day for a 20-working-day month. This is a highly 'believable' usage level, based on the applications for mobile communications. No optimistic projections for growth in airtime per mobile were made.
- No significant suppressed markets were identified which could materially affect demand for MSat. Virtually all MSat users would come from the current mobile communications user population and be covered by the study methodology.

As a result, we consider the projections for the potential MSat market size to have a high degree of confidence

associated with them. With these conservative assumptions and a solid data base from which to develop projections, the result is a very sizeable potential market. While it is not possible to apply statistical confidence limits to these projections, our judgement is that likely upper and lower ranges for the projections of number of users are as follows:

	MSat Potential Market Projections			
	1986	1991	1996	2001
Number of Users (000's):				
Upper Range Estimate	400	550	650	700
The Study Results	351	450	532	596
Low Range Estimate	300	350	390	420

Based on these range estimates, the variation between the study results and upper and lower potentials in 2001 is +17% and -30%.

The above numbers apply to the MSat potential market, not the level of penetration of this market that MSat could be expected to achieve. Market penetration estimates are subject to a large number of uncertainties, such as the actual pricing level and how the service is marketed. As a result, the market penetration scenario is a best estimate in the light of currently available information on MSat, whereas the MSat potential market is a much more concrete projection based on market demand and user requirement factors. In other words, there is a high level of confidence in the potential market being there; but a greater degree of uncertainty at this point in relation to the proportion of this potential market that MSat could secure.

The study results indicate a very sizeable potential market for MSat and suggest that DOC should continue with its program to determine the cost effectiveness and commercial viability of this technology for mobile communications. In addition, the approach to marketing the system should be determined at an early stage since this will impact directly on the ability to achieve the projected levels of market penetration.

APPENDIX B

SELECTED OPTION

CONTENTS

SELECTED OPTION

1. INTRODUCTION

The MSAT Program as described in the Project Plan is the option selected to fulfill the requirements stated in Appendix A. The purpose of this appendix is to outline alternatives considered to meet the stated requirements and to discuss the factors that led to the selection of the MSAT Program as the preferred option. The nature and type of uncertainties associated with the MSAT Program option are described in Section 3 under Certainty of Achievement and Appendix D of the Project Plan.

The results presented are based on studies conducted during Phase A of the MSAT Program. During Phase B any remaining uncertainties associated with the selected option will be clarified. In particular, it is expected that the major Telesat Phase B study on commercial viability of public mobile-satellite services will provide more precise information on the viability of mobile-satellite services and their competitive advantage over terrestrial services for wide-area mobile communications in non-metropolitan areas.

2. OPTIONS TO FULFILL CIVILIAN REQUIREMENTS

2.1 General

Appendix A described the requirements for the mobile-satellite services at 806-890 MHz, environmental data collection services at 401-403 MHz, and emergency beacon monitoring experiment at 406.1 MHz. Only the options concerning the primary service at 806-890 MHz will be discussed in detail. The alternative to an MSAT data collection platform is for Canadian users to continue to rely on foreign systems for the service. As the final decision to include this secondary payload on MSAT will only be made after further study during Phase B, the options to this service are not discussed further. The emergency beacon monitoring experiment at 406.1 MHz is proposed to assess needs and feasibility. Including this on the satellite would have only a minor impact on the MSAT Program and will not be discussed further.

2.2 Options to satisfy service requirements at 806-890 MHz

Considering the requirement for improved mobile communications in Canada, there are three broad system options:

- terrestrial systems
- satellite systems, and
- use of both terrestrial and satellite systems

At the present time there are only terrestrial systems operating in Canada. These systems provide cost effective services in urban areas and in some rural areas of Canada. The main problems are congestion in the cities, inadequate coverage and poor performance in remote and rural areas, and lack of

compatibility in the numerous systems operating in Canada. New terrestrial systems are planned to improve mobile services in the cities; it is not expected that major improvements will be introduced in rural and remote areas using terrestrial systems because of the limited range and poor economics of these in low population density areas.

Satellites can greatly improve mobile communications in rural and remote areas, but have limitations in serving cities. While satellites are expected to be more cost-effective than the terrestrial systems for wide-area coverage in non-metropolitan areas, the opposite is true for the metropolitan areas. Two particular disadvantages of satellite service in cities are the blockage of the required line of sight to the satellite by buildings and the saturation of satellite capacity by the large number of mobile radios and telephones.

To provide nationwide mobile services, complementary use of terrestrial and satellite systems is essential, with each system technology being used where most appropriate from a technical and economic viewpoint.

2.3 Selected option

The development and introduction of satellite service for mobile communications through the MSAT Program is the selected option to fulfill the stated requirement for improved mobile communications in rural and remote areas of Canada. This option is described in detail in the Project Plan and other appendices, and is based on the future use of complementary and compatible terrestrial and satellite systems to provide mobile telecommunications services throughout Canada.

2.4 Alternatives

The economics of alternative terrestrial systems operating at 806-890 MHz was studied during Phase A of the MSAT Program as part of a broader study of the commercial viability of mobile satellite services. This study was conducted by INTEL/Touche Ross under contract to DOC.

The results of the INTEL/Touche Ross Report (Ref. 7) pertaining to the all-terrestrial system option showed that this near Canada-wide terrestrial system option is not as cost-effective as the satellite option for service in rural and remote areas.

Terrestrial systems operating in lower frequency bands are not acceptable alternatives because they cannot provide nationwide compatible services due to frequency congestion in the cities.

2.5 Other factors supporting the selected option

User demand

A substantial demand for the mobile satellite services has been documented by Woods Gordon (Ref. 6, see also Appendix A). The results of this study have been reviewed extensively with the federal and various provincial

governments, by users, and by the telecommunications industry. Potential users of mobile satellite services include current users of terrestrial systems which do not adequately meet their needs. The current users have requirements for improved coverage, better performance, and more cost-effective wide-area mobile communications services. There is extensive interest by users and by the telecommunications and manufacturing industry in the development of mobile-satellite services in Canada. Carriers who have expressed interest or offered co-operation in the MSAT Program include Telesat Canada, Bell Canada, TransCanada Telephone System and the Canadian Radio Common Carrier Association. A wide variety of users have also expressed strong interest.

Nationwide coverage

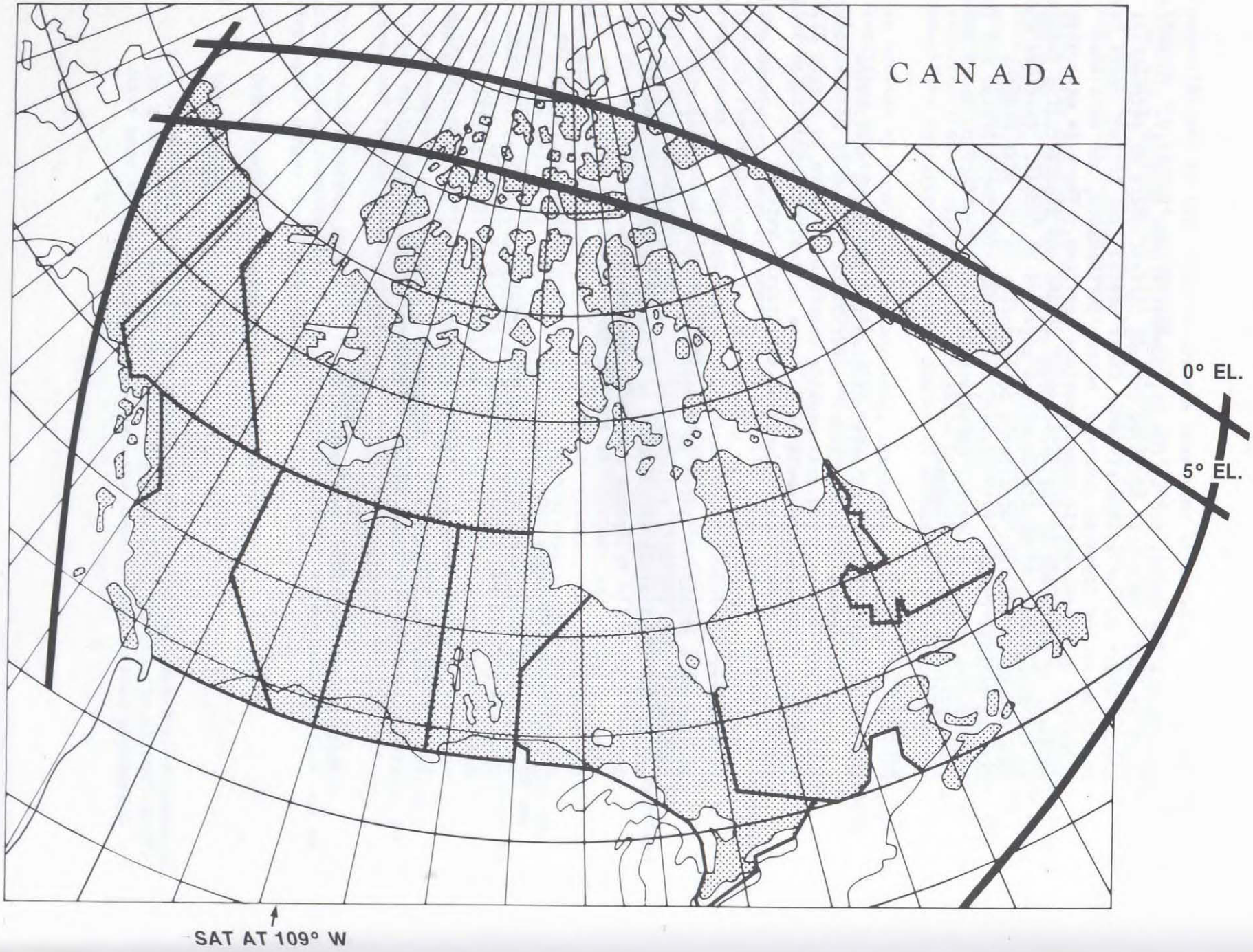
The use of satellites is the only solution for providing nationwide coverage for mobile communications. A satellite located in geostationary orbit at 109° W. longitude will provide coverage as shown in Figure B1. The only gaps in coverage would be in large cities. Adjacent ocean areas are also covered well beyond Canadian territorial waters.

Nationwide compatibility

The use of a satellite system to complement 806-890 MHz terrestrial systems is also the only solution for providing compatible services in cities and rural areas of Canada. As a result of frequency congestion, 806-890 MHz mobile telephone and radio systems will be installed in the major cities in the 1980s. As 806-890 MHz terrestrial systems are not expected to be commercially viable in rural and remote areas, users that need Canada-wide or province-wide mobile communications will need two mobile radios in their vehicles; one for operation in cities and one for operation in rural areas having systems operating at lower frequencies unless a 806-890 MHz satellite system is available to serve non-metropolitan areas. It will be essential that the compatibility standard be established for terrestrial and satellite systems operating in the 806-890 MHz band.

Figure B 1

MSAT 800 MHz COVERAGE CAPABILITY



APPENDIX C

TECHNOLOGY OBJECTIVES

TECHNOLOGY OBJECTIVES OF THE MSAT PROGRAM

1. To demonstrate a satellite system designed to provide nationwide compatible mobile radio and telephone service at 800 MHz, with technology applicable to a subsequent commercial system. This will include:

   - development and demonstration of 800 MHz spacecraft transponder and antenna elements
   - development and demonstration of power and spectrum, efficient voice signal processing and modulation techniques
   - development of a new technical standard for mobile terminals operating in an integrated satellite-terrestrial system providing compatible mobile services
   - development and demonstration of low cost mobile terminals compatible with MSAT and with future terrestrial systems
   - evaluation of network control of mobile terminals in a nationwide compatible system
   - evaluation of spacecraft platforms, deployment and satellite control needed for subsequent operational systems
   - evaluation of propagation losses

2. To demonstrate an experimental military EHF communications system with technology relevant to future military operations in the EHF frequency band.

APPENDIX D

ASSESSMENT OF CONFIDENCE IN ACHIEVING STATED OBJECTIVES

CONFIDENCE IN ACHIEVING STATED DOC OBJECTIVES IN THE MSAT PROGRAM

	OBJECTIVE	CONFIDENCE OF ACHIEVEMENT		
		Actual - End of Phase A	Expected - End of Phase B	Expected 1991
Social Benefit	- follow-on system decision in 1991 - 20 000 users by 1994 - increased access to mobile services	Market confidence is high for system costs assumed Follow on decision and increased access depend on commercial viability and satellite launch	High, assuming commercial viability is confirmed in Phase B	Phase B market projections will have been verified and increased access to 99 per cent of Canada with a 1987 launch
Economic Benefit	- Canadian content - number of high technology jobs - contract sales to Canadian industry - export market sales by year 2000 - domestic market sales by year 2000 - user cost savings	Good Moderate Goals will be refined during Phase B	High High	Demonstrated High
Performance	- 1 spacecraft in orbit and 1 ground spare (elements of) - complement of ground terminals - service to 20 000 users at 800 MHz - data relay service at 400 MHz	Moderate confidence in performing within stated schedule cost	High, due to technology development and further definition, cost and schedule studies in Phase B	Demonstrated
Technology	- design and demonstration of satellite system for mobile users, using new cost-effective technology	Moderate, as proof of concept, and prototype development is needed in several key areas	High, as proof of concept and further detailed design will have reduced technical uncertainty	Demonstrated
Total Cost	- $385M (plus approx. $60M for DND satellite payload) in 1981 dollars	Moderate preliminary estimate	High - class B estimate	Most Actual Costs Known
Time	- November 1987 launch	Moderate	High for a date established near the end of Phase B	Demonstrated

APPENDIX E

RELATED TECHNOLOGY DEVELOPMENT

MSAT RELATED TECHNOLOGY DEVELOPMENT

(FOR CIVIL APPLICATION)

AREA	ITEM
Spacecraft	
o Payloads	- transponders, including second source studies and/or development of key items at 800 MHz, such as filters, power amplifiers
	- antennas and feeds as above, including on-board switching
o Bus	- structures, including composite materials and modal analysis techniques, and mechanics
	- attitude control systems or subsystems
	- reaction control, including further ion-engine studies
	- thermal studies including heat pipes and louvres
	- power subsystem, including solar arrays, batteries and battery management
	- microprocessor controls
Communications Systems	- studies of efficient voice coding and modulation techniques for voice and data systems
	- propagation studies at 800 MHz
Ground Terminals	- studies and development of mobile vehicle antennas from alternate sources for land, ship and aircraft application
	- modem development will continue through contracts for NBFM, LPC and ASCB modems
	- power amplifier studies and development (linear and pulse) at 800 MHz will continue
	- frequency agile local oscillator development will continue
	- field experiments with prototype mobile terminals.

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