

**Department of Communications**

# **MSAT MANUFACTURING IMPACT STUDY**

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## **Volume II: System Definition Industry Capabilities Analysis Export Market Analysis Impact Analysis**

**MARCH 1985**

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**A report from  
The Marketing and Economics Group**

**Woods Gordon**  
Management Consultants



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TECHNOLOGY AND INDUSTRY SECTOR

TITLE: Study to Determine the Impact of Mobile Satellite (MSAT)  
Services in Canada on the Canadian Manufacturing Industry

AUTHOR(S): R. Blanchard

H. Berndt

C.M. Deane

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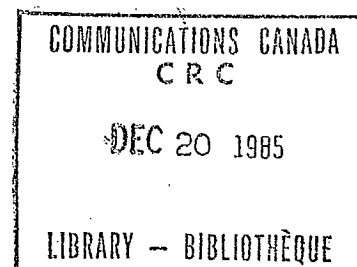
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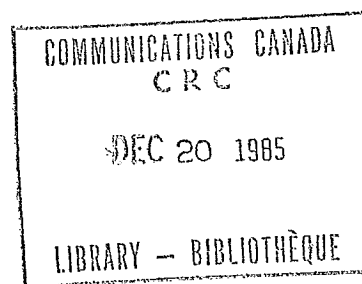
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Management Consultants



A MEMBER OF ARTHUR YOUNG INTERNATIONAL

## Woods Gordon

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March 29, 1985

Mr. J.H.C. Braden  
Manager, MSAT Economic Studies  
Department of Communications  
300 Slater Street  
Ottawa, Ontario  
K1A 0C8

Dear Mr. Braden:

We are pleased to submit our report for the MSAT Manufacturing Impact Study.

Due to the range and complexity of the analysis for this assignment, our report is in three volumes:

- Volume I is the Executive Summary.
- Volume II is the Analysis of Industry Capabilities, Export Market Prospects and Manufacturing Impacts.
- Volume III is the Impact Data.

Our analysis suggests that MSAT could generate significant manufacturing and economic impacts in Canada. However, certain federal measures will help to maximize these benefits. Among the most important of these are:

- Develop a joint Canada/U.S. system for start-up by 1989 or 1990.
- Launch the Canadian spacecraft first in each generation.



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- Prime contract the Canadian spacecraft domestically.
- Provide support for industry's development of new MSAT product lines.
- Aggresively pursue export markets with manufacturers.

It was a pleasure to undertake this assignment for the Department of Communications. Please call if you need further assistance.

Yours truly,

*Woods Gordon*

c.c.: R.F. Blanchard  
C.M. Deane  
H.A. Berndt



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MSAT MANUFACTURING IMPACT STUDY

II: ANALYSIS OF INDUSTRY CAPABILITIES, EXPORT MARKET  
PROSPECTS AND MANUFACTURING IMPACTS

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APPENDIX A: Technical Background on the MSAT Impact Model





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GLOSSARY OF TERMS

## MSAT MANUFACTURING IMPACT STUDY

### GLOSSARY OF TERMS

ACSSB            Amplitude Companded Single Sideband: a type of mobile radio which is more power and frequency efficient than Narrow Band FM.

Antenna Gain    The effectiveness of a directional antenna, expressed as the ratio of standard antenna (isotropic radiated) input power (in decibels) to the directional antenna input power (in decibels) that will produce the same field strength in the desired direction.

BAe             British Aerospace Ltd.

Bands           Portions of the radio frequency spectrum:

<u>Name</u>	<u>Range</u>
C-band	6/4 GHz
K <sub>u</sub> -band	14/11 GHz
K <sub>c</sub> -band	30/20 GHz

BH              Busy Hour: refers to traffic on a telecommunications system.

Bus             A satellite consists of a bus and a payload. The bus performs the telemetry, tracking and control (including fuel) and power (e.g., solar array) functions.

CCS             Central Control Station: controls the communications system; is responsible for the satellite telemetry, tracking and control (TT&C); acts as one of the gateway earth stations and could also be one of the SHF base stations.

DAMA            Demand Assigned Multiple Access: automatically assigns open channels, producing far more efficient channel usage than manual channel selection.



Decibel or dB	A unit for expressing the ratio of two amounts of acoustic signal power equal to 10 times the common logarithm of this ratio.
Deployable Solar Array	An array of solar cells which convert the sun's radiant energy into direct current to power the spacecraft. These appear to be like wings on the satellite, and track the sun by changing angle during the day. They are deployed after the satellite has reached its final orbit position. They are most commonly used with three-axis spin-stabilized satellites, partially accounting for the ability of such spacecraft to generate more power than most spinners. However, HAC has recently designed a new spinner that would also have deployed solar arrays from the de-spun shelf.
De-spun Shelf	Part of a spinning drum type of satellite (like the ANIK-C and ANIK-D series) which is de-spun (i.e., spun in the opposite direction) to keep the communications antennas pointed earthwards.
DCP/DACS	Data Collection Platform or Data Acquisition Control Service: remotely located, self-contained installations that monitor rainfall, water quality, snow cover, pipeline flows, etc.
Dish Antenna	An antenna with a parabolic dish reflector.
EIRP	Effective Isotropic Radiated Power: a measure of the power radiated from an antenna.
EOC	Edge Of Coverage: applies to beam areas.
EOL	End-of-Life: of the spacecraft.
ERLANG	An international dimensionless unit of traffic intensity defined as the intensity in a traffic path continuously occupied.

FM Frequency Modulation: the process of varying the frequency of a signal in telephony, telegraphy, radio and television.

GEO Geosynchronous Earth Orbit: 22,300 miles above the Equator.

GES Gateway Earth Station: links satellite to terrestrial users for all double-hop and all single-hop SHF-UHF communications.

HAC Hughes Aircraft Company.

Hertzian Wave An electromagnetic wave produced by the oscillation of electricity in a conductor (e.g., a radio antenna). Commonly used terminology:

<u>Class</u>	<u>Abbreviation</u>	<u>Value</u>
Hertz	Hz	One cycle per second
Kilohertz	KHz	1,000 Hz
Megahertz	MHz	1,000 KHz
Gigahertz	GHz	1,000 MHz

HS 376 A HAC satellite bus (a de-spun shelf variety used for ANIK-C and ANIK-D).

HS 393 A HAC satellite bus (a de-spun shelf variety, larger than an HS 376).

Kb/s Kilobits per second.

LEO Low Earth Orbit (e.g., orbit achieved by the U.S. Space Shuttle).

MDS Mobile Data Service.



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Mobile  
Satcom

Mobile satellite communications system. Some examples  
are:

<u>Name</u>	<u>Country</u>	<u>Description</u>
MSAT	Canada	Full MRS, MTS, MDS and MPS
GEO/SAT COMM	U.S.A.	Rapid deployment earth terminals for oil & gas industry use
Geostar	U.S.A.	Display and send  brief alphanumeric messages
MOBILSAT	U.S.A.	Full MRS, MTS, MDS and MPS
Skylink	U.S.A.	Full MRS, MTS, MDS and MPS
SpotNet	U.S.A.	Display and send brief alphanumeric messages
PROSAT	ESA	Experimental program to investigate mobile satellite terminals for land, air and marine vehicles

MPS                      Mobile Paging Service.

MRS                      Mobile Radio Service.

MTS                      Mobile Telephone Service.

NBFM                     Narrow Band Frequency Modulation.

SCPC                      Single Channel Per Carrier.



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Thin-route  
Communi-  
cations

The communications service that is provided in regions of low-population density or non-metropolitan areas.

Three-axis  
System

A box type of satellite (like HERMES and ANIK-B), which has an internal stabilization system consisting of several spinning wheels.

TT&C

Telemetry, Tracking & Control: refers to the guidance of the satellite in transfer orbit, drift orbit and on-station orbit.



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MSAT MANUFACTURING IMPACT STUDY

II: ANALYSIS OF INDUSTRY CAPABILITIES, EXPORT MARKET  
PROSPECTS AND MANUFACTURING IMPACTS

1. INTRODUCTION

The ultimate purpose of this study is to estimate the effects MSAT could have on Canadian manufacturers and, through them, on the Canadian economy. Some of the data needed to satisfy this requirement were obtained from other MSAT Phase B studies. However, three important questions must be answered for the impact calculations to be undertaken.

The first is simply: What are the main parts of the MSAT system? This information is needed to assess how much manufacturing might reasonably take place in Canada. It is also needed to develop the relationships between physical output and economic impacts.

The second question is: What are the capabilities and interests of Canadian firms to design, produce and market MSAT systems, products and components? This information is required to confirm that MSAT equipment can be produced in this country. It is also necessary to quantify the potential industry in order to have reference points for evaluating the significance of the estimated impacts from manufacturing MSAT.

The final question is: What are the export prospects for the MSAT equipment manufactured in Canada? This information is needed to complement the Canadian market estimates so that the manufacturing impact calculations reflect the total industry sales.





These three questions are addressed in the next three chapters of this volume, respectively.

The results of this analysis are then used in Chapter 5 to estimate the manufacturing and economic impacts due to MSAT.

Chapter 6 summarizes the implementation strategies we recommend to maximize the Canadian manufacturing benefits from MSAT.



## 2. MSAT SYSTEM PRODUCTS

### 2.1 Introduction

The final products envisaged for MSAT systems are described in this chapter in preparation for the analysis of Canadian manufacturing capabilities and foreign demand prospects in the subsequent two chapters.

This description is undertaken in four sections, each concentrating on one of the major segments of an MSAT system.<sup>1</sup> The first is the satellite itself. The second is the central control station of the satellite system. The third deals with gateway earth stations and SHF base stations. The final section concentrates on the subscriber equipment, consisting of land, aviation and marine user terminals, base stations, personal pagers and data acquisition and control service (DACS) terminals.

### 2.2 The Satellite

The MSAT satellite is the core of the system. Its function is to receive signals transmitted by one user, filter and amplify these, and then transmit them back down to another subscriber or to the public switched telephone network. It is also the most complex and sophisticated part of the system.

---

<sup>1</sup> This subject matter is associated with numerous technical terms. Where possible, these terms have been defined as they arise in the text. Further definitions are contained in the Glossary found at the front of this volume.



The MSAT spacecraft will consist of the same basic elements as conventional fixed communications satellites operating in geostationary orbit positions. A platform (or bus) will be fitted with antenna and transponder sub-systems (or payload), solar cell and battery sub-systems (or electricals) and other housekeeping mechanisms (e.g., the station-keeping rockets).

Two basic satellite designs could be used for MSAT.

One is a spin-stabilized system (or spinner). These are so named because they are essentially cylinders which maintain stability in geostationary orbit by spinning like a gyroscope or a top. The solar cells are attached to the outside of the spinning cylinder, while the other parts of the satellite -- antenna, transponders, electricals and rockets -- are mounted on an internal de-spun shelf which remains in the same position relative to the earth.

A number of INTELSAT's spacecraft, and all of Telesat Canada's ANIK-A, ANIK-C and ANIK-D series are based on this design. Other examples include Brazil's BRAZILSAT, Indonesia's PALAPA series, Australia's AUSSAT and Mexico's ILHUICAHUA.

The main strength of spin-stabilized platforms is their ability to carry large payloads. However, many are "power limited". That is, the solar cells on their outer casings face the sun only part of the time, limiting this primary source of operating power. Also, power generation constraints cannot be offset by increasing antenna gain because many of these platforms are unable to support several, or very large, reflectors.



Hughes Aircraft Company, the main producer of spin-stabilized satellites, has alleviated these problems somewhat through recent design innovations. The HS 393 is a larger version of the HS 376 (the platform used for the ANIK-C and ANIK-D series), 10 meters high (in orbit), and capable of generating 2KW of power. Its design life is 10 years. An even larger design is the HS 394, which carries deployable solar panels attached to the de-spun shelf, as well as solar cells mounted on the spinning shell. Altogether, these arrays are able to generate 4.4KW of power.

The second basic satellite design is the three-axis stabilized system. The platform for these spacecraft is essentially a box, which contains several spinning wheels to maintain stability. In geostationary orbit, one side of this bus always faces earthward. Solar power is generated primarily using deployed solar panels which continuously track the sun's movement.

Examples of such spacecraft include two of Canada's earlier communications satellites -- HERMES and ANIK-B -- as well as the new INTELSAT-VI series, all INMARSAT series (MARISAT and MARECS), and a variety of U.S. and European systems.

The main advantage of these three-axis platforms is their ability to support relatively large antenna structures and deployed solar panels. This means that they can be used in situations requiring high antenna gain and substantial amounts of power. Indeed, the largest of these platforms, the OLYMPUS being developed by British Aerospace, is rated up to 7.5KW of power, and could support reflectors as large as 18 meters in diameter.



Canada's Department of Communications and Telesat Canada have considered a wide range of satellites for the potential Canadian MSAT system. At the present time, it appears that a larger satellite will eventually be required. For example, one equivalent to the HS 396 or the RCA 4000, or any system capable of generating 2KW or more of power at costs that can be supported by the potential base of subscribers.

Based on rough calculations using illustrative PAM-D1 and PAM-D2 buses, an MSAT satellite is estimated to cost approximately \$90 million (in 1984 Canadian dollars) for the first generation and \$126 million (in constant 1984 dollars) for the larger second generation.<sup>1</sup>

These values assume each generation will involve two satellites. The amounts include the cost of prime contracting the spacecraft in Canada, as well as contingency costs and in-orbit incentive payments. Another \$15 million in federal government developmental support would be added to the cost of the first-generation Canadian MSAT satellite.<sup>2</sup>

Many factors affecting price could change before the MSAT spacecraft procurement is contracted. Thus, these values should not be taken as final.

---

<sup>1</sup> Based on data supplied by DOC and Telesat Canada. These estimates do not include such items as launch costs, insurance, upper stage costs, operations, etc.

<sup>2</sup> Ibid.



### 2.3 The Central Control Station

The central control station (CCS) is the heart of the system on ground. Its primary functions are to control the satellite in orbit and to manage the communications system. It may also act as one of the gateway earth stations.

The spacecraft control function for the Canadian MSAT system will likely be accomplished by expanding Telesat Canada's existing facilities somewhat.

The network management function will require considerably more. To handle the high traffic volumes anticipated for MSAT most economically, it will be necessary to minimize the inefficient use of available channel capacity. An illustration of this would be leaving a line open while one caller goes off to get information for the other, so that no one else can use the channel. A demand assignment multiple access (DAMA) system will thus be developed to ensure that channel space is only being allocated to actual transmissions.

Essentially, a DAMA system is a sophisticated piece of computer software. With it, the computer monitors transmissions for extended open spaces, puts such calls on hold (without breaking the connection), and assigns the channel to an active transmission. When the original transmission is re-activated, it then searches for and assigns another channel. In this way, the satellite's limited channel capacity is used to the maximum, thus reducing the spacecraft's size and power requirements.



Preliminary estimates suggest that the initial DAMA and network control system for MSAT will cost roughly \$15 million (1984 Canadian dollars) to develop. Further versions will cost much less -- possibly \$2.5-5 million -- since they will be primarily revised versions of the first.

The systems and equipment for the gateway earth station part of the central control station -- equivalent to those described in Section 2.4 -- will make up most of the remaining cost of the central control station.

Altogether, it is estimated that the CCS for the Canadian MSAT system will cost approximately \$25 million (1984 Canadian dollars) in the first generation.<sup>1</sup> It is anticipated that a further \$1 million<sup>2</sup> will be spent at the start of the second generation, to increase the network management capacity for a larger satellite.

#### 2.4 Gateway Earth Stations and SHF Base Stations

Gateway earth stations (GES) are intended to provide the link between the MSAT users and the public switched telephone network (PSTN). They will consist of the following elements:

- o SHF parabolic antenna
- o Rx-Tx diplexer
- o SHF multi-channel receiver
- o SHF receive divider
- o one intermediate frequency receiver per channel

---

<sup>1</sup> Based on data supplied by DOC and Telesat Canada. This amount is for illustrative purposes only. Changes in technology and costs may occur before the CCS is constructed. Thus, this estimate should not be taken as final.

<sup>2</sup> Ibid.



- o one intermediate frequency transmitter per channel
- o IF transmit combiner
- o SHF multi-channel transmitter
- o one 2.4 Kb/s digital modem per channel
- o one LPC processor or ACSSB modem per channel
- o one voice-operated switch per channel
- o PSTN interface equipment

The price for these stations is expected to be \$129-140,000 (1984 Canadian dollars), depending on the number of channels.<sup>1</sup>

SHF base stations will be virtually the same as the GES, except that they will not have the PSTN interface equipment. It is anticipated that each of these will cost \$85-120,000 (in 1984 Canadian dollars), depending on the number of channels.<sup>2</sup>

## 2.5 Subscriber Equipment

The basic terminal used with the MSAT system is expected to be the land mobile voice radio. This will have many of the same features as conventional mobile radios and cellular mobile radio-telephones. Essentially, both the mobile radios (MRS) and mobile radio-telephones (MTS) will consist of the following:

- o steerable 8 dBi UHF antenna
- o multi-frequency receiver
- o multi-frequency transmitter
- o 2.4 Kb/s digital modem
- o LPC processor or ACSSB modem
- o DAMA processor
- o voice-operated switch

<sup>1</sup> Based on data supplied by DOC and Telesat Canada. Prices are assumed to decline gradually over time due to the learning curve. These estimated prices are weighted averages for the entire 1989-2002 period.

<sup>2</sup> Ibid.





The MTS terminal will also have an Rx-Tx duplexer and a keypad handset, while the MRS terminal will also have an Rx-Tx switch and a simple handset. The estimated price of the MTS terminals is \$3,000 (1984 Canadian dollars), while that for the MRS terminal is \$2,500 (in 1984 Canadian dollars).<sup>1</sup>

Several variations are envisioned for this basic user equipment.

A data-only terminal would consist of the basic radio described above, less the voice-operated switch and the handset, and with a data storage unit, annunciator and keyboard added.

A combined voice/data terminal would be a hybrid of the voice-only and data-only units.

Further, it is anticipated that marine and aviation terminals will also be developed for use with MSAT. These would essentially be the same as the land mobile voice, data or voice/data units. However, extra packaging would be required -- e.g., for the antenna -- to protect these radios from the harsher elements they would likely encounter in the air and at sea. It is estimated that these terminals would thus cost some 80 percent more than their land mobile counterparts.

Another variant of the basic land mobile radio is the UHF base station, to be used by MRS closed system operators. These would also have the same components as the MRS units, but would have 12 dBi non-steerable antennas instead of the 8 dBi steerable units.

---

<sup>1</sup> Based on data supplied by DOC and Telesat Canada. Prices are assumed to decline over time due to the learning curve. These estimated prices are weighted averages for the entire 1989-2002 period.



The cost of these units is estimated to be \$2,100 (1984 Canadian dollars).<sup>1</sup>

Two other types of user equipment are planned for use with the MSAT system.

One of these is land mobile paging units. These would be functionally similar to MRS terminals, but would not offer voice or two-way transmit capabilities -- just a tone and/or alphanumeric message display. They would thus be much smaller than the mobile terminals, consisting of:

- o a steerable 8 dBi UHF antenna
- o single frequency receiver
- o 2.4 Kb/s digital demodulator
- o paging decoder
- o annunciator

It is expected that these units would each cost in the neighbourhood of \$1,500-\$2,000 (1984 Canadian dollars).<sup>2</sup>

Another variation would see MSAT being used to link up existing paging systems in order to extend paging services nationally. If this was permitted by DOC, standard pagers costing around \$200 could be used.

The final piece of subscriber equipment planned for MSAT is the data acquisition and control service (DACS) terminal, or the data collection platform (DCP). These have a variety of potential uses in remote areas, including metering pipeline flows, measuring

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<sup>1</sup> Based on data supplied by DOC and Telesat Canada. Prices are assumed to decline over time due to the learning curve. These estimated prices are weighted averages for the entire 1989-2002 period.

<sup>2</sup> Based on data supplied by DOC and Telesat Canada.



water levels, monitoring climatic conditions and tracking ice floes.

They would consist of the following parts:

- o 8 dBi steerable antenna (if mobile) or a 12 dBi non-steerable antenna (if fixed)
- o Rx-Tx switch
- o single frequency receiver
- o single frequency transmitter
- o 2.4 Kb/s digital modem
- o DACS processor

The polling DACS terminals are estimated to cost approximately \$1,800 (in 1984 Canadian dollars).<sup>1</sup> The alarm DACS terminals are estimated to cost roughly \$3,300 (in 1984 Canadian dollars).<sup>2</sup>

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<sup>1</sup> Based on data supplied by DOC and Telesat Canada. Prices are assumed to decline over time due to the learning curve. These estimated prices are wieghted averages for the entire 1989-2002 period.

<sup>2</sup> Ibid.



### 3. THE POTENTIAL MSAT MANUFACTURING INDUSTRY

#### 3.1 Introduction

Since MSAT is still a conceptual system, none of the items described in the previous chapter are currently being manufactured. This raises two questions. Are domestic firms interested in making MSAT equipment? How large is this potential industry? Our purpose here is to answer both of these questions.

We begin by reporting on our survey of the Canadian firms that might have the needed capabilities -- largely by already producing similar types of space and communications equipment -- and the interest in developing and manufacturing MSAT product lines. Data provided by these firms are then aggregated<sup>1</sup> to determine the approximate statistical reference points for the potential MSAT manufacturing industry. Finally, we examine the factors that could affect the emergence and success of this industry.

These steps are explained in greater detail in the following sections.

#### 3.2 Survey of Canadian Firms

##### 3.2.1 Methodology

A three-part approach was used to determine the capabilities and interests of Canadian firms to design, produce and market MSAT systems, products and components for potential domestic and foreign markets.

---

<sup>1</sup> Individual firm data are confidential and therefore not given in this document.



First, the survey conducted by the Interdepartmental Committee on Space (ICS) in the summer of 1983 provided important details about firms in Canada's space industry. These data included existing product lines, employment, sales revenues and R&D expenditures.

However, further information was required about existing product lines similar to MSAT, import content of these products, interest in developing MSAT equipment, and concerns about the MSAT development process. To obtain these data, Woods Gordon designed a special MSAT questionnaire in consultation with the ICS and Department of Communications. This was attached to the 1983 ICS survey.

The second step in this information collection process was to distribute another questionnaire to manufacturing companies which might produce MSAT equipment, but which were not covered by the ICS survey. Both the contact list and the questionnaire for this Woods Gordon survey were developed with the assistance of the ICS and DOC.

The third step was to discuss MSAT directly with key industry representatives, such as Spar Aerospace Limited, Canadian Marconi Company, Glenayre Electronics Limited, Mobile Data International Inc. and Telesat Canada. Through these interviews, we obtained more general information on how companies operate within their industries, and substantiated some of the more specific conclusions that emerged from the survey process.



### 3.2.2 Response to the ICS Survey

The Interdepartmental Committee on Space mailed out questionnaires to 37 manufacturing firms<sup>1</sup> involved in making space and ground segment products for satellite systems.

Within the group of 25 which responded to the 1983 ICS survey, 23 firms also returned Woods Gordon's add-on MSAT questionnaire. All but three of these expressed some interest in MSAT.

In total, therefore, 20 firms surveyed by the ICS expressed an interest in manufacturing MSAT systems, sub-systems, components or units.

### 3.2.3 Response to the Woods Gordon Survey

Woods Gordon sent special MSAT questionnaires to 24 manufacturing firms which were not covered in the ICS space industry survey.

A total of 19 of these firms responded, either by mailing back the questionnaire or by participating in a follow-up telephone survey. Of these responses, 11 manufacturing companies indicated some interest in developing MSAT product lines or adapting their existing products for use in the MSAT system.

---

<sup>1</sup> The ICS survey also covered 42 other firms, most of which were engineering consulting companies. We reviewed their responses to determine if any were interested in becoming producers of MSAT equipment, and discovered that two fitted this description. They have been included in our analysis.

TABLE 3.3.1

CANADIAN FIRMS INTERESTED IN MANUFACTURING MSAT PRODUCTS  
AGGREGATE SALES REVENUES IN 1981-83

<u>Product Groups*</u>	<u>1981</u>	<u>1982</u> (Millions)	<u>1983</u>
<u>All Sales:</u>			
Satellites	\$109.6	\$155.2	\$195.6
Earth Stations	293.1	358.2	348.5
Antennas	22.8	42.7	49.0
Mobile Radios & Data Terminals	101.5	136.9	164.4
Data Collection Platforms	<u>107.4</u>	<u>105.5</u>	<u>116.3</u>
TOTAL	<u>\$634.4</u>	<u>\$798.5</u>	<u>\$873.8</u>
<u>Space/MSAT-Related Sales:</u>			
Satellites	\$ 64.6	\$118.2	\$156.7
Earth Stations	11.9	16.0	30.0
Antennas	8.7	8.8	14.5
Mobile Radios & Data Terminals	22.3	28.3	40.4
Data Collection Platforms	<u>3.9</u>	<u>9.3</u>	<u>9.0</u>
TOTAL	<u>\$111.4</u>	<u>\$180.6</u>	<u>\$250.6</u>
<u>Space/MSAT Share of All Sales:**</u> (Percentages)			
Satellites	59	76	80
Earth Stations	4	4	9
Antennas	38	21	30
Mobile Radios & Data Terminals	22	21	25
Data Collection Platforms	4	9	8
TOTAL	18	23	29

\* For convenience, the firms have been distributed by product group, according to the existing products they are most usually identified with, or the MSAT products they are most interested in developing.

\*\* By category.

SOURCE: Surveys by the INTERDEPARTMENTAL COMMITTEE ON SPACE and WOODS GORDON in 1983.



### 3.3 The Group of Interested Manufacturers

The ICS and Woods Gordon surveys were concurrent, and contained essentially the same questions. Responses to these two surveys can thus be combined to identify the group of Canadian manufacturers interested in MSAT. This process identified 31 manufacturers that expressed some interest in developing and producing equipment for MSAT.

In the following sections, we review the aggregate sales revenues, employment, and research and development expenditures reported by these firms.

For convenience, the firms have been distributed by product group, according to the existing products they are most usually identified with, or the MSAT products they are most interested in developing.

#### 3.3.1 Sales Revenues

The group of Canadian manufacturers interested in MSAT recorded steady improvement in sales revenues during 1981-83 (see Table 3.3.1). Total revenues rose from \$634 million in 1981 to almost \$875 million<sup>1</sup> in 1983. Space/MSAT-related revenues led this growth, reaching \$250 million by 1983. Reflecting this, the share of space/MSAT-related sales revenues in the group's total revenues increased steadily from 18 percent in 1981 to 29 percent in 1983.

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<sup>1</sup> This growth reflects inflation to some extent. However, there are no appropriate price measures to deflate these values.



TABLE 3.3.2

CANADIAN FIRMS INTERESTED IN MANUFACTURING MSAT PRODUCTS  
SPACE/MSAT-RELATED DOMESTIC AND EXPORT SALES REVENUES IN 1981-83

Product Groups*	1981	1982 (Millions)	1983
<u>Total Space/MSAT-Related Sales:</u>			
Satellites	\$64.6	\$118.2	\$156.7
Earth Stations	11.9	16.0	30.0
Antennas	8.7	8.8	14.5
Mobile Radios & Data Terminals	22.3	28.3	40.4
Data Collection Platforms	3.9	9.3	9.0
TOTAL	<u>\$111.4</u>	<u>\$180.6</u>	<u>\$250.6</u>
<u>Domestic Space/MSAT-Related Sales:</u>			
Satellites	\$32.3	\$42.8	\$36.0
Earth Stations	8.8	11.5	16.8
Antennas	3.4	5.7	11.5
Mobile Radios & Data Terminals	10.0	11.3	13.3
Data Collection Platforms	1.8	4.3	4.3
TOTAL	<u>\$56.3</u>	<u>\$75.6</u>	<u>\$81.9</u>
<u>Export Space/MSAT-Related Sales:</u>			
Satellites	\$32.3	\$75.4	\$120.7
Earth Stations	3.1	4.5	13.2
Antennas	5.3	3.1	3.0
Mobile Radios & Data Terminals	12.3	17.0	27.1
Data Collection Platforms	2.1	5.0	4.7
TOTAL	<u>\$55.1</u>	<u>\$105.0</u>	<u>\$168.7</u>
<u>Domestic Share of Total:**</u>		(Percentages)	
Satellites	50	36	23
Earth Stations	74	72	56
Antennas	39	65	79
Mobile Radios & Data Terminals	45	40	33
Data Collection Platforms	46	46	48
TOTAL	51	42	33
<u>Export Share of Total:**</u>			
Satellites	50	64	77
Earth Stations	26	28	44
Antennas	61	35	21
Mobile Radios & Data Terminals	55	60	67
Data Collection Platforms	54	54	52
TOTAL	49	58	67

\* See footnote \* in TABLE 3.3.1.

\*\* By category.

SOURCE: Surveys by the INTERDEPARTMENTAL COMMITTEE ON SPACE and WOODS GORDON in 1983.



A primary reason for the recent strong growth in the group's space/MSAT-related sales is its success in exporting these product lines, mainly to the United States. While domestic sales of space/MSAT-related equipment rose from \$56 million to \$82 million during 1981-83, export sales grew from \$55 million to \$169 million (see Table 3.3.2). As a result, exports represented 67 percent of the group's space/MSAT-related sales in 1983.

### 3.3.2 Employment

The Canadian manufacturers interested in MSAT employed a total of 11,835 workers in 1983 (see Table 3.3.3). This was down somewhat from 12,437 in 1982, apparently due to the recent recession. Over the same two years the group's space/MSAT-related employment rose from 1,935 to 2,719. This represented an increase from a 16-percent share of total employment to a 23-percent share.

There is some difference between the occupational mix for the group's overall operations and its space/MSAT-related activities. In both sample years, production employment was about 55 percent of the total number of jobs in all operations, but somewhat less (40 percent) in the total for space/MSAT-related operations. Reflecting the higher technology nature of space/MSAT-related products, engineering employment represented about one-third of the jobs in this area of these firms' operations.

### 3.3.3 Research and Development Expenditures

The Canadian manufacturers interested in MSAT spent over \$100 million of R&D during 1983 (see Table 3.3.4). Of this, \$26

TABLE 3.3.3

CANADIAN FIRMS INTERESTED IN MANUFACTURING MSAT PRODUCTS  
AGGREGATE EMPLOYMENT IN 1982-83

Product Group*	1982				1983			
	Eng.	Prod.	Other	Total	Eng.	Prod.	Other	Total
<u>Total Employment:</u>								
Satellites	451	779	539	1,769	479	858	552	1,889
Earth Stations	1,144	3,185	821	5,150	821	2,903	726	4,450
Antennas	93	344	171	608	155	329	154	638
Mobile Radios & Data Terminals	397	1,598	1,031	3,026	403	1,658	1,042	3,103
Data Collection Platforms	<u>210</u>	<u>1,111</u>	<u>563</u>	<u>1,884</u>	<u>215</u>	<u>1,003</u>	<u>537</u>	<u>1,755</u>
TOTAL	<u>2,295</u>	<u>7,017</u>	<u>3,125</u>	<u>12,437</u>	<u>2,073</u>	<u>6,751</u>	<u>3,011</u>	<u>11,835</u>
<u>Space/MSAT-Related Employment:</u>								
Satellites	311	271	274	855	387	438	336	1,161
Earth Stations	121	11	13	145	201	301	73	575
Antennas	48	70	46	165	56	56	27	139
Mobile Radios & Data Terminals	118	300	232	650	126	360	248	734
Data Collection Platforms	<u>56</u>	<u>53</u>	<u>11</u>	<u>120</u>	<u>42</u>	<u>59</u>	<u>9</u>	<u>110</u>
TOTAL	<u>654</u>	<u>705</u>	<u>576</u>	<u>1,935</u>	<u>812</u>	<u>1,214</u>	<u>693</u>	<u>2,719</u>
Space/MSAT Share of Total Employment:**	(Percentages)							
Satellites	69	35	51	48	81	51	61	61
Earth Stations	11	0	2	3	24	10	10	13
Antennas	52	20	27	27	36	17	18	22
Mobile Radios & Data Terminals	30	19	23	21	31	22	24	24
Data Collection Platforms	27	5	2	6	20	6	2	6
TOTAL	28	10	18	16	39	18	23	23

\* See footnote \* in TABLE 3.3.1.

\*\* By category.

SOURCE: Surveys by the INTERDEPARTMENTAL COMMITTEE ON SPACE and WOODS GORDON in 1983.



million (or 25 percent) was in the space/MSAT-related area. These expenditures represented a substantial increase over 1982, when this group spent \$71 million on total R&D and less than \$10 million on space/MSAT-related R&D.

Company funded R&D represented 60 percent of overall R&D spending. Almost 90 percent of this company funded work occurred in the earth station and mobile radio segments. Contract work was 27 percent (led by the satellite segment), while government funded R&D was 12-13 percent.<sup>1</sup>

In contrast with total R&D, company funded spending represented 33 percent of aggregate expenditures on space/MSAT-related R&D. Government funded R&D had a 25-percent share (led by the satellite and antenna segments). Contract work was the largest portion (40 percent), again led by the satellite segment.

The group's total R&D expenditures in 1983 were 12 percent of its overall sales revenues (see Table 3.3.5). Its R&D spending in the space/MSAT-related area accounted for 9 percent of its revenue from these products. In comparison, according the most recent data, Canadian manufacturing firms as a whole spent about 1 percent of their revenues on R&D.<sup>2</sup>

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<sup>1</sup> It is possible that some of the firms included projects paid for directly by the federal government in the "contract" R&D section of their questionnaire.

<sup>2</sup> Canada, Statistics Canada, Standard Industrial R&D Tables, p. 37. It should also be noted that average R&D spending as a percent of sales revenues was 9.8 percent for aircraft manufacturing and 8.3 percent for communications equipment manufacturing.

TABLE 3.3.4

CANADIAN FIRMS INTERESTED IN MANUFACTURING MSAT PRODUCTS  
 AGGREGATE RESEARCH AND DEVELOPMENT EXPENDITURES IN 1982-83\*

Product Groups	1982				1983			
	Company Funded	Gov't Funded	Contract	Total (Millions)	Company Funded	Gov't Funded	Contract	Total
<u>All R&amp;D:</u>								
Satellites	\$ 1.1	\$2.8	\$ 0.9	\$ 4.8	\$ 2.5	\$ 3.9	\$16.6	\$23.0
Earth Stations	25.6	1.5	3.6	30.6	25.9	1.6	6.0	33.5
Antennas	1.2	-	-	1.2	1.4	5.1	2.6	9.1
Mobile Radios & Data Terminals	25.6	0.7	0.9	27.2	29.1	0.5	0.5	30.1
Data Collection Platforms	<u>3.9</u>	<u>1.2</u>	<u>2.1</u>	<u>7.2</u>	<u>3.5</u>	<u>1.8</u>	<u>2.1</u>	<u>7.4</u>
TOTAL	<u>\$57.4</u>	<u>\$6.2</u>	<u>\$7.4</u>	<u>\$71.0</u>	<u>\$62.4</u>	<u>\$12.9</u>	<u>\$27.8</u>	<u>\$103.1</u>
<u>Space/MSAT-Related R&amp;D:</u>								
Satellites	\$0.4	\$1.9	\$0.9	\$3.2	\$1.7	\$2.7	\$7.4	\$11.8
Earth Stations	0.2	0.3	0.8	1.3	2.2	0.9	1.7	4.8
Antennas	0.3	-	-	0.3	0.6	3.1	0.9	4.6
Mobile Radios & Data Terminals	2.9	0.7	-	3.6	3.8	-	-	3.8
Data Collection Platforms	<u>0.5</u>	<u>0.2</u>	<u>0.2</u>	<u>0.9</u>	<u>0.3</u>	<u>-</u>	<u>0.5</u>	<u>0.8</u>
TOTAL	<u>\$4.3</u>	<u>\$3.1</u>	<u>\$1.9</u>	<u>\$9.3</u>	<u>\$8.6</u>	<u>\$6.7</u>	<u>\$10.5</u>	<u>\$25.8</u>

(Percentages)

Space/MSAT Share of All R&D:\*\*

Satellites	36	68	100	67	68	69	45	51
Earth Stations	1	20	23	4	8	56	28	14
Antennas	25	-	-	25	43	61	35	51
Mobile Radios & Data Terminals	11	100	-	13	13	-	-	13
Data Collection Platforms	14	18	10	13	9	-	24	11
TOTAL	7	50	26	13	14	52	38	25

\* See footnote \* in TABLE 3.3.1.

\*\* By category.

SOURCE: Surveys by the INTERDEPARTMENTAL COMMITTEE ON SPACE and WOODS GORDON  
 in 1983.



#### 3.3.4 Summary of the Survey Responses

Responses to the two surveys conducted for this study indicate that 31 Canadian firms are interested in manufacturing MSAT systems, sub-systems or components.

Altogether, these would cover the final products needed for a complete MSAT system. They appear to have considerable experience in the required technical areas, and indeed many already have products similar to those they would develop for MSAT.

Although not a large industry, this group of manufacturers has displayed strong growth in sales. A number have developed substantial export activities, especially in the United States. Moreover, for its size, this group employs a high proportion of high-skilled workers and is active in research and development.

#### 3.4 Possible Problems and Suggested Solutions

The previous section indicated that 31 Canadian firms appear to have the interest and capability to manufacture the final products for MSAT systems. However, this is not to say that problems will not be encountered in the emergence of this MSAT industry. As a result, in this section we identify the kind of obstacles that might arise in the development of MSAT products by Canadian firms, and suggest some ways these might be overcome.

A variety of sources provided the information used in this analysis. Existing studies of emerging high-technology enterprises in Canada provided general insights into the kinds of problems domestic firms have experienced in the past. Responses to our survey questionnaires and interviews revealed some specific

TABLE 3.3.5

CANADIAN FIRMS INTERESTED IN MANUFACTURING MSAT PRODUCTS  
R&D EXPENDITURES AS A SHARE OF SALES REVENUES IN 1982-83

<u>Product Group*</u>	<u>1982</u>	<u>1983</u>
	<u>(Percentages)</u>	
<u>All R&amp;D/Sales:</u>		
Satellites	3	12
Earth Stations	9	10
Antennas	3	20
Mobile Radios & Data Terminals	20	18
Data Collection Platforms	7	6
TOTAL	9	12
<u>Space/MSAT-Related R&amp;D/Sales:</u>		
Satellites	3	8
Earth Stations	8	16
Antennas	3	32
Mobile Radios & Data Terminals	13	9
Data Collection Platforms	10	9
TOTAL	5	10

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\* See footnote \* in TABLE 3.3.1.

SOURCE: Surveys by the INTERDEPARTMENTAL COMMITTEE ON SPACE and  
WOODS GORDON in 1983.



problems they perceive about MSAT. DOC personnel also contributed their insights into the problems they foresaw with domestic manufacturers taking on an advanced system like MSAT.

These potential problems, and our suggested solutions, are outlined in more detail in the following sections.

#### 3.4.1 General Problems and Solutions

Industry representatives and other sources identified a variety of problems which are related more to the realities of successfully developing and sustaining any new high-technology products in Canada.

The domestic market for such equipment is one of the most often cited of these problems. In any country, the domestic market plays a vital role in new product development for a variety of reasons:

- It establishes a need for the product (since many consumers do not recognize their demand for new products until they see them in action).
- It demonstrates the product's technical and commercial feasibility to foreign customers.
- It provides domestic firms with a base of revenues to refine production techniques and begin exploring export markets.

As a general rule, the larger the domestic market, the stronger the benefits to manufacturers. Substantial domestic acceptance stimulates a bandwagon effect in other countries. Large volume runs to satisfy domestic needs tend to reduce unit costs and prices, thereby increasing the attractiveness of the product to both domestic and foreign buyers. High production volumes geared to domestic markets also provide needed revenue streams and show off the





product's feasibility. Further, large markets provide manufacturers with sufficient range of demand to justify diversification of product lines.

Unfortunately, Canada's domestic market is relatively small, typically estimated to be one-tenth or one-fifteenth of the U.S. market. It is thus much more difficult for Canadian firms to grow as large or become as diversified as those based in other major industrialized countries.

This is reflected by the size and range of Canada's space and communications manufacturing industries. With the exception of a few sectoral leaders, Canadian-owned firms in these industries are quite small relative to their European, Japanese and American competitors in terms of their financial, physical and human resources.

One result of this is that some Canadian companies in these industries have difficulty undertaking the original research and development needed for a wide variety of new products on their own. For this reason, Canadian space and communications manufacturers typically specialize in a limited number of products. To many, R&D is primarily final product development, rather than true scientific research (unless funded by government).

Another result is that Canada's relatively small firms can only stage limited international marketing campaigns. Their reputations are generally not worldwide, unlike such large, international companies as RCA, General Electric and Sony. Moreover, unlike these world-renowned companies, smaller Canadian firms often do not have the financial and human resources to establish marketing



divisions in other countries. Thus, many Canadian high-technology companies are forced to concentrate on the domestic and U.S. markets.

A further difficulty related in part to the small Canadian market is the country's relatively narrow industrial base. This forces many domestic companies to import a substantial portion of the material inputs in their finished products.

For example, sources in the mobile radio industry suggest that as much as 50 percent of the value of materials used in their products are imported. Many of these foreign-made goods are more advanced technology items -- integrated circuits, video screens, etc. -- that are either manufactured in too limited quantities or not produced at all in Canada. In many cases, the domestic content thus tends to be assembly and low-technology manufacturing (such as plastic moulding and "metal bashing" to make the bases and cases for the final products).

This reliance on imports places Canadian firms at a competitive disadvantage in both domestic and foreign markets. They are vulnerable to supply disruptions and exchange rate effects. If their material suppliers are also their competitors in final product markets, Canadian manufacturers can be priced out of the marketplace. Further, if still not beyond the threshold stage, they may not be able to obtain as large volume discounts on purchases of inputs.

Finally, lower production volumes in smaller Canadian firms are also a major contributor to relatively higher unit labour costs (essentially, wage rates adjusted by productivity). In recent years unit labour costs in Canada were roughly 20 percent higher than



in the United States and 50 percent higher than in the U.K. The comparison with Pacific Rim countries was even worse.

These general problems will likely be encountered by Canadian manufacturers interested in MSAT. The key question is: Will they prevent domestic firms from successfully launching and selling MSAT products?

The answer to this question can be found by reviewing the domestic high-technology firms that have overcome these general difficulties. Although there are some exceptions, these manufacturers appear to have a common formula for success:

- Identification of an emerging market niche before it has attracted the interest of large (usually more slow to innovate) firms in the same field.
- Development of the "bare bones" product needed to become established in this niche.
- Use of government resources -- e.g., technology transfers, grants, subsidies, loans, purchases -- to support development of the initial product lines.
- Concentration on the domestic market in the early stages to test the product, monitor production processes for quality control, and establish the brand name.
- Avoidance of diversification into all imaginable spin-off products.
- Cultivation of the U.S. market, possibly by associating with American firms or by maintaining compatibility with U.S. systems.
- Improvement on the original, basic product as long as the domestic and foreign demand warrants.
- Development of production facilities in key foreign markets, or in low-cost countries.
- Anticipation of the entry of major manufacturers, either by keeping one step ahead in the niche, or by abandoning the niche for another, or by selling out to another company and starting over.



This formula suggests some guidelines for developing MSAT in a way to ensure the emergence of a successful manufacturing presence in Canada.

The market niche has been identified in Canada<sup>1</sup> and the United States<sup>2</sup>. However, a variety of technologies can be developed to satisfy some of this potential demand (e.g., transportable terminals that can use existing telecommunications satellites, large-cell mobile radio-telephone systems, etc.). Thus, the first guideline is to endeavour to establish MSAT before other systems.

The second is to develop the most straightforward technologies to meet the market's needs. Waiting until the most sophisticated version has been refined only delays implementation of the system. Adding "bells and whistles" or applying untested technologies may not increase the initial demand because the devices are not ready at start-up time, or because they do not function, or because the added features do not increase utility, or because they cost far too much.

The third guideline is to concentrate on developing and producing the initial products for the domestic market. This will demonstrate the new system's practicality and reliability, possibly creating a bandwagon effect among potential users. It will also give

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<sup>1</sup> Canada, Department of Communications, The Market for MSAT Systems, by Woods Gordon (February 1984).

<sup>2</sup> United States, National Aeronautics and Space Administration, Mobile Radio Alternative System Study, by General Electric Company, (Springfield, Virginia: National Technical Information Service, 1983).



domestic firms an opportunity to fine tune their production processes, and provide them with a stream of revenues to recoup their development expenditures and finance marketing efforts.

The fourth guideline is to avoid pursuing system specifications which are likely to be incompatible with long-term trends in other countries, especially the United States. Going it alone with MSAT is likely to result in an expensive, state-of-the-art system that cannot be sold outside of Canada.

Finally, it is apparent that, as the initial developer of MSAT, the Canadian Government will have to play a number of important roles in fostering the emergence of a successful MSAT manufacturing industry:

- Transfer scientific/technical information developed in Communications Research Centre of DOC.
- Support additional R&D in the private firms (through subsidies, grants or loans):
- Provide a clearly defined domestic market for the initial production runs.
- Lend follow-on assistance in penetrating foreign markets.

#### 3.4.2 MSAT-Specific Problems and Solutions

Our questionnaires and interviews revealed some problems which firms identify more directly with MSAT.

On the space side, there are a number of hurdles to get over in order to improve Canada's chances of prime contracting the domestic MSAT satellites, as well as those for the U.S. and any rest-of-world mobile satcom systems.



Our space industry has recorded some major achievements since acquiring its prime contracting capabilities in the second half of the '70s. The Canadarm is one of the most outstanding successes of the U.S. Shuttle Program. The two ANIK-D spacecraft are Canada's first commercial communications satellites to be prime contracted domestically. With the winning bid to prime contract BRAZILSAT, Canada became one of the very few space nations to export a satellite system.

Despite these and other impressive accomplishments, Canada's space industry faces a number of problems:

- Our prime contracting capabilities are still inexperienced relative to Hughes Aircraft Company, RCA Astro-Electronics, General Electric Company, Ford Aerospace and Communications Corp., etc.
- Our production capabilities are small relative to Hughes, RCA, etc., so our space industry is unable to take advantage of economies of large-scale production.
- Our space industry does not have access to substantial military spacecraft expenditures, which have financed much of the R&D that Hughes, RCA, etc. have subsequently applied to their lines of commercial communications satellites.
- Unlike Hughes, Ford or Aerospatiale, Canada's space companies have not had the worldwide exposure, technological infusion or financial gains associated with prime contracting satellites for INTELSAT or INMARSAT.

In addition to these general problems, a major obstacle is that Canada does not have access to a domestic satellite platform. This means that the platforms for any Canadian-made spacecraft must be purchased from foreign companies -- most of which are potential competitors. Some of these foreign firms will simply not sell their technologies -- e.g., become a sub-contractor to a Canadian company. Any that would could easily bump a Canadian firm out of a prime contract competition by setting exorbitant prices for their platforms.



An added cost that a Canadian firm must incur in the process of buying satellite platforms is learning how to build the completed spacecraft. This is a cost that the bus designer/producer is able to amortize over the R&D stage and the repeated usage of its platforms on different satellites.

In the recent past, some of these problems have been solved by joint ventures, such as the agreement between Spar Aerospace Limited and Hughes Aircraft Company. Essentially, this agreement means that Hughes will back-up Spar -- by supplying an HS platform and transferring the necessary assembly information -- in bids that Spar has a better chance of winning (e.g., ANIK procurements), or that Hughes has little interest in pursuing directly (e.g., BRAZILSAT). Conversely, Spar will act as a major sub-contractor to Hughes on bids requiring the expertise and resources of an unlimited prime contractor (e.g., INTELSAT or INMARSAT).

This relationship has proven very advantageous to Spar in winning the ANIK D and BRAZILSAT procurements. However, it should also be recognized that such linkages create an important constraint.

To illustrate, foreign prime contractors might not want such a relationship if their Canadian partners seek to develop similar links with other prime contractors just for the MSAT Program. Also, major competitors may refuse to sell a Canadian firm their technologies to build MSAT satellites as long as linkages to other prime contractors are maintained. In short, it may not be possible to consider a range of different satellite platforms for MSAT and realistically expect a Canadian firm to prime contract the spacecraft.



In view of these factors, the probability of a domestic firm prime contracting MSAT satellites would improve significantly if at least some of the following applied:

- Canada's first-generation MSAT satellite is launched before its U.S. counterpart.
- Sufficient government financial support is provided to permit a Canadian firm to submit a competitive bid for Telesat Canada's first-generation MSAT procurement.
- An MSAT satellite platform is selected that will meet the Canadian system's technical needs, but will at the same time:
  - o not disrupt existing joint relationships.
  - o build upon Canada's current satellite prime contracting capabilities.
  - o coincide with the U.S. operator's design preferences.
- Potential competitors are persuaded to sub-contract to the Canadian prime contractor for specific parts of the MSAT spacecraft. Indeed, this has already taken place since Aerospatiale is developing the large reflector antennas.
- Follow-on marketing support -- trade missions, demonstrations, financing arrangements, offsets -- is provided by the Canadian Government to help Canadian firms develop rest-of-world MSAT markets.

Building the first MSAT spacecraft in Canada would give the domestic firm the technological advantage, credibility, high profile and financial base to compete effectively for the first-generation U.S. and the second-generation Canadian and U.S. MSAT satellites.

The inclusion of other prime contractors as principal sub-contractors will give them a stake in helping Canadian firms win further MSAT contracts, thereby reducing potential competition.





The follow-on marketing support is needed to raise international awareness about MSAT, and to put Canadian firms on a competitive par with their major competitors in the U.S. and Europe.

On the ground side, some firms are quite sceptical that MSAT will ever materialize in Canada, let alone elsewhere. It was suggested that MSAT is just a make-work project to keep Canada's fledgling space industry in business until the next ANIK procurements by Telesat Canada, and will never get beyond the planning stage. Others argued that the domestic demand for MSAT will prove to be too small to warrant implementation, largely because competing terrestrial systems will already have captured much of the market that might have gone to MSAT.

Firms are also sceptical about the survivability of MSAT beyond the first Canadian generation because of potential technical shortcomings they see in some of the system's most advanced technological areas. Examples include the development of marketable PELPC terminals and mobile antennas in time for the start of the first generation. Another illustration is the potential interference with MSAT communications due to nearby hills, trees and buildings, which may force users to be stationary in an unobstructed area to achieve clear transmissions.

In stating these concerns, the firms emphasize the necessity of implementing this system successfully. Their experience has taught them that too many service disruptions or too much user inconvenience in the earliest stages will create long-term marketing problems which may be impossible to overcome.



Given these perceived risks, they indicate that it would be very difficult to justify internal financing of MSAT product development.

Another major problem area that may affect the ability of Canadian firms to produce MSAT radio equipment concerns the anticipated coming boom in metropolitan cellular mobile telephone systems. Essentially, manufacturers expect that these new markets will represent a quantum leap in their current markets in Canada and the United States over the next 10 or so years. If this proves correct, their production capacities and management capabilities will be taxed to the limit, even with planned expansions.

This view contrasts significantly with their scepticism about MSAT. As a result, some are quite unwilling to divert scarce human and capital resources away from a business they perceive to be profitable to one which they consider to be highly uncertain and probably small.

An extension of this problem is that some of the cellular radio manufacturers with U.S. parent companies are actively opposing implementation of an MSAT system in North America.

As explained in more detail in the next chapter, a variety of powerful U.S. firms believe that the demand for cellular radios will be so strong that systems in cities like New York, Chicago and Los Angeles will soon be spectrum-limited. For this reason, they have taken the position that the radio frequencies that might be used by MSAT would be more advantageously assigned to terrestrial cellular



mobile radio services. Consequently, these U.S. manufacturers are explicitly opposed to developing MSAT radio equipment.

This could represent a serious problem because these companies are among the largest and most experienced in the mobile radio field, and their Canadian branch operations might have benefited significantly from their research into advanced areas like PELPC and ACSSB.

These potential MSAT-specific problems could clearly be harmful to the emergence of an MSAT manufacturing industry in Canada. Thus, shortly after the decision is made to proceed with a domestic system, a number of steps should be taken to overcome these obstacles.

Some of the scepticism expressed by Canadian firms will disappear with the decision to implement a domestic MSAT system. However, several additional measures may be needed to instill some enthusiasm in certain manufacturers:

- Design MSAT to be compatible with the satellite mobile communications system selected for the United States.
- Protect the Canadian market, or possibly arrange a joint Canadian/U.S. agreement that gives Canadian manufacturers a share of both markets.
- Specify practical technologies (e.g., which Canadian firms can develop and market). This may mean using systems that are already available rather than those at the leading edge of technical change (e.g., ACSSB radios rather than PELPC/DMSK radios).
- Develop systems or sub-systems with strong follow-up market possibilities (e.g., an inexpensive MSAT sub-system package that can be fitted onto a standard telecommunications satellite for smaller markets).
- Extend MSAT capabilities to be consistent with the existing satellite mobile communications system operated by the International Maritime Satellite Organization (INMARSAT), which operates at 1.5 GHz rather than 800 MHz.



- Resolve the perceived conflict with terrestrial cellular mobile telephone operators and manufacturers.

Some of the more practical problems can be overcome by following the guidelines given in the previous section. In particular, reservations about investing in R&D needed for MSAT product development could be reduced by:

- Making technical data developed by federal researchers available to private firms.
- Providing R&D subsidies, grants or loans.
- Committing to purchase or lease a large part of the initial production runs of MSAT mobile equipment.

#### 3.4.3 Summary of Problems and Solutions

This analysis reveals that the potential MSAT manufacturing industry faces two critical problems. The first is common to many high-technology endeavours in this country: the Canadian market is too small to support numerous world-leading product innovations. The second is that a considerable portion of the Canadian communications industry is sceptical about MSAT, and will have to be convinced of its potential success before becoming seriously involved in the project.

These problems can be overcome. To illustrate, the development of a joint Canadian/U.S. MSAT system -- with guaranteed Canadian manufacturing shares -- would provide domestic firms with the larger market needed to make new product development attractive. Redefining MSAT to be more compatible with INMARSAT equipment would open up further market opportunities. These steps would also lend



much more credibility to the MSAT concept, and thereby reduce the existing scepticism. Furthermore, government assistance in R&D (possibly in the form of technology transfers) and contracted procurements of demonstration equipment in the early stages.

If these problems are overcome, it appears reasonable to expect that the potential MSAT manufacturing industry outlined in Section 3.3 will emerge, and that a considerable amount of MSAT manufacturing could take place in Canada.



#### 4. POTENTIAL MSAT EXPORTS

##### 4.1 Introduction

Recent studies project substantial growth in demand for MSAT services in Canada during 1989-2002. This will provide a solid core market for domestic space and communications equipment manufacturers. Civilian demand for satellite mobile communications may also emerge in other parts of the world, giving these Canadian producers additional business from export sales. Our objective here is to assess these non-military export market prospects.

Projections of demand for mobile satcom services are not available in most countries. Indeed, outside of the major space nations, very little is known about satellite mobile communications since this is still a new and untried concept. As a result, we adopted a top-down approach to assess the worldwide interest in mobile satcom systems, and the export potential for Canada's MSAT manufacturers.

Essentially, our analysis involved four major steps. We specified some "game rules" to reduce the hypothetical possibilities to manageable proportions. Using these, we screened all conceivable markets -- individual countries and relevant international organizations -- to identify reasonable likely possibilities. We then analyzed a sample of these possible markets in detail -- including a series of personal visits -- to assess Canadian export prospects. Finally, we drew upon this in-depth sample analysis to evaluate the overall potential for Canadian manufacturers to export MSAT systems and equipment.

TABLE 4.1

SUMMARY OF MSAT EXPORT MARKET PROSPECTS

	<u>Possible</u>	<u>Doubtful</u>
1. Large Industrial Economies:	United States	Federal Republic of Germany France Italy Japan Union of Soviet Socialist Republics United Kingdom
2. Smaller Industrial Economies:	Australia Sweden	New Zealand Norway South Africa
3. Developing Industrial Economies:	Argentina Brazil India Mexico Nigeria People's Republic of China	Saudi Arabia Indonesia
4. Other Countries:		Algeria Colombia Iran Libya Niger Oman Peru Sudan Venezuela Zaire
5. Regional Organizations:	Andean Group ASEAN ESA Nordic Group	Arab League PATU
6. Global Organizations:	INMARSAT	INTELSAT INTERSPUTNIK



The results of this examination are summarized in Table 4.1, opposite. In the following, we provide a detailed overview of our analysis of the key sample markets:

- o United States
- o Europe
- o International Maritime Satellite Organization (INMARSAT)
- o Australia
- o Brazil
- o Argentina
- o Nigeria

We then present our assessment of the overall prospects for Canadian manufacturers to export MSAT systems and equipment during 1989-2002.

#### 4.2 In-Depth Research in Sample Markets

We took a straightforward approach in this stage of the potential MSAT export market assessment. Essentially, high-level representatives of selected countries and organizations were interviewed in a series of personal visits. The objectives of these was to learn their interest, demand criteria, and prognosis for a mobile satcom system, and MSAT in particular, in their respective situations. This was accomplished in several phases.

Personal trips were made by Woods Gordon study team members to the following countries and organizations<sup>1</sup>:

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<sup>1</sup> In order to prepare our interview subjects for our visits, we mailed out a short briefing note about MSAT. This material was based on the Canadian MSAT system plans at the time (Fall 1983), which were for a pre-operational system (first generation) using an OLYMPUS bus.





Australia: Department of Communications  
Department of Transport - Maritime Operations Division  
Telecom Australia  
AUSSAT  
Motorola Communications Australasia  
Phillips - Radio Communications Division  
Australian Electronics Industry Association  
Natural Disasters Organization

France: Centre National d'Etudes Spatiale  
European Space Agency  
European Space Research and Technology Centre

Sweden: Ericsson Radio Systems  
Swedish Board for Space Activities  
Swedish Ministry for Transport and Communications  
Swedish Telecommunications Administration

U.K.: Department of Trade and Industry  
Racal Electronics  
British Aerospace  
British Telecom International  
INMARSAT

The market prospects in the United States were investigated through a personal visit to one of the mobile satcom applicants (Mobile Satellite Corporation), and through detailed analysis of licence applications to the Federal Communications Commission (FCC), NASA studies and other materials that have recently become available.

Representatives of Spar Aerospace Limited explored the possibilities for MSAT exports through their high-level contacts in Argentina, Brazil and Nigeria.

The information gathered through this extensive research program is summarized in the following sections.



#### 4.2.1 The United States

Interest in land mobile satellite communications appears to be as strong in the United States as in Canada. A major reason for this is the support NASA has shown for the mobile satcom concept, commissioning a variety of studies on the subject by respected members of the U.S. space industry.

In 1979, for example, General Electric Company submitted a report to NASA which concluded not only that "(s)atellite systems can . . . uniquely provide a needed contribution to land mobile and personal communications and do so cost-effectively,"<sup>1</sup> but also that "(t)echnology developments needed are within reasonable extension of the current state-of-the-art."<sup>2</sup>

NASA also commissioned a major study by TRW Inc.<sup>3</sup> This report, submitted in 1983, explored alternative system configurations and technologies, and developed a variety of possible subscriber scenarios.

General Electric Company completed another study for NASA in 1983.<sup>4</sup> In it, GE projected land mobile traffic in the U.S.

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<sup>1</sup> United States, National Aeronautics and Space Administration, Satellite-Aided Mobile Radio Concept Study, by General Electric Company, (Springfield, Virginia: National Technical Information Service, 1979), p. 1.

<sup>2</sup> Ibid.

<sup>3</sup> United States, National Aeronautics and Space Administration, Requirements for a Mobile Communications Satellite System, Volumes I, II, and III, by TRW Inc., (Springfield, Virginia: Technical Information Service, 1983).

<sup>4</sup> United States, National Aeronautics and Space Administration, Mobile Radio Alternative System Study, by General Electric Company, (Springfield, Virginia: National Technical Information Service, 1983).



and estimated a capturable market of almost 500,000 mobile radio-telephone users. This report also provided the functional and satellite system characteristics which would be required in order to meet this demand.

In addition to commissioning these studies, NASA has given further impetus to the mobile satcom concept by establishing strong links to Canada's MSAT Program. When Canada's Department of Communications was still planning a demonstration MSAT, NASA agreed to provide free launch services in exchange for two beams to demonstrate the mobile satcom applications in the U.S. More recently, NASA signed an agreement with DOC to co-operate in the definition of space requirements for a mobile satellite communications service for the two countries.

These activities on NASA's part have stimulated considerable interest in the mobile satcom concept in the United States. In the Fall of 1984, three applications had been made to the FCC for licences to implement such services.<sup>1</sup> Another application has been filed to institute a transportable satellite communications system which could satisfy some of the same needs. Each of these is discussed in more detail in the following sections.

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<sup>1</sup> By February 29, 1985 this number had increased to 12. Also, some of the original four applicants may have altered their final submissions from the early versions we obtained.



Skylink Corporation

One of the mobile satcom licence applications was filed by Skylink Corporation, of Boulder, Colorado. This proposes to establish a system which is not only compatible with, but possibly also jointly operated with a Canadian MSAT system.

Essentially, Skylink intends to provide such services as: rural mobile and fixed radio-telephone, rural digital and voice dispatch, data acquisition and control, position location, environmental monitoring and emergency communications.

The basic user devices in this system would be the mobile remote terminal (similar in size, function and cost to a cellular mobile radio-telephone) and the portable remote terminal. Both would operate in the 800 MHz band, and could be designed for voice, digital or voice/digital modes, as required. Other network ground elements would include base station terminals (owned by a variety of service suppliers) and a central control station.

Three generations of satellites are envisioned. The first, to be launched in 1987-88, would be a relatively small, single-beam system based on an established platform (e.g., an HS-376), and capable of providing 800 voice channels. Skylink proposes that two such satellites be launched: one owned by Skylink America and the other owned by Telesat Canada, each acting as back-up for the other. The second generation, which could be launched as soon as the developmental stage is over, might consist of a larger, multi-beam satellite with capacity for 2,400 voice channels, backed up by two of the first generation satellites. The third generation could involve

TABLE 4.2.1

## U.S. MARKET ESTIMATES - SKYLINK CORPORATION

<u>Market Segment</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
	(erlangs*)		
Rural Telephone	2,500	3,625	5,300
Mobile Telephone	6,250	9,050	13,250
Remote Dispatch	1,400	2,050	3,000
Emergency Services	625	900	1,325
Remote Operations	<u>625</u>	<u>900</u>	<u>1,325</u>
TOTAL	<u>11,400</u>	<u>16,525</u>	<u>24,200</u>

(estimated\*\* number of units)

Rural Telephone	180,000	265,000	385,000
Mobile Telephone	450,000	660,000	970,000
Remote Dispatch	280,000	410,000	600,000
Emergency Services	155,000	225,000	330,000
Remote Operations	<u>25,000</u>	<u>35,000</u>	<u>55,000</u>
TOTAL	<u>1,090,000</u>	<u>1,595,000</u>	<u>2,340,000</u>

\* Skylink Corporation did not provide detailed market projections in its application, except for 1987. Woods Gordon estimated these values using the proportional breakdown Skylink provided for 1987, and the total erlangs the Corporation estimated for 1990, 1995, and 2000. These values have been rounded to the nearest 25 erlangs. It should be noted that Skylink did not distinguish "potential" and capturable markets.

\*\* Estimated by Woods Gordon using the following values provided by Skylink Corporation:

Mobile Telephone :	0.0137 erlangs/unit
Remote Dispatch :	0.005 erlangs/unit
Emergency Services:	0.004 erlangs/unit
Remote Operations :	0.025 erlangs/unit

Woods Gordon assumed 0.0137 erlangs/unit for rural telephones. Values given are rounded to the nearest 5,000.



even larger, multi-beam platforms, each capable of supplying 30,000 voice channels over all North America.

Skylink's application does not contain original market forecasts, but draws heavily upon the estimates made in 1983 by General Electric Company. These suggest that wholesale capacity might rise from approximately 1,000,000 users in 1990 to over 2 million in the year 2000<sup>1</sup> (see Table 4.2.1 on the facing page).

Canadian firms stand a fairly good chance of participating significantly in this market if Skylink is awarded the U.S. mobile satcom licence. Spar Aerospace Limited and Mobile Data International Inc. have assisted Skylink's licence application in the space and data terminal areas, respectively. Moreover, Skylink has endeavored to co-ordinate its plans with those of Telesat Canada, with the intention to develop a North American compatible system.

#### Mobile Satellite Corporation

The second major application for a mobile satcom licence has been made by Mobile Satellite Corporation (MOBILSAT), of King of Prussia, Pennsylvania. This also proposes a system which is similar in concept to Canada's MSAT, but one which is more ambitious than Skylink's in several ways.

MOBILSAT intends to serve virtually the same markets as Skylink:

- o rural land mobile voice or digital communications
- o position location

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<sup>1</sup> Estimated by Woods Gordon using information provided by Skylink Corporation (see Table 4.2.1 for details).

TABLE 4.2.2

## U.S. MARKET ESTIMATES - MOBILE SATELLITE CORPORATION

<u>Market Segment</u>	<u>1990</u>	<u>1995</u> (erlangs)	<u>2000</u>
Oil & Gas: Voice	322	385	452
Data	<u>111</u>	<u>129</u>	<u>150</u>
Total	<u>433</u>	<u>514</u>	<u>602</u>
Trucking: Voice	810	890	990
Data	<u>10</u>	<u>11</u>	<u>12</u>
Total	<u>820</u>	<u>901</u>	<u>1,002</u>
Commercial & Public Radio	4,100	6,600	10,620
Mobile Radio Telephone	<u>6,070</u>	<u>8,520</u>	<u>11,945</u>
TOTAL	<u>11,423</u>	<u>16,535</u>	<u>24,169</u>

(number of units)

Oil & Gas: Voice	35,700	41,400	48,600
Data	<u>7,300</u>	<u>8,400</u>	<u>9,800</u>
Total	<u>43,000</u>	<u>49,800</u>	<u>58,400</u>
Trucking: Voice	87,000	96,000	106,000
Data	<u>168,000</u>	<u>186,000</u>	<u>205,000</u>
Total	<u>255,000</u>	<u>282,000</u>	<u>311,000</u>
Commercial & Public Radio	440,000	709,000	1,142,000
Mobile Radio Telephone	<u>216,890</u>	<u>304,205</u>	<u>426,650</u>
TOTAL	<u>955,890</u>	<u>1,345,005</u>	<u>1,938,050</u>

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SOURCE: Mobile Satellite Corporation.



- o rural dispatch
- o rural fixed telephone
- o emergency communications
- o rural inter-exchange trunking

It also plans to serve a variety of aviation communications needs, including certain air traffic control functions, airline passenger telephone, and airline business operations.

User equipment for this proposed system would be designed to satisfy particular needs:

- o fully mobile, personal portable, transportable or fixed services
- o cellular compatible or stand-alone
- o voice, digital or voice/digital

Land mobile user equipment would operate in the 800 MHz band, while aviation equipment would operate in the L-band (1.6/1.5 GHz).

Ground station facilities would consist of a single central control station, and various gateway earth stations located near telephone exchanges and user installations.

MOBILSAT plans to cover continental North America plus Hawaii and Puerto Rico. To do this, the company has proposed a first generation satellite system, consisting of two large, multi-beam spacecraft, with a combined capacity of some 5,000 duplex voice channels. A third satellite would also be launched in the first generation program to provide back-up for the two operational spacecraft.

MOBILSAT has also relied on the 1983 market estimates provided by General Electric Company. As shown in Table 4.2.2, total U.S. demand for MOBILSAT's services is expected to be in the order of 1 million users by 1990, and almost 2 million by the year 2000.





No Canadian firms have actively assisted MOBILSAT in its licence application, and thereby gained an inside track. Moreover, it might be noted that some of MOBILSAT's executives are former employees of General Electric Corporation, which might give GE a special advantage. Finally, MOBILSAT has apparently not made any special effort to foster compatibility with Canada's MSAT.<sup>1</sup>

Thus, if MOBILSAT does win its licence bid in the U.S., it is possible that Canadian firms will only be able to sell satellite and earth station sub-systems and components, plus base stations and terminals in this market.

#### Geostar Corporation

The third mobile satcom licence application in the U.S. has been filed by Geostar Corporation, of Princeton, New Jersey. This is conceived to be a much simpler service than MSAT, Skylink or MOBILSAT. Essentially, it is a location and digital paging service, accomplished using three satellites (probably in the ATS-6 or RCA SATCOM-1 class), a central control station (with a sophisticated computer system to perform the position function), and hand-held transceivers (about the size of existing personal portables and projected to cost around \$450<sup>2</sup>).

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<sup>1</sup> Indeed, MOBILSAT's licence application suggests that space on a North American satellite should be allocated according to use, which would mean that Canada might only have a 10-percent share.

<sup>2</sup> Estimate made by Geostar (in U.S. dollars).



The target market would include the aviation community (collision avoidance, emergency beacon), and existing land mobile radio-telephone users, taxis, railroads and public safety agencies. Many other applications have been envisioned. Theoretically, the system could accommodate 7-8 million users (since it operates on the "burst transmission" principle).

Canadian firms might not have much opportunity to penetrate this U.S. market if Geostar wins its licence application. For one thing, MSAT equipment is not at all similar or compatible with the Geostar system, so Canadian manufacturers would gain no special advantage from the MSAT Program. In addition, Canadian firms apparently did not contribute to the Geostar licence application (RCA Corporation provided the technical background for the satellite system). Moreover, Geostar intends to license production of the hand-held transceivers. Thus, it is unlikely that Canadian firms would be major suppliers to this market.

#### Other System Concepts

A variety of proximate mobile satcom concepts have also been developed in the United States:

- GEO/SAT COMM is intended to serve the oil and gas exploration industry with fully portable earth stations that can be used with existing telecommunications satellites.



- National Exchange Inc. (NEX) has filed an application with the FCC to implement SpotNet, a system which would give users with transportable, small earth terminals (2-meter dish antennas) access to high-power, multi-beam satellites.
- OMNINET is preparing its licence application to develop a regional system, intended to provide full mobile satcom services across all of North America. Full details will not be available until the formal application has been submitted to the FCC.
- Hughes Communications, Inc. and Hughes Aircraft Company are reportedly considering a mobile satcom licence application as well. No details are currently available. But Hughes' participation could be a strong benefit to Canadian MSAT manufacturers owing to the close co-operation that has gone on in such programs as ANIK-C, ANIK-D and BRAZILSAT.

Furthermore, some of the DBS applicants in the United States have considered using some of the capacity on their high-powered, spot-beam satellite systems to deliver digitized services to subscribers with small earth stations.

#### Other Considerations about U.S. Prospects

In view of all this interest in commercial mobile satcom systems in the United States, implementation of at least one system seems likely. However, it must also be recognized that strong opposition has been mounted against the mobile satcom applications which are most similar to MSAT.

Powerful forces in the cellular radio-telephone area -- such as AT&T, Motorola and the Land Mobile Communications Council -- have been lobbying seriously against any allocation of the 800 MHz band for satellite mobile communications. Their main reason is that this part of the radio spectrum could eventually become essential to serving the demand that is expected to grow rapidly in large



metropolitan mobile telephone systems (e.g., New York, Chicago, Los Angeles).

Additionally, the Rural Telephone Coalition/Rural Electrification Administration has expressed concern that plans by both Skylink and MOBILSAT to serve thin-route fixed telephone needs in rural America would decrease the revenue base for the local telephone companies.

Consequently, it is possible that one of the major mobile satcom applicants -- Skylink or MOBILSAT -- will be tied up by this opposition, and not have sufficient time to launch a service by the end of this decade.

#### Conclusions about U.S. Prospects

Assembling all of this information, it was possible to draw the following conclusions about the export prospects in the United States for Canadian MSAT manufacturers:

- Similar kinds of satellite mobile communications services are demanded in the U.S. and Canada.
- Several of the systems currently being considered could be directly compatible with Canada's MSAT.
- Certain Canadian firms -- Spar Aerospace Limited and Mobile Data International Inc. -- already have some experience in the U.S. system analysis.

Offsetting these promising factors:

- Only one of the current U.S. licence applicants -- Skylink Corporation -- has actively encouraged compatibility with MSAT and Canadian participation. But Hughes Aircraft Company could also become a strong linkage if Hughes Communications, Inc. developed a mobile satcom system.



- The number of potential users in the U.S. could be very large (possibly as much as 10 times greater than in Canada), thus attracting major competitors from the U.S. and other countries.
- Once the U.S. licence has been awarded, production of system elements could be dominated by U.S. firms that assisted the successful licensee's application, or that obtain exclusive rights to manufacture technology developed by the mobile system satcom applicant.
- Implementation of a mobile satcom system in the U.S. could be blocked or delayed by significant pressure groups which are lobbying the federal government and the FCC, and which could eventually take the conflict through the U.S. judicial system.
- Development of a regional North American system, as evidently to be proposed by OMNINET, could significantly reduce Canadian participation in building the spacecraft and central control station, as well as in supplying user/operator equipment (e.g., if different technologies are used).

#### 4.2.2 Europe

From the perspectives of key decision makers in the United Kingdom, France and Sweden, there is very little interest in mobile satcom systems, and very low prospects for purchases of Canadian-made MSAT equipment or its derivatives. This outlook is based on three major points.

The first is that most European countries have already built, or are in the process of installing, nationwide terrestrial systems which will satisfy most of their demands for mobile communications. To illustrate, all of the Nordic countries already have a regional mobile radio-telephone system which provides about 80-percent coverage in Sweden<sup>1</sup>, 75-percent coverage in Norway and

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<sup>1</sup> The remaining areas are considered not worth covering.



Finland, and 100-percent coverage in Denmark. France and the United Kingdom are each developing their own terrestrial systems to provide mobile communications over large parts of their respective countrysides, following all major highways.

Sources in these countries believe that such terrestrial services will present a serious obstacle to implementing mobile satcom systems in Europe for many years. For one thing, many of these terrestrial systems are owned by powerful, state-owned postal, transportation and telecommunications authorities (PTTs), which would likely oppose introduction of mobile satcom services due to the competition this would represent. For another, they argue that the terrestrial systems will corner much of the demand for mobile communications in the foreseeable future. This is because they can be installed now, will be sold aggressively by the PTTs and involve capital equipment with a long lifetime (e.g., 20-25 years).

A second factor is that Europeans tend to have a different attitude toward satellite systems than North Americans. In general, space developments in Europe have been associated primarily with international prestige and industrial development, and much less with domestic demand as in Canada and the United States. According to our sources, this difference has arisen for a variety of reasons:

- European countries have extensive terrestrial telephone systems which virtually blanket the population. Unlike Canada and the U.S., they don't require satellites to fill significant gaps caused by extreme distances and harsh conditions between settlements.



- Partially because of their heavy capital investment in these well-established terrestrial systems, European PTTs view satellites as unnecessary luxuries. They have, in fact, resisted large-scale implementation of satellite communications systems (as of 1982, only one-third of long-distance regional traffic was carried by satellite).
- European nations are very protectionist about communications, and therefore tend to oppose satellite systems which have footprints that extend over national boundaries (and would allow residents access to non-domestic services).
- For the same reason, European countries have a difficult time reaching agreement about regional satellite communications systems (indeed, this was a major factor behind the demise of Sweden's TRUCKSAT proposal).
- Finally, European countries have limited access to satellite systems due to restrictions on availability of orbit slots and radio frequencies (e.g., no orbit positions or radio frequencies have been reserved for mobile satellite communications).

For these reasons, our sources indicated that European countries are very unlikely to become consumers of mobile satcom services, individually or as a regional group.

However, they pointed out that if the Europeans did proceed into the mobile satcom area, primary attention would likely be focussed on systems which served long-haul trucking needs (e.g., the route from the Middle East to the Scandinavian countries) or air traffic control.

In making this point, our sources suggested that Canadian MSAT manufacturers might find it very difficult to penetrate either of these conceivable European satellite mobile communications markets over the foreseeable future.

The main reason for this is that European nations are protectionist about their domestic space industries, and would simply close the trade doors on substantial Canadian involvement.



Even if this were not so, Canadian firms would be endeavouring to compete against some giant European firms (e.g., L.M. Ericsson, Phillips, British Aerospace, Racal, Aerospatiale, MBB, Matra). Many of these firms have the size, market presence, and government backing to stave off incursions by Canadian manufacturers.

To summarize, therefore, it appears that there will not be a significant mobile satcom market in Europe, and even if one does emerge, Canadian firms would have a very difficult time achieving significant market penetration.

#### 4.2.3 INMARSAT

The International Maritime Satellite Organization appears to be moving in directions which could have important implications for Canadian MSAT manufacturers over the next 10-15 years. The first of these relates to INMARSAT's procurement of second generation satellites. The second concerns the Organization's plans to provide service for smaller and less expensive terminals than the current Standard A ship earth terminals.

At the present time, INMARSAT owns two of the original three MARISAT satellites launched by the U.S. in the 1970s (the third was retired after nine years of service). Both of these are now spares, one for the Indian Ocean Region and the other for the Pacific Ocean Region. Additionally, INMARSAT has leased all of the capacity on ESA's MARECS-A, which serves the Atlantic Ocean Region, and MARECS-B2, which serves the Pacific Ocean Region. Furthermore, the





Organization has access to special maritime communications sub-systems fitted on INTELSAT-V-B, (which acts as a spare to MARECS-A) over the Atlantic Ocean, INTELSAT-V-A and INTELSAT-V-C over the Pacific Ocean, and INTELSAT-V-D over the Indian Ocean.

Although launching of INMARSAT's first generation satellite system is still in process, the existing satellites are expected to require replenishment by the end of this decade. As a result, the Organization is already planning its second generation system, possibly involving 7-9 new spacecraft.

At this point in time, two options are being considered. INMARSAT could procure the satellites outright. It could also lease spacecraft which are owned and operated by INTELSAT and ESA (as it does now), or by some other organization. Costs will be the key determinant in making this decision.

In either case, the second generation satellites will be essentially the same, but somewhat improved versions of the first generation systems. At a minimum, they will offer 125 voice channels (compared to the 40-channel capacity of MARECS-A). Furthermore, they will have the power to communicate with small, low-powered terminals with compact antenna systems. This latter design criterion is related to the second major initiative INMARSAT intends to take over the next 10 years: provision of service to subscribers using Standard C class terminals.

Currently, INMARSAT's subscribers use Standard A terminals. These provide a full range of services (e.g., telephone,



telex, 56 kilobit data and telex group calls). However, in order to compensate for power and antenna gain limitations on the available spacecraft, the Standard A terminals are large and expensive. To illustrate, the directional 1-meter dish antennas are about 2 meters tall, and must be mounted on a mast high enough for unobstructed line-of-sight to the satellite. Originally, these cost in the order of \$65,000 (U.S.), but more recently large volume purchasers have been able to obtain them for about \$30,000 (U.S.)

Due to these size and cost characteristics, almost all of the over 2,000 Standard A terminals owned by INMARSAT's current subscribers are mounted aboard large ocean-going vessels or offshore drilling rigs.

In order to expand its potential market, one of the Organization's long-term objectives is to develop the capability to serve terminals which cost around \$5,000 (U.S.), and can be mounted on smaller marine vessels, as well as on airplanes and land vehicles. Owing to satellite and terminal power and antenna gain limitations, it is intended that the first generation of these Standard C terminals will be telex only (e.g., standard digital messages, digitally coded distress messages, digital selective calling signals and automatic telex services).

In fact, ESA's PROSAT program has carried this concept quite far already. A prototype Standard C terminal has been developed, and a year-long series of tests is taking place aboard the vessel Ragnvald Jarl.



Plans are to finalize the Standard C terminal specifications in time for manufacturers to begin supplying commercial units to Maritime users when the first of the Organization's second generation satellites are launched in 1988. Aeronautical versions may also be tested. Furthermore, Standard C models for land applications (such as long-distance trucking) may be developed, but only if sufficient demand is indicated and if jurisdictional problems<sup>1</sup> can be overcome.

INMARSAT will not be in a position to provide voice services to Standard C terminal users, since this would require very powerful satellites -- like the ones envisioned for Canada's MSAT system -- capable of aiming spot beams at specific parts of the globe. If demand warrants, the Organization's third generation satellite system -- for launch starting in the second half of the 1990s -- might have this capability.

In view of these plans, INMARSAT will be a significant factor in the world demand for mobile satcom products, including those manufactured in Canada due to the MSAT Program. The Organization will be procuring, or causing procurement of, a series of powerful new satellites. If it purchases new satellites, INMARSAT will have to develop telemetry, tracking and control facilities.

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<sup>1</sup> To illustrate, some countries in Europe require foreign truckers to leave their mobile communications equipment at the border.



Finally, it will awaken the world market to the possibilities of small mobile satcom terminals.

However, a number of factors suggest that these may be limited prospects for Canadian manufacturers, with or without the MSAT Program.

In international organizations like INTELSAT and INMARSAT, it is generally the case that members which own the largest shares dominate the major procurements. For example, manufacturers in the United States have prime contracted all of INTELSAT's first five satellite series,<sup>1</sup> including the INTELSAT-V satellites which have been fitted with INMARSAT's maritime communications sub-system package. Similarly, ESA has prime contracted the MARECS spacecraft which are leased by INMARSAT.

Unfortunately, Teleglobe Canada has only a 2.6-percent share in INMARSAT, placing it eleventh in importance, behind such other space nations as the United States, the U.S.S.R., the U.K., Japan, Italy, France and West Germany. Canada also ranks behind Norway, Greece and the Netherlands. Thus, Canada may not be able to exert enough influence to direct much of the Organization's new business to domestic firms.

Canadian firms are unlikely to improve upon this situation, even if they participate in the MSAT Program.

INMARSAT's second generation space procurements will involve hundreds of millions of dollars. It will thus attract bids

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<sup>1</sup> Hughes Aircraft Company prime contracted the I, II, and IV series; TRW Systems Group prime contracted the INTELSAT-III series; and Ford Aerospace and Communications Corp. is the prime contractor for the INTELSAT-V series.



from large private firms, such as Hughes Aircraft Company, RCA Corporation and Ford Aerospace, as well as such firms as British Aerospace and Aerospatiale which are actively supported by their respective governments.

Indeed, the contracts are so large (and political pressures so strong) that some of these firms are now forming international consortia to bid on INTELSAT and INMARSAT contracts. Future procurements by INMARSAT could even attract bids from the U.S.S.R.

Relative to this competition, therefore, Canada's space industry is simply too small and inexperienced to play a leading role. At best, some of the Canadian space firms that are already closely associated with the unlimited prime contractors<sup>1</sup> -- e.g., Spar Aerospace Limited, Canadian Astronautics Limited, Com Dev Ltd. and CAE Electronics Ltd. -- will participate in these contracts as suppliers of sub-systems and components.

Indeed, Spar has just obtained two substantial contracts related to Hughes Aircraft Company's INTELSAT-VI and INMARSAT contracts.

These firms would probably perform similar roles even without the MSAT Program.

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<sup>1</sup> Prime contractors that regularly invent, design, develop and produce satellites (e.g., Hughes Aircraft Company and RCA Corporation). In contrast, Spar Aerospace Limited is considered a limited prime contractor, mainly because it does not have its own line of satellite platforms.



On the ground segment side of INMARSAT's activities, Canadian firms may also have a difficult time achieving significant penetration.

No Canadian firms are currently manufacturing Standard A terminals, so an international reputation for Canadian-made equipment has not been established.

Moreover, again because of the large market potential (over \$100 million so far), the INMARSAT terminal market has attracted such major communications equipment producers as Magnavox, Scientific Atlanta, Toshiba and Japan Radio Company. These typically have considerable experience in new product development and worldwide marketing and can operate at large, cost-effective production volumes. All of these factors give them strong competitive advantages over most Canadian mobile radio equipment manufacturers.

Even if this were not so, Canadian firms have not been active in the development of Standard C terminals.<sup>1</sup> In contrast, largely due to ESA's PROSAT Program, European firms have the momentum in this area.

The MSAT Program will not change this because, with the current timing, the Standard C INMARSAT terminals will be available well before any MSAT terminals. Thus, Canadian manufacturers will not have the "head start" that might have given them a better competitive edge in this emerging market.

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<sup>1</sup> The one exception is Miller Communications Systems which is a sub-contractor to Racal in the development of prototype aviation mobile antennas.



For a variety of reasons, it is unlikely that Canada's MSAT Program will alter this situation to any great extent.

The main reason for this is that, although somewhat similar, MSAT is out of the mainstream of INMARSAT's developments.

The major differences include:

- o dominant service (MSAT is land; INMARSAT is marine and possibly aviation)
- o dominant mode (MSAT is primarily voice; INMARSAT is primarily telex)
- o access protocols
- o radio frequency (MSAT is 800 MHz; INMARSAT is 1.5 GHz)
- o power and antenna gain

Because of these key differences, very little of the equipment developed for MSAT would be transferable directly to INMARSAT. Indeed, some Canadian firms believe that they would have to develop entirely new products for INMARSAT. Thus, the only advantage gained from MSAT would be increased experience in product development.

Another important reason is timing. If Canada's MSAT and INMARSAT's second generation system are both launched around 1989, Canadian firms involved in MSAT will be concentrating on product sales in the domestic market. Few have the range and resources to develop, manufacture and market too many all-new, different product lines at one time. Thus, it is unlikely that Canadian MSAT manufacturers will be able to establish an early foothold, and therefore any long-term market share, in INMARSAT's second generation developments.

Added to this effect, a Canadian MSAT may actually keep domestic firms out of the INMARSAT market. This is because typically, in most high technology fields, products do not gain widespread acceptance until the manufacturer has successfully penetrated his home



market. As a result, if MSAT dominates the Canadian market, and thereby minimizes penetration by INMARSAT services, domestic firms will not have a large enough local market to establish any INMARSAT product lines.

Finally, although some difficult problems must be overcome, MSAT essentially represents a repackaging of existing technologies, many of which have already emerged in the United States, Japan or Europe. It is unlikely that Canadian firms participating in MSAT will accomplish any product development needed for INMARSAT that could not easily be achieved elsewhere. Consequently, while Canadian industry would clearly gain valuable experience from the MSAT Program, none of the firms involved can realistically be expected to make the kind of dramatic technological breakthroughs that would put it years ahead of any other INMARSAT equipment producers.

In summary, it appears that Canadian manufacturers involved in the MSAT Program will gain no special advantages insofar as the emerging INMARSAT market is concerned.

From another standpoint, INMARSAT's plans could have serious implications for Canadians attempting to sell MSAT systems or sub-systems to other countries around the world. If INMARSAT is successful in establishing Standard C marine, aviation and land services, it will be a direct competitor with MSAT in the international mobile satcom marketplace.

There are a number of reasons to believe that INMARSAT could dominate this competition:





- The service will be simpler (telex), and likely cheaper.
- Service rates in poorer markets might be subsidized by rates in the high traffic markets (e.g., like the INTELSAT rate structure).
- Countries may be able to acquire needed mobile communications services without going to the expense of procuring a dedicated satellite (as some countries now do with INTELSAT).
- Sales of Standard C terminals will be on a global basis, which may give manufacturers of this equipment competitive advantages due to large volume production runs.
- Equipment for INMARSAT will be less sophisticated, and therefore less costly, than for MSAT.
- Member countries in INMARSAT will have a stake in supporting the Organization.
- Product demonstration will be readily available on-site (e.g., all that will be required is purchase of a demonstration terminal, not a trip to rural Canada or the United States).
- Barriers related to frequency allocation and orbit position will be less important.
- Once established globally, INMARSAT's system could become the standard for domestic systems to follow, in the same way as INTELSAT did for domestic satellite communications systems (like ANIK).

INMARSAT could have a further limiting effect on the ability of Canadian MSAT manufacturers to penetrate the world mobile satcom market. Some of the possible purchasers of mobile satcom systems or hybrid sub-systems are regional groups of countries which belong to INMARSAT (e.g., the ASEAN). However, before such groups could acquire a dedicated mobile satcom system, they would first have to obtain INMARSAT's permission by demonstrating that such an action would cause the Organization no loss of business. Hence, if INMARSAT



experiences strong growth in demand for its Standard C service, it might inhibit some of the potential regional markets from acquiring dedicated mobile satcom systems like MSAT.

In conclusion, it appears likely that Canadian MSAT manufacturers will gain little from INMARSAT's planned growth as a result of their participation in the MSAT Program.

Their products will be too different (as things now stand) and the competition too powerful to gain much of the business generated directly and indirectly by the Organization. Any business they do get would likely come their way even without MSAT. At the same time, INMARSAT's global services could become strong competition for MSAT in potential domestic markets.

#### 4.2.4 Australia

On the surface, Australia appears to be as good a market for a mobile satcom system as Canada or the United States. It is large, has many sparsely populated areas, and significant economic activities in remote areas. Moreover, our interviews in Australia revealed interest in the mobile satellite communications concept. Nevertheless, the general consensus among sources contacted is that Australia will not likely translate this interest into a procurement.

A major reason given for this is that Australia has not attached the same importance to satellite communications systems as Canada or the United States.

One illustration of this is the country's first domestic satellite communications system. AUSSAT will not go into service until 1985, some thirteen years after the launch of the first ANIK-A.

TABLE 4.2.3

EXISTING MOBILE COMMUNICATIONS MARKET IN AUSTRALIA

LAND:

UHF & VHF Mobile Radios (licensed)	202,000
UHF & VHF Mobile Radios (unlicensed)	35,000
HF/SSB Mobile Radios	60,000
400 MHz CB Radios	<u>50,000</u>
Sub-total	<u>347,000</u>

OTHER:

Marine Mobiles (UHF, VHF & HF)	5,000
Aeronautical Mobiles	N/A
Mobile Telephones	<u>2,600</u>
	<u>7,600</u>

TOTAL (approximate) 355,000



Even then, Telecom Australia officials indicated that AUSSAT is not expected to play as significant role in the country's telecommunications system (especially telephone) as the ANIK satellites do in Canada, or the various equivalent systems do in the United States.

The ongoing developments in terrestrial mobile communications will also affect Australia's likelihood of acquiring mobile satcom services.

The data in Table 4.2.3 show that the mobile communications market in Australia is around 355,000 users. This represents 2-3 percent of the country's population of 16 million. In comparison, Canada's user market of just over 500,000 is 2 percent of our population of 25 million. On this basis, the mobile market in Australia would appear to be at least as well developed as in Canada.

This suggests that the potential market for a mobile satcom system in Australia is large. However, two factors appear to reduce this potential considerably.

For one thing, Telecom Australia plans to develop a large cell radio-telephone system for major population areas in the near future. Thus, Australia will already be serving a large portion of the market that might have been available to a mobile satcom system.

For another, Australian manufacturers estimate annual mobile user market growth of no more than 4 percent, which is somewhat lower than in Canada, and suggests a more mature market. As a result, there seems little chance that a mobile satcom market will emerge due to rapid growth.



Partially reflecting these factors, almost no planning has gone into development of mobile satcom services in Australia. From what we were able to determine, this situation is not likely to change in the next 10 or so years.

DOC in Australia is largely an approval organization for the plans and activities of Telecom Australia and broadcasters such as ABC. It is not a planner or innovator in its own right, as is the case with DOC in Canada. Hence, it is not working toward an Australian MSAT.

Any serious consideration of a mobile satcom system would therefore have to come from Telecom Australia (a monopoly since there are no RCCs other than paging companies), or AUSSAT, or directly from potential users.

Our interviews revealed that none of these organizations are currently giving the matter much attention. At this stage, AUSSAT is not in a position to concern itself with anything but its current program. While somewhat interested, Telecom Australia is not likely to pursue the mobile satcom concept in the foreseeable future, certainly not for a dedicated national system. Direct users may have substantial needs for the services that a system could provide, but these needs are unlikely to be translated into a procurement due to the prohibitive costs of mobile satcom systems.

For these reasons, a dedicated Australian satellite mobile communications system seems unlikely in the next 10-15 years.

One possible opportunity could be an add-on mobile satcom sub-system, costing \$10-20 million, for the next generation



AUSSAT spacecraft. Another opportunity could be a regional/international satellite system (in conjunction with the ASEAN or possibly IMMARSAT). As suggested by our interviews, potential users could include the Royal Flying Doctor Service, police forces, government departments, and large private sector concerns.

#### 4.2.5 Brazil

Brazilian sources contacted by Spar Aerospace Limited on Woods Gordon's behalf anticipate no need for a mobile satcom system over the next 10-15 years. They base this conclusion on three key points.

First, a national priority for the last 15 years has been the extension of fixed telephone services to rural communities. Considerable progress has been made in achieving this objective, largely through the use of HF/VHF radio, but also through leased transponders from INTELSAT. BRAZILSAT will permit even greater extension of this thin-route system after the first spacecraft is launched early in 1985. As a result, a mobile satcom system will not be required to satisfy rural and remote fixed telephone needs in Brazil.

Second, the largest demand currently for mobile communications in Brazil is for marine services. However, the country already has a terrestrial system to satisfy most of its marine requirements. Furthermore, Brazil is a member of INMARSAT, so appropriately equipped domestic vessels and ships entering Brazilian

TABLE 4.2.4

COMMUNICATIONS EQUIPMENT MANUFACTURERS IN BRAZIL

Chatral Produtos Eletrônicos Ltda.

Control S.A. Indústria E Comércio

Eletrônica Avotel Inc. E Com. Ltda.

IEC - Ind. Eletrônica De Comunicações Ltda.

Indutel Ind. De Telecomunicações Ltda.

Orteme - Organização Técnica de Manutenção Eletrô

Planar Eletrônica Ltda.

Siteltra

Telecomunicações Intraco Inc. Com. Ltda.

Telepatch - Sistemas de Comunicação Ltda.

Telesate Telecomunicações Ind. E Com. Ltda.

Unitel Ind. Eletrônica S/A

Whinner S/A - Ind. E Com.

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SOURCE: Embratel



waters have access to this global satellite communications system. Brazil anticipates that this number will grow as INMARSAT terminals become smaller and less costly.

Finally, Brazilian officials recognize that improved mobile communications will be required as development of the country's mineral and other natural resources proceeds in the interior, and as expansion of its transportation system continues. However, they point out that these pressures will not grow rapidly enough in the foreseeable future to justify acquisition of mobile satcom services. Additionally, they suggest that some of the problems associated with installing terrestrial mobile radio communications systems in Brazil's rural areas (notably the jungle) will be diminished as the country's transportation system evolves.

In conclusion, Brazil's officials stated that they do not know of any strong interest in MSAT.

If Brazil did proceed with the acquisition of a mobile satcom system or "hybrid" sub-system, Canadian firms might have some advantage on the space side, given the market position Spar Aerospace Limited has built up through its prime contract for BRAZILSAT. However, according to the Brazilian officials consulted, there would likely be sufficient domestic manufacturing capability to produce small/medium earth stations and user terminals. In fact, they provided a list of 13 firms which are already involved in these product areas (see Table 4.2.4). Thus, assuming that these Brazilian firms could be given the technical specifications, Canadian MSAT





manufacturers might have considerable difficulty penetrating this market.<sup>1</sup>

#### 4.2.6 Argentina and Nigeria

Although quite different countries, these two are combined here because attempted probes by Spar Aerospace Limited regarding interest in mobile satcom services met with equally negative responses. Evidently, officials in both Argentina and Nigeria are still too far away from acquiring a standard satellite telecommunications system to envision procurement of a new and untried system like mobile satellite communications.

#### 4.3 Summary of Findings

Analyzing all of this information revealed several key points about the likely developments in the satellite mobile communications marketplace over the next 10-15 years, and Canada's potential role in this overall market.

##### 4.3.1 The Market

The first major conclusion about the mobile satcom market concerns the aggressive programs undertaken by the two global satellite communications systems, INTELSAT and INMARSAT:

1. INMARSAT is developing its second generation satellite system, endeavouring to branch out into the aviation communications area, and encouraging more countries to allow continued use of INMARSAT terminals inside domestic waters.

<sup>1</sup> It should also be noted that, as some Canadian firms have discovered, licensing some South American firms is dangerous because they are not averse to making identical products under a different name and competing with the licensor in other markets.



2. Further, partially due to ESA's PROSAT Program, INMARSAT is moving rapidly toward smaller, lower cost terminals for use at sea, in the air and on land.
3. INTELSAT is introducing VISTA, a new service which will permit Third World nations to develop thin-route, point-to-point communications using inexpensive earth stations and economical transponder leasing arrangements.

As a consequence, demand for mobile satcom types of equipment could be stimulated greatly by these service offerings.

The second finding is that the market for domestic, dedicated mobile satcom systems appears very limited.

Aside from Canada, the United States is the only country which is seriously considering a dedicated mobile satcom system at this time. NASA has completed a number of technical and market studies, and signed an agreement with Canada to co-operate in developing a commercial land mobile satellite communications system. In addition, three private companies<sup>1</sup> -- Skylink Corporation, Mobile Satellite Corporation and Geostar Corporation -- have filed applications with the FCC for mobile satcom licences.

However, the outcome of these applications has been clouded by opposition from large companies involved in cellular mobile radio-telephone undertakings (including AT&T and Motorola) and rural telephone companies. It is thus conceivable that a mobile satcom system may not be implemented in the United States by the time Canada is ready to launch MSAT.

Our research indicates that most other countries and relevant regional groups would not be in the market for a dedicated

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<sup>1</sup> This section was written well before the closing date for licence applications in the United States (February 29, 1985). The number of final applicants at that closing date was 12.



mobile satcom system, even by the end of this century. A number of factors account for this:

- Broadcast and high-density telecommunications services are generally much larger markets, and are thus accorded much higher priority than thin-route/mobile and thin-route/point-to-point communications.
- Terrestrial facilities are usually preferred to satellite communications systems. This is due to technical bias, a belief that satellite systems are more expensive and risky, the possibility of greater domestic involvement, and a view that universal coverage is not as important as coverage of highest density traffic.
- Other satellite communications services (e.g., INTELSAT, INMARSAT, domestic regional or national satellite systems) are expected to fill the important gaps not satisfied by existing or planned terrestrial facilities (e.g., aviation, marine, oil and gas exploration, etc.).

We also discovered that markets such as Australia, the Association of South East Asian Nations (ASEAN), and Brazil could demand mobile satcom sub-systems for communications satellites which are due for replenishment in the 1990s. As things now stand, even these markets could be remote for three important reasons:

- The hybrid satellite concept will have to be proven possible, successful and cost-effective, either by Canada or another space nation. This may not be attainable in time for launch of any of these second generation satellites unless appropriate steps are taken in the near future.
- Technological improvements which are extending satellite lifetimes could mean that these hybrid markets will not re-emerge until the next century if sales are not made at the time the second generation systems are ordered.
- Competing terrestrial systems and global mobile satcom systems may have had a chance to become solidly entrenched in the more lucrative parts of the local thin-route communications markets before the hybrid mobile satcom concept can be proven and sold.

In summary, it appears that the total civilian market for mobile satcom systems or sub-systems outside of Canada will



consist of the continued growth in INMARSAT, the new thin-route services being marketed by INTELSAT, a probable dedicated domestic U.S. system, and possible hybrid domestic satellite systems with mobile satcom sub-systems.

#### 4.3.2 Market Penetration by Canadian Firms

Our findings suggest that Canadian manufacturers could encounter some major obstacles in attempting to penetrate these mobile satcom markets.

Several considerations suggest that competition for the domestic/regional markets which might be served by mobile satcom systems will likely be intense:

- Nationwide terrestrial RF communications systems are being marketed aggressively on a worldwide basis by large manufacturers like L.M. Ericsson (which installed an international system in the Nordic countries and is building another system in Saudi Arabia) and Motorola (which has sold systems in Latin America and Australia). Once in place, these can serve substantial parts of the potential mobile satcom market for many years (e.g., 20-25).
- INMARSAT may follow INTELSAT's lead and eventually begin leasing transponders to countries for domestic use.
- INTELSAT's new service -- VISTA -- will give many less developed countries affordable thin-route/point-to-point communications which they might otherwise have obtained from a dedicated mobile satcom system.
- Significant progress is being made in the development of transportable telephone terminals, which operate with existing 6/4 GHz satellite communications systems (e.g., AEL Microtel's SPACETEL), and might penetrate prospective mobile satcom markets (e.g., oil and gas exploration) before fully mobile satellite systems can be established.



Aside from this competition, some of the key factors discussed in the previous chapter may limit the ability of our domestic space/communications equipment producers to penetrate world markets:

- Some firms import key components made by their competition (e.g., Spar Aerospace Limited obtained the satellite platforms for both ANIK-D and BRAZILSAT from Hughes Aircraft Company). Thus, such Canadian firms are vulnerable to material cost pressures that could weaken the competitiveness of their final products.
- Production costs in Canada may be pushed out of line by relatively high unit labour costs in Canada, and by typically small volume production capabilities (aimed primarily at the domestic market).
- Many Canadian firms do not have worldwide marketing capabilities (Canadian-owned companies typically focus on the domestic and U.S. markets, while foreign-owned companies in Canada usually produce mainly for the domestic market).
- Canadian companies are not generally known as successful product innovators, but as assemblers and packagers of already established products.

Another important factor which may limit Canada's penetration of international mobile satcom markets is that current activities by INTELSAT and INMARSAT may set the standards in the thin-route satellite communications area by the time MSAT equipment can be marketed. This would greatly diminish any competitive advantages Canadian firms might gain from MSAT for a variety of reasons:

- Canada does not own a large enough share of either global system to figure significantly in any procurements made by these organizations, so Canada cannot expect to impose MSAT technology on them.
- Canadian manufacturing firms are hardly associated with INMARSAT at all, and so have not developed a worldwide reputation in satellite mobile communications.



- MSAT equipment, as presently envisioned, will not be compatible with either the INMARSAT or INTELSAT systems, so there will be little opportunity for direct export sales.
- Moreover, sufficient differences exist between MSAT and INTELSAT/INMARSAT systems (e.g., radio frequency, power requirements, voice/alphanumeric mix, etc.) that Canadian MSAT manufacturers would be unable to spinoff products easily and inexpensively, and many indicated that they would simply not bother if they anticipated considerable competition from other manufacturers.

#### 4.3.3 Possibilities for Improving Export Prospects

From our analysis, we believe that the MSAT export market outlook could be brightened if some changes were made before the first generation Canadian system is launched.

A clear result of our research is that INMARSAT will be proceeding rapidly into the MSAT field over the next several years, building upon its existing global operations. ESA is closely associated with these developments through its PROSAT Program, and has begun testing of a prototype Standard C INMARSAT ship terminal. It is quite conceivable, therefore, that many users of mobile communications around the world that might have demanded an MSAT system could instead end up subscribing to INMARSAT.

Compatibility with INMARSAT -- e.g., in the areas of frequency use and call protocols -- is a clear possibility that merits further consideration. Exploring ways to tie MSAT into INTELSAT's new VISTA service concept would also open up new markets.

Furthermore, we discovered that smaller countries -- including Australia and Brazil -- tend to view dedicated mobile satcom systems as expensive luxuries. However, they might be very interested



in adding on an MSAT package to the next generations of their domestic telecommunications satellites, much as INMARSAT has with the INTELSAT-V spacecraft.

Thus, we believe that MSAT export market prospects would improve considerably if Canada developed and demonstrated an MSAT sub-system compatible with the new breed of hybrid satellites in time for system replenishments in such markets as Australia, the ASEAN, Brazil and Mexico.

TABLE 5.1

ESTIMATED MANUFACTURING IMPACTS DUE TO MSAT\*  
(1985-2002)

<u>Scenario</u>	<u>MSAT INDUSTRY</u>			<u>TOTAL ECONOMY</u>	
	<u>Sales</u> <u>Revenues</u> (\$ millions)	<u>Operating</u> <u>Profits</u> (\$ millions)	<u>Net</u> <u>Exports</u> (\$ millions)	<u>Employment</u> (person-years)	<u>GNP</u> (\$ millions)
Base Case	\$1,126	\$183	\$199	33,009	\$1,494
Optimistic (Index to Base Case)	\$1,627 (145)	\$263 (144)	\$611 (307)	48,197 (146)	\$2,169 (145)
Moderate (Index to Base Case)	\$921 (82)	\$146 (80)	\$148 (74)	25,381 (77)	\$1,139 (76)
Pessimistic (Index to Base Case)	\$370 (33)	\$56 (30)	- -	11,727 (36)	\$440 (29)

\* Dollar values are millions of 1984 Canadian dollars





## 5. ANALYSIS OF MSAT IMPACTS

Production of MSAT system elements will generate a variety of industrial and macroeconomic impacts. Our aim in this chapter is to estimate these effects over 1985-2002.<sup>1</sup>

This evaluation could not be accomplished using actual production relationships and unit sales. These do not exist as yet since MSAT is a new and untested concept. We therefore simulated the possible impacts.

A calculation framework was developed to estimate the financial effects on potential equipment producers and the output and employment impacts on the Canadian economy. This framework also netted out the effects of sales foregone due to switchovers from existing mobile communications systems to MSAT.

Also, alternative market scenarios were created to examine the feasible range of industrial and macroeconomic impacts that may be derived from manufacturing MSAT equipment domestically.

The calculation framework and principal exogenous data sources are described in Appendix A.

The estimated impacts in terms of the key manufacturing and macroeconomic measures are summarized in Table 5.1, opposite. In the following sections of this chapter, we assess these simulated impacts in more detail.

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<sup>1</sup> System start-up is assumed to be 1989. However, R&D and production of most MSAT equipment will start in the 1985-88 period.



## 5.1 Base Case Scenario

The Base Case Scenario used in this study was designed in consultation with DOC, and draws heavily upon Woods Gordon's studies,<sup>1</sup> DOC's internal analysis and the studies performed by other consultants. It thus reflects the best available judgements about the likely markets, system elements and unit costs for MSAT.

### 5.1.1 Overview

The key feature of the Base Case Scenario is the assumption that Canada and the United States will develop a joint system. The operator and subscriber equipment used in each country will be essentially identical, even though cross-border usage -- e.g., Canadian subscribers travelling in the U.S. -- will be prevented by differences in frequency allocation and access protocols.

Such a joint system will require only two spacecraft in each generation, one owned by each country. Each satellite will therefore be able to act as a back-up for the other, providing considerable capital cost savings to both system operators.<sup>2</sup>

The launch year for the Canadian MSAT satellite is assumed to be 1989. During the first two years, this spacecraft would serve both Canadian and U.S. requirements. The U.S. satellite would then be launched in 1991. At this time, each spacecraft would begin serving its respective country's market.

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<sup>1</sup> Including the industry capabilities, system specifications and export prospects in this assignment, and Woods Gordon's two studies of the domestic market prospects for MSAT.

<sup>2</sup> Otherwise, each operator would most likely procure two spacecraft, one to be an in-orbit spare.



Satellite lifespan is expected to be seven years. As a result, the second-generation Canadian spacecraft would be launched in 1996, and the U.S. satellite would be placed in orbit two years later.

In keeping with our analysis in Chapter 4, the Base Case Scenario assumes that Canadian MSAT manufacturers will remain focussed on the domestic and U.S. markets until after the first-generation systems have been replenished. Even then, our sources in other prospective markets indicate that the demand for MSAT will be limited.

The Base Case Scenario thus assumes that rest-of-world (ROW) exports by Canadian manufacturers will be one complete MSAT system, equivalent in size and technology to the first-generation Canadian system. This market might be one of the ASEAN, Australia, Brazil, or Mexico. Launch date for this ROW system's first spacecraft is set at 2001.

#### 5.1.2 Canadian Market Assumptions

The Canadian market assumptions are the cornerstone of our analysis. This is not only because the Canadian market will likely be the largest single source of business for domestic MSAT manufacturers, but also because more is known about this market than any other country's.

Our assumptions in this case reflect Woods Gordon's two market studies, Telesat Canada's price/quantity trade-off analysis, and DOC's projections based on information extracted from the other Phase B MSAT studies.

TABLE 5.1.1

BASE CASE SCENARIO  
CANADIAN MARKET ASSUMPTIONS  
(1989-2002)

<u>System Element</u>	<u>First Generation (1989-1995)</u>	<u>Second Generation (1996-2002)</u>	<u>Total</u>
	(Total # of Purchases)		
Terminals: MRS	28,568	59,836	88,404
MTS	9,940	21,511	31,451
DACS: Alarm	4,066	10,299	14,365
Polling	13,604	17,530	31,134
Base Stns: UHF Pvt.	540	1,330	1,870
SHF: 2 Ch.	13	12	25
3 Ch.	11	12	23
4 Ch.	7	6	13
5 Ch.	15	4	19
7 Ch.	10	34	44
10 Ch.	28	33	61
SHF Gateways: 5 Ch.	6	3	9
10 Ch.	16	22	38



Based on Woods Gordon's market research, the total number of Canadian MSAT subscribers in each service category is projected to grow as follows:

	<u>1989</u>	<u>1995</u>	<u>2002</u>
Mobile Radio	1,835	25,971	54,457
Mobile Telephone	665	9,030	19,543
Paging	31,150	88,060	224,817
DACS	1,800	14,000	24,700

Given these user growth projections, and taking into consideration likely equipment lifetimes, the total purchases of MSAT subscriber and operator equipment in Canada shown in Table 5.1.1 were determined for the Base Case Scenario.

The Base Case Canadian market assumptions in part reflect the wholesale prices for the major system elements. These price estimates were derived by preparing rough specifications for each final MSAT product and building up a total value based on anticipated component and production costs. The price assumptions for each final MSAT product are summarized in Table 5.1.2.<sup>1</sup>

According to estimates prepared by DOC in conjunction with Telesat Canada, the Canadian-owned MSAT spacecraft would be in the PAM-D1 category for the first generation and PAM-D2 in the second -- likely requiring a platform in the same size range as the RCA 3000 or RCA 4000 series. The total cost for the Canadian satellites prime contracted domestically was thus estimated at \$105

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<sup>1</sup> The MRS and MTS terminal prices are blended to capture the expected mix of voice-only and voice-data units.

TABLE 5.1.2

BASE CASE SCENARIO  
ASSUMED UNIT PRICES FOR CANADIAN-MADE MSAT EQUIPMENT

<u>System Element</u>	Canadian <u>Market</u> (1984 Canadian dollars)
<u>First-Generation Spacecraft**:</u>	
Canadian Gov't Support	\$15 million
Construction	76 million
Contingency & In-orbit	
Incentives	<u>14 million</u>
Total	<u>\$105 million</u>
<u>Second-Generation Spacecraft**:</u>	
Construction	\$108 million
Contingency & In-orbit	
Incentives	<u>18 million</u>
Total	<u>\$126 million</u>
<u>User/Operator Equipment**:</u>	
Canadian Gov't. Support	\$9 million
Terminals: MRS	\$2,425
MTS	\$3,090
DACS: Alarm	\$3,290
Polling	\$1,825
Base Stns: UHF Pvt.	\$2,140
SHF: 2 Ch.	\$84,000
3 Ch.	\$89,000
4 Ch.	\$100,000
5 Ch.	\$107,000
7 Ch.	\$111,000
10 Ch.	\$122,000
SHF Gateways: 5 Ch.	\$128,500
10 Ch.	\$140,000
<u>Central Control Station:</u>	
Canadian Gov't Support	\$6 million
DAMA	9 million
Other	<u>12 million</u>
Total	<u>\$27 million</u>

\* Spacecraft costs do not include such things as upper stage costs, insurance, launch costs, operations, etc.

\*\* Prices shown for the user/operator equipment are weighted averages over the 1989-2002 period. In the impact calculations, these prices decline gradually over time due to the learning curve effect.



million and \$126 million (1984 Canadian dollars) for the first and second generations, respectively.<sup>1</sup>

This first generation cost estimate includes \$15 million in bid support<sup>2</sup> from the Canadian Government, \$76 million for spacecraft construction, \$6.5 million for contingencies, and \$7 million for in-orbit incentive payments to the prime contractor. The second-generation cost estimate includes \$107 million for satellite construction, \$9.1 million for contingencies and \$8.7 million for in-orbit incentives. Both sets of estimates do not include such things as upper stage costs, insurance, launch costs, operations, etc.

The Canadian Central Control Station for MSAT would likely be established at Telesat Canada's existing facilities, at an estimated cost of almost \$25 million (in constant 1984 dollars) in the first generation and another \$1 million for upgrading in the second generation.<sup>3</sup> The estimated start-up cost includes \$6 million<sup>4</sup> from the Canadian Government to support the development of the sophisticated computer software for the DAMA system.

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<sup>1</sup> These amounts are preliminary estimates. Technology and cost changes could occur before system start-up. Thus, these values are only for illustrative purposes, and should not be taken as final.

<sup>2</sup> This value is for illustrative purposes only. These funds are not committed.

<sup>3</sup> These amounts are preliminary estimates. Technology and cost changes could occur before system start-up. Thus, these values are only for illustrative purposes, and should not be taken as final.

<sup>4</sup> This value is for illustrative purposes only. These funds are not committed.

TABLE 5.1.3

BASE CASE SCENARIO  
COST COMPONENT ASSUMPTIONS

<u>System Element</u>	<u>Materials</u>		<u>Labour</u>	<u>Other</u>	<u>Total</u>
	<u>Domestic</u>	<u>Foreign</u>			
(Percentages of Total Costs)					
Spacecraft	2	50	23	25	100
Terminals	9	12	42	36	100
UHF Pvt. Base Stations	11	15	42	32	100
SHF Base Stations	32	5	43	20	100
SHF Gateways	30	5	43	22	100
Central Control Station:					
DAMA	1	11	64	24	100
Other	21	5	49	25	100





For larger quantity items -- such as the subscriber terminals, UHF/SHF base stations, and SHF gateways -- wholesale prices (in constant 1984 dollars) are expected to decline through time. This is primarily due to the learning curve effect and the economies obtained from increasing annual production volumes. The prices shown for these items in Table 5.1.2 are thus weighted averages over 1989-2002.

As part of this pricing exercise, it was necessary to estimate the cost components associated with producing the various MSAT system elements in Canada. These are outlined in detail in Appendix B. Essentially, they are as shown in Table 5.1.3.

In consultation with DOC and our industry sources, we concluded that Canadian manufacturers might achieve high penetration rates in the domestic market for MSAT products.

The Canadian MSAT spacecraft are assumed to be prime contracted domestically. This reflects three important underlying assumptions:

- Canada would launch the first satellite for the joint system.
- The Canadian Government would provide the domestic prime contractor with \$15 million in bid support<sup>1</sup> for the first generation satellite.
- The Canadian Government would encourage Telesat Canada to procure its MSAT spacecraft from a domestic prime contractor (i.e., by giving a domestic firm first chance to submit a winning bid before opening the competition to all candidates).

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<sup>1</sup> This amount is for illustrative purposes only. These funds are not committed.



It should be noted that a Canadian prime contractor might be much less likely to build the Canadian MSAT if these underlying assumptions are not correct.

We assumed that the Canadian CCS would be built by domestic firms. This is based partially on the fact that Telesat Canada will be responsible for letting this contract. It is also based on the assumption that the Canadian Government will provide \$6 million<sup>1</sup> to subsidize the development of the first-generation DAMA system. Finally, it reflects the strong capabilities several domestic firms have to assemble the CCS.

Regarding the larger volume MSAT equipment for user/operators, we concluded that Canadian firms would also obtain a high domestic market share.

This will likely be due in part to the technical lead they should have by the time of system start-up (1989). In this regard, we have assumed that the federal government will provide \$9 million<sup>2</sup> to help domestic firms prepare the first-generation MSAT products by 1989, and that it will also assure the purchase of a large number of terminals -- e.g., 2-3,000 -- in the initial years.

Nevertheless, Canadian firms can expect some competition in these areas, possibly from U.S. companies that will be making similar products for their own market. Consequently, the Base Case Scenario assumes that Canadian manufacturers would maintain 80 percent of the domestic market for terminals, base stations and gateways.

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<sup>1</sup> This amount is for illustrative purposes only. These funds are not committed.

<sup>2</sup> Ibid.

TABLE 5.1.4

BASE CASE SCENARIO  
CANADIAN PURCHASES FROM CANADIAN MSAT MANUFACTURERS  
 (1989-2002)

<u>System Element</u>	<u>First Generation (1989-1995)</u>	<u>Second Generation (1996-2002)</u>	<u>Total</u>
	(Total # of Purchases)		
Spacecraft	1	1	2
Terminals: MRS	22,854	47,870	70,724
MTS	7,952	17,208	25,160
DACS: Alarm	3,253	8,239	11,492
Polling	10,884	14,025	24,909
Base Stns: UHF Pvt.	432	1,062	1,494
SHF: 2 Ch.	9	10	19
3 Ch.	9	9	18
4 Ch.	6	4	10
5 Ch.	12	3	15
7 Ch.	8	27	35
10 Ch.	22	27	49
SHF Gateways: 5 Ch.	5	2	7
10 Ch.	13	17	30
Central Control Station	1	*	1*

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\* Central Control Station will be upgraded somewhat in 1996 to accommodate the larger capacity of the second generation satellite.



The paging units for use on the MSAT system will be no different than those sold for existing applications. According to our sources, none of the pagers sold in Canada at the present time are domestically made. Further, we are informed that this is a situation that is unlikely to change due to the cost advantages available in Pacific Rim and other countries. Thus, we have assumed that Canadian manufacturers will not make any of the pagers sold for use with MSAT.

Applying these penetration rates to the total market demand projections outlined earlier yields the unit sales estimates for Canadian manufacturers shown in Table 5.1.4.<sup>1</sup>

The switchovers from existing mobile communications systems to MSAT are expected to be quite limited. For the Base Case Scenario, therefore, somewhat over 6,000 mobile radios and 121 mobile radio-telephones that would have been manufactured in Canada during 1989-2002 are assumed to be replaced by MSAT equipment.

#### 5.1.3 U.S. Market Assumptions

As discussed in Chapter 4, a number of uncertainties exist about the U.S. MSAT market. The firms that have applied to the FCC for the U.S. licence have not undertaken their own demand studies. The best indications are the fairly dated -- temporally and technically -- market estimates prepared for NASA. The range of services that will ultimately be supplied is also unclear, since some of the licence applicants have focussed on different market segments.

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<sup>1</sup> The spacecraft values appear as fractions because the satellites will be built in stages, leading up to the launches scheduled for 1989 and 1996. Similarly, the CCS will be constructed over 1985-88, with modifications made in 1996.



It would not have been possible to resolve these uncertainties without considerable research, well beyond the scope of this assignment. Thus, it was necessary to adopt a straightforward approach to quantifying the U.S. MSAT market for this Base Case Scenario.

A fundamental assumption in this Scenario is that Canada and the United States will develop a joint MSAT system, each building a spacecraft that can substitute identically for the other's.

This equivalent satellite capacity does not necessarily imply that the range of services offered/demanded in the two countries would be the same -- for example the U.S. spacecraft could be used only to serve millions of subscribers with pagers. However, two of the leading licence applicants, Skylink and MOBILSAT, plan to implement services very similar to those being considered for the Canadian MSAT system. Thus, it is quite possible that the U.S. service offerings will be very similar to those in Canada.

The satellite power and channel capacity will limit the number of subscribers using the MSAT services available in the U.S. For these technical reasons, the Base Case Scenario assumes that the U.S. market will mirror those projected for the Canadian MSAT market (refer back to Table 5.1.1).

Several factors suggest that a Canadian prime contractor could realistically build both of the U.S. MSAT spacecraft required for this joint Canadian/U.S. system:

- The Canadian MSAT satellites are assumed to be prime contracted domestically and the first launched in each generation.



- The efficiencies of building two identical satellites under one roof will give any firm bidding for both contracts a substantial competitive advantage.
- Among the U.S. licence applicants, Skylink has already aligned itself quite strongly with Spar Aerospace Limited.
- There will be significant U.S. content in the American and Canadian MSAT satellites even if prime contracted in Canada. Thus, the U.S. sub-contractor would likely support the Canadian prime contractor's bid.

Taking these factors into account, we have assumed that the two pairs of satellites required for the joint Canadian/U.S. MSAT system will be prime contracted in Canada.

It is important to note that two of these underlying assumptions are integrally tied to the assumption that the U.S. MSAT satellites will be prime contracted in Canada. Canada's satellites must be launched first and be prime contracted domestically. Otherwise, the Canadian prime contractor will not have the technological lead and the volume efficiencies needed to out-bid American spacecraft manufacturers.

The U.S. central control station will most likely be prime contracted by the American system operator. In view of the strong lead Canada has taken in the development of DAMA software for MSAT, however, it is assumed that Canadian technicians will supply this advanced computer software.

The technological leadership Canada has built up in the MSAT product area will provide domestic manufacturers with some advantages in penetrating the U.S. market for user/operator equipment. But a number of factors will likely limit the extent of this penetration:

TABLE 5.1.5

BASE CASE SCENARIO  
U.S. PURCHASES FROM CANADIAN MSAT MANUFACTURERS  
 (1989-2002)

<u>System Element</u>	<u>First Generation (1989-1995)</u>	<u>Second Generation (1996-2002)</u>	<u>Total</u>
	(Total # of Purchases)		
Spacecraft	1	1	2
Terminals: MRS	5,714	11,967	17,673
MTS	1,985	4,302	6,287
DACS: Alarm	813	2,059	2,872
Polling	2,720	3,508	6,228
Base Stns: UHF Pvt.			
SHF: 2 Ch.	108	265	373
3 Ch.	3	2	5
4 Ch.	2	2	4
5 Ch.	1	1	2
7 Ch.	1	1	2
10 Ch.	5	7	12
SHF Gateways: 5 Ch.	2	0	2
10 Ch.	3	4	7
Central Control Station	1*	*	1*

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\* Canada to supply the DAMA system for the U.S. CCS in the first generation, and to upgrade this for the larger capacity second-generation system.



- Canadian firms will be concentrating on the domestic market, and may not have the capacity to produce substantial volumes for the U.S. market.
- Some of the Canadian MSAT manufacturers are subsidiaries of U.S. companies, and may thus be constrained to producing only for the Canadian market.
- U.S. manufacturers will have competitive advantages in larger plant scale, lower labour costs, lower transportation costs, no import duties, better brand-name recognition, etc.

Taking these factors into consideration, the Base Case Scenario assumes that Canadian manufacturers would supply 20 percent of the terminals, base stations and gateways sold in the U.S. market.

Applying the penetration rate assumptions to the total purchase estimates yields the projections of final product sales by Canadian firms to the U.S. MSAT market shown in Table 5.1.5.

For each of the user/operator system elements, the wholesale prices received by the Canadian manufacturers are assumed to be the same -- in Canadian dollars -- as those charged in the domestic market (see Table 5.1.6).

The cost of the spacecraft and central control station systems exported to the United States are somewhat different than shown in Table 5.1.3, however. In both cases, the federal government's support payments -- \$15 million for the first-generation satellite and \$6 million for the DAMA development (1984 Canadian dollars) -- would not be included in the prices to U.S. purchasers. Also, since the DAMA system sold to the U.S. will likely be very similar to the one developed for Canada, very little new programming will be required. Thus, the cost of the DAMA package to the U.S. operator is assumed to be \$2.7 million (1984 Canadian dollars), which is believed to be a competitive second-round bid price.



TABLE 5.1.6

BASE CASE SCENARIO  
ASSUMED UNIT PRICES FOR CANADIAN-MADE MSAT EQUIPMENT

<u>System Element</u>	<u>U.S. Market</u> (1984 Canadian dollars)
<u>First-Generation Spacecraft:</u>	
Construction	\$76 million
Contingency & In-orbit Incentives	<u>14 million</u>
Total	<u>\$90 million</u>
<u>Second-Generation Spacecraft:</u>	
Construction	\$108 million
Contingency & In-orbit Incentives	<u>18 million</u>
Total	<u>\$126 million</u>
<u>User/Operator Equipment*:</u>	
Terminals: MRS	\$2,425
MTS	\$3,090
DACS: Alarm	3,290
Polling	\$1,825
Base Stns: UHF Pvt.	\$2,140
SHF: 2 Ch.	\$84,000
3 Ch.	\$89,000
4 Ch.	\$100,000
5 Ch.	\$107,000
7 Ch.	\$111,000
10 Ch.	\$122,000
SHF Gateways: 5 Ch.	\$128,500
10 Ch.	\$140,000
<u>Central Control Station:</u>	
DAMA	\$3 million
Other	-
Total	<u>\$3 million</u>

\* Prices shown for the user/operator equipment are weighted averages over the 1989-2002 period. In the impact calculations, these prices decline gradually over time due to the learning curve effect.



#### 5.1.4 Rest-of-World Market Assumptions

Exports by Canadian MSAT manufacturers to markets beyond the U.S. are quite uncertain at this time (see Chapter 4). The better prospects are currently uninterested, and cannot foresee a time when this attitude will change. Also, Canadian producers may encounter stiff competition from U.S. firms that have equivalent products, or from suppliers in other countries that make reasonably close substitutes.<sup>1</sup>

Nevertheless, it is conceivable that this situation will change somewhat once the first-generation Canadian/U.S. MSAT system has been established. The involvement of major space, communications and manufacturing concerns in both countries will lend credibility to the satellite mobile communications concept. Also, it will give potential buyers a working model to observe, which will help stimulate demand.

Reflecting these considerations, the Base Case Scenario assumes that one rest-of-world (ROW) market will develop by the second half of the 1990s.

For want of better data, we assumed that these would be roughly equivalent to the first generation Canadian system in terms of system size and design (see Table 5.1.1).

We also assumed that the spacecraft would cost the same as Canada's first-generation satellite. The CCS is estimated to cost about one-half of the Canadian installation, with the main cost

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<sup>1</sup> For example, the marine mobile satellite communications system Japan has planned to develop, or the newer, smaller equipment to access the INMARSAT system (see Chapter 4).

TABLE 5.1.7

BASE CASE SCENARIO  
ASSUMED UNIT PRICES FOR CANADIAN-MADE MSAT EQUIPMENT

<u>System Element</u>	<u>Rest-of-World Market</u> (1984 Canadian dollars)
<u>First-Generation Spacecraft:</u>	
Construction	\$76 million
Contingency & In-orbit Incentives	<u>14 million</u>
Total	<u>\$90 million</u>
<u>Second-Generation Spacecraft:</u>	
Construction	
Contingency & In-orbit Incentives	
Total	
<u>User/Operator Equipment*:</u>	
Terminals: MRS	\$2,425
MTS	3,090
DACS: Alarm	3,290
Polling	1,825
Base Stns: UHF Pvt.	\$2,140
SHF: 2 Ch.	\$84,000
3 Ch.	\$89,000
4 Ch.	\$100,000
5 Ch.	\$107,000
7 Ch.	\$111,000
10 Ch.	\$122,000
SHF Gateways: 5 Ch.	\$128,500
10 Ch.	\$140,000
<u>Central Control Station:</u>	
DAMA	\$2 million
Other	<u>11 million</u>
Total	<u>\$13 million</u>

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\* Prices shown for the user/operator equipment are weighted averages over the 1989-2002 period. In the impact calculations, these prices decline gradually over time due to the learning curve effect.



reduction occurring due to competitive price bidding for the DAMA. Finally, we assumed that the user/operator equipment would sell for the going market price (see Table 5.1.7).

Given the other assumptions in this Scenario, Canadian firms would seem to have a good chance of playing a significant part in this ROW market:

- Canada would have prime contracted the satellites for both the domestic and U.S. systems, thereby capturing the highest profile element.
- Canadian firms would be able to claim technological leadership in many important aspects of MSAT.
- Canadian MSAT manufacturers would by that time have sold enough products in both the domestic and U.S. markets to establish their brands and to provide competitive prices through volume production.

As a consequence, the Base Case Scenario assumes that Canada would prime contract the two spacecraft for this system, delivering the first for launch in 2001. Similarly, a Canadian firm would prime contract the central control station, for completion in 2001.

In addition, we have assumed that Canadian manufacturers would supply 80 percent of the terminals, base stations and gateways in the first years of this system's operation.

Given these assumptions, the projected unit sales by Canadian firms are shown in Table 5.1.8.

#### 5.1.5 Base Case Impact Estimates

The impacts estimated using these Base Case assumptions are summarized in Table 5.1.9. The detailed print-outs are in the white section of Volume III.

TABLE 5.1.8

BASE CASE SCENARIO  
REST-OF-WORLD PURCHASES FROM CANADIAN MSAT MANUFACTURERS  
 (1989-2002)

<u>System Element</u>		First Generation* (2001-2008) <u>(Total # of Purchases)</u>
Spacecraft		2**
Terminals:	MRS	5,724
	MTS	1,975
	DACS: Alarm	1,060
	Polling	2,716
Base Stns:	UHF Pvt.	104
	SHF: 2 Ch.	3
	3 Ch.	3
	4 Ch.	2
	5 Ch.	5
	7 Ch.	2
	10 Ch.	6
SHF Gateways:	5 Ch.	5
	10 Ch.	5
Central Control Station		1

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\* Values given only cover the portion of the first-generation sales included in the study period (ending in 2002).

\*\* Second satellite not completed until 2003.



According to these calculations, the MSAT manufacturers would obtain net sales revenues of \$1.1 billion (in 1984 Canadian dollars) over 1985-2002. This amount breaks down as follows:

- Just over one-half occurs during the construction and operation of the first-generation North American MSAT system.
- Canada is the dominant market, accounting for 55 percent of total MSAT manufacturing revenues. The U.S. market is responsible for 27 percent, while the rest-of-world sales provide 18 percent of the total revenues.
- Total export sales equal \$508 million, \$373 million in the space segment and \$135 million in the ground segment.
- The space segment is the source of 53 percent of the \$1.1 billion in total revenues. User/operator equipment accounts for 43 percent and the central control station generates 4 percent of total revenues.

As shown in Table 5.1.10, these revenues could be earned by firms across Canada. Quebec-based companies could receive just over one-half, primarily due to the space manufacturing capabilities in that province. Ontario firms might earn about 20 percent, while those in the Prairies and British Columbia could receive 15 percent and 20 percent, respectively.

Our Base Case estimates suggest that the MSAT manufacturers' operating profits would total \$183 million (in 1984 Canadian dollars) during 1985-2002:

- Over one-half are generated during the second-generation North American system (1986-2002).
- Canadian sales account for 58 percent of the total profits, while U.S. and rest-of-world sales account for 28 percent and 14 percent, respectively.
- The spacecraft sales provide 50 percent of total profits. User/operator equipment sales generate 48 percent of profits and the central control station sales provide the remaining 2 percent.

TABLE 5.1.9

BASE CASE SCENARIO  
ESTIMATED NET MANUFACTURING IMPACTS DUE TO MSAT  
(1985-2002)

Impact Measure	System Element	Canada			United States			Rest-of-World	All Markets		
		1985-1995	1996-2002	Total	1985-1995	1996-2002	Total		1985-1995	1996-2002	Total
<u>MSAT Industry:</u>											
(Millions of 1984 Canadian Dollars)											
<u>Sales Revenues</u>	Spacecraft	\$221	\$ 9	\$230	\$179	\$33	\$212	\$160	\$400	\$202	\$ 602
	User/Operator Equip.	133	228	361	31	57	88	32	164	317	481
	Central Control Stn.	26	1	27	3	*	3	13	29	14	43
	Total	\$380	\$238	\$681	\$213	\$90	\$303	\$205	\$593	\$533	\$1,126
<u>Operating Profits</u>	Spacecraft	\$29	\$ 9	\$ 38	\$23	\$11	\$34	\$19	\$52	\$39	\$ 91
	User/Operator Equip.	24	41	65	6	11	17	6	30	58	88
	Central Control Stn.	3	*	3	*	*	*	1	3	1	4
	Total	\$56	\$50	\$106	\$29	\$22	\$51	\$26	\$85	\$98	\$183
<u>Net Exports</u>	Spacecraft	\$-97	\$ 0**	\$ -97	\$+100	\$+22	\$+122	\$ +89	\$ +3	\$+111	\$+114
	User/Operator Equip.	-13	-23	-36	+28	+51	+79	+29	+15	+57	+72
	Central Control Stn.	-2	*	-2	+3	*	+3	+12	+1	+12	+13
	Total	\$-112	\$-23	\$-135	\$+131	\$+73	\$+204	\$+130	\$+19	\$+180	\$+199
(Person-years)											
<u>Direct Employment</u>	Spacecraft	1,965	0	1,965	1,605	222	1,827	1,452	3,570	1,674	5,244
	User/Operator Equip.	1,880	3,120	5,000	424	775	1,999	432	2,304	4,327	6,631
	Central Control Stn.	393	15	408	43	2	45	175	436	192	628
	Total	4,238	3,135	7,373	2,072	1,000	3,072	2,059	6,310	6,193	12,503
<u>Canadian Economy</u>											
(Millions of 1984 Canadian Dollars)											
Real GNP		\$491	\$421	\$912	\$220	\$143	\$363	\$218	\$711	\$782	\$1,493
(Person-years)											
Employment		11,164	8,538	19,702	5,314	2,674	7,988	5,319	16,478	16,531	33,009

\* Value less than \$1 million.

\*\* The second generation Canadian satellite is assumed to be completed for launch in 1996. Thus, all of the necessary imports are included in the \$-97 million net exports for the 1985-1995 period.



The MSAT manufacturing industry is a net exporter in the Base Case, generating a trade surplus of \$199 million (1984 Canadian dollars) during 1985-2002:

- Manufacturing for the Canadian market is associated with a trade deficit of \$135 million, which occurs primarily in the spacecraft construction.
- Sales to the U.S. generate a trade surplus of \$204 million, while the rest-of-world market sales provide a surplus of \$130 million.
- The space segment and user/operator equipment account for 57 percent and 36 percent of the overall surplus of \$199 million, respectively.
- Almost all of the surplus -- 90 percent -- is generated in the 1996-2002 period, reflecting the greater effect of the U.S. and rest-of-world markets.

Our Base Case estimates indicate that direct manufacturing employment associated with MSAT equipment production in Canada would total 12,503 during 1985-2002. These jobs are distributed as follows:

- Slightly more than one-half are in 1996-2002.
- Production for the Canadian market accounts for 59 percent of the total. The U.S. and rest-of-world markets account for 25 percent and 16 percent, respectively.
- User/operator equipment production is associated with 53 percent of the total jobs, while the spacecraft generates 42 percent.

Table 5.1.11 shows how these jobs might be allocated across professional groups and provinces. The majority of jobs could be created in Quebec, again due primarily to the prominence of satellite manufacturing capabilities in that province. Employment increases in Ontario and the Prairies could total around 2,500 over 1985-2002, while jobs in B.C. might increase by over 1,600.



TABLE 5.1.10

BASE CASE SCENARIO  
PROVINCIAL DISTRIBUTION OF MSAT SALES REVENUES\*  
 (1985-2002)

<u>System Element</u>	<u>Quebec</u>	<u>Ontario</u>	<u>Prairies</u>	<u>B.C.</u>	<u>Total</u>
(Millions of 1984 Canadian dollars)					
Space Segment	\$482	\$121	0	0	\$603
Earth Segment	<u>125</u>	<u>112</u>	<u>\$171</u>	<u>\$115</u>	<u>523</u>
Total	<u>\$607</u>	<u>\$223</u>	<u>\$171</u>	<u>\$115</u>	<u>\$1,126</u>

\* These estimates assume that the current provincial shares of space and communications equipment manufacturing will apply to MSAT throughout 1985-2002.

TABLE 5.1.11

BASE CASE SCENARIO  
PROVINCIAL AND OCCUPATIONAL DISTRIBUTION OF DIRECT EMPLOYMENT\*

<u>System Element</u>	<u>Employment Category</u>	<u>Quebec</u>	<u>Ontario</u>	<u>Prairies</u>	<u>B.C.</u>	<u>Total</u>
(Person-years)						
Space Segment	Man & Eng	261	65	0	0	326
	Production	3,830	958	0	0	4,788
	Other	<u>104</u>	<u>26</u>	<u>0</u>	<u>0</u>	<u>130</u>
	Total	<u>4,195</u>	<u>1,049</u>	<u>0</u>	<u>0</u>	<u>5,244</u>
Earth Segment	Man & Eng	300	270	423	283	1,276
	Production	1,123	1,013	1,583	1,059	4,778
	Other	<u>283</u>	<u>256</u>	<u>399</u>	<u>268</u>	<u>1,206</u>
	Total	<u>1,706</u>	<u>1,539</u>	<u>2,405</u>	<u>1,610</u>	<u>7,260</u>
Complete System	Man & Eng	561	335	423	283	1,602
	Production	4,953	1,971	1,583	1,059	9,566
	Other	<u>387</u>	<u>282</u>	<u>399</u>	<u>268</u>	<u>1,336</u>
	Total	<u>5,901</u>	<u>2,588</u>	<u>2,405</u>	<u>1,610</u>	<u>12,504</u>

\* These estimates assume that the current provincial shares of space and communications equipment manufacturing will apply to MSAT throughout 1985-2002.



The specific firms that will be involved in manufacturing the various categories of MSAT equipment are unknown at present, so we cannot relate these impacts to their activities at this time. However, the survey of potential companies described in Chapter 3 provides some idea of the base on which these estimated impacts will occur.

To reiterate, in 1983 the interested manufacturers recorded space MSAT-related sales revenues totalling \$251 million. The satellite manufacturers had revenues of \$157 million, while the ground segment manufacturers had revenues of \$94 million. Space/MSAT-related export sales totalled \$169 million, \$121 million was earned by satellite manufacturers.

The survey responses from these interested firms also indicated that they employed 2,719 workers in their space/MSAT-related activities in 1983, 1,161 in the space segment and 1,558 in the ground segment.

To compare with these annual sales revenue and employment data, we have used annual averages<sup>1</sup> of the MSAT impact estimates as shown in Table 5.1.12.

Taking these annual averages as representative of the typical year's impacts on the interested manufacturers, it is possible

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<sup>1</sup> For consistency, all values are averaged for the 18-year period running 1985-2002.

TABLE 5.1.12

BASE CASE SCENARIO  
AVERAGE ANNUAL REVENUE AND EMPLOYMENT IMPACTS DUE TO MSAT

<u>Impact Measure</u>	<u>Space Segment</u>	<u>Ground Segment</u>	<u>Total</u>
	(Millions of 1984 Canadian dollars)		
<u>MSAT Industry:</u>			
Total Sales Revenues	\$33	\$30	\$63
Export Sales Revenues	\$20	\$8	\$28
		(Person-years)	
Direct Employment	291	403	695



to conclude that MSAT would have a significant effect on their performance<sup>1</sup>:

- Adding \$63 million to the group's recent total space/MSAT-related revenues of \$251 million would have increased the earnings by 25 percent. Space segment revenues would have grown 21 percent and ground segment revenues 32 percent.
- Adding \$28 million to the group's recent space/MSAT-related export revenues of \$169 million would have increased these earnings by 17 percent. Both space and ground segment export revenues would have grown 17 percent.
- Adding 695 workers to the group's recent space/MSAT-related work force of 2,719 would have raised this number by 26 percent. Both space and ground segment employment would have increased 26 percent.

MSAT manufacturing activities will have additional effects on the Canadian economy. Value added and employment will be generated by domestic firms which supply secondary materials to those directly involved in producing MSAT equipment. Further impacts will occur due to the spending of incomes earned by employees of the MSAT manufacturers and their suppliers.

According to our Base Case estimates, the full direct and indirect effects generated by MSAT manufacturing will increase real GNP in Canada by a total of \$1.5 billion (1984 Canadian dollars) over 1985-2002. Additionally, the total direct and indirect employment associated with MSAT manufacturing will be 33,000 person-years.

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<sup>1</sup> To relate the dollar values, we have made the simplifying assumption that no inflation occurred in 1984. To relate the employment effects, we have made the simplifying assumption that one "person-year" is equivalent to one "job".

TABLE 5.2.1

OPTIMISTIC SCENARIO  
COMPARISON OF TOTAL MARKET ASSUMPTIONS WITH BASE CASE  
(1989-2002)

System Element	Optimistic Scenario				Absolute Difference from Base Case			
	Canada (Total # of Purchases)	U.S. (Total # of Purchases)	ROW (Total # of Purchases)	Total	Canada (# of Purchases)	U.S. (# of Purchases)	ROW (# of Purchases)	Total
Spacecraft	2	2	4*	8*	0	0	+2	+2
Terminals: MRS	88,405	88,405	35,724	212,534	0	0	+28,569	+28,569
MTS	31,450	31,450	12,409	75,309	0	0	+9,939	+9,939
DACS: Alarm	14,365	14,365	4,022	32,752	0	0	+2,697	+2,697
Polling	31,135	31,135	14,133	76,403	0	0	+10,738	+10,738
Base Stns: UHF Pvt.	1,870	1,870	744	4,484	0	0	+614	+614
SHF: 2 Ch.	25	25	20	70	0	0	+16	+16
3 Ch.	23	23	16	62	0	0	+12	+12
4 Ch.	13	13	10	36	0	0	+7	+7
5 Ch.	19	19	26	64	0	0	+20	+20
7 Ch.	44	44	12	100	0	0	+9	+9
10 Ch.	61	61	40	162	0	0	+32	+32
SHF Gateways: 5 Ch.	9	9	13	31	0	0	+7	+7
10 Ch.	38	38	28	104	0	0	+22	+22
Central Control Station	1	1	2	4	0	0	+1	+1

\* One not completed until 2003.



## 5.2 Optimistic Scenario

### 5.2.1 Overview

The Base Case Scenario represents the reasonably likely manufacturing impacts that might be generated by MSAT during 1985-2002. It is possible, however, that certain key assumptions incorporated in this scenario will prove too conservative. The Optimistic Scenario allows for this possibility, and thereby provides an estimate of the upper range of impacts due to MSAT.

There are three differences between the assumptions made for the Optimistic Scenario and the Base Case.

First, once the joint Canadian and U.S. system is operating, it is possible that more countries will be interested, so the worldwide mobile satcom market will be larger than indicated in the Base Case. Thus, the Optimistic Scenario assumes that a second non-North American market develops for MSAT, requiring satellites for launch in 1997 and 1999.

It is again assumed that this second rest-of-world (ROW) market will mirror the total final good purchases projected for the initial years of the first-generation Canadian system (see Table 5.2.1).

Second, it is conceivable that Canadian manufacturers will have greater success in penetrating the available mobile satcom markets than assumed in the Base Case. This could happen, for example, if domestic firms gain a clear technological jump on their competitors, and if their cost-competitiveness is assisted by larger production volumes and more beneficial exchange rates. Reflecting

TABLE 5.2.2

OPTIMISTIC SCENARIO  
COMPARISON OF TOTAL PURCHASES FROM CANADIAN MANUFACTURERS WITH BASE CASE  
(1989-2002)

System Element	Optimistic Scenario				Absolute Difference from Base Case			
	Canada (Total # of Purchases)	U.S. (Total # of Purchases)	ROW (Total # of Purchases)	Total	Canada (# of Purchases)	U.S. (# of Purchases)	ROW (# of Purchases)	Total
Spacecraft	2	2	4*	8*	-	-	+2	+2
Terminals: MRS	79,564	35,362	32,152	147,078	+8,840	+17,689	+26,428	+52,957
MTS	28,306	12,580	11,168	52,054	+3,146	+6,293	+9,193	+18,632
DACS: Alarm	12,928	5,746	3,620	22,294	+1,436	+2,874	+2,560	+6,870
Polling	28,021	12,454	12,720	53,195	+3,112	+6,226	+10,004	+19,342
Base Stns: UHF Pvt.	1,683	748	670	3,101	+189	+375	+566	+1,130
SHF: 2 Ch.	24	10	18	52	+5	+5	+15	+25
3 Ch.	20	9	14	43	+2	+5	+11	+18
4 Ch.	11	4	9	24	+1	+2	+7	+10
5 Ch.	17	8	23	48	+2	+5	+18	+25
7 Ch.	39	4	11	54	+4	+2	+9	+15
10 Ch.	55	24	36	115	+6	+12	+30	+48
SHF Gateways: 5 Ch.	8	4	12	24	+1	+2	+7	+10
10 Ch.	34	15	25	74	+4	+8	+20	+32
Central Control Station	1	1**	2	4**	-	-	+1	+1

\* One not completed until 2003.

\*\* DAMA system only for U.S. CCS.



this possibility, the Optimistic Scenario assumes that Canadian firms will:

- Prime contract the MSAT satellites for the domestic, U.S. and both ROW systems, and build the central control stations for the Canadian and both ROW systems.
- Supply 90 percent of the user/operator equipment sold in Canada and the rest-of-world markets (rather than 80 percent in the Base Case), and 40 percent of the user/operator equipment sold in the United States (versus 20 percent in the Base Case).

The results of applying these penetration rate assumptions to the total market projections given in Table 5.2.1 are shown in Table 5.2.2, opposite.

Finally, the Optimistic Scenario differs from the Base Case in that the Canadian content of MSAT end products is assumed to be higher (see Table 5.2.3).

TABLE 5.2.3

OPTIMISTIC SCENARIO  
COMPARISON OF COST COMPONENT ASSUMPTIONS WITH BASE CASE\*  
(1985 - 2002)

<u>System Element</u>	<u>Optimistic Scenario</u>			<u>Absolute Difference from Base Case</u>		
	<u>Domestic</u>	<u>Foreign</u>		<u>Domestic</u>	<u>Foreign</u>	
	<u>Materials</u>	<u>Materials</u>	<u>Labour</u>	<u>Materials</u>	<u>Materials</u>	<u>Labour</u>
	(Percentages of Total Costs)					
Spacecraft	9	45	23	+6	-5	0
Terminals	16	6	42	+7	-6	0
UHF Base Stations	20	6	42	+9	-9	0
SHF Base Stations	35	4	40	0	0	0
SHF Gateways	30	5	43	0	0	0
Central Control Station:						
DAMA	6	6	65	+5	-5	0
Other	21	5	49	0	0	0

\* "Other Cost" shares have not been changed from the Base Case.



TABLE 5.2.4

OPTIMISTIC SCENARIO  
ESTIMATED NET MANUFACTURING IMPACTS DUE TO MSAT  
(1985-2002)

Impact Measure	System Element	Canada			United States			Rest-of-World	All Markets		
		1985-1995	1996-2002	Total	1985-1995	1996-2002	Total		1985-1995	1996-2002	Total
(Millions of 1984 Canadian Dollars)											
MSAT Industry:											
Sales Revenues	Spacecraft	\$221	\$ 9	\$230	\$179	\$ 34	\$213	\$386	\$400	\$429	\$829
	User/Operator Equip.	122	283	405	63	113	176	163	185	559	744
	Central Control Stn.	26	1	27	1	*	1	26	27	27	54
	Total	\$369	\$293	\$662	\$243	\$147	\$390	\$575	\$612	\$1,015	\$1,627
Operating Profits	Spacecraft	\$29	\$ 9	\$38	\$21	\$13	\$34	\$49	\$50	\$ 71	\$121
	User/Operator Equip.	26	47	73	11	22	33	30	37	99	136
	Central Control Stn.	3	*	3	*	*	*	3	3	3	6
	Total	\$58	\$56	\$114	\$32	\$35	\$67	\$82	\$90	\$173	\$263
Net Exports	Spacecraft	\$-86	\$ 0	\$-86	\$+109	\$ +24	\$+133	\$+235	\$+23	\$+259	\$+282
	User/Operator Equip.	-7	-13	-20	+60	+108	+168	+156	+53	+251	+304
	Central Control Stn.	-1	*	-1	+1	*	+1	+25	0	+25	+25
	Total	\$-94	\$-13	\$-107	\$+170	\$+132	\$+302	\$+416	\$+76	\$+535	\$ 611
(Person-years)											
Direct Employment	Spacecraft	1,965	0	1,965	1,605	222	1,827	3,450	3,570	3,672	7,242
	User/Operator Equip.	2,105	3,506	5,611	852	1,554	2,406	2,241	2,957	7,301	10,258
	Central Control Stn.	393	15	408	16	3	18	355	409	373	781
	Total	4,463	3,521	7,984	2,473	1,779	4,251	6,046	6,936	11,346	18,281
Canadian Economy											
(Millions of 1984 Canadian Dollars)											
Real GNP		\$520	\$469	\$989	\$267	\$239	\$506	\$674	\$787	\$1,382	\$2,169
(Person-years)											
Employment		11,782	9,585	21,367	6,325	4,722	11,047	15,783	18,107	30,090	48,197

\* Value less than \$1 million.



### 5.2.2 Optimistic Scenario Impact Estimates

The net impacts estimated using the Optimistic Scenario assumptions are summarized in Table 5.2.4. More details are presented in the pink section of Volume III.

Our calculations indicate that Canadian MSAT manufacturers could derive \$1.6 billion (1984 Canadian dollars) from sales of MSAT equipment if the Optimistic Scenario assumptions prove correct. This represents additional revenues of \$500 million over the Base Case estimate. Other differences with the Base Case revenues include:

- The 1996-2002 period is considerably more important, since 62 percent of revenues would be generated during these years (Base Case: 53 percent).
- The rest-of-world share of revenues would increase substantially from 18 percent in the Base Case to 35 percent in the Optimistic Scenario.

Export revenues would total \$965 million over 1985-2002, almost double the \$508 million estimated in the Base Case. Most of this increase would be due to the sale of an additional satellite system to the second rest-of-world market (bringing in a further \$226 million, including the start-up of the second-generation spacecraft before 2002).

With these gains in export sales and the assumed increases in Canadian content, the MSAT manufacturing industry would be an even more significant net exporter than in the Base Case:

- The trade surplus would total \$611 million (in 1984 Canadian dollars) over 1985-2002, up from \$199 million in the Base Case.
- Canadian market sales would be associated with a trade deficit of \$107 million (primarily due to the high impact content of the satellite).

TABLE 5.2.5

OPTIMISTIC SCENARIO  
ANNUAL AVERAGE REVENUE AND EMPLOYMENT IMPACTS DUE TO MSAT

<u>Impact Measure</u>	<u>Space Segment</u>	<u>Ground Segment</u>	<u>Total</u>
	(Millions of 1984 Canadian dollars)		
<u>MSAT Industry:</u>			
Total Sales Revenues	\$46	\$44	\$90
Export Sales Revenues	\$33	\$20	\$53
		(Person-years)	
Direct Employment	402	613	1,015



- The U.S. and rest-of-world markets would generate total trade surpluses of \$302 million and \$416 million, respectively. These amounts compare to \$204 million for the U.S. and \$130 million for the rest-of-world in the Base Case.
- The user/operator equipment sales would contribute most -- \$304 million to the MSAT industry's net exports, but the spacecraft sales would account for almost as much (\$282 million).

In view of the strong sales growth assumed for the Optimistic Scenario, MSAT manufacturing would directly generate a total of 18,281 person-years of employment during 1985-2002. This would be a gain of almost 6,000 over the Base Case. Over 60 percent of this employment would occur in the 1996-2002 period, when the satellites for the two rest-of-world systems would be under construction. The Base Case employment was, in contrast, almost equal in 1985-95 and 1996-2002.

To gauge the relative effects MSAT would have on domestic manufacturing firms in this scenario, the average annual direct impacts over 1985-2002 are shown in Table 5.2.5.

These are significantly higher than in the Base Case, and would thus have even greater impacts on the group of manufacturers interested in MSAT:

- Adding \$90 million to their 1983 space/MSAT-related sales revenues of \$251 million would have been a 36-percent gain (Base Case: 25 percent). The effect would have been 29 percent on the space segment's revenues (Base Case: 21 percent), and 47 percent on the ground segment's sales (Base Case: 32 percent).
- Adding \$53 million to their space/MSAT-related export sales would have represented an increase of 31 percent (Base Case: 17 percent). The space segment would have made a further 27 percent while the ground segment would have received an additional 42 percent.

TABLE 5.3.1

MODERATE SCENARIO  
COMPARISON OF TOTAL MARKET ASSUMPTIONS WITH BASE CASE  
(1989-2002)

System Element	Moderate Scenario				Absolute Difference from Base Case			
	Canada (Total # of Purchases)	U.S. (# of Purchases)	ROW (# of Purchases)	Total	Canada	U.S. (# of Purchases)	ROW (# of Purchases)	Total
Spacecraft	2	2	2*	6*	0	0	0	0
Terminals: MRS	88,405	88,405	7,156	183,965	0	0	0	0
MTS	31,450	31,450	2,469	65,370	0	0	0	0
DACS: Alarm	14,365	14,365	1,326	30,055	0	0	0	0
Polling	31,135	31,135	3,394	65,665	0	0	0	0
Base Stns: UHF Pvt.	1,870	1,870	130	3,870	0	0	0	0
SHF: 2 Ch.	25	25	5	54	0	0	0	0
3 Ch.	23	23	3	50	0	0	0	0
4 Ch.	13	13	2	29	0	0	0	0
5 Ch.	19	19	7	44	0	0	0	0
7 Ch.	44	44	2	91	0	0	0	0
10 Ch.	61	61	7	130	0	0	0	0
SHF Gateways: 5 Ch.	9	9	6	24	0	0	0	0
10 Ch.	38	38	7	82	0	0	0	0
Central Control Station	1	1	1	3	0	0	0	0

\* One not completed until 2003.



- Adding over 1,000 workers to this group's existing work force of 2,719 would have been a rise of 37 percent (Base Case: 26 percent). The expansion would have been somewhat less in the space segment and somewhat more in the ground segment.

The macroeconomic impacts generated by MSAT manufacturing in this Optimistic Scenario would be similarly expanded over the Base Case estimates:

- The impact on real GNP would total \$2.2 billion over 1985-2002 (in 1984 Canadian dollars), roughly \$600 million more than in the Base Case.
- Direct and indirect employment generated by MSAT would total 48,197 person-years over 1985-2002, about 15,000 more than in the Base Case.

### 5.3 Moderate Scenario

#### 5.3.1 Overview

The Base Case assumes that Canadian manufacturers will be quite successful in penetrating the markets for MSAT user/operator equipment. The Moderate Scenario tests the down-side risks of this assumption.

In the following respects, the Moderate Scenario is identical to the Base Case:

- Canada and the U.S. are assumed to develop a joint MSAT system, each providing one spacecraft in each generation.
- One other MSAT market develops in the second half of the '90s, the first satellite to be launched in 2001.
- Total purchases of MSAT equipment in these three markets are assumed to be the same as in the Base Case (see Table 5.3.1).

TABLE 5.3.2

MODERATE SCENARIO  
COMPARISON OF TOTAL PURCHASES FROM CANADIAN MANUFACTURERS WITH BASE CASE  
(1989-2002)

System Element	Moderate Scenario				Absolute Difference from Base Case			
	Canada (Total # of Purchases)	U.S. (Total # of Purchases)	ROW (Total # of Purchases)	Total	Canada (Total # of Purchases)	U.S. (Total # of Purchases)	ROW (Total # of Purchases)	Total
Spacecraft	2	2	2*	6*	0	0	0	0
Terminals: MRS	44,202	8,840	716	53,758	-26,522	-8,833	-5,008	-40,363
MTS	15,726	3,145	247	19,118	-9,434	-3,142	-1,728	-14,304
DACS: Alarm	7,183	1,436	133	8,752	-4,309	-1,436	-927	-6,672
Polling	15,567	3,113	339	19,019	-9,342	-3,115	-2,377	-14,834
Base Stns: UHF Pvt.	935	187	13	1,135	-559	-186	-91	-836
SHF: 2 Ch.	12	3	1	16	-7	-2	-2	-11
3 Ch.	11	2	0	13	-7	-2	-3	-12
4 Ch.	6	1	0	7	-4	-1	-2	-7
5 Ch.	9	2	1	12	-7	-1	-4	-12
7 Ch.	22	1	0	23	-13	-1	-2	-16
10 Ch.	31	6	1	38	-18	-6	-5	-29
SHF Gateways: 5 Ch.	4	1	1	6	-3	-1	-4	-8
10 Ch.	19	3	1	23	-11	-4	-4	-19
Central Control Station	1	1**	1	3**	0	0	0	0

\* One not completed until 2003.

\*\* DAMA system only for U.S. CCS.



- Canadian firms are assumed to prime contract all six spacecraft, as well as the CCS for Canada and the rest-of-world (ROW) market. Canadians are also assumed to supply the DAMA computer software for the U.S. CCS.
- The costs of the Canadian-made MSAT equipment for the three markets are assumed to be the same as those in Table 5.1.2, Table 5.1.6, and Table 5.1.7.
- The Canadian content of domestically manufactured MSAT equipment is assumed to be the same as shown in Table 5.1.3.
- The switchovers from existing mobile radios to MSAT equipment are assumed to be the same as in the Base Case.

In the Moderate Scenario, however, Canadian manufacturers are assumed to be considerably less successful in penetrating the three markets for MSAT user/operator equipment than in the Base Case. They make only 50 percent of the MSAT terminals, base stations and gateways sold in the Canadian market, rather than 80 percent as assumed in the Base Case. Their penetration of the U.S. market for these equipment categories is reduced from 20 percent in the Base Case to 10 percent in the Moderate Scenario. Finally, they are assumed to supply only 10 percent of the user/operator equipment sold in the ROW market, down from the 80-percent penetration rate assumed in the Base Case.

The effects of applying these reduced penetration rates to the total purchases in these markets are shown in Table 5.3.2.

#### 5.3.2 Moderate Scenario Impact Estimates

The net impacts estimated using the Moderate Scenario assumptions are summarized in Table 5.3.3. More details can be found in the green section of Volume III.



TABLE 5.3.3

MODERATE SCENARIO  
ESTIMATED NET MANUFACTURING IMPACTS DUE TO MSAT  
(1985-2002)

Impact Measure	System Element	Canada			United States			Rest-of-World	All Markets		
		1985-1995	1996-2002	Total	1985-1995	1996-2002	Total		1985-1995	1996-2002	Total
(Millions of 1984 Canadian Dollars)											
MSAT Industry:											
Sales Revenues	Spacecraft	\$221	\$ 9	\$230	\$179	\$33	\$212	\$160	\$400	\$202	\$602
	User/Operator Equip.	86	142	228	16	28	44	4	102	174	276
	Central Control Stn.	26	1	27	3	*	3	13	29	14	43
	Total	\$333	\$152	\$485	\$198	\$61	\$259	\$177	\$531	\$390	\$921
Operating Profits	Spacecraft	\$29	\$ 9	\$38	\$23	\$11	\$34	\$19	\$52	\$39	\$ 91
	User/Operator Equip.	15	26	41	3	5	8	*	18	31	49
	Central Control Stn.	3	*	3	*	*	*	1	3	2	5
	Total	\$47	\$35	\$82	\$27	\$16	\$43	\$21	\$74	\$72	\$146
Net Exports	Spacecraft	\$-97	\$ 0	\$-97	\$+100	\$+22	\$+122	\$ +89	\$+3	\$+111	\$+114
	User/Operator Equip.	-9	-14	-23	+14	+26	+40	+3	+5	+15	+20
	Central Control Stn.	-2	*	-2	+3	*	+3	+13	+1	+13	+14
	Total	\$-108	\$-14	\$-122	\$+117	\$+48	\$+165	\$105	\$+9	\$+139	\$+148
(Person-years)											
Direct Employment	Spacecraft	1,965	0	1,965	1,605	222	1,827	1,452	3,570	1,674	5,244
	User/Operator Equip.	1,242	1,936	3,178	217	384	601	54	1,459	2,374	3,833
	Central Control Stn.	393	15	408	43	2	45	175	436	192	628
	Total	3,600	1,951	5,551	1,865	608	2,473	1,681	5,465	4,240	9,705
Canadian Economy											
(Millions of 1984 Canadian Dollars)											
Real GNP		\$410	\$271	\$681	\$193	\$94	\$287	\$170	\$603	\$535	\$1,138
(Person-years)											
Employment		9,424	5,313	14,737	4,749	1,609	6,358	4,286	14,173	11,208	25,381

\* Value less than \$1 million.



These estimates suggest that Canadian manufacturers would receive \$921 million (in 1984 Canadian dollars) from sales of MSAT equipment over 1985-2002, 18 percent less than in the Base Case. The following are some key points to note about this revenue projection:

- Almost 60 percent occurs in 1985-2002, compared to 53 percent in the Base Case.
- There are substantial differences in the distribution of revenues by system element. The spacecraft provides 65 percent of the total (compared to 53 percent in the Base Case) and the user/operator equipment provides 30 percent (down from 43 percent in the Base Case).

From our calculations, MSAT manufacturers would earn operating profits totalling \$146 million on these total sales revenues. These break down as follows:

- Just over one-half occur in 1985-95, a somewhat greater proportion than in the Base Case.
- Canadian sales provide 56 percent of the total net earnings, while the U.S. and rest-of-world markets account for 30 percent and 14 percent, respectively. These are about the same proportions as in the Base Case.
- The spacecraft sales generate over 60 percent of total profits, compared to 50 percent in the Base Case. In contrast, user/operator equipment sales account for 34 percent of total net earnings, down from 48 percent in the Base Case.

Export sales revenues would total an estimated \$436.8 million (in 1984 Canadian dollars) during 1985-2002, down from \$508.4 million in the Base Case. Most of this decline is due to the reduced export sales of terminals (down \$66 million from the Base Case) and other user/operator equipment (down \$6 million from the Base Case).

TABLE 5.3.4

MODERATE SCENARIO  
AVERAGE ANNUAL REVENUE AND EMPLOYMENT IMPACTS DUE TO MSAT

<u>Impact Measure</u>	<u>Space Segment</u>	<u>Ground Segment</u>	<u>Total</u>
	(Millions of 1984 Canadian dollars)		
<u>MSAT Industry:</u>			
Total Sales Revenue	\$33	\$18	\$51
Export Sales Revenues	\$21	\$ 4	\$24
		(Person-years)	
Direct Employment	291	248	539



Despite these declines in export sales, the MSAT manufacturing industry remains a net exporter in the Moderate Scenario. For the 1985-2002 period as a whole, the direct trade surplus would total \$148 million (in 1984 Canadian dollars), about \$50 million less than in the Base Case. According to our calculations:

- Almost all of this surplus -- 94 percent -- would occur in the 1996-2002 period (up slightly from the Base Case).
- Manufacturing for the Canadian market is associated with a trade deficit of \$122 million (down from \$135 million in the Base Case).
- Production for the U.S. market would generate a surplus of \$165 million (down from \$204 million), while sales to the rest-of-world market would provide a surplus of \$105 million (compared to \$130 million in the Base Case).

Reflecting the reduced sales assumed in the Moderate Scenario, MSAT manufacturing would generate a total of 9,705 person-years of employment over 1985-2002, almost 3,000 fewer than in the Base Case. Other major differences with the Base Case include:

- A greater portion of the employment occurs in the 1985-95 period (56 percent as opposed to 50 percent in the Base Case).
- The spacecraft production accounts for a much larger share of employment (54 percent versus 42 percent in the Base Case), while the user/operator equipment manufacturing is responsible for a much smaller share (40 percent compared to 53 percent in the Base Case).

Table 5.3.4 shows the average annual direct impacts of MSAT on Canadian manufacturers over 1985-2002.

These are unchanged for the space segment from the Base Case. But the ground segment effects are somewhat smaller. Thus, the relative impacts on the group of manufacturers interested in the ground segment are less in the Moderate Scenario:

TABLE 5.4.1

PESSIMISTIC SCENARIO  
COMPARISON OF TOTAL MARKET ASSUMPTIONS WITH BASE CASE  
(1989-2002)

System Element	Moderate Scenario				Absolute Difference from Base Case			
	Canada (Total # of Purchases)	U.S.	ROW	Total	Canada	U.S.	ROW	Total
Spacecraft	2	2	0	4	0	0	-2	-2
Terminals: MRS	44,688	88,405	0	133,093	-43,717	0	-7,155	-50,872
MTS	15,698	31,450	0	47,148	-15,752	0	-2,470	-18,222
DACS: Alarm	11,602	14,365	0	25,967	-2,763	0	-1,325	-4,088
Polling	8,770	31,135	0	39,905	-22,365	0	-3,395	-25,760
Base Stns: UHF Pvt.	1,764	1,870	0	3,634	-106	0	-130	-236
SHF: 2 Ch.	24	25	0	49	-1	0	-4	-5
3 Ch.	20	23	0	43	-3	0	-4	-7
4 Ch.	10	13	0	23	-3	0	-3	-6
5 Ch.	18	19	0	37	-1	0	-6	-7
7 Ch.	10	44	0	54	-34	0	-3	-37
10 Ch.	60	61	0	121	-1	0	-8	-9
SHF Gateways: 5 Ch.	8	9	0	17	-1	0	-6	-7
10 Ch.	38	38	0	76	0	0	-6	-6
Central Control Station	1	1	0	2	0	0	-1	-1



- Adding \$18 million to this group's total space/MSAT-related sales revenues of \$94 million in 1983 would have represented an increase of 19 percent (compared to 32 percent in the Base Case).
- Adding \$4 million to this group's space/MSAT-related export sales revenues of \$48 million would have been an 8-percent increase (rather than the 17-percent gain in the Base Case).
- Adding 248 more workers to this group's existing employment of 1,558 would have represented a 16-percent increase (as opposed to a 26-percent gain in the Base Case).

The macroeconomic -- direct and indirect -- impacts of MSAT manufacturing are also significantly lower in the Moderate Scenario than in the Base Case:

- The contribution to real GNP would total \$1.1 billion (1984 Canadian dollars) over 1985-2002, roughly \$350 million less than in the Base Case.
- Direct and indirect employment generated by MSAT manufacturing would total 25,381 person-years, down over 7,500 from the Base Case.

#### 5.4 Pessimistic Scenario

##### 5.4.1 Overview

The Pessimistic Scenario tests more severe down-side risks in the Base Case assumptions than the Moderate Scenario.

To begin, it is assumed that the total market available to Canadian manufacturers will be significantly smaller (See Table 5.4.1).

Canada and the United States are assumed to proceed with a joint mobile satcom system, but no non-North American MSAT market develops by 2002.

TABLE 5.4.2

PESSIMISTIC SCENARIO  
COMPARISON OF TOTAL PURCHASES FROM CANADIAN MANUFACTURERS WITH BASE CASE  
(1989-2002)

System Element	Moderate Scenario				Absolute Difference from Base Case			
	Canada	U.S.	ROW	Total	Canada	U.S.	ROW	Total
	(Total # of Purchases)				(# of Purchases)			
Spacecraft	*	*	0	*	*	*	-2	-2*
Terminals: MRS	22,344	8,840	0	31,184	-48,380	-8,833	-5,724	-62,937
MTS	7,849	3,145	0	10,994	-17,311	-3,142	-1,975	-22,428
DACS: Alarm	5,801	1,436	0	7,237	-5,691	-1,436	-1,060	-8,187
Polling	4,385	3,113	0	7,498	-20,524	-3,115	-2,716	26,355
Base Stns: UHF Pvt.	882	197	0	1,069	-612	-186	-104	-902
SHF: 2 Ch.	12	3	0	15	-7	-2	-3	-12
3 Ch.	10	2	0	12	-8	-2	-3	-13
4 Ch.	5	1	0	6	-5	-1	-2	-8
5 Ch.	9	2	0	11	-6	-1	-5	-12
7 Ch.	5	1	0	6	-30	-1	-2	-33
10 Ch.	30	6	0	36	-19	-6	-6	-31
SHF Gateways: 5 Ch.	4	1	0	5	-3	-1	-5	-9
10 Ch.	19	3	0	22	-11	-4	-5	-20
Central Control Station	1	1**	0	2**	0	0	-1	-1

\* Canadian firms only act as sub-contractors on all four spacecraft.

\*\* DAMA system only for U.S. CCS.



In addition, the total number of purchases in the U.S. market is assumed to remain the same as in the Base Case. But, as shown in Table 5.4.1, the Canadian market is assumed to be considerably smaller.

Added to these reduced potential markets, the Pessimistic Scenario assumed that Canadian manufacturers will have smaller shares of all three markets than in the Base Case (see Table 5.4.2):

- Canada is only a sub-contractor on the first and second generation MSAT spacecraft for both the domestic and U.S. systems. This would possibly involve supplying the payloads for these satellites.
- Canadian manufacturers obtain only a 50-percent share of the domestic MSAT market for user/operator equipment, and a 10-percent share of the U.S. market.

Canadian firms are nevertheless assumed to prime contract the domestic central control station and supply the DAMA for the U.S. CCS.

The prices of MSAT equipment are assumed to remain the same as in the Base Case. However, a further dimension of the Pessimistic Scenario is reduced Canadian content of the MSAT equipment made domestically. These reductions are summarized in Table 5.4.3.

#### 5.4.2 Pessimistic Scenario Estimated Impacts

The net impacts estimated using The Pessimistic Scenario assumptions are summarized in Table 5.4.4. Further details are in the blue section of Volume III.



TABLE 5.4.3

PESSIMISTIC SCENARIO  
COMPARISON OF COST COMPONENT ASSUMPTIONS WITH BASE CASE  
 (1989-2002)

<u>System Element</u>	<u>Pessimistic Scenario</u>			<u>Absolute Difference from Base Case</u>		
	<u>Domestic Materials</u>	<u>Foreign Materials</u>	<u>Labour</u>	<u>Domestic Materials</u>	<u>Foreign Materials</u>	<u>Labour</u>
(Percentages of Total Costs)						
Spacecraft	2	56	17	0	+6	-6
Terminals & UHF	9	24	30	0	+12	-12
UHF Base Stations	11	24	33	0	+9	-9
SHF Base Stations	25	23	31	-10	+19	-9
SHF Gateways	21	23	34	-9	+18	-9
Central Control Station:						
DAMA	1	23	52	0	+12	-12
Other	13	23	40	-8	+18	-9

\*"Other" cost shares are unchanged from the Base Case.



The substantially reduced markets for Canadian manufacturers in this Scenario are clearly reflected in the estimated net sales revenues. According to our calculations MSAT manufacturers would earn \$371 million (in 1984 Canadian dollars) over 1985-2002. This is roughly one-third of the total revenues generated in the Base Case. Some of the other key differences from the Base Case are:

- The 1985-95 period would produce 70 percent of the total revenues (compared to 53 percent in the Base Case).
- Sales to the Canadian market would represent 66 percent of the total (rather than only 55 percent in the Base Case).
- The spacecraft sales would provide a smaller share of total revenues -- 47 percent as opposed to 53 percent in the Base Case.

Export sales would be sharply reduced in the Pessimistic Scenario as a result of the lower penetration of the U.S. market and the failure of a non-North American MSAT market to develop. Export sales revenues would total an estimated \$126 million over 1985-2002 in the Pessimistic Scenario, almost \$400 million less than in the Base Case. The most significant decrease would occur in revenues associated with spacecraft exports, which would decline from \$372 in the Base Case to \$79 million in the Pessimistic Scenario.

With the reduced export sales and higher import content assumptions used in the Pessimistic Scenario, Canadian MSAT manufacturers would not generate trade surpluses as in the other three scenarios.

As a group, their total export sales revenues over 1985-2002 would exactly match the total cost of the materials they would import. More precisely, estimated trade deficits of \$8 million

TABLE 5.4.4

PESSIMISTIC SCENARIO  
ESTIMATED NET MANUFACTURING IMPACTS DUE TO MSAT  
(1985-2002)

Impact Measure	System Element	Canada			United States			Rest-of-World	All Markets		
		1985-1995	1996-2002	Total	1985-1995	1996-2002	Total		1985-1995	1996-2002	Total
(Millions of 1984 Canadian Dollars)											
MSAT Industry:											
Sales Revenues	Spacecraft	\$ 94	\$ 0	\$ 94	\$70	\$ 9	\$ 79	0	\$164	\$ 9	\$173
	User/Operator Equip.	52	72	124	16	28	44	0	68	100	168
	Central Control Stn.	26	1	27	3	*	3	0	29	1	30
	Total	\$172	\$73	\$245	\$89	\$37	\$126	0	\$261	\$110	\$371
Operating Profits	Spacecraft	\$10	\$ 0	\$10	\$ 9	\$1	\$10	0	\$19	\$ 1	\$20
	User/Operator Equip.	8	13	21	4	7	11	0	12	20	32
	Central Control Stn.	3	*	3	*	*	*	0	3	*	3
	Total	\$21	\$13	\$34	\$13	\$8	\$21	0	\$34	\$21	\$55
Net Exports	Spacecraft	\$-47	\$ 0	\$-47	\$+34	\$ +5	\$+39	0	\$-13	\$+5	\$-8
	User/Operator Equip.	-10	-15	-25	+13	+22	+35	0	+3	+7	+10
	Central Control Stn.	-4	*	-5	+2	*	+2	0	-2	*	-2
	Total	\$-61	\$-15	\$-77	\$+49	\$+27	\$+77	0	\$-12	\$+12	\$ 0
(Person-years)											
Direct Employment	Spacecraft	860	0	860	638	84	722	0	1,498	84	1,582
	User/Operator Equip.	787	988	1,775	217	384	601	0	1,004	1,372	2,376
	Central Control Stn.	393	15	408	43	2	45	0	436	17	453
	Total	2,040	1,003	3,043	898	470	1,368	0	2,938	1,473	4,411
Canadian Economy											
(Millions of 1984 Canadian Dollars)											
Real GNP		\$198	\$104	\$302	\$84	\$54	\$138	0	\$282	\$158	\$440
(Person-years)											
Employment		5,404	2,745	8,149	2,317	1,262	3,579	0	7,721	4,007	11,728

\* Value less than \$1 million.



and \$2 million for the spacecraft and central control station sales would balance the \$10 million surplus for the user/operator equipment sales. The deficit would occur in the 1985-95 period (when the satellites and CCS are being manufactured); the surplus would occur in the 1996-2002 period (when the majority of user/operator units are being sold).

Direct employment associated with MSAT manufacturing in Canada would total 4,411 person-years of 1985-2002. This would be roughly 8,000 less than in the Base Case, with over 4,250 jobs not emerging in the production of user/operator equipment and another 3,600 jobs not developing in the spacecraft industry.

The relative impacts on the manufacturers interested in MSAT would be considerably lower in the Pessimistic Scenario as well. By averaging certain of the estimated impacts over the 18 years in 1985-2002 period, we obtained the following indications of a typical year's effects:

TABLE 5.4.5

PESSIMISTIC SCENARIO  
AVERAGE ANNUAL REVENUE AND EMPLOYMENT IMPACTS DUE TO MSAT

<u>Impact Measure</u>	<u>Space Segment</u>	<u>Ground Segment</u>	<u>Total</u>
	(Millions of 1984 Canadian Dollars)		
<u>MSAT Industry:</u>			
Total Sales Revenues	\$10	\$11	\$21
Export Sales Revenues	\$4	\$3	\$7
		(Person-years)	
Direct Employment	88	157	245



According to our survey of potential MSAT manufacturers, interested Canadian firms earned total space/MSAT-related sales revenues of \$251 million in 1983. Adding \$21 million to this would thus have increased their revenues by 8 percent (rather than 25 percent as in the Base Case). Spacecraft manufacturing revenues of \$157 million would have increased 6 percent and ground segment revenues would have risen 12 percent, both substantially smaller relative additions than in the Base Case.

This pattern is even more pronounced in the case export sales revenues. Adding \$7 million to the interested manufacturers' 1983 export revenues of \$169 million would have been only a 4 percent increase (compared to 17 percent in the Base Case). Raising the space segment's export revenues by \$4 million would have represented a gain of just 3 percent (as opposed to 17 percent in the Base Case). Another \$3 million in export sales for the ground segment would have been a 6 percent increase (substantially less than 17 percent in the Base Case).

Direct employment gains due to MSAT would also have been small relative to these manufacturers' existing activities:

- Adding 245 person-years to their total space/MSAT-related work force of 2,719 would have been an increase of 9 percent (as compared to 26 percent in the Base Case).
- A further 88 employees in the space segment would have represented a gain of 8 percent.
- Adding 157 jobs to the ground segment would have meant a 10-percent increase.

TABLE 5.5.1

ESTIMATED MANUFACTURING IMPACTS DUE TO MSAT\*  
(1985-2002)

<u>Scenario</u>	<u>MSAT INDUSTRY</u>			<u>TOTAL ECONOMY</u>	
	<u>Sales</u> <u>Revenues</u> (\$ millions)	<u>Operating</u> <u>Profits</u> (\$ millions)	<u>Net</u> <u>Exports</u> (\$ millions)	<u>Employment</u> (person-years)	<u>GNP</u> (\$ millions)
Base Case	\$1,126	\$183	\$199	33,009	\$1,494
Optimistic (Index to Base Case)	\$1,627 (145)	\$263 (144)	\$611 (307)	48,197 (146)	\$2,169 (145)
Moderate (Index to Base Case)	\$921 (82)	\$146 (80)	\$148 (74)	25,381 (77)	\$1,139 (76)
Pessimistic (Index to Base Case)	\$370 (33)	\$56 (30)	- -	11,727 (36)	\$440 (29)

\* Dollar values are millions of 1984 Canadian dollars



In view of the substantial reductions in the direct impacts on Canada's MSAT manufacturers, the macroeconomic effects estimated for the Pessimistic Scenario are also significantly less than in the Base Case.

- The total addition to real GNP would be \$440 million (in 1984 Canadian dollars) over 1985-2002, more than \$1 billion lower than in the Base Case.
- The total direct and indirect employment created by MSAT manufacturing would be 11,728 person-years, roughly one-third of the jobs created in the Base Case.

### 5.5 Conclusions

The estimated MSAT manufacturing impacts discussed in this chapter are summarized in Table 5.5.1, opposite.

By comparing the impacts for these four scenarios, it is possible to conclude that MSAT could generate significant benefits for Canadian manufacturers and for the Canadian economy during 1985-2002 as long as:

- Canada and the United States develop a joint mobile satcom system based on MSAT technologies by the end of this decade (preferably with Canada taking the lead in specifying the technology and procuring the first satellite).
- Canadian manufacturers are successful in penetrating the Canadian and U.S. markets, especially in winning the prime contract for the two generations of spacecraft.
- Canadian manufacturers endeavour to maximize the domestic material content of their final MSAT products.
- At least one other mobile satcom system that -- Canadian firms have a good chance of penetrating -- develops outside of North America by the end of the '90s.



Quite simply, satisfying these conditions could reasonably produce the impacts indicated by the Base Case estimates, and might even yield the results suggested by the Optimistic Scenario.

Conversely, failure to establish a joint Canada/U.S. system, prime contract the satellites in Canada, aggressively market Canadian-made user/operator equipment, and foster a rest-of-world market could produce the impacts indicated by the Pessimistic Scenario.





## 6. IMPLEMENTATION STRATEGIES

Our analysis shows that Canadian manufacturers could derive measurable benefits from producing MSAT systems and related equipment. The key factors determining the actual size of these benefits depend on the range of MSAT products made domestically and the success of Canadian firms in selling these products in the available markets.

In the three previous sections, we outlined a number of ways to affect these two key influences to generate the greatest manufacturing impacts from MSAT. In this section, we combine these strategy suggestions into a more comprehensive package.

Maximizing the range of MSAT products made by manufacturers will require strategies at two different levels. The first relates to overcoming the reluctance of some key manufacturers to consider MSAT seriously at this time. The second concerns the success of Canadian manufacturers in developing and producing the leading edge technologies required for some of the MSAT systems, sub-systems and related equipment.

Maximizing the penetration of domestic and foreign MSAT markets by Canadian manufacturers will depend partially on their success in product development. It will also involve certain strategies to nurture markets and open doors to Canadian manufacturers.

The following sections summarize the steps we believe may be necessary in these three areas to achieve the greatest domestic manufacturing impacts from MSAT.



### 6.1 Overcoming Initial Reluctance

Manufacturers essentially ask themselves three questions when considering new product lines. The first is: Can we make it? Second is: Will we recover our development and production costs? Third is: Will another new product give us bigger and/or faster returns?

Our survey and interview program revealed a number of concerns about MSAT that could affect the answers some key Canadian manufacturers would have to these questions. To summarize, these included the possibilities that:

- MSAT might never be launched, (although this feeling does not appear to be as strong as it was two years ago).
- If launched, the Canadian MSAT system would prove to be a one-off phenomenon, not extended beyond the first generation.
- If mobile satcom is successful only in Canada, the small MSAT market may be shared by too many domestic manufacturers of similar equipment (who geared up for larger markets that failed to materialize).
- If mobile satcom is successful in Canada, the U.S. and other countries, the MSAT market may be dominated by U.S. and Japanese manufacturers.
- In any situation, the technical innovations required for MSAT -- especially the large satellite platform, the 5 KHz radios and the mobile antennas -- may not be commercially attainable in Canada by system start-up in 1989-90.

In essence, therefore, some manufacturers are uncertain that:

- They can design, develop and produce the MSAT equipment in time.
- Their sales of MSAT products will be sufficient to cover their costs.
- MSAT products will provide a better return than other attractive new business areas.



As a consequence, some may be reluctant to consider MSAT seriously at the present time.

This could have serious implications for the manufacturing benefits Canada derives from MSAT. If some of the larger Canadian manufacturers abstain from MSAT in the early developmental stages, the remaining firms may lack the technical capabilities, production capacities, financial depth or marketing abilities to generate the full range of MSAT system elements. The resulting product gaps could become permanent if manufacturers in other countries seize the opportunities and establish their products first in the Canadian and other mobile satcom markets.

To avoid this outcome, efforts should be made to encourage the participation of Canada's most able space and communications manufacturers from the start of the MSAT implementation program.

First, it is essential to provide Canadian manufacturers with assurance that MSAT will become a reality. As soon as possible, therefore, the federal government and Telesat Canada should announce:

- A definite commitment to developing a long-term MSAT system for Canada.
- A firm schedule for procuring the MSAT spacecraft and implementing the first generation system.
- A final set of technical requirements for the MSAT system elements.
- Plans to remove possible obstacles to the long-term growth in MSAT product sales (e.g., provision of sufficient frequency spectrum).



Second, representatives of the federal government should undertake a program of meetings to brief manufacturers across Canada about MSAT. These sessions would serve to reinforce Canada's commitment to the system, increase awareness about the opportunities available, and provide a way to respond directly to firms' specific concerns.

Third, as soon as possible the Canadian commitment to MSAT should be reinforced by an announcement of plans to co-operate with the successful U.S. mobile satcom licence applicant. Emphasis should be placed on the compatibility of the two systems and the potential for sales of Canadian-made equipment into the U.S. market.

#### 6.2 Encouraging Competitive Product Development

The previous section's recommendations are aimed just at overcoming the initial reluctance of some Canadian manufacturers to participate in MSAT. The next hurdle involves the development and production of competitive MSAT systems, sub-systems and related equipment by domestic firms.

This is a critical point in the maximization of manufacturing impacts due to MSAT. Technological innovations will be required for many elements of the complete MSAT system (e.g, the DAMA system, LPC/DMSK radios, ACSSB radio-telephones, mobile antennas, frequency control systems, and satellite transponder systems). Thus, manufacturers that master these technologies and develop reliable product lines in time for system start-up will have a substantial competitive advantage over firms that lag behind even 2-3 years.



However, offsetting this attraction is the high risk of investing large sums in innovative technologies that might prove unworkable, uneconomic, or even obsolete by system start-up in 1989-90.

Apprehension about these risks could prevent Canadian manufacturers from aggressively seizing the lead in these new technological frontiers. If firms in other countries grab these niches, domestic manufacturers may permanently lose the ability to compete in these product markets. The resulting limitation on the range of domestically made MSAT final products would seriously reduce manufacturing benefits in Canada. As a consequence, measures will be necessary to reduce the technical and financial risks associated with the innovations required for MSAT.

#### Reduce Technical Risks

We believe that the first step should be for the federal government to take a strong lead in helping private firms solve the technological problems.

To begin, the body of research DOC has commissioned -- from the Communications Research Centre (CRC) and from consulting engineers and space/communications manufacturers -- should be made available free-of-charge to MSAT manufacturers. Further, specialists in the CRC should endeavour to work closely with manufacturers throughout the R&D process to help solve the thorny problems that are likely to arise.



Making these resources available to private firms would reduce the risks of technological innovation in three important ways:

- Canadian manufacturers would not have to go "back to basics", but would start their R&D programs from an advanced position, saving them both time and money.
- Access to government specialists in the area would increase the likelihood that problems are solved quickly -- especially if the lessons learned in one area of research can be transferred to another.
- Participation of government specialists in the R&D process will help maintain consistent, high standards across all MSAT product categories.

#### Reduce Financial Risks

The second major thrust should be to reduce the financial risks associated with the development of new MSAT systems and equipment. We envision three components of this part of the implementation strategy.

Special funds should be made available to assist Canadian firms undertake the highest risk R&D programs. One example is the R&D required for the spacecraft, which will be very costly since no Canadian firm has yet worked with the larger, three-axis satellite platforms being considered for MSAT. Another example is the DAMA control system for the central control station, which will involve a substantial investment in computer programming time that might never be recovered if no further systems are sold.

In addition, potential manufacturers should be made aware of the range of publicly funded industry support programs that



they might take advantage of in developing MSAT product lines. On the federal level, these include<sup>1</sup>:

<u>Program</u>	<u>Sponsor</u>
Development of Space Subsystems and Components	ADMR/DGSTA
Enterprise Development Programs	DRIE
Industrial and Regional Development Program	DRIE
Industrial Research Assistance Program	NRC
Program for Industry/Laboratory Projects	NRC
Source Development Fund	DSS
Space Industry Development Program	DOC

A variety of provincial support programs would also be available.

The final element of the financial risk-reduction package is the initial purchase of a significant number of MSAT made radios and radio-telephones (e.g., 2-3,000) for federal government use. This would provide a number of advantages:

- Guaranteed sales in the start-up years will prevent unnecessary build-up of inventories, and help obtain a quick pay-back on the R&D investment.
- Use of the government's equipment for demonstration purposes will stimulate demand.
- Strong growth in usage of the MSAT system early on will provide greater incentive for the telcos and RCCs to install base stations and gateways.

#### Target Initiatives

It should be recognized that too much success in encouraging firms to begin developing MSAT product lines could lead to some undesirable results.

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<sup>1</sup> Some of these programs may be changed as part of the federal expenditure restraint initiatives.



In large part, this is because the resources that the federal government can allocate to MSAT will be limited. Its technical specialists will have other demands on their time. Its budget for direct support of MSAT manufacturers will be constrained. Cut-backs may eliminate some of the federal and provincial R&D support programs. Also, firms pursuing other new technologies will be competing aggressively for the available R&D support funds.

As a consequence, the more firms that obtain support in the early stages of MSAT product development, the less actual support will be available for individual manufacturers.

Opening up the initiatives to all interested manufacturers could thus mean that:

- No single company would receive enough support to complete its product development program.
- A number of firms that are ill-equipped to develop MSAT products would be drawing down the resources that could have been used by other companies.
- Some manufacturers that might have had the greatest likelihood of success would abstain from MSAT product development owing to the perceived dissipation of available resources across too many firms.
- Some leading companies might abstain because opening the development resources to all interested firms might lead to many sellers competing in a small marketplace.

Any of these outcomes could have serious implications for the long-term success of MSAT since first impressions will affect the attitudes of many potential users. The availability of reliable, economical equipment and service in the first years will therefore be essential to the strong, steady growth in subscriber numbers.





In view of this, we believe that the government's limited resources should be targetted to a small number of Canadian manufacturers, selected on the basis of their ability to succeed in developing MSAT products.

By the nature of the industry, this is unlikely to be a problem in the space segment of MSAT (the satellite and the central control station). For one thing, there are few qualified firms in this field in Canada. For another, satellites and central control facilities are usually developed and assembled by prime contractors -- single firms that have won a bidding competition to produce the final product. Thus, the normal course of business in the space segment will likely isolate the firms to be targetted for the federal government's initiatives.

However, the market process is unlikely to yield such a neat solution in the case of the larger volume items of MSAT equipment (the gateways, base stations, mobile radios, etc.). This is partially because a number of Canadian firms (possibly 20-30) could be interested in using public funds to develop these products. It is also because these companies are used to competing on an ongoing basis -- i.e., none will stand out as the "winners" early on like the successful prime contractors in the space segment. Thus, it may be necessary for the federal government to select the target firms to receive all of the support available for developing the MSAT user/operator equipment.

One way would be to choose the target companies in much the same way as Telesat Canada selects the prime contractors for its



satellites and ground facilities. The government could offer specific technical and financial support packages to the top two to three bidders in each category of user/operator equipment. The successful candidates might be chosen according to such criteria as:

- Track record in developing/producing similar products in Canada.
- Financial commitment.
- Technical capabilities (e.g., R&D staff and facilities).
- Marketing capabilities (e.g., domestic and export).
- Final price estimate.
- Production/servicing reputation and commitment.
- Involvement in preliminary MSAT technological research.
- Likelihood of retaining production in Canada.

By implementing this approach, the government's resources would be allocated most effectively to manufacturers with the best chance of developing reliable, competitive MSAT user/operator equipment.

At the same time, this method would not preclude competition in the marketplace. The successful bidders would be competing with one another. Also, unsuccessful bidders would still have access to the government's body of research and the product specifications, and would not be prevented from developing competitive MSAT products using their own technical and financial resources.



### 6.3 Maximizing Sales

The third major thrust of the strategy to maximize Canadian manufacturing benefits from MSAT concerns domestic industry's success is marketing its products.

To a large extent, this marketing success depends on industry's ability to make reliable, competitively priced products available to consumers, preferably ahead of competitors in other countries. As a result, the initiatives to foster MSAT product development in Canada will significantly affect the total sales attained by domestic manufacturers.

However, there are two aspects of the mobile satcom market that may require the federal government to provide further assistance to Canadian manufacturers. The first involves the sales of MSAT satellites prime contracted domestically. The second concerns the need to nurture markets outside of North America.

Each of these specific needs is examined in the following sub-sections.

#### Prime Contracting Satellites

The estimates outlined in Section 5 highlight the importance of prime contracting MSAT satellites in Canada to the overall manufacturing impacts.

To illustrate, the difference between prime contracting and sub-contracting each MSAT spacecraft is about \$70 million in sales revenues. In the Base Case Scenario, therefore, sub-contracting



rather than prime contracting the six satellites would directly lower total Canadian manufacturing revenues from \$1.1 billion to around \$700 million (constant 1984 dollars).

It is also possible that losing the international prestige associated with prime contracting MSAT spacecraft could also reduce the success of Canadian manufacturers in marketing their ground segment products. Thus, the total loss in sales revenues could be even more significant.

Avoiding this outcome could be difficult because Canada is not a sure winner in any of the potential markets for MSAT spacecraft.

Telesat Canada is not required to procure its satellites from a domestic prime contractor. Instead, it operates a two-stage process that offers a Canadian bidder only limited advantage. The first round is closed to foreign prime contractors. However, if Telesat does not believe that the first-round bid is the best available, the competition is then opened to all interested manufacturers.

Canada's space industry has matured considerably in recent years, and has posted some impressive successes (e.g., prime contracting Canadarm, ANIK-D and BRAZILSAT). However, it still faces considerable difficulties in competing directly with foreign companies. These include:

- The need to import major sub-systems -- e.g., the satellite platform, large travelling wave tube amplifiers, large antenna systems -- from potential competitors.



- The high cost of acquiring the ability to assemble a new satellite using an unfamiliar platform.
- The access of large prime contractors in other countries to military and international projects that fund essential R&D.
- The aggressively competitive behaviour of large prime contractors (e.g., willingness to bid well below cost in order to secure high profile markets like Telesat Canada).
- The much broader experience of large foreign prime contractors, some of which build more satellites in a year than all of Canada's spacecraft put together.

In view of these realities, chances that a Canadian prime contractor will be successful fall appreciably once the Telesat procurement process goes to the second round.

For similar reasons, a Canadian firm on its own has little chance of winning satellite prime contracts in other countries.

As a consequence, it may be necessary for the Canadian Government to help give domestic industry a better edge in the competitions for MSAT satellite prime contracts.

Our analysis suggests that this effort should be directed toward winning the contract to build the first MSAT spacecraft. This initial manufacturer would be much further out on the learning curve than its competitors in future contract bids. It would also gain an international reputation as the builder of MSAT spacecraft. In addition, this firm would be able to offer lower bid prices to other purchasers owing to the production economies derived from building similar satellites (possibly at the same time).

A couple of initiatives would greatly increase the probability of achieving this objective.



Providing direct financial support to the Canadian prime contractor for the first MSAT satellite would offset the competitive disadvantage of importing major sub-systems, and would contribute to the initial R&D needed to assemble a successful bid.<sup>1</sup>

Creating the best bidding environment for the first MSAT satellite would also be a key element of this strategy. Essentially, this means a strong Canadian presence in the initial MSAT spacecraft procurement. This is so that the domestic prime contractor could at least take advantage of its preferential treatment in Telesat Canada's procurement process. There are two ways this could happen:

- Telesat Canada develops a wholly Canadian MSAT system.
- Telesat Canada participates in a joint venture with a U.S. operator, such that:
  - o both countries own an MSAT satellite (each backing up the other)
  - o the two systems are based on identical technologies
  - o Telesat Canada lets the first contract (or an arrangement is made that the U.S. operator will abide by Telesat's prime contractor selection).

Forgoing a strong Canadian presence in the initial MSAT satellite procurement process will greatly reduce the probability that this spacecraft will be prime contracted domestically -- even with the federal government's financial support.

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<sup>1</sup> Determining how much support is a difficult problem. We believe that the federal government should set aside a fixed amount, selected on the basis of potential domestic/foreign cost differences and budgetary considerations. The Canadian prime contractor should then be on its own -- financially -- in its bid for the first MSAT contract.



Nurturing Markets

Our analysis of MSAT export market prospects suggests that some nations outside of North America might be ripe for mobile satcom systems by the mid-1990s. The possibilities we identified include the Association of South East Asian Nations (ASEAN), Australia, Brazil and Mexico. However, we also noted that these market prospects would most likely have to be nurtured.

The first step in this process is the development of mobile satcom systems in Canada and the U.S. As in the case of existing satellite communications systems, many countries will wait to see how MSAT works in North America before they would seriously consider obtaining such a system themselves. For this reason, the measures recommended to speed up the development of MSAT and maximize the Canadian manufacturing benefits from MSAT will also help nurture other markets.

In addition, a number of more directed initiatives will be required to increase awareness of MSAT services and Canadian MSAT manufacturing capabilities in these markets. Some of the main thrusts of this strategy might include:

- Arranging trade missions by representatives of the Canadian Government and MSAT manufacturers to explain the system, show how it could serve the prospective market's needs, and explore ways to provide other benefits to the potential market (e.g., technology transfers, counter trade, financing, training assistance, etc.).
- Hosting visits by representatives of prospective markets to observe how MSAT works in Canada, and to see how well Canadian firms manufacture the system elements.



- Providing financial support to Canadian MSAT manufacturers to aid their competitive positions in the key market prospects (e.g., this support might come from existing programs offered by the External Affairs Department or from special funds set aside for MSAT).

#### 6.4 Conclusions

MSAT can provide Canadian manufacturers with a significant new source of business, and with an important technological infusion in a rapidly changing field. However, a clearly focussed strategy will be needed to maximize the domestic manufacturing benefits from MSAT. Most important, the strong partnership between the federal government and Canada's space and communications equipment manufacturers must be sustained until MSAT is firmly established.





**Woods Gordon**

APPENDIX A

TECHNICAL BACKGROUND ON THE MSAT IMPACT MODEL

## APPENDIX A

### TECHNICAL BACKGROUND ON THE MSAT IMPACT MODEL

In this appendix, we summarize the calculation framework used to simulate the net industrial and economic impacts generated by MSAT for each scenario. Further, we review our sources of data for the essential factors used in these calculations.

#### A.1 Overview of the MSAT Impact Model

For the most part, net manufacturing and economic impacts depend fundamentally on the following factors:

- Total market size (the number of units of each system element purchased in the domestic and export markets).
- The ability of Canadian firms to penetrate these markets (the proportion of total unit sales attributable to domestic manufacturers).
- The selling price of final products.
- The import content of domestically made items.
- The labour content of domestically made items.
- The profit margins for domestically made items.
- The switchovers from existing technologies to new technologies.
- The macroeconomic multiplier effects of domestically made items.

Taking all of these factors together, we developed a series of equations -- for each MSAT system element, each displaced mobile communications product and each affected province -- to



estimate the aggregate industrial and macroeconomics impacts generated by MSAT. The end result was a large series of equations which calculate:

- Each of the 22 MSAT system elements.
- Each year in the 18-year estimation period and the overall total.
- Each market in each scenario.

To ensure accuracy and efficiency, therefore, we developed a computerized version of the model on I.P. Sharp's time-sharing system.

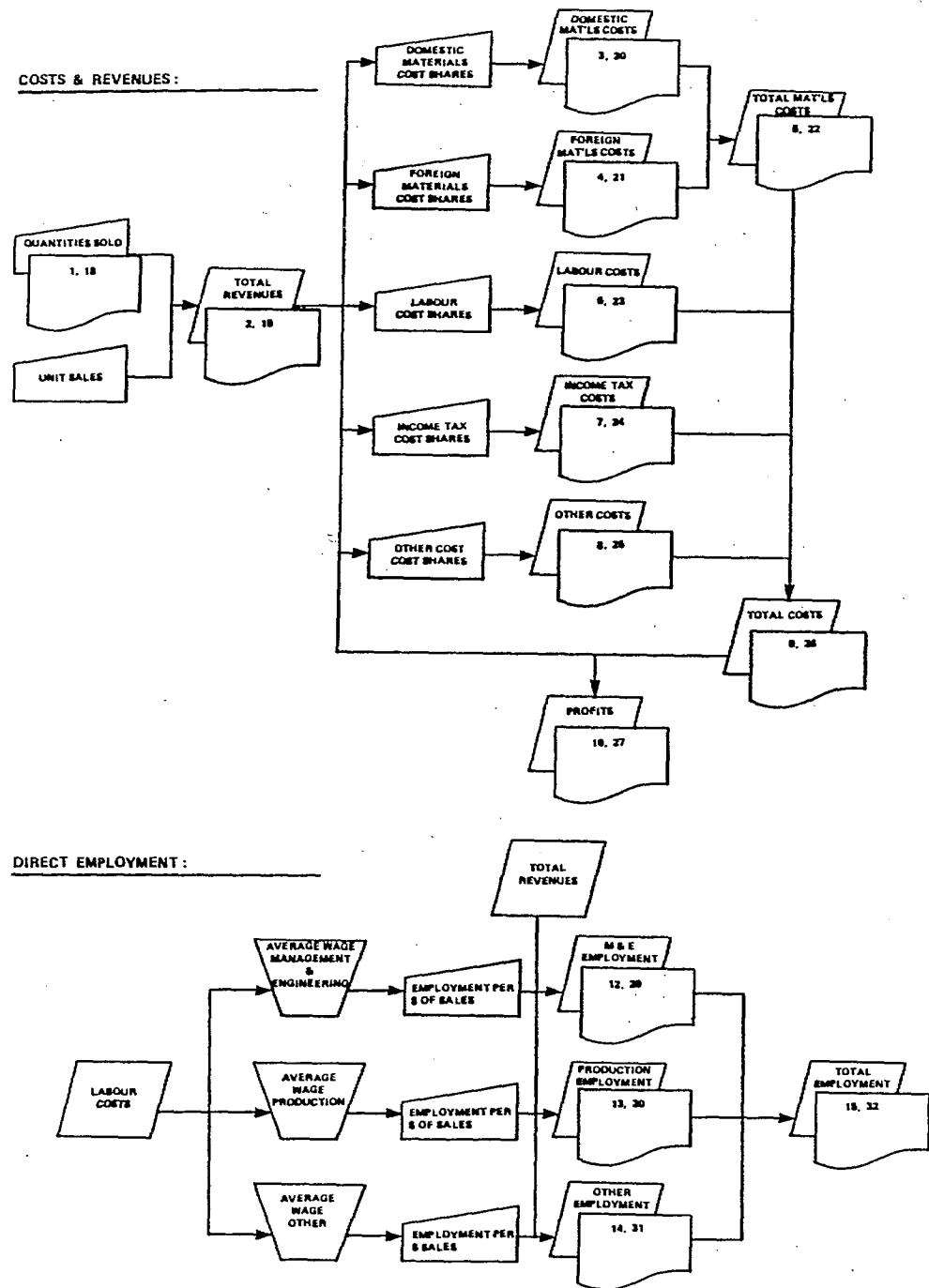
The key exogenous variables -- determined by the particular scenario -- are:

- Number of units of final MSAT equipment sold by Canadian manufacturers (i.e., total sales in any market multiplied by the expected penetration rate for Canadian producers).
- Wholesale prices of each unit of final MSAT equipment.
- Number of Canadian-made units of existing mobile communications equipment that would be displaced by MSAT (i.e., total quantity of displaced units multiplied by the penetration rate for Canadian firms).
- Wholesale prices of each unit of displaced mobile radio communications equipment.

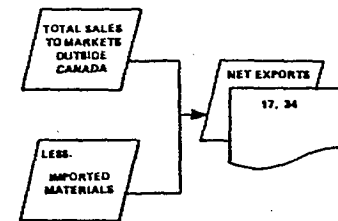
The endogenous variables -- those determined by the model -- include:

- Total revenue generated for each end-user product.
- Total operating cost to manufacture each end-user product.
- Operating cost components -- domestic materials, imported materials, labour, taxes, other -- to manufacture each end-user product.
- Profits generated by manufacturing each end-user product.
- Direct and indirect (i.e., total macroeconomic) output created by manufacturing each end-user product.

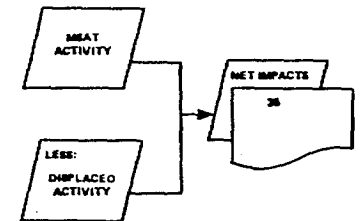
Chart B.1



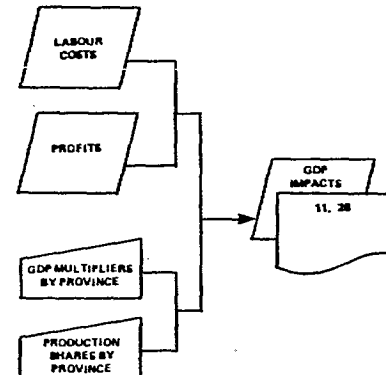
**BALANCE OF TRADE IMPACTS:**



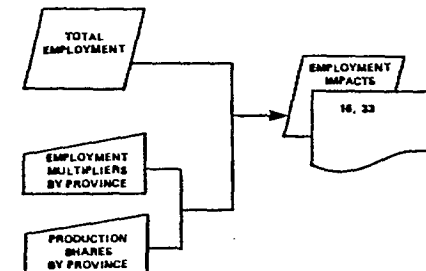
**NET IMPACTS:**



**TOTAL GDP IMPACTS:**



**TOTAL EMPLOYMENT IMPACTS:**





- Employment -- total, management and engineering, production, other -- needed to manufacture each end-user product.
- Direct and indirect (i.e., total macroeconomic) employment created by manufacturing each end-user product.
- Net exports -- direct exports less direct imports -- associated with manufacturing each end-user product.

These are calculated for both the MSAT system elements and any existing mobile communications equipment displaced by MSAT. In addition, a net result for each of these endogenous variables is determined by subtracting the effects for displaced units from the relevant impact for MSAT system elements.

The equations used to compute some of these endogenous variables are quite straightforward. For example, Total Revenue is simply Price multiplied by Number of Units. However, other endogenous variables are calculated by combining exogenous and/or previously determined endogenous values with coefficients that have been derived outside of the model. These include:

- Production cost shares (domestic materials, imported materials, labour, taxes, other)
- Employment shares (management and engineering, production, other).
- Provincial production shares.
- Macroeconomic multipliers.

As shown in Chart 1, the Impact Model determines the endogenous estimates using these exogenous variables and coefficients by working through a series of blocks, the results of some of which are subsequently used as inputs into other blocks. For both the end-user MSAT products and displaced mobile radio terminals, the



sequence is as follows:

- o Sales Revenues
- o Cost of Domestic Materials
- o Cost of Imported Materials
- o Cost of All Materials
- o Cost of Labour
- o Cost of Taxes
- o Other Costs
- o Total Operating Costs
- o Profits
- o Direct and Indirect Output Impacts
- o Employment:
  - o Direct Management and Engineering
  - o Direct Production
  - o Direct Other
  - o Total Direct
  - o Total Direct and Indirect
- o Net Exports

After computing these values for each year and each product for both the MSAT system and displaced equipment, the Impact Model then calculates the total "net" effects on each endogenous variable.

The Model is run for each identifiable market -- e.g., Canada, the United States, rest-of-world -- in each scenario, and the results are then summed to produce total market estimates.

Volume III of this report contains the print-outs for the various scenarios analysed in this study.

#### A.2 Review of Data Sources for Coefficients

The previous section subdivided the input data for the MSAT Impact Model into two categories: exogenous and coefficient. The exogenous data -- penetration rate, number of units sold (or displaced), and price per unit -- are derived from the assumptions underlying each market scenario. These are described in detail in



Chapter 5. However, the coefficients are independent of the scenarios, and not described in the scenario analysis. Our purpose in this section is to outline our sources for these essential inputs.

#### A.2.1 Unit Cost Breakdown of MSAT-Related Equipment

Costs are divided into five groups: domestic and imported materials, labour, taxes, and other. These are placed in the model in the form of unit shares of total price, so the sum of the five coefficients for each MSAT component together with a wholesale mark-up estimate always equals unity. When multiplied by unit prices, these shares determine dollar values for each of the five cost groups.

Estimation of the input unit costs shares was a two-step approach. First, Woods Gordon, using current industry data and results from previous studies, set up initial estimates of the unit cost shares. These shares were then compared with DOC's independently produced MSAT estimates, and checked for consistency and reasonableness in some trial model runs. The Base Case unit cost shares are therefore a combination of the two approaches.

#### Domestic Materials

Four types of material inputs are aggregated to determine the domestic material share for each system element: Canadian-sourced raw materials, components sourced from Canadian manufacturers, sub-assemblies purchased with low labour content, and a 28-percent share of components sourced from Canadian suppliers.



### Foreign Materials

For each system element, the foreign material coefficient includes: foreign raw materials and components, and 56 percent of components sourced from Canadian suppliers.

### Labour Costs

These costs include wages and salaries for all direct employees in production, engineering management and administration roles. Also included are the remaining 16 percent of components sourced from Canadian suppliers and all sub-assemblies that required high labour content in production.

### Taxes

These are assumed to be 40 percent of gross profit, or total revenue less material, labour and other costs.

### Other Costs

These include indirect tax expenditures, fixed capital costs, utilities, and employee benefits.

### A.2.2 Staff Requirements

To determine the effects of each MSAT system element production on employment, labour requirements are divided into three sub-categories:

- Management and Engineering.
- Production.
- Administration and Support.





Estimation of these coefficients was a two-step approach. Initial estimates were obtained from the Profile of Canadian Manufacturing Industry Capabilities (see Volume II, Chapter 3). These data were then checked for consistency with labour cost data.

Using labour costs as a share of total sales (outlined in the previous section) and 1984 average wage for hourly and salaried employees in communications equipment manufacturing industries (Statistics Canada, Catalogue 72-002), we calculated the number of employees per million dollars of sales.

<u>Employee Group</u>	<u>Average Annual Wage</u>
Managerial & Engineering	\$32,000
Production*	\$21,000
Other (Clerical & Administration)	\$21,000

To illustrate:

- labour cost as a share of selling price	= .25
- labour cost per \$ million of sales	= \$250,000
- average wage	= \$ 25,000
- number of employees per \$ million of sales	= 10

The results reflect the different capital intensity and skill requirements associated with each product. Satellites, for instance, have a relatively low staff-to-sales ratio because of their high capital content. On the other hand, earth station production is relatively more labour-intensive because of the large number of construction and installation workers needed. Also apparent are the

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\* Except DAMA programmers, assumed to earn an average of \$35,000 per year.



differences attributable to company size. Antenna manufacturers, which tend to be small, have a low proportion of support or "Other" employees, while the larger firms which make mobile radios and base stations (e.g., Motorola, CGE, Marconi) have a larger proportion.

### A.3 Assumptions for Displaced Mobile Radio Equipment

Existing product displacement will result from sales of MSAT equipment in the Canadian market. Estimates of these displaced sales were supplied by DOC.

Because the perceived displacement effect is very small in relation to MSAT sales (less than 1 percent of base cost estimates), volume estimates were not changed for other scenarios.

Pricing estimates were obtained from existing manufacturers and a disinflation rate of roughly 0.5 percent per year was applied to account for technological progress and efficiency of a higher level of production.

Because existing mobile communications equipment is unlikely to differ greatly from MSAT system equipment, the same coefficient relationships for terminals, documented in Section B.2, have been used.

A.4 Provincial Share of Output

For MSAT, provincial shares reflect the subjective assumptions made with regard to future production of MSAT equipment. As with the existing distribution of mobile radio equipment manufacturing, Ontario, Quebec, Alberta, and British Columbia, are likely to share most of the production. For all scenarios, we assume the same firms that make existing mobile radio equipment, will make MSAT equipment.

Data were collected from major manufacturers in this field with regard to distribution of equipment production, individual market shares, and the share of foreign-made products sold by Canadian (multi-national) manufacturers. Based on the market shares and the provincial origin of the major manufacturers, the following provincial shares were computed:

<u>MSAT System</u>	<u>Quebec</u>	<u>Ontario</u>	<u>Manitoba</u>	<u>Alberta</u>	<u>B.C.</u>	<u>Total</u>
	(Percentages)					
Satellite	80	20	-	-	-	100
Mobile Radio/ Telephones	30	20	-	30	20	100
DACS	20	20	20	20	20	100
Base Stations	-	-	-	-	100	100
Gateways	-	-	-	100	-	100
Central Control Stations	-	50	50	-	-	100
<u>Existing Equipment</u>	<u>Quebec</u>	<u>Ontario</u>	<u>Manitoba</u>	<u>Alberta</u>	<u>B.C.</u>	<u>Total</u>
	(Percentages)					
Mobile Radios	-	-	-	-	-	
Mobile Radio Telephones	-	21	-	78	1	100



#### A.5 Economic Impact Multipliers

Production of Canadian MSAT equipment, together with the displaced production of the existing mobile radios, will have an effects on the Canadian economy that go beyond the immediate manufacturing industry.

Demand for Canadian-made materials will generate additional spending among suppliers, and the succession of firms that supply them. At the same time, income earned by people employed by the industries directly and indirectly affected by MSAT will be spent on consumer goods. This in turn will generate more spending by businesses and their employees.

In this study, the impacts measured are in terms of gross domestic provincial product -- the value-added generated in the economy -- and employment. Initial value-added produced by MSAT when combined with the GDP multiplier will give the net GDP impact (in constant 1984 dollars) through the economy. Similarly, when employment dedicated to MSAT is combined with the employment multiplier, the net employment gain (in person-years) to the economy is produced.

Multiplier estimates are based on the Interprovincial Input-Output Model simulations performed by the Input-Output Division of Statistics Canada. The simulations are based on 1979 economic relationships, and are the most current available.

The Statistics Canada model runs provide GDP multiplier estimates by industry and by province. For our purposes, multipliers for the electrical products industry were used. This industry



includes manufacturers of:

- o small electrical appliances
- o major electrical appliances
- o radio and television receivers
- o communications equipment
- o electrical industrial equipment
- o batteries
- o electric wire and cable
- o miscellaneous.

Because the GDP and employment multiplier estimates only account for in-province impacts (no leakages of benefits) to other provinces are included), an upward revision was necessary. Based on additional information supplied by Statistics Canada, and relying on the linear nature of the Input-Output Model, cross-province multiplier estimates were calculated for all provinces. Depending upon the source province, the national GDP and employment multipliers were in the 2-4 range.

Detailed multipliers for each province, together with our own assumptions of source provinces of production, allowed us to construct a unique multiplier for each system element. Therefore, the national employment and GDP impacts are always the sum of the corresponding provincial impacts. Also, the final economic impacts depended upon not only the relative value of each system element, but the provincial distribution of system element production.

