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Telesat Canada

STUDY OF L-BAND UTILIZATION BY MSAT

SUMMARY REPORT

Prepared For

Communications Research Centre
Department of Communications

Submitted by:

TELESAT CANADA

FINAL

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		DATE
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Study of L-Band utilization by MSAT

Summary Report

Sub-Task 1

Sub-Task 2

Sub-Task 3

Sub-Task 4

Task 19

Task 22

Task 23

Task 24

Concept of providing position determination service via MSAT.

EXECUTIVE SUMMARY

The study results indicate that there are economic penalties in using L-Band frequencies for MSAT. The penalty ranges from $6 million to $69 million in terms of net present value. It is caused by the following factors:

1) A requirement for 22% increase in satellite effective isotropic radiated power.

2) A system capacity decrease ranging anywhere from 34% to 83%.

3) An increase of 16% in mobile terminal cost.

4) A decrease of 2.8% in market penetration.

These penalties are caused by the excess path loss at L-Band due to shadowing. This shadowing could be eliminated if there is a clear line of sight between the ground terminal antenna and satellite. It follows, therefore, that L-Band would be particularly suitable for fixed or transportable service applications where high fade margins are not necessary. Typical examples of this type of application are;

1) mobile service in areas of low foliage blockage, such as the Prairies and the North West Territories and Arctic.

2) Mobile service to customers who can select transmission times when blockage by foliage is minimal.

3) Transportable or fixed service applications where high gain antennas may be used.

4) Aeronautical mobile and maritime mobile services.

TABLE OF CONTENTS

1. INTRODUCTION

In February of 1985, Telesat Canada entered into a contract with the Federal Department of Communications. The objective is to examine the potential impact of using L-Band frequency for mobile satellite services. The purpose of this summary report is to describe the study process, assumptions and the overall study results.

2. STUDY OBJECTIVES AND METHODOLOGY

As stated in Directive #18, the specific objectives of the L-Band study are as follows:

(a) To examine the potential impact of changing the MSAT frequency of operation from UHF (821-825 MH_Z and 866-870 MH_Z) to L-Band (1645.5-1660.5 MH_Z and 1544-1559 MH_Z);

(b) To examine the potential impact of adding L-Band capability to the MSAT system using the UHF spectrum.

The study framework is defined by a reference plan and three alternative plans. The reference plan is the baseline system option as described in the Business Proposal of February, 1985. Briefly, the system has two UHF and one SHF beams providing North American coverage. It is planned to be implemented on the basis of Canada/US cooperation. Other major technical parameters are as follows:

Grade of Service	15% blocking probability (Erlang B) for the busy hour End-of-Life
Average busy-hour traffic per user	0.0106 Erlang
Voice coding/modulation	2.4 kb/s PELPC/DMSK or ACSSB
Data and DAMA	2.4 kb/s DMSK
Channel spacing	5 KHZ
Access technique	SCPC/FDMA demand Assignment
Vehicular Antenna Gain	8 dBiC
SHF Base Station Antenna	3.5 meter diameter
SHF Gateway Station Antenna	5 meter diameter
Mode of operation	Full Duplex
EIRP per channel	UHF 26.5 dBw SHF 8.6 dBw
Spacecraft class	PAM D
No. of Beam	
UHF	2
SHF	1
Lifetime	7 years
System capacity	35,000

To identify and assess the potential impact, three alternative plans are defined. These three plans are as follows:

(i) Plan 1- Change the existing design of UHF frequency to L-Band. Other assumptions are.

Canada/US cooperative

- 2 Satellites	One for Canada One for U.S.A.
- Type of Satellites	PAM D, with PAM DII as an option
- No. of L-Band Spot Beams	2 or 4
- Operating frequencies -1645.5 - 1660.5 MH_Z -1544 - 1559 MH_Z	
- Channel spacing	5 KHZ
- Spectrum Sharing	50% with U.S.A.
- Feederlink	SHF

(ii) Plan 2- Change the existing design of UHF frequency to a concept that integrates UHF and L-Band in one satellite. Other major assumptions are.

Canada/US co-operative

- 2 Dual Band Satellites	One for Canada One for U.S.A.
- Type of Satellite	Size greater than PAM D.
- No. of Spot Beams	2 UHF and 4 L-Band Beams

- Operating frequency for each satellite are,
  - 1645.5 to 1660.5 MH_Z
  - 1544 to 1559 MH_Z
  - 821 to 825 MH_Z
  - 866 to 870 MH_Z

- Channel spacing	5 KH_Z
- Spectrum sharing	50% sharing with U.S.A. for both UHF and L-Band

- Satellite Resources Allocation:
  - After allocating enough satellite resource to satisfy the existing UHF requirements of 35,000 users, the remaining available resource is assigned to L-Band.

- Service Allocation	UHF frequencies are used to provide mobile services; and L-Band frequencies are used to provide transportable, portable, and fixed services.
- Feederlink	SHF

(iii) Plan 3 Employs separate L-Band and UHF satellites.

- System	Canada/US Cooperative
- 4 Satellites	2 L-Band satellites. 2 UHF satellites.
- Type of satellites:	PAM D or possibly PAM D II
- Operating Frequencies	
- 1645.5 to 1660.5 MH_Z	
- 1544 to 1559 MH_Z	
- 821 to 825 MH_Z	
- 866 to 870 MH_Z	
- Channel spacing	5 KH_Z
- Spectrum sharing	Shared with U.S.A. for both UHF and L-Band on an equal basis (50%).
- Service Allocation	Mobile services will be on the UHF satellite, and the transportable and fixed services will be on the L-Band satellite.

The study activities are divided into 4 separate sub-tasks.

Sub-Task 1	System Concept
Sub-Task 2	Space segment concept and costing
Sub-Task 3	Ground segment concept and costing
Sub-Task 4	Market and economic analysis

The overall study work-flow of these sub-tasks is depicted in Figure 1.

The output of the study consists of five reports: one summary report and four separate sub-task reports. The readers are advised to refer to the sub-task reports for specific detail.

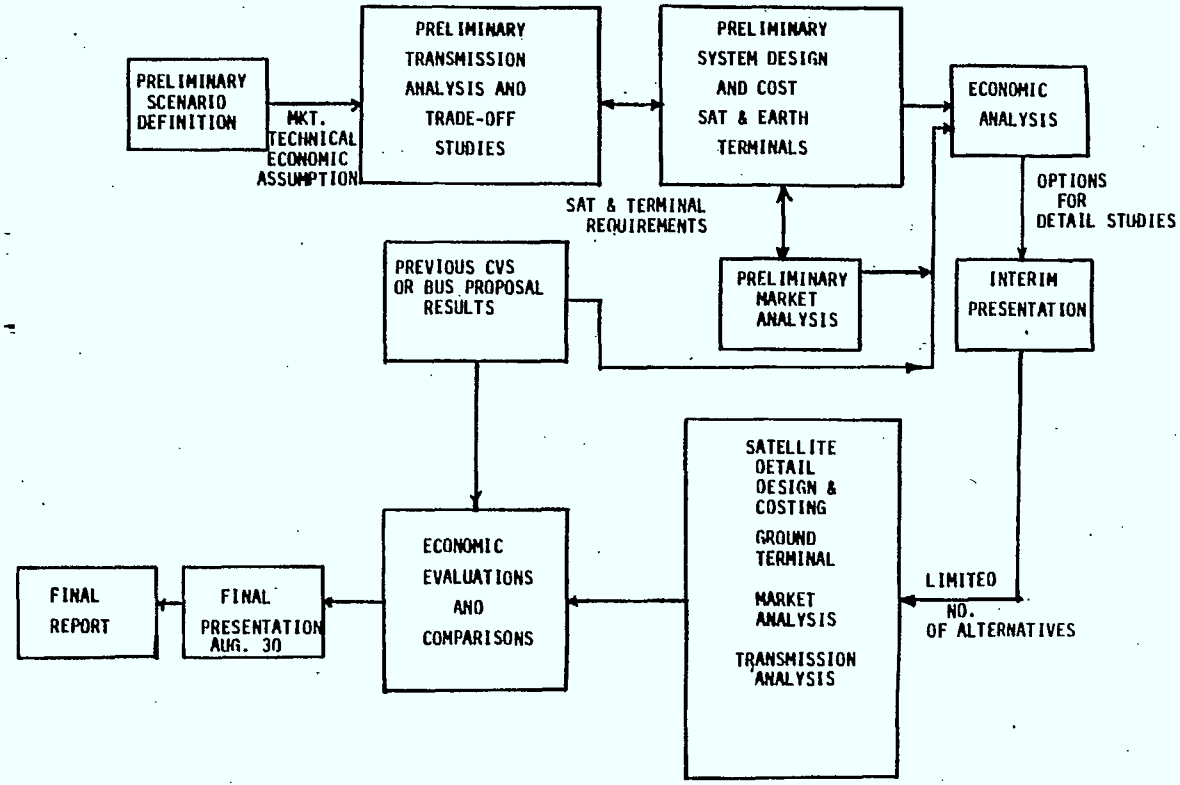


FIGURE 1 - STUDY METHODOLOGY

3. TECHNICAL IMPACT

3.1 Satellite Transmission and Beam Configuration

In order to facilitate the co-operative approach of system implementation with a U.S. operator, the alternative systems will have to provide the same North American coverage as the UHF-only system. Figure 2 shows a two-beam coverage of an L-Band only system, and Figure 3 shows the antenna coverage beam patterns for a system employing either a dual-band satellite or a pair of L-Band and UHF satellites. Based on this fundamental assumption, several system parameters are affected when the operating frequency is changed from UHF (800 MH_Z) to L-Band (1.5 GH_Z).

Firstly, the spacecraft antenna aperture is reduced to maintain the same antenna gain and G/T. For a two-Beam system, the aperture is reduced from 5 meters to 2.64 meters.

Secondly, the satellite EIRP is increased to 32.3 dBW per carrier to maintain a comparable system link performance. When the operating frequency is changed from UHF to L-Band, the downlink free space loss is increased by 5dB. This increase in loss is compensated partially by the vehicular antenna's net gain increase of 3.3 dB. With the additional requirement of a 4.1 dB fade margin to maintain a comparable service quality as the UHF system, the L-Band transmission downlink has a net deficit of 5.8 dB. Consequently, the L-Band satellite EIRP is increased to 32.3 dBW per carrier. Table 1 shows the detailed calculation.

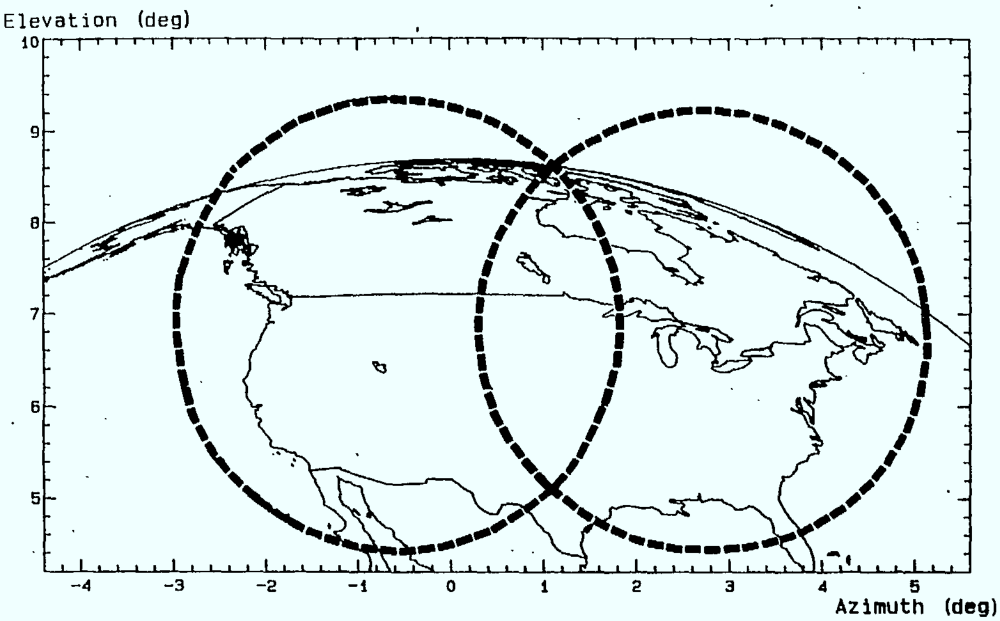
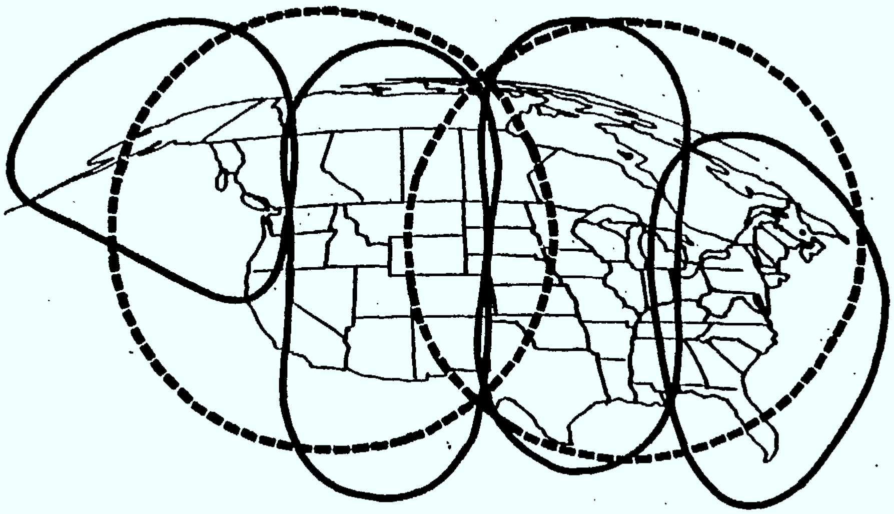


FIGURE 2 - MSAT ANTENNA COVERAGE - 2 BEAMS



MSAT ANTENNA COVERAGE
LEGEND: ---- UHF
—— L-BAND

FIGURE 3 - MSAT ANTENNA COVERAGE - DUAL BAND

Increase In Free Space Loss	
(Forward Path Downlink)	-5 dB
Increase In L-Band Antenna G/T	+3.3 dB
	-1.7 dB
Availability Consideration-Propagation Margin	-4.1 dB
Total Downlink Deficit	-5.8 dB
UHF EIRP per Carrier	26.5 dBW
Therefore, required L-Band EIRP per Carrier	32.3 dBW

Table 1: L-Band Satellite EIRP Requirement

Similarly, due to the increase in the uplink free space loss and the additional requirement of fade margin, the mobile terminal EIRP is increased to 23 dBW. Table 2 shows the detailed calculation.

Increase in Free Space Loss	-6 dB
Increase in Uplink C/N - Propagation Margin	-6 dB
Total Uplink Deficit	-12 dB
UHF Uplink EIRP/Carrier	11 dBW
Therefore, Required Mobile Term EIRP/Carrier	23 dBW

Table 2: L-Band Mobile Terminal EIRP Requirement

The overall comparisons between the UHF and L-Band systems are illustrated in Figures 4 and 5.

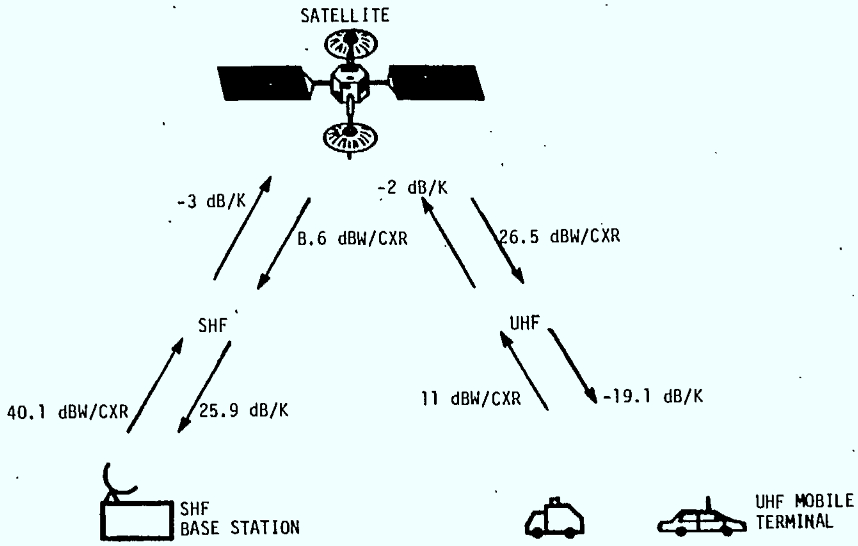


Figure 4: UHF - Only System Communication Link Availability 97%

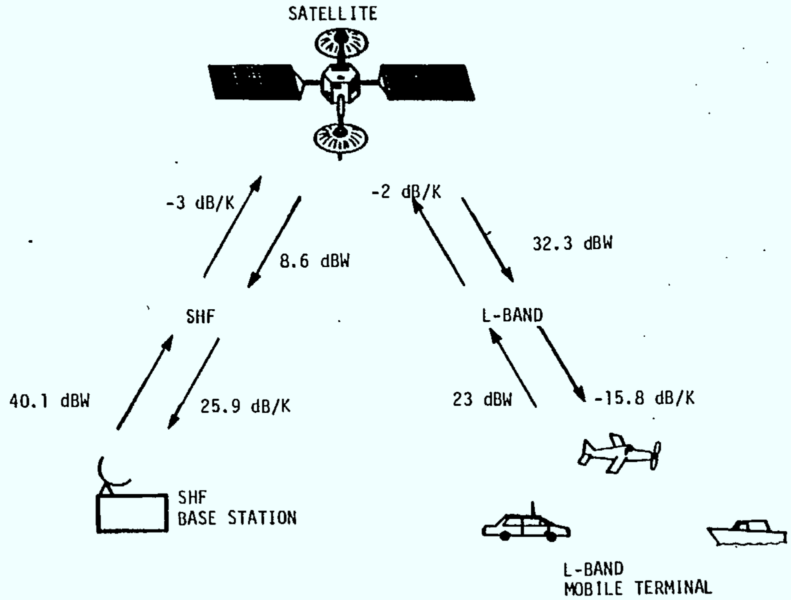


Figure 5: L-Band Only System Communication Link Availability 97%

3.2 Space Segment Concept and Costing

3.2.1 Plan 1: L-Band System

When the spacecraft design is changed from UHF to L-Band, the payload power requirement of the spacecraft is increased. This is due to the requirement of higher EIRP per carrier and the fact that the efficiency of the L-Band solid state power amplifier (SSPA) is estimated to be 20%, rather than 24% as for the UHF SSPA. However, the payload mass is reduced due to the smaller antenna aperture. This mass reduction can generally be traded for increased power from the spacecraft. However, when the spacecraft becomes power-limited, there is no further capacity increase to be gained.

The spacecraft capability can be expressed in terms of number of active carriers, which are simultaneous channels expected to be carrying voice and signalling information at the satellite. It is calculated based on the assumption that for 99% of the time, the number of channels with a voice activity factor of 0.4, demanded in a beam, will not exceed the number of active carriers. This is simply to ensure sufficient satellite power is available for 99% of the time. The number of active carriers thus calculated represents the power/mass limit of the spacecraft. Table 3 shows the amplifier comparison between UHF and L-Band for two beams and four beams respectively.

	REFERENCE PLAN UHF		ALTERNATIVE PLANS L-BAND	
BEAM CONFIGURATION	2	4	2	4
SPACECRAFT CLASS	PAM D	PAM DII	PAM D	PAM DII
EIRP/CARRIER (DBW)	26.5	26.5	32.3	32.3
ANTENNA APERTURE (m)	5	9.14	2.64	5
ANTENNA NET EOC GAIN (dBiC)	25.8	27.6	25.4	28.4
NO. OF ACTIVE CARRIERS/BEAM	90	69	23	33
OUTPUT RF POWER/BEAM (w)	105	53.8	113.4	81
POWER PER CARRIER (w)	1.17	0.78	4.93	2.46

Table 3: Amplifier Power Comparisons

As described earlier, the payload mass of an L-Band spacecraft is less than that of a UHF spacecraft. This is mainly due to the smaller antenna aperture required for an equal RF beam coverage. The smaller antenna is generally less expensive than the large antenna. Therefore, the L-Band spacecraft are less expensive than the UHF ones. Table 4 summarizes the overall comparisons.

	REFERENCE PLAN UHF		ALTERNATIVE PLANS L-BAND		
BEAM CONFIGURATION	2	4	2	2	4
SPACECRAFT CLASS	PAM D	PAM DII	PAM D	PAM DII	PAM DII
COST MCD '3Q' 86	169	210	152	177	198
PAYLOAD MASS (KG)	198	323	173	216	286
PAYLOAD POWER (W)	926	788	1380	2300	2043
LIFE ESTIMATE	7	7	7	7	7
SSPA EFFICIENCY	24%	24%	20%	20%	20%
SATELLITE EIRP (dBw/CARRIER)	26.5	26.5	32.3	32.3	32.3
NO. OF ACTIVE CARRIER PER BEAM	90	69	23	39	33

Table 4: Space Segment Concept Comparison
UHF Versus L-Band

Alternative Plan 2 is a dual band satellite. It has an integrated communications payload: UHF, L-Band, and SHF. The UHF and L-Band share the same reflector providing two UHF beams and four L-Band beams. The analysis was done assuming that the spacecraft payload resource has to satisfy the existing requirement in the reference plan (UHF satellite) and the remainder of the resources will be used for L-Band service. Based on the service criteria of 97% availability, a PAM DII class spacecraft can provide 7 active carriers in the L-Band; while the quarter shuttle can provide 23 additional L-Band carriers. Table 5 summarizes the results of the analysis, as well as the total program cost of one satellite for each case.

BEAM CONFIGURATION	2 UHF 4 L-BAND	2 UHF 4 L-BAND
SPACECRAFT CLASS	PAM D II	HS -393
COST MCD '3Q' 86	216	214
PAYLOAD MASS (KG)	310	366
PAYLOAD POWER (W)	1675	2260
LIFE ESTIMATE	7	7
SSPA EFFICIENCY		
UHF	24%	24%
L-BAND	20%	20%
SATELLITE EIRP (dBw/CARRIER)	32.3	32.3
NO. OF ACTIVE CARRIER PER BEAM		
UHF	90	90
L-BAND	7	23
NO. OF ACTIVE CARRIER PER SPACECRAFT	208	272

Table 5: Space Segment Concept Analysis - Dual Band System

3.3 System Capacity

The system capabilities depend on whether the spectrum boundary or the power/mass boundary is reached first. In this study, the number of active channels that a particular spacecraft bus can provide, is used to calculate the number of assignable channels. The system capacity in terms of number of L-Band users is then determined according to Erlang B traffic theory. The calculation is based on the following assumptions.

(1)	Service Mix:	Mobile Telephone 25% Mobile Radio 75%
(2)	Traffic Intensity:	150 minutes per month per mobile equivalent to 0.011 Erlang per mobile.
(3)	Traffic Discipline:	Erlang B
(4)	Grade of Service:	15%
(5)	Voice Activity Factor:	0.4
(6)	Mode of Operation:	Full duplex operation for intra-beam, mobile-to-mobile traffic.
(7)	Connectivity: L-Band Satellite:	- L-Band to SHF - No L-Band to L-Band cross patch.
	Dual Band Satellite:	- L-Band to SHF - UHF-to-SHF - No L-Band-to-L-Band cross connection - No UHF-to-UHF cross patch - No UHF-to-L-Band cross patch

The results of the L-Band only options are presented in Table 6.

FREQUENCY OF OPERATION	UHF	L-BAND		UHF	L-BAND
BEAM CONFIGURATION	2	2	2	4	4
SPACECRAFT TYPE	PAM D	PAM D	PAM DII	PAM DII	PAM DII
SATELLITE EIRP (dBw/CARRIER)	26.5	32.3	32.3	26.5	32.3
NO. OF ACTIVE CARRIER	180	46	78	276	132
NO. OF ASSIGNABLE CHANNELS	362	74	140	556	228
SYSTEM CAPACITY NO. OF USERS	35,000	6,000	13,000	51,000	21,000

Table 6: System Capacity Comparison
UHF Versus L-Band

In comparing with the UHF systems, one can observe that

1) The capacity of two-beam system employing a PAM D class spacecraft is decreased from 35,000 users to 6,000 users, a reduction of 83%.

2) Using a bigger bus such as PAM DII in place of PAM D, one can double the capacity of a two-beam L-Band system. However, the net result still indicates a 63% capacity reduction from that of the UHF system.

3) In a four-beam configuration, the capacity of an L-Band system is 59% less than that of the UHF system.

4) In an attempt to improve the system capacity, the number of beams is increased from two to four, and the spacecraft size is increased from PAM D to PAM DII. The net result still shows that the L-Band system capacity is 34% less than that of the UHF two-beam system.

Similarly, for a dual band system, the number of active L-Band carriers in addition to the 180 UHF carriers is used to calculate the assignable channels and hence the capacity. The results are listed in Table 7. They show that the PAM DII class spacecraft can provide only 1,000 users in addition to the 35,000 UHF users. On the other hand, an HS 393 or similar class of spcecraft can accommodate 35,000 UHF users and 12,000 L-Band users, for a total system capacity of 47,000 users.

BEAM CONFIGURATION	2 UHF 4 L-BAND	
SPACECRAFT TYPE	PAM DII	HS393
SATELLITE EIRP (dBw/CARRIER)	32.3	32.3
NO. OF ACTIVE CARRIERS		
UHF	180	180
L-BAND	28	92
NO. OF ASSIGNABLE CARRIERS		
UHF	362	362
L-BAND	28	148
SYSTEM CAPACITY		
NO. OF USERS		
UHF	35,000	35,000
L-BAND	1,000	12,000
TOTAL	36,000	47,000

Table 7: Capacities of Systems Employing dual Band Satellites

In plan 3, where the system consits of one UHF and one L-Band spacecraft of similar PAM D class, the capacity is 41,000 users, which is the sum of the individual spacecraft capacity.

In gerneral, the results show that with moderate capital investment, a dual band system can provide a better system capacity as compared to the L-Band system as well as the system where separate UHF and L-Band spacecraft are used.

3.4 Ground Segment Concept and Costing

3.4.1 General

When the operating frequency is changed from UHF to L-Band, three ground system components are affected: mobile terminal antenna, mobile terminal radio sub-system, and the DAMA system.

As described in Section 3.1, there is about 6 dB more of free space loss in L-Band than in UHF. Including the additional fade margin of 6dB required to maintain a comparable service quality as for the UHF system, the total uplink deficit is about 12 dB. This deficit can be compensated by the increase in the antenna gain and the radio-frequency power.

3.4.2 Antenna

The L-Band steerable phased array antenna of the same size as the UHF version, can provide a transmit gain of 12.3 dBiC, and a receive gain of 11.3 dBiC. These increases in the antenna gain improve the downlink budget by 3.3 dB and the uplink budget by 4.8 dB. Because the number of elements in such an L-Band antenna is three to four times greater than that of the UHF type, the cost is expected to be $500 more expensive.

3.4.3 Radio Frequency Power Amplifier

Assuming that the satellite G/T remains constant, the uplink net deficit is calculated to be 12 dB, as shown in Table 2 in section 3.1. Since the antenna can contribute 4.8 dB to reduce the deficit, the remaining 7.2 dB would have to be provided by the mobile terminal power amplifier. Consequently, the power amplifier output is increased from 2 watts to 12 watts. This increase in RF power output is expected to cause the terminal cost to increase by approximately $200. Table 9 provides an overall comparison between UHF and L-Band mobile terminal parameters.

Parameter	L-Band	UHF
Transmit Gain, dBiC	12.3	7.5
Transmit EIRP/Carrier, DBW	23.0	11.0
Transmit Power, Watts	12	2.24
Receive Gain, dBiC	11.3	8.0
Receive Noise Figure, dB	2.0	2.0
Receive G/T, dB/K	-15.8	-19.1
Cost Estimate	$5,200	$4,500

Table 8: Comparison between the UHF and L-Band Mobile Terminal Parameters

3.4.4 DAMA

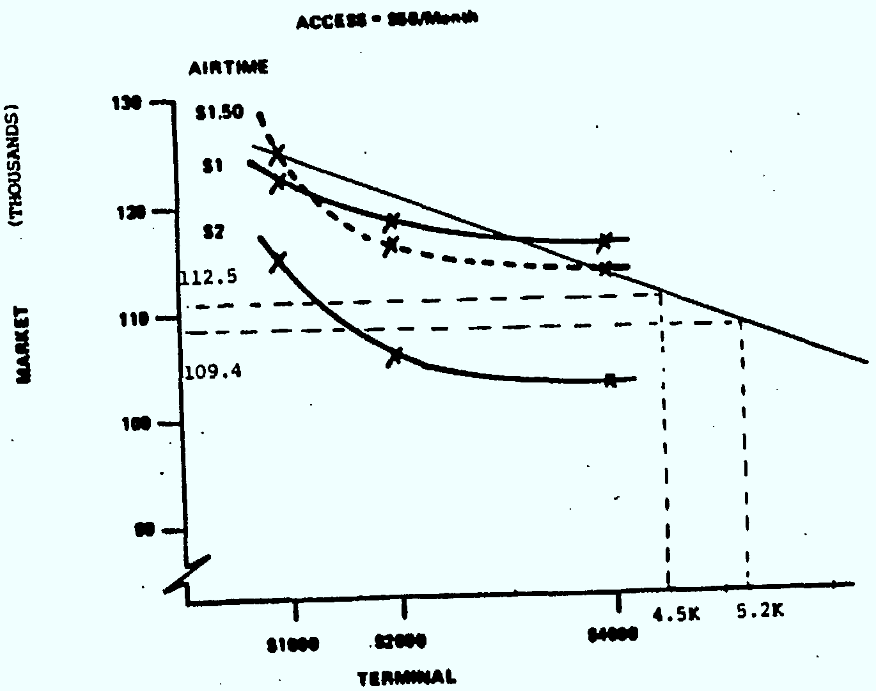
As described in section 3.3, when the operating frequency of the UHF system is changed to L-Band, and the same spacecraft and number of beams are maintained, the number of active carrier is reduced and hence the overall system capacity. The reduction in capacity seems to have little impact on the DAMA hardware because the number of random access channels remains unchanged.

Since the cost of the DAMA system is mainly dependent on protocol algorithms, it is relatively insensitive to the decrease in capacity. However, when the number of beams is increased to six (2 UHF and 4 L-Band) as in the case of a dual band system, the DAMA cost is increased by $3.2M, a 12% increase from the UHF DAMA cost. This is mainly due to the additional DAMA hardware required to accommodate the additional number of beams.

4. Market and Economic Impact

4.1 L-Band Market Forecast

As described in Section 3.4, the L-Band mobile terminal cost is estimated to be $5,200, an increase of $700 as compared to the UHF terminal cost. Based on Woods Gordon's Market demand/price elasticity curve and some extrapolation of the data as shown in Figure 4, this cost increase caused the demand to drop by 2.8%. The curve of interest is the dotted one corresponding to an airtime charge of $1.50 per minute. A straight line going through the two end points is assumed to be an approximation to the curve. From the straight line, it can be seen that when the terminal cost increases from $4,500 to 5,200, the number of terminal decreases from 112,500 to 109,400, a drop of 3,100 or 2.8%. Figure 6 shows the overall impact on the market penetration.



<u>2 DATA POINTS</u>

TERMINAL COST $	NO. OF TERMINAL ('000)
4500	112.5
5200	109.4
DECREASE	3.1
PERCENT DECREASE	2.8

Figure 6: <u>MSAT Potential Market Sensitivity to Variations in Price of User Terminals</u>

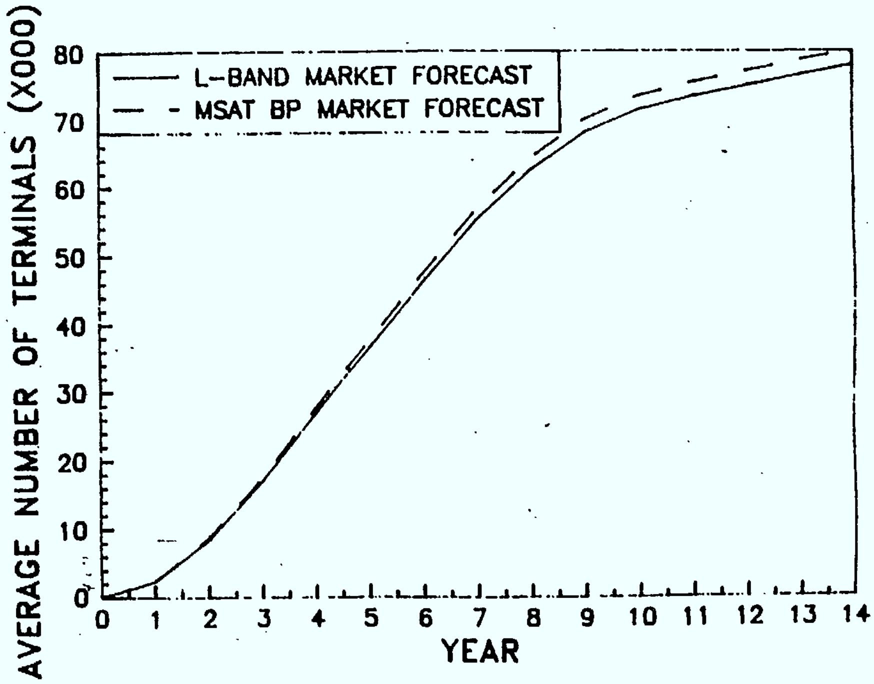


Figure 7: MSAT Business Proposal and L-Band Market Forecasts

4.2 Economic Impact

4.2.1 Summary of Definitions of Reference and Alternative Plans

(1) Reference Plan

The reference plan is the baseline system option as described in the Business Proposal of February, 1985. It can be described as follows:

No. of Beams	2
No. of Spacecraft	2
Class of Spacecraft	PAM D
Operating Frequency	UHF
Feeder Link Frequency	SHF
Payload Configuration	UHF
System Availability	98.4%
System Capacity	35,000
Net Present Value (1984) $MCD	-16

8363z

(2) Alternative Plans

As described in Section 2, there are three alternative plans of using L-Band for MSAT services. Within these three plans, there are various options of implementation. They are summarized in Table 9.

	ALTERNATIVE PLANS					
	Plan 1			Plan 2		Plan 3
NO. OF BEAMS	2	2	4	2 UHF & 4 L-BAND		2 UHF & 2 L-BAND
NO. OF SPACECRAFT	2	2	2	2		2 UHF, 2 L-BAND
CLASS OF SPACECRAFT	PAM D	PAM DII	PAM DII	PAM DII	HS 393	PAM D
OPERATING FREQUENCY	L-BAND	L-BAND	L-BAND	UHF & L-BAND	UHF & L-BAND	UHF & L-BAND
FEEDER LINK FREQUENCY	SHF	SHF	SHF	SHF	SHF	SHF
PAYLOAD CONFIGURATION	L-BAND	L-BAND	L-BAND	UHF/L-BAND	UHF & L-BAND	UHF & L-BAND
SYSTEM AVAILABILITY	97%	97%	97%	97%	97%	97%
SYSTEM CAPACITY	6,000	13,000	21,000	36,000	47,000	UHF 35,000 L-BAND 6,000

Table 9: Summary of Alternative Plans

4.2.2 Economic Study Assumptions

(1) Study Period

The economic analysis was done on all alternative plans for a study period of 14 years, commencing 1984. As shown in Figure 6, it is assumed that the US satellite will be launched in 1990, and the Canadian satellite in 1991. Since the MSAT in-service date is assumed to be 1990, the service is offered via the US satellite during the first year. The operating life of the satellite is assumed to be seven years. Therefore, the end-of-study date is 1997, for a one-generation study.

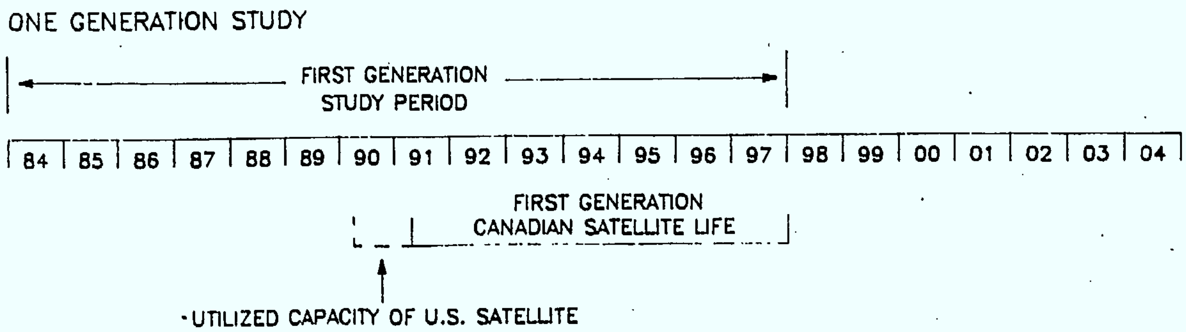


Figure 8: Study Period Assumptions

(2) Financial Parameters

	Rate
cost of long term debt	13%
cost of equity	15%
debt ratio	50%
composite cost of capital	14%
income tax	50%

(3) Customer Charges

	USER'S COST	TELESAT REVENUE	SERVICE PROVIDER REVENUE
ACCESS CHARGE PER MONTH PER TERMINAL	$50.00	$25.00	$25.00
AIRTIME CHARGE PER MIN.	$ 1.50	$ 1.25	$ 0.25

4.2.3 Study Results

The overall results in terms of net present value in 1984 dollar are presented in Table 10.

	ALTERNATIVE PLANS						
	Plan 1			Plan 2		Plan 3	
NO. OF BEAMS	2	2	4	2 UHF & 4 L-BAND		2 UHF & 2 L-BAND	
NO. OF SPACECRAFT	2	2	2	2		2 UHF, 2 L-BAND	
CLASS OF SPACECRAFT	PAM D	PAM DII	PAM DII	PAM DII	HS 393	PAM D	
OPERATING FREQUENCY	L-BAND	L-BAND	L-BAND	UHF & L-BAND	UHF & L-BAND	UHF & L-BAND	
FEEDER LINK FREQUENCY	SHF	SHF	SHF	SHF	SHF	SHF	
PAYLOAD CONFIGURATION	L-BAND	L-BAND	L-BAND	UHF/L-BAND	UHF & L-BAND	SEPARATE UHF AND L-BAND	
SYSTEM AVAILABILITY	97%	97%	97%	97%	97%	97%	
SYSTEM CAPACITY	6,000	13,000	21,000	36,000	47,000	UHF 35,000 L-BAND 6,000	
CUMMULATIVE CAPITAL COST	213	242	265	286	278	405*	466
CUMMULATIVE OPERATING EXPENSE	130	130	130	130	130	130	130
CUMMULATIVE REVENUE	147	284	466	707	827	764	764
NPV (1984) $MCD	-84	-75	-60	-35	-21	-33*	-78

NOTE: *L-Band satellite launch deferred

Table 10: Summary of Economic Evaluation

Plan 1: L-Band System

On the basis of providing a comparable service quality of 97% availability none of the L-Band only options can achieve the same economic viability as the UHF system. The economic impact of replacing the UHF system with an L-Band is a reduction of net present values ranging from $45M to $69M. This is mainly due to the decrease in revenue as the capacity decreases. The impact can be reduced by either lowering the service quality, or increasing the service price, or both. However, it is expected that such strategy may not bring enough improvements to make the L-Band system economically comparable to the UHF system. To improve the net present values of all the L-Band only options to the same value as the UHF system, one would have to lower the system availability, or increase the service price, or carry out both. In any case, the service would change from a mobile nature to a fixed transportable type.

Plan 2: Dual Band System

The systems employing dual-band satellites with a 7 year operating life, have better NPV's than the L-Band only systems. However, they are still not comparable to the UHF system. These dual band systems have $6M to $20M less NPV that the UHF systems.

Plan 3: Separate UHF & L-Band Satellite

In this alternative plan two options of satellite launch were considered.

(1) Both UHF and L-Band satellites are launched in the same time frame;

(2) The L-Band satellite is launched when the UHF capacity is exhausted.

Both cases generate negative NPV's although case 1 out-performs case 2 by $45M in NPV.

5. CONCLUSION

The three alternative plans of using L-Band for MSAT services have been studied on a comparative basis. The results show that there are economic penalties in using L-Band. In terms of net present value, the penalty ranges from $6M to $69M. This is due to the following factors:

1. A higher satellite Effective Isotropic Radiation Power (EIRP) of 32.3 dBW per carrier as opposed to the UHF EIRP of 26.5 dBW per carrier, is required to maintain nearly the same link availability for mobile services.

2. Because the satellite EIRP is increased, the system capacity of a given spacecraft is decreased. Consequently, the revenue is reduced for a given price strategy.

3. The power output of the mobile terminal is increased from 2 watts to 12 wats in order to make up for some of the uplink budget deficit. This drives the terminal cost from $4,500 to $5,200, an increase of 16%.

4. This increase in mobile terminal cost effects a drop of 2.8% on market penetration which directly affects the net revenue.

However, among the three plans, Plan 2 with a dual band payload on a HS 393 bus looks promising. Therefore, it has been chosen as a candidate for further study to find ways and means of improving its viability. The results of such system optimization show that a dual band satellite of the size equivalent to 27% shuttle occupancy in a 10-year service mission can generate a positive NPV of $38M. This is currently the baseline system concept for the revised MSAT Business Proposal. The detailed description of this optimization is contained in "MSAT Business Proposal Update: Scenario Definition and Economic Analysis".

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