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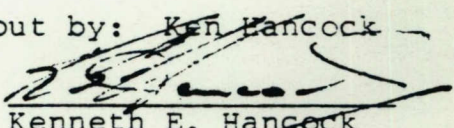
OLYMPUS SATELLITE PROGRAM
PARTICIPATION
BENEFITS STUDY

Carried out for the
Satellite Programs Group
DPM
Communications Canada
under
Letter of Agreement
No 36100-7-0337

Report #003/88
March 1988

Work Carried out by: ~~Ken Hancock~~

Approved by:


Kenneth E. Hancock
President

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Lapp-Hancock Associates Limited

280 Albert Street, Suite 904
Ottawa, Ontario, Canada K1P 5G8
Telephone (613) 238-2483
Telex 053-3576 (Nunasicorp Ott)

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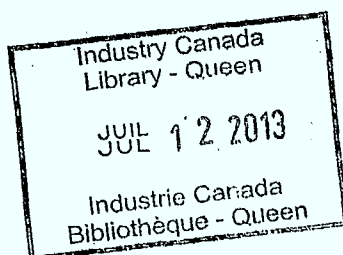
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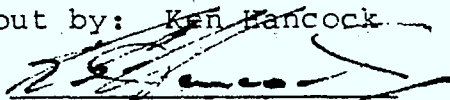
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**OLYMPUS SATELLITE PROGRAM:
PARTICIPATION BENEFITS STUDY**

1.0 INTRODUCTION

Canada, under Agreement for Close Cooperation, participates in selected programs of the European Space Agency (ESA), with base participatory funding supplied by the Ministry of State for Science and Technology (MOSST). As such, Canada receives a percentage of ESA's base study contracts, and has the opportunity to contribute to, and participate in, other major ESA projects such as the Olympus Program. The Canadian Contribution to this program is managed by Communications Canada.

The Olympus Program was proposed by ESA in 1979 following a detailed survey of potential markets - European and non-European - for telecommunications satellites of European manufacture within the next 10-15 years, and was initially called the Large Satellite Program or L-Sat.

The concept proposed was of a multipurpose satellite with sufficient flexibility to support a high proportion of foreseen missions. Further studies carried out by ESA defined a desirable spacecraft platform and subsystems and came to the conclusion that the proposed spacecraft should be compatible with both the U.S. Space Shuttle (STS), and the European Ariane 3 launcher.

Based on these studies, the L-SAT Program was proposed to ESA Member States. In July, 1979, seven ESA states (U.K., Italy, Netherlands, Switzerland, Belgium, Denmark, Spain) agreed to initiate the L-SAT Program; Canada and Austria subsequently joined the program.

Canada's major industrial participants in the program are SPAR Aerospace Limited and Com Dev.

Canada's share of the Olympus program, based on the distribution of contracts between Olympus participant members of ESA was, as of mid 1983, 11.02 percent. This results in a total DOC investment, to date, in the Olympus program of about \$88.5 M consisting of \$80M in contributions to the program and \$8.5M in supporting contracts to SPAR and other

indirect expenditures. The project total investment to completion of the program is about \$100M.

In general terms, Spar's Olympus activities consist of:

- participation as the major subcontractor to British Aerospace Limited (BAe), the Olympus prime contractor, for the complete solar array subsystem.
- The provision to BAe of complete spacecraft assembly, integration and test facilities at the David Florida Laboratory, together with assignment of core integration personnel to the BAe team.
- The development and manufacture, as subcontractors to the Italian company of Selenia, of 12 GHz and 4 GHz channel amplifiers for the communications system payload.

In general terms Com Dev's Olympus activities as a result of this DOC investment consisted of:

- Olympus Microwave Component Sub-contracts to Selenia (Italy) and Marconi Space Systems (U.K.)

Benefits foreseen for Canada were:

- license-free access for Spar to the bus per an existing SPAR/BAe Agreement;
- follow-on sales of bus and payload sub-systems and components for Olympus and other satellites;
- follow-on sales of integration and test services using the DFL facilities; and
- closer continuing relationship with European space firms and customers for space hardware.
- Establishment of a good working relationship between Com Dev and Selenia leading to significant export sales to Italy by supplying sub-systems for ITALSAT

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The purpose of this study is to identify, within the limits of the very limited budget for the study, the benefits accruing to Canada from participation in the Olympus program.

2.0 OBJECTIVE OF THIS STUDY

The objective of this study is to recommend practical means by which the benefits that have accrued, or may accrue, to Canada may be enhanced as a result of the Canadian participation in the Olympus program of the European Space Agency and to update the benefits previously identified in the Mid-Term Review.¹

3.0 BRIEF SUMMARY OF THE MID-TERM BENEFIT STUDY: JANUARY 1985

The Mid-Term Benefit Study carried out in the latter half of 1984, identified, in the light of the space industry environment that existed at that time, the following major benefits likely to accrue to Canada as a result of Olympus program participation:

- The use of the Olympus bus for Telesat programs is now considered unlikely, however RADARSAT will almost certainly use an Olympus bus, modified for low earth orbit operation.
- Current projections of direct sales for the Olympus bus, including the L1, L2 and RADARSAT buses are for a high figure of 19 and low figure of 8. This would generate for Canadian industry direct revenues of \$107.44M and \$45.26M respectively assuming that assembly, integration and test for all buses is carried out in Canada.
- Indirect sales as a result of Olympus are estimated at:
 - . solar arrays: \$150M (low confidence)

¹ Mid-Program Benefit Study of the Olympus Program by Philip A. Lapp Limited, Report #01/85, January 1985.

- . assembly, integration and test: significant but not quantifiable at this time
- . channel amplifiers: \$17.7M
- Major intangible benefits are:
 - . indirect benefits to a large number of suppliers to the Canadian Space industry, thus extending their viability and capability
 - . the availability of the L1 demonstration Olympus for Canadian experiments in the 30/20 GHz band, a matter of considerable future importance to Canada
 - . a positive but unquantifiable impact on Canada's general foreign trading capability
 - . the maintenance of current and future prime contractor capability
 - . a significant improvement of Canada's space industry European market prospects as a result of cooperation with ESA

The mid-program benefit study drew a number of conclusions and made a number of recommendations.

In particular, these recommendations identified potential activities on the part of the Department to enhance benefits stemming from participation in the Olympus program. In virtually all cases these recommendations were acted upon by the Department. Appendix D outlines the conclusions of the mid-program benefit study together with the recommendations and the actions carried out by the Department to fulfill these recommendations.

4.0 MAJOR CHANGES IN THE OPERATIONAL AND MARKET ENVIRONMENT SINCE 1985

Since the mid-program benefits study of January 1985 there have been a number of major changes in the operational and market environments for satellite communications and for space activities as a whole. Unfortunately a number of these changes have tended to have a negative impact on the future potential for Olympus buses and for Olympus based technology.

The changes include, but are not necessarily limited to:

- The conditional approval by the Canadian government of the RADARSAT program
- The definition, and subsequent approval, of a Canadian space plan
- The current significant delay in the announcement of a coordinating body for Canadian space activities (the Canadian Space Agency)
- The refusal by the British government to approve the space plan put forward by the British National Space Centre (BNSC), or to increase the limited provisional funding for British space activities.
- The major disagreement by the British government with the future space plans of the European Space Agency (ESA).
- The emasculation and disarray of the British non-military space program caused by the two previous items.
- A perceived universal trend away from high power direct-to-home broadcast satellites. (The recent failure of the German high power television satellite may reinforce this trend.)
- The space shuttle disaster of November 1985, the subsequent cancellation of commercial payloads on future shuttle flights and the negative impact on all space activities of the continuing failure of the space shuttle program to resume.
- The impact of a string of Ariane launch failures on the European and North American space infrastructure, particularly (when combined with the shuttle disaster) on the space insurance sector.
- The positive impact of the recent successful renewal of the Ariane launch program.

- The appearance on the world launch facility market of a wide range of launch vehicle capacities, including very high capacities, from the Russian, Chinese and Japanese space programs.
- A major, and very significant, development in high capacity, low cost, fibre optic trunks as an alternate technology to point-to-point satellite communications on a trans-oceanic and trans-continental basis.
- The inclusion in the Canadian Space Plan of M-SAT and the current activities of Communications Canada, Transport Canada and Telesat Canada relating to land, Maritime and Aeronautical Mobile Satellites.
- A planning trend towards the use of significant on-board processing for communications satellites and toward multi-band hybrid use communications satellites. Both of these trends are leading toward plans for large bus structures requiring significantly higher levels of primary power as exemplified already by RCA 4000/5000, Hughes 393 and Fordsat derivatives in an extremely competitive environment.

It is against the background of these significant changes in the space industry environment, and in particular those changes impacting upon the market for satellite communications using large bus structures and other uses of such structures, that this study was carried out.

5.0 STRATEGY AND METHODOLOGY FOR THIS STUDY

While viewed as an important asset for future planning of Canada's space activities, and in particular those related to enhancing industrial benefits to Canada stemming from participation with ESA in the Olympus Program, this study has been severely constrained by time (six weeks total elapsed time) and budget (\$5,000 max.) restraints. With these limitations in mind the strategy of the study has been to limit personal interviews to the five key organizations participating in the Olympus program as follows:

- SPAR Aerospace RMS Division (solar arrays)
- SPAR Aerospace Satellite and Aerospace Systems Division (Channel amplifiers)

- Com Dev (microwave sub-systems and components)
- Communications Canada, Satellite Programs Group, DPM.
- Staff of the David Florida Laboratory of Communications Canada (Spacecraft integration and test) and the SPAR team at this laboratory.

Interviews with these key groups have been backed up by a considerable study of the literature* and by the use of the consultant's previously involved in the mid-program benefit study, thus ensuring essentially a zero "learning curve". In addition the consultant's broad knowledge of the major players space industry was drawn upon heavily.

These factors permitted valid conclusions and recommendations for the future to be made despite the constraints of the study.

6.0 INTERVIEW TOOLS

The prime interview tool used in this study were lists of the information that was attempted to be gained from each of the interviews. It has been found that lists of this type are more beneficial to indepth information gathering than are formal questionnaires. The former permit interviews to be structured around the specific interview environment and allow the flexibility to generate the maximum information and informal comments by the interviewees to permit a valid and indepth evaluation of the interviewees perception of the situation. These lists are given in Appendix C.

7.0 INPUTS RELATING TO THE OLYMPUS PROGRAM AS A WHOLE

In this section, and indeed in the subsequent four sections, inputs received from the various interviews are presented. It is considered that to be of greatest benefit in meeting the objectives of this study, significant comments and inputs are best presented essentially in verbatim form but without attribution. Although this will of course provide a certain amount of contradictory input it will permit the

*See Appendix B

analysis of the opinions of the interviewees as a whole and lead to more balanced conclusions. It should be noted that in some instances statements made are at variance with the author's understanding of a given situation and contrary to data enunciated by the scientific authority. In some instances, items not specifically germane to the objectives of this study are included in order to present a more complete picture.

Hereunder are the inputs received regarding interviewees' perception of the Olympus Program as a whole:

- The program has been very useful as an entry to the European market and this usefulness is continuing. Successful Canadian participation has had a major commercial impact on the ability (of this company) to obtain significant contracts in quite unrelated projects in Europe.

It is thus felt that it is very important for Canada to maintain, and indeed increase, its participation in the European Space Agency Payload Spacecraft Development and Experimentation Program (PSDE) particularly the aeromarine satellite payload ARAMIS Program. This program will be the first to use On-Board Processing (OPB) and will have a major impact on the INMARSAT Program. An additional ESA Program in which Canadian participation is important is that of the Earth Observation Preparatory Program (EOPP). Successful Canadian participation in these programs will be of significant benefit to this company and to the Canadian Space Industry as a whole.

- The Olympus bus is too large for current requirements such as M-SAT. It is possible that a second generation M-SAT would require a bus this large either dedicated to mobile satellite requirements or as a hybrid. Unfortunately hybrids have a high inherent launch risk and are not

gaining popularity. Thus with any single payload requirement for a bus of this size for M-SAT being two or three generations away, little encouragement is seen for Olympus. BAe now show little interest in pushing Olympus as a communications payload bus, and have apparently written off the project as a "one off" government purchase. However the experience gained in Canada could be a catalyst for major new sub-systems particularly for the ARAMIS Program. Thus while the original benefits perceived for Olympus have diminished or vanished it is possible that there are other significant intangible benefits and linkages. The entry into Europe which has been achieved could be a valuable commodity.

Care should be taken in considering large buses carrying combination payloads as the intermodulation problems could be severe and this is an area which has received little investigation.

- Considerable analysis has been carried out in Canada to determine the viability of using Olympus for M-SAT and RADARSAT.

With M-SAT becoming a joint U.S. Canadian program the possibility of using an Olympus bus essentially disappeared, particularly as for current M-SAT configurations the bus is too large and too heavy.

RADARSAT is now a team program with the U.K. BAe providing the bus. This would be an Olympus bus modified for low earth orbit (LEO) operation.

Unfortunately the U.K. Government has not yet approved British participation in RADARSAT. There has recently been a major meeting between Prime Minister Mulroney and Prime Minister Thatcher on this matter, but Mrs. Thatcher has deferred making a decision. However she has agreed to a 31st of March, 1988

deadline for such a decision. As RADARSAT is currently the only defined use for the Olympus bus beyond the initial hybrid communications experimental satellite, this decision will have a significant, if not a deterministic, impact upon the future viability of the Olympus bus. While that decision will take place after the completion of this study, recent British Government cuts in their space program do not lead to optimism that the decision will be positive.

It will be recalled that originally Olympus was planned for launch in 1985. The current ARIANE manifest calls for launch in March of 1989. Thus the program has been too long with too many delays and the technology is now tending towards obsolescence. In the meantime competitors such as Ford Aerospace, Hughes and RCA have developed new large buses with current technology aimed towards the low end of the Olympus capacity where the market now appears to be developing. However Olympus will be the first of these large buses to be launched and the approach should be to highlight this fact at the launch period, emphasizing that Olympus is the first high power satellite and that it has flexibility (providing the U.K. decision is positive) to operate in both GEO and LEO. However it is unlikely that a payload customer would look at only one potential bus, i.e. Olympus. When it was unique it didn't attract direct customers. Now that there is potential competition it is unfortunate that this competition has new technology and are mainly derivatives from proven operational satellites, thus giving them the edge. As previously mentioned a possible saving grace may be that Olympus will be the first up and working. However its physical size is a liability and selling Olympus will be

difficult. Notwithstanding this, SPAR is stepping up its PR at Olympus launch time to exploit any possible advantage.

On the positive side SPAR's participation in Olympus has had a number of indirect, but definable advantages. For example the expansion of the David Florida Laboratory (DFL) to accommodate the assembly, integration and test of Olympus has been a great benefit to SPAR in the development of ANIK E, and is expected to be of considerable benefit for future satellite prime contractor activities. In addition, SPAR's experience with the integration, assemble and test of Olympus apparently had a significant impact on Telesat in making the decision to award ANIK E to SPAR. SPAR was seen as having experience in large dual band spacecraft.

In considering the major down turn in direct benefits from the Olympus Program from those projected at the beginning of the project it is perhaps appropriate to review the current status of the various satellite projects making up the forecast Olympus market capture produced by BAe in 1981.

Considering these potential Olympus markets in order, the following current situation pertains:

Projected

Current Situation

- | | |
|--|---|
| • Four Canadian Direct Broadcast Satellites | Requirement dropped |
| • Three Canadian Telesat Communications Satellites | RCA 5000 being used |
| • Three Italian Direct Broadcast Satellites | now considered unlikely with TV Sat failure |

- Four Italian Communications Satellites now considered unlikely with the advance of fibre optic technology
- Five U.K. Direct Broadcast Satellites Hughes bus used and requirement greatly reduced
- Five EuroSat Communication Satellites Eurostar bus being used
- Three Military Satellites Eurostar likely to be used
- Four Western Europe Inter-City Satellites Requirement reduced and Eurostar is being used.

In other markets, the U.S. Department of Defence (DOD) market has been impossible to penetrate and there are now viable domestic alternatives. Telesat is happy with the ANIK E size making selection of the Olympus in the future unlikely. The trend at INTELSAT is for smaller rather than larger satellites. Similarly other potential markets such as future Aussats are unlikely to be attracted to Olympus.

However Olympus has had additional spin-off benefits, in particular the relationship that has been set up between SPAR and BAe. SPAR now have working relationships with three major prime contractors, Hughes, RCA and BAE and has thus broadened its capability.

- It should be noted that with ESA the limitation of Canadian participation is a significant factor. In the 1982/1983 time period SPAR bid on the RF sub-section package for the ERS 1 Program. They won this extremely competitive bid with leads in both technology and price. However, as this would have put overall Canadian participation over the

limit, this award was not made to SPAR. It should be noted however that SPAR did receive the data handling subsystem on this program.

8.0 INPUTS RELATING TO THE SOLAR ARRAY DEVELOPMENT AND MARKETS

Prior to providing the inputs obtained regarding the benefits pertaining to the development of the solar array for the Olympus Program, it is perhaps appropriate to briefly describe this work and its background. Solar arrays are panels of photo-voltaic semi-conductors, usually silicon, that are used in spacecraft to convert solar energy to direct current electricity to provide power for the spacecraft and its payload. The vast majority of spacecraft use these devices for the generation of primary power, although certain specialized satellites may use other power generating devices such as nuclear generators.

Solar panels are of three main configurations. The spin stabilized satellite configuration, typified by ANIK's A, C & D, have their cylindrical bodies clad with solar cells. As the satellite spins, approximately 50% of the cells are in sunlight at any one time and provides power to the satellite. As the number of cells are limited by the surface area of the body of the satellite, this configuration has significant power limitations.

Three axis stabilized satellites commonly use rigid arrays of solar panels arranged on either side of the satellite in a "wing" configuration. The solar panels are stowed during launch and deployed usually in transfer orbit or in final orbit. They are oriented toward the sun to provide maximum power. During the launch phase the panels are stowed against the bus and require a comparatively complex mechanism to deploy them when required. This mechanism, as well as the supporting framework for the solar panels, represents a weight and volume overhead to this power generating device. While able to provide considerably more power than the spin stabilized configuration there is an upper limit set by the size of these rigid panels that can be stowed in the payload launch shroud.

The third configuration of solar arrays embodies the flexible array. In this approach, the solar cells are mounted on a flexible array which is then furled or rolled to occupy minimum space during stowage. Upon deployment an assembly

unfurls the solar panels and provides a ridge tensioning and support mechanism. The panels are then oriented once more toward the sun to provide maximum power. This is a far more complex sub-system than the other two described, and has a considerable mass overhead due to the deployment assembly. However it permits significant increases in power over the rigid array. It is thus most appropriate for larger, high powered spacecraft.

The Olympus satellite being a large, high powered spacecraft uses a flexible solar array designed and manufactured by the SPAR RMS Division in Toronto under sub-contract to BAe. At the time Olympus was designed the "cross-over point" for viability of power levels between rigid and solar arrays was approximately 3 kW. Improvements in rigid array technology, particularly in weight reduction of the supporting structure, has increased this cross-over point to the general area of 6 kW. At the same time improvements in efficiency, consumption and the trend away from very large spacecraft has limited the applications of flexible arrays.

The following information was received from the various interviewees regarding the benefits accruing to Canada from SPAR's flexible solar array work:

- Work on the Olympus solar arrays is not yet fully complete due to an accident (human error) to the astromast during the test of the first flight set of solar panel wings. The broken astromast was replaced with that from the second flight set, and the first flight set is now complete, tested and is now being integrated at DFL. The second flight set is now partially assembled but not integrated. The second flight set of solar panel wings is not on the critical path.

It should be emphasized that the astromast problem was a human error caused by pressure in the testing cycle and not a system or design failure. The mast was repaired by Astro but a second failure occurred due to a defect in the vibration test equipment causing excessive (200g) acceleration during the vibration test. The mast has now been re-repaired and tested.

In addition to the long standing sub-contract for the solar arrays from BAe, SPAR has recently received from BAe an additional sub-contract for the assembly, integration and test of the flight models. This work is being carried out by SPAR, Ottawa.

After the last tests at DFL, the solar cell sub-contractor, AG, will replace some 15 defective cells out of the 22,000 that make up each 3 kw wing.

When Olympus was initially designed, flexible arrays appeared to be the answer to the power/weight ratio problem. Since that time rigid arrays have become lighter so the cross-over point between flexible and rigid arrays has increased to approximately 6 kw.

There are currently two competitors to SPAR in the flexible array market, Lockheed and Solar Dynamics. Lockheed have flown their large flexible array on the shuttle, albeit a non-working model. Lockheed has had problems with a flipped batten. Lockheed's panels are designed to be fully retracting which SPAR'S aren't at this time. Solar Dynamics is taking over the Space Station requirement but not in this phase. There appears to be very little chance of SPAR getting into the U.S. space station or free flyer flexible array market.

- It is seen that the flexible solar array market could well re-awaken when the Olympus flies next year. One of the problems in this market is that the Direct Broadcast Satellite (DBS) market has been very slow in developing. The U.S. private sector has dropped out of it completely. In addition the large bus market has not developed for fixed satellite services. For example INTELSAT VII will be smaller than

INTELSAT VI. Although it is not felt that the development of fibre optic terrestrial trunks has had any major impact on the C-Band replacement market, the hybrid satellite approach that Olympus was designed for has not developed due to the risk factor involved and the lack of a market for the very large number of transponders involved.

Market projections are now much more difficult to determine due partially to the shuttle failure and a general shake-up in the market.

On the military side the Booster Surveillance and Tracking System (BSTS) is a possibility with a 5 to 7 kw requirement. The bidders on this were TRW, Lockheed, and Grummond/Rockwell. SPAR worked with TRW on this requirement but this company was eliminated from the bidding.

SPAR has investigated the possibility of getting into the rigid array market by negotiating with Fokker for flexible array technology transfer in return for rigid array technology transfer. These negotiations have not progressed to the program phase although SPAR has carried out a small market study. The Fokker prices are very high.

SPAR has been looking very seriously at the GPS Block 2R market. This involves some 20 to 26 satellites requiring rigid arrays. Unfortunately from the North American commercial market viewpoint, and from the GPS market viewpoint, the ESA participation in Olympus is seen as a liability. This is primarily due to a perceived R & D mentality and a Committee Design approach by ESA.

With regard to the GPS market, low prices are likely to win. SPAR is looking for a method to bring considerable rigid array technology in-house. In particular they are investigating the feasibility of cell lay-down of the solar array. The technology available at Fleet and Boeing (Winnipeg) is being investigated.

RADARSAT is the key here. If it committed to a rigid array, it would give SPAR an entry into this technology and thus bring down the non-recurring costs.

With regard to GPS Block 2R this is a firm market with a virtually guaranteed follow-on. It is considered that Rockwell is likely to get the GPS Block 2R contract from the U.S. Air Force as its competitor, G.E., has two current major contracts, thus Rockwell will have to be really deficient in its proposal to loose the GPS contract.

- The BSTS has now become a "no foreign participation" project except for government-to-government "cash buy in" situations. SPAR is investigating this. Rockwell are prime contractors for the BSTS bus and discussions between SPAR and Rockwell have taken place. The solar array requirement is for 7 kw but in a rigid array. SPAR had no knowledge of any rigid array supplier capable of producing this power level. Despite the no foreign participation classification of BSTS, SPAR is in the beginning stages of investigating the possibility of government assistance in freeing up the solar array from the no foreign participation restriction. BSTS is a very real program and is likely to go forward regardless of the eventual fate

of the Strategic Defence Initiative (SDI).

Of the SDI programs, SPAR have been reviewing the Space Surveillance and Tracking System (SSTS). It is considered that this has a smaller chance of happening. The solar array requirements are 4 to 5 kw and it is considered that it would be very difficult to get involved in this program as both potential prime contractors, Lockheed and TRW, have their own rigid array capability in this range.

Another potential program is of course the Air Force Space Based Radar (SBR). This has the huge requirement of 30-40 kw.

A further SDI program under review is Zenith Star. This satellite is planned for use in the testing and tracking of radars. It is planned to have a number of arrays for day-to-day operation.

The U.S. Air Force programs have perhaps the greatest potential for selling solar arrays. The programs under review include:

- . GPS Block 2R
- . Defence Satellite Communications System (DESCOS)
- . Defence Meteorological Satellite Program
- . MILSTAR (Data Relay)

The first three of these projects are all in the RFP planning phase for the second generation. MILSTAR is into Block procurement and not much opportunity is seen as the prime contractor, Lockheed, has its own flexible array. However this flexible array does use the SPAR U.S. (ASTRO). astronaut developed for Olympus.

The RFP for GPS Block 2R covering a total of 26 satellites has been issued.

It is felt that Rockwell is in a very good position for this requirement. GPS in the past has had a rigid array but Rockwell is interested in the SPAR packages for 1.2 and 1.6 kw even although SPAR currently does not have a rigid array capability. However the Olympus array capability has given an entry into this door. SPAR is thus looking extremely seriously at developing a rigid array capability. The market is there with RADARSAT requiring some seven panels and each GPS requiring two. Currently SPAR does not manufacture a big enough part of the array. Cell lay-down is required. This would not be viable for a single satellite such as RADARSAT but GPS, with a 26 satellite requirement, provides a more valid scenario for acquiring cell lay-down capability.

SPAR is investigating the possibility of new government investment to assist in achieving cell lay-down capability. Such government assistance would be requested on the understanding that it would only be activated should SPAR receive the GPS solar array contract. The timing here is extremely critical as the agreement must be in place in the next few months. The production RFP is to be in place and contracted by May 1989. By December 1988 Rockwell must have its sub-contractors in place and the contracts signed. Rockwell plan to have the RFP's for the solar panels issued in June with a decision in August or September. Any government agreement must be in place by this time. Discussions with Rockwell are moving into the final negotiation stages now.

Rockwell plan to call for bids on a complete integrated package and compare these bids with the separate panel and adapter approach it is currently using.

SPAR's presentation to Rockwell leaned very heavily on its Olympus experience. SPAR is currently discussing with Rockwell senior staff a visit to DFL to see the facilities and the Olympus solar panels developed by SPAR.

The GPS is seen as a major opportunity. It has survivability requirements (electro-magnetic pulse and laser) and a requirement for a rotating array, all of which capability would serve SPAR well in the future.

Fokker as a potential competitor would appear to have a problem with Rockwell due to security. The use of AG cells would also be a problem thus Canadian sources at Boeing (Winnipeg) and Fleet are being investigated.

The GPS solar array market is seen as being some \$50,000,000 U.S.

The GPS program is a five year one with five satellites per year being required. This would fit the SPAR RMS capability extremely well.

The competition for the GPS solar panels is seen as being:

- . Fokker
- . MBB
- . TRW

As Fokker and MBB are outside of North America, Rockwell will not deal with them directly and they are not considered likely to transfer technology to permit build-to-print in North America. Thus TRW is the major competitor.

TRW has been involved in the GPS Block 2 solar panels. They carried out cell lay-down for 24 of the 26 panels. Rockwell integrated the panels and had major problems. In the re-bid, TRW

lost out, although the problem with the first 24 panels was apparently not theirs. Spectro-Lab, a subsidiary of Hughes, did the cell lay-down for the final two wings. However Spectro-Lab do not make arrays. They would however be a bidder for cell lay-down to Rockwell for the non-integrated package.

In considering the lead time required for cell lay-down five different levels of participation could be used on a year-by-year basis. A fair amount of development could be carried out in Phases C and D. The first spacecraft delivery of this procurement would not be until 1995, at which time Block 3 procurement would commence.

It should be noted that the U.S. Air Force have other smaller procurement requirements for about the same power, but these would not present a viable market unless SPAR was successful with GPS.

SPAR has not currently discussed cell lay-down capability assistance with the Canadian Government, although the DRIE Memorandum Of Understanding (MOU) is a possible approach. SPAR views the GPS Block 2R solar array procurement as key in its business plan and is making major plans to win this contract.

It is possible that SPAR would sub-contract Spectro-Lab for the lay-down of the first few panels if they were successful.

- The commercial market for big flexible arrays is probably limited to Space Station. The quantities are very low with four 20 kw wings for the industrial space facility. The U.S. space facility will have a similar array. It likely however that Lockheed

will be award this contract with their flexible array.

The Columbus European requirement will be a separate module of Space Station, using Space Station power. Columbus future arrays are likely to be rigid.

Columbus could be a target market if the Canadian Government participated significantly in the ESA Columbus program.

The Man Tended Free-Flyer (MTFF) part of Columbus has a 15 kw power requirement and this would probably be made up of 4 kw rigid arrays. It should be noted that the U.K. is not contributing to Columbus if Columbus includes the MTFF.

9.0 INPUTS RELATING TO THE CHANNEL AMPLIFIER DEVELOPMENT AND MARKETS

Prior to providing the inputs obtained regarding the benefits pertaining to the channel amplifier development, it is perhaps appropriate to briefly describe this work. Channel amplifiers are required in the transmit chain of the on-board transponders to amplify the receiver outputs to provide the appropriate drive level for the travelling wave tubes in the Olympus TV broadcast payload amplifiers or in the up converters in the 20/30 GHz payload. In certain circumstances channel amplifiers are incorporated with the transmitter unit and separate amplifiers are not required. Traditionally channel amplifiers can be set to provide steps of gain and are not continuously adjustable. The channel amplifiers specified for Olympus, and sub-contracted by Selenia to the Satellite and Aerospace Systems Division of SPAR broke from this tradition by requiring continuous variation of output. In addition the amplifiers were required at both 4 and 12 GHz. To meet the continuous gain variation requirement a new technique involving dual-gate field effect transistor (FETS) technology was used. The gain flatness and long-term drift requirements of these gain controlled channel amplifiers was a significant step forward in the state-of-the-art.

Four engineering models were manufactured, two at 4 GHz and two at 12 GHz. In addition, six 4 GHz flight models and eight 12 GHz units were manufactured and delivered.

The following information was received from the various interviewees regarding the benefits accrued to Canada from this channel amplifier work:

- Since receiving the Olympus Channel Amplifier sub-contract, SPAR Aerospace have carried out channel amplifier work for both the ANIK E and the INTELSAT VI channel amplifiers. While both of these projects involved both C and Ku-Band channel amplifiers, both were of the stepped gain variety and did not draw directly on the key advances of the Olympus channel amplifiers.
- The Olympus Channel Amplifiers are unique in their use of dual-gate FETS and AGC. They are modularized and the regulator circuitry and fixed gain modules have been used in the ANIK E and INTELSAT V work. These modules, while having specifications equivalent to the industry best do not represent any technological breakthrough.

Most customers currently require fixed gain systems, but it is seen that future satellites with significant on-board processing are likely to require the use of channel amplifiers with continuously variable gain and AGC, as developed for Olympus.

As a result of the Olympus Program a good sub-contractor relationship has been set up with PLESSEY of U.K. PLESSEY supply the dual-gate FET chips. It should be noted that there are no Canadian suppliers of these devices, and while SPAR is searching for a viable second source they have not been successful up to this time. NEC supplied some chips early on in the program, but these were not acceptable

and the sub-contractor relationship with this company did not develop further.

Participation in the Olympus Program has made SPAR considerably more visible among the payload companies of Europe.

- The Channel Amplifier Program has had a considerable positive impact on SPAR's image in Europe. Having developed, built and delivered the channel amplifiers has added considerably to SPAR's and Canada's credibility as sub-system suppliers.

It should be noted that each sub-system requirement is unique, thus the question of selling Olympus channel amplifiers per se does not arise. The exception to this would be a decision on the part of a customer to go ahead with a Olympus with an identical C-Band and Ku-Band payload, a circumstance which hasn't arisen, and is unlikely to arise. The channel amplifier work has permitted SPAR to offer a broad range of communications capabilities, and has been beneficial in this respect.

SPAR bid on the Telecom II channel amplifier requirement but was not successful. It should be noted that Selenia, the prime contractor for the Olympus transponders has not as yet carried out any additional work requiring channel amplifiers in the C or Ku-Bands.

It is felt likely that future Ku-Band payloads will require channel amplifiers and will thus be a market for SPAR. However most future C-Band payloads would incorporate the amplifiers within the transmitter amplifier.

Little direct marketing of Olympus channel amplifiers is being carried out

as this is not appropriate to the marketplace. However the work has generally been useful in expanding SPAR's overall communications payload capability. When there is a specific requirement for channel amplifiers with continuous gain and AGC, the Olympus work will of course be emphasized.

The U.S. channel amplifier market is a uniquely difficult one to enter. Likely customers such as RCA Astro, Hughes, TRW, Ford Aerospace, Rockwell, and MacDonald Douglas all have their own capability. Thus all that is left is the second source market when a conscious "buy outside" decision has been made for whatever reason. Notwithstanding this sales have been made to TRW for communications sub-systems, but this did not involve Olympus technology. In addition, a bid has been made for portions of the space station communications package which could involve channel amplifiers.

There have been no opportunities in the Japanese or in other markets.

There are opportunities for communication sub-systems, including possible channel amplifiers, surfacing in Europe. These include the space station communications package for the European portion of space station, and possibly for a U.K. DBS, should this be funded.

The Olympus channel amplifier work has assisted SPAR and Canada in Europe as most payload integrators are looking for sub-contractors with minimum non-recurring costs.

10. INPUTS RELATING TO MICROWAVE COMPONENTS DEVELOPMENT
AND MARKETS

Once more it is perhaps appropriate to briefly describe this work. The microwave output portion of the Olympus payloads require complex multiplexers and other passive and active microwave components. This work was carried out by Com Dev of Cambridge, Ontario using state-of-the-art facilities to meet the advanced specifications for these components. The work consisted of the design, manufacture and test, including vibration testing, of the complete multiplexers and associated microwave components.

The following information was received from the Com Dev interviewees:

- All multiplexer and microwave component work for Olympus was completed, tested and delivered in 1985.
- The increase in knowledge and technical capability brought about specifically by this work is regarded by Com Dev as being significant.
- As all work is carried out in-house, no Canadian or foreign sub-contractor relationships were built up as a result of this work.
- Olympus has been an entry into most available European markets.
- Com Dev has had very significant sales over the last two years in the European market and it is considered that these opportunities can be traced back to the early ESA/Olympus work. In marketing in Europe track record is the key.
- European contracts have included multiplexers in Ku and Ka bands, switches, loads, isolators and other passive and active components.
- The programs in which Com Dev has been successful subsequent to Olympus have included ITALSAT, ERS-1, and Telecom

2. All of these have been built on the Olympus success of Com Dev.
- It is considered that Canadian participation in ESA, and in particular the PSDE program, is critical to the Canadian space industry. Current work with ESTEC is part of the PSDE program.
 - The ESA ERS program is also of considerable interest to Canada.
 - Com Dev would greatly encourage maximum DOC participation in PSDE. Previous Canadian Government participation in Olympus and other projects has resulted in a documented Canadian Government to Com Dev benefit ratio of 1 to 12 of which 1 to 10 has been off shore contracts.
 - Com Dev has had total space exports of \$80,000,000 over the last five years.
 - Com Dev's current business plan projects a 1-16 ratio of return of government participation. This is based on well defined projects including the expanding defence market.
 - Com Dev does not have a major "no foreign content" problem as there are very few companies of Com Dev's specialized capability in the marketplace.
 - Com Dev is very proud of its world class manufacturing and test facilities but frequently feels somewhat isolated from Canadian Government view. It strongly encourages DOC and other government department staff to visit Com Dev facilities in Cambridge. The position of Com Dev is that due to the difficulty of accessing Canadian Government space programs it has been forced to develop markets elsewhere, albeit with considerable success. SPAR is not a major customer of Com Dev.

There is considerable concern at Com Dev over what it is perceived as the unbalanced distribution of Canadian space contracts.

- Com Dev participated in the DND EHF Satcom studies at their own expense and is very satisfied with this work. It is understood that DND will issue a Statement of Interest for systems studies in the EHF follow on work. EHF Satcom draws heavily upon the ESA work.

11.0 INPUTS RELATING TO THE ASSEMBLY, INTEGRATION AND TEST OF OLYMPUS

The David Florida Laboratory (DFL) of the Communications Research Centre (DOC) is a world class satellite assembly, integration and test facility. As such it is used by many, if not all, of the private sector companies making up Canada's space industry for the testing of satellite components and sub-systems. In addition, it is used by SPAR Aerospace, Canada's sole satellite prime contractor, for the assembly, integration and test (AIT) of complete satellites and by government organizations such as NRC. Finally, the facility is used on occasion by foreign space companies for similar activities. All work is carried out on a cost recovery basis.

The Olympus prime contractor, BAe, sub-contracted with SPAR Aerospace for support in the AIT of the Olympus spacecraft. They in turn have sub-contracted with DFL for the use of the DFL test facilities.

The AIT of the flight model of Olympus is currently being carried out at the DFL using a team made up of BAe and SPAR personnel.

DFL invoices SPAR on a regular basis for all support facilities provided to the Olympus program under a formal contract between DFL and SPAR. SPAR in turn reflects the amounts concerned in their billings to BAe under the sub-contract for AIT support, for ultimate payment via ESA. The total revenues generated to DFL from the Olympus program up to October 1988 (the completion of the AIT phase) are expected to amount to \$1,800,000. This does not include the solar array development testing, or the ground

support equipment, for which a fee waiver of \$1,233,000 has been granted by Treasury Board. Of this, approximately \$800,000 has been used.

The following information was received from both CRC and SPAR personnel regarding the benefits accruing to Canada from the Olympus Assembly, Integration and Test activities:

- The large size and multiple payloads of the Olympus spacecraft has required significant expansion of the DFL facilities which has resulted in Canada being able to offer to its space industry, and indeed to the world, satellite AIT facilities of world class with some features unmatched elsewhere.

The improvements made for the Olympus activities fall into two parts. The first and most major part consists of generic improvements to the laboratory. These include a complete, new large Bay, Bay III, and significant extensions to the thermal laboratory. This work was funded through a specific Treasury Board submission at a cost of \$5,500,000 and is of course available for future programs such as ANIK E, RADARSAT, MSAT, etc.

The second part of the expansion is the addition of program specific capital equipment. The specific test equipment required for Olympus has been quite extensive and has been paid for by the Olympus program. Much of this test equipment has been brought in by BAe and operates on 50 Hz prime power. The laboratory has therefore been completely wired for 50 Hz prime power as well as the standard North American 60 Hz prime power. This has improved its attractiveness to European users.

The prime improvement to the thermal laboratory was the development of an infrared (IR) thermal test system to eliminate the need for a solar simulation (SS) test. This system is

extremely flexible with the intensities and positioning of the IR sources being computer controlled to permit flux distribution to be tailored closely to specific spacecraft. The ± 0.20 C temperature measurement accuracy is the current state-of-the-art and uses an innovative, probably unique, DFL developed approach to achieve this. The IR system has the advantage of being able to simulate end-of-life conditions and eliminate spacecraft orientation problems. It permits the simulation of other parameters such as albedo and planet shine effects. It thus has considerable advantage over the SS approach. It will be used extensively for ANIK E and other future AIT activities. ESA is committed to providing full correlation information with the SS system for the Olympus program. Although the approach is being used by RCA in simple form, the DFL system is considerably more advanced. The flexibility of this thermal test approach contrasts with the solar simulation facilities in which ESA has invested heavily.

A major facility in Bay III is the new large seismic facility designed for large spacecraft. Using an innovative design approach that improves the tensional stress characteristics of the seismic block, it provides a 3-100 Hz unresponsive block for modal testing. This facility is backed up by world class documentation. Large spacecrafts such as RADARSAT will depend critically on modal testing for which this state-of-the-art seismic block is a necessary base.

Vibration and mass measurement facilities have also been significantly improved and the rigs for the solar arrays may be re-used for Olympus derivatives. The vertical guidance system can withstand a 3,000 pound load

and with air bags, over 8,000 pounds. Significant improvements in the processing capability reduces testing time. This facility is now fully proven and will be applicable to ANIK E and other spacecraft.

The Olympus was the first spacecraft to have complete electro-magnetic compatibility tests with the entire spacecraft in DFL an anechoic chamber. The chamber has been modified to provide the equivalent of a shielded room and is now suitable for any large spacecraft in the C, Ku and Ka frequency bands. It is thus suitable for future DND EHF work and the space based radar as well as ANIK E and RADARSAT.

Significant improvements have been made to the overall data processing facility.

The Olympus program has required a massive documentation process to European standards which is now essentially complete. This will stand DFL in good stead for future European work.

The vibration testing of Olympus involving the spacecraft full of fuel substitute has provided DFL with invaluable experience in the safe handling of toxic fuel substitutes.

The Olympus program called for the assembly bay (Bay III) to have a clean room rating of 100,000. After modification the facility is an order of magnitude better than this, with frequent readings below 1,000. This performance was so good that the monitoring equipment was initially disbelieved by the BAe inspection staff.

Should the RADARSAT go ahead using a modified Olympus bus produced by BAe, with SPAR producing the payload, it is expected that the final AIT would be carried out at DFL. However, the DFL facility is ideal for the basic integration of the BAe bus. The RADARSAT team seems not to have pursued this approach to any significant extent with BAe and it is recommended strongly that an aggressive marketing effort should be undertaken on the part of the RADARSAT team to obtain this work for DFL.

The Olympus program has given a high profile to DFL at ESA. The Program Manager of a space science satellite, the Solar and Heliosphere Observatory Satellite (SOHO) has expressed preference for DFL in carrying out the AIT for this program. SOHO is an ESA/NASA program and would thus not have the Canadian participation in the requirements of other ESA projects. A quid pro quo is being discussed whereby the Space Sciences Directorate of NRC would be permitted to fly instrumentation, free of charge, on the ESA CLUSTER program, operated under the same Project Manager. The Space Sciences Directorate would then pay DFL for the SOHO AIT work. As DFL charges would be in the order of \$5,000,000 and the value of the CLUSTER facilities would be in the order of \$50,000,000 if Canada were to share in the normal manner, such an agreement, if finalized, would be extremely beneficial to Canada. One of the major drivers for this work is the extreme cleanliness of the DFL AIT facilities as described above.

A benefit to Canada which is a probable result of the higher profile in Europe brought about by the Olympus work is the fact that Dilworth, Secord, Mar and Associates have won a bid to supply an

acoustic test facility for ESTEC. This high level acoustic facility provides a noise level of 150 dB above ambient. NAE has been active in assisting the procurement of this program. The original contract was worth approximately \$5,000,000, but this has recently been increased to approximately \$7,500,000, with the size of the acoustic chamber significantly increased.

An indirect benefit of the Olympus AIT work which is not normally considered, is the fact that approximately 40 BAe and ESTEC staff have been located in Ottawa for up to 18 months. Based solely on the known per diem for these staff members this has brought over \$2,500,000 into the Ottawa area. In addition many of the staff members, have brought their families. As well as these semi-permanent staff members the work has necessitated a very large number of short term visits from ESA and BAe staff which has also brought additional wealth into the area.

- The Olympus program AIT activities have created a very positive impact on Canada's capability in this area. However the program has gone on far too long. If the original launch date of 1984 had been met it could have been considered a very good program.

The AIT team has now been working on Olympus for seven years, to European standards and methods. While this has been a good experience the extended period has inhibited the use of this team, and its experience, on other projects such as ANIK E. One team member will soon be transferred to Space Station work but this project will use only a small number of the Olympus team, and those not immediately. At the completion of the Olympus work, towards the end of 1988,

team members will be available for RADARSAT and M-SAT work when this is appropriate.

The British government has very recently stated that it can't make the RADARSAT decision by the end of March as previously proposed. As a result of this Canada is now considering as a matter of priority, alternate U.S. buses for RADARSAT. This of course could have a major negative impact upon the Olympus program and follow on AIT activities.

Olympus has provided invaluable experience in flight spacecraft which will be needed for ANIK E, RADARSAT, etc.

Many new facilities have been developed including the in-line bearings for vibration, new acoustic tests at NAE, the HAMS facility and many other expanded facilities at DFL. A very great deal of this equipment will be used for ANIK E and for other spacecraft. DFL can now be considered a true world class AIT facility.

The development of an infrared thermal facility for use instead of solar simulation is a major improvement that SPAR is developing further with its own and government funding. This facility will be used for ANIK E. Without the new IR facility neither the Olympus thermal testing nor the ANIK E thermal testing could have been carried out in Canada. Notwithstanding this, it has been difficult to convince ESA and the European community of the flexibility, usefulness and validity of IR testing as a replacement for SS. Perhaps in part this is due to the fact that ESTEC has recently made a major investment in solar simulation facilities and does not want to accept that IR testing is a better choice in many circumstances.

This has been reflected the fact that far tighter tolerances (10%) have been placed upon the specifications for IR testing as compared with those for SS testing (30%).

SPAR will be using infrared testing for ANIK E thermal balancing and the thermal model has already been further developed using MOU funding. This is a very significant development and the DFL measurement system is the best in the world.

Discussions have taken place with the ESA/NASA SOHO team regarding the use of DFL facilities for AIT work on this spacecraft. The team were very impressed but nothing has been heard from them recently.

The big thing now is to get Olympus AIT completed and the satellite launched. Current launch date is March, 1989 but ARIANE Aerospace will be issuing a new manifest in April to confirm this date.

12.0 CONCLUSIONS

From the inputs derived from interviews with all key participants in the Canadian Olympus activities; from a study of the literature; from discussions with Communications Canada staff participating in the program, and from the knowledge and experience of the consultant for this study, the following conclusions regarding benefits to Canada from the Olympus satellite program have been drawn:

- Canadian participation in the ESA Olympus program has been instrumental in significantly developing the capability of SPAR Aerospace, Com Dev and the David Florida Laboratory in the following state-of-the-art satellite communications activities:
 - . assembly, integration and test of large spacecraft to world leading standards;

- . the development, manufacture and test of state-of-the-art space segment multiplexers and microwave components in the Ku and Ka bands. The manufacturing and test facilities developed for these components are a major step forward in Canadian satellite communication capability and are currently unsurpassed anywhere in the world;
- . the development, manufacture and test of flexible solar arrays capable of producing high primary power levels for large spacecraft;
- . the development, manufacture and test of C band and Ku band spacecraft transponder channel amplifiers. These amplifiers represent a significant step forward in technology by providing continuously variable output by the use of an automatic gain control (AGC) in conjunction with dual-gate FET state-of-the-art, solid state technology.
- The Olympus satellite was designed to prove out the concept of a large, high power communication satellite capable of providing direct broadcast TV capabilities and point-to-point satellite voice and data capabilities concurrently in the Ku and Ka bands, thus meeting a perceived high demand for these facilities in an innovative and cost-effective manner. As such it was expected to be the precursor of a generic line of operational spacecraft, and to lead to a very significant direct return on investment for all participants.

The program commenced in 1979 and the first launch was planned for 1984. Considerable slippage of this schedule has taken place with the first launch now expected in March 1989. Over this extended period of development, manufacture and test of the Olympus spacecraft the whole satellite communications environment has changed significantly. Key changes that have

impacted upon the viability of the Olympus bus and its payloads are:

- . the withdrawal of essentially all potential participants from the high power, direct broadcast satellite market;
- . the development of low cost terrestrial fibre optic trunk systems that has significantly reduced the market for high capacity point-to-point satellite links;
- . a series of satellite launch disasters in the Western world which eliminated the total launch capacity for a period of time, created huge backlogs in satellites waiting to be launched, and has significantly affected the credibility of satellite communications in the eyes of investors, financiers, and insurers;
- . the trend towards larger and larger spacecraft has plateaued in the general area of the Olympus bus size, but with technological improvements in weight and reduced solar power requirements which has tended to leave Olympus obsolescent even before launch.

Because of these factors the direct returns that can be expected from Olympus "follow on satellites" or from Olympus derivatives have very significantly diminished or vanished.

- In the time period covered by the Olympus program the U.S. commercial communications satellite market has tended towards saturation concurrent with a strengthening of domestic manufacturing capability. At the same time the military satellite market in the U.S. has expanded greatly, but in the majority of cases is inaccessible to Canadian manufacturers due to the "no foreign access" policy. Thus the European space market has gained a far greater

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significance for the Canadian space industry. Participation in Olympus has given a high profile in Europe for SPAR Aerospace, Com Dev and the David Florida Laboratory. These organizations have successfully exploited this market and have very significantly increased their exports to Europe. Most participants see this success as directly related to their Olympus activities. In addition other Canadian companies, not participating in Olympus, have also successfully entered the European market. While not necessarily having a direct impact on this increased market share by non-Olympus participants, the Olympus program has assisted in developing a positive climate in Europe towards the Canadian space industry as a whole. This situation shows every sign of continuing with major European space contracts being obtained by Canadian participants within the last month, with a number of others currently under negotiation.

New
involvement

- The use of a modified Olympus bus for RADARSAT appears to be the most likely, and indeed the only, potential direct use of the Olympus bus technology that can realistically be projected after the launch of the initial flight model. Unfortunately this application is predicated upon U.K. accepting responsibility for the modification of the Olympus bus for low earth orbit. Overall British government support of space is currently at a nadir. The promised U.K. government decision on participation by the end of March, 1988 has now been delayed, apparently causing the RADARSAT team to give serious consideration to alternate U.S. buses. Significant delay either in the U.K. decision, and if this should be positive, in the implementation of the modifications to the bus by BAe, could start RADARSAT on the same disastrous rounds of delay that, in the opinion of the writer, has cost Olympus its place in effective, operational space technology.

- The market for Canadian flexible solar arrays has diminished extensively with improvements in rigid array technology; the effective demise of the high power DBS market; and the development of competitive flexible arrays by Lockheed with its dominating position in the U.S. military and commercial market for these devices. To counter this critical change in market direction, SPAR Aerospace is rigorously addressing mechanisms for developing rigid solar array capability and entering the lucrative U.S. military market for these devices. Consideration of this activity is however only marginally connected with the Olympus program.
- There is currently a well defined trend towards the use of considerable on-board processing (OBP) in future communications satellites to provide flexibility of use and a buffer against changing applications and markets. The technology derived from the development of Olympus multiplexers, microwave components and channel amplifiers are likely to give Canada a significant advantage in this market. In particular, the multiplexers and microwave components have already provided Canada with an excellent return for the DOC investment in the development of these components. It is further concluded that future support of ESA programs where such technology could be used is likely to be very beneficial to Canada. Such programs would include ARAMIS and the satellite-to-satellite microwave links in the ESA PSDE program and the ESA ERTS program.
- The Olympus program has been instrumental in greatly improving the AIT capabilities of the David Florida Laboratory. While providing world class, and in some cases unique facilities for the assembly, integration and test of Olympus to unprecedented standards, these facilities are now available for the AIT of ANIK E, M-SAT and RADARSAT. In addition DFL's North American competence in AIT will stand it in

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good stead in attempting to attract both U.S. and European AIT contracts. Potential examples of this are the Space Based Radar and the ESA SOHO satellite.

- While the likelihood of significant follow on use of the Olympus spacecraft with its current communications payload is considered very minimal, it will still be the first commercial communications satellite of this size and complexity to be launched. Besides such features as the flexible array, it will provide such facilities as concurrent high power Ku band transponders and Ka band transponders. It will be very much in the interest of future spin off markets for the Canadian space industry to publicize Canadian participation in Olympus to the maximum extent at time of launch.

13.0 RECOMMENDATIONS FOR THE FUTURE

In this section will be made the recommendations for future activities on the part of the Satellite Programs Group, based upon the conclusions drawn above, by which the benefits to Canada from participation in the Olympus program may be enhanced. It is therefore recommended that:

- Funding and support for the Olympus program be maintained until launch and for the in-orbit trials and demonstration phase. At the time of launch maximum publicity should be given to Canada's participation and achievements in the Olympus program. These should include the DFL facilities, the facilities for manufacture and test of multiplexers and microwave components, the flexible array capability and the variable output channel amplifier capability. Ministerial participation in these public relations activities should be sought.
- Unless there is a significant change in the defined market for Olympus follow on satellites, no additional government funding, other than that identified above, should be allocated to the Olympus program.

- Done.*
- There should be an immediate inter-departmental investigation into appropriate mechanisms to apply pressure to the United Kingdom for a positive decision on the modification of the Olympus bus by BAe for use by RADARSAT. Possible mechanisms for this activity could include direct contact with Dr. J. Leeming, Acting Director, British National Space Centre; joint representations with the RADARSAT Office; approaches through the Inter-Departmental Committee on Space; continued joint action with the Department of External Affairs and the Prime Minister's office, and cooperative approaches with the senior corporate management of SPAR Aerospace.
 - Recognition in future Communications Canada plans that ESA, and the European market as a whole, is becoming the major source of joint forward thinking space R&D accessible to Canada. Enhanced participation in carefully selected ESA programs such as PSDE should be strongly pursued. However in assessing the benefits to Canada to justify such increased participation, it should be recognized that indirect returns are likely to be of greater long term benefit than are direct returns that are subject to changes in environment and attenuation due to delays.
 - That recognition to the fact that a high profile and reputation in the European market has been achieved by the participation in the Olympus program by the Canadian space industry.
 - That further analysis be carried out to identify those areas of government support that have been most successful in the past in terms of cost benefit ratios with a view to emphasizing government support in these areas in the future.
 - That additional analysis be carried out to identify those projects within the ESA PSDE program, the ERTS program and other

appropriate ESA programs where increased Canadian government support is likely to have a major multiplying factor on Canadian space industry activities. This should emphasize, but not necessarily be restricted to, those space industry activities for which the Olympus program has acted as a catalyst. The investigation should include the determination of appropriate levels of funding to optimize potential return ratios to Canada.

- The greatly advanced capabilities of the David Florida Laboratory for large and small spacecraft assembly, integration and test brought about by the Olympus program should be exploited to the full. A significant, but appropriate, P.R. program should be inaugurated in both the European and U.S. markets to maximize the use of DFL for both spacecraft and subsystem AIT requirements by these non-Canadian space communities. In addition to a broadly aimed campaign, specific requirements should be dynamically pursued. As part of this it may be appropriate to implement an immediate study to determine the most appropriate projects to pursue.
- That consideration be given to positive (but not financial) support of the likely SPAR proposal for the development of a rigid solar array capability under the DRIE MOU.

* * *

APPENDIX A

List Of Interviewees and Contacts

- | | |
|--------------------------------|---|
| 1. Mr. Graham Booth: | Chief; Satellite
Programs; DPM,
Communications Canada |
| 2. Dr. R.W. Breithaupt: | Director General,
Communications
Applications,
Communications Canada |
| 3. Mr. Vic A. Wehrle: | Directorate of Space
Mechanics,
Communications
Research Centre;
Communications Canada |
| 4. Dr. Rolph Mamen: | Director; David
Florida Laboratory,
Communications Canada |
| 5. Mr. George Skinner: | Director, SPAR (DFL)
Operations |
| 6. Mr. Charlie Dannemann: | Director, Space
Systems & Products,
RMS Division, SPAR
Aerospace |
| 7. Mr. Brian R. Fuller: | Manager, Business
Development, Space
Systems & Products,
RMS Division, SPAR
Aerospace |
| 8. Mr. Bradley C. Bourne: | Marketing Manager,
Space Systems &
Products, RMS
Division, SPAR
Aerospace |
| 9. Mr. W.E. (Bill) Stanbridge: | Program Manager,
Olympus, RMS
Division, SPAR
Aerospace |

10. Mr. J. Gareth Lewis: Manager Business Development, Spacecraft Prime Contracts; Satellite and Aerospace Systems Division, SPAR Aerospace Limited, Ste-Anne-de-Bellevue
11. Mr. Bob Borbridge: Manager Business Development, Satellite and Aerospace Products; Satellite and Aerospace Systems Division, SPAR Aerospace Limited, Ste-Anne-de-Bellevue
12. Dr. O. Osborne: Director, Advanced Development, Satellite and Aerospace Systems Division, SPAR Aerospace Limited, Ste-Anne-de-Bellevue
13. Mr. Graham Arbery: Project Supervisor, Receiver and Channel Amplifier Section; Satellite and Aerospace Systems Division, SPAR Aerospace Limited, Ste-Anne-de-Bellevue
14. Mr. Val O'Donavan: President, Com Dev, Cambridge, Ontario
15. Mr. Ken Alstaff: Marketing Director, Com Dev, Cambridge, Ontario

APPENDIX B

Documents Used

1. Statement of Work: Olympus Program Study; Communication Canada; February 1988.
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APPENDIX C

INTERVIEW TOOLS

OLYMPUS SATELLITE PROGRAM:
PARTICIPATION BENEFITS STUDY
INFORMATION REQUIRED FROM INTERVIEWS

- 1 FROM ALL INTERVIEWS
 - 1.1 Reference Information:

Company Affiliation: Name & Address
Interviewee(s): Name, Position & Phone #:
 - 1.2 General comments on past, present and future of Olympus program
 - 1.3 Any perceived major limitations, constraints, or benefits to Canadian participation in the Olympus program
 - 1.4 Comments on the viability of Olympus as major competitor for the large bus market
 - 1.5 Comments on the perceived size of the large bus market 1990 to 2005

2 FROM SOLAR ARRAY INTERVIEWS

2.1 Is All Solar Array Work for Olympus Now Complete

2.2 Comments on Increase In Knowledge and technical Capability Brought About Specifically by the Olympus Solar Array Contract. Techniques, power capacity, etc.

2.3 Comments On Sub-Contract Relations Built Up By Olympus Solar Array Work

2.3.1 Canadian
2.3.2 Foreign

2.4 Has the Olympus Solar Array Work Led To Any New Work, Contracts or Sales

2.4.1 Directly
2.4.2 Indirectly

2.5 Perception Of Future Markets For:

2.5.1 Olympus Solar Arrays
2.5.2 Other Solar Arrays Using
 Olympus Derived Technology

2.6 Is SPAR Currently Investing In:

2.6.1 Significant Marketing Effort
 Based On Olympus Developed
 Solar Array Technology
2.6.2 Significant R & D activity to
 improve/modify Olympus solar
 array technology to meet future
 market needs

2.7 Has the Olympus Solar Array Work Improved SPAR's Market Position:

2.7.1 In Europe
2.7.2 In U.S.
2.7.3 In Canada

3.0 INFORMATION REQUIRED FROM CHANNEL AMPLIFIER INTERVIEWS

3.1 Is all channel amplifier work for Olympus now complete, if so when was it completed, if not when will it be completed

3.2 Comments on the increase in knowledge and technical capability brought about specifically by the Olympus channel amplifier contract. What improvements in noise figure, bandwidth and other parameters were achieved

3.3. Comments on sub-contract relations built up by the Olympus channel amplifier work

3.3.1 Canadian

3.3.2 Foreign

3.4 Has the Olympus channel amplifier work led to any new work, contracts or sales:

3.4.1 Directly

3.4.2 Indirectly

3.5 Comments on the perception of future markets for:

3.5.1 Olympus channel amplifiers

3.5.2 Other channel amplifiers using Olympus derived technology

3.6 Is SPAR currently investing in:

3.6.1 Significant marketing effort based on Olympus developed channel amplifier technology

3.6.2 Significant R&D activity to improve/modify Olympus channel amplifier technology to meet future market needs

3.7 Has the Olympus channel amplifier work improved SPAR's market position in:

3.7.1 Europe

3.7.2 U.S.

C-5

3.7.3 Canada

3.7.4 Elsewhere

3.8 Any other comments on Olympus channel amplifier work,
past, present, future.

4.0 FROM MICROWAVE COMPONENT INTERVIEWS

4.1 Is all Microwave Component work for Olympus now complete. If yes, when was it completed, if no when will it be completed.

4.2 Comments on increase in knowledge and technical capability brought about specifically by the Olympus Microwave Component Contract.

4.3 Comments on new techniques, frequency bands, power capacity, isolation and other parameters.

4.4 Comments on sub-contract relations built up by the Olympus Microwave Component work:

4.4.1 Canadian

4.4.2 Foreign

4.5 Has the Olympus Microwave Component work led to any new work, contracts or sales:

4.5.1 Directly

4.5.2 Indirectly

4.6 Perception of future markets for:

4.6.1 Olympus Microwave Components

4.6.2 Other Microwave Components
using Olympus derived
technology

4.7 Is ComDev currently investing in:

4.7.1 Significant marketing effort
based on Olympus developed
Microwave Component technology

4.7.2 Significant R&D activity to
improve/modify Olympus
Microwave Component technology
to meet future market needs

4.8. Has the Olympus Microwave Component work improved ComDev's market position:

4.8.1 In Europe

C-7

4.8.2 In U.S.

4.8.3 In Canada

4.8.4 Elsewhere

4.9. Any other comments on Olympus Microwave Component array work past, present or future.

* * *

APPENDIX D

CONCLUSIONS OF MID-TERM BENEFIT STUDY (1984/85)

- There can be no doubt that since the 1981 assessment, the more direct benefits to Canada of participation in the Olympus program have significantly decreased. This has been caused primarily by the general turn-down in the world-wide economy which in turn has impacted negatively upon the rate of increase of the communications satellite market in general, and that portion of the market to be served by large satellites in particular.

Notwithstanding this, this mid-program assessment of Olympus is seen as providing sufficient indication of benefits to justify Canada's continuing participation in the Olympus program, and in the European Space Agency.

- One of the major new thrusts in the Olympus program has been that of recognition of its potential significance for low earth orbit requirements, such as Radarsat, and the investment by the British Government of significant sums to meet this requirement. There is every likelihood that the Olympus bus, with certain modifications, would be used for Canada's Radarsat satellite, and this could well be the first use of a production Olympus bus, albeit in modified form. This in itself could give Canada very significant negotiating power in ensuring not only that SPAR is prime contractor but the Canadian content is maximized. It should also stand Canada in good stead if, as it seems likely, this market for large remote sensing satellites develops.
- With regard to the prime purpose of the original Olympus development, that is as a geosynchronous multi-band, multi-purpose communication satellite, the current market has decreased significantly. Although there is likely to be a market for this type of satellite in the future, advances of technology, and the delays caused by the economic situation, could well put the time slot for the use of such large buses with Olympus technology outside of the expected usual time frame for the first generation Olympus. Thus although it is seen (see Table 2) that at least eight Olympus buses, including the two initial units, would be sold, with possibly a maximum of 19, the likelihood of continuing significant production now seems remote. A number of interviewees have repeated the theme that "Olympus is five to ten years ahead of its time and market".

- Notwithstanding the reduced expectations identified above, the Olympus program has acted as a significant catalyst in Canada's space program, particularly in the development of assembly, integration and test facilities capable of handling the largest spacecraft currently planned, and of providing world class service; and in the development by SPAR of state-of-the-art satellite channel amplifiers. Both of these areas of activity appear destined to provide considerable indirect sales in the future.
- The future of the solar array development stemming from the Olympus program appears to be more in doubt. Spacecraft requiring the powers developed by SPAR's flexible arrays (up to L-Max) have been delayed, while at the same time rigid array technology is improving to break into these power brackets. While a turnaround of this situation is not inconceivable, it certainly cannot be predicted with any certainty.
- The intangible benefits of Canada's participation in Olympus appear to be significant. Only one of the persons interviewed felt that Olympus had not had a significant impact upon the ability of Canada's space industry to compete in the international market. Paradoxically this one company has successfully competed in Europe, and several other interviewees see at least part of its success as stemming from a higher Canadian visibility in Europe due to the Olympus program.
- A considerable number of Canadian subcontractors have been used in the Olympus program, and while many of these were already suppliers to Canada's aerospace industry, some of them are newly developed. In all cases the Olympus program has assisted in providing a continuing space related market to these subcontractors and assisted in building Canada's international space capability.
- A benefit of the Olympus program not previously documented is the right of Canada to use the 30/20 GHz payload of the Olympus demonstration model for Canadian experiments. The Department has submitted to ESA a proposal for CRC to carry out such technical experiments. As there is no other satellite available to carry out such experiments, and given Canada's previous dynamic approach to the utilization of new communications satellite frequency bands, such expeditious use of this right by the Canadian government is the first step to putting Canada in a

competitive position for timely exploitation of this frequency band.

- Two new potential applications of the Olympus bus, as space station "free flyers", and as near polar orbit, multi-sensor, remote sensing satellites, could well open up areas of utilization of the Olympus bus not previously considered.
- It is seen that, due in part to the Olympus program, Canada's image as a competitive force in the international space industry has been considerably enhanced since the 1981 assessment. A "space infrastructure" of professional services in the international banking, insurance and legal fields relating specifically to the space industry is now developing in Canada.
- There has been a strong, but patchy, impact on Canada's international trading ability. Up until recently Canada's image as a provider of wheat and forest products has hindered the sales of high technology goods on the international market. Olympus, among other programs such as Canadarm and Brazilsat, is materially assisting in changing this image.
- There is some reason to conclude that current marketing of Olympus, and in particular the utilization of the L2 model on a commercial basis, has been less than adequately pursued. One factor in this lack of marketing success could be the low utilization factor of STS cargo space due to the current solid fuel type of perigee motor. STS launches are therefore comparatively expensive.
- The majority of the marketing of Olympus is carried out by the Olympus Policy and Marketing Committee (PMC), an organization made up of representatives from the industrial participants in Olympus, and which operates primarily on a consensus basis. Because of this it perhaps lacks the dynamism to optimize Olympus marketing thrusts in a rapidly changing environment. Thus despite a significant investment in Olympus (approximately \$85 million), the Department of Communications lacks a mechanism for on-going monitoring and participation in Olympus marketing related decisions and initiatives.

RECOMMENDATIONS AND ACTIONS TAKEN BY DOC
IN RESPONSE TO THE 1984/85 STUDY RECOMMENDATIONS.

RECOMMENDATIONS

At the Department of Communications investigate ways of increasing Canadian (government and private sector) involvement in Olympus marketing decisions, and of influencing the Policy Marketing Committee to take a more dynamic approach to promoting Olympus sales.

An immediate investigation should be commenced with the participation of SPAR Aerospace and others to ascertain what recommendations could be made to the Policy Marketing Committee to ensure the expeditious sale of the L2 Olympus for commercial operation.

That a mechanism be set up and funded by the Department to permit frequent indepth monitoring of the Olympus program with a view to providing information from which decisions can be made to optimize Canada's benefits from its

OUTCOME

Through a more focussed departmental/SPAR interaction, one resulting initiative was a SPAR/DOC jointly funded Olympus Reconfiguration Feasibility Study, the results of which were presented to the Olympus participants by SPAR personnel at a meeting at British Aerospace, the Olympus prime contractor, under the sponsorship of the JPB/PMC.

Considerations in this respect have included the use of Olympus bus component designs for Radarsat and Space Station free-flying platforms and of the L2 model as a vehicle for various quasi-commercial payloads such as LOCSTAR, the Italian RAI (direct broadcast) and ARAMIS, the aeromarine mobile satellite payload for INMARSAT, cost estimates for the latter mission were prepared by JPB/PMC.

Program monitoring on a continuing basis is provided by DOC program management and by regular attendance at the quarterly meetings of ESA's Joint Communications Board (JCB). However,

investment, e.g. a regular update of this report. It is further recommended that a report on the results of such monitoring, together with any appropriate recommendations for change, should be made available at intervals of no greater than six months.

under the Olympus principles for commercialization, marketing related decisions are the responsibility of British Aerospace and its industrial partners. In answer to concerns that the industrial consortium was not marketing Olympus aggressively, actions were initiated at ESA to instigate greater effort. As a result, a joint ESA/DOC cost-competitiveness review team was set up and ESA requested an industrial consortium report to the JCB on their marketing plans. The matter was also raised with departmental counterparts in the U.K. government.

That a small, but active, advisory committee, chaired by the Department but made up of members from other interested Departments and from the private sector, be formed with the objective of reviewing the six monthly monitoring reports and advising the Deputy Minister on any policy or operational changes required to optimize Canada's benefits from participation in Olympus. The mandate of the advisory committee should include as a minimum that it investigate and advise on the following:

A landmark meeting attended by involved departments and industry addressed the proposed terms of reference of a possible advisory group. No decision was taken to set up an advisory group as actions agreed then and already in hand indicated that such a group would add little to the expertise already being applied to the problem by ESA, DOC, and industry.

- methods of effectively marketing Olympus in a changing environment

- methods of improving the cost effectiveness of launching Olympus by STS (including the development of a modified perigee motor)
- how to ensure that sales are generated in the under-utilized 1987 to 1992 timeframe
- methods of extending the lifetime of the Olympus technology by, for example, on-going development
- how Olympus can be best utilized for low earth orbit applications including those of future polar orbiters and space station free flyers.

That the Department makes use of these approaches to ensure that every encouragement is given to ESA and the Radarsat office of the Department of Energy, Mines and Resources to use a low earth orbit version of the Olympus bus for the Olympus program.

As above.

That Canada uses all opportunities to further its negotiating position derived from such use of an Olympus low earth orbit bus to optimize its benefits by, for example, acting as prime contractor for this work and by increasing the Canadian content of the Olympus Radarsat to the maximum.

As above.

That a study be carried out to investigate the most appropriate methods of extending CRC's 30/20 GHz communications experiments on the L1 demonstration Olympus into an integrated EHF communications program. This should include an investigation of potential

A study to identify EHF applications, EHF systems and components that have the potential for viable commercial exploitation was commissioned in December, 1986. The study results together with DOC in-house analyses and

users and markets as well as the more technical aspects of such experiments.

input from the Olympus program, were aimed at forming the basis for the development of a cohesive EHF policy and program for Canada which is the underlying aim of the department's EHF Program Coordinating Group.

That SPAR Aerospace be given every encouragement to market its state-of-the-art channel amplifiers and to maximize the return to Canada from these devices. Such encouragement could include, but not be limited to, liaison between the Department and SPAR Aerospace to ensure normal government overseas marketing assistance mechanisms are used to the full; that government to government trade negotiators are aware of the availability of this Canadian product and that steps are taken to ensure its maximum use overseas, while any possible foreign protective measures are discouraged or fought.

Noted and actioned as appropriate by departmental marketing support function.

That the David Florida Laboratory, which has been significantly improved as a result of the Olympus program, and which is now in a position to offer world class facilities and services for the largest spacecraft currently projected, be given positive encouragement to supply these services to Canadian and inter-national clients on a profitable but competitive basis. This would include insuring that the David Florida Laboratory has the flexibility to price its services to ensure the greatest overall return to Canada from the space

It is not intended that the David Florida Laboratory profit from Canadian industry for the provision of spacecraft assembly and environmental test facilities but rather to provide these services as a national facility on a cost-recoverable basis. To permit competitive pricing by industry of its test items (spacecraft, sub-systems, components etc.) every effort is taken within the constraint of allocated budgets to provide the facilities at

program, rather than exclusively implementing short term cost recovery principles.

internationally competitive prices. For instance, it has been estimated that the use of the IR test facility provides savings in excess of U.S. \$1M per spacecraft because of lower capital investment and operating costs. Further savings are effected by the provision in one location of all required facilities thereby eliminating additional costs and unnecessary schedule delays.

That Canada's achievements in Olympus, and all space related projects, be fully publicized overseas to enhance Canada's position in the strongly competitive international spacecraft market. Mechanisms currently in place should be primarily used to achieve this objective.

Besides brochures on Olympus produced by ESA and the industrial consortium, DOC has an Olympus Fact Sheet (latest issue June 1987) for general distribution. By far the most significant PR activity was the holding in Canada in October, 1987, of a meeting of ESA's Joint Communications Board. Visits for participating national delegations and ESA personnel were arranged to view the Olympus spacecraft under test at the David Florida Laboratory and for briefings at SPAR SASD, Com Dev and Canadian Astronautics.

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TK5104.2 .O49 H3 1988
Olympus satellite program
participation benefits study

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