Ranking Process

for

Strategic Technologies for

Automation and Robotics

(STEAR)

Prepared for Program Manager

STEAR Program

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Table of Contents

1.0 INTRODUCTION

This report describes the process that has been used to assign priorities to technology proposals which are candidates for support under the Strategic TEchnologies for Automation and Robotics (STEAR) Program.

The STEAR Program supports technologies which on the one hand will be incorporated into future generations of the Mobile Servicing System (MSS), and on the other will make significant socio-economic contributions to Canadian society. STEAR technologies are selected on the basis of their ability to score well in both of these incommensurate fields. The procedure adopted reflects this requirement.

While this report describes a process, it also includes the results of an actual application. Prior to ranking a number of proposals, the rating panel were briefed on Requests for Proposal already issued. This was done to be sure those doing the rating were aware that some decisions had already been taken. Furthermore, it is recognized that although we have suggested a procedure for ranking proposals, the program manager must take the final decision regarding what proposals to support.

2.0 METHODOLOGY

Each technology proposal must meet one essential criterion - there must be an application for the technology in the evolutionary MSS. In addition, there are a number of desirable criteria against which each technology proposal should be judged. The following paragraphs describe a procedure for ranking the desirable criteria.

The ranking procedure has been divided into two components. One deals with the technical, and the other with socio-economic assessments.

A number of criteria were developed for the technical assessment, and a separate set were developed for the socio-economic assessment. These were proposed and tested by individuals with appropriate backgrounds. Ten criteria were established for each assessment. Testing suggested that the original ten criteria were unnecessary, and the number was collapsed to four for technical ranking and five for socio-economic ranking. These are more manageable numbers and adequate for purposes of differentiation.

Not all criteria within a set are of equal importance. In order to arrive at appropriate weightings, each technical criterion was compared with each other technical criterion to assess if it were more important, equal in importance, or less important. This led to weightings which have been expressed in percentages. The same procedure was followed for the socio-economic criteria.

Two separate teams were established to rate candidate technologies. One team dealt with technical aspects and the other with socio-economic aspects.

In order to introduce uniformity into the rating process, each criterion was defined by four separate descriptors. These descriptors carried numerical values from 4 to 0. A candidate technology that met the criterion well received a 4. One that failed to meet the criterion received a 0.

The teams examining the candidate technologies arrived at a consensus regarding the numerical value to be assigned to the technology for each criterion. The numerical value was multiplied by the weight to obtain the "score" of the candidate technology for a particular criterion.

Scores for the four criteria, in the technology assessment, were added to give an overall "technical" score. The same procedure was followed for the socio-economic ranking. At the end of this activity each candidate technology proposal had a technical score and a socio-economic score.

Since the technical rating was independent of the socio-economic rating, the overall rating of each technology proposal was displayed on an X-Y plot. The ordinate represented socio-economic score and the abscissa the technology score. This type of display provides an opportunity to judge between candidate technology proposal on the basis of technological and socio-economic importance.

Although the process is numerical, the numbers only quantify judgement. The quality of the end product depends entirely on the quality of the individual participants. The method is useful when the ranking procedure may be subjected to detailed scrutiny.

3.0 CRITERIA

Key people working in the Canadian Space Station Program developed the criteria using their best judgement. These were then compared with the criteria used in the U. S. Space Station Program to ensure that any critical consideration was not overlooked. The criteria adopted, together with the scoring guide, is presented below.

3.1 Technical Criteria

1. Performance Enhancement.

   Some technologies contribute more than others to MSS objectives; for instance those that lead to autonomous operation, use of artificial intelligence, human interface with computers; technologies that maintain or develop Canadian leadership in the technology; timing of adoption is a consideration.

2. Successful Deployment.
   Proof-of-concept and adoption are good measures of the success of a technological development; the best concept is only valuable if it can be developed; success is tied to underlying technological strength.

3. Enhanced Productivity.
   Some technologies more than others will reduce time devoted to operations and will improve efficiency; will be less demanding of resources on Space Station (power, data handling, data storage); will reduce costs, will reduce requirements for ground support, reduce maintenance, reduce logistics; will improve reliability, throughput per unit time, lifetime, load capability, dexterity.

4. Improved Safety.
   Some technologies more than others will reduce risk to crew members (such as reducing time for EVA); will improve collision detection and avoidance; will improve fault tolerance.

3.1.1 Scoring Guide - Technical Criteria

1. Performance Enhancement.

   4. Major contribution to meeting MSS objectives of autonomous operation, use of AI, increase human-

computer interface; will lead to introduction of next generation technologies; timing fits exactly with other developments.

3. Contributes to MSS performance objectives; may lead to introduction of next generation technologies; timing uncertain.
2. Slight contribution to MSS objectives; little opportunity to build to new technologies; timing may be wrong, too soon.
1. Contribution to MSS objectives marginal; no opportunity to build to new technologies; timing probably wrong.
0. Maybe some contribution to MSS objectives; timing wrong.

2. Successful Deployment.

4. Underlying strength has been demonstrated; experience suggests that technology will be developed and adopted as expected; will lead to enhancement of competence in this technological area.
3. Strengths exist; development and deployment probable.
2. Strengths need development; good chance of success.
1. Strengths and chance of success marginal.
0. Chance of successful adoption unlikely.

3. Enhanced Productivity.

4. Very significant system capability improvements; will also lead to reduction of demand on resources on Space Station; will improve throughput; will reduce logistics support requirements.

3. Some system capability improvements; some reduction in demand on resources on Space Station; may improve throughput; may reduce logistics support requirements.
2. Little improvement in productivity; reduction of demand on resources on Space Station; some improvement in throughput or reduction in logistics support requirements.
1. Small or narrowly selective productivity improvements will come about.
0. Improvements not identified.

4. Improved Safety.

4. Greatly reduces EVA; collision avoidance/detection and fault tolerance greatly improved; possibility of human error reduced; possibility of improper command sequences reduced.
3. Moderate reduction in EVA; moderate improvement in other aspects relating to safety; monitoring improved.
2. Small reduction in EVA; modest improvement in safety; some reduction in possibility of improper command sequences; some improvement in monitoring.
1. May be some reduction in EVA; general safety slightly improved.
0. No discernable improvement in safety.

3.2 Socio-economic Criteria

1. Regional Distribution Targets.

The federal government has set regional targets for expenditure of federal funds on space activities; the location of the development of technologies will support these targets.

2. Wealth Creation.

   Some technologies more than others will improve the technological base of the country through diversification and diffusion; commercialization will be enhanced; there will be more opportunities to lever funds from other sources.

3. Reinforcement of Strengths.

   Canada has particular strengths in certain technological areas; synergism between technologies in related fields which promote the continued development of such strengths should be encouraged; skills will be developed; quality of employment will be improved.

4. Export Potential/Import Substitution.

   Some technologies will contribute more than others to the export of goods and services and/or to increase substitution for imports.

5. Contribution to National Prestige.

   Canadian are justly proud of accomplishments in space; some technologies will result in more international acclaim than others; opportunities for international cooperation will be enhanced; licensing to off-shore companies is possible.

3.2.1 Scoring Guide - Socio-economic Criteria

1. Regional Distribution Targets.

   4. Is essential to achieving regional distribution targets.
   3. Makes a major contribution to targets.
   2. Makes a significant contribution to targets.

1. Makes a small contribution to targets.
0. No discernable contribution.

2. Wealth Creation.

4. Development will lead to new technological capability that will open up markets for commercial exploitation; funding will be levered from other programs.
3. Markets likely to be developed but may be slow; commercialization may be in the future; funds may be levered.
2. Market opportunity may be limited to a niche.
1. Market development is expected, but the exact nature is difficult to identify.
0. Technology will only be used in the Space Station program.

3. Reinforcement of Strengths.

4. Will permit organizations to make significant improvements in their field of specialization or to develop next generation technologies; there will be a significant positive impact on quality of employment and the development of local skills.

3. Will build on existing strengths, with some improvement in quality of work and skills up-grading.
2. Adds to strengths, but in a narrow field.
1. Limited improvement in quality of work or skills up-grading.
0. No significant contribution to existing strengths.

4. Export Potential/Import Replacement

4. Majority of goods/services will be sold off-shore; very substantial import reduction.
3. About 50% off-shore sales/import replacement.
2. Moderate off-shore sales/import replacement.
1. Some off-shore sales/import replacement expected.
0. No discernable off-shore sales/ import replacement.

5. Contribution to National Prestige.

4. Will identify Canada as the world leader in a socially acceptable space-related technology; licensing certain.
3. Will enhance reputation of Canada as a high technology country; good opportunity for licensing.
2. Will maintain Canada's reputation in S and T; some opportunity for licensing.
1. Makes modest contribution to Canada's reputation; little opportunity for licensing.
0. Will not make much impact on Canada's reputation; no opportunity for licensing.

4.0 WEIGHTING OF CRITERIA

The weighting procedure for both technological criteria and socio-economic criteria followed the same pattern. The procedure is described in Appendix A. The results are given below.

4.1 Technical Criteria Weights

Criterion	Weight
Performance Enhancement	35
Successful Deployment	20
Enhanced Productivity	35
Improved Safety	10

4.2 Socio-economic Criteria Weights

Criterion	Weight
Regional Distribution Targets	20
Wealth Creation	30
Reinforcement of Strengths	25
Export Potential/Import Replacement	15
Contribution to National Prestige	10

5.0 SCORES

Following is a summary of the scores for each of the 13 technology proposals rated. Appendix B contains the rationale for the rating of each individual technology proposal.

No.	Technology Proposal	Technical	Socio-Economic
1	Automatic Target Array Recognition	220	225
2	Autonomous System Demonstration Project	295	260
3	Artificial Neural Based Object Recognition	205	190
4	Tactile Sensor Technology	125	280
5	Application Specific Integrated Optic Sensor	75	270
6	Potential field Method & Impedance Control	225	295
7	Control of Co-operating Robot Arms	180	235
8	Control Strategies for Dexterous Robots	235	255
9	Trussarm	145	215
10	Reliable Computing Concepts	165	210
11	Space Mechanism Tribomaterials	230	210
12	Protective Measures for MSS Structures	190	250
13	Software Tools for Ada Design	190	180

The positions of each technology proposal are shown on a scatter diagram in Figure 1 below. The positioning is relative, with the relative socio-economic position as ordinate and the relative technology position as abscissa.

The display permits decisions to be taken with respect to issuing RFPs based on judgement on how well the selected technologies meet both technology and socio-economic criteria.

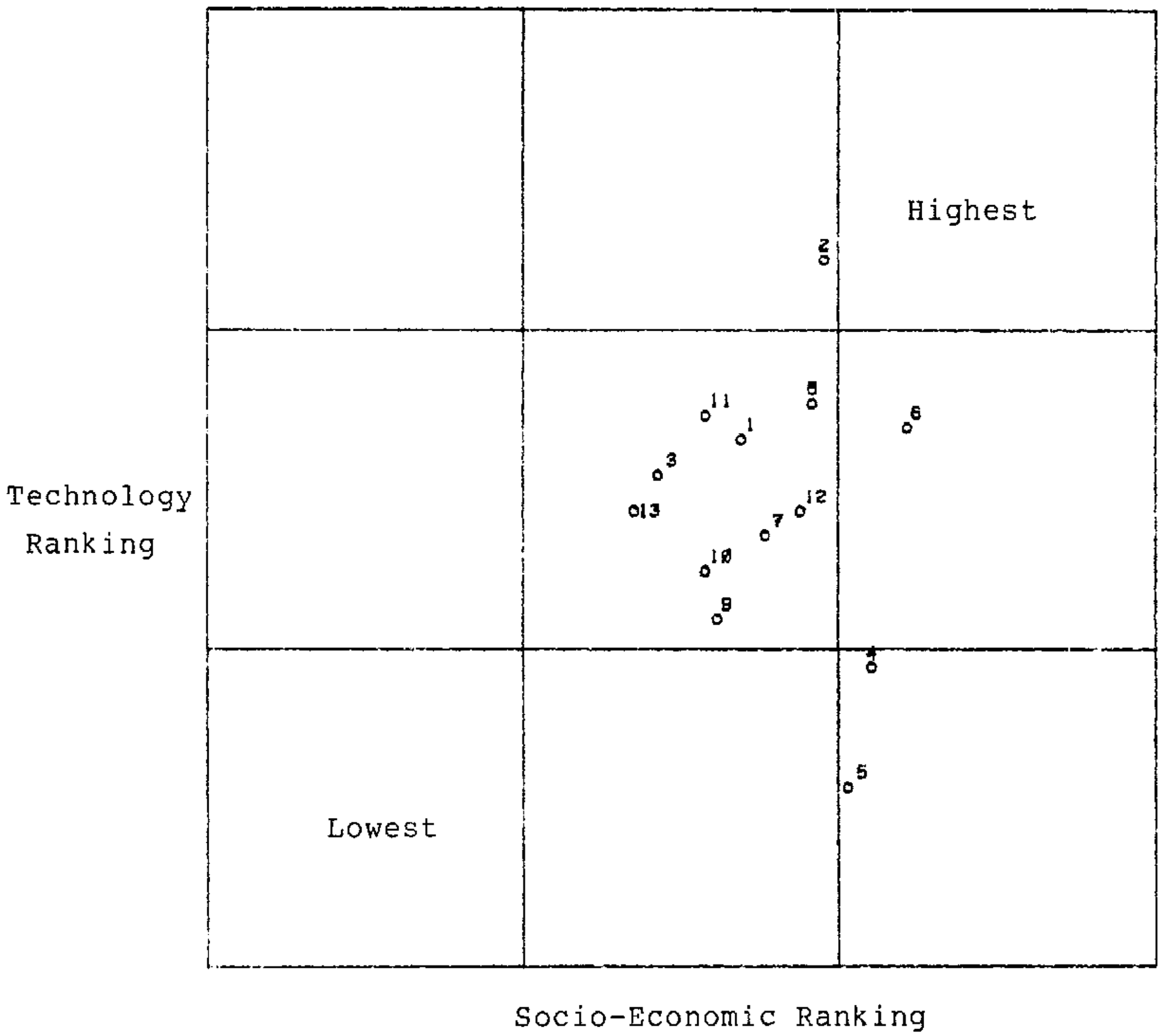

Figure 1

1. Automatic Target Array Recognition
2. Autonomous System Demonstration Project
3. Artificial Neural System Based Object Recognition
4. Tactile Sensor Technology
5. Application Specific Integrated Optic Sensor
6. Potential Field Method & Impedance Control
7. Control of Co-Operating Robot Arms
8. Control Strategies for Dextrous Robots (force/moment and impedance control)
9. Trussarm (serpentine manipulator)
10. Reliable Computing Concepts
11. Space Mechanism Tribomaterials
12. Protective Measures for MSS Structures
13. Software Tools for Ada Design

6.0 ADDITIONAL RANKING

In an earlier and separate project carried out in 1986, a group of specialists from government and industry identified a number of technologies that will be of strategic importance to the evolutionary MSS. These have been termed Strategic Technologies, and were used to solicit the technology proposals that are the subject of the present activity.

In a separate exercise using the technical panel which rated the proposals, each strategic technology identified in the NRC report was ranked against each other strategic technology for contribution to the evolutionary MSS. This provides some guidance on priorities from a purely technical point of view.

The results of this ranking are shown below.

Technologies of Strategic Importance to MSS

Group 1

- Vision Systems
- Expert Systems in Operations
- Manipulator Control
- Human-Machine Interface/Telepresence
- Software Development and Verification

Group 2

- Robot Programming
- Manipulator Analysis
- Sensors

Group 3

- Robot Mechanisms
- Materials

Group 4

- Lubrication in space
- Simulators
- Processor Systems and Interprocessor Communications
- Automated Test Equipment
- Automated Power Management
- Automated Data Management

Group 5

Power Systems
Qualification Strategies

7.0 COMMITTEE MEMBERSHIPS

7.1 Technical Ranking Committee

Pierre Maltais, Federal Government (SSPO, chairman)
Don Smith, Federal Government (SSPO)
Harvey Werstiuk, Federal Government (SSPO)
Doug Bassett, Federal Government (SSPO)
Richard Hughes, Federal Government (SSPO)
Victor Wehrle, federal Government (CRC/SMD)
Dave O'Hara, Federal Government (NRCC/LIS)
Fred Christie, Federal Government (observer)
John Keys, Philip A. Lapp Limited (coordinator)

7.2 Socio-economic Ranking Committee

Don Smith, Federal Government (SSPO, chairman)
Greg Hart, Federal Government (SSPO)
Dave Keys, Federal Government (DSS)
Bob Kingsbury, Federal Government (NRCC)
Peter Lawrence, Federal Government (DRIE)
Saskia Meuffels, Federal Government (MOSST)
Fred Christie, Federal Government (observer)
John Keys, Philip A. Lapp Limited (coordinator)

SSPO	-	Space Station Project Office
CRC/SMD	-	Communications Research Centre/Space Mechanics Division
NRCC/LIS	-	National Research Council of Canada/Laboratory for Intelligent Systems
DSS	-	Department of Supply and Services
DRIE	-	Department of Regional Industrial Expansion
MOSST	-	Ministry of State for Science and Technology

Appendix A

Derivation of Weights

A.1 Procedure

The method used to determine weights requires that each criterion be compared with each other criterion. The results are presented in the two tables below for the technical criteria and the socio-economic criteria. The detailed procedure is explained following the tables.

Weight	Criteria (Technical)				Pts
35	Performance Enhancement →	1	.5	1	2.5
20	Successful Deployment	→↑	0	.5	.5
35	Enhanced Productivity		→↑	1	2.5
10	Improved Safety			↑	.5

Weight	Criteria (Socio-economic)					Pts
20	Regional Distribution Targets →	.5	0	.5	1	2
30	Wealth Creation	→↑	.5	1	1	3
25	Reinforcement of Strengths		→↑	.5	.5	2.5
15	Export Potential/Import Replacement			→↑	.5	1.5
10	Contribution to National Prestige				↑	1

1. Rank each criterion against the ones below it by placing a 1, .5 or 0 in the appropriate box.

2. A 1 signifies more important than.
   A .5 signifies equal to.
   A 0 signifies less important than.

   For example, Regional Distribution Targets is judged equal to Wealth Creation. A .5 is therefore placed in the first box on the Regional Distribution Targets line. It is judged less important than Reinforcement of Strengths, and a 0 is placed in the second box.

3. For each criterion a) sum horizontally
   b) add the .5's that appears vertically

c) for each 0 vertically add 1
d) for each 1 vertically ignore

4. Place the total in the column on the right - Pts (n).

5. The sum of the Pts must equal the number of boxes used (N).
6. The Pts derived in this exercise can be converted into fractions for the rating process in the usual way - n/N.

7. The fractions can then be rounded to percentages and entered in the left column labelled Weight.

8. Review percentages to see if they correspond to judgement. If not, adjust accordingly.

Appendix B
Ranking Descriptions

TECHNOLOGY ASSESSMENT SUMMARY

Title : Automatic Target Array Recognition and Acquisition

Technology : TELEOPERATION & ROBOTICS
Vision Systems

Number : 1

TECHNOLOGICAL IMPORTANCE

Performance Enhancement. Score 70

Moves toward autonomous operation; incremental improvement over the existing system; is an improvement when the target is lost, avoiding the need to re-acquire the target; the existing system requires the operator to lock on to the target.

Successful Deployment. Score 80

Can be done with clever ideas which are around.

Enhanced Productivity. Score 70

Small addition to existing technology; astronauts may have to do less work, but not much less.

Improved Safety. Score 0

No improvement in safety; humans are best for decisions.

Total Score 220

SOCIO-ECONOMIC

Number 1

Regional Distribution Targets. Score 40

Companies with the required capability are located in B.C., the mid-West, and Quebec. A very specialized technology. Ontario strong, and may therefore limit opportunities in other regions.

Wealth Creation. Score 60

There are potential military applications accessible through the defence sharing agreements. This is a narrow specialty, and there is a narrow market opportunity. The automotive field is promising in the future.

Reinforcement of Strengths. Score 75

This is an enhancement to an existing technological base. The fact that it is a niche may be an advantage to a Canadian company.

Export Potential/Import Replacement. Score 30

Good opportunity to export into the military market provided it can be penetrated. If this can be added to RAST, which has been sold to the U.S. Navy, there is good export potential. There may also be a market with the U.S. Coast Guard and the merchant marine.

Contribution to National Prestige. Score 20

This will form a small component of a larger system. There will be a modest impact.

Total Score 225

TECHNOLOGY ASSESSMENT SUMMARY

Title : Autonomous System Demonstration Project

Technology : TELEOPERATION & ROBOTICS
Vision Systems

Number : 2

TECHNOLOGICAL IMPORTANCE

Performance Enhancement. Score 140

There are no autonomous operations in the existing baseline; this technology will lead to the next generation.

Successful Deployment. Score 40

The individual technologies are likely to be developed; strengths exist; the challenge lies in the integration.

Enhanced Productivity. Score 105

There will be a significant reduction in IVA time.

Improved Safety. Score 10

Automation does not always improve safety; the astronauts will be very careful; some small improvement in safety.

Total Score 295

SOCIO-ECONOMIC

Number 2

Regional Distribution Targets. Score 60

There is a lot of capability in the robotics field in the West. A good network of companies and universities is in place. There are good opportunities for small firms to obtain sub-contracts. Technology transfer will occur.

Wealth Creation. Score 90

A company would have to be significantly into the market in order to capitalize on this development. It would be an enhancement of an existing niche; the field is competitive and potential is constrained. There are long range opportunities, undersea mining for one. Funds may be levered from a range of sources.

Reinforcement of Strengths. Score 50

Government laboratories and universities are strong in this area. There are pockets of expertise in small firms. Ultimate commercialization is uncertain; there is no strong lead company.

Export Potential/Import Replacement. Score 30

There may be exports in narrow niches. The software architecture contributes to two-arm operations. There is some uncertainty about the ability to insert this technology into someone else's system.

Contribution to National Prestige. Score 30

This will be high profile if commercialized. It will impact on two sectors - software and robotics. There may be opportunities for licensing.

Total Score 260

TECHNOLOGY ASSESSMENT SUMMARY

Title : Object Recognition (Neural Systems)

Technology : TELEOPERATION & ROBOTICS
Vision Systems

Number : 3

TECHNOLOGICAL IMPORTANCE

Performance Enhancement. Score 105

This is a big project; it is at the early stage of development with the effort mostly in universities, not much in industry; it has potential but is not essential as there are other ways of achieving the same end; the technology will permit the recognition of more general objects; timing distant.

Successful Deployment. Score 20

At a very early stage; too early to assess.

Enhanced Productivity. Score 70

Has potential to relieve humans; may save inspection time; immature at present.

Improved Safety. Score 10

May replace a boring activity and therefore contribute to increased safety.

Total Score 205

SOCIO-ECONOMIC

Number 3

Regional Distribution Targets. Score 20

This is an embryonic technology, well suited to university work. There is industrial competence on the West Coast centered in a small firm who have done some work for JPL. Small companies may find it difficult to invest in such a long term project.

Wealth Creation. Score 60

This is at the proof-of-concept stage, and future commercialization is doubtful. The probability of success is uncertain. However, the Canadian infrastructure can deal well with this type of technology.

Reinforcement of Strengths. Score 50

There are only a few organizations in Canada that can deal with this technology. The field is advancing quickly, however.

Export Potential/Import Replacement. Score 30

Results from this development alone would not generate much in the way of export, or import replacement.

Contribution to National Prestige. Score 30

Success would give Canada a lead in an emerging technology.

Total Score 190

TECHNOLOGY ASSESSMENT SUMMARY

Title : Tactile Sensing Technology Development

Technology : TELEOPERATION & ROBOTICS
Sensors

Number : 4

TECHNOLOGICAL IMPORTANCE

Performance Enhancement. Score 70

Most tasks will be designed to make this irrelevant, but may be useful in failure situations; allows robot to operate where there is no vision, but we may not have many of this type of task.

Successful Deployment. Score 20

Technically feasible but may be little demand; some strengths exist.

Enhanced Productivity. Score 35

Role of tactile sensors uncertain; improvements will be in instructional situations.

Improved Safety. Score 0

Difficult to identify a situation where this would increase safety.

Total Score 125

SOCIO-ECONOMIC

Number 4

Regional Distribution Targets. Score 40

The capability to develop this technology resides in B.C., the Prairies, Ontario and Quebec. There is no expertise in Atlantic Canada.

Wealth Creation. Score 90

This technology is a good extension to the existing base in robotics. It fits neatly into the next generation, and will have applications in many industries. There is a requirement for integration.

Reinforcement of Strengths. Score 75

Canada has strength in this technological area.

Export Potential/Import Replacement. Score 45

There is good potential where industrial robots are used. There is a possibility for export into niche areas, but there are many other players in this game.

Contribution to National Prestige. Score 30

This development will add to Canada's expertise in the subject area.

Total Score 280

TECHNOLOGY ASSESSMENT SUMMARY

Title : Application Specific Integrated Optic Sensors

Technology : TELEOPERATION & ROBOTICS
Sensors

Number : 5

TECHNOLOGICAL IMPORTANCE

Performance Enhancement. Score 35

Not needed for the MSS; will not add any new capability.

Successful Deployment. Score 40

Reasonable chance of deployment; aircraft industry is heavily funding development of this technology and commercial products are near.

Enhanced Productivity. Score 0

Won't do anything that cannot be done now.

Improved Safety. Score 0

No discernable improvement in safety.

Total Score 75

SOCIO-ECONOMIC

Number 5

Regional Distribution Targets. Score 40

The main strength lies in Ontario, but there are a number of companies in the subject area in the West and in Quebec. The prime candidates for carrying out this development are in Ontario and Quebec.

Wealth Creation. Score 90

This is a low risk technology. There is a large market in the automotive industry but there are many competitors. This technology could do well in niche markets. There may be potential in the military market.

Reinforcement of Strengths. Score 75

This technology is embryonic. There is a good base in Canada and we are competitive with the rest of the world.

Export Potential/Import Replacement. Score 45

Canada has done well in the optics field, and although there is strong international competition, the U.S. defence market is available.

Contribution to National Prestige. Score 20

Canada has a good reputation in electro-optics which this will maintain.

Total Score 270

TECHNOLOGY ASSESSMENT SUMMARY

Title : Potential Field Method and Impedance Control in a Manipulator Arm

Technology : TELEOPERATION & ROBOTICS
Manipulator Control

Number : 6

TECHNOLOGICAL IMPORTANCE

Performance Enhancement. Score 105

May interact with objects on contact in a better way; may speed up operations; a more integrated step in technological development; may solve some instability problems; provides a new baseline technology.

Successful Deployment. Score 40

Basically a re-load of software; may need increased computing power.

Enhanced Productivity. Score 70

Will improve productivity but there is strong competition from existing technology which may be difficult to displace.

Improved Safety. Score 10

No relation to EVA; may be slight gain in safety while doing mechanical tasks.

Total Score 225

SOCIO-ECONOMIC

Number 6

Regional Distribution Targets. Score 40

The main concentration of capability resides on the West Coast. There may be further applications in non-underwater industries such as forestry, oil and mineral exploration. Concentration is also in the West for these applications. There may be some speculative applications in the East.

Wealth Creation. Score 90

There are good prospects for spin-offs in other areas. These could occur serially with progressive benefits. There is a good base upon which to build but developments may be slow - not in the next two years. There may be some weakness in the industry.

Reinforcement of Strengths. Score 100

This is a direct reinforcement of West Coast capability. Adding additional strength to the main company will be advantageous. Control and reliability will be important, particularly if military markets are involved. There are possibilities for licensing the technology.

Export Potential/Import Replacement. Score 45

Company has history of strong off-shore sales. There may be more domestic sales as the technology moves to other markets.

Contribution to National Prestige. Score 20

In this field, Canada has a good reputation which this technology will help maintain.

Total Score 295

TECHNOLOGY ASSESSMENT SUMMARY

Title : Control of Co-Operating Robot Arms

Technology : TELEOPERATION & ROBOTICS
Manipulator Control

Number : 7

TECHNOLOGICAL IMPORTANCE

Performance Enhancement. Score 70

Will lead to greater dexterity that may be needed in the future; an incremental increase in capability; has both a technological development aspect and a research aspect.

Successful Deployment. Score 40

Strengths exist, but development of the technology is required; good chance of success; JPL and others are taking the same approach.

Enhanced Productivity. Score 70

Little improvement in productivity; may save time over telepresence technology; may require upgrading of computer resources; saves IVA resources.

Improved Safety. Score 0

No improvement in safety.

Total Score 180

SOCIO-ECONOMIC

Number 7

Regional Distribution Targets. Score 40

A very advanced technology. There will be some, but not a major, contribution to regional distribution in Atlantic Canada.

Wealth Creation. Score 60

This is a good field for Canada, with good downstream potential, but may be limited to a niche. The process of commercialization is not clear and will take a major development effort.

Reinforcement of Strengths. Score 75

This technology is closely related to automation and robotics requirements and builds on strengths. It could act as a catalyst.

Export Potential/Import Replacement. Score 30

There are unlikely to be significant off-shore sales or import replacements. Countries tend to develop their own high technology products in this field.

Contribution to National Prestige. Score 30

This is a very visible technology. There may be some potential for licensing.

Total Score 235

TECHNOLOGY ASSESSMENT SUMMARY

Title : Control Strategies for Dexterous Robots

Technology : TELEOPERATION & ROBOTICS
Manipulator Control

Number : 8

TECHNOLOGICAL IMPORTANCE

Performance Enhancement. Score 105

This is a practical approach to improved performance; may parallel SPAR's approach, but the area is sufficiently important to have a similar program; may provide a way of involving robotics companies that are not now in the space program.

Successful Deployment. Score 60

Strengths exist in industry and government; success likely.

Enhanced Productivity. Score 70

A little improvement in productivity.

Improved Safety. Score 0

No contribution to increased safety.

Total Score 235

SOCIO-ECONOMIC

Number 8

Regional Distribution Targets. Score 40

A very advanced technology. There will be some, but not a major, contribution to regional distribution in Atlantic Canada.

Wealth Creation. Score 90

This is a good field for Canada, with good downstream potential, but may be limited to a niche.

Reinforcement of Strengths. Score 75

This technology is closely related to automation and robotics requirements and builds on strengths. It could act as a catalyst.

Export Potential/Import Replacement. Score 30

There are unlikely to be significant off-shore sales or import replacements. Countries tend to develop their own high technology products in this field.

Contribution to National Prestige. Score 20

This is a very visible technology. Licensing potential uncertain.

Total Score 255

TECHNOLOGY ASSESSMENT SUMMARY

Title : Trussarm

Technology : TELEOPERATION & ROBOTICS
Robot Mechanisms

Number : 9

TECHNOLOGICAL IMPORTANCE

Performance Enhancement. Score 70

An alternative to the present way of carrying out tasks; may be preferential in the long term; may have a longer reach but may lose in other aspects such as the "give" in joints; doesn't fit with the current concepts.

Successful Deployment. Score 40

Good chance of successful development but there are some engineering problems to solve.

Enhanced Productivity. Score 35

Will likely be lighter for a given stiffness or strength; will be more flexible in dealing with unusually shaped objects.

Improved Safety. Score 0

No improvement in safety.

Total Score 145

SOCIO-ECONOMIC

Number 9

Regional Distribution Targets. Score 20

Potential for dissemination to regions is small. This will make only a small contribution to regional targets.

Wealth Creation. Score 60

The market for this technology will not develop quickly. Performance including price will determine acceptance. This is a niche technology with a low risk factor.

Reinforcement of Strengths. Score 75

This technology will add to existing strengths and improve skills.

Export Potential/Import Replacement. Score 30

There may be resistance in target markets. There will be weak penetration of export markets.

Contribution to National Prestige. Score 30

Any penetration will make this a highly visible technology. Good potential for licensing.

Total Score 215

TECHNOLOGY ASSESSMENT SUMMARY

Title : Development of Reliable Computing Concepts for an Evolutionary MSS DMS

Technology : ELECTRICAL & ELECTRONICS
Processor Systems and Interprocessor Communications

Number : 10

TECHNOLOGICAL IMPORTANCE

Performance Enhancement. Score 35

MSS is already locked into a system which this one won't displace unless a lot of problems arise.

Successful Deployment. Score 40

Work on this technology has been going on for a number of years and there is capability in the private sector; this is a fault-tolerant DMS technology which is not compatible with present approach.

Enhanced Productivity. Score 70

Reliability would be increased and this would be reflected in increased productivity.

Improved Safety. Score 20

The ability to detect and recover from faults will increase safety.

Total Score 165

SOCIO-ECONOMIC

Number 10

Regional Distribution Targets. Score 60

Capability exists in the West, Quebec and possibly in Atlantic Canada. This is one of two indigenous technologies which are candidates for development in Atlantic Canada.

Wealth Creation. Score 60

The main market is Space - NASA, ESA. There is some potential in the chemical industry, but it is a difficult field to penetrate commercially. It is most likely a niche technology with latent potential.

Reinforcement of Strengths. Score 50

Current skills exist; this technology will build on these strengths.

Export Potential/Import Replacement. Score 30

Exports may be limited to Space. That market is difficult to penetrate. There may be a modest level of activity in the international markets.

Contribution to National Prestige. Score 10

This technology will make only a modest contribution to national prestige.

Total Score 210

TECHNOLOGY ASSESSMENT SUMMARY

Title : Space Mechanism Tribomaterials

Technology : STRUCTURES & MATERIALS
Lubrication in Space

Number : 11

TECHNOLOGICAL IMPORTANCE

Performance Enhancement. Score 35

This is a highly specialized technology; needed in the mainline program; contribution to evolving MSS uncertain.

Successful Deployment. Score 80

Expertise exists, suggesting that better materials can be developed and adopted.

Enhanced Productivity. Score 105

There will be a general improvement in productivity as a result of using longer lasting materials, thus reducing the need for replacement.

Improved Safety. Score 10

May be some reduction in EVA.

Total Score 230

SOCIO-ECONOMIC

Number 11

Regional Distribution Targets. Score 40

There may be an opportunity for Atlantic Canada to participate in developing this technology. There is also some capability in Quebec. This is one of the few areas where Atlantic Canada can contribute but it will require pushing. The involvement of that region will likely be in a sub-contracting role.

Wealth Creation. Score 60

Successful development for the Space environment will likely lead to spin-offs. However, there is only an indirect link to earth-based markets.

Reinforcement of Strengths. Score 75

This is a narrow field with capability mainly in universities. There is some opportunity for transfer to industry. DME has strength in this technology, and there is a small but competent base upon which to build.

Export Potential/Import Replacement. Score 15

Exports uncertain.

Contribution to National Prestige. Score 20

This technology will add to Canada's prestige if successful.

Total Score 210

TECHNOLOGY ASSESSMENT SUMMARY

Title : Development of Protective Measures for MSS Structures and Materials

Technology : STRUCTURES & MATERIALS
Materials

Number : 12

TECHNOLOGICAL IMPORTANCE

Performance Enhancement. Score 35

The problem this technology will address is not unique to MSS; can be solved at the laboratory scale but large scale coatings pose problems that must be solved; not much improvement in operations.

Successful Deployment. Score 40

There are a number of approaches to large scale coating but no agreement; strengths exist in universities and government labs; industry may rely on other countries for solutions.

Enhanced Productivity. Score 105

Will significantly reduce maintenance and refurbishing requirements.

Improved Safety. Score 10

Reduced maintenance will lead to reduced EVA.

Total Score 190

SOCIO-ECONOMIC

Number 12

Regional Distribution Targets. Score 60

This is one of the main areas where Atlantic Canada can contribute. Quebec and B.C. can also participate. This is a technology well suited to small companies.

Wealth Creation. Score 90

Synergism and diffusion will increase the exploitation of this technology. It will follow an evolutionary path. A process developed for the Space environment may not apply directly on Earth, but there may be hidden applications.

Reinforcement of Strengths. Score 50

There is capability in government laboratories and some in industry where there is interest in pursuing technologies in the fields of coatings and treatment of surfaces. It is a narrow field.

Export Potential/Import Replacement. Score 30

This technology fits well with small companies who may find the cost of achieving export sales beyond their means. There is a lot of work in the U.S. in this field.

Contribution to National Prestige. Score 20

Application in Space will not have much impact on the public. However, corrosion is a significant public issue and if the technology can be transferred to Earth, there will be a big impact.

Total Score 250

TECHNOLOGY ASSESSMENT SUMMARY

Title : Computer Aided Software Engineering Tools for Ada Design

Technology : VERIFICATION
Software DEvelopment & Verification

Number : 13

TECHNOLOGICAL IMPORTANCE

Performance Enhancement. Score 35

If we could operate independently we would adopt this technology, but we are locked into another system; phases 1 and 2 would fit the main program; phases 3 and 4 are very long term; marginal contribution to MSS objectives.

Successful Deployment. Score 40

The difficulty in timing for both near term and long term components suggests that although there is a good chance of success for phases 3 and 4 strengths need developing.

Enhanced Productivity. Score 105

This technology will reduce software development costs, result in better integration and verification will be easier; it will shorten the design cycle and lead to reduced operational maintenance costs.

Improved Safety. Score 10

General safety somewhat improved.

Total Score 190

SOCIO-ECONOMIC

Number 13

Regional Distribution Targets. Score 20

The centre of competence is in Ontario but there may be some potential for diffusion to laboratories in the regions. Sub-contracting is a possibility.

Wealth Creation. Score 60

This technology basically serves the military market. This is a restricted market with the U.S. military designating areas where foreign technology is unacceptable. There may not be a substantial company to capitalize on the technology. However, tool development can be profitable.

Reinforcement of Strengths. Score 50

Canada has front line expertise in Carleton University which could make Canada a world leader. However it may be difficult to penetrate the U.S. market.

Export Potential/Import Replacement. Score 30

The restriction placed on foreign supply will encourage the development of indigenous capability. There is a joint Canadian U.S. agreement on developing standards for Ada tools. Where standards are in place, export restraints are eased.

Contribution to National Prestige. Score 20

This technology will make a modest contribution to national prestige.

Total Score 180