NORDICITY
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Opportunities for the Use of Artificial Intelligence Systems within the Government of Canada

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Opportunities for the Use of Artificial Intelligence Systems within the Government of Canada

A Study Commissioned by
Department of Supply and Services
Under the Scientific Authority of
Ministry of State for
Science and Technology

Prepared by

Nordicity Group Ltd.
in Association with
Canadian Artificial Intelligence Products Corp.

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VOLUME I

Table of Contents

		Page
	Preface	
	Executive Summary	i
1.0	**ARTIFICIAL INTELLIGENCE: AN OVERVIEW**	1
	1.1 Orientation of the Report	1
	1.2 Artificial Intelligence: a Scientific Overview	2
	1.2.1 Principles of AI	3
	1.2.2 AI Techniques	6
	1.2.3 AI Methodologies	7
	1.2.4 AI Applications	9
	1.3 Artificial Intelligence: A Technology Overview	9
	1.4 AI Applications and their Emerging Market	16
	1.5 International Programs in AI	20
	1.6 Summary	22
2.0	**IDENTIFYING AI OPPORTUNITIES**	24
	2.1 The AI Applications Identification Process	24
	2.2 Identifying Information Needs	27
	2.3 Conversion from Needs to AI Opportunities	27
	2.3.1 Productivity in Government Operations	31
	2.3.2 Renewable/Non-renewable Resources	33
	2.3.3 Training/Retraining and Counselling	34
	2.3.4 Information and Communication Products and Services	35
	2.4 Opportunities by Information Processing System	36
	2.5 The US Government Experience	41
	2.5.1 Internal Revenue Service	41
	2.5.2 Agriculture	43
	2.5.3 Federal Bureau of Investigation	43
	2.5.4 National Institute of Health	44
	2.5.5 Office of Technology Assessment	44
	2.5.6 Summary of US Government Activities	44
	2.6 Summary	45

Table of Contents
(continued)

		Page
	5.3 Interdepartmental Strategies	81
	5.3.1 Cross-Departmental Collaboration	81
	5.3.2 Interdepartmental Policy Responsibilities	83
	5.4 Resource Implications from AI Use	84
6.0	**STRATEGIES FOR PROCUREMENT**	90
	6.1 Rationale for AI Industrial Development	90
	6.2 Nature of the AI Supplier Industry	91
	6.3 Critical Role of Government Procurement	92
	6.4 Procurement Strategies	94
	6.5 Strategic Targets for Industrial Development	97
	6.6 Conclusions	99
7.0	**CONCLUSIONS AND RECOMMENDATIONS**	100
	7.1 Development of AI	100
	7.2 Identifying Government Needs	102
	7.3 Government Use Strategies	104
	7.4 Industrial Development Through Procurement Strategies	105
APPENDIX A:	Study Methodology	
APPENDIX B:	List of Workshop Participants	
APPENDIX C:	Evaluation of AI Opportunities in the Federal Government	

Table of Contents
(continued)

		Page
3.0	**A METHODOLOGY FOR EVALUATING AI OPPORTUNITIES**	47
	3.1 Suitable Critieria for Evaluation	47
	3.1.1 Limitation to Complexity (Exhibit 3-1)	48
	3.1.2 Major Improvements Possible Exhibit 3-2)	50
	3.1.3 Go-Ahead Requirements (Exhibit 3-3)	50
	3.2 Evaluation Procedure	53
	3.2.1 Step 1 - Scoring the Opportunities	53
	3.2.2 Step 2 - Scoring the Criteria	54
	3.3 Summary	56
4.0	**EVALUATION OF OPPORTUNITIES**	58
	4.1 Results of the Evaluation	58
	4.2 Further Analysis of the Results	64
	4.2.1 AI Field	64
	4.2.2 Sponsoring Agencies	65
	4.2.3 Information Systems Status	65
	4.2.4 Priority of Opportunity	65
	4.2.5 Significance to Government	66
	4.3 Applications in the Rest of Government	67
	4.4 Summary	70
5.0	**STRATEGY FOR GOVERNMENT USE OF AI**	72
	5.1 Setting the Strategic Direction	72
	5.1.1 Government Needs	72
	5.1.2 AI Pay-off for Government	73
	5.1.3 Pay-off for the Economy	75
	5.1.4 Elements of a Strategy	76
	5.2 Intra-departmental Strategies	78
	5.2.1 AI Demonstration Projects	79
	5.2.2 Coordination within Departments	79

Preface

This study was conducted for the Department of Supply and Services under the Scientific Authority of MOSST. It was received by an ad hoc steering committee consisting of knowledgable officials in MOSST, DSS, DOC, EMR, and DOE.

The purpose of this study was:

(a) to determine the "demand" or opportunities for the introduction of Artificial Intelligence based (AI) systems within the Federal Government over the near and medium term; and

(b) to develop a strategy by which the Federal Government could stimulate the development of AI in Canada, while meeting its own needs.

The selection of priority application areas in the Federal Government and potential user departments and agencies was mainly through the convening of departmental and theme workshops.

In total, some 60 government personnel were involved in staging these workshops and meetings.

Executive Summary

Preamble

This study was commissioned by the Department of Supply and Services to: (i) explore opportunities within Federal Government operations to use artificial intelligence (AI) technologies; and (ii) to examine the potential leverage of procurement for stimulating industrial development in the AI field in Canada.

The Ministry of State for Science & Technology was designated as the Scientific Authority for the study, in view of its central agency role in science and technology policy formulation. The study was guided by a Steering Committee consisting of officials from the Department of Supply and Services, the Ministry of State for Science and Technology, the Department of Communications, Department of Energy, Mines and Resources, and the Department of Environment.*

Study Focus and Methodology

The orientation of this study was toward "market pull", as opposed to "technology push". That is, the study sought opportunities to apply AI in a range of government activities, rather than identify expressions

* The Steering Committee consisted of: Mr. Ozzie Silverman, Director, Strategic Planning (MOSST), Mr. Robert Weese, Director General, Supply Management Directorate, (DSS), Dr. John Harrison, Senior Science Advisor (EMR), Dr. David Goodenough, Head, Methodology Section, CCRS (EMR), Mr. Bruce Atfield, Director, Computing and Communications Branch, Atmospheric Environment Service (DOE), Mr. David Waung, Manager, Information Systems Technology Assessment (DOC).

of AI research interest by scientists and other technical people in government.

The immediate objective was to determine whether there are applications within government suitable to current AI technologies, as well as which might benefit from AI technologies which are expected to emerge in the medium term. To meet this objective, the study developed methods to identify opportunities for AI application and determine whether such opportunities were viable. Eleven workshops were organized by the study team. Five of them crossed departmental lines and centred on the broad theme of information processing. Six workshops focussed on individual departmental needs. To assess these opportunities, each potential AI application was evaluated according to criteria developed for the study. This analysis provided a basis for reaching conclusions about the suitability and timing of various potential AI applications in the Federal Government.

Study Findings

Some forty candidate AI opportunities emerged from the study. Since the study was a first effort at AI opportunity identification and covered about a third of the Federal Government's activity, this initial set of 40 opportunities is likely to represent only a fraction of the potential.

It is anticipated that opportunities will multiply with the successful demonstration of an AI application. Further anticipated declines in system design and software/hardware costs will make even more AI applications economically viable.

As part of the evaluation process, each opportunity was considered in terms of the type of AI application, the type of application being replaced or supported by AI and the timeframe for implementation.

After a rigorous evaluation of the 40 AI opportunities identified, it was found that:

- Type of AI Application (see Exhibit 1)

  The most useful AI applications are "expert systems" that help make decisions, increase operational productivity, and improve service to the public; the use of natural language for data base query is the next most useful set of AI based applications.

- Type of Application Being Replaced or Supported by AI (see Exhibit 2)

  Most of the AI opportunities lie in areas whose current operations are strictly manual and not yet computerized or automated; the majority of the remainder involve semi-automated information systems, while only a few of the AI opportunities are extensions of fully automated systems.

- Timeframe Implementation (see Exhibit 3)

  Over a third of the AI opportunities (i.e. 15 of 40) identified are suitable for immediate implementation using today's technology; less than a quarter (i.e. 9 of 40) require considerably more technical developments in AI before they can be implemented.

Exhibit 1

Type of AI Application

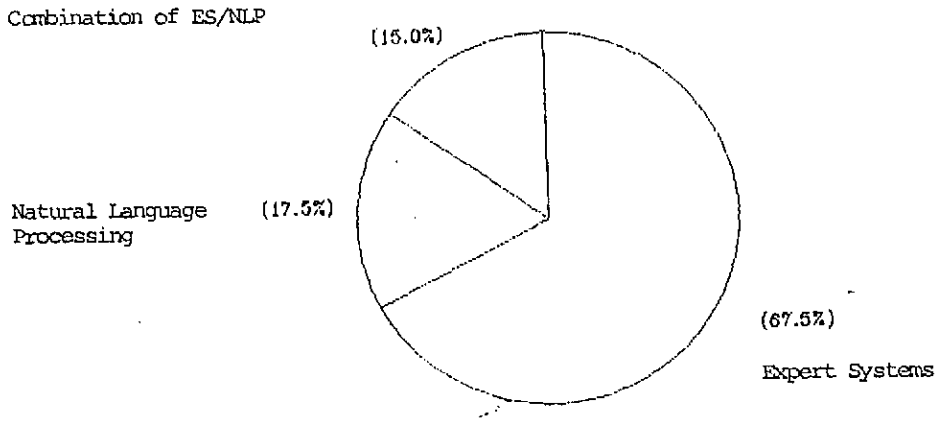


Exhibit 2

Type of Application Being Replaced or Supported by AI

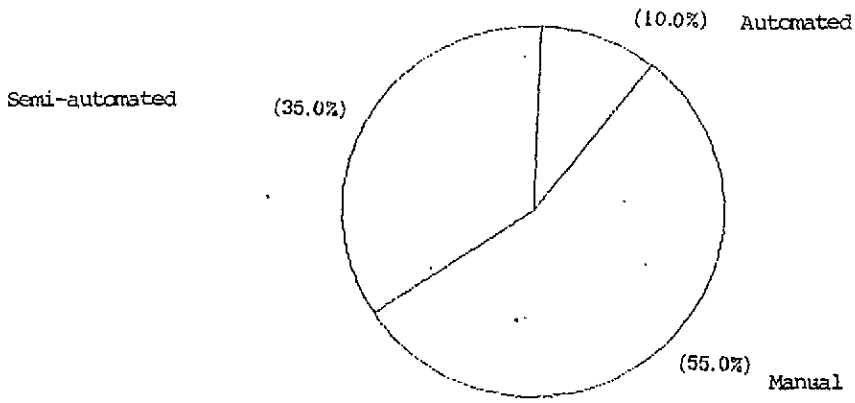
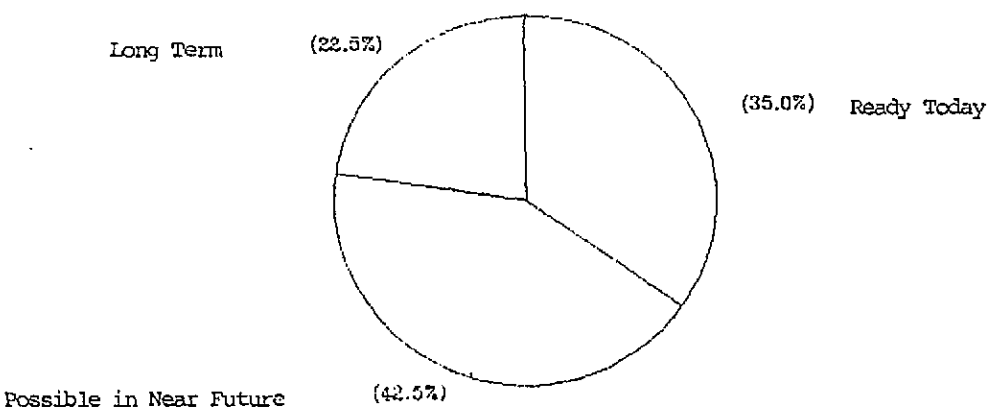


Exhibit 3

Timeframe for Implementation



In short, there are opportunities that can use AI technologies which are readily available. These are opportunities that are not esoteric extensions to complex computer systems, but rather apply in situations which have not yet yielded to computerization. The most frequent potential application is the expert system, which would assist (but not replace) government officials in undertaking certain kinds of complex tasks.

Government Use of AI - Conclusions and Recommendations

The analysis of potential AI applications in government operations, revealed that AI has the potential to do the following:

- **Improve government productivity:** AI should help to more effectively exploit scarce or expensive expertise. For example, potential applications are:
  - real property life cycle management
  - operational procedures
  - forms processing
  - translation
- **Provide faster and better decision support systems:** For example, AI should help in situations where economic stakes are significant, in areas such as:
  - fisheries stock management
  - air traffic control
- **Improve service to the public:** AI can provide new ways for departments to deliver their mandates, by improving the level and quality of service, for example:
  - training
  - income tax queries
  - regulatory approvals
  - counselling

The study findings show that AI is relevant to almost all operations of the Federal Government. Given the continuing development of AI technology and its potential application to government, the study concluded that **the introduction of AI technologies into the Federal Government should be the result of a planned, deliberate strategy, rather than a haphazard, potentially redundant process.**

Priority Selection

In 1985, an Interdepartmental Working Group on AI proposed four priority areas upon which the Federal Government should focus its AI effort, namely:

- government productivity
- resources development
- training, and
- informatics/communications.

All forty candidate AI applications identified in this study were related to government productivity. Most were found to also fit with one of the other three priority areas. Generally, then, the findings of this study support these proposed priorities.

Given that limited resources will likely be available to start AI applications, decisions will have to be made as to which potential applications should receive priority. In assigning these priorities, implementation feasibility and payback are recommended as the most

important criteria. **That is, AI applications should receive priority where implementation can be achieved easily and where the payoff to government is clear.**

While the investment emphasis should be on high payoff AI applications that can be done with today's technology, the Federal Government should also consider longer term needs. Some potential AI applications have a significant future payoff in terms of meeting government or uniquely Canadian needs and they therefore merit early development investment. For example, machine translation is in need of considerably more R&D before it can be implemented beyond a very limited number of translation applications. Therefore, in cases such as this, the Federal Government should consider significant and longer term R&D investments. AI is an evolving field. Opportunity exists to match developments in AI to needs in government. A strategy should be developed to manage both AI developments and longer term needs.

The introduction of AI in government departments should begin with demonstration projects. Such projects need the involvement of departmental personnel who are enthusiastic and skillful and have the right technical environment to create and support an AI project. While demonstration projects are underway, departments should move to set priorities for the allocation of resources for the implementation of AI in the broader operational environment.

Priorities should be linked across departments, in order to create more synergy in the development of applications. This will result in a broader diffusion of AI knowledge and experience in government as a whole. Departments can then share their experience and engage in joint AI projects with others as appropriate.

As an implementation plan, it is recommended that:

i) **each department pursue a course of AI implementation through demonstration projects**

ii) **each department evolve its own internal coordination mechanisms to ensure department-wide implementation**

iii) **an inter-departmental user group be established to support and stimulate the development of AI applications in government**

iv) **one agency be designated to coordinate a government-wide strategy for AI and act as the central focus in determining how government can exploit AI opportunities effectively**

v) **over time, the central or service agencies such as Supply & Services, Treasury Board, and Public Service Commission should develop specific AI plans in terms of procurement, productivity enhancement, personnel classification and budgetary allocation.**

Government Procurement of AI - Conclusions and Recommendations

The complementary objective of the study concerned the potential leverage of Federal Government procurement of AI products, systems, and services for stimulating Canadian industrial development in the AI field. As in many high technology industries, government procurement is likely to be critical to the nurturing of a strong AI industry in Canada. Based on the potential range and size of AI applications in government, it would appear that Federal procurement could play a major role in developing Canadian corporate capabilities.

Government procurement is important for the growth of the AI supplier companies, by providing these companies with opportunities to commercialize technologies developed in response to government needs. In return, these companies become part of an AI infrastructure which can help upgrade productivity across the board in government. As well, these same companies will contribute to productivity gains in the private sector and enable Canada to have "something to trade" in the world pool of technology.

AI Supplier Capability

World demand for AI hardware, software, and services is projected to grow to $4 billion in 5 years time from approximately $700 million in 1985. The private sector capability to serve the AI market is in a highly dynamic state. In the U.S., scattered pockets of AI capability, often originating at the university level, are now being gelled into industrial capabilities with commercial AI products. Large companies, which have concluded that they will need AI applications for their operations, are investing in these smaller companies or are otherwise entering into long term contracts with them.

This AI supplier development activity is occurring in Canada at a slower rate than in the U.S. Canada's ability to foster small company spinoffs from universities is much weaker than in the U.S. As well, Canada's stock of large companies with the need and resources to invest in AI supplier companies is proportionately lower than in the U.S. Consequently, Canadian AI supplier companies are few in number and

are the product of persistent entrepreneurs. They have required innovative business arrangements in terms of joint ventures among firms, networking arrangements with Canada's academic community, and alliances with non-Canadian multi-nationals.

Canadian suppliers are still developing and face formidable barriers relative to their U.S. counterparts. **It is concluded, then, that procurement policy should be developed as an aspect of industrial stimulation, or else Canada is likely to have a very weak AI supplier base.**

Strategic Targets

A procurement strategy needs targets for industrial development, as well as mechanisms to implement the strategy. Therefore, **it is recommended that government establish targets for the evolution of an indigenous AI supplier industry over the next five years.**

To achieve these targets, Canada will have to specialize in certain AI fields and applications. This will involve investment choices, with an unavoidable role for the Federal Government in view of its importance as a key early customer.

These priorities could emerge from the analysis of departmental experience, both from working together and individually. As far as the supplier companies are concerned. Their specialization will be determined by market opportunity, for example: space station development, geomatics, expert systems in government

administration, process control systems in natural resources industries and machine translation. The Federal Government will have to work closely with industry to concentrate the investment in areas of high potential commercial pay-off for the industry.

Development targets should also consider the need for critical mass and regional objectives. To establish critical mass, the emerging AI community in Canada should be encouraged to develop in various geographic centres. AI applications should establish key linkages to regional university and Federal and Provincial Government research activities, and in this way become the agents of technology transfer.

Finally, Federal Government procurement should be constructed so as to faciliate the innovative business arrangements of the AI supplier industry. To date, such arrangements have included joint ventures, strategic alliances, consortia, and university linkages, among others. A relatively complex supplier infrastructure is likely to be the state of the short to medium term AI supplier industry.

Procurement Guidelines

The general thrust of a supplier development strategy would be to create a demand for AI products and services through Federal Government procurement, with explicit use of the contracting out policy. Additional guidelines that would support the procurement process are the following:

- o academic resources should be encouraged to participate with the private sector firms;
- o companies and government must be prepared for multi-year commitments, so that the companies have something marketable to the world afterwards;
- o the government procurement process should also foster Canadian private sector AI usage - to obtain further dollar commitments that in turn support AI suppliers;
- o while multiple procurements should foster strong companies, the broad range of AI applications suggests there is merit in triggering multiple supplier firms.

It is concluded, therefore, that a substantial number of AI applications which can generate real benefit in terms of productivity, decision-making support and enhanced service exist in government. These applications should be pursued as part of an overall strategy within each department, and the experience from the initial applications should be shared on an inter-departmental basis. In parallel with this application development process, the government should establish specific procurement strategies and policies to promote the growth of domestic suppliers. AI technology, properly applied, can result in benefits which are a large multiple of the original cost.

1.0 Artificial Intelligence: An Overview

In this introductory section, we provide an overview of artificial intelligence (AI) as both a science and a technology. We then explain its growing economic importance and describe how other countries have committed resources to the field, in order to accelerate the development and commercialization of the technology.

1.1 Orientation of the Report

The operations of government are diverse and complex, and are increasingly dependent on the collection, processing and management of information. In addition, there is a current emphasis on downsizing in the public sector, on increased productivity, and on improving the quality of planning, management and service to the public. These factors provide the justification to examine the potential of new technologies which can support the objectives of efficient and effective government.

This report assesses the potential demand within the Federal Government for computer systems and related technologies which exhibit performance characteristics commonly considered to be associated with human intelligence. These systems have their origins in the scientific discipline known as artificial intelligence. Artificial intelligence is concerned with making machines more useful by causing them to mimic processes that, if performed by humans, would be considered intelligent.

Artificial intelligence is a central component in the development of new types of computers and systems, collectively called Advanced Information Technology (AIT). Today, there are significant national level AIT

programs in many countries. These are primarily large research and development initiatives, intended to produce a new generation of information technologies. This approach to AIT is considered to be "technology push", that is, a focus on the development of AI technologies for yet unspecified commercial applications.

In contrast to a "technology push", the emphasis in this report is on the "demand" or "market pull" for new solutions to existing problems. It seeks to identify opportunities to apply AI in areas involving greater complexity than has heretofore been possible to address by previously conventional computer-based systems.

1.2 Artificial Intelligence: A Scientific Overview

AI is a young science and is only now emerging as a technology. The roots of AI can be traced back to work in cybernetics, psychology, linguistics, philosophy and mathematics during the 1940's and 1950's. By the late 1950's, the term "artificial intelligence" had been coined to reflect the emergence of a new interdisciplinary scientific effort to make machines smarter while at the same time attempting to develop a deeper understanding of intelligence.

The science of AI is concerned with the study of systems that represent, acquire and use knowledge in order to perceive, reason, plan, act and use language. In other words, AI attempts to understand and emulate many of the processes that we associate with biological intelligence. Nonetheless, there are fundamental differences between these forms of

"intelligence". Exhibit 1-1 illustrates some examples of the differences between biological intelligence and artificial intelligence.

The processes by which intelligence is imbedded into machines are extremely complex. Consequently, the characteristics of AI as illustrated in Exhibit 1-1 are constrained in sophistication and range of application. These limitations are imposed by the current state of our scientific knowledge. In fact, no significant scientific breakthroughs have occured in recent years. However, progress is being made on many fronts.

In broad terms, we can consider AI to be comprised of four distinct but highly integrated components: principles, techniques, methodologies and applications. Exhibit 1-2 illustrates this structure, along with examples associated with each component.

1.2.1 Principles of AI

Artificial intelligence, like other disciplines, rests on a few fundamental principles. For purposes of illustration, several key principles in AI will be considered. One such principle is that of "search". The objective is to limit the search for a solution to a given problem; in other words, minimize the search for a path from some initial state to a desired final state. This approach is best illustrated by an analogy with the game of chess. Since the possible board positions are some 10 to the 120th power, it quickly becomes clear that achieving success through random search for the next decision point

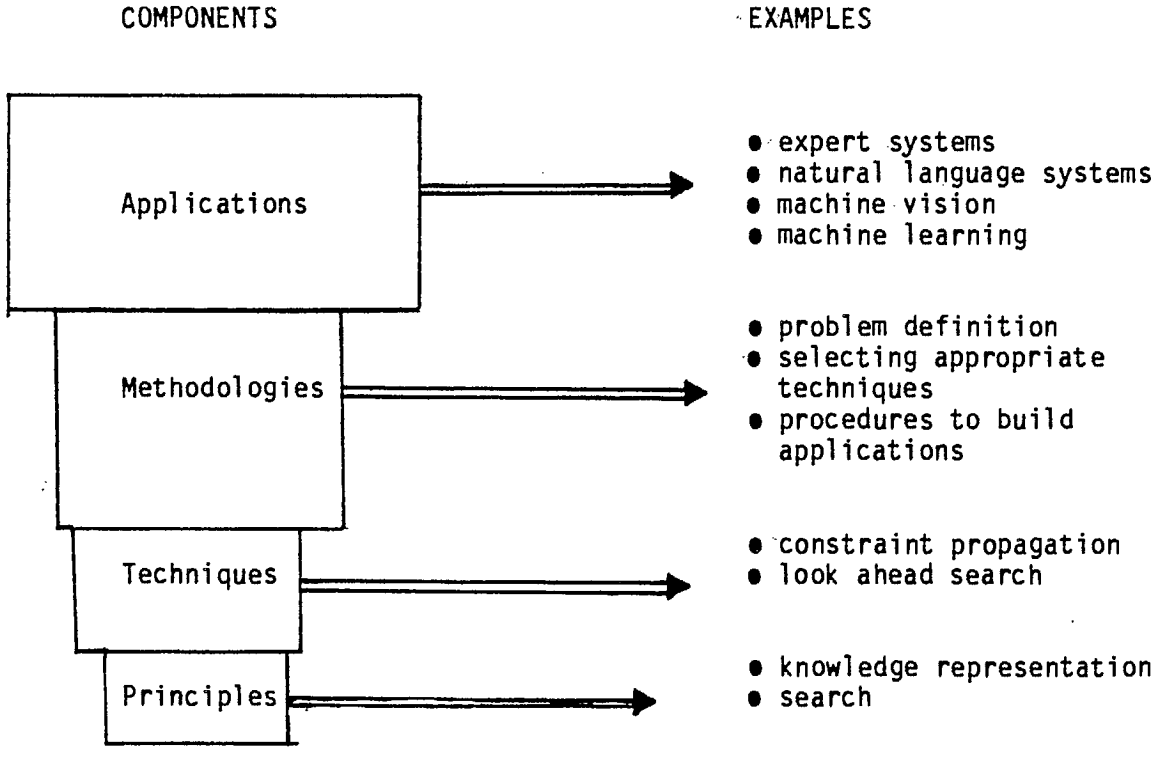
Exhibit 1-1

Intelligence Characteristics

Biological Intelligence	Artificial Intelligence
perishable	permanent
difficult to transfer	easy to duplicate
erratic	consistent
difficult to reproduce	easy to document
creative	uninspired
learned	programmed
sensory input	symbolic input
wide context	narrow focus

Exhibit 1-2

The Basic Components of AI



is severely restricted by an exponential growth in the number of choices. However, we know that a good player "automatically" reduces the problem of choosing the next move to a managable proportion of the possibilities corresponding to the most promising lines of attack. Consequently, choices are reduced to about 10 raised to the power 2 (ie. 100). Imbedded within this "automatic" constraining lies part of the essence of intelligence: finding ways to solve otherwise intractable problems by limiting the search for solutions. Research into the problem of search constraints has shown that a key to limiting the search space is knowledge -- tremendous amounts of knowledge.

In order to imbed knowledge into machines, it is essential to have the means or structures for representing knowledge. Consequently, another principle of AI is "knowledge representation". It is the process of organizing knowledge about a problem in a way that makes the problem easier to solve. The most successful AI applications are knowledge-based systems, or more specifically, expert systems. They operate in well defined and highly constrained applications where there is a large volume of specific knowledge about the particular application.

1.2.2 AI Techniques

The achievements of expert systems and other AI based applications rest on a vast array of techniques designed to handle general or specific classes of problems. For example, a variety of techniques have been developed for knowledge representation. Extensions to these, and the development of richer and more powerful techniques continue as part of the scientific pursuit of AI.

Traditional computer-based applications (such as data processing) and AI are fundamentally different in approach. The algorithmic approach, characteristic of traditional data processing, prescribes solutions to problems by exhaustive search and test procedures, coupled with necessary numerical compilation. In contrast to this is the heuristic approach, a common AI technique, which can be thought of as a "rule of thumb".

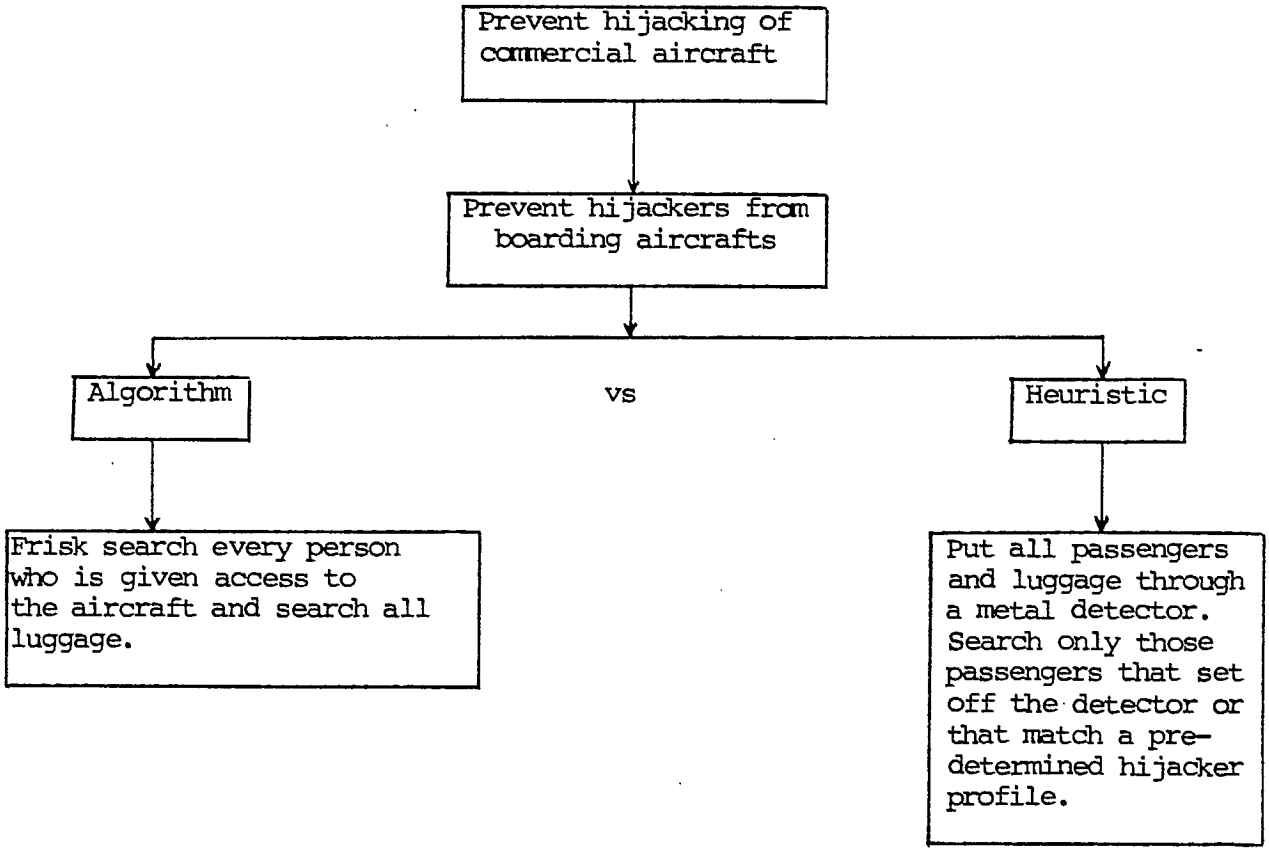
In order to appreciate this difference in approach, consider the analogy illustrated in Exhibit 1-3, in which we compare an algorithmic versus heuristic solution to a real problem -- a means to prevent aircraft hijackings. In this case, the use of a heuristic rule makes the search for solutions much easier and more practical than an algorithmic approach. However, it does not guarantee absolute success in screening passengers. A tolerable risk exists. This "imperfection" is typical of AI-based systems.

1.2.3 AI Methodologies

Methodologies describing how and when to use various AI techniques are complex and in many cases not well defined outside of specialized research groups. This area requires considerably more research and development in order to prescribe how and when to differentiate and integrate AI techniques. The development and refinement of the methodology will be an important step toward increasing the understanding and use of AI-based techniques for a wider audience.

Exhibit 1-3

Algorithmic Versus Heuristic Technique



1.2.4 AI Applications

The net result of these various steps in the evolution of AI has been the development of practical AI-based applications characterized by:

- expert systems (which reproduce human expertise in highly specific areas)
- natural language text systems (which are capable of "understanding" many words and certain word patterns);
- computer vision and image processing (ability to recognize patterns in a scene), and
- speech recognition (ability to recognize the spoken word).

In turn various combinations of these applications provide higher levels of integration in areas such as:

- machine translation
- instructional technology
- man-machine interfaces
- robotics, and
- systems with distributed intelligence.

The consequence of all these advances has been the recent emergence of an AI technology. Thus, AI applications, as the last basic component of AI (as per Exhibit 1-2), are indeed AI technologies.

1.3 Artificial Intelligence: A Technology Overview

The evolution of AI as a technology has depended on various scientific advances in the field but more directly on the ability to "engineer" AI technique and methodology into practical applications involving narrowly defined AI problems. This success has been fostered

by the development of special purpose AI computers known as LISP machines.

In essence, AI technology is manifested in applications in the form of the packaging of techniques that collectively result in specific problem-solving procedures. Appreciation for these recent accomplishments can best be gleaned from a closer examination of several applications areas in which AI has been used to:

- simulate human expertise by encoding knowledge and rules of thumb into a computer; the computer is equipped with a mechanism which can infer new relationships about the rules within the encoded knowledge base (i.e., expert systems);
- enable people to interact with computers and stores of information by means of natural language dialogue between the user and the machine (i.e., natural language systems); and
- assist other machines in performing tasks and actions such as the provision of sensory information and scene analysis (i.e., computer vision).

Concentrating on the simulation of human expertise has produced the most successful AI programs in the form of expert systems. They require a lot of high quality, specific knowledge about a particular topic. In addition to the generally demonstrated scientific success of expert systems, the effective engineering of software has led to the development of powerful tools called "expert system shells". These labour and time saving tools are then used to develop expert systems. This means in effect that people with less expertise can develop their own expert system.

Today, expert systems represent the most successful transfer of AI technology into the marketplace. This has resulted in a wide range of applications characterized by the generic categories illustrated in Exhibit 1-4.

Exhibit 1-4

Generic Categories and Typical Objectives Associated with Expert Systems Applications

Category	Objective
Interpretation	inferring situation descriptions from sensor data
Prediction	inferring likely consequences of given situations
Diagnosis	inferring system malfunctions from observations
Design	configuring objects under constraints
Planning	designing actions
Monitoring	comparing observations to expected outcomes
Debugging	prescribing remedies to malfunctions
Repair	executing plans to administer prescribed remedies
Tutor	diagnosing, debugging and correcting "student" actions
Control	interpreting, predicting, repairing and monitoring system behaviour
Advisor	expressing opinions after drawing from relevant facts
Tools	defining, building and executing other expert systems

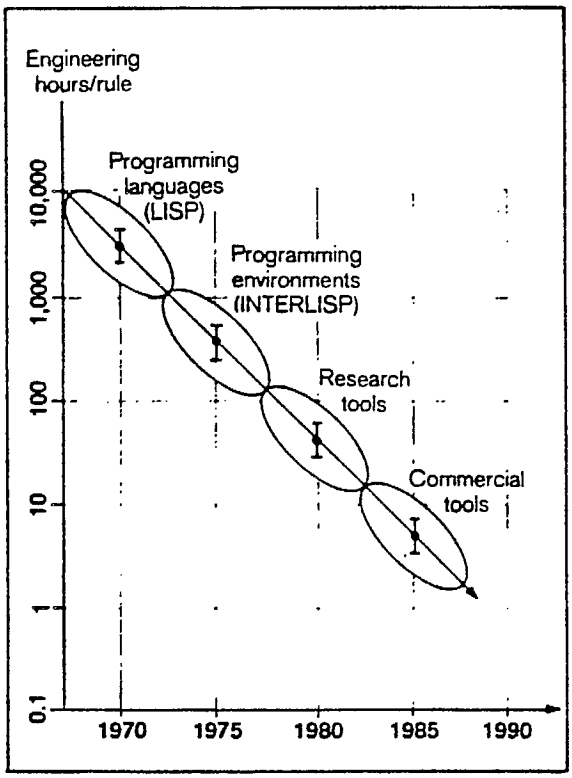
Literally thousands of expert systems have been built, almost all within the last few years. There are outstanding examples in any of the these generic categories. Almost all of them are industry proprietary or military. Consequently, there is limited technical information available and virtually no economic data. However, the few expert systems that have received publicity are yielding substantial economic benefits, as well as preserving and building valuable knowledge bases for their operators. This benefit is characterized by an ability to do things well and more efficiently.

In recent years, the increasing opportunity to develop expert systems in a commercial setting is a consequence of rapid performance increases in such areas as software tools. This alone has resulted in a dramatic reduction in the cost/benefit ratio of developing knowledge-based or expert systems. An excellent example of this trend in performance is represented in Exhibit 1-5. In this context, a "rule" is a procedural way of representing knowledge. This exhibit illustrates that the cost in developing an expert system has dropped three orders of magitude in terms of hours per "rule" from 1970 to 1985. Thus today, using commercial software packages, it is possible to build 'rules' in only a few hours. The trend is to still further performance increases.

Natural language processing (NLP), which allows computers to work with human language instead of just specially constructed artificial languages, has emerged in recent years in a variety of applications ranging from database query systems to machine translation. Exhibit 1-6 illustrates generic categories and typical objectives associated with NLP.

Exhibit 1-5

The Declining Cost of Developing an Expert System as Measured in Engineering Hours/Rule from 1970 to 1985



Source: Harmon & King, 1985

Exhibit 1-6

General Categories and Typical Objectives Associated with Natural Language Processing Applications

Category	Objective
Query systems	provide access to databases
Text critiquing	provide correction and advise on composition such as spelling, grammar and style
Abstracting	abstract the essence from a larger set of text
Language synthesis	generate coherent text from non-linguistic information such as numerical tables
Machine-aided human translation	provide human translator with productivity tools such as on-line dictionaries, terminology banks, lexicons, text critiquing and query system access to databases.
Human-aided machine translation	provide basic automation of translation process with options for human intervention before, during and after basic translation for purposes of improving quality of translation.

Natural language processing is extremely complex and thus applications of NLP are restricted to well defined and constrained problems. The greatest successes to date have been in query systems associated with databases. Commercial software tools have emerged that are analogous to expert system shells, insofar as the specific language requirements of the intended application are encoded into the query system.

Selected applications of machine translation have also been successful, but have been limited in their use of AI techniques. However, there is considerable technology development underway today to imbed AI into the machine translation process.

In summary, major technical advances in "packaging" AI techniques into useful tools have occurred in recent years. The leading successes are expert systems, followed by natural language systems, particularly in database query applications. Prospects for significant enrichment in existing tools as well as major advances in development of new tools with wider applications appear promising given the recent transformation of AI from the laboratory to practical applications and the subsequent emergence of a market. More important than this is the recognition that AI is an enabling technology, with the potential to transform the way the workplace -- be it the office, factory or mine -- will function in the future. This enabling feature comes as a result of the power of AI to link various technologies, such as office and manufacturing equipment, to provide significant enhancement in product capabilities, and enhanced market leverage over existing products.

1.4 AI Applications and Their Emerging Market

The emergence of AI in the marketplace is characterized by three distinct but interrelated groups of technology:

- Expert Systems
- Natural Language Systems, and
- Sensate Systems (ie, vision, voice, touch)

From an applications perspective, these segments have predominant markets in terms of:

	Market		
	Management	Service	Industry
Expert Systems	X	X	X
Natural Language Systems	X	X	
Sensate Systems	X		X

Commercial AI is comprised of both products and services. The products are both hardware and software. Hardware is predominantly in the form of AI computers, often called LISP machines. Software is generally classed as:

- expert systems
- natural language systems
- visual recognition
- voice recognition, and
- AI languages.

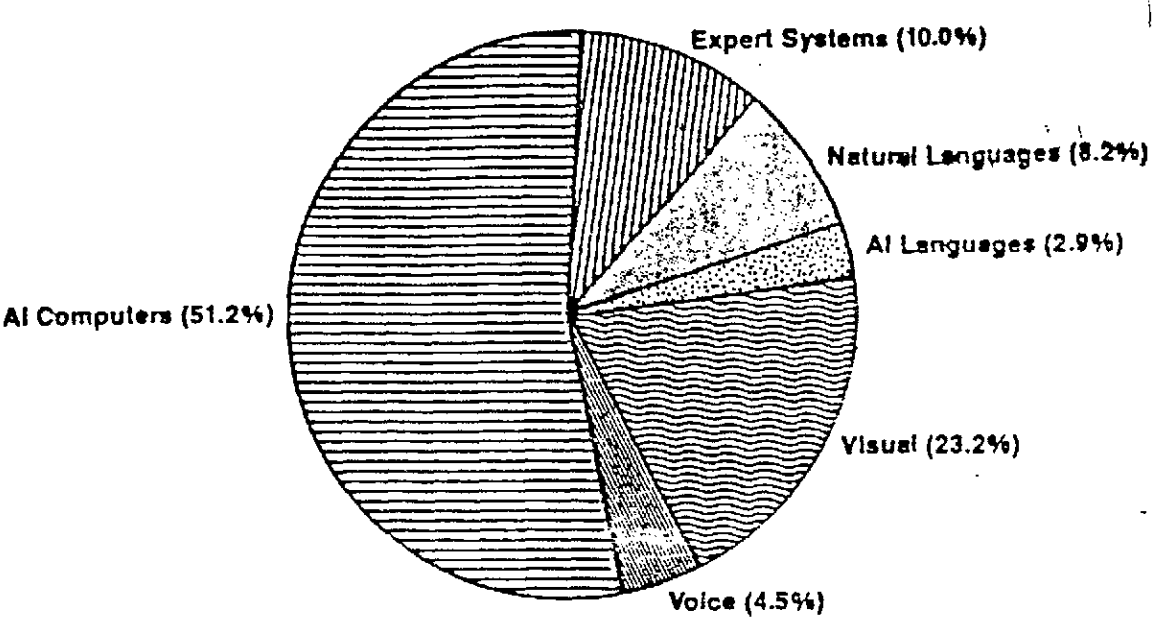
Exhibit 1-7 illustrates the hardware and software market for AI in 1985. The market shown for hardware and software are approximatley equal. In addition to products, there is a significant service revenue emerging for applications of AI to business problems.

From a modest start of some $55 million in revenues in 1981, the AI market in the United States is projected to grow to over $4.2 billion by 1990 according to the AI market research firm DM Data. This is reflected in the US forecast for AI products and services (government only) presented in Exhibit 1-8. According to these figures, AI software revenues are expected to grow to approximately 60 percent of the total AI market by 1990. These figures do not include anticipated revenues from the sale and use of conventional computers for AI work, nor do they include non-government services.

International Resource Development Inc., another US based market research firm has also analyzed the emerging AI market. Their aggregates for the US AI hardware, software and services segments of the market for the period 1983-1993 are presented in Exhibit 1-9. These data are broken out into a set of principal market segments comprised of factory, office, home, R&D and education. Exhibit 1-10 illustrates this distribution of AI revenues.

Although the absolute revenue figures and their related distribution across product types and services vary among forecasters, it is clear that there is an emerging AI market that will measure its revenues in the billions of dollars by 1990. These forecasts are based on current

Exhibit 1-7
Artificial Intelligence Market Product Areas in 1985



Source: DM Data in E.F. Hutton, 1985

Exhibit 1-8

THE ARTIFICIAL INTELLIGENCE MARKET
(Millions of Dollars)

MARKET AREA	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Expert Systems	4	9	17	38	74	145	245	385	570	810
Natural Language	5	8	18	40	59	125	210	320	465	650
Visual Recognition	10	22	51	116	168	260	370	500	660	840
Voice Recognition	5	7	11	20	33	55	85	140	200	270
AI Languages	3	5	8	12	21	35	45	65	80	105
AI Computers	28	56	103	217	364	510	710	970	1250	1570
Government Contracts*	20	30	40	50	95	150	150	155	175	200
TOTAL	55	107	208	443	719	1130	1665	2380	3225	4245

*Not in total, already included in other areas.

Source: DM Data in E.F. Hutton, 1985

Exhibit 1-9

Summary Ten Year Forecast For AI Products and Services, 1983 - 1993

($ Millions)

	1983	1985	1988	1991	1993
Hardware	$22	$85	$350	$950	$2,500
Software	19	50	275	1,095	5,300
Services	25	85	155	355	735
Total (constant 1983 $M)	$66	$220	$780	$2,400	$8,535

Source: International Resource Development Inc., 1983

Exhibit 1-10

Market For AI Products and Services, By Market Segment, 1983 - 1993

	Annual Sales (1983 Constant $M)				
Market Segment	1983	1985	1988	1991	1993
Factory	$4	$57	$210	$575	$1,305
Office	28	110	365	1,025	3,850
Home	1	13	120	520	2,435
Research & Development	33	38	70	200	435
Schools/Education	--	2	15	80	510
Total (Constant 1983 $M)	$66	$220	$780	$2,400	$8,535

Source: International Resource Development Inc., 1983.

expectations in demand and do not take into account the massive international R&D efforts in the field. In addition, all the forecasters see the priority areas to be expert systems, natural language systems, sensate systems and special purpose AI computers. Furthermore, the anticipated major users of AI will be in offices, although there is still debate as to whether the factory or the home will be the second largest consumer of AI products and services by the early 1990s.

AI in fact, is a strategic technology in the economy. As part of the advanced information technology family, AI is expected to be key to the competitive strength of a wide range of industries. It is also transformative in that the process of manufacturing, resources development, and services delivery will be fundamentally altered by AI technologies. As a strategic technology then, AI has an economic importance far beyond its own direct market significance.

1.5 International Programs in AI

In many Western countries, governments have initiated major AI programs in order to take advantage of its potential application throughout the economy. The US, Japan, Britain and other countries have all made major long-term R&D budget commitments to AI and have launched applied research and demonstration projects in an endeavor to achieve market position. The following international programs are of particular note:

- United States: Traditionally, the US has stimulated advances in high technology through the military and aerospace industry. In the case of AI, a major military thrust has been launched through the Strategic Computing Program, a ten year $600 million program to promote advances in, and integration of, microelectronics and artificial intelligence through a series of demonstration projects. Software development for the Strategic Defense Initiative also constitutes a major AI initiative. On the civilian side, the robotics and advanced automation components of the NASA space station project represent a major thrust in advancing AI frontiers and applications.

  A number of major computer companies and related technology corporations have banded together in order to pool precompetitive R&D resources. The most widely known of these ventures is the Microelectronics and Computer Technology Corp. (MCC), with nearly two dozen major corporate members and $150 million earmarked for research from 1983-86.

- Japan: (ICOT) The Fifth Generation Computer Project is the focus of a national R&D effort, funded by government and industry. The R&D themes are organized around four key "functions": problem-solving and inference; knowledge-base; intelligent interfaces; intelligent programming. Included is a significant program in machine translation and natural language processing. These all constitute important sub-fields of AI.

- United Kingdom: A national five-year plan in advanced information technology has been established (called the Alvey Programme), controlled by the government and linked to industry and academia. The program is aimed at developing technologies for knowledge (rather than data) processing. It focuses on four interrelated themes: software engineering, intelligent knowledge-based systems, man-machine interfaces, and very large scale integration (VLSI). Again, AI is a central focus within each of these themes.

- The EEC: A key element in the new industrial strategy for Europe is ESPRIT--the European Strategic Program for Research and Development in Information Technology, funded at $1.5 billion from 1984-88. The themes are: advanced microelectronics, software technology, advanced information processing, office automation and computer integrated manufacturing. The aims are to ensure a strong European capability and to integrate their manufacturing base in order to supply their own markets and develop world class products.

Canadian expertise in AI is primarily at the university level, although there are a growing number of companies involved in commercializing and applying AI. As yet, there are no comparable advanced technology thrusts in Canada that approximate the initiatives of our trading partners cited above.

1.6 Summary

It was noted at the outset that the operations of government are diverse and complex and that advanced information technology and its application are important to supporting government activities. In particular, artificial intelligence based systems, which exhibit performance characteristics commonly considered to be associated with human intelligence, offer unique opportunities to satisfy various needs in government.

The science of artificial intelligence is relatively new, having emerged as a discipline in the 1950s. The objective has been to attempt to make machines more useful while at the same time trying to understand biological intelligence. Scientists have discovered a sufficient amount about constraining, representing and processing complex problems associated with "intelligence" that technical implementation of their findings have produced the first wave of machines which display, in a rudimentary way, "intelligent behavlour". These early "successes" are characterized by applications involving narrowly defined and well understood problems, such as adopting computer software to handle highly constrained natural language text in order to open access to computers to a wider audience of users.

The market for AI applications is expected to increase dramatically over the next few years. Today, greater awareness and understanding of the potential of AI are leading to a demand for application of AI systems in industry and government. In addition, major R&D programs, designed to accelerate scientific and technical developments in this field, are preparing the foundations for future applications.

Canada has not yet enunciated an AI strategy nor explicitly integrated AI into other technology thrusts. In our view, Canada should be in step with international developments in AI. This will require the formulation of an overall AI strategy. It is hoped that this study of AI demand in government may make some contribution toward the development of such a Canadian strategy, particularly by raising the profile of the potential of artificial intelligence to directly affect the performance of government.

2.0 Identifying AI Opportunities

This section provides a brief review of the workshop process by which opportunities to apply AI in the Federal Government were identified. We then outline the information system needs as they emerged from the discussions in the AI opportunity workshops. Next, these needs are recast as AI opportunities according to a preliminary classification of AI priorities as determined by Federal Government Ad Hoc Interdepartmental Working Group; finally, they are organized according to whether the information system they would potentially assist is manual, semi-automated, or automated. For purposes of comparison, we discuss current AI applications being implemented in user departments of the US Federal Government.

2.1 The AI Applications Identification Process

The market for AI based applications is only now emerging. Therefore, the focus of this study was on the potential "demand" for AI applications in government. From the outset, it was assumed that few areas in government would be considering AI based solutions to their existing problems or planning to use AI within their information system enhancements. We anticipated finding a few exceptions in technical and research operations.

Potential AI applications were identified through a process of workshops and staff interviews. Details on how these relate to the study rationale and approach are presented in Appendix A. Workshop

summaries, the opportunities identified, and assessments as to whether each opportunity lends itself to AI application are to be found in Volume II of this report.

In summary, the workshops were divided into two groups - "horizontal" sessions which covered broad areas of government activity (eg, forms processing) and "vertical" workshops which concentrated on the specific needs of selected departments (eg, DOC). Further details were gleaned from follow-up interviews with various government personnel. The horizontal and vertical workshop themes are identified in Exhibit 2-1.

In the 11 workshops, some 40 separate AI opportunities surfaced from the discussions. In this report, these opportunities are presented first as information needs, or problems identified and discussed in each workshop. We then convert these needs into opportunities for the application of AI technologies. The opportunities described are placed in tentative categories of government priorities, which have been proposed by the Interdepartmental Working Group on AI to demonstrate the relevance and importance of the opportunities for using AI in the Federal Government.

The field results of the workshops formed the basis of the first step in the analytical process. In examining the AI opportunities, it became apparent that they were all related to information-processing systems -- either as a replacement for existing ones, or interfacing with them. For presentation purposes, we organized the opportunities according to whether the information processing systems are (i) manual, (ii) semi-automated or (iii) automated.

Exhibit 2-1

Workshop Themes

Horizontal Workshops

Counselling/Training

Intelligent Buildings

Forms Processing

Informatics

Machine Translation

Vertical Workshops

Energy, Mines and Resources (EMR)

Department of National Defence (DND)

Department of Fisheries and Oceans (DFO)

Department of Supply and Services (DSS)

Ministry of Transport (MOT)

Department of Communications (DOC)

This three step process is described below.

2.2 Identifying Information Needs

The general needs expressed by workshop participants are compiled and presented in Exhibits 2-2 and 2-3. We also added an impact statement which reflects the potential benefits perceived if the need could be satisfied by AI. One can see, for example, that a wide range of benefits are considered possible through: productivity gains, improved consistency, enhanced service to a larger number of people, cost savings, and improvements in safety.

2.3 Conversion from Needs to AI Opportunities

During the workshops, and following them, we sought to convert the expressions of information needs to distinct possibilities for AI applications. The more detailed description of this process of converting needs (or problems) to candidate AI applications is to be found in the workshop summaries in Volume II. Here we present the opportunities according to a first cut of the Federal Government's attempt to set AI priorities. In 1985, an Interdepartmental Working Group on AI identified four categories of priority with respect to the application of AI by the Federal Government. These are as follows:

- o increase productivity in government operations;

Exhibit 2-2

Summary of Workshop Results - Horizontal

Workshop	Needs	Impact
Counselling (CEIC,RCMP,PSC)	- improved federal (and provincial) counselling service - PSC layoff counselling	- serve greater numbers; improve consistency; provide better service; eliminate embarrassment
Training (CEIC,RMCP, PSC)	- individual to mass classroom	- make better use of computer-based training - extend field workers' expertise
Translation (DOC, SoS)	- hierarchy of translation needs by level of difficulty	- near term productivity gains through machine assisted translation
Forms Processing (HWC, CEIC, Revenue Canada)	- data collection, assessment - reference for service to public	- reduce delays in information to public - extend field workers' expertise
Intelligent buildings (PWC, NHW, DOC)	- building management (environmental analysis, maintenance) - building design cost estimating system - communication analysis	- major cost containment requirements; 1% improvement yields substantial savings in maintenance - better design of building by improved client analysis - improve consistency of cost estimating procedures - all have major applications to private industry needs

Exhibit 2-3

Summary of Workshop Results - Vertical

Workshop	Needs	Impact
F&O	Fisheries - assessment of yields - improve fresh water fish data base - crisis management	- major economic ramifications if small efficiencies achieved in assessing fish stocks - knowledge bases have world market potential
	Oceans - processing large amounts of data and turn into salable products quickly - automated cartography	- improve access to previously "unuseable" data - ocean information has major impact on other dept's (ie. EMR, MOT, DOE)
MOT	- scheduling tools - operational planning - inventory management	- since MOT is industry responsive, large economic impacts are possible, eg. improving rail car utilization through scheduling. North America has $5 billion freight train market - a vehicle weights program has a $50 million Canadian impact - safety implications in air traffic control systems and remote sensing flows
DND	- radar target analysis	- improve reliability of detection
	- courseware development	- improved quality of course by accommodating student model
	- courseware delivery	- improved cost performance, increased efficiency in course delivery
	- manpower substitution	- improved safety.

Exhibit 2-3

Summary of Workshop Results - Vertical
(continued)

Workshop	Needs	Impact
EMR	- more effective access to databases	- increased productivity, serve greater no. of users
	- general tools for building intelligence systems (eg, for the for the scientists)	- increased research tool options; increased research productivity, and retention of rare expertise
	- map revision	- reduce manual complexity, increase efficiency in maintenance and delivery of products
	- tools for spatial databases	- new products, research opportunities, and increased distribution of expertise
	- geological mapping aids	- increased productivity; enhanced quality of product
	- reduction in complexity of research, technical and production system software	- dramatic improvement in productivity; major cost savings over conversion, modular software; improved software methodology and maintenance, and easier to use by resource managers
DOC	- study the cost and benefits of AI technology	- increased awareness in communications sector
	- improve regulatory process such as spectrum management interference complaints, navigational equipment, regulation query system	- increased productivity; better service to the public
	- research in applying AI to communications problems such as satellite systems	- better and more reliable systems
	- telephone network capacity fore-casting	- better equipment utilization; improved budgetary and cost control.

Exhibit 2-3
continued

Workshop	Needs	Impact
DSS	- more effective method in choosing appropriate software tools	- increased productivity, access more applicable software
	- coursware development	- improved quality of course, increased productivity by improving teacher input
	- more effective access to policy guidelines	- reduce manual search, serve greater number of users
	- improve policy impact analysis techniques	- increased quality of decisions, with the ability to examine more scenarios
	- reduction in search time through data bases	- increased productivity, system assists user in identifying specific data requirements
	- aid to evaluating bids, in the sourcing system	- improved quality of decisions, more systematic evaluation procedures

- o assist in the management, exploration and exploitation of renewable and non-renewable resources;
- o facilitate training and retraining; and,
- o encourage the enhancement of the value-added components of Canadian information and communications products and services.

The AI needs identified in the workshops can be grouped according to these four priorities, which are discussed below. A selection of these opportunities is shown in tabular form in Exhibit 2-4.

2.3.1 Productivity in Government Operations

The ability to improve productivity was most evident in the forms processing workshop. The attendees of this workshop included representatives of three of the largest forms processing departments in the Federal government - HWC, CEIC and Revenue Canada. Between CEIC and HWC alone, $250m is allocated to processing claim forms for unemployment insurance and old age security cheque issuance.

Two factors contribute to present bottlenecks in forms processing. First, the allotted search time allowed to agents for case study is inadequate due to the complexity of the rules and regulations to which they must have access. Second, most case decisions are judgemental, which leaves room for inconsistencies in rulings. If criteria were computerized and available on-line to all agents, more timely, more accurate and consistent decisions could be rendered.

Exhibit 2-4

Summary of Opportunities By Priority Area

Priority Area	Opportunity Identified
Increase productivity	- automate search through complex rules & regulations - improve consistency of rulings in unemployment insurance applications and many other form processing activities - on-line information to improve service to the public - database maintenance system to keep manuals up to date - train and heavy vehicle scheduling systems - cartographic map revisions
Renewable/Non-renewable Resource Development	- image data gathering (eg. remote sensing) and analysis applications for land and ocean resource monitoring - retention of rare expertise, dissemination of knowledge - automated cartography - improve accuracy in assessing fish yields - integration of remote sensing with resource management systems - simplification of information extraction from remotely sensed data
Training/Retraining	- intelligent computer-based training (ie., curriculum design based on profile of user) - expert system based training where client interacts with computer via natural language - database maintenance system to keep up-to-date job market information - intelligent computer-assisted counselling
Information & Communication products and services	- "intelligent building" systems ranging from diagnostic air quality capabilities, digital sensor components and tenant analysis packages - machine translation systems ranging from new hardware products (ie. translator's workstation) to automated text translation systems - natural language interfaces to large databases - spectrum management

Forms processing is, of course, conducted in other departments and agencies. The key to applying AI in this field is that the data must meet a set of rules and the comparison of results are yes/no decisions.

2.3.2 Renewable/Non-renewable Resources

This opportunity area is typified for the potential AI applications in the Department of Fisheries and Oceans (DFO). The Department has large data gathering, processing and information extraction components in its day to day operational requirements. Each of these activities has characteristics amenable to AI. For example, the Ocean Sciences Sector of DFO has requirements in image data gathering and analysis applications for ocean resource monitoring. This could be supplemented by automated or computer-aided cartography.

The largest potential impact of AI in DFO arises in expert systems applications for example, assisting in the development of biological prediction models. Improved optimization in predicting yearly fish yields could have major ramifications on the commercial fisheries. For example, increasing the cod catch by only a few percent based on a $600 million catch could have significant economic impact.

In fact, artificial intelligence has much applicability to resource exploration and exploitation. To survey and monitor our resources we make use of many techniques, such as remote sensing. The large volumes of images acquired by satellites and aircraft must be analyzed, and turned into resource information which is then used by resource managers. In British Columbia, for example, forest resource managers

use remote sensing to manage and to report annually on the state of the forests. Resource management systems for renewable resources are complex and use highly skilled expertise. Artificial intelligence techniques can simplify the operation of resource management systems and, by incorporating knowledge, enable rare expertise to be preserved and disseminated. While our study only touched on some of the AI application opportunities, we understand that expert systems for resource management systems are now being developed in several federal departments (eg. EMR and Agriculture).

2.3.3 Training/Retraining and Counselling

Computer-based training (CBT) systems are ideal candidates for applied AI. By making truly conversational and flexible self-paced CBT systems -- ie. intelligent computer-based training (ICBT) systems, dramatic productivity improvements in training are expected. For example, the application of AI to CBT can be used in:

- curriculum design: an expert system which prescribes the logical steps and requirements for developing a training package;
- specific course programs: a truly interactive process (not just yes/no) where dialogue is in natural language and the system understands the student; and,
- database update: updating the course content to replace hard copy manuals, which are updated infrequently.

Besides the area of training, AI can improve the Federal Government's delivery of counselling services. The application of AI could take computer counselling a step beyond the rigidly structured interaction with the computers currently in use. This would help overcome the problems of the lack of experts, time required for each client, the need

for up-to-date knowledge of job market information, and the needs of specific target groups, such as retirees.

2.3.4 Information and Communications Products and Services

Two applications areas are considered here: intelligent (or smart) buildings and machine translation. Each is described in turn.

Intelligent Buildings

The concept of a "smart building" involves integrating building systems and services with state-of-the-art hardware and software. There is a real need for the Department of Public Works (DPW) to be cost conscious, with over $5 billion spent a year in maintenance costs on their property holdings and a policy of "revenue dependency". The sheer size of the space to be managed creates logistical problems. With the growth of digital sensor components and sophisticated computer monitoring and planning systems, the management and effective utilization of data facilities has become even more important.

A good example of an AI based solution to fit this need is a diagnostic system for air quality. With constant information being logged, a fully automated system could monitor air quality and take corrective measures in balancing the quality of building air to a pre-defined standard and giving advice to a human operator, or making automatic adjustments. Although this is a small application in the total realm of building maintenance, it illustrates the possibilities if a full needs analysis could be undertaken by DPW.

Machine Translation

Machine translation (MT), is an important potential application area for AI. The demand for translated material in Canada continues to grow. For example, since the adoption of the Official Languages Act in 1968-69, the workload of the Federal Translation Bureau has jumped from 78 million words per year to 290 million words in 1985-86. Similarly in industry, most large exporting companies as well as those serving the domestic market have had to develop sizable translation services to meet their customers' multiple language requirements. Machine translation offers several suboptimal solutions characterized by the quality of the output text required. While not removing human translators from the process, these approaches should increase their productivity.

The short-term impacts of MT will be relatively small, since only limited translation is possible. However, economies will be realized as a greater portion of all translation work is done by the use of improved translation aids. In the short term, this means expanded terminology banks and split screen workstations. In the medium to longer term, this requires AI embedded capabilities such as syntactic and semantic analysis.

2.4 Opportunities by Category of Information Processing System

Access to, and use of information and knowledge, play a major role in government operations. Therefore, it is not surprising to find that the opportunities identified in the workshops are dependent upon either using natural language (ie, English or French) as a means of access to information, or a need to provide expert opinion. Thus, the AI

opportunities in the Federal Government relate basically to the need for improved information processing systems.

The AI opportunities in information processing systems lie in improvements in operations such as: ease of use, efficiency and consistency. The AI opportunities arise from planned enhancements and replacements of current information systems. For purposes of further analysis, then, we sought to organize AI opportunities according to whether the information processing systems are currently manual, semi-automated or fully automated. Exhibits 2-5, 2-6 and 2-7 identify the 39 information systems identified in workshop discussions, categorized in this way. In addition, a lead department is identified with each proposed application.

The largest list of potential applications - 22 of them - is for replacement or support of manual systems (Exhibit 2-5). They all represent tasks which are currently carried out by human experts and therefore have traditionally been difficult to automate.

The next largest group - twelve applications - are semi-automated systems (Exhibit 2-6). The majority of them represent traditional data processing front-ends which require experts to interpret and make use of their outputs. Here, the automation of the data processing has been the "easy" part. Considerable complexity is inherent in the human processing part of these systems.

Exhibit 2-5

Proposed AI Applications to Support or Replace Current MANUAL SYSTEMS

AI Opportunity Identified	Lead Department
Telephone Network Capacity Planning	DOC
Machine Assisted Human Translation	SOS
Human Assisted Machine Translation	SOS
Computer Capacity Planning	DSS
Building-Tenant User Requirements	PWC
Applications Software Selection (micros)	DSS
Microcomputer Configuration	AGR
Text Critiquing	DOC
Language Synthesis	DOC
Text Abstracting	DOC
Counselling Assistant	CEIC
On-line Course Manuals	CEIC
Policy Impact Analysis	DSS
On-line User Profile Assessment	DSS
Microfossil Analysis	EMR
Spectrum Management Policy Analysis	DOC
Course Delivery	CEIC
Curriculum Design	CEIC
Query System to Access Policy	DSS
Navigational Equipment Regulation Monitoring	DOC
Query System to Access Spectrum Regulations and Policies	DOC
Fish Yield Assessment	DFO

Exhibit 2-6

Proposed AI Applications to Support Current SEMI-AUTOMATED SYSTEMS

AI Opportunity Identified	Lead Department
Tax Form Analysis	RC
Diagnosis of Air Quality in Buildings	PWC
Building Life-Cycle Management	PWC
Sourcing System Aid	DSS
Oil Spill Analysis	EMR
Map Revision Assistant	EMR
Cartographic Data Interchange and Correlation	EMR
Econmic Geology Assessment	EMR
Remote Sensing Analyst Advisor	EMR
Diagnosis of Network Faults	DSS
Interference Complaints Analysis	DOC
Radar Target Analysis	DND

Exhibit 2-7

Proposed AI Applications to Support Current AUTOMATED SYSTEMS

AI Opportunity Identified	Lead Department
Rules and Regulations Tutor for Old Age Security System	HWC
Query System to Access Rules and Regulations	CEIC, HWC
On-line Counselling Aid to CHOICES Job Bank	CEIC
Cost Estimating System for Property to Support COMPEST	PWC
Upgrade Image Analysis Software	EMR

The remaining five applications are automated systems (Exhibit 2-7). The opportunities suggested for AI in these cases relate to enhancing existing traditional data processing systems.

2.5 The US Government Experience

To provide a perspective on AI opportunities in government, we examined US government departments involved with AI activities (see Exhibit 2-8). In a field trip to Washington, D.C., the research emphasis was on the agencies in which there is a potential "market pull" for AI, rather than a "technology push". In the latter category, the two outstanding examples are the Department of Defense and NASA, both of which have funded substantial AI research and development.

In all cases, the organizations visited were "acting on their own"; that is, there were no cross-organizational linkages. Awareness was built from top management and sustained by their perceived need to drive AI applications to a level of success and acceptance in their organizations.

2.5.1 Internal Revenue Service

The Internal Revenue Service (IRS) offers a very effective, well planned model for applying AI to meet information technology needs. A champion represented the cause at the Assistant-Undersecretary level. He ensured broad peer support by launching an internal training program involving financial support and sharing across the entire organization at the Assistant-Undersecretary level (ten people). Key personnel were selected for an in-house one year, and university run two year, training

Exhibit 2-8

Selected US Federal Government Experience

(as of October 1985)

US	Experience to Date	Application to Canada
Internal Revenue Service (Treasury) (IRS)	completed survey, identified opportunities, trained staff, began development (eg, demand investigation)	good process model (top down approach), environmental scan, cross-board endorsement, long term training of internal experts
Agriculture (AGR)	preliminary studies, reviewing science/engineering applications	similar needs
Federal Bureau of Investigation	feasibility studies, now actively building two ES (eg. terrorism, labour racketering)	potentially similar; RCMP and Security Service aware but have not shown interest to date
National Institutes of Health (NIH)	long time funder of ES to medicine; currently porting diagnostic systems into micro computer environment for use in clinical setting	similar needs
Office of Technology Assessment (OTA)	Conducting strategic studies to examine specific opportunities including AI, at request of Congress	no such awareness yet at Parliament level, but applicable in concept to Canada

program. The objective was to train domain experts and have them ready to begin the development and support of various applications across the organization. Interestingly, the data processing shop was supportive of the effort but was not instrumental in conveying the value of AI to the organization. Currently, three expert systems are at various stages of development. They involve both staff and contractors for the medium to longer term (three years plus). They expect to do most of the work in-house.

2.5.2 Agriculture

In the Department of Agriculture, the AI effort is also supported from a senior level, in this case the Undersecretary. The initiative is not as advanced as the IRS in terms of process. This is also reflected in the current planning, which includes externally funded studies and prototype development, but does not include an internal component able to accept and enhance applications supplied by contractors. This shortfall may cause delay and resistance to accepting new AI based systems.

2.5.3 The Federal Bureau of Investigation

The FBI is building several expert systems, using both internal and external resources. Interestingly, the applications currently under development had been discussed with Canadian officials in the RCMP and the Canadian Security Intelligence Service, but they are reported to have shown little interest. The reasons for this are not clear.

2.5.4 National Institute of Health

The National Institute of Health (NIH) has been a long time funder of AI research in support of the medical sciences. More recently, and at senior management levels, efforts are being made to "commercialize" selected expert systems applications for clinical use. This effort is being driven and supported using internal resources. The commercial product will be controlled initially by NIH and possibly santioned by the American Medical Association. There are, however, within the US, emerging issues about the ethical use of expert systems in a general clinical setting. It is in part for this reason that NIH is maintaining the control on expert system development and distribution.

2.5.5 Office of Technology Assessment (OTA)

The OTA responds to requests from Congress on issues of technology. AI has been, and continues to be, an area of strong interest. There are currently four projects underway examining various aspects of AI. These should all be published through OTA within the next year. To date, OTA has been looking at AI from a technology push perspective. However, it began recently to consider the demand side of AI within government.

2.5.6 Summary of US Government Activities

In summary, from a market demand perspective, the US government demand is no further advanced than the Federal Government in Canada. Individual groups within organizations are actively pursuing AI applications and they are doing so without consultation or discussion with other agencies of government. This is markedly different than in Canada, where several departments are pursuing AI in interdepartmenal

consultations. In the cases examined in the US, the data processing shops are not the leaders, and each effort is driven by senior management endorsement and involvement.

2.6 Summary

The identification of AI opportunities in the Federal Government required the development of new survey and analytical methodologies. Since there is no existing set of AI applications readily identifiable as being pertinant to government, we began with a process of identifying government information system needs or problems. This process was organized around specific themes (forms processing, intelligent buildings, machine translation, informatics, and training/counselling), and around specific departments (DOC, EMR, DSS, DFO, DND).

During and following the workshops, we continued the process of AI opportunity identification by translating these needs into candidate AI applications. This process resulted in some 40 applications being identified as possible areas for AI technologies to assist in government operational improvements. Whether these candidate application areas are feasible in terms of effective utilization of today's AI tools, is a question which is addressed in subsequent sections of this report.

However, the potential does exist for working directly on the four areas of priority as set in a preliminary way by government, namely:

- o productivity improvements, typified best in forms processing and operational manuals applications;
- o renewable and non-renewable resources management, exemplified in image data gathering and analysis and in improved decision-making related to fish harvesting;
- o training/retraining, for example in curriculum design and specific course development; and,
- o information and communications products and services, such as smart buildings and machine translation.

Upon further analysis, it appears that the AI opportunities are all related to information systems, with the application interacting with, enhancing, or replacing an existing system. Most current information systems for which there is a potential AI application are manual, several are semi-automated, and a few are fully-automated.

3.0 A Methodology for Evaluating AI Opportunities

This section presents a methodology for evaluating whether the specific opportunities identified in the workshops are amenable to AI treatment, ie, whether government requirements can in fact be met by current AI technologies. Evaluation criteria are proposed, ranked in relative importance, and an evaluation procedure described.

3.1 Suitable Criteria for Evaluation

In all development activities there must be criteria for determining if the investment in resources for development should be committed. For many fields, these criteria are well established. The criteria for determining whether artificial intelligence systems should be launched are not firmly established because the field is still young. However, we have attempted to develop working criteria for determining which opportunities are suitable candidates for AI application. These criteria are most useful in the case of expert systems and natural language systems, which characterize virtually all of the AI opportunities.

In general terms, a potential AI application involving an expert system must be constrained in scope (i.e., complexity) and must promise substantial improvement over existing systems or operations, while at the same time providing a reasonable pay-off related to the investment.

Upon review, we proposed thirteen separate criteria to judge each opportunity. Since not all thirteen criteria are equally important, we devised a relative weighting system to rank the importance of the criteria, as follows:

- "A" means the criterion is essential;
- "B" means it is important but not essential; and,
- "C" means it is helpful, but neither essential nor important.

The ranking is based on the study team's experience and knowledge about assessing the applicability of AI to business problems.

Essentially, the thirteen criteria can be grouped into three categories - three tests that must be passed; namely,

(i) is the potential application opportunity sufficiently limited in complexity so that current technology can be considered? (ii) is the nature of the problem such that improvements are possible through AI application? and (iii) is it important enough to merit attention and resources to justify a go-ahead decision for development? Below we describe each of these criteria sets.

3.1.1 Limitation to Complexity (Exhibit 3-1)

There are limitations to the complexity of problems which can be assisted by AI. Therefore, a key to the successful introduction of AI is:

Exhibit 3-1

Criteria used in Selecting AI Applications: Limitation in Complexity

Criteria	Explanation	Ranking
opportunity defined	- a clear description of problem exists and applicability of specific AI techniques is defined	A
bounded domain	- the scope of the problem is sufficiently narrow and concisely defined that the problem is tractable to conventional AI solutions.	A
large amount of task specific data available	- sufficient data/information must exist to substantiate system development	C
information specialized	- information associated with domain is detailed and specific	C

Ranking interpretation
A essential
B important
C helpful

- o clarity of definition;
- o restricting the problem's parameters, ie. a "bounded domain";
- o ensuring sufficient data is available; and,
- o limiting the application within a specialized field.

Limiting the complexity of the problem is particularly important. Projects have a natural tendency to grow in size and complexity, so that a project that starts big will get bogged down in the ensuing growth in complexity.

3.1.2 Major Improvements Possible (Exhibit 3-2)

Whether major operational improvements are possible depends on the nature of the problem or information system that AI is expected to improve. First, the resolution of the problem should be readily possible through the application of known rules and data. Second, the problem should be one that is currently routinely solved through the application of judgement by an expert in that particular field. Third, while the problem is being resolved, there are inefficiencies in view of bottlenecks associated with access to the right expert. The more these three conditions are met the greater are the potential improvements in the information system.

3.1.3 Go-Ahead Requirements (Exhibit 3-3)

The final set of criteria are related to the practicalities of tackling the problem through AI and the expected return on the investment necessary to set up an expert system or natural language system. The pragmatic hurdles are:

Exhibit 3-2

Criteria in Selecting AI Applications: Major Improvements Possible

Criteria	Explanation	Ranking
agreement about knowledge	- experts agree on the knowledge domain and access options	B
implementation procedure	- current procedures exist to solve the problem (ie, manual or otherwise)	B
quality/information/ knowledge	- degradation in quality of information/ knowledge through loss of expertise or inability to disseminate appropriate information/knowledge in a timely manner	B

Ranking interpretation
A essential
B important
C helpful

Exhibit 3-3

Criteria Used in Selecting AI Applications: Go-Ahead Requirements

Criteria	Explanation	Ranking
availability of experts	- experts must be available to supply procedures and knowledge as well as build the system	A
short-term benefits	- system should achieve a performance rating above that of an average user	B
expertise scarce	- limited number of experts currently available for routine access and consultation	A
size	- problem should be manageable with a short development cycle	A
test case available	- documented test cases serve as useful calibration mechanisms	C
importance	- the solution must promise substantial improvement over existing systems or operaitons while at the same time providing a reasonable cost/benefit ratio.	A

Ranking interpretation
A essential
B important
C helpful

- o availability of experts who will work with the AI "knowledge engineer";
- o a relatively short development cycle enabling go/no-go decisions to be made stage by stage;
- o use of existing AI technologies, ie. not dependent on application of the latest research findings; and,
- o test cases available to serve as benchmarks for progress.

Apart from these practical realities, the application must meet the traditional cost-benefit test - is the pay-off large enough to warrant the investment.

3.2 Evaluation Procedure

The 40 AI opportunities identified in the previous section were evaluated according to the thirteen criteria established above. The evaluation procedure was carried out in two steps.

3.2.1 Step 1 - Scoring the Opportunities

A simple 1, 2, 3 scoring system was established to determine how well the opportunities measure up to each criterion, as follows:

- o "1" implies that it is very likely that the opportunity meets the test of that particular criterion;
- o "2" indicates that the opportunity could meet the test; and,
- o "3" suggests that the opportunity does not meet the test very well.

This evaluation system is qualitative, and not absolute - a "3" score does not "fail" an opportunity per se. However, the scoring system applied to each criterion does provide a way to evaluate each AI opportunity on a systematic basis.

3.2.2 Step 2 - Scoring the Criteria

Since each criterion has a relative importance (essential, important, helpful), the second step in the evaluation procedure was to take into account this relative importance. Again, we assigned a simple 1, 2, 3 value, as follows:

- "1" for A (essential)
- "2" for B (important)
- "3" for C (helpful).

The opportunity score was then multiplied by the criterion score to arrive at a weighted value for the opportunity against a specific criterion. All values were summed for a total score for each AI opportunity. The total scores provide a means of comparing the relative suitability of the opportunity for applying AI technology. A low score means the opportunity identified is relatively amenable to an AI application; a high score, the reverse.

The evaluation process is best illustrated by example. Consider the case of developing an "intelligent" microfossil analysis system - one of the opportunities identified at a workshop. The criteria, criteria score, opportunity score and weighted values are illustrated in Exhibit 3-4.

Exhibit 3-4
Example Evaluation of An AI Opportunity
Microfossils Analysis System

	Criteria	Criteria Score*	Opportunity Score**	Weighted Value
	Limitation in Complexity			
1.	Opportunity defined	1	1	1*1 = 1
2.	Bounded domain	1	2	1*2 = 2
3.	Large amount of task specific data available	3	2	3*2 = 6
4.	Information specialized	3	1	3*1 = 3
	Appropriate Technical Parameters			
5.	Agreement about knowledge	2	1	2*1 = 2
6.	Implementation procedure	2	1	2*1 = 2
7.	Quality of information/ knowledge	2	1	2*1 = 2
	Go-Ahead Requirements			
8.	Availability of experts	1	2	1*2 = 2
9.	Short term benefits	2	3	2*3 = 6
10.	Expertise scarce	1	2	1*2 = 2
11.	Size	1	1	1*1 = 1
12.	Test case available	3	2	3*2 = 6
13.	Importance	1	2	1*2 = 2
	Total weighted Value			37

* Criteria Score: "1" criterion is essential ("A")
"2" criterion is important ("B")
"3" criterion is helpful ("C")

** Opportunity score
"1" opportunity likely to meet test
"2" opportunity could meet test
"3" opportunity does not meet test well

3.3 Summary

As in any development activity, candidate developments must be evaluated to determine their suitability. In view of the infancy of AI, we had to develop an evaluation procedure to determine which of the AI opportunities identified (see section 2) would be suitable.

Thirteen criteria were established, grouped into three categories:

- o limitation in complexity, i.e., the problem being resolved by AI has to be well defined and not overly complex;
- o major improvements to the information systems are possible with the application of AI technology; and,
- o go-ahead requirements in terms of practicalities and development investment pay-off must be met.

At this stage, it is not possible to set rigorous tests in terms of defining the necessary and sufficient conditions for implementation. Therefore, a scoring system was developed as part of the evaluation procedure, namely:

- o rating the candidate AI opportunity in terms of meeting each criterion, and
- o rating the relative importance of the criteria among each other.

This scoring system provides a quantitative basis for evaluating AI opportunities. It is stressed that the methodology is not sufficiently rigorous to provide a mechanistic evaluation procedure. However, it does go some way in establishing a procedure to determine whether the AI

opportunities identified in the previous section are feasible candidates for AI application - and the broader question of the utility of AI to the Federal Government using AI technologies which are currently available.

4.0 Evaluation of Opportunities

In this section, we use the proposed evaluation methodology (see Section 3) to assess how appropriate AI opportunities (identified in section 2) are to Federal Government information systems. The results of the systematic application of the evaluation methodology to the 40 AI opportunities are provided. As well, an estimate is made as to the representativeness of these opportunities in terms of the total Federal Government.

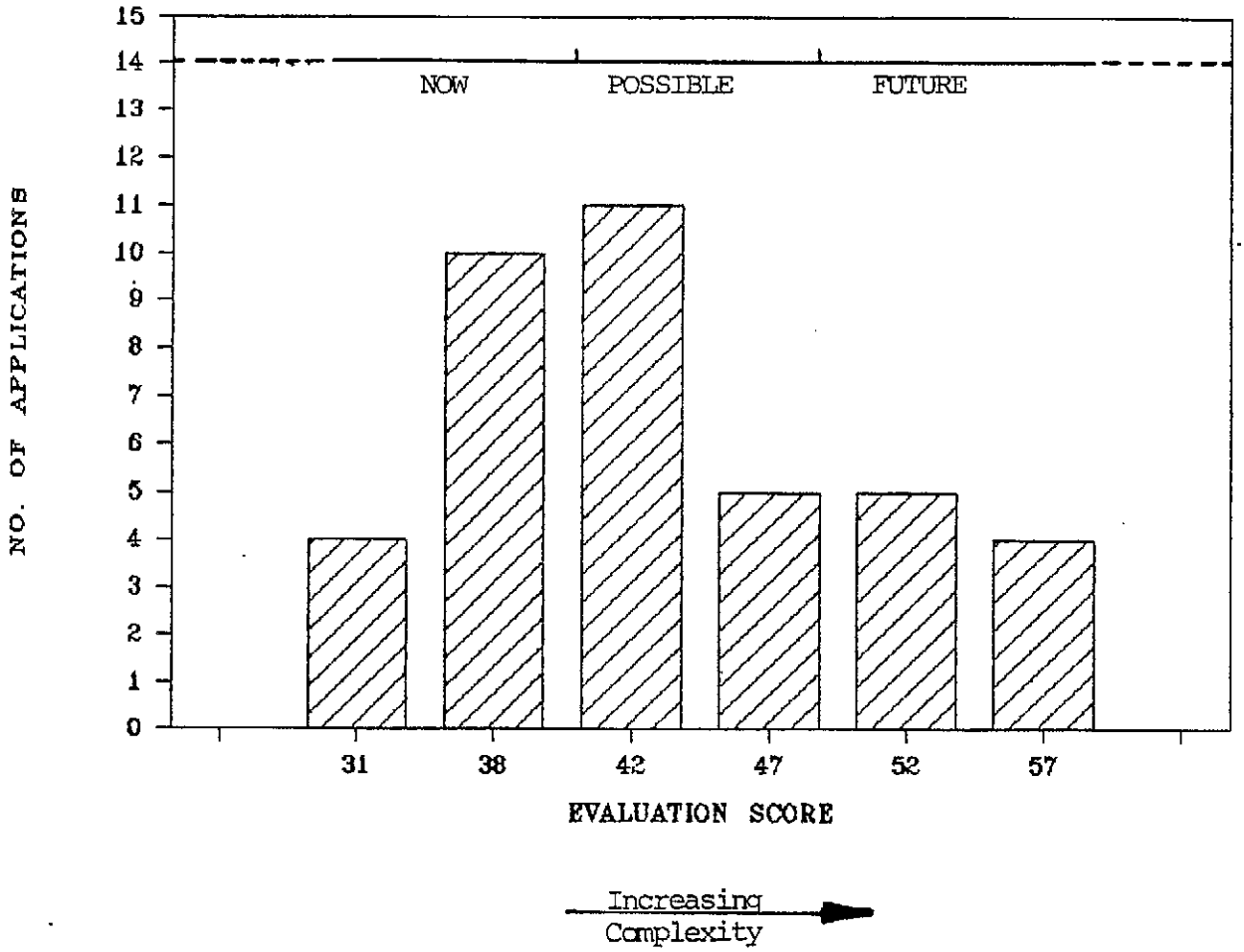
4.1 Results of the Evaluation

The purpose of the opportunity evaluation is to assess which AI opportunities can be accomplished with current technologies and are worth the investment. Without such an evaluation, we would not be able to distinguish between an AI "wish list" and those problems for which AI can truly be applied in a productive way.

All 40 opportunities were evaluated according to the evaluation methodology. Since each evaluation was based on a very limited exposure of the study team to departmental problems (the workshops), the evaluations are not full cost-benefit assessments. Nevertheless, the evaluation reveals what is practical, given the state of AI technologies today and in the context of budget restraint. The detailed results of the evaluation, i.e., the scoring of the criteria and opportunities, form Appendix C in Volume II of this report. A rank distribution of the scores for the 40 opportunities is shown in Exhibit 4-1.

Exhibit 4-1

RANK DISTRIBUTION AI OPPORTUNITIES



The scores ranged from 31 to 57 (note: lower scores signify that a potential opportunity is more amenable to AI application). On the basis of this evaluation process, systems with total weighted scores in the thirties constitute good candidates for immediate application of AI techniques. Opportunities which scored in the forties could proceed but should be considered more carefully. Delay in developing these systems could benefit from further progress in the development of AI techniques and tools. Proposed projects which scored in the fifties are not recommended to proceed at this time, although for policy or strategic reasons, some of them should be actively considered.

In addition to the distribution of scores, Exhibit 4-1 illustrates the number of applications that can be addressed with current AI tools and techniques. Second, it shows which of them are possible, given further analysis and availability of more advanced AI tools. Third, it shows the number of identified applications that require considerably more technical developments in AI and in problem definition before solutions are demonstrable.

Exhibits 4-2, 4-3 and 4-4 present the specific applications identified within each of the three ranges discussed above. According to our evaluation, any of the opportunities listed in Exhibit 4-2 could proceed once resources are made available. Applications in Exhibit 4-3 require further analysis to ascertain details about the nature of the problem and may require further developments in AI tools and techniques before a realistic solution can be developed. Finally, the applications identified in Exhibit 4-4 are not recommended to proceed as stand alone initiatives, due to the high degree of complexity associated with each application.

Exhibit 4-2

Opportunities suitable for Immediate Applications of AI*

Opportunity	AI	Sponsor(s)	Current Status	Priority	Significance
Navigational Equipment Regulation Monitoring	ES	DOC	M	1	OP
Fish Yield Assessment	ES	DFO	M	1,2	OP, ST
Application Software Selection	ES	DSS	M	1	OP
On-Line Course Manuals	ES	CEIC, DSS, DND	M	3,1	OP, ST
Counselling Assistant	ES	CEIC	M	1	OP, ST
Microfossil Analysis	ES	EMR	M	1,2	OP
Remote Sensing Analyst Advisor	ES	EMR	S	1,2	OP, ST
Query System to Access Policy	NL	DSS, DOC	M	1	OP
Building Tenant User Requirements	ES	PWC	M	1,4	OP, ST
Tax Form Analysis	ES	RC	S	1	OP
Sourcing System Aid	ES	DSS	S	1	OP
Diagnosis of Air Quality	ES	PWC	S	1,4	OP, ST
Diagnosis of Network Faults	ES	DSS	S	1,4	OP
Cartographic Data Interchange and Correlation	ES	EMR	S	1,2,4	OP, ST
Upgrade Image Analysis Software	ES	EMR	S	1,2,4	OP, ST

* for legend see page 64

Exhibit 4-3

Opportunities Suitable for Possible Applications of AI

Opportunity	AI	Sponsor(s)	Current Status	Priority	Significance
Microcomputer Configuration	ES	AGR	M	1	OP
Machine Assisted Human Translation	NL,ES	SOS, DOC	M	1,4	ST, OP
Spectrum Management Policy Analysis	ES	DOC	M	1,4	OP
Policy Impact Analysis	ES	DSS	M	1	OP
Query System to Access Spectrum Regulations and Policies	NL	DOC	M	1	Op, ST
Telephone Network Capacity Planning	ES	DOC	M	1,4	OP
Curriculum Design	ES,NL	CEIC,DND	M	3,1	OP, ST
Map Revision Assistant	ES	EMR	S	1,2,4	OP, ST
Interference Complaints Analysis	ES	DOC	S	1	OP
Oil Spill Analysis	ES	EMR	S	1,2	OP
Radar Target Analysis	ES	DND	S	1	OP
Economic Geology Assessment	ES	EMR	S	1,2	OP
Building Life-Cycle Management	ES	PWC	S	1,4	OP, ST
Building Cost Estimating	ES	PWC	A	1,4	OP, ST
Query System to Access Rules and Regulations	NL	HWC,CEIC	A	1	OP
On-line Job Counselling	NL	CEIC	A	1,3	OP

Exhibit 4-4

Opportunities Not Yet Ready for the Applications of AI

Opportunity	AI	Sponsor(s)	Current Status	Priority	Significance
On-line User Profile Assessment	ES,NL	DSS	M	1,3	OP
Computer Capacity Planning	ES	DSS	M	1,4	OP
Human Assisted Machine Translation	NL,ES	SOS,DOC	M	1,4	OP, ST
Text Critiquing	NL	DOC	M	1,4	OP, ST
Language Synthesis	NL	DOC	M	1,4	OP, ST
Crisis Management Information System	ES	DFO	M	1,2	OP
Text Abstracting	NL	DOC	M	1,4	OP, ST
Course Delivery	NL,ES	CEIC, DND	S	3,1	OP, ST
Rules and Regulations Tutor	NL,ES	HWC	A	3,1	OP, ST

4.2 Further Analysis of the Results

Besides the scoring of each opportunity and its allocation of one of three broad categories, other assessments were made about each opportunity area. This further analysis of the results is shown on Exhibits 4-2, 4-3 and 4-4 as follows:

- field of AI, whether expert system (ES) or natural language (NL);
- principal departments or agencies expressing an interest in the opportunities (ie. sponsor(s));
- current status of information system as either manual(m), semi-automated(s) or automated(a);
- priority in terms of the opportunity as fitting government priorities, namely:

  1 - increased productivity
  2 - resources management, exploration, exploitation assistance
  3 - facilitates training/retraining
  4 - enhancement of Canadian information and communications products and services

- significance to government in terms

  OP - operational enhancement
  ST - strategic to government and Canadian needs

Each is discussed in turn.

4.2.1 AI Field

As indicated in section 1, it was felt at the onset that the most common potential AI application would be for expert systems, followed by natural language processing. The results of the analysis support this

initial assumption, where 27 of the 40 opportunities are expert systems, seven are natural language systems, and six need both expert system and natural language technologies. As well, the expert sytems are found most frequently among the AI opportunities most suitable for immediate AI application.

4.2.2 Sponsoring Agencies

Some eleven departments shared the classification of sponsoring agency, reflecting the focus of the study's research. It is important to realize that there is no dominant AI user, and that interest in usage is to be found throughout the major government organizations.

4.2.3 Information System Status

As analyzed in section 2, the most frequent AI opportunity lies in information systems now operated on a manual basis. It is interesting to note here the presence of manual systems across all three categories of opportunity - from those most suitable to those not yet ready. Among the few automated systems identified, none were ranked among the opportunities most suitable for immediate application.

4.2.4 Priority of Opportunity

While the government AI priorities are only preliminary, it is useful to examine where the volume of applications fit in terms of these priorities. The number of times each was registered, counting applications which appear to suit more than one priority are:

- productivity - 40
- resources - 9
- training - 5
- information/communications - 16

The obvious conclusion to this tally is that increased productivity runs through all applications. It is also notable that all applications fit into one or more of the government priority areas, which probably means that the "priorities" are more closely akin to categories than actual priorities. Nevertheless, all priorities were covered by at least six opportunities identified.

4.2.5 Significance to Government

Not surprisingly, all 40 applications are significant in terms of operational enhancement, while only half could be considered strategic. The importance of this distinction is made evident by the examination of the opportunities judged to be not yet ready for AI application. Six of the nine applications in this group are classified as strategic, in terms of their overall importance to government. Furthermore, all six applications involve a substantial component of natural language technology. Given the need for natural language technology to support translation and enhanced access to computers in general, these areas could form the core of an R&D program sponsored by government in support of strategic procurement.

4.3 Applications in the Rest of Government

As indicated in section 2, this study covered only a sample of the Federal Government, and was far from complete in covering all potential applications within the departments reviewed. However, it is important to determine the universe of applications, at least on a preliminary basis.

It is difficult to extrapolate the study sample to the rest of the government, although it is clear that in the short term (1 - 3 years) the only significant opportunities that will be possible relate to expert systems and limited natural language systems. What remains to be seen is how much of the rest of government, which was not covered in this study will be interested in developing AI systems. Even in this study, the selection of AI candidates was typically the informal choice of the workshop participants. Therefore, the opportunities identified are only representative and not comprehensive.

To extrapolate the results to the rest of the government, we used an approximate measure of importance - budgets, person-years and S&T expenditures. Exhibit 4-5 shows departments and agencies in alphabetical order, with their 1985-86 net expenditure budgets, person years and S&T expenditures. For each department, we estimated the proportion of potential AI applications identified in a preliminary way in the study. The overall total indicates that somewhat in excess of thirty percent of the Federal Government was covered by this study.

Exhibit 4-5

Federal Budgets, Person Years and S&T Expenditures

Departments	Net Total Expenditures ($000,000 '85-86)	Person-Years (000 '85-86)	S&T (1) Expenditures ($000,000 '85-86)	% of Department Represented By Three Survey Techniques
Agriculture	$1680	13.3	$295	5
Communications	353	2.4	109	30
Consumer/Corporate Affairs	193	2.5	-	-
Employment & Immigration	4045	24.1	-	40
Energy, Mines & Resources	2820	5.3	388	60
Environment	726	10.3	412	10
External Affairs	779	4.6	-	-
Finance	5523	.9	-	-
Fisheries & Oceans	629	6.4	267	60
Indian & Northern Affairs	2285	6.3	-	-
Justice	158	1.4	-	-
National Defence	9383	35.6	204	60
Health & Welfare	633	9.8	115	20

Exhibit 4-5
continued

Departments	Net Total Expenditures ($000,000 '85-86)	Person-Years (000 '85-86)	S&T Expenditures ($000,000 '85-86)	% of Department Represented By Three Survey Techniques
National Revenue	$1129	29.9	-	10
Parliament	189	.1	-	-
Privy Council	42	.6	-	-
Public Works	1217	8.6	-	50
Regional & Industrial Expansion	1275	2.8	$174	10
Science & Technology/NRC	752	3.5	524	-
Secretary of State	3093	3.2	-	40
Solicitor General/RCMP	1015	19.6	-	10
Supply & Services	256	10.4	-	60
Transport/CTC	3661	22.8	-	60
Treasury Board	656	.8	-	-
Veteran Affairs	1577	4.1	-	-
Totals	42836	229.2	2488	
Overall Estimate of(2) Department Activities Covered	31%	32%	26%	

Notes
1) Figures only include major performers of S&T activities
2) Calculation based on column totals divided by our estimate of the level of activity within each department covered.

4.4 Summary

The 40 opportunities identified through the workshops were evaluated according to procedures developed for this study. The results are:

- o 15 opportunities are suitable for immediation application of AI;
- o 16 opportunities are suitable for possible AI application and need more examination; and,
- o 9 are not yet ready, although because of their strategic significance several could receive special R&D focus.

All opportunities would employ expert system and/or natural language technologies, primarily the former. The opportunities were spread relatively evenly among the key departments participating in the workshops. As determined earlier, the largest group of candidate opportunities are for manual systems. All the opportunities examined are related to productivity, while many touch on other government priority areas. Nearly half the opportunities could be considered strategic to government needs.

Thus, the use of AI in government is a very real possibility, not some far off potential application of an esoteric technology. Needs cross all departments and agencies, and touch at the heart of present day concern of government - doing more with less. The potential widespread application of AI technologies in government is documented by this analysis, and is the product of the high volume of information and knowledge collection, processing and dissemination activities of a modern government. Setting in motion the processes for diffusing the AI

technologies throughout government and preparing Canadian expertise and capacity to assist this process are the subjects of the next two sections.

5.0 Strategy for Government Use of AI

This section proposes a strategy for the Federal Government in adopting and developing AI based applications in support of government needs. The general direction of the strategy is set, and then the institutional arrangements are designed to deal with AI within departments and on an interdepartmental basis. Finally, we discuss resource implications for AI.

5.1 Setting the Strategic Direction

5.1.1 Government Needs

In this study, we have emphasized the "demand" potential of AI applications within the Federal Government. That is, we have consciously sought to identify "information problems" for which AI could provide solutions. Thus, the strategy is biased toward existing and potential demand for AI based systems (ie, responding to "pull"), rather than prescribing processes for advancing various facets of the field in the form of a technology "push".

There are three categories of information problems which encompass most government activities:

- o decisions based on information that has been assembled, requiring knowledge of policies, rules and procedures;
- o timely access to the right information (or databases) in order to make decisions; and,

- specialized processing of information whose characteristics are unique to the Federal Government (like conflict resolution in an aerodrome, or in French-English translation).

The Federal Government is less directly concerned with the use of information in manufacturing (i.e., robotics). Also, government is no more or less in need of certain office productivity tools (eg, voice recognition systems) than the private sector.

Our survey of government needs reinforces this general categorization. Of the 40, some opportunities identified that we believe to be amenable to the application of AI, the majority involved aiding decision-making or accessing information.

5.1.2 AI Pay-off for Government

The AI applications most appropriate for the Federal Government are expert systems (ES) to assist decision-making and natural language processing systems (NLP) to facilitate access to electronically stored information by government and the public alike.

In terms of actual government activities, the following areas of application illustrate the potential value of expert systems:

- areas where regular economic advice/technical expertise is needed for decisions of significant economic impact;

- o areas where manuals for operating procedures are required, especially complex manuals and those in need of continual updating;
- o areas requiring processing of massive quantities of forms (eg, personnel applications, income tax returns, customs declarations); and,
- o areas where individual Canadians require answers from government on a face-to-face or telephone basis (e.g., job counselling, responding to income tax queries, benefits questions).

Many areas of government require access to databases. The easier it is to get at the information, ideally through plain English (or French), the more widely the information can be used by government employees and the general public. For example, natural language front-ends to databases are important to resolving information access problems in ten cases identified in the workshops.

The essential pay-off to government in the use of AI is in terms of productivity gains, (i.e., assisting public servants in providing services more efficiently and with increased consistency). Specifically, AI based systems can:

- o provide faster and better decision support systems in situations where economic and human stakes are significant (e.g., air traffic control, fisheries stock management);
- o help constrain the person-year growth in government and improve the productivity of existing human expertise (e.g., real property management, translation, training); and
- o improve the level and quality of service to the public (e.g., forms processing, counselling, regulatory approvals).

Aside from these government administration and management areas, where increased operational productivity is the key to the rationale for applying AI, government carries out numerous complex and highly technical functions where AI systems can also be utilized effectively. This leads to the use of AI that can respond to the third category of government need -- specialized applications. A major example is the area of text translation. Other specialized applications that were rated in the workshops included the use of AI in sonar (DND) and for satellite system diagnostics (DOC). The overall pay-off for government from the exploitation of AI then, encompasses these more specialized applications, as well as those inherent in the government's administrative and regulatory responsibilities.

5.1.3 Pay-off for the Economy

Reference was made in section 2 to the AI priority areas identified by the ad-hoc interdepartmental committee on AI, namely productivity in government, resources exploration and exploitation, training/retraining, and informatics/communications. Besides the concern for productivity in government, to which this report is primarily addressed, there are specialized applications where AI systems can be utilized effectively. These applications relate generally to government assistance toward enhancing the nation's economic performance.

The use of AI in government can make a positive contribution toward economic development. For example, take the renewable/non-renewable resources area. Intelligent methods for extracting information from images are called collectively computer vision. For both

non-renewable and renewable resource exploration, scientists often use multiple sources of data. For non-renewable resources, such data sets would include remote sensing, seismic, geological, and geophysical measurements. By combining the knowledge of geologists, for example, with artificial intelligence and traditional methods, we predict substantial improvements in the efficiency and economy of resource exploration. Robotics also have a role to play in resource exploration, especially in reducing the exposure of human beings to hazardous situations and to improving the quality of produced products. By combining Canada's natural expertise in resources with artificial inteligence methodology, we improve our traditional resource sector of the economy.

As this example illustrates, the further application of AI in government operations has a direct pay-off for the economy. Strengthening AI capability in the priority areas proposed by the ad-hoc committee then, is an important aspect in the rationale for the use of AI in government.

5.1.4 Elements of a Strategy

As indicated earlier, we have found that the greatest potential for AI applications is in areas where computer systems have not yet been developed. The second largest group of potential applications lies in activities for which computer applications form only a part of the existing operation. Collectively, the application of AI within these groups introduces the computer to tasks not previously automated. Thus, a great deal of an initial government AI strategy is concerned with

generating awareness and the setting of the institutional processes to facilitate the adoption of AI.

The elements of the proposed strategic direction for the use of AI in government is summarized as follows:

- o Increase the awareness in the power of AI of Federal departments and agencies as practical ways to improve government productivity;
- o Develop government's capacity to exploit AI tools;
- o Facilitate the implementation of demonstration projects, experimentation, and applications development;
- o Establish the appropriate central agency responsibilities for AI, for S&T policy, productivity and supplier development; and,
- o Develop appropriate funding mechanisms, resource commitment, levels, and cost-benefit methodologies for introducing AI.

As indicated earlier, we have found that the greatest potential for AI applications are in areas where computer systems have not yet been developed. The second largest group of potential applications lies in activities for which computer applications form only a part of the existing operation. This means that AI tools will introduce computers where they have not previously been utilized. In this situation, a great deal of the government AI strategy is concerned with generating awareness and the setting of institutional processes to facilitate the adoption of AI.

Where computers are now extensively utilized there will also be important AI applications. It is in these areas, however, that AI awareness is apt to be greater; incorporation of AI applications into the existing computer environment will occur more easily.

A caution that must be raised stems from the limitations of AI. Despite its promise, there is a danger of overselling its value by missmatching its capabilities with the complexities of the real world. The sophistication of AI tools and techniques is expected to continue to increase, however, the strategies for its use by the Federal Government should take into account the uncertainty in the rate of basic AI developments.

5.2 Intra-departmental Strategies

Strategies should be government-wide (inter-departmental) and within departments and agencies (intra-departmental). We lead off with a discussion of intra-departmental strategies, because effective exploitation of AI technologies will ultimately be accomplished at the unit level in Federal departments and agencies. From our analysis the need is (a) to identify problems amenable to AI application, and tackle them through demonstration projects, and (b) to establish mechanisms for intra-departmental coordination.

While cross government attention to AI is necessary, government departments should at the same time be examining their own needs in AI to identify fertile areas for application. The time needed for the development of a centralized effort should not hold up applications that spring from the examination of needs by individual departments. Departments may wish to acquire off-the-shelf hardware and software for well defined needs. As well, departments may develop or acquire appropriate expertise for applying AI tools to a problem they are trying to solve. Like computers, AI applications will touch on a myriad of

government concerns, and so the attention to AI should not be overly centralized.

5.2.1 AI Demonstration Projects

Part of the task of building up AI expertise should be accomplished through demonstration projects. This approach puts the department up the learning curve through the process of action-by-doing in respect of developing AI based applications. At the same time, it helps to solve actual problems and extend existing systems, with the result being a "real" pay-back in meeting organizational needs and experience gained. For example, upon successful development of a demonstration system, the same expertise could be tapped for new or related projects. The result is that each success could have a significant multiplier effect on the rest of government.

We have not selected specific AI tools (e.g., expert system shells) for demonstration projects, because the needs are still highly specific. In the workshops, many candidate demonstration projects were discussed, and have been ranked in section 4. These projects, discussed in more depth in the workshop summaries (Volume II of this report) show the rich potential for initiatiating the demonstration projects process within departments.

5.2.2 Coordination within Departments

From our discussions with officials, we have found that while they were interested in solving problems rather than introducing AI per se, they were conscious of the need to formulate an explicit AI strategy

within their department. Given the uneven awareness and knowledge of AI, some central knowledge base is needed as a guide and coordinator, within each department. As well, the applications of AI often require some up-front investment, which has resource implications that may cut across branch boundaries within a department. Hence, departments should develop their own internal AI strategies.

In our US field trip, it became evident that commitment at the senior levels of American departments and agencies was indispensable to the implementation of AI technologies. For example, in one particular far-sighted department, several department officials were sent to take "knowledge engineering" training, in the expectation that upon their return, they would form a nucleus for the further development of AI. This is an explicit strategy clearly communicated from an Assistant Undersecretary level official, who is committed to an appropriate AI application plan. This kind of senior management attention in Canada will be vital to an effective AI strategy within departments.

Organizational interests in AI range from R&D establishments to EDP and office automation units, policy planning functions, and line operations. Since AI is currently in the technology push phase, the first tendency is to confine it to R&D establishments. However, just as computers spread to many facets of government life, AI tools and applications will involve a wider diversity of interests. Therefore, departments should not make a priori judgement as to who should lead the strategic planning for AI applications within their organization. Some care must be taken to identify an AI "product champion", wherever such a person emerges in the organization.

By the very nature of AI, the product champions are likely to emanate from departments with applications where computers are heavily used. That is, professional people already familiar with advanced computer systems are among the most likely to see the benefits of AI. While AI should spread the application of computers to department operations not now so engaged, the leading forces within departments may well come from the most computer-literate public servants.

5.3 Interdepartmental Strategies

Interdepartmental strategies are needed because of the evident cross-departmental interest in most areas of application. The first issue for interdepartmental planning and organization to be discussed is collaboration among several potential AI users in government. Second, there are issues of cross-departmental policy responsibilities of central agencies in the areas of procurement, productivity, science and technology, budget allocation, and supplier development.

5.3.1 Cross-Departmental Collaboration

Based on the results of the study survey, a number of the AI opportunities which were identified have applications across several departments. This suggests that a collaborative effort be considered, in order to develop these AI applications as demonstration projects. Areas of mutual interest to more than one department set the themes for the horizontal workshops, namely:

- personnel administration
- intelligent buildings

- o access and modification to regulations
- o training/counselling; and,
- o machine translation.

In each of these areas, there appear to be grounds for the pooling of interdepartmental resources to create demonstration projects.

It should be noted, however, that the complexity inherent in each area of mutual interest is varied. It ranges from "straightforward" development of expert systems in the areas of forms processing and modification, to regulations, through to complex research and development requirements to satisfy needs in areas such as training systems and machine translation. The technical and economic feasibility of specific applications within each area of mutual interest need to be assessed and ranked in terms of technical complexity and cost. Furthermore, as reported in the workshop descriptions in Volume II, each theme generated its own collaborative procedures, although the intensity of follow-up without further leadership may be tenuous at this time.

A number of additional AI based opportunities identified in the workshops would make ideal demonstration projects. For example, one area is information and database access. However, they tend to be highly specific to a department's mandate. Consequently, collaborative efforts could more rapidly disseminate and apply AI based approaches rather than specialize in meeting the needs of a specific department.

We believe that cross departmental collaboration should be stressed, but as stated earlier, this should not preclude departments from launching their own pilot or demonstration projects.

5.3.2 Interdepartmental Policy Responsibilities

The mandate of this study does not encompass policies in support of AI development generally, or recommend which departments should have specific responsibilities with respect to the application of AI to solve problems in government. However, from our observations we would recommend taking steps to coordinate government departments as AI users. A coordinated, cross-departmental focus on AI use in government would lead to the following benefits:

- foster a greater awareness of the potential applications of AI throughout government to improve productivity and enhance Canadian capabilities in natural resources, human resources and industrial development;
- promote collaborative efforts among departments, in view of many problems whose solutions are generically quite similar;
- provide an effective linkage between AI applications to solve government problems and to promote industrial development and strategic technologies; and,
- act as a reference point for individual departments as users, until they can develop their own competence in AI applications.

At this stage, the use of AI is embryonic and technology driven. However, it has appropriate applications throughout government. AI needs some central coordination to help evolve more definitive policies and practices regarding its use.

We have not conducted sufficient analysis to suggest whether there should be a special AI program, with earmarked funds for assisting AI applications for government use. However, it is apparent that there is a need to address that issue, likely in the context of considering AI as a strategic technology for industrial purposes. The particular responsibility for productivity improvements, procurement standards, and the appropriate amount of "R" versus "D" versus application is ultimately best left to the line departments which decide to adopt AI.

We suggest that the Ministry of State for Science and Technology (MOSST) could utilize the results of this study to initiate discussion about the roles and responsibilities of line and central agency departments in fostering the application of AI technologies to government needs. A central agency like MOSST should coordinate the development of an interdepartmental user strategy. The mandate would be to address the various roles of departments and agencies, as well as the awareness, collaborative, industrial linkage, and service to user functions outlined above.

5.4 Resource Implications From AI Use

With the general constraint on person-years and the demand for productivity now prevalent in the Federal Government, AI activity is likely to grow considerably over the next two to three years, whether or not a strategy is formulated. For example, one department indicated that its R&D unit with 3-4 person-years and a $500,000 budget devoted to AI now, could easily become a 10-person year, $5 million operation within two years.

The key to the degree of acceptance of AI technology by line departments depends on their ability to be cost-effective in the development and use of AI based systems. If successes have demonstrable positive effects on cost containment or productivity gains with a relatively small cost of development in the short term, our research has indicated that there are then numerous applications in over twenty different departments, each willing to attempt small scale projects.

To temper this enthusiasm, we must recognize two constraints:

- Currently, a gap exists between research and the commercial application of AI products. Major success has only been with expert systems operating in a highly structured and narrowly defined knowledge base.
- Experienced AI talent (knowledge engineers, programmers) is scarce. There is a need to encourage in-house staff development, attract students to applied AI and to deal with outsider AI professionals.

To incorporate a range of AI application possibilities, we have devised a demand schedule representing 3 potential scenarios:

Scenario A - involves the status quo. This means maintaining the present diffusion process of having interested individuals developing applications and finding solutions within their own limited funding and planning functions.

Scenario B - involves stimulation provided through a technical or procurement thrust from a lead government department. This scenario calculates requirements based on minimum levels of staffing (as identified by departments) to maintain a full-time AI activity.

Scenario C - Is based on an optimistic acceptance level of AI's potential. Again stimulation must be provided by a central authority to ensure momentum. The only limiting factor in this scenario is the lack of AI-trained personnel available. Certain departments (at least (three) - MOT, F&O and EMR), have identified that they each have enough work today for ten AI-dedicated staff.

For each scenario, we have projected demand schedules for the next four years. As shown on Exhibit 5-1, PYs in year 4 range from 35 - 65 in scenario A to 100 - 250 in scenario C.

In addition to PY impact, we projected potential expenditures for hardware, software and R&D (plus engineering) contracts. The results, shown in Exhibit 5-2, indicate total expenditures could range from $40 to $175 million by the third or fourth year.

One major caveat in these projections is that they are independent of a major AI technology push, such as that contemplated for the Space Station. Commitment to AI for specific, major R&D projects could have a further pronounced positive effect on the projected demand.

We anticipate that the source of resource requests and their justifications will be varied. For example, departmental Organization and Methods budgets could incorporate some off-the-shelf software/hardware purchases, but only limited allocations for R&D activities. There remains a problem in justifying R&D in areas of government activity where there is little tradition for it, such as in normal administrative/regulatory operations.

Exhibit 5-1

Scenarios for Federal AI Demand

Scenarios	Year 1	Year 2	Year 3	Year 4
A status quo	five to 10 departments have individuals working in AI, only a few of which are dedicated 20-30 PYs + EMR present #s	as individual projects grow, small add'ns to AI related staff 25-40 PYs + EMR	still relying on champions for AI, AI is now more successful, more initiatives to be funded 30-50 PYs + EMR	natural growth progression of a new successful technology 35-65 PYs + EMR
B incremental requirements in PYs over scenario A	five lead departments possible: (CEIC, NHW, F&O, EMR, DPW or MOT) 1 or 2 demonstration projects each 10-20 PYs	expertise grows within dept, moderate early success, another project begins. Sister dept's perceive similar needs, chip in with 1 or 2 projects 20-50 PYs	commercial availability of initial projects, 10 projects in implementation stage, 20 projects in development stage 40-75 PYs	depending on success of initial projects, person years should approximately double as some are in the user stage and some in the research and development phases 80-125 PYs
C incremental requirements in PYs over Scenario A	five lead departments receive complement of staff they request 20-40 PYs	sister departments develop projects. AI expertise grows and is fed to existing gov't personnel 40-75 PYs	success in final products effectiveness quite evident. gov't priorities given to continue AI developments 75-150 PYs	optimistic view of AI penetration. If correct projects picked and results are extremely positive, the "muchrooming" effect is great 100-250 PYs

Exhibit 5-2

Scenarios for Projected Federal AI Expenditures - Years 3 - 4

Scenario	$ for Hardware		$ for Software[2]		$ for design/engineering		$ Total (millions)
	Work stations	Minis	Specialized work station	gen'l purpose micro	gen'l purpose mini		
A	$3 million (mm)	$5 million at $500K/mini x 10 minis	3	2 million for 2000 users	1.5 million at $150K/mini x 10 minis	25 million in contracts	$39.4
B	$6 million	$12.5 million at $500K/mini x 25 minis	6	10 million at $1K/users x 10,000	3.7 million at $150K/mini x 25 minis	50 million in contracts	$88.2
C	$9 million	$25 million at 500K/mini x 50 minis	9	25 million at $1K/user x 25,000	7.5 million at $150K/mini x 50 minis	100 million in contracts	$175.5

Assumptions

1. Constant value but increasing performance, although bulk purchasing could lead to discounted prices.
2. Cost of specialized software is expected to be roughly equal to that of hardware.

Scientific applications for AI would be incorporated in R&D budgets, and so do not present the same problem. There may be a problem in the orientation of effort among science departments. For example, making information accessible to the public may be more possible through NLP, but not considered a high priority by the department. This focus on what to do with information is not a direct concern of AI policies, but the potential value of AI could trigger this type of policy discussion.

At this point in the development of AI use strategies, we suggest merely that the resources requirements and how they are adjudicated is an important part of policy development.

6.0 Strategies For Procurement

So far, this report has addressed the nature of the problems that AI applications might help the government solve and suggested procurement of AI systems as a means of meeting identified needs. This section describes how the Federal Government could utilize its procurement activities to help stimulate the development of a national capability in AI based systems, while meeting the needs of government. This is a key element of an overall strategy to develop Canadian capability.

6.1 Rationale for AI Industrial Development

The rationale for supporting Canadian commercial initiatives in artificial intelligence technologies is that it is strategically important to future economic development. It is strategic primarily because AI will pervade all sectors of the economy and will affect the productivity of Canadian enterprise in all sectors. AI is of strategic importance secondarily as a potentially highly important job generator in itself.

We recognize that at this point, the strategic nature of AI is simply asserted without being substantiated. However, industry observers project that AI will be as omnipresent in the 1990s as present generations of computers are today. As indicated in section 1, the advanced Western countries have made the same assumptions as to AI's strategic importance, and have formulated concrete plans to participate in the on-going developments in this field. Moreover, our research among federal departments was concentrated on identifying opportunity areas mainly in applications where computers are not now used. The evidence of such opportunities reinforces the argument for AI as a

strategic technology, requiring concerted government attention to fostering its development.

From the federal perspective, there is a practical rationale for stimulating the private sector in AI. As is shown in Section 5 of this report, there could very well be a mushrooming effect of demand for AI applications. To respond to this demand will require an adequate stream of human resources with technical capability and organizational resources for the private sector in Canada to respond to ongoing government needs. This need cannot simply be met by offshore suppliers, in view of strong requirements for interaction.

In summary, government support of Canadian supplier capability is important for the growth of those companies themselves, for the linkages that they have with the university research capabilities, for the need to upgrade productivity across the board in government and industry, for the need to develop "something to trade" in the world pool of technology, and for the opportunity to commercialize technologies developed in response to government needs.

6.2 Nature of the AI Supplier Industry

The private sector capability in AI technologies is in a highly dynamic state, with many types of firms in North America positioning themselves to benefit from the growth of the AI "industry". Scattered pockets of AI capability, often originating at the university level, are now being gelled into industrial capabilities with commercial applications of AI products. Venture capital companies are supporting the new AI suppliers (often former academics), in hopes of duplicating the phenomenal success of certain business software programs. The nature of the positioning activity is illustrated by the following:

- o hardware companies (e.g., Symbolics Inc.) are embedding intelligence into their product lines and creating specialized AI products;
- o some specialized companies (e.g., Intellicorp, Inference Corp.) have developed AI shells with sales to the users at a range of $100-$100,000 per unit, depending on the level of complexity;
- o engineering and technical expertise in specific fields are joint venturing with AI companies or developing their own experts; and,
- o new AI companies are being formed, combining knowledge engineering and "domain expertise" for application to a specific industrial sector (e.g., oil and gas, transportation, defence, space and communications).

At the other end of the scale, large companies with strong R&D activities are looking at ways to graft on AI expertise to exploit the new technologies for their own fields. Such major industrial concerns are giving contracts to, and putting equity into, AI engineering companies, as a way of ensuring the development of AI in their particular field.

6.3 Critical Role of Government Procurement

This AI supplier development activity is occurring in Canada at a rate that is directly reflecting Canada's human resources and less diversified industrial sector than in the US. There is no obvious Canadian company with a hardware product in AI, although some Canadian AI suppliers are distributors of such products and are using them to develop their own applications.

There are important research efforts at Canadian universities, but little successful commercialization of the research results. There are one or two examples of marriages between venture capitalists and university researchers in Canada, but nothing like the new company formations in the US. As well, there are one or two cases of large manufacturers or resource companies investing in Canadian AI companies (through equities or large orders), but not to the same degree as in the US.

As in many other areas, Canadian supplier growth is a function of the buyer and financial intermediary market infrastructure. Accessing US and other foreign institutions is a way to make up deficiencies in Canada, but the price can be rapid erosion of the Canadian value-added component of the product offering. Again, as in many high tech industries, a strong Federal Government demand that is structured to assist Canadian capabilities is likely critical to the nurturing of a strong Canadian industry.

Government orders are extremely important to Canadian supplier development because of their impact on company finances. Concrete (and sizeable) contracts generate bank and investment capital support for companies that emerge to seize new opportunities or make substantial new commitments to do the same. The chronic undercapitalization of Canadian firms is addressed better through the contractual process than R&D or other grant type support. Armed with a backlog of orders, well structured young, technology companies can find the necessary short term and long term capital required.

In the past 10-15 years, Federal Government orders have been made to companies who might not have otherwise been considered strong enough (financially and organizationally) to handle such contracts. It is in this tradition that procurement should be considered as a critical policy tool in stimulating Canadian AI development.

6.4 Procurement Strategies

There is considerable truth to the anodyne that where there is a market, suppliers will emerge. This is probable in the case of AI where a growth in Request for Proposals for AI development, systems and products will generate a supplier base. The first element of a supplier development, then, is simply to create a demand through contracting out policy. Beyond that, recognition of the nature of the AI need and the supplier community will suggest how to exercise the procurement leverage to maximum effort. What should be accomplished in the procurement process is the following:

- academic resources should be tapped - though doing so directly is generally frustrating for the user and academic;
- companies and government must be prepared for long-haul commitments, so that the companies have something marketable to the world afterwards;
- the government procurement process should also foster Canadian private sector AI usage - particularly where Canadian private sector companies are generally cautious about taking on such development roles;
- while multiple procurements should foster strong companies, the broad range of AI applications suggests there is merit in triggering multiple supplier forms - a few firms cannot possibly cover the range of AI possibilities;
- AI supplier firms will devolve from a variety of corporate combinations, particularly through the marriage of AI knowledge engineering and domain expertise.

Procurement strategies should not, of course, be rigid in stipulating requirements to meet the above objectives. However, it is important to establish practices which take account of the nature of the AI demand and supplier characteristics. To ensure that universities are linked to commercial suppliers, an explicit part of the procurement contract could stimulate this linkage. This kind of arrangement obviously reinforces the university role in human resource development and the transfer of know-how, expertise and new research out from unversities to commercial applications. It also tends to foster the linkage of the research with a problem by academics, to its later solution and development into particular applications of commercial value.

In the product development stage, there is very little off-the-shelf procurement that is possible. The requirement consists typically of a needs identification, contract R&D and engineering, the combination of equipment supply with intelligence embedded in it, and converting applications into real time use. To maximize the leverage value, line departments should be involved in stating requirements, and in designing the actual contract itself. The design of a contract to incorporate a front-end R&D phase ensures enough lead time and follow-through for a company to develop a high value-added product.

To achieve long-term commitments, a policy of selective sourcing within a competitive framework is required. While early development and conceptualization can be a subject of competition among Canadian firms, subsequent phases could be sole sourced to the original winner under a multi-phased contract.

At the same time, active participation in the development of AI by several departments will lead to the development of several suppliers. Through the multi-phased contract approach, then, federal procurement should lead to AI specializations by several companies.

In fact, the nature of AI brings out the potential of multi-departmental sourcing for AI applications. Such sourcing helps defray the up-front investment effort for the firm or firms involved. Therefore, the result will be several Canadian suppliers focussed in specific areas, potentially in relationship with several departments.

Some examples of early supplier development include the following:

- the integration of Sparks and Clayton and academics (the US in this case) in obtaining the "heavy vehicle configuration" contract from the Road Transportation Association of Canada and Transport Canada, is a match of "domain expertise" with AI expertise. The client actually had at least three valid bids from just such transportation engineering/AI joint ventures;
- the expert system development for satellite fault/anomoly analysis contracted by the CRC to help user client Telesat. The contract was a result of a joint venture between CAIP Corporation and aerospace sub-contractors from the U.S.
- DOC requirement for AI applications to communications and informatics was the result of a consortium of four companies comprised of CAIP Corporation, Cognicom Inc., Nordicity Group Ltd., and Trigon Systems.

In general, the private sector procurement of AI will be quite conservative. Companies will not buy AI per se, but only practical products that fit into their conventional understanding of the business in which they are situated. Government procurement more easily embodies the original research phase in order to help suppliers get to the much more commercial level of supporting private sector activity.

The Government can take steps to encourage a more open private sector user community. For example, "industry opportunities workshops" are one informal but effective mechanism to draw in private sector user firms together with government users and industry suppliers. One such workshop, sponsored by DOC, was held for communications-related AI applications. This initiative has triggered promising new supplier-buyer relationships.

6.5 Strategic Targets for Industrial Development

While procurement policies are related obviously to government needs, as well as industrial objectives, it is appropriate to have targets in mind for the development of an AI supplier industry. Three such targets involve:

- o critical mass of AI applications firms;
- o skills and specialization related to Canadian needs;
- o international orientation and export capability.

With respect to critical mass, the budding AI community in Canada should, over time, develop further in various geographic centres. Such firms should have established key linkages to university and government research and become the agents of technology transfer.

Some companies involved in AI will remain small; others will grow, perhaps embracing more than one AI specialization. The objective from an industrial perspective would be to have enough Canadian capacity to diffuse AI technologies throughout the economy, by incorporating the world's progress in the AI field.

The specializations and skills of the supplier community will emerge from market opportunities, for example: Space Station development, geomatics, expert systems in government administration, process control systems in natural resources industries, machine translation, etc. Procurement contracts with suppliers should be made with an interest in the entrepreneurial capabilities of the recipients to extend the work to a competitive specialization, preferably in areas where Canadian needs will be of relatively greater importance than Canada's proportion of total economic activity in world terms.

Some supplier firms will remain distributors of AI systems or products created elsewhere, or as conduits for external developments. They are important as part of the overall industrial infrastructure. However, as a target Canada should export as much as it imports - in dollar terms, of course, since Canada will always be a generator of only a small portion of international AI technology development.

In an effort to stimulate private sector development, the supplier companies themselves should be encouraged to help formulate development targets. While they will naturally be concerned with their individual priorities, an early and continued coherence as an industry should be of enormous assistance in the formulation of procurement strategies.

6.6 Conclusions

The institutional arrangements for the procurement of AI require additional study and clarification. The proposed direction discussed here emanates from day to day practical involvement in the AI supplier industry, and not from a study of that nature. However, the AI industry is like many other emerging ones in terms of the critical role that government can and must continue to play to help support the development of Canadian industry.

It is our conclusion that procurement policy should be developed as an aspect of industrial stimulation, that mechanisms should be designed into the procurement process that consider the effects of procurement on Canadian industry, and that industrial development objectives be established as targets for the ideal outcome of the procurement process.

7.0 Conclusions and Recommendations

In this section, we draw together the previous sections in the form of conclusions and study recommendations. We make observations about AI developments and present the key findings from the survey of opportunities in the Federal Government. We recommend strategies related essentially to the process of incorporating AI in the Federal Government operations and in using federal procurement as leverage to stimulate the development of a Canadian supplier capability in AI.

7.1 Development of AI

AI is both a science and a technology. It is a relatively young science from which practical technologies are only now emerging, characterized by:

- expert systems (which reproduce human expertise in highly specific areas)
- natural language text systems (which are capable of "understanding" many words and certain word patterns);
- computer vision and image processing (ability to recognize patterns in a scene), and
- speech recognition (ability to recognize the spoken word).

In turn, various combinations of these applications provide higher levels of integration in areas such as:

- machine translation
- instructional technology
- man-machine interfaces
- robotics, and
- systems with distributed intelligence.

The consequence of all these advances has been the recent emergence of an AI technology.

Today, expert systems represent the most successful transfer of AI technology into the marketplace.

The few expert systems that have received publicity are yielding substantial economic benefits, as well as preserving and building valuable knowledge bases for their operators. The increasing opportunity to develop expert systems in a commercial setting is a consequence of the rapid performance increases in such areas as software tools.

Natural language processing (NLP) enables computers to work with human language instead of only specially constructed artificial languages. NLP has emerged in recent years in a variety of applications ranging from database query systems to machine translation. The greatest successes to date have been in query systems to databases.

Selected applications of machine translation have also been successful, but have not been based on AI principles and techniques. There is however, considerable technology development underway today to imbed AI into the machine translation process.

AI is expected to be pervasive in the economy, just as previous computer generations have been. AI products themselves are expected to be a multi-billion dollar market in the 1990s. Other countries recognize this and have orchestrated efforts to partake in the resulting economic activity.

Given these AI developments and their expected importance, we conclude that **the introduction of AI technologies into the Federal Government be the result of a planned, deliberate strategy; otherwise it may become a haphazard, potentially wasteful process.** Furthermore, the Canadian Government could show international leadership, through the systematic exploitation of AI technologies for government applications.

7.2 Identifying Government Needs

Our canvassing of government AI needs was directed at the use of existing AI technologies in government operations (i.e., market pull), rather than their development as a product of further R&D activities (i.e., technology push).

We found that pockets of government, particularly the scientifically sophisticated, are already using AI to extend their existing capabilities to meet operational responsibilities. Even more importantly, **we found that a major, across-the-board opportunity exists in the Federal Government for a progressively widespread application of AI to improve the performance of government functions.**

Through eleven workshops involving 23 government departments and agencies, we identified some 40 potential applications for AI opportunities to improve government performance, e.g.,:

- o the marriage of expert systems and query systems to improve public (and government) accessibility to the myriad of rules and regulations affecting a large volume of government activities;
- o the use of expert systems to disseminate scarce expert knowledge for services to the public in career counselling, social benefits applications, and income tax preparation; and,
- o the use of expert systems in improving government decision-making in complex areas affecting significant economic decisions like offshore fishing stock management.

While our survey covered about a third of Government department activity, we believe that we have only scratched the surface of potential AI applications. Most opportunity areas involved dealing with information systems where no computer-based systems have been effectively developed. **Thus, there are many AI applications that are not readily apparent, whose numbers could mushroom over time as awareness increases, successes are achieved, and AI tools are advanced.**

In our evaluation of the AI opportunities, we identified those most amenable to AI application. We included technically qualifying criteria (e.g., where the problem was sufficiently constrained to permit knowledge processing) as well as criteria relating to national cost-benefit analysis.

Apart from tagging opportunities which could be implemented with current AI technologies, there are areas where government may wish to mount a larger AI development program. In areas like machine translation, for example, current AI technologies can be of help but much further work is needed. However, **the problem areas are so significant to government needs — and world market prospects exceptional to the successful innovator — that an AI program should be considered seriously as a focus for AI activity.**

In this study it is also appropriate to reinforce the four areas of priority suggested by the Interdepartmental Working Group on AI. They were developed on the basis of a need to blend AI technology with existing domestic strengths. **Besides government productivity to which this study is primarily addressed, then, the Federal Government should recognize the contribution of government use of AI to the country's economic performance: principally in the areas of resources development, training/retraining, and the informatics/communications sector itself.**

7.3 Government Use Strategies

An overall government AI strategy should rest on the two goals of (a) early diffusion of AI technologies in government, and (b) stimulus to Canadian private sector AI development. This is how the Canadian economy could most benefit from AI development, given the state of our technical, financial and industrial resources. Strategies for achieving the first goal relate primarily to government processes - both intra-departmental and inter-departmental.

We recommend that each department pursue a course of AI implementation through increased awareness, developed via demonstration projects in the support of AI product champions in government departments. At the same time, we recommend that government departments evolve their own internal coordination mechanisms, to ensure that department-wide implementation is achieved - intelligently.

In order to support and stimulate the development of new AI applications in governmentwe **recommend the establishment of an inter-departmental user group.** For example, this group could facilitate technology transfer within government and assist in various aspects of AI technology planning, preparations of RFP's and reviews of proposals and projects.

With respect to inter-departmental strategies, we recommend that a **single agency seize the initiative to coordinate a government-wide strategy for AI - to act as the central focus in how government can effectively exploit AI opportunities.** Over time, in view of the pervasive role of AI in government operations, **other central agencies should develop specific AI plans in terms of procurement, productivity, enhancement, personnel classification and budgetary allocation.**

7.4 Industrial Development Through Procurement Strategies

Besides government use, the second goal proposed for government relates to the promotion of industrial development. Specifically, this refers to supplier firms and university resources in the AI field, who

will be generating jobs and exports, as well as facilitating the spread of AI throughout the public and private sectors in Canada. The potential need for a major R&D program in AI technologies is not addressed here; nor do we suggest that the full array of Federal Government instruments of support be used for the private sector and university-government research sector. Since Federal procurement policies are critical to any AI supplier support program - **we recommend that appropriate procurement policies should be developed in parallel to and integrated with, the strategies for government use of AI.**

The procurement process should be designed to recognize the impact on Canadian suppliers, including such issues as:

- o generating long term commitments by suppliers;
- o developing several supplier firms with sufficient specialization to gain access to export markets; and,
- o engaging the involvement of private sector firms with common needs, as well as tying in universities to the AI commercialization process.

To help focus specific strategies **we recommend that government should establish targets for the evolution of an AI supplier industry over 5 and 10 year periods.** Without pre-determining the precise nature of supplier capability, this would key procurement to the creation of a critical mass of firms with a strong export capability.

AI procurement strategies are also desirable in some areas that are not directly related to immediate government needs. The most notable example is the proposed Space Station, whose total economic spinoff is projected to be 30,000 jobs. AI is a key component of this effort. **Thus, we recommend the continued treatment of AI as a strategic technology in itself, for which a procurement strategy should be designed.**

APPENDICES

Appendix A

Study Methodology

Appendix A

Study Methodology

A.1 Study Purpose and Approach

The purpose of this study was to:

(a) determine the "demand" for Artificial Intelligence based (AI) systems within the Federal Government over the near and medium term; and

(b) develop a strategy by which the Federal Government could stimulate the development of AI in Canada, while meeting its own needs. own needs.

The nature of the "demand" is not in the normal context of departmental "requirements", because there are very few explicit requirements for AI systems as such. Therefore, demand is determined through:

- identifying activities of departments and agencies for which AI applications could be pursued;
- assessing the potential for collaborative effort in AI development among departments with common needs;
- outlining how AI based systems can be used to help departments execute their mandates more effectively.

Following the identification of demand/opportunities, resource implications for government are estimated.

With respect to Federal AI strategies, the following avenues are explored:

- the potential of procurement leverage to stimulate Canadian AI development;
- the identification of demonstration projects;
- impact assessment of specific cases where AI applications seemed appropriate;
- implementation strategies for specific departments and agencies involved.

The study does not concern itself per se with the Canadian AI supplier community, although the contractors' experience in this regard is reflected in the analysis.

A.2 AI Workshops

To review existing and potential AI applications, a search of existing documentation was made, including U.S. and world-wide market forecasts for various types of applications. A visit to U.S. Federal agencies in Washington was also undertaken.

The process to select priority application areas and potential user departments and agencies was undertaken mainly through the use of workshops.

Initially, the range of federal activities subject to workshop discussion was divided into two broad categories:

Services to Government	Services to the Public
• Personnel Administration • Training, Staffing • Job Classification • Financial/Administration • Database • Legal • Parliament • Accommodation • Procurement • Information/Public Relations	• Regulatory - goods/services delivery • Program delivery to the public at large • Scientific research

From this first "cut" of workshop categories, there evolved specific workshop topics based on interest garnered through telephone contacts within and across departments. The workshops were finally organized in a cross-reference fashion -- ie. by both subject area and by department. The subject area workshops (or "horizontal" workshops) included representatives from several departments. The subject areas covered were:

- Forms processing
- Intelligent buildings
- Informatics
- Machine translation
- Training and counselling

The departmental (or "vertical") workshops included the following:

- Communications
- Fisheries and Oceans
- National Defence
- Energy, Mines & Resources
- Transport
- Supply & Services

In total, some sixty government personnel were involved in staging these workshops and meetings.

Appendix B

Workshop Attendees

APPENDIX B

Workshop Attendees

Workshop	Name	Dept/Title
Training/ Counselling	J. Hamill	PSC/Head, Training Technology Branch
	G. Gauthier	PSC/Director, Staff Training Directorate
	S. Conger	CEIC/Director General, Employment Support Services Branch
	C. Casserley	CEIC/Chief, Counselling Development Programs
	T. Green	PSC/Head, Language Training Program
	G. Mabe	RCMP/Head, Training Division
	P. MacNaughton	RCMP/Manager of Systems Research & Development
Intelligent Buildings	G. Ala	DPW/Asst. Director, Strategic Planning Corporate Policy
	D. Sander	NRC/Thermal Performance Section
	R. Henry	DPW/Chief, Energy Technology
	E. Hara	DOC/Director, Technology Assessment & Applications Planning
	T. Wilson	DOC/Manager, Program Planning & Assessment
Machine Translation	M. Tsui	SoS/Acting Director General, Planning Mgmt & Technology Branch
	F. Gobiel	SoS/Director, Technology Directorate
	E. Macklovitch	SoS/Project Officer, Technology Directorate
	D. Waung	DOC/Manager, Technology Assessment Information System
	F. Symons	DOC/Senior Analyst, Industry & Economic Development
Forms Processing	D. McCabe	NHW/Assistant Director Information Systems, Income Security Programs Branch
	C. McCann	Rev Cda/Mgr, Corporation Statistics
	L. Routliffe	CEIC/A/Chief, Liaison & Procedures

Workshop Attendees (continued)

Workshop	Dept/Title	
Informatics	H. Jones	F&O/Oceanographic Data Management Specialist; Data Source Development (MEDS)
	D.W. Hagborg	AGR/Manager, Micro-Computer Centre Systems to Consulting Directorate
	J. Oakes	DSS/Senior Policy Planner National Objectives Group
	W. Sawchuk	CRC/Difector General, Information Technology & Systems R&D
	H. Manor	DSS/EDP Security Co-ordinator
MOT	R. Lewis	Chief, R&D & Planning
DND	Ken Preebles	Director, R&D Communications & Space
	Jim Arkwright	DRDCS
	Vince Taylor	DRDCS
	John Moldon	Directorate R&D Maritime
	Frank Payne	DRDM
	George Spindlar	Director, R&D, Human Resources
	Derek Schofield	Chief, R&D
F&O	John Lark	A/Chief, Fresh Water Habitat Division
	Tim Hsu	Chief, Statistical Unit
	Doug McKone	Manager, Policy & Program Advisory
	Graham Armstrong	Chief, Administrative Operations
	Dick Stoddart	Officer, National Oceans Science Affairs Division
	Hank Jones	Oceanographic Data Management Specialist, Data Service Development (MEDS)
DSS	R.D. Weese	Director General, Program Development & Evaluation
	Ms. Josee Butter-field	Director, Policy Development & Evaluation Branch

Workshop Attendees (continued)

Workshop	Dept/Title	
DSS	Gilles Mongeau	Science Program Branch
	James Moir	Director, Product Technology & Account Management Branch
	Jennifer Stewart	Account Manager, Compensation & Payment Services Branch
	Kalma Fejos	Terminal & Network Support Div., Planning & Technical Support Br.
	Bill Dexter	Director, Management & Technical Services Branch
	Brad Ralph	Manager, Supply Management Br.
	John G. Oakes	Research & Analysis Group, Plans & Strategies Coordination Branch
EMR	Mike Berry	Earth Physics
	P. Charlesworth	Head, Data Systems - Geological Survey of Canada (GSC)
	D. Goodenough	Head, Methodology Section, CCRS
	Randy Goebel	Logic Programs & AI Group, University of Waterloo
	Laird Roe	Ministry of State for Science & Technology
	D. Armstrong	Systems Engineer, Topographical Surveys
	Mark Doherty	Surveying Engineer, Branch HQ
	B.A. Low	Development Group, Surveys & Mapping
	John E. Harrison	Senior Scientific Advisor, Earth Sciences
	Frits Agterberg	Head, Mathematical Applications in Geology - GSC
	Robert Garrett	Research Geochemist, GSC
	Pierre Lapointe	Senior Scientific Advisor, Earth Sciences Sector
	Doug Trigg	Chief Instrumentation Section, Geophysics Division, GSC
	Chris Hughes	Director, Computer Services Centre

Workshop Attendees (continued)

Workshop	Dept/Title	
DOC	T. Whalen	Manager, Behavioural Research
	G. Dobbin	Manager, Information Technology R&D
	Z. Muscati	Manager, Telematics Systems
	M. Sablataash	Manager, Information Technology R&D
	A. Gouin	Manager, GTA Planning
	G. Lockwood	Consultant, Systems Engineering
	J. Hothi	Officer, Technology & Policy Assessment
	D. Waung	Manager, Information Systems Technology Assessment

Appendix C

Evaluation of AI Opportunities in the Federal Government

Appendix C

Evaluation of AI Opportunities in the Federal Government

Following a preliminary evaluation of AI opportunities in each workshop (see Appendices D to N), we fine tuned these evaluations as shown in the following paper.

Two ranking systems have been used to evaluate each of the opportunities identified during the workshops. Each opportunity was rated on a scale of 1 to 3 against each criterion to produce an opportunity score. The resulting values were then weighted against the priority assigned to each criterion (ie, A, B and C where A = 1, B = 2, C = 3). The opportunity score was then multiplied by the criterion score to arrive at a weighted value for the opportunity against a specific criterion. All values were summed and the sums for each opportunity compared.

This process is best illustrated by example. Consider the case of developing an "intelligent" microfossil analysis system. The criteria, criteria score, opportunity score and weighted values are illustrated in Exhibit A.

On the basis of this evaluation process, systems with total weighted values in the thirties constitute good candidates for immediate application of AI techniques. Opportunities which scored in the forties could proceed but should be considered more carefully. Delay in developing these systems may benefit from ensuing progress in AI techniques and tools. Proposed projects which scored in the fifties are not recommended to proceed on the basis of straightforward development, although strategic procurement and R&D stimulation by the Federal government could alter these recommendations.

The opportunities are presented in three groups: manual, semi-automated and automated. The scores are in ascending order within each group. For details on the evaluation criteria and the evaluation process, see Section 3 and Section 4 of this report.

Title: Navigational Equipment Regulation Monitoring

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	1	1
Bounded domain	1	2	2
Large amount of task specific data available	3	2	6
Information specialized	3	1	3
Agreement about knowledge	2	2	4
Implementation procedure	2	1	2
Quality of information/ knowledge	2	1	2
Availability of experts	1	1	1
Short term benefits	2	2	4
Expertise scarce	1	1	1
Size	1	1	1
Test case available	3	1	3
Importance	1	2	2
		Total	32

Current status: Manual

Sponsor(s): DOC

Title: Fish Yield Assessment

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	1	1
Bounded domain	1	1	1
Large amount of task specific data available	3	2	6
Information specialized	3	1	3
Agreement about knowledge	2	2	4
Implementation procedure	2	2	4
Quality of information/ knowledge	2	2	4
Availability of experts	1	1	1
Short term benefits	2	1	2
Expertise scarce	1	1	1
Size	1	2	2
Test case available	3	1	3
Importance	1	1	1
		Total	33

Current status: Manual

Sponsor(s): DFO

Title: Application Software Selection

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	2	2
Bounded domain	1	1	1
Large amount of task specific data available	3	1	3
Information specialized	3	1	3
Agreement about knowledge	2	1	2
Implementation procedure	2	2	4
Quality of information/ knowledge	2	2	4
Availability of experts	1	2	2
Short term benefits	2	2	4
Expertise scarce	1	1	1
Size	1	2	2
Test case available	3	1	3
Importance	1	3	3
		Total	34

Current status: Manual

Sponsor(s): DSS

Title: On-Line Course Manuals

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	2	2
Bounded domain	1	3	3
Large amount of task specific data available	3	1	3
Information specialized	3	1	3
Agreement about knowledge	2	2	4
Implementation procedure	2	2	4
Quality of information/ knowledge	2	2	4
Availability of experts	1	2	2
Short term benefits	2	2	4
Expertise scarce	1	2	2
Size	1	2	2
Test case available	3	1	3
Importance	1	1	1
		Total	37

Current status: Manual

Sponsor(s): CEIC, DSS, DND

Title: Counselling Assistant

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	2	2
Bounded domain	1	3	3
Large amount of task specific data available	3	1	3
Information specialized	3	1	3
Agreement about knowledge	2	2	4
Implementation procedure	2	2	4
Quality of information/ knowledge	2	3	6
Availability of experts	1	1	1
Short term benefits	2	2	4
Expertise scarce	1	1	1
Size	1	1	1
Test case available	3	2	6
Importance	1	1	1
		Total	37

Current status: Manual

Sponsor(s): CEIC

Title: Microfossil Analysis

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	1	1
Bounded domain	1	2	2
Large amount of task specific data available	3	2	6
Information specialized	3	1	3
Agreement about knowledge	2	1	2
Implementation procedure	2	1	2
Quality of information/ knowledge	2	1	2
Availability of experts	1	2	2
Short term benefits	2	3	6
Expertise scarce	1	2	2
Size	1	1	1
Test case available	3	2	6
Importance	1	2	2
		Total	37

Current status: Manual

Sponsor(s): EMR

Title: Query System to Access Policy

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	1	1
Bounded domain	1	2	2
Large amount of task specific data available	3	1	3
Information specialized	3	2	6
Agreement about knowledge	2	1	2
Implementation procedure	2	2	4
Quality of information/ knowledge	2	3	6
Availability of experts	1	2	2
Short term benefits	2	1	2
Expertise scarce	1	3	3
Size	1	1	1
Test case available	3	2	6
Importance	1	1	1
		Total	39

Current status: Manual

Sponsor(s): DSS, DOC

Title: Building-Tenant User Requirements

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	1	1
Bounded domain	1	1	1
Large amount of task specific data available	3	2	6
Information specialized	3	1	3
Agreement about knowledge	2	2	4
Implementation procedure	2	2	4
Quality of information/ knowledge	2	3	6
Availability of experts	1	3	3
Short term benefits	2	2	4
Expertise scarce	1	1	1
Size	1	2	2
Test case available	3	1	3
Importance	1	1	1
		Total	39

Current status: Manual

Sponsor(s): PWC

Title: Micro-computer Configuration

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	1	1
Bounded domain	1	2	2
Large amount of task specific data available	3	2	6
Information specialized	3	2	6
Agreement about knowledge	2	3	6
Implementation procedure	2	2	4
Quality of information/ knowledge	2	2	4
Availability of experts	1	1	1
Short term benefits	2	2	4
Expertise scarce	1	1	1
Size	1	1	1
Test case available	3	1	3
Importance	1	2	2
		Total	41

Current status: Manual

Sponsor(s): AGR

Title: Machine Assisted Human Translation

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	1	1
Bounded domain	1	2	2
Large amount of task specific data available	3	2	6
Information specialized	3	2	6
Agreement about knowledge	2	2	4
Implementation procedure	2	2	4
Quality of information/ knowledge	2	2	4
Availability of experts	1	2	2
Short term benefits	2	2	4
Expertise scarce	1	1	1
Size	1	1	1
Test case available	3	2	6
Importance	1	1	1
		Total	42

Current status: Manual

Sponsor(s): SOS, DOC

Title: Spectrum Management Policy Analysis

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	2	2
Bounded domain	1	2	2
Large amount of task specific data available	3	1	3
Information specialized	3	2	6
Agreement about knowledge	2	3	6
Implementation procedure	2	2	4
Quality of information/ knowledge	2	2	4
Availability of experts	1	2	2
Short term benefits	2	2	4
Expertise scarce	1	2	2
Size	1	2	2
Test case available	3	1	3
Importance	1	2	2
		Total	42

Current status: Manual

Sponsor(s): DOC

Title: Policy Impact Analysis

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	2	2
Bounded domain	1	3	3
Large amount of task specific data available	3	1	3
Information specialized	3	3	9
Agreement about knowledge	2	2	4
Implementation procedure	2	2	4
Quality of information/ knowledge	2	2	4
Availability of experts	1	1	1
Short term benefits	2	2	4
Expertise scarce	1	1	1
Size	1	1	1
Test case available	3	2	6
Importance	1	1	1
		Total	43

Current status: Manual

Sponsor(s): DSS

Title: Query System to Access Spectrum Regulations and Policies

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	2	2
Bounded domain	1	2	2
Large amount of task specific data available	3	1	3
Information specialized	3	3	9
Agreement about knowledge	2	2	4
Implementation procedure	2	2	4
Quality of information/ knowledge	2	2	4
Availability of experts	1	3	3
Short term benefits	2	1	2
Expertise scarce	1	1	1
Size	1	2	2
Test case available	3	2	6
Importance	1	2	2
		Total	44

Current status: Manual

Sponsor(s): DOC

Title: Telephone Network Capacity Planning

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	2	2
Bounded domain	1	3	3
Large amount of task specific data available	3	2	6
Information specialized	3	1	3
Agreement about knowledge	2	2	4
Implementation procedure	2	2	4
Quality of information/ knowledge	2	2	4
Availability of experts	1	2	2
Short term benefits	2	2	4
Expertise scarce	1	2	2
Size	1	2	2
Test case available	3	2	6
Importance	1	2	2
		Total	44

Current status: Manual

Sponsor(s): DOC

Title: Curriculum Design

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	2	2
Bounded domain	1	3	3
Large amount of task specific data available	3	3	9
Information specialized	3	2	6
Agreement about knowledge	2	2	4
Implementation procedure	2	2	4
Quality of information/ knowledge	2	3	6
Availability of experts	1	1	1
Short term benefits	2	2	4
Expertise scarce	1	1	1
Size	1	2	2
Test case available	3	2	6
Importance	1	1	1
		Total	49

Current status: Manual

Sponsor(s): CEIC, DND

Title: On-Line User Profile Assessment

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	2	2
Bounded domain	1	3	3
Large amount of task specific data available	3	3	9
Information specialized	3	2	6
Agreement about knowledge	2	2	4
Implementation procedure	2	3	6
Quality of information/ knowledge	2	2	4
Availability of experts	1	3	3
Short term benefits	2	1	2
Expertise scarce	1	1	1
Size	1	3	3
Test case available	3	2	6
Importance	1	2	2
		Total	51

Current status: Manual

Sponsor(s): DSS

Title: Computer Capacity Planning

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	3	3
Bounded domain	1	3	3
Large amount of task specific data available	3	1	3
Information specialized	3	1	3
Agreement about knowledge	2	3	6
Implementation procedure	2	3	6
Quality of information/ knowledge	2	2	4
Availability of experts	1	2	2
Short term benefits	2	3	6
Expertise scarce	1	1	1
Size	1	2	2
Test case available	3.	3	9
Importance	1	3	3
		Total	51

Current status: Manual

Sponsor(s): DSS

Title: Human Assisted Machine Translation

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	1	1
Bounded domain	1	3	3
Large amount of task specific data available	3	2	6
Information specialized	3	2	6
Agreement about knowledge	2	2	4
Implementation procedure	2	3	6
Quality of information/ knowledge	2	3	6
Availability of experts	1	2	2
Short term benefits	2	3	6
Expertise scarce	1	1	1
Size	1	1	1
Test case available	3	3	9
Importance	1	1	1
		Total	52

Current status: Manual

Sponsor(s): SOS, DOC

Title: Text Critiquing

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	3	3
Bounded domain	1	3	3
Large amount of task specific data available	3	1	3
Information specialized	3	2	6
Agreement about knowledge	2	3	6
Implementation procedure	2	3	6
Quality of information/ knowledge	2	2	4
Availability of experts	1	2	2
Short term benefits	2	3	6
Expertise scarce	1	1	1
Size	1	2	2
Test case available	3	2	6
Importance	1	2	4
		Total	52

Current status: Manual

Sponsor(s): DOC

Title: Language Synthesis

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	3	3
Bounded domain	1	3	3
Large amount of task specific data available	3	1	3
Information specialized	3	2	6
Agreement about knowledge	2	3	6
Implementation procedure	2	3	6
Quality of information/ knowledge	2	2	4
Availability of experts	1	2	2
Short term benefits	2	3	6
Expertise scarce	1	1	1
Size	1	2	2
Test case available	3	3	9
Importance	1	2	3
		Total	54

Current status: Manual

Sponsor(s): DOC

Title: Crisis Management Information Access

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	2	2
Bounded domain	1	3	3
Large amount of task specific data available	3	2	6
Information specialized	3	3	9
Agreement about knowledge	2	3	6
Implementation procedure	2	3	6
Quality of information/ knowledge	2	2	4
Availability of experts	1	2	2
Short term benefits	2	3	6
Expertise scarce	1	2	2
Size	1	2	2
Test case available	3	2	6
Importance	1	2	2
		Total	56

Current status: Manual

Sponsor(s): DFO

Title: Text Abstracting

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	3	3
Bounded domain	1	3	3
Large amount of task specific data available	3	2	6
Information specialized	3	2	6
Agreement about knowledge	2	3	6
Implementation procedure	2	3	6
Quality of information/ knowledge	2	2	4
Availability of experts	1	2	2
Short term benefits	2	3	6
Expertise scarce	1	1	1
Size	1	2	2
Test case available	3	3	9
Importance	1	2	2
		Total	56

Current status: Manual

Sponsor(s): DOC

Title: Course Delivery

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	2	2
Bounded domain	1	2	2
Large amount of task specific data available	3	3	9
Information specialized	3	2	6
Agreement about knowledge	2	2	4
Implementation procedure	2	3	6
Quality of information/ knowledge	2	2	4
Availability of experts	1	3	3
Short term benefits	2	3	6
Expertise scarce	1	3	3
Size	1	2	2
Test case available	3	3	9
Importance	1	1	1
		Total	57

Current status: Manual

Sponsor(s): CEIC, DND

Title: Tax Form Analysis

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	1	1
Bounded domain	1	1	1
Large amount of task specific data available	3	2	6
Information specialized	3	1	3
Agreement about knowledge	2	1	2
Implementation procedure	2	1	2
Quality of information/ knowledge	2	2	4
Availability of experts	1	1	1
Short term benefits	2	2	4
Expertise scarce	1	3	3
Size	1	2	2
Test case available	3	1	3
Importance	1	2	2
		Total	34

Current status: Semi-automated

Sponsor(s): Revenue Canada

Title: Sourcing System Aid

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	1	1
Bounded domain	1	1	1
Large amount of task specific data available	3	2	6
Information specialized	3	1	3
Agreement about knowledge	2	2	4
Implementation procedure	2	2	4
Quality of information/ knowledge	2	2	4
Availability of experts	1	1	1
Short term benefits	2	2	4
Expertise scarce	1	2	2
Size	1	1	1
Test case available	3	1	3
Importance	1	1	1
		Total	35

Current status: Semi-automated

Sponsor(s): DSS

Title: Diagnosis of Air Quality

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	1	1
Bounded domain	1	2	2
Large amount of task specific data available	3	1	3
Information specialized	3	2	6
Agreement about knowledge	2	1	2
Implementation procedure	2	2	4
Quality of information/ knowledge	2	2	4
Availability of experts	1	1	1
Short term benefits	2	2	4
Expertise scarce	1	2	2
Size	1	2	2
Test case available	3	1	3
Importance	1	2	2
		Total	36

Current status: Semi-automated

Sponsor(s): PWC

Title: Cartographic Data Interchange and Correlation

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	2	2
Bounded domain	1	3	3
Large amount of task specific data available	3	1	3
Information specialized	3	2	6
Agreement about knowledge	2	2	4
Implementation procedure	2	2	4
Quality of information/ knowledge	2	2	4
Availability of experts	1	2	2
Short term benefits	2	1	2
Expertise scarce	1	2	2
Size	1	2	2
Test case available	3	1	3
Importance	1	1	1
		Total	38

Current status: Semi-automated

Sponsor(s): EMR

Title: Diagnosis of Network Faults

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	2	2
Bounded domain	1	2	2
Large amount of task specific data available	3	2	6
Information specialized	3	2	6
Agreement about knowledge	2	2	4
Implementation procedure	2	1	2
Quality of information/ knowledge	2	1	2
Availability of experts	1	1	1
Short term benefits	2	1	2
Expertise scarce	1	2	2
Size	1	2	2
Test case available	3	2	6
Importance	1	1	1
		Total	38

Current status: Semi-automated

Sponsor(s): DSS

Title: Map Revision Assistant

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	1	1
Bounded domain	1	2	2
Large amount of task specific data available	3	1	3
Information specialized	3	1	3
Agreement about knowledge	2	2	4
Implementation procedure	2	3	6
Quality of information/ knowledge	2	2	4
Availability of experts	1	1	1
Short term benefits	2	2	4
Expertise scarce	1	3	3
Size	1	2	2
Test case available	3	2	6
Importance	1	2	2
		Total	41

Current status: Semi-automated

Sponsor(s): EMR

Title: Interference Complaints Analysis

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	1	1
Bounded domain	1	1	1
Large amount of task specific data available	3	2	6
Information specialized	3	1	3
Agreement about knowledge	2	2	4
Implementation procedure	2	2	4
Quality of information/ knowledge	2	3	6
Availability of experts	1	3	3
Short term benefits	2	2	4
Expertise scarce	1	2	2
Size	1	2	2
Test case available	3	1	3
Importance	1	2	2
		Total	41

Current status: Semi-automated

Sponsor(s): DOC

Title: Oil Spill Analysis

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	1	1
Bounded domain	1	1	1
Large amount of task specific data available	3	2	6
Information specialized	3	1	3
Agreement about knowledge	2	3	6
Implementation procedure	2	2	4
Quality of information/ knowledge	2	2	4
Availability of experts	1	1	1
Short term benefits	2	2	4
Expertise scarce	1	2	2
Size	1	2	2
Test case available	3	2	6
Importance	1	2	2
		Total	42

Current status: Semi-automated

Sponsor(s): EMR

Title: Radar Target Analysis

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	1	1
Bounded domain	1	2	2
Large amount of task specific data available	3	2	6
Information specialized	3	1	3
Agreement about knowledge	2	3	6
Implementation procedure	2	2	4
Quality of information/ knowledge	2	2	4
Availability of experts	1	1	1
Short term benefits	2	3	6
Expertise scarce	1	1	1
Size	1	2	2
Test case available	3	2	6
Importance	1	2	2
		Total	44

Current status: Semi-Automatic

Sponsor(s): DND

Title: Economic Geology Assessment

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	2	2
Bounded domain	1	3	3
Large amount of task specific data available	3	1	3
Information specialized	3	2	6
Agreement about knowledge	2	2	4
Implementation procedure	2	2	4
Quality of information/ knowledge	2	2	4
Availability of experts	1	2	2
Short term benefits	2	3	6
Expertise scarce	1	1	1
Size	1	2	2
Test case available	3	2	6
Importance	1	2	2
		Total	45

Current status: Semi-automated

Sponsor(s): EMR

Title: Building Life-Cycle Management

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	2	2
Bounded domain	1	2	2
Large amount of task specific data available	3	3	9
Information specialized	3	2	6
Agreement about knowledge	2	2	4
Implementation procedure	2	2	4
Quality of information/ knowledge	2	1	2
Availability of experts	1	2	2
Short term benefits	2	3	6
Expertise scarce	1	2	2
Size	1	2	2
Test case available	3	2	6
Importance	1	2	2
		Total	49

Current status: Semi-automated

Sponsor(s): PWC

Title: Upgrade Image Analysis Software

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	1	1
Bounded domain	1	1	1
Large amount of task specific data available	3	2	6
Information specialized	3	1	3
Agreement about knowledge	2	1	2
Implementation procedure	2	2	4
Quality of information/ knowledge	2	2	4
Availability of experts	1	1	1
Short term benefits	2	1	2
Expertise scarce	1	2	2
Size	1	2	2
Test case available	3	2	6
Importance	1	2	2
		Total	36

Current status: Automatic

Sponsor(s): EMR

Title: Building Cost Estimating

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	2	2
Bounded domain	1	2	2
Large amount of task specific data available	3	1	3
Information specialized	3	2	6
Agreement about knowledge	2	2	4
Implementation procedure	2	1	2
Quality of information/ knowledge	2	2	4
Availability of experts	1	2	2
Short term benefits	2	3	6
Expertise scarce	1	1	1
Size	1	2	2
Test case available	3	2	6
Importance	1	1	1
		Total	41

Current status: Automated enhancement

Sponsor(s): PWC

Title: Query System to Access Rules and Regulations

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	2	2
Bounded domain	1	3	3
Large amount of task specific data available	3	3	9
Information specialized	3	2	6
Agreement about knowledge	2	2	4
Implementation procedure	2	2	4
Quality of information/ knowledge	2	1	2
Availability of experts	1	2	2
Short term benefits	2	3	6
Expertise scarce	1	2	2
Size	1	2	2
Test case available	3	2	6
Importance	1	1	1
		Total	49

Current status: Desired as automated aid to Old Age Security System and Unemployment Claims System, currently Manual

Sponsor(s): HWC, CEIC

Title: On-Line Job Counselling

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	3	3
Bounded domain	1	2	2
Large amount of task specific data available	3	1	3
Information specialized	3	2	6
Agreement about knowledge	2	3	6
Implementation procedure	2	2	4
Quality of information/ knowledge	2	2	4
Availability of experts	1	2	2
Short term benefits	2	3	6
Expertise scarce	1	1	1
Size	1	2	2
Test case available	3	3	9
Importance	1	1	1
		Total	49

Current status: Automated aid to CHOICES, currentaly Manual

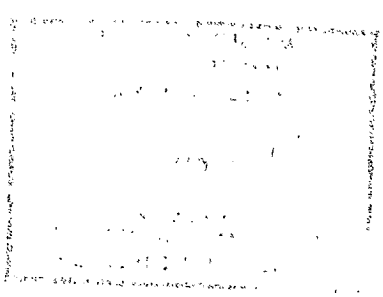
Sponsor(s): CEIC

Title: Rules and Regulations Tutor

Criteria	Criteria Score	Opportunity Score	Weighted Value
Opportunity defined	1	2	2
Bounded domain	1	2	2
Large amount of task specific data available	3	2	6
Information specialized	3	3	9
Agreement about knowledge	2	2	4
Implementation procedure	2	3	6
Quality of information/ knowledge	2	3	6
Availability of experts	1	2	2
Short term benefits	2	3	6
Expertise scarce	1	2	2
Size	1	2	2
Test case available	3	2	6
Importance	1	2	2
		Total	55

Current status: Desired as an automated aid to Old Age Security Systems, currently Manual

Sponsor(s): HWC



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