NORDICITY GROUP LTD.

Federal AI Demand Study

Draft Final Report

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Prepared for

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Federal AI Demand Study

1.0 Overview and Conclusions

This report examines the potential demand for Artificial Intelligence (AI) or more specifically knowledge-based systems within the federal government, identifies opportunities for exploiting selected AI technologies, and examines how federal government usage could be of significant benefit to Canadian industry and the economy as a whole. In this section we provide an overview of the report and summarize our conclusions.

1.1 Artificial Intelligence: An Overview

The primary goal of artificial intelligence (AI) is to make machines smarter. This is achieved by employing methods and techniques derived from several fields including among others; computer science, pychology and linguistics in order to make machines mimmic intelligent behaviour. The potential for applications of intelligent machines is vast in terms of creating more flexible and useful human-machine interfaces as well as providing sophisticated processing of information and knowledge in order to support various human activities.

AI is now emerging as a practical technology with pervasive implications to social and economic activity. This report considers the potential demand for this knowledge based technology within the framework of government activities, both internally as well as in a supporting role to Canadian industry.

Scientific and technical resources are currently scarce. A means must be found to foster support and development of these needed skilled resources.

1.2 The Pay-off for Government

The field of artificial intelligence has moved dramatically in recent years from a science to a technology. As a technology, the application of knowledge-based systems can reap major pay-offs for the federal government, highlighted as follows:

- o AI based systems can provide both faster and better decision support systems including situations where economic and human stakes are enormous (eg. fishing stock management, air traffic control);
- o AI based systems can help constrain the government's person-year growth, while improving productivity of existing expertise (eg. in real property management, translation, training);
- o AI based systems can improve the level and quality of service to the public (eg. in forms processing, counselling, navigational aids);
- o AI can spur industrial and resource development.

It is premature (and perhaps too ambitious) to undertake a government-wide cost-benefit analysis for AI based applications given that AI is in an early stage of commercialization. However, cost-benefit analysis for specific applications can be undertaken at this time. For our study, we have observed substantial promise for applied AI in almost every area examined. Since we believe government departments will be drawn into expenditure on AI applications in any case, it is important to channel scarce resources into appropriate applications. We view this government-wide study as a first step in a focussed, well-managed AI strategy which will likely carry on into the next century.

Although our study covered only a sample of federal government departments and agencies, it provides some useful indicators of where to look for appropriate applications of AI based systems and tools. These can be described as follows:

tie to AI tools

- o areas where regular economic advice/technical expertise is needed for decisions which have large impacts in terms of dollars;
- o areas where manuals for operations procedures are required, especially continual updating of technical information;
- o areas where extensive data base management is needed, and where machine based natural language would improve access to data;
- o areas where processing of voluminous quantities of forms or personnel applications are required;
- o training and counselling; and,
- o areas where "experts" are retiring or transferring, whether the experience is institutional or domain specific.

This list of generic applications indicates the breadth to which AI may be incorporated into routine government operational tasks. The remaining sections of this paper attempt to, in turn, define more precisely the present status of AI development and how AI technology can be incorporated most efficiently into the federal government.

1.3 Opportunities for the Application of AI in the Federal Government

At present, AI applications are scattered throughout the federal government, mainly in scientific and technical departments. For example, DOC is developing expert system applications for satellite fault anomaly and diagnosis for Telesat Canada; DOE is developing natural language systems for environmental reports. DND is considering expert systems applied to military intelligence.

Following the search for application opportunities in federal departments and agencies, we can conclude that there are potential applications in almost every important area of government activity.

The current activities represent a commitment of several million dollars and a few dozen person-years (although most people are not dedicated solely to AI development). Much of the budgetary commitment is for hardware (eg. for work stations), and software (eg. special languages and tools), and consultation studies and design/engineering contracts to universities and private sector suppliers.

Our analysis would suggest that the **AI R&D and application activity in the federal government is likely to grow considerably on its own volition over the next two to three years,** reaching perhaps a few hundred person-years and a few tens of millions of dollars by the end of the decade.

If there were a more focused effort to stimulate the development of AI based systems to assist government in carrying out its myriad of mandates, the activity could mushroom more quickly, with more person-years devoted to AI related work and software/hardware applications budgets reaching several tens of millions of dollars. The impact would be felt by hundreds and perhaps thousands more public servants who would actually be using AI based systems in their day-to-day work.

The general constraint on person-year growth in the public service and demand for productivity improvements in government is likely to drive the application of AI. However, the pace at which AI is exploited is primarily a function of senior management commitment and investment.

In the longer term, the federal government will become a major user of AI based products, systems, and services, just as it has become for conventional computer systems. **The challenge is to implement AI technologies wisely** -- so as to disseminate knowledge effectively while avoiding being taken in by the hype often associated with this growing field -- **and to do so with as much economic spin-off benefit to the Canadian economy as possible.**

1.4 Implementation Strategy - Systematic but Opportunity-Driven

From our observation of the process of implementation of AI based systems in the federal government, we conclude that **there should be a central focus but with encouragement to departments to pursue specific AI applications which provide them with a high pay-off.** Such an approach would lead to a systematic but opportunity-driven implementation plan.

The establishment of a centralized service would help departments assess potential AI applications and share information about existing systems, software, hardware and user experiences. **Such a centralized service (or secretariat) would promote, educate, and help transfer AI technologies into federal government applications.**

At the same time, **government departments should launch pilot projects** in one or more areas of high impact. Individual pilot or demonstration projects are an excellent way to start small and work incrementally toward more complex systems and more widespread use. Some projects can be confined to a unit within a department; others might incur the collaboration effort of a few departments; and some applications (such as training) could affect nearly every department. It is important to note however that **many departments require a through needs assessment to determine what problems are amenable to AI solutions in the short to medium term.**

1.5 Implementation Strategy - Private Sector Involvement

To ensure effective spin-off benefits to the Canadian private sector, as well as efficient supply sources to the federal government, **private sector suppliers of AI based applications engineering, software, systems, and hardware should be involved at an early stage.** Outside contractors should be involved in needs assessment studies, design pilot projects, provide assistance to the centralized secretariat and other government departments and agencies, and provide work stations, AI tools and associated software systems. **DSS should ensure that Canadian companies have the full exploitation rights to systems, service and hardware developed for or involving value-added components in federal applications.** As well, PILP, for example, should be brought into the picture early, to ensure that the results of government pilot projects are captured by industry.

1.6 International Developments in AI

To group the importance of AI it should be considered in strategic terms. There are applications possible in so many areas of human endeavour that its effects on work patterns and knowledge expansion are incalculable. However, its importance can be measured in straight economic terms as well. In fact, it is the vast economic potential of advanced information technologies which is driving a fierce international competition in AI. The US based consulting firm, A.D. Little, estimates the AI market will be worth between $50 and $100 billion, comprising 10-20% of the computer industry, by the year 2000.

In many Western countries, governments have initiated major AI thrusts 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. In Appendix A we describe major international initiatives. Of particular note are the following:

- United States: Traditionally the US stimulates 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 $600,000 million plus 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 (NLP). These all constitute important subfields of AI.

- United Kingdom: A national five-year plan in advanced information technology has been established, 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 bilion for 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 the manufacturing base in order to supply its 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 (see Appendix A for a description of Canadian AI expertise). 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 AI strategy.** It is hoped that this study of AI demand may make some contribution toward the development of a Canadian program, particularly by raising the profile of AI's potential to directly affect the performance of government.

2.0 Study Rationale and Approach

In this chapter, we state the purpose and rationale for this study, and describe how we undertook the demand study of federal government institutions.

2.1 Study Terms of Reference

The purpose of this study was (a) to determine the "demand" for Artificial Intelligence (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 nature of the "demand" as articulated in the letter of proposal is not in the normal context of departmental "requirements", because there are very few explicit requirements for AI systems as such. Therefore, part (a) of the purpose was pursued as follows:

- o to identify departments and agencies which are potential users and developers of AI applications and technology;
- o to identify the potential for collaborative effort among departments with common needs that could be grouped by applications requiring AI based solutions; and
- o to outline how AI based systems can be used to help departments execute their mandates.

This demand/opportunities part of the study was then assessed with respect to the resource implications for government.

In response to part (b) of the study purpose, the potential of procurement leverage was addressed through the identification of demonstration projects, an impact assessment of the implementation of AI technologies in specific cases, and the development of strategies for implementation with the departments and agencies involved. The study did not concern itself per se with the supplier community, although the contractors' experience in this regard was brought into the analysis.

2.2 Study Rationale

There are several federal departments interested in AI systems from different aspects -- development of the technology, expansion of market opportunities for Canadian industry, and improvement of internal productivity. Consequently, a review of existing and potential AI applications was needed to determine the nature and significance of this opportunity to both government and industry. Priorities could then be established for the areas where AI can be applied, and demonstration projects developed. There was also a need to assess the potential of a coordinated and focussed government procurement effort to enhance the value-added components of Canadian information and communication products and services, with little or no additional cost to the government. Once this information gathering and consultation process had taken place, strategies for developing specific AI opportunities could then be recommended.

2.3 Study Methodology

To review existing and potential AI applications, a search of existing documentation was made, including US and world-wide market forecasts for various types of applications. A visit to US 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 specific AI workshops involving government officials.

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

Services to Government	Services to the Public
Personnel administration Training, Staffing Classification Financial/Administration Database Legal Parliament Accommodation Procurement Information/PR	Regulatory - goods/services delivery Program delivery (funds/programs to specific clients and constituencies) Scientific research

From this first "cut" of workshop categories evolved specific workshop topics based on interest garnered through informal telephone contacts within and across departments. The workshops were ultimately 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:

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

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

- o Communications (pending)
- o Fisheries and Oceans
- o National Defence
- o Energy, Mines & Resources (pending)
- o Transport
- o Supply & Services

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

Appendix B provides an in-depth review of the study process.

3.0 Artificial Intelligence -- an Overview and Application Criteria

In this chapter we provide an overview of AI, describing it as a science, as a technology, and the impact of factors external to AI that have led to greater practical applications of AI.

We also address the issue of selecting candidate problems for which AI solutions could be viable. In this discussion, we outline generically how certain problems are more amenable to AI than others. The criteria so developed were used in each workshop and subsequent analysis to help identify specific targets for the application of AI in the Federal Government.

3.1 AI Technologies - Pracatical Solutions in the Marketplace

Artificial intelligence is concerned with making machines more useful by permitting them to mimic processes that, if done by humans, would be considered intelligent.

3.1.1 AI as a Science

AI is both a science and a technology. As a science, it is concerned with the study of systems that represent, acquire, and use knowledge in order to reason, perceive, plan, act and use language. In order to achieve this kind of behaviour the AI field is a combination of research disciplines focussed on:

- reasoning, planning and learning
- natural language processing (ie, man-machine interaction in a language such as English or French)
- knowledge representation (eg, the way knowledge - as opposed to data - can be structured in a computer)
- pattern matching and searching
- perception, and
- new computer architectures.

In various combinations, the techniques associated with these disciplines have led to a wide range of AI applications. These are characterized by:

- expert systems
- natural language systems
- computer vision
- image processing
- man-machine interface
- machine translation
- graphics, and
- robotics.

Furthermore, the field is being shaped by a number of factors outside the traditional bounds of progress in the basic science of AI. These include:

- new finds outside of the AI field
- discovery of new AI problems
- special purpose AI computers, and
- availability of software tools.

The specific successes attributed to these advances include:

- o demonstrable success in solving narrowly defined AI problems, and,
- o emerging market pull for solutions to problems involving AI.

3.1.2 AI as a Technology

The consequence of these advances has been the recent emergence of AI as a technology. In particular, expert systems and natural language systems have matured to a point of modest commercial applications. In addition, AI can be considered as a technology front which is allowing higher levels of integration of a variety of technologies such as very large scale integration (VLSI) and parallel computer architectures.

The implications of AI as a technology and its role as a facilitator to higher level integration of advanced microelectronics have caused many specialists to consider AI as both a strategic technology and a transformative technology. As a strategic technology it is seen as a key element in the emergence of the 'information economy' and as such a major source of economic wealth in the years ahead. As a transformative technology the various manifestations of AI are perceived to be capable of a massive range of applications involving tasks normally associated with human activity and consequently will have a profound impact on society. By analogy, electricity reflects the notion of a transformative technology - seemingly unbounded applications with massive potential for creating wealth and jobs.

From an applications perspective contemporary AI is used to:

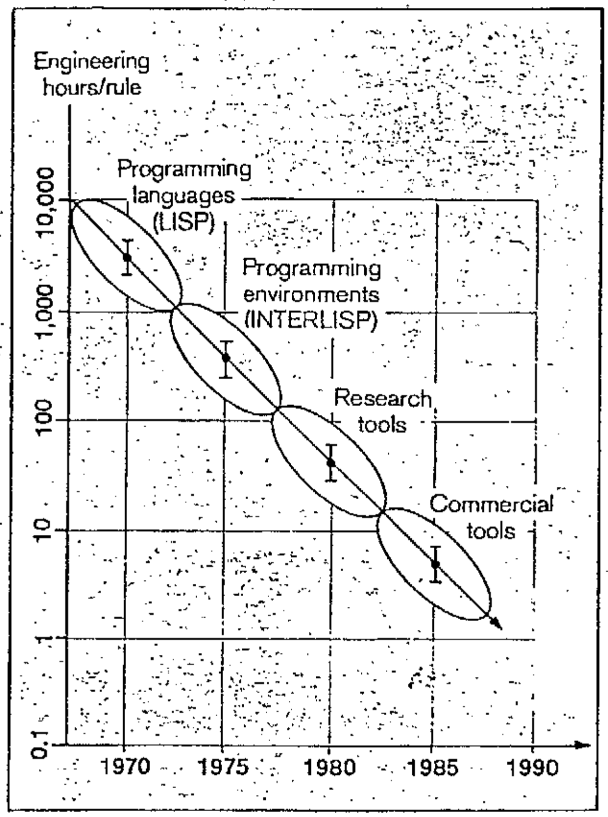
- o simulate human expertise by encoding knowledge and rules of thumb into a computer equipped with a mechanism which can infer new relationships about the rules within the encoded knowledge base (ie, expert system);
- o enable people to interact with computers and stores of information by means of natural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

In recent years, the viability of applying this technology in a commercial setting is a consequence of rapid performance increases in such areas as software tools resulting in a dramatic reduction in the cost/benefit ratio of developing knowledge based systems. A typical and excellent example of this trend in performance is represented in Exhibit 3-1. The cost in developing an expert system has dropped three orders of magnitude 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.

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 following generic categories as illustrated in Exhibit 3-2.

Literally thousands of expert systems have been built, almost all within the last three years. There are outstanding examples in any one of the generic categories illustrated in Exhibit 3-2. Almost all of these are industry proprietary. Consequently, there is limited technical

Exhibit 3-1
The declining cost of developing an expert system as measured in engineering hours/rule from 1970 to 1985.



Source: Harmon & King, 1985

Exhibit 3-2

Generic categories and typical objectives associated with expert systems

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 remidies to malfunctions
Repair	exicuting 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

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.

3.2 Problems Amenable to AI Applications

There are limitations to the complexity of problems that can yield to contemporary AI techniques. In the context of expert systems, for example, the limitations are often constrained by the ability to represent within a computer the knowledge structure about a particular problem or class of problems. However, there are methodologies that have arisen recently on approaches to building applied AI systems, most notably in the area of expert systems. These include means of selecting a problem and matching this knowledge representation techniques appropriate to the problem.

A key to success in applying AI is restricting the problem to a narrow domain. This is important in terms of both the degree of complexity that can be handled (eg, the way in which knowledge can be structured, the depth of reasoning and planning and the dexterity in processing language) and the skill, understanding and practice a team has in building AI based systems (eg, expert systems).

In this study, we have developed criteria to evaluate whether specific problems would be subject to AI applications on the basis of both the limitations of current AI techniques and the practicality and experience of 'first time' developer/users. These criteria are set out in

Exhibit 3-3. In addition to a brief description of each of the criteria a ranking of either A, B or C is applied to provide a relative weighting as a common evaluation method suitable for all potential applications considered in this study. The ranking is based on the study team's experience and knowledge about assessing the applicability of AI to business problems.

Based on these criteria, two emerge as central to allow a measure of success -- size and importance. Thus, in general terms a potential application involving say an expert system must be constrained in scope (ie, complexity) and must promise substantial improvement over existing systems or operations while at the same time providing a reasonable cost/benefit ratio.

More specifically, there are at least three reasons that size is a crucial factor for demonstration projects at this early stage of AI technology development. These are:

- appropriate manageable problems ensure a relatively short development cycle, thus allowing go/no-go decisions to be made in incremental stages. The 'prototyping process' of systems development inherent in many approaches to AI based applications development is ideally suited to this management style. Furthermore, maintenance throughout the production cycle (eg, in the case of expert systems) is evolutionary and amenable to gradual enhancements, alterations and available funding and expertise. The net result is that risk and exposure to failure are minimized with careful problem selection and a gradual approach to enhancing the complexity of the system.

- A project should be designed in relation to what is actually possible and not focus on applying the latest research findings; and,

Exhibit 3-3

Criteria used in Selecting AI Applications

Criteria	Explanation	Ranking
Knowledge source		
expertise perishable	- expertise is lost through transfers, retirement, attrition, death	B
expertise scarce	- limited number of experts available for specific tasks	A
Problem identified		
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
agreement about knowledge	- experts agree on the knowledge domain	B
large amount of task specific data available	- sufficient data/information must exist to substantiate the knowledge base	C
information specialized	- information associated with domain is detailed and specific	C
Go-Ahead requirements		
availability of an expert	- domain expert must be available to supply knowledge base	A
short term benefits	- system should achieve a performance rating above that of an average user	B

Exhibit 3-3

Criteria used in Selecting AI Applications continued

Criteria	Explanation	Ranking
size	- problem should be manageable with a short development cycle (ie. prototyping)	A
test case available	- documented test cases serve as useful calibration mechanisms.	C
importance	- the solution must promise substantial improvement over existing systems or operations while at the same time providing a reasonable cost/benefit ratio	A

Ranking interpretation

- A essential
- B important
- C helpful

- Appropriately chosen projects have a natural tendency to grow in size and complexity. Consequently, success in seeing a project through conception to production must have strong management support and a 'champion' to lead the cause for applying an AI based solution.

When considering the importance of a project the key is assessing whether the problem can be solved by more conventional techniques. Assuming that an AI solution is appropriate it is then important to assess, as in the case of expert systems, whether the solution is either 'shallow' or 'deep'. In the case of a shallow solution, the system is able to achieve some level of performance in its limited domain, however, it is based on various ad hoc 'tricks'. Most often, shallow systems represent suboptimal solutions which can be sufficient to warrant development. Deep systems, on the other hand, are based on a causal model of the processes being mimicked. In principle, as the tasks in a problem become more difficult, the complexity of shallow systems increases at a much greater rate than deep systems.

4.0 Opportunity Areas

In this chapter, we provide a short description of the potential AI applications identified in the study. Details are given in the workshop descriptions in the appendices.

4.1 Opportunities for AI Applications

The Interdepartmental Working Group on AI (IWG) (see Appendix B for membership list) has identified four areas of priority with respect to the application of AI. The workshops conducted in this study collectively covered AI application possibilities in each of the priority areas as follows:

- o increase productivity in government operations eg. forms processing (eg. DND, DSS);
- o assist in the management, exploration and exploitation of renewable and non-renewable resources (eg. F&O, EMR);
- o facilitate training and retraining (eg. CEIC, PSC);
- o encourage the enhancement of the value-added components of Canadian information and communication products and services (eg. machine translation systems, informatics).

Each workshop began with a review of the study objectives and an overview of AI. This was generally followed by a wide ranging discussion of problem areas, possible AI applications as solutions to these problems, the impact of these solutions, and possible follow-up. The results form the substance upon which we have based the analysis and conclusions of this report. Each of the nine workshops is described fully in Appendices C through K. Example results of the workshops are shown in Exhibit 4-1.

Exhibit 4-1

Summary of Workshop Results

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 (at same time as above)	- individual to mass classroom	- make better use of CBT - 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 (NH&W, CEIC, DNR)	- data collection, assessment - reference for service to public	- reduce delays in info to public - extend field workers' and expertise
F&O	on fish side: - assessment of yields - improve fresh water fish data base - assess wide range of info fast (crisis mgmt)	- major economic ramifications if small efficiencies discovered in assessing fish stocks - knowledge bases have world market potential
	on ocean side: - processing large amounts of data and turn into salable products quickly - automated cartography	- improve access to previously "unuseable" data - ocean info'n has major impact on other dept's (ie. EMR, MOT, DOE)

Exhibit 4-1

Summary of Workshop Results
continued

Workshop	Needs	Impact
MOT	- scheduling tools - operational planning - inventory management	- since MOT is very industry responsive therefore, large economic impacts are possible, eg. - improving rail car utilization through scheduling has a $5B N.A. market - a vehicle weights program has a $50M Cdn. impact - safety implications in air traffic control systems and remote sensing of ice flows
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

Other general observations derived from the workshops include:

- There was a keen awareness by several participants in the need for linking AI development and fostering Canadian industry.

- There was considerable interest in follow-up activities including: focused workshops, intra- and inter- departmental strategies, creation of AI user groups, an integrated cabinet submission, and trial or demonstration projects.

- Many expressed sensitivity with respect to the human element of their organization, and were not naive as to the introductory problems of AI technologies.

- In most theme workshops, interdepartmental collaborative efforts were discussed. AI was not necessarily the glue to such collaboration -- each had its own rationale for which AI was only a part.

Exhibit 4-2 summarizes the potential applications according to the priority areas described at the beginning of this section. To elaborate on this exhibit, we now discuss the specific examples of AI applications.

4.1.1 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 - NHW, CEIC and Revenue Canada. Between CEIC and NHW 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 alloted 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, thus leaving room for great inconsistencies in rulings. If criteria were computerized and available on-line to all agents, more timely, accurate and consistent decisions could be rendered. Forms processing is, of course, conducted in many

Exhibit 4-2

Summary of Opportunities By Priority Areas

Priority Area	Opportunity
Increase productivity	- automate search through complex rules & regulations - improve consistency of rulings in unemployment insurance applications and any other form processing activity - on-line information to improve service to the public - database maintenance system to keep manuals up to date efficiently - train and heavy vehicle scheduling systems
Renewable/Non-renewable Resource Development	- image data gathering (eg. remote sensing) and analysis applications for ocean resource monitoring - automated cartography - improve accuracy in assessing fish yields
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
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. translators workstation) to automated text translation systems - natural language interfaces to large databases to improve time spent in the normal query process

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

4.1.2 Renewable/Non-renewable Resources

Fisheries and Oceans has large data gathering, processing and information extraction components in its day to day operational requirements. Each one of these activities has characteristics amenable to AI. OSS has requirements in image data gathering and analysis applications for ocean resource monitoring. This could be supplemented by automated or computer-aided cartography. However, the largest potential impact of AI in F&O 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.

4.1.3 Training/Retraining

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;

- o specific course programs: a truly interactive process (not just yes/no) where dialogue is in natural language and the system understands the studen;

- o database update: updating the course content to replace the hard copy manuals, which are updated infrequently.

Counselling: The application of AI could take computer counselling a step beyond the rigidly structured interaction with computers currently in use, overcoming 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.

4.1.4 Information and Communication Products and Services

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 DPW to become 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 of data has become difficult. 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 can analyze the information and take corrective measures. 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 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 78m words per year to 290m words in 1985-86. Similarly in industry, most large exporting companies as well as those serving the domestic market have been forced to developed sizable translation services to meet their customers' multiple language requirements. Machine translation offers several suboptimal solutions characterized by the quality of output text required. These approaches, while not removing human translators from the process, 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 symantic analysis.

The horizontal and vertical workshops provided representative AI opportunities in all four priority categories. In our view, such classification may be useful for communicating the breadth and depth of AI opportunities to be derived from federal needs. However, it is very difficult to set priorities on an a priori basis. The AI applications identified should be rationalized within their own program areas (ie. meet cost-benefit tests). There is hardly an aspect of modern government (from the CRTC, the RCMP, to the CBC) which does not have potential needs for AI based applications.

5.0 Application to the Rest of the Goverment

As indicated in chapter 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.

5.1 About a Third of government was Covered in the Study

Since there is no surrogate indicator for "AI amenable" in government, it is difficult to extrapolate the study sample to the rest of the government. The fact is that many departments were not represented, (eg, major line departments such as DIAND and DOE, central agencies such as Treasury Board and Finance, regulatory agencies such as the CRTC and CTC, and crown corporations such as AECL and Air Canada). In the case of the six departments to which a workshop was devoted, there was generally a reasonable spread of people representing concerns for problems for which AI offers potential solutions. Yet, even in these cases, the selection of candidates was typically the informal choice of the contact person, who either selected individuals connected to actual AI initiatives, expressed an interest in AI or were seeking to expand their computer functions. Therefore, the opportunities identified are only representative and not comprehensive, even in those departments contacted.

The other 20-odd departments/agencies which participated in the workshops represented only pockets of AI-interest groups, or those who had some problems we (or they) thought solvable by AI. A more systematic needs assessment in these departments would likely multiply the AI opportunities by several times.

To extrapolate the results of the rest of the government we used an approximate measure of importance - budgets, person-years and S&T expenditures. Exhibit 5-1 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 somewhat in excess of 50% coverage of the federal government by this study.

5.2 Some Important Departments Not Covered Represent Major AI Application Opportunities

A few of the AI activities of which we are aware in departments not covered by the study include:

- Treasury Board is developing an expert system for rules of travel;
- The National Library, DSS/DOC and CCSTI have an interest in ES protocol converter for electronic communications (eg, conversion of MARC tapes); and
- DRIE is examining the application of computer vision to resource and manufacturing sectors.

Exhibit 5-1

Departments	Net Total Expenditures (000,000 '85-86)	Person-Years (000 '85-86)	S&T (1) Expenditures (000,000 '85-85)	% of Department Represented Three Survey Techniques
Agriculture	1680	13.3	295	5
Communications	353	2.4	109	30*
Consumer/Corporate Affairs	193	2.5	-	-
CEIC	4045	24.1	-	40
EMR	2820	5.3	388	60*
Environment	726	10.3	412	10
External Affairs	779	4.6	-	-
Finance	5523	.9	-	-
F&D	629	6.4	267	60
DIAND	2285	6.3	-	-
Justice	158	1.4	-	-
DND	9383	35.6	204	60
NHW	633	9.8	115	20

* workshop pending

Exhibit 5-1
continued

Departments	Net Total Expenditures (000,000 '85-86)	Person-Years (000 '85-86)	S&T Expenditures (000,000 '85-85)	% of Department Represented Three Survey Techniques
National Revenues	1129	29.9	-	10
Parliament	189	.1	-	-
Privy Council	42	.6	-	-
DPW	1217	8.6	-	50
DRIE	1275	2.8	174	10
MOSST/NRC	752	3.5	524	-
Secretary of State	3093	3.2	-	40
Solicitor General/RCMP	1015	19.6	-	10
DSS	256	10.4	-	60
MOT/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.

One of the larger AI cognizant centres in government resides in NRC. NRC, with its interests and activities in R&D, is indirectly involved with computer technology and AI rather than concentrating on direct AI research.

In terms of advancing AI technology, the Integrated Service and Test Facility (ISTF) option Canada has identified as a potential for participation in the Space Station, contains various AI elements. A sophisticated space service facility would require:

- visual and tactile sensors and advanced systems for processing sensory data;
- expert systems for fault detection, trend analysis, logistics, operational planning and scheduling; and
- a large remote manipulator arm and several small dextrous robots to perform inspection and repair functions.

The ISTF would require major R&D dollars involving a range of activities in which NRC and other Canadian institutions are well positioned for, namely: sensory processing systems, robotics, expert systems, advanced computer architectures and data management systems. Aside from space station involvement, NRC has worked on other AI related projects in areas such as image processing and computer vision, parallel processing architectures, natural language processing and knowledge-based systems in industrial robots.

5.3 The US Government Experience

In this study, we made a field trip to Washington and met senior level representatives of US government departments involved with AI activities (see Exhibit 5-2).

Exhibit 5-2

Selected US Federal Government Experience

US	Experience to Date	Application to Canada
Internal Revenue Service (Treasury)	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	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 not shown any interest to date
National Institutes of Health	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	Conducting strategic studies to examine specific opportunities including AI at request of Congress	no such awareness yet at parliament level, but applicable in concept form to Canada

We concentrated on the agencies in which there is a potential "market pull" for AI, rather than a "technology push". In the latter case, the two outstanding examples are the Department of Defence and NASA, both of which have funded substantial AI applications development.

In all cases, the organizations visited, were "acting on their own", 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. In the case of OTA awareness was high in the organizations but the need to act was in concert with Congressional requirements.

The IRS offered a very effective, well planned model for pulling AI into meeting their 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 (10 people). Key personnel were selected for this in-house 1 and 2 year training program. The objective being 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 (3 years plus) it is hoped to do most work in-house.

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 prepared to accept and enhance contractor prepared applications. This shortfall may cause delay and resistance to accepting new AI based systems.

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

The 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 from internal resources. The commercial product will be initially controlled by NIH and possibly sanctioned 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 these reasons that NIH are maintaining the control on expert system development and distribution.

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. Only recently have they begun to consider the demand side within a government context. There is however limited progress on this approach to date.

The key findings from the US enquiries are summarized in Exhibit 5-2. The prime example of a "good" model with the potential for being used in a Canadian context is that of the IRS.

In summary, the US government demand is no further advanced than that in 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 marketly different than in Canada where several departments are pursuing AI in interdepartmental consultations. In the cases examined in the US the data processing shops are not the leaders, although each effort is driven by senior management endorsement and involvement.

6.0 Strategy for Government

In this chapter we provide some observations about a potential strategy for the federal government with respect to the application of AI to government problems. This perspective is based on discussions in workshops about possible interdepartmental collaborative efforts and other implementation considerations. It is primarily oriented to applying AI (eg. "pull") in specific government sectors, as opposed to describing details for advancing the facets of the field (eg. "push"). Strategies for stimulating the private sector through procurement are considered in chapter 7.0.

6.1 Government Department Pilot Projects

Part of the task of building up AI expertise should be accomplished through actual pilot projects. This approach puts the department up the learning curve while helping to solve actual problems.

We have not selected specific AI tools (eg, expert system shells) or specific applications as pilot projects, because the needs are still highly specific. The demonstration or pilot projects should be "needs driven". For example, DNR's statistical analysis of medium and large size firms could be subject to ES development. Upon successful execution as a prototype, the same expertise could be tapped for actual assessment of income tax returns. This is a strong conclusion, in that one success could have a great multiplier effect on the rest of government.

In our organization of the study survey we found that some AI tools which had cross-department applications were subject to collaborative treatment, while others were highly specific to a department's mandate. As reported earlier the themes of forms processing, machine translation, informatics, intelligent buildings, and training/counselling attracted multi-department interest, as did other multi-department subjects like regulation, personnel, database interface (for which no workshops were held). In each of the above areas there appear to be grounds for the pooling of resources in pilot or demonstration projects. As reported in the workshop descriptions in the appendices, each theme generated its own collaborative procedures, although the intensity of follow-up without further leadership may be tenuous at this time.

Again we wish to re-inforce the message that the collaborative effort is toward some form of productivity gain, rather than AI applications per se. For example, in intelligent building systems, AI technologies represent only a component of the collaborative effort to increase the accommodation investment pay-back.

6.2 Identify Problems Amenable to AI Solutions

While **a centrally coordinated effort is recommended,** government **departments should at the same time be examining their own needs in AI** to identify fertile areas for application. A centralized effort should not hold up applications that spring from the examination of needs by individual departments. AI technologies are already imbedded in some specific hardware that departments may wish to acquire for well defined needs. Also, 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.

From our discussions with departments, we have found that (a) they have problems to be solved rather than a desire to introduce AI per se, but (b) at the same time an explicit AI strategy for each department should be fostered. Putting intelligence into computers and other devices is only a means to an end. However, given that the concept of adding "artificial intelligence" is not second nature and often requires some up front investment, the development of an AI strategy on a department by department basis should be explored.

In our US field trip, it became evident that commitment at the senior level 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. A similar example in Canada involves DND where the Chief of Research & Development (CRAD) has explained that AI expertise was being developed for specific sonar-related applications, resulting in an expertise that could be applied to other parts of the R&D effort in the department.

As to which part of an organization should be responsible for the strategic plan for AI, it is probably too premature to say. Our survey experience illustrated several approaches within departments, where the AI "champions" emanated from several different levels (from officer to DG and even ADM). One department, for example, finally replied that person A would be the coordination point because of his wider perspective of department operations, although person B had the knowledge and interest, and person C had a higher rank.

Organizational interests range from R&D establishments, 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 establishment. However, just as computers spread to many facets of government life, AI tools and applications will involve a wider diversity of interests. Therefore, **there should be a priori determination of who should lead the strategic planning for AI applications within departments.**

6.3 Interdepartmental Coordination

The mandate of this study does not encompass policies in support of AI development generally, or 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 consideration of coordinating government departments as AI users.** A coordinated, cross-departmental focus on AI use in government would lead to the following:

- o 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;

- o promote collaborative efforts among departments, in view of many problems whose solutions are generically quite similar;

- o provide an effective linkage between AI applications to solve government problems and to promote industrial development and strategic technologies; and,

- o 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 it into 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" vs "D" vs application is ultimately best **left to line departments, and to central agencies** (eg. Treasury Board, DSS, and MOSST).

Our conclusion at present is that **MOSST should utilize the results of this study and other inputs to take at least a further step beyond the documents produced by the ad hoc working committee on AI.**

MOSST should consider coordinating the development of an interdepartmental user strategy, one which would address the various roles of departments and agencies, as well as the awareness, collaborative, industrial linkage, and service to user functions outlined above.

6.4 AI Development Paths

Once potential applications have been selected--problems identified and resources committed, then a staged development plan can be set in motion. The stages would move from a feasibility study, to a prototype experiment on a real problem, to a field test controlled by user personnel, and finally to a production system (see Exhibit 6-1).

The time and personnel required to develop AI based systems depend on the approach adopted in solving the problem such as whether the system is being built from the ground up or with the aid of tools. Another factor is the availability of experts or domain specialists and knowledge engineers. Once the tools and personnel are in place, a project could take only a few weeks to bring a prototype on stream. Outside suppliers will have to be involved in knowledge engineering until some internal expertise is recruited or retrained.

6.5 Initial Projects Can Have a Mushrooming Effect

The initial applications must be modest in scope, but important in terms of their impact. Two examples serve to illustrate this approach:

- If an AI tool which is developed for the processing of statistical information from a sample of corporate tax forms is deemed to be useful, then the more generic AI shell can be used to great benefit in personal income tax assessment itself.

Exhibit 6-1

Sample Staged Development Plan for AI Applications

Stage	Resources Required (commercial example)
Feasibility study	1/4-1 person-years
Prototype - experiment on real problems	1-2 person-years knowledge engineering 1/2 person-year from expert
Field test system - controlled use by user personnel	1-2 person-years of user personnel 1/2 person-year from expert
Production system - user interface - documentation, training - on-going refinement	Same level of typical high-level software applications support today

Assumptions

Departmental personnel have to be committed. Likely, an outside knowledge engineering supplier may be required, an expert system shell, and possibly a work station may be required.

- If a curriculum design program is developed for electricians, then the generic program for curriculum design would have over 200 applications in the federal government alone.

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 federal government line departments depends on its ability to be highly cost-effective. If successes have demonstrable positive effects on cost containment or productivity gains with a relatively <u>small</u> cost of development in the short term, our research has indicated that there are 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 commercial application of AI products. Success has been only with limited narrow applications. The jump required in our demand schedule is based on moving AI to the marketplace in quick order.

- o Experienced AI talent (knowledge engineers, programmers) is scarce. Although we may identify 5 to 10 potential projects, the resources in terms of in-house or private sector AI personnel may be limited.

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 scientific 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 (3)- MOT, F&O and EMR), have identified that they each have enough work today for 10 AI-dedicated staff.

For each scenario, we have projected demand schedules for the next four years. As shown on Exhibit 6-2, year 4 PYs range from 35 - 65 PYs in scenario A to 100 - 250 PYs 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 6-3, indicate total expenditures could range from $40 to $175 million by the third or fourth year.

Exhibit 6-2

Scenarios for Federal AI Demand

Scenarios	Year 1	Year 2	Year 3	Year 4
A status quo	five to 10 dep'ts 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 individual motives 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 dep'ts 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 dep'ts receive complement of staff they request 20-40 PYs	sister dep'ts develop projects. AI expertise grows and is fed to existing gov't personnel. Still development functions 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 "mushrooming" effect is great 100-250 PYs

Exhibit 6-3

Scenarios for Projected Federal AI Expenditures - Years 3 - 4

Scenarios	$ For Hardware [1]		$ for Software		$ for design/engineering		Total
	work stations	minis	specialized w.s. [2]	gen'l purpose micro	gen'l purpose mini		
A	$3mm	5mm at 500K/mini x 10 minis	3	2mm for 2000 users	1.5mm at 150K/ mini x 10 minis	25mm in contracts	39.4
B	$6mm	12.5 at 500K/mini x 25 minis	6	10 for 10,000 users	3.7 at 150K/ mini x 25 minis	50mm in contracts	88.2
C	$9mm	25 at 500K /mini x 50 minis	9	25mm for 25,000 users	7.5mm at $150/ mini x 50 minis	100mm 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.

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 effect on the demand for AI.

6.6 Demand on Suppliers and Government Resources

The number of suppliers of AI hardware and software is growing; for example, there were three consortia bids for the MOT/RTAC Heavy Vehicle Configuration project. There is a shortage of trained people and universities would have to step up their activities in AI to supply an increased Canadian demand. One of the driving forces behind AI expansion is that it reduces the number of people required to do specific work. The investment needed is likely to come from existing budgets, shifted from other programs and priorities, in view of the long-term advantages to be gained -- although higher investment is needed at the beginning of a concentrated federal government AI push.

7.0 Use of Procurement Leverage

In this chapter we describe how the federal government could best utilize its procurement function to help stimulate the development of private sector capability in AI software, hardware, and systems. To this point, this report has addressed the procurement question from the perspective of meeting government needs and the nature of the problems that AI applications might help the government solve. It is fully recognized that the application of AI will require the purchasing of hardware systems as well as the design and engineering capability of external resources to fulfill government requirements. As in the case of other key industrial areas, the use of procurement to lever Canadian industrial development in AI should be well thought through and put into a policy framework at this early phase in the development of AI.

The rationale for specifically using procurement as a lever to support Canadian initiatives in artificial intelligence technologies is that it is strategically important to future economic development. It is strategic in the sense that it will pervade all sectors of the economy and greatly increase the productivity of Canadian enterprise in all sectors, as well as being a potentially highly important job generator in itself. We recognize that at this point the strategic nature of AI is simply proposed rather than as yet being substantiated. However, as indicated in section 3, many advanced Western countries have made the same assumptions as to its strategic importance.

In specific terms, AI technology should be used to create strong Canadian supplier capabilities, 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 the Canadian economy, to develop "something to trade" in the world pool of technology, and the transfer of government technology to private sector users.

There is an additional rationale for stimulating the private sector in AI. As is shown in section 6 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 knowledge engineering capability and organizational resources for the private sector in Canada to respond to ongoing government need. The interaction between needs and suppliers, is strong enough that domestic capability will be important, rather than having a predominant import of expertise and products.

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. The nature of the positioning activity is illustrated by the following:

- hardware companies are embedding intelligence into their product lines;
- some specialized companies (eg. Intellicorp, Inference, etc) have developed AI shells with sales to the users at a range of $100-$100,000 per unit depending on level of complexity;
- engineering and technical expertise in specific fields are joint venturing with AI companies or developing their own experts;
- conversely, AI companies are developing their own "domain expertise" for application to a specific industrial sector (eg. oil and gas, transportation, defence, space and communications);
- 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;
- venture capital companies are supporting AI suppliers in hopes of duplicating the phenomenal success of certain business software programs.

This activity is appearing 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. As in many other areas, Canadian supplier growth is a function of how strong the market is in creating opportunities for these companies. In this context, a strong federal government demand that is structured to assist Canadian capabilities could be quite important.

7.1 The Government Procurement Role

It should be recognized that government orders and supplier resources are interactive, ie. a contract generates bank and investment capital support which are critical resources to the development of a supplier industry. If this interaction is ignored, the potential supplier might not be considered strong enough (financially and organizationally) to handle a specific contract simply because a supplier does not have the contract. The chronic undercapitalization of Canadian firms is best addressed through the contractual process. Armed with an order of backlog, well structured young, technology companies can find the necessary short term and long term capital required.

The procurement process is also a way to link the universities and suppliers, by making it an explicit part of the contract. This kind of arrangement obviously reinforces the university role in human resource development and the transfer of technology out from universities to commercial applications. It also tends to foster the linkage of the research into a problem by academics to its later solution and development into particular applications of commercial value.

In the product developmental stage there is very little off-the-shelf procurement that is possible. The requirement is typically a needs identification, contract R&D and engineering, and combination of equipment supply with intelligence embedded in it, and converting applications into real time use. To maximize the leverage value requires the following:

- The line department must be involved in stating requirements, and in designing the actual contract itself. Real requirements are to satisfy a need which is the best way to focus private sector R&D efforts. As well, 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.

- It is possible and indeed necessary to achieve selective sourcing within a competitive framework. 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 multiphased contract.

- The nature of AI brings out the potential of multi-departmental sourcing for AI applications. Such sourcing helps defray the upfront investment effort. Obviously, the Department of Supply and Services could play a financial role in development under the unsolicited proposal route.

Some examples of good supplier development include the following:

- the integration of Sparks and Clayton and academics (the US in this case) in obtaining the HEVCO contract from MOT is a good 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 subcontractors involving Spar.

- DOC requirement for AI applications to communications and informatics was the result of a consortium of 4 companies comprised of CAIP Corp., Cognicom Inc., Nordicity 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 in to 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 institutional arrangements in procurements of AI need more study and clarification. The general proposals discussed here emanate 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 general role that government can and must continue to play to help support development of Canadian industry.

Appendices

Appendix B

B.1 Study Methodology

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

The process to select priority application areas and potential user departments and agencies was undertaken in three phases:

- o development of a questionnaire and its administration through the Interdepartmental Working Group on Artificial Intelligence;
- o development of a series of specific AI workshops involving government officials; and
- o conduct and reporting of workshops.

Each is discussed in turn.

B.1.1 Questionnaire Development

In the first phase, a project steering committee was formed to include five AI knowledgeable government officials, as previously indicated. This committee approved the survey instruments for departments and agencies, primarily the distribution of a general AI questionnaire and AI background brief to main centres of AI interest in the government (see Exhibit B-2 at the end of this Appendix for a copy of the cover letter and questionnaire). The first group of contacts to be approached in the federal government to determine those centres of interest consisted of an in-place AI Interdepartmental Working Group on AI (see Exhibit B-1 for the list of 18 officials) of which all but one was contacted by either letter or telephone.

Exhibit B-1

Interdepartmental Working Group Officials

Mr. L. Derikx
Director, Planning & Budgeting
Natural Sciences & Engineering Research Council

Mr. J. Scrimgeour
Senior Advisor
National Research Council

Mr. A. Letendre
Senior Consultant
Department of Regional Industrial Expansion

Mr. R.D. Weese
Director General
Supply & Services Canada

Dr. W. Sawchuk
Director General
Communications Research Centre

Mr. Fernand Gobeil
Director, Technology Directorate
Secretary of State

Mr. J. Burpee
Chief, Transfer & Simulation Analysis
Health and Welfare Canada

Mr. R.T. Lewis
Chief, Research, Development and Planning (RDP/X)
Transport Canada

Dr. J. Harrison
Senior Science Advisor
Dept. of Energy, Mines & Resources

Mr. H.R. Edel
Remote Sensing Coordinator
Fisheries & Oceans

Exhibit B-1

Interdepartmental Working Group Officials
continued

Dr. Frank Payne
Directorate of Research & Development Maritime (2)

Mr. Bruce Atfield
Director
Atmospheric Environment Service

Mr. David Waung
Manager, Technology Assessment
Dept. of Communications

Dr. David Goodenough
Head, Methodology Section
Dept. of Energy, Mines & Resources

Mr. Gordon Ala
Assistant Director
Public Works Canada

Mr. John Greenwood
Director, Program Analysis & Information
Employment & Immigration Canada

Mr. D. Stuart Conger
Director General
Employment, & Immigration Canada

In addition to determining first level entry points in the federal government, the steering committee provided criteria for selecting other potential user departments and agencies. It was considered highly desirable to include departments which have major opportunities for potential AI applications, but who themselves are not necessarily knowledgeable about AI. Although specific requirements of all departments could not possibly be examined within the confines of this study, a good cross section of potential demand centres in the federal government has been defined and analyzed. It is estimated that about one third of the federal government was covered in this process, a calculation which is described in more detail in Section 5.

B.1.2 Organization of Workshops

The second phase evolved from the initial consultation process with the Interdepartmental Working Group. The approach then was to call likely candidates, largely identified through referrals; to invite the respondent to participate in appropriate AI workshops; to follow up these workshops on a one-on-one basis for additional problem identification; to analyze workshop sessions; and to review results with appropriate workshop participants. The workshop preparation required substantial front end calling, explaining the purpose of the study, obtaining referrals, and in some cases approvals to participate. Through this process, 25 departments/agencies were contacted, 20 questionnaires distributed, 9 workshops held (with one or two more pending) and 55 people attending.

The approach followed was "bottom up", rather than offical entry at the top (eg, via a letter to each Deputy Minister). In this process, we learned that:

- o AI awareness varies between keen interest and general skepticism; however, there are AI "application champions";
- o the locus of interest was either (i) scientific, ie, the technology push, or (ii) those concerned with the application of technology to departmental needs, ie, market pull;
- o some groups in departments hesitated to become involved because they were in the middle of their own planning of advanced technology applications; and
- o there was uncertainty about the appropriate positional level about who should respond (DG, Director, Chief, etc.); we never reached the ADM level.

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

Services to Government	Services to the Public
Personnel administration	Regulatory
Training, Staffing	- goods/services delivery
Classification	
Financial/Administration	Program delivery (funds/programs
Database	to specific clients and
Legal	constituencies)
Parliament	Scientific research
Accommodation	
Procurement	
Information/PR	

From this first "cut" of workshop categories evolved specific workshop topics based on interest garnered through informal telephone contacts within and across departments. The workshops were ultimately 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 (pending)
- Fisheries and Oceans
- National Defence
- Energy, Mines & Resources (pending)
- Transport
- Supply & Services

At least one member of the Interdepartmental Working Group on Artifical Intelligence attended each workshop.

B.1.3 Conduct/Reporting of Workshops

The workshop sessions focused on the discussion of problems involving knowledge acquisitions and knowledge processing and thus AI application opportunities. The nature of the discussion varied considerably, although the agenda was consistent:

- brief AI overview, with tailoring to the particular workshop topic;

- o round table discussion of problems and opportunities associated with each participant;
- o discussion of past computer-based or other advanced technology experience in the subject area;
- o discussion of collaborative efforts, demonstration projects, and strategy to proceed.

At each workshop we committed the project team to review the report of each workshop with appropriate officials. The draft write-ups (prior to this review) constitute appendices C through K of this report. It is these workshops that provide the substance upon which the rest of the report is based.

Exhibit B-2

October 9th, 1985

⊠

Dear ⊠:

Re: Federal Government Future Demand Study for Artificial Intelligence (AI) Technology

Nordicity Group Ltd., in association with Canadian Artificial Intelligence Products Corp. (CAIPC), has been commissioned by DSS and MOSST to undertake a study on the federal government's future demand for artificial intelligence (AI) technology. The purpose of the study is to identify opportunities for reducing operating and/or administrative costs within government departments, as well as identifying more effective ways departments can fulfill their mandates, by applying AI techniques.

Your department was viewed to be one which is expected to benefit from this technology. To facilitate an understanding of what AI can do for your particular department, we propose a working session discussing AI applications that might assist in improving functional activities. This working session would begin with a presentation by an AI expert from our study team and then proceed to address your department's particular requirements. (A proposed agenda is attached).

Also attached is a short introduction to AI concepts and a questionnaire which will help your department identify potential application areas. We ask you to share this material with others who you think appropriate to invite to the workshop.

Your assistance in this study will be greatly appreciated as it will contribute to the formulation of a coordinated government policy on AI. The final output of the study will be an integration of findings from all participating departments. Your participation will also ensure you are kept abreast of future federal government activities in AI.

.../2

The study team will contact you in the near future regarding further arrangements and timeframes for the working session. If you wish further information, please contact the undersigned at 236-5867 or Peter MacKinnon of CAIPC at 727-0082.

Yours very truly,

R. Brady

for Peter Lyman,
Managing Partner.

PL:bf

encl.

Questionnaire Preface:

Introduction to AI

The following questionnaire is the focal point for a DSS-sponsored study to determine the need for, and potential applications of, a new class of computer-based tools derived from the multi-faceted research field known as artificial intelligence (AI). The study is critical in determining the role to be played by the federal government in influencing the directions taken by Canada in the applied research and development of advanced computer-based information technologies and products.

In order to answer this questionnaire it is not necessary for you to have a detailed understanding of AI technology. Nor is it our intention to give you a course on it. What we would like to do is give you a high-level view of AI, and ask you to think about (in broad terms) whether or not these would be of significant benefit within your organization, and if so, where. In essence, we wish to put forward a framework for conceptualizing AI and what it will offer, and ask you to look at this within the context of your organization.

We believe that AI is best conceptualized as a multi-faceted technology front. The essence of AI is that it will vastly extend the capabilities of computers as tools. To date, computers have been extremely limited in two ways:

(1) **accessibility** - In general, special training has been needed for anyone wishing to use a computer. Human-computer interactions have been carried out more in the computer's terms than in ours. The prospective user must learn the (often cryptic) language of the machine or application. Although significant strides have been made in improving the 'user-friendliness' of machines, effective utilization of computer-based tools is generally achieved only by a small number of experienced and/or computer-literate users.

(2) **capability** - Computers have been more or less restricted to dealing with the storage, manipulation, retrieval and display of data (numbers and text). The truly useful commodity is not data, but rather information, and this has until recently been beyond the scope of computers.

It is these two issues that AI technologies address. Specifically:

(1) **accessibility** - AI-based computers will be far more accessible as tools (and hence, far more useful to a greater number of people). The need for special training will be greatly reduced (and possibly eliminated). Computers will be able to understand and communicate with their users in natural language (ie. plain English or French). They will be able to guide their users through various applications, acting as knowledgeable 'experts' within an application domain. They will eventually be capable of understanding and generating speech, largely eliminating the need for a keyboard.

(2) **capabilities** - The new generation of computers will be able to deal not simply with data, but with information, a far more useful and powerful commodity. Already we are seeing the tip of this iceberg, with computers being used as advisors in such diverse and specialized areas as medical diagnosis, geological exploration, crisis management, and so on. Areas which involve a great deal of information, complexity and change are among the prime candidates for this new generation of computer-based tools.

In order to determine where AI solutions can be appropriate, the following criteria should be considered:

- o traditional computer capabilities do not work;
- o there are recognized experts in the field in question whose knowledge can be tapped in preparing computer-aided solutions;
- o a consistent pattern of thought or chain of reasoning is normally followed to solve the problem in question;
- o the domain of the problem can be defined and is relatively confined even if complex.

Several hundred working applications involving AI technology already exist. Currently, the most advanced stages in the commercialization of AI exists in natural language processing (NLP) and expert systems (ES), eg.

Natural Language Processing	Expert Systems
Database interface	Prediction
Machine Translation	Diagnosis
Expert System Interface	Design
	Monitoring
	Instruction
	Planning
	Control
	Debugging
	Interpretation

Although not exhaustive, this list should begin to give an idea of the potential of AI in terms of problem solving in a government setting. Along with the rest of this preface, we trust this introduction provides insight into answering the following questionnaire.

AI Questionnaire

We would appreciate it if you would spend approximately an hour thinking about the questions and/or discussing them with you colleagues responsible for the various functions or programs in your department/agency. The questions have been kept as broad as possible in order to provide you with reasonable flexibility. However, in answering them you should try to make reference to individual programs or functions.

Our study team will be contacting you within a few days to discuss the Questionnaire. If you have any questions regarding this document and Questionnaire, or require further clarification in any area, please contact Dick Bondy at Nordicity Group (236-5867).

1. **What is the importance of information to the core of your organization (its utilization and dissemination)**

a) within each of the main program areas, across those program areas, and external to your department/agency?

b) with respect to your internal administration? You may wish to consider areas such as

- personnel administration
- financial administration
- translation
- procurement
- information services
- database services

and so on.

2. **How is the <u>information</u> critical to your organization currently dealt with (<u>accessed, utilized,</u> disseminated)?**

Information may take many forms. You may wish to consider

- paper-based information;
- computer-based information;
- people-based information (ie. where expertise/knowledge resides with certain individuals).

Try to answer for each program or function considered.

3. **In <u>your</u> view, what are the main opportunities for improvement within your organization in dealing with <u>information?</u> (again with reference to specific functions or programs)**

You may wish to consider such issues as:

- accuracy
- updating information;
- interpretation of complex information;
- accessibility to relevant material;
- repetitive access of routine information;
- presentation of data;
- quality of staff in computer access and use;
- availability of scarce human resources;

among others.

4. **How would you rate each of the opportunities you have listed above in terms of their relative importance?**

This question should probably be answered in the light of the organization's goals and mandates, and how seriously the various problems impact the ability of the organization to fulfill these in a productive and harmonious manner.

5. **Do you see any <u>solutions</u> to the above opportunities?**

You should consider both

- technology-based solutions

  Here you may be reasonably 'utopian' in your thinking. Don't be too concerned about pragmatics at this point, or about current technological capabilities as you understand them.

- non-technology-based solutions.

  Here you may wish to consider issues such as

  - staffing
  - reorganization
  - redefinition of tasks
  - external services

  and so on.

6. **If the above-proposed solutions were adopted, what impacts do you foresee?**

In your answer you may wish to consider impacts on some of the following areas:

- greater capability performing tasks/services not previously possible;
- increased productivity and efficiency in normal duties;
- change in requirements (need to increase, decrease, or redistribute personnel, to redefine tasks, etc);
- positive or negative response by employees;
- organizational problems created by these solutions;
- greater access to public.

7. **Is there any additional information that you feel is relevant to the potential application of AI technology to your organization?**

Appendix C

Forms Processing

This section has been prepared as a result of a workshop held in the Nordicity Group Ltd. offices on November 18, 1985 (see list of participants attached).

C1.0 Introduction to Forms Processing as an AI Application Area

The term 'forms processing' is self-explanatory, but it can be amplified by adding that it is a data collection and analysis function. For this study, we examined three of the largest forms processing departments in the federal government:

- o Health and Welfare Canada (HWC) -- the Old Age Security system;
- o Canada Employment and Immigration Commission (CEIC) -- the unemployment claims processing system;
- o Revenue Canada -- the analysis of tax forms.

The dimensions of each of the three processes are large:

- o HWC has 300 offices across Canada, with 3000 public servants employed. Some offices receive 2000 queries a day. The operational costs are over $100 million per year for simply processing applications and 8 million cheques are issued each month.
- o CEIC has 450 offices across Canada, with 5000 public servants employed. The operational costs are $150 million per year and 1.5 million claims are processed per year.
- o Revenue Canada - only the 15,000 small-medium sized firms operation was analyzed in this particular function. All the work is done at headquarters in Ottawa and 15 experts are employed in this small section.

Forms processing is, of course, conducted in many other government departments and agencies. The key in looking at possible AI applications is to realize that it includes any activity that provides data to meet a set of rules, and the comparison results in yes/no decisions. Therefore, the application area can also be extended to include regulatory activities dealing with the public. Examples are: the CRTC application process for radio station licenses, etc.; and the marketing board/quota systems operation in Agriculture Canada.

C2.0 Problems Identified and Current Technology Solutions

- The search time allowed to personnel/agents is limited because of time constraints -- ie, the caseload is too heavy.

- The search is difficult because of the complexity of the information. Rules and regulations are constantly being changed and personnel do not have sufficient access to up-dates on manuals or explanations of new criteria.

- The search process is cumbersome, as the agents must obtain information from the client and previous employers. Streamlining is needed.

- Agents are a volatile working group in terms of job movement. It is difficult to keep experienced agents and therefore there is a need for a good training system and/or a computerized assistant which prompts inexperienced agents to ask correct questions.

- Most decisons are still judgemental, which leaves room for great inconsistencies in rulings. If criteria were computerized and available at the tips of the fingers of all agents, more consistent decisions could be rendered and cases with extenuating circumstances would be reduced substantially.

- Good service to the public is lacking in areas where prompt and expedient responses are needed. With some offices receiving 2000 calls a day, the need is intense. Most problems arise in interpreting legislation and regulations and current operations include manual searches of documents and a return phone call many hours later.

In Revenue Canada's case, there is little communication with the public until after the assessment process is completed. Explicit areas of expertise, ie, tax accounts, are involved here. The work is fairly judgemental and the agents have to check against a list of criteria to ensure consistency of assessment.

Current technologies in place do not provide assistance in these tasks. The major problem to overcome is marrying the accountant with computer techniques. Revenue Canada is very interested in developing computer languages which the subject expert (accountant) can work with.

In Health and Welfare's income security branch, most of the information is in a paper-based form. Access, utilization and dissemination are through the traditional forms of mail, courier, etc. There has been a move in the last year to access the data electronically but the systems in place are so diverse that access is extremely difficult.

C3.0 Potential Impact of AI Applications

The greatest, across-the-board impact of applying AI techniques to forms processing would be in productivity. The number of hours that could be saved with "intelligent" machines doing much of the work could be very large. The productivity impact would have a ripple effect in solving other problems, such as providing greater service to the public; more consistent rulings in tax and unemployment forms processing; greater access to more data. In addition, employees are often frustrated with the cumbersome processes involved in carrying out their duties efficiently, and a positive response to increased machine capacities might be expected. We do not minimize, however, organizational and personnel problems associated with changing procedures in large forms processing departments.

C4.0 Identification of AI Applications

The potential for the application of AI techniques to forms processing is wide.

C4.1 Query Systems and Tutor Systems

Both of these systems would improve productivity. They are both natural language processing (NLP) driven and, therefore, have a wide scope for systems improvements.

A query system is a machine system which assists the human user by providing prompts in real time, ie, as the interview is proceeding, information is being fed in and questions are forwarded by the system to fill in the remaining information gaps. It is a real time productivity tool.

Whereas a query system is on-line, a tutor system would act as a training or refresher tool. It would maintain up-to-date interview techniques and lists of criteria or information needed to process claims. It could greatly assist in up-grading the quality of agents. A tutor system is an off-line quality improvement tool.

Both these applications will require technical development because of the large domain of information that is required, and its necessary logic system. The NLP requirement adds to the difficulties in producing a viable project in the short term.

C4.2 A Data Base Maintenance System

This system would be used for updating legislative rules and regulations. A system which can compare data and rules ranks favourably in terms of demonstration projects. A data base maintenance system involves computerizing manuals (see Training section) and making them available to the agents. As a client asks a specific question, the agent would have access to the latest regulatory information, thus providing prompt delivery of the correct information. It would eliminate the current manual search required.

The best method of maintaining consistency in decisions being made in these application areas is to use one system to compare input data with the rules. Once good data is collected, it must be processed correctly in terms of meeting or not meeting regulations or laws.

An expert system (ES) to compare collected data and rules can be applied to all three departments examined. HWC and CEIC are analyzing the potential use of ES based on defined criteria. Revenue Canada is making professional judgements based on interpretations of law. The best feature of this type of system is its bounded domain, or the limited decision paths it can take to solve the question of, eg, eligibility for an income security program.

In summary, ES could greatly assist in basic, continual functions of forms processing, such as updating information, interpretation of complex information, and repetitive access to routine information.

C5.0 Assessment of Candidate AI Applications

Having identified the generic AI applications, we now examine whether the applications meet the criteria for implementation in the near to medium term (as outlined in Section 3.2 of the main report). As a first step, we systematically ranked the four candidate applications determined through the workshop session and discussions (see Exhibit C1). These are: intelligent query system (per activity), data base maintenance (laws and regulations), data versus rules analysis system (per activity), tutor system for fact finding (per activity). From this, we have the following observations:

- o The system for analysing data obtained against the rules ranks as the best prospect because: the opportunity is well-defined, there is agreement about the knowledge, the information is specialized, and an expert can be committed to the project.
- o The system for managing data on laws and regulations ranks a close seocond for many of the same reasons, and particularly because the expertise is perishable.
- o The other two fall considerably further behind in the ranking because the short-term benefits cannot be precisely identified and the domain is not closely bounded.

Exhibit C1

	Intelligent Query System (per activity)	Data Base System (legislative)	Analysis System (per activity)	Tutor System for Fact Finding (per activity)
Expertise Perishable	1	1	2	3
Expertise Scarce	2	2	3	2
Opportunity Defined	2	1	1	2
Bounded Domain	3	3	1	2
Agreement About Knowledge	2	1	1	2
Large Amount of Task Specific Data	3	2	2	2
Information Specialized	2	2	1	3
Commitment of an Expert	2	1	1	2
Short-term Benefits	3	2	2	3
Test Cases Available	2	2	1	2
Rank Total	46	35	32	50

Legend:

1) highly demonstrable
2) existing
3) not existing to degree necessary

Appendix D

Intelligent Buildings System (IBS)

This appendix is the result of a meeting at Public Works Canada on November 7, 1985, convened jointly by PWC and NGL (see list of participants attached), with the dual purpose of serving this study and launching an IBS initiative by PWC. Subsequent interviews and independent research complemented the meeting.

D1.0 IBS as an AI Application Area

The "intelligent building" system is sometimes called "smart buildings" or "expert systems for building management". The telecommunications network and services that provide a building with "intelligence" can be regarded as the fourth utility -- after the three utilities of electricity (wiring), water (plumbing), and air (heating, ventilating and air conditioning).

Creating an intelligent building essentially involves integrating building systems and services with state of the art hardware and software, generally within three broad areas:

- o <u>building services</u>: monitoring and control systems for elevators, lighting, heating, ventilation, air conditioning, fire, security, etc.;
- o <u>tenant services</u>: communications, computer services, electronic mail, and shared services (for computers, telephone answering, reproduction, etc.);
- o <u>building facilities management</u>: space planning, energy management, occupancy management, etc. (See Exhibit D1).

At present, there are no commercial bodies that can provide turnkey installation of fourth utility services, let alone architects who have embraced the concept. Less expensive and more sophisticated individual systems (or components) are being used more and more frequently in buildings, but they are still normally used on a rather fragmented, or piecemeal, basis.

Recently there have been moves to start to use (or at least to talk about using) these components in a more comprehensive and integrated manner (Portland's Federal Building East, DND Halifax Shipyard, the proposed MICOT building in Hull, etc.).

The federal government is a landlord with extensive property services and management responsibilities -- $50 billion in real estate holdings and $5 billion a year in maintenance costs. It must run its buildings economically, in line with the policy of "revenue dependency" and with coherent planning around the concept of a 30-35 year life cycle for buildings.

Public Works officials described intelligent building systems as a strategic technology in a presentation to the Interdepartmental Committee of Strategic Technologies: "Clearly, artifical intelligence, expert systems, computer-aided design, and information and telecommunications must be considered technologies of strategic importance to Canada and to the Canadian economy, and consequently should be encouraged and supported."

There is a real opportunity to increase productivity and reduce costs through an IBS approach at this time. The potential is further enhanced by the December 9, 1985 announcement that all services related to the operation, maintenance, construction and leasing of property now located in other departments will be centralized in one department -- Public Works Canada.

D2.0 Problems Identified and Current Technology Solutions

The sheer size of the space to be managed (60 million square meters) creates logistical problems in managing the data. With the growth of sophisticated computer monitoring and planning systems, engineers are receiving large amounts of complex data from many sources which they, in turn, must digest and use to make continuous judgements regarding the status of the building -- in both the design and maintenance phases. These developments have coincided with cutbacks in personnel, causing the expertise to be spread too thin; reaching a critical level in day-to-day operations.

A further function of size is the magnitude of the costs. If only 5% of the $5 billion a year maintenance bill can be reduced through the use of AI products, major savings will have been made.

Another major problem area is the maintenance of a current knowledge base concerning the advancement of compatible technologies in building design. For example, a telecommunications technology expert must be able to work with a computer-aided building designer, who in turn has responsibilities to an enivronment maintenance engineer, and so on. The domain expert is becoming more and more specialized and systems must be developed to marry all advancing technologies most efficiently.

Current technologies being used under PWC normal operations:

- o energy management
- o building environmental analysis
- o office planning and design
- o building control systems
- o heating, ventilation and air conditioning
- o informatics (computer systems)
- o computerized design and analysis
- o maintenance management.

Pilot projects where PWC is involved:

- o office communications (the OASIS system on Parliament Hill and DOC pilots) -- NRC and DOC;
- o computer aided drafting ("as built drawings") -- NRC;
- o computer aided building facilities and inventory management (interdepratmental);
- o ORBIT (Office Research in Building Information Technology).

Outside activities:

- o computer aided design (R&D and demonstration);
- o computer aided drafting (a strategic technology;
- o computer aided mapping (a strategic technology);

These activities can be efficiently pursued under the umbrella of Intelligent Buildings Systems.

D3.0 Potential Impact of AI Applications

The principal impacts of applying AI technologies to the construction and management of large buildings is in productivity gains, cost reductions, and upgrading/increasing services during the life span of a building. Savings in the overall life cycle costs of facilities could be achieved through AI applications, though it is likely to require up front investment in instituting specific applications.

Specific areas where efficiency and cost improvements can be made:

- o diagnostic system for air quality;
- o improve a cost estimating system (Compest)
- o development of the data base for specific buildings (which remains after the manager leaves);
- o project delivery system improvements would make processing, scheduling and development of master specifications for private contractors more efficient;
- o building-client analysis capabilities.

D4.0 Identification of AI Applications

Of the three broad areas identified as needing the IBS approach -- building services, tenant services, and building facilities management -- the latter is the area which would benefit most from the application of AI technologies. The problems outlined in section 2.0 can be considerably alleviated with AI products which merge the enormous quantities of data, and give answers to the building engineers. Space planning, energy management, occupancy management, etc., can be handled more efficiently by fewer people.

But the whole process of running the federal government's real estate holdings, from planning and designing the building to the end of its life span, can be assisted by expert AI systems. At an implementation level, that is consistent with the specificity required of other workshops, three potential small but important possibilities have been identified by DPW. In brief, they are:

1) diagnostic system for air quality: presently humans monitor data, make decisions on appropriate corrective steps. If a system could improve the time interval in which decisions are made and process the increased amounts of data, productivity and safety measures could be improved. Diagnostic tools on a generic level have great potential, for energy management, climate control or security.

2) improve a cost estimating system called COMPEST: this system tracks cost information and makes economic decisions on appropriate paths. It is a well defined problem that has been attempted by state-of-the-art computer technologies, but needs some "intelligence" and NLP capabilities. Since it is a tracking system, it has a large data base, that requires self-feeding, thus it needs good quality data. The present bottle-neck exists in the speed of delivery and ease of use. The system is based on a mainframe with the 3 day turnaround times and the typical problem of economists (or any domain expert) not being computer literate to query for the correct data.

3) building-tenant analysis package: developers need assistance which determines building user requirements. Presently score-cards are prepared and analyzed on a somewhat ad hoc basis leading to imperfect decisions on what type of building should be designed. If a natural language query system could automate this scorecard activity, then important criteria could be determined and fed into the design process.

A fourth application, the largest in both impact and size, is in assisting in building operating and maintenance.

The potential for ES in life cycle decisions is great. For instance,

- o all buildings are moving to direct digital controls (electronic signals) which means vast amounts of data not previously available are being compiled and analyzed;
- o if data can be analyzed, to decide when to replace parts and schedule maintenance activities, large impacts are possible in certain maintenance categories.

In short, cost of construction is now cheaper than to maintain the building. In DPW's opinion, concentrating on saving in maintenance activities will have greater impact than reducing up-front or construction costs.

In general, DPW has great hopes in the application of AI technology. However, they need immediate assistance in defining appropriate applications and learning more about AI capabilities. Although attending seminars has been initiated by senior management, DPW wishes to involve the domain experts in understanding AI and thus having the working level or line activities determine opportunities.

D5.0 Assessment of Candidate AI Applications

As described in an earlier section, there are criteria under which AI solutions are most feasible. Intelligent building systems have a number of interesting matches. The previously discussed application possibilities in IBS revolve around three generic themes:

(i) Building design

(ii) Building control and maintenance

(iii) Informatics and communication systems.

Under the building design activities falls the cost estimating system and the Building-Tenant Analysis system. From Exhibit D-1, a cost estimating solution ranks third as an implementative possibility. As with any activity under the building design theme, it may be difficult to find the initial "go ahead" requirements simply because of the long and tedious planning and design process a structure goes through. A tenant analysis package ranks better because of its narrow range of data to knowledge requirements, almost to the extent that it is too small an application.

The air quality diagnostic system and the life cycle analysis package appear under the building control and maintenance theme; however both at the opposite end of the possibility spectrum. A diagnostic system ranks well because of the ability of analyzing very task specific data in a very confined context. As well, one of the main areas of commercial success of AI to date is in diagnostic systems (medicine and TV cable default analysis). Combining these characteristics provides strength for a successful application. For the exact opposite reasons, a life cycle decision tool, for equipment resident in a building, may have difficulty in implementation. Although an important solution, the opportunity is just too wide in scope to build an appropriate system over the short term.

Exhibit D1

	Air Quality Diagnostic System	Cost Estimating System	Building Tenant Analysis	Life Cycle Decision Analysis
Expertise Perishable	2	2	3	1
Expertise Scarce	2	1	1	2
Opportunity Defined	1	2	1	2
Bounded Domain	2	2	1	2
Agreement About Knowledge	1	2	2	2
Large Amount of Task Specific Data	1	1	2	3
Information Specialized	2	2	1	2
Commitment of an Expert	1	2	3	2
Short-term Benefits	2	3	2	3
Test Cases Available	1	2	1	2
Rank Total	32	40	36	43

Legend:

1) highly demonstrable
2) existing
3) not existing to degree necessary

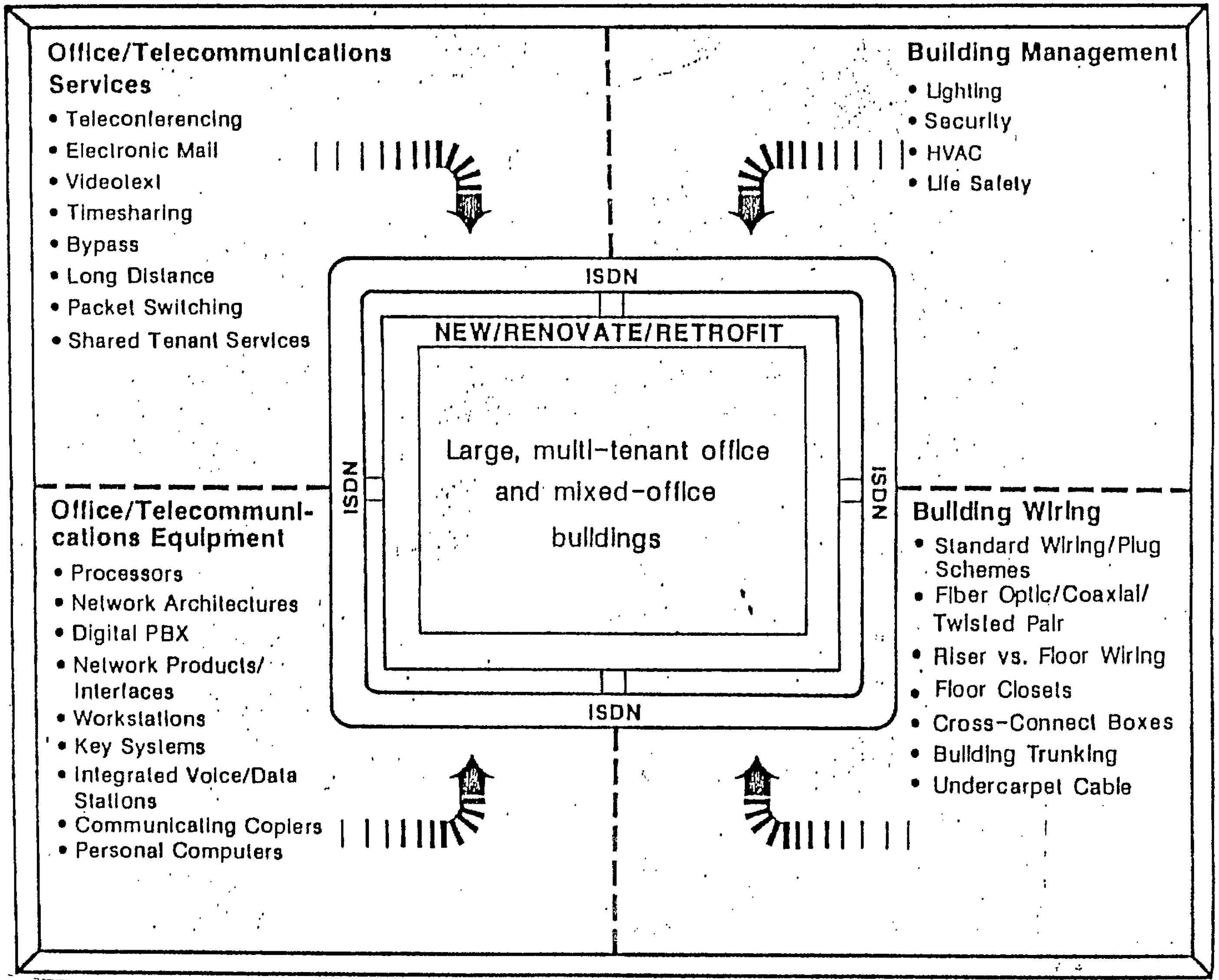
D6.0 Implementation Considerations

To implement IBS in the federal government, a coherent focus is needed among the departments with the technological interest and knowledge: NRC, MOT, DND, DOC. PWC has demonstrated interest in being the catalyst and workshop participants from other departments expressed interest in participating. Some of the general implementation steps that an IBS thrust could have are:

- Pilot projects could be defined for AI within the operational mandates of each federal department involved.
- Collaboration could be extended to the private sector with the aim of forming one or more turnkey IBS builder(s)/project manager(s).
- Collaboration could be extended, as well, to provincial governments on an ad hoc basis. For instance, within the Ontario government, there is interest from the OPP and MTC.

Exhibit D-2

PRODUCT AND APPLICATION SCOPE



Appendix E

Informatics

This section has been prepared as a result of a workshop held in the Nordicity Group Ltd. offices on November 21, 1985 (see list of participants attached).

E1.0 Introduction to Informatics as an AI Application Area

The other AI applications in this study have all related to the mandates of specific lead departments, whose representatives have worked with us in defining specific AI opportunities. With informatics, however, every department with large computer service requirements is involved. This means that each department should have similar problems and similar opportunities.

Informatics is a loosely-defined term which applies to a broad range of information-handling technologies which provide automated capabilities for: data collection; data input; information storage and retrieval; information processing; communication.

Informatics also means the processing of content and conveyance of the content, and deals with the human interface -- usually associated with office communications and increasing office automation.

Applying AI techniques to informatics means the development of intelligent, deductive databases -- which comes out of basic research in computational logic and knowledge representation. The development aim in informatics is to make human-computer interaction as natural as possible. Although we are far from achieving this state, incremental steps can be taken to push us closer.

Informatics improvements can affect a wide range of government activities and improve productivity everywhere. The dimensions are indicated by the fact that the Department of Supply and Services has a $92 million budget in informatics.

E2.0 Problems Identified and Current Technology Solutions

User access to databanks is a serious bottleneck to making computerized information more generally available, and hence more useful. If databanks are large and if the users are non-technical people, the access problem becomes critical to the useability of databanks. Access can be blocked entirely, or it can involve lengthy query systems or unnatural languages.

Software application is also a problem, since literally thousands of software packages are available to a micro-user, guidance in choosing what package to buy is needed.

With more and more use of computers by the federal government, uncoordinated purchasing of micro hardware is becoming a problem. Attention is needed to the compatibility of systems -- to their ability to "talk" to each other -- in order to take full advantage of the new technologies being put in place.

In addition to micro systems coordination, the lack of mainframe capacity management, or planning system, across all departments means optimal use is not being made of the capacity.

E3.0 Potential Impact of AI Applications

Overall productivity in government information-handling needs can be increased dramatically through "intelligent" databases. The interests of the departments which participated in this part of the study are wider than informatics, but they can be served by the addition of AI tools and techniques. The departments identified the following:

Department of Communications

- o broad communication needs;
- o orderly introduction of communication R&D;
- o application of informatics in office surroundings will provide support to decision processes.

Department of Supply and Services

- o needs its own applications, such as in: tendering, contract management, travel regulations, sourcing systems;
- o needs its own electronic data processing (EDP) planning, ie, capacity management;
- o needs an information processing strategy to improve government productivity and spin-off benefits to industry.

Agriculture

- o has needs in research and information dissemination;
- o micro configuration planning would improve output.

Fisheries and Oceans

- o has needs in information sharing, utilization of micros.

AI technology offers the prospect of not only storing and retrieving information, but also structuring the information so as to allow logical inferences to be drawn from it efficiently. When information is stored in such a way as to allow logical inferences and problem solving to occur, it ceases to be mere information and becomes knowledge.

Across-the-board improvements of user-access to computer databases will greatly improve the utility of the machines. Systems which allow the user to interact with a number of computer systems in natural languages are now available commercially and research is continuing.

The process of generating coherent running natural language narrative reports or bulletins from tabular or other highly-formatted material from non-linguistic sources would also greatly enhance computer utility.

A central library system to assist the users in choosing the software system most appropriate to their needs would assist in coordination of systems.

E4.0 Identification of AI Applications

E4.1 Natural Language Processing

A NLP system which understands documents, produces an abstract of a piece, perhaps alerts people who might be interested, and answers questions on its content is the wave of the future in informatics. Such systems could be paired with document generators which produce training or procedure manuals.

Natural language inferfaces have certain limitations, the first of which is technical. Document understanding systems are still in the future, but an incremental step could be the production of intelligent library systems, which aid people in searching and evaluating large bodies of information, eg, as contained in manuals. Dealing with very large databases is an area where spinoffs from AI research have made their way into advanced computer science applications. Much more of this combining of AI and general computer science research can have great payoffs.

Other applications in the NLP area which could be begun now are in the development of "front ends" or interfaces to computer systems or databases, to improve the query and log-on systems.

E4.2 Expert Systems

There are several ways in which expert systems can play a role in interfacing users with databases:

- o query and search optimization;
- o transaction management -- aids in retaining the integrity of the data;
- o inferring facts not explicitly stored -- an ES with the requisite knowledge to infer that there is a different question from the one asked that produces the same answer, and is retrievable;
- o database advisor -- of particular value when the user knows very little about the organization of the material, or if the information sought is not clearly defined.

In relation to some of the problems outlined earlier in this report, an interactive ES could identify the characteristics of software packages, work the user/client through all the needs, and pick the software package appropriate to the project.

ES could also optimize microcomputer purchasing. Local area networks could be designed and planned, based on criteria forwarded by an ES.

DSS has begun a five-year plan called Information Processing Planning and Strategy (IPPS), which is an example of how AI techniques can tie into informatics systems already in place.

E5.0 Assessment of Candidate AI Applications

Having identified the generic AI application, we now examine whether the application meets the criteria for implementation in the near to medium term (as outlined in Section 3.2 of the report). As a first step, we systematically ranked the four candidate applications determined through the workshop session and discussions (see Exhibit E-1). These are: capacity planning system, software library system, microcomputer configuration system, and diagnostic system for network faults. From this, we have the following observations.

The optimization of microcomputer systems ranks as the best prospect because it is important to rationalize and make compatible micro purchasing in the government, and it is a "small" manageable project by department. In addition, the opportunity is well-defined and expertise is scarce.

The software package library system ranks second because of a great deal of information is needed in a single source -- and if this can be done, the impact on productivity would be great.

Exhibit E1

	Capacity Planning System	Software Library System	Microcomputer Configuration System	Diagnostic System for Network Faults
Expertise Perishable	2	2	2	1
Expertise Scarce	1	1	1	2
Opportunity Defined	3	2	1	3
Bounded Domain	3	2	2	3
Agreement About Knowledge	3	1	3	2
Large Amount of Task Specific Data	1	1	2	2
Information Specialized	1	1	2	2
Commitment of an Expert	2	3	1	1
Short-term Benefits	3	2	2	1
Test Cases Available	3	1	1	2
Rank Total	48	37	34	41

Legend
1) highly demonstrable
2) existing
3) not existing to degree necessary.

The diagnostic system for network faults and, even more, the capacity planning system, fall to the bottom of the ranking because the tasks are too large at this time and they, therefore, do not fit the criterion of a small, manageable project.

E6.0 Implementation Considerations

The Office Communications Systems program is an important analogy which may serve to illustrate one model for follow-up demonstration. This was a $10 million program with three demonstration projects involving user departments, Treasury Board, DOC, and industrial suppliers. There has been extensive evaluation of this program which may serve to help design an appropriate model for demonstration projects in AI applications in informatics.

The IPPS plan referred to earlier is an example of studying how to tie AI into informatics.

Appendix F

Machine Translation (MT)

This section has been prepared as a result of a workshop held in the Nordicity Group Ltd. offices on November 6, 1985 (see list of participants attached), with several subsequent individual interviews with personnel from the Translation Bureau, Secretary of State.

F1.0 Introduction to MT as an AI Application Area

Machine translation is an important potential application area for AI, in view of the bilingual nature of this country. Canada has an urgent need for help with its translation task. There is not only a strong demand for machine assistance in dealing with the volume of text translated in Canada every year, there is also an ever-burgeoning demand internationally. With the increasing interdependence of national economies, ever-greater amounts of information must be disseminated globally.

In Canada, 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, with an $86 million budget and 1000 full-time translators (out of a total staff of 1800).

In addition to these internal requirements of the federal government, some provinces also have large translation needs; notably Quebec, Ontario, New Brunswick -- and especially Manitoba where the courts have ruled that all statutes must be translated.

In industry, most large exporting companies have been forced to develop sizable translation services to meet their customers' language requirements.

Three quarters of a million words per year would, therefore, seem to be a very conservative estimate of the total current Canadian market. With the average cost at 20 cents per word, the Canadian translation market is worth at least $150 million per year.

The last 30 years have seen many attempts to use the computer in translation, occasionally with some moderate degree of success. Until recently, Canada was a leader in the field, but several other countries, particularly Japan and the EEC, are now pursuing major efforts in MT. Canada does not have a program of action in this area.

A study of machine translation and natural language processing by Cognos in February 1985 concluded:

- o there is a great need for technological assistance in translating the enormous volume of text in this country;
- o there is a demonstrated expertise in Canada in the design of advanced and large scale machine translation systems, as evidence by the TAUM project. In addition, Canadians have accumulated a large amount of general experience with machine aids to translation (such as terminology banks) in the Translation Bureau of Secretary of State and in a number of private translation services;
- o in the world market, MT is a significant niche market in which Canada has a tremendous opportunity.

There is the perception that a focused R&D program could place Canada in the forefront of a high-demand, ever-increasing, international market. Conversely, if this line of research is not pursued enthusiastically, there is every reason to believe that the experience and expertise Canada now has will be wasted in economic terms, and our competitive edge in this field will be lost;

MT research should be mounted in the context of developments in AI and NLP in general, and such research could then be exploited in other areas not directly related to MT.

F2.0 Problems Identified and Stages of MT Development

From the workshop and follow-up discussions with Translation Bureau personnel, it is clear that the major translation problems faced are:

- the high volume of words to be translated, a volume which is steadily increasing;
- the need for fast turn around;
- the varying levels of language quality required, at both the technical and non-technical levels.

The positive view of the position of MT in AI research must be tempered with the realization that high quality understanding of natural languages is a difficult task in the short and medium term. MT will progress through three generations of development:

1) word-for-word translation
2) syntax ability (present state-of-the-art)
3) knowledge-driven, inference engine, with interpretative abilities (major technological advances required).

The use of MT with current technologies remains largely confined to situations where high quality translation is not required. An early enthusiasm for MT (mid sixties) gave way to a realization that the problem was much more difficult than had initially been supposed and a consequent reduction of research between 1965 and 1975. More recently the continuing market pull has led to a stepped-up MT research effort world-wide.

The second generation prototype systems worked on in Austin, Grenoble and Montreal moved the technology beyond the first stage of simple word-for-word schemes to a separation of the grammatical analysis between the two languages involved, making it easier to state translation rules that take into account a wide context.

Machine translation developments should progress through the following three stages:

- o Machine-aided Human Translation (MAHT)
- o Human-aided Machine Translation (HAMT)
- o Fully-Automatic High Quality Machine Translation (FAHQMT).

Each is discussed in turn.

Machine-aided Human Translation (MAHT): This stage involves developing, or improving existing, automated aids for the human translator, leaving the basic translation initiative to the translator.

A specialized workstation could integrate several tools, including split-screen text processor and access to on-line dictionaries, etc. An initial contract has been let by the Translation Bureau to define the functional characteristics of a specialized work station, with the report due at the end of March 1986.

Human-aided Machine Translation (HAMT): The next level of sophistication is the reverse of MAHT - ie. human-aided machine translation. With HAMT, the machine has the initiative in the translation process, but human translators are required to assist the machine with problems that are beyond its capabilities. The Translation Bureau has been testing commercial products available (eg. the WIEDNER system), but the present systems have not met its needs of high quality. However, new products are appearing with greater frequency, such as those listed in Exhibit F-1. This requires a major effort by the Translation Bureau to keep up with and assess the new products as they emerge. At some point there will likely be procurement requests for commercially-available MT products, although such requests are not yet imminent.

Fully-Automatic High Quality Machine Translation (FAHQMT): As mentioned above, a very large leap in the technology of handling language texts is required to reach the ultimate stage of FAHQMT. At this point there are limited cases where translation can be fully automated when designed for a highly restricted application. The classic example of a highly restricted natural domain can be found in the Canadian developed TAUM -METEO system. It takes advantage of the

Exhibit F-1

Inventory of Operational MT Systems

System	Language Pairs	Hardware	Suboptimization Methods	Techniques/ features
SYSTRAN	English-French English-Spanish English-Portugese English-Italian English-German English-Japanese English-Arabic Russian-English French-English Japanese-English	IBM Mainframes	post-editing, specialized dictionaries	direct approach, some semantic and syntactic information in dictionary, interfaced with OCR and with WP
LOGOS	German-English English-German (current version) Russian-English English-Vietnamese English-Farsi (former versions)	Wang OIS	post editing, specialized dictionaries, some interactive pre-editing	dictionary maintenance, system integrated with WP, large German-English dictionary
ALPS	English-French English-Italian English-Spanish English-German English-Arabic French-English	DG MV-4000	some pre-editing, post-editing, specialized dictionaries, interactivity, also MAHT mode	direct approach, integrated with WP, interfaced with OCR
WEIDNER	English-French English-German English-Spanish English-Arabic English-Portugese English-Japanese French-English German-English Japanese-English Spanish-English	DEC PDP-11, IBM PC	some pre-editing, post editing, specialized dictionaries also MAHT mode	direct approach, online dictionary maintenance, system integrated with WP
SMART	English-French English-Italian English-Spanish English-German English-Japanese	IBM 370, DEC VAX	restricted input, post-editing	online text critiquing, system integrated with WP
METEO	English-French	CDC CYBER	sub language, restricted to weather forecasts, not commercially available	second generation, complete sentence analysis, detects unanalyzed sentences

Exhibit F-1

Inventory of Operational MT Systems

continued

System	Language Pairs	Hardware	Suboptimization Methods	Techniques/ features
E.T.L.	English-Japanese	Fujitsu FACOM M200	input restricted to titles and indexes of technical papers	second generation
ATLAS/I	English-Japanese Japanese-English	Fujitsu FACOM M-180II	restricted to computer manuals, pre-editing, interactive	transfer approach, case frame analysis
SPANAM	Spanish-English English-Spanish	IBM Mainframe	post-editing	direct approach, integrated with WP
TITUS	between English, French, German, and Spanish in all directions	NA	artificially controlled input	predefined sentence patterns, closed vocabulary

very tight sublanguage restrictions found in weather forecasts to translate accurately and automatically more than 80% of the weather bulletins submitted each day at Dorval Airport. This one system can be called a fully automatic high quality translation (FAHQMT) and to our knowledge is the only reported case of a system at this level.

Secretary of State funding for the TAUM project at the University of Montreal, which developed METEO, ceased in 1981 when no further cost benefits could be realized without embarking on a major research program. It is now widely accepted that FAHQMT (using unrestricted texts) requires systems capable of reaching a very deep level of understanding of natural language, and can only be based on significant advances in AI technologies - the ability to store, retrieve and appropriately use vast amounts of linguistic as well as general knowledge.

F3.0 Potential Impact of AI Applications

The rationale for AI stems from the benefits or productivity gains that could be derived from the application of AI tools and techniques, namely:

- o increase in productivity achieved by speeding the translation process. The demand by clients for fast turn-around is constant and will deepen as the new technologies make faster and faster publication of information a norm;

- o removing the need for the human translator completely in areas of high volume, restricted languages applications -- such as weather bulletins;
- o the possibility of keeping costs relatively stable while the volume increases, after the initial investments, as the need for highly-trained (expensive) personnel decreases.

The Translation Bureau is examining how much of the translation requirements can be machine assisted to achieve some of these benefits. It has identified some 264 subject areas which have their own specific characteristics (eg. agriculture market reports, weather forecasting, and competition announcements). A "text type" system has been devised to compare these subject areas, an illustration of which for competition announcements is shown on Exhibit F-2. The text types can be defined by: the number of different words in a 5000 word sample; the estimate of total vocabulary; the sentence length; and the semantic properties.

It is not expected that many subject areas will be immediately appropriate, which means that the short-term impacts of MT on the total translation requirement will not be large. Over the longer term, however, a more significant proportion of all translation work would be automated. A sustained multi-year effort would shorten the pay-back period for machine translation.

F4.0 Identification of AI Applications

The potential for the application of AI techniques to machine translation has been discussed. However, much of the work to be done in the short term is in engineering and hardware, not AI software. An example is the integration of dual image word processing and terminology banks. Thus, MT is a combination of the application of current technologies (eg. in OCR or information storage), currently

Exhibit F-2

Dr. Kettridge Developed Method for Comparing Text Types

abbreviation code	*text title or type*	*source of text*
AC	competition announcements (fr: "avis de concours")	Public Service Canada

frequency of publication	*typical length (words)*	*annual volume (words)*	*similar texts*
daily	150	1,500,000	statements of qualifications (SQ) position descriptions (PD)

translation turnaround time	*useful life of text*	*stylistic quality requirements*	*tolerance of rigid style*
48 hours	weeks	moderate	good

Lexical measurements:

- *number of different words (root form types) in 5000-word sample* 891
- *estimate of total vocabulary for the domain (root forms)* >5000
- *sentence length: typical range (median)* 2 - 30 (10)

Syntactic properties:

interrogative sentences — —
imperative sentences —
conjoined sentences +
subordinate clauses —
topicalizations — —
parentheticals +

telegraphic forms: several types
article deletion +
verb deletion —
noun phrases:
empilages +
conjoined +
est.no. syntactic patterns >300

Text structure:

text grammar possible? only for global structure
inter-S pronominalization no
other linking characteristics no

Semantic properties:

use of frames possible? no (except "OPEN TO" subsection)
temporal reference present (generic)
modalities must, may, should
degree of domain closure poor to moderate
important semantic classes limited possibilities

Translation difficulties: lack of sufficient context to determine intended meanings; lack of uniform use of job descriptions, titles, etc.

General comments: context of human translation strongly suggests a system including:

1. an interactive module for composing the source document in which writer would try to choose from among proposed options; include text editing capacity and document file;
2. a translation module which would include terminology lookup, access to standard job descriptions, previously translated documents, names of institutions, etc.
3. automatic routing and transfer to posteditor, printer (or electronic bulletin board,etc)

available products and software (eg. word processors and processing) and new MT tools like Q-Systems and GRAM R.

There are characteristics which make a translation requirement promising from the perspective of applying MT. There are three necessary conditions:

1) A high and steady volume of words to be translated. For example, METEO processes 700,000 words per month. Some sublanguages (text type) are specific enough for MT but do not generate a high enough volume for MT. For example, Agriculture Market Reports could be a good test case but only 400,000 words are generated per year and the reports are not produced on an even, constant basis. Only 1 1/2 translator person years are required for this volume, which is not enough demand to warrant spending scarce capital funds on developing a system.

2) Fast turn-around time. The clients (ie. other departments) for federal translation are very concerned with speed -- they are not concerned with <u>how</u> the translation is done, only that it be done quickly. This criterion is the strongest client-driven requirement in the federal government. Two examples serve to illustrate:

   - Statistics Canada material is needed by its consumers as soon as it has been computed, because of its short life span;

   - Revenue Canada legislation and regulations must be translated immediately in order that field workers have constantly up-to-date guidelines.

3) Restricted syntax or limited grammar. The present state of the technologies dictates this criterion. The building of automated dictionaries are extremely expensive, therefore dictionaries must be small. For current machines to handle the word, small sub-languages must be attacked first; eg. building on the METEO success with a system such as TAUM-Aviation. Translation of large text types is simply not technically possible yet.

Two other factors are important in determining the potential for application.

4) The characteristics of the intended user and use. For example, material for distribution to the public ranks high in terms of volume of users, but the high quality work needed may be too much to overcome at this time. On the other hand, announcements of job competitions are distributed to 300,000 public servants, where higher error could be tolerated and where the language could be restricted to enable MT to be successful.

5) Repetitive nature of the material. If there is a uniform use of similar terms, and the documents to be produced are constant in size and composition, the translation requirement would lend itself to MT. Quality should be considered as a variable in determining MT projects, but in fact, it is a given. The Translation Bureau provides high quality material and its clients will not be satisfied with lesser quality. Therefore, MT quality must be consistent across all applications.

F5.0 Assessment of Candidate AI Applications

Unlike other workshops, where individual discrete AI applications are described and analyzed, MT is a complex application by itself and the next level of implementation is to identify appropriate sub-languages. It is beyond the scope and ability of this study to determine ground rules for these sub-languages and then apply these rules to rank the specific languages to concentrate on. The Translation Bureau of SoS is in the process of defining these criteria in a more substantial manner and should be able to provide guidelines in the near future.

Since the current technologies do not yet allow for quality, literary texts to by translation by machine, restricting the input and standardizing requirements could go a long way to increasing MT productivity in the next five years. If source documents can be standardized, the text type is narrowed to more manageable levels for MT.

Expert systems could be used for text writing, limiting the source language vocabulary and syntax through the use of an interactive editing tool. If the system reads a sentence that it cannot translate, it will ask the inputer to rearrange the sentence, or recompose the sentence itself and ask the writer for approval.

DOC and the Translation Bureau are planning to increase knowledge of the total translation market as a step toward developing a full MT program. The federal government need is fairly well documented, and there is some knowledge of the needs of the provinces. However, the non-government need, ie. the private sector in Canada, and particularly the needs in other countries is much less well known.

DOC is preparing a three-pronged approach to the implementation on a MT development program, which is based on:

- o technological push
- o industrial support, and
- o market pull.

With respect to the technological pull an R&D plan is being prepared to encompass government, university and industrial research. An industrial support plan is also being prepared, involving technology transfer, marketing support and investment incentives. Finally, the "capital budget" part of the Translation Bureau is viewed as a means to automatic translation over time.

In terms of the translation business resources outside government, the main developments in research and industry software/hardware suppliers are external to the country. There are some 400 suppliers of translation services in Canada, of which only about 15 could actually be considered companies. These companies, the Translation Bureau and major companies represent the potential domestic user base for MT tools and products. A concerted effort is required to stimulate Canadian industry and linkages to university research resources. The DOC program appears the logical starting point.

Appendix G

Training and Counselling

This section of the appendix has been prepared as a result of the October 28, 1985 workshop (see participants attached) held in Nordicity Group Ltd. (NGL) offices, with several follow-up individual interviews of participants.

G1.0 Introduction to AI Application Area

Training and counselling comprise an important potential area for the application of AI, in view of the extensive responsibilities of the federal government to the general public, the federal public service and with the provinces. The main program responsibilities are:

- delivery of counselling services to the general public in about 1000 regional and district offices of the Canadian Employment and Immigration Commission (CEIC), involving some 2500 counsellors and 1.3 million Canadians counselled per year;
- through CEIC contracting out and providing grants to private sector and public and non-profit institutions for the operation of training programs;
- training and counselling programs operated directly by the Public Service Commission (PSC) for federal public servants;
- individual federal departmental and agency training responsibilities for specialized skills (eg. aircraft maintenance, national parks supervision, pesticide control, etc), estimated to cost about 6% of discretionary funds per annum.

G1.1 Counselling

In counselling these responsibilities require the continual updating of information regarding employer needs, judgement in matching them with job seeker skills, distribution of this knowledge throughout the country, and making it accessible to ordinary Canadians.

Counselling clients range from high school drop-outs, to women re-entering the work force, to retirees who do not want to leave the work environment on a full-time basis. Increased use of machine assisted counselling that is easily accessible and useful in individual application has the potential to improve counselling productivity.

G1.2 Training

In training the federal government has a massive, continuous task of upgrading its human resources skills in the operational aspects of public administration, second language training, and in specific skills related to the particular mandates of departments and agencies. While the training function will always involve direct instruction or guidance by human trainers, the design, production and updating of course material (such as training manuals) could be greatly improved through AI tools.

G2.0 Problems Identified and Current Technology Solutions

Counselling and training each have major barriers to productivity improvement, for which conventional computer technology has been explored as a potential tool for overcoming problems. Each is discussed in turn.

G2.1 Counselling

From discussions with CEIC officials in the counselling/training AI workshop, the major problems in terms of improving the productivity of counselling services include:

- wide diversity of counselling knowledge requirements with a scarcity of real counselling experts (there are "about 10" such experts in Canada, half of whom are in academic institutions);

- lack of counsellor familiarity with and up-to-date knowledge of job market information - skills, openings, career development paths, and adult educational possibilities (counsellors are more geared to human interaction or the psychology of the client's particular situation);

- insufficient time available for individual consultation with clients - an average of about 20 minutes per session is all that is possible to meet the demand within existing resource constraints;

- difficulty in being systematic in counselling advice given the diversity of knowledge required and the variability among counsellors.

The counselling service has made a sustained effort, over the last decade to exploit developments in information technology, in order to improve the program's productivity. For example, a specialized software program ("CHOICES") was developed to provide an accessible data base in occupational training choices. This program information on specific occupations is compiled to help a client determine what training possibilities are most appropriate to his background and experience. The Department is exploring further exploitation of existing technology, for example tutorial self-development programs to improve life skills (for which a set of scripts would be prepared by experts; and a matrix of life roles and goal statements defined).

G2.2 Training

The problems in training are in many ways similar to counselling, but there are also significant differences. As a start, lack of curriculum or instructional design expertise is a critical bottleneck in the further exploitation of computer-based training (CBT), whatever advances are made in CBT itself. This is particularly so in face of the wide array of subject needs in training. The match-up of course designer with computer systems expert is often difficult to arrange, except in the rare case where the instructor and /or curriculum designer has both personal knowledge of the content and familiarity with CBT capabilities.

Accessibility of all federal employees to similar levels of training is often logistically impossible, in view of travel costs and time constraints for both instructor and student. If CBT were available and easily accessible to the layman (ie. through a natural language rather than a computer programming language), the logistics of training would be greatly reduced.

Although severely limited in budget terms, the PSC has examined the application of CBT to its training needs. Some systems promoted by major manufacturers have proven too overly complex and even intimidating to users. Other technologies, such as the use of videotex, show promise but as yet are not being used. Students and trainees become frustrated in the loading, starting, and processing CBT programs that have been developed. Lack of adequate documentation of CBT materials inhibits instructors. A further important limiting feature is the lack of an "authoring language" which teachers and instructors could use to develop materials without having to become CBT experts.

G3.0 Potential Impact of AI Applications

The rationale for AI stems from the benefits or productivity gains that could be derived from the application of AI tools and techniques. Therefore, we begin by listing the potential impact if AI tools were able to increase the productivity of training/counselling.

Serving greater numbers

- o distribution of training/counselling systems to remote field offices;
- o computerization of routine tasks to release counsellors/ curriculum designers for more essential activities;
- o improved training of counsellors and trainers themselves.

Improving accessibility to user

- o more in-depth, personalized counselling and training services to users;
- o improvements in person-machine interface (some forms of counselling is actually more effective through machine rather than human interaction).

Improving the quality of the service

- o providing up-to-date information and data bases and expertise at more locations;
- o more systematic application and deployment of knowledge;
- o automation of certain activities such as preparing and retrieving biographic information on clients.

G4.0 Identification of AI Applications

The potential for the application of AI techniques to CBT (and its counselling variants) stems from the shortcomings and inherent complexity barriers in traditional CBT. The typical CBT approach is characterized by presenting the student (or client) with instructional material that requires brief answers, then informing the student whether the answer was correct, and finally to advise the student how to proceed through the subsequent instructional material. The main problem with computer based techniques has been to develop truly conversational and flexible self-paced computer based systems.

CBT systems are ideal candidates for acquiring AI characteristics, in fact to become "intelligent computer based training" (ICBT) systems. The main components of ICBT are:

- o <u>problem-solving expertise,</u> ie. the subject expertise to be learned: the objective of an ICBT system is to understand what the student is supposed to do, understanding what he is actually doing, and using the students mistakes to diagnose his misunderstandings;

- o <u>student modelling capabilities,</u> ie. a model is developed for each student to enable the system to make hypotheses about the student's misconceptions and approach - so that the tutoring module can teach the student through a dialogue with the student;

- o <u>tutoring strategies,</u> ie. the ICBT system should know when to interrupt a problem-solving activity, what to say, and how best to explain and give advice to a student.

Two illustrations of ICBT systems are WHY and SOPHIE, briefly described below:

- WHY: a tutoring system designed to teach students about the complex geophysical process of rainfall - through a set of heuristic rules (eg. "if...then" rules);

- SOPHIE (sophisticated instructional environment): a learning environment associated with acquiring problem-solving skills by trying out ideas rather than by instruction - for diagnosing malfunctioning electronic equipment.

These examples provide specific illustrations of the possibilities of AI in training/counselling. From the workshop session on training/counselling and subsequent discussions, we have prepared a preliminary list of AI applications, briefly described as follows:

1) Curriculum design: a basic "authoring language" to assist course designers develop specific courses. This is really an expert system that spells out the logical steps and requirements for developing a training package, including:

   - task analysis of subject;

   - analysis of intended student groups;

   - development of training objectives or learning points;

   - development of materials - courseware

   - system for keeping content of sourseware up to date.

2) ICBT for a specific course: as described in section X of the report, the critical ingredients are a truly interactive (not just yes/no) process where a student asks a question in a natural language.

3) Data base update: a system for updating the course content to replace the hard copy manuals, which are updated too infrequently.

4) Counselling assistant: a computer aided assistant, say a data base with an expert system to help a counsellor for specific target groups (eg. retirees).

5) Computer counselling: a system where a client interacts with a terminal (a step beyond the rigidly structured interaction involved in the CHOICES program).

G5.0 Assessment of Candidate AI Applications

Having identified the generic AI application, the next step is to examine whether the application meets the criteria for implementation in the near to medium term timeframe. As a first step on Exhibit G-1 we have systematically ranked the five candidate applications described above. From this we have the following observations:

The necessary conditions for inclusion of an application as AI - solvable - small in scope and important - are met by the 5 applications determined through the workshop session. All are deemed as important because of the sheer numbers of individuals that are either trained or counselled by the respective lead federal departments. The potential size of the applications varies depending upon the level of specificity of implementation. A generic course delivery system is quite a grandiose task and is outside the realm of present possibilities. However, as a first project, a system for training meteorologists, such as WHY, could be attempted with fairly predictable

Exhibit G-1

Assessment of Candidate AI Applications in Training and Counselling*

	Curriculum Design	Course Delivery	Data Base Update	Counselling Assistant	Computer Counselling
Expertise Perishable	3	2	2	2	3
Expertise Scarce	1	3	2	1	1
Opportunity Defined	2	2	1	2	3
Bounded Domain	3	2	3	2	3
Agreement About Knowledge	2	2	2	2	3
Large Amount of Task Specific Data	3	3	1	1	1
Information is Specialized	2	2	1	1	2
Commitment of an Expert	1	3	2	1	2
Short-term Benefits	1	3	2	2	3
Test Cases Available	2	3	1	2	3
Rank Total	40	52	39	34	51

LEGEND:

1) highly demonstratable
2) existing
3) not existing to the degree necessary

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* The lower the rank total, the more viable the candidate project.

requirements and therefore results. Thus, if we qualify each of the applications as pertaining to specific target groups, the applications can meet the size criteria. Two applications - course delivery and computer counselling - require a certain level of NLP capabilities which adds another dimension of complexity to the overall task. For this reason alone, they could be ranked below the remaining three applications in terms of feasibility.

Furthermore, from this analysis a counselling assistant solution, as described earlier, ranks as having the greatest possibility of success. This is mainly due to the high degree of importance placed on this activity. The ability to improve the quality of decisions in human counselling will have a profound impact on CEIC's service to the public. Major improvements are possible because of the scarcity of present expertise devoted to this function as well as the positive impact on productivity that is attainable as a result of an AI solution. A curriculum design system and the database update system rank slightly lower in terms of requirements met, but are still quite likely to yield productivity benefits.

G6.0 Implementation Considerations

From the training/counselling workshop in this project, there was no apparent move toward interdepartmental or concerted action toward AI-based productivity improvements. However, there is interest by individual departments, and specific plans by at least one to introduce AI techniques (ie. CEIC in counselling). It was observed that development budgets for training do not seem to gain priority status, possibly because the potential pay-offs from the application of AI techniques have not been identified.

The immediate first step in addressing this lack of AI awareness is to organize a major ICBT seminar, with outside experts, users of existing ICBT systems (like SOPHIE or WHY), and those responsible for training in several major federal departments and agencies (including the PSC and Treasury Board). It would be one of the purposes of the seminar to have departments with major training responsibilities to put forward pilot ICBT projects.

The CEIC counselling service is an exception, and an AI application could be initiated without necessarily a specialized seminar being organized for that purpose.

Appendix K

Department of Supply and Services

This section of the appendix has been prepared on the basis of the workshop which took place December 20th, 1985 at the Department of Supply and Services (DSS) (see attached list of participants).

K1.0 Introduction to the Department and AI

The Department of Supply and Services is a service agency providing certain operational functions for all departments. The degree of potential automation involved ranges from pure data processing functions of payroll and accounting at one end of the spectrum to contract negotiations at the other. To ensure consistency and increase performance a major effort is spent in maintaining policy guidelines and updating them continuously.

Voluminous hard copy manuals exist for such diverse topics as superannuation, personnel and procurement activities. The maintenance and revision of policy manuals in terms of analyzing potential ramifications of policy refinements requires a unit of 40 PYs. While this task is fairly repetitive, it does involve a very large database.

Once policy has been developed, a major task of DSS is disseminating that information or making information accessible through a general query process. This user requirement is important because it applies both to internal government requirements as well as service to the public.

K2.0 DSS - Problems Amenable to AI

Three major problems were identified during the workshop, all with a repetitive theme of requiring the constant access of hardcopy manuals for policies and procedures.

The first problem identified was the complexity of the analytical process performed when changes in government policy are contemplated. When revising policy, the impacts on other policies have to be assessed. If all related policies were logically interrelated then impact analysis could be turned over much more quickly offering greater range of test cases and more consistency in the results.

The second problem identified was in fact discussed in 3 different workshops, namely, improved training techniques. The key, in DSS's opinion, is to establish a system which provides the ability to perform a cognitive analysis of the user. This means that the trainee would be screened by the computer system to identify gaps in his/her knowledge of the subject. If the trainee skill levels are identified, then a much more efficient delivery of relevant material would occur. As an intermediate step, DSS is working on putting hard copy manuals on disk. A relatively simple extension of this activity could be a Natural Language front end or a query system which branches them swiftly through to the correct chapter of the manual.

A final problem area discussed at the workshop involved the whole gamut of improving sourcing activities. Assistance from DSS is required from the moment a need for a product or service is identified, internally or externally to DSS, to any legal requirements after the contract is delivered. For example, a typical sourcing process appears as:

i) a search for firms with required capabilities;

ii) once a source list is identified it is analyzed to draw a bidders list;

iii) an RFP is structured based on the rules of DSS and contracting department;

iv) the evaluation factors are determined;

v) the submitted proposals are evaluated and rank against the set of criteria;

vi) a contract is generated;

v) a monitoring process ensures the contract milestones are met.

Although a very cursory review of the sourcing procedure was conducted during the workshop, we believe that each one of these steps is a possible opportunity for an AI application. In fact, DSS is developing a program entitled PASS which automates to some extent this procedure. PASS (Procurement Acquisition Support System) is a computerized support system which has integrated 4 existing systems of the procurement process into one. It is used department wide by both Headquarters and the regions to efficiently track the progress of contracts being prepared or in progress. It is estimated that PASS will realize a net saving of $5m over the next 3 years over the previous combination of systems. An important feature is the improved automated support functions now available. For example, clients now have the ability to produce on-line status reports on their particular contract. Since PASS is presently a sophisticated computer system, the ability to add AI products and services may be a relatively simple task, that could provide further significant productivity improvement.

K3.0 Identification of AI Applications

Each of the three kinds of problems discussed above lend themselves to typical AI solutions. Two potential applications meet the characteristics of an expert system. The first is the automation of certain steps in the sourcing activity. This involves the matching of data to criteria that then generate basic yes/no decisions. AI applications can be devised to help encode the criteria and evaluate data against them.

A second expert system application could involve a policy impact analysis tool. On an appropriately disaggregated level, an expert system could perform the analysis required to determine the impacts of the revision of specific policies. At the very least, a system could be constructed to assist the policy analyst in running through a common checklist of potential impacts. As described in the text of this report, a system of this type is considered an "assistant". It is a system that is early in the evolution process of developing a full-fledged ES, and is therefore a desirable demonstration project for which commercial AI techniques are available.

The third and fourth applications of AI in solving DSS problems are linked and involve the use of natural language (NL) interfaces. An NL query system assists the user by providing prompts in real time, namely, as the search is proceeding, questions are forwarded by the system to assist the user in identifying the specific data required. Natural language interfaces also would help analyze the characteristics of the user to determine for the user what information is required. Both these systems are potentially real time productivity tools.

K4.0 Assessment of Candidate AI Applications

Having identified the generic AI applications, we now examine whether the applications meet the criteria for implementation in the near to medium term. As in other workshops, we systematically ranked the candidate applications based on 10 criteria shown on Exhibit K-1.

From this analysis it is observed that automating a few steps of the sourcing process with AI capabilities ranks as the best opportunity. This arises for two reasons. First, efforts are presently underway to automate the process using present computer techniques (PASS). Thus, it should be a relatively simple matter of adding "intelligence" to certain portions of the new software packages. Second, if each step of the sourcing process is taken as a discrete activity, the potential application is highly defined and should have a narrow domain within which to operate. The combination of a bounded domain and present development activity also lends itself to other desirable implementation criteria such as providing identifable test cases, short term benefits and commitments of experts.

Two other applications (policy impact analysis and natural language access to policy) are equivalent in their ranking but represent two diverse "arms" of AI research. Policy impact analysis tool is a perfect example of an expert system which attempts to identify the logical relationships between government policies. Its strength is its ability to assimilate increased amounts of data through expertise that is well defined and in certain cases scarce. The problem, however, is in the

Exhibit K-1

	Policy Impact Analysis System	Query System to Access Policy	Expert System for Sourcing Activity	Cognitive Analysis of Access User
Expertise Perishable	2	3	2	2
Expertise Scarce	1	3	2	1
Opportunity Defined	2	1	1	2
Bounded Domain	3	2	1	3
Agreement About Knowledge	2	1	2	2
Large Amount of Task Specific Data	1	1	2	3
Information Specialized	3	2	1	2
Commitment of an Expert	1	2	1	3
Short-term Benefits	2	1	2	1
Test Cases Available	2	2	1	2
Rank Total	39	39	31	44

Legend:

1) highly demonstrable
2) existing
3) not existing to degree necessary

lack of a bounded domain, ie. the subject area is too complex. A change in one aspect of one policy may have ramifications that are just too broad to incorporate in a small expert system. A test case for this application would have to be chosen very carefully.

The other second-ranking application involves natural language capabilities. Similar to the two workshops on forms processing and counselling, substantial productivity improvements can be made in search time through policy manuals. This is possible by providing a front end natural language query system. As in other NL applications the drawback is the commercial availability of a high quality complex system. This problem alone may hinder the development of feasible demonstration projects in the near term.

The final application analyzed involved an interactive cognitive analysis system in identifying levels of knowledge in the actual user who wants to access the system. A profile of the user will assist in the quality of the user's search. While the previously described NL system will help speed the search process of a knowledgeable user, a user analysis system will determine gaps in the user's knowledge and provide necessary details. This system ranks near the top in terms of benefits or impact; however, its is a very complex task to attempt to build a system which could analyze every potential data base user. This problem of unlimited size places this application at the bottom of the list for demonstration project viability.

K5.0 Implementation Considerations

Two key implementation possibilities exist:

i) Collaborate with other departments who require document search activities and plan an NL query system which provides intelligent branching techniques through large amounts of hard copy manuals.

ii) Work within the present PASS development process, adding incremental sections of AI techniques.

Note: The remaining appendices to date (DSS, DFO, DND) are being circulated for comment to the respective departments and are not available at this time.

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