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VOLUME 3

NATURAL LANGUAGE AUTOMATED PROCESSING AND ARTIFICIAL INTELLIGENCE: POSSIBLE SOCIAL AND ECONOMIC IMPACTS

COGNOS

1984 FEBRUARY 29

DSS FILE 12ST.41414-2-03X2

NOTE

This report, Possible Social and Economic Impacts, is the third volume in a series of reports addressing Natural Language Automated Processing and Artificial Intelligence. The reports in this series are:

- The State-of-the-Art
- Implications of New Technology Thrusts
- Possible Social and Economic Impacts
- Opportunities for Canada
- A Program Plan, and
- Priorities for Canada

ACKNOWLEDGEMENT

This report has been prepared by Dr. Michael Gurstein of Socioscope Inc., a subcontractor to Cognos Incorporated. Various members of the study team as well as participants in a Project sponsored workshop provided input and comment on this report.

EXECUTIVE SUMMARY

This is an attempt to identify the social and economic impacts arising from developments in the broader field of Natural Language Processing and Machine Translation. The report begins with an overview of the areas of AI development focussing in on likely areas of application.

A variety of reasons for treating the substance of the report as tentative and speculative are presented. The general lack of literature in the area is noted.

The report reviews the potential economic impacts of machine translation and natural language processing and indicates that in both areas markets of enormous potential are likely to develop. Canada may have unique requirements and advantages in support of developments in the machine translation area.

Generally positive social impacts from all areas of AI application are anticipated although significant technology advances may cause great turbulence in employment in information based occupations especially the professions.

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1. INTRODUCTION

Artificial Intelligence (AI) will be, in the term used by the Science Council of Canada - "transformative" ie. it will not simply contribute to an evolutionary change but rather it will transform those areas it touches.

This will be for three reasons:

- AI will raise the level of intelligence with which many conventional activities are currently conducted.
- AI will substitute machine intelligence for human intelligence in a variety of knowledge intensive human activities.
- AI will permit the performance of tasks heretofore impossible with conventional technology.

That such developments are likely, even inevitable is widely accepted in the scientific community. In fact crude operational systems are currently being marketed in such areas as expert advice, image interpretation, machine translation, speech recognition, intelligent database management and so on.

These crude systems both prefigure and indicate appropriate cautions concerning the more sophisticated and widely applicable systems which will follow. They indicate that AI in its variety of potential applications is technically feasible and they also demonstrate the theoretical and technological developments which must yet

be made before AI techniques come into widespread application and the transformations we have mentioned will begin to occur.

The State of the Art report indicates among other things that no straight line technical trajectory of the development of AI systems can be drawn (witness the ebbs and flows of interest and progress in machine translation) and also that it is unrealistic to anticipate the schedule for the scientific developments and breakthroughs which are necessary in the development of the ultimate fully operational systems.

A significant theme of other reports is the recognition of the validity and utility of sub-optimal solutions and sub-optimizing systems. Such a recognition is a realistic response to the problems which have been identified. It suggests that the introduction of AI systems and services will be gradual and evolutionary - the steady replacement of ever more sophisticated sub-optimizing systems arranged in an optimizing sequence. The overall anticipated process is evolution over time rather than a sudden or sharp break with the past. The sum of these changes is likely moreover to be transformative both socially and economically.

The combination of these factors however:

. the lack of a clear consensus on the rate of technology advance

- the introduction of technology in a sub-optimizing sequence

- an overall process of developmental evolution rather than sharp technology spurts.

makes the assessment of likely social and economic impact within particular time horizons extremely difficult.

Historically, social and economic impact assessments have dealt with single technology events, clear implementation schedules and identifiable rates and patterns of diffusion. The analysis of the impact of hydro dams, pipelines, or housing developments has provided the basis on which the concepts and methodologies of impact assessments have developed.

There are several problems in doing an impact assessment within the conditions outlined for AI developments:

- any sub-optimizing technology will have an impact directly commensurate with its operational capability. This operational capability will be specific to each machine system. An impact assessment dealing with the technology stream as a whole (machine translation for example) will necessarily be vague, imprecise and speculative since one is examining the impact not of a device or even of a technology system but rather of a set of anticipated and idealized functions (machines which do "x"). How or by what means "x" is performed and what the additional impacts of "x" may be, cannot in general (and unfortunately) be derived in advance of the actual performance of "x".

- while AI may be developing on a relatively broad front scientifically, how advances are translated into operational systems will depend on the vagaries of the market and on the interests and expertise of those individuals and firms who undertake these tasks. Thus while overall AI diffusion may be anticipated, particular developments in particular spheres may proceed haphazardly.

- advances in AI as other technologies takes place in a broad economic, social and technological context. Given that the broad schedule for technology development is indeterminable, the possible influence of exogenous factors on this advance and thus on overall impact is also indeterminable. The Japanese Fifth Generation (G5) Project and the international responses to this are an example of national priorities looking to accelerate the pace of AI development, just as the effect of the ALPAC report is an example of a national development redirected AI research and technology advance.

Within this context the social and economic impact assessment becomes a process of asking and answering a series of "what if" questions ie. "if" such and such were the case "what" would be the impact?

It should be made clear however, that broadly speaking in the area of AI we are dealing with a very important and transformative technology. This is not in dispute. What is not known is the pace and manner of the development and diffusion of AI based systems and services. (Reference #1, 5, 6, 7, 8, 9, 10, 11)

2. AREAS OF LIKELY APPLICATION

2.1 INTRODUCTION

While this report is primarily concerned with the social and economic impacts of natural language processing (NLP) and machine translation (MT) it is not reasonable to look at these in isolation from other AI based technologies.

NLP and MT systems will draw on developments from other areas of research both theoretical and application-oriented and it is likely that AI based technologies will be configured as components for overall integrated systems. Thus expert systems can be expected to have a natural language interface and possibly even a machine translated output. The "impacts" of these end user systems will be based on the total configuration rather than attributable to one or the other specific component.

In this section we will review likely areas of AI based system development and implementation. As we have already noted however, over the longer term it is likely that AI based systems or AI based enhancements to existing systems or services will become pervasive. In this section we are only looking to give a brief indication of the possible scope of AI systems and how AI may affect existing industries given our current level of knowledge concerning AI applications.

2.2 EXPERT SYSTEMS

It is well known that roughly 50% of Canadians are currently employed in information related occupations. These occupations range from teaching, through most of the public service, to the professions and the variety of such service occupations as insurance, real estate, marketing research and so on.

A large proportion of those occupations involve in one manner or another information brokerage ie. taking information produced by one group, modifying it in more or less significant ways and providing it to others. Teachers, lawyers, most physicians, insurance salesmen, real estate agents, consultants are all to a greater or lesser extent involved in information brokerage.

Expert systems, certain specific examples of which are currently on the market, are being developed precisely to perform the information brokerage function. Such systems as Prospector (Geological consulting), eMyecin (medical diagnosis), LEXA (systems consulting) are currently functioning so as to substitute for or supplement the activities of experienced professionals in these areas. As was already noted in another report, an insurance consultant expert system is being developed and a variety of teaching systems are currently under active study.

While no specific employment or other impacts of these systems are yet visible (the systems are too new and too limited in their fields of expertise) significant resources are being directed in this area to respond to

an evident market demand. One can expect a gradual extension in the range and depth of these systems. The eventual combination of these with natural language interfaces and intelligent data base management systems (as is described in the G5 project) will make available personal and public advisors at low cost and with an acknowledged utility. Ultimately these will significantly impact the whole range of information brokerage services.

Certainly information brokers such as teachers and doctors serve other functions besides information synthesis and transmission. Their role in providing emotional support and reassurance, in responding to the affective dimensions of information services in addition to the cognitive will probably not be subtitutable for by AI; but the nature and form of information intensive services will almost certainly be transformed.

A secondary impact of the development of such systems will be the internationalization of knowledge bases and the increasing commoditization of information and knowledge. Canada already experiences this to a degree through the importation of school text books, newspapers and magazines. One can expect that the sale of knowledge and expertise through expert systems will become a highly significant and internationally competitive industry just as for example engineering and project management expertise currently is. The translation of current Canadian expertise into expert systems in such areas as geological assessment, forest mangement, hydrology,

hydro-electric power engineering and so on represents significant medium term opportunities assuming the development of expert system capability in Canada. (#13, 27, 30, 62)

2.3 INTELLIGENT INTERFACES WITH STORED INFORMATION

A second area of significant current development is in facilitating access to computer stored information. Ever larger amounts of information are coming to be stored in machine readable form or are being created directly on electronic devices. A major bottleneck is developing between this information and its ultimate users as current systems demonstrate their limitations both in intelligently managing information being stored and in providing ready access by non-professionals to this information resource.

A major market pull is developing for systems to overcome these problems and such systems as Intellect are using AI techniques in partially responding to this. As already noted one can anticipate significant developments in those areas which make access to information resources increasingly transparent to naive users and information bases increasingly responsive to the needs of their users.

The twin problems of information management and information access are to a considerable degree the primary functions of the large administrative organizations which characterize contemporary management both in the government and the private sectors. Office automation

will serve the function of automating current organizational processes of information creation, management and distribution. Foreseeable developments in AI will call into question many if not most of those functions as information users can go directly to the needed information and by-pass most of the intermediary steps.

With ready access to stored information, with databases capable of interpreting and responding to the needs of users both corporate and public, many if not most of those middle managers currently involved in information related activities - planning, research, control - may no longer be needed. Equally many of those involved in processes of information dissemination may find their current functions redundant.

When this has been combined with rapidly emerging means for very low cost information storage and retrieval there is an increased likelihood of major changes in the structure of large scale organizations and the relationships of large scale organizations to their client and supplier groups. Current plans by General Motors for allowing suppliers direct access to production data bases so as to facilitate production planning are a foretaste of this.

Broadening and deepening access both public and private to stored information will almost certainly have profound impacts throughout society as a whole. Problems of security/privacy both individual and corporate will multiply. The pace of innovation will increase as the cost and time involved in the lag between information

creation and information dissemination declines. The nature of public processes of accountability and authority may change as well with ever larger components of the citizen population having access to the information required for effective decision making. (#17, 18, 19, 68)

2.4 LANGUAGE PROCESSING

Central to many of the emerging frontiers of AI development and to market pull for AI products is language processing. By language processing is meant the range of applications involving an appreciation/ understanding of either or both of the form or the content of language (from a technical point of view, of course the understanding of language form as in speech recognition, or language content as in machine translation are developing along for the most part, discrete trajectories).

The capability of communicating with a machine and knowing that the machine understands and can respond in an appropriate and intelligent manner is critical to enabling many of the other anticipated AI applications. This will of course, also have the effect of vastly extending individual access to computer and other technical and information resources.

If and as the broader problems of language processing are resolved it is likely that these may be integrated into developments in the area of machine translation.

Language processing capability will have effects in a variety of areas:

- it will allow for direct voice to text production (voice activated typewriting). This will affect office organization and employment in a manner similar to word processing except that where word processing makes editing and revising more efficient while

leaving primary text inputting at relatively the same level of productivity, voice activation will increase the efficiency of primary text inputting.

- it will eliminate the keyboard bottleneck to computer use by certain segments of the population - notably senior citizens, senior executives, the ill-educated and so on. This will further democratize access to computer use and computer stored information and may affect employment in such areas as key punch operators.

- it will allow for machine use in a variety of lower level intellectual fields such as abstracting information, cataloguing, reviewing repetitive texts (essay questions in high school examinations are an example), compiling documentation, scanning material for significance and so on. This will have a significant impact on those currently active in certain areas of the information services sectors.

- it will provide the opportunity for direct language to language translation. Such a capability could have significant impacts in a variety of areas by decreasing the costs involved in interlingual trade and commerce and facilitating communication between language groups. In this instance there is significant potential impact on existing translation/interpretation personnel and systems. (#15, 23, 24, 55, 57, 63, 66, 67)

3. SOCIAL AND ECONOMIC IMPACTS

3.1 INTRODUCTION

The social and economic impact of a new technology system is always difficult to anticipate. It may not be as widely accepted as was expected. It may be used in ways unpredictable to those who were involved in its development. The secondary or indirect impacts of the system's use may be as or more important than the direct or primary impacts.

The problem is even more acute when one is dealing at a level of general technological advance rather than specific technology application, the discovery of electricity rather than the electric light bulb for example.

3.2 NATURAL LANGUAGE PROCESSING AND MACHINE TRANSLATION IN THE CONTEXT OF ARTIFICIAL INTELLIGENCE

This report will focus on the social and economic impacts of natural language processing and machine translation. However NLP/MT are subfields of the broader field of Artificial Intelligence. While it is evident that progress may be made in NLP/MT without parallel progress in other fields of AI, nevertheless it is the broader field of AI applications which provide the context within which NLP/MT and especially their social and economic impact will take place. Thus for example, in all likelihood NLP/MT will become widely available when broader AI related technologies are available and where they include NLP/MT hardware or software as one of their components.

It is likely if not inevitable that NLP and MT systems will be both separate technologies with particular and specific applications and also functional components integrated into larger multifunctional intelligent systems. The Japanese G5 project for example, envisages NLP/MT as a constituent element of its anticipated functional architecture. It is likely that a natural language processing interface will allow for naive user access to and control of 'intelligent' devices including expert systems, large scale data bases, robots and so on. MT thus will be used for the multi-lingualization of these functions, i.e. their use irrespective of user language as well as for more conventional direct uses in translation and interpretation. (42)

3.3 INTRODUCTION TO SOCIAL AND ECONOMIC IMPACT

There are a variety of techniques for examining social and economic impact. Most of these however, have been developed for and are most appropriate to the examination of specific actions or projects where it may be assumed that the larger societal context is an extension of current realities. Thus the impact of a dam or pipeline project can be examined in terms of the numbers of jobs created, the recruitment necessary for those jobs, provision of necessary facilities for new employees, displacement of existing residents, and so on. The list of these questions is relatively straightforward and has to a considerable degree been codified based on extensive experience with similar developments in the recent past.

This approach to social and economic impact however has been widely criticized in that it tends to ignore the secondary or 'contextual' impacts which projects may be having. For example, how have new populations or displacement of an existing population affected traditional on-going social and economic activities; or how will it affect the relative positions of power and influence between social or cultural groups (men vs. women for example)? A simple examination of direct impacts tends to overlook these broader questions.

3.4 IMPACT AT A DEEPER LEVEL

At an even more profound and less accessible level what impact could a major project have on broader developmental/historical patterns for the society as a whole or for the impacted population? If there may be such an impact, the question becomes whether this is an issue to be addressed by the research scientist looking for 'objective' truth or by the politician, the historian or the theologian looking for emergent, contingent and qualitative realities. On the one hand the James Bay Hydro development project was an extension and fulfillment of the 'national' destiny of Quebec and thus irresistable; on the other hand the land to be flooded was both a physical and a spiritual homeland to native Indian and Inuit people - whose loss some argued, could not be monetarily or otherwise compensated for.

In looking more narrowly at NLP/MT it may be that we are examining technologies which will impact not simply the mode of communication but also the context of

communication, i.e. the nature of language and through language the content and ultimately the form of culture. We can, of course, thank Marshall McLuhan for the insight that the medium is (at least to some degree) the message. However 'transparent' the technology for achieving natural language processing or machine translation, we can anticipate that initially and at least for some time to come language processing and translation programs will introduce an 'interference' between the language input and the transformed language output. This 'interference' will reflect machine characteristics and constraints and not 'human' ones and their effect will be to introduce those characteristics into the flow of communication of which they are a constituent element. The very success of these systems will be a measure of the quantity of the impact of the constraints on communication and ultimately on culture.

3.5 SOCIAL AND ECONOMIC IMPACT AND SOCIAL GOALS

It is well to note that the Japanese Fifth Generation project has been introduced and framed within the context of achieving certain social and socio-economic goals as contrasted with strictly technological or commercial goals. A listing of those objectives suggests that they are a set of national objectives for which AI may provide practical and economical resolution. Thus AI in this context becomes a problem or set of problems looking for solution, rather than as is so often the case with new technologies - a solution in search of a problem.

Examples of the latter can be found in currently popular technologies - such as home computers and videotex where we have technology available with few widely accepted applications. This being the case (at least nominally since some have suggested that the Japanese G5 objectives are only a smokescreen for the underlying and more pressing objective of achieving commercial and technical dominance), an impact analysis of the G5 project would be relatively straightforward - will the technology do what it is intended to do and if it does, what other consequences may arise?

For the Occidental world our analysis would be more difficult; technologies generally are developed in no coherent pattern - they arise from independent and often competitive research efforts or they are developed for one specific purpose (often a military application) and then they are re-engineered or adapted for other areas of possible use. Thus the chronology of technology insertion into the social and economic environment and the possible user-impacts/effects of the on-going introduction of a variety of technologies remains at the level of pure speculation. It is not a question of examining the possible impact of a coherent plan for technology innovation but one of attempting to guess how, when and in what form new technologies may be marketed and assimilated. (#32, 42)

4. THE LITERATURE

4.1 SOCIAL AND ECONOMIC IMPACTS OF COMPUTERIZATION

There has of course been very considerable writing in the area of the social and economic impact of computers and computerization and more recently in the area of the social and economic impact of various specific applications of computer and /or telecommunications technologies. Videotex, robotics, office automation, computer conferencing and a whole range of others all have sub-literatures devoted to examining their implications in such well recognized areas as employment, personal privacy, health and safety, industrial relations, among others.

These writings and the issues most frequently discussed, by now are widely known and need not be reviewed in this context. To a very considerable degree AI and/or the computers which will make AI and AI applications possible can be seen as only more sophisticated and more powerful extensions of existing systems whose impacts will be similar to the impacts already identified. In that sense AI and AI applications will be standing on the shoulders of earlier technologies, the impacts of which we are currently or will soon be directly experiencing and which a variety of researchers and commentators are already documenting or have documented.

AI however, and the more specific AI applications/functions represent both an extension of on-going computer based technologies and a generational (in technology terms)

advance on earlier systems. The development of machines capable of inferential reasoning is perhaps as significant a technological leap forward as was the development of the digital switch or the integrated circuit. In both of these cases the effect was not simply to bring about a revolution at the level of technology but also to make possible entirely new classes of functions and applications at the end user level. It became possible to do things which had not been possible before - what had previously been science fiction became technological reality. Developments in AI and the kinds of technology advances needed to make AI a reality are widely seen as being of this order of significance.

The purpose of this digression is twofold: first to suggest that in one area of thinking about AI at least, the thinking computer is seen as radically differing in impact from the non-inference drawing computer, and secondly, to indicate how in science fiction at least, the difference in social impact is perceived.

It is almost a cliché to point to specific science fiction authors to demonstrate how specific speculations or predictions have now come to be realized. The reason for doing this is not to demonstrate the prescience of particular authors but rather to indicate that what had previously only been fantasy and conjecture has often been realized in fact. At the level of forecasting technology trends at least, it may have been the science fictioneers who were the true 'scientists' and it was the more conventional observers of scientific progress (and social and economic impact) whose vision has proven to be inadequate.

Certainly this is the case with AI. Thinking machines of one sort or another have been almost a commonplace in science fiction. Equally interesting of course is the degree to which machines which otherwise have the appearance of thought and human action but who lack the redeeming quality of the human soul have figured so prominently among the terrors of literature. The Golem of medieval Czechoslovakia, the 'Frankenstein' monster of Mary Shelley, and in our time Arthur C. Clarke/Stanley Kubrick's HAL all come immediately to mind.

We have not systematically examined the science fiction literature for the perceptions of AI. However anyone who conscientiously undertakes the task of examining the 'literature' concerned with the social and economic impact of AI would probably be as well advised to review and consult this as any other.[1]

There is in science fiction at least, a fairly clear distinction to be shown between visions of the future with conventional computers - a place where man struggles using creativity and passion against computing devices used to control and enforce conformity; and a future with "machines who think" where man has lost control and become pampered and tolerated domestic pets in a world where the decisions and ultimately the control rests by right with the machines.

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1 An anonymous editor writing in a recent special issue of the Communications of the ACM (Sept. 1983) makes a similar point. (p 618)

The distinction is clear. Projections into the future of conventional computers see them being used by malevolent forces for control and restriction but in this version computers are still seen essentially as highly superior calculators. When one comes to thinking machines however, the science fiction imagination quickly recognizes how superior to humans these thinking machines are likely to be. The implication of this for mankind's future is an atrophying of man's productive decision making/ information processing capabilities in favour of more child-like, playful or creative pursuits.

4.2 OTHER LITERATURE

The conventional literature in the area of the social and economic impact of AI, not to speak of specific AI applications such as Natural Language Processing or Machine Translation is to say the least sparse. A computerized search turned up virtually nothing. However several discussions of the impact on translators and translating of MT (#3, 15, 16, 20, 23, 26, 33, 35, 36, 41, 55, 56, 63, 64) and a series of discussions at a recent AI conference dealt with this issue but in only a vague and general way (#47).

It is well to recognize that commentators and researchers in the area of social and economic impact are only just now catching up with the bio-technology, computer and telecommunications revolutions we have recently entered into.

The attempt to discern the possible social and economic impact of future technologies such as AI has largely been left to the scientists and researchers who have been concerned with the technical development of these systems. This of course, has tended to give these analyses a peculiar set of biases and emphases, which analysts less intimately involved with the technology might not have. Further, it has tended to limit discussion concerning these areas to those who see these technologies as a panacea - a solution to all or at least most of man's ills, as for example is present in the G5 documents or alternatively (and a distinctly minority opinion) as a unique and possibly overwhelming threat to man's future as in Weizenbaum for example (#72).

Most of those active in the technical field do not appear to be interested in these questions or if they are interested their observations have not as yet appeared in the literature. The Japanese Fifth Generation project did however stimulate outside of Japan considerable discussion among both AI researchers and others about the role of AI in overall economic development and specifically in R & D investment and strategy. Interestingly, although as we will note below the G5 documentation discusses at some length the social and economic impact of the G5 computer, there has been little discussion concerning this aspect of Japanese thinking while the technical and commercial aspects of the development have been the subject of enormous debate.

4.3 ISSUES RAISED IN THE LITERATURE

Probably the most extensive documents concerning the possible social and economic impact of AI are the two background papers to the G5 project. (#35, 42) Both of these documents are concerned almost exclusively with the social uses and economic benefits to be achieved through the G5 computer.

They see it as a means for example to:

- eliminate dirty jobs
- cut down on government bureaucracy
- more widely distribute services
- increase accessibility of Japan to the rest of the world

... and so on.

The kinds of fundamental concerns regarding the appropriate use of computers especially intelligent computers as raised by the AI pioneer Joseph Weizenbaum in Computer Power and Human Reason (#72). He is concerned with how computer use (or misuse) will affect man insofar as it comes to be a substitute for man or take over those activities which he considers to be most appropriately the responsibility of man.

Other commentators such as Margaret Boden in her book Artificial Intelligence and Natural Man (#14) examine similarly the 'philosophical' questions under the heading of 'social significance'. She too is concerned with the appropriate use of computers especially AI computers without however, examining what the ultimate effect on the

society or the individual might be of the use of such computers.

A paper delivered at a recent conference on AI examining social impact was unable to go much beyond generalities about loss of jobs in skilled occupations and the possibility of more universal access to computer stored data. (#43) In fact apart from this and one or two other scattered references, the non-technical literature in the area consists either of popular descriptions of AI or exhortations (of greater or lesser degrees of authoritativeness) to get on to the Japanese G5 bandwagon.

5. THE FIFTH GENERATION AND JAPANESE SOCIAL AND ECONOMIC PROBLEMS

5.1 INTRODUCTION

As noted elsewhere in our overall series of reports the Japanese G5 project is of considerable technological and commercial interest since it has focussed research and market attention on AI and AI applications. The project, as presented in its documents, is of considerable interest from a social and economic impact interest as well.

It is noteworthy that the keynote address at the 1981 conference which announced the G5 project to the world chose to focus its attention on the social and economic objectives which the project was meant to achieve and the Japanese social problems the G5 computer was meant to resolve. The speech did not discuss in equivalent detail the technical problems which the project might present or the commercial opportunities which the project might provide.

The major problems/objectives were as follows:

- to increase productivity in low productivity areas;
- to meet international competition and contribute toward international cooperation;
- to assist in saving energy and resources, and
- to cope with an aged society.

While these objectives are to some degree specific to Japan, at least in their conception and descriptive detail they are also more widely applicable to all countries both developed and developing.

These objectives of course, are quite general and could provide a rationale for virtually any new technology whether it is a fast breeder nuclear reactor or Telidon, however, the report goes on to examine the impacts of the 5G computer in the light of these objectives and in a subsequent paper to link the applications required more directly to the functions being developed. Here is how Pamela McCorduck, an American science writer, describes it:

"And yet what has captured the world's imagination in the Fifth Generation project isn't so much the millions of LIPS (logical instructions per second) that will be ours for the asking, or the ever more dense chips, or the promise of brilliant solutions to the problems of parallel processing, important as all these are.

No, the appeal of the Fifth Generation lies in its coherent and, I would say, noble vision of the future that the Japanese suggest can belong to us all. Here is a future where knowledge - not mere information, but knowledge of the highest quality, pared, shaped and tailored to individual needs - will be accessible to anyone, anywhere, any time, in fast, powerful, and useful ways. It is a future where knowledge is the new wealth of nations.

A noble goal had a noble genesis. Tokyo University's Professor Tohru Moto-oka, who chaired the research and study committees that preceded the actual formation of ICOT, tells us that in planning for the next computer generation, the Japanese did not try to predict what the 1990's would be like. Instead, they chose to try

> and envisage an ideal society for that decade, and then designed information systems and computers that would help realize that ideal. It seems to me no detraction from the nobility of that vision that the Fifth Generation is also intended to thrust Japan into a preeminent world position in computing in the 1990's.
>
> Grasp it they have. I cannot remember the last time computing offered the world something inspiring, noble - or even exciting, for that matter. The Japanese have offered us all three. They have forced computing up from short-run concerns about incrementally better operating systems, incrementally faster algorithms, next month's bottom line, and other sorts of epiphenomena, and reminded us that as a species, we humans are still capable of taking risks on behalf of grand purposes. We need only imagination, will, and courage." (#40)

The Japanese thus prefer to examine the social impacts of the technology in terms of its social uses rather than for example the issue or problem areas which it might generate. Interestingly neither the British 'Alvey Report' nor the Dutch report on AI, nor the various recent U.S. publications have examined or discussed either the social uses or the social issues arising from AI developments except in the context of the commercial threat the Japanese project ultimately poses (#1, 31).

The technological context here is revealing. The developments in micro-electronics and related technologies including photonics (fibre optics/lasers etc.), bio-technology and so on have thrown open a virtual infinity of possible directions for R & D activity and investment. Until the Japanese 5G project - AI was only one among a number of secondary or even tertiary areas of interest. In fact apart from the overarching framework of defence oriented research especially in the U.S. and traditional

Government 'dirigiste' involvements in French industry it could almost be said that there was relatively little 'agenda setting' in the area of technology development and that whatever agendas there were did not include AI as a very high priority.

The choice of AI as a priority area surprised most western observers and could be said to have directly precipitated the widespread current interest in the subject. Examining the stated objectives of the plan suggests that rather than these being simply an ex ante justification provided so as to obtain support for funding or as a public rationalization of a decision made for strictly commercial reasons, the 5G project may in fact be meant to respond to widely perceived social needs in Japan:

- the difficulty both with the Japanese written language (from an Office Automation perspective) and with the Japanese spoken language (from an international trade and commerce perspective) are seen as being major barriers to continuing Japanese economic advance and improvements in white collar productivity and suggest the need for machine translation

- the relatively low productivity in the Japanese service sector (similar of course to services sectors in other countries) is seen as an economic dead weight and indicate the need for expert systems

- the aging of Japanese society (at a rate faster than virtually all of its trade partners) is seen as a significant medium term social and economic threat, and would support both expert systems and natural language interfaces, and

- the instability of energy supply for energy poor Japan is perceived as a major threat to long term economic and thus social stability and provides the rationale for knowledge processing as applied to complex planning tasks.

AI, offering computer support to language processing and translation, to the provision of social and other services through expert systems, and to complex energy planning and control techniques through sophisticated sensing, robots and decision support is clearly a technology solution to widely perceived problems, as well of course, as providing Japan with a lead in the next major micro electronics based technology advance.

5.2 AI AND CANADIAN OBJECTIVES

In the Canadian context, areas of technology excellence and continuing technology innovation most notably in telecommunications and space have equally reflected technology solutions to widely perceived social requirements, in these cases the need to link together a small population dispersed over a vast territory.

It is notable that the Canadian concern with inter-lingual communication as between Anglophone and Francophone Canadians has provided the stimulation for the development of the Canadian area of excellence in machine translation both because of a widely perceived need and because considerable academic and other attention has been focused on the translation question.

Thus accelerated Canadian support in the area of MT and the broader area of NLP could be seen not only as being directed toward commercial objectives (and positive economic impacts) but also as continuing the on-going search for more effective means for achieving the positive social impact of facilitating intergroup communication in Canada.

Such a targetting of effort in this AI area would be consistent with the continuing national objective of bilingualism (and multi-culturalism) and could provide a basis of participation in the broader international G5 research and product commercialization developments.

It is of considerable interest that the Advisory Committee established for this study, when challenged to identify priority areas for Canada in the AI field, responded by pointing to NLP/MT because there was a substantial domestic market for products in this area, i.e. there was a widely experienced social and economic need.

In addition NLP can be seen as continuing Canada's initiatives in mass public information systems e.g. Telidon. A concern with providing public access through

NLP to computerized data bases and information processing can be seen as a continuation of Canada's concern with ensuring a broad distribution of public information and communication services.

6. DEFINITIONS

6.1 SOCIAL AND ECONOMIC IMPACT

By 'social impact' we mean those effects which the technology will have - directly or indirectly - on the society, the community or group, or the individual; what social or cultural changes the technology will result in and what the significance of those changes will be. We will have to make certain assumptions about the rate of diffusion of the technology. Inevitably these will be optimistic ones since possible impacts will generally be silhouetted most clearly where the technology has been widely diffused rather than where it is only used by a few.

By 'economic impact' we mean those effects which the technology will have on the economy - on income, employment, production, and so on. What new jobs will be created or destroyed, new industrial opportunities opened up or closed off? In this area we will not look at the possible multiplier effects of the direct economic impacts as these will take us too far afield, but we will examine possible indirect economic benefits and costs.

In the area of economic impact of new technologies it is often difficult to predict in advance potential markets for the projected systems. In many cases (such as NLP for example), the new technology really has no market equivalent against which it could be measured. Computer games did not compete with and attract a market share of an existing product - rather they grew into a multi-billion dollar industry by creating a new and quite

unforeseen market. The same may be said for both home and personal computers. What appears to be the case is that new technology systems re-organize expenditure patterns in unpredicted ways. Thus quantitative projections concerning markets, employment, export/import potentials and so on must be treated with the greatest of caution and skepticism.

6.2 ECONOMIC IMPACTS

An examination of the economic impact of AI is an attempt to answer several questions:

- what effect will the technology or specific of its applications have on employment
    - the number of employees
    - the type of skills required

- What effect will it have on Gross National Product
    - will the value of goods produced increase or decrease
    - will the value of goods imported relative to those exported increase or decrease

- What effect will it have on productivity and thus on our capacity to compete with other countries for domestic or for foreign markets

- Overall what effect will it have on the structure of the economy and on Canada,s economic relations with other countries?

Canada has traditionally been and to a considerable degree remains, an economy dependent on the production and exporting of unprocessed resources. But while exploitation of resources retains its importance in our economy, productivity in these industries has increased and our share of international markets has declined thus reducing employment requirements overall.

At the same time Canada's position as a manufacturer has been seriously undermined by our relatively low productivity and high cost structure. Our wage rates have surged far ahead of emerging competitors in Asia and in some cases even the U.S., while our productivity has lagged behind.

Only in the service economy has there been a major post war expansion in employment as education, public service, administration and so on have grown up in response to public demands and increasingly complex political and social environments.

Information technologies are being introduced in all sectors. Computers are assisting in oil exploration and extraction, in identifying areas for timber harvesting, in improving crop yields. Robots are being introduced in automobile and appliance factories. Computer controlled looms are making fabrics, and so on.

But the area of greatest potential impact of the new technologies is in services. Banks and insurance companies now could not operate without computer support. The offices of governments and large corporations are

rapidly becoming computerized in order to increase the productivity of white collar employees. And since employment in the services sector is currently holding steady or in slight decline this increased productivity may mean extensive job loss in this sector.

The notion is that with AI based systems and services individuals will not only work more efficiently and productively, they will also 'work smarter'. Thus for example, where computers may increase the speed at which tasks are performed, AI may allow for a qualitative improvement in the manner in which the activity is performed. An expert system may allow for better decisions to be made, for more complex problems to be solved, for longer term plans to be developed, for more informed conclusions to be drawn - and all with fewer human knowledge handlers and processors.

Comparison is frequently made with the impact of the pocket calculator. This technology has very quickly become almost ubiquitous partly because the function it supports - numerical calculation - is so common. If one substitutes 'intelligence' for 'calculation' and anticipates that AI devices will support the intelligence component of ongoing activities in a similar manner to the way in which calculators support the calculation component an image begins to emerge of an economy where work is done 'smarter'.

The net effect of this will probably be that information related work will become more productive while requiring less labour especially less non-creative intellectual

labour as for example the type of labour involved in collating, reformatting and redistributing information. Such semi-professional and professional occupations with a high information content as insurance agents, travel agents, public servants, teachers, lawyers, doctors may all be very severely impacted as expert systems accessible by the general public perform a considerable proportion of the information distribution role which these occupations currently are performing. Thus while economies are able to become more productive, the need for labour - especially highly skilled labour will decline. There is evidence already that white collar automation is reducing middle level employment as compared to the very highly skilled or the relatively unskilled.

Of significance at the international level will be the commoditization of knowledge and an increasingly crucial competition in this area. As artificial intelligence becomes an increasingly significant factor of production at the expense of labour or raw material costs for example, the market for AI generated and generating knowledge will become more significant. Countries or industries which can't or won't 'work smarter' will be forced to cut labour costs to retain markets.

6.3.1 Social Impact

The analysis of social impact is concerned both with determining the effect on society as a whole as well as the effect on certain specific groups who may because of their particular characteristics be particularily at risk in the face of the technological innovation. These latter groups are generally referred to as 'stakeholders'.

As we have reviewed the various likely application areas of AI it has become clear that the impact of the on-going developments may be pervasive. Some will be affected by enhancements in the access to or the quality or efficiency of services. Others will be affected directly by increasing competition for scarce employment. Still others will find their job or more broadly their work modified in greater or lesser degrees by developing machine capabilities. To a significant degree we are all "stakeholders" with respect to the impacts of AI.

Some possible stakeholders groups however are more vulernable or salient with respect to the technology than others (recognizing that an individual may be a member of more than one stakeholder group). Thus for example labour may be impacted through the elimination of jobs, organized labour through significant changes in the types of jobs, women because the jobs which they most frequently have access to may be the most directly affected.

Among those particularily at risk in the area of technology change are:

- labour - because of changes in the overall demand for labour and for specific kinds of trained employees; changes in the content of jobs; and changes in the conditions of work

- women - may be particularily affected because of impacts on jobs with a high proportion of women

- senior citizens and the poor - may have less access to information and information technologies because of cost or training inadequacies

- regions - new technologies may differentially impact particular language groups, rural or remote areas, one geographic location as against another

- less developed countries - may be affected through changes in commodity demands, (including labour) and changes in access to information.

6.3.2 Impact Matrices

In this section we present a set of matrices of anticipated impact of AI technologies on the various identified stakeholder groups within two time frames - the short term 3-5 years and the longer term 10-15 years.

In these matrices and the accompanying discussion we will attempt to present the material gained in our interviews especially in the areas of MT and NLP, the results of the workshop sessions dealing with social and economic impact, our review of the very limited literature on the social and economic impact of AI and our projection of probable impacts ('what if' thought experiments). In a number of areas as we have already noted, the time line for technology development is not clear and to a considerable degree the development of fully operational systems cannot be confidently anticipated within our time horizons.

The results are necessarily subjective and speculative and should be seen as serving to sensitize the reader to possible outcomes and issues rather than as providing definitive or 'hard' information.

3-5 yrs	Canadian Society	Labour	Women	Senior Citizens	The Poor	Regions
Machine Translation	-possible industrial opportunity -increased efficiency of translation -increased volume of translation	-stability in translation employment as MT only involved in specialized applications	-slight shift to males in translation as it becomes more mechanized	-little impact	-little impact	-facilitate translation -possible decrease in cost
Natural Language Processing	-possible industrial opportunities	-little impact	-little impact	-easier access to computer power eg. voice recognition	-easier access to computer power	-little impact
Expert Systems	-possible benefits through development of Canadian systems -cheaper delivery of services	-net increase in employment for production of systems	-no direct impact	-possible delivery of services to senior citizens making services more accessible	-service delivery	-broader access to expertise -French language systems
Intelligent Interfaces	-democratization of information -increasing pace of innovation	-net increase in employment in installation of systems & adaptation of systems to organizations	-no direct impact	-more ready access to computer stored info	-more ready access to computer stored info	-make info decentralization possible

10-15 yrs.	Canadian Society	Labour	Women	Senior Citizens	The Poor	Regions	Developing Countries
MT	-industrial opportunities -increase in indirect efficiency -broadening of impact of language rights	-significant change in nature of translators' jobs -stability or decline in employment	-jobs affected in translation both male and female -jobs now highly technical more male oriented	-no direct impact	-no direct impact	-increased regional access to info resources (Que) -weakening of ling. barriers	-limited use for high volume translation -possible opportunities in high volume MT post editing
NLP	-greater diffusion of access to computer power -elaboration of language related services	-job loss in info processing activities	-jobs affected mainly female secretaries, research assistants librarians	-much more extensive use of voice recognition especially oriented to groups such as seniors not using keyboards	-voice activation	-no direct impact	-limited use
Expert Systems	-possible major industrial opportunity -significant cultural effects	-possible job loss in management categories	-jobs affected largely male jobs	-extensive use in delivery of services - high quality lower cost, less personal	-use of system in service delivery	-broadening of access to expertise and equalization of regional opportunities -decreasing locational significance -dispersal of information intensive production	-signficiant threat to emerging info economy and professional/intellectual classes -broadening of access to foreign intellectual technology -balance of payments problems
Intelligent Interfaces	-increasing efficiency in info management -flattening of organizations such as government -possible decentralization	-possible job loss in middle management jobs	-jobs affected largely male jobs	-broadening of use of systems especially in entitlement areas	-equality of access to info	-possible centralization of control/also decentralization -development of regional organizations -network style organizations	-increasingly efficient systems for control in authoritarian regimes but probably insufficient infrastructure
Overall Impacts		-jobs affected moderately high skilled info worker jobs	-women not affected directly Perhaps more competition from men for jobs traditionally women's -increasing emphasis on affective domain	-better but more impersonal service delivery -empowerment and access	-better service delivery -jobs of poor little affected	-effect be to reduce regional info economy advantages	-the overall effect of AI is likely to retard the development of an info economy in developing countries as info products & services are imported at lower than development costs from developed countries

7. MACHINE TRANSLATION

7.1. INTRODUCTION

Currently the translation process is a highly labour intensive activity and would appear directly suitable for some degree of automated support.

In the translation field in Canada it is estimated that there are some 2500 professional translators and perhaps an equal number of part-time or occasional translators. This estimate is based on the current employment of some 1200 translators by the federal government and estimates that a roughly equal number are employed elsewhere. The Statistics Canada figures of some 6000 translators includes those who may be otherwise retired or full-time homemakers but whose major source of outside income is translation or interpretation on a part-time basis.

Current federal government expenditures directly for translation services are some $75,000,000 annually with an estimate that this figure doubled ($150,000,000) would cover total Canadian expenditures on translation. Internationally Canada is one of the largest users of translation services.

Estimates are that there may be up to 180,000 full time translators internationally and annual expenditures of some $3 Billion. However, no comprehensive data on translation expenditures is available either for Canada as a whole or internationally. The reason for this is

evident - once one moves beyond the small number of larger translation users (governments especially in multi-lingual countries and international agencies) the market for translation is highly fragmented both on the supply side and on the demand side with large numbers of relatively small suppliers and a somewhat larger number of limited or occasional users of translation services.

In addition to the expenditures on direct translation (including interpretation) services there are a large number of indirect costs which can be associated with multi-lingualism and the difficulty of the conduct of translation. In providing an overall assessment of the economic impacts of machine translation one must take into account the effects on such areas as:

- inter-lingual/international trade - it is estimated that some 3-5% is added to the cost of international trade and commerce by multilingualism and the costs of translation and interpretation, multilingual documentation and forms, premiums paid to bilingual (or multilingual staff) and the mistakes caused by language misunderstanding. As the volume of international trade increases and as the items traded increase in complexity (note the figures quoted on documentation for hi-tech products in an earlier report) this figure (according to the Canadian Organization for the Simplification of Trade Procedures - COSTPRO) is likely to increase.

- education - very significant volumes of resources are expended internationally on language training and multi-lingual education (not to speak of the translation of teaching materials etc.) In Canada alone the Federal Government spends $175 million on bi-lingual primary and secondary education. Provincial Governments spend at least this amount and private companies and individuals also purchase service in this area. The reasons for these expenditures are many - political considerations, commercial considerations, cultural values and so on. While such training may be seen as a good in itself it also must be seen as a cost of living in a multi-lingual world.

- inter-lingual inefficiencies - any organization required to function in a multi-lingual environment finds itself subject to significant hidden costs as a result. It must hire (and generally pay a premium to) multi-lingual staff, it must absorb the considerable costs of maintaining multi-lingual systems for internal and external information provision, for multi-lingual filing, for the delays involved in translation, for the language training of monolingual staff. It is estimated that up to 1/3 of the cost of the administration of the European community (ECE) is related to its multi-lingual functioning.

It should be noted that no computerized system of MT, however proficient, is likely to eliminate most of these costs. The need for multi-lingual real-time interpretation is not likely in the near future, to be

susceptible to mechanical substitution. This will mean that the need for language training for those working or anticipating participation in a multi-lingual environment will not diminsh.

The cultural and political significance of language is unlikely to diminish. Thus the need for bi-lingual persons to communicate across language frontiers and for the partially symbolic gestures of translation/ interpretation are likely to be maintained.

However, beyond this the cost burden of translation is open to productivity enhancement through mechanical or other means.

7.2 ESTIMATING THE DEMAND FOR TRANSLATION SERVICES

The demand for translation should be understood as being of two types, market based and non-market or symbolic.

The market based demand for translation can be seen as related to the need for translated material in order to sell or to allow for the sale of goods or service. Thus marketing and promotional materials, user manuals and so on are market based. One can assume that the current volume of market related translation is more or less stable, is directly linked to inter-lingual trade volumes and that MT would be acceptable in so far as it was capable of reducing the cost (whether in money or in time) of translation.

Non-market translation is translation which is done for the most part for symbolic or political reasons. Thus laws or regulations determining what will (and will not) be translated may serve a functional purpose but they are responding to symbolic rather than economic forces.

The rules governing symbolic translation are generally framed within a context of allowing uni-lingual individuals to comfortably participate in certain more or less clearly defined areas of information exchange. These limits are arbitrary in that they deliberately include some areas, exlude others and leave others in a grey and judgmental zone. Inclusions generally involve information areas politically interpreted as crucial, while other areas are seen as being of more limited importance. The ultimate constraint on translation in this area must be seen however to be resources - financial and human. There is not enough money to translate all that could or should be translated and not enough translators.

In a MT environment the resource question would change. Demands which are now made for broader inclusion and which are denied because of resource constraints would probably be accepted. And thus one could expect that rather than produce cost or other resource savings the effect of MT would be simply an extension of the boundaries of symbolically defined translation-inclusion and perhaps a decline in the rate of increase of translation related expenditures rather than an absolute decline in that expenditure.

In the Canadian context the extension of translation requirements to provincial and municipal governments, to a broader range of internal Federal Government documents, to native languages and even ultimately to ethnic languages would likely arise if significant additional resources were available or if the cost of translation for the existing volume were to decline significantly.

Table 1: The Estimated Market for Translation

		Full-Time Translators
Canadian Gov't Expenditure (1982)	$75,000,000	1,200
Other Canadian (est.)	75,000,000	1,200
International (1981 est.)	3,000,000,000	180,000
Estimated latent demand - 30% (Van Slype)		
Estimated total demand Canada	$200,000,000	
International	$4,000,000,000	

7.3 SOCIAL AND ECONOMIC IMPACTS OF MT

7.3.1 Canadian Society

7.3.1.1 Introduction

Other studies in this series have discussed the possibilities of sub-optimal technology developments in the area of MT. Such solutions could range from the provision of word processing capability to translators, through partially automated translation, through to full machine translation. The economic impact of MT will necessarily vary as between the alternative developments.

To determine economic impact however, one must discriminate as between the various components of such an impact. These components would include:

- direct cost saving as a result of MT ie. the redirection in the amount spent on translation when the number of words stays the same but cost per word declines.

- impact on number and cost of employees. Will MT lead to an increase or decrease in the number of those employed in translation and the total wages paid to them.

- impact on domestic manufacturing services import/exports. Is the MT technology locally produced? Is it having an employment effect domestically? Is it capable of being exported or is it imported with some or no local value added?

- impact on the cost of government or of doing business with translation and other multi-lingual related costs as overhead items. How does MT affect these and could it affect the position of domestic producers vis-a-vis international competitors?

7.3.1.2 Direct Cost Impact

To date there is no evidence that sub-optimal MT has had a significant cost impact where it has been introduced. Cost-benefit analyses of word processing as applied to translation, several sub-optimal systems (Systran, WEIDNER) and full MT systems (METEO) have not shown a significant cost saving for MT over human translation if the real cost of the technology is amortized into the analysis. (#15, 16, 23)

However the cost of computing systems and computing components is declining rapidly which would suggest a longer term cost saving for installed systems. As we have already noted there is a significant latent demand for translation. We might expect that any potential cost saving in translation might be absorbed by an increase in demand for translation and thus translation volume.

7.3.1.3 Employment Impact

Assuming a constant expenditure and improved technology one can anticipate higher translation through-put. Thus while direct translators may be

displaced to a limited degree, pre-edit and post-edit translation positions are likely to increase significantly. It is thus likely that a larger number of translators may be employed with higher average earnings (since pre-editing and post-editing are likely to call for specialized skills and training over and above conventional translation skills) in a sub-optimal MT environment.

This impact is likely to be manifest up to the introduction of full MT facilities which is not anticipated within our identified horizon 10-15 yrs.

7.3.1.4 Impact on Domestic Manufacturing and Services

At the moment translation is highly labour intensive and low technology based. Technology used would in general be no more sophisticated than an electric typewriter or dictation machine. (The Government of Canada's terminology bank is a notable exception). Business machine systems are overwhelmingly imported into Canada.

In addition there is a limited market in the export (and import) of translation services. Canada as a high wage area (especially in the area of translation), imports translation services to a limited degree. Canada with its well-developed translation service sector also exports translation services, to the United States especially; there is also activity in Canada in the subtitling and dubbing of films and video for export into the Francophone community.

The overall volume of importing and exporting of translation services however would appear to be small, almost certainly no more than 10% of the current domestic market ($15 million).

The development of MT is likely to change dramatically the current situation where equipment investment per translator is under $1000 and perhaps $500 worldwide (for a total of only $2,500,000/ $90,000,00). This could change with word processing to an investment of $5-10,000/translator (for a total of $12.5 million - $25 million) in a relatively short period of time. With more elaborate available systems the capital investment per translator would increase significantly (the Weidner system requires an investment of $25-50,000/translator).

With an estimated 180,000 translators world-wide the potential market for technology in support of the translation function would appear to be great. Even assuming that perhaps half of this number use nothing more than a pen and paper the volume of current investment for the other half would be $90,000,000 and assuming a possible upgrading investment to $5000/translator a potential market of $900,000,000 could exist world wide.

Table 2. Capital Investment for Translation

	Translators	Investment/Translator	Total
Canada-Current	2500 (full time)	$1,000	$2,500,000
Worldwide-Current	180,000	$ 500	$90,000,000
Partial Automation (WP)			
Canada	2500	$5,000	$12,500,000
Worldwide	180,000	$2,500	$450,000,000
MT System $10,000?			
Canada	2500	$10,000	$25,000,000
Worldwide	180,000	$ 5,000	$900,000,000

An expenditure of this kind would only be made if significant increases in efficiency of translation throughput were able to be realized. This increase in productivity could lead to a very great expansion in the international trade in translation services (aided by improvements in computer communications and telecommunications in general).

Canada it should be noted has one of the largest consumer markets and expenditures on translation services in the world, a relatively high concentration of that market in two or three cities and a relatively small number of major purchasers of the service.

Significant translation volumes will be required to warrant the expenditures on information technologies to enhance productivity. Canada has these volumes. With the hardware having been purchased the dramatically lower per word cost anticipated through MT systems could mean that Canada could support a contract translation industry which could effectively compete with domestic suppliers elsewhere for those components of the $3 Billion annual translation expenditures which are free floating. Even 1% of this market would be $30,000,000 annually.

7.3.1.5 Impact on Productivity

The overall impact of MT on productivity is difficult to determine. As already noted the translation requirement introduces significant delays into organizational systems as documents need to be

translated before distribution. A speeding up of the translation process i.e. the time required to translate a single page might increase productivity by reducing waiting time for documents, response time to requests and so on.

Overall productivity increase resulting from MT and speeding up of translation would have to assume that those waiting for translation were not doing anything during the waiting period. This of course is not the case. Significant improvements in response time ie. quality of service in addition to an increase in the volume of white collar output in general might be anticipated.

In the commercial sector translation related delays may in fact reduce productivity as sales are lost or held up; as resources are expended which need not be; or as translation is not done which ideally should be done due to the high per unit cost of translation or the slowness of the translation process. It is difficult to quantify these gains but the autombile manufacturers estimate a 6% incremental cost in Canada from having to distribute in a bilingual environment. Any reduction in the cost of bi-lingualism could potentially decrease costs to consumers and also decrease the costs of certain of our exports.

7.3.2 Impact on Labour

MT will as we have noted probably not in the foreseeable future diminish the overall number of employed translators but it is likely to significantly change the content of the jobs translators do. While translators are currently responsible for word for word textual translation, in an MT environment they will shift over to pre-editing and post-editing texts and to machine operation. The current training and selection procedures for translators will become obsolete. Translators will need a broad understanding of the original language but the emphasis will be on their literary (editing) skills in the target language. In addition they will need to have some training in the operation of the support machines whether it be word processors or more advanced MT systems.

Simple linguistic skills will be of less importance. It may be that the somewhat more specialized post MT skills may be more highly prized in the marketplace.

The conditions of labour will also change. The somewhat informal and decentralized translation environment will necessarily change as increasing investment is made in the translator's working equipment. Freelance translation will probably diminish for the same reason and one can anticipate overall "industralization" of translation resulting from machine support.

7.3.3 Women

The impact of MT on women will differ from its general impact only insofar as women are disproportionately employed as translators. In fact the proportions in Canada, at least, appear to be somewhat unbalanced with a 55% (women) - 45% (men) proportion.

The mechanization of translators may discriminate somewhat against women in that there appears to be a tendency for men to be more comfortable with and more responsive to training in computer operation than women.

7.3.4 Senior Citizens and the Poor

Machine translation, by lowering the cost of translation will make translated material more widely available. This should be of some assistance to those with only limited access to information in other languages.

7.3.5 Regions

7.3.5.1 Language Rights

The availability of MT will, in the context of a bi-lingual country like Canada have the effect of making possible the carrying through of government objectives of allowing for citizens to freely and fully participate in the life of the society in either "official" language. This could have the effect of reducing inter-lingual tension caused by the restricted status of a minority language. In addition

it would allow for the extension of "language rights" into new areas and support the efforts of those looking to retain the use of minority languages in the context of dominant language majorities.

With the free availability of relatively low cost MT - pressure will build for government to support translations in third (ethnic) languages and fourth (aboriginal) languages. In this context MT may have an effect on the subtle interplay of language based politics and inter-ethnic relations as groups look to achieve linguistic status equivalent to languages accorded constitutional protection.

7.3.5.2 Industrial Development

Any developments of a Canadian MT industry either in hardware or services would almost certainly tend to be located in regions with existing (if limited) hardware capability or where a translation service infrastructure already exists. While the development of MT hardware might take place in Ontario it would more likely develop in Quebec where there is already some expertise in the field.

A contract translation industry based on MT would likely be located in Montreal. The dominant market which would be served (in Canada) would probably be as is currently the case, from English to French. MT technology would favour general literary (as opposed to purely linguistic) skills and the availability of

both native language English and French speakers and centers of higher education would support this development as would the presence of native third language speakers.

Given the nature of language, MT is likely to remain relatively labour intensive (although the words per translator will increase) and translation services based on MT technology could provide a significant source of white collar employment. Trends toward the internationalization of the U.S. economy through trade (with the consequent demand for translation services) would tend to support this especially given the ready proximity of the large U.S. East Coast market.

7.3.6 Developing Countries

MT is, because of its technical sophistication likely to be a product of the developed world. Given that many developing countries are characterized by significant linguistic diversity a very low cost system of MT might be useful but it would have to have a very low cost indeed to compete with prevailing labour costs in many of these countries.

In that MT is likely to make information in general more available in a variety of languages, this should provide some benefits to developing countries especially those for whom the dominant European language is other than English. Since the overwhelming volume of science and technology related publications are in English this causes

special difficulty to those countries where educated populations are working in a language other than English since much information is not currently available in translation.

MT, insofar as it has a broad impact on the global translation service market is likely to have a negative impact on developing countries. MT being capital and technology intensive will lead to a shift of translation activity to the developed countries (such as Canada) and away from local translators. This will further exacerbate internal imbalances in the global division of service related labour.

8. NATURAL LANGUAGE PROCESSING

8.1 INTRODUCTION

Natural Language processing (NLP) is developing and will develop as a component of other information handling systems. The objective of NLP is to allow communication between man and machine to take place in as linguistically natural a mode as possible. Thus speech recognition, speech synthesis, text understanding and text generation, and even optical character recognition and optical sensing may be included under the general category of NLP.

NLP components are being envisaged as database interfaces for command and control systems and for robots. Specific applications could be voice activated typewriters, the synthesis of written or verbal communications from machine generated data and public access information systems.

The driving force behind NLP is the need to make access to computing power and information stored in machine accessible form available to the general public without special knowledge, training or skills. Thus it is believed that lack of keyboard skills or reluctance to use a keyboard limits the willingness of senior executives to use computer terminals. Similarly the requirement to think in a systematic manner or to learn specialized terms limits the market for such technologies as personal computers and management information systems.

8.2 ECONOMIC IMPACT ON CANADA

NLP in one or another of its forms will be incorporated into existing or developing systems so as to facilitate the public access to databases. It is not yet clear whether NLP will be a form of machine intelligence based on software integrated into other systems, a particular piece of specialized hardware (a chip for example), or an approach which influences the design of new systems (or any and or all of these). Thus the shape of an NLP industry is not evident.

The industry could take several forms:

- the development of NLP software packages sold as such by software companies to other companies who are developing new systems or enhancing existing products.

- the development of chips or sub-systems incorporating NLP technology sold as components to system or product developers. Specialized chip manufacturers carry on this type of business currently.

- the development of expertise in NLP available for sale (as consulting contracts for example) to those looking to develop systems incorporating NLP. Several firms in the Telidon and fibre optic area are attempting to do this currently for their technologies.

- the development of new products incorporating NLP technology. One could see for example a Teldon system with an NLP interface being developed and offered for sale, also voice controlled graphics systems, voice activated telephone sets and so on.

While positive employment and other economic benefits would derive from all of these activities it is likely that the major economic benefits will come from the development and sale of new consumer oriented systems especially mass market items. One can anticipate a new generation of mass market applicance and business machines with voice activation and voice synthesis capabilities. Limited capability devices are currently on the market (warning devices for autos, sound recognition light switches etc.)

Historically the pattern appears to be that such devices benefit most those who are both technologically innovative and who have the industrial and market base to support the initial marketing of such products. Canada unfortunately is weak in the secondary industrial sectors oriented toward home appliances and office machinery where the major developments of new products are likely to occur. In the automative sector Canada is integrally connected to the U.S. manufacturers who have for some time now, been lagging in the incorporation of new technologies into their products.

Canada perhaps has greater opportunities in other areas, but the economic benefits derivable from these, especially in the context where there is fierce international competition and where there is little significant end-user markets in Canada to pull the development of the technology may be limited. Unless there were to be a major and unpredictable breakthrough which was specifically Canadian there appears to be little or no comparative advantage for Canada in this area as against its OECD competitors.

In fact it appears unlikely that there will be a significant breakthrough - rather developments will occur on a number of fronts and in an incremental fashion and there will likely be a number of competing solutions to the NLP problems each of which may capture a specialized share of the market as is the case currently for software. In this context Canada, given its current level of expertise and with suitable levels of additional resources could expect to obtain a portion of the international market for NLP software and services (as it does currently in other software areas) but Canada is not likely to derive disportionate economic benefits.

On the user side NLP systems are likely to act as enhancements for existing systems rather than as direct replacements for a large number of employees. Likely to be affected are those who act as human interfaces to existing pieces of hardware or databases. However, even in these instances (typists, telephone operators, archive clerks) they generally perform other functions in addition to the interface ones. Even for the interface functions a human back-up will probably be necessary for the foreseeable future. Thus though there will be some employment impact (as there has been for example in the case of voice synthesis in telephone systems) the more likely effect is an extension of existing services - new services, services available to more user, or better quality service - than a directly negative impact on employment.

Further, given the circumstance that most of the systems which could incorporate NLP interfaces are currently

imported, the addition of NLP technology may increase to a degree the value of these imports but not otherwise significantly impact current Canadian trade. NLP technology will thus contribute to existing trade deficits rather than be an independent cause of these.

It is truly impossible to anticipate the likely indirect market for NLP technology. However they may, at least for the foreseeable future be so error prone and restrictive in language acceptance as to be of very limited application. NLP systems could provide the basis of whole new approaches to the provision of information or internal information services but this is only a possibility since it will likely be highly threatening to those currently delivering these services and it would involve a complete redesign of these services.

NLP systems could continue to function as toys or components of toys for an extended and unpredictable period of time until the technology is perfected and ready for general use.

8.3 IMPACT ON CANADIAN SOCIETY

NLP systems could provide the means for a mass diffusion of access to information and other computer related resources. By making these accessible without having to learn either specialized commands or a special language - computerized databases, expert systems, computerized data manipulation and other facilities which previously had been available only to a few - could be made available to the many.

By making information more widely accessible, a more informed electorate could be fostered and decentralized decision making could be strengthened.

By facilitating access to expert systems the roles and privileges of specialized knowledge providers could be threatened and the benefits which flow from this knowledge could be more widely distributed.

By generalizing access to computerized power for information manipulation it should be possible for the work force to "work smarter" and thus more productively.

NLP and natural language interfaces could assist in breaking down the barriers to providing widespread distribution of the advantages and benefits of computers. Some would argue that such a result would in itself justify the investment in AI and NLP. Clearly the Japanese through G5 are seeking NLP as a means to break through with computerized technology to broad application and utilization among the general public with the cost savings and service quality enhancements which would follow.

8.4 LABOUR

We have already mentioned the possible effect on labour. It is unlikely that NLP will directly be the cause of the elimination of large numbers of jobs. In fact by broadening public access to computer databases and computer power and by expanding the range of computer based services to which the public could have ready access, NLP might in fact expand the number of jobs. Thus for example, if information is more readily available and if it became more widely used because of NLP technology then those responsible for developing, supporting, managing (and so on) the databases might increase in numbers both with use and with the number of databases being made available. New information technologies such as videotape or video disc have not eliminated or replaced jobs in other sectors, rather they have added jobs and generated extensive economic activity in a variety of sectors.

In other contexts NLP technology may eliminate or diminish certain job functions while increasing the requirements for other functions. A voice activated typewriter may reduce the need for typists while increasing the demand for proofreading and text editing; computers which respond to natural language commands may eliminate the need for some data inputters and programmers while increasing the requirement for skills in information interpretation and analysis.

8.5 WOMEN

NLP systems will facilitate access to computer power and computerized databases. Insofar as women appear to be less willing to learn computer skills than men, NLP systems should tend to equalize opportunity as between men and women.

However, many of the text or data entry jobs which will be affected by NLP systems are currently occupied by women (typists, telephone operators, archive clerks etc.).

8.6 SENIOR CITIZENS AND THE POOR

As these groups have information needs but a general lack of computer skills, NLP systems should be highly advantageous insofar as they are applied to facilitating public access to computer held information resources.

NLP systems especially voice activation could be used as command systems for a variety of prosthetic and other devices which would be very beneficial to the elderly and the handicapped. Voice command systems for appliances, for public services such as banking and so on, could act so as to normalize opportunities for otherwise physically disabled individuals.

NLP systems could also act as means of 'amplifying' the restricted opportunities imposed by lack of education, lack of linguistic skills or lack of intelligence. If the computer can understand what the individual wants, it can find the most effective means for achieving this - much beyond what the individual may be capable of determining for himself/herself.

8.7 REGIONS

NLP technology is unlikely to impact regions on a differential basis.

8.8 DEVELOPING COUNTRIES

Given that NLP systems will primarily be components of larger systems the limited installation of computer systems in developing countries is likely to limit the impact on developing counties for the foreseeable future.

9. OVERALL ECONOMIC IMPACTS OF NLP AND MT SYSTEMS

9.1 TRANSLATION SERVICES

The Federal Government spends approximately $75 million annually (1981) on translation services. This represents an employment base of some 1200 translators, writers, interpreters and support staff. Those interviewed estimated that a roughly equal amount was spent and numbers employed in the private sector in translation in Canada.

The total expenditures thus on translation related activities would be roughly $150 million/year. Statistics Canada however, indicates that some 6,240 persons identified their occupation as translator, although many of these may be part-time workers.

Internationally it is estimated that some $3 billion is spent on translation and that some 180,000 people are employed as translators or interpreters.

It is not anticipated that either in the short or foreseeable longer term MT would have a significant impact either on the expenditures on translators or on the numbers employed in translation. There may however be significant impacts on the nature of the translation sector and on the international trade in translation services (currently estimated to be very small).

Nevertheless direct translation services represents a significant domestic market and a highly significant international market for MT technology.

9.2 LANGUAGE TRAINING

An important language related sector is in the area of language education and training. Current Federal Government expenditures in this area are some $250 million/annum with an estimated $500 million/annum, being spent by the Provincial Governments, private sector and personal services. According to Statistics Canada some 30,315 are employed as language teachers or trainers in Canada.

Internationally the estimates concerning second language training are $15 billion with some 900,000 being employed (based on a proportion of similar expenditures and employment proportions as in the translation services area). The international trade in language training services is significant and rapidly growing, representing a sizeable source of invisible earnings for such countries as Britain.

MT and NLP technologies combined could have an effect on language training by allowing for the partial substitution of technology systems for human training. It should be noted that language training is currently quite technology intensive. Whether new AI based language training systems would directly replace existing human language trainers or would simply represent an upgrading of existing technology systems remains to be seen. However, it is likely the

Table 4:

CURRENT EXPENDITURES	TRANSLATION SERVICES		LANGUAGE TRAINING & FOR. LANG		TEXT PROCESSING (typists, word processor ops. data entry)		LANGUAGE RELATED to trade (excluding translation)	
	$	people	$	people	$	people	$	people
Canada	150 million	6,240 (full and part time)	750 million	30,315	4 billion	204,095	350 million	4,400
International	3 billion	180,000	15 billion	900,000	40 bill U.S. 160 billion world	2,000,000 US 8,000,000 world	7 billion	42,000

latter since it is unlikely that machine based systems will effectively substitute for one-on-one training and the social re-enforcement which are key aspects of effective language learning.

The gross estimated expenditures in this area however is striking and a very significant potential market.

9.3 TEXT PROCESSING AND OFFICE AUTOMATION

Statistics Canada determined (in the 1981 census) the following employment in text processing related occupations:

Table 5:

typists and clerks	105,255
electronic & data processors (W.P.)	76,810
office machine operators	14,185
supervisors of the above	7,845
TOTAL	204,095

If one estimates that the average current investment on typists and clerks is $2000/individual and for electronic data processors is $10,000, then the total investment currently for this group would be roughly $4 billion. Applying a proportionality of 1:10 the comparable figures for the U.S. would be $40 billion and 2,000,000 employed. On a world-wide basis, assuming that the U.S. represents some 25% of global information related employment the comparable figures would be $160 billion and 8,000,000 employees.

These figures represent one of the possible opportunities for NLP based devices and of course reflect only partial applications for NLP even in the office environment.

We would anticipate that even with relatively widespread availability of NL interfaces the numbers of those employed in text processing activities would not decline significantly (just as for example the introduction of word processing has not lead to a significant decline in those employed as secretaries).

Text processing is only one aspect of office automation. Both NLP and MT can be seen as significant possible components of OA systems with NLP providing a simplified interface into OA systems and services and MT providing a means for facilitating multi-lingual inputs and outputs.

9.4 INTERLINGUAL TRADE AND COMMERCE

It is extremely difficult to calculate the net cost of inter-lingual activities in the area of trade and commerce. Automotive companies have indicated that the cost of doing business in two languages in Canada contributes between 5 and 8% to the selling price of an automobile.

The apparent cost to the Federal Government of conducting its business in two languages is some $250 million per annum according to the Commissioner of Official Languages. If one assumed that non-Federal expenditures including Provincial and private sector were roughly equal

(the Federal Government represents some 20% of G.N.P. but it has accepted a special responsbility in this area over and above all others in the community) then the expenditures would be $500 million/annum.

Federal employees supporting this activity total some 5,300. On a national basis comparable figures would be 10,000. Using similar proportions to those for the translation services, costs associated internationally with multi-lingual trade and commerce would be $10 billion/annum and total employment of 212,000.

Multi-lingual agencies such the European Community and the United Nations spend large amounts of money and accept significant inefficiencies because of the necessity for multi-lingual translation. The E.C.E. estimates that it spends some one-third of its administration budget on translation related activities. In addition the work of the organization is slowed significantly as it is required to provide translation into six languages (soon increasing to nine). The E.C.E. is also experiencing some difficulty in finding qualified translators for certain language sets (Danish to Greek is often cited).

Given the well known problems in the quantification of white collar productivity it is not possible except qualitatively to estimate the loss of efficiency associated with multi-lingualism but it is reported that these problems can and do delay the work of the community typically from six weeks to three months 'while material is in translation.'

9.5 IMPACTS

As already noted the economic impact of MT and NLP technology is subject to a variety of factors which are difficult to predict. Among these are:

- rate and pattern of technology development
- method and rate of diffusion
- cost of and functionality of the technology.

Thus any speculation about the ultimate impact is to a very considerable degree price dependant. In addition of course, many of the figures we are presenting concerning expenditures and employment are highly speculative. Nevertheless it is possible to get some idea of the order of magnitude of possible impacts.

9.6 MARKETS FOR MT

In the area of MT we have estimated a combined annual expenditure on training, translation and trade and commerce activities of some $1.25 billion/annum in Canada and some $22 billion annually internationally or some $500 million and $100 billion respectively, excluding language training.

At the moment MT is not cost competitive with human translation. As MT improves in efficiency a cross-over point will be reached where for certain applications at least, MT will be cost competitive especially with appropriate amortization periods for the systems. If one uses a five year period then the total expenditure pool

for the sale of possible MT systems becomes $6 billion in Canada and some $110 billion internationally. The potential market either for the development and sale of MT systems or for translation services based on MT thus would be enormous.

9.7 MARKETS FOR MT/NLP BASED LANGUAGE TRAINING SYSTEMS

We have estimated an annual expenditure for language teaching of $750M in Canada with some 30,000 person identifying themselves as language teachers. Of the total expenditure perhaps some $15,000,000 (an estimated $500/teacher) is spent on educational technology with the rest providing for salaries, overhead and administrative support.

In this context MT systems alone would probably not find a ready market in that language teaching like other forms of teaching, is seen as requiring a maximum of interpersonal contact. (We have left out of our analysis those who may be purchasing equipment for language teaching on a personal basis). However our basis of estimating total expenditures was an extrapolation from Federal expenditures in this area which would include both self-teaching and teacher led systems and which would probably over-represent rather than under-represent expenditures). Hardware expenditures alone were not a major item in this and other areas of teaching.

Major impacts would occur only if MT systems could be combined with natural language interface systems and AI based expert systems, to develop highly effective interactive and intelligent teaching machines. In this

context the calculation of cross-over would be similar to that for industrial robots. If some $25,000/year is spent in Canada on each language teacher this becomes $125,000 over a five year period or a total expenditure of $3.85 billion. On an international scale the total is $75 billion, over five years. This would represent a highly significant potential market. If the MT device were to only function as a teaching aide increasing teacher productivity by 1/3 the Canadian market would still be $1.3 billion over five years and the international market $25 billion over five years. Although these markets await significant developments in the area of AI research it may be that sub-optimal integration at available levels of development may be sufficient to produce a system for this market.

9.8 MARKETS FOR NLP

The market for NLP is even more difficult to predict than other areas of AI because NLP will not provide a replacement for an existing job specific activity for the most part. Rather NLP will be introduced as a sub-component of a replacement system extending the functionality of existing technology. Thus for example a new generation of word processors or either text generators or data input devices may incorporate NLP features, but of course text creation is only one of the activities in the office.

Estimates of the market even for text creation however are revealing. We estimate a $4 billion investment in text processing and data entry technology based on estimates of $2000 investment per typists and $10,000 investment per

word processor or data entry operator. Extrapolation to the U.S. market and the global market suggest a $40 billion investment in the U.S. and $160 billion in the world (assuming that the U.S. has approximately 25% of the information related technology in the world). Total employment in this area we estimate at 8 million world wide of which perhaps 6,000,000 is in OECD countries. If one were to add value of perhaps $100 with some sort of NLP interface to the work station of each of these operatives this would represent a $600,000,000 market.

Of course adding value in this area is only one of a broad range of possible applications including the upgrading of existing information or human interface services as well as the development of a whole new range of services directed toward the general public.

9.9 IMPACT ON EMPLOYMENT AND TRAINING

It is still too early to make serious predictions concerning the impact of NLP and MT on employment or training. It is unlikely that in the near future either technology will have a highly significant effect on any specific job category. Rather it is more likely that there well be a gradual shift in the content of particular jobs (translator, language training, text entry etc.) as new technologies are introduced and a measure of adaptation, re-training and job migration may result.

The most appropriate strategy in this area from an employment perspective would be to be open to and accepting of technology change; to have training systems

sufficiently responsive to the evolving environment; for appropriate training to be developed in tandem with technologies as they come on to the market; for individuals to be trained so as to have sufficient flexibility to adapt to an increasing technology component in their jobs and to overall re-organization of the content of their jobs; and that they be prepared to be re-trained several times in the course of their careers.

That jobs will be impacted there can be no doubt, the specific nature and extent of these impacts however, will only be predictable on a technology-item by technology-item basis.

10. EXPERT SYSTEMS

10.1 THE TECHNOLOGY

As already noted in the 'State-of-the-Art Report' a variety of expert systems are currently available and a large number are under active development. In addition the quite considerable cost of development of a system is likely to decline as standard methodologies and generally applicable modules for certain elements of systems become available or as existing systems are extended in their range of application and expertise.

To date expert systems have been used only as a supplement to expert knowledge by specialists in particular areas. It is likely that in the short term most expert systems will be of this form thus minimizing the possible broader impacts. However at least one system (in the insurance area) is under active development for use by non-specialists and one could expect the development of others in parallel areas in the short term. Their assimilation into widespread use is likely to be limited in the 1-5 year period.

Considerable resources nevertheless, appear to be flowing towards expert systems and one could expect that the foundations for the broad and more significant developments which will take place through the rest of this century will be laid in this period. Thus while the short term impact of the technology will be slight, the long term impact of not responding to opportunities in

this area may be highly significant. In the next several years methodologies will be developed (perhaps in patentable form), the shape of the market will begin to become clear, and certain building block short cuts will become available.

10.2 SHORT TERM IMPACTS

10.2.1 Canadian Society

10.2.1.1 E.S. Development

Canada as a society with a highly educated population could serve as the site for the development of expert systems. To date however little expert system work has been conducted in Canada. Of the expert systems currently available none appear to be operational in Canada although, one or another may be converted by or for companies with specific information requirements.

Canada has a number of areas where domestic expertise could be translated into expert systems (Canadian geological expertise has already been so treated by U.S. organizations). Such areas as medical research, oceanography, resource management and exploration and so on would appear to be ideal areas.

While there is currently no direct imperative to launch E.S. projects in any of these areas, and some discentives for doing so (for example possible loss of competitive advantage based on current expertise, high level job displacement etc.) the possibility that

others with similar expertise might do so is a real one. In that event Canada would ultimately end up importing such systems and foregoing any advantages which might entail from their development.

It is not possible to put dollar figures on either the current value of the expertise or on the value of E. S. systems which might be developed, (although the cost of system development is currently estimated in the $1-3 million range). However systems with wide appeal as for example medical or educational systems or in high value areas such as mineral or petroleum exploration could be expected to show a very high rate of return as they would have international markets.

10.2.1.2 Impact on Information Related Employment

In the short term there is unlikely to be any significant impact on information related employment. It is important to note however that some 40-50% of all employment now is in information related jobs. As expert systems are able to substitute machine intelligence for human intelligence in certain areas so there may in the long term be a gradual displacement of information workers.

A non-AI based example of this type of substitution may be found in the use of answering machines with intelligence which can tell the caller that the wrong number has been reached and what it is or tell a caller concerning a changed number. In this instance the machine has eliminated the job of a number of telephone operators.

In the U.S. the number of operators employed by the Bell system has declined as follows:

1960	1970	1980
220,000	160,000	140,000

while the number of calls handled has increased some five fold.

Exactly the form expert systems might take is not clear. They have to date been concerned largely with narrow fields of expertise. One could foresee however, their use in a wide variety of areas where there is a market for specialized if not "expert" information such as real estate, insurance travel and so on.

The possibility of public access videotex systems linking into intelligent software for a variety of purposes certainly could pose a considerable threat to employment in some areas.

10.2.1.3 Service Delivery

With the feasibility of building expertise into machines it is likely that public agencies will look to reduce service delivery costs by making such systems available to the public in place of some at least human experts. An obvious example is in the area of medical diagnosis where crude computer based initial screening of patients is already taking place. One could expect an extension of this into other service areas as well for example social welfare services, educational services, public information services and so on.

10.2.2 Labour

As we have already noted in the short term there is likely to be little or no impact of E.S. on employment or even on job content or employment structures. In fact in the Canadian context with appropriate levels of public and private investment there could be the development of a significant amount of highly skilled R&D work in the expert systems area.

Expert systems however, only require some 3-5 man years for their creation and the trend is to make them less labour intensive through the development of building blocks. The development of E.S. are unlikely ever to provide significant amounts of direct employment.

10.2.3 Women

The impact of expert systems on women is likely to be paradoxically slight. The initial waves of new technologies were directed at lower level information processing jobs such as typing, filing, form handling etc. the type of white collar jobs most frequently occupied by women. The more advanced systems are being directed towards higher level information handling activities - planning, managing, analysing etc. which have traditionally been the responsibility of middle management males.

Expert systems will be directed toward information occupations which are either predominantly male or generally mixed male and female.

10.2.4 Senior Citizens and the Poor

Within the short term period we may expect to see the beginning of the use of E.S. in service delivery. As the use of these systems in the delivery of public services will be primarily for cost reduction purposes it is likely that they will be used in services directed toward the poor and the elderly.

However most of the services directed towards these groups are only partially information related. Where the problem of interface with the machine (either because of fear or language difficulty) is potentially a significant one, it is likely that (at least until their use becomes widespread) E.S. will not be widely used in service delivery to such groups as senior citizens or the poor.

10.2.5 Regions

10.2.5.1 Equalization of Opportunity

Expert systems will have the on-going effect of equalizing the access to expertise of rural, remote or unfavored regions. Machine based expertise is of course both completely mobile and totally accessible through telecommunications technology. Such an effect should make both living in and being economically productive in such regions easier and more efficient. Thus medical expertise may be as accessible in Tuktoyaktuk as Toronto, a prospecting expert may be as available on Baffin Island as in Calgary.

In fact however, the market looks after such inequities with premiums being paid to attract experts to ill-favored regions or through the use of telecommunications to access human experts.

The net effect of the availability of this expertise is likely to be more economic than social - reducing the cost of doing business in certain regions. Given that such expertise is not usually a significant component of economic activity in such regions the impact is likely to be slight.

10.2.5.2 French Language Systems

Apparently all E.S. developed to date have been developed in English including Japanese developed systems and the system developed by Schlumberger, a French engineering company. Given the nature of E.S. it is likely that direct translation may be difficult. This will tend to reinforce the strong tendency for English to be the language of high technology.

Given Canada's bilingual character and the possibility of developing dual language hi-tech expertise it may be that a significant opportunity exists in Canada for developing French language equivalents for popular English language E.S. This would require less expertise than the development of full systems but greater expertise than pure translation. There is precedent for this in the current development in Quebec of French language adaptations of popular software programs.

10.2.6 Developing Countries

Given the level of technical sophistication required for E.S. both in the development of the system and in the expert area, developing countries are likely to experience expert systems only as consumers and even then only to a very limited degree. Initial high costs will compare unfavourably with the cost of local expertise often trained to international levels.

In the longer term as the cost of expert systems decline they are likely to be acquired for use in appropriate areas similarily to developed counties. The danger exists that expert systems may develop to a sufficient degree to provide higher quality and lower cost service than local professionals. Such a development could severely inhibit developing countries in a variety of ways by for example limiting the development of information intensive industries and employment opportunities. This would overall have the effect of limiting the development of the well educated professional middle class on which most developed democratic political and social systems are based.

10.3 EXPERT SYSTEMS - LONGER TERM - 10-15 YEARS

10.3.1 The Technology

In the longer term we can expect to see the deepening understanding of the nature of expert knowledge and with it a broadening of the areas amenable to expert systems and to an extending of the range of expertise of individual systems (i.e. being available to respond in broader domains).

Exactly what range or what areas will be covered is not yet evident although it is likely that it will move out of narrowly academic areas into more commercially interesting or more publicly useful areas.

It is well to note that ES are currently in place and being used in operational contexts; that considerable resources both private and public are being directed to this area based on current successes; and that no major technical problems appear to exist to limit incremental progress in the field. Thus developments in the longer term are likely to be extensive elaborations and wide diffusion of systems not significantly dissimilar from those currently being made available.

The impacts of these systems thus may be seen as longer term extrapolations of current trends assuming normal rates of advance and rates of diffusion similar to other information intensive technologies.

10.3.2 Canadian Society

In the event of significant ES developments and widespread diffusions there are likely to be substantial economic and social impacts for example the commoditization of 'expert' knowledge. Currently expert knowledge is in the form largely of personal training, experience and skill. The cost to the consumer is a component of the cost of the service being provided. Individuals receive a return on their expertise through commensurate salaries or fees for service.

Commoditized expertise will be available directly to the user at a relatively high initial cost in development but at a low 'retail' fee because it will be possible to amortize development costs over a much larger number of consumers than individual expertise is able to do.

Thus the market for expert systems is likely to be large and in most areas is likely to be highly competitive with human expertise. The effect of this is to create an international market in E.S. as expertise commodities are developed with high rates of return to the owners of successful systems presumably those with venture capital available for their development.

To take an example an expert tax lawyer may charge clients up to $200/hour or $1500/day. At an average of 220 working days per year he might receive billings of $330,000/year. There are perhaps 500 such tax lawyers in Canada for a possible total of $16,500,000 billings per annum (ignoring all the other tax law advice given by

accountants, tax consultants and non-tax specialist lawyers). Perhaps there is an annual market for tax law advice of $30,000,000/year in Canada and $300,000,000/year (using the 10X multiple for Canadian U.S. comparison). Given that expert systems currently cost in the $1-$3,000,00 range to develop, an ES serving the tax law market place (and law given its emphasis on reason and argument from principle might be very amenable to such a system) might be a very appropriate application. Clearly a market would exist, and that such a system could be developed is agreed upon. The effect of such a system on the existing tax advice market would be significant and is but one rather limited area of possible E.S. application.

Tax law is an area relatively specific to national legal systems; however, other areas of expertise such as travel planning, medicine, weather forecasting, systems analysis and so on all would appear to be amenable to international development and marketing.

The flow of revenues into or out of countries based on the international marketing of expert systems could be a very substantial one if one recognizes that health care and education, both highly expertise-intensive together represent some 20% of the G.N.P. of the industrialized countries.

. the major impediment to and the most significant social impact of E.S. may both derive from the same feature - the significance of the non-cognitive element in areas of expertise. For ES systems to be widely diffused they will have to come to be accepted

ie. trusted by the users of expertise. In fact evidence from the Eliza system was that users feel better able to confide in the mechanical system precisely because it was mechancial and thus non-judgmental. In the ES case confidence would come from the fact that one could rely on the disinterested character of the systems and also on the fact that they can provide a reasoned account of the basis for the advice offered.

The social impact is of course, that to a considerable degree the cognitive component may be stripped away from many 'expert' occupations - leaving behind and of increased importance the affective or 'emotional element'. Medical doctors, especially general practioners recognize that a very substantial component of their work is to provide reassurance and comfort to their patients. This need not change. However the nature of certain professions and their recruitment and training may change substantially.

10.3.3 Labour

ES systems will have its greatest effect on professional and quasi-professional information workers. It is likely that at least initially these systems will be introduced as supplements to or support for existing expertise, with professionals acting as intermediaries between the ES and the user public.

This will allow for the provision of significantly greater amounts of such service at similar net cost or much lower per unit cost. Such a development would lead to little decline in demand for professional labour or even a slight

increase while changing significantly the content of the professional task from one of direct utilization of expert knowledge to one of mediating between the ES and the user, translating or editing the ES output into a form which the user can understand.

In the longer term and with the development of natural language interfaces and intelligent databases this mediating function may to a considerable degree be eliminated and the end user will come to be in direct contact with the ES. When and or if this takes place the effect would be highly significant as highly paid professionals find themselves in competition with machines with vast memories; infallible reasoning powers; and the capability of learning from their mistakes and the environment in general. The comparison with the transition from craft production to industrial production comes to mind.

The effect on rates of pay, conditions of work, training and so on for these professionals will be profound and the overall effect of this on societies which depend on this group to a great degree for political, social and cultural leadership, would be significant.

10.3.4 Women

The long term effect of ES on women is likely to be a positive if paradoxical one. While reducing the number of those higly skilled jobs to which women are increasingly aspiring, they are likely to strongly reinforce those areas of emotional support, reassurance, nurturing and empathy which have traditionally been identified with women.

If for example, teachers are no longer required for supporting the cognitive development of children - one can realistically envisage the development of ES which could do the job better in most areas than all but the very best teachers - the role of teachers will change. It may then be to provide the nurturance and emotionally supportive context in which learning can occur and which (many are arguing) is increasingly absent in some families.

10.3.5 Senior Citizens and the Poor

One significant incentive for the development of ES (note for example the G5 project) is the rapidly increasing costs of the delivery of human expertise especially health services to senior citizens and the population in general. A significant component of these increases is in the cost of human expertise especially as associated with the increasingly sophisticated diagnostic equipment generally becoming available.

A highly likely development is the building of these diagnostic systems with natural language interfaces and expert systems for the partial bypassing of human expertise in the diagnostic process and also in other areas such as preliminary medical screening, routine physical checkups, emergency medic alerts and so on. There already are trends in these directions.

Other potentially affected services currently provided by state agencies for fully or partially dependent groups would include legal advice, nutrition and financial

consultation, provision of information concerning services and entitlements and so on. ES involvement will be part of the ongoing moves to make the delivery of these services more efficient, less costly and more in response to user initiative.

The overall effect of this will probably be to make these services more widely available but less accessible to the target population in that there may be emotional reluctance to obtain certain services mechanically rather than from a human source. In addition a considerable component of the effective delivery of these services comes from the personal reassurance and emotional support which may be provided in addition to the pure information component of the services. Also in many areas the delivery of service allows the service provider to achieve other objectives with respect to the service user including assessment of other problems, provision of other related but not directly requested information and so on. Such processes, now the indirect consequences of service delivery may, with the introduction of ES based service, have to become the object of new directly delivered services.

10.3.6 Regions

The process of diffusion of ES combined with other computer and information and telecommunications systems will continue the erosion of the need for the geographical proximity of information to its user. While there may be an advantage to having expertise in close proximity to those who are using it whatever the sophistication of the

available telecommunications services, with mechanically based epertise there is no such advantage. Thus we could anticipate that the relationship between availability of expert information and location of place of residence or place of work will to a very considerable extent disappear.

This will have a variety of effects:

- the concentration of professional expertise in capitol or other central locations will decrease and one will see a broader diffusion of intermediary experts throughout the entire range of population centers.

- businesses or other organizations currently located so as to have access to certain types of expertise (medical research laboratories, developmental engineering companies etc.) will become increasingly footloose locating in areas based on other criteria of desirability such as climate, cultural variety, taxation etc.

- cities whose primary functions include provision of expertise to a geographical hinterland may experience a loss of population or at least an erosion of their tax base - these would include provincial capitols, and financial and service centers such as Toronto and Montreal.

In Canada, Quebec will experience a variety of conflicting trends:

- an industry developing French language adaptations of English language ES may develop

- in some areas English language ES may make inroads in service delivery, further undermining the significance of the French language.

- in other areas service may continue to be provided by Francophone experts in French but in increasing isolation from leading edge intellectual advances available only through ES.

- paradoxically the development of French language ES will allow for a reinforcement of French language use, ie maintenance of French language 'purity' (it will be easier to police systems than people), and linguistic isolation among those who seek this for themselves.

10.3.7 Developing Countries

In the longer term ES and associated systems will have opposing but related effects on developing countries (or developing regions of developed countries):

- on the one hand it will allow for increased access to the most advanced expertise available anywhere in the world and probably at significantly less cost than currently. This will be desirable in certain areas, for example, education, medical care (although the gap between highly sophisticated information and very unsophisticated medical services will be accentuated), engineering and so on. Whether developing regions will be able to effectively use such information is of course a serious question even in current circumstances based on human and relatively inaccessible expertise

- on the other hand ES may function in a fashion parallel to existing information products marketed internationally such as films, books etc. There is a tendency to view these markets as peripheral and these products may be 'dumped' on local markets at uneconomic prices. This retards the development of local expertise in the area, and distorts local perceptions and practices since, in many cases the product is culturally or otherwise inappropriate.

11. INTELLIGENT INTERFACES (II)

11.1 INTRODUCTION

As we have already noted intelligent interfaces are currently available in primitive form. We can expect that just as with E.S., II will respond to market pull and the discipline of the marketplace and gradually become more powerful and more useful - certainly being able to provide broad access to machine power and machine stored information is a likely objective for longer term R&D activities.

However, although increasingly powerful systems are likely to develop over the medium to longer term one can anticipate significant resistance to their widespread implementation. It is well known that information is one of the most potent sources of power in modern society. One can recognize that there will be considerable resistance on the part of those currently with control over certain bodies of information to give up this control to others who may wish direct access to it and to the power it accords. Current concerns in large organizations regarding control over micro-computer distribution and also with control over access by those with micro-computers to the data bases of the organization are clear indications of how managers and others will respond to the possiblity of executive or client groups bypassing them and interfacing directly (and with AI support) with databases.

Thus while more powerful systems are likely to become available their range of use and application is difficult to determine.

The economic aspects of such systems is equally difficult to determine. They will be providing a substantially new service, one for which a demand but no current market exists. The value of the information accessed may be high but by providing easy access such services may be available at relatively low per unit cost and still be profitable.

One of the significant marketing problems for the range of new systems and services coming on to the market is how to price and market appropriately. Intelligent interfaces to large scale databases would be one such service.

11.2 CANADIAN SOCIETY

In the short term 1-5 years there is unlikely to be any significant social or economic impact in Canada of II devices. There is currently relatively little R&D activity in this area in Canada. Systems of foreign development may be installed in Canada but these are not likely to be sufficient in number nor so widely diffused as to have significant impact.

What will be significant in the short term will be the investments which are made in the area and decisions concerning the longer term institutional and service implementation of these systems. As already noted II systems combined with large scale data storage systems and

appropriate telecommunications facilities will present the possibility of significant modification in the way large scale organizations are internally organized and the way they deliver services to the public.

Thus one could anticipate both a radical centralization as senior management would have direct and intelligent access to information required for appropriate decision making without having to pass through several layers of information analysts, researchers and synthesizers and one could also anticipate radical decentralization as those responsible for the execution of decisions would be enabled to have direct access to the information (from centralized data bases) required for their actions. One could also envisage various combinations of both.

It is also likely that II will make possible the introduction to the general public of significant new information services or extensions of existing services. The notion of the personalized newspaper where the database is daily scanned for information of particular interest to an individual; or dial-up reference information services; or personalized - investment analysis and so on would become reality.

The market for such services is still not known. Existing (non-intelligent) database interface services such as Comp-u-Serve, the Source, Dow Jones, Prestel etc. have not yet turned the anticipated financial corner and begun to pay off their substantial investments. Whether the problem with them is the relative skill required, the undoubtedly tedious means required for accessing the

information (which II would overcome); or whether it is because the market for electronic provided information is more limited than its promoters believe, remains to be determined. However, it is certainly the case that intelligent interfaces would find ready markets if this industry does take off; and the predictions concerning the potential value of this industry are very optimistic.

11.3 LABOUR

The longer term effect of II should be to reduce the ranks of middle managers and others responsible for information analysis, review, abstracting, synthesizing and so on. Such a development could be significant proceeding as it would, fairly suddenly with systems being implemented and marketed and existing functions being directly mechanized.

The extent and the pace of such impact is difficult to predict however, given that sufficiently powerful systems are not likely to be available in the short term. In the longer term the manner of the introduction of such systems is likely to determine the labour effect. Thus for example, whether II systems are used as part of an expansion of existing programs or simply installed in the context of existing services may determine the extent of labour displacement.

The type of employment likely to be affected are as follows:

- information compilers
- reference librarians

- abstractors
- middle manager primarily involved in information compilation for reports
- researchers
- information officers

These categories of employment have grown significantly as the volume of information, demand for information and complexity of information has increased. Since the rate of change in these variables is not likely to diminish, the introduction of II devices is likely to slow the rate of increase in these types of jobs rather than cause them to diminish in the medium term.

What is more likely to happen is that the nature of information delivery services will change and thus the employment will change as well as the quantity and skills of required employees. It is too early as yet to make useful predictions concerning these changes.

11.4 WOMEN

While the earlier phases of information technologies are impacting on employment categories most strongly represented by women, later phases are likely to affect more sophisticated information related employment where men are predominant. For II technologies the significant impacts are likely be with those currently providing information access and analysis services where (especially for middle management) men are most highly represented.

The new technologies do not in principle select either for men or women (although direct computer interfacing appears to be male associated). II devices will overcome some of the apparent reluctance of women to operate the new technologies. In this way they will enhance the position of women.

11.5 SENIOR CITIZENS AND THE POOR

II systems should broaden the access to information sources and information technologies for those constrained in such areas by reason of lack of education or training, or emotional inhibition. This broadening of access to information should have a positive effect by allowing those currently without such access to gain information concerning their rights, legal entitlements and other areas.

11.6 REGIONS

The development of II access to information bases will allow for the significant restructuring of information intensive organizations. This restructuring could go in several directions - it could lead to increased centralization as senior managers are able to command required information directly without going through layers of middle management information compilers and synthesizers. It could also allow for significant decentralization as those in the farther flung regions are able to directly access and manipulate centralized information in order to make decisions at a more local level.

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