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## Contents

	<u>Page</u>
I. Introduction	1
II. Research and Development in the Yukon	6
Current status	6
Future Directions	8
General	8
Opportunities	9
Biotechnology	10
Satellite Technology	11
Tourism	12
The Next Steps	13
Conclusion	16
Appendix 1. Yukon Science Policy	18
Appendix 2. Definitions in science, technology, and innovation; R&D	26
References	29

## I. Introduction

We live in an era that grew out of the Renaissance, one that an increasing number of historians call the scientific revolution. No other period had been as deeply affected by science and technology as the 20th century. We now live in an age of permanent revolution brought about by continuous developments in science and technology. Our understanding of the past and our expectations of the future are undergoing continuous and rapid changes.

For the past 50 years, leading political figures, scientists, historians, and philosophers in countries throughout the world have testified to the multifold opportunities science and technology has to offer a nation for the improvement of the well-being, safety, and personal development of its citizens. At the same time, great concern has arisen around the globe about the application of science and technology. People are worried about the growing cost and safety of high-tech facilities (nuclear reactors, genetic manipulation); the deleterious side-effects of technology (pollution); and the negative social consequences of adapting to very rapid technological changes (retraining, dislocation, etc).

The most notable development of this revolution has been Japan, a country without any natural resources of consequence, which has used science and technology to support a sustained economic growth rate unequalled by any other nation. In many other countries the development of science and technology has helped to produce the fastest rate of economic growth in the history of the world.

Our own universities, the federal and provincial research organizations, and private research institutes all agree that research and development is the key to the economic renewal of Canada. Others are less optimistic - they maintain that our very economic survival is dependent on our ability for technological innovation or the adaptation and/or transfer of foreign technologies. It is estimated that as much as two-thirds of our recent economic growth is attributable to technological change and there is every reason to believe that its influence will grow (3).

In the latest (October 1, 1986) Speech from the Throne, the Government of Canada recognized this fact and reaffirmed its commitment to research and development and science and technology as a motive force in Canada's economic growth:

"My Ministers have begun to forge a partnership with the provinces, with the scientific and educational communities, and with business and labour in an effort to stimulate increased technological development in Canada. To assist and encourage cooperation between the universities and private sector in research and development, my government has announced an initiative that could provide a billion dollars in new funding for scientific research over the next five years."

"First, my government will appoint a National Advisory Board for Industrial Technology, chaired by the Prime Minister and composed of some of Canada's leading industrialists and scientists. This committee will assess national science and technology goals and policies, and their application to Canada's economy. Second, in full cooperation with the provinces, my government will seek to achieve high standards of excellence in education, technology development, and innovation. Third, it will introduce a new Federal Science and Technology Strategy, building on the initiatives undertaken to date. The strategy will introduce the necessary reforms within the federal administration to encourage Canada's international competitiveness. Fourth, my government will convene a National Conference on Technology and Innovation to define new technology goals."

The Yukon must be prepared to participate in the opportunities that will arise out of these national initiatives for an increased application of science and technology for social and economic growth.

Our ability to remain competitive in the natural resources sectors and to build new industries will depend on our capability to apply existing and new technologies. New industrial opportunities will arise from innovation, and the application, adaptation, and transfer of appropriate technology. The Yukon, like the rest of Canada, must be ready and able to seize the emerging opportunities for economic growth. Economic growth is no longer a simple function of more and bigger projects as in the past. It will be increasingly dependent on information, research, and technological innovation and application.

The political and economic realities of the very recent past have provided Canada and the Yukon with ample evidence of the inherent weakness and vulnerabilities of our resource-based economies. These have been exacerbated by plummeting world prices for metals, oil and gas, and agricultural products. Some of our resource-based industries are so heavily subsidized that our competitors have been demanding, and getting, substantial tariffs against our products. Furthermore, we can no longer consider our non-renewable resources as infinite assets - many of the economically more viable deposits are already showing signs of exhaustion. We are also extremely vulnerable to foreign competitors who are vigorously developing materials to substitute for our natural resources - for example, ceramics and plastics for metals, new fibres for wood, and protein substitutes for meat. It is becoming increasingly evident that Canada and the Yukon can no longer rely on our natural resources to provide long term economic stability.

The problems facing Canada with respect to its reliance on traditional resource based economic sectors are magnified when viewed from the Yukon perspective. With very few non resource related industries the fragility of our future becomes all too apparent.

Added to this reliance on the resource sectors, and contributing to our long term economic instability, is the Yukon's heavy reliance on southern Canada for goods and services. The resulting import leakages seriously weaken attempts to develop economic stability and self reliance.

It is clear that our economic base must be broadened to incorporate new, non-traditional industrial sectors. It is also clear that the Yukon's dependence on outside suppliers and services must be reduced. It is further known that existing sectors must be made more efficient in order to remain competitive.

Most nations and all provinces of Canada have recognized that in order to meet the challenge of the future more and more attention must be paid to research and development and to the application of existing and new technologies to the economic opportunities and realities existing in specific regions.

In Canada, all jurisdictions are working extremely hard to identify existing economic sectors requiring an infusion of research and development and are finding ways to use technological change and innovation to create new industries appropriate to the capabilities of the regions.

In Canada today the federal and provincial governments spend over 4 billion dollars annually in research and development in order to support the goal of economic and social development and renewal.

A lot of money. Yet Canada's international competitors on average spend almost twice as much per capita as we do.

## II. Research and Development in the Yukon

Current status While some \$4.1 billion is spent by governments on research and development and science and technology each year in Canada, little finds its way north. Even less is devoted to the particular problems facing northerners. While some funding is available for specific projects under EDA agreements there is no concerted, coordinated R and D strategy.

The reasons for the Yukon's inability in the past to access the substantial funding available are manyfold and have included:

- a) The lack of a locally based public and private sector research infrastructure.
- b) The absence of a comprehensive Yukon Science Policy and related programs.
- c) The tendency of the federal government in recent years to concentrate on "high tech" industries.
- d) The lack of a university or college where pure research may be carried out.

Some of these constraints have recently been weakened by local developments. The Yukon Government has for example, adopted a science policy which can lay the groundwork for the development of an R and D strategy. The Government is also pursuing with the federal government, options for the establishment of an appropriate infrastructure and programs designed to foster R and D and science and technology.

At the same time the Yukon Science Institute has been established. This private sector organization is made up of a concerned core of dedicated lay people and professionals who have taken it upon themselves to further the cause of science in the Yukon. They have volunteered their time and expertise to create an organization to "encourage, promote, and support research on scientific, engineering, medical, and socio-economical matters that will contribute to the achievement of the social and economic goals of the people of the Yukon Territory." The Yukon Science Institute, like its more established counterpart in the NWT, could be a very significant factor in shaping the future of science and technology in the Yukon.

Still, roadblocks remain. Not the least of which is the development of priorities for a R and D program. Research and development and the transfer of technology must reflect the economic and social priorities of the Yukon. For example there would likely be little point in the Yukon investing heavily in research into high tech industries. On the other hand significant work can be done in such areas as mining, forestry, agriculture, wood product manufacture, construction, remote sensing and tourism, to name a few.

## Future Directions

### General

No one is under the illusion that the application of science and technology or increased R&D activity will bring a quick and permanent end to Yukon's socio-economic problems. An immediate and large infusion of dollars for S&T and R&D would be a solution that could not resolve the problem because the mechanisms for its implementation simply do not exist. It would be analogous to implementing a health-care system without administrative support personnel, health-care professionals, hospitals or nursing stations; or, an education system without teachers, administrators, or schools.

However, we are not unrealistic in our expectations that the development of an organization and infrastructure to support research and development in the Yukon will yield substantial dividends. Dividends and benefits, it must be added, that the rest of Canada and other parts of the North have come to expect as a natural outcome of the research and development activities in their regions. At the same time, we know that Yukoners do not labour under the illusion that we can compete with the Southern industrial-technological complex; nor do we believe that our higher education-scientific capabilities can, or for that matter, should match those of Southern Canada. However, that does not mean that we have to stand still and watch all the technological developments relating to the North take place in the South. Nor does it mean that the Yukon should not work strenuously to develop its own research and development programs that focus on those areas of specific concern to the Yukon's social and economic development.

The Yukon could in fact become the leader in some forms of R and D. For example, while placer gold mining is a minor economic sector in many regions it remains a critical component of the Yukon's economic base. The development of a specific R and D program directed at this industry could lead to the Yukon becoming a world leader in placer mining innovation. The development of new and improved mining technologies would be a boom to an industry that has changed little in centuries. This technology could then be exported, creating an additional industry for the Yukon.

Similar efforts could be made in the fields of northern agriculture, construction, fur farming, aquaculture and others. Yukon could, by concerted R and D efforts in these areas, become the innovator as opposed to simply being a user of southern or foreign technology.

### Opportunities

To this point, no Territorial administration has ever seriously considered a policy of systematically applying S&T and R&D to further Yukon's socio-economic development. The adoption by the present administration of a Yukon Science Policy is a fundamental first step in the right direction, provided that these policies lead to concrete programs and projects. In its Science Policy the government has outlined a course of action that could quickly integrate the Yukon into the mainstream of the Canadian research and development scene.

While opportunities for technological innovation do exist in the Yukon, its application seems to be more a question of economic survival rather than one of industrial competitiveness. Study after study has shown that economies based on primary resources are in serious trouble. The evidence is all around us: - falling wheat sales in the Prairies, the besieged lumber industry in B.C., the virtual collapse of the oil and gas industry on the East Coast, the Beaufort Sea, and in Alberta and shutdowns and lay-offs in mining industries across Canada.

The Federal and Provincial Research Organizations and their political leaders are aware of this and recognize that something must be done. Both levels of government are channelling increasing portions of their time, money, and manpower to seeking ways of improving the resource-based industries. Considerable attention is being given to maintaining our traditional share of the world market for natural resources. Options being explored include the application of the latest technologies to improve productivity, more efficient extraction of resources, and exporting a more value-added product. The Yukon cannot afford to do any less.

Currently, significant advances are being made in a number of fields of interest to the Yukon. Among them are:

#### Biotechnology

Relatively small research groups can quickly gain the critical expertise necessary to create a foundation for commercial opportunities in this field. In the Yukon potential applications exist in forestry, mining, agriculture, and fur and fish farming, to name a few. For example:

- a firm in Québec has successfully used microbial fertilizer technology to produce trees which grow rapidly in poor soils. Millions of such trees have been used in reforestation projects at the Manic 5 and James Bay hydroelectric sites.
- a firm in Ontario is carrying out a demonstration project to assess in-situ microbial leaching of minerals.
- researchers at the University of Utah have learned to control the reproductive cycle and the fertility of fur-bearing animals in captivity. They have succeeded in identifying and synthesizing the chemical that triggers the reproductive cycle when introduced into feed. Litter sizes were increased by 50 to 100%. The implications for fur farming are obvious.
- a Toronto firm has developed vaccines to prevent disease in fish farming. Other fish-health products aimed at the aquaculture markets are also being developed. A salmon-sex test is also under development for fish farming.

#### Satellite Technology

A couple of dramatic developments in satellite communications could have a significant effect on socio-economic development in the Yukon. First, technological developments are expected to make mobile satellite services (MSAT) a reality in a few years.

The new service, which appears to have great potential for the Yukon, will make it possible to communicate by radios which are installed in vehicles or ones that can be carried in backpacks to any point on the North American continent. Economic spin-offs can be expected from applications in:

- the provision of government services to industry and the general public in remote regions and small settlements;
- distance education and tele-health services;
- communications, navigation, and position location services for search and rescue, outfitters, hunters and trappers, tourists, etc.

Second, the rapid evolution of remote sensing satellite systems (eg. RADARSAT) will provide our resource managers with exceptionally accurate data in the fields of forestry, hydrology, and geomorphology. Both programs, MSAT and RADARSAT, are expected to be operational in the early 1990's; both offer the Yukon exciting opportunities for participation in these high-tech developments. For example, the Yukon should become involved in any plans the RADARSAT program may have for this Territory with respect to the provision of reference data for validating the satellite gathered information. Ground truth data gathering systems designed to operate in extreme conditions will be a vital component of the RADARSAT program. That, and the integration of remote sensing data with in-situ data, is an area where Yukoners could make a useful contribution to, and reap economic benefits from, the program.

#### Tourism

Tourism is obviously a very important pillar of the Yukon economy. A more sophisticated application of the latest research techniques (in sociology, psychology, demography, etc) may make it possible to identify that portion of the world's travelling population that would be most likely to enjoy a Yukon vacation. Advertising and marketing campaigns could then place a greater emphasis on this sector of the potential tourist population.

The above is only a representative outline of a few of the potential opportunities for research and development in the Yukon. And as such, it makes no pretense to be a thorough study of the many possibilities; however, one hopes that it is sufficient to stimulate further debate and to elicit additional ideas on how we might use research and development as one means for socio-economic renewal in the Yukon.

In addition to the above it should be noted that a great deal of effort is expended in northern research by the Scandinavian countries and by Russia. To this point the Yukon has paid little attention to the potential for the adaptations of new technologies developed by these countries. Efforts should be made to investigate further applicable R&D being carried out in these countries and its potential for the Yukon.

#### The Next Steps

In setting the course for the Yukon's economic future a number of decisions will have to be made and questions asked regarding the role R&D and science and technology will play. Already certain steps have been taken.

As mentioned earlier, the Territorial Government has accepted and approved a Yukon Science Policy. In it, the government attaches considerable importance to science, research, and technology as being among the prime movers of economic revival and socio-economic development. Their overall goals and objectives for science and technology in the Yukon are clearly identified and thus the policy framework for research and development in the Territory is already in place.

A Yukon counterpart of a Provincial Research Organization would appear to be a fundamental prerequisite if the Territory intends to become an active participant of the Canadian research and development community. For example, the government will have to consider some sort of formal science organization if it wants to access and use the available research grants and subsidies. An administrative mechanism will be required in order to tap Southern sources of funds and information.

The successful application of S&T to the economic renewal of a country or a region requires more than simply additional tax dollars or government reports extolling the benefits of technological innovation. A scientifically literate society and a technologically well-informed public is just as important. Public understanding and support are essential ingredients of any technology development strategy and hence of economic strategy. We must pay special attention to communicating science and technology developments to the public with the overall objective of raising public awareness of the importance of S&T to their everyday lives. To make informed political choices in technological matters, a greater degree of scientific culture and literacy is needed by the population at large - science education should start at the earliest school level.

In general, our educational system has not given its citizens even a modest understanding of the simplest concepts in the physical or biological sciences. This is because the primary school curriculum does not provide it, and the teachers themselves do not have it.

In the secondary school system, the freedom given to students to choose among many options makes it impossible to ensure that all secondary school graduates understand the basics in these fields. This goal could be achieved by having a set of core science subjects that all students must take.

Among the questions that need to be answered before R&D and science and technology become active components of social and economic renewal are the following:

1. How much emphasis should be placed on R&D?
2. Where do public and private sector responsibilities lie?
3. What are the priorities for R&D in the Yukon Today?
4. What will the priorities be by the year 2000?
5. How best should R&D be coordinated?
6. What mechanisms and infrastructuve are required for the successful development and delivery of R&D and technology programs?
7. What types of programs would be appropriate for the Yukon?
8. What should be the relationship between R&D programs and the education system?
9. What are the social issues facing the Yukon that require a significant increase in R&D?
10. How do we best create a local climate condusive to innovation and entrepreneurship?

### Conclusion

This paper has not attempted to explore the full dimensions of the importance of Research and Development and Science and Technology to the Yukon's social and economic future. The Yukon has only recently awakened to the critical need to incorporate R&D and S&T into its economic planning. A great deal more needs to be done before the Yukon can effectively take advantage of existing technological advances and before it can begin to develop its own new approaches to its economic sectors.

The paper does hope to stimulate discussion on how best to continue in the development of a climate that will stimulate R&D and S&T in the Yukon. It also hopes to stress the clear message that continued reliance on traditional resource based industries can only result in continuing economic instability. The traditional resource industries need to be made more efficient and competitive if they are to continue to be the cornerstone of our economy. R&D and the application of new technologies can help achieve this end. At the same time Research and Development and new technologies must be applied in developing new industries applicable to the Yukon's economic potential and opportunities. The challenge for the Yukon is to find the proper mechanisms that will allow R&D and S&T to effectively contribute to our economic future.

The paper has as well, not explored the very clear need for an increased R&D effort in social development. Much work is required in the areas of northern health, culture and language, social welfare, and education to name a few. Currently what work that is being done in these areas is done without significant focus and usually by southern academics. Yukon needs some way to direct such work along lines that are appropriate to Yukoners' aspirations and that are appropriate to the realities of the Yukon.

Finally the paper has not fully developed the urgent need to ensure that the Yukon's R&D and S&T initiatives are developed as a close and on-going partnership between government and the private sector. The nature of this relationship must be carefully established if our R&D efforts are to be effective and appropriate to the Yukon's goals for its economic future.

## Appendix 1. Yukon Science Policy

### Foreword

The need for a Yukon Science Policy arose from this government's recognition of the global importance of science, research and technology as the prime movers of economic revival and socio-economic development. It has been estimated that as much as two-thirds of the recent economic growth in Canada has been attributed to technological change and there is every reason to believe that its influence will grow.

A Science Policy is a fundamental first step towards developing our indigenous scientific and technological capabilities and integrating these into the mainstream of the research activities of the national and international scientific communities.

Our Science Policy is a clear signal to the federal science organizations, the granting agencies, and the universities that we are preparing to take a more active role in determining the nature and scope of science in the Yukon. The goals of the policy include the eventual establishment of a "science presence" and infrastructure within the government to: a) attract the scientific projects and personnel, programs, and funds to help further the Yukon's socio-economic development; b) attract and promote science programs that can create new educational opportunities and incentives for Yukon students; and, c) strive for the establishment of a Yukon-based scientific resource centre, essentially independent from government and industry, that is capable of conducting sound research on northern issues as defined by northerners and their institutions.

We are in the very early stages of developing a strategy on how best to employ science and technology as tools of the economic engine. Our resource-based industries need innovative methods to reduce costs and to increase productivity if we are to maintain or increase our share of the market.

The development of new technically advanced industries must be encouraged wherever these match the natural advantages of the Yukon. For example, new methods of locating, processing and refining metal ores could revitalize marginal operations. Innovations in the chemical and bio-technological leaching of precious metals could radically change the face of our metal industry; and, recently, startling advances have been made in controlling the fertility and reproduction of fur-bearing animals in captivity. We need a Yukon-based science capability because it is important to know what others are doing and to judge whether their advances can be usefully applied at home.

The publication of a Yukon science policy will demonstrate to the Canadian science community that we have formulated clear and specific goals and objectives for the role of science and technology in territorial affairs. It will show that the Yukon is taking positive steps towards becoming a serious contender for the available research funds and scientific support services. It will serve notice that we are preparing the groundwork for the devolution of federal science programs and the associated regulatory functions of federal science departments.

A statement of policy in itself is only the beginning of our efforts to ensure that science and technological adaptation become components of our long term social and economic strategy. On the basis of this policy, specific actions will be taken to help us reap the benefits that science and technology can provide. Through the development of such activities and programs the Yukon will be able to look forward to the future with the confidence that it is capable of taking advantage of the limitless opportunities science and technology offer.

Tony Penikett

### YUKON SCIENCE POLICY

#### Basic Principles

A Yukon Policy, like all other public policies, is based on the three basic objectives of society in general: a) cultural enrichment, b) economic growth, and c) public welfare.

- a) The advancement of scientific knowledge can play an increasingly important role in moving towards the goal of cultural enrichment. It is often said that basic research is a purely curiosity driven activity that has no practical purpose. Granted, a practical mission is not the primary objective of fundamental research but it does have a clear and definite purpose - scientific discovery and the advancement of knowledge. And that makes it an essential element of our cultural life and civilization.
- b) Society's other interests in research and development center around the two broad categories of the innovation process. The first of these is aimed at the market place and is more related to economic growth. It is the natural result of industrial research and development.
- c) The second category of innovation is aimed at solving broad social problems such as health, crime, poverty, poor education, and pollution. Thus, innovation in the social sciences for the public welfare constitutes another major goal of research and development and therefore of science policy.

With these broad social goals in mind, we can make some general statements on the guiding principles for a Yukon Science Policy. The overall science policy goal for Yukon is the creation and development of an independent research organization and infrastructure that can:

1. Identify research gaps and opportunities; plan and manage the resulting scientific activities and programs; and, evaluate the results.
2. Encourage scientific activity and research that will effectively contribute to: a) the protection and enhancement of Yukon's superb and spectacular environment; b) the attainment of balanced development; and, c) the enhancement of the quality of life in the Yukon.
3. Create and maintain an intellectual environment that will attract, promote, and support scientists and academics from home and abroad.
4. Lead to the development of an indigenous scientific community.

Additional overall tasks of a Yukon Science Policy are:

1. To maintain an integrated network for scientific and technological information on what is happening in the Yukon and elsewhere;
2. To ensure that the Yukon scientific establishment is adequate relative to national and international developments in science and technology;
3. To provide a balanced supply of scientific manpower and facilities relative to Territorial requirements;
4. To ensure a proper balance between scientific disciplines; between pure research, mission-oriented research, and development work; between government, industry, and the universities as performers of research;
5. To prevent over-expansion in certain areas of research and development and to identify and fill significant gaps in others; and
6. To ensure co-ordination in the overlapping needs of government departments where multi-disciplinary and inter-departmental programs are essential.

#### Some Specific Objectives

The following statements of objectives are meant to provide direction to Government of Yukon science activities and programs in pursuing the overall policy goals and tasks as described above.

1. Strive for the establishment of a Yukon-based scientific resource centre, independent from the federal government and industry, and capable of conducting sound research on Northern issues as defined by Yukoners and their institutions. The creation and development of independent research facilities together with close links to other northern and polar research institutes is the key to the development of a capable Yukon-based science community.
2. Give priority to the active recruitment and training of interested Yukoners with the objective of supporting the establishment and maintenance of a strong Yukon-based science community. We should develop incentives and provide stable educational opportunities for students to train in and enter professional careers in science.
3. Ensure that government research programs and activities lead to levels of industrial and resource development that are ecologically sustainable, environmentally safe, socially acceptable, and economically sound. If balanced development is to be achieved, our science programs must keep pace with industrial activity. A much greater effort is needed in basic research on northern ecosystems and the socio-economic and environmental effects of industrial activity.

Research, intelligence, and monitoring programs are also needed by both government and industry to allow timely responses to unforeseen impacts and developments.

4. Ensure the timely availability of science-based information for development and the accompanying environmental regulatory process. There is a need for an information centre to serve as a repository and clearing house of scientific information and to quickly and efficiently disseminate the results of research to the public.

It is important that Yukoners have ready access to public information produced by the scientific community. Well-informed citizens and groups are a key element of the successful implementation of many public policies and programs. This can be done through original research, the establishment and maintenance of long-term data bases, through data acquisition links with Southern information networks, and the establishment of a Yukon-based scientific reference centre. Supporting conferences, symposia, seminars, workshops, and lectures are other excellent means of information dissemination. Encouraging organizers to convene such meetings in the Yukon can have additional benefits.

5. Increase the level of research to improve baseline data and the understanding of natural ecosystems, thus leading to a more effective management of our renewable resources and more balanced development. There is a need to establish and operate long-term research sites in relatively undisturbed areas of Yukon for uninterrupted monitoring of natural and man-made changes.

The government's scientific data bases are frequently based on short-term impact studies, and there are not enough qualified scientific personnel within its ranks to interpret industry's research methods and conclusions. Too often, industry's data bases and interpretations are the only information available for government decision-making. The effectiveness of government planning (whether in the regulatory process, land-use, or development) is vitally dependent on ready access to unbiased and up-to-date information.

6. There are issues in science which require federal, provincial, territorial, or international cooperation and action. The most notable of these are the ones concerning river systems and fresh-water resources, migratory species, the marine environment, and air quality. It is particularly important that we cooperate with our Canadian and circumpolar neighbours in the development and exchange of scientific information needed to manage these emerging issues.

7. Ensure that government research programs and activities contribute effectively to the protection and enhancement of Yukon's spectacular and unspoiled environment. The welfare of every human being is vitally linked to the quality of the natural environment, making this a very important and complex issue. The issues surrounding man-environment relationships and government response to them are particularly relevant in the Yukon. Here the relationships between environmental realities and human activities and welfare are very direct. As environmental quality deteriorates so do the social, physical, psychological, and economic indices of society's well-being. Northern ecosystems are particularly vulnerable and there is little leeway for error.
8. Increase the level of research in the social sciences to promote social innovation and to enable Yukoners to improve their welfare and the quality of their lives.

The Canadian North has a social environment that is often classified as a frontier, a place with a less entrenched social establishment, where social mobility is easier to achieve, and where rapid socio-economic changes create significant upheavals in the social order.

The unacceptably high rates of suicide, homicide, accidents, alcoholism, abuse, and unemployment among northerners are all indicative of a highly stressed society. The traditional modes of adaptation are clearly no longer adequate and the newly emerging modes are but poorly understood.

These problems have reached epidemic proportions in the North. There is an urgent need for fundamental research in the social sciences to uncover the roots of these problems and, more importantly, to find acceptable solutions.

9. We need a cooperative research strategy involving all sectors of the research establishment operating in the Territory. The fragmentary and independent approach of past projects will, of necessity, be replaced by more coordinated research efforts. Effective coordination can prevent duplication, increase efficiency, and facilitate exchanges and transfers of data and information between government, industry, and academic organizations and scientists. The successful solution of an ever increasing proportion of research problems is dependent on a multidisciplinary or interdisciplinary approach, making the role of coordination that much more important.

10. There has been insufficient emphasis on the role of economics in interdisciplinary research regarding energy and mineral development, renewable resources, and transportation systems. It is difficult to apply conventional theories of economic development to Northern situations because little is known of the unique problems of developing vast, remote, and sparsely settled regions. The natural environment is harsh and precarious, and physical access is limited by environment, technology and cost.

There is a need for a careful re-examination of our development experiences with past "boom and bust" projects. Objective cost-benefit analysis are needed to clarify the real costs of these projects to society. We should weigh the immediate and obvious benefits of resource development (employment, increased economic activity, etc.) against the ultimate costs to society (social upheavals, pollution, environmental damage, etc).

We must also find means of evaluating the economic worth of Yukon's wildlife, spectacular scenery, and superb recreational opportunities. The final net worth of these amenities may be many times greater than the short-term benefits of resource development. Economic research and analysis are needed to clarify the relative and long-term merits of investing in resource development versus banking on Yukon's recreational and tourism potential. Standard economic analyses are not applicable to measuring the true value of these amenities. More interdisciplinary research is needed to develop new techniques for evaluating their worth to society in the real terms acceptable to policy makers, planners, and developers.

11. Strive to ensure, whenever possible and/or practical, that government research programs and scientific activities support and complement the science programs provided by the Territorial school system. We should endeavour to provide the educational opportunities and incentives to encourage careers and provide the manpower needed to Northern science and engineering.

Some of the ideas and concepts found in this document have been used in other places, at other times, and for different purposes. We respectfully acknowledge our indebtedness to the public servants and scientists who have shown us the way. While we cannot claim total originality, we readily accept the challenge of implementing these ideas under our unique Northern conditions and circumstances. A Yukon Science Policy is a first step towards creating and developing a science presence and infrastructure in the Territory.

To that end, all of our options are open. We can learn from the mistakes of the scientifically more advanced regions of Canada, and we have the enviable opportunity of doing things right.

## Appendix 2. Some definitions in science, technology, and innovation; research and development

### Science

Science is the rational and systematic understanding of man and nature. Its goal is to explain human and natural phenomena as they are and to formulate empirically verifiable laws accounting for their behaviour. Basic scientific research is essentially a passive and contemplative activity attempting to discover what already exists. It produces knowledge, not tangible results. The natural fruit of science is always good and its impact on society can only be beneficial(1).

### Technology

Technology is the organization of knowledge for the achievement of practical purposes(2). The search for new technology is aimed at changing man and his environment through the development of new products, new processes, and new ways of doing things. It is essentially active and creative. A scientific theory is true or false according to whether it accounts for reality or not. A new technology is good or bad according to whether it can improve reality or not.

### Innovation

Innovation is the first use of new technology - the introduction for the first time of a new product, a new process, or a new way of doing things.

There is evidence to suggest that the average time for the transfer of science to technology has been about 20 to 30 years, and from technology to innovation about 9 years(2).

It is helpful to differentiate between five categories of activity usually included under the general heading of research and development:

1. Pure basic research
2. objective basic research
3. applied research (project)
4. applied research (operational)
5. development

However, there can be no clear-cut line of demarcation between one form of research and another; basic research and development are opposing bands of a continuous spectrum. Furthermore, most organizations engaged in research are involved, to some extent, with the whole range of research and development.

1. Pure basic research is carried out solely to increase scientific knowledge.
2. Objective basic research denotes research in fields of recognized potential technological importance. It is primarily stimulated by technological needs.
3. Applied research (project) has as its object the attainment of a practical goal such as a new process or piece of equipment.

4. Applied research (operations) has as its object the improvement of an existing process or piece of equipment.
5. Development bridges the gap between research and production. Development will often include the implementation or erection of pilot projects; it may involve the construction of a prototype.

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YUKON 2000

'AN ALTERNATIVE R AND D PROPOSAL  
BASED ON INDIGENOUS SKILLS AND APPROPRIATE TECHNOLOGY'

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Draft Discussion Paper  
Prepared for the  
Yukon Economic Development Strategy  
Fall Conference

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AN ALTERNATIVE R AND D PROPOSAL  
BASED ON INDIGENOUS SKILLS AND APPROPRIATE TECHNOLOGY

While southern-based research and development and science and technology go hand in hand, this does not necessarily mean that all northern-based research and development should follow the same approaches and utilize the same concepts. Arguably, a Yukon research and development policy should also contain enough scope for appropriate technology to be developed along with high technology, and for local thinkers and experts to offset, to an appropriate degree, the contributions of southern experts. It is not enough for Yukon to strive for research and development along southern means because Yukoners often perceive different ends.

Many other regions of Canada, notably the Northwest Territories and rural areas of the Maritimes, also must cope with the isolation from markets, small population base, and limited economic base that characterize the Yukon. In developing an alternate research and development proposal based on indigenous skills and appropriate technology, there are several useful recent experiences to study and compare. One example of such efforts is underway at St. Francis Xavier University in Antigonish, Nova Scotia, where the Extension Department offers the annual Topshee Memorial Conference aimed at "building solidarity and coalitions for social and economic betterment". The conference is really an opportunity for organized labour, credit unions, cooperatives and the provincial government to meet to collectively influence economic development - in its broadest sense, this too is research and development planning. The Topshee Memorial Conference is now in its third year and seeks to promote continuous research and development discussions at the grassroots level. Implicit in this approach is the value placed upon local wisdom.

Another similar venture is underway in the Mackenzie Valley, where the Shihta Regional Council and the Beaufort/Mackenzie Delta Development Impact Zone Society are meeting to plan a strategy for community-based economic survival in the wake of falling oil and gas prices. Both organizations are starting with local workshops to bring together community leaders, entrepreneurs, native organizations and the general public to examine strategies in the cause of developing a Western Arctic economic strategy.

This strategy would include suggestions relating to community and regional infrastructure, industry infrastructure and training programmes which would help the region economically in the short term while investing in the long term growth and prosperity of the Western Arctic  
(Shihta Regional Council Informer, first issue, 1986, p.7).

While importation of the latest technologies and adding value to locally extracted raw materials are of obvious benefit in many southern locales, it is important not to underestimate the issues of proximity to market, cost of labour, and cost of technology importation in northern regions. While extensive southern research and development has made production of northern oil and gas reserves technically feasible, construction of the necessary transportation systems is prohibitive in the current market regime. Southerners do not always have all of the answers. There is a lesson here in the importance of sustained development and benefit as a result of research and development expenditures. As far as possible, they should be made in economic sectors for which there is the possibility of sustained production and delivery to local buyers in local markets.

Another dilemma associated with open or unquestioning acceptance of southern research and development/science and technology schemes is the conscious promotion, often bordering on zealotry, of science courses (and careers) in the school system. This promotion is often linked to potential career earnings, job stability, and status in society. Instead of choosing careers based upon their interests, many southern students are being advised to focus on engineering, computer science, allied health programmes and pure science. Paradoxically, 1986 marks the year that Canadian college students have begun a swing back to the general arts programmes so favoured in the late 1960's and early 1970's. Some southern educators are beginning to speculate that in times of economic stress and structural economic change, wise generalists will be favoured in the job market over focussed specialists. Paul Hawken (The Next Economy, 1983) advises today's students to seek a broad, generalist training in disciplines that they love, because the next economy (the information as opposed to smoke stack economy), will be led by those who are the most intelligent in their field. "This intelligence will not be a measure of IQ, but a measure of how thoroughly our lives and work are integrated" (ibid., p.185).

Having reviewed some of the downside of importing unquestioned southern science and technology to the Yukon, it remains to speculate on how best to integrate an alternate research and development programme into the goals of YUKON 2000. In basic terms, an alternate programme would be based on economic sectors chosen by Yukoners with direct, relevant experience in those sectors. It would build upon existing expertise, and focus on stemming dollar leakage from the Yukon economy, at the same time as enhancing local management and financial control. Such a programme would work to strengths that are already apparent.

## OPPORTUNITIES FOR ALTERNATE RESEARCH AND DEVELOPMENT IN THE YUKON

### 1) Tourism

Yukon is rich in unspoiled wilderness, a commodity in increasingly short supply. Given the emerging trend to non-consumptive, adventure vacations, l'auberge-style accommodation, and knowledgeable personal service, tourism research and development studies should focus on demographics of next economy tourists. Ecosummer of Vancouver, Blythe and Associates of Toronto and Lindblad Expeditions of New York are pioneers in specialized tours featuring a high degree of personal service. Their success deserves study and more locally controlled application. While the gold rush romance continues, and is undoubtedly a primary draw for Yukon tourism, next economy tourists will likely be seeking more local value added services, skill acquisition, and the wilderness experience.

The recent development of "church supper" restaurants in Prince Edward Island, Native Indian tour companies in the Queen Charlottes and the Mackenzie Valley, and adventure heritage tours in Alberta (led by Canada Everest Team members), demonstrates the emerging potential of next economy tourism. To fully take advantage of the new market, research and development studies of its characteristics should begin now.

### 2) Northern Building Science

While the challenges of northern housing construction have long been apparent to northerners, for too long the design, supply, and even construction of housing have been in southern hands. In the early 1970's, the Arctic Institute of North America sponsored two workshops on building in northern communities, with an emphasis on the processes of application of research and experience to the solution of ill defined problems. Topics

covered in the two workshops included foundation design and permafrost, northern climate and environmental design, pollution control, energy conservation, factory built structure and building systems, psychological problems and northern design, community planning, community participation, and planning as a means of cultural survival.

Given the perennial problem of professional job turnover in the north, many (if not all) of these topics are still current today, and deserving of locally controlled research and development studies on a continuing basis.

When appropriate building technology is developed in the north by northern users, it arguably has a better chance of adoption and use by other communities of northern users. Here is a classical opportunity for local value adding and marketing.

### 3) Agriculture

While Pierre Berton occasionally mentions the topic in connection with his parents' vegetable garden in Dawson City, northern agriculture research and development is a topic deserving of more local initiative. Recent developments by Sprung Instant Structures Ltd. and Sprung Enviroponics Ltd. of Calgary have advanced greenhouse design for northern climates to the point where year round production of vegetables is commercially viable in Calgary, and potentially so in regions north of 60 degrees. Recent advances in hydroponics have further reduced growing time to harvest maturity and the need for an inert medium to provide mechanical support for growing vegetables. Research and development in this field could make considerable contributions to stemming dollar leakage caused by the importation of southern foodstuffs, and once again contribute to the development of northern expertise for sale to other northern markets.

#### 4) Entrepreneurial Skills

While research and development as a concept is predicated on entrepreneurial values for its application, those values and their development are often ignored in the school system. This lack of support is irrational given the Canadian record of small business in net new job creation (66%), and the tremendous growth of the Canadian service sector. In 1985, just over seven in ten working Canadians were employed in the service sector, more than 1.8 million more than a decade earlier, a 31% increase. It is also interesting to note that there has been virtually no growth in employment in goods producing industries (Tomorrow's Customers, 1986, p.7). The single greatest increase within the service sector was in community, business and personal services - the traditional domain of small business.

Dr. Marilyn L. Kourilsky, Dean of Teacher Education at UCLA's Graduate School of Education, has recently created the Mini-Society Programme - an innovative method of teaching the basics of business and economics to elementary school children. This programme is really a grassroots research and development project to instill risk taking and entrepreneurial values in grade school. Dr. Kourilsky's research shows that 25% of kindergarten children demonstrate entrepreneurial talent in that they consistently show qualities usually identified with business success, such as risk taking and the need for achievement. By high school, however, the 25% has fallen to about 3%. Something is happening along the way in the education process, and we need to study how the risk takers become risk averse. It is worth noting that more than half of the states in the USA now require economics courses for high school graduation, including California, which passed such a bill in January (Across the Board, September, 1986, pp.44-49).

Given that big business and big government will not be engines of economic growth in the information economy, research and development should focus on means of instilling small business values and capabilities in the current generation of northern students. If current trends continue, this research and development investment may out perform all the rest, yielding a total attitude change in favour of creating employment and wealth instead of depending upon big institutions for its delivery.

#### CONCLUSIONS

This brief consideration of alternate research and development options for Yukon has focussed on basics: food, housing, education and wilderness values. The hypothesis of the paper is borrowed from E.F. Schumacher, namely that world economies must start to devise technologies that are more in harmony with people, and with the environment, and less dependent on non-renewable resources. For more detail on the emerging alternate research and development in Canada, the reader is recommended Chapter 6, "Canadian Initiatives", in George McRobie's Small Is Possible (1982), the sequel to E.F. Schumacher's Small Is Beautiful. Of particular interest to the author is the section on Prince Edward Island, describing a classic example of the "hinterland effect", the destructive impact of large scale technology upon the structure of a community that is on the periphery of a centralized metropolitan economy (*ibid.*, pp.169-174). There are potential lessons here for Yukon.

Faced with the prospect of increasing economic dependence on the south or developing an indigenous research and development policy for Yukoners and northern markets, based on local resources and local needs, the choice seems obvious. In Prince Edward Island similar arguments and choices led to the creation, in 1975, of

the Institute for Man and Resources, an independent, non-profit organization with a mandate to:

develop, test and assess appropriate energy systems based on solar, wind, water biomass and other sources;

identify potential benefits from local manufacture of equipment related to these systems;

develop, test and assess appropriate food and crop production, transportation, and shelter systems which will reduce use of non-renewable resources and inappropriate equipment;

provide service and assistance to individuals, groups, communities and governments in making appropriate resource management choices;

test and evaluate new inventions for the better use of renewable resources;

gather and distribute information on appropriate food, shelter and energy systems; and

design and implement programmes and processes beneficial to the long term economy of Prince Edward Island and to other areas of the world.

The Institute now offers consultation services to the public and policy advice to the provincial government and is well into a comprehensive programme covering all aspects of its mandate. The work programme of the Institute is funded by a combination of provincial and federal groups, as well as private sector and individual donations.

The conclusion of this paper is that Yukon and Yukoners could benefit from the creation of a similar institute.

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