

# Brief to the House of Commons Standing Committee on Industry, Science and Technology

Submission by

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and

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## Part One: Science and Technology Applied to Peace

Concern for mankind himself and his fate [humanity itself and its fate] must always form the chief interest of all technical endeavours ... never forget that in the midst of your diagrams and equations.

– Albert Einstein

This advice of the scientist-sage Albert Einstein to his Princeton physics students about science and technology could equally apply to others, including professors in other disciplines and politicians on science and technology (S&T) committees. The call for S&T to be practiced with *conscience* is the basis of our organization. Science for Peace was created by scientists in 1981 at a dangerous time of the Cold War, when a nuclear holocaust was a looming threat. Fortunately, sanity prevailed; the Cold War ended without a mushroom cloud but the possibility of nuclear explosions through accident or miscalculation remains and new threats have arisen. Along with these new and immense S&T challenges (like climate change), however, we also recognize new and tremendous S&T opportunities. Science for Peace is devoted to both reducing the negative impact that S&T has in human affairs and increasing the positive peaceful role of S&T.

In a world where deadly conflicts rage, S&T does indeed play both roles. For instance, some of the most advanced technologies in the world were used to target, bomb and invade Iraq. How sad that the fruits of decades of intellectual labour were used in a fashion that violated and denigrated international law, and continues to undermine our fragile human solidarity today. International law, like science, was built up over centuries but it suffered a setback that will take strenuous efforts for decades to overcome. Fortunately, international initiatives to control the negative uses of science are continuing.

The draft cluster bomb treaty, adopted by 111 nations in Dublin on May 30 [last Friday], provides a much needed step in limiting human barbarity caused by those sophisticated tools of destruction. It has been too long, over ten years, since any multilateral disarmament treaty has emerged. The 1997 Ottawa Convention that banned anti-personnel landmines gave considerable pride and prestige to Canada. The cluster bomb ban is a natural extension of the landmine ban

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since both weapons hurt civilians terribly through their wide area and long-term effects. Unfortunately, Canada was not a leader in this recent process and even sought to dilute the treaty. It turned from leader to obstructor, though it did, in the end, agree to the Dublin consensus. **We hope that Canada will pass laws to implement the strictest export regime for parts that could be used in cluster munitions, and find ways to make the treaty robust and effective.**

There is much positive that Canada could do for this treaty and for disarmament more generally with the political will to apply science and technology for knowledge-based peace-promoting action. Canada was once the world leader on verification research for arms control and disarmament. Unfortunately, the government's Verification Research Unit (VRU) was disbanded some years ago. But significant expertise still remains in the public and private sectors as well as our universities that can be harnessed for the important international cause of strengthening treaties. **We urge Canada to re-establish an arms control verification program and to incorporate treaty verification research into the work of the Defence Research and Development Canada (DRDC).** Thus, we will build on our past success, our current expertise and our hopes for a brighter future in applying science directly to peace.

Another important way that Canadian science can contribute directly to peace is through monitoring technologies for knowledge-based peacekeeping and humanitarian action. For this, our country's most advanced monitoring asset, Radarsat 2, could play an important role. We were greatly relieved that the Canadian government has stopped the sale of Radarsat 2 and its owner, MacDonald-Dettwiler & Associates (MDA) space division, to US arms manufacturer Alliant Techsystems (ATK). We thank the Committee for any influence it might have had on that decision. ATK boasts that it is the largest US manufacturer of munitions, and this includes cluster bombs. By contrast, an MDA working in the service of Canadian goals and traditions can do much good with recently-launched Radarsat 2, not only for our own territorial surveillance but for hotspots around the world. **Canada must continue to support Radarsat 2 and MDA, including by providing imagery to the UN.**

Radarsat 2 has the capability of monitoring virtually all places on the earth under all weather conditions day and night. In conflict regions like Darfur, the Congo and Haiti, the perpetrators of atrocities and human rights violations often use the cover of darkness to commit their heinous acts. The UN, which has peacekeeping operations in many of these areas, desperately needs the satellite imagery and other surveillance technologies. MDA has provided limited and so far disappointing service to the UN cartographic section for map production, but it could do much more to provide the world organization with new data that is operationally useful.

Currently, the UN carries out its important monitoring tasks almost exclusively with "the human eyeball on patrol." While the human presence is still needed, it is limited in viewing large areas, over remote terrain, at night and in locations too dangerous to tread. Yet technologies now in the possession of Canada, like Radarsat 2 and its Ground Moving Target Indicator (GMTI), can serve as a key enabler for surveillance under those difficult conditions. Canada may not be able to provide substantial numbers of soldiers for UN peacekeeping (it is now dropped to a disappointing 53<sup>rd</sup> place from its former number one spot and currently provides only 64 soldiers to the UN).<sup>2</sup> **But Canada can provide aerospace technologies** that will help the UN stop ethnic cleansing, protect refugee camps, verify peace agreements and make warlords think twice about becoming spoilers of peace processes.

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<sup>2</sup> Based on data available from the United Nations Department of Peacekeeping Operation at [www.un.org/Depts/dpko/dpko/contributors/2008/apr08\\_2.pdf](http://www.un.org/Depts/dpko/dpko/contributors/2008/apr08_2.pdf).

Similarly, uninhabited aerial vehicles (UAVs) could help greatly improve UN peacekeeping. Canada and other developed nations have not yet shown the political will to make such contributions.<sup>3</sup> As the Canadian Forces acquires a new set of UAVs, at least **a few UAVs should be deployed to assist the UN in peacekeeping operations**, where a small number can serve as much greater “force multipliers” than they would in Afghanistan, where the world’s most sophisticated militaries already have their assets.

The UN has only a few night-vision devices, mostly purchased from a Toronto-based firm.<sup>4</sup> But these are older-generation devices (Gen 2+) and **Canada could help equip the UN** with night-vision devices to the same level that any modern military in the developed world has come to expect. Canada could help in the development of radars for aerial and ground surveillance, and networked video to provide real time imagery of hotspots.

Your fellow parliamentarian Senator Lieutenant General (ret’d) Roméo Dallaire, when he was Force Commander of the United Nations Mission for Rwanda, complained about being “deaf and blind” in the field. He was not given the equipment he needed to confirm the forewarnings of impending genocide nor to prevent its horrific spread across the country. We remain guilty today for not giving the UN the technological and other tools to stop the Darfur tragedy. Technologies can be the “eyes in the sky” and the “ears on the ground” to predict the movement of Janjaweed militias, as a necessary first step to preventing their pillaging. Technologies are not currently—but they deserve to be—“tools of the trade” for UN peacekeepers. They ought to serve as the eye and ears of the international community as it tries to solve the world’s most pressing problems, moving peace processes forward and meeting humanitarian needs.

Although altruism is certainly a part of this great Canadian calling for peace work, there is plenty of national interest to be served as well. Firstly, the UN reimburses countries (in some cases generously) for equipment deployed on UN missions. Secondly, world conflicts become hotbeds for discontent, discrimination and terrorism, and it is in Canada’s interest to address conflicts before their effects reach our shores in our increasingly globalized world. Thirdly, as the US seeks the UN’s help to extract itself from the difficult situations it has found itself in Iraq and Afghanistan, it will improve our bilateral relationship to be a solid UN contributor. Lastly, the rest of the world will see that the technologically-advanced Canada is back as a leader in peacekeeping, ready to improve its considerable reputation and UN service, the one which is well illustrated on the back of the ten-dollar bill, which features a female soldier wearing a blue beret looking through binoculars underneath a banner motto “In the Service of Peace / Au service de la paix.” In the future, our peacekeepers could and should be using more than binoculars but the goal remains the same.

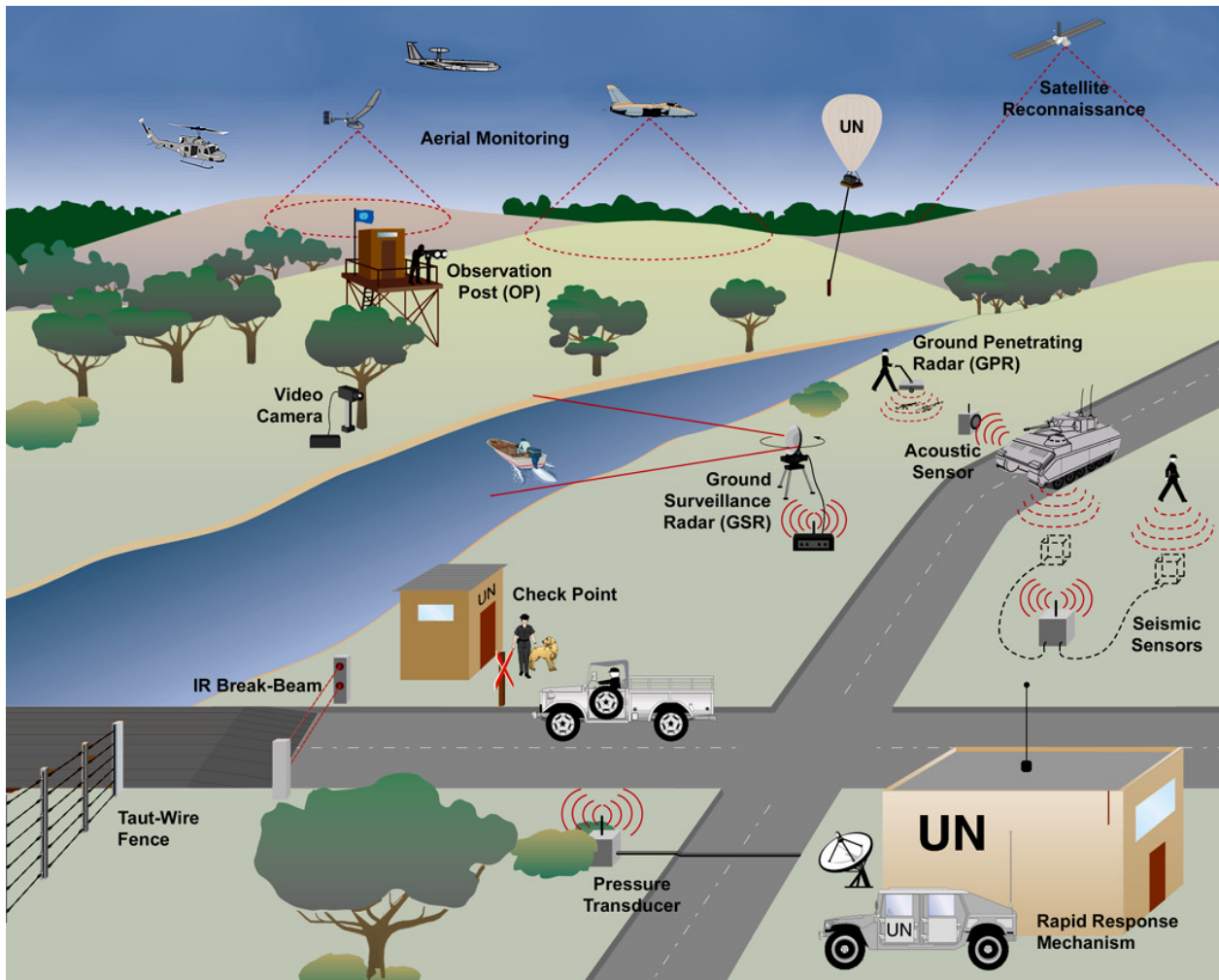
Figure 1 illustrates the range of technologies that could and should be explored in peacekeeping. Technologically-aided and knowledge-based peacekeeping is an area that is ripe for application. It requires only leaders devoted to the cause of peace with shared vision for science and technology. **Canada can lead.** Will Canada lead? That is in the hands, in part, of the politicians of Canada. As the UN waits, and lives are lost, can Canada afford not to say yes? As Einstein reminded us, concern for humanity should be the primary motivating force – we hope you will not forget this when you prepare your important report for parliament. There are many ways that S&T can be made a boon, and not a curse, for humanity.

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<sup>3</sup> Belgium is an exception. It showed international leadership by fielding a UAV system (B-Hunter type) as part of the EUFOR mission to assist the UN Mission in the DR-Congo (MONUS) during the fragile elections process in the summer of 2006.

<sup>4</sup> Newcon Optik Ltd of Toronto, [www.newcon-optik.com](http://www.newcon-optik.com).

Figure 1. Monitoring Technologies Much Needed for UN Peacekeeping



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## Part Two: Industry, Science and Technology for Sustainable Development

### I General Considerations

#### **The need for dialogue between Science and Government**

There has been no period in Canada in modern times when the need for communication between Science and Government has been greater, and gap between Science and Government wider. The closure of the Office of the National Science Adviser has been described as “the last straw” in the prestigious journal *Nature* (Editorial, 21, February 2008). The Government needs increase its exposure to independent scientific thinking. Also, there is an almost complete absence of scientists in parliament. We cannot examine the causes of such deficiencies, but surely this fact puts greater onus on parliament and the Cabinet to ensure it is well informed by science about the leading problems of today. These include the world’s deteriorating environment and the depletion of species globally and of virtually all resources. Overconsumption, especially in North America, is clearly central and is closely linked with global warming and other environmental problems. Ronald Wright (see below) refers to the “hemorrhage of waste” in the North American economy.

At the turn of the century, the Government set the National Roundtable on the Economy and the Environment (NRTEE) the challenging task of creating indices of environmental health, a task that NRTEE completed to its great credit about 2004. However, it is clear the Government has not understood the value of these indices, or the limitations on the type of projections that can be derived from them. The work of NRTEE expanded the understanding of “capital” to include not only natural capital and built capital, but also human capital, thus including human resources in their reckonings. The work of NRTEE could set Canada on the way toward a new approach to economics, a matter we shall return to below.

On the need for dialogue between Science and Government, five successive Federal Governments in Canada have chosen to minimize and even discard the clear evidence that climate change is a world emergency. This glaring truth, more evident each month, has been conveniently dumped onto the backburner of political expediency — see section on climate change, below.

We have asked, “What is current Government policy on the subjects to be addressed here?” and find some answers in research we have sponsored (Stephen James Kerr, draft paper to be published 2008). We draw the following list from how government spends its funds, rather than solely from statements of policy. Current policy would thus appear to be as follows:

- a) the growth economy must remain a primary goal of Canadian policy on research and development;
- b) industrial innovation is key to keeping the economy competitive;
- c) subsidies will continue to go mainly to the big players;
- d) scientific research in universities will more and more be directed to increasing commercialization of those institutions.

The above goals generally meet with applause from captains of industry, and would appear to favour corporate survival and profit, at least in the short term. However, they take no account of the support system for our industries, which is the ecosphere itself, or of the burgeoning world population. Suppose, as is projected by several models (Sergey Kapitza, *Global Population Blow-Up and After*, Club of Rome 2006; and Robert Hoffman, linear model using the Global Systems Simulator, private communication, 2007), the world reaches a maximum population

around 2110 of about 11 billion people and then begins a very slow decline, it is clear that an economic solution will have to be found. An expanding economy, as measured in the consumption of resources and energy, cannot possibly continue for any length of time beyond that date. In fact, growth would have had to begin its inevitable reduction long, long before that date. We argue that the fundamental goal of maximizing the growth rate of the economy is already at odds with that of preserving the health of the ecosphere and, in the medium term, of preserving civilization itself — which brings us to the subject of collapse.

Having studied the literature on the collapse of past civilizations, we make two comments only. First, all civilized societies that have collapsed have exhibited declining marginal returns in the pre-collapse period (Joseph Tainter, *The Collapse of Complex Societies*, CUP 1988), and second, our civilization is already in a pre-collapse mode (Ronald Wright, *A Short History of Progress*, House of Anansi Press 2005). The meaning of “diminishing marginal returns” is that it becomes more and more costly to obtain improvements in productivity. The pre-collapse phase, when failure is becoming evident, is characterized by the following three phenomena: a concentration of power, an increase in the gap between rich and poor, and an increase in militarism. All three of these features have been visible in Canada in recent years. In the United States, all three have been evident for many years. Wright (*loc.cit.*) also points out that new technology often sets the scene for more consumption, which exacerbates the problem of overconsumption. In his view, “the compelling reason to change our current [politico-economic] system is that it is in the interest of no one to maintain it. It is a suicide machine.” Thus technological advances, *per se*, are not necessarily beneficial, in the context of preserving civilization, and the need to change the politico-economic system is paramount.

We need criteria for assessing technology, and here the new paradigm will be helpful.

### **A paradigm for the 21<sup>st</sup> century**

The paradigm with which Western civilization developed and has thriven (when it wasn't engaged in wars) arose in the Age of Enlightenment, in which human dominance of the planet was taken for granted, and resources of all kinds, including the Earth's species were all thought of as subject to human control. Unfortunately, the industrial revolution was so successful that it enabled the human race to exceed its ecological footprint (see next subsection), something that hadn't been thought of until recently. In the process of rapid industrial and population growth, many species have been rendered extinct.

The new paradigm required today is very different in two essentials, though it must continue to be based in rationality. It must be founded upon the preservation of the web of life, recognizing that the creatures and other living species around us inhabit this planet by the same right as we, and that we cannot exterminate them without risk of doing the same to ourselves. Since everything we do is based upon Earth's resources, the capacity of the Earth to supply them must be respected at all times, notwithstanding inconveniences to those who think they should have anything they want at any time. This awareness of the capacity of the biosphere to supply needs is paramount when planning any enterprise. Unfortunately, most countries have allowed their consumption habits to exceed the ability of their natural resources to supply their lifestyles. A most useful concept in assessing such factors is ecological footprint.

### **Ecological footprint**

The concept of ecological footprint was first proposed by W.E. Rees, and has recently been considerably refined (in *Renewables-Based Technology: Sustainable Assessment*, eds. Jo De Wolf and Herman Van Langenhove, Chichester UK: John Wiley 2006, Chapter 9) where he states how the ecological footprint is now defined and ascertained. For a specified population it

is “the area of land and water ecosystems required on a continuous basis to produce the resources that the population consumes, and to assimilate (some of) the wastes that the population produces, wherever on Earth the relevant land/water may be located” (*loc. cit.*). The bio-capacity of the area occupied by the same population, by contrast, may be larger or smaller than the footprint. If the bio-capacity is smaller, the population can only sustain its existing lifestyle by importing or by living on its natural capital, which has the effect of reducing its bio-capacity later. The ecological footprint of most countries has far exceeded the bio-capacity. Canada is a lucky exception, because of its vast area and resources, particularly forest. But even Canada could easily exceed its sustainable ecological footprint if the population were to double in a continuing economy of waste. Scientific and industrial policies should aim to reduce the footprint, so as to move the world toward sustainability. The footprint is a measuring tool that should be incorporated scientifically into industrial policy.

### **Climate Change**

In January 2008, NRTEE released its report on how Canada might reduce its greenhouse gas emissions by 65 percent by the year 2050. The target of 65 percent reductions was chosen because the federal policy of that time called for 65 percent reductions by 2050. We have studied the report, and find it solid, subject to further considerations that NRTEE is not ignoring in its continuing work. However, no appropriate government action has followed from the NRTEE report, though it is clear that Canada’s path will continue to be one of increasing greenhouse gas emissions unless radical steps are taken by provincial and municipal governments in the very near future. It is a sad fact that the federal efforts will not be significant in the foreseeable future, notwithstanding a civil service that welcomed the NRTEE report. It is clear that political considerations that are not based upon sound science are holding up appropriate federal responses to the threat of global warming in Canada.

### **Climate change as a world emergency**

It is still not widely enough understood why climate change is a world emergency. The most potent reason arises from three natural sources of greenhouse gases, whose emissions could very easily be triggered. They are the oceans, the tundra and the forests, including forest floors. The tundra will yield its greenhouse gas (methane) as soon as it becomes unfrozen. The seas will begin to emit dissolved carbon dioxide as soon as a given temperature is reached, and the forests can give up their carbon at any time and put it back into the atmosphere. Once these mechanisms are sufficiently set in motion, global warming will continue without help from the human race and the warming will have become self-sustaining. Nobody knows how close we are to that point of no return. The precautionary principle would dictate immediate action to reduce greenhouse gas emissions.

We have long looked at aspects of climate change, and followed the work of the International Panel on Climate Change, one of whose leading authors is a member of Science for Peace. We organized an international Roundtable last year with the cooperation of the David Suzuki Foundation and the Breuninger Foundation of Germany. Out of that community of scientists and thinkers we produced a statement entitled the Wasan Action Framework, which we present to you as a guide to action on climate change, energy, population and forests.

We note in addition that the tropical rainforests (the world’s major carbon sink) are being destroyed at a rate that will reduce them to insignificance within 23 years, and the necessary remedies are known, but international action is still awaited. Canada has a major part to play, leading the rich nations of the North to finance the known, largely social remedies in the much poorer South. But time is of the essence. Such efforts should receive top priority and fully adequate funding.

### **General comments on a long-term industrial future**

Numerous people have studied the probable requirements of a long-term future for civilization, and it is likely that localization will be important in a crowded world. Localization is essentially the opposite of globalized trade in which products are manufactured at great distances from the place where they are to be used or consumed. Since globalization tends to create huge energy requirements for long-distance transport, it would appear that localization of manufacture and agricultural production must be favoured in the long term.

This does nothing to tell us how to get from where we are now to where we shall need to be later this century. The time to begin thinking about viable industrial strategies is surely now. Such studies will need to envision viable, sustainable long-term futures and plot possible paths.

### **Technology and research**

Having indicated that unbridled technology advances can lead to ever greater resource consumption, and thus greater ecological footprints, advances need to be made, for example in the provision of adequate, non-polluting electrical generation and transport, essential to the survival of civilization. In our view Canada lags in most such areas. The remedy will lie in tailoring the advances to an appropriate long-term industrial strategy, as proposed above.

### **Water**

Canada has no comprehensive water policy guidelines, and has allowed its in-house scientific and policy expertise on water to decline so seriously that it appears to have little capability to deal with the myriad water crises that are pending in Canada — a situation that we want remedied now. Water is a necessity for all living systems. Farming, electric power production and most of our industry depend heavily on it. We therefore see a need for policies protecting water basins, watersheds, and water tables, lakes and rivers, such that the supply of water for the preservation of life can be assured, and that legitimate and useful industries can continue, and do so without wastage or polluting. Science for Peace itself is planning an expert Roundtable on Water (with follow-up) in November 2008, which deserves the Government's attention and support.

### **Fisheries**

The relevance of fisheries to the present discussions arises from ships and machinery that scrape the ocean bottom. This is a misuse of technology and a malpractice of modern fisheries arising from the growing need to find edible fish — these being increasingly scarce — and the need to find other ocean life suitable for consumption by predator fish in fish farms. The ocean floors are part of the global commons, and nobody has the right to desecrate them. A suitable initiative by the Ministry of Science and Industry would be to propose a comprehensive global ban on scraping the ocean floors and on the use of the fishing vessels and equipment used for that purpose.

### **Tar sands, ethanol from food, and transportation**

Much has been written on the ecological disaster of tar-sands exploitation we are witnessing in Alberta. We suggest that there is an illusion at work here, namely, that the current hemorrhage of waste of oil, especially in Canada and the United States, must be allowed to continue as long as possible. We feel that the environmental damage being done in Alberta may be irreversible.

No change could likely be achieved without political upheaval, but surely there is too much at stake to go on ignoring the process of wounding the planet.

Possibly the illusion just referred to is also accelerating development of ethanol at the expense of food. One of us has published on this, showing the extraordinary energy inefficiency of growing crops specifically to supply liquid fuel (Helmut Burkhardt, "Physical Limits to Large-Scale Global Biomass for Replacing Fossil Fuels" in *Physics in Canada*, vol. 63, No.3,



July-Sept 2007, pp. 113-15). By contrast, a combination of policies aimed at reducing distances driven per motor vehicle, and advances toward optimized hybrid vehicles, could drastically reduce the need for oil in North America within fifteen years. For transport by diesel trucks, more drastic developments may be needed, and we see an urgent need to consider rebuilding the railway system across North America as the only solution. A suitable approach will be to set in motion a study for the long-term future of trucking. Relevant recommendations on energy and transportation were already presented to Government in 1977 by the Science Council of Canada (Report No. 27, pp.72-74), but have been ignored.

### **Nanotechnology**

While not professing expertise in the details of nanotechnology advances, we have noted that most if not all nanotechnology developments concentrate on achieving spectacular new possibilities in science, medicine and industry generally, without looking at the negative consequences. In particular, what is the final resting place of a nanoparticle? We note that one tonne of nanoparticles, if spread into a monolayer, can cover tens of thousands of square km. What does this mean for the potential of nanoparticles to pollute, or to produce chemically active surfaces in our environment that were not previously present? We consider that nanotechnology requires a precautionary regime that would look into such problems before the large-scale manufacture of nanoparticles is permitted. Furthermore the regime should be international.

### **Choosing between technologies**

At present many provinces in Canada are having to plan their electrical futures, and find themselves confronted with difficult choices. It is the great misfortune of such decision makers that the Federal Government many years ago chose nuclear energy, despite all the unanswered objections to nuclear, and the abysmal economic record of nuclear in Ontario. All recent Governments have followed suit. Report No. 27 of the Science Council of Canada (Ministry of Supply and Services Canada 1977) strongly recommended renewable energy (pp.76-77 of the Report). The cumulative subsidy to nuclear energy since the inception of its development in Canada amounts to \$189 billion in 2007 dollars (private communication with Greenpeace).

Choices also have to be made within particular subfields. For example, most hydroelectric authorities are still focused upon dams and their associated generating technology. However, the record of dams is in many respects poor, except for the highly efficient conversion of the available energy to electric. Most high dams have flooded valuable agricultural land, and some have caused pollution, of which mercury pollution is an example. An alternative, which has been available for some years, is underwater turbines. These require modification of a watercourse where they are to be used, so as to increase the rate of water flow in the channel where the turbines are to be placed. However, such narrowing of a watercourse tends to increase the land surface rather than decrease it. It is clearly time that such alternatives be taken fully into account in planning hydroelectric developments. Far too often in the past, the more environmentally damaging choice has been made.

### **Publicly funded research and the general position of Canada in the world**

We oppose the continued plan to remake the culture of Canadian universities with the object of emphasizing innovation. We view this as a serious misunderstanding of the nature of universities and of their contribution to our nation. The traditional role of academic research has been to test the correctness or the range of validity of our understanding of the world and of ourselves. Every advance therefore means a new or more developed paradigm. Some of those advances open whole new paths for our governance, health, or industry. The current drive for innovations that are capable of instant commercialization has the effect of seriously reducing the capacity of universities to add to our more profound knowledge. This comes at a time of great threat to

human existence through weapons of mass destruction, poor environmental practices, and economic practices that lead to deprivation of various kinds.

From an academic perspective, many of the innovations produced are trivial. They are also deceptive when looked at from the framework of full-cost accounting, or from the standpoint of diminishing marginal returns. Thus the current policy of influencing universities toward limited innovation seems to be shortsighted, and could be dangerous, and it diverts attention from the need for extensive research.

It is doubtful that Canada can foster scientific knowledge and creativity within current government policy. In conventional measures of productivity and research and development, Canada lags far behind other OECD countries. In the 2006 Human Development Report, Canada ranked 15<sup>th</sup> in its percentage of GDP spent on research and development. In productivity, the OECD lists Canada 47<sup>th</sup> out of 50 developed countries. In social spending as a percentage of GDP, Canada is in 25<sup>th</sup> place among 30 major industrial nations. It is well established that investment in education is highly correlated with economic stability and well-being. The latest edition of the UN Human Development Report reveals that Canada is in 57<sup>th</sup> place in expenditure on education as a percentage of GDP. In public expenditure on education as a percentage of all government spending, Canada is in 90<sup>th</sup> place (Mel Hurtig, *The Truth about Canada*, McLelland and Stewart, 2008). From a scientific and social perspective, the changes that can ensure societal and social well-being are clearly feasible.

### **Subsidizing industry**

The pattern of subsidy of Canadian industries is well established. However, the tendency has been to give the most to large industries, some of which are referred to as “sunset industries”, that is, industries that are or should now be in decline. Subsidy, if any is required, should surely go to new industries such as those that would carry us through this century into a sustainable mode of life and work, with proper regard to the preservation of resources, energy conservation, and the restoration of contaminated and depleted land.

## **II Industry and Intellectual Property**

### **Publicly funded intellectual property**

We have stated our objections to the commercialization of universities through inappropriate emphasis on innovations. However, we equally object to inventions produced at public expense becoming the private property of corporations.

### **Cooperative research**

There is, however, a role for cooperative research, which could do much to improve the spread of the benefits of research to the public, and could increase the efficiency of industrial research, that is, the cost/benefit ratio to industry, and therefore the cost to users of consumers. This is an area where the marginal returns could be increased. The model we are referring to has been tried in various industries in the past, and works as follows. Industries in a given field collaborate in setting up research facilities and each contributes to the research budget. The inventions of the collaborative then become available to all paid-up members. Such a model would undoubtedly bring down the cost of pharmaceutical research and therefore the cost of the pharmaceuticals themselves, as well as allowing profits to remain high. Similar cooperative research institutes could reduce costs considerably in many other industries.

### III Recommendations

#### **We recommend that:**

- Canada pass laws to implement the strictest export regime for parts that could be used in cluster munitions, and find ways to make the cluster bomb ban robust and effective.
- Canada re-establish an arms control verification program and incorporate treaty verification research into the work of the Defence Research and Development Canada (DRDC)
- Canada provide aerospace technologies for arms treaty monitoring and UN peacekeeping
- Canada continue to support Radarsat 2 and MDA, including by providing MDA imagery to the UN
- Canada deploy Uninhabited Aerial Vehicles (UAVs) and Night Vision Devices (NVD) to assist UN peacekeeping operations

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- the Government of Canada set up enhanced mechanisms by which it and Members of Parliament can dialogue with scientists
- the reports of the National Round Table on the Environment and the Economy be acted upon appropriately
- a committee or council be set up to study paths to a sustainable future, or that the National Round table be assigned that duty, such studies to include localization
- both officials and politicians accept the need for a new paradigm along the lines shown in this Brief
- politicians and officials become educated in the concept of ecological footprint
- climate change be recognized as a world emergency
- most of Canada's water being non-renewable, only the amount of water that is replaced by annual precipitation should be available for use
- plans be initiated without delay to halt the ecological ruin of the Province of Alberta
- inappropriate ethanol production be stopped
- a study for a new, electrified railway system for Canada be initiated as a partial solution to the problem of truck transport
- Government should undertake oversight of nanotechnology to prevent the irreversible release of harmful nanoparticles into the air and water, by industry, or from consumer products
- the precautionary regime of the previous recommendation should include facilities for investigating such questions in depth
- the Ministry of Industry make strong efforts to prevent poor choices of technology
- the Ministry of Industry reduce and eliminate subsidies to sunset industries
- steps be taken to reverse the commercialization of universities
- efforts be made to raise Canada's standing in all the cited international lists