TRENDS AND OPPORTUNITIES IN MARINE AND FRESHWATER REMOTE SENSING TECHNOLOGY

A Report prepared for the

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Executive Summary

1. OBJECTIVE AND METHODOLOGY

The objective of this report is to provide the Canadian remote sensing community (including industry, government and academia) with information supporting a coordinated approach to ocean and freshwater-related national and international market opportunities within the context of government priorities[1]. Unlike previous studies focussed on what remote sensing technology can provide, this study is based on an analysis of *issues and problems, and how these are changing*. It begins with a review of ocean and freshwater related issues and problems, proceeds to a summary of the *data, product, service and information requirements* associated with these issues. With this understanding, potential market opportunities for remote sensing products and services are suggested. The report concludes with a series of proposed actions aimed at stimulating the Canadian marine and freshwater remote sensing communities.

The approach taken was to:

1. Identify scientific, management and regulatory issues relating to the marine and freshwater environments: today and in three to five years time.
2. Identify the organisations with management responsibilities for the various issues (i.e. the clients) and the data and information products and/or services needed to address these issues.
3. Identify and assess the strengths and weaknesses of the various data collection platforms (e.g. ships, aircraft, and satellites) and sensors (e.g. current meters, acoustics, active and passive microwave, and visible-IR): today and in three to five years time.

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[1] The government's current priorities include:

- *innovation* (in the case of marine and freshwater management, especially within the delivery of public services, including *government-on-line* services as applicable);
- the development *centres of excellence* and/or *clusters* involving government, industry and academia (to address, for example, international ocean, exclusive economic zone and/or coastal zone issues, or regional freshwater management issues - wetlands or dry land agricultural practices);
- *horizontal co-ordination* among departments (reflecting the fact that issues of public concern no longer fall within the traditional mandate of any one department - for example, the impact of climate change on Canadian society and the economy);
- the development of internationally recognised *Canadian "brand" goods and services* associated with marine and freshwater management issues (for example, standardized spatial data products for the coastal zone and operational hydrologic models for freshwater management that include remote sensing inputs); and
- *security*, especially along Canada's frontiers (most of which are water).

4. Determine the role of remote sensing from aircraft and satellites and the sensors that best meet the data requirements, together with the appropriate information management tools.
5. Establish Canadian capabilities, including provision of platforms, instrumentation, data collection and processing, and provision of information products and services.
6. Identify the challenges facing the Canadian Space Agency and the role the Agency can play in facilitating Canadian industry's involvement in meeting marine and freshwater information product and/or service requirements in Canada and around the world, especially as they pertain to the role of remote sensing technology

The work began during the summer of 2001 with an Internet-based survey of more than 300 individuals around the world to identify and rank ocean-related issues and the identify data and information products and/or services that managers needed to address the key issues. Seventy-seven telephone interviews were also conducted.

The work was extended to include freshwater issues early in 2002. The smaller freshwater study component did not include a web-based survey, but key freshwater issues identified via an online literature review were confirmed during twenty-five telephone interviews.

2. THE ISSUES AND INFORMATION NEEDS

The key issues and their respective information needs identified (Table E1) can be organised in four categories:

In ***International waters,*** the major issues are **weather and ocean-state forecasting, and climate change research**. The information needed is generally **long term physical, chemical and biological coverage of the surface and sub-surface waters to support predictive models**. There is an important trend to international co-operation in global ocean research, with many countries launching satellite sensors.

In the ***Exclusive Economic Zone (EEZ),*** the **major issues for every country are the maintenance of sovereignty over resources, their management, and protection of the environment**. The environmental information needed is similar to that for international waters, but it is needed more frequently and with a higher resolution. Most fisheries management for example, is conducted in the EEZ. The sovereignty and regulatory enforcement issues within the EEZ require on-demand information on vessel activities. Canada has important needs on all three coasts, but the **information gaps are especially acute in the Arctic**.

Coastal Zone issues are largely **people-problems stemming from urbanisation and various forms of development**. These issues range from disaster preparedness planning and response, safety and surveillance, oil and gas and other resource management, through mapping and monitoring of ecosystems, to the impact of on-shore economic developments. Predictive oceanographic and biological modelling capability, detailed hydrographic, habitat and topographic maps of the near shore areas are sorely needed, together with frequent observations of physical, chemical and biological conditions, and land use maps.

The major ***freshwater*** issues concern the **quantity and quality of the water supply**. Information is needed for prediction of precipitation (rain or snow), land cover and

soil/geological characteristics, soil moisture, surface run-off rates and groundwater replenishment/withdrawal rates. Water supply is of critical importance in all economies, and wars are already being fought over water availability. Water quality everywhere is being degraded by agriculture, industrial and municipal development, and more than half of the world population does not have safe drinking water. Remote sensing can provide local, regional and trans-boundary monitoring of water quality including the impact of point and non-point source pollutants and erosion as indicated by changes in water colour, turbidity and/or biological activity. In Canada, there is **an important need to map the great wetland resource in the north**.

3. THE ROLE OF REMOTE SENSING

Remote sensing is a relatively young and quickly changing technology. It currently is used most extensively in weather forecasting and climate studies where is provides **broad area coverage not available by any other means** and ice monitoring, where it provides a **significant cost advantage**. With time, the spatial advantages of remote sensing will become recognised in other areas also. While it does not see the largest part of water bodies that is below the surface, remote sensing provides **rapid *repeatable* coverage of large, inaccessible or hostile areas at a low cost. In Canada it provides the *only* practical way to repetitively monitor much of our territory.** In many kinds of environmental studies, for example climate change or the effects of development, time series of imagery are of great importance.

The trend in remote sensors, whether operating in the microwave, visible or infrared part of the spectrum, is toward increased spectral and spatial resolution. This is making them more relevant to day-to-day problems and issues. Satellite sensors of all types have become an essential part of the study of the ocean, especially over international waters where their spatial resolution is adequate and there are few alternative sources of data. Over the EEZ, the coastal zone and in inland waters, higher resolution active microwave and visible-IR sensors like MERIS, and especially Canada's RADARSAT-2 and the proposed Canadian Satellite Hyperspectral Imager can play an important role in ecosystem mapping (Table E1). Canadian industry can offer airborne radar and made-in-Canada visible-IR sensors that overcome many of the limitations of satellite sensor coverage in the coastal zone and for freshwater areas.

As more and more sensors become available, and improve in spatial, spectral, radiometric and temporal resolution, remote sensing data archives will grow enormously. We have already witnessed the beginnings of this growth, and to some extent are managing to keep up because of the growth of computing capacity. It will be increasingly important to retain not only the image data, but all of the meta-data including calibration, links to other forms of data including ground truth data.

Table E.1. Key issues and problems in marine and aquatic systems, the main types of information required to address these problems, and the potential role of remote sensing.

Issue/Problem	Information Needs	Role of Remote Sensing
International Waters		
Weather/ocean state forecasting; climate change	Long term physical, chemical and biological information over wide areas to support predictive models (including sea temperature, salinity, sea level slope, winds and colour)	Repeatable low resolution wide-area coverage; from optical, IR and passive microwave radiometers, scatterometers, altimeters and other satellite sensors (including a new salinity sensor) and *in situ* observations from ships and buoys.
Exclusive Economic Zone		
Sovereignty, enforcement; pollution monitoring; safety of navigation, search and rescue	Near-real time vessel monitoring; mapping of sea ice; mapping of slicks and currents	Integrated wide area monitoring using coastal HF radar, aircraft surveillance and spaceborne synthetic aperture radar
Environmental protection and resource management	Long term environmental information over wide areas to support predictive models (including sea temperature, salinity, sea level slope, winds and colour)	Repeatable low resolution wide-area coverage; from optical, IR and passive microwave radiometers, scatterometers, altimeters and other satellite sensors (including a new salinity sensor) and *in situ* observations from ships and buoys.
Coastal Zone		
Weather/safety/security	Near-real time monitoring of winds, sea state, ice, vessels and pollution. Prediction of weather and sea conditions.	Repeatable moderate resolution coverage from satellite synthetic aperture radar and scatterometers and aircraft surveillance, with *in situ* observations from ships, buoys and coastal installations.
Environmental protection, resource management	Near real time monitoring of a wide variety of physical, chemical and biological parameters in water, on the bottom, on the shoreline and in coastal watersheds at all scales (including sea temperature, salinity, sea level slope, winds and colour). Prediction of natural and manmade changes in the ocean and coastal watersheds at all scales. Forecasts of impacts of harvesting, industrial agricultural or municipal development, ocean and climate change	Repeatable moderate and high spatial resolution coverage from spaceborne optical and IR radiometers, synthetic aperture radar and many other satellite sensors (including a new salinity satellite and a possible Canadian hyperspectral satellite) to support and extrapolate *in situ* observations. Aircraft flying very high resolution hyperspectral or other sensors are required to match tidal cycles.
Freshwater		
Water quantity	Monitoring and prediction of water supply (precipitation, snow water content, break-up, runoff, stream flow, soil moisture, evapo-transpiration, freeze-up)	Near real-time high spatial resolution imaging with passive microwave, synthetic aperture radar, optical and IR radiometers and other satellite sensors in conjunction with a wide variety of *in situ* systems.
Water quality	Mapping and monitoring of wetlands and water bodies as in the coastal zone, and of land cover/use/development in *entire watersheds.* Prediction of natural and manmade changes at all scales.	Moderate and high spatial resolution imaging with passive microwave, synthetic aperture radar, optical and IR radiometers and many other satellite and aircraft sensors with a wide variety of *in situ* systems. Hyperspectral sensors have a special role to play.
Safety (flooding and erosion), navigation	Digital elevation models of flood plains; Mapping of extent of floods; ice monitoring	High spatial resolution airborne LIDAR and synthetic aperture radar at a variety of time scales.

4. THE CHALLENGES

4.1 Gaining acceptance for Earth Observation information services

Despite many years of feasibility and demonstration projects, remote sensing products and/or services have rarely established themselves as an integral part of public or private sector ocean or freshwater management operations. The **slow acceptance** of remote sensing data by Canadian and other nations' ocean and freshwater management and service agencies has **inhibited the sale of Canadian products and services both within Canada and abroad**. The survey returns and interview findings repeatedly highlighted the following mostly human challenges to wide spread operational adoption of remote sensing:

- There are continuing **negative perceptions amongst potential end-users** that remote sensing data are expensive, inaccurate, and difficult to access and use, and will require expensive retraining of personnel and new equipment.
- The **cost** of remote sensing data and of generating 'one-off' customized information products is inhibiting the development of novel applications by the typical small Canadian value added company. The cost issue is partly due to the fact that remote sensing can rarely replace present data sources, and must be an addition to conventional programs – at least at the beginning.
- Reflecting the present market in Canada for remote sensing product and services, **the remote sensing industry is dominated by very small companies** with limited financial resources and limited ability to market their capabilities abroad.
- The current government policy of **partnering and cost sharing** the development of novel remote sensing products and services with a company is an **inefficient use of both party's resources** when the eventual buyer is likely to be a Canadian government department or agency.

Despite these negative findings, the survey returns and interviews also strongly suggest that **remote sensing will play an increasingly important role** as a source of *spatial* data throughout the marine and freshwater environments. The survey emphasised a **growing need for spatial and temporal information as concern for management of coastal zones and freshwater resources increases around the world**. This information is required as **input to multi-parameter interpretative models** that enable managers to better predict the impact of environmental and anthropogenic changes.

The public sector is the predominant client for information on the oceans and on freshwater. While they often do not have enough budget flexibility left to try new methods, many government interviewees recognised the eventual need to make more use of remote sensing information products as their **resources for conventional sampling continue to shrink**. The continued down-sizing and imminent mass replacement of retiring government workers at all levels presents **an opportunity to introduce new geography-based methods in many sectors**. With education, encouragement and assistance they may be convinced to include remote sensing in their programs where it makes economic sense. Applications by commercial users will follow, as VARs and data suppliers develop expertise and streamlined supply chains.

The need to address ocean-related issues is now recognized in international policies and programs, including the Biodiversity Convention, Climate Change Convention, UNCED's Agenda 21, and the FAO Code of Conduct for Responsible Fisheries. Multilateral development organisations like the World Bank and national official development agencies like the Canadian International Development Agency are responding to these policies through the establishment of ocean-related priorities and programs. UNESCO's International Hydrological Programme (IHP), an intergovernmental scientific co-operative programme in water resources, is a vehicle through which Member States can upgrade their knowledge of the water cycle and thereby increase their capacity to better manage and develop their water resources. Such programs also offer opportunities for Canadian companies, provided that the constraints identified above can be overcome.

4.2 Policy Actions

To capitalise on public sector opportunities there is a need:

1. To **accelerate** the movement of remote sensing technologies from research and/or demonstration projects to operational applications.
2. To **facilitate** increased public sector acceptance and commitment to the use of commercial remote sensing data products and information services.

A number of specific policy actions could be considered:

1) To help address the negative perceptions and lack of awareness in potential users, **a campaign should be implemented aimed at raising the level of awareness of remote sensing in Canada,** ***first within and then outside of the government***. In the short term, government managers need to be educated in what remote sensing can and can not do. In the longer term, this should be extended to the general public and perhaps be part of a focus on water issues in general. At this stage, one possibility might be to display real-time RADARSAT imagery in major airports and shopping malls – perhaps from a live CSA Internet feed. The long term campaign should also involve curriculum development at high school, college and university level. No Canadian science student should graduate from a Canadian university without at least some exposure to remote sensing and GIS.

2) Clear-cut cost savings associated with the use of remote sensing are difficult to demonstrate, especially as marine and freshwater operations managers must nearly always maintain their traditional data sources in parallel with the new remote sensing source(s). **A series of planning studies in co-operation with other federal and provincial departments, university and industry** in the context of the government-wide priorities identified earlier:

- Document the role of remote sensing in support of government and commercial operations through a series of **case studies** to establish an understanding of the full costs and savings/benefits of adapting an operational marine or hydrological service to include satellite remote sensing.
- On the basis of the case study results, develop a **strategy** that will encourage the continuous development of Canadian marine and freshwater remote sensing from

the feasibility phase to the capability to offer operational marine information services to clients in Canada and abroad; and

- Within the strategic framework established above, **a detailed plan** for each new program under consideration should be developed in order to establish the full implications for Canadian hardware suppliers, applications developers and (especially) how the system will meet the needs of end users.

3) Based on the results of the planning studies, government departments and agencies should work together to **facilitate the *operational* use** of remote sensing data and information products in support of their various regulatory and service mandates. As suggested in the previous section, *facilitating the fusion of imagery with multi-parameter predictive models* might be the most efficient way to do this.

4) The *Canadian Oceans Strategy* developed under the auspices of the Oceans Act, and the emerging Canadian Freshwater policy have no unique expression in currently available funding programs[2]. The government should **consider the establishment of a "bridging fund"** as the planning studies are expected to show that additional resources will be required by the operating departments and agencies for several years as they adapt their operations to include remote sensing products and services.

5) Despite the numerous business opportunities (especially IFI funded projects abroad), the typical small Canadian remote sensing company frequently has difficulty capitalising on them. It is suggested that:

- Government departments and agencies with marine or aquatic responsibilities in Canada and abroad to develop/purchase and use **"standard information products**" based on, or involving remote sensing data products, and suitable for incorporation into their respective decision support systems. This would help Canadian companies develop exportable information products.
- Government departments and university groups work with Canadian industry in a **Team-Canada approach** to provide a 'made in Canada solution' for foreign projects and to **broker Canadian participation in specific marine and freshwater overseas commercial and aid projects.**

The development of such 'Canadian' information products will build on and further augment Canada's international reputation, foster closer links between Canadian government, university and industry that are badly needed, and greatly enhance the visibility and reputation of Canadian companies offering services abroad.

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[2] Federal government programs with ocean and freshwater related elements can be described in three classes:

- support to government in-house programs (a very small amount of this money will flow to Canadian companies for contractual support);
- support to university research (an even smaller amount flows to companies; some may flow to Canadian companies for data acquisition, where an operational capability does not reside in university); and
- direct support to industry (these can generally be categorized as "risk-sharing" assistance for technology development and international marketing, often with repayment requirements).

Canadian remote sensing companies, reflecting the current market need for demonstration rather than long term operational services, are generally very small, with fewer than 25 employees and often cannot afford to participate in "cost and risk-sharing" government programs. Many think that it should not be required when the most likely customers will be eventually be government agencies.

4.3 Project actions

A number of multi-faceted projects are proposed to keep Canada at the forefront of remote sensing of international waters, exclusive economic zones, coastal zones, and freshwater areas. Each proposed project involves the use of existing and planned satellite, airborne and ground-based sensors and should involve the public and private sectors and universities. Two key objectives for each project are:

- to **accelerate operational use** of remote sensing by public and private sector organizations within Canada; and
- to **develop the capability of the Canadian remote sensing industry** to a point where it can service operational public and private sector marine and freshwater information needs.

In almost every case, the projects proposed below involve predictive modelling (socio-economic, environmental, biological, physical, climate/weather). **An inter-departmental program to develop Canadian expertise and products using remotely sensed imagery to initialize, constrain and verify predictive models would be highly beneficial.** Such a program could begin with a workshop designed to establish the present capability and to facilitate future collaboration**.** Predictive capacity is sorely needed in all sectors, and the efficient use of imagery in forecasting models would produce the 'user pull' that CSA is seeking.

An over-arching issue is that of data management. As remote sensing and other data archives continue to grow, they will become more and more cumbersome, unless **special attention is paid to building interconnected data-archiving schemes that retain all of the meta-data for any particular sensor and *easy-to-use* links to other sensors and data**. Retention of distributed archives may become a financial issue as groups now acquiring data of various kinds face fiscal restraint and, or changing priorities.

4.3.1 International Waters

The key issues in International waters are the acquisition and interpretation of many kinds of satellite data in conjunction with ocean surface and sub-surface data for weather and ocean state forecasting and climate change research. The CSA has advised ESA that Canada wishes to participate in the SMOS Soil moisture and Ocean Salinity sensor project scheduled for launch in 2006. **A 3 to 5 year project designed to assess the merits of the ESA/SMOS sensor for ocean salinity mapping and monitoring would greatly facilitate production of this important data in Canada by Canadians**. Such data are expected to be used by EC/MSC to provide an important input to operational ocean weather forecasts for Canada, and by both EC/MSC and DFO/Oceans as an input to estimating climate change impacts on Canadian society and the economy.

4.3.2 Exclusive Economic Zone

The key issues for Canada and all countries in their Exclusive Economic Zone (EEZ) are maintenance of sovereignty over resources, protection of the environment and resource management. Canada's Arctic is very large, remote and difficult to access because of the ice cover. For these reasons it is not as well described or monitored as Canada's southern areas. These characteristics make it an obvious place to implement remote monitoring. Canada

should be making special efforts to **develop and operationalise remote sensing applications in support of Canada's Arctic responsibilities**. There are several multi-departmental Arctic initiatives currently under discussion in Canada, and CSA could provide important assistance to other departments to include remote sensing (provided by Canadian companies) as a key component in these plans

At present, many Canadian government departments and agencies have resource management and environmental monitoring responsibilities in the EEZ. These organisations use shore-based systems (e.g. dockside inspections, over-the-horizon radar), ship-based observers, aerial and satellite positioning and tracking systems to carry out their various responsibilities. RADARSAT can make an important contribution to this surveillance, but can not replace the requirement for other sources of data. In fact, no single data source is adequate for the task. An emerging issue is the effective fusion of data from the various data sources to provide a cost-effective *integrated* information service for the different departments and agencies.

Canadian government departments and agencies with EEZ-related responsibilities need to work together to implement an integrated information management service that combines inputs from all required data collection platforms and systems and provides the information products as and when needed by the user organisations. With adequate security safeguards, such a multi-agency service could be developed and operated by a Canadian private sector organisation. With time, this system could be provided to other countries, and involve export of Canadian data, software and services.

4.3.3 Coastal Zone

The greatest direct impact of the oceans on humans and *vice versa* is felt in the Coastal Zone (CZ) and this is where the largest problems such as urbanisation, development and pollution manifest themselves. Most issues in the CZ require more frequent, detailed and timely information than in the open ocean, and the trend to increasing spatial resolution is making remote sensing more relevant. The higher spatial resolution and multiple polarization capabilities of RADARSAT-2 should provide important new capabilities for the coastal zone.

There are many EEZ, CZ and freshwater issues that require measurements of phytoplankton, turbidity, or suspended and dissolved materials that water colour sensors can provide. Landsat Thematic Mapper and SPOT have the high spatial resolution required very near the coast, but relatively poor radiometric sensitivity and few spectral bands. MERIS, launched by ESA in March 2002, finally provides the combination of frequent orbital repeat, spectral bands and moderate spatial resolution that will make it very useful for monitoring all three zones. While Canadian airborne hyperspectral imagers can provide very high spatial resolution data for occasional mapping of small areas, especially of intertidal areas, this is expensive. There is still an important need for a satellite hyperspectral sensor with high spatial resolution and wider area coverage. A Canadian hyperspectral sensor could have an important role in repetitive monitoring of water quality in relatively defined areas such as harbours, individual lakes or embayments. On longer time scales, it could map water quality, shoreline, wetland and upland vegetation, and provide a ‘hyperspectral zoom’ diagnostic capability for wider area lower resolution monitoring for example from MERIS.

Canada needs to continue with support for and advancement of MERIS, airborne and satellite hyperspectral sensors.

The Canadian marine remote sensing industry needs the credibility that comes from Canadian government purchase of its products and services. To meet this need, **Canada needs a multi-agency initiative for the private sector to *systematically* map the Canadian coastal, freshwater and wetland ecosystems to uniform standards, with the results being made available on the Internet in the form of GIS "layers" that can be selected as needed by users to meet their specific needs.** This effort will involve contributions from many kinds of sensors working in parallel, from radar and hyperspectral satellite and aircraft sensors, to underwater acoustic swath imaging, and considerable effort is required to integrate and fuse data from many different sources. Special attention must be paid to making this a *user oriented* program, with seamless and non-technical image ordering. However, many kinds of new and easy to use software tools are required at all points in the supply chain from the satellite or aircraft through the data provider, to the VAR, to the end-user.

In general, CZ information requirements offer the best commercial opportunities, but the users of remote sensing data products are still predominantly from the public sector. Contract opportunities for the Canadian remote sensing industry also exist in the Coastal Zones of developing countries (particularly the small island developing states) that have no equivalent in Canada. Also, if the CSA decides to proceed with a satellite hyperspectral sensor, it will have to undertake a range of pre-launch applications development and demonstration projects that are tailored to meet user requirements - including those in the CZ of tropical and sub-tropical countries. To meet both these requirements, it is suggested that the CSA in co-operation with other government departments (including CIDA, IDRC and through these agencies, key IFI's), **develop and operate a GlobeSAR-like global hyperspectral applications development program**. As a result of such a project, Canada and the Canadian remote sensing industry would establish its credibility in the shortest possible time in an important world market.

4.3.4 Freshwater

The major Freshwater issues are the quantity and quality of the water supply. Information is needed for precipitation (rain or snow), the topography, land cover and soil/geological characteristics, surface run-off rates and groundwater replenishment/withdrawal rates. Information for water quality includes the impact of point and non-point source pollutants and erosion products usually indicated by changes in water colour, turbidity and/or biological activity.

A program is needed **to assist federal, provincial government departments and water agencies already operating hydrologic modelling programs, to incorporate multiple *operational* remote sensing inputs (e.g. active and passive microwave and visible-IR sensors on airborne and satellite platforms).** The program should address important water management issues, for example mapping and monitoring of wetlands, forecasting and monitoring precipitation and water availability for dry land farming and for hydroelectric power generation. Such projects could attract climate change funding, and the dry-land farming example could involve U.S. agencies south of the Manitoba-

Saskatchewan-Alberta border. The hydroelectric companies represent important customers for data and information products.

Secondly, there is significant benefit to be gained (both for Canada and for Canadian companies) through **participation by government agencies in international projects to demonstrate Canadian industry capabilities**. An example of such a project is one focused on the Aral Sea where the IFI's and ODA's (including CIDA) already have a number of projects that could benefit form remote sensing inputs. Others could be implemented in Africa where Prime Minister Chrétien has recently promised mapping assistance.

5. A VISION FOR CANADA

There are major opportunities for the Canadian remote sensing industry in the coastal zone and in freshwater. With the longest coastline in the world, 10% of the world's freshwater, 25% of the world's wetlands, and with a sterling international reputation for remote sensing in general, Canada should be a world leader in mapping, monitoring and managing of these areas.

A national project to map the Canadian coastal, aquatic and wetland resources would be in direct support of Canada's *Oceans Act*, the Federal *Water Policy* and the *Innovation Strategy* and would provide a highly visible demonstration of the combined Canadian capability and commitment to the water issues. Such an inter-departmental effort, involving all parts of the marine and freshwater community, should include a wide public awareness campaign aimed at raising the interest and knowledge of Canadians of water and water issues in general, and of the role remote sensing can play. It would help to foster a national, inter-departmental and cross sector horizontal co-operation that is called for in the Innovation Strategy. It would be highly beneficial to Canada, and provide a coherent framework and focus for future work.

It could begin rather inexpensively by collating, co-ordinating, upgrading and making available on-line the many individual remote sensing projects done as separate demonstrations across Canada. This in itself would be a dramatic demonstration of Canada's data acquisition, analysis and information production capabilities, and provide a vehicle for the development of Internet delivery mechanisms, data visualisation, modelling and predictive capabilities that we need.

Finally this program would also include an International component, by which Canada could offer to the world our knowledge, expertise and assistance in mapping and managing water resources in other countries. With a co-ordinated focus, inter-departmental co-operation between CSA, Fisheries and Oceans Canada, Environment Canada and the active participation of academia and an experienced family of VARs, and software and hardware suppliers, Canada can make an important international contribution.