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Global Markets for Ocean Observation Systems
Executive Summary

November 2006

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Introduction

Ocean Observation Systems (OOS) allow us to take the pulse of the planet. OOS exist in various forms in most areas of the world, with data from academic and governmental programmes being shared by internet. However, the world market for OOS is enormously diverse – the subject is vast and involves a considerable complexity of interlinked funding and operational organisations, programmes and projects.

International research towards a Global Ocean Observation System has been driven by the UN (UNESCO), through the IOC and the United States' National Research Leadership Council, which includes bodies like NOAA (USA) and JAMSTEC (Japan), or through regional groupings such as countries that share ocean boundaries.

In the United States alone, the Congressional Budget Office estimates expenditure to develop and operate an integrated coastal and ocean observing system will cost between 1.8 billion and 2.2 billion USD over the 2006-2010 period. An additional $700 million for 2007 has also been announced and is a good example of last-minute, single-year funding approval and an indication of the increased awareness in Congress that OOS is important, but most importantly the heightened sensitivity in the US to sea-based aggression.

OOS represent an evolving market with no formally-accepted definition. During an initial project meeting in Montreal it was decided that 'real-time' systems of gathering data, should be the focus – concentrating on multi-parameter networks involving data distribution, sampling, warehousing, etc. The methodology of this study therefore focuses on evaluating existing and future projects and programmes and then following the market drivers and funding trail to forecast opportunities and trends.

The aim of this report is to value global markets and outline where technology is being applied; now and in the future, considering market drivers, trends and market values. However, it is important to note that OOS often does not conveniently divide itself into sectors. Programmes may source from one and deliver benefits to many.

In addition to the discrete application sectors, a number of sectors may be brought together under the term, 'Ocean Management & Stewardship'. Examples of initiatives include Canada's 'Ocean Management Research Network' (OMRN) and the work ongoing in Norway to monitor environmentally sensitive areas such as the arctic Barents Sea which is very important for both fishing and offshore oil & gas industries.

This report is based on both desk research and a series of in-depth surveys of 56 high level decision-makers in OOS-related organisations in 18 countries worldwide. Some 86% of those interviewed worked for research or equipment manufacturing organisations.

Most interviewees were interested in gathering a very wide range of data. There were very few instances of requirements to measure a single parameter. In short they were very much 'system' oriented. The largest grouping of interviewees was involved in ocean data & models, or the weather / climate area. (However, in practice it can be very difficult to separate the areas.)

Much of the civil sector work we have seen over the years on the subject of OOS has been academic (scientific) research driven – based on a desire to access data mainly for investigation into climate and tectonic work; or technology driven – a desire to develop and deploy new data gathering systems. There has been much work on the ‘tools’ and technologies involved, from permanently moored subsea or seabed arrays, to drifting buoys, autonomous vehicles, earth observation (by satellite), etc.

There have also been a number of ‘cost-benefit’ analyses which focus on the many and real economic, social, environmental, climate change and disaster avoidance deliverables of OOS. However, there is virtually nothing published on the demand and associated expenditure – in other words “the markets” – the major area addressed by this report.

Global Market Drivers

The global market for OOS is driven by a complex and interrelated set of factors ranging from climate change to the geopolitical, from military to geological. But without doubt, the largest driver for OOS is climate change.

The overall picture is of more and more people being exposed to the potentially disastrous consequences of any severe ‘ocean-event’. Sea levels are rising as glaciers recede, arctic sea-ice melts and increased temperatures raise wind speeds. A series of natural disasters has hit the world in the past few years, some of which, such as the Gulf of Mexico hurricanes of 2005, are thought to be directly due to climate change and its impact on the world’s oceans. Another notable event was the devastating S E Asian tsunami of December 2004. Such events, together with the growing awareness of the importance of measurement of ocean parameters have accelerated the installation of OOS and proposals for many more.

In the military arena, the end of the cold war caused the major powers to re-focus their naval activities from nuclear submarines in the deep ocean, to modern diesel submarines prowling coastal or ‘littoral’ waters. This was reinforced by the US response to 9/11 and the ‘war on terrorism’ may have marked the start of a new type of low-intensity war with occasional flare-ups in different parts of the world. Regional wars and prolonged domestic or ethnic violence create some of the most pronounced shocks to the world economy, due to the substantial costs faced by the countries or regions involved. Increasingly, disputes may involve using the control of a vital commodity, such as oil, against the other party.

Meanwhile growing economic activity in the developing world, most recently in the People’s Republic of China (PRC) is having major impact. One result has been a major growth in many aspects of marine activity, in particular shipping, as greatly increased volumes of imported raw materials and exported manufactured goods are moved across the world. With this comes a growing need for monitoring shipping and indeed providing mariners with more precise weather information.

Energy demand has increased dramatically in the past three years bringing a doubling of the prices of oil, gas and coal. Growth in demand for natural resources from fossil fuels to forest timber and ocean fish has been considerable. It is having a great environmental impact and in particular on the generation of greenhouse gases thought by most to be responsible for global warming and believed to be the cause of climate change.

It is believed that the oceans offer one of the last great unexploited oil & gas resources, particularly in deepwater and in pristine arctic regions, resulting in a need for enhanced levels of environmental monitoring and ocean observation systems. In addition, energy directly generated from wind, waves and tides is sustainable and readily accessible to the growing coastal populations of many countries.

Population growth and increasing levels of disposable income are resulting in a boom in ocean-related recreational activity from cruise vacations to boating, fishing and scuba diving. All of these are in reality also ‘ocean industries’ and greatly dependant upon information on the oceans.

Interview Results

56 in-depth interviews were carried out worldwide over the period May-June 2006. The main focus was the two primary markets (funding sources) for systems providers, North America and Europe, then Asia Pacific. Samples were also taken from other regions. The largest proportion of interviews by country were the USA 30% and UK 27%, the rest of Europe accounted for a further 15% followed by Canada at 9%. Due to the very wide range of bodies involved in OOS, Organisations were chosen to span the many interest and funding groups. These ranged from NOAA to a Marine Warfare Centre, from Marine Laboratories to the Dubai Municipality and from commercial service providers to individual equipment manufacturers. The majority of the interviews were concentrated amongst the suppliers of products and services to the OOS community and their customer base – the research organisations.

Most organisations were involved in both national and international activities and to a lesser extent regional. There were also significant partnerships and cooperatives between industry and academia. The overall picture is of great volumes of data being gathered and being made available either direct or via the results from, say, weather models. Integration of space-based and in-situ observations was “A very important point and a core issue at international level”.

Ocean Observation Systems – Key Strategic Considerations

Evolving standards – There is agreement in the need to develop international ocean observing system standards. These include: calibration (methods & frequency), IT standards for cyber infrastructure, data standards, collaborative collection, met data standards, baseline standards, interoperability standards for moving to multi-use and modularity, coordinated expectations and parameters and user and collection guidelines. In the USA, NOAA is expected to take the lead in developing OOS standards over the next two to three years. In the EU, standards are being improved as a result of commercial and government client requests and the WMO.

Infrastructure support is lagging – The infrastructure support requirements include: real time data acquisition software,[1] wireless networks, HF radar, x-band radar, computational resources and communication systems (ranging from PCs to supercomputers and intra-nets to satellite based global telecommunications gateway), wave buoys, wave gauges, oceanographic buoys, CTD, met equipment, gliders, autonomous underwater vehicles, pier-based sampling systems, weather stations, acoustic transmitters and hydrophones.

International initiatives have similar objectives and challenges – There are over 85 variables measured by organizations associated with OOS. The priority variables recommended for global ocean and coastal monitoring as part of initial IOOS are as follows: water level; ocean storage & global transport, carbon, heat, fresh water; air-sea exchange of heat & fresh water; extent & condition of pelagic & benthic environments; abundance & distribution of living marine resources; freshwater flows & fluxes of sediments, nutrients, contaminants.

Development of "appropriate" technology is necessary –There is common international agreement that product improvements are needed in:

- Data acquisition systems to gather better core variable data. Smaller, lighter, less expensive, more robust/longer lasting, less sophisticated (plug & play), interoperable systems. Better communications (i.e. getting data real time from remote locations), lower costs (particularly the "final mile" out to the moorings) and transmit the data safely across long distances.
- Long-term reliability of sensors on surface and subsurface buoys will demand improvement in corrosion and bio-fouling control and in measuring very long-term calibration accuracies.
- Meteorological data gathering must provide high quality and accurate reference data in real time to check, verify and calibrate met measurements.
- Coastal zone observations require development of new products with real time and multi-use features for devices such as acoustic sensors that measure fish and marine mammal population properties.
- Oceanographic sensors for subsurface moorings will need to have mechanical profiling platforms for operating sensors that will be more reliable over long-term operational periods for many years.

"*IOOS are collecting the wrong data for water quality management*", states one member of USGOOS's Steering Committee. "*Biological & chemical sensors are the least developed products for global ocean and coastal monitoring purposes. Sensors need to measure pathogens.*"

Partnerships are essential for OOS to develop into a viable market – According to a member of staff within NOAA's Communications & Education office, "*IOOS is still a nebulous concept for many people*" including the important government funding agencies and end users. There is a major challenge in clearly identifying user applications and value-added education to promote the necessity of OOS. With NOAA as the lead agency, IOOS development will occur through partnering with other federal agencies, regional associations (RAs) and also through international collaborations. The task has been described as "*trying to herd cats*". A shift is taking place in the reassigning of budgets from other areas that are now to be consolidated under OOS. For example, homeland security has had a huge and immediate effect on activities grouped under OOS.

Finding the people is a challenge – "*There is a difficulty in finding people to work on ocean observing systems*" states a US based technical director. In the US the educational component is being addressed through new ocean observing courses at Texas A&M, University of South Florida and Rutgers University. These courses cover numerical methods, GIS training and data management tasks typically encountered in work situations related to "observing". EU educational development is, in part, supported through Continuous Professional Development (CPD) initiatives.

Developing IOOS-related partnerships with NASA is challenging – "*IOOS is an operational effort, NASA is a research-orientated mission*", according to a Technical Director for the GCOOS-RA. There are, however, recent signs of improved collaboration. In 2007, NASA has budgeted $65 million for continued development through critical design and initial test of the Aquarius satellite to measure global ocean surface salinity for the first time.

An Ocean Surface Topography Mission (OSTM) is scheduled to be launched in 2008. This is an international joint partnership arrangement with the French agency, CNES. The mission will strive to observe changes in ocean surface topography with an accuracy of one to two centimetres. According to a scientific engineer for the NASA program, "*this will require improved space-borne sensors such as advanced high resolution altimeters, salinity sensors and GPS reflections*".

Integrating space-based and in-situ observations – Other future OOS technologies that integrate space-based and in-situ observations include lidar technologies for coastal and sea level monitoring and GPS/tide gauge geodetic packages, GPS reflections for monitoring ocean microseisms and autonomous aerial vehicles capable of long flights over the ocean. New technology is needed to handle sub-arctic data gathering that will make better use of satellite data for ice-bound areas.

Future technologies are becoming reality – Some of the most exciting future IOOS technologies are autonomous underwater and ocean surface vessels (AUVs, gliders & SUVs) that patrol the coastal and deep ocean. These systems will operate collaboratively with each other; interact with satellites, unmanned and aerial vehicles (UAVs) and adaptively without direct communication. Operational centres will mange these assets. Eventually, robots will replace and refurbish sensors and instruments on moored platforms.

OOS, an emerging market – The primary enabling force of OOS is government funding and supported by environmental regulations, global warning concerns and offshore oil & gas activities.

Government is the key client – Many of the players / end-users do not directly purchase OOS data but instead receive it free of charge. A typical exception to this would be a custom weather forecast delivered by a commercial organisation to a commercial client. For example, a 2004 survey of the commercial exploitation of EO satellite data in Europe and Canada estimated 2002 revenues as $317 million of which 78% of sales were to Government and other public sector clients. [2]

Canada

About 62% of those interviewed in our survey have had some experience of working with Canadian organisations in various situations from supplier to partnering in a research project and these individuals seem to have had a very positive experience:

- *"Better and more co-operative to work with than the Americans."*
- *"Would like to work with Canadians."*
- *"Would be very keen to work with Canadian companies."*
- *"Canada has strong academic programs in GPS geodesy."*

Furthermore, 90% of those able to answer saw no restrictions to working with Canadian companies. In the case of those that did, this related to a lack of knowledge about their organisation's policy towards purchasing foreign goods & services. (It is of note that these 'policy issues' were raised by US organisations and not in Europe!)

However, there is a lack of international awareness about Canadian OOS-related projects (other than Neptune Canada and some university applied R&D activities) and a belief that Canada represents a small potential market.

Canada is, however, recognized in the academic community as a leader in spatial information software/open source software development and several Canadian companies have banded together to develop ISO ice observation standards. However, potential foreign customers for Canadian companies are often buying OOS-related products and services from competitors in the US and Europe.

[2] The State and Health of the European and Canadian EO Service Industry – ESA, VEGA, Booz, Allen and Hamilton – August 2004.

Conclusions

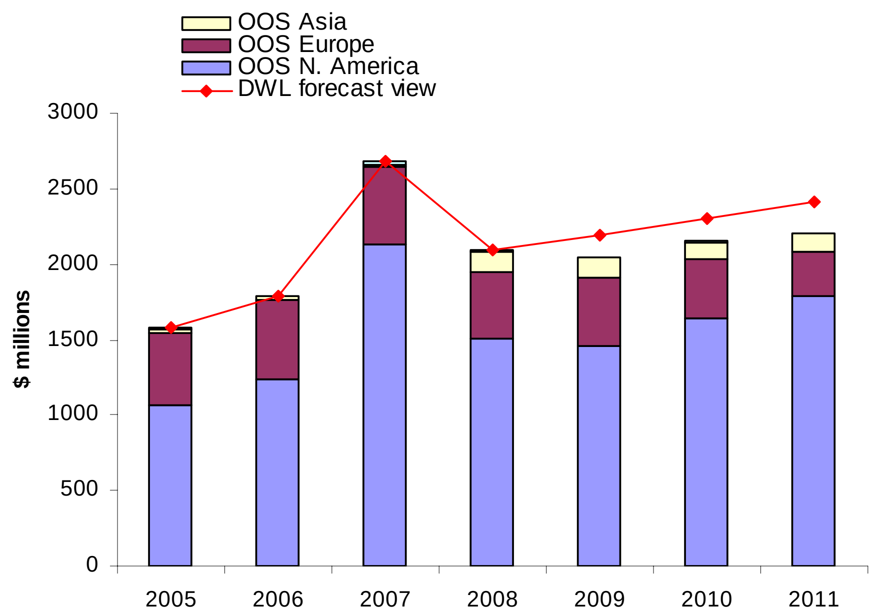

Figure 1: Global OOS Market Forecast 2006-11 ($ million)

OOS is a major market – based on identified programmes, we value the global market for ocean observation systems at some $1.8 billion in 2006 and existing programmes will result in growth to $2.2 billion by 2011. A very high level of activity can be identified in 2007, due to a one off US government expenditure on IOOS of $700m. With increasing growth and the impact of the market drivers, in particular the response to global warming, we expect total forecast expenditure to grow significantly, perhaps to $2.4 billion by 2011. This may in time prove to have been too conservative a view.

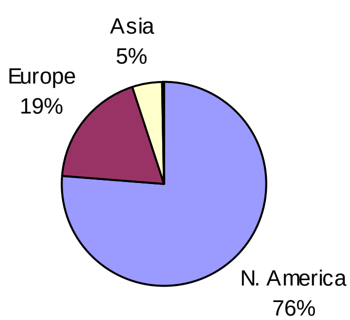

Figure 2: OOS 2007-11 – Global Segmentation

The U.S. is the world's largest ocean industries player with estimated annual expenditures of $750 billion in 2002. One-half of these expenditures are generated by the oil & gas industry and one-third is attributed to the Navy.[3] US federal expenditures for OOS have been estimated at $1 billion in 2006.[4] However, we estimate that total US expenditure is closer to $1.2 billion.

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[3] Dr. Andrew Clark, President, Marine Technology Society, in a presentation to the President's Commission on Ocean Policy, Nov. 13/01; and also stated in the Ocean Commission presentation " Technology & Marine Operations: Strategy for Technology Development to Meet the Nation's Needs", Nov. 2002 [www.ocean commission.gov/documents].

[4] Mike Hemsley, Dep. Dir., Ocean.US.

Data management and communications (DMAC) is the glue that holds OOS together and accounts for 12% of US annual OOS expenditures. One quarter is committed to the global component and three quarters to coastal management.

Naval involvement is important – much of the global ocean knowledge has been collected as a result of the United States ONR-funded programs, including funding for marine meteorology, small-scale ocean physics, optical oceanography, bioacoustics, coastal geosciences and instrument development.

An essential tool – Ocean Observation Systems are essential for the ocean-user community – in other words all of us – and without doubt are fundamental to increasing the understanding of the oceans and their role in climate change. As this realisation becomes more widespread we believe that OOS will receive more funding from governments worldwide and the commercial opportunities for the supply chain will grow accordingly.

Prospective Further Work

- Develop a strategy to address the opportunities offered by the OOS market – this must acknowledge and address the strengths and weaknesses of Canada in the sector.
  - Address the US market – as the world's largest OOS market this demands specific study.
  - Work at raising awareness of Canadian ocean technology.
- Focus on identified technology needs:
  - Users require improvements in accuracy, resolution, reliability, lifetime and cost. Low maintenance costs are a key concern and can, for example, be achieved by improved anti-fouling.
  - Select a few sectors – carry out detailed market study on areas such as chemical and biochemical sensors and improvements to satellite-based sensors.
  - Low-cost platforms such as autonomous vehicles
  - Improvements in data transmission and management
- Develop standards – there is a great need for OOS standards. Could Canada take a lead?