NDP
National Development Plan 2007 - 2013

epa
Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil

Climate Change Research Programme (CCRP) 2007-2013
Report Series No. 8

An Earth Observation Strategy for Ireland

GSI

ENTERPRISE IRELAND

SSTI
Strategy for Science, Technology and Innovation

Comhshaol, Pobal agus Rialtas Áitiúil
Environment, Community and Local Government

Environmental Protection Agency

The Environmental Protection Agency (EPA) is a statutory body responsible for protecting the environment in Ireland. We regulate and police activities that might otherwise cause pollution. We ensure there is solid information on environmental trends so that necessary actions are taken. Our priorities are protecting the Irish environment and ensuring that development is sustainable.

The EPA is an independent public body established in July 1993 under the Environmental Protection Agency Act, 1992. Its sponsor in Government is the Department of the Environment, Community and Local Government.

OUR RESPONSIBILITIES

LICENSING

We license the following to ensure that their emissions do not endanger human health or harm the environment:

- waste facilities (e.g., landfills, incinerators, waste transfer stations);
- large scale industrial activities (e.g., pharmaceutical manufacturing, cement manufacturing, power plants);
- intensive agriculture;
- the contained use and controlled release of Genetically Modified Organisms (GMOs);
- large petrol storage facilities;
- waste water discharges.

NATIONAL ENVIRONMENTAL ENFORCEMENT

- Conducting over 2,000 audits and inspections of EPA licensed facilities every year.
- Overseeing local authorities' environmental protection responsibilities in the areas of - air, noise, waste, waste-water and water quality.
- Working with local authorities and the Gardaí to stamp out illegal waste activity by co-ordinating a national enforcement network, targeting offenders, conducting investigations and overseeing remediation.
- Prosecuting those who flout environmental law and damage the environment as a result of their actions.

MONITORING, ANALYSING AND REPORTING ON THE ENVIRONMENT

- Monitoring air quality and the quality of rivers, lakes, tidal waters and ground waters; measuring water levels and river flows.
- Independent reporting to inform decision making by national and local government.

REGULATING IRELAND'S GREENHOUSE GAS EMISSIONS

- Quantifying Ireland's emissions of greenhouse gases in the context of our Kyoto commitments.
- Implementing the Emissions Trading Directive, involving over 100 companies who are major generators of carbon dioxide in Ireland.

ENVIRONMENTAL RESEARCH AND DEVELOPMENT

- Co-ordinating research on environmental issues (including air and water quality, climate change, biodiversity, environmental technologies).

STRATEGIC ENVIRONMENTAL ASSESSMENT

- Assessing the impact of plans and programmes on the Irish environment (such as waste management and development plans).

ENVIRONMENTAL PLANNING, EDUCATION AND GUIDANCE

- Providing guidance to the public and to industry on various environmental topics (including licence applications, waste prevention and environmental regulations).
- Generating greater environmental awareness (through environmental television programmes and primary and secondary schools' resource packs).

PROACTIVE WASTE MANAGEMENT

- Promoting waste prevention and minimisation projects through the co-ordination of the National Waste Prevention Programme, including input into the implementation of Producer Responsibility Initiatives.
- Enforcing Regulations such as Waste Electrical and Electronic Equipment (WEEE) and Restriction of Hazardous Substances (RoHS) and substances that deplete the ozone layer.
- Developing a National Hazardous Waste Management Plan to prevent and manage hazardous waste.

MANAGEMENT AND STRUCTURE OF THE EPA

The organisation is managed by a full time Board, consisting of a Director General and four Directors.

The work of the EPA is carried out across four offices:

- Office of Climate, Licensing and Resource Use
- Office of Environmental Enforcement
- Office of Environmental Assessment
- Office of Communications and Corporate Services

The EPA is assisted by an Advisory Committee of twelve members who meet several times a year to discuss issues of concern and offer advice to the Board.

EPA Climate Change Research Programme 2007–2013

An Earth Observations Strategy for Ireland

The Future of Earth Observations in Ireland: A Report of the GMES/GEO Ireland Project

CCRP Report

Prepared for the Environmental Protection Agency

by

Athlone Institute of Technology

Author:

Brendan Kelly

ENVIRONMENTAL PROTECTION AGENCY

An Ghníomhaireacht um Chaomhnú Comhshaoil
PO Box 3000, Johnstown Castle, Co. Wexford, Ireland

Telephone: +353 53 916 0600 Fax: +353 53 916 0699
Email: info@epa.ie Website: www.epa.ie

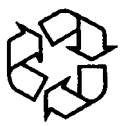
DISCLAIMER

The EPA Climate Change Research Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.

EPA CLIMATE CHANGE RESEARCH PROGRAMME 2007–2013

Published by the Environmental Protection Agency, Ireland

PRINTED ON RECYCLED PAPER



ISBN: 978-1-84095-414-2

Price: Free 11/11/100

ACKNOWLEDGEMENTS

This report is published as part of the Climate Change Research Programme 2007–2013. The programme is financed by the Irish Government under the National Development Plan 2007–2013. It is administered on behalf of the Department of the Environment, Community and Local Government by the Environmental Protection Agency which has the statutory function of co-ordinating and promoting environmental research.

The author would like to gratefully acknowledge the advice, assistance and continuous support of the members of the Global Monitoring for Environment and Security/Group on Earth Observations (GMES/GEO) Ireland project steering committee, the members of which were Dr Frank McGovern, Environmental Protection Agency, Dr Barry Fennell, Enterprise Ireland, Mr Gerard Fenner, Enterprise Ireland, and Dr Patrick O'Connor, Geological Survey of Ireland. In addition to this input, Enterprise Ireland kindly provided logistical support to the project by allowing the use of its facilities for a number of significant meetings and workshops.

The enthusiasm and co-operation of the other members of the Irish GMES/GEO Forum is gratefully acknowledged, in particular the Environmental Protection Agency, the Geological Survey of Ireland, the Marine Institute, Teagasc, Met Éireann, TechWorks Marine Ltd, the Naval Service, the Coastal and Marine Resources Centre (CMRC) at University College Cork, the Maritime and Energy Research Campus and Commercial Cluster (MERC3), and Nowcasting International Ltd.

The project benefited greatly from collaboration with the Sixth European Union Framework Programme (EU FP6) project GMES Network of Users (GNU). Thanks are due to Dr Herbert Haubold of the Austrian Federal Environment Agency for the kind invitation to join the GNU consortium. Some of the work carried out within the GNU consortium is presented here, but further information on GMES from the perspective of an Earth Observations (EO) user can be found at the GNU website (http://www.gmes-network-of-users.eu).

Details of Project Partner

Dr Brendan Kelly
School of Science
Athlone Institute of Technology
Dublin Road
Athlone
Co. Westmeath
Ireland
Tel.: +353 906 424411
Email: bkelly@ait.ie

Table of Contents

Executive Summary

Information is vital for effective decision making in areas of planning, infrastructure development and resource use. It is essential for the management of a wide range of environmental and societal issues, such as climate change, energy and water resources, sustainable agriculture, biodiversity, and the prevention and mitigation of natural and human-induced disasters. 'Earth observations' (EO) is the collective term for measurements of land, ocean, and atmospheric parameters by in-situ, airborne and satellite systems. Historically, observations have been primarily ground based but satellite-based EO systems have developed rapidly in recent decades and have grown in scope, reliability and importance. Europe has identified the space domain as a key platform for social, economic and strategic development, enhancing knowledge generation, stimulating development of new products and services, fostering industrial co-operation, and therefore being a driving force for innovation, growth and job creation. From a strategic perspective, the European Union (EU) aims to be a major actor in the global development of space-based systems and resources. This determination is being realised in two major flagship initiatives of EU space policy development:

1. The satellite communications project, Galileo; and
2. The EO programme, GMES (Global Monitoring for Environment and Security).

This document is focused on how Ireland can effectively engage with the GMES initiative and other relevant processes administered by the European Space Agency (ESA), as well as with the intergovernmental Group on Earth Observations (GEO). For this, a national EO strategy is required. This should:

- Build on and advance existing capacities in priority areas of interest and relevance for Ireland, such as land-cover mapping, maritime surveillance and atmospheric constituent analysis;
- Engage relevant government departments and state agencies to progress use of advanced EO systems in support of existing and future work;
- Involve research organisations in the development of new observation systems, data analysis approaches and management tools;
- Enhance commercial-sector engagement, support economic growth and job creation in delivery of EO services, within and outside Ireland; and
- Enable, with the increased utilisation of EO, enhanced implementation of national and EU policies in the areas of environment, civil security and governance of key domains (e.g. in providing cost-effective and more complete information in maritime security).

The benefits of a co-ordinated national strategy include:

- Developing EO services can contribute to the national goal of developing 'smart' industries in a 'knowledge economy' and should complement and enhance investment areas, such as those under the remit of Science Foundation Ireland (SFI) (e.g. Information and Communications Technology (ICT) and sensors development);
- Developing further capacity in EO can stimulate an EO services industry in Ireland, enhancing national self-sufficiency and increasing the ability to compete in international markets; and
- A strong national capacity will enable Irish researchers and small- to medium-sized enterprises (SMEs) to compete successfully in EU and international research programmes, such as the Seventh EU Research Framework Programme (FP7), thus maximising Ireland's drawdown of such funds and increasing related employment opportunities.

Maximum benefit is likely to be gained by focusing efforts on priority areas utilising existing capacities and strengths. Specific information services have been identified in the marine, land and atmosphere domains which could be provided by interdisciplinary consortia, comprising expertise and capacity from across public agencies, the research community and SMEs. Ireland's EO strategy needs to encompass engagement at all levels – official, expert, scientific, technical and user. A co-ordinated national approach should help in influencing GMES developments, ensuring that they respond to Ireland's requirements across a range of policy areas.

A key recommendation is the establishment of a cross-departmental group, tasked to provide a national policy framework for GMES and broader EO issues. Such an initiative is most appropriately advanced by the Department of Jobs, Enterprise and Innovation which leads on national engagement with space issues. The group should cover environmental, civil security and enterprise issues, as well as areas of national and global governance, including aid investment and food security matters. The policy framework, which would need to be adopted and approved at a senior government level, should provide overall guidance and principles for development and co-ordination of ongoing work on EO in Ireland. It should also include issues of communication, outreach and branding of Ireland's EO activities.

This vision for EO in Ireland could be linked to a high-profile launch and used to raise Ireland's profile at national and international events. This should enhance uptake in the education, research and enterprise sectors and assist ongoing work by Enterprise Ireland in building international collaborations in this area.

1 Introduction

In its 2007 Space Policy (Commission of the European Communities, 2007), Europe articulated its aim to play a lead role in the global development of space as a platform for Earth observations (EO). The Council of the European Union (2011) document *Towards a Space Strategy for the European Union that Benefits its Citizens* further envisions space as a key platform for social, economic and strategic development. It is also seen as a tool for policy support in areas such as the environment, climate change, public/civil security, humanitarian and development aid, transport and the information society. In economic terms, space-related activities are considered to be at the forefront of knowledge generation, stimulating the development of new products and services, fostering industrial co-operation and, therefore, being a driving force for innovation, growth and job creation. From a strategic perspective, the European Union (EU) aims to be a major actor in the global development of space-based systems and resources. This determination is being realised in two major flagship initiatives of EU space policy development:

1. The satellite communications project, Galileo; and
2. The EO programme, GMES (Global Monitoring for Environment and Security).

This document focuses on how Ireland can effectively engage with the GMES initiative and other relevant processes administered by the European Space Agency (ESA), as well as with the intergovernmental Group on Earth Observations (GEO). Such engagement will provide clear benefits by supporting national governance and operational activities, enhancing technological research and development, and developing a vibrant downstream EO service industry that can generate employment in this high-technology sector.

Ireland is already actively involved in these initiatives at various levels and these activities are projected to increase. However, it is important to define a national strategy to enhance the work in this area, which can serve the environmental, scientific and technological needs of Irish society and economy, by fostering strong industry and science research partnerships and developing a skilled workforce that is responsive to global commercial market demands.

The aims of this strategy are:

- To build on and advance existing capacities in areas of interest and relevance for Ireland such as land-cover mapping, maritime surveillance and atmospheric constituent analysis;
- To engage relevant government departments and state agencies to progress use of advanced EO systems in support of existing and future work;
- To involve research organisations and bodies in innovative and challenging research aimed at the development of new observation systems, data analysis approaches and management tools; and
- To enhance commercial-sector engagement, support economic growth and job creation in delivery of world-class information and services linked to EO within and outside Ireland.

A pathway for development of such a strategic approach for Ireland is outlined in this document.

1.1 Background

Information is vital for effective decision making in areas of planning, infrastructure development and resource use. It is essential for the management of a wide range of environmental and societal issues, such as climate change, energy and water resources, sustainable agriculture, biodiversity, and the prevention and mitigation of natural and human-induced disasters. ‘Earth observations’ is the collective term for measurements of land, ocean, and atmospheric parameters by in-situ, airborne and satellite systems. Historically, observations have been primarily ground based but satellite-based EO systems have developed rapidly in recent decades and have grown in scope, reliability and importance. These have

included commercial missions, as well as those carried out by space agencies. There has also been significant development in the analysis and dissemination of EO data, with a strong growth in commercial-sector provision of services in this area.

On a practical level, it is evident that global information is required for a range of management and governance issues, in particular global environmental problems. Currently, satellite information is used operationally in areas such as weather system monitoring and forecasting, land-cover mapping, physical oceanography and maritime surveillance. Satellite observation systems are already a recognised component of climate observation systems under the United Nations Framework Convention on Climate Change (UNFCCC). There is likely to be increased reliance on satellite information for decision making on the management of global grand challenges, such as climate change, biodiversity loss and desertification, where they are seen to be essential tools (e.g. in monitoring land use and deforestation).

It is estimated that there are currently over 260 EO satellite missions either operational or planned for the next 15 years (Committee for Earth Observation Satellites, 2010). As the capabilities of these satellites become increasingly sophisticated, EO systems are projected to become key data sources across a range of sectors. This development is regarded as a driver of future information systems that will provide end-user information services to governments, government agencies, businesses and citizens. This is envisaged as being similar to the development of Global Positioning Systems (GPS), but on a far broader level of information provision.

Ireland is well positioned to be at the forefront in exploiting these emerging commercial, societal and scientific opportunities, as well as to take advantage of the benefits of improved efficiency in monitoring, analysis and management across a wide variety of activities. This would contribute to the growth of the Irish economy, including an increase in employment in a high-technology, high-value industry sector, and sustained growth in the research sector.

1.2 International Initiatives on Earth Observations

The importance of EO has been recognised globally and a number of international mechanisms have been established to co-ordinate the development of new information systems and operational services based on EO. The two major initiatives are the intergovernmental GEO and the GMES programme, which is the European contribution to the GEO.

The EU and the ESA have advanced the development of the GMES initiative since the early 1990s. Significant technical challenges have been overcome during this time, so that EO, in general, and the GMES initiative, in particular, can now provide quantitative data with high reliability, in a timely and efficient manner. The aims of the GMES programme are to provide continuous access to information services on the environment and civil security, using an array of permanent, space-based observation and in-situ infrastructures. GMES systems will contribute to marine, land and atmospheric monitoring in support of European and global policy development and implementation. This will help underpin sustainable resource use and enhance information on climate change, including the monitoring of the effectiveness of policy responses. It will also contribute to civil security, crisis prevention and management, with particular emphasis on humanitarian aid, development assistance and civil protection. The overall GMES system combines data from EO satellite and in-situ sensors (i.e. ground-based sensors, airborne and marine-deployed sensors). These data are processed to provide users with required information via the GMES services. GMES development has focused the delivery of services related to:

1. Land use
2. Ocean
3. Atmosphere
4. Emergency response; and
5. Civil security.

These services are at different levels of development[1], with the land-use service (which builds on existing land-use analysis carried out under CORINE (Co-ordination of Information on the Environment)) being regarded as the most advanced service. Climate change issues are currently covered by Services 1–3 and elements of Service 4, but there is also a proposed new GMES service specifically covering climate change monitoring in support of adaptation and mitigation policies. The emergency response service is focused on issues of floods, fires and major accidents, and the support of rescue and aid efforts. The civil security service deals with issues such as maritime surveillance, border control and humanitarian aid. The improved provision of these services to policy makers, citizens and other decision makers is considered to have the potential to create private-sector opportunities in information provision. It is envisaged that the growing user community, both within the EU and beyond, will increase its demand for value-added EO information from satellite systems for a range of regulatory and other information activities.

An investment of over €2.2 billion has been made in the GMES initiative by the EU and the ESA. This investment is designed to take GMES out of the research or 'pre-operational' phase into the fully operational phase. In October 2010, the European Parliament regulation on the GMES programme came into force. The Parliament also approved €107 million in extra funding for the 3-year initial operations phase to supplement the €209 million contribution from the EU Seventh Research Framework (FP7) programme. In the most recent FP7 Space 2010 call for proposals, Ireland secured a total of €756,000 in funding, part of which was in the area of EO applications.

The GMES initiative is effectively an enabling service, which allows value adding and opportunities for development of products and services. It provides information at the regional scale, together with some basic analysis, but it is envisaged that more sophisticated analysis and tailored, value-added products and services will be provided to end-users by downstream service providers. This represents an opportunity for research and commercial organisations to build product and service offerings that can be brought to market. It also has a global dimension, which can be linked to issues and actions on global governance and investments, for example in areas such as climate change where validation of EU investments in mitigation actions in developing countries will require independent verification.

The intergovernmental GEO initiative[2] has provided an avenue for the global development of EO information systems. It is an international partnership of more than 86 countries, committed to an effort to build the Global Earth Observation System of Systems (GEOSS), focused on providing information of benefit to society in nine specific areas:

1. **Water:**
   Improving water-resource management through better understanding of the water cycle;

2. **Energy:**
   Improving management of energy resources;

3. **Climate:**
   Understanding, assessing, predicting, mitigating, and adapting to climate variability and change;

4. **Ecosystems:**
   Improving the management and protection of terrestrial, coastal, and marine ecosystems;

5. **Agriculture:**
   Supporting sustainable agriculture and combating desertification;

6. **Biodiversity:**
   Understanding, monitoring, and conserving biodiversity;

7. **Disasters:**
   Reducing loss of life and property from natural and human-induced disasters;

8. **Health:**
   Understanding environmental factors affecting human health and well-being; and

1. See http://www.gmes.info for more details.

2. http://www.earthobservations.org

9. **Weather:**
   Improving weather information, forecasting, and warning.

The GMES initiative is the EU contribution to the GEO and the GEOSS. This provides an additional stimulus for the global development of the GMES programme.

1.3 Earth Observations and Ireland

Ireland has a significant history and continuing role in EO. This has primarily been in ground-based meteorological and environmental measurements, with regionally and globally significant observational records for Valentia Island, Kerry, and Mace Head, Galway, among others. Engagement with satellite-based EO has primarily been within specific interest areas, such as the work of Met Éireann with the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), and research links with the international satellite observations community by sectors of the Irish research community. Ireland's strategic location on the western boundary of Europe and its relatively clean environment have been factors in attracting research interest and links to the international satellite analysis community.

Since 1990, the development of EU-wide analysis of land cover based on satellite data has been promoted under the CORINE programme of the European Commission (EC). In Ireland, the Environmental Protection Agency (EPA) and Teagasc have taken a leading role in the recent development of CORINE land-cover analysis. CORINE has served to increase the use of satellite information for environmental assessment. However, it has also highlighted the limitations that can arise from use of such continental-scale analysis at the national scale, and underlines the need for active local engagement with development and validation work, in order to provide robust and meaningful analysis.

A major step forward was taken when Ireland became a member of the ESA Earth Observation Programme Board in 2008. This has facilitated Irish participation in the third period of the Earth Observation Envelope Programme (EOEP3), which runs from 2008 to 2012. Under this programme, Irish researchers have obtained enhanced access to satellite data. Raised awareness of the ESA's EO programmes has seen over 30 official data requests from Irish-based researchers in support of projects encompassing ESA-captured EO for Ireland. Furthermore, researchers have become involved in a range of new projects to develop EO-based solutions to practical issues, ranging from improving inventories of forestry resources to the detection of land-cover change in Ireland and the improved prediction of storm sea-surge events worldwide.

The GMES Forum was established in 2003 to provide a co-ordination mechanism for EO in Ireland for public bodies, academia and small- to medium-sized enterprises (SMEs). It enabled a consideration of national responses to developments under the GMES initiative (e.g. the work of the GMES Advisory Council (GAC) and the GEO, including the EU high-level co-ordination group). The GMES/GEO Forum has also provided a useful mechanism for consideration of opportunities under the ESA EOEP and the EU FP7 programme on the themes of *Space* and *Environment (including Climate Change)*. The GMES/GEO Forum continues to meet on an ad-hoc basis. However, the mandate for the group and its role need to be reconsidered in the context of the requirements for engagement with the GMES initiative as it moves out of the research phase into operational mode.

There is also a vibrant EO community that has for several years organised an annual Irish Earth Observation Symposium. This community has also been considering how best to develop EO in Ireland. It has recently forged strong links with the UK Remote Sensing and Photogrammetry Society (RSPSoc)[3] and, in 2010, held a joint symposium with this society.

3. http://rspsoc.org/

2 Earth-Observations-Related Challenges for Ireland

A key issue that has limited Ireland's ability to engage with the major development groups, either at the EU or wider international levels, relates to the limited number of people in Ireland with appropriate expertise in the use of satellite data. Long-term operational use of satellites has been confined to the area of meteorology, with only a limited appreciation of how they can be used operationally in other areas. Consequently, focused investment in promoting education, research, development and operational use of EO has not occurred, while there has been a major investment in other sensor development areas and associated information and communications technology (ICT). This has resulted in inertia amongst the potential user communities, which prefer to rely on conventional methodologies and data streams for core activities, and a dearth of a significant well-trained and informed research community in this area.

Although a large volume of EO data has been obtained by satellite information systems over a number of decades, their use remains relatively underdeveloped in Ireland. The reasons for this are complex but, in addition to the limited human capacity, barriers include:

- Perceptions that the data are complex to work with and require significant expertise for interpretation;
- Lack of knowledge on how to access the data and products;
- Data cost and the infrastructural requirements for large data-handling capacity; and
- Technical issues regarding cloud cover in Ireland.

Fuller utilisation has, therefore, been limited outside of specialist areas, such as weather forecasting. These concerns and limitations in regard to continuity of access, processing and interpreting ability have led to a focus on in-situ observations and the use of pan-European analysis based on EO (e.g. on land use), some of which have been shown to have many limitations when used for national-scale applications.

These issues, therefore, encompass areas of policy and administration, as well as scientific and technical barriers. Ireland's experience in these areas is not unique. However, movement toward solutions is hindered by the absence of clear national policy for this domain. This serves to foster the ad-hoc nature of the use of EO data and limits support and investment, including that in research and development. The GMES programme can be viewed as a major initiative to overcome key barriers at an EU level, in order to mainstream the use of satellite-based EO in important EU policy areas. The response in Ireland to the GMES initiative also provides an opportunity to better determine Ireland's approach and policy in this area, including the identification and promotion of opportunities. A sustainable, indigenous capacity in working with EO is vital so that Ireland can address areas of concern, rather than relying on generic or inappropriate solutions offered by outside entities. The GMES initiative offers SMEs and research centres the opportunity to develop value-added products and services with a global interest and can, therefore, stimulate employment in this high-tech sector.

3 Opportunities for Development

At a scientific and technical level, Ireland's location and geography have resulted in considerable interest in the use of in-situ data for validation of combined satellite systems model analysis. Apart from areas of scientific interest, the main benefits of EO for Ireland are considered to include that:

- EO can enable enhanced implementation of national and EU policies in the areas of environment, civil security and governance of key domains (e.g. in providing cost-effective and more complete information in maritime security);
- Developing EO services can contribute to the national goal of developing 'smart' industries in a 'knowledge economy' (Department of Enterprise, Trade and Employment, 2009) and should complement and enhance investment areas, such as ICT and sensors development (e.g. the CLARITY CSET[4]);
- Developing further capacity in EO can stimulate an EO services industry in Ireland, enhancing national self-sufficiency and increasing the ability to compete in international markets; and
- A strong national capacity will enable Irish researchers and SMEs to compete successfully in EU and international research programmes, such as the EU FP7, thus maximising Ireland's drawdown of such funds and increasing related employment opportunities.

Although current EO capacity in Ireland is relatively limited, it provides a strategically important platform for development. Examples of this include the delivery of postgraduate courses in the area of EO in University College Cork[5] and the National University of Ireland, Maynooth[6], an active research base within the third-level sector, and a number of agencies and SMEs that are following the GMES initiative and other EO service developments and contributing to other space domains within Ireland, via support from the ESA, EU FP7 and Enterprise Ireland. The main stakeholders in Irish EO are listed in Table 3.1. Maximum benefit is likely to be gained by initially focusing development efforts on enhancing existing capacity with a focus on areas of strength, as well as priority issues for Ireland. These include specific information requirements for marine, land and atmosphere domains. A number of these requirements are outlined here and can be progressed though strategic research investment and infrastructure development.

3.1 Protection and Management of Ireland's Maritime Resources

Ireland's marine territories are significantly larger than its land base. It is in the strategic national interest that these areas are protected and that the resources are managed in a manner that is sustainable and that enhances socio-economic development. The resources required to monitor, protect and manage Ireland's maritime resources are considerable. However, use of these resources can be considerably improved through the use of satellite EO systems, which can provide information at an unparalleled spatial and temporal coverage on a range of issues from ship movements, environmental hazards (e.g. oil spills) to phytoplankton blooms and wave height estimation. Irish research groups are already involved in activities in these areas through ESA and EU FP7 projects. The development of enhanced EO services in this area can further support strategic areas of economic interest (e.g. wave energy, maritime surveillance and security) and contribute to an understanding of longer-term changes (e.g. ocean surface temperature increase and sea-level rise).

- **Recommendation 1**
  Ireland requires strategic engagement with the GMES initiative and the ESA on the sustainable use of EO systems for the protection and development of its maritime resources. Enhanced national investment in this area linked to EU-wide investment is required. This could build on the

4. http://www.clarity-centre.org/
5. www.ucc.ie/en/geography/postgrad/mscgisrs/
6. http://geography.nuim.ie/postgraduates/ mscingisremotesensing

Table 3.1. Irish Earth observations (EO) stakeholders.

Name of group	EO areas of relevance
Athlone Institute of Technology	GMES Atmosphere Services, PROMOTE, GEMS, MACC, PASODOBLE
Bord Gáis	GMES Marine Services (Flood Prediction)
Bord na Móna	CORINE Land Cover, GMES Land Service
Department of Agriculture, Fisheries and Food (DAFF)	GMES Land Services, Land Parcel Information Service (LPIS)
Dublin City University (DCU)	GMES Marine and Atmosphere Services
Electricity Supply Board (ESB)	GMES Marine Services (Flood Prediction)
Enterprise Ireland (EI)	GMES
Environmental Protection Agency (EPA)	CORINE Land Cover, GMES Land Services, GMES Atmosphere Services
ERA-MAPTECH Ltd	CORINE Land Cover, GMES Land Services, MOLAND
Forest Service (DAFF)	CORINE Land Cover, GMES Land Service
Geological Survey of Ireland (GSI)	CORINE Land Cover, GMES Land Services, GMES Service Element 'Terrafirma'
Irish Coast Guard (IRCG)	GMES Marine Services, GMES Emergency Response and Security Services, EMSA's CleanSeaNet
Irish Naval Service	GMES Marine Services, GMES Emergency Response and Security Services, LIRGUARD, VMS
Local authorities	GMES Land, Marine and Atmosphere Services
Marine Institute (MI)	GMES Marine Services, Tide Gauge Network
Maritime and Energy Research Cluster (MERC)	GMES Marine Services, GMES Emergency Response and Security Services
Met Éireann (ME)	GMES Atmosphere and Marine Services, TRITON
National Council for Forest Research and Development (COFORD) (DAFF)	CORINE Land Cover, GMES Land Services
National Parks and Wildlife Service (NPWS)	CORINE Land Cover, GMES Land Services
National University of Ireland, Galway	GMES Marine and Atmosphere Services, PROMOTE, GEMS, MACC
National University of Ireland, Maynooth	GMES Land, Marine and Atmosphere Services
Northern Ireland Electricity	GMES Marine Services (Flood Prediction)
Nowcasting International Ltd	GMES Marine and Atmosphere Services, PASODOBLE
Teagasc	CORINE Land Cover, GMES Land Services
TechWorks Marine Ltd	GMES Marine Services, MyOcean, Mersea, ECOOP
University College Cork	GMES Land, Marine and Atmosphere Services
University College Dublin	GMES Land Services

GMES, Global Monitoring for Environment and Security; PROMOTE, PROtocol MOnitoring for the GMES Service element: atmosphere; GEMS, Global Earth-system Monitoring using Satellite and in-situ data); MACC, Monitoring of Atmospheric Composition and Climate; PASODOBLE, Promote Air Quality Services integrating Observations; MOLAND, Monitoring Land Use/Cover Dynamics; LIRGUARD, current fisheries protection system; VMS, Vessel Monitoring System; TRITON, Area Storm Surge Prediction and Management System used by Met Éireann; ECOOP, European COastal-shelf sea OPerational observing and forecasting system.

experience gained in pilot activities and focus on a number of demonstration projects that link research bodies, public bodies and SMEs to deliver targeted products and services.

3.2 Enhanced Terrestrial Monitoring

As outlined above, EO analysis of land use and land-use change is relatively well advanced at EU and national levels through the development of CORINE. This analysis has limitations and its use is primarily for pan-European rather than national scales, where other data can provide more detailed information. In Ireland, CORINE is used in national assessment and for reporting to international bodies such as the UNFCCC. However, there is an increasing need for a national land and soil analysis capacity to comply with national and EU requirements to improve management of land, soils and freshwater resources. Research projects in Ireland have illustrated the potential of alternative and improved approaches to land-cover/use data extraction from satellite EO information. It is essential that the development and consolidation of necessary national capacity and structures for analysis of land and water resources is linked with relevant work under the GMES initiative and the ESA (e.g. moving towards a spatial resolution that is required for analysis of key features of the Irish landscape and its management).

- **Recommendation 2**
  Development of required national capacity for analysis of land and fresh water should be intrinsically linked with relevant initiatives under the GMES programme and the ESA. A number of pilot projects in this area should be identified that aim to enhance the analysis provided in support of national and international reporting requirements, thus enhancing monitoring, detection and enforcement capacity.

3.3 Atmospheric Protection

Ireland's location on the western boundary of Europe with open access to the North Atlantic Ocean is a major factor in ensuring that our air quality is generally good. Because of this unique geography, Ireland is ideally positioned to provide baseline and background data on pollutants, including greenhouse gas (GHG) concentrations, in the North Atlantic region. This is the basis on which NUI Galway's Mace Head site[7] has developed into a leading global location for a range of atmospheric observations. Ireland's vulnerability to large-scale atmospheric transport of material was also dramatically illustrated by the volcanic plume from Iceland, which disrupted air transport for significant periods during 2010. Ireland is also vulnerable to transport of pollutants and hazardous material from other European countries and to a lesser extent from transatlantic sources. Ireland, therefore, has unique advantages and interests in the use of EO for atmospheric protection. The work at Mace Head and linked sites within and outside Ireland, in Europe and globally, can enhance validation of satellite products and improve algorithm development. Ireland can play a leading role in this work.

- **Recommendation 3**
  Ireland should exploit its unique advantages of geography and location to build on existing leadership in atmospheric observations and analysis by furthering strategic linkages with GMES and ESA EO work on air pollutants and GHG analysis. The development of a number of pilot projects in this area that are of interest to Ireland, the EU and the global air quality community should be advanced. These should aim to build a sustained EO capacity in this area.

3.4 Civil Security

The GMES work on civil security and emergency support can enhance areas of national interest. These include issues of flooding, large-scale fires and major accidents both on land and at sea. Support for this area has already been exemplified through applications of satellite-based information systems (e.g. in maritime surveillance, flood forecasting and storm surge prediction). Ongoing communication with authorities in Ireland and relevant groups working under the GMES initiative is required for the development and increased utilisation of these services.

In addition to the areas identified above, it is considered that the global dimension of GMES and ESA EO needs greater recognition within Ireland. This includes the ongoing development under the GEO and

7. http://macehead.nuigalway.ie/mace1.html

its aim to provide global data on key societal benefit areas such as water, energy, climate and land use. Use of information from the GMES programme and the GEO may have particular value for aid assistance work in regions of Africa where Ireland has a number of partner countries. The use of such information warrants further exploration, particularly in the context of food security issues.

3.5 Infrastructure Development

The building of infrastructures to enable Ireland to effectively interface with the development of space-based EO systems is considered to be an essential requirement. This encompasses a number of dimensions, including infrastructures for validation or 'ground-truthing' of remotely sensed observations, satellite communications, data analysis, storage and display, as well as service provision. In relation to these areas, investments have been already made. These have not necessarily been designed to link with satellite-based EO, but may be open to orientation in this manner.

In relation to ground-truthing, the island of Ireland and its environment remain a key infrastructure, whose size, location and geography have already attracted interest from the satellite EO community. Further investment in key locations, such as the ocean–land boundary site at Mace Head, can provide unique opportunities for development of integrated EO systems. The significant investment in ICT and development of sensor technologies by Science Foundation Ireland (SFI) and others also provide opportunity for integration with a range of space-based systems, including communications, analysis and systems support. The ongoing development of satellite data reception and transmission centres by public and commercial organisations also provides opportunity for development.

As part of the encouragement of EO activities in Ireland, investment in the development of existing and new infrastructure, as well as some element of reorientation of current activities, is warranted. This should be part of an overall strategy to ensure that Ireland is optimising its role in EO development and availing of opportunities that arise.

4 A Role and Opportunity for Ireland

As a member of the EU GMES development bodies and the ESA EOEP, Ireland has a real opportunity to participate in the development and use of satellite observation systems. A strategic, co-ordinated approach to these developments is advisable. This should build on areas of national interest, areas of advantage and existing capacities. A number of these have been outlined in Chapter 3. However, consideration should be given to other potential opportunities where Ireland may not currently benefit from EU and global initiatives.

Ireland's GMES strategy needs to encompass engagement at all levels – official, expert, scientific, technical and user. A co-ordinated, national approach will be effective in influencing GMES developments so that they respond to Ireland's interests and needs across a range of policy areas. A key step in this process is considered to include the establishment of a cross-departmental group to provide a national policy framework for GMES and broader EO issues. The cross-departmental body should be tasked to produce an outline policy framework for responding to developments of space-based EO and related areas.

Such an initiative is most appropriately advanced by the Department of Jobs, Enterprise and Innovation which leads on national engagement with space issues. The group should cover environmental, civil security and enterprise issues, as well as areas of national and global governance, including aid investment, food security and support for countries with which Ireland has ongoing links and shared interests.

The policy framework should provide overall guidance and principles for development. It may provide a clear mandate and role for the GMES/GEO Forum or a similar expert and technical body to provide support and advice on implementation and response to EU development. This could include a mandate to provide regular reports to government on EO developments, challenges and opportunities for Ireland, and for co-ordination of ongoing work on EO in Ireland. This is considered to include the following elements:

- To actively engage with implementation of policy in relevant state agencies and government bodies;
- To assess EO research issues and findings of relevance for national and EU policy implementation; and
- To work with SMEs and other commercial groups to develop opportunities for Ireland arising from EO.

The determination of an overall vision for EO development, including issues of user engagement, communication, outreach and branding of Ireland's EO activities, could also be part of the remit of the GMES/GEO Forum. This would need to be adopted officially at a high level within participating organisations and be approved at senior governmental level. This vision for Ireland and EO could be linked to a high profile launch and used in major national and international events. Enhancing the profile of Ireland's role in regard to EO would enhance uptake in the education, research and enterprise sectors and assist ongoing work by Enterprise Ireland in building international collaboration in this area (Enterprise Ireland, 2010).

The mandate should also give guidance on the membership and role of the GMES/GEO Forum which can then define its arrangements to carry out its work. This may include the development of working groups in key domains such as marine, land and atmosphere.

A key part of an Irish EO strategy is to influence GMES and ESA policy matters early in their development cycles, so that the agreed funding calls, products and services are relevant and appropriate for Ireland. Significant engagement with European bodies and groups is required to advance this objective. This would include engagement with similar countries in the

EU and wider (e.g. Norway, Denmark, Sweden and Switzerland) in the context of EO policy development.

As has been outlined above, a number of priority issues have been identified, as well as the steps required to advance work in these areas. This work could attract investments either through central or sectoral research funding in projects and/or infrastructure to enhance use of EO data and participation of key groups within Ireland in both EU and global EO developments. This should take place within a policy and implementation framework that is targeted at the priority issues for Ireland, via pilot and demonstration projects that enable the formation of consortia to use expertise and capacity across public agencies, the research community and SMEs. This should aim to establish a longer-term vision of a sustainable EO community in Ireland that is engaged in regional and global EO activities.

5 Conclusions

Ireland can obtain considerable environmental, scientific, technological and economic benefits from strategic engagement with the GMES initiative, the GEO and the ESA on EO. Ongoing ad-hoc activities need to be enhanced and put on a sustainable footing if Ireland is to avail of the opportunities for improved resource management, governance and service provision. This will involve development of a number of existing activities in Ireland through research investment and enhancing links with European and wider international bodies. However, a positive and visionary policy framework, supported at senior government level, is required for this, coupled with an effective co-ordination structure and implementation process that engages expertise and knowledge from the policy, research, operational and commercial sectors in Ireland. Such an approach would provide a coherent basis to enable Ireland to advance beneficial work in priority areas. This approach requires formal endorsement at senior government level, and may include the establishment of an EO brand for Ireland. A strategic approach such as this is required in order for Ireland to be recognised as a key participant in the development and use of EO technologies and to provide the relevant support to build on areas of national interest and advantage, in partnership with EU and wider international bodies.

References

Commission of the European Communities, 2007. *Communication from the Commission to the Council and the European Parliament: European Space Policy.* Brussels, Belgium. Available from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2007:0212:FIN:EN:PDF (accessed 12 July 2011).

Committee for Earth Observations Satellites, 2010. *The Earth Observation Handbook***.** Available from http://www.eohandbook.com/ (accessed 12 July 2011).

Council of the European Union, 2011*. Towards a Space Strategy for the European Union that Benefits its Citizens: Council Conclusions*. Brussels, Belgium. Available from http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/intm/122342.pdf (accessed 12 July 2011).

Department of Enterprise, Trade and Employment, 2009. *Science, Technology and Innovation: Delivering the Smart Economy.* Department of Enterprise, Trade and Employment (now Department of Jobs, Enterprise and Innovation), 23 Kildare Street, Dublin, Ireland. Available from http://www.djei.ie/publications/science/2009/Delivering_the_Smart_Economy.pdf (accessed 12 July 2011).

Enterprise Ireland, 2010. *Ireland's Space Strategy.* Enterprise Ireland, Dublin, Ireland. Available from http://www.enterprise-ireland.com/en/Research-Innovation/Companies/Access-EU-Research-Innovation-reports/National-Strategy-for-European-Space-Agency-Participation.pdf (accessed 12 July 2011).

Acronyms and Annotations

Core service	GMES service providing standardised multipurpose information common to a broad range of EU policy-relevant application areas.
CORINE	**Coordination of Information on the Environment** A programme aimed at gathering information relating to the environment on certain priority topics for the European Union (land cover, coastal erosion, biotopes, etc.).
Downstream service	GMES service serving specific (trans-) national, regional, or local information needs. A downstream service may be derived from core services or be totally independent of these.
EC	**European Commission** The 'Civil Service' of the EU and the main driving force of GMES (together with the ESA). The EC is the main funding body for GMES (mainly through FP6 and FP7).
EO	**Earth observations** 'Earth observations' is the gathering of information about planet Earth's physical, chemical and biological systems. This can involve satellite and other remote sensing, as well as in-situ monitoring.
EOEP3	Earth Observation Envelope Programme
EPA	Environmental Protection Agency
ESA	**European Space Agency** One of the two original drivers of the GMES initiative (the other being the EC). The ESA is responsible for the GMES space component.
EU	European Union
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FP6	**Sixth EU Framework Programme for Research & Technological Development** FP6 covered the period from 2002 to 2006. Its total budget was €17.5 billion.
FP7	**Seventh EU Framework Programme for Research & Technological Development** FP7 covers the period from 2007 to 2013. Its total budget is €51 billion.
GAC	**GMES Advisory Council** The GAC brings together the EU Member States, the European Commission, the ESA, and other relevant agencies active in EO in order to provide advice on GMES-related matters. It usually meets several times each year in Brussels.
GAS	**GMES Atmosphere Service** One of the pilot services, dealing with atmospheric issues such as air quality and climate change.
GEO	**Group on Earth Observations** The GEO is a voluntary partnership of governments and international organisations. It co-ordinates the efforts to set up the GEOSS.

GEOSS	**Global Earth Observation System of Systems** The GEOSS will provide decision-support tools to a wide variety of users. It will be a global and flexible network of content providers (see GEO).
GHG	Greenhouse gas
GMES	**Global Monitoring for Environment and Security** European initiative for the implementation of information services dealing with environment and security.
GPS	Global Positioning Systems
ICT	Information and communications technology
In-situ data	Data collected from in-situ monitoring systems
In-situ monitoring	Air-, sea and land-based systems collecting measurements compliant with GMES service requirements (i.e. EO monitoring systems which are not deployed in space).
RSPSoc	UK Remote Sensing and Photogrammetry Society
SFI	Science Foundation Ireland
SMEs	Small- to medium-sized enterprises
UNFCCC	United Nations Framework Convention on Climate Change
User	The general term ‘user’ is employed in a number of different contexts in the GMES programme: • An individual, group, body, public agency or commercial entity that is a partner or is actively engaged in a GMES Service Element (GSE) project or a GMES-related FP6 or FP7 project to utilise and evaluate a GMES service • An individual, group, body, public agency or commercial entity that, while not technically part of a GSE or GMES-related FP6/FP7 project, has negotiated access to and employs the results of a GMES service in the course of its work • Potential new ‘users’ of existing or future GMES services • An entity may be (or potentially be) a user of a core GMES service but may then utilise that service to provide a downstream service, and thus have both user and provider roles in the context of GMES • A GMES ‘user’ entity (such as a large public agency) may currently utilise a GMES service in a particular part of the organisation and therefore that organisation might be considered a ‘GMES user’. However, it may be that other parts of the organisation may not be involved in or aware of corresponding GMES services in other relevant subject areas as might be expected

An Ghníomhaireacht um Chaomhnú Comhshaoil

Is í an Gníomhaireacht um Chaomhnú Comhshaoil (EPA) comhlachta reachtúil a chosnaíonn an comhshaol do mhuintir na tíre go léir. Rialaímid agus déanaimid maoirsiú ar ghníomhaíochtaí a d'fhéadfadh truailliú a chruthú murach sin. Cinntímid go bhfuil eolas cruinn ann ar threochtaí comhshaoil ionas go nglactar aon chéim is gá. Is iad na príomh-nithe a bhfuilimid gníomhach leo ná comhshaol na hÉireann a chosaint agus cinntiú go bhfuil forbairt inbhuanaithe.

Is comhlacht poiblí neamhspleách í an Ghníomhaireacht um Chaomhnú Comhshaoil (EPA) a bunaíodh i mí Iúil 1993 faoin Acht fán nGníomhaireacht um Chaomhnú Comhshaoil 1992. Ó thaobh an Rialtais, is í an Roinn Comhshaoil, Pobal agus Rialtais Áitiúil.

ÁR bhFREAGRACHTAÍ

CEADÚNÚ

Bíonn ceadúnais á n-eisiúint againn i gcomhair na nithe seo a leanas chun a chinntiú nach mbíonn astuithe uathu ag cur sláinte an phobail ná an comhshaol i mbaol:

- áiseanna dramhaíola (m.sh., líonadh talún, loisceoirí, stáisiúin aistrithe dramhaíola);
- gníomhaíochtaí tionsclaíocha ar scála mór (m.sh., déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta);
- diantalmhaíocht;
- úsáid faoi shrian agus scaoileadh smachtaithe Orgánach Géinathraithe (GMO);
- mór-áiseanna stórais peitreail;
- scardadh dramhuisce.

FEIDHMIÚ COMHSHAOIL NÁISIÚNTA

- Stiúradh os cionn 2,000 iniúchadh agus cigireacht de áiseanna a fuair ceadúnas ón nGníomhaireacht gach bliain.
- Maoirsiú freagrachtaí cosanta comhshaoil údarás áitiúla thar sé earnáil - aer, fuaim, dramhaíl, dramhuisce agus caighdeán uisce.
- Obair le húdaráis áitiúla agus leis na Gardaí chun stop a chur le gníomhaíocht mhídhleathach dramhaíola trí comhordú a dhéanamh ar líonra forfheidhmithe náisiúnta, díriú isteach ar chiontóirí, stiúradh fiosrúcháin agus maoirsiú leigheas na bhfadhbanna.
- An dlí a chur orthu siúd a bhriseann dlí comhshaoil agus a dhéanann dochar don chomhshaol mar thoradh ar a ngníomhaíochtaí.

MONATÓIREACHT, ANAILÍS AGUS TUAIRISCIÚ AR AN GCOMHSHAOL

- Monatóireacht ar chaighdeán aeir agus caighdeáin aibhneacha, locha, uiscí taoide agus uiscí talaimh; leibhéil agus sruth aibhneacha a thomhas.
- Tuairisciú neamhspleách chun cabhrú le rialtais náisiúnta agus áitiúla cinntí a dhéanamh.

RIALÚ ASTUITHE GÁIS CEAPTHA TEASA NA HÉIREANN

- Cainníochtú astuithe gáis ceaptha teasa na hÉireann i gcomhthéacs ár dtiomantas Kyoto.
- Cur i bhfeidhm na Treorach um Thrádáil Astuithe, a bhfuil baint aige le hos cionn 100 cuideachta atá ina mór-ghineadóirí dé-ocsaíd charbóin in Éirinn.

TAIGHDE AGUS FORBAIRT COMHSHAOIL

- Taighde ar shaincheisteanna comhshaoil a chomhordú (cosúil le caighdéan aeir agus uisce, athrú aeráide, bithéagsúlacht, teicneolaíochtaí comhshaoil).

MEASÚNÚ STRAITÉISEACH COMHSHAOIL

- Ag déanamh measúnú ar thionchar phleananna agus chláracha ar chomhshaol na hÉireann (cosúil le pleananna bainistíochta dramhaíola agus forbartha).

PLEANÁIL, OIDEACHAS AGUS TREOIR CHOMHSHAOIL

- Treoir a thabhairt don phobal agus do thionscal ar cheisteanna comhshaoil éagsúla (m.sh., iarratais ar cheadúnais, seachaint dramhaíola agus rialacháin chomhshaoil).
- Eolas níos fearr ar an gcomhshaol a scaipeadh (trí cláracha teilifíse comhshaoil agus pacáistí acmhainne do bhunscoileanna agus do mheánscoileanna).

BAINISTÍOCHT DRAMHAÍOLA FHORGHNÍOMHACH

- Cur chun cinn seachaint agus laghdú dramhaíola trí chomhordú An Chláir Náisiúnta um Chosc Dramhaíola, lena n-áirítear cur i bhfeidhm na dTionscnamh Freagrachta Táirgeoirí.
- Cur i bhfeidhm Rialachán ar nós na treoracha maidir le Trealamh Leictreach agus Leictreonach Caite agus le Srianadh Substaintí Guaiseacha agus substaintí a dhéanann ídiú ar an gcrios ózóin.
- Plean Náisiúnta Bainistíochta um Dramhaíl Ghuaiseach a fhorbairt chun dramhaíl ghuaiseach a sheachaint agus a bhainistiú.

STRUCHTÚR NA GNÍOMHAIREACHTA

Bunaíodh an Ghníomhaireacht i 1993 chun comhshaol na hÉireann a chosaint. Tá an eagraíocht á bhainistiú ag Bord lánaimseartha, ar a bhfuil Príomhstiúrthóir agus ceithre Stiúrthóir.

Tá obair na Gníomhaireachta ar siúl trí ceithre Oifig:

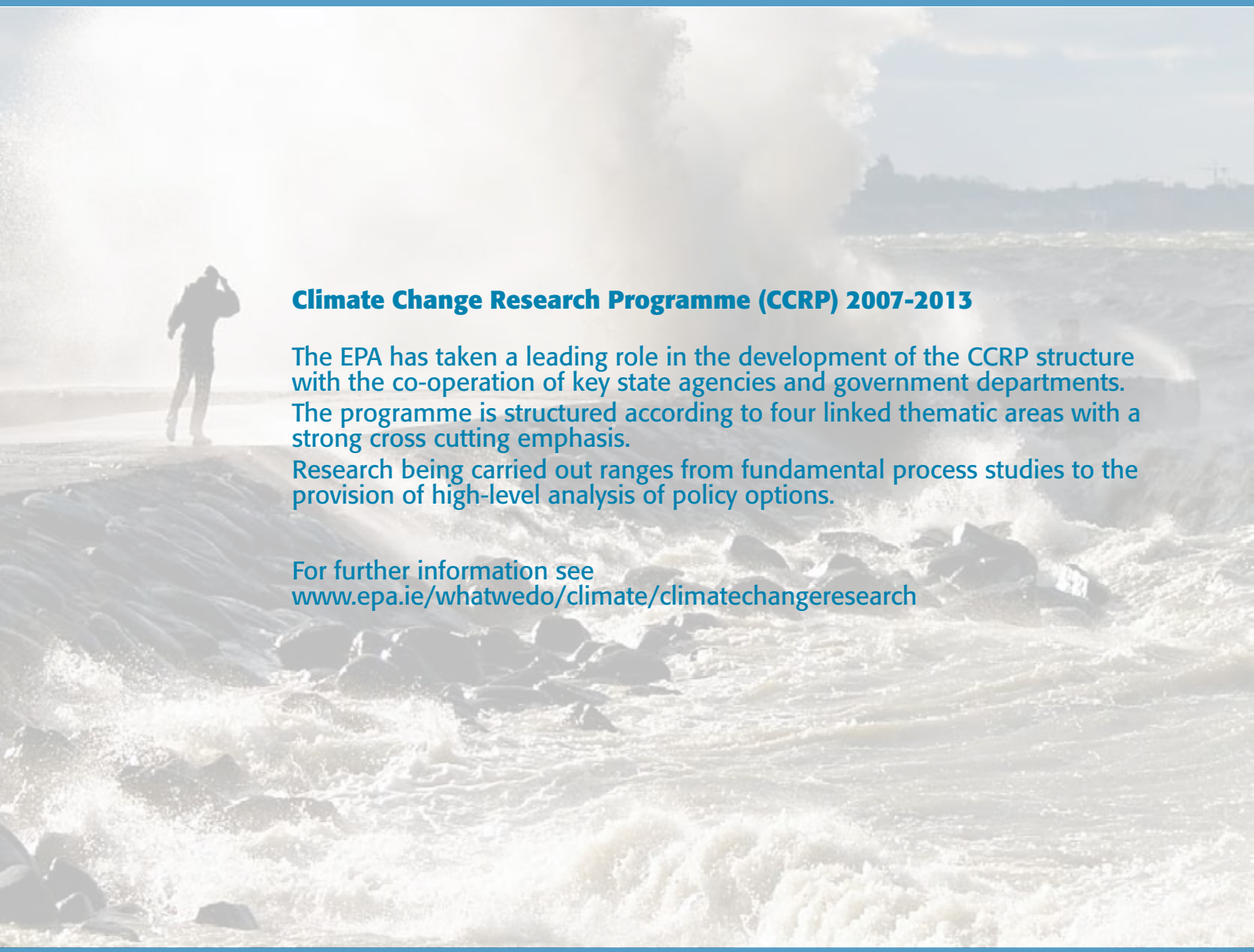
- An Oifig Aeráide, Ceadúnaithe agus Úsáide Acmhainní
- An Oifig um Fhorfheidhmiúchán Comhshaoil
- An Oifig um Measúnacht Comhshaoil
- An Oifig Cumarsáide agus Seirbhísí Corparáide

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag ball air agus tagann siad le chéile cúpla uair in aghaidh na bliana le plé a dhéanamh ar cheisteanna ar ábhar imní iad agus le comhairle a thabhairt don Bhord.

National Development Plan 2007 - 2013

GSI

ENTERPRISE IRELAND



Climate Change Research Programme (CCRP) 2007-2013

The EPA has taken a leading role in the development of the CCRP structure with the co-operation of key state agencies and government departments.

The programme is structured according to four linked thematic areas with a strong cross cutting emphasis.

Research being carried out ranges from fundamental process studies to the provision of high-level analysis of policy options.

For further information see
www.epa.ie/whatwedo/climate/climatechangeresearch

Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil

ENVIRONMENTAL PROTECTION AGENCY
PO Box 3000, Johnstown Castle Estate, Co. Wexford, Ireland
t 053 916 0600 f 053 916 0699
LoCall 1890 33 55 99
e info@epa.ie w http://www.epa.ie

SSTI
Strategy for Science, Technology and Innovation

Comhshaol, Pobal agus Rialtas Áitiúil
Environment, Community and Local Government