Chapter 6
Earth Observation—UK Perspective and Policy

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6.1 Observations Providing Scientific Evidence to Support Decision-Making

Observations of the physical and built environment are of critical importance to every country. Since these environments are directly tied to national wellbeing, prosperity, and security, robust observing systems are vital for understanding, managing, and forecasting environmental change. The UK is no exception to this and it is important to capitalize on such observations to support decision-making in government with accurate and timely scientific evidence for the greatest public benefit.

Knowledge of the consequences of urban and rural development on the quality of life, as well as the efficiency of business, can only be gained through comprehensive, continuous, and fresh observational data derived from a wide variety of sensors and sources. Comprehensive environmental observation also requires systems that can be applied to various timescales, from short-lived events that need to be monitored on an hourly or daily basis to long-term climate and geological changes. Robust, continuous and accurate data are required to help the UK Government make evidence-based decisions about the effects of climate change and their possible mitigation. These observations need to be assured over the long-term so that they can provide information on trends such as the rate of the global rise in sea level, the contribution of greenhouse gases and the effect of air traffic on the solar radiation budget.

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6.2 Challenges for UK Society and Role of Observations

The UK faces a number of specific challenges: a growing and ageing population necessitating urban development and improved infrastructure services; a shift from traditional industries to an information-based economy that requires ubiquitous communications; increased severity of impact and frequency of natural events; and a need for actionable knowledge to counter the threats posed by terrorism. The need to adapt to the changing environment necessitates the monitoring of a growing range of parameters that feed into increasingly sophisticated models, using information derived from observation data to provide a more comprehensive picture on which government departments can base strategic, policy, and tactical decisions. These decisions will have significant impact on the UK economy, as well as the health and safety of its citizens. There are, however, a number of challenges in capitalizing on these almost overwhelming streams of sensor data. Exponentially growing databases need to be stored, processed and transformed into concise information products that are useful for knowledge-based decision-making across government, industry, and business.

Significant variations in prevailing UK climate conditions are already affecting housing, agriculture and livestock, and the reliability of transport. The UK observation policies and planning aim to address both monitoring these near-term phenomena and long-term trends. An understanding of the impact upon the UK of climate changes occurring beyond our shores is, of course, necessary and relies upon observations that are global and long-term, with international standards of interoperability so that data can be shared and used globally.

Environmental observation from space is a fast-moving field. Sensor and instrument technologies are developing rapidly, along with the platforms to carry them, especially the recent deployment of constellations of smaller, lower cost satellites and/or networks of sensors alongside larger multi-instrument platforms. Combined with tremendous advances in storage and data-processing capabilities, there are unprecedented opportunities for space-borne instruments to enhance our understanding of the dynamic environment. However, to take best advantage of these advances the UK sees that there is an urgent need for an integrated, coordinated, and sustained international climate observing system.

6.3 New Technologies and Opportunities

There are new techniques emerging and on the horizon that will dramatically change the field of Earth observation, both in technological capability and the need for new policies and, possibly, legal frameworks.

Constellations comprising hundreds of highly capably small satellites (such as those proposed by Google, Facebook, SpaceX, UrtheCast, OneWeb), operating alongside conventional large-scale science observatory missions, will provide agile global monitoring with a variety of rapidly developed sensors on a greatly expanded scale and persistence.

Possibly the most significant change may come from automated sensors connected to the internet for real-time data as part of the 'internet of things'. This, coupled with the wider use of opportunistic data from systems not originally designed for environmental observation (hand-held devices, cars, aircraft, etc.), could result in an entirely new dimension to data gathering, creating both high spatial and temporal observations. The emergence of crowd sourcing and 'citizen science', when combined with authoritative data sources, could provide unprecedented feedback on the effectiveness of policy and timely evidence of environmental impact. These developments will cause an avalanche of data. Cloud computing techniques will be employed for the effective processing, storage, and dissemination of the observations and enable to powerful data mining and cross-correlation on a scale almost unimaginable hitherto. However, it is critical to move these new technologies from research to operational deployment in a timely manner.

The resulting information base will provide policy makers with unprecedented opportunities for extracting actionable knowledge to respond to near-real-time events, such as floods and pollution, as well as longer duration trends, such as tracking sea level rise and the shrinking of polar ice caps and forests. Planning for the future is based on understanding the past, the present, and trends. Forecasts and planning data are intended to provide consistent and timely information to governmental and commercial planners to reduce uncertainty in multiple sectors, e.g. transport, agriculture, insurance, energy, and healthcare.

6.4 The National and International Contexts

Potential policy and economic benefits of observing systems are tied to national interests and priorities, but some policy and legal aspects of environmental observing systems have regional or global implications and can only be addressed in an international context. Many international agreements and undertakings depend on high quality, fresh, geospatial, and environmental data. The UK is a relatively small island but, whilst it has its own specific concerns, it is inevitably affected by phenomena beyond its shores. For example, data with high spatial and temporal resolution on a regional basis are needed to assess air quality, attribute the source of air pollution, and identify pollution transport mechanisms to identify specific regional problems and to monitor for compliance with treaties on climate, stratospheric ozone depletion, etc.

The UK approach is to recognize that contributions by all forms and sources of observations, both national and international, are needed and that, if treated coherently, the value of this whole is greater than the sum of the parts. The UK therefore contributes substantially to international observing programmes (e.g. Copernicus) whilst also supporting national applications through the Harwell Applications Catapult to provide better and easier access to data and the assurance of data continuity that are essential for entrepreneurs and small to medium-sized enterprises (SMEs) to commit to developing information products and services. Thus, there is a growing realization and move towards dissolving data barriers and sharing public and private observational data between government departments, institutions, and commercial entities, thus encouraging a pan-government appreciation of the benefits of observations and cooperative exploitation for policy and action. With the right observation infrastructure, skills base, and international partnerships, the information gathered from these systems can drive social policy and economic growth.

6.5 The Importance of Sustained Funding and Stakeholder Dialogue

The UK government understands that sustaining services and research and making the necessary advances in monitoring and forecasting in the future requires stable long-term funding, accompanied by wise policies governing observation methods. The improved understanding of the natural environment, together with enhanced predictive capability in weather, climate and related hazards, create opportunities for industry and business in this developing global market.

There are, however, new policy challenges brought about by these advances. The increased ubiquity, coupled with spatial and temporal resolution, raises questions associated with individual privacy. Non-state rather than institutional players may soon dominate observation data banks and their exploitation for commercial benefit may give rise to conflicts of interest. Increasing ease and affordability of access to the space environment will bring into question present export policies, shutter control policies and drive regulations regarding orbital debris. The growth in capability of commercial UK small satellites for optical Earth observation and radar remote sensing has driven the UK Space Agency to develop a national Earth Observation policy for the first time.

To ensure that these critical issues are addressed and the best use of environmental observations is made for national interests, the UK understands that there is a clear need for continuing dialogue between government stakeholders, industry, business and the academic/expert community. This dialogue should address the need for effective, efficient exploitation of existing systems and evaluate opportunities for new capabilities for environmental monitoring. It is important to capitalize on environmental observations to support decision-making in government with accurate and timely scientific evidence for the greatest public benefit.

6.6 An Example of Novel International Collaboration on Earth Observation Led by the UK

In 2002, the UK formed and led the international Disaster Monitoring Constellation (DMC), a wide-area satellite surveillance system based around a constellation of small Earth observation satellites specifically to provide daily revisit anywhere in the world to assist in the monitoring, assessment, and mitigation of natural and man-made disasters.

The constellation comprised satellites contributed by different nations (Algeria, China, Nigeria, Spain, Turkey, UK), each built and launched by SSTL in the UK. A total of seven microsatellites and one minisatellite carrying 600 km wide-swath medium-resolution ($\sim$20 metres GSD) imagers have been launched into the same 686 km polar sun-synchronous orbit and manoeuvred so that they are equidistant around that orbit. This ensures that the wide imaging swaths provide the rapid revisit capability.

Each satellite is owned and operated in orbit by a different country and organization and used to meet their individual national Earth observation needs; however, the constellation has been coordinated by SSTL, through DMCii Ltd, to be able to provide rapid imagery in response to activations of the International Charter or directly to stricken areas of the constellation members. Members of the constellation also exchange data to be able to gain the benefits of a constellation of multiple satellites whilst only having to fund a single satellite. As disasters occur relatively infrequently, the excess capacity of the satellites was used extensively for monitoring agriculture, water and land resources, mapping, pollution, deforestation, and desertification, as well as providing data to commercial users. The 600 km wide imaging swath provided users with immediate large-area views, rather than having to be built up from a mosaic of scenes collected on different dates, sometimes weeks or months apart with a variety of lighting conditions. The wide swath is also a major advantage for disaster monitoring/relief operations; for example, the entire area of the Indian Ocean basin that was affected by the tsunami in 2004 was mapped by DMC satellites in less than 2 weeks, enabling comprehensive analysis of the worst-hit areas and the queuing of higher resolution (but limited swath) satellites from other Charter contributors to assess in greater detail.

For this reason, in addition to the wide-area payload, the fifth satellite in the series was equipped with a much higher resolution camera that permitted objects as small as 4 m on the ground to be distinguished and to provide more detailed follow-up observations of smaller areas (up to 24 km in extent), which were identified as being of particular interest through the analysis of the medium-resolution data. Subsequently, in 2011 and in 2015, more capable minisatellites with resolutions down to 1 m ground sample distance alongside improved medium-resolution wide-swath imagers were added to the DMC. The DMC proved to be a highly effective and novel form of partnership in Earth observation using small satellites.

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Author Biography

Sir Martin Sweeting has pioneered rapid-response, low-cost, high-performance small satellite development since the foundation of Surrey Satellite Technology Ltd. (SSTL) as a university spin-off company 30 years ago. SSTL has grown today to a company of 550 employees and has built and launched 47 satellites including the European Galileo constellation and high-resolution Earth observation satellites. Prof. Sweeting is also distinguished professor at the Surrey Space Centre, University of Surrey, leading advanced space technology research. Prof. Sweeting was knighted by Her Majesty the Queen in 2002 for his services to small satellite engineering. He is fellow of the Royal Society and the Royal Academy of Engineering.