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Remote Sensing Policy

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INTRODUCTION

> Policy: (1) a course or principle of action adopted or proposed by an organization or an individual; (2) prudent or expedient conduct or action. Origin: from the French *police*–bill of lading, contract of insurance. *Oxford English Dictionary*

> Act so as to produce the greatest good for the greatest number. *The Principle of Utility*, Jeremy Bentham (1748–1832)

The history of satellite remote sensing has so far shown a commendable although unconscious example of Bentham's *Principle of Utility*, or *Utilitarianism* (Harte and North 2004). Satellite remote sensing missions have mainly been general purpose satellite missions, such as Landsat, designed to capture environmental data that can be used by anyone with the knowledge and technical capability to do so. Sometimes policy development has preceded this technical capability and sometimes followed it, but remote sensing policy has in general been characterized by utilitarianism, that is the greatest good for the greatest number.

Remote sensing policy is mainly written by governments in some form, be it through national legislation as in the USA or through national representation in international organizations, such as the European Space Agency (ESA) or Eumetsat. In that sense remote sensing is often an extension of national policy. The USA is a good case in point. Each fiscal year a report is sent to the US Congress entitled *Our Changing Planet* (CCSP 2006). The report, which summarizes a great deal of US remote sensing research and applications, describes the activities and the plans of the Climate Change Science Program that was established under the US Global Change Research Act of 1990 and the US Climate Change Research Initiative established by the US President in 2001. While the report has the appearance of a science progress report it has a foundation in national government policy that is part of a wider US policy landscape, for example on science, national security and industry privatization. The report *Our Changing Planet* is transmitted each year to the US Congress by the Secretaries of State for Commerce and for Energy, both political appointments, together with the Director of the Office for Science and Technology Policy of the Executive Office of the President. Where governments appear not to be directly involved in remote sensing policy they still have a responsibility for regulation or licencing. Fine spatial resolution missions such as DigitalGlobe or IKONOS operate with a licence issued by the US government which in turn relays the national commitments it has entered into as well as reflecting national government priorities.

Government influence is therefore important in understanding remote sensing policy. As different national governments around the world have different political complexions, and indeed political complexions that change over time, so remote sensing policies are different. The remote sensing policy debate is especially contentious within the Group on Earth Observation (GEO) initiative to the extent that the term 'data policy', a key part of remote sensing policy, is deliberately avoided and only the term 'data sharing' is allowed (Achache 2006). This book examines a very wide variety of remote sensing data, techniques to process the data and applications of the data. This chapter looks at remote sensing policy, trying to disentangle the ways in which the organizations responsible for providing the data examined in later chapters have come to their different views. This chapter will concentrate on data policy because this is where remote sensing policy has the greatest impact on access to and use of remote sensing data, while commenting on wider policy concerns where appropriate. The chapter opens by examining remote sensing policy agreements reached at the global scale, and then goes on to examine the policies developed in the USA and Europe as major organizational actors in remote sensing. A review of selected national policies is used to highlight differences in approach to policy, for example India's very clear concern with national security, before the conclusion points to critical tensions such as pricing policy and the overall sustainability of remote sensing.

Whether in the public sector or the private sector Bentham's *Principle of Utility* is without doubt an unconscious characteristic of remote sensing. One could go even further along the road of utilitarianism and argue that the comments of the Roman senator Cicero are also applicable to twenty-first century remote sensing (Oxford 1981):

> Salus populi suprema est lex
> [The good of the people is the chief law]

GLOBAL SCALE REMOTE SENSING POLICY

United Nations Principles on Remote Sensing

On 3 December 1986 the United Nations (UN) reached agreement on the *UN Resolution Relating to the Remote Sensing of the Earth from Outer Space* (Jasentuliyana 1988, von der Dunk 2002). This Resolution contains 15 principles on remote sensing that were agreed as a compromise between the perspective of state territorial sovereignty and the principle of the freedom to use outer space that is embodied in the Outer Space Treaty.[1] Those nations that had satellite remote sensing capability both wanted and needed freedom to capture remote sensing data for any and all parts of the Earth. Some of those nations that lacked a satellite remote sensing capability wanted to control access to the outer space above their territory in much the same way as they controlled the air space above their territory (Harris and Harris 2006). This approach of control envisaged the concept of ownership extending to a limitless distance above a nation's territory and would have invited all organizations that orbited remote sensing spacecraft to seek the permission of each and every country to allow orbital passes over their country. The compromise between the points of view of open access and control was the agreement of the 15 UN Principles on Remote Sensing. While all 15 principles are relevant to this book, four principles are particularly important.

> ***Principle I.*** *For the purposes of these principles with respect to remote sensing activities: (a) The term 'remote sensing' means the sensing of the Earth's surface from space by making use of the properties of electromagnetic waves emitted, reflected or diffracted by the sensed objects, for the purpose of improving natural resources management, land use and the protection of the environment.*

This first principle (of which only part (a) of five parts is reproduced here) provides a definition of the scope of the later principles. At the time of the agreement the UN principles were thought to apply to civil remote sensing only of the land surface, but since 1986 the term 'protection of the environment' has taken on a much wider meaning because of the concerns about climate change (IPCC 2007) and it is now difficult to identify which elements of the Earth system (ocean, ice, atmosphere, land) fall outside the scope of the protection of the environment. Principle I may therefore now be considered very wide in scope.

> ***Principle IV.*** *Remote sensing activities shall be … carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and stipulates the principle of freedom of exploration and use of outer space on the basis of equality. These activities shall be conducted on the basis of respect for the principle of full and permanent sovereignty of all States and peoples over their own wealth and natural resources, with due regard to the rights and interests, in accordance with international law, of other States and entities under their jurisdiction. Such activities shall not be conducted in a manner detrimental to the legitimate rights and interests of the sensed State.*

This principle strikes at the core of the dilemma noted above: the freedom of the use of outer space by those nations equipped to do so and the sovereignty that nations have over their own territory and resources.

> ***Principle XII.*** *As soon as the primary data and the processed data concerning the territory under its*

jurisdiction are produced, the sensed State shall have access to them on a non-discriminatory basis and on reasonable cost terms.

Principle XII means that space-faring nations cannot keep the remote sensing data collected by their space missions to themselves, and answers in part the question posed by Principle IV. Principle XII allows a state sensed by a remote sensing satellite to have access to the data collected by the satellite under three conditions: as soon as the data are produced; on a non-discriminatory basis; and on reasonable cost terms. None of these three conditions of access is tightly defined: the balance of issues around these three terms is discussed at length by Frans von der Dunk in Harris (2002).

> ***Principle XIV.*** *… States operating remote sensing satellites shall bear international responsibility for their activities and assure that such activities are conducted in accordance with the provisions of the Treaty and the norms of international law, irrespective of whether such activities are carried out by governmental or non-governmental entities or through international organizations to which such States are parties. This principle is without prejudice to the applicability of the norms of international law on State responsibility for remote sensing activities.*

The UN principles were agreed between states, so are private companies and other organizations exempt? Principle XIV covers both governmental and non-governmental entities which brings private companies and other organizations into the scope and the legitimacy of the UN Principles. This principle therefore covers the authority of governments to grant licences to private companies such as DigitalGlobe and to participate in international organizations such as Eumetsat.

United Nations Charter Space and Major Disasters

As well as drawing up the set of 15 Principles the United Nations has been active in arranging major meetings of all UN member states to discuss the opportunities offered by the use of outer space. There have been three such major meetings called UNISPACE conferences. At the third UNISPACE conference in Vienna in 1999 the ESA and the French Space Agency (CNES) launched the idea of a UN Charter on Space and Major Disasters. The basic idea of the Charter is to provide a unified system of space data acquisition and delivery to those affected by natural or man-made disasters through the mechanism of authorized users. The UN Charter has two major objectives.

- Supply during periods of crisis, to states or communities whose population, activities or property are exposed to an imminent risk, or are already victims, of natural or technological disasters, data providing a basis for critical information for the anticipation and management of potential crises.
- Participation, by means of this data and of the information and services resulting from the exploitation of space facilities, in the organization of emergency assistance or reconstruction and subsequent operations.

Following the lead given by Europe other members have joined the Charter, namely Canada, India, Japan, the US National Oceanic and Atmospheric Administration (NOAA), US Geological Survey (USGS) and the participants in the Disaster Management Constellation of small satellites (Algeria, Nigeria, Turkey and the United Kingdom).

When a disaster strikes an authorized user can contact a single point to request satellite remote sensing data acquisition. The space agency members of the Charter then work together to plan image acquisitions and provide data of the disaster location to the authorized users free of all charges. Each year there are approximately 20–30 activations of the Charter, acquiring data of, for example, floods in Indonesia, a typhoon in the Philippines, an oil slick off the coast of Lebanon, an earthquake in Pakistan, the 2004 tsunami in the Indian Ocean and forest fires in Portugal. Further discussion on the use of remote sensing in disaster applications is given by Teeuw et al. (in this volume).

World Meteorological Organisation Resolution 40

A second policy related to remote sensing that is global in nature was that agreed by the World Meteorological Organisation (WMO) in 1995. At the Twelfth Meteorological Congress in Geneva in June 1995 the WMO passed 41 resolutions covering a wide range of its activities from the use of the Portuguese language to the Global Climate Observing System (WMO 1995). One of these resolutions, Resolution 40, states the WMO policy for exchanging meteorological data including remote sensing meteorological data. The policy applies to all 187 WMO member states and so is a policy that is global in reach. WMO Resolution 40 has at its core:

> As a fundamental principle …, WMO commits itself to broadening and enhancing the free and unrestricted international exchange of meteorological and related data and products.

Resolution 40 then provides advice to WMO member states on the practice of the resolution (WMO 1995):

> Members shall provide on a free and unrestricted basis essential data and products which are necessary for the provision of services in support of the protection of life and property and the well-being of all nations, particularly those basic data and products as … required to describe and forecast accurately weather and climate, and support WMO programmes.

Annexes to the resolution provide advice on how to implement the basic ideas of free and unrestricted access. The meteorological community has always practiced relatively unrestrictive exchange of weather data and this principle is followed through to cover meteorological remote sensing data. Resolution 40 is important in remote sensing policy because it provides a clear statement of one community's view of how remote sensing data should be regarded. There is an implicit assumption that meteorological remote sensing data are a public good (Samuelson 1954, Pearce 1995, Longhorn and Blakemore 2004, Miller 2007), an attractive idea in the development of the information society but an idea not without its problems such as financing the systems that deliver the data.

International Council for Science

In 2004 the International Council for Science (ICSU) published a report that is essentially a guidance document for science data policy (ICSU 2004). It covers all science data and information, identifying especially remote sensing data and biomedical data as exemplars of massive data sets that are presenting new challenges to science. The ICSU recommendations cover the roles of the public and private sectors in the production of scientific data and information, data rescue and safeguarding, interoperability, dissemination, intellectual property rights and funding. For remote sensing policy a key issue can be summed up in the recommendation on professional data management (ICSU 2004):

> The panel recommends that ICSU play a major role in promoting professional data management and that it foster greater attention to consistency, quality, permanent preservation of the scientific data record, and the use of common data management standards throughout the global scientific community.

This book is concerned with the acquisition, treatment and use of remote sensing data, yet these data are more than just digits. They are information resources about the state of the Earth, resources that are important in understanding the Earth both now and in the future. Professional approaches to data management will improve the access to remote sensing data and will improve the opportunity to gain a greater scientific and operational return on the large investments involved. The International Polar Year and the Electronic Geophysical Year (both having a focus on 2007–08) have been stimulated by the ICSU policy ideas in developing their own policies and frameworks for data, including policies on the legacy that will be left in the form of professionally archived data sets.

All users of remote sensing data benefit from improvements in policy definition because it means that the conditions of access are explicit and known. Initiatives such as Global Monitoring of Environment and Security (GMES) and Global Earth Observation System of Systems (GEOSS) increasingly rely on data that are robust and have a known pedigree, which in turn means that professional data management and clear data policies become essential to progress in the field of remote sensing.

UNITED STATES

The United States has the most developed and the most formal approach to remote sensing policy. The major national initiatives that incorporate remote sensing are frequently passed as national laws and are then subject to regular, formal review. The US has an overall law on access to all data produced by the Federal government. This is the Paperwork Reduction Act of 1995[2] that was made operational in the Office of Management and Budget (OMB) Circular A-130. The Act is relevant to remote sensing because it mandates that all data produced by the Federal government, including remote sensing data produced by federal agencies, should be provided to users with no restrictions and no copyright protection. This means that when a user acquires, for example, a Landsat ETM+ or a MODIS digital image then this data set can be provided to other users free of any copyright restrictions. By contrast this is not the case for SPOT (Satellite pour l'Observation de la Terre) data which cannot be copied freely to other users by the initial purchaser. The general approach in the US is that the tax payer has paid once for remote sensing data and so to maximize the value of the data then they should be provided to as many users as can benefit from them with low barriers to use.

The US Climate Change Science Program (CCSP) was created in 2002 as a combination and integration of two government policy actions, the Global Change Research Act of 1990,[3] which was approved by Congress, and the Climate Change Research Initiative which was established by

President Bush in 2001. This formal arrangement for global change science explains in part why the US National Aeronautics and Space Administration (NASA) is so well funded for its remote sensing work compared to other countries. In Financial Year 2005, NASA received US$292 million for research and US$972 million for space-based observations as part of the Climate Change Science Program (CCSP 2006). Presidential directives have long been important for remote sensing in the US. The development of fine spatial resolution commercial systems, such as IKONOS, depended on the US government's agreement for commercial operators to launch remote sensing sensors with pixel sizes of around 1 m. For example, in April 2003 a National Security Presidential Directive provided guidance on licencing commercial satellite sensors of fine spatial resolution, and indicated how the US government would access these data and how the data would fit in with US foreign policy (Anon 2003).

Landsat missions have been exemplars of the strong role that government plays in US remote sensing (Goward et al., in this volume). Since its inception in 1972 as the Earth Resources Technology Satellite (ERTS), the Landsat program has had involvement from NASA, NOAA, the Department of Defense and the private sector (CES 1995). The Land Remote Sensing Policy Act of 1992[4] directed that when a successor was considered to Landsat 7 'preference should be given to the development of such a system [namely the Landsat follow-on] by the private sector'. This broad approach, called the Landsat Data Continuity Mission (LDCM), had its own policy approved by NASA and the US Geological Survey (USGS) in 2002 (Gillespie 2005) that focused on the supply of data to the user community rather than necessarily on the provision of a satellite. Long term provision of Landsat sensor data has been the subject of a further law, Public Law 102-555, that established the National Satellite Land Remote Sensing Data Archive (NSLRSDA). The law stated that:

> It is in the best interest of the United States to maintain a permanent, comprehensive Government archive of global Landsat and other remote sensing data.

The NSLRSDA is located at the EROS Data Center and provides an extensive archive of remote sensing data in the United States. An interesting policy element of the archive is that all organizations in the US that wish to dispose of a large archive of remote sensing data must first offer the archive to the NSLRSDA, which in turn may or may not choose to accept it.

NOAA implements US government policy by providing much of its remote sensing data free of all charges. The basic model is that the data themselves are free: any costs that are incurred above the provision of the basic data are in principle met by the user. Thus, data that are provided through online web access or by direct broadcast from NOAA satellites are free of charge because no extra costs fall on NOAA, while large amounts of data that require special archive access or are transcribed to CD are provided at the cost of fulfilling a user request, also termed COFUR. The COFUR concept is a common part of remote sensing data policy in the US and elsewhere as it plays out the policy of no restrictions on distribution of data produced by the Federal government while avoiding limitless financial commitments through excessive user demand. For example, Landsat 7 data are provided at COFUR, approximately US$600 per scene. The data from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) flying on the NASA Terra platform was originally provided completely free of charge, but in August 2002 a charge of US$55 per scene was introduced for ASTER data (increased in 2006 to US$85) to bring the data provision in line with NASA's COFUR data policy.

EUROPE

European Space Agency

The main ESA remote sensing satellite so far in the twenty-first century has been Envisat, launched on 1 March 2002. The predecessors to Envisat were the ERS-1 and ERS-2 satellites. The data policy for ERS-1 was not agreed by ESA member states until well after the launch of ERS, so for the Envisat mission ESA was determined to plan ahead on policy. During the period 1997–1999 ESA and the member states developed a data policy and an implementation plan to formalize the conditions under which Envisat sensor data are made available. The Envisat data policy was subsequently retrofitted to apply to the ERS missions for the last few years of the ERS satellites' lifetime. Taken together, the Envisat data policy and its accompanying implementation document is probably the fullest statement of an Earth observation data policy yet produced. The objectives of the Envisat data policy are to maximize the beneficial use of Envisat data and to stimulate a balanced development of science, public utility and commercial applications, consistent with the Envisat mission objectives (Harris 1999, 2003). The Envisat data policy recognizes two categories of use of the data, namely (ESA 1998):

Category 1 use. Research and applications development use in support of the mission objectives, including research on long term issues of

Earth system science, research and development in preparation for future operational use, certification of receiving stations as part of the ESA functions, and ESA internal use.

Category 2 use. All other uses which do not fall into Category 1 use, including operational and commercial use.

An important element here is the word *use* and not *user*. A user, for example a national meteorological service, can have many different uses (e.g., research, operations, commercial) but it is the use criterion that is the objective assessment and the use criterion that fits with the objectives of the Envisat data policy.

ESA is normally responsible for the distribution of category 1 use data. Such distribution is typically to Principal Investigators. ESA delegates the distribution of category 2 use data to distributing entities appointed by ESA, although ESA retains the intellectual property rights in the standard Envisat products. The distributing entities, currently the companies EMMA and SARCOM, then sell Envisat standard products and value-added products that they produce themselves in the open market, thus contributing to the development of a market for Envisat data.

European Commission

The European Commission has been active in creating policies that implicitly include remote sensing data through directives either on the environment or on general data bases. The European Council Directive 90/313/EEC of 7 June 1990 (EurLex 2006a) defined the terms of access to environmental information held by public bodies with the main objective being freedom of access to the data. The Directive mandates European Union (EU) Member States to ensure that public authorities make available information on the environment, including remote sensing data, to any natural or legal person and that the charge for supplying the information must not exceed a reasonable cost. This is somewhat similar to the COFUR concept used in the United States, although the term 'reasonable cost' is not as clear as the term COFUR. A replacement Directive 2003/4/EC of the European Parliament and Council entered into force on 14 February 2003 (EurLex 2006b). This new directive ensures that environmental information is systematically available and disseminated to the public. The environmental information available includes the following.

- Data on activities affecting the environment
- Environmental impact studies and risk assessments
- Reports on the state of the environment
- Environmental authorizations and agreements

The Directive mandates that the environmental information must be available no later than one month after the receipt of a request, but that 'all information held by public authorities relating to *imminent threats* to human health or the environment is *immediately disseminated* to the public likely to be affected' (my emphases).

By contrast the Directive on the legal protection of databases, Directive 96/9/EC of 11 March 1996 (EurLex 2006c), is designed to afford an appropriate and uniform level of protection of databases to secure remuneration to the maker of the database. There is some scope for conflict between the Environmental Information Directive and the Database Directive. The first is targeted at public information and the second is targeted at private sector information: indeed the Database Directive was stimulated by concern for protection of the music industry as the industry became increasingly digital. However, even though the Database Directive was intended for the digital music industry it is also potentially applicable to the digital remote sensing sector. This is what lawyers call 'black letter law' where the written word is definitive, and not conditioned by the intentions of the original authors.

The EU and the ESA have gone through a series of steps along the road of creating a common European Space Policy (Peter 2007). The EU and ESA agreed to publish a White Paper and then a Framework Agreement (EC 2003) on how to collaborate and these discussions were held at ministerial level in Europe. The broad balance of the European Space Policy is for:

1 the EU to focus on space-based applications that contribute to the achievement of its policies, particularly Galileo for navigation and GMES for environment and security, and to provide the optimum regulatory environment for space activities in Europe;
2 the ESA to focus on space science, space exploration and on the development of the basic tools that allow access to space and to the exploitation of space for the benefit of European citizens.

Eumetsat

Eumetsat is primarily responsible for the Meteosat series of geostationary meteorological satellites. In addition, Eumetsat launched its first polar orbiting satellite on 19 October 2006. Eumetsat has had an explicit interest in the policy for its data since 1989 when it organized the First Eumetsat Workshop on Legal Protection of Meteorological Satellite Data

(Eumetsat 1991). Starting in 1998 and continuing to 2006 Eumetsat has defined and later refined its policy on access to Meteosat data. The core of the Eumetsat data policy is a set of 12 agreed policy statements that define access conditions for the national meteorological services (NMS) of Eumetsat member states, the national meteorological services of non-member states, education and research users, and all other users including commercial broadcasters. Eumetsat fulfils its obligations under WMO Resolution 40 through its policy statements and through its implementing rules, especially rule 4:

> Eumetsat shall make its Six-hourly Meteosat Data, its WEFAX Data, the Meteosat Derived Products and the data offered through its Meteosat Internet Service available to all users world-wide on a free and unrestricted basis as 'Essential' Data and Products in accordance with WMO Resolution 40 (Cg-XII). (Eumetsat 2006)

Eumetsat recognizes a special category of use in education and research and makes special provision for such use, requesting though that 'all results obtained [from the research] are openly available at delivery costs only, without delay linked to commercial objectives, and that the research itself is submitted for open publication' (Eumetsat 2006). The policy defines a concept that is essentially the same as COFUR in the USA, although it is named by Eumetsat as 'without charge'. This term is intended to mean without charge for the data, but explicitly includes the cost of distribution media, documentation, software licences, delivery or transmission, direct labour costs and any other direct costs.

The technical way in which Eumetsat controls its data is through encryption, a concept that may be more widely applicable in remote sensing (Harris and Browning 2005). The six-hourly Meteosat data are available without encryption. All other data are normally encrypted and can be decrypted only through a decryption key provided to recognized users by Eumetsat. When disasters or emergencies occur Eumetsat makes Meteosat data available without charge for a limited period.

Eumetsat acknowledges in its policy the concept of an ability to pay. It distinguishes poor countries that have a Gross National Income (GNI) per capita of below or equal to US$3500 per annum and grants to the national meteorological service of these countries Meteosat data without charge for official duty use. For countries with a GNI per capita above US$3500 per annum the national meteorological services are charged a fee for hourly, half hourly and quarter hourly Meteosat data. Table 2.1 shows a selection of the charges based on these rules.

Eumetsat is moving beyond a data policy for its Meteosat satellites because it now has responsibility for the Eumetsat Polar System (EPS). EPS is not only a means of sharing responsibility for the provision of global meteorological satellite data, EPS also carries instruments for NOAA, in particular the highly successful Advanced Very High Resolution Radiometer (AVHRR). This sharing has led to discussions between Eumetsat and NOAA on the policy for EPS data (Ernst 2004). There is broad agreement on sharing of data between Eumetsat and NOAA, with the access dependent on the respective policies of Eumetsat and the USA. However, there are two challenges. First, in a situation of crisis or war NOAA may ask Eumetsat to authorize selective denial of critical data from US instruments on Eumetsat satellites to an adversary of the US or its allies. Second, there is debate around access control to data from EPS on an instrument by instrument basis to account for the different policy positions found in the USA and Europe. This policy debate illustrates the close linkage between remote sensing policy and remote sensing instruments and their data.

Comparisons – USA and Europe

Both the USA and Europe are committed to maximizing the use of remote sensing data. However,

Table 2.1 Annual fees applicable to national meteorological services of non member states of Eumetsat for official duty use of Meteosat data. Period 2007–08. Gross National Income per capita data are drawn from the World Bank. Source: Eumetsat 2006

Country	*GNI per capita US $*	*Hourly data € 000*	*Half-hourly data € 000*	*Quarter-hourly data € 000*
Brazil	2,710	0	0	0
Burundi	100	0	0	0
Canada	23,930	60	80	100
Cyprus	12,320	60	80	100
Egypt	1,390	0	0	0
Israel	16,020	60	80	100

the policies differ. The US view is that the maximum value can be gained from government investment in space by encouraging free and open access to federally-produced data, while at the same time encouraging the private sector to be involved in remote sensing through a licencing structure. The European view is that while governments need to be involved in remote sensing during its early years as a way of stimulating a new, high technology sector, governments want an exit that encourages other organizations to take over the operations of remote sensing missions in the long term. The maximum value to the tax payer is achieved in the European perspective through the growth of operational environmental services using remote sensing in both the private and public sectors, building on the research and development investments by governments in remote sensing systems but at the same time encouraging the transition of the funding to the users who are ultimately in the best position to judge the value of remote sensing information.

These two views are echoed around the world. Two common opinions are often heard. First, remote sensing should be freely available and free of charge. Second, the government departments that fund remote sensing missions seek to recoup all or part of their investment in those missions through sales of the remote sensing data. These two sentiments are largely incompatible.

NATIONAL CONTRASTS

Security

India has the most coherent remote sensing programme on Earth. It is coherent in that it has a staged structure for spatial resolution from the sensors with a 2 km pixel size on the INSAT geostationary meteorological satellites down to the 1 m pixel size of Cartosat. In addition, Indian remote sensing satellites have consistent wavelength bands across many missions that allow for inter-comparison of data at different spatial scales. As with the USA, India has a formal remote sensing policy adopted by the government, the ISRO EOS Policy 01:2001 (ISRO 2001). The policy affirms that there is a national commitment to remote sensing in support of public policy objectives such as improvement of agriculture, regional development and poverty alleviation, and in that sense remote sensing is in direct support of the public good. The government of India owns the data from its remote sensing satellites and gives a licence to use the data to users, a model comparable to that used in Europe. Where the remote sensing policy in India stands out is in its explicit recognition of security, noting that the 'security situation of the country [is of the] utmost importance'. The Indian policy defines three categories of data type in relation to security.

1 Remote sensing data with a pixel size larger than 5.8 m is available on a non-discriminatory basis and on request.
2 Data with a pixel size in the range 5.8 m to 1 m is actively screened to identify sensitive areas.
3 Data with a pixel size less than 1 m is subject to a formal clearance procedure and is reviewed in detail before access is granted.

A concern for security in remote sensing is not uncommon in many countries. Remote sensing data are often seen as a form of spying, especially at very fine spatial resolution. In the Sultanate of Oman, for example, areas of the country regarded as militarily sensitive, such as barracks, ports and the sultan's palaces, are censored and blacked out of aerial photographs, even those aerial photographs used by government ministries. The development of remote sensing from space at very fine spatial resolution means that data with a pixel size comparable to low altitude aerial photography are openly available, revealing all the barracks, ports and palaces in the case of Oman. Malaysia plans to launch its Razaksat remote sensing satellite in 2007 or 2008. Razaksat has a sensor with a 2.5 m pixel size. Data from Razaksat will be screened by an internal security organization before distribution because the government policy is to regard as sensitive any image data with a pixel size less than 5 m. In India Google Earth gave rise to security concerns. In *The Times of India* on 26 December 2005 President Abdul Kalam declared serious security concerns that Indian army headquarters, other defence establishments such as the Rashtrapati Bhavan and the Parliament House were readily visible on Google Earth images. An expert group was formed by the Indian government to establish India's formal position on access to Google Earth. Subsequent to this national security concern by politicians, the Indian Army's 3 Corps, based at Rangapahar, decided to subscribe to *Google Earth Pro* to gain access to remote sensing data of the northern states of India to assist with counter-insurgency operations (Anon 2006). While Google Earth is free to any user, Google Earth Pro costs US$400 for a licence and provides additional geographic data of a higher quality.

Military and intelligence requirements have always been important stimuli to remote sensing in the USA. While the country recognizes open access to data for both scientific and commercial reasons, security remains a concern for both domestic and foreign policy. An interesting illustration is the case of Israel. The Kyl–Bingaman Amendment to the U.S. National Defense Authorization Act of 1997[5] requires the operators of very fine spatial resolution sensors to degrade the spatial resolution of their data over Israel to no better than the resolution available from other commercial sources (see also the discussion on fine spatial resolution remote sensing by Toutin (in this volume)). This restriction has been called ‘shutter control’. The Kyl–Bingaman Amendment translates into a limit on spatial resolution of 2 m pixel size: data of Israel may be collected at pixel sizes smaller than 2 m but can only be distributed at a 2 m pixel size or larger. The US retains the right under its legislation to restrict access to any remote sensing data from US government or commercial sources at times of national crisis.

Japan and the public good

Japan shares with India an extensive remote sensing programme, one that is broadly focused on the public good. The Japanese space agency JAXA has two core objectives for its remote sensing missions: to contribute to the protection of the Earth-environment system and to contribute to sustainable development. Japan has two main policy approaches in remote sensing. First, the scientific approach where its remote sensing data are used in national and international science projects. Second, a public benefit approach in which JAXA cooperates with operational agencies in Japan such as the Geographical Survey Institute, the Meteorological Agency and the Fisheries Agency to exploit the research investment in remote sensing by JAXA. An example of the public benefit approach can be seen in the name of the operational geostationary meteorological satellite mission MTSAT. The MT part of the name refers to the Japanese Ministry of Transport which is the institutional home for the Meteorological Agency. There is some similarity with Europe on remote sensing policy in that research and development is funded by one agency and when remote sensing systems move to an operational status then they fall under the responsibility of another organization that has an operational responsibility.

Geospatial data in Australia, New Zealand and Canada

Australia and New Zealand have well-developed policies on geospatial data, of which remote sensing data form a part. In August 2000 the Australian government established an Interdepartmental Committee on Spatial Data Access (IDC 2001). This Interdepartmental Committee produced four main recommendations on access to geospatial data, of which the first two are particularly important for remote sensing.

1 Provide fundamental spatial data free of charge over the Internet, and at no more than the marginal cost of transfer for packaged products and full cost of transfer for customized services, without any copyright licence restrictions on commercial value-adding. Fundamental spatial data sets … will be identified in a public schedule.
2 Develop an Internet-based public access system, within the framework of the Australian Spatial Data Infrastructure. Agencies will be responsible for maintaining their own data access and management systems, but must comply with an agreed set of standards.

These ideas share common ground with the US policy approach in reducing barriers to data access. One objective of the Australia and New Zealand Land Information Council (ANZLIC) is to maximize the benefits of geospatial data by providing data at marginal cost of transfer so that (ANZLIC 1999):

> … the community has easy, efficient and equitable access to spatial data in an environment where technology requirements, data formats, institutional arrangements and contractual conditions do not inhibit use.

In New Zealand the safeguarding of geospatial data is formalized through the Public Records Act and implemented by a specific government department known as Archives New Zealand. The approach taken by Archives New Zealand is comparable to the National Satellite Land Remote Sensing Data Archive in the USA: if a government department wishes to dispose of a data set, including a remote sensing data set, then it must act within a legal framework to offer the data set to the archive.

GeoConnections in Canada is the organization that is implementing Canadian national policy on geospatial data. A guide developed in GeoConnections on best practice in the dissemination of government spatial data in Canada (Werschler and Rancourt 2003) noted the problems posed by the variety of policies at federal and state level:

> … the data dissemination and licensing frameworks used to promote, extend and support the use of government geographic data generally have not kept pace with developments in technical capacity and growing user demand. … The variety of terms of use, fee structures, source acknowledgment and termination clauses used by federal departments

makes it difficult to optimise the use of government geographic data.

An interesting development here is the view of copyright. The concept of copyright is often regarded as a restriction, but GeoConnections promotes the view that copyright can be used to protect or even promote data integrity and quality, a way of stating a brand or quality seal on data and information products. At the present stage of maturity of remote sensing such an approach has merit for helping to build a sound foundation for the exploitation of remote sensing data. For example, the Normalized Difference Vegetation Index (NDVI) is a commonly used product in remote sensing applications (Cracknell 1996, Mather 2004), but there is no agreement on which specific wavelengths of data are used to create an NDVI product beyond a combination of visible and near infrared wavebands, but the data used will affect the resulting NDVI product and its use in applications projects. Copyright could be used as a way of defining the input variables in an NDVI product, the processing steps followed and the quality of the output product.

DISCUSSION AND CONCLUSIONS

Pricing policy

An implicit theme in the development of policy in remote sensing is the question *who pays?* Open access and no cost for remote sensing data carries with it the implication that some organization, typically a government department, will pay for the remote sensing mission, the launch, the ground segment and the operations. As long as the government maintains funding then open and free access can be maintained. Conversely, if there is a change in government policy then funding may dry up. An alternative approach is for the user to pay. The success of the user-pays model depends on the ability and appetite of the user organization to pay and therefore on the value of the remote sensing data to the user (Miller 2007). Remote sensing data are objectively neither expensive nor cheap. A 100 euro image may be expensive to one user if it has no information of value, but cheap to another user if it allows that organization to be more effective in what it does. In considering remote sensing pricing policy there are normally seven models that are used, and the arguments for and against these models are summarized in Table 2.2 (Harris 2002).

Sustainability of remote sensing

The pricing policy debate is wider than an argument about who pays for remote sensing data. One aspect of many remote sensing policies is to achieve sustainable systems in the long term. For example, a contribution envisaged by the Group on Earth Observations (Christian 2005, Lautenbacher 2006) is to:

> … realize a future wherein decisions and actions for the benefit of humankind are informed via coordinated, comprehensive and sustained Earth observations and information.

Table 2.2 Pricing models for remote sensing data

Pricing model	*Main characteristics*
Free data for all users	Encourages sharing and extensive use, and is simple to administer. Maintains the costs on the supplier and fails to recognize the value of the data through the pricing mechanism.
Marginal cost price to all users	Termed COFUR in the USA and 'without charge' by Eumetsat. Encourages active selection by the user and avoids large deficits consequent upon large data requests. Maintains the core costs on the supplier and is expensive to administer.
Market price for all users	Can produce surpluses that can be reinvested in future missions. May restrict the use of data because of high prices.
Full, commercial price	Recovers all investment costs and can be sustainable. May be too expensive to create a healthy market for remote sensing data.
Two tier prices	Market prices for all except for a preferred group (usually research) that pays a marginal cost price. Recognizes differing abilities to pay and focuses on value for most users. May be open to misuse and is difficult to administer.
Access key pricing	Encrypted data are provided for free and the charge is for a decryption key. Encourages wide dissemination and at the same time focuses attention on the role of the remote sensing data in a user organization. Could involve very large volumes of data and restricts access to those with suitable technology.
Information content pricing	Products are sold on the basis of the information not on the basis of data volume. Maintains a focus on the value of the data to the user. Challenges the remote sensing community on how to measure and attribute value.

The question then becomes how best to achieve sustainable remote sensing? One route is to encourage those remote sensing systems that have become mature and for which there is a user base to make a transition from the research domain to the user domain. This has an important shift in the type of funding: a shift from funding in a sponsorship mode that is seeking to experiment, test and evaluate remote sensing systems to funding in an operational mode where the information provided meets an operational need that can be given a value. The operational user can equally be in the public or the private sector, for example a government environment department or a private forestry company. A second route is to regard remote sensing as a legitimate responsibility of government in collecting information that can be used for the greatest good for the greatest number. ESA uses this concept when referring to Envisat as providing a *Health Check* on planet Earth. This route is comparable to building road infrastructure that operational road users (public buses, private cars, company lorries) then use. A problem with remote sensing policy currently is that these two routes are often muddled with conflicting voices making conflicting demands.

The sustainability of remote sensing has been the focus of attention of several major initiatives, none of them so far successful in achieving operational remote sensing systems.

- The Centre for Earth Observation (CEO) of the European Commission provided funding to bring remote sensing scientists, technologists and users together to build environmental information systems that could form the basis of operational remote sensing. The CEO adopted and expanded a model developed in the UK by the British National Space Centre (BNSC), the Applications Development Programme.
- NASA provided funding in its Earth Observations Commercialization Applications Program (EOCAP) to stimulate a wider use in the private sector of remote sensing data from NASA missions (Macaulay 1995).
- ESA and the European Commission are collaborating on the GMES initiative. GMES focuses on a short list of remote sensing applications and provides funding to technologists and users to explore the use of remote sensing data in the expectation that users will be persuaded of the value of the remote sensing data and continue to pay for the data once GMES has finished. The GEOSS has similar objectives to GMES but is global in scope (Macaulay 2005).

Given that remote sensing can be technically used for all of the applications envisaged in these environmental programmes, applications such as crop monitoring, forest mapping, urban expansion measurement and natural disaster management, why has remote sensing not become truly operational, with the notable exception of meteorology? Satellite communications has moved from the research domain to the operational domain, so why not remote sensing? As this chapter has shown, remote sensing policy drives access to data and drives the opportunities to develop remote sensing missions. More analysis of how remote sensing policy influences remote sensing systems will help tease out how the remote sensing science and technology described in this book can take further steps into a sustainable, operational mode. Alongside this challenge there are also policy challenges in aligning international remote sensing policy, particularly the UN Principles on Remote Sensing, with new technology that employs pixel sizes of less than 0.5 m, improving technical access to data through international agreement on data formats and standards, ensuring that remote sensing data are safeguarded on a century time scale, and developing institutional capacity to use the data.

It is clear that remote sensing can be used for the greatest good for the greatest number. Remote sensing needs to take further policy steps to maximize its utility.

NOTES

1. The full title of the Outer Space Treaty is the *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Celestial Bodies*, adopted 19 December 1966, opened for signature 27 January 1967, entered into force 10 October 1967 (von der Dunk 2002).
2. US Public Law 104-13, 109 Stat 163.
3. US Public Law 101-606, 104 Stat. 3096–3104.
4. US Public Law 102-155, section 401.
5. US Public Law 104-21.

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