

Open Access to Earth Observation From Space:

Opportunity or Threat to Security?

by

José Achache

Director of Earth Observation

ESA (European Space Agency)

I. Introduction

Between February 20 and 27, 2003, under the code name 'Schriever II', friendly 'blue' forces faced 'red' enemy forces during 8 days of a fierce battle in outer space. More than 300 military and civilian experts from more than 30 US agencies participated in this space war that took place 14 years in the future. Schriever II was only a war game, set in the year 2017! It took place at Schriever Air Force base, Colorado, under the supervision of General Lance Lord, commander of Air Force Space Command and was intended to explore 'critical space issues and the integration of space into the joint fight'. The objectives of the war game focused on examining space capabilities and laws, policies and strategies, not only those available now, but also those anticipated. The insights gathered from the war game will be used to design future acquisition policies. The concept was similar to Schriever 2001, the first war game to test space systems' vulnerabilities.

This example illustrates how closely space is and will remain associated to military activities. Closer to us, and dreadfully real, the ongoing war in Irak is demonstrating every day how much the Global Positioning System (GPS) satellite navigation system is an indispensable military tool, both for navigation and for

precision weapon guidance. The Allied Forces space warfare also includes the Defence Support Program (DSP) array of missile warning satellites which provides the detection of missiles immediately after launch, secured telecommunications, eavesdropping systems and, of course, optical and radar imagery satellites. Besides telecommunications, most of these capabilities are US owned and France is the only other NATO country which currently operates a military remote sensing system, Helios.

In just a few decades, satellites have penetrated every parts of our daily lives. Some of their applications have become so transparent that we have almost forgotten the contribution from space. Every day, billions of people consult the weather forecast, communicate via telephone and internet, watch television thanks to satellites. Trucks, ships, airplanes, cars and even cross-country bicycles are localized with GPS receivers. Earth Observation has undergone an explosive growth over the last 40 years. Since the first images of the Earth from space were transmitted by the Tiros-1 satellite back in the 1960s, mankind has recognised the benefits of this unique, global perspective of our home planet that space is providing.

Public and commercial space capabilities have grown tremendously over the last decade, with the expansion of communication satellite networks, the development of Earth Observation for scientific purposes and the advent of public and privately owned imaging satellites. During this period, the use of civil space data and services by security/defence customers has become common practice. Commercial communications satellites are proving to be a critical adjunct to military systems. Defence authorities are currently the largest customers of commercial civilian imagery. Cartographic applications cover both civil and part of military needs: the extensive use of Spot data during the 1991 Persian Gulf war as well as Spot and Ikonos data during the

Afghanistan campaign are well documented examples. The idea that defence should be a customer of commercial space systems and data whenever available, while developing dedicated systems only where the requirement cannot be met by civilian systems, has become common practice.

The consequences are, however, quite different for telecommunications and for Earth Observation. In the former case, commercial activities are sufficient to warrant a profitable business and the investment in space infrastructure relies on private funding. As for the case of Earth Observation, in most countries except the United States, satellites are publicly funded and privately operated. The United States developed a specific approach to allow for the private funding of the space infrastructure. A military agency, the National Imagery Mapping Agency (NIMA), is tasked to provide anchor tenancy for these private initiatives (Space Imaging, Digitalglobe, Orbview). This policy has not proven to be sufficient to bring these initiatives to a sustainable level and the recent decision to support these companies through the “Clearview” contracts should be seen as a demonstration that this mechanism is no different from the public approach.

In this paper, I would like to emphasize the drawbacks of these policies regarding the development of Earth Observation for non-military purposes. Indeed, it is the opinion of the author that such practices are putting strong limitations to the peaceful use of many existing and future Earth Observation systems whether for scientific studies, the development of public services as well as commercial applications. Today, easy access to data is advocated by many as a necessary condition for the development of civilian space applications. On the contrary, the current defence data procurement policy is setting an artificially high price tag on space imagery and

imposing additional control to data distribution by advocating security issues, thus creating two major obstacles to public use: the barrier of data cost and the hurdle of data access. The situation described above also demonstrates that in the absence of a significant civilian service industry to develop the commercial use of Earth Observation, the institutional role is essential for guaranteeing the availability of the infrastructure. But this institutional role will be justified only if there is a demonstrated public need and if the free dissemination of data does not represent a threat to national security.

II. Public Access to Earth Observation data

The use of space-based Earth observation systems is firmly anchored in international space law, as well as national law, customary law and the application of equity principles. The first, and most important, of these is the 1967 Outer Space Treaty, which determines that there is freedom of scientific investigation in space for governmental, intergovernmental and non-governmental entities. All nations have the non-exclusive right to use space. Earth observation systems have been accepted as legal users of space since the early 1970s. The Principles Relating to Remote Sensing of the Earth from Outer Space, adopted as a UN General Assembly Resolution in 1986, define the general purpose of space-based Earth observation and regulate the rights and duties of states conducting or being observed by remote sensing satellites. According to the principles, the sensed state shall have access to the primary data and the processed on a non-discriminatory basis and at reasonable cost. Although the UN resolution is not a treaty, the principles have achieved the status of customary international law and have been incorporated in the domestic law of some nations, as well as in many Earth observation missions and agreements.

Thus, Earth observation data are in principle available to everyone. However, each data provider has its own data policy, and there is no standard pricing policy for Earth observation data. Of course, data from scientific satellites operated by public agencies are made available to the scientific community free of charge. This is also the policy for data acquired by meteorological satellites. In some cases, data from commercial satellites used for research or other non-commercial applications are made available at very low cost. However, for commercial or operational applications, a fee is normally charged and varies between providers. As we shall see below, this pricing policy has failed to allow the development of a related service industry of any economic significance.

The only exception is when the national security of a country may be at risk. Some governments choose to exercise the right to withhold access to such data with ‘shutter control’ agreements, which allows them to stop the acquisition or distribution of satellite data over certain areas. However, these cases are generally limited to war zones during time of war. We shall see also that, with the current multiplication of imaging satellites, this policy is neither feasible nor really necessary.

III. Commercial Earth Observation

An Earth Observation service industry came into existence (thanks in particular to the efforts of the French company SPOTIMAGE) in the late 1980s and grew steadily in the 1990s, riding a wave of optimism resulting from the initial availability of data from the first commercial high-resolution satellites. The total annual revenue of the European Earth Observation industry at the end of 1997 was 207 Meuro, representing

an annual growth of 6% over 1995-96. While the private market has been continuously strengthening, it still remains much smaller than the public sector market, mostly defence, still representing 64% of the total market. The private sector growth benefited mainly from the telecommunication sector (infrastructure deployment for cellular phones), followed by oil and gas exploration.

In 1998, the industry itself forecast that its revenues would rise to between 245 Meuro and 340 Meuro by 2000. In the event, by 2000, the total European revenues had reached only 216 Meuro. This is equivalent to an annual growth of only 1.4% over 1998-2000, which represents a decline if annual inflation is taken into account. Revenues are coming from the sale of data and data rights (20%), sales of ground segment equipment and software (26%) and sale of services and value added products. It is estimated that over the period 1998-2000, public money of the order of 25 Meuros/year was injected in the sector for the development of services and value added products. All together, the value adding industry has remained small, dispersed and fragile and heavily dependent on income from government programmes

There may be several reasons for this disappointing performance. One is, possibly, the fact that space agencies worldwide have put their focus on the development of space hardware rather than the development of services. This lack of substantial public investments in the downstream sector was matched by industry, given the bleak perspective and the disappointing market pull by the user community. Indeed, users, customers and market owners have been reluctant to express requirements and to integrate Earth Observation information sources in their business practices. Another cause resides in the fact that the validation of new information sources and of new services is not a one off operation and needs to be supported over a sufficient term to

encourage users to adopt new business practices. Also, many potential users and customers of space information are simply not aware of the benefits they could acquire from using Earth Observation.

But the most fundamental explanation is that there is a need for information and services, not for data. Services, whether commercial or public, are about the provision of the right information at the right moment to the proper person. High-level operational information services are needed, and not simply space data or satellite images. Scenarios, estimates of socio-economic impacts, quantitative statistics, trends and forecasts are demanded at various geographical and temporal scales in support of public policies and private decision-making. Quantitative assessment and control are required in support of industrial and commercial activities (agriculture, insurance, construction, tourism). Future information services will be characterized by a stronger integration of space data with all kinds of other data and information and require a knowledge-based approach making full use of expertise in Earth sciences, information technologies, economics and social sciences. The complexity of this next generation of integrated services may also require a network of partners who will contribute to the production of information services. This will definitely require that Earth Observation data reach out as far as possible away from the space community. Because space data will represent a very small fraction of the value chain of these services, they should only represent a small fraction of the cost of delivery. Raw space data should, therefore, be made available at a very low cost.

It is currently very difficult and expensive to access and integrate Earth Observation data from several different sources. It will therefore be necessary to develop tools to allow operational data acquisition and handling in coherent formats and

through a coordinated access chain. The successful, mature uptake of Earth observation will require an integration of all sorts of capabilities in modelling, data management and in service delivery.

Amongst the other inadequacies of existing Earth Observation systems that are often cited, one of the most important is the lack of timeliness and the insufficient frequency of observations. For example, in order to provide useful information to support prevention, assessment and support in case of natural disasters, frequent coverage and near real time access to information, not data, is a crucial requirement, a must. Despite the many Earth Observation satellites in orbit, it is not yet possible to get “the right information at the right time”. When used separately, few if any of the current in-orbit systems can provide operational information to a wide community of users, whereas used in a cooperative way, as a single interoperable system, they could. Therefore, the situation can be improved significantly by better integrating existing satellite sources even of different resolution, quality, etc. Currently, more than 50 Earth Observation satellites are in orbit worldwide, carrying more than 150 sensors. Among those, there are about 15 civilian Earth observation satellites available, which provide imaging data in the 3-30 metre resolution range using optical, infrared or radar sensors. Each of these instruments has its own specific purpose, but there is a clear lack of an integrated and synergistic approach to fully exploit the very large volume of available measurements. There is a major opportunity within reach at this moment in time to overcome the individual shortcomings of each mission by jointly operating and exploiting this multitude and variety of instruments and thus easing the task of building and providing operational services.

Of course, the major obstacle to solving all these problems is commercial competition, not security. However, we believe that this competition is biased by the current procurement approach of defence communities throughout the world. Indeed, these communities represent today the major customers of commercial imagery companies. The Clearview contracts underline that, in the US, these companies rely almost a hundred percent on military customers. But the situation is not that different in other parts of the world. This leads to one question. It is essential to assess whether this situation is intentionally maintained by national security authorities in order to limit the proliferation of Earth Observation data, thus imposing some sort of “soft shutter control”. If this is not the case, then the situation needs to be challenged. Indeed, the defence procurement policy, which was intended to improve the overall cost-efficiency of public investment by sharing the benefits with other public and private users, de facto prevents these users from having access to these space infrastructures.

IV. Science and Defence. Sharing the benefits of Earth Observation

Over the past 50 years, Earth Sciences have consistently benefited from military Earth Observation programs. It must be acknowledged indeed that, in Earth Sciences, several major discoveries have originated in defence programs. A number of major Earth observation programs were initiated immediately after World War II and particularly over the oceans. The US Navy had appeared extremely vulnerable to German submarines during the war and the US Government tasked the Lamont Doherty and the Scripps Institute with the extensive exploration of the Atlantic and Pacific oceans. It is fair to say that these programmes have been instrumental in the elaboration

of the theory of Plate Tectonics. Later on, during the cold war, surveillance and reconnaissance became major requirements of the two super powers worried about the respective build-up of nuclear arsenals. Traditional information-gathering methods were replaced towards the end of the 1960s by satellite observations. The USA and the USSR rapidly built up their respective reconnaissance capabilities, and in the 1970s deployed numerous spy satellite constellations, known as Keyhole, Lacrosse and Cosmos. Like most of the major technological breakthroughs of the 20th century such as electronics, aeronautics, ceramics and other new materials and computers of course, Earth Observation from space appears as the result of warfare competition.

It would not be possible to describe, here, all the scientific benefits that Earth observation from space for military purposes brought to the Earth Science community. It has revolutionised entirely our vision and our understanding of the Earth from plate tectonics to atmospheric dynamics, ocean circulation and ice shelves stability. Density anomalies in the crust and the mantle were revealed through the mapping of the gravity field. It was needed by defence for the guidance of ballistic missiles. The dynamic topography of the oceans revealed the distribution of major ocean currents and allowed us to understand the El Nino mechanism. Before being conducted as a scientific programme with the NASA-CNES's Topex-Poseidon and Jason and ESA's ERS and ENVISAT altimetry satellites, it began as a military-led program, GEOSAT. Then, of course, came the Global Positioning System (GPS), the first space system designed for the simultaneous benefit of defence and civilian users. This system has been widely used by geophysicists and was instrumental in understanding plate motions, tectonic deformations, volcano inflation and other ground motions, although today, it is more and more replaced by SAR differential interferometry which provides better accuracy

and geographic coverage. It should be observed on all these examples except GPS, the programmes and their related data sets were initially classified and eventually became declassified. By that time, they were taken over by the scientific community for the great benefit of Earth Sciences without ever putting national security at risk. On the contrary, the new algorithms developed for scientific purposes often benefited the defence applications tremendously.

The use of space-borne SAR to support navigation in ice-infested water or to control maritime traffic in specific areas offers additional examples of dual use. On the one hand, civil authorities want to control fishing activities in EECZ or illegal oil discharge at sea while security authorities would use the same technique to monitor maritime traffic in strategic areas. Derivation of Digital Elevation Models (DEM) from civil optical or SAR sensors is exploited for civil but also security applications.

Military programs have also led to major progresses in our numerical modelling capabilities. Thus, after having turned the Earth into an observable system, geophysicists were also given the ability to model it. Weather forecasting was among the first disciplines to benefit from numerical modelling but it took a couple of decades before space observations were routinely used together with in-situ data in operational weather forecasting. Today, it is the most well-known example of what can be achieved when combining such observing and modelling capabilities. Weather forecasting is another example of the dual use of space for a wide number of applications ranging from air-traffic management to maritime navigation support, battlefield weather conditions and even the fine control of missile trajectories. In Europe, meteorological services have been supported and used by the military sector from the very beginning. In the United States, the government has decided the phasing out of the dedicated

civilian-only (POES) and military-only (DMSP) meteorological satellite systems, to converge into an integrated dual use system (NPOESS).

In light of all these examples, we may reasonably expect that high-resolution imagery will soon be available without restrictions, at least not in the name of security! Indeed, since the beginning of the war in Irak, neither the US nor the French governments have issued any official shutter control. Already during Operation Enduring Freedom in Afghanistan in 2002, shutter control was not activated officially. Instead, the US government implemented what industry officials called “checkbook shutter control” by purchasing all available commercial imagery. As discussed in a recent issue of Spacenews, “With so many sources of high-resolution imagery now available, White House and other government officials say shutter control, whether by direct blackouts or by the purchase of all available satellite imagery is neither feasible nor terribly desirable”. The report goes on by quoting a spokesman for the defence National Imagery and Mapping Agency (NIMA): “It’s probably not very helpful to the commercial satellite industry and it shouldn’t be the first resort”. And for the first time, the pressure is not coming from the scientific community alone. There is also a legal issue in the US since, “if the government were to block imagery from Irak, the news media is poised to file suit charging prior restraint to the First Amendment”.

The benefit of such a policy change is further recognized by the World Meteorological Organization (WMO) community which states that “space agencies will continue to be encouraged to make their observations available to the Global Observing System (GOS) without restriction. This will include data from R&D satellites which are deemed to be relevant to the GOS” but should also include “high resolution optical and radar space imagery [for which] access to data remains an issue. The aim is to bring

about a very significant increase in the availability and utilisation of data, products and services, not only in terms of volume and variety, but also in the geographical spread of the users. The increases which are already promised by the upcoming satellite systems in terms, for example, of higher spatial resolution, more frequent observations and the availability of more spectral bands, are not simply minor improvements, but represent in many cases step changes. Making these significantly improved data, products and services available and at the same time aiming to increase the number and geographical spread of the users, will represent the major challenge for the WMO Space Programme in the next decade.”

V. A Public Need For Space Imagery

A. Environment diplomacy

In July 2001 in Bonn, representatives of 188 countries recognised the dangers of global warming and agreed on guidelines for the implementation of the Kyoto protocol. The last report of the Intergovernmental Panel on Climate Change (IPCC) makes a number of categorical points. First, atmospheric temperatures have risen over the past century by 0.6°C on average. Second, the composition of the atmosphere itself has changed, particularly the amount of greenhouse gases, the result of human activity. Finally, if nothing is done to reduce emissions of greenhouse gases, by the end of the century the average temperature on the planet will rise by 1.4°C to 5.8°C, depending on the scenario used. To get an indication of what this means, the transition from the most recent ice age to the temperate climate we are currently enjoying was the result of a temperature rise of no more than 4°C. Current modelling techniques do not allow us to

predict with any certainty what the consequences of global warming will be for individual regions. Considerable variations are to be expected, however, which will mean droughts and desertification for some regions, storms and flooding for others. The greening of the Sahara, predicted in some models, appears attractive; but the one thing to which all forecasts point is an increasingly unstable climate, in which major disturbances and weather extremes will be much more common than they are now. The drastic flooding witnessed in Europe in recent years may be a harbinger of this evolution; the extent to which our civilisation is sensitive to even minute climate variations is becoming increasingly evident.

A second conclusion follows from the IPCC report: humans are acting as a burden on the environment, on the climate and on natural resources. The question is no longer whether we can keep atmospheric carbon dioxide content from doubling, but rather how fast that will happen, and whether we will be prepared for the consequences. The human species has become the biggest single factor in erosion, ahead of wind, rain and river action, and it is the main agent of deforestation. Drastic changes to the landscape and to vegetation cover fundamentally alter the natural balance. Already the greater part of the potable water available at the surface is being siphoned off for use by people. Environmental degradation, resource depletion, deforestation, drought, contamination of groundwater and soil: these are some of the types of stress to which our environment is subjected, and which translate into uncertainty, upheaval and conflicts. Environmental stress is behind certain new pathological developments. In urban areas it is respiratory ailments caused by atmospheric ozone and nitrogen dioxide; in Africa it is a resurgence in meningitis epidemics, a result of the increased aerosol

count that accompanies desertification; and throughout the tropics there is a rise in haemorrhagic fevers that flourish with their insect carriers.

A collective response on a global scale is in the making on the basis of international conventions. Although the first multilateral environmental agreement (MEA) dates back over a century, widespread public awareness of ‘the environment’ only emerged in the 1960s and 1970s. Since the UN Conference on the Human Environment, held in Stockholm, Sweden, in 1972, the number of MEAs has grown considerably from 140 in 1970 to over 240 today. Among these are the three Rio conventions—the 1992 UN Framework Convention on Climate Change (UNFCCC), the 1994 Convention to Combat Desertification and the 1992 Convention on Biological Diversity. Many governments established environment ministries and environment protection agencies in the 1970s and 1980s.

Most of these agreements require, directly or indirectly, continuous monitoring of a number of parameters of the land surface, oceans and atmosphere. The most concrete example is the UNFCCC and its Kyoto Protocol. Parties to these treaties have agreed to report on specific parameters which will be used to assess their compliance. Rapid advances in satellite technology, an increase in the number of available sensors taking more frequent measurements, and an increased awareness of the need for global environmental observation have progressively introduced space technology to the environment community. This is not without good reason. Information derived from space has a number of distinct advantages over conventional, ground-based measurements:

- Satellite-derived information is *comparable*. The same instrument takes measurements of the whole globe, allowing data to be compared between different geographic areas and times of acquisition.
- Satellite measurements are taken *remotely*. Satellite operators do not need the consent of a country or a party to a treaty to monitor a particular area.
- Satellite measurements are *verifiable*. Raw satellite data can be reprocessed by independent parties from commonly accessible data archives.
- Satellite measurements are *continuous*. Their global nature and long-term operation help to close measurement gaps in space and time, providing a more integrated picture of the state of the earth's environment.

Above all,

- Satellite measurements are *fair*. Ground-based measurements often require expensive instrumentation and maintenance. Once a sensor is in space, it can be operated over any part of the world, irrespective of the national resources available. Indeed, space observations have been instrumental in bringing weather forecasts in the southern hemisphere to the same level of reliability as in the northern one.

Indeed, at the World Summit on Sustainable Development (WSSD), held in Johannesburg, South Africa, in September 2002, heads of state and government adopted the Johannesburg Declaration, which identifies environmental and development goals for the coming century and call for the increasing use of satellites to achieve these goals. These will be particularly challenging because of the expected 50 percent increase in global population over the next 50 years. The Johannesburg Declaration's supporting

Plan of Implementation has identified satellite Earth observation as a crucial information source for a number of disciplines relevant to sustainable development.

Earth observation is specifically mentioned as a key decision-making tool for better management of water resources, natural disasters monitoring, conflict management, climate monitoring (including El Niño/La Niña forecasts) and desertification monitoring. The Plan of Implementation contains specific paragraphs referring to the need for earth observation for sustainable development. For example, article 36 of the Plan of Implementation states that:

Actions at all levels are required to... promote the systematic observation of the Earth's atmosphere, land and oceans by improving monitoring stations, increasing the use of satellites, and appropriate integration of these observations . . .

B. Example: Monitoring the Kyoto protocol

The UNFCCC, adopted in 1992, led to the 1997 Kyoto Protocol, which sets limits to the emission of a 'basket' of six greenhouse gases (GHGs). The Kyoto Protocol strengthens parties' obligations under the UNFCCC by imposing quantified, legally binding commitments to reduce atmospheric concentrations of GHGs. These can be met either by reducing emissions or by balancing them using biological carbon sinks. Although the protocol left many details unresolved, it set the course for subsequent specifications and negotiations in the conferences of the parties (COPs). A matter of great controversy during this process was the question of sinks, or land use, land-use change and forest (LULUCF) activities. COP7 held in Marrakech, Morocco, in October 2001, also agreed that an afforestation, reforestation and deforestation (ARD) scheme

was covered by the UNFCCC. Indeed, approximately three-quarters of the anthropogenic emissions of carbon dioxide (CO₂) into the atmosphere during the past 20 years were due to the burning of fossil fuels. The rest was predominantly due to land-use change, especially deforestation. An IPCC special report states that: “Scenarios that create ARD land on the basis of a wide range of activities, including harvest/regeneration cycles and natural disturbances followed by regeneration (as in land cover or FAO scenarios), will result in a much larger area of ARD land. The data requirements for area determination under such scenarios may be met through approaches that are based on monitoring land-cover change, such as remote sensing”.

Earth observation can provide information about forest area, forest type, density, species and the health of a forested area. Deciduous, coniferous, broadleaf and mixed forests can be distinguished from each other. Very-high-resolution sensors (1 metre or less) can be used to identify individual trees for forest type classification. Sensors in the visible, IR and radar range of the electromagnetic spectrum are suitable for monitoring changes in afforestation, reforestation and deforestation. The state of a forested area—whether healthy or stressed—can be determined and monitored. This affects the carbon storage of the forested area.

Satellite sensors can also be used to monitor agricultural activities. Important parameters include type of crop (such as wheat, maize, rice, barley, soya beans, potatoes or sunflowers) and the state and productivity of crops. Taking several images during the growth cycle makes it possible to draw conclusions about field management practices, such as crop rotations, irrigation cycles and harvesting times. If remote sensing data are combined with agro-meteorological models and plant physiology information, yield estimates can be retrieved to obtain countrywide agricultural statistics. The European

Commission, for example, has established an operational agricultural monitoring system which monitors and predicts yields for the 10 most common crops across the European Union using field-sampling methods. Information on rice fields, for example, is important, since they contribute up to one-quarter of global methane emissions.

Vegetation fires have a double impact on global carbon stock changes because (a) the burning process releases CO₂ and (b) the vegetation cover which absorbs carbon from the atmosphere is reduced. Changes in vegetation cover need to be accounted for in the national inventories submitted under the Kyoto Protocol. Vegetation fires are monitored on a daily basis and on a global scale by a number of satellite sensors at medium resolution. If more detailed area analyses are required, high-resolution satellites are commonly used.

The use of Earth observation to verify MEAs other than the Kyoto Protocol follows the same principal approach. For most of the agreements dealing with issues relating to land surface such as biodiversity, wetlands and desertification, Earth observation has proved in hundreds of individual examples how it can be used to map and continuously monitor the type and state of health of vegetation, changes in land use and other environment-related parameters. Similarly, space techniques allow the measurement of concentrations of trace gases in the troposphere and stratosphere. Several efforts are under way, using remote sensing, to support the 1973 International Convention for the Prevention of Pollution from Ships, the MARPOL Convention, or the UN conventions to combat desertification and on biodiversity. Here, while the advantages of using space techniques are clear, the challenges remain the same as those for the Kyoto Protocol, namely, to convert space-derived data into the required para-

meters and to introduce the tool as an internationally accepted method of verifying treaties. Here, the challenges of science end and the challenges of politics begin.

C. Natural disasters

The concentration of populations in vast urban zones has made humanity more vulnerable to natural disasters. Today some three billion humans are gathered in conurbations that cover only a few percent of the Earth's surface, clustered along rivers, near major seismic faults and in coastal regions where they are exposed to hurricanes, floods, landslides and earthquakes.

This vulnerability has both economic and wider human implications. How long can we continue to put up with natural disasters like the recent spate of deadly earthquakes: 25 thousand killed in Turkey in 1999, 6 thousand killed in Kobe, Japan in 1995. Floods, while less deadly, are devastating in their own right, afflicting developed and developing countries alike. As the climate becomes more unstable, flooding becomes more common. A major reinsurer recently estimated the economic cost of such disasters for a single year, 1999, at over €100 billion.

The threat of natural disasters demands integrated surveillance, prediction and warning systems to anticipate and prevent disaster-related damage, and not simply assess them after the fact. Exploratory ventures have been set up to demonstrate in actual operation how space techniques can be used to prevent, predict and manage the response to disasters. Notably, this has been the International Charter on Space and Major Disasters set up by ESA, the French space agency CNES and the Canadian Space Agency and recently joined by ISRO the Indian Space Research Organisation and

NOAA, the US National Oceanic and Atmospheric Administration. The International Charter on Space and Major Disasters is a first answer from the space community to face some of these challenges. The Charter is working successfully and provides to civil protection agencies access to data from a range of satellites. For example, during 2002, 7 major disasters were covered by the Charter. This was supplemented by another 8 activations for minor disasters, out of about the 100 which occurred worldwide. In the case of the Prestige oil spill, where all concerned countries made extensive use of ERS, Envisat and Radarsat data, the first image was acquired after three days. Today ERS and Envisat follow the event at the rate of two images every three days. The mechanism of the Charter, although successful in giving access to data, suffers evident shortcomings owing to the lack of data integration and of association with an operational service provider.

VI. GMES: An environmental intelligence system

GMES (Global monitoring for environment and security) was set up by ESA and the European Commission. The objective is to coordinate space programmes and non-space based Earth observation and environmental observation to build a complete decision support system for public and private use, with the capability of acquiring, processing, interpreting and distributing all useful information relating to the environment, disaster risks and natural resources.

As discussed above, satellites are the ideal tools for global surveillance, since they can provide a continuous, reliable stream of environmental data to monitor the atmosphere, oceans and landmasses. Satellite observation is infinitely scalable in terms

of space and time: from the size of a continent down to the size of a house; from decades, for studying climate change, down to an hour, for tracking hurricanes.

That said, satellites will never make other forms of observation obsolete. Many essential parameters require measurements to be taken in the atmosphere, on the ground or underneath it, and in the oceans – particularly where chemical and biological samples are needed. A system such as GMES must therefore rely on traditional environmental data-gathering techniques as well, in the same way that intelligence gathering uses satellites to complement information gathered in the field.

Ongoing, comprehensive and continuous environmental data collection must be the first objective of GMES, given that analysis and understanding of the environment and its interaction with human society are only possible on the basis of long-duration observation. This will make it possible to identify what processes are responsible for the gradual deterioration of resources and the global environment, and to produce sophisticated forecasting models able to take into account natural processes and human choices on matters such as energy supplies, industry and agriculture, land-use planning and urbanisation, and, most importantly, society's future needs and growth capacity.

Reducing uncertainties, making forecasts and managing the planet are other objectives of GMES. The big unknowns in climate change at present are the role played by clouds and aerosols, exchanges between the ocean and the atmosphere, carbon sources and carbon sinks, the effects of changing land use, the role of the polar ice-caps and, crucially, the effects of complex coupling in the “climate machine” between different types of atmospheric pollution, between changes to the ozone layer and the greenhouse effect. As for natural disasters, while the past decade has seen encouraging

advances, considerably uncertainty remains, particularly on the mechanisms that trigger them and those that govern the response of the environment, and on the impact human activity has on those mechanisms.

VII. Information Dominance or Global Transparency

A machinery of environment diplomacy has been created, with scientists and politicians from most countries in the world preparing and negotiating the terms of the agreements. Environment diplomacy is concerned with defining regulations and creating concepts for planetary environment governance: it attempts to define economic and political models for sustainable development, create the right conditions for developing countries growth, and, above all, agree on rules for managing and sharing natural resources, especially water. In all of these matters, international negotiation presupposes accurate knowledge of the true state of the environment and its evolution and an understanding of the causes and mechanisms of observed change, to be able to evaluate the environmental, social and economic implications of proposed measures. Finally, implementation of formally concluded treaties and conventions depends on the existence of methods of verifying and evaluating compliance.

Thus, in environment negotiations, as in other forms of diplomacy, controlling information is crucial. Throughout the cold war, the major powers relied on highly capable intelligence services tasked with collecting and analysing all potentially useful information for the benefit of political decision-makers and diplomats. With the fall of the Berlin Wall, sovereignty was increasingly defined in economic terms, i.e. the international ambitions of companies striving to conquer markets and gain control of

manufacturing, instead of territorial conquest and zones of influence. These development in the past twenty years led to the Uruguay round of GATT negotiations and the new World Trade Organization that emerged from that last round. A new type of diplomacy was born. In the new “trade diplomacy”, the key was once again access to information and control over its disclosure. In the United States this was formulated as the doctrine of “information dominance”. At the heart of the doctrine are powerful satellite systems such as Echelon, a global network for communication surveillance, processing and analysis.

Future environment negotiations will be governed by the same rules. The parties must have the capability to gather “environmental intelligence”. This will serve to monitor, analyse, explain and predict environmental changes, resource deterioration and depletion, the associated risks for the population and, most importantly, the political, economic, social and environmental implications of actions as they become necessary. In environment diplomacy, sovereign states will not be the only ones seated around the negotiating table; they will be joined by numerous other protagonists, in particular NGOs and representatives of the scientific community. This unusual situation raises the question of access to satellite observation and communications, for scientific questions and problems related to global change and sustainable development, as a minimum. Will we be able to make access to information more transparent, particularly information gathered from space? This is the question of “global transparency”.

In moving towards an internationally agreed mechanism to use Earth observation for MEA verification, institutional and political obstacles are certainly among the more difficult ones to overcome. While the merit of using space technology is in many cases acknowledged, the main difficulty is the introduction of a new observation tech-

nology into an existing, often decades- or centuries-old, political and institutional structure. Changes may require the abolition or modification of current techniques, such as ground-based observation, the reorientation of budget and staff resources in government organisations, the creation of a new legislative framework but, above all, an easier and cheaper access to space data.

The experience gained from the use of space systems for the mitigation of natural disasters, through the International Charter mechanism as well as otherwise, has shown that the image resolution, cycle time and reliable communications needed to assess damage and manage the emergency response are very close to the specifications and operational constraints of military systems. This raises the problem of utilising military surveillance systems for civilian purposes, and, more generally, dual use of space systems for civilian and military purposes. Once again, the choice will be between “information dominance” and “global transparency”!

We have seen that many scientific communities requiring operational data series, which, by themselves, are a justification for operational satellites, have difficulties in obtaining these data. We believe that facilitating the generation and circulation of space information will foster the development of Earth Sciences and the better understanding of Earth phenomena. This will, in turn, have an immediate impact on the development of services since scientific mastering of phenomena is a prerequisite to the development of reliable applications. We also have many reports of academic groups and small private service companies developing prototype applications using space data. The validation at full scale of these services would require amounts of data that they just cannot afford under the current data policy conditions. These actors are left with the alternatives of either giving up their spin-off projects or using less adequate

data which are available free of charge. It should be recalled that millions of applications of Internet could be developed by academic spin-offs and private initiatives because the system was freely and easily accessible. It is therefore important that data from operational satellites should be made available to scientists. This as well is global transparency!

Environmental monitoring, hazards mitigation, sustainable development and resources management is beginning to take benefit from Earth Observation as an information source. The requirements in these domains materialize from a wide range of institutional entities at national and international level. With the GMES initiative in Europe, and similar ones in other countries, we see the need for integrated operational information services to support public policies more widely recognized. Like scientific programs, these services would certainly benefit from a smoother and more integrated access to data from a wider range of satellite resources. Global transparency!

We believe that the fostering of Earth Observation requires the development of an integrated, transparent and user-friendly infrastructure to access information from all satellites. In this new paradigm, easy and inexpensive access to Earth Observation data is seen as the critical element and should be granted to any partner willing and capable of developing innovative science, new applications or commercial services. In the long-term, the benefits for society of this paradigm will greatly compensate for the short-term drawbacks.