LOOKING DOWN ON EARTH

POST REPORT SUMMARY
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This is a summary of a 50-page report available from the PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY (extension 2840).

The Future of Earth Observation from Space

- *What is EO used for?*
- *Barriers to better use.*
- *More cost-effective future missions.*

Earth observation (EO) satellites are a primary tool of the weather forecasters and for investigating the effects of human activity on the global environment. Other operational and commercial applications are growing in government and in industry, and EO comprises the largest component (£100M p.a.) of the UK's space programme. Even so, there are concerns that the full potential is unrealised.

POST has carried out a study of satellite-based EO and the barriers to its more effective use. This note summarises the full report[1].

CURRENT APPLICATIONS

The full report describes the evolution from weather satellites to current EO satellites, and looks at the types of instruments deployed and the measurements made. Earth observation enables us, for example, to:-

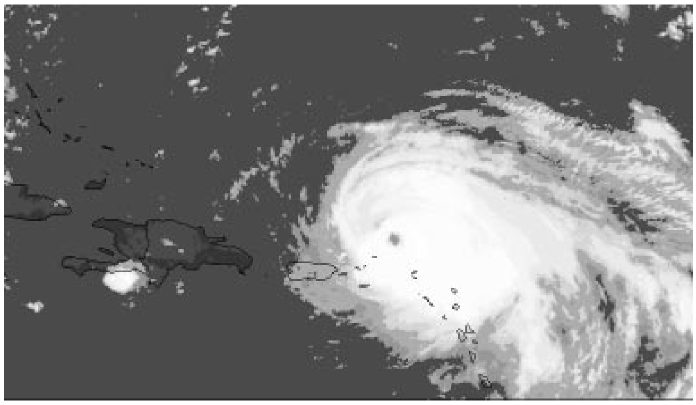
- generate photographic images and digital representations of surface features and weather systems;
- measure atmospheric parameters in 3-D;
- measure ocean temperatures, topology, wave motion and wind speeds;
- monitor precipitation and the behaviour of the ice sheets and snow fields;
- measure levels of water vapour, ozone and other gases and aerosols in the atmosphere to help in understanding effects on the ozone layer, on global climate, as well as the effects of man-made pollutants, emissions from volcanoes etc.

These data are critical to many scientific disciplines, including meteorology, climatology, atmospheric chemistry and physics, oceanography, ocean biology, land studies, etc. But increasingly, Earth observation has become a critical source of operational data in many fields discussed in detail in the full report.

For example, in the field of **meteorology**, EO allows increasingly reliable forecasts up to 2 weeks ahead, tracks storms and hurricanes (**Figure 1**), and allows scientists to monitor climate change and to verify climate prediction models. Ice masses can be monitored (e.g. in Feb 1995, a huge iceberg the size of Oxfordshire separated from the Larsen Ice Shelf on the Antarctic Peninsular - **see Postnote 61**).

1. **The full report "Looking Down on Earth - the Future of Earth Observation from Space" is available from POST, 7 Millbank, London SW1P 3JA (tel 0171-219-2840). Free to Parliamentarians; £12 otherwise.**

FIGURE 1 HURRICANE LUIS FROM SATELLITE, SEPTEMBER 1995



Visible images supplement or substitute for traditional methods of aerial photography and terrestrial survey. They yield information on mineralisation and geology at a considerable saving over speculative field-work, while 3-dimensional relief maps can be produced which can form 'digital terrain maps', be incorporated into **geographic information systems** and applied to **land-use mapping**.

EO is used in **agricultural monitoring** for mapping and classifying land use and crop type; commodities forecasting; crop area mapping; monitoring crop condition and forecasting yield; monitoring deforestation; disease and pest warning. One prominent and growing application across Europe is in verifying claims for **agricultural subsidy**.

Over the **oceans**, EO could help determine the most likely location of fish stocks, as well as playing a pivotal role in enforcement of catch quotas. Wave-detection instruments, such as the synthetic aperture radar (SAR) can be used to track ships, and provide safety information to shipping companies. They are also capable of detecting water-borne pollution and could be used to provide advance warning of pollution events, such as oil slicks. EO also supports many global scientific programmes in which the UK (via NERC Institutes and individual universities) is an active player.

MANAGEMENT OF EARTH OBSERVATION

The full report looks at current and future trends in civilian EO satellites of which there are currently over 50 in orbit. Over the next 15 years, the world's space agencies plan another 80 or so missions carrying over 200 different instruments. Nevertheless, simple numbers of satellites do not reveal whether they provide the optimum data for scientific and commercial needs, and there is a continued debate about the requirements for EO satellites and how they will be funded.

The relevant roles of the various national, regional and global space agencies are described in the full report. As far as the UK is concerned, the main bodies of interest are the **British National Space Centre (BNSC)** which is part of the DTI and is responsible for coordinating national space policy. The UK is a member of the **European Space Agency (ESA)** and many of its EO activities are funded through the UK's subscription to ESA's mandatory and optional programmes. At the same time, the UK meteorological community is active in **EUMETSAT** which is taking over from ESA operational control of weather satellites.

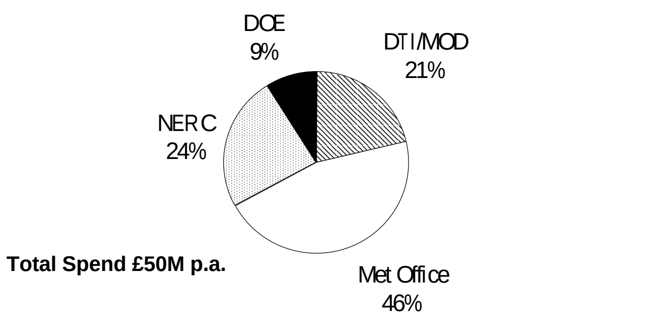
The USA has a very active EO satellite programme, which is described in the full report, along with the activities of other current and emerging players including France, Japan Russia, Canada, China and India. International coordination is important and the **Committee on Earth Observation Satellites (CEOS)** was formed in 1984 to optimise the benefits of EO through cooperation in mission planning and developing compatible data, services, applications and policies.

The UK spends about £180M on space each year of which Earth observation accounts for just over half. The UK has supported all three of ESA's EO satellites: ERS-1, ERS-2 and ENVISAT (see full report for a description). UK contributions to these projects range from 13 to 19%, with Germany and France being the most active partners. The UK is also involved in the joint ESA/EUMETSAT meteorological satellites METEOSAT Second Generation (MSG) and the proposed METOP-1. The EUMETSAT contributions will be funded through the Meteorological Office (in proportion to GNP) at 14.09% of programme costs.

Within the EO budget, UK spending is divided fairly equally between the provision of satellites with the associated infrastructure (funded primarily through the DTI's subscription to ESA) and applications-oriented expenditure (supported by the 'user' departments of NERC, DoE, the Meteorological Office and MOD - **Figure 2**). For instance, EO data are used by NERC for research purposes, by the Meteorological Office for weather forecasting and climate modelling and by MAFF in policing claims for subsidy.

The full report also looks at ways in which investment in Earth observation **benefits UK industry**. The total UK space industry turnover in 1993-94 was about £710M (up from £530M in 1991-92) and the total space related employment in the UK increased from 6140 to around 6360. As far as Earth observation is concerned, the market for satellite data and services is growing at 15-20% p.a. and is expected to rise to £1B world-wide by

FIGURE 2 NON-ESA SPENDING BY BNSC MEMBERS 1994-95



2000. The predicted UK share of 13% gives a £130M market. As for the potential market for the supply of satellite and associated ground infrastructure, which is expected to be about £300M in 2000, the UK's current 13% share would be worth some £40M p.a.

An **Application Demonstration Programme (ADP)**, was established by BNSC in 1993. Projects are jointly funded by DTI (through the BNSC) and industry; in the first round, seven projects will receive a total of £3.8M from the DTI by 1996. A second round in 1995, where the DTI target is to award 25% of the first £800K of eligible costs, has selected eight projects at a total cost to DTI of £1.6M over up to 2 years.

In September 1995, the DTI, NERC and the DoE launched an **Earth observation LINK** programme. This will support collaborative research between industry and academia to meet needs identified in the Technology Foresight Programme. Up to £2.5M of funding is available over five years, to be matched by funds from industry, to support around eight projects each year.

ISSUES

The full report reviews a number of policy issues related to EO - in particular how the benefits of investment in this technology might be maximised and the effect of current policy initiatives.

There are both national and international initiatives aimed at improving access to EO data by making more available on-line, including CEOS' **International Data Network (IDN)** and the ESA and the EC's developing **European Earth Observing System (EEOS)** with the EC's contribution the **Centre for Earth Observation (CEO)**. The aim of such systems is to make it easy to retrieve and process EO data, and encourage wider applications. The user must still however think of possible applications and carry out initial research to see what information could assist. **More proactive measures are needed to encourage innovative thinking and evaluation of potential applications, and to address the key aspects of pricing and cost-effectiveness of future EO programmes**.

As far as the UK Government is concerned, the ideal goal is a self-sufficient EO industry where the cost of satellites and infrastructure are met wholly by the users - analogous to the telecommunications satellite market. The full report reviews this analogy and the telecoms model is seen as inappropriate, or at least premature, with the danger that attempts to load full costs onto the user too early would threaten the emergence of a viable EO industry. In any case, UK policy on cost recovery and pricing would be difficult to apply 'in a vacuum' and could well be undermined by policies overseas - e.g. attempts to charge full economic costs for data from the US LANDSAT have been reversed and the data will now be sold at the nominal cost of delivery.

The full report reviews the economic prospects of EO applications in addition to those required on basic scientific grounds (climate change, ozone monitoring etc.). Some sectors are near self-sufficiency, typified by meteorology. Agricultural monitoring and commodities forecasting are also areas where user communities might be able to afford to meet their own data requirements. Outside such fields, there are barriers to developing and applying even obvious EO applications, especially where the application is non-obvious or requires much developmental and validatory work. **For example, fisheries protection relies on aerial surveillance, but has not yet developed a use for satellite data (even as a way of directing aircraft to the most important areas to monitor). The use of satellite data for coastal defence is still very much in its infancy despite the obvious potential of having overviews of areas at risk and the detailed elevation maps which can be derived. In other cases, the national (or international) capability of satellite sensing (e.g. for forestry) may not mesh with local or regional responsibilities**.

There are several weaknesses in the current system. The industry is fragmented and driven too much by the efforts of SMEs which, despite good ideas, lack the necessary capital base. **One need seen by many is to encourage a more integrated approach to market development.** Other weaknesses are seen in the limited attention given to applications in **university courses**. Other areas which could help market development include **better links with existing models and datasets** in NERC on chemical, physical and biological processes which could be combined with EO data by commercial companies into comprehensive commercial information systems. **The role of 'middlemen' from the 'value-added' EO industry is critical**, since they can identify customer needs and then match these to available EO data or services.

Ministers have agreed that BNSC should launch a programme of awareness-raising in industry during 1996. DTI Ministers have also raised the issue with their colleagues in user (e.g. MAFF, DoE, DoT) Departments. The full report looks at whether more could be done without running the risk of pushing 'inappropriate technology'. One option would be to carry out a more methodical review of departmental activities by **placing a duty on departmental 'champions' or Chief Scientific Officers**. An alternative would be to **expand the existing LINK and ADP schemes** to serve as an incentive for the EO industry to search more energetically for potentially viable applications. Some applications may be held back by a lack of adequate science in EO where **collaborative NERC projects** to develop such understanding could be encouraged. Another would be to support the development of sets of useful intermediate information. Thus, a **national digital elevation map** might be constructed to facilitate applications in many fields - ranging from map updating, through cellular phone planning to flood defence maintenance. Such initiatives could have as an explicit **objective helping the fledgling UK EO industry to pull together and develop a sufficient critical mass to operate globally and export its services.**

The full report also looks at the issues raised in **planning Future Missions**. UK involvement in meteorological programmes is being decided into the next century through EUMETSAT and ESA. The geostationary METEOSAT Second Generation (MSG) series is agreed and the first is scheduled for launch in 2000. It is also proposed that a polar series (METOP) should provide a European low orbit capability in operational meteorology and some climate monitoring from 2000 to 2015. However, the more general purpose remote sensing satellite ENVISAT, which is expected to take over from ERS-2 in 1998, will serve only until 2003. Given the long lead times involved for development and procurement, **attention is already turning to the options for future missions in EO**.

The METOP series will provide some data for climate monitoring and environmental applications, and in the absence of a clear successor to ENVISAT, many see it is an important series for parts of the UK EO industry as well as the Meteorological Office. In this context, **it is important for the MoD and BNSC/DTI to develop a joint understanding of the UK role in METOP so that the series is not delayed and the UK can gain from a full level of industrial participation**.

As far as other EO needs are concerned, as discussed above, some user communities (e.g. in agriculture) might be able to support small, specialised missions, but the majority of potential commercial applications still require support from public funds. Even more significantly, many key applications, such as climate modelling, oceans, deforestation monitoring, oil slick detection, etc. are of public policy rather than commercial interest - here continuity of data is essential if scientific conclusions robust enough to inform political decision-making are to be ensured.

Most observers thus conclude that **some public funding for post-ENVISAT EO activities will be required**, and the full report looks at how to organise this in as cost-effective a way as possible, including the potential of international collaboration. The best prospect for optimising the allocation of limited resources may be to encourage **better bilateral links** between national and regional space agencies - e.g. between ESA and US agencies such as NASA. The **UK might also encourage better cooperation between Europe and other players such as Russia, Japan and India**.

With **European collaboration**, moves are afoot in ESA to separate routine operational EO activity and deliver it at more usable cost, but another option would be to meet such requirements separately from ESA altogether, by defining customers or '**anchor tenants**' who could place long-term contracts for data to provide the minimum necessary market to make a satellite commercially viable. In view of the key role of public applications of EO, most see the **most likely source of anchor tenants as national or regional Government** acting as direct or 'proxy' customers. Thus DGVI of the Commission might contract for a service on agricultural fraud monitoring sufficient to allow the space industry to supply the necessary infrastructure (a contract of £25M p.a. for 5 years could provide a sufficient incentive). If sufficient national (as opposed to EU) needs could be identified, **satellite provision might be a candidate for the Private Finance Initiative (PFI),** whereby user communities such as fisheries enforcement, oil slick monitoring, etc., might band together to support dedicated satellites.

This would still leave substantial needs for EO in public sector applications in climate research, ozone monitoring and other global environmental impact studies, as well as those related to other fields of scientific research. These should however be capable of being met by a less complicated (and less expensive) successor to ENVISAT, possibly procured through competitive contracts operated by, for example, EUMETSAT.

The full report also looks at **Military/Civil Interfaces** where attempts to commercialise civil sources of EO have to take into account the possibility that better quality data from military sources may emerge as a serious competitor in the future.

As far as **UK organisation** arrangements are concerned, the full report asks whether current BNSC arrangements might be modified. Issues addressed include:

- Whether the membership of BNSC should be broadened to be more representative of users, both in Government and in industry.
- Whether BNSC might be separated from DTI by establishing it as an agency.
- The case for an 'EO-only agency'.
- How far it is prudent to press for UK spending to be shifted from BNSC to user departments.

On the specific expenditures by the **Research Councils**, prior to April 1994, nearly all space activities were administered via the Science and Engineering Research Council (SERC), but afterwards, EO was transferred to the NERC, along with the then EO budget of around £7M p.a. Concerns were expressed at the outset that there could be difficulties in meshing the particular characteristics of space-related research with the other 96% of NERC activities, and these are reviewed in the full report.

IN CONCLUSION

Despite the complexity of Earth Observation, one theme is constant throughout - the continued need to evolve from an industry which has historically been technology or hardware led, to one where applications drive expenditure and priorities, and where technology is the servant of clearly-defined user requirements. This means that the development of EO satellite programmes is at something of a cross-roads, and the challenge is to map out mechanisms which will allow for this transition.

Since the UK is in the lead in promoting this change in the short time before the next missions are planned, a heavy burden falls on UK policy in meeting a number of key challenges: -

- finding an appropriate mechanism for UK Departments to develop and support applications in the area of their responsibility;
- encouraging an EO applications industry to generate wealth from exploitation of EO data and become internationally competitive;
- finding the right levers for change in a field where much of the pricing/access policy is determined regionally, or by other nations, and which therefore constrains the freedom of the UK to act very differently than the international 'norm'.

The way in which this policy is pursued may be critical for the future of EO applications, and the extent to which the investments in satellite hardware can be fully exploited. It will also be critical for the fledging UK EO industry. Moving too fast may stifle the market before it has time to grow and provide economies of scale, and weaken the UK industry's ability to compete internationally. Moving too slowly will perpetuate the historical situation where large national and international space budgets are increasingly difficult to justify in harsh fiscal environments, because their full potential is not seen to be realised. It is hoped this report will help inform parliamentary consideration of this subject.