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A COMMUNITY RESEARCH PROGRAMME ON THE REMOTE SENSING OF EARTH RESOURCES.

A review of work being pursued by the Joint Research Centre of the Commission of the European Communities.

1. - What is remote sensing of earth resources and what is its purpose?

The moon race and the big programmes to build space vehicles involved the development of technologies which have since become available for a wide range of uses. The remote sensing of earth resources is also a by-product of the big aerospace programmes of recent decades. Remote sensing of earth resources involves the visual detection of objects on the earth's surface from a platform located in the air or in space (balloon, aircraft, satellite). Although traditional airphotogrammetry (black and white photographs) can be regarded as a basic form of remote sensing, this concept is today generally understood to only cover techniques based on the spectral analysis of reflections or electromagnetic emission from the objects observed.
Today it is possible to use "passive systems", which are based on natural radiation, or "active systems" using an artificial electromagnetic radiation source (radar, lasers, etc.)
For these techniques the following apparatus are used:

- multispectral cameras;
- multispectral scanning systems to pick up wavelengths from the visible to the thermal infra-red range;
- radiometers with passive hyperfrequencies (frequencies up to several tens of gigaherz);
- refractometers;
- fish-eye and SAR-Radar;
  (the range of frequences used for the two last mentioned devices correspond to the bands designated L,S,C, and X in telecommunications).

With the exception of the multispectral camera, which makes a series of photographs for each of the spectral bands selected, the data are logged digitally, stored on board or transmitted, via complex telecommunications systems comprising several receiving and remote transmitting stages, from the satellite to a ground station. Thereafter, the data received are decoded in order that the desired information can be further processed. The visual observation of electronically reconstructed photographs (photo-analysis) is replaced today by computer-aided processing with immediate visualization of results on the colour screen of a dialogue console. Each object investigated shows a specific property known as "spectral identification". The computer is first given the relevant signal identification by means of a preliminary comparison measurement on the ground. The computer then locates with the same threshold and produces the appropriate card for it; this is known as "limited selection". If no comparative identification values are available, the computer groups the equal identification data which are then identified by measurement nearer to ground level. This is known as "unlimited selection".

1.1. What aids are available for remote sensing in the European Communities?

The first satellite specially built for earth sensing, LANDSAT - 1, was launched by the US National Aeronautics and Space Administration (NASA) in July 1972. In the meantime, two further satellites of the same family, LANDSAT - 2 and 3, have also been launched. LANDSAT - 1 was taken out of service in 1977. As part of the tests on the Skylab space laboratory in 1974, NASA also conducted a programme on earth sensing. All the information obtained with the LANDSAT satellites will be used when a high performance satellite, LANDSAT - D, is put into orbit around the earth in 1981. The LANDSAT satellites operate by multispectral scanners and videosystems with backscattering in the visible light and infra-red range.

In 1978, NASA launched two further earth sensing satellites (HCMM and SEASAT); a third - NIMBUS - G - is to follow. The Heat Capacity Mapping Mission (HCMM) installed aboard one of the satellites in the Explorer - A family operates in the thermal infra-red range and has the task of charting temperatures on the surface of the earth during the day and at night, while SEASAT operates in the active and passive hyperfrequences and is specially geared to the investigation of oceanic phenomena. All of these satellites are non-geostationary satellites with low orbits, i.e. below altitudes of 1000 km.

Mention should also be made of the non-geostationary meteorological stations (NOAA-5 and TIROS-N belonging to the American National Oceanic and Atmospheric Administration (NOAA), which are shortly to be launched, and METEOSAT, belonging to the European Space Agency (ESA), which is orbiting at an altitude of 36 000 km above the equator (longitude and latitude 0) in a geostationary orbit. These meteorological satellites can also be used for terrestrial purposes.

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With the exception of METEOSAT, whose control and ground station is in Darmstadt (Federal Republic of Germany), Europe has at present no earth sensing satellites of its own. Several projects are at the planning stage both at the European Space Agency and in the Federal Republic of Germany. The only project on which a definite decision to build has been taken is that of the French satellite (SPOT), which is being developed by the Centre National d'Etudes Spatiales.

Europe has access to the data emanating from the American space vehicles via a network of receiving and observation stations (EARTHNET), administered by the European Space Agency and involving the following stations: FUCINO (Italy) KIRUNA (Sweden) for the LANDSAT - satellites, LANNION (France) for the NIMBUS - G - satellites and OAKHANGER (UK) for the SEASAT satellites.
As part of the European participation in the SPACELAB project, which is to be launched by 1980 by a NASA space transporter, the European Space Agency is at present preparing two earth sensing experiments for the first flight, comprising a measurement chamber and X-ray scattering radar. It may be assumed that several laboratories in the Community area will be involved in these two experiments.
Even though Europe is still only engaged in the preparation of space missions and as yet has no carrier rockets, there are aircraft in several European countries which are equiped with multispectral cameras, mechanical or electronic multispectral scanners, radiometers for hyper-frequencies and suitable radar equipment. It has been possible in Europe, by using this equipment in conjunction with the American satellites, to gather operational experience and to form a picture of the advantages to be gained from exploiting remote sensing and hence to gain a better understanding of the earth's natural phenomena.

1.2. For what applications is remote sensing of use to us?

Remote sensing as a new technology brings direct benefits:

in agriculture	- for taking stock of harvests, surveying afforested areas in the Community, early detection of diseases and their propagation and yield forecasts;
in physical planning	- for the reconnaissance and classification of rural and urban areas;
in environmental protection	- for the detection of freshwater and seawater pollution and for surveying the effects of environmental stress on vegetation;
in oceanography	- for the investigations of currents, coastal protection, iceberg movements and available fish stocks and for monitoring shipping movements;

in geology and the study of mineral deposits	- for terrain exploration and the reconnaissance of geological structures;
in hydrology	- for the investigation of catchment areas for water supply and quantities of snow available to feed water courses.

As these examples show, the evaluation of the remote sensing data acquired is a multidisciplinary process and requires cooperation between experts in the most varied fields of specialization such that cooperation transcends existing political frontiers.

2. The research programme of the European Communities.

This new technology of remote sensing has aroused considerable interest in the Member States and is therefore being included by the Community in its Multiannual Research Programme.

The Commission considers these measures to be of great importance to the future, since they will yield important data and new knowledge in several policy sectors - especially agriculture and environmental protection.

The Joint Research Centre (JCR) is carrying out a research programme on remote sensing as a direct action project forming part of the Multiannual Research Programme, in cooperation with the Directorates-General for Agriculture, Development and Research, Science and Education and with the Statistical Office.

The JCR's Ispra establishment has been working in close conjunction with NASA since 1973; it is through the AGRESTE project one of the main contributors research work for LANDSAT - 2. In the meantime, this cooperation has been extended to HCMM and NIMBUS-G.

Endeavours are being made to avoid overlapping and duplication of work through cooperation with some 50 laboratories in the Community. Thanks to this form of action it is becoming possible to conduct major programmes, the results of which it will be possible to extrapolate to others, by virtue of their application to a variety of fields of experimentation in a number of different regions and countries.

Agricultural applications and the pollution of seas close to the coasts have been selected as priority topic areas for Community programmes.

The AGRESTE project is concerned with surveying rice fields, the early recognition of plant diseases and yield forecasts for the forthcoming rice harvests. In addition to these operations, a survey of existing poplar and beechwood stocks is also being undertaken.

The topic area selected is a particularly intricate one, owing to the multiplicity of the ecological conditions covered (the rice fields constitute a closed, artificial ecosystem and the beech forests in mountainous areas a natural system) and owing to the varied climatic zones (Mediterranean, Continental and Alpine).

The project began in 1973 as part of a Multiannual Programme (1973-76) and was carried out in cooperation with French and Italian laboratories in Southern France and Northern Italy.

The results obtained provide a glimpse of the potential of remote sensing for agricultural stocktaking. This project is currently being extended albeit with limited financial resources.

The TELLUS project involves the determination of ground humidification in areas with a semi-arid to humid climate. Ground humidity is a basic precondition for plant growth and constitutes a basis for forecasting harvest yields.

In each of these projects the use of satellites is of crucial importance. For purposes of comparison, however, measurements have also been carried out by aircraft in order to test new methods and instruments and to check the satellite results already obtained.

The EURASEP project currently in progress is being used for the assessment of chlorophyll sedimentation in coastal areas and the recording of green areas present in those regions. The tests cover areas of the Mediterranean, the Adriatic, the Atlantic, the English Channel, the North Sea and the Irish Sea. Chlorophyll- a is the phytoplankton element on which the regeneration capacity of the sea depends. Large-area measurements of phyto-plankton content provide an immediate means of assessing the State of health of the sea. By determining the burden of sediment in coastal waters, it is possible to gain an understanding of the mechanisms of transport and diffusion of environmental nuisances of various origins, particularly in the region of river estuaries.

3. Conclusion

Remote sensing techniques are a rapid and economically interesting instrument for the evaluation of earth resources. It is important that this technology be developed in Europe by tests and experiments transcending national frontiers in such a way that they can be effectively applied to bring benefits to a wide variety of areas. The programme of work and experimentation on the remote sensing of earth resources by the Commission of the European Communities and the verification of the applicability of this technology in European conditions is yielding not only technically and economically useful knowledge but is also promoting, both directly and indirectly economic cooperation across frontiers in Europe and is contributing, through its partnership with NASA in the United States to worldwide fruitful competition in the development of new technologies.