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TOWARDS A WORLD INDEX OF SPACE IMAGERY

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ABSTRACT

The need for a quick reference data base on the source of world-wide available aerial and outer space imagery has become increasingly apparent in recent years, particularly for those concerned with natural resources surveys and management. With this in mind, FAO has held two expert consultations (1977, 1979). This paper reports on the findings of the consultations and outlines the measures needed to provide a world index of space imagery (WISI).

1. INTRODUCTION

The need for a data base providing world-wide information on the available sources of aerial (inner-space) imagery and satellite (outer-space) imagery has become increasingly apparent in recent years. More and more time is wasted on finding out about existing imagery, how and from whom it can be ordered and what is the quality of the imagery. With this in mind, and based on experience gained from its field programmes and the consensus of opinion of several major sources of supply, FAO convened in November 1977 an exploratory small Expert Consultation on a World Index of Space Imagery (FAO, 1978). This was followed by the Second Expert Consultation in December 1979 (FAO, 1980).

The 1979 meeting was held with the purpose of reviewing and discussing the overall problem of obtaining information on availability and supply of remote sensing imagery and was attended by a group of international experts representing a wide range of activities extending from the collection of data by satellite and airborne remote sensing to data analysis and information use.

In the period between the first and second Expert Consultation on a World Index of Space Imagery (WISI), satellite remote sensing has considerably expanded with the launching of new satellites such as HCMM and METEOSAT in 1977; LANDSAT-3, SEASAT-1, NIMBUS-7 and TIROS-N in 1978; and NOAA-6 in 1979. Moreover, it is to be expected that in the near future the experimental status of satellite remote sensing will be phased into an operational stage, particularly as the sensors on board the spacecraft attain improved performance and reliability in terms of spectral, spacial and temporal resolution. In passing the following planned satellites may be mentioned as indicative of continuation of satellite sensing during the 1980's: an additional GOES and METEOSAT-2 in 1980/1982, LANDSAT-D and D' in 1981/1982, SPOT in 1984, MOS-1, 2 & 3, LOS 1-2, NOSS and ERS 1 & 2 in 1985/1990.

2. BACKGROUND

During the Second Expert Consultation, it was noted that there is a rapid world-wide growth in data acquisition and that it is convenient to recognize four stages between raw data collection and the final end-user. These stages, summarized in Fig. 1 are as follows:

A. Raw data collection and raw data handling

B. Pre-processing, archiving, and remote sensing data dissemination (e.g. hard copy prints, CCT's)

C. Remote sensing data use/analysis (including aerial photo-interpretation)

D. Final end-use (by planners, managers, administrators and other decision makers).

A. Raw Data Collection and Raw Data Handling

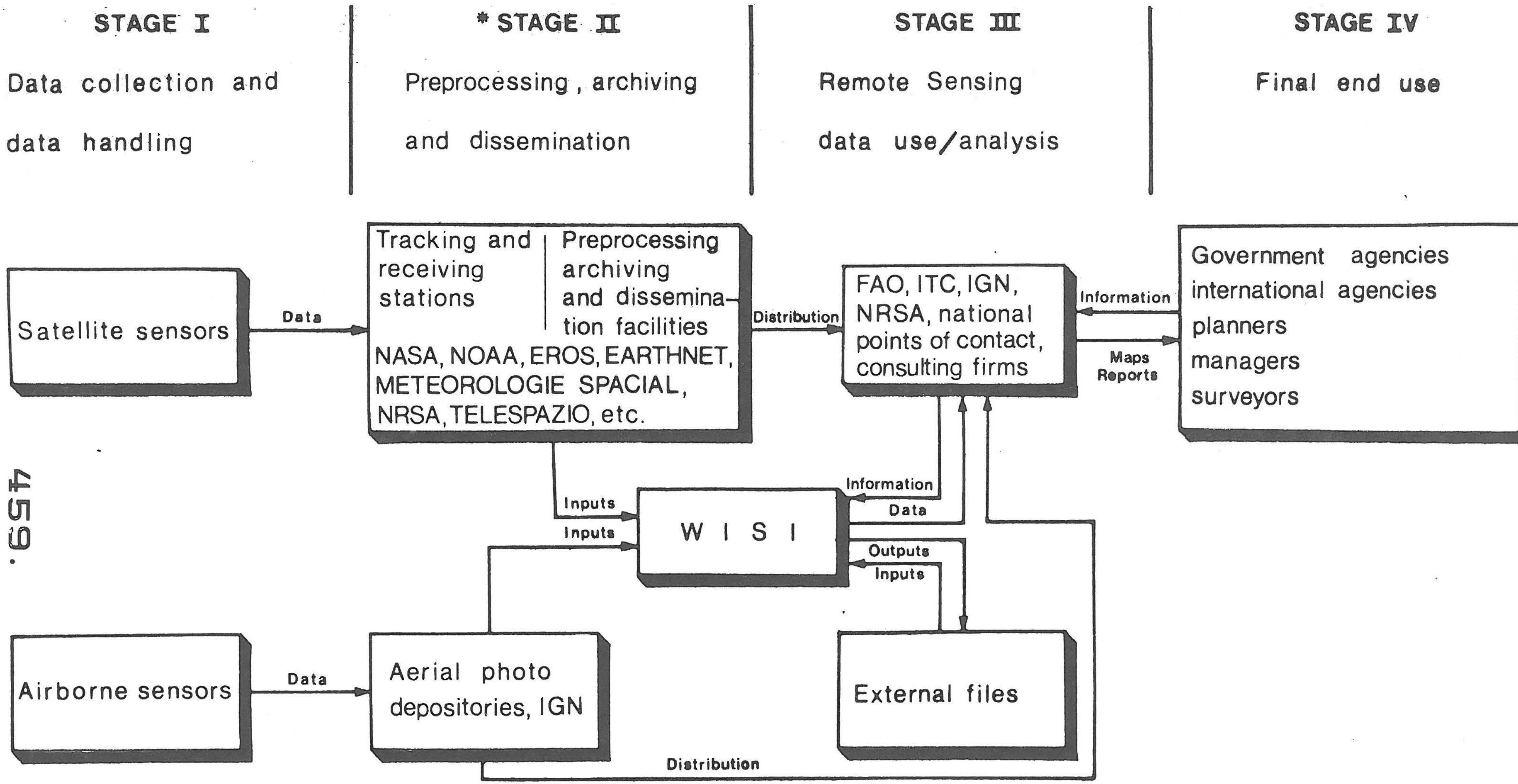
With the prospects of new satellites to be launched in the 1980's, very rapid growth can be expected in the acquisition of new satellite data, which will present an enormous burden on national and regional data handling and data storage facilities.

As we know, full resolution data readout stations for environmental satellite data, used primarily for meteorological purposes, already provide world-wide coverage by polar-orbiting and geo-stationary satellites. Stations are located, for example in Australia, Brazil, Canada, China, France Japan, USA and the USSR. Additional stations are planned in Latin America (e.g. Argentina), and Africa (e.g. Kenya, Nigeria, Upper Volta), and Asia (Bangladesh, Iran).

The present growth in Landsat receiving stations, nationally based but with a regional function, is rapidly tending to provide world-wide land coverage. This is indicated by Fig. 2. Tracking and receiving stations already exist in Australia, Canada (2), Brazil, India, Italy, Japan, Sweden and the USA (3); there are stations under development in Argentina and Iran, and under consideration are stations for several other countries.

However, with the advent of LANDSAT-D, the quantity of data will be greatly increased due to the smaller pixels of the transmitted data and more spectral channels being used. This will place a much heavier load on existing receiving stations. At the same time, the range of the receiving stations will be reduced and there will be no data storage facilities onboard the satellite, which will transmit in S-band as well as X-band.

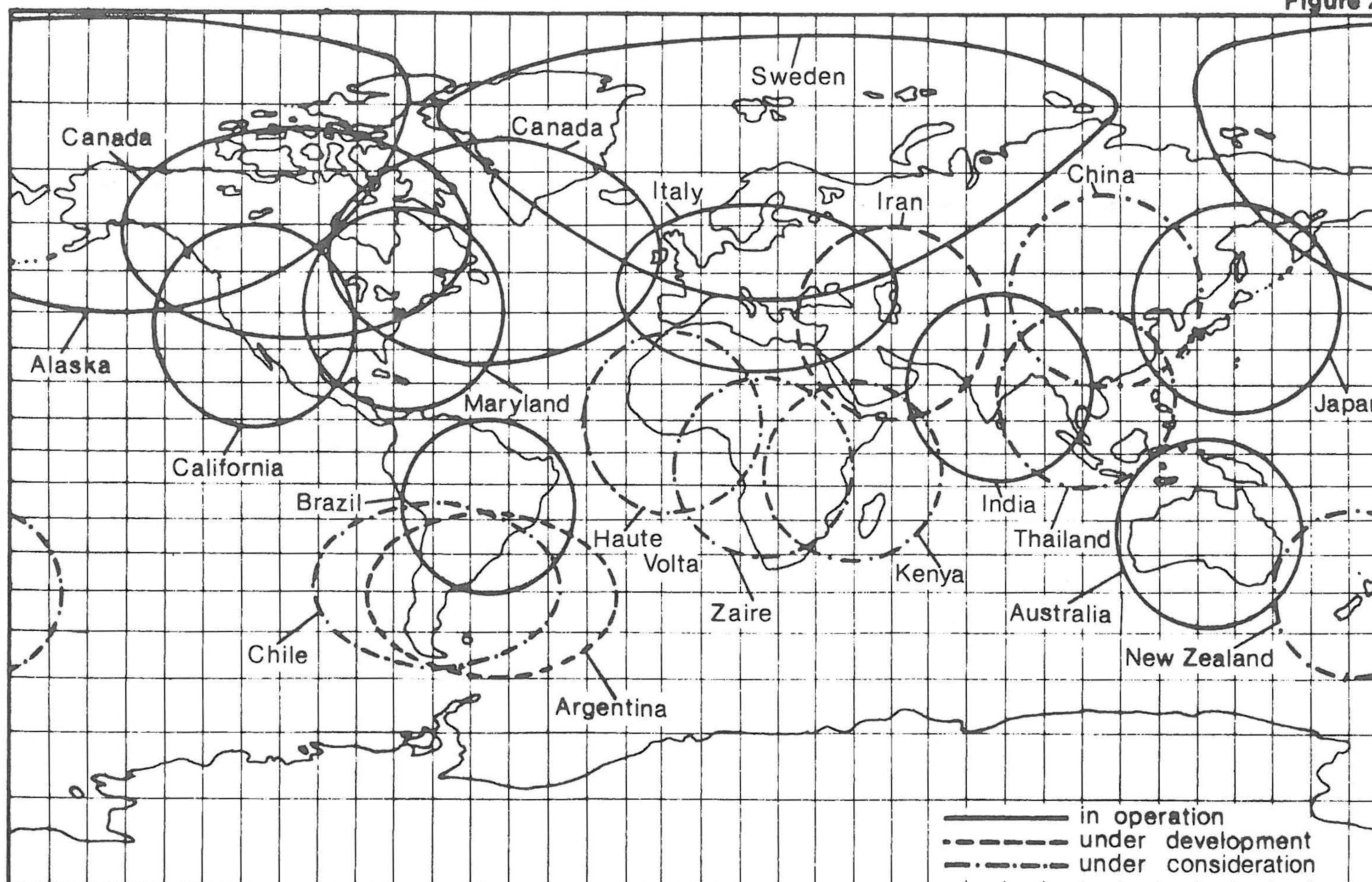
Concerning airborne sensing, which provides extensive coverage of the earth's surface, aerial photography remains pre-eminent although few statistics are available on recent acquisitions and rate of coverage as compared with SLAR, which has been used in recent years to provide coverage of extensive areas of Latin America (e.g. Brazil and parts of Colombia and Ecuador) and, more recently (1978), extended to provide complete coverage of Nigeria - the first African country to be covered.



FLOW DIAGRAM SHOWING THE FOUR MAJOR STAGES FROM SPACE DATA COLLECTION TO DATA USE

LANDSAT Ground Stations in the World

Figure 2



It is known that about 90% of the land area of the world is covered by aerial photography useful for base mapping and that every year about 4% to 5% of the land area is annually covered by new aerial photography. Also the incentive to continue this type of survey is high, since at present only about two thirds of the land area of the world is covered by accurate geodetic networks. Additional information will be obtained from the UN 1980 World Cartography Status Questionnaire. In addition, it is known that there is increased interest in high altitude aerial photography for thematic mapping (e.g. Sierra Leone covered by high altitude infrared colour photography in 1978 at nominal scale of 1:74 000. Also, small format photography from light aircraft has expanded in recent years, along with airborne OM-scanning for pollution studies; but neither provide systematic coverage of relatively large areas and there is usually no ready access to information on what areas have been covered.

B. Pre-processing, archiving, and remote sensing data dissemination

The second stage in the general flow of remote sensing data, on its way from the sensor to the user can be viewed as the pre-processing of the raw data received directly from the satellite its archiving and dissemination.

i. Pre-processing

This is obviously different for satellite sensing and aerial photography. In aerial photography this stage is relatively simple and involves processing of the exposed film into negative and the printing of photographs from the developed film.

For satellite data the stage is much more complicated and expressive as it involves activities between digitally recording the received satellite data on magnetic tape at the ground receiving station up to the transforming of the stored digital data into output products. The latter can include black-and-white and colour film imagery and the geometrically corrected computer campatible tapes (CCT's) as required by the user community. The first activity is often termed pre-processing, although in the United States pre-processing also includes final product processing.

ii. Data Archiving

As we know satellite data is archived in the form of photographic imagery or computer compatible tapes (CCT's). However, a major problem is the storage of the tremendous amount of data. For example, since the launch of the first environmental satellite in 1960, NOAA has archived 8 million photographic images and 20 thousand computer tapes; and the data base of EROS Data Center contains information on over 6 million frames of imagery.

The advent of the TIROS-N series of polar orbiting satellites with its attendant ten-fold increase in data production has added greatly to this problem. With respect to the earth resources satellite, LANDSAT-D, there will be also a considerable increase in data flow compared with LANDSAT-3.

For the storage of aerial photographs a somewhat similar problem exists, but is not so serious. Increasing quantities of processed negative film and prints require storage under controlled environment. This is usually at the national level; but the French National Aerial Photographic Library in Paris, for example, has in store, three million negatives covering all the French territories and most francophone countries - to service this, 29 people are employed full-time.

Probably the most comprehensive aerial photograph reference is the one that belongs to the surveying and mapping data bank of the Department of Photogrammetry Laval University, Quebec (Canada). It is believed that this non-military data bank is presently the most complete in the world. Files are maintained by country and territory. It includes about 100 000 organizations and key persons (names and addresses) concerned with survey operations (geodesy), aerial photography (and space imagery), topographic and thematic mapping, and various ground survey operations (cadastral, construction engineering, hydrographic, mining, resources, etc.). Information is available on educational institutions; central-, provincial-, and local government agencies; government enterprises; aircraft, aviation and space companies; cartographic firms; construction-, engineering-, and power companies; equipment, system and research companies; environment, geology, mining, oil and resources companies (including agriculture); many aerial survey and photogrammetic companies; service companies (computer services, etc.); transportation companies; and thousands of private survey firms.

iii. Dissemination

In comparison with dissemination of aerial photographic data techniques have been continually improved for disseminating satellite imagery. Frequently, the user of aerial photographs has problems in knowing which imagery exists, what the quality is, and how and from whom it can be ordered. Experience of the archives in the USA and Europe, shows that for the user of satellite data, the ideal dissemination system is the one which provides an easy and quick answer to questions in the following order; what data is available for specific geographic areas, what quality, what date or period, what sensor or wavelength, what resolution and scale, which gives the user a quick-look at the imagery before ordering, and ordering procedure. A quick-look imagery archive in the form of hardcopy (ESRIN) and microfilm/fiche (EROS Data Center), assists the user in checking the quality and location of the clouds on the imagery.

The files within the archives have to be indexed and arranged to facilitate retrieval of data to answer these requests. The historical sequence of the data search used, for example, by the EROS Data Center is as follows:

1) country-wise in the form of computer printouts;
2) coordinates or acquisition number in the form of monthly and cumulative catalogues;
3) country-wise in the form of microfiche;
4) path and row in the form of microfiche.

Very promising for users are computer assisted search and retrieval systems, which are on line directly accessible by terminals such as developed by EROS Data Center (USA), ESRIN (Europe) and CCRS (Canada). These systems combine fast access with fast updating.

C. Remote Sensing Data Analysis Including Photointerpretation

As we know, remote sensing data is used as hardcopy imagery or in tape-format for a rapidly expanding variety of activities. Experienced users know the limitations of the various remote sensing methods, and are able to select the remote sensing system that provides cost-benefit-wise the maximum amount of information for survey, management and planning.

It was recognized that the future developments in remote sensing analysis will involve very much digital image processing. New software and hardware techniques will improve at reduced cost, enhancement and information extraction capabilities. This, is being aided by the declining costs of computer processing equipment, much of which is not directly associated with remote sensing. Experience of the FAO Remote Sensing Centre has shown that a small digital analysis systems can now be installed for less than 50% of the cost of comparable equipment five years ago.

3. RESULTS OF THE CONSULTATIONS ON A WORLD INDEX OF SPACE IMAGERY (WISI)

a. Satellite data

Following the 1978 consultation, steps were taken by the EROS Data Center in the USA to simplify their file reference system on LANDSAT data acquired by read-out stations in the USA and to bring onto file information on LANDSAT data acquired by the LANDSAT receiving stations in Canada, Brazil and Italy. In addition the European Space Research Information Network (ESRIN), at Frascati in Italy, commenced expanding their own files along somewhat similar lines; and the National Environmental Satellite Service (NESS), NOAA at Washington, D.C. planned to provide information on what coverage is not available for any specific geographic area at any defined time. The latter procedure takes into consideration the enormous volume of available data from the environmental satellites.

After the presentation of key position papers at the 1979 Consultation, it became clear that the rapid growth of data acquired from satellites and the prospects of new satellites to be launched during the 1980's probably ruled out the possibility that any single data base could serve the whole world. It seems essential for countries with the major receiving stations to maintain the basic archives; but rapid and effective communications need to be established, by satellite where appropriate, so that each station and the national point of contact can interrogate the records of data held in these archives. This requires that all data be held in compatible forms.

Whatever forms are adopted, these must permit centres to search any archive for data of areas to be defined by latitude and longitude. Maps need to be prepared for each satellite receiving station area showing the extent of coverage and path and row notation, in relation to grid cells where this is appropriate. It would be beneficial if all receiving stations (or the organizations operating them) prepared browse imagery in microfiche form. It should be the aim that such browse imagery be transmittable on demand for visual display to users at other national and international centres. In the long term, it may be feasible to transmit by satellite precise processed imagery to such centres without serious loss of resolution and at acceptable cost. The view was also expressed that there is relatively little operational use made of data from essentially short-period experimental satellites which do not give extensive coverage across ground tracks; and therefore rapid access to archives for such imagery seems of lower priority.

b. Aerial photographs

In the case of aerial photography (and side-looking airborne radar), it appears that provided recording can be kept in a simple form, a world index which records aerial coverage is feasible without excessive demand upon computer storage or data processing. It is recognized that the full archives must remain under national control and the purpose of the world index would be simply to establish the existence and technical characteristics of cover and the location of the controlling agency; and countries would be requested to make this limited information internationally available and to up-date it regularly.

Several possibilities exist for recording aerial photographs and their coverage at a national level. It may be possible, for example, to record systematically the centre point of each photographic exposure in national computerized data systems as well as providing ready access to the relevant aerial photograph cover charts. However, as at world level, it may be only practicable to record the outline of large areas covered by polygons, it seems that a simplified system based on grid cells, recording whether any cell is either wholly or partially or not covered by a specific chart, would meet most first stage enquiries.

Proposed for this purpose, is a grid cell system based on latitude/longitude with a cell surface area fluctuating around 100 km^2. This can be achieved for mid-latitudes by utilizing 7'30" quadrangles as was adopted for the Canadian National Topographic System (NTS). However, at the equator the cell area is about 200 km^2 and if the 7'30" quadrangle is used as the basic grid cell the resolution capacity of the retrieval system would be thereby reduced considerably. Further, as many developing countries are situated in the tropics/semi-tropics, this resolution loss is undesirable; but the problem can be probably best overcome by dividing the 7'30" quadrangle into two cells of equal areas at about the 45° latitude.

In the past, a number of attempts have been made to prepare generalized aerial photographic coverage charts for countries, such as appear in the atlases produced by the Organization of American States; or for regions, for example, the current cartographic inventory project of the Economic Commission for Africa. However, such graphic representations are not easily kept up-to-date. If achieved the digital aerial photographic records of WISI would permit generalized coverage charts to be produced for the first stage enquiries at the global level, and would encourage the maintenance of national detailed registries in either digital or graphic form. Concerning SLAR the acquisition of information on areas covered is relatively easy to obtain, since the countries concerned can be identified with the assistance of several major contractors.

The collection of international data on aerial photographs will require the overcoming of several problems, such as the dispersal and incompatibility of many existing records and the cooperation of the countries covered. If the fullest benefits are to be obtained from national archives of aerial photography and SLAR, it is almost essential that countries all establish national centres which serve both as centralized archives and enquiry points. It is recognized that the cooperation and assistance of regional and inter-regional organizations will be required.

As a first stage to international cooperation the basic questions on national photographic archives will be included in the forthcoming UN questionnaire on mapping and surveying services to be circulated by the UN in 1980 to all Member States. This additional data will, in due course, be used by FAO to help develop that part of the World Index of Space Imagery related to aerial photography.

4. RECOMMENDATIONS OF THE SECOND EXPERT CONSULTATION (1979)

On the last day of the Expert Consultation, reporting groups identified and reported on the key-areas of interest and formulated recommendations on developing a World Index of Space Imagery (WISI). These maybe summarized as follows:

i. General

a. It was confirmed that WISI should be developed as soon as possible, being seen as a decentralized number of data points linked preferably by a world-wide telecommunication network accessible through terminals. An element in developing this is to establish an international terminal network covering archiving organizations and major user organizations through continued cooperation and coordination at national and international levels.

b. It was recognized that there is an urgent need for the establishment of national points of contact through which users can have access to information about inner and outer space imagery and where they can also obtain advice on potential application and use of the data in order to solve their problems. When developing WISI, the special circumstances in many developing countries would need to be taken into consideration.

c. In respect to future earth resources imagery, it was recognized that latitude and longitude must constitute the overall indexing technique.

d. It was noted that follow-up consultations at FAO will be required after the Congress of the International Society of Photogrammetry in August 1980 and after dissemination of the Consultation Report.

ii. Incorporation of earth resources imagery

At the present time this concerns mainly the LANDSATS. Because of the systematic nature of LANDSAT coverage, the path/row notation of the existing reference system is acceptable as the principle indexing technique; but for cross referencing with other sources of imagery the centre point of each scene needs to be referenced by latitude and longitude.

The minimum LANDSAT imagery data to be included in WISI in order to readily identify the location of imagery for specific areas on the earth's surface was identified as: - date of acquisition; - time of acquisition; - scene identification; - quality; - cloud cover; - sensor type; - path/row notation; - centre point location in latitude/longitude; - location of archiving system.

iii. Incorporation of environmental satellite imagery (e.g. for meteorology)

Owing to the high frequency of image acquisition, it was concluded that themost practicable approach would be to include in WISI only missing data on orbiting and geostationary satellites. It was note that it would be very useful if the Index would be extended to include all high resolution data.

iv. Incorporation of aerial photography in WISI

a. In this respect the UN Cartographic Section, New York has been requested to include in its 1980 World Cartography Status Questionnaires specific information on aerial photography.

b. It was recommended (see 1977 report) that the world-wide Index should be constructed upon a grid cell basis. For each cell, cover should be recorded as "complete" or "partial". Any system should accept search areas defined by geographical co-ordinates and that aerial photography (and SLAR) with an area of 100 km^2 or more should be indexed.

c. The recommended computer indexing parameters for the coverage of each aerial photographic mission would be as follows: - geographic coverage (based on $7\frac{1}{2}^{\circ}$ grid cells; fully or partially covered); - date of coverage; - film type; - stereoscopic; - endlap: (> 55%) or under (55%); scale; focal length; address of supplier (source of supply).

d. It was recommended that FAO with its world-wide activities using aerial photography, should continue to assist in developing and compiling a data base on the availability of aerial photography (and SLAR); and further, that this would require the cooperation and assistance of other key organizations.

5. DISCUSSION

In conclusion it can be stated that the volume of data expected to be produced in the future rules out the possibility of one centralized data base. Furthermore, the special circumstances prevailing in developing countries, must be recognized. The effectiveness of WISI would depend therefore upon (1) basic compatibility of all its component systems and (2) rapid and reliable communications between national and regional points of contact and data holding centres. It was considered that this could best be achieved by using direct satellite links between centres, initially to transmit information on the availability of data and, possibly later, satellite imagery.

Once WISI is established, as a global network of data banks, it is viewed as essential that it and the national centres, through which users will gain access to data, are adequately publicised. Preferably centres should not be regarded as passive repositories or "post offices" for the transmission of data, but positive units staffed by people oriented to the solving of problems. For many years the majority of users are likely to be people with little specialized knowledge of the sensing data and systems available to them. These users will need advice regarding the selection of imagery, mode of analysis and interpretation. It may be possible for national/regional points of contact to develop the necessary interface between the users and the network of data banks.

Reference: Report of the Second Expert Consultation on WISI- 12 Contributors