A TYPICAL CASE OF INTEGRATED REMOTE SENSING CENTER CONCEPT: THE NAIROBI MULTIPURPOSE RECEPTION AND PROCESSING CENTER.

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I. REMOTE SENSING AS A TOOL FOR COUNTRY MANAGEMENT

I. 1. The Need for Remote Sensing

Remote sensing is a self consistent wording for a technique which aims to derive, from remote measurements, the properties of natural bodies. Since many years, photogrammetry or cartography are techniques which have made large use of pictures taken by balloons or aircrafts but the availability of spaceborne equipment, first in the field of meteorology (NIMBUS, METEOSAT and GOES), and since 1972 devoted to Remote Sensing (LANDSAT-1 to 5, SPOT and soon ERS-1) open the door to operational and large scale utilization.

I. 2. Political Status of Remote Sensing in EAST Africa

The development and applications of remote sensing technology in Africa is progressively becoming a vital tool for planning and management of the vast unexploited natural resources. The decision for a coordinated promotion of remote sensing technology in Africa originated from the United Nations Economic Commission for Africa (UN/ECA) Conference of Ministers of February 1975 in Nairobi and because the starting point of the settlement of the EAST AFRICAN REGIONAL RECEIVING STATION PROJECT.

A study financed by The European Economic Community is now underway to precise the technical definition of the project before implementation.

I. 3. East African Countries Requirements in terms of Remote Sensing Applications

The requirements of East African countries are those related to the general needs of developing countries and which chiefly correspond to data collection for development planning and management of natural resources. There is an urgent need in information of various kinds for economic planning and management which is missing by lack of means of all sorts.

This information is more specifically required in three sectors of the economy:

- Food production;
- Mineral and energy potential assessment and exploitation;
- Socio-economy.

Space Remote Sensing can bring at least part of the needed data to solve these problems. A regional ground receiving/processing station, with an adequate product distribution system, should allow the necessary fast dispatching of required data to users.

II. USERS REQUIREMENTS GENERAL APPROACH

The design of a ground station for receiving and processing of data from remote sensing satellites is a challenging task. Although a number of stations have been put into operation in the past no standardized layout is feasible as the requirements for such a station vary with the needs of the region it has to serve. Users needs impose the requirements on throughput, product quality, types of products and general services as for instance proper archiving. These needs are not stable but vary with time and require a flexible response from a central ground station.

The ultimate justification of such a Receiving Station and its operation primarily depends on the proper utilization by the Users Community of the Remote Sensing materials produced and disseminated.

The baseline for the project development leads to consider a two steps approach aiming at gracefully fullfilling Users Requirements. It should comprise:

- A BASIC SYSTEM able to generate films and digital products on a semi operational basis. Such a system will be implemented first by erecting the receiving and Quick Look Facilities (Phase 0) and thenafter introduce the basic preprocessing and interpretation subsystems (Phase 1).

- An ENHANCED SYSTEM providing all the necessary elements for the production of the full range of products but taking advantage of the experience gained during the running of the BASIC SYSTEM. The ENHANCED SYSTEM (Phase 2) should reflect the full Users Requirements satisfaction and in that respect is more closely bounded to the knowledge of it. The necessary inputs for the proper ENHANCED SYSTEM definition are going to result from investigations made in relation with the Users Community. In general, the Users Community can be identified by potential users of the following categories:

  a) The Member States;

b) Non-Member States within the visibility range of the Station;
c) Other countries, international and multinational organizations;
d) Agencies and institutions dealing with mapping and monitoring projects (resources inventories, land use planning, environmental monitoring, etc..);
e) Educational and research institutions.

III. SATELLITE SYSTEM SELECTION

III. 1. Potential Space Systems

Although data and information have been collected for many developing countries in particular by means of aerial survey over many decades, they are still not adequately available for planning and development programs. The advent of Remote Sensing Satellites has however provided the potential for a significant and fast improvement in this situation due to the capacity of these systems to perform large scale repetitive timely observations, to better interpretation techniques, to the application of appropriate field sampling programs and the availability of less expensive and less sophisticated analysis procedures. Thus, in addition to fulfilling basic requirements in cartography, survey, monitoring, planning and development programs in agriculture and forestry or water resources, for example, such tasks can be carried out more efficiently and much quicker than was previously possible; Early warning and the survey of a number of catastrophic situations are also potentially possible.

The era of Remote Sensing Satellites carrying imaging instruments specifically designed for exploration of natural resources over the whole surface of the Earth was open in 1972 by ERS-1 (LANDSAT-1), followed by LANDSAT-2, 3, 4, all three dedicated to land observation, and by SEASAT-A (July/October 1978) dedicated to ocean observation. The utilization of data produced by these satellites on a worldwide basis has steadily increased since 1972, whereas certain shortcomings concerning the spatial resolution of the LANDSAT series (80 m), for example, became evident as regards a number of important applications which cannot therefore be satisfactorily implemented. The second generation of Remote Sensing Satellites took the shortcomings revealed by such experience into account. Now, LANDSAT-5 is offering a spatial resolution of 30 x 30 (multispectral) while SPOT is offering 20 x 20 m (multispectral) and 10 x 10 m (panchromatic) resolution in the visible spectrum. In addition, SPOT also incorporates a stereoscopic imaging capability. LANDSAT-5 and SPOT are both dedicated to land observation, but it is worth mentioning also that plans concerning the utilization of microwave sensors for sea and land observation will come to reality with ERS-1 (and its 25 m resolution) satellite due to be launched early 1990.

Several other projects are also underway conducted by JAPAN (JERS), CANADA (RADARSAT), INDIA (INSAT) and others will offer complementary information, but have not been today considered as first priority because not yet offering the commercial long term service guaranty to users.

III. 2. Space Sensors Choices

A basic prerequisite concerning a receiving system lies in its grow up capability and potential flexibility to accomodate different spaceborne sensors.

Apart from the SPOT serie, which is already committed till the end of the 1990's decade, few other systems have been till now implemented on such a long term operational basis. As a first approach, three types of sensors must be addressed:

- Meteorological sensors because of their high impact on wheather forecast and monitoring;
- Optical sensors which today are the most widely utilized;
- Micro-wave sensors to bring the all wheather capability.

A receiving station must be defined in such a way as to minimize investment costs while not hampering future sensors accommodation. Owing to the time scale allocated for the project and LANDSAT-5 status it is likely that no "in flight" LANDSAT-5 will be available at station start-up. In that respect it is planned to receive LANDSAT-6 straight-on.

To illustrate the suggested choice one can refer to figure 2 which clearly indicates that basic requirements should concentrate on:

- METEOSAT/NOAA for meteorology;
- SPOT and LANDSAT-6 for optical sensors;
- ERS-1 for the micro-wave sensors.

At a later stage other sensors could be accomodated like MOS, other SPOT sensors like vegetation, etc...

IV. GROUND SEGMENT FUNCTIONAL REQUIREMENTS

IV. 1. General System Layout (Ref. fig. 4/5)

Once the satellite has acquired pictures, they are transmitted to the ground, synchronised, formatted, and finally transferred to a raw processing unit which performs mainly near real-time compensations.

The time constraint related to this first step does not allow for a very refined level of compensation, not only because of the inherent hardware limitation, but also because the measurement of many necessary correction parameters cannot be achieved in such a short time scale.

Thus raw processing is related to predicted effects only, so-called System Corrections (SC). For example, the orbit parameters, the skew on on-board mechanisms, scanning errors, etc..., can be compensated at this level. Accuracy, however, remains limited.

There are residual errors which cannot be eliminited by a predetermined law. These arise because:

- Instruments cannot be perfectly characterised;
- In-flight degradation may occur, which is not immediately evident on the ground;
- Small erratic errors can always appear because of the limited accuracy of any "à priori" law.

To obtain the highest quality level, it is therefore necessary to treat the image by using instrument and satellite knowledge, plus measurements and determinations performed on the images themselves.

This level of pre-processing is usally called Precision Preprocessing (PP).

The RRSCN program involves the setting up and running of a National Remote Sensing Center to meet the goals and objectives outlined in the term of references and furthermore allows the generation of products covering the whole range of necessary qualities.

The two steps approach described in § II will cover the production of SC Product in the BASIC SYSTEM and PP Product in the ENHANCED SYSTEM.

One must furthermore mention that besides technical aspects no successfull REMOTE SENSING CENTER can be set up if a proper Users acceptance is not prepared, which means that complementary activities such as Training and Users Assistance must be provided in view of:

- Ensuring that the East African Region has immediate and reliable real-time access on operational bases to Satellite Remote Sensing data;

- Developing human resources within the Region through extensive training and methodology development;

- Enabling the Receiving Center to assist neighboring countries and giving the necessary support for the obtaining of satellite data and related interpretations.

The Center will have two main functional elements (Fig. 3):

a) The Data Receiving Facilities (DRF) performing the Data Reception and first Quick Look elaboration. The coverage zone depicted in figure 1 looks very complementary to presently known receiving centers like MAS PALOMAS, SAUDI ARABIA, FUCINO and TOULOUSE.

b) The Data Handling Facilities (DHF) covering any technical facilities and located at the Regional Center incorporating the:
   . DPA for Data Preprocessing and Archiving Facilities;
   . DID for Data Interpretation and Dissemination Facilities.

IV. 2. The Data Receiving Facilities (DRF)

The function of the Receiving Center, operating in X band, is to collect the image signal from the Remote Sensing Satellite to amplify and transform this signal in order to record the data on a High Density Digital Tape (HDDT). This tape will later be processed into the DRF. Such a system must achieve high level performances on:

- Availability is achieved by using reliable equipment and with an effective preventive maintenance;

- Quality of the recorder data (data low bit error rate).

The duration of one pass is usually not exceeding 13 minutes and, because of the satellites local time spreading, should not lead to data reception overlaps.

IV. 3. The Data Handling Facilities (DHF)

They cover two types of function:

- Data Preprocessing and Archiving, mostly interacting with the DRF;

- Data Interpretation and Dissemination, mostly linked to Users requirements.

The Data Preprocessing and Archiving Facilities

The Data Preprocessing and Archiving Facilities take care of raw data evaluation, classification and archiving. These data are in fact impaired by a number of radiometric and geometric errors that have to be rectified prior to exploitation. On request, these data are processed, corrected and set in Users format: photographic film or Computer Compatible Tape (CCT). The Center deals with Users queries and edits catalogs. It also communicates with the satellite operator. The functions supported by the system fall in three categories:

- The Technical Functions that enable the evalutation, screening and archiving of the satellite data as well as the film and CCT production;

- The Production Functions that ensure an optimal performance of the system and a quality service to the Users. These functions include production, planning and control, Users request management, support of interactive queries, etc...

- The Test Functions that provide a comprehensive set of programs and tools for adequate quality control and efficient maintenance of the system.

Technical Functions

.Quick Look Processing of new tapes: the data recorded during one day at the Receiving Center arrives at the Preprocessing Center in the form of High Density Digital Tape (HDDT). There is one HDDT per satellite orbit. Every new HDDT has to be evaluated, classified and archived.

.Radiometric Correction: radiometric errors originate from the fact that several detectors are used for measurements on each of those detectors present slightly different responses to the same input.

.Geometric Correction: image data received from satellites are distorted by sereral factors that change the geometry of the picture. The geometric correction function calculates for each orbit of the satellite the geometric corrections to apply, based on the following parameters:

- Earth rotation and curvature;
- Satellite ephemeris and attitude;
- Used map projection (SOM, UTM, other).

The Production Functions

The incoming raw flux of data is splitted into as many as necessary scenes of standard size, then the system allows to produce high resolution film images (black and white or colour) and CCT's containing data for one satellite scene.

The Production Control subsystem optimizes the system production by relating and processing simultaneously several work orders originating from different requests but concerning the same HDDT. The Production Control Function enables a complete, day by day, production planning. Products quality control is also managed by the system in charge of:

- Generation of image catalogs;
- Display of the availability and operational status of the system;
- Work order generation.

V. FIRST CONCLUSIONS

The present description mainly deals with system layout. Major open questions are now focusing on:

Insertion of such an advance system within the region. To effectively make the NAIROBI RECEIVING STATION operational a great deal of efforts will be spent on users training, assistance and full coordination with satellite operators like SPOT-IMAGE, ESA, EOSAT. In other words, make it "fully user effective".

Incorporation of up-coming technologies.
Such a development must not be made for the sake of engineering satisfaction but made to reduce costs, increase operator efficiency and simplify the data interpretation process.

Lowering costs is also speeding the amortization time of investment and helps on investment decisions.

These technologies are mostly inpacting on:

- Improved receiver performances enabling antenna size reductions;

- Recorders with new tape device with little maintenance;

- Optical disk storage drastically lowering archiving costs;

- Improved processors utilizing RISC technology or transputer devices, multiplying by several powers of ten cost/performances ratios.

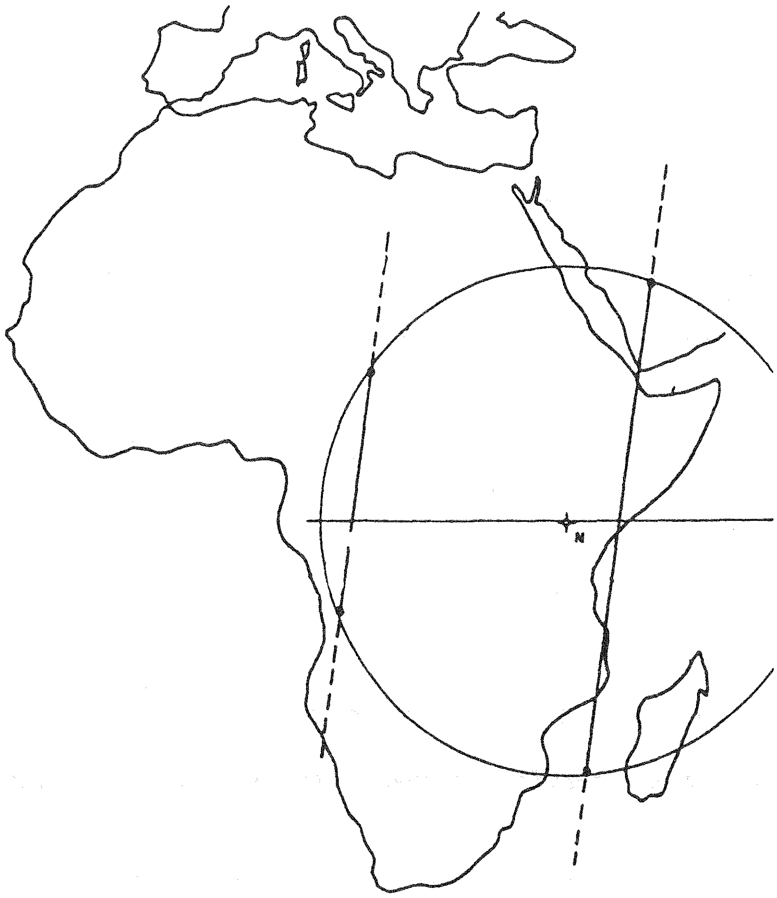
- Interactive and easy to drive displays and image processing system leading to desktop processors providing the computational capability equal to the 70's large mainframe;

- Improved photographic restitutors enabling simplified photo process and quick product availability.

In short, after having served developed countries, new emerging technologies are simplifying and offering at lower costs sattelite imagery handling.

One may assist, in near future, on a cost inversion effect between picture costs and processing costs which can be summarized as follows:

"The cost of a picture lies in its information content".

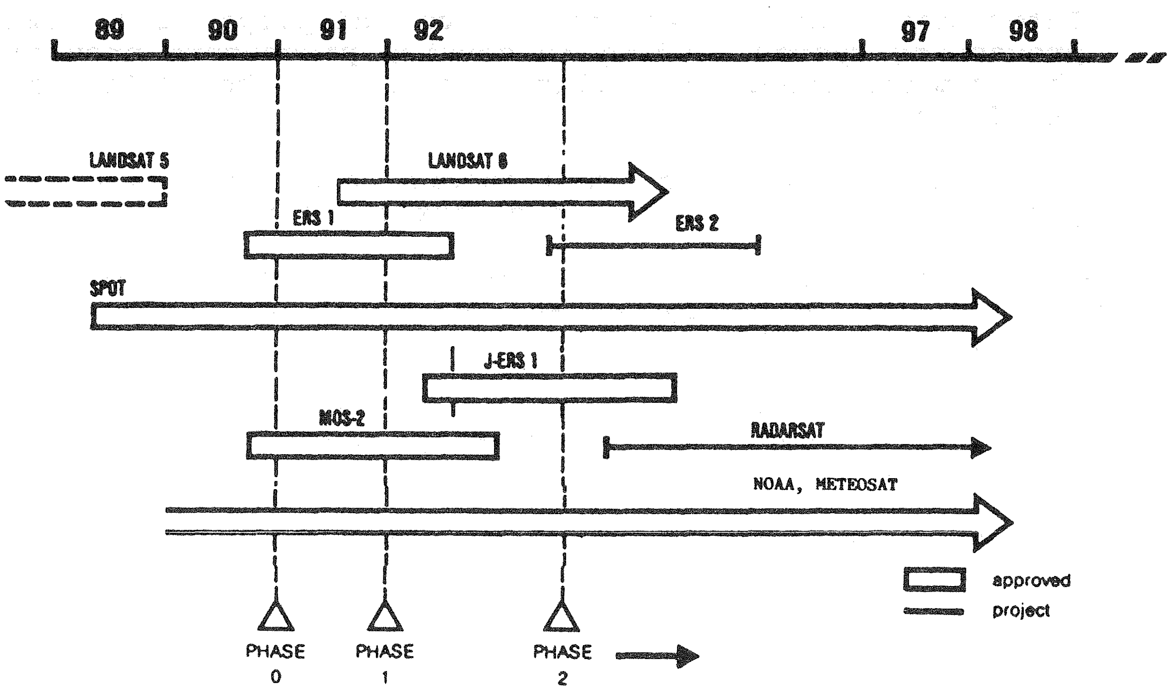


Visibility of SPOT and ERS from NAIROBI

Minimum elevation : 5°

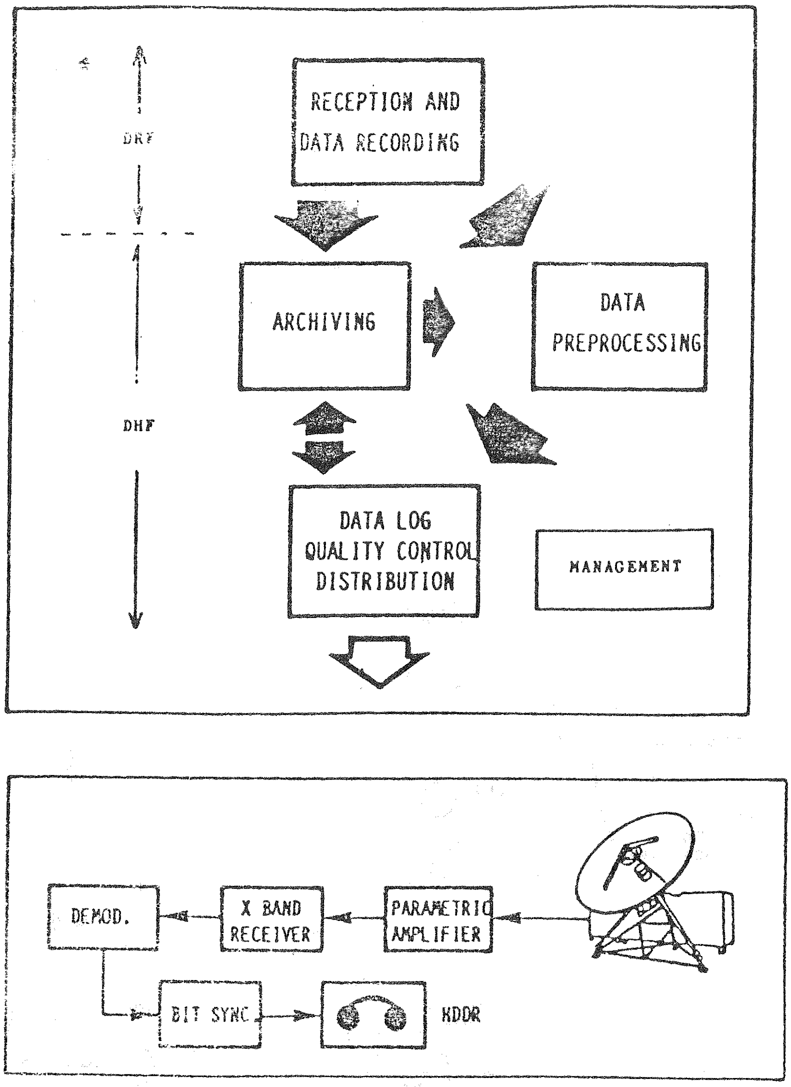
1 : 40 000 000

(Fig. 1)

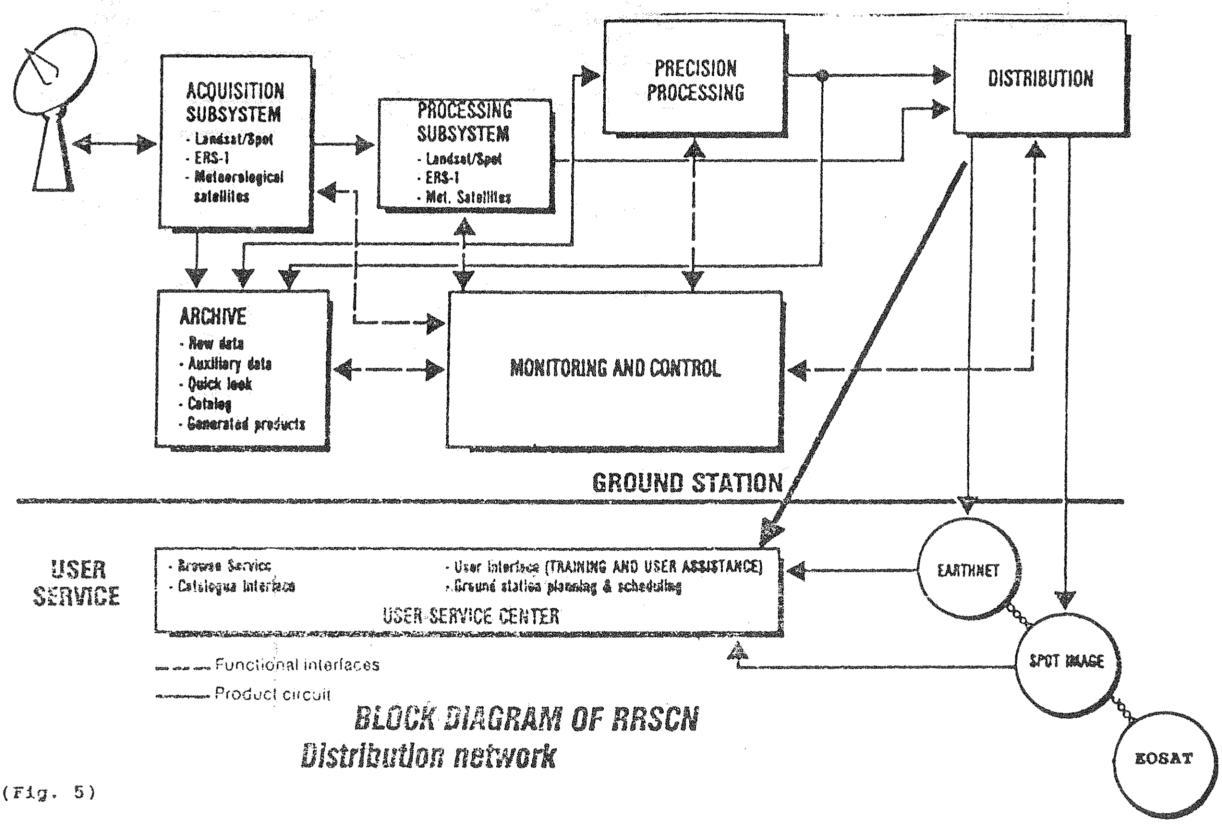


MAJOR SATELLITE SYSTEM LIKELY TO BE AVAILABLE

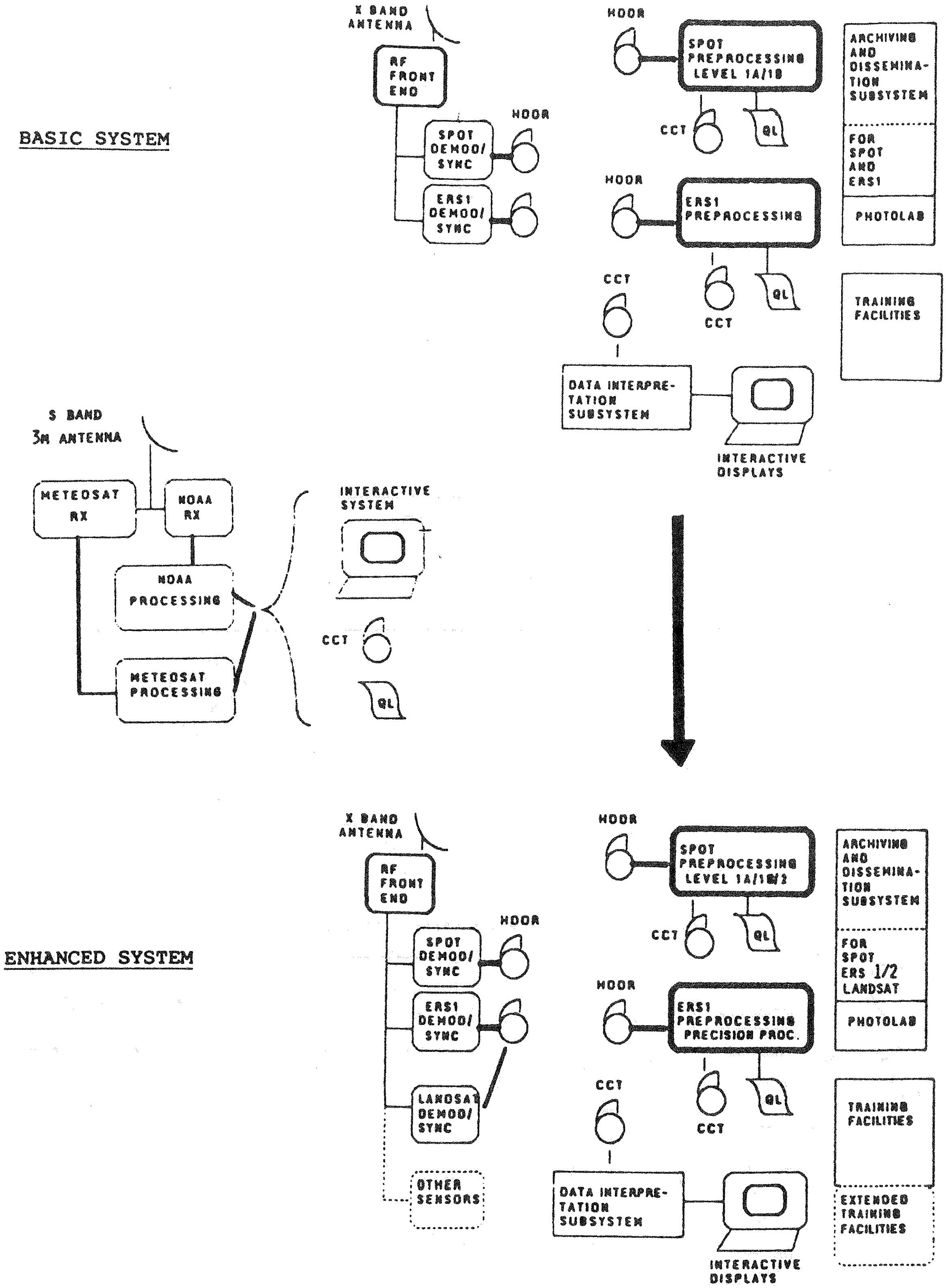
(Fig. 2)



(Fig. 3) RECEIVING STATION GENERAL LAYOUT



(Fig. 5)



(Fig. 4) NAIROBI RECEIVING CENTER TECHNICAL DEVELOPMENT