SPOT PRODUCTS AND ANTICIPATED DATA DISTRIBUTION SYSTEM

RESULTS OBTAINED FROM SIMULATED DATA

A. FONTANEL
SPOT IMAGE
18 avenue Edouard Belin
31055 TOULOUSE, France

ABSTRACT

The high resolution of SPOT images as well as the stereoscopic capability offered by this satellite will make the applications of SPOT comparable to those of aerial photography at a scale of 1:100,000 and in some cases of 1:50,000. Panchromatic products will offer the best resolution, 10 m, and multispectral products (resolution 20 m) will make various thematic applications possible.

Furthermore, SPOT will be able to take oblique views up to an incidence angle of 27° and so will make it possible to revisit a given area much more often than with an exlusively vertical- viewing satellite and to obtain stereo pairs with base : height ratios of up to 1.2.

Data distribution will be made on an operational and commercial basis by SPOT IMAGE Company, through various distribution centers located in different countries.
Foreign receiving stations will be invited to participate in this general distribution network.

The operation of the overall system will be managed with a constant view to provide an operational service.

1. INTRODUCTION

The decision was made in 1978 to develop the SPOT program, and the first satellite is scheduled to be launched in the middle of 1984.

The launching of a second satellite, SPOT N°2, which was first conceived as a backup for SPOT N°1, is planned for 1986 if the lifetime of SPOT N°1 is two years as expected. It is considered that two or three more satellites could be launched between 1988 and 1994 to ensure the continuity of service over a 10 to 12 year period because this condition is essential for developing the operational use of remote sensing for many applications where this technique is now only in an experimental stage.

The SPOT system will be made up of three entities :

- The French Space Agency (CNES) which is responsible for the general development of the program. CNES will also control the Mission Center in charge of programming the satellite once it is in orbit.

- Foreign receiving stations having an agreement with CNES for the reception of SPOT data.

- The SPOT IMAGE Company, which is responsible for promoting and marketing SPOT products on a worldwide basis. SPOT IMAGE will have access to data received within the visibility range of French receiving stations as well as to data recorded aboard the satellite. Therefore, it will have access to remote regions of the world and in particular to those located beyond the view of foreign ground stations.

2. CHARACTERISTICS OF THE SPOT PROGRAM AND SYSTEM OPERATIONS

The SPOT program differs from other current satellite-based earth observation programs in two key respects. The first is related to the technical characteristics of the satellite, the second to the way in which the complete system will be operated.

The key technical features of the SPOT satellite system can be summarized as follows :
- exceptional revisit capability : the SPOT off-nadir viewing capability means that zones on either side of the satellite ground track can be imaged more or less as required ;
- high geometrical resolution of images (10 m and 20 m) ;
- capability for recording stereopairs with base : height ratios of up to 1.2.

As regards system operation, the key points are : the importance that will be attached to providing a fully operational service matching the users' precise requirements, and guaranteed continuity of service for at least ten years.

The operation of the overall SPOT system (i.e. space and ground segments combined) will be managed with a constant view to providing an operational service.

2.1. General catalog of SPOT data

SPOT data will be received worldwide by stations having signed appropriate agreements with CNES and SPOT IMAGE. Each station will keep a constantly updated catalog of all data received.

In addition, station catalog data will be regularly forwarded to SPOT IMAGE so that a worldwide SPOT data catalog can be built up by the company. This catalog or data base will be available for consultation by any user either directly or indirectly using any of several modes of access : letter, telephone, telex, data transmission networks plus terminals that will be set up at strategic locations around the world. Catalog data will be accessible 24 hours a day every day of the year. It will be possible, for instance, to determine not only what images are available of a given zone, but also what images would be required to assemble a mosaic, produce a stereopair, and so on.

This catalog will include the 700 SPOT scenes received daily at the central station in Toulouse as well as approximately 2500 other scenes which may be received at other stations in the world.

2.2. Satellite programming

Where client requests cannot be met using catalog images, or where it is necessary to acquire new images in order to monitor time-varying phenomena, SPOT IMAGE (or the receiving station concerned) will forward a programming request(or requests) to CNES.

Receiving stations and SPOT IMAGE will manage programming requests of their own clients so as to ensure that they are either grouped for optimal efficiency or given priority ratings before being forwarded to CNES. CNES, in turn, will do all it can to meet these requests while taking into consideration the capabilities of the satellite and any relevant technical constraints.

3. SPOT PRODUCTS - POSSIBILITIES OFFERED BY THE SATELLITE

3.1. Panchromatic and Multispectral products

Two identical sensors (HRV) will be aboard the satellite and will be controlled independently of each other. Each of these instruments operates in either of two modes :

- in the multispectral mode, observations are made in three bands with a ground resolution of 20 m :

a green band from 0.50 μm to 0.59 μm
a red band from 0.61 μm to 0.68 μm
a near IR band from 0.79 μm to 0.89 μm

- in the panchromatic mode, observations are made in a single broad band, from 0.51 μm to 0.73 μm, with a ground resolution of 10 m.

These multispectral bands have been selected to take advantage of the interpretation methods developed over the last ten years. They must provide optimum discrimination among crop species and among different types of vegetation, using only three channels. The green band can also be used for water surveys such as detecting and monitoring coastal pollution, estimating water depth, etc.

The panchromatic band will provide the best geometric resolution (10 m) and will make it possible to update maps up to scales of 1:50,000 and in some cases of 1:25,000 for thematic applications. It will comply with cartographic standards for a scale of 1:100,000. In this sense, SPOT applications will cover part of the field of aerial photography.

3.2. Vertical and Oblique Viewing Modes Stereoscopy - Revisit Capabilities

All these panchromatic or multispectral images will be obtained in either a vertical mode or an oblique mode using a steerable mirror. With this ground-controlled mirror, the incidence angle can be varied step by step in a range from 0° (vertical viewing) to 27° (fig.1). This steering capability will provide two important possibilities :

First, it will be possible to revisit a given area much more often than with an exclusively vertical-viewing satellite. The orbital cycle of SPOT will be 26 days, and during this period a zone situated at the Equator can theoretically be visited 7 times, a zone at 45° latitude 11 times, and visits can be more often at higher latitudes.

It should be mentioned that two images (2 x 60 km) are lost each time the steerable mirror is rotated because of vibrations imparted to the spacecraft. Confusion must be avoided between this mirror and the permanently rotating mirror of a scanner. Solid-state technology (CCD) is used in SPOT, and there is no mechanical scanning mirror.

Because of this revisit capability, there will be greater opportunities of obtaining an image of an area during a given period of the year, and this will facilitate classifications or dynamic studies using multitemporal analysis. It will also facilitate change detection and the monitoring of natural disasters such as floods, volcanic eruptions, etc.

A simulation has been performed using meteorological statistics compiled over a ten-year period to estimate the time required to make a complete coverage of France with its area of 551,000 km2 and its situation at 45° N latitude. This simulation has shown that the time required for such a complete coverage can be significantly reduced by using the steerable mirror of SPOT. In this simulation, SPOT was first used only in the vertical-viewing mode. Then after all the passes over France were completed, the steerable mirror was used to obtain images of the areas previously covered by clouds. By using only incidence angles between $\pm$ 10° around the vertical axis, this simulation has shown that France can be covered twice as quickly as with a solely vertical-viewing satellite.

The steerable mirror will also make stereoscopy possible. Stereo pairs will be obtained from different orbits, and by choosing the proper satellite passes it will be possible to select different B/H ratios depending on altitude differences in the zone studied (fig.2).

Simulated SPOT images have shown that either two oblique views or an oblique and a vertical view can be used for stereoscopic interpretation. Therefore, it can be seen that once a systematic coverage of a region has been made in the vertical-viewing mode, stereoscopy can be added by taking oblique views of the same area.

Fig.3 shows a simulation of SPOT stereoscopic products. In this example, stereoscopy is obtained between an orthophotography (vertical viewing mode, on the left) and an oblique photography (oblique-viewing mode, on the right). The oblique view has an incidence angle of 21.5 degrees from the West. The basis on height ratio is 0.44. This example is part of a SPOT simulation program conducted in 1980 on Southeastern France (Camares region). The geometric resolution is 10 m and the original scale was 1:125,000.

From what was said above, it is obvious that programming the satellite will be an important and delicate task. Programming demands will be addressed to the CNES Mission Center by SPOT IMAGE and the different receiving stations as a function of their own program and of their users' requests. In some cases, the Mission Center will have to handle possibly conflicting demands as well as priority orders while taking optimum use of the satellite into consideration.

SPOT IMAGE requests will pertain to areas within the visibility range of the Aussaguel Station, situated near Toulouse, France, as well as to areas elsewhere in the world, thanks to the possibilities offered by the onboard recorders. A new program will be loaded into the satellite computers every 24 hours, but requests will pile up for a week at the Mission Center so as to make up a sufficiently large backlog to enable optimum use to be made of the satellite. Very urgent demands will bypass this backlog and be programmed within a 24 - or 36-hour period.

4. STANDARD PRODUCTS - CHARACTERISTICS OF PREPROCESSED DATA

4.1. Scene Coverage

Two independent and identical HRV instruments will be aboard SPOT and will have a swath width of 60km each at vertical incidence. The swath width will be 85 km when the maximum incidence angle of 27° is used. A SPOT scene will hence represent an area of 60 x 60 km or 60 x 85 km at maximum incidence angle.

The two HRV instruments can operate independently or in a twin mode with adjacent traces and a small overlap of 3 km. In this case, the equivalent total swath width of SPOT will be 117 km (fig.4), but the scenes from each HRV will always be processed separately from one another.

4.2. Standard products

The characteristics of the standard products preprocessed at French stations and marketed by SPOT IMAGE have already been defined. Foreign receiving stations will process their own data, but minimum standardization levels will be defined in the agreements between CNES - SPOT IMAGE and the foreign ground stations.

Level 1A

This is the rawest level with no geometric corrections. Radiometric corrections will include only normalization of detector elements without any interband calibration. This product will be available only on CCTs.

Level 1B

In the case of oblique viewing, geometric corrections will be made for earth rotation and panoramic effect. These corrections will be made without ground control points and will be based solely on knowing satellite pass predictions and viewing directions. Satellite velocity variations will also be corrected. Cartographic location accuracy will be 1,500 m (rms), with scale distorsion less than 1%. Radiometry will be corrected using MTF functions.

This level will be available to users on either CCT or photographic films. The smaller scale will be 1:400,000 because a complete SPOT scene (60 x 60 km in vertical mode or 60 x 85 km with an incidence angle of 27°) enters a 24 x 24 cm film format. Larger scales up to 1:50,000 will be obtained by photographic enlargements. Larger scales will also be obtained directly from magnetic tapes by juxtaposing pixels in both directions or by using standard interpolation techniques.

Level 1B products can be used for making mosaics and, by using stereoscopic methods, for photointerpretation.

Level 2. Precision processed level

Geometric corrections will be made using 6 or 8 ground control points per scene. The corrected images will be superimposable on a map with an accuracy of 50 m.
Several cartographic projections will be available, i.e. Lambert, UTM, polar stereographic, etc. Radiometric corrections will be the same as for level 1B. A map library will be set up before launching, and regions will be chosen according to map availability and to anticipated users' demands.

Levels S1 and S2

Where no map is available, SPOT images will be corrected in respect to a reference scene. If the reference scene is on level 1B, the corrected product will be on level S1. If it is on level 2, the corrected product will be on level S2. The superposition accuracy will be half a pixel, i.e. 5m in the panchromatic mode and 10 m in the multispectral mode.

4.3. Value-Added Products

SPOT IMAGE will market standard products as well as value-added products obtained, for example, by merging SPOT data with other satellite data or geophysical data. These products will be obtained by photographic or digital processing.

Photographic enlargements of subscenes will be made up to a scale of 1:25,000. CCTs will be delivered in a 6250 bpi or 1600 bpi density with or without special stretching, ratios of spectral bands, principal components, etc. SPOT IMAGE will also offer services in the different fields of remote sensing.

5. DISTRIBUTION OF SPOT PRODUCTS

A number of market surveys have been performed in Europe and the USA, either sponsored by CNES or in other contexts. Their various conclusions are fairly consistent. They point to the existence of a large potential market. Applications in the field of extractive industries - oil and gas, mineral resources exploration - are already extensively developed, but other applications have yet to be developed in such fields as the management of renewable resources, land use management and environmental protection.

These potential markets could be converted into actual markets if several conditions are fulfilled :

- guaranteed delivery schedules for data,
- long-term continuity data,
- acceptable prices for data,
- extended distribution network,etc.

SPOT IMAGE

SPOT data will be distributed by SPOT IMAGE and/or the foreign receiving stations. Each station will be appointed by CNES as the exclusive distributor in a zone of commercialization contained within the so-called "range of visibility" of the station. Within this zone, the station will distribute data received directly from the satellite and for which a licence for reproduction, distribution and sale has been granted by CNES. Elswhere, i.e. everywhere not covered by station franchises, SPOT IMAGE will be the distributor of SPOT data.

It should also be noted that images can be obtained of zones not covered by direct receiving stations by using the satellite's onboard recorders. SPOT IMAGE will be the sole distributor of all data stored by the onboard recorders.

SPOT IMAGE will be a private company operating on a commercial basis and responsible for the promotion, reproduction and marketing of SPOT data on a worldwide basis. This company will be set up mid-1982 and will be formed by a number of French organizations already associated with CNES and involved in the different fields of remote sensing, and possibly with some foreign participation.

So as to achieve the optimum organization of the services offered to users and to promote SPOT data, this company will set up a distribution network extending to different countries. This network will include subsidiaries, local correspondents, agents, etc. It will be supported by the foreign activities of SPOT IMAGE shareholders. Furthermore, operators of foreign stations receiving SPOT data will be offered the possibility of participating in this distribution system. (fig. 5)

CONCLUDING REMARKS

Future remote sensing satellite systems are being considered in various countries (Brazil, Japan, India, European Space Agency, ..) and LANDSAT D is to be launched by NASA in a few months. SPOT will be launched mid 1984 approximately at the time where thematic mapper data will become available to users.

LANDSAT D will procure a wealth of improved spectral information, SPOT will provide higher resolution, with a capability for stereo coverage and frequent access to user-specified sites.

It is likely that significant advantage can be derived from complementary capabilities of the different systems.

FIG. 1

Light enters the HRV instrument via a plane mirror, that is steerable by ground control. The maximum off nadir angle is ± 27°.

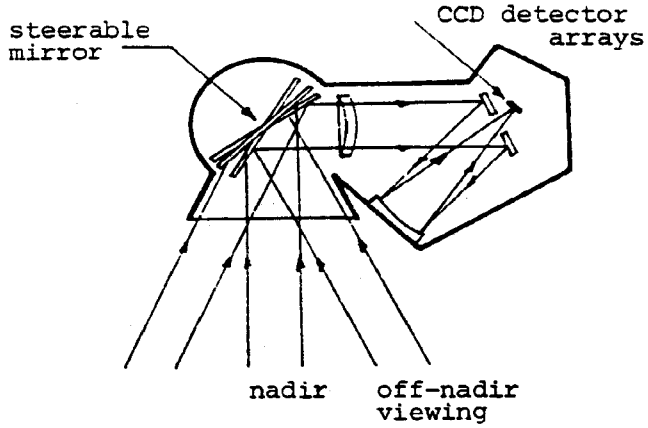
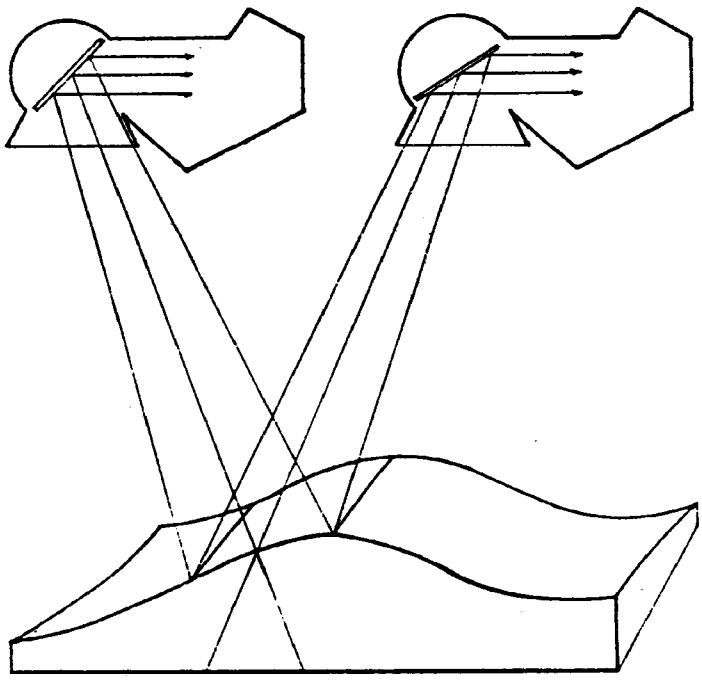
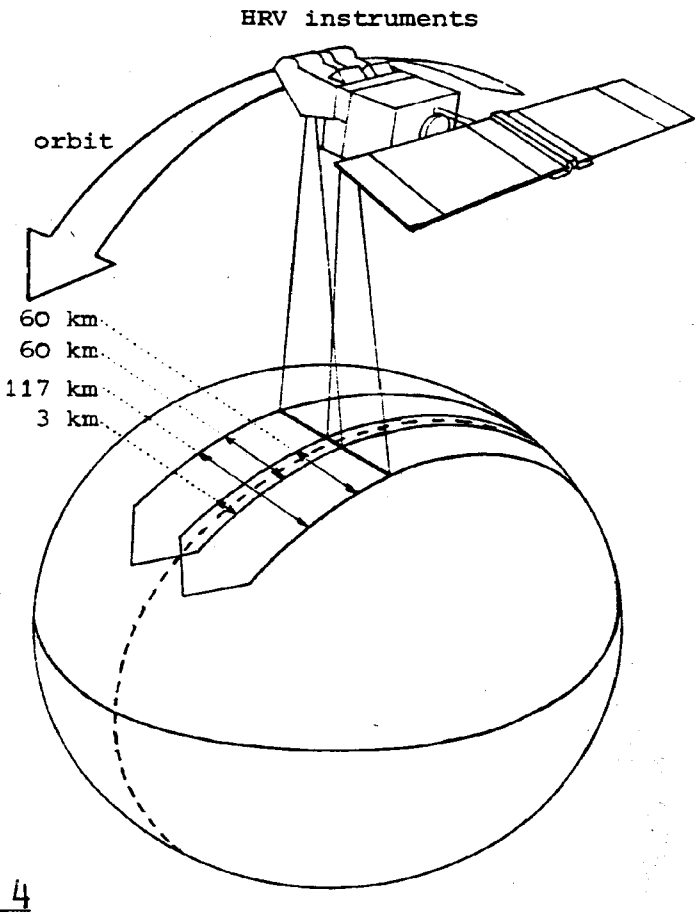


FIG. 2



Oblique observation can be used to obtain stereoscopic image pairs of the same area, taken at different angles on successive satellite passes, within visible range of the area concerned. Potential applications include photogrametry and photointerpretation, both of which require differenciation of relief.

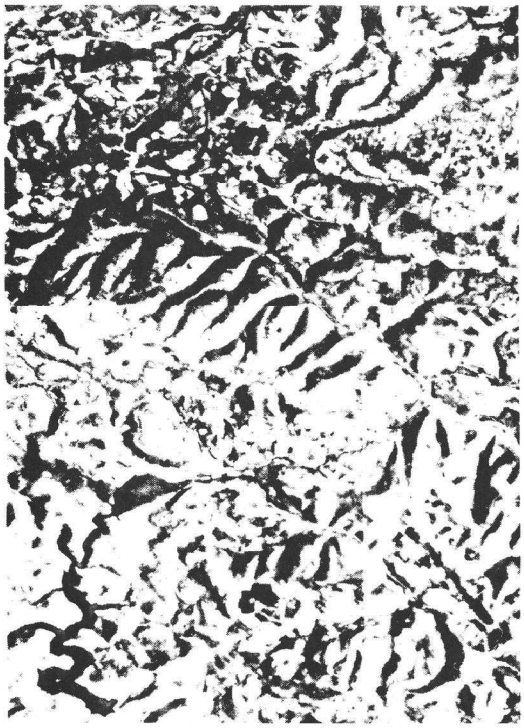


The two HRV instruments (sensors) can be pointed so as to cover adjacent fields. In this configuration, the total swath width is 117 km (nadir) and the two fields overlap by 3 km. They can also be used independently.

FIG. 4

FIG. 3

SIMULATION D'IMAGES SPOT
SPOT IMAGERY SIMULATION

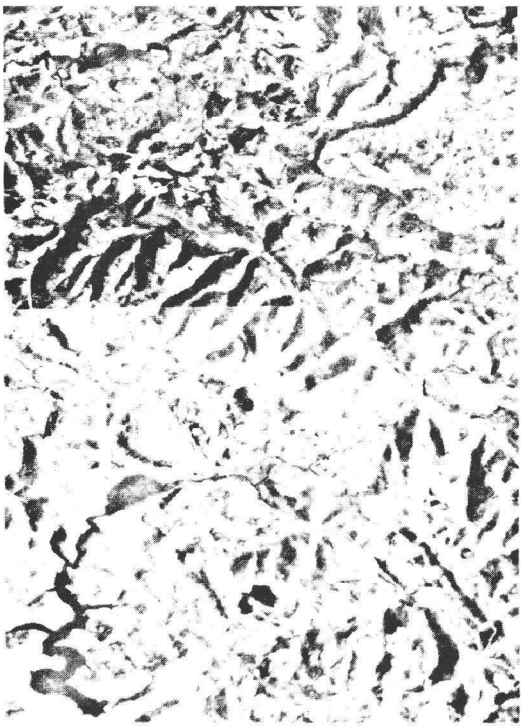


Vue verticale
Vertical view

Stéréoscopie : B/H = 0,44
Pincement d'orbite : 3,5°

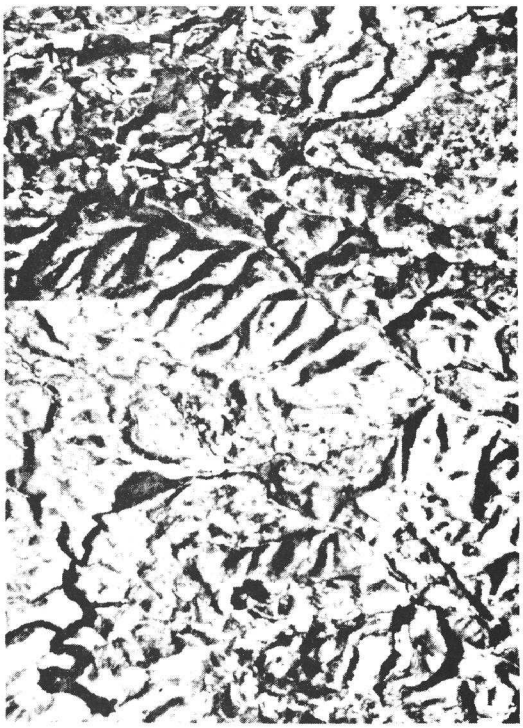
Vue oblique OUEST α = + 22,6°
West oblique view α = + *22.6°*

Stereopair : B/H = 0.44
Path to path toe-in : 3.5°



Vue oblique EST α = - 21,5°
East oblique view α = - *21.5°*

Stéréoscopie : B/H = 0,88
Pincement d'orbite : 7°

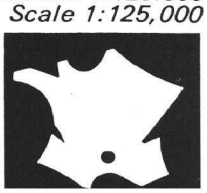


Vue oblique OUEST α = + 22,6°
West oblique view α = + *22.6°*

Stereopair : B/H = 0.88
Path to path toe-in : 7°

0 2Km

Echelle 1:125.000
Scale 1:125,000



SPOT IMAGE AND THE SPOT SYSTEM

FIG. 5

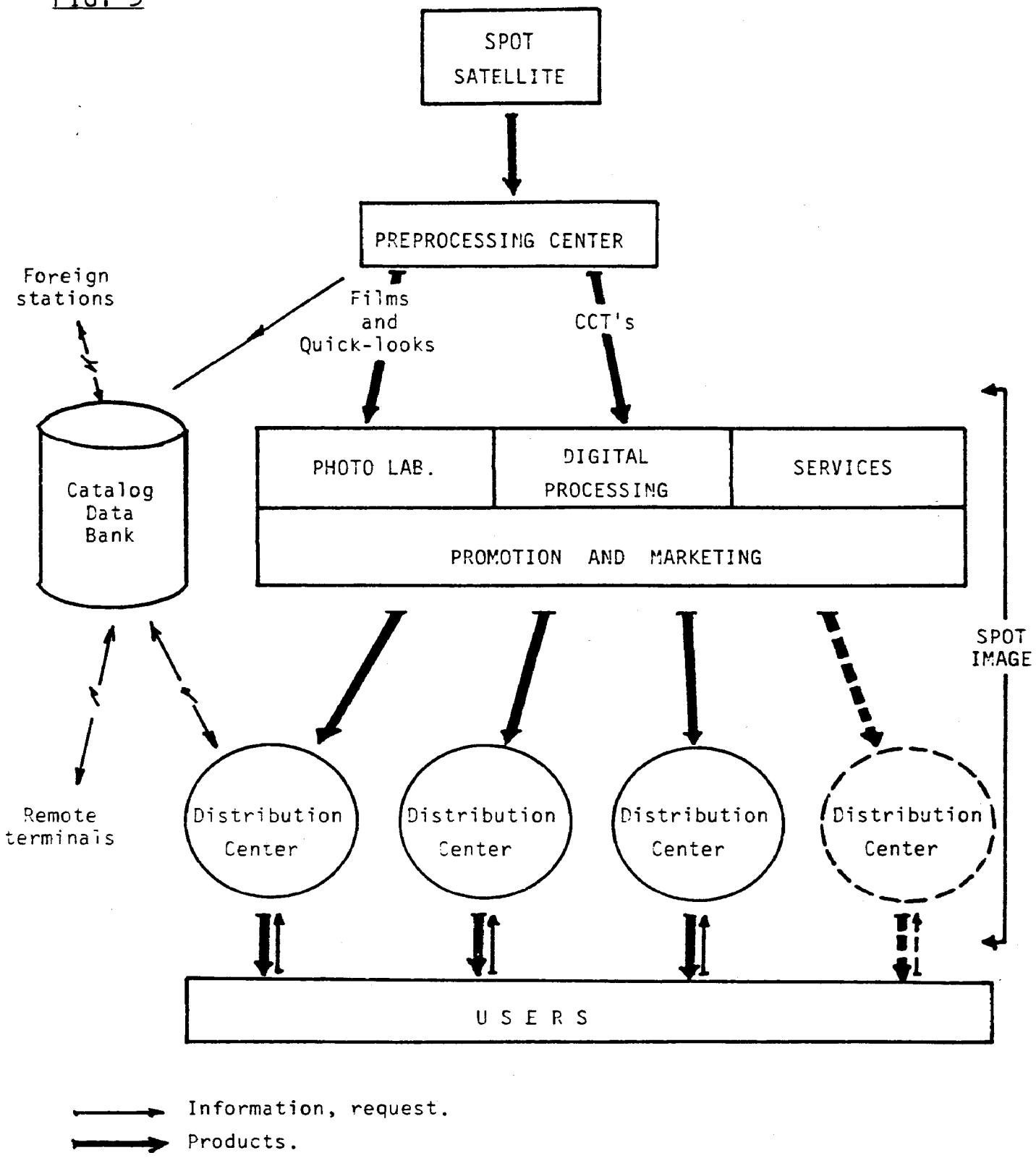


Figure 5