THE 1983 U.S. SPOT SIMULATION CAMPAIGN: MAXIMIZING THE POTENTIAL OF AERIAL IMAGE ACQUISITION

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SPOT IMAGE Corporation (SICORP) was incorporated in the state of Delaware on December 7, 1982. It followed by only five months the birth of its parent company, SPOT IMAGE S.A., in France. Armed with the challenge of awakening the United States to the coming of the "Satellite Probatoire d'Observation de la Terre", a Washington office and a tiny but eager team sprung into action.

The task was to find and develop the market for SPOT's remote sensing data products. The difficulty lay in the lack of a real product. SPOT will be launched in 1985, but 1985 is too late to begin informing future users of SPOT about the technical benefits and cost-effectiveness of what will most certainly be perceived by first-time users as a high-tech, high-cost, complex tool.

Thus the decision to simulate SPOT's spectral coverage and resolution by conducting an airborne campaign which would acquire electronic data over diverse geographic locations within the conterminous U.S. For experienced users of remotely-sensed imagery, the SPOT simulation campaign would enhance their knowledge and understanding of the technology in general, and of the added value (or lack thereof) of SPOT's advanced features. For beginning users, the data packages would be an introduction to remote sensing, and encourage further exposure to this, and other, systems. Finally, for SICORP, the completion of the simulation campaign would mark SPOT's arrival on the American scene, demonstrate its serious technical and commercial nature, and provide a data base with which to further pursue and develop new markets for remotely sensed satellite imagery.

In early 1983, SICORP awarded a contract to Daedalus Enterprises Inc., of Ann Arbor, Michigan, to manage the data acquisition phase of the simulation campaign. Likewise, Earth Satellite Corporation of Chevy Chase, Maryland won the bid for the ground processing of the multispectral scanner data acquired by aircraft, Precision Photo Laboratories, Inc. of Dayton, Ohio took charge of the metric camera film processing, and GDTA* of Toulouse, France served as technical consultant during the acquisition and processing phases of the program (see Fig. 1).

At about the same time, SICORP solicited test-site location proposals from the recognized U.S. user community, and received

SCHEDULE OF EVENTS

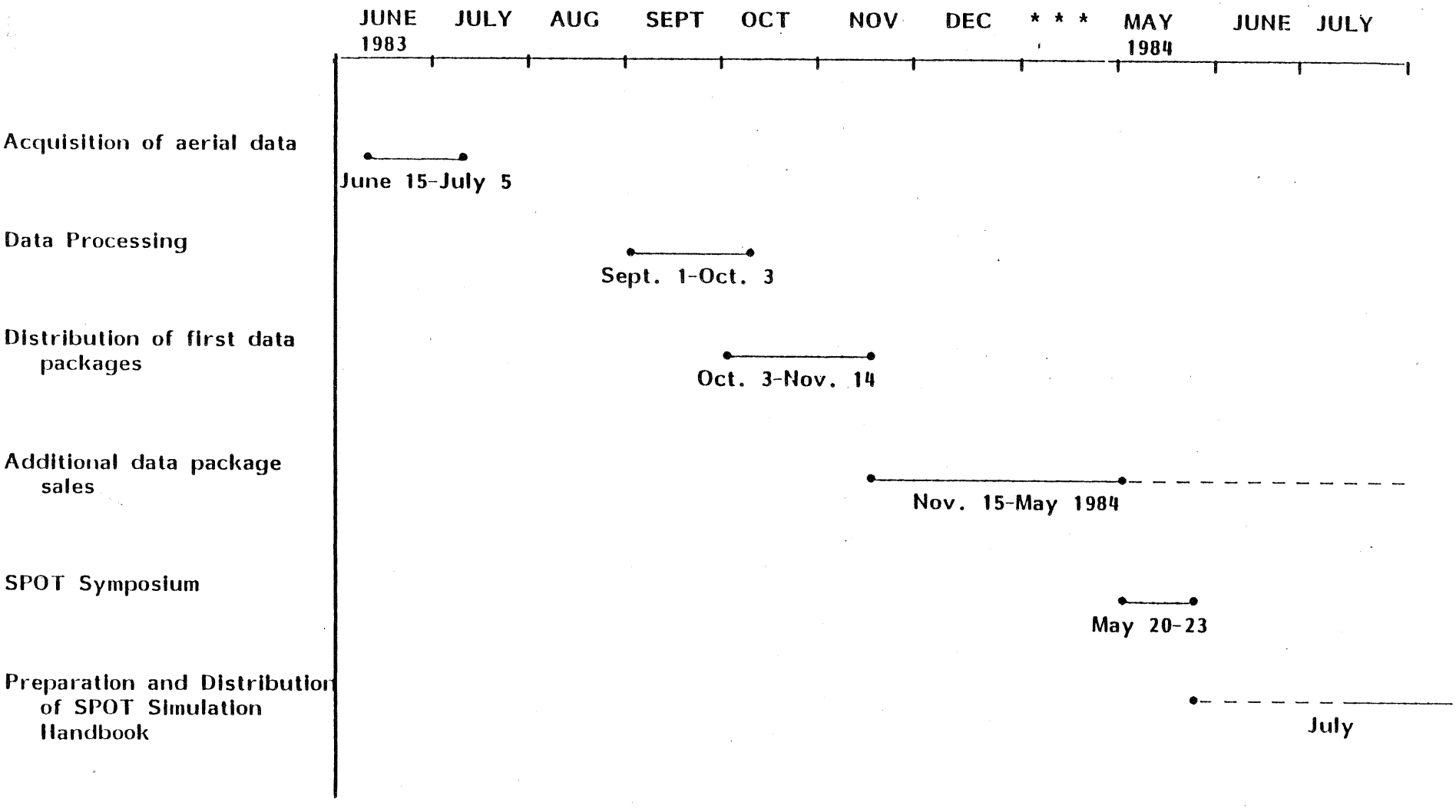


Figure 1

approximately 300 responses to an initial mailing of 1500 letters. After considering proposals on the bases of geographic site location, usefulness of the application-oriented study and the sector (public or private) of the proposer, a slate of sites representative of each of these criteria was selected.

In designing the airborne simulation campaign, SICORP recognized the need to deviate in certain instances from the expected behavior of the SPOT satellite. While the overwhelming majority of these "inconsistencies" were due to the use of an aircraft, as opposed to a spaceborne, platform, one of the barriers was simply that of cost. The Learjet 25-C selected to fly was retained for a fixed period of 21 days and 45 flight hours. Any extension thereof would require additional financing. Thus, in order to contain the cost to SICORP as well as to the customers, limitations were placed on the geographic choice of sites (Alaska and Hawaii were proposed but rejected because of the number of flight hours required) as well as on the total number of sites to be attempted.

Another modification imposed by cost considerations was that of the time window. SPOT, flying in a near-polar, sun-synchronous orbit, passes over the mid-U.S. at approximately 11:00 a.m. Unless daily acquisition during the simulation was severely limited, this "U.S." window, while within the range of solar height, could not be achieved in terms of solar time. Thus, the campaign allowed for a broader window -- from approximately 10:10 a.m. to 2:00 p.m. solar time.

Additionally, SICORP did not attempt to simulate the flight orientation of the satellite. The aircraft's mobility permitted SICORP to respond to the orientation needs of the site proposer; SPOT's fixed track mode will permit only one scanline orientation, but will be able to acquire side-looking, or off-nadir data by virtue of its pointable mirrors and programmable nature. The pointable mirrors were of course also not simulated, for the multispectral scanner was not capable of off-nadir viewing. Another important feature of the SPOT satellite, its rapid revisit capability, allows from one to several day intervals between same scene acquisition. This characteristic was excluded from the simulation, as overflight number 2 would have had to occur at precisely the same solar time as that of overflight number 1.

The data acquisition portion of the 1983 SPOT Simulation Campaign was designed to optimize the number, scope and geographic distribution of simulation sites (Fig.2). In order to accomplish this, it was necessary to configure an aircraft capable of rapid deployment as weather conditions changed, and a communications plan that would maintain contacts between the flight crew and both Daedalus and SPOT headquarters personnel.

The campaign objectives included data acquisition throughout the U.S. and required the use of a specially configured multispectral scanner and a metric mapping camera. Even though metric camera imagery is not a feature of the SPOT system, much of the data purchased would be used in a research mode, and

SIMULATION CAMPAIGN

SITE REQUESTORS

ECONOMIC SECTOR	NUMBER
Federal Government	16
State Government	4
Local/Regional Government	1
Value Added (Private)	7
Other Private Industries	8
Academic Institutions	14
TOTAL	50

PROPOSED SITE APPLICATIONS

APPLICATION	NUMBER
Agriculture	10
Forestry	11
Geology	37
Technical	2
Urban Planning	19
Water Resources	20
TOTAL	99

(Of the 99 proposed sites, 36% were "S" sites
64% were "P" sites)

Figure 2

simultaneous coverage by such an instrument was considered beneficial to the exercise. In addition, the aircraft had to be capable of operations to altitudes above 12,000 meters to simulate the 20 meter resolution, multispectral-mode operation of the SPOT satellite. Daedalus conducted a search for a suitable platform and selected a Learjet 25C, operated by Hauts Monts, Inc. of Beauport, Quebec, Canada. A subcontract negotiated with Hauts Monts provided the aircraft equipped with a Zeiss RMK 15/23 camera, pilot, co-pilot, and camera operator. Daedalus supplied a special scanner door mount for the aircraft as well as a modified AADS 1268 multispectral scanner, operator and project manager.

The site nomination and flight planning process ended with final site selections made in mid-May. In order to facilitate communications, all sites were specified as either 10 m resolution ("P" or panchromatic-mode) sites or 20 m resolution ("S" or multispectral-mode) sites and were identified by geographic coordinates and plotted on 1:250,000 scale USGS topographic maps. Each site was given a unique site number and was selected to demonstrate a particular application for SPOT data. Of approximately 110 sites proposed, more than 90 sites were identified and plotted, but some were withdrawn before initiation of the flight campaign.

In late May, the final sites were analyzed and grouped by geographic location and aircraft altitude requirements. The groups were then studied to select optimum bases of operations from which to conduct the acquisition flights. The base selections were made using several criteria. It was desired that each base have adequate facilities for supporting the Learjet, including fuel, runway length and a good weather station. In addition, major airports used by many commercial flights were avoided due to excess ground time requirements. Other criteria included the location with respect to sites so that sites existed in several directions from each base to take advantage of variable local weather conditions and to permit acquiring several sites within the nominal four hour solar window each day. Since the Learjet had a 450 knot capability at altitude, sites could be as far as 500 miles from a base of operations and still be candidates for acquisition. High altitude sites were grouped together so that once the aircraft climbed to altitude, several sites could be acquired before descending for fuel. Daedalus drafted a complete flight plan identifying bases of operations, the simulation sites to be acquired from each base, sites per flight sortie, and the preferred sequence in terms of solar time and altitude. The final flight plans were then transferred from the topographic map base to low-altitude navigation charts for transmittal to Air Traffic Control Centers. Each center in which flight operations were to be conducted received a set of charts with sites plotted and altitudes specified. Centers were then contacted by telephone to arrange for expedited clearances once the flight campaign was initiated. This procedure greatly minimized in-flight delays of obtaining ATC clearance for a particular site.

The Daedalus AADS 1268 multispectral scanner was configured for the SPOT simulation campaign in late May. All eleven spectral bands of the standard system would be recorded and the SPOT bands would be simulated by combination in digital image processing. While this made the image processing step somewhat more complex, it provided flexibility for creating other spectral combinations in order to study future SPOT spectral band options. The scanner's 1.25 milliradian spatial resolution provided the 10 and 20 meter simulated SPOT resolution at altitudes of 6350 and 12,700 meters respectively. The actual ground resolution was greater than the 10m and 20m desired, but the data were to be resampled during image processing to simulate SPOT's resolution. The total field of view of the scanner was modified to 43°. The metric camera was equipped with a 6" focal length lens and special filters for use with color infrared film which was used to acquire simultaneous photographic coverage of the test-sites.

The Learjet 25C was outfitted in early June 1983, and is illustrated in Figure 3. Mobilization occurred in Ann Arbor, Michigan, and on June 16, after two brief local test flights, the campaign officially commenced. Procedures were established for daily contact between the flight crew and the Daedalus office early each morning and upon completion of the flights each day. SPOT and Daedalus were also in at least twice a day contact. SPOT personnel inspected National Weather Service satellite images each morning and that outlook was compared with local weather and pilot reports at the base of operations. A decision was then made on which sites to attempt and whether or not to change to a new base of operations. The mobility of the entire operation was an important asset. Travelling west, the aircraft could mobilize approximately 1000 miles in the morning and still have time within the solar window to acquire data over several sites. Eastbound ferry trips had to be made in the evening so as to be available for acquisition during the following day's solar window.

By carefully monitoring the weather patterns, the flight campaign was conducted with only one redundant trip across the country. Figure 4 illustrates the approximate flight track of the aircraft during the campaign. A total of 61 simulation sites were successfully acquired during the 23 days of the flight campaign. During this time, only one day was lost due to aircraft mechanical problems and no malfunctions occurred with either the scanner or the camera. A total of 55 flight hours were accumulated during a campaign which covered more than 20,000 miles.

Upon completion of the flight campaign, Daedalus produced "quicklook" prints of one channel of the scanner data for each site. One print was sent to the site proposer and a second to SICORP. After selection of the exact geographic area of interest for each site, Daedalus produced a computer compatible tape (CCT) from the high density digital tape (HDDT) for each requested site. All initial orders for prints and CCTs were delivered in September 1983.

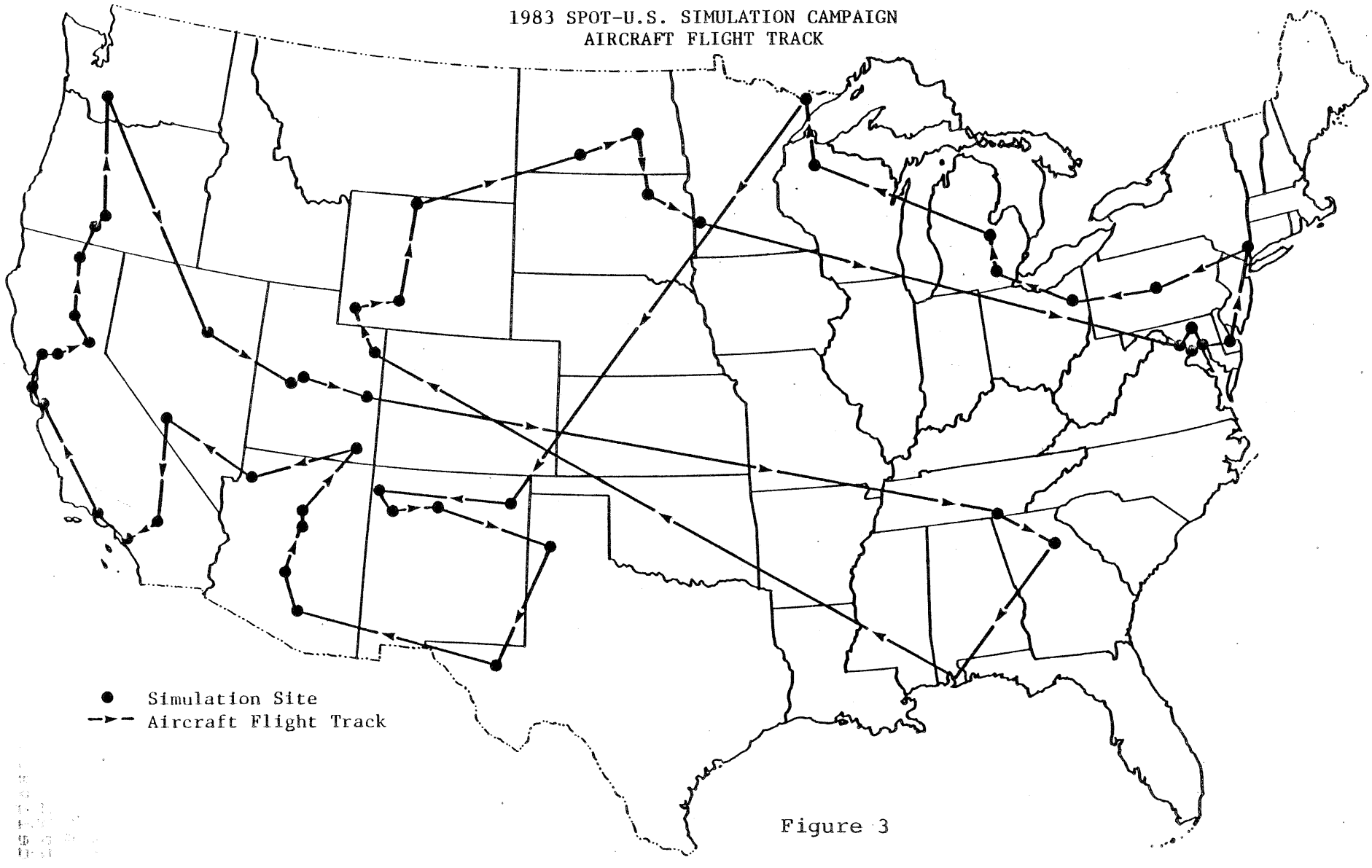
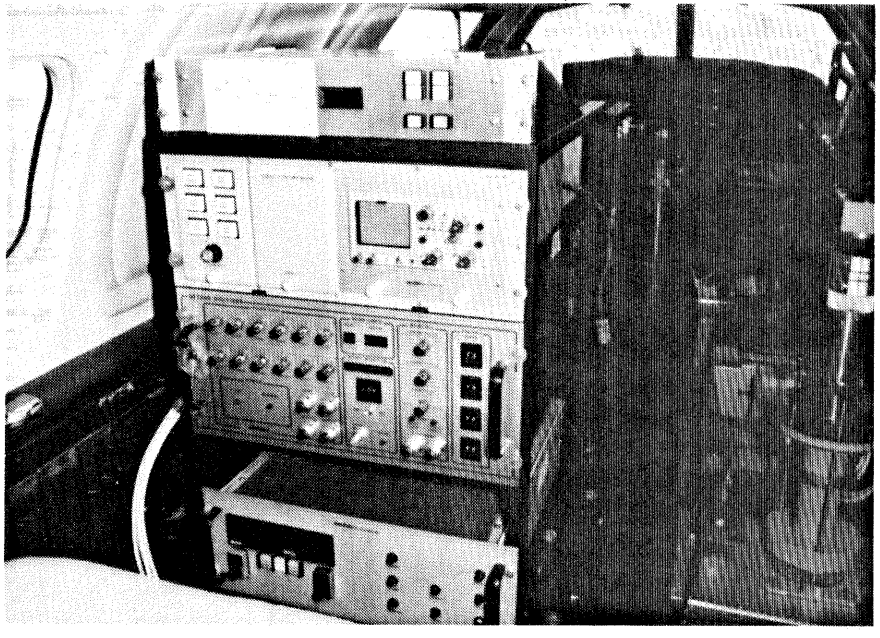

1983 SPOT-U.S. SIMULATION CAMPAIGN
AIRCRAFT FLIGHT TRACK
Simulation Site
Aircraft Flight Track

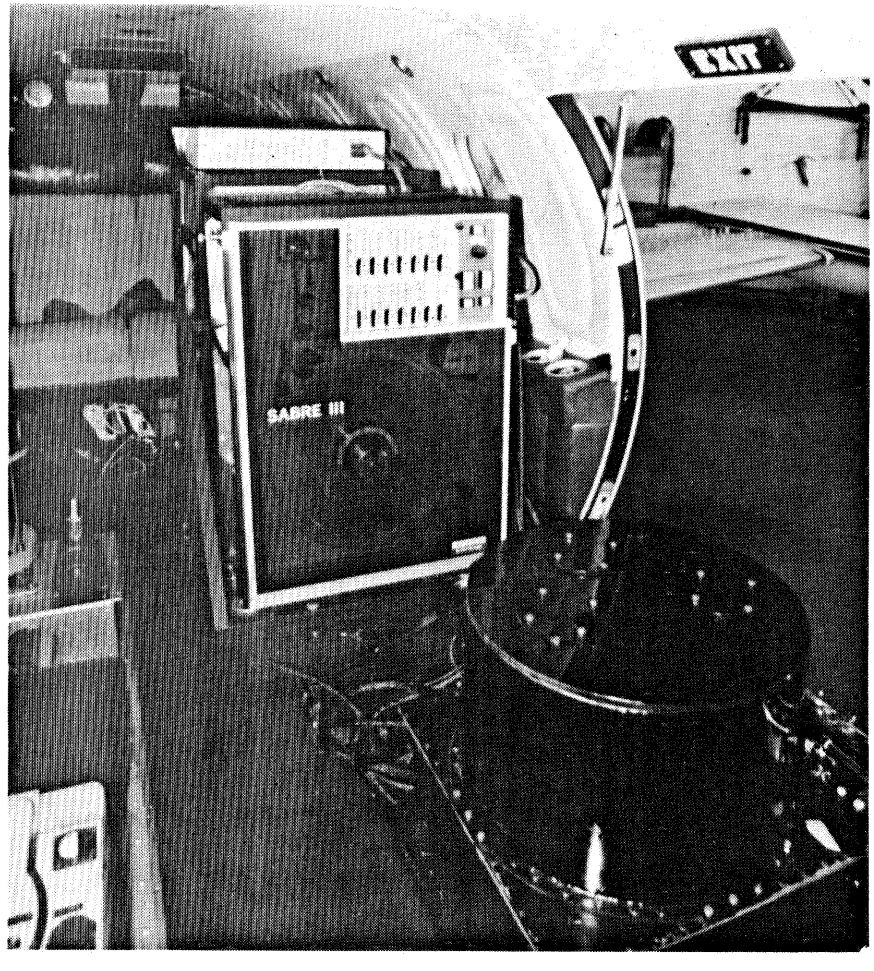
Figure 3

1983 SPOT-U.S. SIMULATION CAMPAIGN
AIRCRAFT SCANNER INSTALLATION



The Daedalus AADS1268 airborne scanner and Zeiss RMKA 15/23 metric camera used in the SPOT Campaign.

The instruments were mounted aboard a Gates Learjet 25C.



The scan head in a pressurized dome developed by Daedalus for high altitude operation.

Figure 4

SPOT simulated data, in the form of Computer Compatible Tapes and color composite prints were produced by Earth Satellite Corporation, under the supervision of SICORP and GDTA* specialists. For each flightline acquired during the airborne campaign, a data package was generated, containing the abovementioned CCT and print, as well as black-and-white transparencies of each of the four SPOT bands, the metric camera aerial photo set and written documentation to facilitate analysis of the data.

In retrospect, one of the most crucial lessons learned by SICORP was the degree to which communication had to be maintained by all parties involved. The experience lasted one year, as the campaign evolved from its pre-operational, to operational, to post-acquisition phase. At each juncture, communication had to be assured with contractors, clients and SICORP personnel. In addition, certain communication lines had to be protected. [Some site proposers requested direct communication with the flight crew.] The overriding conclusion, however, was that direct, effective contact was essential to the success of a customized data-gathering system. Continuity of data stream from a satellite to a receiving station is only the first step; data distribution and customer service follow-up is equally important, and must be mastered in order to ensure user satisfaction.

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On November 1, 1983, data package delivery began, and continues to this day by virtue of additional package sales. In conducting this complex and lengthy exercise, SICORP has achieved its goal of maximizing the potential of aerial image data acquisition. The 1983 U.S. SPOT Simulation Campaign has responded to present users by providing a high-quality sneak preview of the SPOT system designed to improve end-user expertise, and permit the vastly important value-added industry to upgrade and innovate processing techniques to meet the needs of SPOT data users. It has reached out to inform new communities about the value of remote sensing. And, perhaps most salient in terms of the viability of remote sensing as a commercial product, it has become a practical yardstick, defining the priorities, worries and dreams of the American remote sensing user community. With such a yardstick, SPOT IMAGE Corporation hopes to create a dream come true.

* Groupement pour le Développement de la Télédétection Aérospatiale.