An artist's impression of the operation of the HRS along-track stereo-imager utilizing forward and backward pointing (±20∞) linear arrays for data acquisition during a single orbital pass of the SPOT-5 satellite.

The Future Direction of the SPOT Programme

SPOT-5 International Conference

SPOT Image held a two-day Conference on 14th/15th June at the France Meteo Centre in Toulouse in south-west France. The Conference was sponsored by CNES and Astrium, the two main shareholders in SPOT Image, and it attracted an attendance of nearly two hundred persons from all parts of the world. The main purpose of the meeting was to introduce the forthcoming SPOT-5 satellite and its enhanced imagery to representatives of the company's subsidiaries, industrial partners, agents, re-sellers, etc. and to a number of its major clients. Currently the satellite is scheduled for launch at the end of the first quarter of 2002 - i.e. in ten months' time. Besides the detailed technical information that was given regarding the main characteristics of the satellite and its imaging sensors, there were a substantial number of presentations on the products and services that are expected to be provided from the improved imagery that will be generated from SPOT-5. The Conference also provided a platform for a cross-section of SPOT Image's existing customers to give an account of their experiences with the imagery that is currently available from the SPOT-1 to -4 satellites and of their expectations for the SPOT-5 imagery.

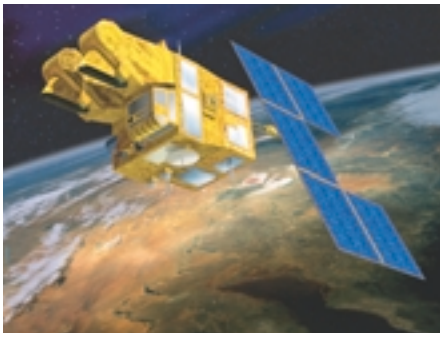
By Prof. Gordon Petrie

It seems appropriate next to try and summarize what the participants learned about SPOT-5 from all the various presentations given at the Conference. On the one hand, SPOT Image and CNES were keen to emphasize its high degree of continuity with the preceding series of SPOT-1 to -4 satellites. Thus the satellite orbit (i = 98°); the swath width of the main imaging sensors (60km); the spectral bands being used; and the ability to point to targets well off-nadir (up to ±27°), are essentially the same as those being used with the existing SPOT satellites. Also SPOT-5 will carry the same low-resolution (1 x 1km ground pixel), wide swath (2,200km) Vegetation imager with four spectral bands (blue, red, near IR, SWIR) that was first deployed on SPOT-4.

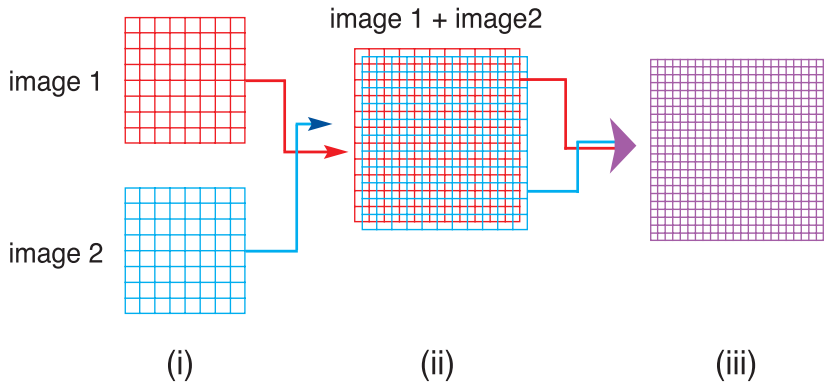
SPOT-5 Innovations

The major innovations and improved capabilities that will be introduced on SPOT-5 are the following:-

(1) The **main imaging sensors -** comprising a pair of HRG (High Resolution Geometry) pushbroom scanners operating side-by-side - will provide Pan images



Artist's impression of the SPOT-5 satellite orbiting the Earth.



This diagram shows the Supermode method of acquiring and processing the Pan image data that will be produced by the SPOT-5 satellite. The image data (with a 5m ground pixel size) will be acquired by the HRG pushbroom scanner. This imager is equipped with two parallel CCD linear arrays, each of which is offset with respect to the other by half-a-pixel. (i) The data acquisition phase produces two overlapping images (im1 & im2) simultaneously, each having a 5m ground pixel size. (ii) The subsequent data processing stage involves the superimposition, interlacing and interpolation of the two overlapping images. (iii) The final single Supermode image will be produced having a 2.5m ground pixel size.

with a 5m ground pixel in normal mode and 2.5 to 3m in the enhanced Supermode. As noted above, each HRG scanner will maintain the 60km swath width of the previous SPOT satellites, notwithstanding the improved ground resolution.

(2) The **multi-spectral (M/S) capabilities** will also be improved. The M/S images from SPOT-5 will have a 10m ground pixel size instead of the 20m ground pixel of the M/S images produced by the previous satellites in the SPOT series.

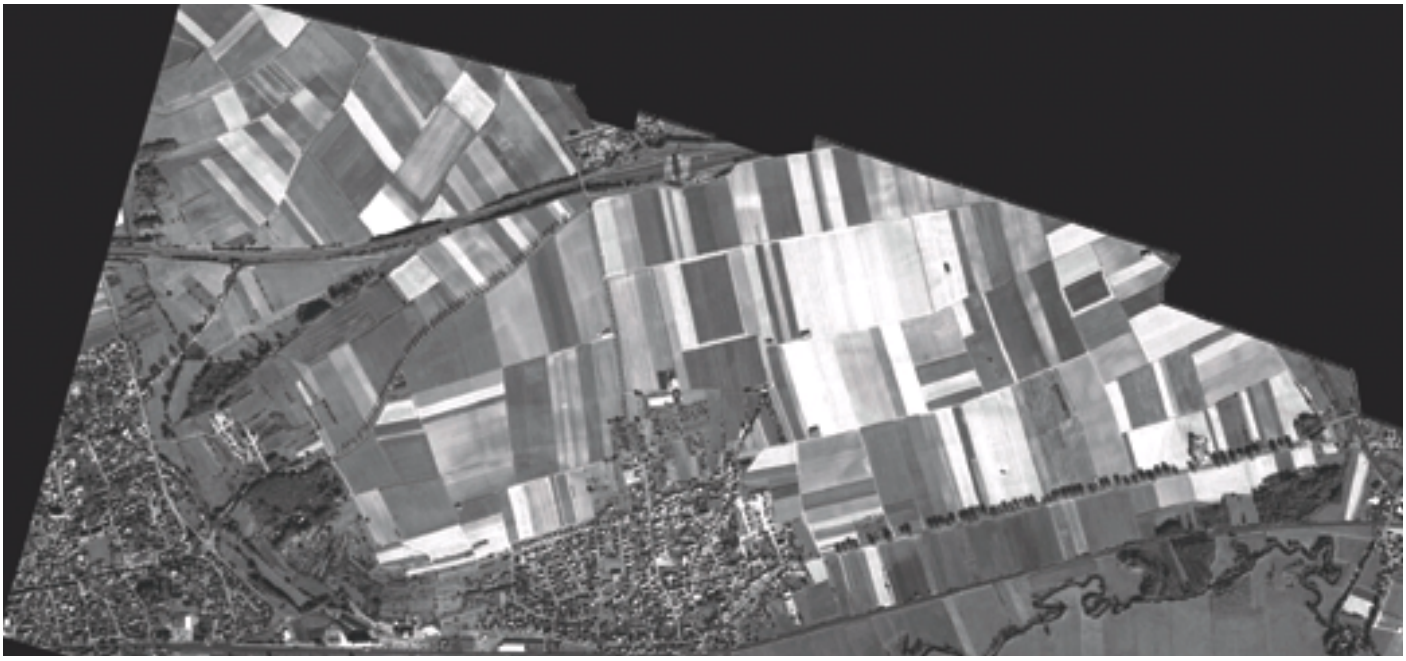
(3) The SPOT-5 satellite will have a star sensor added to form part of a substantially improved **location and attitude instrumentation package** (DORIS). This will provide a raw location accuracy of 50m, a ten-fold improvement on the nominal 500m positional accuracy of the previous SPOT satellites.

(4) A major innovation for SPOT-5 will be the inclusion of the HRS (High Resolution Stereo) imager that will provide **stereo-coverage** of the terrain. This data will be acquired in an along-track mode - similar, though not identical, to that being used on the MOMS, IKONOS and ASTER satellites. The HRS imager will use forward and backward pointing (±20°) linear CCD arrays, each having 12,000 pixels. This will provide Pan imagery with a rectangular pixel measuring 5m in the along-track direction and 10m in the cross-track direction. This will result in the cross-track coverage having a 120km (10m x 12,000 pixels) swath. Along-track, the data will be collected in 600km segments, rather than in the continuous strips imaged by MOMS, IKONOS and ASTER. Obviously the HRS imager is designed specifically to provide overlapping stereo-coverage with a view to DEM production.

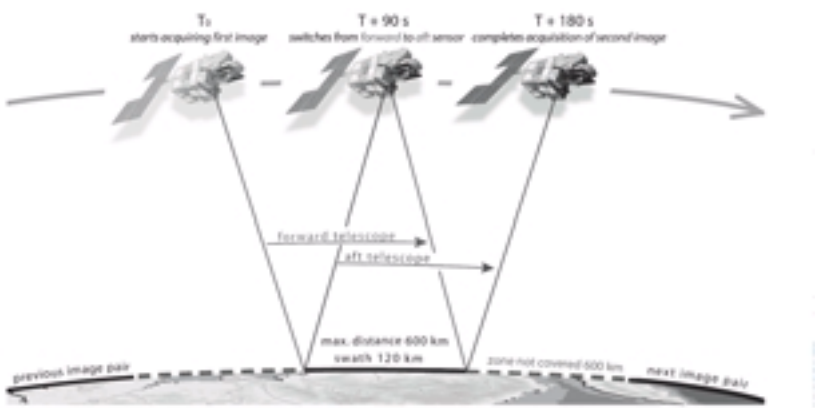
(5) SPOT-5 will be equipped with a 90 Gigabyte **solid-state memory** that will allow it to store up to 550 images on-board the satellite.

SPOT-5 Market Positioning

As set out at this Conference, the SPOT-5 marketeers would like to consider SPOT-5 as occupying a unique position in the future market-place for space imagery. This revolves round their perception of it combining a reasonably high ground resolution (2.5/5m ground pixel) with a fairly wide (60km) area coverage. This places it conveniently between **(i)** the commercial high-resolution satellites like IKONOS and the forthcoming QuickBird and OrbView-3 and -4 satellites producing imagery with a 1m ground pixel size or better, but with a narrow ground coverage; and **(ii)** the medium-resolution Landsat-7 ETM+ imager with its 15m ground pixel and its 185km swath width. However this simple comparison ignores the Indian satellites. These comprise the existing IRS-1C & -1D satellites



A simulated Supermode Pan image of the La Zorn area near Strasbourg in Eastern France.



The diagram shows how the stereo-coverage of a 600km segment of the terrain surface (having a swath width of 120km) will be acquired by the HRS along-track stereo-imager over a time period of 180 seconds.

producing images with a 6m ground pixel and a 70km swath width and the forthcoming Cartosat (also to be launched in 2002) with its 2.5m ground pixel images and a somewhat narrower swath width. The Japanese ALOS (also scheduled for launch in 2002) with its 2.5m ground pixel Pan imagery will also enter the same market. But still, even if it is not quite as unique as is being made out, obviously SPOT-5 will indeed offer products based on the HRG imagery that are very attractive to many users concerned with smaller-scale, wide-area mapping and GIS. Furthermore SPOT Image's commercial network is much better developed than those of these potential rivals.

SPOT-5 DEMs & Orthoimages

Which brings up next the matter of the HRS stereo-imager. Eventually it transpired from the answers given to questions asked by participants during the Conference that SPOT Image plans to deliver only **value-added products** from this imager - i.e. DEMs and orthoimages - to customers, in much the same manner as Space Imaging does with IKONOS stereo-pairs. This news was received poorly by many of the re-sellers and customers attending the Conference. What the SPOT-5 marketeers seem not to realize is that this removes from both its re-sellers and its customers the possibility of them generating the DEMs and orthoimages that they are very well equipped to provide. Indeed they have already been carrying out these operations using the overlapping cross-track imagery from the SPOT-1 to -4 satellites. However, under this new marketing plan, SPOT Image will now be competing with its own re-sellers and removing a profitable revenue stream from their operations. Furthermore many end-users simply want to acquire overlapping stereo-imagery that will allow them to carry out 3D stereoscopic interpretation of the imagery for their own particular activities and applications, based on their own specialized local knowledge and experience that cannot be duplicated or supplied by SPOT Image. Apparently - at least on the basis of what was said at the Conference - this possibility will be denied them! Which - in my own personal opinion - does not seem to be good thinking!

Pleiades

During their Conference presentations, both **Gerard Brachet** and **Gilbert Pauc** gave some details of the next generation of French civilian Earth Observation satellites. From this, it does seem that SPOT-5 will be the last in the series. Over the last three or four years, in a series of presentations given principally by **Alain Baudoin** of CNES, we have heard that SPOT will be replaced by the so-called 3S (Small SPOT Satellites). This would comprise a number of smaller, lighter and more agile satellites built at a lower cost, instead of the large, heavy (and very expensive) individual satellites that have characterised the SPOT series. However this concept has now been modified in the light of a new collaborative programme with Italy, called Pleiades. Under this programme, France will construct, launch and operate a series of **optical satellites** (HR-1, -2, etc.), while the Italian partners will produce and operate a complementary series of **radar satellites** (Ra-1, -2, -3, etc.). The formal inter-governmental agreement for this collaborative programme to be undertaken was signed in Turin on January 21st 2001. From press reports, it appears that the satellites will be for dual (military and civilian) use. The main contractors will be Alcatel Space (France) and Alenia Aerospazio (Italy).

- French (Optical) Component
Under the Pleiades programme, the French satellites will deliver high-resolution (0.8m ground pixel) Pan images having a swath width of 20km with both lateral (off-nadir) pointing and along-track stereo-imaging capabilities. All of which sounds like a very similar specification to that of the American IKONOS, QuickBird and OrbView commercial high-resolution satellites. A very brief mention was also made of a wider field imaging capability producing images having a larger (2.5m) ground pixel over a wider (40km) swath. The French Pleiades satellites will also feature a "superspectral" system with a larger number (probably 10) of spectral bands than the present SPOT or Landsat-7 satellites. These will produce M/S images with a 10m ground pixel over a 32km swath width using nadir viewing.

- Italian (Radar) Component
The Italian satellites will be equipped with an X-Band radar capability providing both narrow- and wide-band imaging modes. The highest resolution images will feature a 1m ground pixel size. A very brief mention was made of an **Interferometric Cart Wheel** (ICW). If I understood the concept correctly, this would comprise three passive radar satellites flying in formation and picking up the return signals from a SAR device mounted in an active (lead) satellite. Obviously, if my understanding of the technique is correct (N.B. it is based on the very brief remarks made in the oral presentations by Pauc and Brachet), then this novel concept would appear to be oriented towards the generation of DEMs using interferometric SAR techniques. It will be very interesting to hear and learn more about this particular development.

Conclusion

This was a short, intensive, but very interesting and highly informative Conference that really did provide a valuable insight into the thinking behind and the prospects for the new SPOT-5 satellite. Let us hope and pray that the present problems with the Ariane-5 launcher with respect to the Artemis and B-SAT communication satellites do not manifest themselves with SPOT-5 in April 2002. A further introductory two-day Conference on SPOT-5 with an emphasis on its potential applications will be held by CNES and SPOT Image in Toulouse on 27th & 28th November 2001.

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