

**The HRS-SAP initiative:
A scientific assessment of the High Resolution Stereoscopic instrument on board of SPOT 5
by ISPRS investigators.**

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ABSTRACT:

SPOT 5 has been commissioned after performed its launch in May 2002 and the geometric calibrations and assessments show the good quality of the images. Few months after this launch CNES proposed to ISPRS a joint initiative for assessing the new HRS (High Resolution Stereoscopic) instrument and especially the quality and accuracy of DEM which could be derived from HRS stereo pairs. This proposal was agreed and the announcement of the program (HRS-SAP) and its organisation (HRS Study Team) was made during the ISPRS Commission I Symposium in Denver (November 2002).

The HRS-SAP is organised within a HRS Study Team with a Secretariat, Principal Investigators and Co-Investigators. Nine test areas have been selected with associated PI's. In addition 15 more Co-Investigators have been accepted and they have now received HRS images and Reference Data. Final results should be achieved by end 2003 and a synthesis made by May 2004, to be presented during the ISPRS Congress in Istanbul in July 2004.

Introduction

The HRS Scientific Assessment Program is a new initiative for CNES and its partners in the SPOT program. It is the first time that an international user community (ISPRS) is formally associated to the scientific assessment of the "system" quality of a satellite, in this case SPOT 5 and especially its new instrument HRS (High Resolution Stereoscopic)

The results of this program, to be presented during the next ISPRS Congress in Istanbul, July 2004, should help CNES to improve its future Earth Observation systems and all users to better know and trust the accuracy and quality of the HRS instrument and of the derived DEM.

SPOT 5

SPOT 5 is the latest satellite of the SPOT family, launched during the night of the 3rd to the 4th of May 2002 from the European Spaceport in Kourou (French Guyana) with one of the last Ariane 4 to be used. (Flight V151 with AR42P) This satellite ensures data continuity with the

previous satellites but provides also enhanced images (at 2.5 m resolution with its two HRG instruments) and new stereoscopic capabilities with the HRS instrument. A fourth imaging sensor, Vegetation 2 (recurrent model of Vegetation 1 on SPOT 4) gives a wide-swath (2500 km) daily coverage. A star tracker is used to get better attitude measurements and therefore better image location.

HRS characteristics

The High Resolution Stereoscopic instrument (HRS) has already been described in many papers (Baudoin, 1999; Fratter, 2001; Bernard, 2001) With two telescopes HRS acquires nearly simultaneous stereopairs (at 90-second interval) of 120-km swath, along the track of the satellite, with a B/H ratio of about 0.8. A continuous strip of 600 km length can be covered stereoscopically with 10 m ground resolution across track and with 5m ground sampling distance along track (parallax lines).

HRS partners

One particularity of this instrument is its programmatic framework. In January 1999 CNES, Spot Image and Matra Marconi Space (MMS which is now Astrium) signed an Agreement about the development of this instrument in which Spot Image is funding 54% of the cost of the instrument. This private investment on an instrument was quite new in the Spot program, previously paid by French, Swedish and Belgian public funds only (excepted the SPOT 5 ground segment paid by Spot Image). In April 2002 another Agreement was signed between CNES, the French Ministry of Defense and Spot Image about the use and exploitation of the HRS instrument, split between French Defense and civilian / commercial market. Spot Image and IGN (Institut Géographique National, the French Mapping Agency) have also defined together a new 3D Database, named Reference3D, mainly extracted from HRS data. (Airault, 2003)

These agreements are reflecting the fact that the main HRS objective is to produce DEM on (very) large areas to satisfy dual (military and civilian) use. Therefore no original image data will be offered on the market.

HRS assessment

After a two-month in-flight commissioning phase, the use of the satellite was given in the hands of its commercial operator, Spot Image, on the 12th of July 2003.

All on-board equipments have been checked and declared operational. About twenty well-equipped test areas all over the world have been used for either radiometric or geometric calibration. (Breton, 2002)

For the HRS payload the two telescopes, HRS1 and HRS2, were calibrated with a remaining error of less than 0.05 pixel (Bouillon 2003). HRS absolute location accuracy, decreased from an initial 63 m value right after the commissioning phase (July 2002), down to about 33 m (Bouillon, 2003). This result is even increased (16-m @ 90%) using spatiotriangulation (bundle block adjustment on a large area) (Airault, 2003)

First assessments of DEM accuracy derived from HRS give good results, even better than expected: In flat or low-relief landscape the altimetric accuracy is better than 5m RMS, with more than

95% good correlation. (Rudowski, 2003; Nonin, 2003; Valorge, 2003).

It can be noticed that this HRS assessment has been performed on very large areas (about 600 km by 200 km over the Alps) and with high quality reference data (DEM derived from aerial photogrammetry on Manosque area, one of the HRS-SAP test site)

Background of the HRS-SAP

As mentioned in the introduction the HRS-SAP is a new initiative. Its originality is due to new status and capabilities of the HRS instrument.

Previously, for SPOT 1 to SPOT 4, and this is also true for the main payload of SPOT 5 (the two HRG instruments) all images (at several geometrical processing levels) are available to any user, through the Spot Image distribution network.

This is not usually the case for the HRS instrument which images are archived and processed to produce and market Digital Elevation Models, as said previously.

Nevertheless, many scientific users asked to get HRS images not only for deriving HRS DEMs, but also for other photogrammetric purposes or for thematic evaluations.

It has been recognised that, beyond the operational use of HRS, for which stereopairs are intermediate products, some selected scientific and/or assessment projects could be given the permission to use original HRS images. The Earth Science and Applications unit at CNES then proposed to set up an international team in association with ISPRS especially for the photogrammetric assessment of the HRS instrument. For other scientific projects, other solutions, on a case by case basis, are also possible.

CNES reached an agreement with ISPRS for promoting and organizing such assessment in July 2002, agreeing that the announcement of this common initiative should be done during the Commission I Symposium, in Denver in November 2002.

Manfred Schroeder, as Chairman of WG I-2 of ISPRS (Sensor calibration and testing), agreed to represent ISPRS and co-chair this "HRS Study Team". The initiative was announced during the

Denver Symposium and also published on the ISPRS website and E-mailed to about 200 potential participants.

The HRS Study Team

The HRS Study Team is organized as follows:

A Secretariat, composed by the authors of this paper, is in charge of the management of the Program. It is co-chaired by Alain Baudoin for CNES and Manfred Schroeder for ISPRS. The other members are representing CNES (Christophe Valorge) in charge of image quality, Spot Image (Marc Bernard) in charge of HRS production and delivery and IGN (Véronique Rudowski) in charge of Reference Data assessment and of result synthesis.

The Principal Investigators (PI's) are responsible for providing reference data on selected test areas. This Reference Data should be more accurate than the expected HRS accuracy (5m) and include a precise DEM (derived from photogrammetry or laser with 1-2 m Z accuracy) and/or Ground Control Points (with X-Y-Z accuracy better than 1m).

Co-Investigators (as well as PI's) should use HRS stereo pairs and Reference Data to produce DEM (with one or several methods) and to evaluate them in terms of quality and accuracy, and when possible to compare (or combine) them with other sources (ex HRG, SRTM, laser...).

The PI selection

After the publication of the HRS-SAP initiative 34 proposals were received from all parts of the world. A Selection Team was organized on March 19, 2003 in Toulouse, with the HRS Secretariat and the ISPRS Secretary General.

Each proposal was quoted according to several criteria. Due to the very short schedule only areas where HRS data was already available were accepted. Then the expected quality of the proposed Reference Data and also the experience and scientific references of the candidates were also quoted.

From the 34 proposals 11 have been selected. The candidates were informed of this selection. When preselected they have been asked to formally agree the HRS SAP rules and to send the proposed Reference Data for checking.

Among those pre-selected PI's most of them have agreed and signed the PI Agreement, and sent their Reference data to the Secretariat. Unfortunately an interesting site in India could not be confirmed, as the Reference DEM has been found not enough accurate. Another site in the Alps was also cancelled due to the fact that the pre-selected PI, (due to too large snow coverage) did not accept the proposed HRS images.

Then nine sites were confirmed : three in France: Manosque, Aix-en-Provence and Montmirail; three in Europe, outside France: Chiemsee (Bavaria - Germany), Liege (Belgium), Barcelona (Catalonia- Spain); and three in other parts of the World: Merowe (Sudan -Africa), Melbourne (Australia) and Rasht (Iran). Unfortunately, no sites could be selected in America. The selected sites are well diversified in terms of climate, relief or landscape and it is hoped that future results could be representative of most situations in the world.

Co-I selection

Few days after the pre-selection of the PI's in March 2003 a call for participation as Co-I was published by ISPRS. Then 19 new proposals have been received by the end of May 2003.

The selection was made using email exchanges between the Selection Team, asking when necessary more information to the candidates. For this selection the main criterion was the scientific and technical professional capacity (in DEM production) of the proposed team.

After this selection, made on June 14, 2003, 15 Co-Investigators have been agreed and all of them signed the requested Co-I Agreement. As some of them were already PI's and some have been selected on two test sites the total number of experiments is 28.

For each test site the number of investigators is between two and seven:

- 2 for Merowe (Sudan), Liege (Belgium), Melbourne (Australia), Aix-en-Provence;
- 3 for Manosque (France), Montmirail (France) and Rasht (Iran);
- 4 for Barcelona (Spain);
- 7 for Chiemsee (Germany)

Data delivery

In order to avoid unnecessary data duplication all HRS images and Reference Data were produced and sent to the PI's and Co-I's at the same time, by mid July, by Spot Image. It can be noted that on the Barcelona test site two HRS stereo pairs have been provided, and also two HRG images, at 2.5m resolution, giving the opportunity to test tri-stereo.

By end of August most of the HRS Study Team members should have already worked on the images and already some of them have given first results or asked questions. (ex: Reinartz, 2003)

Next steps

In October 2003, during this Hanover Workshop, up to date information on the preliminary results of the experiments will be given.

By the end of the year 2003 all PI's and Co-I's should have produced at least one DEM derived from HRS data and a report describing his results. The DEM and the report will be sent to the HRS Secretariat.

A synthesis of all results will be produced by IGN by May 2004, to be ready, as well as each experiment, for a presentation during a dedicated workshop on 13 July 2004, organized within the ISPRS Congress in Istanbul,

Conclusion

The HRS SAP program has now achieved its first step, the acquisition and delivery of the HRS and Reference data to the PI's and Co-Is. 28 assessments are currently done on 9 sites by 22 investigators. Only very preliminary results could be presented to this Hanover Workshop. But the first exchanges between the investigators and the HRS Secretariat show the interest for such initiative, giving the opportunities for all members of the HRS Study Team to get more information (sometimes not expected) on image quality assessment, DEM generation etc. Comparison of different approaches and methods should be very useful not only for the participants to this HRS-SAP program but also to all DEM producers and users.

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