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THE FRENCH REMOTE SENSING PROGRAM : NOWADAYS AND FOR THE FUTURE

LE PROGRAMME FRANCAIS EN TELEDETECTION AUJOURD'HUI ET DEMAIN

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ABSTRACT

France has been engaged for more than ten years in an exemplary spatial effort.

Among the main channels, remote sensing of land resources holds a privilegiate place since 23 % of the budget of the Centre National d'Etudes Spatiales are reserved for it, and only the launching projects require more.

This effort aims at meeting the more and more urgent needs of the international community both in land and marine space management and, on a longer term, in the survey of our environment.

Beyond the SPOT channel which was inaugurated 4 years ago an now is at the first range of the world-wide civil observation systems, technologies are appearing that are necessary to integrate complementary technics into optical observation, such as microwave.

This introduction will try to show the actual appraisal of the SPOT program its technical evolution on a middle and long term, on one hand, and the participation of France in all of the important projects aimed at reaching a better operational mastery of the remote sensing tool, on the other hand.

RESUME

La France est engagée depuis plus d'une décennie dans un effort spatial exemplaire.

Parmi les grandes filières retenues, la Télédétection des ressources terrestres occupe une place très privilégiée avec 23% du budget du Centre National d'Etudes Spatiales, seulement dépassée en importance par les programmes de lanceurs.

Cet effort vise à satisfaire des besoins de plus en plus pressants de la communauté internationale tant sur le plan de la gestion des espaces terrestres ou maritimes que celui à plus long terme du suivi de notre environnement.

Au delà de la filière SPOT inaugurée voici plus de 4 ans et aujourd'hui en première place des systèmes d'observation civils mondiaux, se profilent déjà les technologies nécessaires à l'intégration de techniques complémentaires à l'observation optique telle que micro-ondes.

La présentation s'efforcera de montrer, d'une part, le bilan actuel du programme SPOT, son évolution technique à moyen et long terme et, d'autre part, la participation de la France dans l'ensemble des grand programmes visant à une meilleure maîtrise opérationnelle de l'outil Télédétection.

INTRODUCTION

The SPOT satellite Earth observation program has been developed by France with the participation of Sweden and Belgium. The main contractor for the program is the Centre National d'Etudes Spatiales.

The first satellite, SPOT 1, was launched in february 1986 followed by SPOT 2 in January 1990 in view to ensure the continuity of service beyond the year 2000 with the help of SPOT 3 and SPOT 4.

SPOT is a permanent data source for geographic information and offers unique features in the field of spaceborne remote sensing : ground resolution of 10 and 20 meters, extremely flexible acquisition possibilities for any point on the Earth's surface, the possibility of stereoscopic viewing and excellent geometric accuracy. These qualities make it ideal for mapping, renewable and nonrenewable natural resource inventories, civil engineering and urban planning studies, and in general for all disciplines requiring accurate, up to date geographic information about the Earth' surface.

The data gathered by the different receiving stations throughout the world are marketed and distributed to users by the SPOT IMAGE company, either directly, or through its commercial network spanning more than 50 countries.

SPOT 1 TO 3 MAJOR CHARACTERISTICS

The SPOT satellite from 1 to 3, (cf. figures 1, 2 and 3) is designed for a Sun synchronous orbit at 832 km. It is composed of a multipurpose platform and two identical HRV instruments (HRV stands for High Resolution Visible).

Each HRV instrument can be operated in two modes, either 20 or 10m sampling step, or both. This later capability is required in most agricultural projects.

In the 20m mode, three spectral bands have been selected which match precisely the significant features of the vegetation spectral signatures (0.55, 0.64, 0.85 microns center wavelenght). Moreover, they give access to water quality assessment and bare soil mapping....

In the 10m mode, which provides 4 times more pixels than the 20m mode, only one, wider band has been implemented, adapted to the needs of the cartography of vegetated area as well as urban or natural areas.

Pointing of each instrument

The optical axis of each HRV can be steered to any of 91 positions sidewise, from -27° to 27°. This corresponds on the ground to a band of access of 950 km centered on the satellite ground track, independently for each instrument. Sterring of the mirror is executed upon commands stored in the on board computer.

The two HRV can be operated jointly, covering a swath of 117 km at nadir or a little more when off nadir. This mode includes a 5 % overlap between the two fields of view (3 km). The consequences of cross track pointability are :

- high accessibility to a given point (2.5 days average at 45° latitude).
- Stereoscopic capability,
- Off nadir reflectance measurements.

Let also mention DORIS instrument embarqued on board SPOT 2 and 3 performing very precise location measurements to better than, the decimeter accuracy.

The Centre National d'Etudes Spatiales (CNES) announced on July 21, 1989, that the French government had approved funding for SPOT 4. Final development and construction has begun immediately and the spacecraft is expected to be ready for an Ariane 4 launch as early as 1995, which is estimated quite adequate with respect to for SPOT 3 expected lifetime.

The SPOT 4 design, (cf. figure 4) differs from the earlier SPOT series (SPOT- 1/2/3) in the following aspects : five years lifetime design as opposed to three years ; a new extended platform design ; new on board magnetic tape recorders enabling the 10 and 20 meters resolution data to be co-registered on board the satellite instead of on ground ; and the addition of a middle infrared band to the standard SPOT sensore for improved vegetation analysis capability.

An additionnal payload called VEGETATION with a ground swath of 2 200km, a resolution close to 1km and the same spectral than the improved HRV is under consideration in view of enabling large scale environmental monitoring of the earth (cf. figure 5).

In addition to the established SPOT program cooperation with Belgium and Sweden, the European Space Agency (ESA) and CNES will launch a joint experiment on SPOT 4 called "PASTEL". PASTEL is a prototype high data rate intersatellite transmission system using lasers (cf. figure 5).

THE GROUND SEGMENT

Acquired data are retransmitted to the ground either directly to X band receiving station spreaded all over the world or recorded on board for playback toward Toulouse and KirunaA main receiving centers.

SPOT 2 is now fully activated as prime satellite while SPOT 1 is kept as backup system able to restarted at any time (on board recorder excepted).

Direct receiving station are becoming numerous as illustrated by table 1.

The French Governement's recent decision to go ahead with SPOT 4 confirms the importance for the governement of continuing with the Earth observation program, a program in which continuity of service is a decisive factor for the user community.

The ground segment is keeping pace, with the forthcoming arrival of the new digital quick-look which, from end 1990, will give users the opportunity of consulting an illustrated world catalogue! Not to mention the development of a new Mission Center which, from 1992 will allow to respond better and faster to programming requests and imaging time slot reservations.

FUTURE SPOT PROGRAM (AFTER SPOT 4)

In order to improve the quality of data and services given to the SPOT users CNES is studying new instruments and system, to be ready about the year 2 000.

The two main objectives are (cf. figure 6) :

First to improve the optical sensors (HRVIR) with a new capability of getting very high resolution images (5m or even better) and along track stereoscopic data (cf. figure 7), which are required for many applications, especially for cartography (to produce 1/25 000 scale topographic maps and digital elevation models) or for agriculture (to get more accurate classification in small fields areas).

Secondly to avoid the cloud cover which reduces the number of opportunities to get good quality images when they are needed. This could be possible with a SAR, with a high resolution. Existing applications of SPOT could be improved in tropical areas thanks to a SAT (for topographical and geological mapping), and new applications, combining optical and microwave images, could be envisaged everywhere ; water resource management timber assessment...

Status

These two programs (Optical and SAR) are in preliminary phases and for these phases CNES works in cooperation with BNSC.

The objectives of these preliminary phases are to define possible missions of these systems, and to assess the technical issues (cf. figure 8).

For the Optical System a first launch should be possible. If necessary, in 1998 and phase A activities should begin next year (mid 1992).

For the SAR System a first launch is foreseen in 2002 and phase A activities should begin in 1983.

Description

Optical system (SPOT-NG).

Same platform as for SPOT 4, with HRVIR plus specific instruments for Very High Resolution (5m and may be 2,5m) and Along Track Stereo (20° fore and 20° aft), or new sensors combining HRVIR functions and the new ones. Different options are under study (with different number and range of spectral bands), (cf. figure 9).

The payload would be completed with a large field sensor : VMI (Vegetation Monitoring Instrument).

On board recorders and/or direct receiving stations could be used.

Same orbit as for SPOT 1 to 4, to ensure the continuity of the data.

SAR System (SPOT-Radar)

Same platform as for SPOT 4, with a SAR using an active antenna, with one or two frequencies (X or X&L to be confirmed), several polarisations and a possible choice between. Other instruments could be added to the SAR (TBD).

Orbit : Sun-synchronous at about 750km, with a repeat cycle of 7 days. The equator local time could be 10h30.

GROUND SEGMENT

The existing, or future ground segment for SPOT 2-3-4, should be used and adapted to the new missions. Every Direct Receiving Station of the SPOT Network should be able to receive the same type of data for the previous SPOT. The new type of data should be received either only in some Main Receiving Stations, or in all upgraded direct receiving stations (the two options are compared with respect to their economical interest).

A commercial entity, SPOT IMAGE (possibly with new shareholders from outside France), will remain the interface with the user community.

New products and services could be provided to the users.

The development of these facilities is not yet studied in details, and will be analysed in the future, taking in account the experience from SPOT 1 and 2, in order to better serve the user, in accordance with governmental and international constraints.

Station location	Country	Commissioning date	Organizator
Prince Albert	Canada	June 16, 1988	CCRS
Gatineau	Canada		
Hyderabad	India	May 5, 1987	NSRA
Maspalomas	Spain Canary Islands	November 4th, 1987	ESA
Cuiaba	Brazil	April 1st, 1988	INPE
Lad Krabang	Thailand	May 1st, 1988	NRCT
Hatoyama	Japan	October 1st 1988	NASDA
Islamabad	Pakistan	June 1st 1989	SUPARCO
Hartebeeshoek	South Africa	August 1st 1989	CSIR
Riyadh	Saoudi Arabia	October 1st, 1989	KACST
Cotopaxi	Equador	1991	CLIRSEN
Alice Springs	Australia	1990	NATMAT
Beijing	Chine	----	SSTC

Table 1 : list of SPOT direct receiving stations.

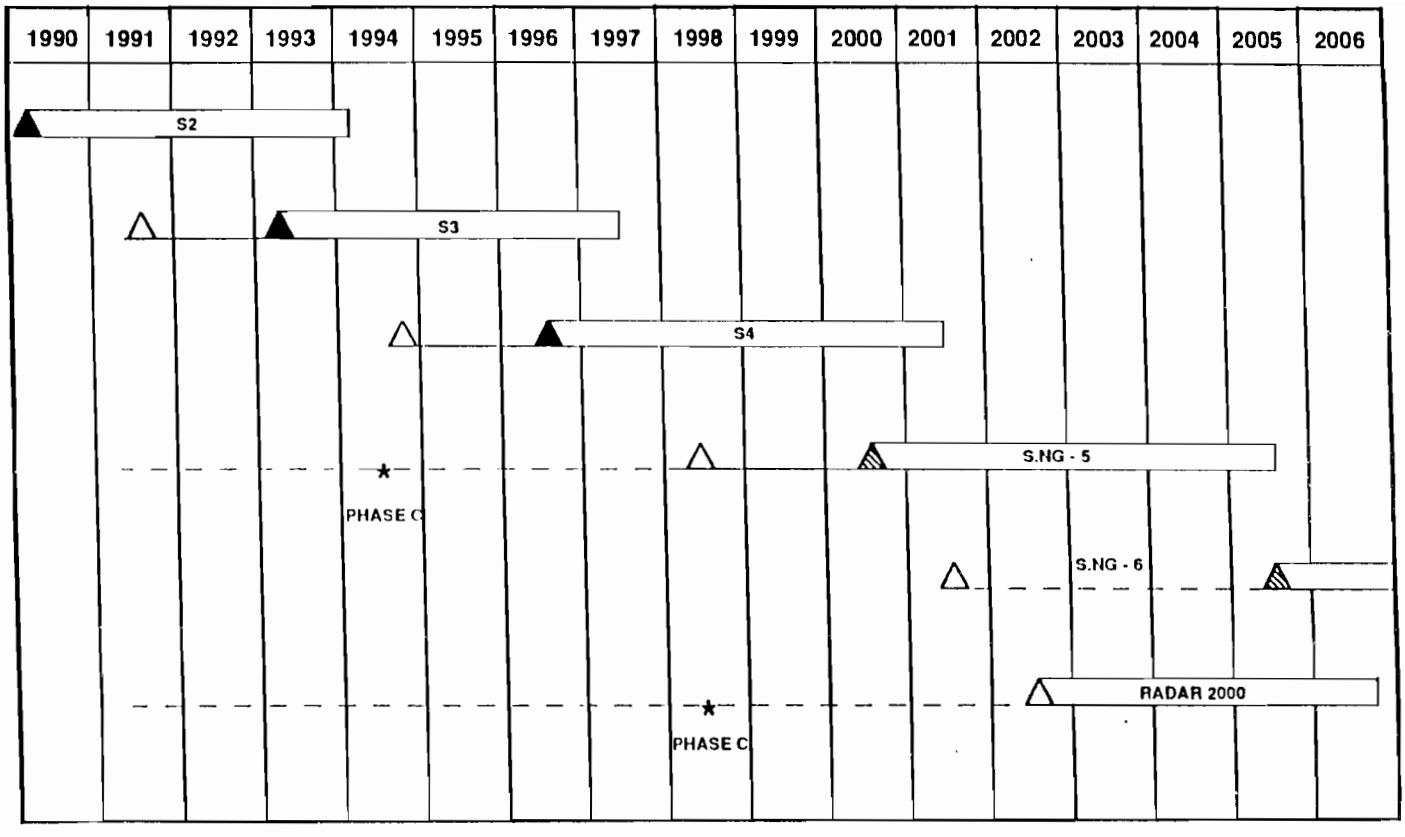


Figure 1 : SPOT family.

SPACECRAFT	SPOT 1	SPOT 2	SPOT 3	SPOT 4
DESIGN		Identical to SPOT 1	Identical to SPOT 2	Advanced platform Improved payload Extended lifetime
AVAILABILITY	End of 1985	Mid 1988	Mid 1991	1994
NOMINAL LAUNCH DATE *	Feb. 1986	Jan. 1990	Beg. 1993	Beg. 1996

* Assuming proper launch and operation of the earlier spacecraft

Figure 2 : SPOT programme planning.

	SPOT 1 / 2 / 3	SPOT 4
HRV	3 Spectral bands 20 m registered	1 supplementary band 20 m : 1,5 - 1,7 µm
PAYLOAD	1 panchromatic band 10 m	10 m and 20 m bands registered
	Recording capacity : 22 mn	Recording capacity : 40 mn
		Data transmission in "mode SPOT 1" and "mode SPOT 4"
DORIS	Precise location system (from SPOT 2)	Precise location system
LIFETIME	3 years	5 years

Figure 3 : SPOT 1, 2, 3 and 4 missions characteristics.

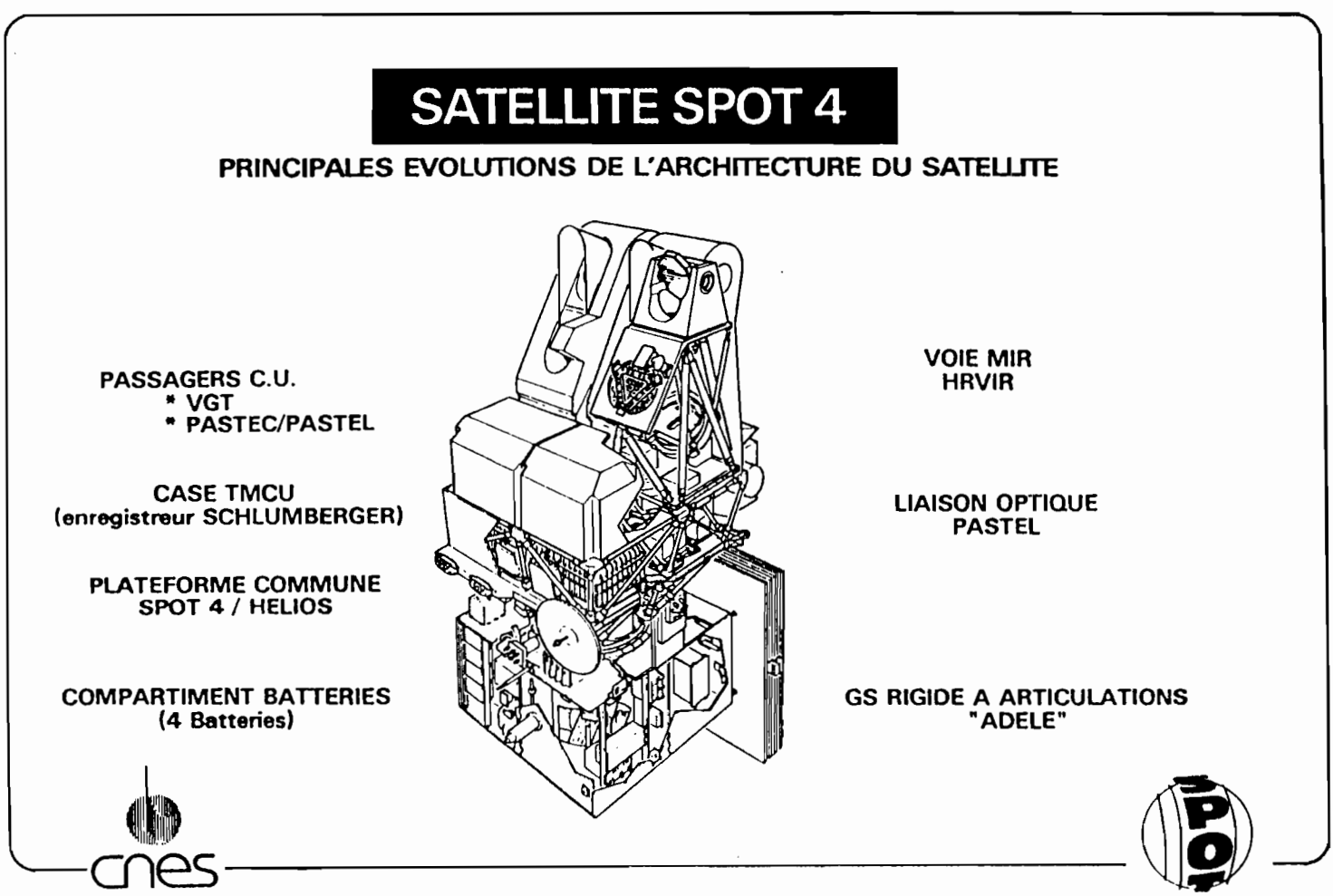


Figure 4 : SPOT 4 ; main satellite architecture evolution.

VEGETATION MONITORING INSTRUMENT = V.M.I.

MONITORING OF LAND AND OCEAN ON DAILY BASIS

- Spectral bands identical to HRV + blue band (0,4 - 0,52 μm)
- Ground resolution ≈ 1 km (Nadir)
- Swath width ≈ 2 200 km

PASTEL EXPERIMENT

LASER INTERORBIT IMAGE TRANSMISSION EXPERIMENT

- Link at 60 Mb/s of HRV images via ESA SAT 2
- ESA provided on board terminal

Figure 5 : SPOT 4 ; optional payload.

MARKET STUDIES EMPHASIZE THE INTEREST OF THE FOLLOWING IMPROVEMENTS :

HIGHER RESOLUTION
IMPROVED STEREOSCOPIC COVERAGE
BETTER REVISIT CAPABILITY
TO FREE OF CLOUD COVERAGE

↓

2 TECHNOLOGIGAL WAYS OF DEVELOPMENT

VERY HIGH OPTICAL SPATIAL RESOLUTION (HRG)
SPOT NG
DEVELOPED IN CONTINUITY
WITH THE OPTICAL SPOT SERIES

SAR
SPOT RADAR
DEVELOPED AT ITS OWN PACE
WITHOUT CONSTRAINTS ON RENEWAL STRATEGY

Figure 6 : SPOT programme follow on.

	RESOLUTION	STEREO (B/H)	SWATH WIDTH	SPECTRAL BANDS
CARTOGRAPHY	2 - 5 m	F + A 1 (F + V 0,5)	40 - 60 km	P
URBAN PLANNING	5 m	TBD	30 - 40 km	P (NIR)
GEOLOGY	5 m	F + A 1	30 - 40 km	P + NIR
SURVEILLANCE	5 m	F + V 0,75	> 30 km	P + NIR
PUBLIC WORKS	5 m	F + A 1 (F + V 0,5)	> 10 km	P + NIR

F : fore
V : vertical
A : aft

P : panchro
NIR : near infared

Figure 7 : HRG ; Requested specicifations from users.

2 INSTRUMENTS

GROUND RESOLUTION ≈ 5 m

SWATH WIDTH ≈ 40 to 60 km

INSTRUMENT VIEWING : Fore/Aft
or Nadir/Aft
or Fore/Nadir

B/H ≥ 0,5

SPECTRAL BANDS : 1 to 3 in VIS and NIR range

POINTING CAPACITY : 4 to 5°
More if accessibility needed

Figure 8 : SPOT programme follow on, HRG preliminary characteristics.

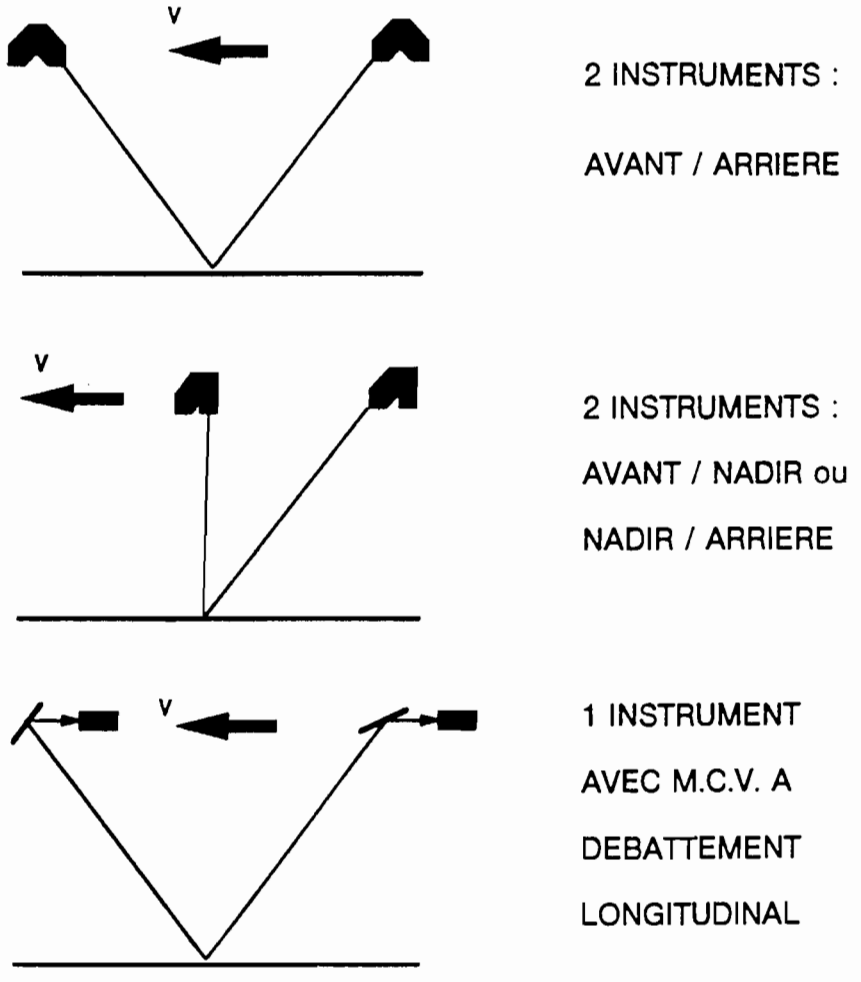


Figure 9 : High geometric resolution (HRG), possible configurations.

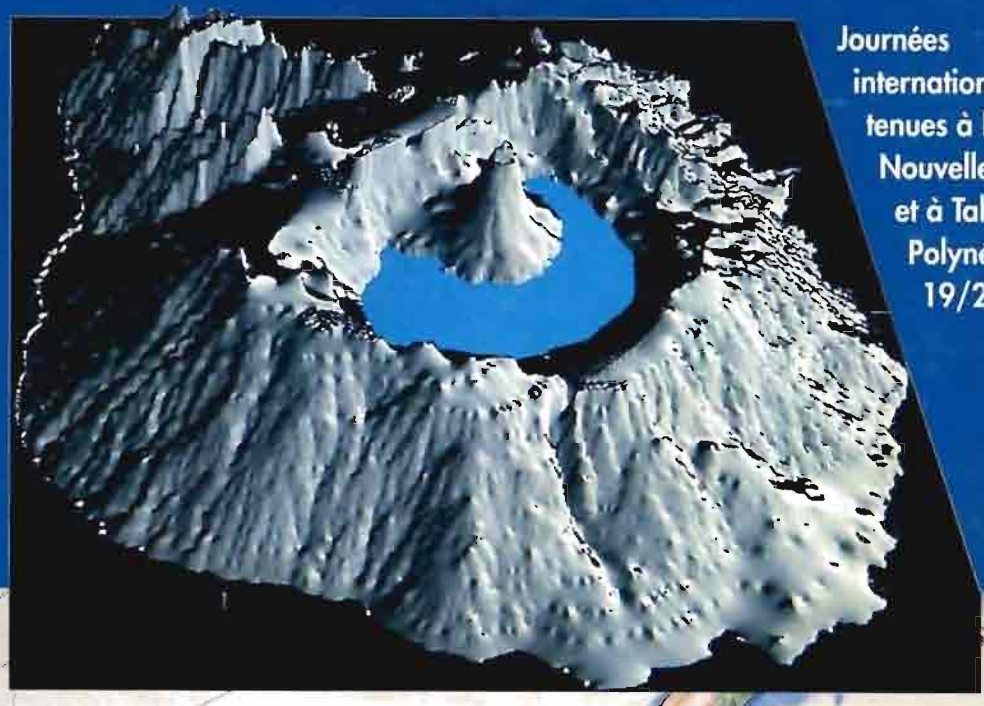
"PIX'ILES 90"

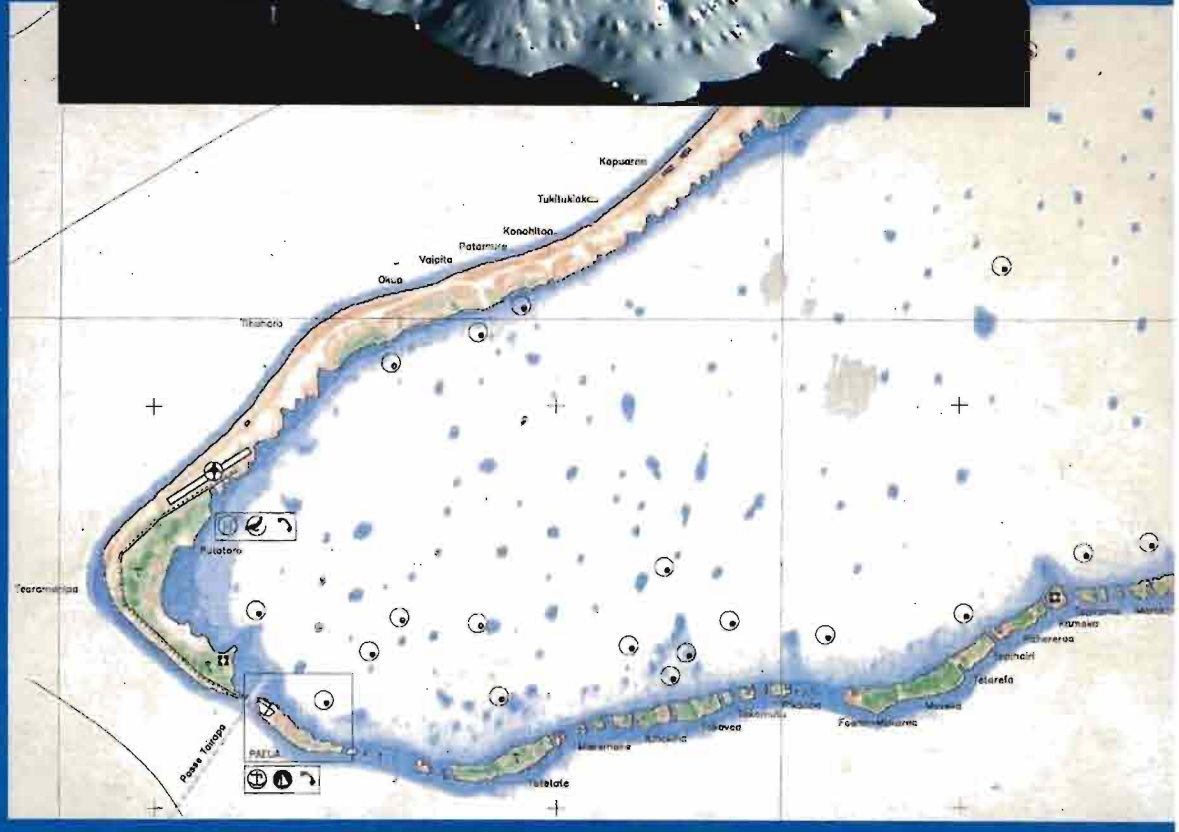
TELEDETECTION ET MILIEUX INSULAIRES DU PACIFIQUE : APPROCHES INTEGREES

REMOTE SENSING AND INSULAR ENVIRONMENTS IN THE PACIFIC : INTEGRATED APPROACHES

International workshop held at Noumea New Caledonia and Tahiti French Polynesia Nov. 19/24 1990

Journées internationales tenues à Nouméa Nouvelle-Calédonie et à Tahiti Polynésie Franç 19/24 nov. 199





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