ALOS Optical Data Verification

Verification and Implementation Plan

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DOCUMENT CHANGE LOG

Issue	Date	Section / Page	Description	Author
0.9	01/05/2005	All	Draft - Creation of the document	S. Saunier
1.0	01/09/2005	All	Internal Review Added new ESA test sites. Added details to validation items. Added annex parts related to Expert tools.	S. Saunier
1.1	05/01/2006	All	Added information related to radiometric calibration plan Added unconsolidated Jaxa simulation results for PRISM / AVNIR-2 test sites.	S. Saunier
1.2	02/03/2006	All	Review with P.Goryl. For each phase, validation items are described step by step.	S. Saunier
1.3	16/03/2006	All	Update of the document after ALOS data study, and geometry partial implementations. Issue for PI contributions	F. Pidancier S. Saunier

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 Purpose of this document

This document is aimed at defining a detailed plan for all the activities required to achieve the validation / verification of the ALOS AVNIR-2 / PRISM level 1b data products.

1.2 Applicable documents

[AD-1] Request For Quotation - AMALFI Multi-Mission Facility
RFQ/3-11341/05/I-LG
Issue 1 Revision 0 - 10 May 2005
ESA-ESRIN

[AD-2] Contract - AMALFI Multi-Mission Facility
19284/06/I-LG
14 February 2006
ESA-ESRIN

1.3 Reference documents

[RD-1] *COMMISSION PHASE PLAN*
November 12th, ,2004
JAXA / EORC

[RD-2] *CALIBRATION AND VALIDATION OF PRISM ON BOARD ALOS*
Tadono T and al.
ISPRS - 2004
http://www.isprs.org/istanbul2004/comm1/papers/3.pdf

[RD-3] *ALOS/AVNIR-2 Level 1 product format description*
NEB 00016
Rev G - August, 2005
JAXA

[RD-4] *ALOS/PRISM Level 1 product format description*
NEB 00016
Rev G - August, 2005
JAXA

[RD-5] *ALOS Algorithm description (PRISM / AVNIR-2)*
NEB 01006
Rev G - August, 2005
JAXA

[RD-6] *ALOS, a radiometric strategy, an example for high resolution sensor*
Internal document
February, 2006
R. Santer

[RD-7] *Transfer function and estimation for space borne telescopes*
G.Le Besnerais and L.M.Mugnier
PICIP - 2001.

[RD-8] *SPOT image quality performance*
C443-NT-0-296-CN
CNES Image quality team, C.Valorge, P. Delcaux
CNES - May, 2004.

[RD-9] *High resolution DEM generation from ALOS PRISM data*
Simulation and Evaluation
Tako Tadono and Al.
IEEE - 2004.

[RD-10] *MERIS FR 1b, absolute geo-location status*
GAEL P179-TCN-006 Issue 1 Revision 0
Sebastien Saunier, Philippe Goryl
GAEL Consultant, ESA/ESRIN - August, 2004
http://earth.esa.int/pcs/envisat/meris/documentation/GAEL-P179-TCN-006-01-00-Meris_Absolute_location_control_report.pdf

[RD-11] *MERIS FR-FS-0, Geometry Control*
GAEL-P223-DOC-001
Sebastien Saunier, Ludovic Bourg, Philippe Goryl
GAEL Consultant - February, 2006.

[RD-12] *Cross Calibration of the Landsat 7 ETM+ and EO ALI Sensor*
Gyanesh Chander, David J Meyer, and Dennis L Helder
IEEE TOGARS – December, 2004.

[RD-13] *An example of radiometric intercomparison of optical imaging spectrometer over a natural target*
Marc Bouvet (ESA / ESTEC)
CEOS IVOS Working group – November, 2005.

[RD-14] *3D precision processing of high resolution satellite imagery*
Armin Gruen, Zhang-li, Henri Eisenbeiss
ASPRS 2005 annual conference – March, 2005.

[RD-15] *Requirements for ALOS expert tools*
GAEL-P224-TCN-001-01
Issue 1 Revision 1 - 20/01/2006
GAEL Consultant

1.4 Abbreviations and Acronyms

This section controls the definition of all abbreviations and acronyms used within this document. Special attention has been paid to adopt abbreviations, acronyms and their definitions from international standards as ISO, ANSI or ECSS.

ADDS	ALOS Data Distribution System
ADEOS	Advanced Earth Observing Satellite
ADIS	ALOS Data node Interface System
ALOS	Advanced Land Observing Satellite
ANSI	American National Standards Institute
AOCS	Attitude & Orbit Control System
APID	Application Process Identification
ARTEMIS	Advanced Relay and Technology Mission Satellite
ASF	Alaska SAR Facility

ATT	Attenuator
AUIG	ALOS User Interface Gateway
AUSLIG	Australian Surveying & Land Information Group
AVNIR-2	Advanced Visible and Near Infrared Radiometer type 2
BOM	Beginning of Message
CAL/VAL	Calibration and Validation
CCSDS	Consultative Committee for Space Data Systems
CNES	Centre National d'Etudes Spatiales
CR	Carriage Return
DEM	Digital Elevation Model
DM	Deployment Monitor
DRC	Data Relay Satellite Communication
DRN	Data Ready Notification
DRTS	Data Relay and Tracking Satellite
DT	Direct Transmission
ECI	Earth Center Inertial coordinates
ECR	Earth Centered Rotating coordinates
ECSS	European Cooperation for Space Standardization
EOC	Earth Observation Center
EOL	End of Life
EOM	End of Message
EORC	Earth Observation Research and Application Center
ERSDAC	Earth Remote Sensing Data Analysis Center
ESA	Earth Sensor Assembly
ESA	European Space Agency
FBD	Fine Resolution Mode, Dual polarization
FBS	Fine Resolution Mode, Single polarization
FIFO	Fast-In Fast-Out
FTP	File Transfer Protocol
GA	Geosciences Australia
GCMP	Ground control matching pattern
GCP	Ground control point
GN	Ground Network
GPS	Global Positioning Satellite
GPSR	GPS Receiver
GSI	Geographical Survey Institute
HCE	Heater Control Electronics

HK	Housekeeping
HSSR	High Speed Solid State Recorder
ICD	Interface Control Document
IGS	International GPS Service
IRU	Inertial Reference Unit
ISO	International Organization for Standardization
JAXA	Japan Aerospace Exploration Agency
JCG	Japan Coast Guard
JERS	Japanese Earth Resources Satellite
LLM	Low Load Mode
LNA	Low Noise Amplifier
LR	Laser Reflector
LSSR	Low Speed Solid State Recorder
MAFF	Ministry of Agriculture, Forestry and Fisheries of Japan
MDR	Mission Data Recorder
MGC	Manual Gain Control
MMO	Mission operation Management Organization
MOE	Ministry of Environment
MOIP	Mission Operations Implementation Plan
MOIS	Mission Operations Interface Specification
MTF	Modulation Transfer Function
NASDA	National Space Development Agency of Japan
PALSAR	Phased Array type L-band Synthetic Aperture Radar
PCD	Payload Correction Data
PI	Principal Investigator
PRI	Pulse Repetition Interval
PRISM	Panchromatic Remote-sensing Instrument Stereo Mapping
RARR	Range and Range Rate Measurement
RCN	Receipt Confirmation Notification
REV	Rotating Element Electric Vector
RF	Radio Frequency
RS	Reed-Solomon
RSP	Reference System for Planning
SEES	Space Environment & Effects System
SLC	Single Look Complex
SLR	Satellite Laser Ranging
SMTP	Simple Mail Transfer Protocol

SN	Space Network
STC	Sensitivity Time Control
STT	Star Tracker
TACC	Tracking And Control Center
TBD	To Be Determined
TBR	To Be Reviewed
TCP/IP	Transmission Control Protocol/Internet Protocol
TEDA	Technical Data Acquisition Equipment
TKSC	Tsukuba Space Center
TT&C	Tracking Telemetry and Control
USB	Unified S-Band
UTC	Universal Time Coordinated
VCA	Virtual Channel Access
VCDU	Virtual Channel Data Unit
VCID	Virtual Channel Identification
VMD	Virtual channel Multiplexer and Distributor
WB1	Wide Area Observation Mode (Burst mode 1)
WWW	World Wide Web

2 SUPPORT TO ALOS OPTICAL DATA VERIFICATION

Within EADN (ESA Data Node) framework, GAEL Consultant is proposing its support to ESA / ESRIN for ALOS optical data verification (AVNIR and PRISM instruments). ALOS optical data verification as a part of the ALOS commissioning phase will last (1) Year: from verification and implementation plan design (pre-launch phase) to consolidated calibration / validation final report to be released at launch (L) plus one (1) Year.

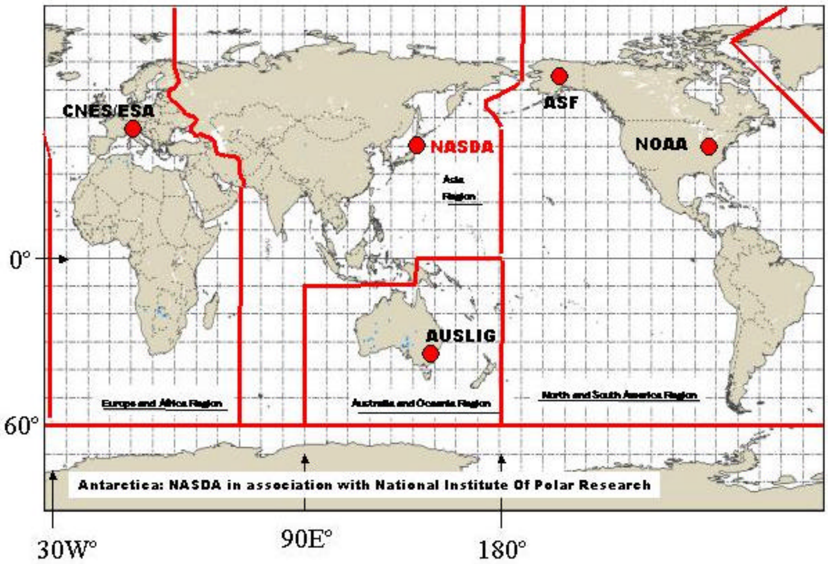

fig. 1 - ALOS data node; ESA Data Node (EADN) is in charge of European and African region.

2.1 Verification plan, overview

Verification plan can be split into three distinct phases: phase A, B and C. Each phase is associated to the achievement of a verification / validation report.

2.1.1 Phase A

Phase A is dedicated to a quick assessment of product quality and aims at mainly providing qualitative results. Main objectives are:

- To validate the assessment tools,
- To demonstrate that ALOS mission operates nominally, and basic user requirements are fulfilled,
- To check that ESA / ALOS PRISM and AVNIR-2 processing chain is working as expected,
- To defined criteria of success to be applied during the next phases.

Results from phase A will be reported into the preliminary verification report.

2.1.2 Phase B

Phase B, so called 'in-depth assessment' will address critical points. Activities will be performed according validation items which are as close as possible to those defined by JAXA. Main of them are summarized just here below:

- Geometry control and the evaluation of inner geometry consistency for the three PRISM cameras,
- Geometry control and the checking PRISM stereoscopic capability,

- Image quality and the MTF characterization, the Signal to Noise Ratio determination and the assessment of the JPEG compression.

Results from phase A and B will be reported into the consolidated verification report.

2.1.3 Phase C

Phase C encompass sensor inter comparison and vicarious calibration activities. In addition, the validation of digital elevation model extracted from PRISM data will be done as well.

At the end of phase C, the consolidated calibration/validation report will reflect ESA contribution to the characterization of the PRISM / AVNIR-2 instrument capabilities.

The following document details the verifications and implementations that will be setup to successfully achieve these 3 phases.

2.2 Resources / Teams

For phase A,B and phase C, a team of experts will be constituted and coordinated by GAEL Consultant respectively the verification team and the Calibration / Validation team.

Identified identities for the verification team are:

- **Institute of Geodesy and Photogrammetry at the ETH Zurich (ETH),**
- **GAEL Consultant,**
- **"Université du Littoral" (LISE),**
- **ONERA**

Identified entities for the calibration / validation team are:

- **ESA/ ESTEC**,
- **ESA/ ESRIN,**
- **ETH**,
- **GAEL Consultant,**
- **LISE,**
- **USGS.**

Details on actors belonging to entities are listed in table just here below.

Name	Sur name	Entities	E-mail address	Tel
Bouvet	Marc	ESA/ESTEC	marc.Bouvet@esa.int	00 31 715 656 571
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Goryl	Philippe	ESA/ESRIN	philippe.goryl@esa.int	00 39 069 418 0638
Gruen	Armin	ETH Zurich - IGP	armin.gruen@geod.baug.ethz.ch	00 41 163 330 38
Mambimba	Aboubakar	GAEL Consultant	aboubakar.mambimba@gael.fr	00 33 164 739 955
Mugnier	Laurent	ONERA Chatillon	laurent.mugnier@onera.fr	00 33 146 734 747
Pidancier	Frédéric	GAEL Consultant	frederic.pidancier@gael.fr	00 33 164 739 955
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Saunier	Sebastien	GAEL Consultant	sebastien.saunier@gael.fr	00 33 164 739 955
Vaillefont	Francoise	ONERA Toulouse	francoise.viallefont@onecert.fr	00 33 562 252 605

table 1 - Actors of investigator calibration teams.

Figure (fig. 2); just here after depicts organization between the whole of entities. Entities are grouped by topic of validation; format, geometry, image quality and radiometry.

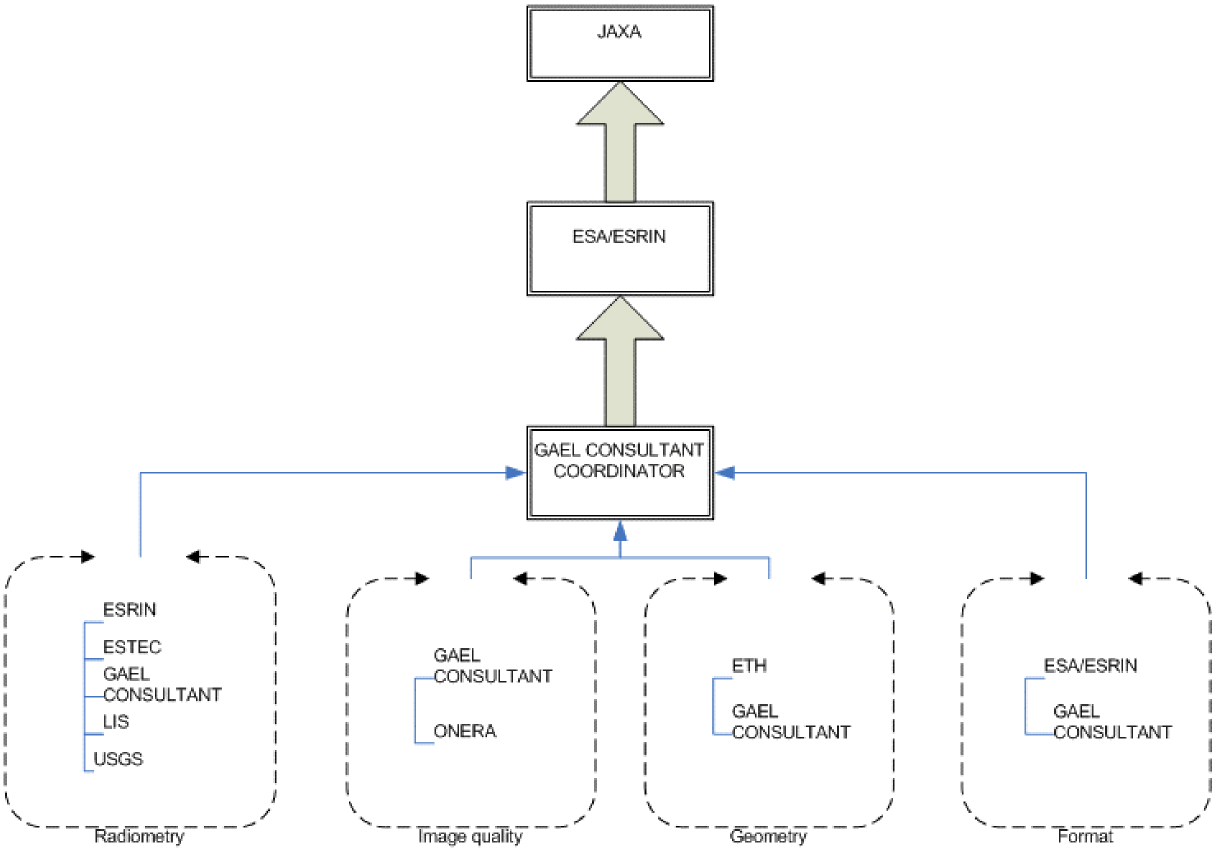


fig. 2 - Organization.

2.3 Schedule

During the initial check out phase (from Launch + 1 Month (M) to Launch + 3 M) JAXA keeps the exclusivity of ALOS data. First AVNIR-2 / PRISM data reception at ESA ground station is foreseen at L + 4 M and will trigger implementation of the verification plan.

The schedule is foreseen to be as follow:

1. July 2005: Verification and implementation plan,
2. L + 4 M: Data reception, start of quick verification activities (phase A),
3. L + 5 M: Preliminary verification report (end of phase A),
4. L + 5 M: Start of In deeper-assessment activities (phase B),
5. L + 5 M: Calibration team is operational,
6. L + 5 M: Start of cross and vicarious calibration activities (phase C),
7. L + 8 M: Consolidated verification report (end of phase B),
8. L + 8 M: Preliminary calibration / validation report,
9. L + 1 Y: Consolidated calibration / validation report (end of phase C).

The main schedule and resource team involved in the ESA ALOS optical data verification are summarized in the figure just here below (fig. 3).

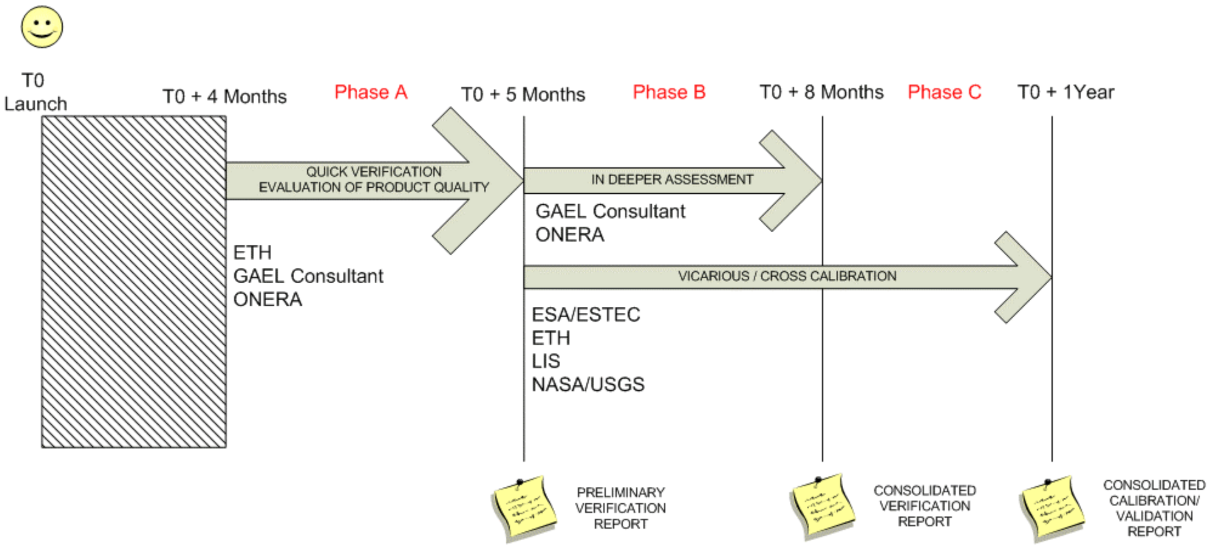


fig. 3 - Schedule of verification tasks.

2.4 Verification plan, validation items definition

The prime task of GAEL Consultant is the design of the ESA/ALOS verification and implementation plan based on validation items. The validation items should be as near as possible to those defined by JAXA such as defined in [RD-1]. However methodology used will differ slightly.

The ESA/ALOS verification plan should be focused at a product level. It is aimed for checking and evaluating product quality according to duly defined validation items gathered into the four following categories:

1. Product readability and product format consistency,
   a. Format checking
   b. Products comparison
   c. Performance indicator recording
2. Geometric accuracy of acquired optical data,
   a. GAEL Sensor model validation
   b. Geo referencing function validation
   c. Scene center and scene corners accuracy evaluation
   d. Densely GCP study
   e. Along GCP study
   f. PRISM DEM capabilities and performances
3. Radiometric fidelity of acquired optical data,
   a. Processor calibration derive between L1B1 and L1B2
   b. Relative calibration study
   c. Absolute calibration study
4. Image quality.
   a. Visual inspection
   b. Signal to noise ration
   c. Modulation transfer function

This verification plan will be disseminated among verification and CAL / VAL teams. It will inform on procedure, validation items (tests) and its associated criteria of success (threshold).

All along the phase B, verification team members will operate according to verification plan and will report test results according to PASS/FAILED criteria.

Next sections provide for the three phases of verification plan a detailed statement of work focusing on each validation items. A purpose, an objective, a team, an output, a schedule, equipment and a tool define the validation item.

2.5 Validation item and entitie(s)

Validation item	Format	Geometry	Radiometry	Image quality	Phase			Entitie(s)	Instrument	
					A	B	C		PRISM	AVNIR-2
Format checking	X				X			GC	X	X
ESA/JAXA product comparison	X				X			GC, ESA/ESRIN	X	X
Performance indicateur recording	X	X	X	X	X	X	X	GC	X	X
Validation of the sensor model		X			X			ETH, GC	X	X
Validation of the fidelity of the geo-referencing functions		X			X			ETH, GC		
Interband alignment		X			X	X	X	GC		X
Rough estimation of absolute location in GIS		X			X			GC	X	X
Absolute location accuracy		X			X	X	X	GC	X	X
Visual inspection		X	X	X	X	X	X	GC	X	X
Radiometric quality comparison			X			X		GC	X	
"Densely GCPs" study		X				X		GC		
"Along GCPs" study						X		GC		
Relative digital elevation model accuracy		X				X		ETH	X	
Relative calibration evaluation			X			X		GC, LIS	X	X
In flight MTF assessment				X		X		ONERA	X	X
Signal to Noise ratio assessment				X		X		GC	X	X
Cross calibration				X			X	ESA/ESTEC, USGS		X
Vicarious calibration							X	ESA/ESRIN-ESTEC		X
Elevation performance							X	ETH	X	

table 2 - Validation item, validation category, schedule, entities and instrument.

2.6 Data distribution and organization

ESA is contributing to ALOS calibration/validation phases. JAXA is considering ESA as a Prime Investigator entity. Validation items will be applied to JAXA products.

JAXA will systematically deliver to ESA data acquired over EADN test sites and processed at JAXA facilities. Regarding the products proposed to ESA, they will systematically be processed into CEOS format and the whole of product levels will be disseminated (raw, 1A, 1B 1B2 R and 1B2G).

ESA ground segment facilities for PRISM/AVNIR-2 data is located at Neustrelitz, Kiruna and ESRIN (Frascati). Products will be processed into CEOS and Earth Explorer formats, and only level 1B2 product will be output.

Due to limitation of band X receiver, ESA ground stations are not able to acquire data of three PRISM views (with transmission data rate 240 Mbps/s). So that, only PRISM nadir view products will be available.

Two image catalog systems will be proposed for supporting data dissemination during CAL/VAL period. The first one will be used at GAEL Consultant and partially opened to other Prime Investigators. The second one will be integrated to the ESA CAL/VAL portal (Please see the last document section, before appendix, for more information on catalog.).

JAXA warns that disseminated data should be used for the calibration and validation purposes and only.

3 PHASE A: QUICK VERIFICATION / EVALUATION OF PRODUCT QUALITY

3.1 Introduction

During the first part of ESA ALOS optical data verification, it is foreseen to address the following issues:

- The checking of product format consistency,
- The evaluation of PRISM / AVNIR-2 1B2 product geo-location
- The radiometric and image quality

As output of this period, PASS/FAILED criteria of success for items should be defined. Theses criteria will be operational during phase B. PHASE A will last one Month; from Launch+4 M until Launch+5 M.

3.2 Format

3.2.1 Format checking

3.2.1.1 Purpose

Purpose of this validation is the format checking of ALOS optical data products. First the CEOS format will be controlled with a systematic and automatic field-by-field pattern/value checking. Due to technical constraints the Earth-Explorer format validation will be made possible according to the project AMALFI multi-mission planning achievement.

3.2.1.2 Method

Product format fields are checked. Pattern of the value (length, offset, formatting) read in the product must be rigorously identical to the one defined in the associated product format document specification ([RD-3] and [RD-4]).

Format, which will be rigorously checked during this phase, are:

- ALOS PRISM OBS1 to OBS9 (9 observation modes) + products levels 1A, 1B1, 1B2R, 1B2G
- ALOS AVNIR2 products levels 1A, 1B1, 1B2R, 1B2G.

This includes 40 different products to validate, according to a processor identification and version.

Before the beginning of the tests, a matrix table per processor and QUISS software version will be setup to show the products received, the one checked and the total amount of errors.

Each time an update of the software and/or the processor version change, a new validation matrix should be performed.

3.2.1.3 Team

GAEL Consultant

3.2.1.4 Output

The output of this test is a user readable report focusing on the detected errors, for each sample product; especially report will point out mismatching between format pattern required (such defined in specification document) and the one extracted from the product.

The matrix tables will also made available.

3.2.1.5 Schedule

Format fields control will be started at first product reception.

Result will be report into the preliminary verification report issued at L+5 (fig. 3).

3.2.1.6 Working data

Sensor	Product level/OBS	Format	Target zone	Acquisition date
AVNIR-2	1A 1B1 1B2 / NA	CEOS / Earth Explorer	Sivas Tarsus	22/04/2006
PRISM	1A 1B1 1B2 / OBS1 –OBS9	CEOS / Earth Explorer	Sivas Tarsus	02/05/2006

3.2.1.7 Tool

ALOS expert tool: QUISS/Field control test.

3.2.2 ESA / JAXA product comparison

3.2.2.1 Purpose

Validation of ESA processing chain will be performed through a comparison with a JAXA product; obviously having the same reference as the ESA one.

3.2.2.2 Method

This validation step is doing for ensuring that ESA processing chain is aligned on JAXA processing chain. Most important fields of the ESA product will be compared with the corresponding ones of the JAXA product. The importance is defined regarding different levels of data decoding capabilities.

a. Is the product comprehensible
    i. CEOS structure respect (if CEOS format)
    ii. Satellite and sensor identifiers.
    iii. Product level identifier
    iv. Observation mode identifier
b. Is the image readable:
    i. Line number
    ii. Pixel number
    iii. Data depth
    iv. Offset to the pixels and dummy pixels
c. Can the radiometry be processed
    i. Observation date
    ii. Sun angle/elevation
    iii. Look angle
    iv. Radiometric parameters
d. Can the geometry be processed
    i. Map projection data
    ii. Satellite positioning data

Any discrepancies will be flagged and subsequent investigation will be undertaken for determining the origin of the misalignment.

This validation flows will be runt for AVNIR-2 data products and PRISM data products.

Processor version identification is mandatory to make sense to the output report.

3.2.2.3 Team

GAEL Consultant

3.2.2.4 Output

The output of this test is a user readable report focusing on the detected errors, it will point out format discrepancies between the both products.

3.2.2.5 Schedule

ESA/JAXA product comparison will be started at first product reception.

Result will be report into the preliminary verification report issued at L+5 (fig. 3).

3.2.2.6 Working data

The main constraint of this validation item is the processing of a same PRISM/AVNIR-2 product in one hand by the JAXA processing chain and in the other hand by the ESA processing chain.

Applicable target zone and acquisition date is still unknown since dependant of the ESA processing chain.

Sensor	Product level	Format	Target zone	Acquisition date
PRISM	1A/1B1/1B2	CEOS		
AVNIR-2	1A/1B1/1B2	CEOS		

3.2.2.7 Reference data

We suppose that reference data is the product provided by JAXA processing chain.

3.2.2.8 Tool

Technically, Derby Application® and DRB API® components through DiffTool component will be used and a report of discrepancies will be issued.

3.2.3 Performance indicator recording

3.2.3.1 Purpose

Purpose of this validation item is to perform a short term monitoring (one year) of product quality and by extent instrument stability. This validation item aims at proposing a tendency regarding the product performances coming from tests results, or directly from the product.

3.2.3.2 Method

Performance indicator is defined as quantitative measures output from a quality control test.

Performance indicators will be automatically stored in a database after a product quality control session within QUISS session.

3.2.3.3 Output

The output of this test is a trend analysis for every performance indicators collected. It will provide a support for determining some criteria of success.

In addition, in case of ALOS optical data will be put into operation and products delivered to user, this validation item will support ESA for determining test sequences to be embedded within Amalfi Multi Mission.

3.2.3.4 Team

GAEL Consultant

3.2.3.5 Schedule

Performance indicator recording task is planned to start once a product will be received at GAEL Consultant, hopefully in May of Year 2006 beginning.

Result will be reported into the preliminary verification report issued at L+5 (fig. 3).

This task will continue during phase B, C.

3.2.3.6 Working data

Sensor	Product level	Format	Target zone	Acquisition date
PRISM	All	CEOS	All	-
AVNIR-2	All	CEOS	All	-

Reference data

No reference data

Tool

QUISS application and all the tests should be upgraded for this assessment.

3.3 Geometry

The geometry assessment activity is defined within 3 separate stages for the phase A:

- PRISM and AVNIR2 sensor models validation
- Embedded polynoms verification
- Embedded control points verification (scene center and corner coordinates)
- Interband alignment – band to band registration
- Rough estimation of absolute location in GIS
- Absolute calibration accuracy

Once the first stage completed, the GAEL sensor model will be considered has the reference model and allow assessing absolute geodetic accuracy of PRISM and AVNIR 2 L1B2G/D products, controlling the PRISM image geometry (level 1B2), verifying PRISM stereoscopic capability (level 1B1).

3.3.1 PRISM and AVNIR2 sensors models validation

3.3.1.1 Purpose

The first stage of geometry activity is the validation of PRISM and AVNIR2 sensors models. At GAEL, for image orientation procedure, a generic approach for push broom scanner based on a physical sensor model derived from co-linearity equations, has been implemented. Algorithms use geometry of the detectors, satellite attitudes and ephemeris, viewing angle and incidence angles.

This model shall be validated when crossing accuracy results with those obtained from another sensor model implemented by ETH Zürich laboratory.

Then, this sensor model will be the key element for validating the fidelity of geo referencing functions embedded within AVNIR2 and PRISM for level 1B1 and 1B2 products location.

3.3.1.2 Method

For validation of sensors models a common working data set for GAEL Consultant and ETH is mandatory. Also the same study will be perform twice with a first chosen base altitude to 0 metre, and second to 1000 metre. The reference projection datum and ellipsoid should also be well defined. The most important is the relative comparison and so that the similarity between results of the two models.

Validation of sensor model must be performed as follow:

- To check RMS results of working data without taken any GCPs, as specified by JAXA ([RD-8]), PRISM horizontal accuracy will achieve less than 6.0 meters.
- To re-affine model adding one GCP; deformations due to translation are compensated,
- To re-affine model adding two GCPs; deformations due to scale are compensated,
- To re-affine model adding three GCPs, deformations due to rotation are compensated,
- To re-affine model adding four and more GCPs; RMS results should become constant.

3.3.1.3 Output

The both models should provide similar RMS results and the report will be expressed as follow:

Number of GRP	Altitude	X	Y	Lat	Long	RMS ETH model	RMS GC model
0	0						
1	0						
2	0						
3	0						
4	0						
0	1000						
1	1000						
2	1000						
3	1000						
4	1000						

table 3 - Report form for the comparison of sensor model accuracy.

3.3.1.4 Team

GAEL Consultant, ETH Zurich

3.3.1.5 Schedule

Sensor model verification will start once ETH Zurich will be up to provide GAEL Consultant with a working data and a report such as described in table 3.

Result will be reported into the preliminary verification report issued at L+5 (fig. 3).

3.3.1.6 Working data

1A and 1B1 levels of products are necessary to validate the sensor model and regardless test site. For getting consistent and absolute results, PRISM/AVNIR-2 products should be processed with consolidated orbit and attitude data. Thus, any doubts regarding a bad image orientation would be discarded.

3.3.1.7 Reference data

The reference is the report (table 3) duly filled. The report will list results based on the accuracy of at least five GCPs selected by ETH.

GAEL Consultant do not need of GCPs image chips but request only the image coordinate (x,y) and corresponding latitude, longitude and the default altitude used of each GCP such as formulate by the report (table 3).

3.3.1.8 Tool

Projection module embedded in the export tools.

3.3.2 Validation of the fidelity of the geo referencing function

3.3.2.1 Prerequisites

- The validation of the sensor model should be completed for levels 1A or 1B1.
- Syscor improved model for level 1B2R products levels.
- Geocoded improved model for level 1B2G products levels.

3.3.2.2 Purpose

ALOS AVNIR2 and PRISM data includes polynomial coefficients for image orientation. Mathematical functions are given for converting image pixel index to latitude longitude.

Purpose of this validation item is to compare location results from two methods:

1. Using the Gael reference model (Sensor, Syscor or Geocoded, according to the product level)
2. Using product geo-referencing function.

Purpose of this validation item is to check consistency of polynomial coefficients given for computing the geo referencing function.

3.3.2.3 Method

Geo-referencing function will be checked for level 1B1 and for level 1B2. In the both cases; the procedure can be summarized as follow:

3. Affine the model in taking at least ten very accurate GCPs sufficiently spaced over working data (It is very important for the accuracy, that the control points be well distributed upon the different lines of the product).
4. Generate a latitude and a longitude, with GRS80 ellipsoid and Geodetic coordinates to WGS84 (ITRF97) with altitude 0, grid based on pixel index coordinate using the sensor model,
5. Generate a latitude and a longitude grid based on pixel index coordinate using the polynomial function,
6. Compute the difference between grids (latitude and longitude)
7. Start a data analysis and output statis tics.
8. (Compare statistics on geo referencing function with those of ETH Zurich.)

3.3.2.4 Team

GAEL Consultant, (ETH Zurich)

3.3.2.5 Output

Four outputs will be issued from this validation item and they will focus on:

1. Geo-referencing function of PRISM level 1A and 1B1 product,

2. Geo-referencing function of PRISM level 1B2R product,
3. Geo-referencing function of PRISM level 1B2G product,
4. Geo-referencing function of AVNIR-2 level 1A and 1B1 product,
5. Geo-referencing function of AVNIR-2 level 1B2R product.
6. Geo-referencing function of AVNIR-2 level 1B2G product.

A standard report will encompass a set of statistics on deviation of geo-referencing function results from the expected ones (with re-affine sensor model).

Sensor Product level	Mean	Standard deviation	Minimum	Maximum	RMS
PRISM level 1A and 1B1					
PRISM level 1B2R					
PRISM level 1B2G					
AVNIR-2 level 1A and 1B1					
AVNIR-2 level 1B2R					
AVNIR-2 level 1B2G					

fig. 4 -Report for the geo-referencing function validation.

3.3.2.6 Schedule

This validation item is scheduled to take place after completion of validation of the sensor model item.

Validation of the fidelity of the geo referencing function will be performed once PRISM data reception of PRISM product dated of.

Result will be reported into the preliminary verification report issued at L+5 (fig. 3).

3.3.2.7 Working data

Geo-referencing function

Over a very flat area, purpose of this validation item is to compare location results from two methods: the sensor physical model and product geo-referencing function.

Sensor	Product level	Format	Target zone	Acquisition date
AVNIR-2	1B1 / 1B2 R/G	CEOS	Spa 1 2 La Crau	TBC
PRISM	1B1 / 1B2 R/G	CEOS	Fontainebleau	08/05/2006
PRISM	1B1 / 1B2 R/G	CEOS	Piemont	tbc

A particular attention will be paid regarding the PRISM observation modes, and the artefacts due to the forward and backward pointing angles.

3.3.2.8 Reference data

3.3.2.9 Tool

ALOS EXPERT TOOL: GEOREF will be used for this task.

3.3.3 Validation of scene center and corners coordinates

3.3.3.1 Purpose

This validation stage aims to validate the corner coordinates provided within the ALOS products.

3.3.3.2 Method

Once the sensor model will be validated, this basic control is dedicated for checking that geographical information provided with product format is consistent.

3.3.3.3 Team

GAEL Consultant

3.3.3.4 Output

RMS on scene center and corner coordinates.

3.3.3.5 Schedule

3.3.3.6 Working data

3.3.3.7 Reference data

3.3.3.8 Tools

3.3.4 Interband alignment; band to band registration

3.3.4.1 Purpose

Purpose of the validation item is to check that AVNIR-2 channels of L1B2 product can be perfectly superimposed.

3.3.4.2 Method

Verification is performed through an automatic test for measuring the offset of all band pair. The method relies on correlation matrix algorithm. It allows interpolation in a reference band of an estimated in other bands.

Test is applied for data acquired over a dedicated test site. Actually for results consistency, spectral difference between bands shall be minimized so that AVNNIR-2 data from desert area has to be chosen.

3.3.4.3 Team

GAEL Consultant

3.3.4.4 Output

Results of this validation items will be reported using the following form:

Displacement along X axis (vertical)

channels	1	2	3	4	5	6	7	8	9
1	-	-	-	-	-	-	-	-	-
2	-	-	0.000	-	-	-	-	0.214	-
3	-	-	-	-	-	-	-	-	-
4	-	-	-	-	0.000	-	-	-	-
5	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-0.812	-	-
7	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-

Displacement along Y axis (horizontal)

channels	1	2	3	4	5	6	7	8	9
1	-	-	-	-	-	-	-	-	-
2	-	-	0.000	-	-	-	-	0.188	-
3	-	-	-	-	-	-	-	-	-
4	-	-	-	-	0.000	-	-	-	-
5	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-0.667	-	-
7	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-

Mean of interband misalignment

channels	1	2	3	4	5	6	7	8	9
1	-	-	-	-	-	-	-	-	-
2	-	-	**0.000**	-	-	-	-	**0.214**	-
3	-	-	-	-	-	-	-	-	-
4	-	-	-	-	**0.000**	-	-	-	-
5	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	**0.812**	-	-
7	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-

table 4 - Sample of report for interband alignment validation item within Landsat product.

These results will be recorded and stored in the database as product performance indicators.

3.3.4.5 Schedule

Interband alignment task is planned to start at reception of first AVNIR-2 product acquired over Spain test sites. Results will be reported into the preliminary verification report issued at L+5 (fig. 3).

This task will continue during phase B, C.

3.3.4.6 Working data

This task will be operated on products acquired over Spanish and Lybia test sites. First products to be checked are listed just her below:

Sensor	Product level	Format	Target zone	Acquisition date
AVNIR-2	1B2R/1B2G	CEOS	Lybia	25/04/2006
AVNIR-2	1B2R/1B2G	CEOS	Spa1	09/05/2006
AVNIR-2	1B2R/1B2G	CEOS	Spa2	09/05/2006

3.3.4.7 Reference data

No reference data will be used.

3.3.4.8 Tool

Interband test and Flicker tool embedded within ALOS expert tools will be used for this task.

3.3.5 Rough estimation of absolute location in a GIS

3.3.5.1 Purpose

Purpose of this task is to simulate the import of PRISM / AVNIR-2 scenes performed by an end-user within his GIS containing vectorial layers. It leads to a visual inspection of the scene location, no quantitative results will be provided.

3.3.5.2 Method

Scenes should be geocoded, image orientation procedure is based on self-calibration. GMT vectorial Layer will be superimposed on image data.

3.3.5.3 Team

GAEL Consultant

3.3.5.4 Output

Output of the method will be a set of snapshots magnifying the matching between vectorial layer and related image features belonging to data to be tested.

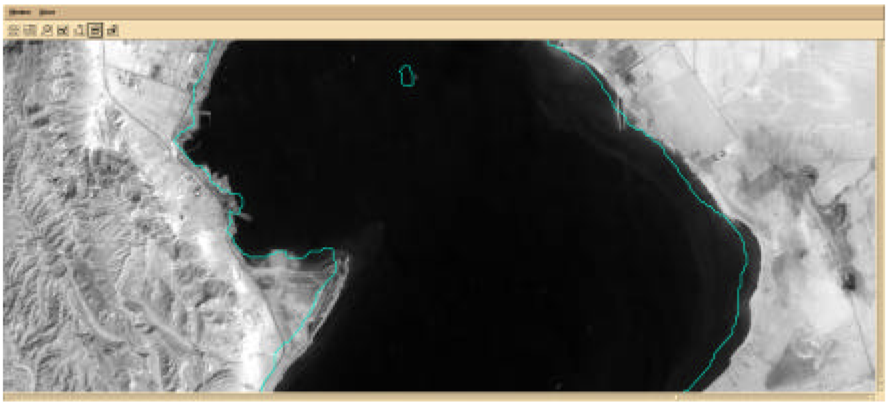


fig. 5 - Example of output of 'rough estimation of absolute location in a GIS' validation item.

3.3.5.5 Schedule

Rough estimation of absolute location in a GIS is planned to start at L+4.

Results will be reported into the preliminary verification report issued at L+5 (fig. 3).

This task will not be continued for phase B, C. periods.

3.3.5.6 Working data

First products to be verified are listed in table just here below:

Sensor	Product level	Format	Target zone	Acquisition date
PRISM	1B2G	CEOS	Sivas Tarzus	2/05/2006
AVNIR-2	1B2G	CEOS	Spa1	22/04/2006

3.3.5.7 Reference data

Reference data are GMT vectorial layer and GPS tracks.

3.3.5.8 Tool

FRAME embedded within ALOS expert tools will be used for this task.

3.3.6 Absolute location accuracy

3.3.6.1 Purpose

Purpose of this validation item is the assessment of geodetic accuracy of PRISM / AVNIRS-2 L1B2G. This validation item will not addressed issue regarding internal geometry control. Main output of this task would be the location accuracies expressed in term of root mean square results. The mean displacement of product location will be highlighted.

For AVNIR-2 products, the multi-temporal case will be a part of this validation item.

3.3.6.2 Method

Method is semi-automatic; an operator sets GCP points manually on the working data. Sensor model computes and predicts the corresponding one belonging to the reference data. Operator adjusts the GCP location for ensuring the best matching between the both views.

In doing this with at least 20 GCPs, model of acquisition is re build and compare to the reference model. Method leads to a statistical displacement between the map-projected images in term of easting and northing.

3.3.6.3 Team

GAEL Consultant

3.3.6.4 Output

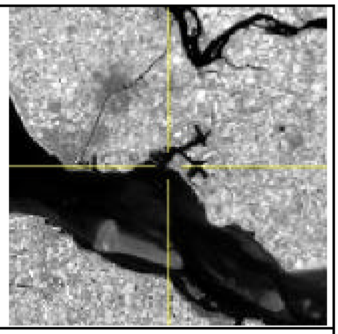
- Tie points quality assessment
- Geodetic accuracy of L1B2G PRISM / AVNIR-2 products.

Following table just here below lists all statistics on GCPs provided as output of this assessment.

For every GCP, the displacement is given, the report displays image chip from working image and the corresponding one of the reference image. A screenshot of the working image overlaid by error vector fields is issued as well.

Algebraic mean ðX
Algebraic mean ðY
Error modulus arithmetic mean
Standard deviation ðX
Standard deviation ðY
Error modulus standard deviation
Quadratic mean (RMS) ðX
Quadratic mean (RMS) ðY
Error modulus quadratic mean (RMS)
Number of points inside limit

Working Image



Reference image

table 5 - Ouput statistics from GEOREF and image chips.

These results will be recorded and stored in the database as product performance indicators.

3.3.6.5 Schedule

This task strongly depends on geometric model validation task.

First results will be reported into the preliminary verification report issued at L+5 (fig. 3).

Number of product processed should be six units.

This task will continue during phase B, C.

3.3.6.6 Working data

Absolute location accuracy will be systematically performed on PRISM product acquired over test sites dedicated to the verification of the geometric quality (table 9) – for acquisition date please refer to (table 15).

First products will be the following ones:

Sensor	Product level	Format	Target zone	Acquisition date
PRISM	1B2R/1B2G	CEOS	Paris-Champs	25/05/2006
AVNIR-2	1B2R/1B2G	CEOS	Spa2	09/05/2006

3.3.6.7 Reference data

Reference data are image data and vectorial data (points and sample of points; tracks).

3.3.6.8 Tool

ALOS expert tool will be used for this task.

3.4 Image quality / radiometric quality

3.4.1 Visual inspection

3.4.1.1 Purpose

Visual inspection is used for appreciating the good quality, the good shape of image data. This step is mandatory and very important. Results will induce focus points for the next phase.

3.4.1.2 Method

The visual inspection is a qualitative assessment. Image quality depends on exogenous parameters, such as view angle, sun elevation, shadowing, season, and atmospheric conditions. So that, to the final appreciation will be added a report on all these parameters.

Visual inspection will be based on evaluation of such parameters:

- Image artefacts; shadow and saturation, hot spot, staircase…
- Radiometric quality; noise, edge sharpening, spilling, jpeg compression, detector-to detector calibration.

JPEG compression is applied on PRISM data before downlink. The compression is a discrete cosine transform (DCT) with Huffman coding; the rate of compression is 4/5. Qualitative status on this artifact is mandatory. It will trigger the design of a test for automatically detect it.

PRISM and AVNIR-2 data are quantized to 8-bit radiometric resolution. Histogram control consisting in checking the dynamic range and sensitivity each spectral band is providing. Qualitative approach will be lead to discern if DN values are full range.

The visual inspection procedure will provide an appreciation of the image interpretability capability.

3.4.1.3 Team

GAEL Consultant

3.4.1.4 Output

All “acquisition” parameters such the following ones will be reported.

- Acquisition date,
- Viewing angles,
- Sun elevation,
- Sun azimuth,
- Shadow length for a given object size,
- Atmospheric condition; cloudy, hazy; sunny.

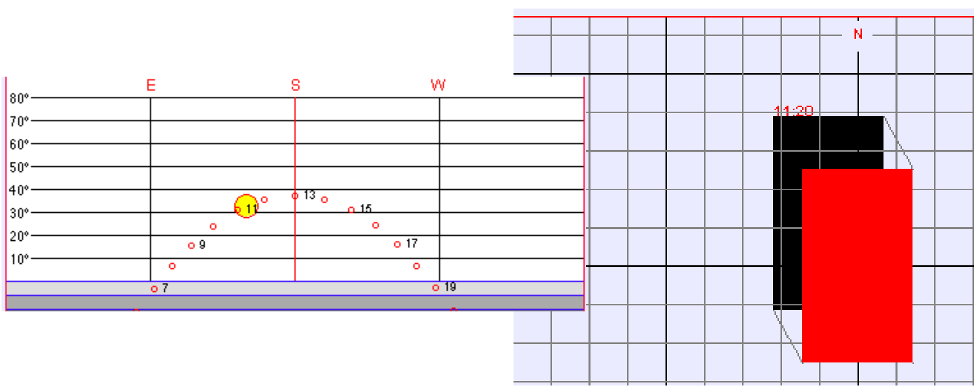


fig. 6 - Representation of a shadow for given object size (right), sun elvation (left).

The report regarding visual assessment will be split into two main parts, image artefact and radiometric quality. Within each part; item to be assessed will be appreciated according to modalities. Report will be illustrated by screenshots.

3.4.1.5 Schedule

This task will be intensively performed during the phase A.

Results will be reported into the preliminary verification report issued at L+5 (fig. 3).

This task will continue during phase B, C.

3.4.1.6 Working data

First products for which a visual inspection will be performed are the following ones:

Sensor	Product level	Format	Target zone	Acquisition date
PRISM	1B2R/1B2G	CEOS	Paris-Champs	25/05/2006
AVNIR-2	1B2R/1B2G	CEOS	Spa2	09/05/2006

3.4.1.7 Reference data

No reference data will be used.

3.4.1.8 Tools

The viewer and statistical tools embedded within ALOS expert tool will be used for this task.

4 PHASE B: IN-DEPTH ASSESSMENT

4.1 Introduction

Phase B is dedicated to in-deeper assessment. Product quality shall be evaluated according to PASS / FAILED criteria such as defined from phase A.

Phase B will start from L+ 5 Months (data reception) and will late until L+ 8 Months (End of commissioning phase).

Validation items remaining active during phase B period will be:

- Format checking,
- Performance indicators recording,
- Absolute location of PRISM / ANIR-2 L1B2G product,
- Visual inspection.

Additional activities durin this phase are:

- Geometry:
  - Densely GCP study
  - Along GCP study
  - DEM generation capabilities.
- Image Quality:
  - Comparison with high resolution sensor,
  - In flight MTF
  - SNR

4.2 Geometry

4.2.1 Densely GCPs and PRISM's CCD alignment, attitude/position sensors

4.2.1.1 Purpose

Densely GCPs studies are dedicated to test the stability of camera for short temporal and spatial acquisition periods. Pointing stability assessments focus on the following validation items:

1. Relative alignments between each CCD and their variation;
2. Evaluation of "post processing" pointing direction accuracy within 5s of acquisition.

4.2.1.2 Method

Geometric validation activities, for which reference data is necessary, will be performed within a common AVNIR-2 or PRISM sensor grid.

Hence, referenced data will be re-mapped to be as near as possible to the sensor geometry. The interests of this technique are two fold: assess original (i.e. unaffected) products rather avoiding re-processing artifacts and providing figures immediately exploitable in the processor, instrument and platform engineering reference systems (e.g. along or across track drifts instead of map projection northing or easting shift not directly correlated to the platform).

4.2.1.3 Team

GAEL Consultant

4.2.1.4 Output

Main output of the report will be:

- Measurement distribution graphic (CE90),
- Root mean square on location of measures (along/across track).

4.2.1.5 Schedule

L+8: Consolidated verification report – end of commissioning phase.

4.2.1.6 Working data

From table of test site (table 9), validation related to "Densely GCPs" will be performed over test id number 1,2,3,4,12,13.

Products processed into CEOS format, Level 1B-1, are required.

4.2.1.7 Reference data

Acquisition date of SPOT 5 data should be chosen as close as possible to the one of products on which validation will be focused (One Year period will be accepted).

Aerial dataset of Bordeaux test site are partially suitable for this assessment.

GPS vector will be used.

4.2.1.8 Tools

Disparity analysis tool as part of ALOS expert tool will be used.

4.2.2 Along GCPs and geometric accuracy evaluations over 100 seconds

4.2.2.1 Purpose

Along GCPs studies, are dedicated to the checking of pointing stability during a long acquisition period; It enables to discern if thermal effects occur; to verify consistency of results between products acquired over Northern and Southern hemisphere.

1. Evaluation of variations of "post processing" pointing direction accuracy over 100s;
2. Evaluation of "post processing" pointing stability;
3. Alignment between three radiometers at same time (triplet mode);
4. "post processing" pointing control accuracy; + / 15degres of pointing angle at nadir view;Va

For "Along GCPs" and Densely GCPs" studies, an accurate pre-processing is mandatory. Assessment of pointing accuracy will be performed within a common AVNIR-2 or PRISM sensor grid.

Geometry of reference is then as near as possible to the sensor geometry to be evaluated. Main advantages of such method are that results are not correlated with artifacts due to processing from level 1 B1 to level1B2 and detector displacements can be expressed in term of along/across track directions.

4.2.2.2 Method

Geometric validation activities, for which reference data is necessary, will be performed within a common AVNIR-2 or PRISM senor grid.

Hence; referenced data will be re-mapped to be as near as possible to the sensor geometry. The interests of this technique are two fold: assess original (i.e. unaffected) products rather avoiding re-processing artifacts and providing figures immediately exploitable in the processor, instrument and platform engineering reference systems (e.g. along or across track drifts instead of map projection northing or easting shift not directly correlated to the platform).

4.2.2.3 Team

GAEL Consultant

4.2.2.4 Output

Main output of the report will be:

- Measurement distribution graphic (CE90),
- Root mean square on location of measures (along/across track).

4.2.2.5 Schedule

L+8: Consolidated verification report – end of commissioning phase.

4.2.2.6 Working data

From table of test site (table 9), validation related to "Along GCPs" will be performed over test id number 5,6,7,8.

Products processed into CEOS format, Level 1B-1, are required.

4.2.2.7 Reference data

Acquisition date of SPOT 5 data should be chosen as close as possible to the one of products on which validation will be focused (One Year period will be accepted).

Aerial dataset of Bordeaux test site are partially suitable for this assessment.

GPS vector will be used.

4.2.2.8 Tools

Disparity analysis tool as part of ALOS expert tool will be used.

4.2.3 DEM generation capabilities

4.2.3.1 Purpose

Main purpose of this validation item is to check if image pair can be used under epi- polarity constraints through a quality assessment of views matching. It will be verified that correlation procedure matches correctly.

4.2.3.2 Method

Process for computing the relative DEM can be summarized as follow:

- Image orientation using self-calibration method,
- Computation of stereo model
- Extraction of elevation parallaxes,

4.2.3.3 Team

ETH, GAEL Consultant.

4.2.3.4 Output

A relative method is interesting for observing efficiency of the matcher. This method will not be able to output any accuracy regarding the acquisition system.

4.2.3.5 Schedule

L+8: Consolidated verification report – end of commissioning phase.

4.2.3.6 Working data

Piemont test site (latitude / longitude of scene center; 44.5 dd/7.3 dd) is acquired in triplet mode (Backward, Nadir, and Forward camera view).

Product has to be processed into CEOS format, level 1B1.

Simulation from JAXA is not available.

PRISM scenes are related to path number 320 frame 540, 541, 542

4.2.3.7 Reference data

A coarse DEM, 50 m ~~x~~y-resolution will be used for this assessment (please refer to table 10 for more information on reference data).

4.3 Image quality

4.3.1 Comparison with high resolution sensor

4.3.1.1 Purpose

All hypothesis results during visual inspection of PRISM scene should be re-evaluated and quantified in comparing PRISM data with data from another sensor.

4.3.1.2 Method

Comparison will be successful if scenes are carefully selected (same acquisition geometry) and are coincident.

Radiometric correlation

- ➢ Relative location of channels from the both scenes,
- ➢ Geometric co-registration procedure,
- ➢ Comparison of scene geometries (feature extraction capability),
- ➢ Radiometric correlation ("Color matching" function of REGIST process),
- ➢ Statistic over uniform area (gain and offset issue).

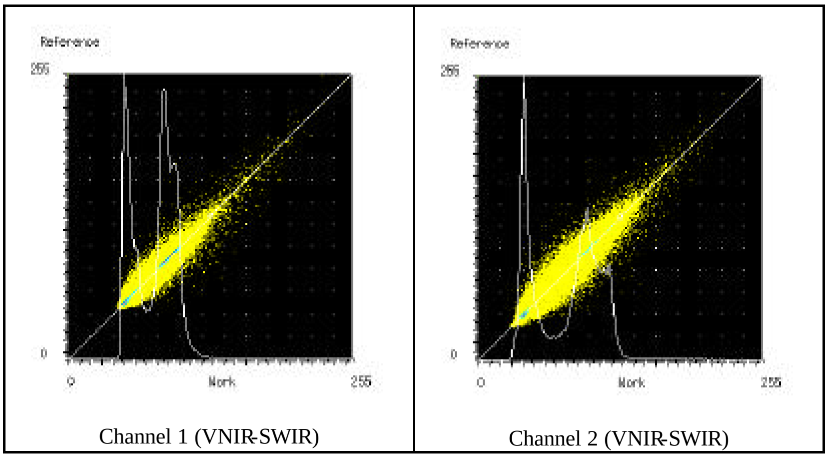


fig. 7 - Color matching, output chart.

4.3.1.3 Team

GAEL Consultant

4.3.1.4 Output

Report will contain results illustrated by screenshots for each item of comparison.

4.3.1.5 Schedule

L+8: Consolidated verification report – end of commissioning phase.

4.3.1.6 Working data

Because analysis must be performed with concurrent acquisitions, the working data is still unknown. This study will be focused on only one level 1B2 PRISM product, more likely acquired over Spanish test site.

Sensor	Product level	Format	Target zone	Acquisition date
PRISM	1B2	CEOS	Spain	3005/2006

4.3.1.7 Reference data

Data from SPOT5 HRS or IKONOS will be suitable.

fig. 8 - Ikonos data – Paris Montparnase.

4.3.1.8 Tool

Flicker and statistics tool embedded in ALOS expert tool will be used.

4.3.2 In flight MTF assessment

4.3.2.1 Purpose

The MTF is representative of the spatial resolution, its evaluation will be done through the two following procedure:

- Comparison of in-flight PRISM MTF measurements with pre-flight specifications,
- Comparison of in-flight AVNIR-2 MTF measurements with pre-flight specifications; a bi-resolution method (co registered AVNIR-2/PRISM image pair) will be applied.

4.3.2.2 Method

To be clarified with partners.

4.3.2.3 Team

ONERA (Toulouse, Chatillon)

4.3.2.4 Output

Report on MTF assessment should contain a table of summary results, which can be disposed as follow:

MTF (f/fe)	0	0,1	0,2	0,3	0,4	**0,5**	0,6	0,7	0,8	0,9	1
PRISM											

4.3.2.5 Schedule

L+8: Consolidated verification report – end of commissioning phase.

4.3.2.6 Working data

Data will be available on line through a web map server (GAEL Consultant and/or CAL/VAL portail). Actors will be able to crop the area of interest on working data and convert it into TIFF format. A process will then ensure the download from the server to the prime investigator home directory.

For Pirenne, and Istres test sites, we are waiting for flight plan from JAXA. First acquisitions of La Crau test site are listed in table here below:

Sensor	Product level	Format	Target zone	Acquisition date
PRISM	1B1	CEOS	La Crau Istres Salon	12/07/2006

4.3.2.7 Reference data

Sensor	Detector Size	Lens focal length	Clear aperture
PRISM	7 (CT) x 5.5 (AT) µm	2000 mm	300 mm
AVNIR-2	11 5 µm (square)	800 mm	240 mm

4.3.2.8 Specifications

Thanks to refer to APPENDIX D.

4.3.2.9 Tool

Data will be available on line through a web map server (GAEL Consultant and/or CAL/VAL portal). Actors will be able to crop the area of interest on working data and convert it into TIFF format. A process will then ensure the download from the server to the prime investigator home directory.

4.3.3 Signal to Noise Ratio (SNR)

4.3.3.1 Purpose

Purpose of this item is the determination of the signal to noise ratio. The signal-to-noise ratio is representative of the radiometric resolution. A basic method will be implemented for performing successfully this activity.

4.3.3.2 Method

Firstly, the noise quantity contaminating an image is usually determined on basis of the knowledge of the input signal.

In our case, due to operational constraints we are planning to not be able to estimate the input signal radiance. However, we will fix strong requirements regarding the test site: it has to be uniformed, stable and Lambertien.

So that, method should be operated for different suitable test sites (Snow, desert, water…) and it will be performed on a large sample of data products to make more consistent statistical results.

Main objective of this activity is to discern and quantify the noise in lines from the noise in column.

In a short term, basic statistical measurements (mean, standard deviation) will be output. SNR calculation in the Fast Fourrier domain will be proposed as well.

For calculating the “line noise” we applied a mono-dimensional discrete Fourier transform to each line pixel mean. For calculating the “column noise” we applied a mono-dimensional discrete Fourier transform to each column pixel mean.

4.3.3.3 Team

GAEL Consultant.

4.3.3.4 Output

SNR in line, column and for the image.

4.3.3.5 Schedule

L+8: Consolidated verification report – end of commissioning phase.

4.3.3.6 Working data

Data from Lybia , Antartica, US and Water test site are suitable.

Working data are similar to the ones used for relative calibration activities.

Sensor	Product level	Format	Target zone	Acquisition date
PRISM	1B1	CEOS		
AVNIR-2	1B1	CEOS		

4.3.3.7 Reference data

No reference data

4.3.3.8 Specifications

PRISM (>70), AVNIR-2 (>200).

4.3.3.9 Tools

SNR and statistics tool embedded in ALOS expert tool will be used.

5 PHASE C: CALIBRATION / VALIDATION

5.1 Introduction

The phase C is dedicated to:

- Consolidate results phase B,
- Assess PRISM/AVNIR-2 sensor performance working with physical measures and provide quantitative measure on detector response and calibration quality.
- To initiate long term monitoring of product quality

For a given spectral band; the calibration gain coefficient is used to convert image digital number outputs from the instrument to radiance at sensor aperture.

Absolute calibration activities based on cross and vicarious calibration method will enable to provide an estimate of these calibration coefficients, that will be compared to the pre flight ones such as defined by JAXA.

5.2 Absolute calibration

5.2.1 Sensor inter comparison – Landsat TM-ETM+ / ALOS AVNIR-2

5.2.1.1 Purpose

Validation item will be carrying on AVNIR-2 sensor. Method will lead to determination of absolute calibration coefficients by comparison with those of TM and ETM+ sensors respectively on board Landsat 5 and Landsat 7.

The ability to detect and quantify changes in the earth's environment and its global energy balance depends on satellite sensors that can provide calibrated, consistent measurements of the earth's surface features. It is necessary and a requirement to achieve consistency in interpretation of image data acquired by different sensors. A critical step in this process is to put image data from subsequent generations of sensors onto a common radiometric scale. To evaluate ALOS utility in this role, image pairs from the ALOS AVNIR-2 and L5 TM/L7 ETM+ sensors will be compared.

5.2.1.2 Method

Method for this cross calibration experiment will be similar to the one followed during the cross calibration between EO-ALI sensor and Landsat ETM+ sensor [RD-12]. The approach involves comparison of nearly simultaneous surface observations based on image statistics from large common areas observed by the two sensors.

All computations and comparisons are performed from TOA radiance measurements and/or reflectance measurements. A reduction in between-scene variability can be achieved through normalization for solar irradiance by converting the spectral radiance to a planetary or exoatmospheric TOA reflectance.

When comparing images from different sensors, there are two advantages to using reflectance instead of radiances. First, the cosine effect of different solar zenith angles due to the time difference between data acquisitions can be removed, second, it compensates for different values of the exoatmospheric solar irradiances arising from spectral band differences

5.2.1.3 Team

Gyanesh Chander (SAIC/EROS/USGS), Marc Bouvet (ESA / ESTEC), Sebastien Saunier (GAEL)

5.2.1.4 Output

Report on Absolute gain coefficients.

5.2.1.5 Schedule

L+1Y: Consolidated verification report – end of commissioning phase.

5.2.1.6 Working data

The test sites used for sensor calibration of the solar reflective bands are primarily located in desert regions. These regions are used for several reasons. First, these sites exhibit high surface reflectance, which decreases uncertainties in the calibration. Second, the low probability of cloud coverage improves the chances of the sensor imaging the test site at the time of overpass. In addition, the low aerosol loading typical of these regions decreases uncertainties due to the atmospheric characterization[5].

AVNIR-2 L1B1 product level is required.

AVNIR-2 data acquired over La Crau, Lybia and US test sites. Coincident TM/ETM+ and AVNIR-2 acquisitions remain unknown for La Crau and US test sites. However, plan for Lybia site is available and acquisition dates are listed in table just here after:

Libya		
Path 181 / Row 40		
L5 TM	**L7 ETM+**	**AVNIR-2**
29/04/2006		
		30/04/2006
		06/05/2006
	07/05/2006	
15/05/2006		15/05/2006
		22/05/2006
	23/05/2006	23/05/2006
		15/06/2006
16/06/2006		16/06/2006
		03/07/2006
02/07/2006		
	10/07/2006	10/07/2006
		17/07/2006
18/07/2006		
	26/07/2006	26/07/2006
		27/07/2006
		18/08/2006
19/08/2006		

table 6 - TM / ETM+ and AVNIR-2, coincident scene list for Libya test site.

5.2.1.7 Reference data

Matera station should save TM data acquired over La Crau test site into RCC format.

Because acquisition of Landsat 7data at Matera station are not operational, ETM+ data acquired over La Crau test site should be saved into the Landsat 7 STT recorder for downlink to EROS.

5.2.1.8 Specifications

Target accuracy of the method ??

5.2.1.9 Tools

Data will be available on line through a web map server (GAEL Consultant and/or CAL/VAL portail). Actors will be able to crop the area of interest on working data and convert it into TIFF format. A process will then ensure the download from the server to the prime investigator home directory.

5.2.2 Sensor inter comparison

5.2.2.1 Purpose

Objective is the determination of absolute calibration coefficients in comparing calibration of AVNIR-2 with those of numerous other sensors operating in VIS/NIR channels (MODIS, SEAWIFS, MERIS, PROBA/CHRIS…). One sensor is considered as reference and comparison is performed at Top Of Atmosphere level.

5.2.2.2 Method

Sensor inter comparison procedure over Salar de Uyni relies on the following test site characteristics:

- A surface with a spectrally white reflectance to minimize the radiometric differences due to Relative Spectral Responses
- Located at high altitude to reduce the atmospheric signal
- Lambertian or with a well characterized BRDF to minimize the difference due to illumination and observation geometry
- Spatially homogeneous to reduce the errors due to geolocation errors on the TOA signal
- Large (at least 30 km x 30 km) to reduce the adjacency effects due to neighboring surfaces having differing spectral signature
- Flat to avoid shadowing effects affecting the reflective properties

Identical and reciprocal geometries between AVNIR-2 and other sensors will be looked for. These, if identified, should enable direct comparisons of instruments calibration (after correction for differences in relative spectral response).

More likely, we will consider that pointing angle will remain constant (0) all over the AVNIR nadir view scenes. So that conditions related to identical and reciprocal geometries between AVNIR-2 sensor and the reference one will only be constraint by the sun elevation angle.

In case no geometrical match between AVNIR-2 and other sensors is identified, the Top Of Atmosphere (TOA) signal of AVNIR-2 bands will be simulated from the data of reference sensor in accounting for directional effects, atmospheric conditions, and spectral discrepancies. The use of PARASOL Bidirectional Reflectance Directional Function (BRDF) data (6km resolution) is planned for accounting for directional effects.

After atmospheric corrections of TOA reflectance of reference sensor to surface reflectance and spectral resampling, a radiative transfer code will enable to simulate TOA signal in AVNIR-2 bands.

Output of the method will be based on the comparison between the TOA data from AVNIR-2 sensor and the simulated ones.

Regarding test site specificities, salt crust inherit to test site could influence results when trying to qualified a ten - meter instrument resolution.

5.2.2.3 Team

Marc Bouvet (ESA / ESTEC)

5.2.2.4 Output

Target accuracy of absolute gain estimate should be about +/- 10%. Results will address radiometric performance of the four AVNIR-2 spectral bands.

5.2.2.5 Schedule

L+1Y: Consolidated verification report – end of commissioning phase.

5.2.2.6 Working data

First working data over Salar de Uyni test site are listed in table just here after:

Sensor	Product level	Format	Target zone	Acquisition date
AVNIR-2	1B2R	CEOS	Salar	26/05/2006
AVNIR-2	1B2R	CEOS	Salar	06/05/2006
AVNIR-2	1B2R	CEOS	Salar	22/07/2006

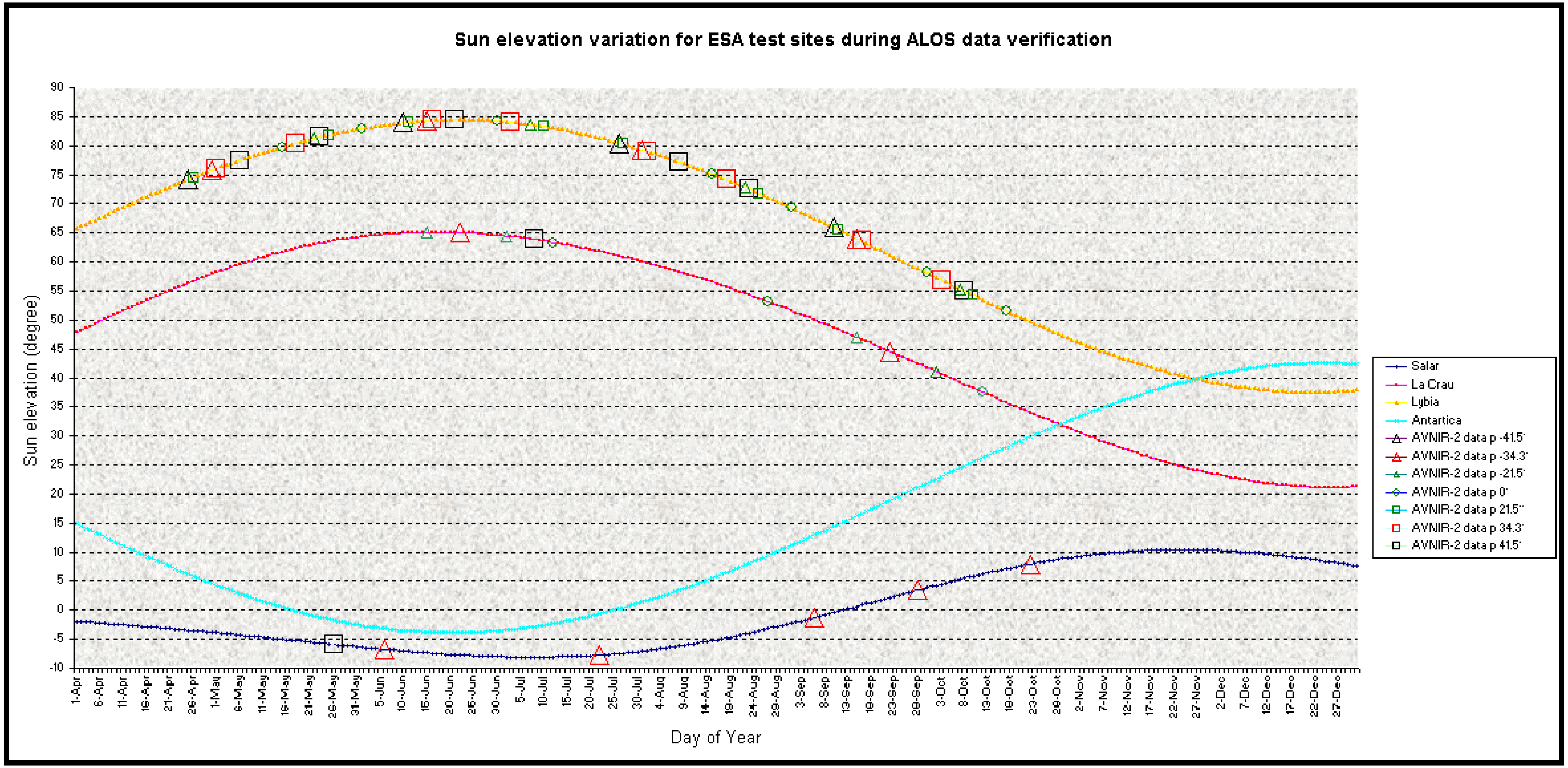


fig. 9 - Variation of Sun elevation (10h30 UT) over radiometric calibration test sites.

5.2.2.7 Reference data

Such as detailed in the methodology two kinds of reference data are required:

- Data for cross calibration; Meris, Modis, Proba/Chris; Landsat, has to be either from coincident satellite path or from path for which identical and reciprocal geometry conditions are verified,
- Data as input parameters for applying atmospheric model in forward mode.

5.2.2.8 Specifications

5.2.2.9 Tools

Data will be available on line through a web map server (GAEL Consultant and/or CAL/VAL portail). Actors will be able to crop the area of interest on working data and convert it into TIFF format. A process will then ensure the download from the server to the prime investigator home directory.

5.2.3 Vicarious calibration

5.2.3.1 Purpose

Main objective is the determination of absolute calibration coefficients of AVNIR-2 spectral bands using ground-based surface reflectance measurements.

5.2.3.2 Method

Purpose of the method is to establish a link between a radiance simulated on basis of ground reflectance measurements and the at sensor radiance such as given by calibrated product.

The method consists in the following steps:

1. Ground based surface reflectance measurements of the La Crau test site will be routinely recorded during moth of June and July 2006.
2. Ground and surface data are used in a radiative transfer code operating in forward mode (6s),
3. TOA reflectance results are output from the atmospheric model and are compared to values extracted from AVNIR-2 data.

The instrument for collect of ground surface reflectance measurements is a CIMEL CE 318N designed by Richard Santer belonging to ESA/ESTEC and used by Marc Bouvet.

It is an automatic ground based radiometer devoted to the characterization of the aerosols. The optical part is composed by a filter wheel and two collimator (“SUN” and “SKY”) of respectively 1° and 3° field of view associated to two silicium detectors.

Regarding spectral configuration, 8 filters are onboard on the device; three filters, 550 nm, 670nm, 870 nm, 10nm wide to be as close as possible of SPOT HRV bands, two filters, 440nm (10nm wide) and 1600nm (50nm wide) to correspond to VEGETATION bands; two filters (10nm wide) are used for describing water vapor content (937 nm and 1020 nm), the last filter (380nm, 10 nm wide) has been introduced for supporting calibration regarding Raleygh scattering.

5.2.3.3 Team

Marc Bouvet (ESA / ESTEC), Philippe GORYL (ESA / ESRIN).

5.2.3.4 Output

Average vicarious gains given with an accuracy of 5 %.

5.2.3.5 Schedule

L+1Y: Consolidated verification report – end of commissioning phase.

5.2.3.6 Working data

AVNIR-2 data over La Crau test site.

Campaign is planned to occur between June beginning and July ending – Acquisition date of product to be evaluated is depending on the date of the campaign.

5.2.3.7 Reference data

Fields measurements - Campaign performed with CIMEL device.

5.2.3.8 Specifications

5.2.3.9 Tools

Data will be available on line through a web map server (GAEL Consultant and/or CAL/VAL portail). Actors will be able to crop the area of interest on working data and convert it into TIFF format. A process will then ensure the download from the server to the prime investigator home directory.

5.3 Geometric calibration

5.3.1 Elevation performance

5.3.1.1 Purpose

Elevation performance is dedicated to evaluate the z-accuracy of the absolute digital elevation model extracted from PRISM data.

5.3.1.2 Method

Process for computing the relative DEM can be summarized as follow:

- Image orientation using art least 30 GCPs,
- Computation of stereo mode,
- Extraction of elevation parallaxes,
- Computation of XYZ cartographic coordinates,
- Representation of the DEM with the generation of a regular grid.

The DEM computation will lead to the evaluation of

- Stereo model computation,
- Elevation extraction results.

5.3.1.3 Team

ETH

5.3.1.4 Output

Report should contain evaluation on the sensor model computation and on the elevation model extraction results. Main items for sensor model computation should be:

- RMS from image orientation procedure of image triplet, number of GCPs (planimetric error)
- Results consistency of bundle adjustment process,
- Error propagation tracking and compensation,
- Impact of elevation extrapolation.

Main items for the evaluation of elevation results should be:

- Qualitative and visual inspection of the full DEM, inspecting mismatch areas and blunders, and appreciating how the DEM reproduces terrain relief, cartographic and topographic features (mountains, valley, small details …
- Statistical evaluation of the DEM when comparing z results with elevation of reference data. Results of the assessment shall be grouped according to area and coverage type. Results of the assessment shall be grouped according to the altitude. The DEM accuracy at 0 metre is generally different from the DEM accuracy at 2000 metre.

5.3.1.5 Schedule

L+1Y: Consolidated verification report – end of commissioning phase.

5.3.1.6 Working data

Product level L1B1 Data from Piemont test site (Acquisition date unknown).

5.3.1.7 Reference data

SPOT BD 3D over part of geographical area delimited by Piemont test site area. Area boundary should be defined as soon as possible.

5.3.1.8 Tools

SAT-PP - ETH tool.

6 EQUIPMENT TARGET ZONE AND FLIGHT PLAN

6.1.1 Equipment-reference data

6.1.1.1 Image data

SPOT 4 data

Location accuracy specifications for standard SPOT-4 HRVIR product are following ones ([RD-8]):

	Across track	Along track	Global
Mean	189	23	190
Std	204	149	253
Max/90%	278	151	316

table 7 - SPOT 4 HRVIR location accuracy.

Thanks to a rigorous sensor model, the geodetic location of product is corrected. Reference data used for this procedure are cartographic map with a scale of 1/25 000.

The correction makes product location accuracy around 10 metres.

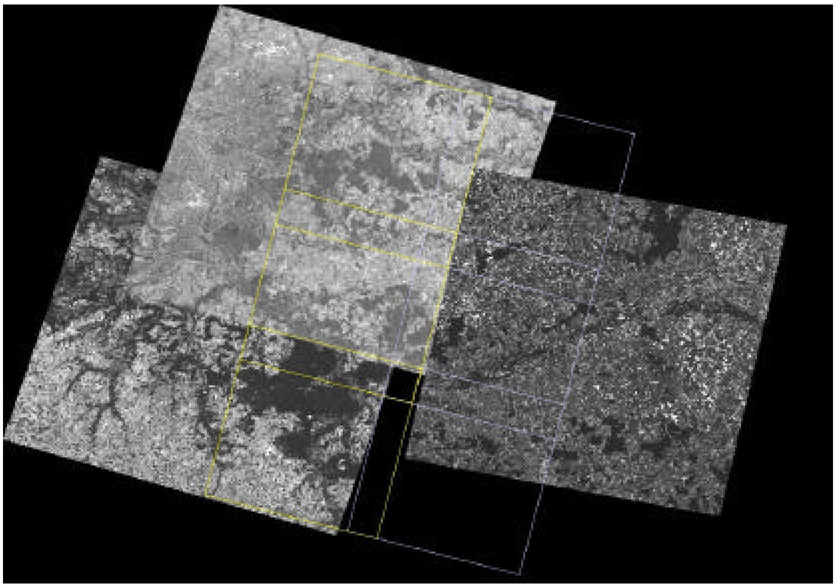


fig. 10 - SPOT 4 data quick look overlaid with PRISM scene footprints (RSP 331).

SPOT 5 data

Location accuracy specifications for standard SPOT-5 HRG product are following ones ([RD-8]):

	Across track	Along track	Global
Mean	-1	-2	2
Std	10	13	16
RMS	10	13	16
Max/90%	17	21	27

table 8 - SPOT 5 HRS location accuracy (aft sept 2003).

SPOT –5 rigorous sensor model works according to two modes; a standard mode for scene acquired after September of Year 2003, and correction mode for scene acquired before September of Year 2003.

The correction mode has been implemented according to technical note provided by SPOT image. Because of bad initialization of the on board stat tracker's relativist compensation location performance of product acquired before September of Year 2003 are less accurate. So that, a correction model has been proposed to recover the initial geodetic location such as defined by specifications.

With a post processing similar to the one used for SPOT 4 data, location accuracy of SPOT 5 data reach 2.5 m.

IKONOS

IKONOS data, spatial resolution of 1-meter, corrected with RPC model, offers a geodetic location accuracy from 0.5 metre uo to 2 metres RMS.

Aerial data

Bordeaux private data cannot be disseminated.

6.1.1.2 Elevation data

DEM 50 m resolution

The digital elevation reference data is extracted from topographic map (1/10 000) with a 50.0 m resolution. The accuracy of z-axis is less than 5 metres.. DEM area of coverage is illustrated in figure just here below (fig. 11).

The DEM includes vegetation, hilly and mountainous landscapes with valleys and lakes. Altitudes is spanning from 10 m up to 4000 m.

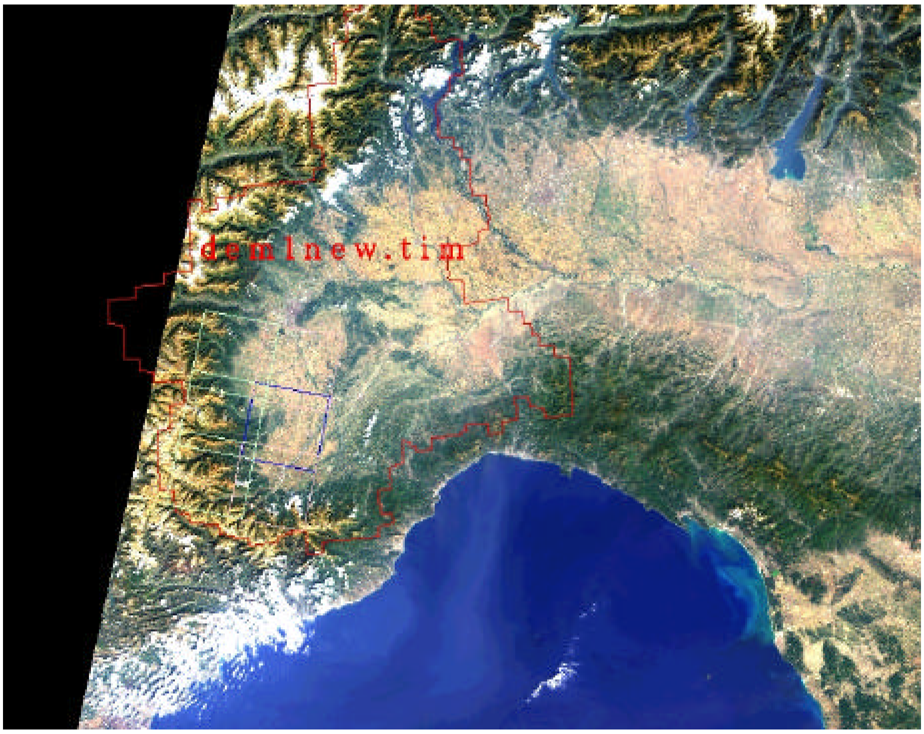


fig. 11 - DEM 50 m resolution boundaries (red) for Piemont test site superimposed over MERIS-FR image.

SPOT BD 3D

The whole of reference data relate to digital elevation model will be managed by ETH.

6.1.1.3 Ground Control Points

<u>Collect of GCP</u>

Ground control will be surveyed by precise DGPS technique and stored in geographic coordinates (Ellipsoid WGS 84).

For the assessment of product geodetic accuracy, point coordinates will be converted into UTM coordinates.

<u>GCPs population</u>

All of GCPs are stored, documented and maintained. The GCP population is managed and used accordingly.

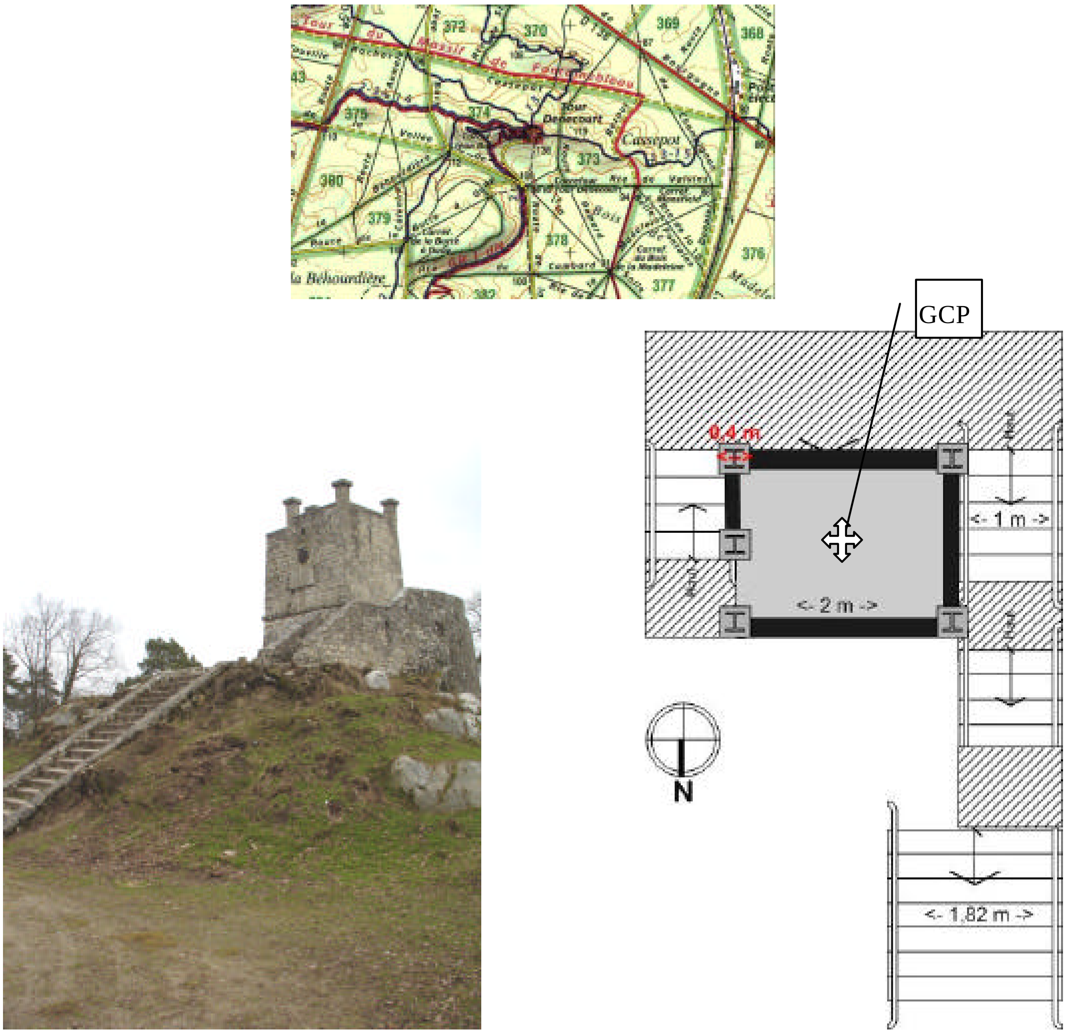


fig. 12 - GCPs population; cartographic map, schema, photo.

<u>Sharing of GCP</u>

JAXA is expressing its requirement for sharing GCPs used as basis for geometric validation. On both side methodology will differ slightly and for the most critical points to be addressed such as PRISM inner CCD orientation characterization, GAEL Consultant used an automatic approach based on statistical correlations through DISPAR process. Obviously, in this case, sharing GCPs maybe constraints since GCP is located on pixel for which confidence value is above a given threshold.

However, for validation exclusively focused on absolute location accuracy assessment, a GCPs sharing process can be conceived and proposed to JAXA.

6.1.2 Target zone definition

Test sites are mainly spread over Europe and Africa continents. Test sites are strongly associated to the quality item they aim at validating.

Test sites for radiometric and quality image activities are mainly located over well known calibration sites; La Crau, Salon de Provence and Lybia desert. Some US test (Railroads Valley, Whitesands…) have been added and Salar de Uyni test site (Bolivie) have been added for activities related to absolute calibration, (phase C).

Regarding geometric verification, test sites location is strongly related to item to be evaluated (pointing stability over 100s, pointing stability with 5s …).

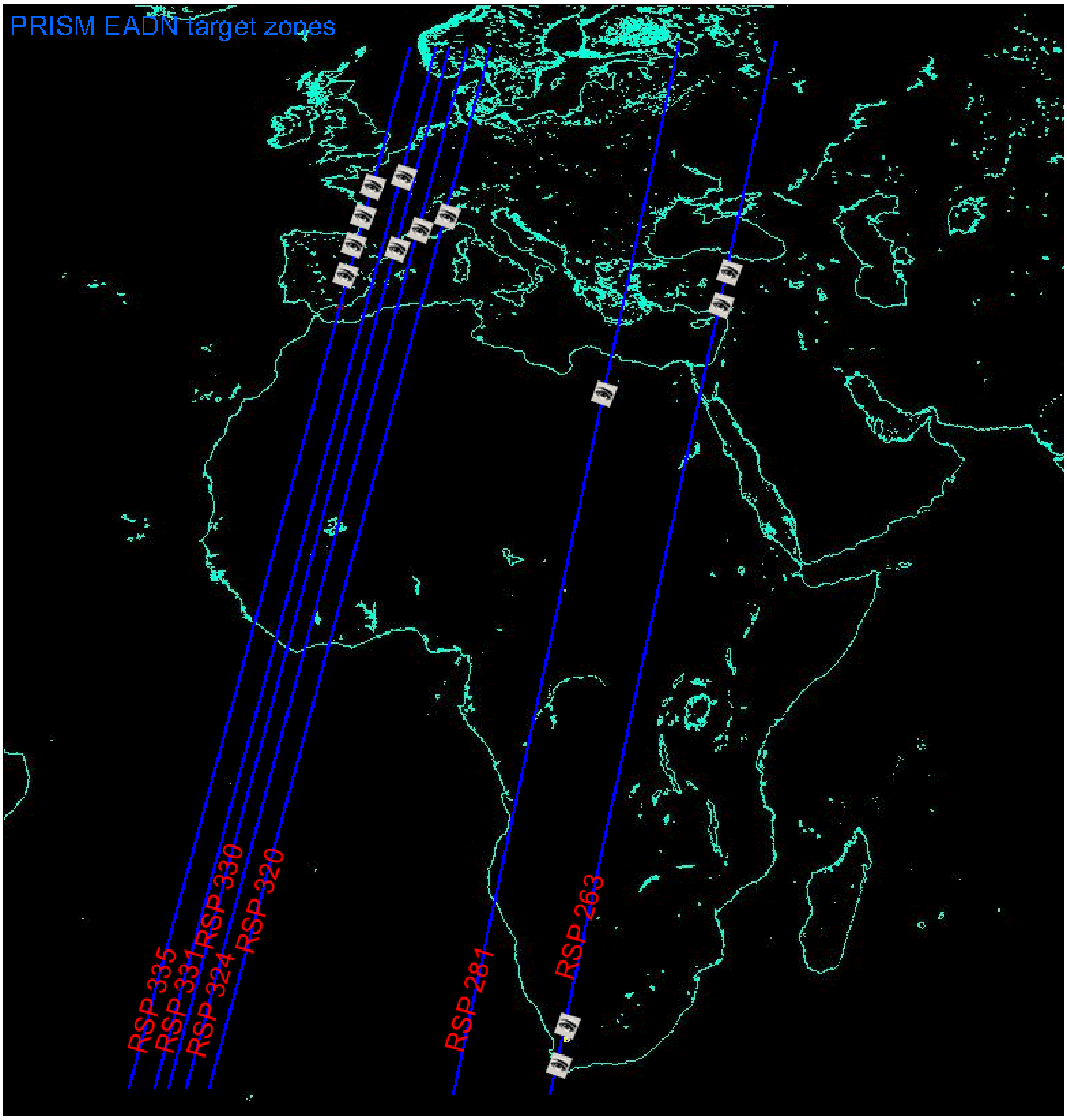


fig. 13 - Test sites – overview.

6.1.2.1 Test sites for activities related to geometric calibration

Test site		Center or UL	
		Lat (dd)	Lon (dd)
1	Orleans (France)	47,52	0,55
2	Bordeaux (France)	44,83	-0,56
3	Spain 1 (Spain)	42,19	-1,54
4	Spain 2 (Spain)	39,44	-2,38
5	Sivas (Turkey)	39,74	36,17
6	Tarsus (Turkey)	36,98	35,64
7	Lake Prieska (South Africa)	-31,54	19,61
8	Cape Town (South Africa)	-34,03	18,39
12	Fontainebleau (France)	48,420	2,680
13	Champs/Marne (France)	48,870	2,300

table 9 - Test sites for geometric quality verification.

6.1.2.2 Test sites for activities related to evaluation of DEM accuracy

Test site		Center or UL	
		Lat (dd)	Lon (dd)
14	Piemont (Italy)	44,500	7,300

table 10 - Test sites for evaluation of PRISM DEM accuracy.

6.1.2.3 Test sites for activities related to radiometric calibration

Test site		Center or UL Lat (dd)	Center or UL Lon (dd)
10	Lybie(180_40) (Libyan)	28,90	23,75
11	La Crau (France)	43,51	4,87
13	Salar de Uyni (Bolivia)	-20,200	-67,600
17	Deminn (Germany)	53,920	13,120
18	Whitesands (US)	32,500	-106,200
19	Ivanpahplaya (US)	35,500	-115,400
20	LunarLake (US)	38,400	-116,200
21	Railroad Valley (US)	38,500	-115,690
22	Ely (US)	38,330	-115,930
22	Fairbanks (Alaska)	64,860	-147,830
23	Antartica (Antartica)	-69,750	39,550
24	Antartica (Fairbanks)	-69,000	39,500
25	Moby	20,820	-156,980
26	San Nicolas	33,250	-119,480
27	South Pacific	-30,000	-100,000

table 11 - Test sites for verification of radiometric calibration..

US, Alaska and Antartica data are additional; they are acquired and processed by ALOS data node which are different from the European.

6.1.2.4 Test sites for activities related to image quality

Test site		Center or UL Lat (dd)	Center or UL Lon (dd)
11	La Crau (France)	43,51	4,87
15	Salon (France)	43,514	5,184
16	Pirenne (France)	43,385	1,290

table 12 -Test sites for verification of image quality.

table 13 - Test sites for verification of radiometric calibration quality.

6.1.3 Flight plan and validation activities

Acquisition date	site	Validation activity	PHASE
22/04/2006	Sivas-Tarsus		
24/04/2006	Sivas-Tarsus		
25/04/2006	Lybie		
26/04/2006	Lybie		
29/04/2006	Sivas-Tarsus		
30/04/2006	Lybie		
01/05/2006	Lybie		
02/05/2006	Sivas-Tarsus		
05/05/2006	Sivas-Tarsus		
06/05/2006	Lybie		
09/05/2006	Spa1-Spa2		
12/05/2006	Sivas-Tarsus		
15/05/2006	Lybie		
18/05/2006	Lybie		
22/05/2006	Sivas-Tarsus		
22/05/2006	Lybie		PHASE A
23/05/2006	Lybie		
25/05/2006	Lybie		
26/05/2006	Salar		
27/05/2006	Sivas-Tarsus		
29/05/2006	Sivas-Tarsus		
01/06/2006	Lybie		
02/06/2006	Spa1-Spa2		
06/06/2006	Salar		
07/06/2006	Sivas-Tarsus		
09/06/2006	Spa1-Spa2		
09/06/2006	Sivas-Tarsus		
10/06/2006	Lybie		
11/06/2006	Lybie		
14/06/2006	Sivas-Tarsus		
15/06/2006	Lybie		
15/06/2006	La Crau		
16/06/2006	Lybie		
17/06/2006	Sivas-Tarsus		
20/06/2006	Sivas-Tarsus		
21/06/2006	Lybie		
22/06/2006	La Crau		
24/06/2006	Spa1-Spa2		PHASE B/C
26/06/2006	Spa1-Spa2		
27/06/2006	Sivas-Tarsus		
30/06/2006	Lybie		
02/07/2006	La Crau		
03/07/2006	Lybie		
07/07/2006	Sivas-Tarsus		
07/07/2006	Lybie		
08/07/2006	Lybie		
08/07/2006	La Crau		
10/07/2006	Lybie		
12/07/2006	Sivas-Tarsus		
12/07/2006	La Crau		
14/07/2006	Sivas-Tarsus		
18/07/2006	Spa1-Spa2		
22/07/2006	Salar		
23/07/2006	Fontainebleau		
23/07/2006	Sivas-Tarsus		
24/07/2006	Orleans		
25/07/2006	Spa1-Spa2		
25/07/2006	Sivas-Tarsus		

Acquisition date	site	Validation activity	PHASE
26/07/2006	Lybie		PHASE B/C
27/07/2006	Lybie		
28/07/2006	Orleans		
29/07/2006	Paris-Champs		
30/07/2006	Fontainebleau		
30/07/2006	Sivas-Tarsus		
31/07/2006	Lybie		
01/08/2006	Lybie		
02/08/2006	Sivas-Tarsus		
05/08/2006	Sivas-Tarsus		
06/08/2006	Fontainebleau		
06/08/2006	Lybie		
08/08/2006	Fontainebleau		
09/08/2006	Paris-Champs		
09/08/2006	Spa1-Spa2		
11/08/2006	Orleans		
11/08/2006	Spa1-Spa2		
12/08/2006	Paris-Champs		
12/08/2006	Sivas-Tarsus		
15/08/2006	Lybie		
16/08/2006	Fontainebleau		
16/08/2006	Paris-Champs		
17/08/2006	Orleans		
18/08/2006	Lybie		
21/08/2006	Orleans		
22/08/2006	Sivas-Tarsus		
22/08/2006	Lybie		
23/08/2006	Paris-Champs		
23/08/2006	Lybie		
25/08/2006	Paris-Champs		
25/08/2006	Lybie		
27/08/2006	Sivas-Tarsus		
27/08/2006	La Crau		
29/08/2006	Sivas-Tarsus		
30/08/2006	Orleans		
30/08/2006	Spa1-Spa2		
01/09/2006	Lybie		
02/09/2006	Paris-Champs		
02/09/2006	Spa1-Spa2		
03/09/2006	Paris-Champs		
06/09/2006	Salar		
07/09/2006	Sivas-Tarsus		
08/09/2006	Orleans		
09/09/2006	Spa1-Spa2		
09/09/2006	Sivas-Tarsus		
10/09/2006	Lybie		
11/09/2006	Lybie		
12/09/2006	Orleans		
14/09/2006	Sivas-Tarsus		
15/09/2006	Lybie		
15/09/2006	La Crau		
16/09/2006	Lybie		
17/09/2006	Sivas-Tarsus		
20/09/2006	Sivas-Tarsus		

table 14 - AVNIR-2; data acquisition date, ESA site name and associated validation activity.

Acquisition date	site	Validation activity	PHASE
02/05/2006	Sivas-Tarsus		
08/05/2006	Fontainebleau		
15/05/2006	Lybie		
25/05/2006	Paris-Champs		PHASE A
30/05/2006	Orleans		
30/05/2006	Spa1-Spa2		
01/06/2006	Lybie		
11/06/2006	Paris-Champs		
17/06/2006	Sivas-Tarsus		
23/06/2006	Fontainebleau		
04/07/2006	Sivas-Tarsus		PHASE B/C
12/07/2006	La Crau		
15/07/2006	Orleans		
15/07/2006	Spa1-Spa2		
17/07/2006	Lybie		
02/08/2006	Sivas-Tarsus		
08/08/2006	Fontainebleau		
15/08/2006	Lybie		
25/08/2006	Paris-Champs		
27/08/2006	La Crau		
30/08/2006	Orleans		
30/08/2006	Spa1-Spa2		
01/09/2006	Lybie		
11/09/2006	Paris-Champs		
17/09/2006	Sivas-Tarsus		
23/09/2006	Fontainebleau		
04/10/2006	Sivas-Tarsus		
10/10/2006	Fontainebleau		
12/10/2006	La Crau		
15/10/2006	Orleans		
15/10/2006	Spa1-Spa2		
17/10/2006	Lybie		
10/07/2006	Fontainebleau		

table 15 - PRISM; data acquisition date, ESA site name and associated validation activity.

Color Code	
	Radiometric fidelity
	Radiometric fidelity/Image quality
	Image quality
	Geometry; product absolute location
	Stereoscopic capability
	Geometry;Pointing stability - densely study
	Geometry;Pointing stability - along study

table 16 - Color code of validation activity, in table 14 and table 15.

Note:

- 25 AVNIR-2 acquisitions will be operated between the 21/09/2006 and 23/10/2006.
- Stereoscopic capability validation item will be performed on data acquired over Piemont test site. For this area, communication of JAXA regarding acquisition plan is not available, but should be soon.
- A part of image quality validation item will be performed on data acquired over Pirenne and Salon test site, same remark as the previously one can be formulated.
- A part of radiometric validation will be performed for data from non-ESA test sites, PRISM / AVNIR-2 acquisition dates for these areas are still unknown

6.1.4 Tool

6.1.4.1 Useful document and news

Useful documents such as technical documents, implementation plan, progress reports are make available from the following GAEL Consultant webpage (http://www.gael.fr/eoqc/index.php?id=alos).

6.1.4.2 Data distribution

GAEL portal/ ESA CAL/VAL Portal

GAEL has already setup a small map server dedicated to the ALOS Pis, able to distribute subsets of ALOS images according to a selected region of interest. Images distributed in this server will be radiometrically and geometrically pre-processed by GAEL Consultant, in order to be sure that data matches the need of the users. The system aims to makes available PRISM and AVNIR mapped products. The limited charge capacity (2/3 simultaneous connections) makes the system not operational for a larger distribution scope.

For a more operational purpose, ESA and Brockmann-Consult Company have initiated the development of the CAL/VAL portal (http://www.brockmann-consult.de/CalValPortal/).

6.1.4.3 ALOS expert tools

See document GAEL-P224-TCN-001 (Reference [RD-15]) for detailed description of ALOS export tools.

ALOS expert tools will be distributed to prime investigators and some persons belonging to ESA Staff.

APPENDIX A ALOS DATA PRODUCTS AND FORMATS

A.1 Definition of ALOS data products

Common

Level	Definition	Option	Note
Raw	Demodulated bit stream		Packetized

table 17 - Level Definition of Raw Data.

AVNIR-2 – standard products

Level	Definition	Option	Note
0	Frame synchronization and PN decoding of CADUs (Channel Access Data Units) and Reed-Solomon error detection and correction of VCDUs (Virtual Channel Data Units) Extracted mission telemetry, orbit and attitude data are stored on separate files		Separate data files for each VCID
1A	Uncompressed, reconstructed digital counts appended with radiometric calibration coefficients and geometric correction coefficients (appended but not applied)		Separate image files for each band
1B1	Radiometrically calibrated data at sensor input		Separate image files for each band
1B2	Geometrically corrected data Option G: Systematically Geo-coded R: Systematically Geo-referenced D: Correction with coarse DEM (Japan area only) Option G or R is alternative	Map projection Resamplig Pixel spacing	Separate image files for each band

table 18 - Product Level Definition of AVNIR-2 Data Products.

PRISM – standard products

Level	Definition	Option	Note
0	Frame synchronization and PN decoding of CADUs (Channel Access Data Units) and Reed-Solomon error detection and correction of VCDUs (Virtual Channel Data Units) Extracted mission telemetry, orb it and attitude data are stored on separate files.		Separate data files for each VCID

Level	Definition	Option	Note
1A	Uncompressed, reconstructed digital counts appended with radiometric calibration coefficients and geometric correction coefficients (appended but not applied). Individual files for forward, nadir and backward looking data.		Separate image files for each CCD
1B1	Radiometrically calibrated data at sensor input		Separate image files for each CCD
1B2	Geometrically corrected data Option G: Systematically Geo-coded R: Systematically Geo-referenced Option G or R is alternative	Map projection Resampling Pixel spacing	Single image file.

table 19 - Product Level Definition of PRISM Data Products.

High level and research products

Sensor	Definition	Note
AVNIR-2	Ortho-rectified image	High level products
PRISM	Digital elevation model and ortho-rectified image	High level products
PRIM & AVNIR-2	Land Use Land Cover(LULC) classification and vegetation, Albedo, Mountain and Glacier map. Pan sharpened image using AVNIR-2 and PRISM, and scene DEM by PRISM.	Research products

table 20 - High level and research products

A.2 Format definition

ALOS product based on PRISM and AVNIR-2 data will be processed into CEOS and Earthnet format.

http://sppd.tksc.jaxa.jp/Alos/

APPENDIX B MISSION OPERATIONS BACKGROUND

B.1 Data node organization

Recognizing that the total data produced by the ALOS sensors on a daily basis (1 Terabyte) is beyond the capabilities of any single agency or country to attempt to manage, but that there was world-wide interest in the use of that data, JAXA proposed the concept of the ALOS Data Nodes with local archives, as a mechanism for sharing the processing and distribution load.

To promote international data use and operational use of ALOS data, data node organizations will be appointed for different regions world-wide. The data node organizations will receive ALOS Level 0 data from JAXA and generate and distribute products to regional users in accordance with their agreement with JAXA. And also the data node organizations will be able to receive ALOS data via X band stations (regarded as Foreign Ground Station in this project) by agreement with JAXA.

The benefits of the ADN concept are:

- increased capacity for ALOS Data processing and archiving;
- accelerated scientific and practical use of ALOS data;
- increased international co-operation including on validation and science study activities;
- enhanced service for potential users of ALOS data.

The ADN concept is envisaged as a new model for the provision of Earth observation missions, bringing mutual benefits for both the funding agency and the global partners involved in the distribution and application of the data.

The current concept envisages 4 Nodes world-wide in order to achieve the necessary global coverage as described above.

In addition, GISTDA of Thailand was accepted to the ADN scheme as a 'sub-Node' within Asia, including for direct reception of ALOS data to promote ALOS data utilization.

- Data Node in charge of Asian Region	: JAXA
- Data Node in charge of European and African Region	: ESA
- Data Node in charge of North and South American Region	: NOAA/ASF
- Data Node in charge of Oceania Region	: GA

Each Node is associated with a geographical zone - which defines the physical location of the ALOS users which the Node has a mandate to support as an ADN partner.

APPENDIX C DEFINITION OF THE ALOS OBSERVATION ORBIT

Definitions of longitude of ascending node and path number about the ALOS observation orbit are shown below.

C.1 Observation Orbit of ALOS

The observation orbit of ALOS is as follows:

(1) Type	Sun-Synchronous Subrecurrent
(2) Local Time at DN	10:30 AM ± 15 min.
(3) Revolution per day	14+27/46 rev./day
(4) Recurrent Period	46 days
(5) Altitude	691.65 km (above equator)
(6) Inclination	98.16 degree
(7) Orbital Period	98.7 min
(8) Revolution per recurrent	671 rev.
(9) Longitude Repeatability	+/-2.5km (cross track direction)

C.2 Definition of Path Number

The definition of the path number is given below.

It is the number which is assigned in order for the ground track of the satellite orbit, and the unit is one orbit until an ascending node through the North Pole and the South Pole from an ascending node. The ALOS path number is 1 to 671.

The relationship between the path number and the accumulated orbit number (orbit) which is assigned by the time series as a unit from an ascending node to the next ascending node is given by follows.

The orbit which passes the first ascending node after launch is orbit = 1,

$$\text{path} = [46 * \text{orbit} + \alpha] \bmod 671 + 1$$

where, α is the value (integer) determined by the injected orbit.

C.3 Numbering of Path Number

The numbering rules of the path number are:

(1) The path number starts at the ascending node, and numbering is westward for descending orbits.

(2) Match the path over central Tokyo with the path of ADEOS.

(3) Area between the descending orbits of path 671 and path 1 is not located over the main continents.

According to (3), when the ascending node of path 671 is defined as around 0 degree of East Longitude, this condition can be satisfied for the main continents except polar regions.

The following variables are defined in order to calculate how to attach the path number which fulfills the above-mentioned conditions.

path : path number (1to 671)

n : revolution per recurrent (671)

I : 180 – satellite orbit inclination (81.84 degree)

γ : argument of latitude (elongation along the orbit to the satellite from the ascending node)

λ_{A0} : longitude of the ascending node of path 671

T : orbital period (98.7 min)

W_e : angular velocity of the earth rotation in the inertial system (0.25 degree/min)

W : satellite angular velocity around the center of the earth (3.6467 degree/min)

a : equatorial radius of the earth (6378.137 km : WGS-84)

b : polar radius of the earth (6356.752 km : WGS-84)

λ_A : longitude of the ascending node of the sub-satellite point

ϕ_{C0} : geocentric latitude of the sub-satellite point

ϕ_{D0} : geodetic latitude of the sub-satellite point

θ_0 : angular difference between the ascending node longitude and sub-satellite longitude

λ_0 : geodetic longitude of the sub-satellite point

where, the following relations exists between each variable:

$\lambda_A = \lambda_{A0} - 360.0° * path / n$		(1)
$\sin \phi_{C0} = \sin \gamma * \sin I$		(2)
$\tan \phi_{D0} = (a / b)^2 * \tan \phi_{C0}$		(3)
$\theta_0 = \tan^{-1}(\cos I * \tan \gamma)$	$(0° = \gamma < 90°)$	(4)
$\theta_0 = 90°$	$(\gamma = 90°)$	
$\theta_0 = \tan^{-1}(\cos I * \tan \gamma) + 180.0°$	$(90° < \gamma < 270°)$	
$\theta_0 = 270°$	$(\gamma = 270°)$	
$\theta_0 = \tan^{-1}(\cos I * \tan \gamma) + 360.0°$	$(270° < \gamma < 360°)$	
$\lambda_0 = \lambda_A - \theta_0 - W_e * \gamma / W$		(5)

λ_A; the longitude of the ascending node of the path which passes through the Tokyo central part (139.745° of East Longitude, 35.654° of North Latitude) is given by follows:

$\phi_{D0} = 35.654°$

From equation (3), $\phi_{C0} = 35.472°$

From $90 < \gamma < 270$ and equation (2), $\gamma = 144.11°$

From equation (4), $\theta_0 = 174.136°$

From $\lambda_0 = 139.745°$ and equation (5), $\lambda_A = 323.760° = -36.240°$

When the path which passes through the Tokyo central part is defined as path 68, the longitude of the ascending node of path 671 is near 0 degree of East Longitude from equation (1). In this condition, the longitude of the ascending node of path 671is as follows:

$\lambda_{A0} = 360.243° = 0.243$

APPENDIX D PRISM / AVNIR-2, TECHNICAL SPECIFICATIONS

D.1 PRISM / AVNIR-2 spectral sensitivity

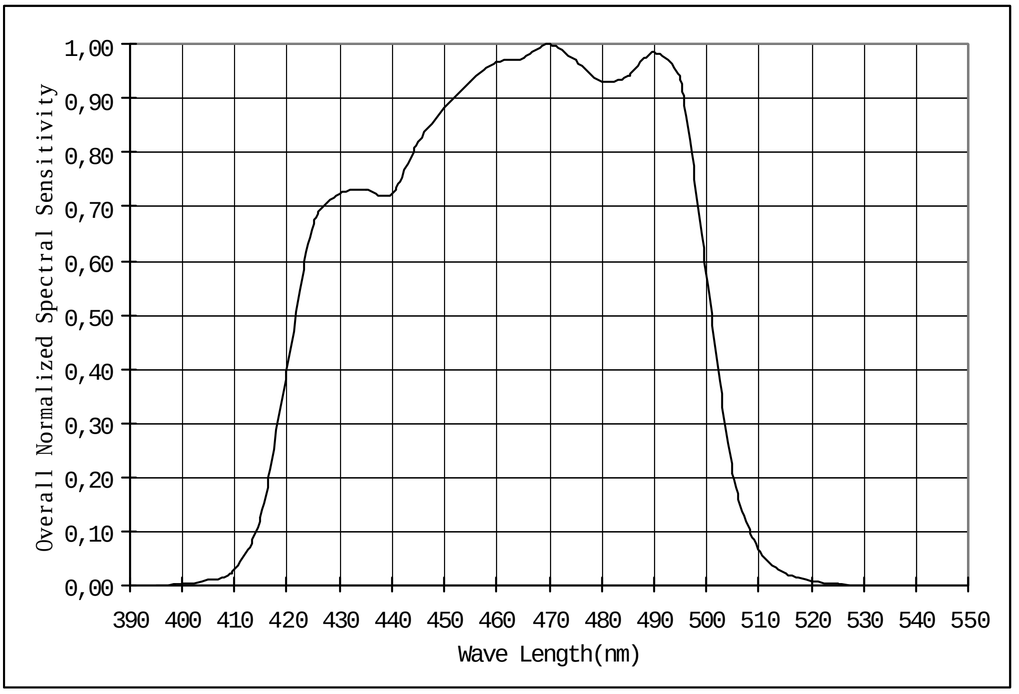


fig. 14 - AVNIR-2, spectral sensitivity of band 1.

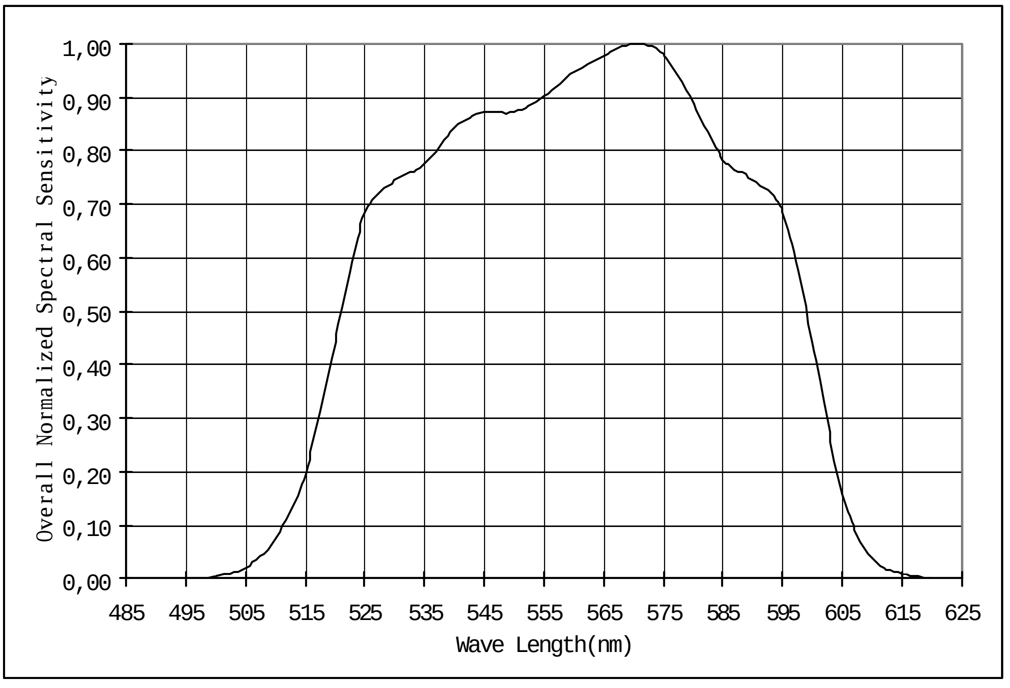


fig. 15 - AVNIR-2, spectral sensitivity of band 2.

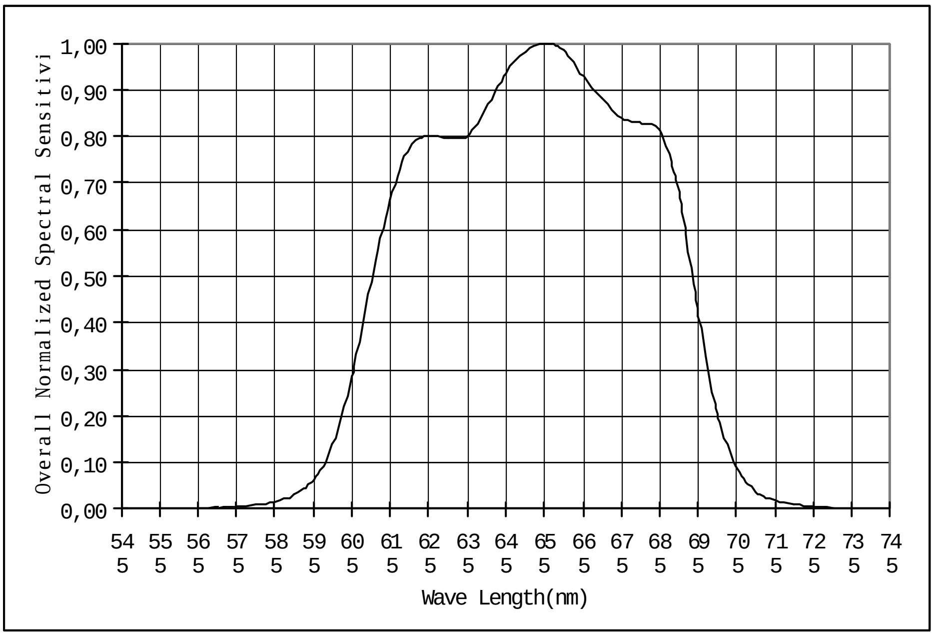


fig. 16 - AVNIR-2, spectral sensitivity of band 3.

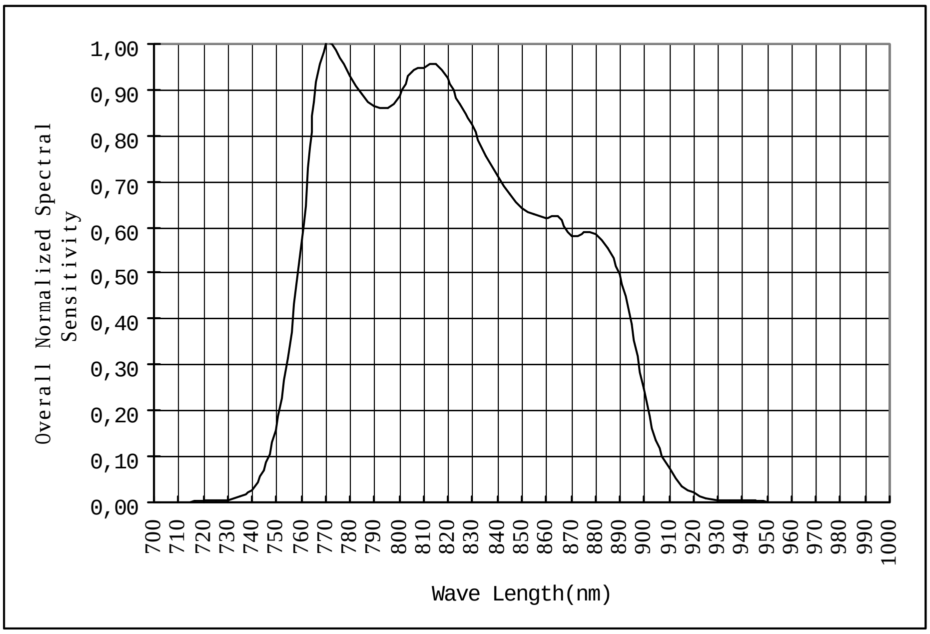


fig. 17 - AVNIR-2, spectral sensitivity of band 4.

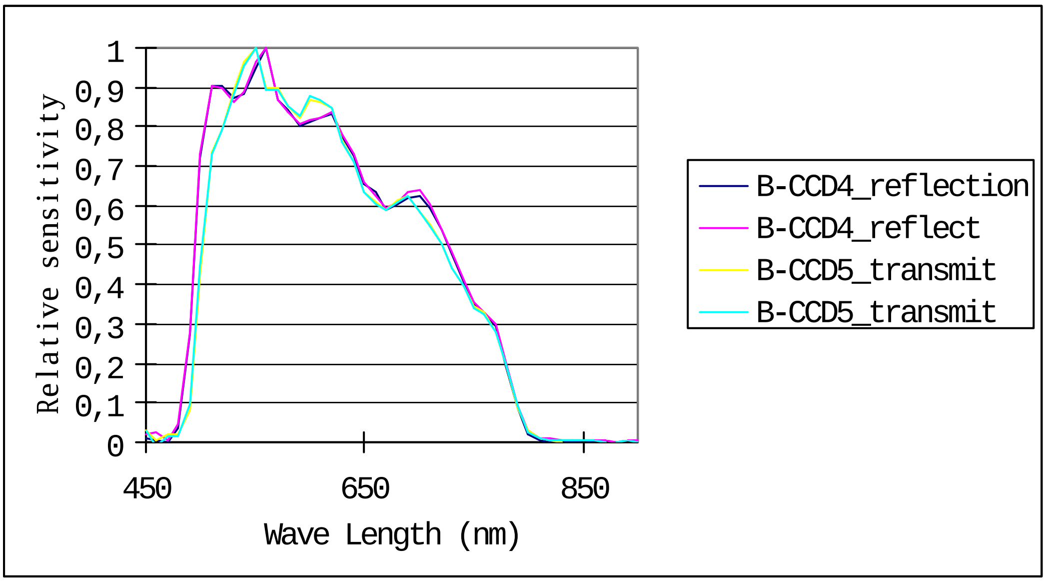


fig. 18 - PRISM, spectral sensitivity of nadir camera.

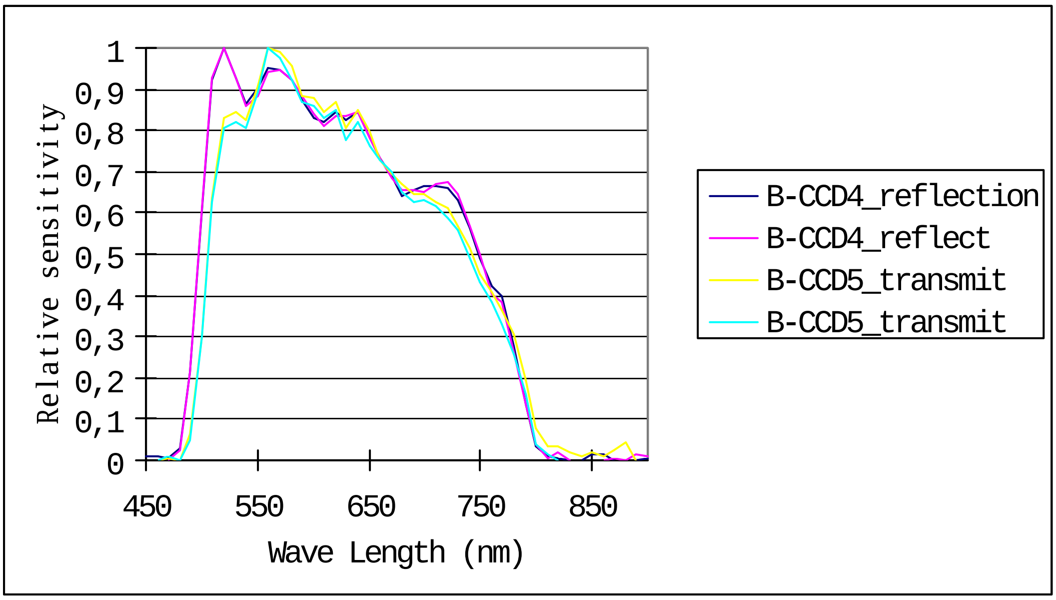


fig. 19 - PRISM, spectral sensitivity of forward camera.

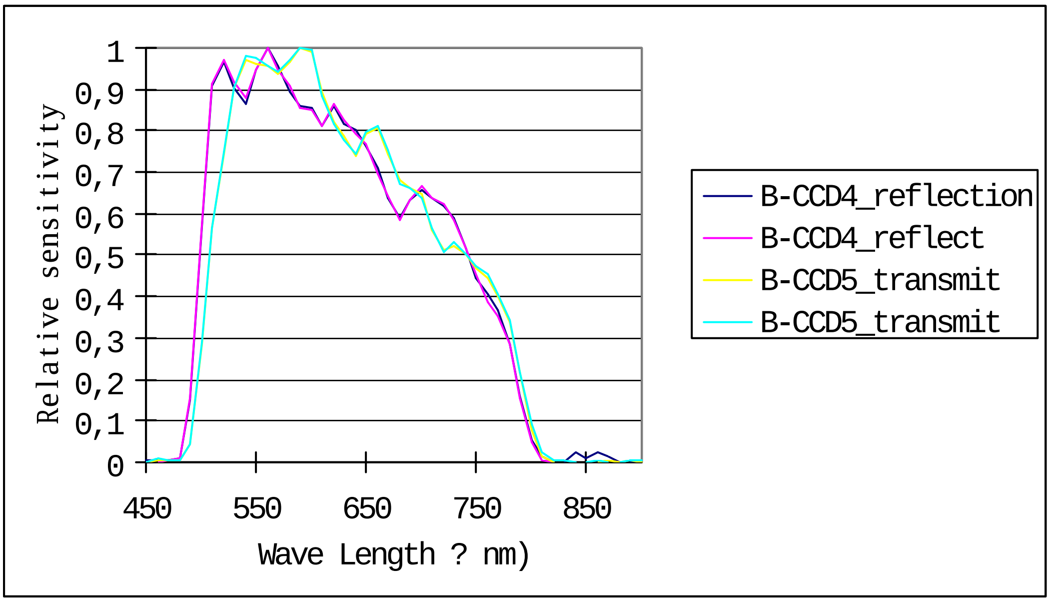


fig. 20 - PRISM, spectral sensitivity of forward camera.

D.2 On ground MTF

PRISM

SRU-F			
		MTF	
		HMTF(AT)	VMTF(CT)
P9	CCD8	0,215	0,288
P8	CCD8	0,226	0,284
P8	CCD7	0,229	0,285
P7	CCD7	0,238	0,294
P7	CCD6	0,215	0,273
P6	CCD6	0,233	0,293
P6	CCD5	0,234	0,295
P5	CCD5	0,209	0,298
P5	CCD4	0,229	0,279
P4	CCD4	0,229	0,276
P4	CCD3	0,236	0,271
P3	CCD3	0,227	0,27
P3	CCD2	0,231	0,265
P2	CCD2	0,23	0,266
P2	CCD1	0,221	0,276
P1	CCD1	0,228	0,25
	mean	0,226875	0,278938

SRU-B		
	MTF	
	HMTF(AT)	VMTF(CT)
CCD8	0,229	0,269
CCD8	0,236	0,293
CCD7	0,241	0,278
CCD7	0,238	0,288
CCD6	0,228	0,286
CCD6	0,236	0,298
CCD5	0,24	0,295
CCD5	0,239	0,288
CCD4	0,238	0,303
CCD4	0,236	0,291
CCD3	0,235	0,305
CCD3	0,228	0,293
CCD2	0,226	0,287
CCD2	0,223	0,282
CCD1	0,235	0,284
CCD1	0,232	0,269
mean	0,23375	0,288063

SRU-N			
		MTF	
		HMTF(AT)	VMTF(CT)
P7	CCD1	0,216	0,283
P6	CCD1	0,235	0,276
P6	CCD2	0,223	0,27
P5	CCD2	0,232	0,258
P5	CCD3	0,24	0,244
P4	CCD3	0,221	0,253
P4	CCD4	0,222	0,229
P3	CCD4	0,207	0,218
P3	CCD5	0,204	0,205
P2	CCD5	0,215	0,205
P2	CCD6	0,207	0,207
P1	CCD6	0,21	0,225
	mean	0,219333	0,239417

AVNIR-2

band		specification	estimated MTF*	exp. Coefficient
1	AT	>0.25	>0.353	0,527
	CT		>0.539	
2	AT		>0.335	0,534
	CT		>0.505	
3	AT		>0.357	0,345
	CT		>0.480	
4	AT	>0.20	>0.242	0,635
	CT		>0.468	
* based on laboratory test				