GAEL Consultant

reference	GAEL-P237-DOC-005
issue	1 revision 0
date	2006-12-20
page	1 of 22

ALOS CAL/VAL

PRISM Consolidated Verification Report

	name *company*	*date* *signature*
prepared by	Sébastien Saunier *EOQC project manager* GAEL Consultant *sebastien.saunier@gael.fr*	
with	contribution of ESA Prime Investigators	
and	Aboubakar Mambimba *Cartography manager* GAEL Consultant *aboubakar.mambimba@gael.fr*	
authorized by	Christophe DEMANGE *General Manager* GAEL Consultant *christophe.demange@gael.fr*	
approved by	Philippe GORYL *Project manager* ESA-ESRIN *Philippe.Goryl@esa.int*	

DISTRIBUTION LIST

GAEL	External	
S. SAUNIER	P. GORYL	ESA-ESRIN
Y. RODRIGUEZ	P. GRIMONT	ESA-ESRIN
A. MAMBIMBA	F. VIALLEFONT	ONERA
	D. LEGER	ONERA
	A. GRUEN	ETH Zurich
	S. KOCAMAN	ETH Zurich
	K. WOLF	ETH Zurich

DOCUMENT CHANGE LOG

Issue	Date	Section / Page	Description	Author
0.1	2006-12-19	All	Draft - Creation of the document	S. Saunier
1.0	2006-12-20	All	Review with Philippe Goryl (ESA).	S. Saunier

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 Purpose of this document

Purpose of this document is to report to ESA consolidated results collected during ALOS / PRISM data verification period.

This document is a deliverable of the Phase B of the project "ALOS CAL/VAL", governed by the contract N°19284/06/I-LG, agreed between the European Space Agency and GAEL Consultant.

1.2 Document plan

- Chapter 1 Introduction and results summary,
- Chapter 2 Presents results from product geo location accuracy
- Chapter 3 Presents results from stereoscopic capability validation item,
- Chapter 4 Presents results on image quality, especially from modulation transfer function measurements

1.3 Applicable documents

[AD-1] *AMALFI Multi-Mission Facility – Contract*
19284/06/I-LG
February 13th, 2006
European Space Agency – ESRIN

1.4 Reference documents

[RD-1] *ALOS optical data verification*
Verification and Implementation Plan
GAEL-P224-DOC-002
Issue 1, Revision 3 – March 16th, 2006
GAEL Consultant

[RD-2] *ALOS-Product-Description*
GAEL-P224-DOC-003
Issue 1, Revision 0 – July 07th, 2005
GAEL Consultant

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

[RD-4] *ALOS algorithm description*
NEB 01006
Rev G - August, 2005
JAXA

[RD-5] *ALOS On-Orbit MTF assessment*
RT 1/11824-DOTA
F.Viallefont D. Leger
ONERA

[RD-6] *Support to GAEL Consultant for the assessment of PRISM sensor model*
A.Gruen, S. Kocaman, K. Wolf.
ETH Zurich

1.5 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.

ALOS	Advanced Land Observing Satellite
ANSI	American National Standards Institute
AUIG	ALOS User Interface Gateway
AVNIR-2	Advanced Visible and Near Infrared Radiometer type 2
CAL/VAL	Calibration and Validation
CCD	Couple Charge Device
DEM	Digital Elevation Model
DSM	Digital Surface Model
ECI	Earth Center Inertial coordinates
ECR	Earth Centered Rotating coordinates
ECSS	European Cooperation for Space Standardization
ESA	European Space Agency
GCP	Ground control point
GPS	Global Positioning Satellite
GPSR	GPS Receiver
ISO	International Organization for Standardization
JAXA	Japan Aerospace Exploration Agency
MTF	Modulation Transfer Function
NASDA	National Space Development Agency of Japan
PCD	Payload Correction Data
PI	Principal Investigator
PRISM	Panchromatic Remote-sensing Instrument Stereo Mapping
TKSC	Tsukuba Space Center
UTC	Universal Time Coordinated

1.6 Summary

This document reports results from ‘in depth assessment’ phase as part of ESA contribution to ALOS / PRISM calibration / validation activities. Main outputs of this technical study are summarized just here after.

The geo location accuracy of PRISM 1b1 and 1B2 products has been largely studied during this second verification stage. The bottom line was to remain on the user side, using only information embedded within product (polynomial coefficient) for image orientation procedure The study demonstrates that geometric transformation (image orientation) based on polynomial coefficients do not offer a good quality; product absolute geo location accuracy (RMS) is varying from 700 m to 2 m. State vectors (platform position and velocity vector) provided with the leader file are themselves not reliable such as demonstrated with QUISS test (ephemeris and attitude) in comparing with those belonging to supplemental file (Ancillary 8). We are wondering if the polynomial coefficient computation is not based on state vectors from the leader file instead of using those of supplemental file. When compensating polynomial transformation with estimate of basic external orientation parameters, the product geo location accuracy can reach 4 metres (RMS) without taking into account effect due to parallax. Theses results are closer than accuracy one can expect.

Regarding sensor model determination using Piemont Test field, ETH team highlights sub pixel accuracy is not reached yet. Actual sensor model accuracy is about 2.5 metres (planimetric) and 1.35 metres (height). Equipment over Piemont test field has been reinforced, and after a new sensor determination exercise, accuracy may reach operational goal of 1 meter (planimetric) and 2 meter (height). Sensor model determination will be followed with the evaluation of Rationnal Polynomial Coefficients (RPCs) and Digital Surface Model (DSM)

PRISM MTF evaluation performed by ONERA team has revealed a good behavior of MTF results according to across track direction (within specification > 0.2). On the other hand, improvements should be done regarding along track MTF. Assumptions according to which JPEG compression disturb or even destroy MTF measurements have been formulated. In addition, a part of dataset used as input of this validation item was contaminated with image saturation. Standard methods for estimating step edge response were not suitable and a new method based on interpolation has been set. PRISM MTF assessment should be consolidated and completed. A new dataset is now waiting for the adjustment of MTF model fitting parameters.

In the field of image quality, reduction of stripe noises and block noises remains a priority for JAXA. ESA may be brought its support in studying the relation between optical black values and jpeg artefact.

1.7 PRISM data

The Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM) is on board the Advanced Land Observing Satellite (ALOS).

ALOS is flying along a nearpolar, near-circular and Sun-synchronous orbit at a mean altitude of 691.65 km (equator), with an inclination of 98.16 degrees and a mean revolution period equal to 98,7 minutes.

PRISM is a panchromatic radiometer with 2.5-meter spatial resolution. Its data will be used for extracting highly accurate digital elevation model (DEM). Instrument is fully described in [R-2].

PRISM get capability to image a same point over the Earth surface according to three views from forward, nadir and backward camera.

PRISM instrument belongs to the class of push broom sensor and data are acquired by a linear CCDs array. It consists of six CCDs dedicated to nadir view radiometer while 8 are dedicated to backward and forward view radiometers. Each contains about 5000 detectors [R-4].

During the ESA calibration/validation phase, triplet acquisition mode is nominal; acquisition of each view is performed simultaneously.

Standard scene in triplet mode sizes 35 km width for a pixel ground resolution that is around 2. 5 m. And ESA PRISM product are processed into CEOS format for level 1B1, 1B2R, and 1B2G . The whole of product level are listed just here after.

Level	Definition
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

Level	Definition
1A	Uncompressed, reconstructed digital counts appended with radiometric calibration coefficients and geometric correction coefficients (appended but not applied)
1B1	Radiometrically calibrated data at sensor input
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

table 1 - PRISM product level.

PRISM data is mainly dedicated to cartographic activities, especially for stereo processing performed for a same-date thanks to along track stereo data acquisition capability (Triplet mode). Time spanned between two acquisitions of a same point of the Earth surface is about 41 seconds. This short delay guarantees minor temporal change. In addition, correlation process between two PRISM views might be more efficient than within a multi date context.

2 PRODUCT GEOMETRY

2.1 Dense study

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.

2.1.2 Method

Study is focused on geometric quality assessment of 1B1 level product. Data from backward, nadir and forward views are controlled on a CCD basis. Image orientation model based on polynomial coefficients is checked. Orientation parameters are not estimated. We expected coherent results between views.

Ground Control Points (GCPs) have been collected during several campaigns over the Ile de France test field. The procedure is the standard one; GCP are identified on working data and manually set. Method leads to a statistical displacement results in term of easting and northing between geographical position predicted with polynomial model and real one such as measured with GPS device.

2.1.3 Working data

Following ALOS / PRISM dataset sample, acquired over Paris target zone (lat / lon 48.42° / 2.68°) has been used for assessment on product geo location.

Observation date	Processing date	File names	Orbit Data Precision	Attitude Data Precision
7-juin-06	5-sept-06	ALPSMB019602675-O1B2R_UB-A0601131-006 ALPSMN019602620-O1B2R_UN-A0601131-005 ALPSMF019602565-O1B2R_UF-A0601131-004	Precision	AOCSPrecision

table 2 - Dataset used for 'dense' study.

2.1.4 Team

Aboubakar Mambimba, Yoelma Rodriguez, Sébastien Saunier, (GAEL Consultant)

2.1.5 Results

Observation dated of June,7 2006 has been processed two times. A first processing has been done in July (software version 03601012056011) and a second one in September 14, (2006 Software version 0360102056007). One can observed a strong improvement regarding the across track shift, especially for observation with forward camera (table 4).

Software version 03601012056011.

Software version 0360102056007.

table 3 - Processing version and geo location, comparison.

	CCD1	CCD2	CCD3	CCD4
GCP number	1	12	3	2
Mean X	52,86	48,41	51,56	62,83
Mean Y	149,07	154,56	165,49	187,45
Mean	158,17	161,98	173,34	197,71
Std X	0,00	3,12	5,50	5,04
Std Y	0,00	3,91	13,30	8,31
Std	0,00	4,52	14,39	9,48
RMS X	52,86	48,51	51,86	63,03
RMS Y	149,07	154,61	166,03	187,63
RMS	158,17	162,04	173,94	197,93

table 4 - ALPSMB019602675, geo location results.

	CCD1	CCD2	CCD3	CCD4
GCP number	15	8	3	
Mean X	38,893	43,688	43,43	
Mean Y	153,167	156,915	163,071	
Mean	158,0278	162,883	168,755	
Std X	2,649	4,245	1,426	
Std Y	3,197	4,519	2,909	
Std	4,151868	6,20011	3,23972	
RMS X	38,98311	43,8938	43,4534	
RMS Y	153,2004	156,98	163,097	
RMS	158,0824	163,001	168,786	no data

table 5 - ALPSMN019602620, geo location results.

	CCD3	CCD4	CCD5	CCD6
GCP number	14	7	1	5
Mean X	0,812	4,651	-0,635	-1,767
Mean Y	-0,274	4,686	-2,003	-0,69
Mean	0,856983	6,6023	2,10125	1,89694
Std X	1,375	7,27	0	0,636
Std Y	4,843	10,63	0	6,678
Std	5,034409	12,8783	0	6,70822
RMS X	1,596862	8,63045	0,635	1,87797
RMS Y	4,850745	11,617	2,003	6,71355
RMS	5,106828	14,472	2,10125	6,97127

table 6 - ALPSMF019602565, geo location results

Results from each camera are not consistent. Image data from forward view offer a good quality whereas it is not the case for the backward and nadir view.

For Backward and Forward, CCD4 results are upper than those from the other CCDs.

For backward and Nadir view, displacement is mainly along Y axis (North-South direction) and standard deviation is more important along this direction.

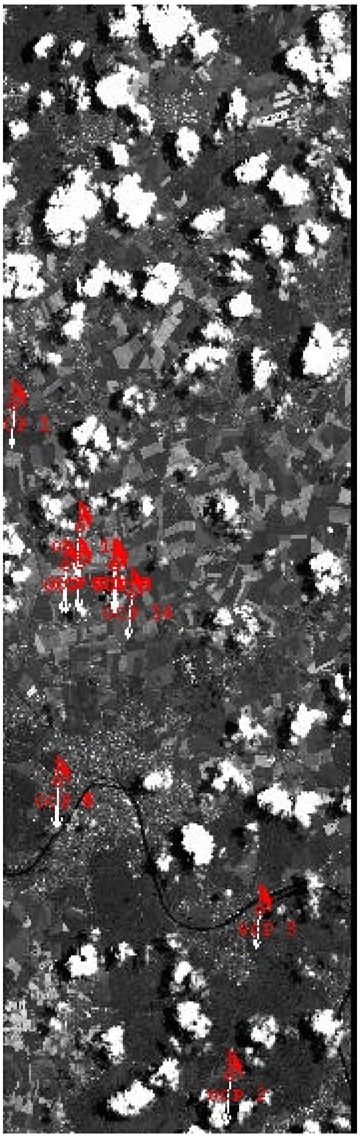


fig. 1 - Dense study Back View, CCD 2.

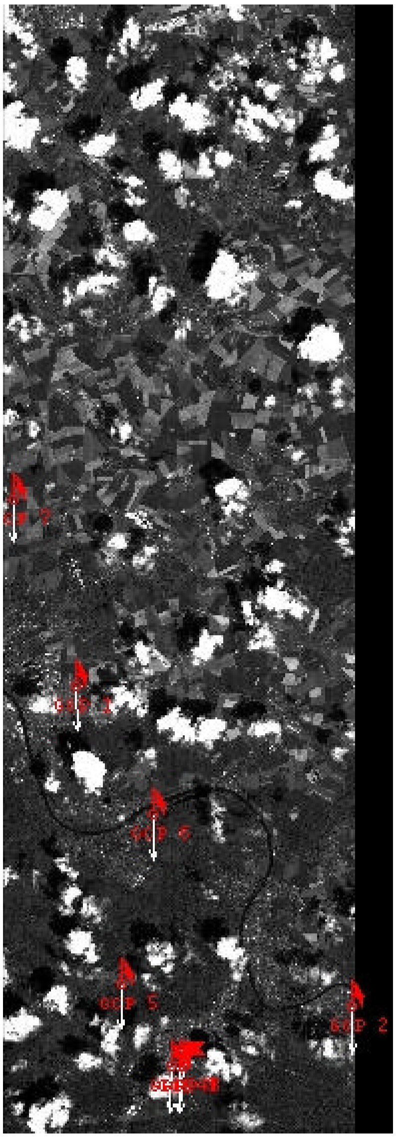


fig. 2 - Dense study, Nadir view, CCD 2.

fig. 3 - Dense study, Forward view, CCD 3.

2.1.6 Ile de France test field

Site (2.68°E, 44.42°N) is located at the eastern part of Paris suburb area. Located close to GAEL Consultant, after several GPS campaigns about 30 GCPs have been collected. The site displays mean size urban areas, agricultural fields and forest landscape. The airport of Melun-Villaroche (table 3) forms a good site since track takeoff direction is perfectly aligned with satellite track orientation.

2.2 Triplet mode study

2.2.1 Purpose

Purpose of this validation is to assess 1B2 product geo-location for data acquired in triplet mode. Underlined verification is the checking of radiometer alignments and the evaluation of prost processed pointing.

2.2.2 Method

We consider a dataset sample from the three PRISM views acquired at the same time (scene center time is 11:03:41.420 UT). Geographical distance between Image data from backward / forward views and image data from nadir view is about 350 km.

The image orientation procedure has been performed using polynomial coefficients such as provided with product (leader file (Ancillary 1, map projection)).

Method leads to a statistical displacement results in term of easting and northing between the PRISM 1B2 geo coded image and a corresponding reference one.

Without ground reference point, the actual image orientation procedure is not accurate; it leads to strong first order displacements and it makes difficult to appreciate internal geometry of image data.

To overcome this issue, few exterior orientation parameters (translation, similitude, rotation) are estimated in order to compensate error due to polynomial transformation. In doing this, an improved image orientation procedure is used and a new product geo location assessment is performed.

Method for controlling image geo-location is semi - automatic; Ground Control Points (GCPs) are manually set on the working data. GCP geographical coordinates are matched with the ones belonging to the reference data; the GCP location in working data is adjusted for ensuring the best geo location matching between reference and working data.

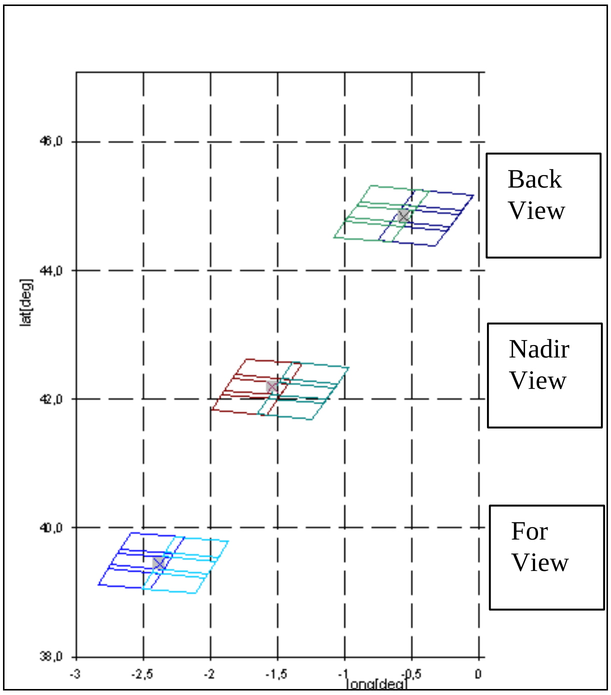


fig. 4 - PRISM scene location for study on triplet mode

2.2.3 Working data

Following ALOS / PRISM dataset sample has been used for study on 'triplet'. Dataset has been delivered by JAXA to ESA. Study has focused on 1B2 product level.

Observation date	File names	Orbit Data Precision	Attitude Data Precision
14-août-06	ALPSMB029522750-O1B2R_UB-Z0602946-001 ALPSMN029522750-O1B2R_UN-A0601405-010 ALPSMF029522750-O1B2R_UF-Z0602947-004	Precision	OnSitePrecision

table 7 - Dataset used for 'triplet' study.

2.2.4 Team

Aboubakar Mambimba, Yoelma Rodriguez, Sébastien Saunier, (GAEL Consultant)

2.2.5 Results

File name	ALPSMB029522750-O1B2R_UB-Z0602946-001								
GRP	RMS	RMS dx	RMS dy	Mean	Mean dx	Mean dy	Std Dev	Std Dev x	Std Dev y
0	730,26	560,55	468,06	728,59	559,61	466,35	49,29	32,43	40,08
1	55,77	40,23	38,62	52,51	-38,89	-28,96	18,77	10,27	25,55
2	46,91	19,37	42,73	34,93	12,58	21,60	31,31	14,73	36,86
3	49,81	13,48	47,95	41,42	4,27	-7,61	27,67	12,79	40,08

table 8 - ALPSMB029522750 geo-location results.

File name	ALPSMN029522750-O1B2R_UN-A0601405-010								
GRP	RMS	RMS dx	RMS dy	Mean	Mean dx	Mean dy	Std Dev	Std Dev x	Std Dev y
0	290,36	139,07	254,88	289,93	138,19	254,66	15,73	15,67	10,76
1	17,36	14,12	10,10	16,12	-3,90	4,95	6,46	13,57	8,80
2	15,48	13,29	7,94	12,10	3,78	3,34	9,66	12,74	7,21
3	14,45	10,64	9,78	11,36	-3,00	4,86	8,94	10,21	8,49

table 9 - ALPSMN029522750 geo-location results.

File name	ALPSMF029522750-O1B2R_UF-Z0602947-004								
GRP	RMS	RMS dx	RMS dy	Mean	Mean dx	Mean dy	Std Dev	Std Dev x	Std Dev y
0	754,70	619,46	431,08	754,62	619,20	-429,50	11,37	17,76	36,84
1	44,33	24,59	36,89	40,36	-15,53	-1,76	18,33	19,07	36,85
2	45,74	19,74	41,26	41,97	4,93	16,94	18,17	19,11	37,62
3	22,52	5,31	21,89	15,06	1,72	-1,06	16,75	5,03	21,86

table 10 - ALPSMF029522750 geo-location results.

Due to image quality, identification procedure of ground control point over image data from backward view can be confused, it can impact more or less results consistency.

Image orientation procedure is more accurate for data from Nadir view than for data from Backward and Forward views. Geometric distortions such scaling and bending impact more seriously image from theses views. Three ground reference points added for refined image orientation procedure improve significantly image geo location. In doing this, we observed that compensation of external errors through correction of polynomial behavior remains not sufficient and sub pixel accuracy goal is not achieved.

2.2.6 Test fields

Test fields are equally spaced of about 350 km along with sub satellite track Up to 20 GCPs for every test fields have been collected during GPS campaign operated by GAEL Consultant during spring 06'.

Country	Site name	Long (dd)	Lat (dd)
France	Bordeaux	-0.561	44,826
Spain	Madrid	-1,538	42,19
	Saragoza	-2,378	39,44

table 11 - Test fields' location

2.3 Along track stability

2.3.1 Purpose

Along GCPs studies, are dedicated to the checking of pointing stability during a long acquisition period; It aims at discerning if thermal effects occur and 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

2.3.2 Method

Method used for along track stability study is rigorously identical to the one use in the frame of triplet study (refer to 2.2.2).

2.3.3 Working data

Following ALOS / PRISM dataset sample has been used for along track study. Dataset has been processed by JAXA on July, 11, 2006. Study has focused on 1B2 product level.

Observation date	File names	Orbit Data Precision	Attitude Data Precision	Site
1-juin-06	ALPSMN018714285-O1B2R_UN-A0600977-013	Precision	AOCSPrecision	Le cap (South Africa)
1-juin-06	ALPSMN018712800-O1B2R_UN-A0600977-002	Precision	AOCSPrecision	Tarsus (Turkey)

table 12 - Dataset used for' along track' study.

Because of no reference data, over Turkey, PRISM dataset quality from observation over Tarsus (lat / lon 36.9830°/ 35.635°) has not been done.

2.3.4 Team

Aboubakar Mambimba, Yoelma Rodriguez, Sébastien Saunier, GAEL Consultant

2.3.5 Results

File Name	ALPSMN018712850-O1B2R_UN-A0600977-005 [processed with software version 036010056006 one second shift delay was not corrected]								
GRP	RMS	RMSX	RMSY	Mean	Mean X	Mean Y	Std Dev	Std Dev x	Std Dev y
0	7876,32	1826,9	7661,34	7876,32	1826,89	7661,34	4,14	3,613	3.762
1	6,266	2,201	5,866	5,73	0,21	4,706	2,536	2,191	3.502
2	5,317	2,563	4,658	4,667	-0,275	1,05	2,547	2,548	4.538
3	3,837	2,759	2,666	3,625	1,174	2,081	1,259	2,497	1.668
4	3,866	3,078	2,338	3,351	-0,569	-0,774	1,927	3,025	2.207

table 13 - ALPSMN018712850; geo-location results.

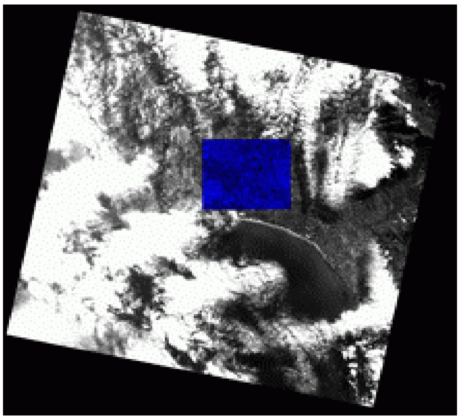


fig. 5 - IKONOS data (blue) overlay PRISM data.

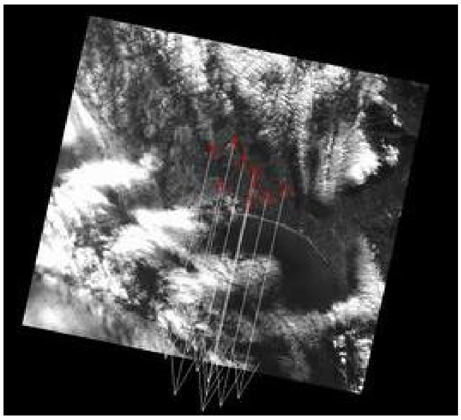


fig. 6 - ALPSMN018712850, Error vector fields X3.

PRISM dataset sample has been processed in July 06'; an old processor version were in use, and one second shift delay correction had not been applied yet.

When correcting data from translation, we observed (refer to table 13) that RMS value is around 6.266 m.

With three-ground reference points added for image orientation procedure, geo location accuracy remains below 4 metres and no improvement is observed with four grps. Residual errors observed are so that mainly due to parallax effect. Geometric quality of data acquired over southern hemisphere regions does not differ from the one we can expect for data from the northern hemisphere regions.

The on-going study will be based on comparison between PRISM observations from Turkey and the one from South Africa, the both product belonging to the same satellite path. For doing this, it is planned to get a reference data over Turkey test field for completion of this validation item.

2.3.6 Le Cap test field

Reference data used for this validation exercise is a dataset from IKONOS sensor. Product is orthorectified using digital elevation model (20 m grid).

Site (18.391°E, -34.034°N) is located over Le Cap city in South Africa. The site mainly displays urban, residential area with very well defined limit between city structures. The site elevation, for region defined as the overlap area between IKONOS and ALOS / PRISM data is about 60 metres. Main limitation of such site is the weather, image are often cloudy.

3 STEREOSCOPIC CAPABILITY

3.1 Sensor model determination

3.1.1 Purpose

Purpose of this work ([RD-6]) is to evaluate stereoscopic capability of PRISM triplet scenes.

3.1.2 Method

Such as seen previously, image orientation procedure based on polynomial method does not offer a good quality (see previous section).

A standard image orientation procedure cannot be applied to PRISM dataset because of lack of information (sensor parameters). A part of internal and external orientation parameters should be estimated. For doing this, ETH Zurich Laboratory developed bundle adjustment techniques based on least squares.

The external orientation modeling takes into account physical properties of the sensor and satellite position.. As part of adjustment, the Direct Georeferencing Model (with stochastic exterior orientation) approach is adopted for modeling the sensor trajectory.

On the other hand, results from laboratory calibration regarding camera interior orientation parameters are not given to the community. Estimation of these parameters is performed through self-calibration procedure during bundle adjustment. The main objective of self-calibration is to estimate systematic errors that occur in the whole system (camera, trajectory, etc). The potential systematic errors of the camera might occur in CCD line (change in pixel size, shift, rotation, line bending) and in the optical system (displacement of lens principal points, change of the focal length, lens distortion).

Bundle adjustment is a simultaneous solution for estimation of the sensor exterior and possibly (if the network allows) interior orientation. Statistical results listed here have been computed by use of modified (for Linear Array geometry) bundle adjustment.

A set of 23 GCPs collected during GPS campaign has been provided to ETH Zurich. Four (4) of them have been discarded from this validation exercise because of bad measurements; the differential method for measurement consolidation procedure did not work. Ten (10) GCPs have been used as check point, and nine (9) GCPs as control points. Control points are used in the bundle adjustment procedure and lead to the estimation of exterior (and possibly) interior orientation parameters. GCP coordinates are introduced as observations into the adjustment and constrained stochastically, according to their measurement and definition accuracy.

3.1.3 Working data

Following ALOS / PRISM dataset sample has been used for sensor model validation. Dataset has been delivered by JAXA to ESA. Study has focused on 1B1 product level.

Observation date	File names	Orbit Data Precision	Attitude Data Precision
4-sept-06	ALPSMB032582755-O1B1___B-A0601646-025 ALPSMF032582645-O1B1___F-A0601646-023 ALPSMN032582700-O1B1___N-A0601646-024	Precision	OnSitePrecision

table 14 - Dataset used for stereoscopic capability assessment.

3.1.4 Team

Armin Gruen, Kirsten Wolf, Sultan Kocaman (ETH Zurich)

3.1.5 Results

At the end of bundle adjustment, internal and external accuracy can be analyzed. The sigma naught is equal to 3.64 microns and forms an estimate of image measurement accuracy. The accuracy results below are based on the check points..

Parameter / Axis (object space)	RMSE	Max Residual (m)	Sigma (m)
X	2.48	4.96	0.95
Y	2.60	5.41	1.02
Z	1.35	2.54	2.64

table 15 - Image orientation, test results.

Root mean square error (RMSE) is a statistical parameter and computed through the residual errors of check points' coordinates (difference between computed and given ground coordinates) and reflects external accuracy.

Sigma values indicate the internal accuracy of the model; its computation is based on covariance matrix.

If model is improved and any kinds of error compensated, planimetric and height residual should reach theoretical precision computed with covariance matrix.

A good definition and repartition into the image of the points and quality of self-calibration are correlated. A high number of well-defined GCPs is mandatory for a good statistical interpretation of results. Distribution of residual errors is depicted on figure just here after. 'Red triangle' symbol makes reference to a control point where as 'dot' symbol represents a checkpoint.

After this first analysis, future work is toward refinement of adjustment procedure using new GCPs, extraction of elevation parallaxes; determination of XYZ cartographic coordinates and representation. Data surface model output from this procedure. Output DSM will be validated using SPOT3D reference data. Rational Polynomial Coefficient derived from this study will be validated as well.

3.1.6 Piemont test field

Site (7.3°E, 44.5°N) is located at edge of Mt Viso, a natural frontier between France (Queyras) and Italy (Piemont). The site displays mountainous landscape (forest, bare soil), agricultural fields over flat area, and small urban areas. The elevation ranges from 40 meter to 3841 meter.

Two GPS campaigns have been funded by ESA over Piemont test field. The first one has been operated by GAEL Consultant and has occurred in September 06' during which about 23 GCPs have been collected. The present report is based on these first measurements.

The second one has been done conjointly with GAEL Consultant and ETH Zurich. About 20 measurements have been collected and they are using for results consolidation before data surface model generation. Results will be published in the next document version.

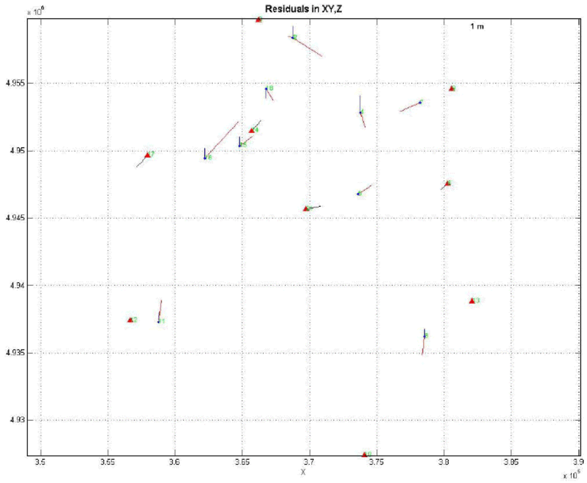


fig. 7 - Planimetry and height residuals distribution in object space.

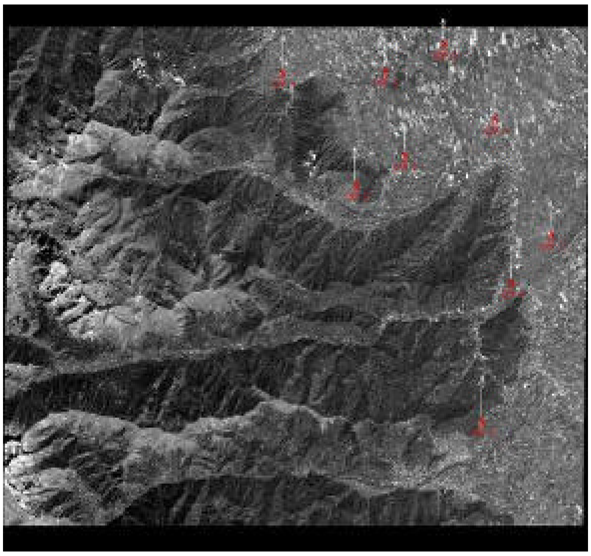


fig. 8 - Piemont site, a part of GRPs collection.

3.1.7 Paper index

Gruen, A., Zhang, L., 2003. *Sensor Modeling for Aerial Triangulation with Three-Line-Scanner (TLS) Imagery. Journal of Photogrammetrie, Fernerkundung, Geoinformation, 2/2003, pp. 85-98.*

Gruen, A., Beyer, H.A., 2001. *System Calibration Through Self-Calibration. Calibration and Sensor Orientation of Cameras in Computer Vision, Eds. Gruen, Huang, Springer-Verlag Berlin, Heidelberg, pp.163-193.*

Gruen, A., 1978. *Progress in Photogrammetric Point Determination by Compensation of Systematic Errors and Detection of Gross Errors. Nachrichten aus dem Karten- und Vermessungswesen, Series II, 36, 113-140.*

Gruen, A., 1985. *Data Processing Methods for Amateur Photographs. Photogrammetric Record, 11 (65), pp. 567-579.*

3.2 DSM Evaluation

The determination of the sensor model activity such as defined previously will be used for generating a set of Rational Polynomial Coefficients (RPCs) and the Digital Surface Model (DSM).

This validation exercise is planned to be done during the last stage of data verification and will rely on comparison between of z accuracy between PRISM DSM and SPOT3D product considered as reference data.

4 PRODUCT IMAGE QUALITY

4.1 Visual inspection

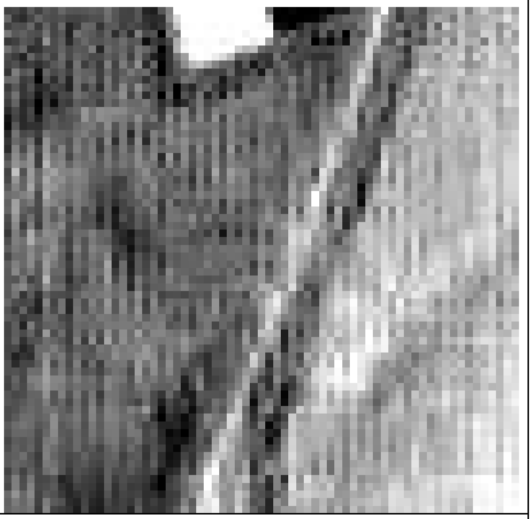
	
“Salon dataset” 06/09/2006Blocking artifact	“Salon dataset” 09/09/2006 Blocking artifact

fig. 9 - Blocking artifact.

4.2 Saturation

Saturations on several PRISM images are due to the use of wrong parameters regarding on board filter gain. This situation should be clarified follow the setting of a new system that computes the best suitable filter gain state for a given geo graphical location.

4.3 Modulation transfer function results

4.3.1 Purpose

Purpose of this work ([RD-5]) is to measure the on orbit MTF for ALOS / PRISM sensor. The results from output of this validation item will be a good indicator on PRISM sensor capability to discern ground features.

4.3.2 Method

MTF computation method developed at ONERA is based on the step edge method. Image data used as input are from natural or artificial target for which sharp transition between dark and bright uniform areas is observed.

MTF is calculated as the ration between the Fourrier Transform (FT) of the observed step (output signal) and the FT of the ideal Heaviside step (input signal).

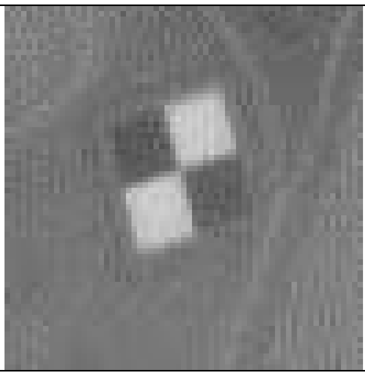
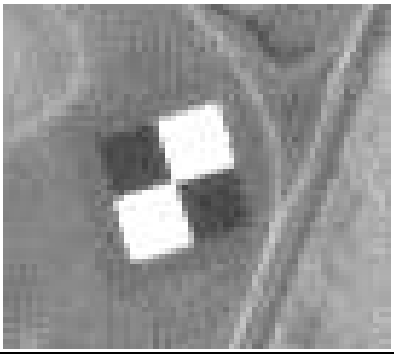
The measurements have been mainly performed on artificial target located at Salon de Provence (South of France, lat / lon 43,514 / 5.184). The target looks a draughtboard; its size and surface reflectance properties are well known.

4.3.3 Working data

Following ALOS / PRISM dataset sample has been used for sensor model validation. Dataset has been delivered by JAXA to ESA. Study has focused on 1B1 product level.

Observation date	Scene Id	Comment
9-juin-06	ALPSMB019892775-01B1___B-A0600745-005 ALPSMF019892665-01B1___F-A0600745-004 ALPSMN019892720-01B1___N-A0600745-005	Satuartion of the white areas of SALON target
11-août-06	………..	Cloudy
9-sept-06	ALPSMB033312780-O1B1___B-Z0603591-002	Haze, Salon target only on Backward view

table 16 - Dataset used for MTF assessment.

	
06/09/2006 low gain used but hazy conditions	09/06/2006 Saturation of the white areas

4.3.4 Team

Françoise Viallefont, Dominique Leger (ONERA).

4.3.5 Results

The measurements corresponding to the image dated of 09/09/06 are plotted in fig. 10 and listed into table 17.

Unfortunately, target was only observed on image data from PRISM backward view.

We observed a nominal behavior of across track MTF (MTFx) curve. In track MTF curve (MTFy) is falling down more faster than MTFx one and its value at Nyquist frequency (Fe=0.5) is very low.

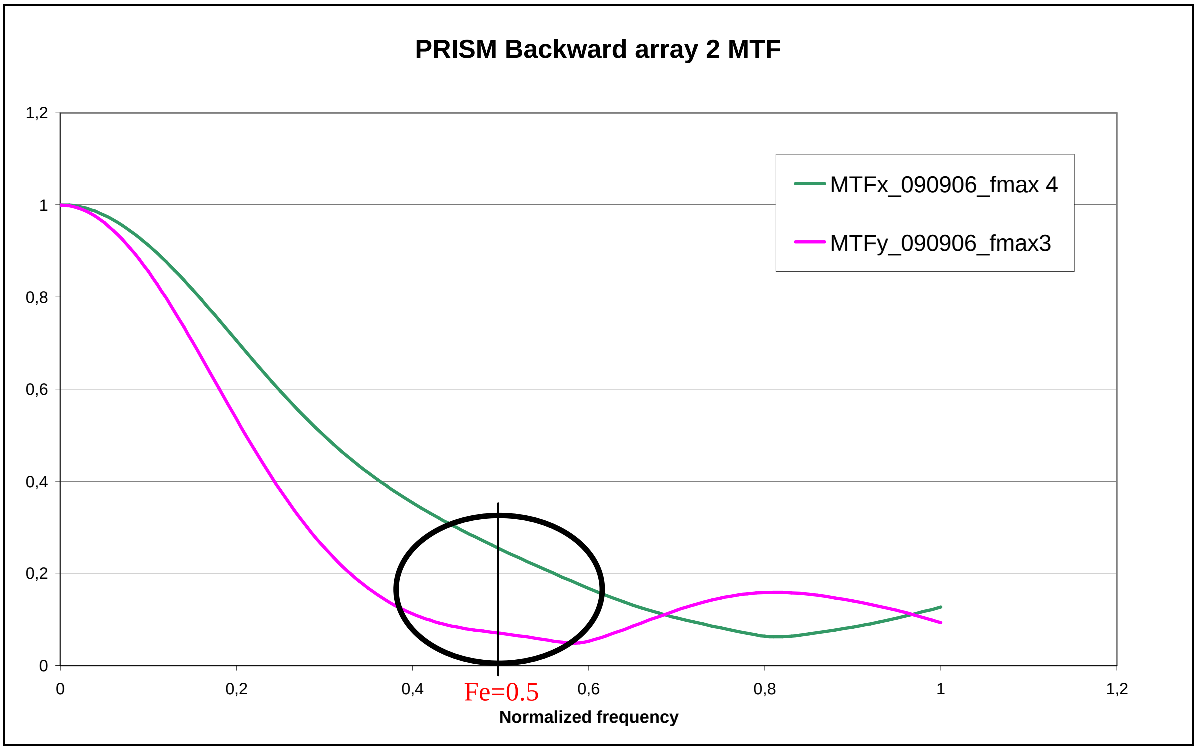


fig. 10 - Backward MTF curves.

Normalized frequency	0.1	0.2	0.3	0.4	**0.5**	0.6	0.7	0.8	0.9	1
Cross-track MTF	0.91	0.71	0.50	0.35	**0.25**	0.17	0.10	0.06	0.08	0.13
Along-track MTF	0.85	0.53	0.26	0.11	**0.07**	0.05	0.12	0.16	0.14	0.09
Cross-track pre-flight MTF					0.29					
Along-track pre-flight MTF					0.23					
Specification					>0.20					

table 17 - Backward MTF results.

The second step of this study consisted in comparing previous results with those obtained on image dated of June 2006. Image saturation for artificial targets has forced to improve MTF model adding interpolation. A similar method applied on these two datasets gives closer results for across track MTF than for along track MTF.

It looks difficult to formulate conclusion regarding along track MTF. The discrepancies observed are either due to a change of along-track MTF behavior along time (between June and September) or due to compression artifact that disturb MTF assessment.

The third step was dedicated to comparison between MTF measurements from the three PRISM views (for image dated of June). On one hand; across track MTF results are consistent and fit to MTF model; on the other hand along track MTF results are again difficult to fit with MTF model.

This last step strengthens assumption according to which JPEG compression disturbs or even destroys MTF measurements.

PRISM MTF assessment should be consolidated and completed. A new dataset is now waiting for the adjustment of MTF model fitting parameters.

fig. 11 - Salon test field.