



Centre National d'Etudes Spatiales



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**Activity : CAL/VAL
Registration**

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Contents

1. OBJECTIVE	2
2. METHODS	2
3. SUCCESS CRITERIA	3
4. RESULTS	4
4.1. PRODUCT L1A1 NOMINAL MODE	4
4.1.1. C1/C2	4
4.1.2. C2/C3	5
4.1.3. C3/C4	6
4.1.4. SHIFTS AND OVERLAP RATIO AVERAGES	7
4.2. PRODUCT L1A1, RESULTS OBTAINED ON MT MODE ACQUISITIONS	8
4.2.1. RESULTS OF MASSIVE CORRELATIONS	8
4.2.2. SHIFTS AND OVERLAP RATIO AVERAGES	8
4.3. CONCLUSION	8
4.4. PRODUCT L1A2	9
5. CONCLUSION	9

1. OBJECTIVE

This study deals with Scarab performances in terms of inter-channel registration.

2. METHODS

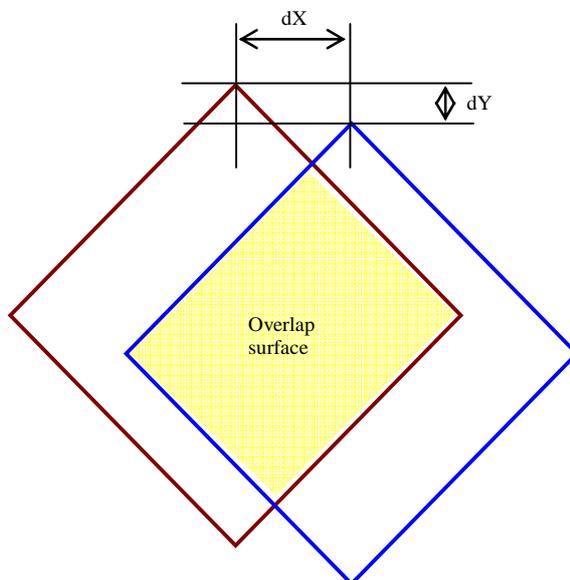
The general requirement is based on the percentage of overlap between the ground footprint of a pixel in 2 channels. On flight, in order to achieve this measurement, a massive correlation is performed between the different channel images that have been previously radiometrically corrected. L1A1 products are used, because L1A1 images have not been resampled.

The massive correlation provides statistics about shifts between a reference and a secondary image. Shifts are given in “fractions of pixels” in both directions of the images (dX : along scan=across track, and dY : across scan=along track).

Shifts in “fractions of pixels” refer to the sampling grid of the acquisition, that is to say, the grid corresponding to the different positions of the pixels centers. For example, if a dY shift of 0.5 is found for a pixel P(scan i, sample j), that means that the same pixel is found in the secondary image in the middle of scan i and scan i+1.

The overlap surface measurement is performed using the following formula :

$$\text{Percentage of overlap} = 100 * (1 - |dX+dY|/\text{sqrt}(2)) * (1 - |dX-dY|/\text{sqrt}(2))$$



**Figure 1 : Computation of the overlap surface
(considering Nadir geometry, footprints are squares)**

From several orbits available at TEC (Technical Expertise Center), massive correlations have been performed in order to compute statistics on shifts between channels. The most part of products tested have been split into two data subsets according to their scanning type (backward or forward) and are nominal acquisitions. A reduce dataset, made up of few acquisitions in MT (no solar filter

for Channel 3 and Channel 2) mode, has also been used to check whether or not, results obtained for nominal products suffer from correlation problems between channels 2 and 3.

3. SUCCESS CRITERIA

Mission requirements for surface registration	90%	98%	90%
Expected surface registration (before launch)	89%	97.4%	93%

The expected value is slightly under requirement for channels 1 / 2 and 2 / 3. This point was accepted before launch.

4. RESULTS

4.1. PRODUCT L1A1 NOMINAL MODE

The following figures present the results of massive correlation between C1/C2, C3/C2 and C3/C4 for forward and backward scanning product.

4.1.1. C1/C2

— forward scanning products used,

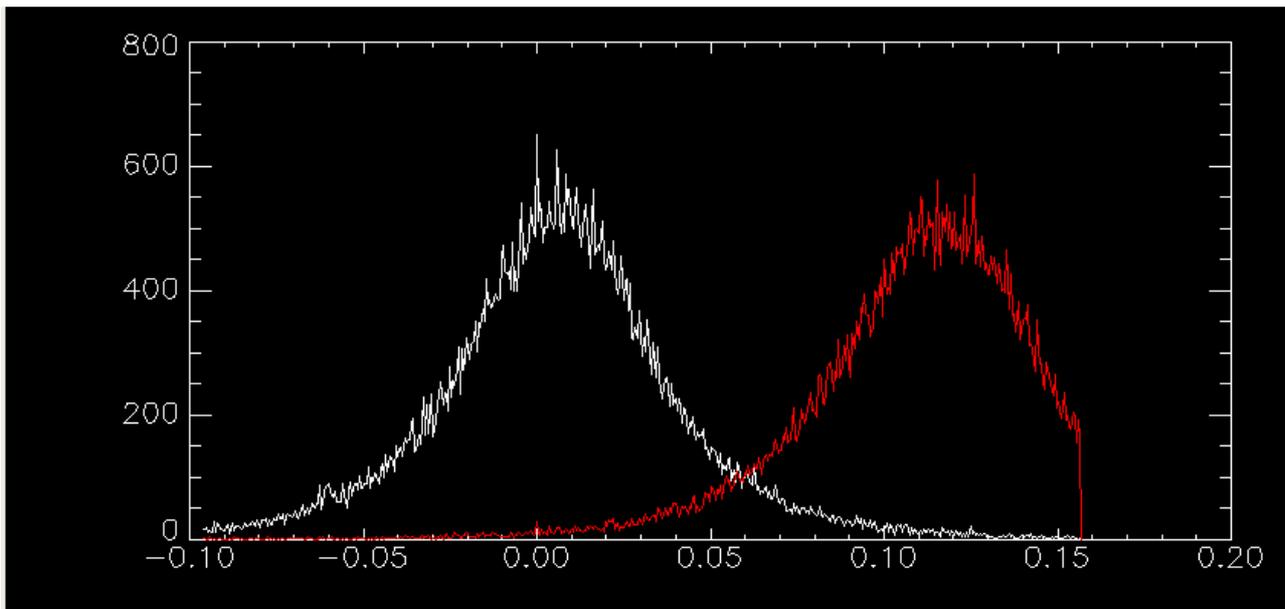


Figure 2 : across track and along track shifts histograms between C1 and C2 respectively in red and white

— backward scanning products used.

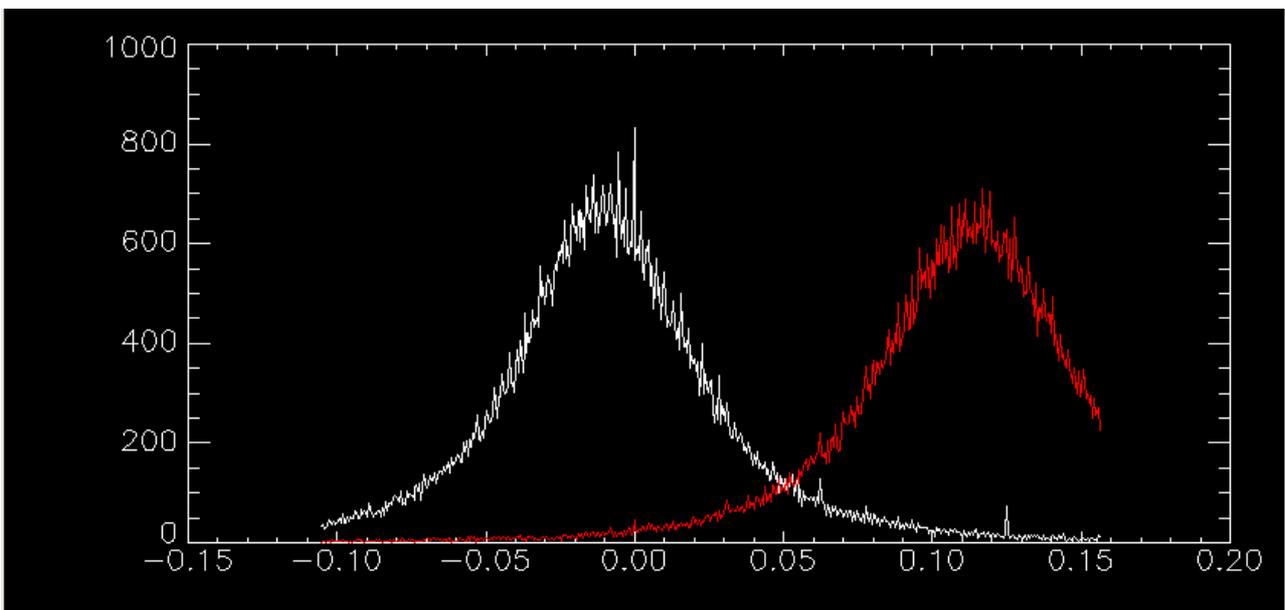


Figure 3 : across track and along track shifts histograms between C1 and C2 respectively in red and white

4.1.2. C2/C3

— forward scanning products used,

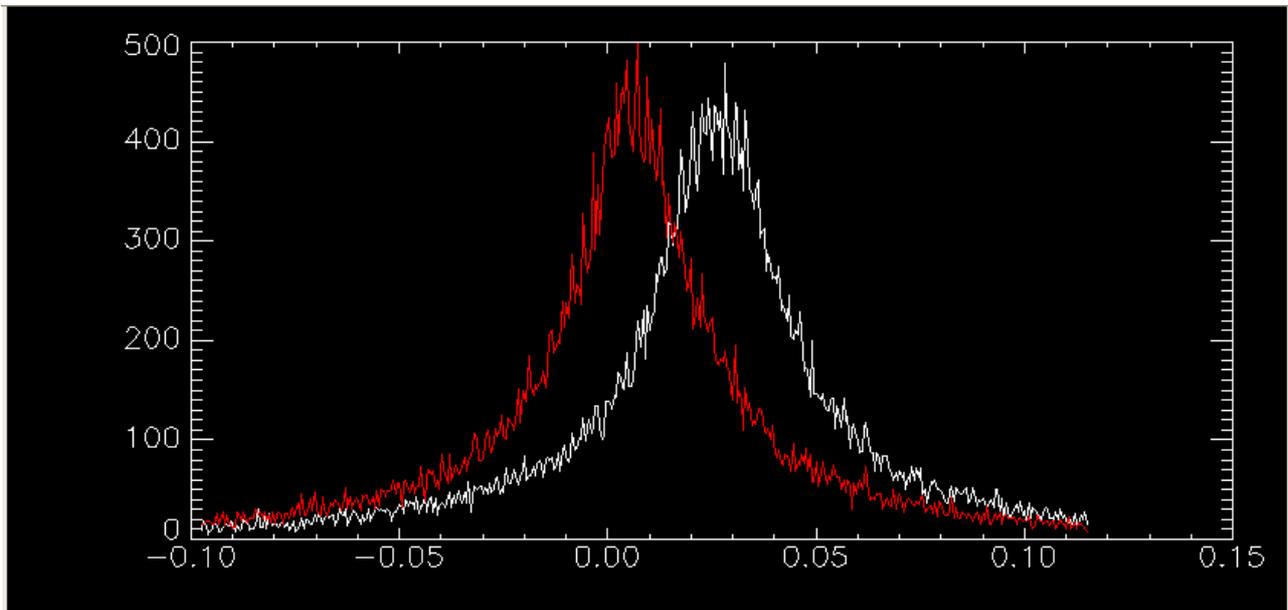


Figure 4 : cross track and along track shifts histograms between C3 and C2 respectively in red and white

— backward scanning products used.

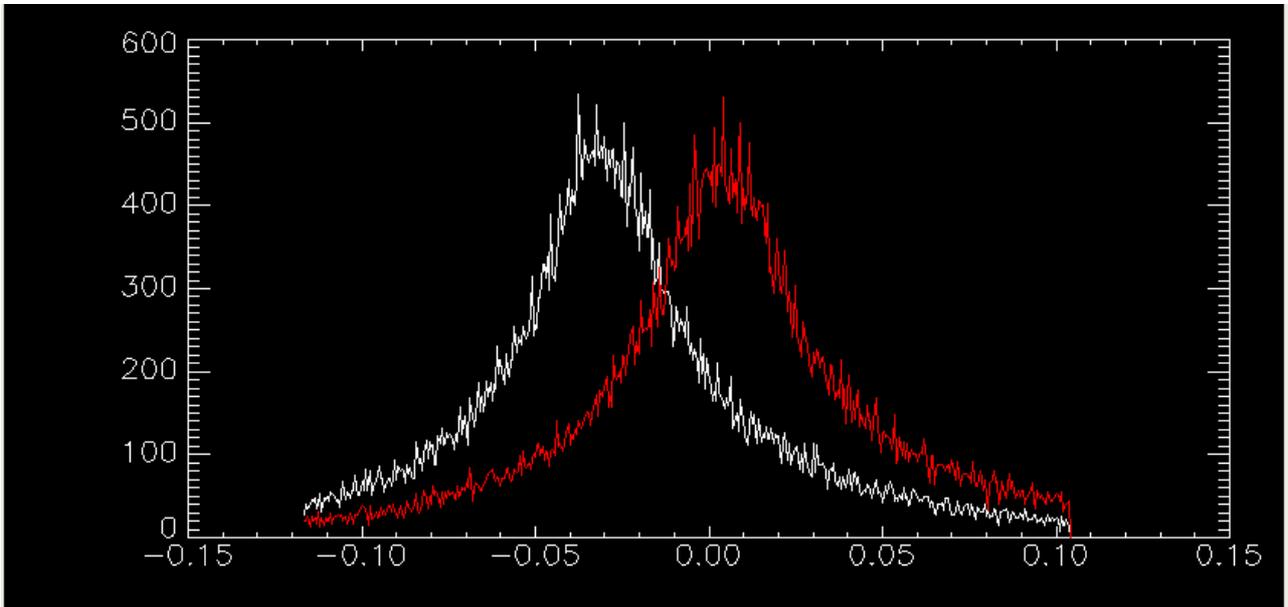


Figure 5 : cross track and along track shifts histograms between C3 and C2 respectively in red and white

4.1.3. C3/C4

— forward scanning products used

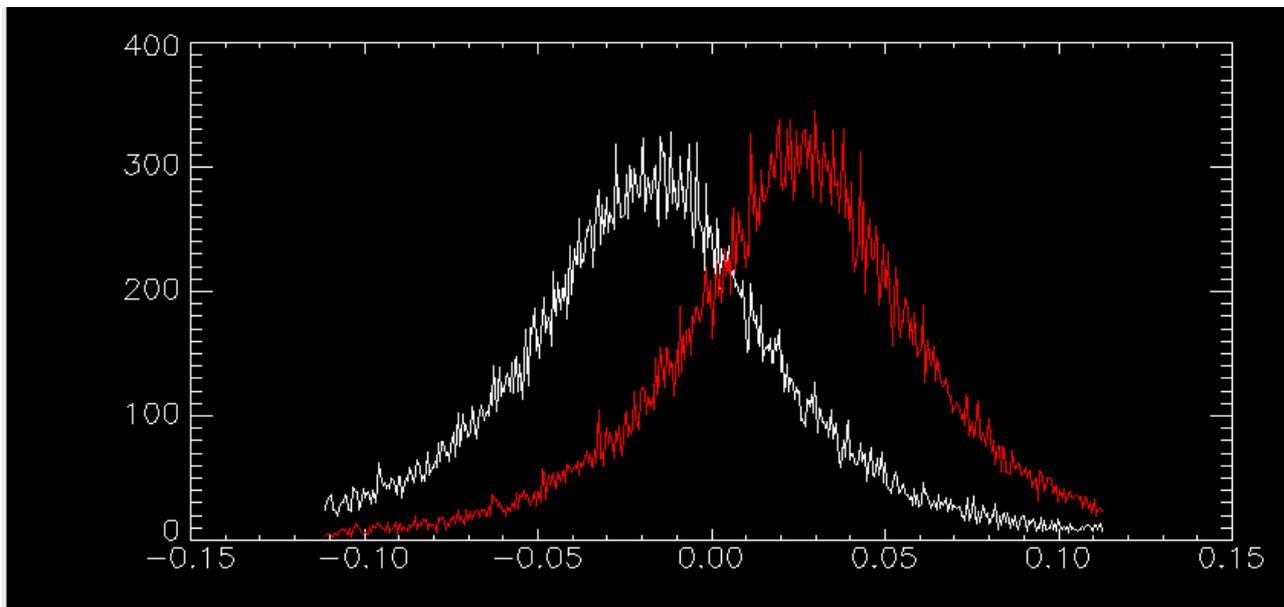


Figure 6 : across track and along track shifts histograms between C4 and C3 respectively in red and white

— backward scanning products used.

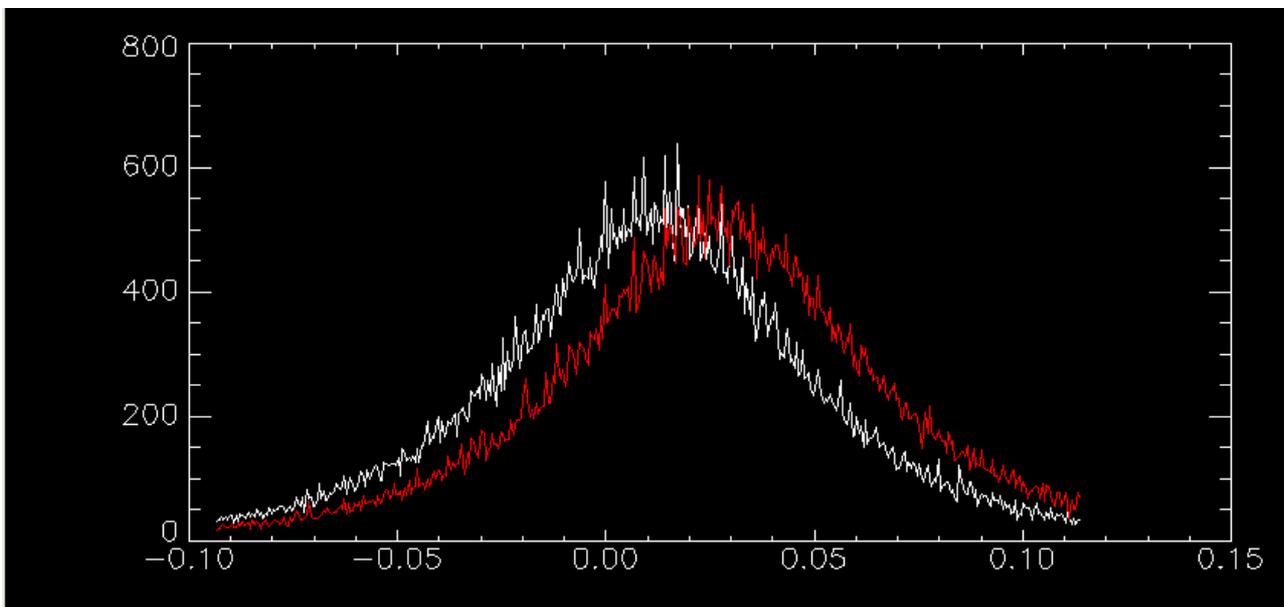


Figure 7 : across track and along track shifts histograms between C4 and C3 respectively in red and white

Observations and analyses derived from the above figures are presented hereafter. Firstly, histograms presented show low values very close to zero which is a good point and very low dispersions which give us a great confidence in measures. Secondly, whatever the scanning type, histograms of shifts between channels 2 and 3 are thinner than the other ones. This is logical

because channel 2 and 3 are more similar to each other in term of radiometric content than any other channel pair ((1,2) (1,4) (1,3)...). Actually, these histograms suffer less from noise and errors in correlations. Thirdly, there is an inversion in along track shift value averages between forward and backward scanning products. Finally, there is a shift across track between C2 and C1 whereas there is a shift along track but less strong between C2 and C3 or C3 and C4.

We also noticed that:

- Correlations between C1 and C2 and between C2 and C3 work very well on parts of orbits acquired by day.
- Correlation between C3 and C4 work well on parts of orbits acquired by night.

4.1.4. SHIFTS AND OVERLAP RATIO AVERAGES

The results in terms of shifts (dX, dY) computed and percentage of overlap are summarized in the table below.

Shifts and overlap ratio averages in forward scanning	C1/C2	C3/C2	C4/C3
overlap ratio average %	92,11	97,84	98,18
dX average (in fraction of diagonal)	0,057	0,003	0,013
dY average (in fraction of diagonal)	0,004	0,015	-0,011

Table 1 : shifts and overlap ratio averages for nominal forward scanning products

Shifts and overlap ratio averages in backward scanning	C1/C2	C3/C2	C4/C3
overlap ratio average	92,12	97,68	98,00
dX average (in fraction of diagonal)	0,057	0,004	0,014
dY average (in fraction of diagonal)	-0,005	-0,016	0,007

Table 2 : shifts and overlap ratio averages for nominal backward scanning products

4.2. PRODUCT L1A1, RESULTS OBTAINED ON MT MODE ACQUISITIONS

For MT acquisitions, Channel 2 and Channel 3 have no filter. So they should produce almost exactly the same image. Correlation between these two channels should be better.

For MT mode acquisitions, only backward scanning products have been used.

4.2.1. RESULTS OF MASSIVE CORRELATIONS

The following figures present the results of massive correlation between C1/C2, C3/C2 and C3/C4.

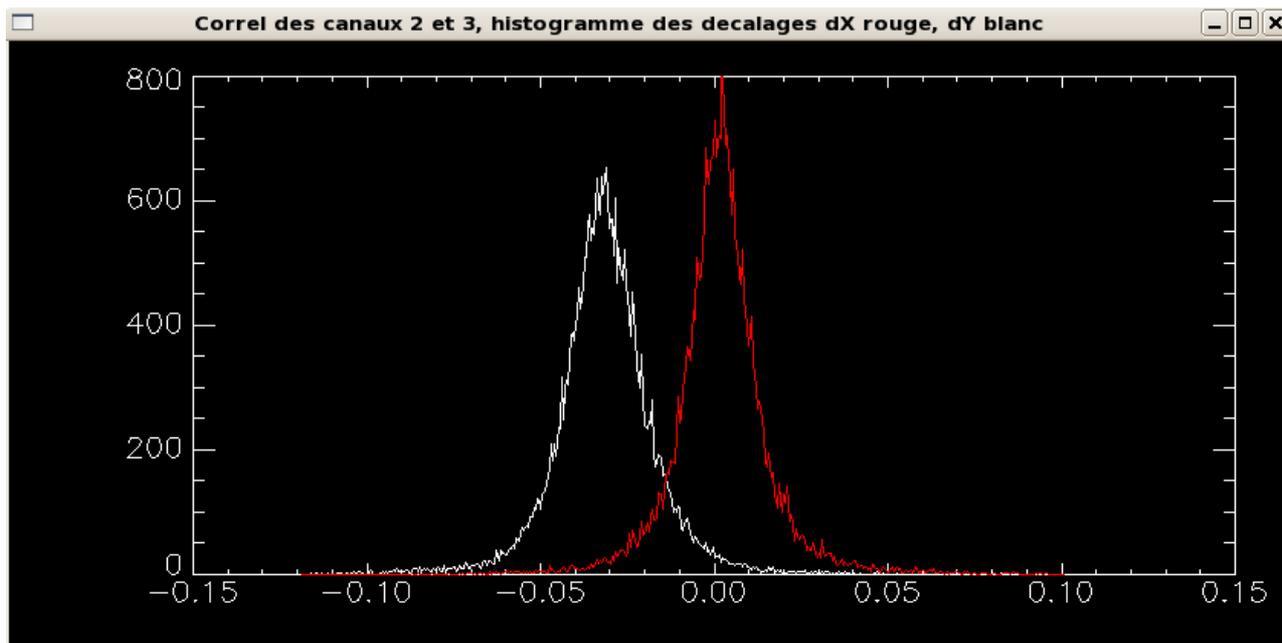


Figure 8 : Across track and along track shifts histograms between C3 and C2 respectively in red and white for MT mode products

4.2.2. SHIFTS AND OVERLAP RATIO AVERAGES

The results in terms of shifts (dX, dY) computed and percentage of overlap are summarized in the table below.

Shifts and overlap ratio averages	C1/C2	C3/C2	C4/C3
overlap ratio average		97,35	
dX average (in fraction of diagonal)		0,001	
dY average (in fraction of diagonal)		-0,019	

Table 3 : Shifts and overlap ratio averages for MT backward scanning products

4.3. CONCLUSION

Expected surface registration (before launch)	89%	97.4%	93%
In orbit measured value	92.1%	97.3 - 97.8 %	98%

In orbit values and expected value are very similar, especially for channel 2 and 3, which are the most important ones.

4.4. PRODUCT L1A2

For this product, Channels 1, 3 and 4 are resampled on Channel 2. This is possible because Scarab spatial sampling respects Shannon theorem.

Shifts and overlap ratio averages in forward scanning for nominal products	C1/C2	C3/C2	C4/C3
overlap ratio average	98,18	99,28	99,39
dX average (in fraction of diagonal)	0,013	0,001	0,004
dY average (in fraction of diagonal)	0,005	0,005	-0,003

Table 5 : Shifts and overlap ratio averages for L1A2 nominal forward scanning products

Results obtained on L1A2 nominal products (obits 323, 359 and 1686) produced with bias matrices and showed in the Table above are very satisfactory.

5. CONCLUSION

L1A1 registration performances are fully coherent with expected values.

L1A2 registration performances are excellent.