1 Subject

The report covers the geometric validation of ETM + products outputs from Landsat archive re processing (ESA DSI project). The purpose is the validation of the multi temporal accuracy of delivered dataset.

2 Document Change Record

<table>
<thead>
<tr>
<th>Issue</th>
<th>Revision</th>
<th>Date</th>
<th>Comment</th>
<th>Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>07/07/2014</td>
<td>Estimate multi temporal registration accuracy of ETM+ product in MPS dataset.</td>
<td>S. Saunier, A. Doeuvre</td>
</tr>
</tbody>
</table>

Table 1. Document change record.
3 Executive summary

This document, version 1.0, reports the last validation results obtained over a sample of SLAP V3.03 products.

<table>
<thead>
<tr>
<th>Validation Item</th>
<th>Comment</th>
</tr>
</thead>
</table>
| Multi Temporal geolocation Accuracy (L1T PCD/DEF Product) | MPS dataset,  
No geometric problem found on L1G products.  
After filtering* (9 products), the multi temporal registration accuracy, CE90 metric is 5 m. The registration is correct. No bias between successive scenes has been measured. Main contributor to RMSE is the standard deviation of measurements in both directions.  
The geometric accuracy report in the MTL file, is largely below accuracy deduced from this validation exercise. The accuracy given in metadata is associated with residual errors from geometric adjustment and does not come from independent check. |

*For explanation on the method, in particular filtering process, refer to section below.
4 Input data

MAASPOMAS, TDS is build up upon data observed over the following WRS SCENE (205 / 50), city Dakar, 29 ETM products have been downloaded, 9 products have been selected (20 products have been removed due to an important cloud coverage or GCPs Spataial coverage being not appropriate). The reference data is from the dataset itself.

MAASPOMAS, TDS **TBD** in the next version of the document.

![A Landsat scene over Dakar (Senegal) Area, Geometric Test site (Path / Raw 205 / 50).](image)

**fig 1.** A Landsat scene over Dakar (Senegal) Area, Geometric Test site (Path / Raw 205 / 50).
5 Analysis Methodology

The multi temporal geo-positional accuracy is associated to a dataset observed over the same region of interest with temporal data involved. The accuracy of each product is assessed by considering as reference either one product from the dataset or an external raster reference.

As outputs of the study there are different categories of information,
- Overall Statistics associated to the dataset
- Statistics associated to each products
- Internal geometry analysis.

The standard statistics, applicable at point/product/dataset level used to report the geopositional accuracy are defined as follow;

- The standard deviation
- The Root Mean Square Error (RMSE) in one direction
- Two dimensional RMSE
- The Circular Error probable error at 90 percentile (CE90) or 95 percentile (CE95)

The methodology to validate the multi temporal registration accuracy is not straightforward; in particular because several products, observed at different locations over the Earth, according to different configuration, are needed in order to obtain a robust estimate of this quality parameter. For cost effective approach, it is therefore more convenient to automatize process by using image matching technics. The success of image matching depends on matching factors, which can be summarized as follow;

- The quality of the images (noise, blurring);
- The seasonal variation and meteorological / atmospheric properties,
- The properties of the terrain, relief, surface reflectance, and information content,
- The similarities of spectral bands (in case of different cross comparison),
- The scene content (frequency content).

In addition, the results of image matching should be carefully checked and filtered because a significant number of GCPs can be retrieved from image matching, but kept depending on the matching confidence and on the spatial distribution. Actually, the accuracy should be associated to the full extent of the product footprint. It should not include an over contribution of errors located in a certain part of the image. Aside,
ETM Validation Report
Landsat SLAP products
SLAP SW V3.3

when addressing the multi-temporal case, it sounds important to consider, for a same area of interest, the same GCP, whilst the spatial content of an image is changing with time.

Therefore; the proposed methodology is basically broken down into three mains stages; the dense matching process between an input images and a reference images, the filtering of the correlation grid and the accuracy analysis.

The following main outputs are given and the document is organized accordingly.

- **Overall statistics**, this is a summary of the product accuracy to be communicated to the general audience. The statistics are based on accuracy obtained for each product. The data stack, as input, has been filtered in a way that selected results are relevant for the GCP covering the full extent of the scene and a multi temporal GCP set is considered.

- **Circular Error(CE) at 90 percentile is computed at point level**, considering GCP sample, and deducing multi temporal accuracy from this sample. It is somehow more informative approach, and there is no accuracy specification output from this approach.

- **Circular Error (CE) at 90 percentile is computed at Product level**, considering sample before and after filtering process. A figure is provided showing the CE90 and the error distribution. The accuracy specification is computed based on the filtered sample data.

- **Multi-temporal analysis** of geolocation accuracy reports accuracy metric depending on the observation date, report in fractional day of year. The graphic plot includes the accuracy report in the Landsat product metadata file as well.

- **In depth analysis of some products** is dedicated to products that have been, in most cases, discarded from statistics the overall statistics because of quality issues.
6 MPS dataset – Results

6.1 Overall Statistics

The centering is correct, perfectly within expectations (less than 1.5 meters for 30 meters of pixel resolution). The standard deviation in both directions remains below 1 pixel which conformed to the specification.

Two images have been kept for statistics, but these have an important standard deviation which impacts the overall results. More information about these images is provided at the end of the document.

<table>
<thead>
<tr>
<th></th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean of dX</td>
<td>-0.412621 m</td>
</tr>
<tr>
<td>Mean of dY</td>
<td>1.35768538 m</td>
</tr>
<tr>
<td>Std of dX</td>
<td>18.7734284 m</td>
</tr>
<tr>
<td>Std of dY</td>
<td>23.7651075 m</td>
</tr>
<tr>
<td>RMS of dX</td>
<td>19.0673606 m</td>
</tr>
<tr>
<td>RMS of dY</td>
<td>23.9021685 m</td>
</tr>
<tr>
<td>RMS 2D</td>
<td>30.5840221 m</td>
</tr>
<tr>
<td>Circular Error (Empirical)</td>
<td>5.0906 m</td>
</tr>
<tr>
<td>% points within Circle</td>
<td>88.4017214</td>
</tr>
<tr>
<td>% points within Ellipse</td>
<td>74.1906783</td>
</tr>
</tbody>
</table>

fig 2. Overall Statistics, 9 products.
6.2 Circular error at Point level

The errors associated to each point of the filtered multi temporal dataset are gathered all together to compute the circular error. The circular error is in this case 22.73 m. The centering accuracy is correct. It is confirmed with the plot of the radial error broken down into fixed size bin (3 m range).

![Circular Error Plot](image)

**fig 3.** Circular Error Plot computed based on all multi temporal points – The dots depict each GCP, the black ellipse is the 1 sigma error and the blue circle is the circular error plot.
6.3 Circular error at Product level

The circular error at product level is a commonly used metric. Because of scene content, a part of the image displaying sea area, the spatial distribution of GCP over scene is not 100%. The CE90 accuracy achieved is about 5 m, which is extremely correct.

**fig 4.** Repartition of the radial error, with cumulative function intersecting the 90th percentile line – The radial error of 30% of the points is between 0 – 3 m.
fig 5. **Product Circular Error @90 Plot** – (Filtered sample), 66% of products are within the black ellipse, which the 1 d sigma error ellipse.
ETM Validation Report  
Landsat SLAP products  
SLAP SW V3.3

![Graph: ETM Maspalomas (confidence above: 0.98)]

**fig 6.** *Product Repartition, 30% of products have a radial error between 2-3 m, the distribution is flat.*

### 6.4 Multi temporal

When using accuracy results from filtered dataset in order to analyze, if whether or not, degradation has occurred, there is change during the year 2002. It might be due to the scene vegetation, cloud coverage and it is to be investigated.
ETM Validation Report
Landsat SLAP products
SLAP SW V3.3

The comparison with value from MTL file is interesting to be done. In particular, it looks that a same trend is observed although the RMS from MTL file is 3, 4 times below the accuracy obtained from validation.

Two images have a standard deviation more important than the other ones that contribute to increase RME. It can be difficult to find accurate and well distributed GCPs because of small clouds spread all other the scene. As shown in figure below, GCPs are not well distributed over scene extent.

Ref: IDEAS-TN-06-L7_SupportToDSI-ETM_DataValidation
Issue/Rev: 1/1
Date: 07/07/2014
**ETM Validation Report**
Landsat SLAP products
SLAP SW V3.3

| Mask of temporally stable GCPs. | Small cloud affecting, frequently, Senegal image. It has been removed. |

Ref: IDEAS-TN-06-L7_SupportToDSI-ETM_DataValidation
Issue/Rev: 1/1
Date: 07/07/2014