Radiometric Uncertainty Tool (RUT): Task 3 coordination meeting

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TASKS DIVISION

- OBJECTIVES
- WP1: RADIOMETRIC PERFORMANCE ANALYSIS
- WP2: UNCERTAINTY THEORY
- WP3: SOFTWARE IMPLEMENTATION
- WP4: RUT APPLICATIONS
- BP1: DEVELOPMENT OF SPECIFIC MISSION RUT
- BP2: S2 PERFORMANCE SUPPORT

OBJECTIVES

1. Providing a methodology to identify and assess the radiometric uncertainty in an EO image at pixel level based on a combination of instrument and ground segment components; using pre– and in- flight characterisations/calibrations. That is, the identification of uncertainty contributions from the radiometric model and their probability distribution. It will also review specificities/peculiarities of different types of missions and describe how to perform an uncertainty analysis and the means to assess the contributions.
2. Describing a method based on GUM (QA4EO gdl 6) for uncertainty combination and propagation, the assessment of the covariance between the different terms and the validation of the combination by using a Montecarlo approach.
3. Implementing the design as a software tool and describing the ways to ingest the product, the limitations in terms of latency/memory and the usage of the metadata parameters.
4. Explaining the potential applications of the RUT and its usage for higher level product uncertainties.

What are the deliveries?

- S2-UAR: Uncertainty Analysis Report

  Theoretical approach to the radiometric uncertainty per pixel: model description and validation and uncertainty assessment

- S2-RUT-DPM: RUT Detailed Processing Module

  Description of the code: I/O routines, uncertainty contributors algorithms, memory management, tile selection process…

- S2-RUT code: Radiometric Uncertainty Tool

  Python 2.7 code and binaries

- S2-RUT-UG: RUT user guide

  Execution of the code, input and output parameters; and examples and applications of the L1 uncertainty to end-users.

- Support to S3 RUT development

  Agreement with ESTEC to support a YGT starting soon.

- Support to S2 PDGS/QWG/MPC

  e.g. reviewing the ICCDB

Project strategy and deadlines

- The WP division is not simple to follow and fit into the deliveries. Thus, the approach is:
  - Working in the S2-UAR, S2-RUT-DPM and RUT code development simultaneously.
  - Final task will be the development of the S2-RUT-UG
  - Parallel activities with the S3 RUT support and S2 QWG
- TBD with ESA but initially discussed:
  - KO: February 2015
  - RUT v1 November 2015
  - RUT v2 April 2017

S2-UAR

Radiometric analysis of S2 MSI instrument, model description and model validation.

Analysis start point is the ICCDB and references pointed by this.

Comments were made for upgrade of the database.

Change of approach for uncertainty contributors assessment. Not a WC/compliant approach but a scientific/standard approach→ a parameter that characterises the dispersion of values attributed to a quantity (≠max. error)

E.g. example of diffuser creeping in next 2 slides.

S2-UAR

Example: diffuser planarity

The final value proposed is 0.13º with an impact of 0.4% in lambertian terms and 0.04% in BRF model→ WC assessment

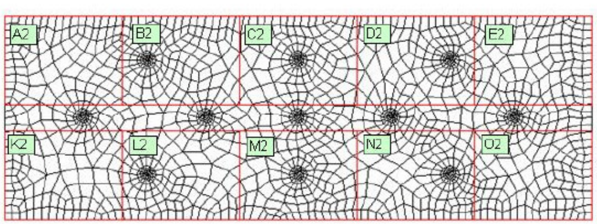
The uncertainty is about distribution of values

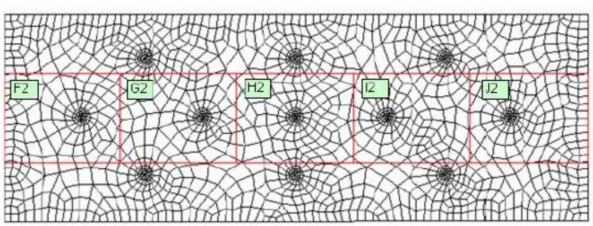
The tests of vibration and thermal cycling provide several values at several diffuser parts→ infer a probability distribution (type B uncertainty)

- **Angular subpupil variation**

	Vibration wrt initial	cycle 1 wrt initial	cycle 1 wrt vibration	cycle 2 wrt initial	cycle 2 wrt cycle 1	cycle 3 wrt initial	cycle 2 wrt cycle 2
A2	0,005	0,022	0,018	0,035	0,014	0,032	0,006
B2	0,002	0,043	0,041	0,073	0,030	0,063	0,015
C2	0,009	0,078	0,069	0,121	0,043	0,142	0,036
D2	0,012	0,100	0,092	0,169	0,069	0,201	0,035
E2	0,006	0,037	0,034	0,068	0,031	0,087	0,021
F2	0,010	0,055	0,045	0,093	0,038	0,085	0,009
G2	0,016	0,010	0,023	0,005	0,008	0,033	0,038
H2	0,004	0,034	0,035	0,067	0,033	0,118	0,052
I2	0,021	0,108	0,103	0,185	0,077	0,248	0,072
J2	0,010	0,139	0,130	0,235	0,097	0,300	0,066
K2	0,011	0,021	0,014	0,031	0,010	0,029	0,010
L2	0,012	0,057	0,051	0,081	0,025	0,047	0,035
M2	0,023	0,075	0,056	0,112	0,039	0,108	0,029
N2	0,010	0,075	0,077	0,126	0,053	0,125	0,035
O2	0,009	0,069	0,061	0,111	0,044	0,150	0,040
MAX	**0,023**	**0,139**	**0,130**	**0,235**	**0,097**	**0,300**	**0,072**
MAX without J2, I2	**0,023**	**0,100**	**0,092**	**0,169**	**0,069**	**0,201**	**0,052**
MAX without J2, I2, D2, E2, N2, O2	**0,023**	**0,078**	**0,069**	**0,121**	**0,043**	**0,142**	**0,052**

(GS2.NC.CSL.MSI.09002)





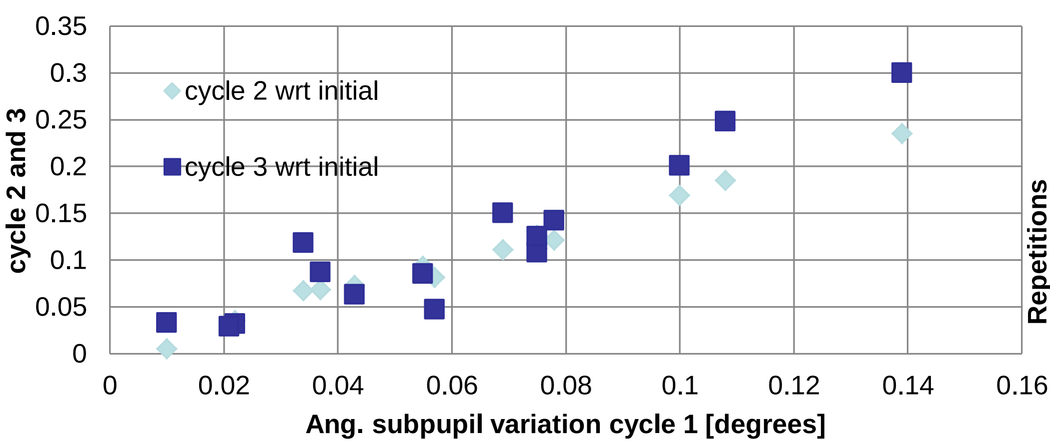
S2-UAR

If we eliminate the outliers (>0.2º due to a screw issue), the correlation moves from (cycle 1-2) 0.99 to (cycle 1-3) 0.85→ randomising changes

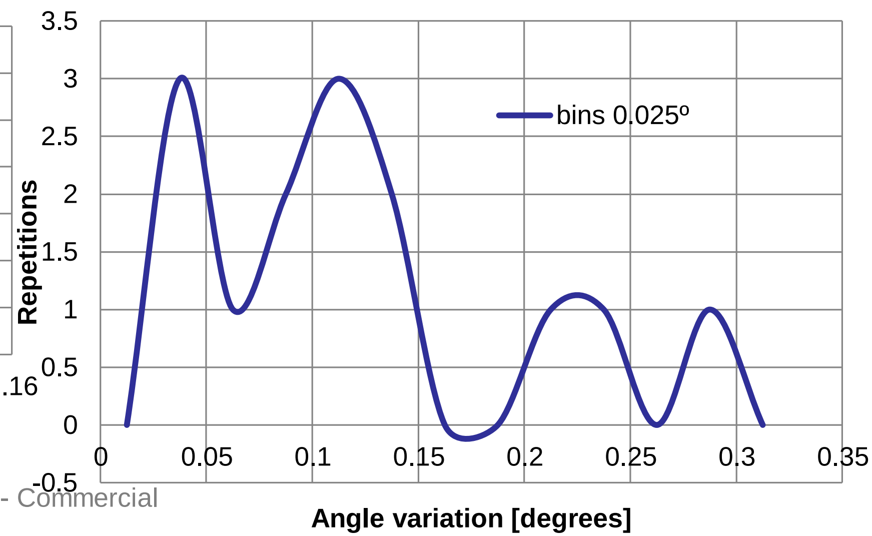
Without the outliers, the output distribution is close to a rectangular (or trapezoidal) distribution. E.g a limit close to 0.15º would give us an “equivalent Gaussian” 1σ→±0.086º (absolute variations)→~0.26%≠0.4%

Note: the assessment is based not only in data, but previous experience, assumptions…they must be reasoned!!!

Angular subpupil variation correlation



Histogram cycle3 wrt initial

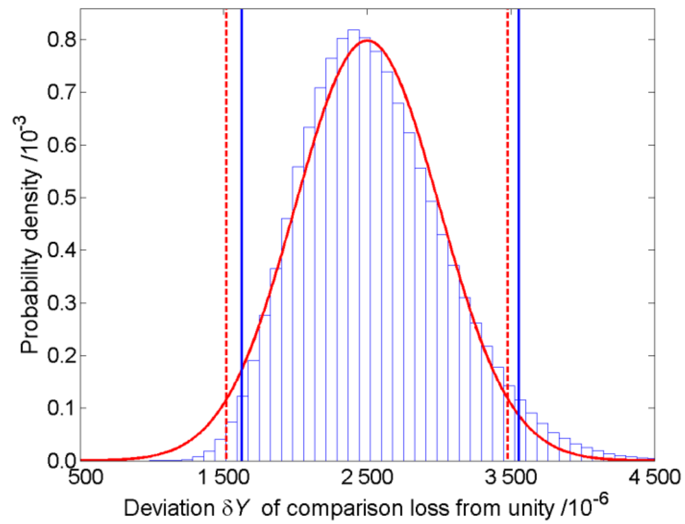


S2-UAR

Model validation: Montecarlo vs. GUM

What is the effect of higher order derivatives

Possibility of running the code in parallel (JASMIN)



Relative gains→ "*the accuracy of it is to be evaluated over 100 consecutive pixels*". There is a model, let's propagate through Montecarlo.

Y=f(X) with u(X) and u(f())!!!

Study the effect of **covariance**: analytically and/or experimentally

It is very limited because experimentally has not been done in most cases and the analytical relationship is not well understood.

e.g. interference filters and detectors are correlated by temperature.

It will be easier to understand the effect indirectly through the model validation.

S2-RUT-DPM and code

Completed: read of the S2 tile images (13 bands) and write of the uncertainty images in less than 30 minutes per tile!!!

How do I read the images? Blocks of 64 rows(x3 and x6 for 20m and 10m bands) and all columns.

What does it mean? Possibility to account for effects ACT (focal plane reconstruction using the detector footprint mask e.g. for potential crosstalk correction at L1C), neighbourhood effect (geometric uncertainty) and spectral effects (13 bands at once)

How to codify the uncertainties? 1 byte/pixel (uint8) enough. Codification from 0% to 25.4% in 0.1% steps

And memory? would this work in my PC? Yes, perfectly.

Image slice is in pixel numbers: 64x1830x3 = 351360 pixels (60m bands), 192x5490x6 = 6324480 pixels (20m bands) and 384x10980x4 = 16865280 pixels (10m bands). It sums up a total of 23541120 pixels.

The image codifies the pixel with 2 bytes and the uncertainty is codified with only 1 byte. Thus, in memory space it means a total of 23541120 pixels x 3bytes = 70623360 **(~70MB**)…(next slide)

S2-RUT-DPM and code

(continued from previous slide)…Once the variables have been used they are cleared in memory for the next loop slice.

The tool requires other type of variables to be loaded as look-up tables (LUT) or GML masks (e.g. footprint detector mask).

And the outputs? what do you provide? where are they saved? First, any “prompt” or “GUI” is avoided but console messages. It will help to adapt to the ground segment or the Sentinel Toolbox.

For each tile, 13 uncertainty images are generated (same name as L1C images + sufix “_UNC”) for each tile XML with basic info: min, max…

RUT does not offer a “by-side product” but a “product enhancement”. For each one of the tiles a subfolder “UNC_DATA” is created containing the uncertainty images and XML. If the directory already exist, the user selects whether to overwrite or not. E.g.:

```
In [1]: from RUT_main import *
The uncertainty folder in tile name
S2A_OPER_MSI_L1C_TL_CGS1_20130621T120000_A000065_T14SLD_N01.01 already exists.
Do you want to overwrite this tile (Y/N)?:N
No uncertainty was calculated for the
tileS2A_OPER_MSI_L1C_TL_CGS1_20130621T120000_A000065_T14SLD_N01.01
```

S2-RUT-DPM and code

National Physical Laboratory

Next step, focus in:

- uncertainty contributors algorithm
  - Specific ones to L1C (spectral response and geometric uncertainty)
  - Review of the ICCDB budgets
- Metadata, auxiliary and quality information (GML and XML parsing)
  - Diffuser BRF from the GIPP
  - Detector footprint
  - Cloud, land and water masks
  - Etc…

Contact Brockmann to start the collaboration

<3 months for launch!!!