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ENVISAT RA-2 RANGE INSTRUMENTAL CORRECTION: USO CLOCK PERIOD VARIATIONS AND ASSOCIATED AUXILIARY FILE

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1 SCOPE

This document presents a study performed on the USO clock period along with the analysis of the results. This document shall support the update of the USO clock period Auxiliary Data File format used within the Envisat PDS RA-2 Level1b data processing.

2 ACRONYMS

ADF	Auxiliary Data File
IPF	Instrument Processing Facility
IECF	Envisat Instrument Engineering Calibration Facility
PDS	Payload Data Segment
OBDH	On-Board Data Handling
RA-2	Envisat Radar Altimeter
USO	Ultra Stable Oscillator

3 INTRODUCTION

The conversion of the RA-2 receiving window time delay into altimetric range requires the estimation of the Ultra Stable Oscillator clock period. This computation is nominally performed by means of the on-board USO clock period, regularly measured and updated in the IPF ground processing via a dedicated Auxiliary Data File (ADF RA2_USO_AX).

The nominal value of this parameter is equivalent to 12500 picoseconds. The characterisation value measured on ground is equal to 12501 picoseconds, actually present in the Characterization Auxiliary file (ADF RA2_CHD_AX) but not used in the processing. In the operational processing the nominal value is actually used and with it the in-flight measured USO clock period has to be compared. Note that the in-flight USO clock period is presumed to drift during the mission lifetime as a consequence of the USO ageing. For this reason the USO drift needs to be estimated with a very high accuracy.

4 REFERENCE DOCUMENTS

[R – 1] ENVISAT-1 Products Specifications Volume 14: RA-2 Products Specifications, PO-RS-MDA-GS-2009
[R – 2] Instruments Corrections Applied on RA-2 Level-1B Products, paper presented at the Envisat Calibration Workshop, September 2002
[R – 3] ENVISAT-1 Instrument Calibration Detailed Processing Module, Volume 3 : RA-2/MWR Calibration, 190190-PA-NOT-005, Issue 2.3
[R – 4] RA-2 Algorithm Specification for Level 1b Software Prototyping, TNO/RAS/0018/ALS, Issue 12 draft
[R – 5] ENVISAT Radar Altimeter and Microwave Radiometer Cross-Calibration and Validation Plan, PO-PL-ESR-RA-0005

[R – 6] ECAR, Envisat Cyclic Altimetric Report, Quality Assessment Report, ENVI-GSOP-EOPG-03-0011 (http://earth.esa.int/pcs/envisat/ra2/reports/pcs_cyclic/)

5 USO CLOCK PERIOD EVALUATION

5.1 Algorithm used

The algorithm used for the USO clock period (P_{USO}) evaluation from the L0 products is reported hereafter. It is identical to the one presented in [R – 2].

1. Extract from a sequence of RA-2 Source Packets the quantities {USO(n),UTC(n)} where
   a. USO(n) is the USO counter annotated in every Source Packet
   b. UTC(n) is the Source Packet time stamp (calculated starting from the OBDH datation associated to each Source Packet, using the algorithm described in [R – 4])

2. Compute the clock period according to the following formula (that does not take into account scaling factors):

$$P_{USO} = \frac{UTC(n+m) - UTC(n)}{USO(n+m) - USO(n)} \qquad \textbf{(1)}$$

where *m* is a number strictly related to the time distance between the pairs of Source Packets used in the equation.
Based on the results from the Commissioning Phase as described in [R – 2], the value of m shall be equal to 86400 seconds, i.e. one day.

5.2 Results

The USO clock period has been evaluated over the time period covering cycle 17 (2nd of June – 7th of July 2003).
Two different tools have been used in order to make cross-comparison and cross-validation. These are a specific routine from the Envisat IECF facility (ref. [R – 3]) as well as an IDL tool, specifically developed in-house for this purpose.

The upper panel of Figure 1 and Figure 2 exhibits the USO clock period values with respect to the nominal one (12500 ps), obtained with the two different tools.
Even if the average values are very close in both cases, the variability of the IECF results appears to be one order of magnitude higher. Considering the characteristics of the Ultra Stable Oscillator, the IECF results seem to be not realistic. This aspect is currently under investigation. On the other hand, the values reported in Figure 2 are analogous to the Envisat Commissioning Phase results illustrated in [R – 2].

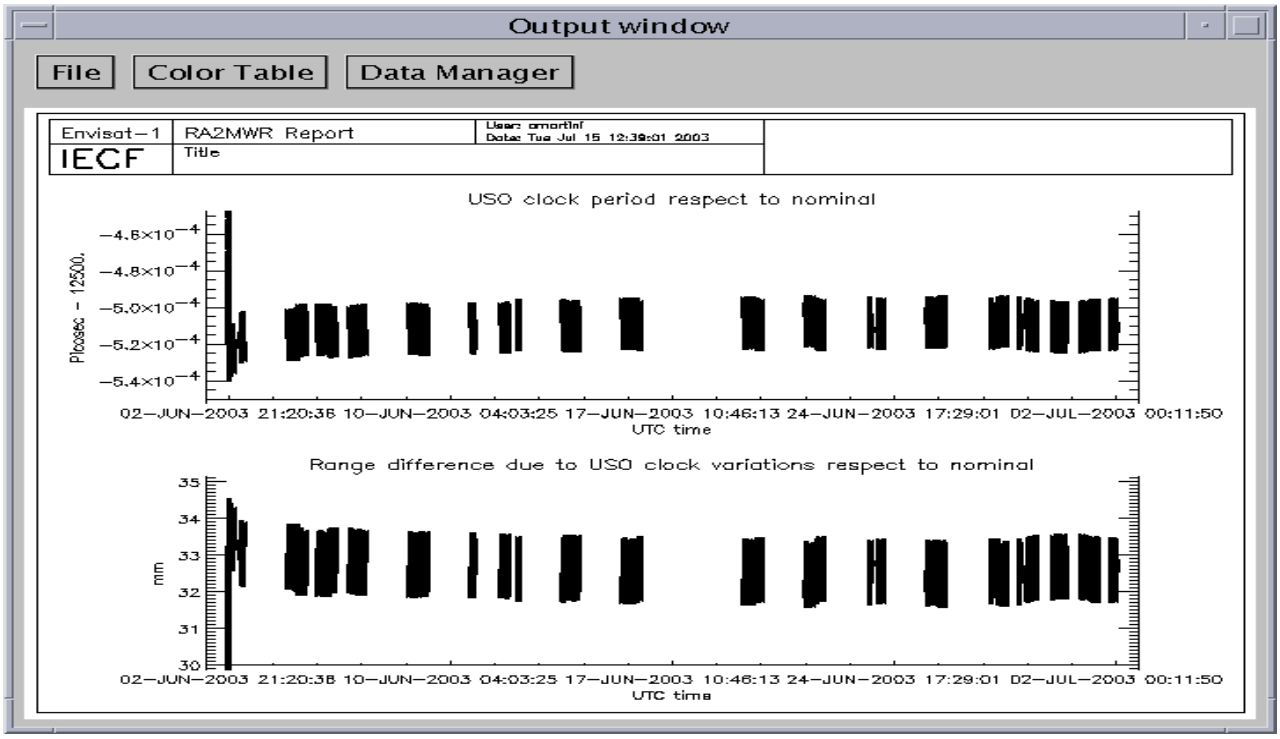

Figure 1: USO clock period and Range difference obtained with the IECF tool over the period 2nd June to 7th July 2003.

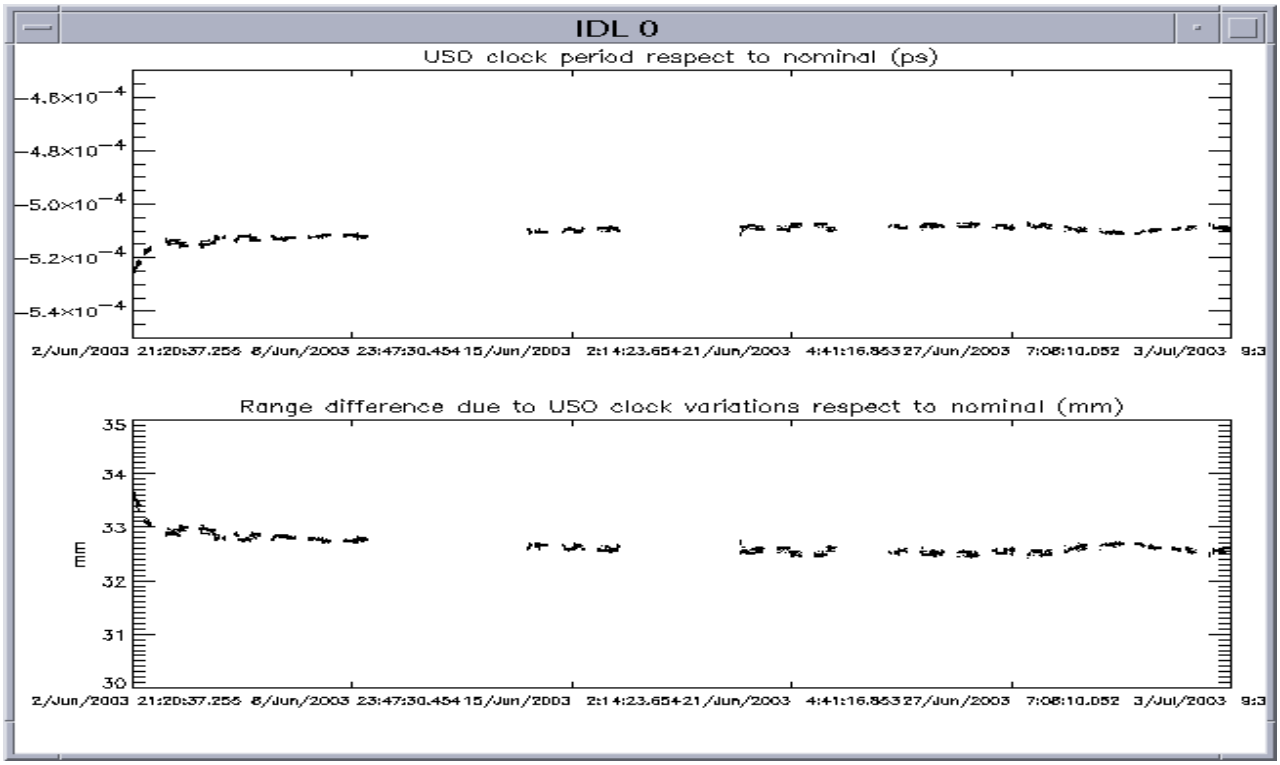

Figure 2: USO clock period and Range difference obtained with the IDL tool over the period 2nd June to 7th July 2003.

5.3 Impact on the range

The USO clock period drift directly impacts the RA-2 altimetric range and as such is to be considered as a major engineering instrumental correction.
The effect of the USO clock drift, with respect to the nominal values is translated in terms of altimetric range variation. The calculation of the altimetric range deviation is done according to the formula reported hereafter:

$$\Delta Range(n) = \frac{F_{USO}(n) - F_{USO\_nom}}{F_{USO\_nom}} H \qquad \textbf{(2)}$$

where:
$F_{USO}(n)=1/P_{USO}(n)$
$F_{USO\_nom}=1/P_{USO\_nom}$
P_{USO_nom}=12500 picoseconds
H=800 Km (mean average satellite altitude)

The lower panel of Figure 1 and Figure 2 exhibits the altimetric range impact computed with the two different tools. The altimetric range variation due to the USO clock period drift over the concerned one month period clearly exhibits a bias of 32 mm as well as a slight drift about 0.3 mm, the initial range being shortened by the bias while the drift is going in the opposite sense.

Worthwhile to notice that the impact on the range for what concerns the drift is to be related with an USO clock period variation of the order of $5*10^{-6}$ picoseconds.

An update of the bias and the drift will be made available to the user community at every cycle within the proper Envisat Cyclic Altimetric Report [R – 6].

6 AUXILIARY FILE (RA_USO_AX)

6.1 Actual USO ADF Format versus USO clock variability

The format of the RA2_USO_AX Auxiliary Data File is given in [R – 4]. As a brief description, the USO clock period used in the IPF ground processing is provided as an unsigned long integer in picoseconds as units of measurement. This means that the value used for the processing shall not change until the variations in the real USO clock period would be of one picosecond, i.e. not before years considering the current drift.

In other words, any USO clock variation lower than one picosecond shall not be reflected in the Auxiliary Data File and consequently not considered within the processing.

This is the weakness of the USO ADF file currently used with the Envisat IPF Level 1B processing chain up to Version 4.56.

6.2 USO clock period Required Accuracy

Based on the figures presented in par. 5.3, and considering the required precision on the Altimeter range measurements of half a centimetre drift per year [R- 5]; the USO clock period clearly needs to be reported in the corresponding ADF as an unsigned long long integer with a 10^{-6} picoseconds unit of measurement.

With this new accuracy, the minimum variation of the USO clock period contained in the RA2_USO_AX ADF file, will correspond in a mean altimetric range variation of less than 0.1mm which is ten times lower than the intrinsic accuracy of the range given the units currently used (mm). This means that any variation of the last digit of the USO clock period shall not be noticed as a range variation. However this choice allows us to stay on the safe side for what regards this type of error.

7 CONCLUSION

This document describes an analysis performed on the Envisat RA-2 USO clock period drift with two different tools and the comparison of the obtained results. A review of the RA2_USO_AX Auxiliary Data File format used in the ground processing chain is also presented when taking into account the observed clock period variability.

An upgrade of the Auxiliary Data File format and IPF processing chain is required to be compliant with the RA-2 Altimetric Range accuracy mission requirement.