S3-A SRAL Cyclic Performance Report

Cycle No. 009

Start date: 17/09/2016

End date: 14/10/2016

Ref.: S3MPC.ISD.PR.04-009
Issue: 1.0
Date: 21/10/2016
Contract: 4000111836/14/I-LG
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**Project:** PREPARATION AND OPERATIONS OF THE MISSION PERFORMANCE CENTRE (MPC) FOR THE COPERNICUS SENTINEL-3 MISSION

**Title:** S3-A SRAL Cyclic Performance Report – Cycle 009

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**Distribution:** ESA, EUMETSAT, S3MPC consortium

**Accepted by ESA:** P. Féménias, MPC TO

**Filename** S3MPC.ISD.PR.04-009 - i1r0 - SRAL Cyclic Report 009.docx

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1 Introduction

1.1 Scope of the document

This document is dedicated to describe the cyclic monitoring of the SRAL instrument calibration parameters within the Sentinel-3 MPC project. Also a whole mission analysis is given.

It will be distributed during the Commissioning Ramp-up Phase to the MPC team and to ESA, on a cyclic basis.

1.2 Applicable Documents

| AD. 1 | Cal/Val Plan for the MPC Commissioning Phase - STM, S3MPC.CLS.PLN.009, issue 1.1, 26/05/2015. |

1.3 Acronyms

| ADF | Auxiliary Data File |
| Cal/Val | Calibration / Validation |
| CNES | Centre National d’Études Spatiales |
| DEM | Digital Elevation Model |
| ESA | European Space Agency |
| ESL | Expert Support Laboratory |
| ESTEC | European Space Technology Centre |
| HKTM | House Keeping Temperatures Monitoring |
| IOCR | In-Orbit Commissioning Review |
| LRM | Low Resolution Mode |
| MPC | Mission Performance Centre |
| PTR | Point Target Response |
| SAR | Synthetic Aperture Radar |
| SCCDB | Satellite Calibration and Characterisation Database |
| SCT | Satellite Commissioning Team |
| SRAL | Synthetic Aperture Radar Altimeter |
| TBD | To Be Done |
2 SRAL Internal Calibration Monitoring.

2.1 Introduction

The SRAL instrumental calibration is assessed during the mission. Several parameters are monitored and analysed in detail in order to characterise the altimeter performance along the mission lifetime.

Two main groups of calibration parameters are monitored.

The first is derived from the Point Target Response (PTR) calibration (CAL-1 mode and product). The PTR signal follows the same circuitry path as the science waveforms within the calibration loop. The delay caused by the travel through the calibration path can be measured and afterwards compensated in the total range computation. The attenuation suffered by the waveforms when traveling through the instrument also needs to be monitored and the waveform needs to be compensated for. Moreover, there are a collection of other parameters to be checked, such as the PTR width and the secondary lobes features. These CAL-1 parameters are produced separately for LRM and SAR modes, as they follow different instrumental paths, and also they are duplicated for Ku-band and C-band. Also there are different options for characterising the delay and power of the closed loop signal, such as the PTR maximum power or PTR maximum position.

The second is related to the Instrument Transfer Function (CAL-2). The science waveforms spectra is distorted by the on-board instrumental sections. Therefore, in order to retrieve the original echo shape, we need to undo this effect. Several parameters are derived from the analysis of the CAL-2 waveforms for characterizing it and dissect any feature along the mission lifetime. The CAL-2 waveform is the same for both modes LRM and SAR, but there is a distinction between bands Ku and C.

Additionally, for SAR mode, the two intra-burst corrections are monitored: power and phase progression within a burst. Some characteristics are computed for describing and following up their behaviour along the S3 mission.

It is also of major importance the monitoring of the on-board clocks. The altimeter clock counter, responsible for computing the echo travel time, has the biggest impact in the range determination. The platform clock is responsible for the overall platform instruments datation. Their stability and performance are to be supervised along the mission.

Finally, the data coming from the thermistors located in the different sections of the on-board HW (HKTM products), are to be analysed in order to check the relation of any calibration parameters anomaly with the thermal behaviour, and find solutions for modelling the instrument characterisation (for instance orbital oscillations) if needed.

The above instrumental characterisation is checked in different time baselines, depending on how interesting is to show each parameter progression. It could be an orbital or a cyclic series, yearly, or a complete mission for long term-drift assessments. Also comparison between similar periods could be developed (inter-orbital or inter-cycle analysis) when appropriate.
2.2 Cycle 8 In-Flight Internal Calibration.

In this chapter, the monitoring of all CAL1 modes is described, including figures of the main parameters and a brief explanation of the observations on the results.

2.2.1 CAL1 LRM

The geographical distribution of the SRAL CAL1 LRM measurements is shown in Figure 2.2-1.

The two main variables computed from the PTR waveforms are used for the power (total power of the PTR) and range (difference of travel between the transmission and reception lines) corrections. Their monitoring result is detailed from Figure 2.2-2 to Figure 2.2-5.
In terms of CAL1 time delay, the Ku band inter-annual slope is of -0.24 cm/yr, lower in absolute terms than the C band -1.13 cm/yr. The peak to peak of the C band is higher, showing more variability than the Ku band series, visible also in the standard deviations results (see figure’s legend).
In terms of CAL1 power, the Ku band inter-annual slope is of -0.61 dB/yr, slightly lower in absolute terms than the C band, of 2.05 dB/yr. Here again the variability for the C band is higher than for the Ku band series: C band standard deviation is around five times the one of Ku band.
The variable selected for determining the SRAL CAL1 time delay is the difference of travel between transmission and reception lines. But there are also other PTR time delay related variables that are sensible to the CAL1 delay measurement, represented in Figure 2.2-6 and Figure 2.2-7. They are the CAL1 waveform median position, and the PTR maximum power position. The Ku band shows a significantly lower standard deviation and trend than the C band for the PTR delay parameters. The Tx/Rx difference of travel and PTR median position shows an extremely similar behaviour in each band case. The suspicious flat line for the PTR maximum position seen in previous cycles, here switching between two values, is related to the variable resolution and how it is calculated within the L1b CAL1 processing.

![Period trend of all CAL1 PTR Delay related variables for LRM mode.](image-url)

**Figure 2.2-6.** CAL1 LRM Ku Time Delay related variables trend. The green line (Diff of travel between Tx & Rx lines) is hidden below the blue line (PTR Median Delay).

![Figure 2.2-7. CAL1 LRM C Time Delay related variables trend.](image-url)
Also the PTR width is monitored. This instrumental calibration parameter has an impact on the SWH L2 variable retrievals. The two bands CAL1 PTR width trends are shown in Figure 2.2-8 and Figure 2.2-9. The Ku band show lower standard deviation of the PTR width than the C band in the analysed period.

**Period trend of the CAL1 PTR width for LRM mode.**

![Period trend of the CAL1 PTR width for LRM mode.](image)

**Figure 2.2-8.** CAL1 LRM Ku PTR width trend.

![Period trend of the CAL1 PTR width for LRM mode.](image)

**Figure 2.2-9.** CAL1 LRM C PTR width trend.
Finally for CAL1 LRM, the secondary lobes parameters are shown. In Figure 2.2-10 and Figure 2.2-11 we can see the power and position of every secondary lobe measured by the CAL1 L1b processor. We observe here again a better behaviour of the Ku band (with a more stable series) with respect to the C band.

![Distribution of the PTR secondary lobes within the CAL1 PTR waveform for LRM mode.](image1.png)

Figure 2.2-10. CAL1 LRM Ku PTR secondary lobes Power and Position within the PTR waveform.

![Figure 2.2-11. CAL1 LRM C PTR secondary lobes Power and Position within the PTR waveform.](image2.png)
The secondary lobes power trend along the analysed period is shown in Figure 2.2-12 and Figure 2.2-13. It is notable the lower variability of the Ku band PTR power trend with respect to that of the C band.

Figure 2.2-12. CAL1 LRM Ku PTR secondary lobes Power trend. In the legend it is specified the secondary lobe index.

Figure 2.2-13. CAL1 LRM C PTR secondary lobes Power trend. In the legend it is specified the secondary lobe index.
The standard deviation and inter-annual slope of each of the secondary lobes is represented in Figure 2.2-14. In the X axis we see the index of each of the secondary lobes. In the legend we can check the colour code of each line. Here again, we observe a higher dispersion of the C band data (cyan line) with respect to the Ku band (green line), and a less stable power slope behaviour along the collection of secondary lobes of the C band (red line) than those of the Ku band (blue line).

Figure 2.2-14. CAL1 LRM PTR secondary lobes characterisation. The inter-annual slope (in dB/year) and standard deviation (in dBx10^-2) of each of the secondary lobes during the period are shown.
2.2.2  CAL1 SAR

The geographical distribution of the SRAL CAL1 SAR measurements is shown in Figure 2.2-15.

![CAL1 SAR Locations](image)

Figure 2.2-15. Location of the CAL1 SAR measurements.

The PTR power (total power of the PTR) and time delay (difference of travel between the transmission and reception lines) corrections are shown from Figure 2.2-16 to Figure 2.2-19.
In terms of CAL1 time delay, the Ku band inter-annual slope is of -0.21 cm/yr, lower in absolute terms than the C band -1.11 cm/yr. The peak to peak of the C band is higher, than the one of the Ku band series (see also the standard deviation differences).

Period trend of the PTR time delay for SAR mode.

Figure 2.2-16. CAL1 SAR Ku Time Delay Trend.

Figure 2.2-17. CAL1 SAR C Time Delay Trend.
In terms of CAL1 power, the Ku band inter-annual slope is of -0.61 dB/yr, lower in absolute terms than the C band, of -2.04 dB/yr. The standard deviation of the C band is much higher than the one of the Ku band series. The CAL1 SAR power series shows a very similar stability and slope compared to the CAL1 LRM power series in both bands.

Figure 2.2-18. CAL1 SAR Ku Power Trend.

Figure 2.2-19. CAL1 SAR C Power Trend.
The three SRAL CAL1 time delay variables are represented in Figure 2.2-20 and Figure 2.2-21. Here we see the CAL1 waveform median position, and the PTR maximum power position, in addition to the selected PTR Delay variable for the SRAL mission. The Ku band series shows here again a lower dispersion and slope than the C band. The suspicious flat line for the PTR maximum position is related to the variable resolution (see CAL1 LRM). The Tx/Rx difference of travel and PTR median position shows an extremely similar behaviour.

Figure 2.2-20. CAL1 SAR Ku Time Delay related variables trend.

Figure 2.2-21. CAL1 SAR C Time Delay related variables trend. The green line (Diff of travel between Tx & Rx lines) is hidden below the blue line (PTR Median Delay).
The PTR width is shown in Figure 2.2-22 and Figure 2.2-23 for the two bands. The Ku band shows much lower standard deviation of the PTR width than the C band in the analyzed period. The Ku band PTR width is decreasing, the C band one is increasing. All PTR width statistics are similar to the LRM IQ mode case.

![Period trend of the CAL1 PTR width for SAR mode.](image1)

![Figure 2.2-22. CAL1 SAR Ku PTR width trend.](image2)

![Figure 2.2-23. CAL1 SAR C PTR width trend.](image3)
The CAL1 SAR secondary lobes parameters are shown in Figure 2.2-24 and Figure 2.2-25, where we can see the power and position of every secondary lobe measured by the CAL1 L1b processor. We observe here again a better behaviour of the Ku band (with a more stable series) with respect to the C band.
The secondary lobes power trend along the analysed period is shown in Figure 2.2-26 and Figure 2.2-27. It is notable the lower variability of the Ku band PTR power trend with respect to that of the C band.

Figure 2.2-26. CAL1 SAR Ku PTR secondary lobes Power trend. In the legend it is specified the secondary lobe index.

Figure 2.2-27. CAL1 SAR C PTR secondary lobes Power trend. In the legend it is specified the secondary lobe index.
The standard deviation and inter-annual slope of each of the secondary lobes is represented in Figure 2.2-28. Here again, we observe a higher dispersion of the C band data (cyan line) with respect to the Ku band (green line), and a less stable power slope behaviour along the collection of secondary lobes of the C band (red line) than those of the Ku band (blue line), although the mean power slope is similar for some indexes.

![Figure 2.2-28. CAL1 SAR PTR secondary lobes characterisation. The inter-annual slope (in dB/year) and standard deviation (in dBx10^-2) of each of the secondary lobes during the analysed period are shown.](image-url)
Additionally, and only for SAR mode in Ku band, the intra-burst corrections are monitored. They are used for the correction of the SAR burst data during the L1b processing, in power and phase. First, the Power and Phase Arrays history over the monitored period, are shown in Figure 2.2-29 and Figure 2.2-30 respectively.

Figure 2.2-29. CAL1 SAR Ku Power intra-burst correction along the period.

Figure 2.2-30. CAL1 SAR Ku Phase intra-burst correction along the period.
The slopes of both corrections are monitored along the analysis period. It is shown in Figure 2.2-31.

![Figure 2.2-31. CAL1 SAR Ku Phase & Power intra-burst corrections slopes over the analysis period.](image)

Finally, each of the pulses indexes in the burst are analysed in terms of standard deviation, with the aim of detecting any anomalous behaviour in a particular pulse index. As we can see in Figure 2.2-32, the stability behaviour is quite similar along the burst pulses. The first phase pulse index is always zero (hence, showing a null standard deviation), because the phase intra-burst correction is computed as a phase difference with respect to the first pulse index in the burst.

![Figure 2.2-32. Pulse by pulse standard deviations of the CAL1 SAR Ku Power and Phase intra-burst corrections.](image)
2.2.3 System Transfer Function (CAL-2)

The System Transfer Function (CAL-2) is given as a waveform that enables the L1b Calibration Processing to correct the echo shape distortions caused by the on-board instrument along the spectra.

The geographical distribution of the SRAL CAL2 (Ku in green, C in red) measurements is shown in Figure 2.2-33.

![Location of the CAL2 measurements.](image-url)
A general overview of the CAL2 waveforms shape along the analysis period is shown in Figure 2.2-34 and Figure 2.2-35. There we can observe how the CAL2 Ku band waveforms are more similar between themselves than the ones of the C band, showing more clearly in Ku band the typical oscillations along the spectra of the transfer function.
If we average these CAL2 waveforms, we get the results of Figure 2.2-36. Again here we observe the cleaner oscillations of the CAL2 spectra of the Ku band waveform with respect to the one of the C band, although they look aligned.

![Figure 2.2-36. Averaged CAL2 Ku and C waveforms over the period.](image)

Other CAL2 parameters are computed in the L1b calibration processing and contained in the L1b CAL products. They are computed separately for the right and left sides of the CAL2 spectra, and are here below shown.
In Figure 2.2-37 and Figure 2.2-38 we can observe the series of the CAL2 waveform right and left side slopes over the analysed period. For the C case we see a better agreement between both sides slopes series than for the Ku band case; in this last case the GPRW spectra starts with a lower slope than how it ends. We do not observe a clear drift in any of the Slope series.

![Time series of CAL2 waveforms right and left sides Slope.](image)

**Figure 2.2-37.** CAL2 Ku waveforms right (blue) and left (red) sides Slope over the period.

![Time series of CAL2 waveforms right and left sides Slope.](image)

**Figure 2.2-38.** CAL2 C waveforms right (blue) and left (red) sides Slope over the period.
In Figure 2.2-39 and Figure 2.2-40 we can check the Standard Deviation of both CAL2 waveform sides and bands. We see here clearer the persistently higher Standard Deviation of the C band case with respect of that of Ku band.

![Time series of CAL2 waveforms right and left sides Standard Deviation.](image)

**Figure 2.2-39.** CAL2 Ku waveforms right (blue) and left (red) sides Standard Deviation over the period.

![Time series of CAL2 waveforms right and left sides Standard Deviation.](image)

**Figure 2.2-40.** CAL2 C waveforms right (blue) and left (red) sides Standard Deviation over the period.

If we compute the Standard Deviation over the slope (i.e. after de-sloping the CAL2 waveform sides), we have a better idea of the dispersion without the effect of a slope. Due to the very little slope values of the CAL2 waveform sides, the standard deviation results before and after de-sloping are very similar. Hence, the ones after de-sloping are not shown here.
There are other CAL2 waveform sides parameters that are checked but will not be shown here, such as the mean, the maximum position and the peak to peak power. The above plotted parameters give an overall idea (and the most important information) of the CAL2 data characterisation. If any of the not plotted parameters have a strange behaviour, it will be analysed in this report.
2.2.4 AutoCal (CAL1 SAR Auto)

This CAL1 SAR configuration is devoted to the auto-calibration of the Attenuation Steps. The instrument has a series of Attenuation Steps that ideally has 63 levels of attenuation from 0 to 62 dB. But the instrument does not perform ideally, hence the real attenuations values of each attenuation step have to be monitored and accounted for in the sigma-0 retrievals. For instance, for an ideal attenuation value of 20 dB, the instrument could be actually attenuating 20.33 dB.

The geographical distribution of the SRAL AutoCal measurements is shown in Figure 2.2-41.

The ideal and real attenuation tables are present in the L1b products for the two bands, Ku and C. If we subtract one table to the other, we can observe how far the real attenuation values are from the ideal values. An average of this subtraction during the analysis period is shown in Figure 2.2-42.
The on-board attenuation is in general over the ideal reference values.

2.2.5 On-board Clock Performance

The altimeter and platform clock frequencies will be here below depicted and analysed when available. Their assessment is very important for the identification of the range anomalies causes, all along with calibration parameters such as the PTR time delay, and the datation issues during the mission.

Anyhow, the clock counter data, needed for the study of the clock frequency behaviour, is not included in L0 or L1b files, the products available so far.

2.2.6 Housekeeping Temperatures

The orbital behaviour of the instrumental HW and waveguides is very much related to the on-board thermal conditions. The identification of the reasons for any calibration parameter orbital excursion or mid-long term drift needs the assessment of its correlation with the temperatures on-board.

The results of such assessment can be essential for modelling the orbital oscillations of any calibration parameter if it is possible (i.e. if the calibration parameter is measured along the orbit), or analysing the long-term on-board instrumental conditions.
The thermal parameters to be monitored are contained in the Calibration ISP telemetered product as a collection of “THERM” fields.

From Figure 2.2-43 to Figure 2.2-48 we represent the thermistors values versus time, for each calibration mode, packed in two groups of thermistors for the sake of clarity, and averaged over each calibration products duration.
Time series of thermistors temperatures on CAL1 LRM IQ mode over the analysed period.

Figure 2.2-43. First group of Thermistors time series on CAL1 LRM IQ mode. The temperatures are averaged for each calibration product over the analysis period.

Figure 2.2-44. Second group of Thermistors time series on CAL1 LRM IQ mode. The temperatures are averaged for each calibration product over the analysis period.
Time series of thermistors temperatures on CAL1 SAR mode over the analysed period.

Figure 2.2-45. First group of Thermists time series on CAL1 SAR mode. The temperatures are averaged for each calibration product over the analysis period.

Figure 2.2-46. Second group of Thermistors time series on CAL1 SAR mode. The temperatures are averaged for each calibration product over the analysis period.
The thermal behaviour above observed is relatively stable for all modes in both thermistors groups for the whole cycle, although a bump up of several degrees Celsius (up to 2) is observed for some thermistors after the first half of the cycle, with a duration of several days.
2.3 SRAL Dedicated Investigations

This chapter is devoted to the investigations derived from observations in the previous sections. The on-going investigations results will be updated in each new version of the report, and information about SPRs and Anomaly Reports will be included accordingly.

Each independent investigation will be addressed in a separate subchapter. When a particular issue can be considered as solved and no more interesting, it will be dismissed from the report.

Two minor issues have been detected so far, not impacting the quality of the science data:

- The flagging of some L1b CAL2 parameters (slope, mean and standard deviation over the slope) is reversed.

Also a previously detected issue has been studied and here below described:

- The PTR maximum position show a variation along the monitored period with a much higher quantization step compared to the other two CAL1 delays parameters (in the previous cycles it was not possible to observe the quantization step due to the stability of the parameter). This PTR maximum behaviour has been already identified, based in the CAL1 L1b processing. The nature of this variable behaviour comes from the CAL1 L1b processing particularities, being different from the other two CAL1 power variables showing more resolution. Its value is nominal and it is not the time delay variable used for the science range instrumental correction.

2.4 Cycle 9 SRAL Status Summary

This section is dedicated to a summary of the up-to-date status of the above altimeter parameters performances.

The L1b and L0 data used cover from 17th of September (beginning of cycle) to 9th of October, as some data at the end of the cycle was not available yet. The cycle ends at 14th of October.

For the analysed period, none of the calibration parameters is showing a significant anomalous behaviour, although some specific observations are explained here below.

As expected, the Ku band (SAR science main band) calibration parameters performances are better than the ones from the C band. The calibration data dispersion is higher for the C band.

For a comparison between some L1b CAL1 parameters values with the on-ground reference values (read from the Characterisation auxiliary file), we can check the Table 2-1.
In Table 2-1 we can see that, although the CAL1 time delay parameters stability is better for the Ku band than for the C band (see previous figures standard deviations in the legends), the current Ku band time delay values are farther from the reference ones than the C band values.

The CAL1 power trend for Ku band in both modes, is no longer close to -1 dB/yr as in previous cycles (see section 2.5).

We have to state that all the observed CAL1 power differences with respect to the on-ground values are very high, and that further checks have to be made in order to clarify the reason of these magnitudes. For example, for the SAR C case the in-flight value is more than 11 dB below the on-ground reference value, meaning that it is more than 12 times smaller: an unrealistic difference.

For the C band PTR width, we see similar little differences for LRM and SAR where the in-flight PTR main lobe is narrower than its on-ground reference value. The Ku band main lobe width looks wider than its reference value also in less than 1 mm for the two modes.
The CAL2 parameters are showing in some cases a worsening of the instrument performance with respect to the pre-launch values. For instance, the in-flight standard deviations of the C band GPRW waveform sides are around 0.3 dB, and the on-ground correspondent values are far below, around 0.12 dB. In the Ku band case, the in-flight values are around 0.12 dB, closer to the on-ground values, around 0.10 dB, hence a lower degradation is observed.

The thermistors values are showing a stable series over the analysed period except a bump up of up to 2 degrees Celsius for some thermistors in the second half of the cycle, lasting few days. This temperature excursion does not impact any calibration measurement.

All these observations are related to the different SRAL calibration parameters during this cycle. We must be cautious by making extrapolations of the cyclic behaviour for the future instrument performance, as it may change from cycle to cycle.

Therefore, a whole mission observation is needed, and is here below developed.

### 2.5 Mission SRAL Status Summary

The main L1b calibration parameters series are gathered and plotted in this section, in order to observe their whole mission behaviour. For the sake of simplicity, the C band has been excluded.

They are:

- CAL1 time delay
- CAL1 power
- PTR width
- Burst corrections (power and phase)
- CAL2 waveform shape
- Autocal averaged differences
Whole mission trend of the PTR time delay.

Figure 2.5-1. CAL1 SAR Ku Time Delay Whole Mission Trend.

Figure 2.5-2. CAL1 LRM Ku Time Delay Whole Mission Trend.
Whole mission trend of the PTR Total and Maximum Power.

Figure 2.5-3. CAL1 SAR Ku Power Whole Mission Trend.

Figure 2.5-4. CAL1 LRM Ku Power Whole Mission Trend.
Whole mission trend of the CAL1 PTR width.

Figure 2.5-5. CAL1 SAR Ku PTR Width Whole Mission Trend.

Figure 2.5-6. CAL1 LRM Ku PTR Width Whole Mission Trend.
CAL1 SAR mode Ku intra-burst corrections: Power and Phase.

Figure 2.5-7. CAL1 SAR Ku Power intra-burst correction along the whole mission.

Figure 2.5-8. CAL1 SAR Ku Phase intra-burst correction along the whole mission.
We could say that the only clear and notable drift observed in the whole mission series is in the CAL1 Ku (LRM and SAR) Power series, where we observe for both modes a significant power decay close to 1 dB/year. Anyhow, it begins to show signs of change at the last 2 cycles, decreasing the observed trend so far. In cycles 6, 7 and 8 the whole mission power trend was respectively of 1.02, 0.94 and 0.89 dB/year. Hence, we can state the slow stabilisation of this parameter.
For a comparison with the on-ground reference values, a similar table as in the previous subchapter (Table 2-1) is shown hereafter in Table 2-2. Here the C band values are considered.

<table>
<thead>
<tr>
<th>Calibration Parameter</th>
<th>In-flight Ku</th>
<th>On-ground Ku</th>
<th>In-flight C</th>
<th>On-ground C</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRM CAL1 time delay</td>
<td>1.0083 m</td>
<td>1.0048 m</td>
<td>0.8937 m</td>
<td>0.8923 m</td>
</tr>
<tr>
<td></td>
<td>Delta = 3.5 mm</td>
<td>Delta = 1.4 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAR CAL1 time delay</td>
<td>1.0077 m</td>
<td>1.0030 m</td>
<td>0.8941 m</td>
<td>0.8931 m</td>
</tr>
<tr>
<td></td>
<td>Delta = 4.7 mm</td>
<td>Delta = 1 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LRM CAL1 power</td>
<td>58.29 dB</td>
<td>61.55 dB</td>
<td>51.40 dB</td>
<td>60.01 dB</td>
</tr>
<tr>
<td></td>
<td>Delta = -3.26 dB</td>
<td>Delta = -8.61 dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAR CAL1 power</td>
<td>62.74 dB</td>
<td>59.81 dB</td>
<td>48.91 dB</td>
<td>60.00 dB</td>
</tr>
<tr>
<td></td>
<td>Delta = 2.93 dB</td>
<td>Delta = -11.09 dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LRM CAL1 PTR width</td>
<td>0.4167 m</td>
<td>0.4159 m</td>
<td>0.4548 m</td>
<td>0.4555 m</td>
</tr>
<tr>
<td></td>
<td>Delta = 0.8 mm</td>
<td>Delta = -0.7 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAR CAL1 PTR width</td>
<td>0.4165 m</td>
<td>0.4160 m</td>
<td>0.4547 m</td>
<td>0.4555 m</td>
</tr>
<tr>
<td></td>
<td>Delta = 0.5 mm</td>
<td>Delta = -0.8 mm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2-2. Comparative table with in-flight (whole mission) and on-ground calibration parameters values.

The CAL1 Time Delay for both bands and modes are less than half a centimetre from the ground reference values.

The CAL1 Power show the same big differences addressed in the previous subchapter. This are to be studied and eventually corrected.

The PTR width for both bands and modes are less than one centimetre from the reference values. For the Ku band it is bigger and with a small positive trend (around 0.1mm/yr), while for the C band it is smaller and approaching the reference value (slope is 1.8 mm/year). The PTR width standard deviation for the C band is around 6 times higher than the one from the Ku band, for both modes.

Finally, the collection of statistics for the main calibration parameters is depicted in Table 2-3 for both modes and bands. Once more we observe the better performance (less standard deviation) of the Ku
band with respect to the C band, and the general similar values between modes (with some exceptions as the Ku time delay slope).

<table>
<thead>
<tr>
<th>Calibration Parameter</th>
<th>Ku Band</th>
<th>C Band</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>annual slope</td>
</tr>
<tr>
<td>LRM CAL1 time delay</td>
<td>1.0083 m</td>
<td>-2.70 mm</td>
</tr>
<tr>
<td>SAR CAL1 time delay</td>
<td>1.0077 m</td>
<td>-1.90 mm</td>
</tr>
<tr>
<td>LRM CAL1 power</td>
<td>58.29 dB</td>
<td>-0.80 dB</td>
</tr>
<tr>
<td>SAR CAL1 power</td>
<td>62.74 dB</td>
<td>-0.81 dB</td>
</tr>
<tr>
<td>LRM CAL1 PTR width</td>
<td>0.4167 m</td>
<td>0.01 mm</td>
</tr>
<tr>
<td>SAR CAL1 PTR width</td>
<td>0.4165 m</td>
<td>0.01 mm</td>
</tr>
</tbody>
</table>

Table 2.3. Collection of calibration parameters statistics for all modes and bands covering the whole mission.

The long term drift for the time delay and power variables is higher in absolute terms for the Ku band than for the C band, while the standard deviation is always lower for the Ku band. This means that, although the Ku band chain performance is better than the one from C band, the Ku band ageing is faster than the one from C band, probably caused by the more stressed Ku band instrumental operations (e.g. bursts transmission & reception only in Ku band).

We observe that the behaviour of all calibration parameters is nominal. Nevertheless the different values shall be compared to the official S3 mission SRAL instrumental requirements in order to make a final statement. Once they are gathered, the calibration performance check versus requirements will be exposed in this document.
3 Events

No SRAL special events have been observed during the cycle.
4 Appendix A

Other reports related to the STM mission are:

- S3-A MWR Cyclic Performance Report, Cycle No. CCC (ref. S3MPC.CLS.PR.05-CCC)
- S3-A Ocean Validation Cyclic Performance Report, Cycle No. CCC (ref. S3MPC.CLS.PR.06-CCC)
- S3-A Winds and Waves Cyclic Performance Report, Cycle No. CCC (ref. S3MPC.ECM.PR.07-CCC)
- S3-A Land and Sea Ice Cyclic Performance Report, Cycle No. CCC (ref. S3MPC.UCL.PR.08-CCC)

All Cyclic Performance Reports are available on MPC pages in Sentinel Online website, at: [https://sentinel.esa.int](https://sentinel.esa.int)

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