Independent Calibration of the Sentinel-1C SAR System

Patrick Klenk[a], Jakob Giez[a], Kersten Schmidt[a], Matteo Nannini[a], and Marco Schwerdt[a]
[a]German Aerospace Center (DLR), Germany, contact: **patrick.klenk@dlr.de**

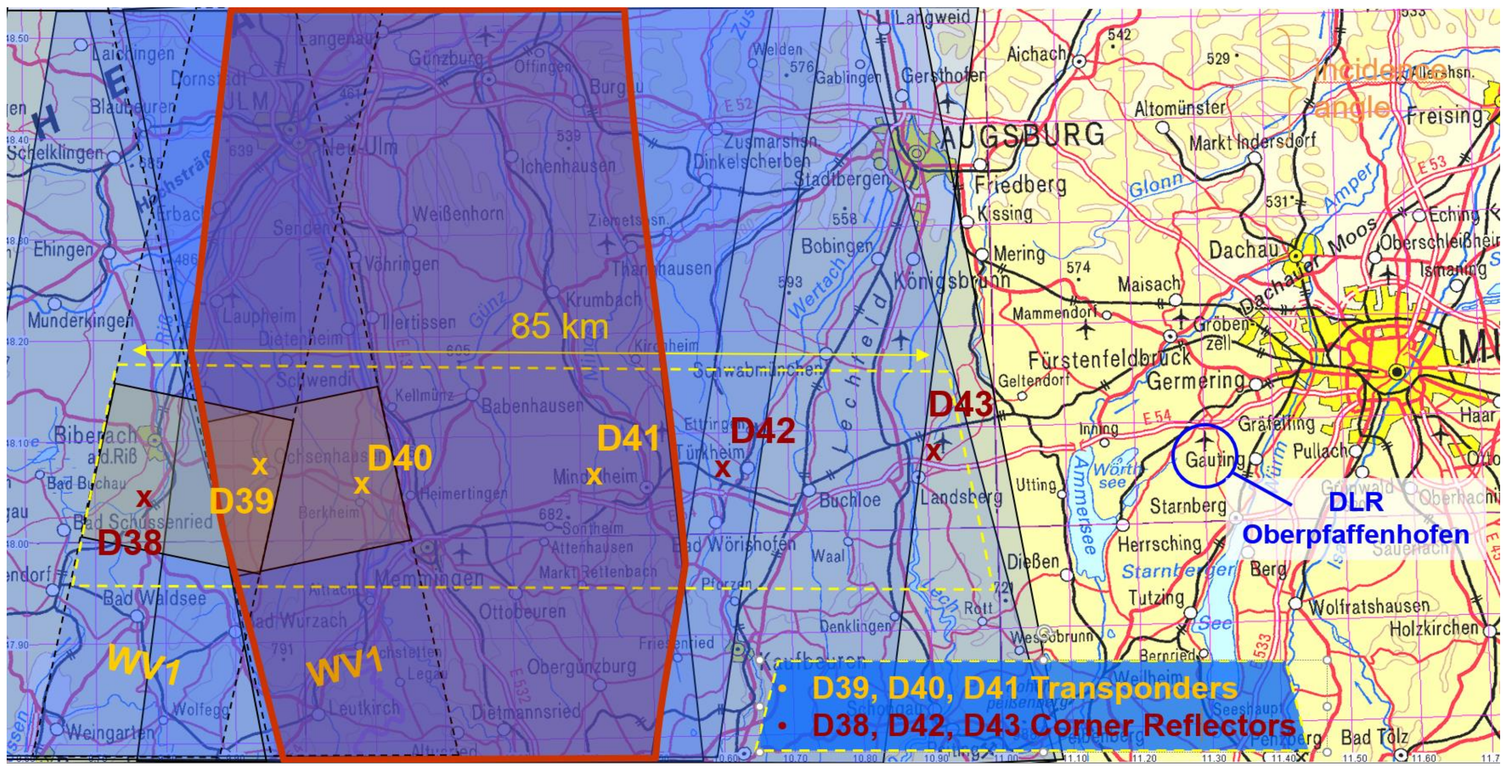


Figure 1 S1 coverage of the different beams selected for inflight measurement over the DLR calibration field.

Sentinel-1C (S1C) will be the third satellite of the Sentinel-1 (S1) mission [1] and is to be launched in late 2024. In parallel to the commissioning of S1C by the European Space Agency (ESA), an **independent system calibration** will be performed **by the DLR SAR Calibration Center** under an ESA contract. Based on an efficient calibration strategy [2] developed by DLR, we here describe the different activities to be performed by DLR during the commissioning phase (CP) of S1C.

1 DLR SAR Calibration Center

- Responsible for the overall calibration concept and the calibration algorithms for all Sentinel-1 systems/satellites
- Calibration field (**Figure 1**) of highly accurate and stable [3] [4] ground targets, as central calibration site for Sentinel-1 in operation since 2014
- Independent assessment of end-to-end SAR system calibration of S1A in 2014 [5] and S1B in 2016 [6]
- Longterm System Monitoring of Sentinel-1 as part of S1 Mission Performance Center [7]

2 Novel Calibration Aspects for S1C

- S1C implemented hardware improvements compared to S1A/B [8] [9]
- Simplification of calibration pulse sequence, dropping S1A/B's APDNCal and TaCal pulses
- RF-Characterization (RFC) mode timeline adjusted
- Additional interleaved noise pulses for IW, EW and WV modes [9]

3 Preparations for DLR's S1C Independent Calibration Campaign

- Calibration algorithms adjusted to improved hardware of S1C
- DLR's calibration tools updated for S1C
- RF-Characterization (RFC) module adapted to the new S1C timeline (**Figure 2,** also verifying the reference values provided by ESA in the S1C ICDB)

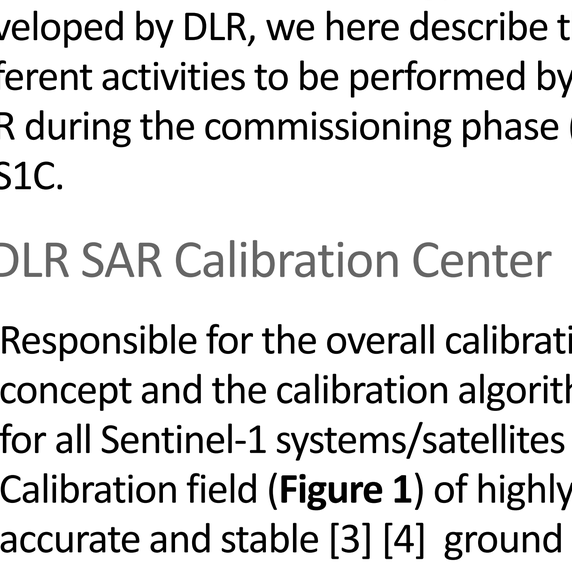
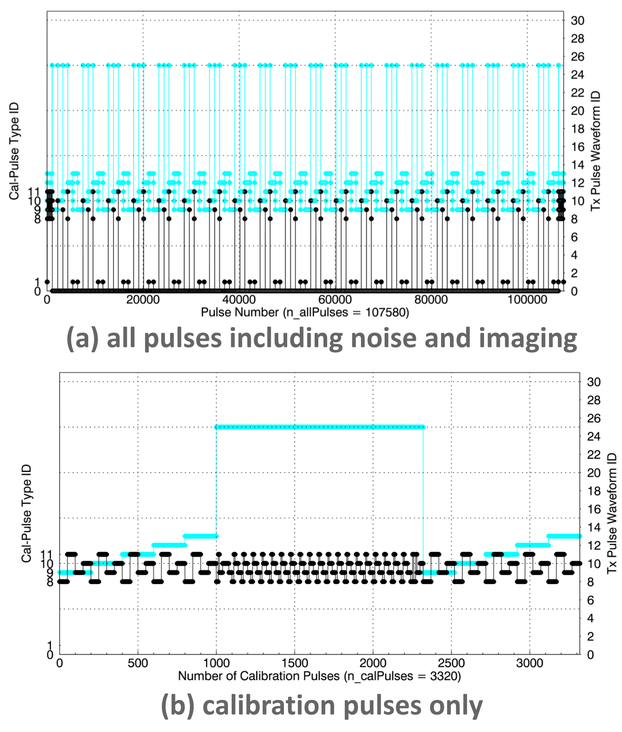


Figure 2 - Tx-chain error matrix calculated from S1-C OGC data and the provided reference values extracted from the internal calibration database (ICDB).



(a) all pulses including noise and imaging

(b) calibration pulses only

Figure 3 - Pulse types (black) and Tx Waveform IDs (cyan) extracted from header information of an S1C EW datatake acquired in VV-pol during on-ground-characterization (OGC).

- Internal Calibration module revised for processing the new S1C sequence of pulses (**Figure 3,** depicting the pulse types (black) and the Tx-pulse waveform IDs (cyan) as retrieved from S1C on-ground characterization (OGC) data) as well as for evaluating the additional noise pulses.

4 S1C In-Orbit Calibration Plan

- Dedicated in-orbit calibration plan derived for the S1C commissioning phase (CP) activities (**Figure 4)**, including multiple acquisitions over the DLR calibration field
- All tasks to be completed over seven repeat cycles of the nominal S1C CP
- Initial CP activities (four cycles) with 30 degree orbit phasing to S1A, rest in 180 degree phasing

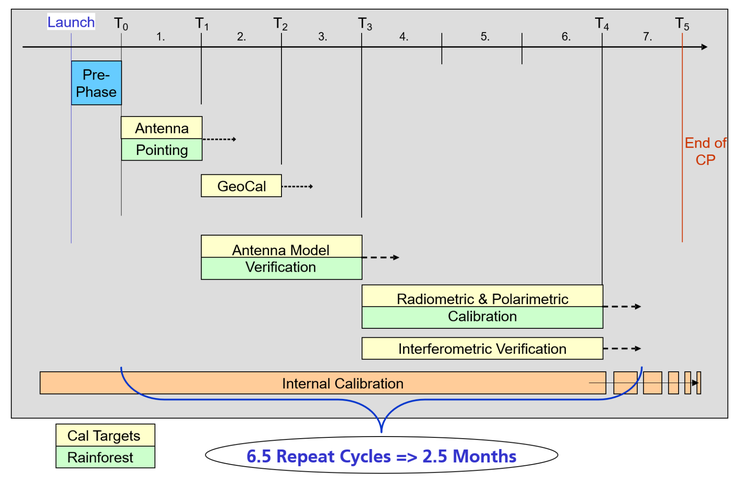


Figure 4 - Schematic overview of the timeline for the planned in-orbit calibration activities for S1C.

Take Away Messages

Sentinel-1C will be the third Sentinel SAR system to be **independently calibrated by DLR** on behalf of ESA. This presentation describes the **current status** of DLR's preparations for the S1C mission, discusses **novel aspects** of calibrating the new system and outlines the **activities planned for the DLR calibration campaign**. We demonstrate that we are well-prepared for supporting a successful S1C commissioning phase.

References

[1] R. Torres et al, "GMES Sentinel-1 mission," Remote Sensing of Environment, vol. 120, pp. 9–24, 2012.
[2] M. Schwerdt et al, "In-Orbit Calibration Plan of Sentinel-1," in EUSAR 2010, pp. 350-352, 2010.
[3] M. Jirousek et al, "Development of the highly accurate DLR Kalibri Transponder," in EUSAR 2014, pp. 1176–1179, 2014.
[4] B. Döring et al , "The Three Transponder Method: A Novel Method for Accurate Transponder RCS Calibration," PIERS B, vol. 61, pp. 297–315, 2014.
[5] M. Schwerdt et al, "Independent Verification of the Sentinel-1A System Calibration," IEEE JSTAEORS, vol. 9, no. 3, pp. 994–1007, March 2016.
[6] M. Schwerdt et al, "Independent System Calibration of Sentinel-1B," Remote Sensing, vol. 9, no. 6, 2017.
[7] K. Schmidt et al, "Radiometric Re-Compensation of Sentinel-1 SAR Data Products for Artificial Biases due to Antenna Pattern Changes," Remote Sensing , Vol. 15, No. 5: 1377, 2023.
[8] P. Potin et al, "Sentinel-1A/-1B Mission and Performance Status, Sentinel-1C/-1D Improvements," in EUSAR 2022, pp. 141–146.
[9] E. Schied et al, "The Sentinel-1 C & D SAR Instrument," in EUSAR 2018, June 2018, pp. 632–635, 2018.

Further references reported in the conference paper

DLR SAR Calibration Center

DLR