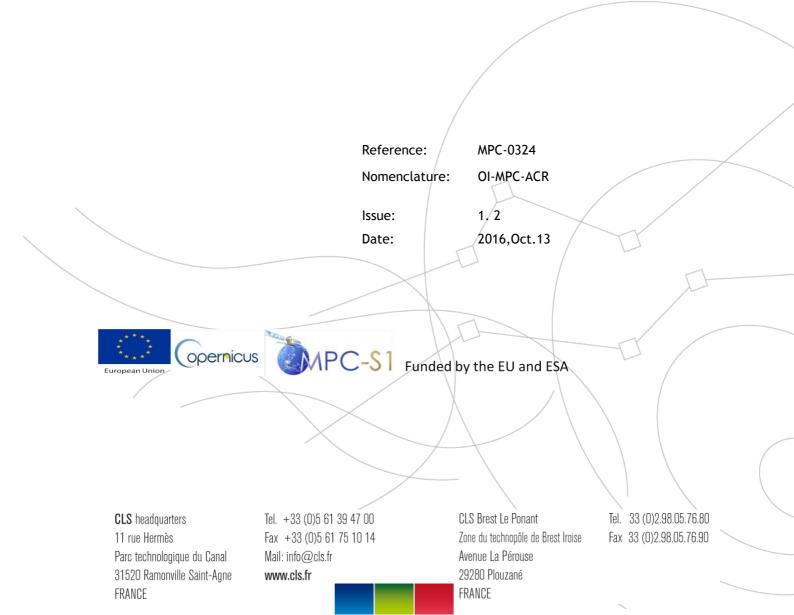


MPC-S1

Sentinel-1A Tile #11 Failure



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Chronology Issues:

Issue:	Date:	Reason for change:	Author
1.0	06.07.2016	First Issue	MPC-S1
1.1	11.07.2016	Update Nomenclature + place logos in first page	MPC-S1
1.2	13.10.2016 Sections 3, 4 and 5 updated with new results		MPC-S1

People involved in this issue:

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Application authorized by (*):	N. Miranda	Date + Initial:(visa ou ref)

*In the opposite box: Last and First name of the person + company if different from CLS

Index Sheet:

Context:	Investigation on L1 data quality related to antenna failures
Keywords:	S-1A, Antenna, Tile, Failure
Hyperlink:	

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Reference documents

RD-1 Sentinel-1A Tile #5 intermittent failure: Impact on L1 product quality, 30th January 2016, OI-MPC-OTH-0204-1-0.

RD-2 Sentinel-1A SAR Instrument: GS1_SC-129 Tile 11 TPSU 1 Switch Down Investigation Antenna, Airbus Defence and Systems, 28th June 2016, S1-RP-ASD-PL-0491.

RD-3 S1A Recovery SAR Product Analysis, Aresys presentation, 1st July 2016 S1A_MPC_Aresys_Tile11_Issue_Sentinel_1A_Recovery_SAR_Products_Quality_Assessment_v2_0.pdf

RD-4 S1A Resumed Operations Checks, BAE presentation, 1st July 2016 BAE_Product_Analysis01Jul2016_S1A_Resumed_Operations.pdf

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1. Purpose and scope

The present technical note discusses the impact of the Sentinel-1A tile 11 issue that occurred during June 2016 (Section 2). This is assessed via the expected changes in the elevation and azimuth antenna patterns and Doppler calibration profiles (Section 3), the impact on the internal calibration (Section 4) and the measured impact from L1 products (Section 5).

The document collects the relevant analyses and results generated in the framework of the Sentinel-1A Mission Performance Centre, with the purpose of giving a clear picture of the L1 data quality.

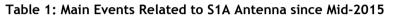
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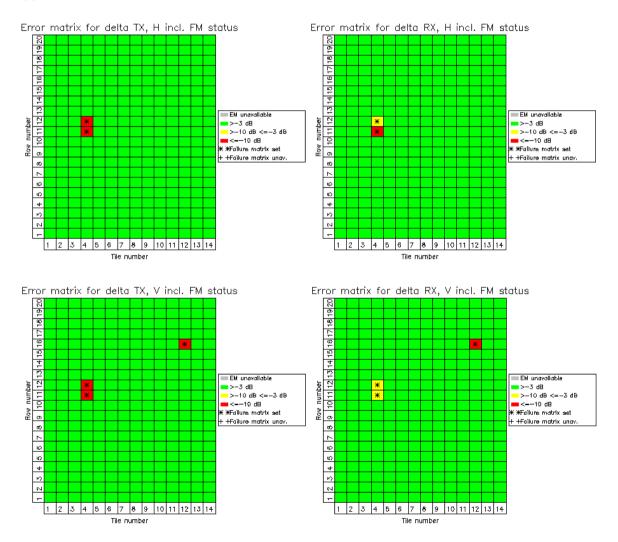
2. Tile 11 Issue

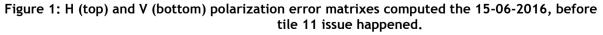
The Sentinel-1A antenna is routinely monitored through the processing and analysis of the RFC mode data. Since mid-2015, the following antenna related events have been recorded.

Date	TILE	ROWs	Tx/Rx - H/V	Description
22 July 2015	5	1-20	Rx H, Rx V	Switch to redundancy (RDB#5)
16 June 2016	11	1-10	Tx H, Tx V	TPSU-1 failure and reduced TRM power



Since mid-2015, after switch to redundancy for tile 5 (**RD-1**), no antenna events were recorded. The figure below report the H and V error matrixes computed on the 15-06-2016, before tile 11 issue happened.





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On the 16-06-2016 SAR went to pause refuse mode for the first time due to a current/voltage anomaly on TPSU-1 within tile 11. After several attempts to recover SAR operations, the SAR was definitely available again since the 27-06-2016 June. In order to ensure SAR operation a reduction of the Tx power for half tile 11 was necessary. This can be clearly noticed in the figure below, reporting the error matrixes computed on the 27-06-2016 June.

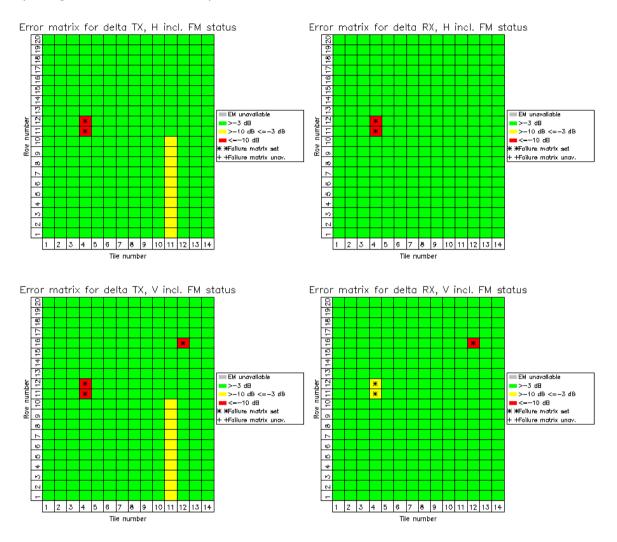


Figure 2: H (top) and V (bottom) polarization error matrixes computed the 27-06-2016, after SAR operation successful recovery.

A further effect of the instrument configuration change was a drop of the phase of all the TRMs of tile 11 (not only the ones with reduced TX power). This can be clearly noticed in the following plots, showing the TX excitation coefficients (averaged per tile) obtained processing RFC products since 1st May 2016. Tile 11 shows an average gain reduction of about 4 dB and an average phase drop of about 30 deg. For more details on the anomaly please refer to **RD-2**.



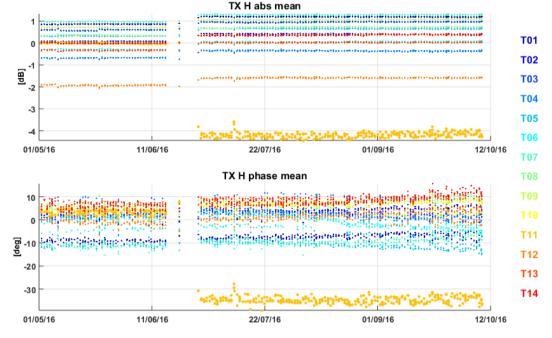


Figure 3: RFC TX H excitation coefficients gain (top) and phase (bottom) averaged per tile.

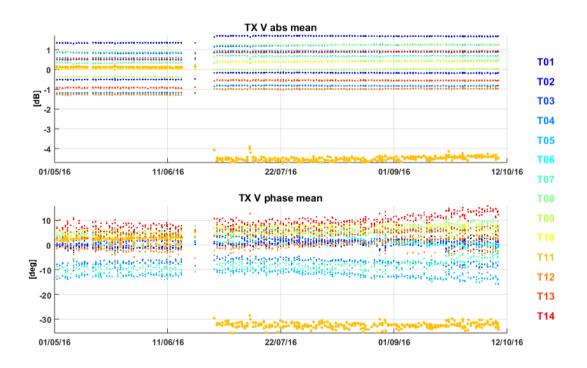


Figure 4: RFC TX V excitation coefficients gain (top) and phase (bottom) averaged per tile



3. Impact on S1A Antenna Patterns

The Antenna Model has been used to generate patterns which represent the state of the antenna before and after the tile 11 issue.

The antenna patterns before the tile 11 issue have been generated considering:

- A failure matrix with the failed elements indicated in Figure 1 with a black star
- An error matrix representing the state of the antenna from the RFC products acquired on the 15-06-2016

The antenna patterns after S1A recovery have been generated considering:

- The same failure matrix considered above
- An error matrix representing the state of the antenna from the first RFC products acquired after S1A recovery on the 27-06-2016

The figures below represent the differential Error Matrix, i.e. the delta coefficients (gain and phase) between the 27-06-2016 and the 15-06-2016. As expected the Tx coefficients of half tile 11 (TRMs from 1 to 10) show reduced power. As reported in the previous section the new antenna configuration has an impact on the TRMs phase as well. The following sections describe the impact of the modified antenna state on the S1A patterns.

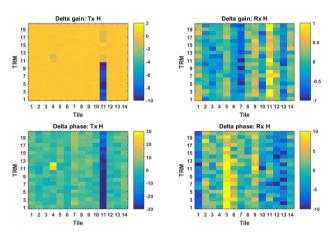


Figure 5: H-pol differential Error Matrix: Δ gain (top) and phase (bottom) between 27-06-2016 and 15-06-2016

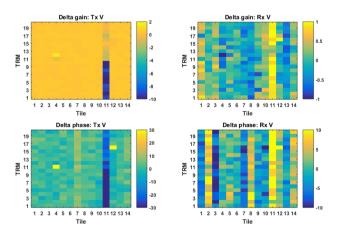


Figure 6: H-pol differential Error Matrix: delta gain (top) and phase (bottom) between 27-06-2016 and 15-06-2016



6 ©©

3.1. Azimuth Antenna Patterns (AAPs)

Figure 7 shows the gain difference between the azimuth antenna patterns before and after the tile 11 issue for IW TopSAR beams. The comparisons for the other modes and polarisations are consistent with those shown here and are reported in **RD-3**. The plots show that there is a change in the shape of the azimuth antenna patterns over the main lobe, in particular for HH and VH patterns. The observed gain slope can be explained with a slight change in the electronic azimuth pointing of the antenna. This change is confirmed by the Doppler Calibration Profiles (see Section 3.3 for more details).

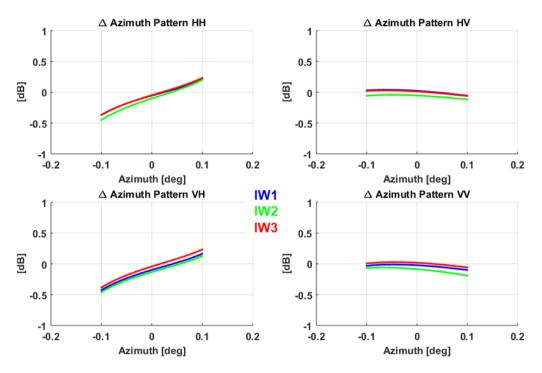


Figure 7 Gain difference between the azimuth antenna patterns before and after tile 11 issue for IW TopSAR beams.

The phase difference between the azimuth antenna patterns is shown in Figure 8 for TopSAR IW beams. The comparisons for the other modes and polarisations are consistent with those shown here and are reported in **RD-3**. A similar negative phase ramp can be observed for all modes and polarizations. Such phase ramp, if not compensated during focusing can introduce a shift of the focused targets, whose magnitude can be derived from the well-known relationship between frequency phase ramp and delay. In particular a frequency phase ramp $e^{-j2\pi\Delta tf}$ introduces a time delay Δt . The value of the time delay can be obtained as:

$$\Delta t = s \frac{\lambda}{4v\pi}$$

where *s* is the measured slope (-20 deg/deg), λ is the sensor wavelength (0.055 m) and ν is the ground velocity (about 6900 m/s). The resulting delay is about 15 µs corresponding to approximately -0.10 m of targets shift in the focused images.

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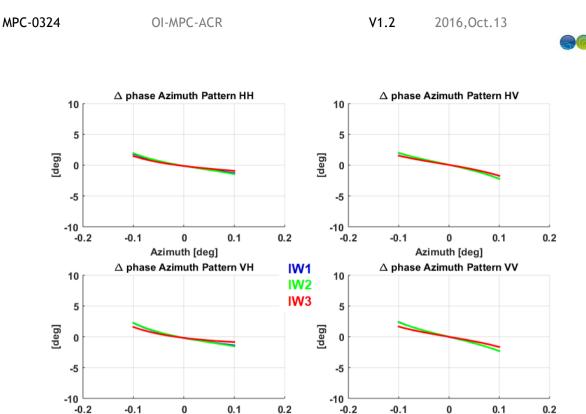


Figure 8 Phase difference between the azimuth antenna patterns before and after tile 11 issue for IW TopSAR beams.

Azimuth [deg]

3.2. Elevation Antenna Patterns (EAPs)

Azimuth [deg]

Figure 9 shows the gain difference between the elevation antenna patterns before and after the tile 11 issue for EW TopSAR beams. The comparisons for the other modes and polarisations are consistent with those shown here and are reported in **RD-3**. Small changes in almost all the beams can be observed. The most impacted beam is the EW1 (HH and HV polarizations) where peak to peak differences of about 0.5 dB are predicted. The AM prediction shows that small radiometric jumps (up to 0.3 dB) could be observed at sub-swath boundaries (EW1-EW2 and EW2-EW3). A similar jump is expected between IW1 and IW2 sub-swaths as well, as reported in **RD-3**. Note that no changes in the average level of the patterns is shown. This is due to the fact that radiometric changes are compensated in the processing with the PG value obtained from internal calibration. By maintaining at a fixed level the elevation patterns, a double compensation of the radiometric loss due to the reduced transmitted power is avoided. More detail on the internal calibration analysis will be shown in Section 3.3.

The phase difference between the elevation antenna patterns is shown in Figure 10. The comparisons for the other modes and polarisations are consistent with those shown here and are reported in **RD-3**. The overall phase changes are very reduced with a maximum peak-to-peak variation of the order of 3 degrees. The effect of this variation on interferometric applications is deemed negligible.

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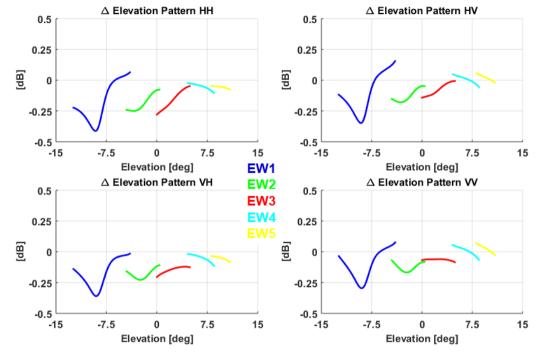


Figure 9 Gain difference between the elevation antenna patterns before and after tile 11 issue for EW TopSAR beams.

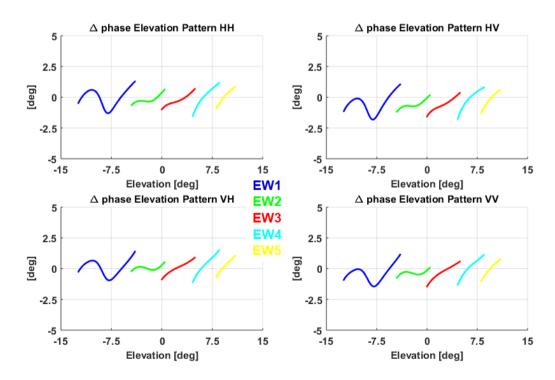


Figure 10: Phase difference between the elevation antenna patterns before and after tile 11 issue for EW TopSAR beams.



9 **9**

3.3. Doppler Calibration Profiles

The Doppler Calibration Profile is a measure of the antenna electronic azimuth mis-pointing. Figure 11 show the comparison between the DCP before (left) and after (right) tile 11 issue, computed for IW VV beams. A clear change of the DCP shape can be observed in particular for IW2 and IW3 beams. On the plot the DCP differences at the sub-swath boundaries are reported. The reported values are quite in line with those represented in Figure 12. This was obtained by evaluation the DC difference between sub-swaths within the range overlap region for each L1A slice. The difference was evaluated in the period covering the tile 11 issue. The values obtained from the data are in line with those predicted by the S1 CFI AM.

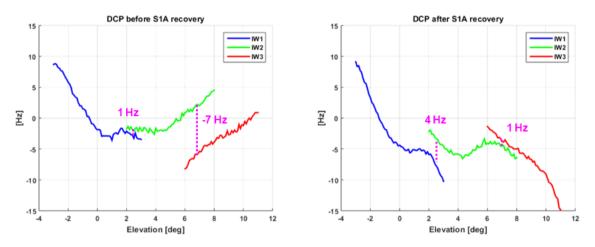


Figure 11: Doppler Calibration Profiles before (left) and after (right) tile 11 issue for IW VV beams.

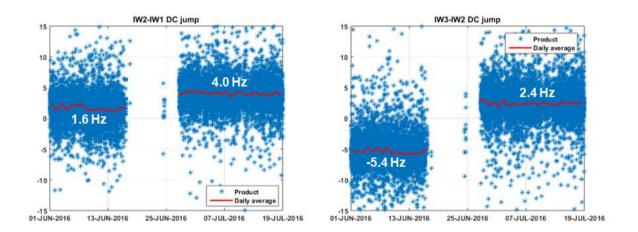


Figure 12: Sub-swaths DC jumps calculate from IW VV products during tile 11 issue period.



3.4. Resume

The following points are the main outputs of the analysis preformed to characterize the tile 11 issue effects on SAR data exploiting S1A CFI antenna model and RFC products:

- From RFC measures a phase bias is observed for all the TRMs of tile 11. The phase bias was expected only for the TRMs 1 to 10 (transmitting with reduced power). This phase bias can give antenna patterns distortion.
- Small gain ramps in the differential AAPs can be observed. They are originated by small electronic azimuth mis-pointing
- Small phase ramp in AAP can be observed as well. They could result in a localization error up to -0.1 m if not compensated during focusing
- Difference in EAPs (up to 0.5 dB) are expected. EW1 beam is the most impacted. Such gain differences could potentially result in small radiometric jumps at sub-swath boundaries. In particular between:
 - IW1 and IW2
 - EW1 and EW2
 - EW2 and EW3
- The phase difference in EAP are very reduced (included in the range ±2 deg) and deemed negligible for interferometric applications
- > The changes predicted by the S1 CFI AM in the Doppler Calibration Profiles for IW VV subswaths are confirmed by the modification of the DC jumps measured from the data.





4. Impact on Internal Calibration

The Internal Calibration processing shows a decrease of the PG value for all modes of about 0.3 dB. The actual value shall be confirmed with more products acquired and considering all beams and polarizations separately. The inverse of the IW beams PG value (used by IPF for SAR data normalization), retrieved from the internal calibration products is reported in Figure 13.

The increase of 1/PG value allows to compensate the radiometric loss due to the reduction of the transmitted power. If the current instrument configuration is confirmed a new AUX-INS file shall be circulated with updated PG reference values. Note that the PG allows to guarantee the radiometric stability, as demonstrated by the PS-CAL time series for IW beams reported in Figure 14, of the instrument whereas the radiometric accuracy will be impacted by the slightly reduced SNR.

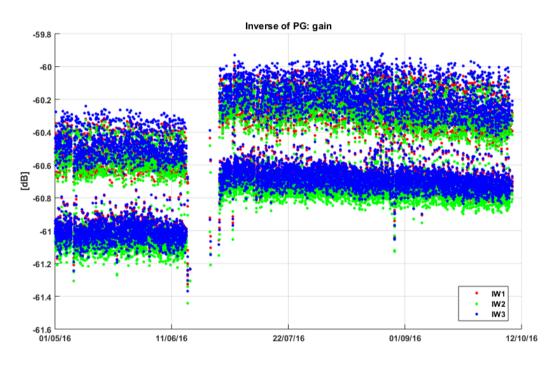


Figure 13: Evolution of the PG product (1/PG) since 01/05/2016 for IW beams

The following tables report the average of the PG values from CAL100 pulses before and after the tile 11 issue. The PG value reduction is in the order of -0.3 dB for all the TopSAR beams and polarizations.

Mode	Pol.	PG May 2016 [dB]	PG July 2016 [dB]	∆ [dB]
IW	HH	60.46	60.17	-0.29
IW	VV	60.95	60.63	-0.32
IW	HV	60.82	60.51	-0.31
IW	VH	60.61	60.30	-0.31
EW	HH	65.19	64.89	-0.31
EW	VV	65.93	65.61	-0.32
EW	HV	65.85	65.52	-0.33
EW	VH	65.33	65.04	-0.29

Table 2: Daily average	PG values on the	27/06/2016
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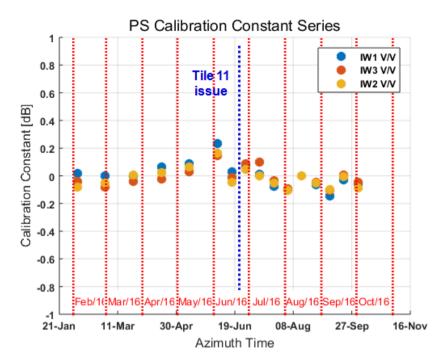


Figure 14: PS calibration time series for IW VV sub-swaths for an interferometric stack of 16 images over Paris.

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5. Impact on L1 Data Products Quality

A selection of imagery since the resumption of data acquisitions on 26th June 2016 have been analysed to assess the quality of data products and their potential impact on users. The L1 product analysed just after the Tile 11 failure are given Table 3 while a presentation of these results can be found in **RD-4**. Table 4 give a list of additional L1 products analysed later.

Target	Acquisition Date	Mode	Filename
Amazon	27/06/2016	IW	S1A_IW_GRDH_1SDH_20160627T224543_20160627T224608_011902_01253F_8562.SAFE
Amazon	29/06/2016	EW	S1A_EW_GRDH_1SDH_20160629T101216_20160629T101321_011924_0125E3_CEB1.SAFE
Amazon	01/07/2016	EW	S1A_EW_GRDH_1SDH_20160701T095600_20160701T095704_011953_0126D6_F8E1.SAFE
AU Corner Reflectors	28/06/2016	IW	S1A_IW_SLC1SSH_20160628T083225_20160628T083255_011908_012567_9FFC.SAFE S1A_IW_SLC1SSH_20160628T083253_20160628T083323_011908_012567_97BF.SAFE
DLR Targets	28/06/2016	IW	S1A_IW_SLC1SDV_20160628T170704_20160628T170731_011914_01258C_25B3.SAFE
BAE CR	29/06/2016	EW	S1A_IW_SLC1SDV_20160629T174927_20160629T174955_011929_012602_8EF2.SAFE

Table 3: L1 Products

Target	Acquisition Date	Mode	Filename
Amazon	07/09/2016	IW	S1A_IW_GRDH_1SDH_20160907T224548_20160907T224612_012952_0147D0_3233.SAFE
Amazon	17/09/2016	EW	S1A_EW_GRDH_1SDV_20160917T230216_20160917T230322_013098_014C97_BE5D.SAFE
Amazon	01/10/2016	IW	S1A_IW_GRDH_1SDH_20161001T224549_20161001T224613_013302_015333_216E.SAFE
AU Corner Reflectors	12/03/2016	IW	S1A_IW_SLC1SDV_20160312T083220_20160312T083250_010333_00F4D2_4670.SAFE S1A_IW_SLC1SDV_20160312T083248_20160312T083318_010333_00F4D2_2CF1.SAFE
AU Corner Reflectors	24/03/2016	IW	S1A_IW_SLC15SH_20160324T083221_20160324T083250_010508_00F9B6_E491.SAFE S1A_IW_SLC15SH_20160324T083248_20160324T083318_010508_00F9B6_D529.SAFE
AU Corner Reflectors	17/04/2016	IW	S1A_IW_SLC15SH_20160417T083222_20160417T083251_010858_01040F_46C2.SAFE S1A_IW_SLC15SH_20160417T083249_20160417T083319_010858_01040F_67CA.SAFE
AU Corner Reflectors	22/07/2016	IW	S1A_IW_SLC1SSH_20160722T083227_20160722T083256_012258_0130C7_5535.SAFE S1A_IW_SLC1SSH_20160722T083254_20160722T083324_012258_0130C7_236F.SAFE
AU Corner Reflectors	15/08/2016	IW	S1A_IW_SLC1SSH_20160815T083228_20160815T083258_012608_013C5B_33B0.SAFE S1A_IW_SLC1SSH_20160815T083256_20160815T083325_012608_013C5B_99E1.SAFE
AU Corner Reflectors	08/09/2016	IW	S1A_IW_SLC1SSH_20160908T083229_20160908T083259_012958_014801_054A.SAFE S1A_IW_SLC1SSH_20160908T083257_20160908T083326_012958_014801_BFB5.SAFE
DLR Targets	17/04/2016	IW	S1A_IW_SLC1SDV_20160417T170716_20160417T170743_010864_01042F_6D7B.SAFE
DLR Targets	29/04/2016	IW	S1A_IW_SLC1SDV_20160429T170652_20160429T170719_011039_0109A8_B335.SAFE
DLR Targets	11/05/2016	IW	S1A_IW_SLC1SDV_20160511T170655_20160511T170722_011214_010F2F_A7E8.SAFE
DLR	22/07/2016	IW	S1A_IW_SLC1SDV_20160722T170705_20160722T170732_012264_0130EC_5C58.SAFE

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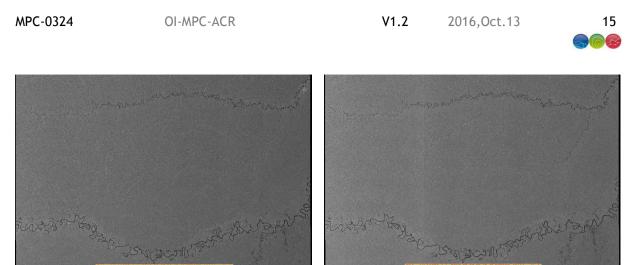


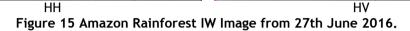
Targets 08/09/2016 IW \$1A_JW_SLC_1SDV_20160908T170707_20160908T170734_012964_014825_4CAE.SAFE DLR Targets 16/09/2016 IW \$1A_JW_SLC_1SDV_20160908T170707_20160908T170734_012964_014825_4CAE.SAFE DLR Targets 20/09/2016 IW \$1A_JW_SLC_1SDV_20160920T170708_20160920T170735_013139_014DEE_873F.SAFE DLR Targets 02/10/2016 IW \$1A_JW_SLC_1SDV_20160920T170708_20160920T170735_013314_015387_B4AA.SAFE BAE CR 08/07/2016 IW \$1A_JW_SLC_1SDV_20160708T061423_20160708T061450_012053_012A21_EAB4.SAFE S1A_JW_SLC_1SDV_20160708T061423_20160708T061450_012053_012A21_EAB4.SAFE \$1A_JW_SLC_1SDV_20160708T061417174125_012206_012F1A_560F.SAFE BAE CR 08/07/2016 IW \$1A_JW_SLC_1SDV_20160708T061417174125_012206_012F1A_560F.SAFE S1A_JW_SLC_1SDV_20160708T061417174125_012206_012F1A_560F.SAFE \$1A_JW_SLC_1SDV_20160723T174928_20160783T0718T174125_012206_012F1A_560F.SAFE S1A_JW_SLC_1SDV_20160804T174929_0106084T174957_012266_012F1A_560F.SAFE \$1A_JW_SLC_1SDV_20160804T174929_20160804T174957_012266_012F1A_560F.SAFE S1A_JW_SLC_1SDV_20160804T174929_20160804T174957_012266_012F1A_560F.SAFE \$1A_JW_SLC_1SDV_20160804T174929_20160804T174957_012266_012F1A_560F.SAFE S1A_JW_SLC_1SDV_20160804T174929_20160804T174957_012266_012F7A644.SAFE \$1A_JW_SLC_1SDV_20160804T174957_012629_0132FF_A644.SAFE <tr< th=""><th></th><th></th><th></th><th></th></tr<>				
Targets OO/ 07/ 2016 III IIII Targets 16/09/2016 IW \$1A_IW_SLC15DV_20160916T174100_20160916T174128_013081_014BFC_60C0.SAFE Targets 20/09/2016 IW \$1A_IW_SLC15DV_20160920T170708_20160920T170735_013139_014DEE_873F.SAFE Targets 02/10/2016 IW \$1A_IW_SLC15DV_20161002T170708_20160708T061450_012053_012A21_EAB4.SAFE BAE CR 08/07/2016 IW \$1A_IW_SLC15DV_20160708T061423_20160708T061450_012053_012A21_EAB4.SAFE SIA_IW_SLC15DV_20160708T061423_20160708T061450_012053_012A21_EAB4.SAFE \$1A_IW_SLC15DV_20160718T174057_20160718T174125_012206_012F1A_560F.SAFE SIA_IW_SLC15DV_20160718T174057_0160718T174125_012206_012F1A_560F.SAFE \$1A_IW_SLC15DV_20160723T174928_20160723T174956_012279_01316F_D7C1.SAFE SIA_IW_SLC15DV_20160804T174929_20160804T174929_20160804T174957_012454_01373F_14DF.SAFE \$1A_IW_SLC15DV_20160811T174028_201068117174057_012454_01373F_14DF.SAFE SIA_IW_SLC15DV_20160813T061424_20160813T061452_0127573_01344_A39D.SAFE \$1A_IW_SLC15DV_20160811T174029_201608161174957_012629_013CFF_A644.SAFE SIA_IW_SLC15DV_20160804T174929_201608161174957_012629_013CFF_S3_014444_A39D.SAFE \$1A_IW_SLC15DV_20160823T174114_20160823T174143_012731_014082_27C0.SAFE SIA_IW_SLC15DV_2016080151174029_201608161174929_201608161174957_012629_013CFF_S3_014444_A39D.SAFE \$1A_IW_SLC15DV_2016090101606621_20160910	Targets			
Targets IOFOT 2010 IIII Targets 20/09/2016 IW \$1A_IW_SLC_1SDV_20160920T170708_20160920T170735_013139_014DEE_873F.SAFE DLR Targets 02/10/2016 IW \$1A_IW_SLC_1SDV_20161002T170708_20161002T170735_013314_015387_B4AA.SAFE BAE CR 08/07/2016 to 03/10/2015 IW \$1A_IW_SLC_1SDV_20160708T061423_20160708T061450_012053_012A21_EAB4.SAFE SIA_IW_SLC_1SDV_20160718T174057_20160718T174125_012206_012F1A_560F.SAFE \$1A_IW_SLC_1SDV_20160718T174057_0160718T174125_012206_012F1A_560F.SAFE SIA_IW_SLC_1SDV_20160723T174928_20160723T174956_012279_01316F_D7C1.SAFE \$1A_IW_SLC_1SDV_2016084T174929_2016084T174957_012454_01373F_14DF.SAFE SIA_IW_SLC_1SDV_20160811T174058_2016084T174957_012454_01373F_14DF.SAFE \$1A_IW_SLC_1SDV_2016084T174929_2016084T174957_012454_01373F_14DF.SAFE SIA_IW_SLC_1SDV_20160813T061424_20160813T061452_012578_013B61_7AB3.SAFE \$1A_IW_SLC_1SDV_20160823T174114_20160823T174143_012731_014082_27C0.SAFE SIA_IW_SLC_1SDV_20160825T061425_0160825T061452_012753_014144_A39D.SAFE \$1A_IW_SLC_1SDV_20160825T061425_01608250164452_012753_014144_A39D.SAFE SIA_IW_SLC_1SDV_20160825T061425_0160825T061425_014082_012753_014144_A39D.SAFE \$1A_IW_SLC_1SDV_20160825T061425_01608250164453_012928_0147711_F9A4.SAFE SIA_IW_SLC_1SDV_20160825T061425_0160825T061425_0140845_012025.014485_7D20.SAFE \$1A_IW_SLC_1SDV_20160825T061425_0160901T066648_012855_014485_7D20.SAFE <tr< td=""><td></td><td>08/09/2016</td><td>IW</td><td>S1A_IW_SLC1SDV_20160908T170707_20160908T170734_012964_014825_4CAE.SAFE</td></tr<>		08/09/2016	IW	S1A_IW_SLC1SDV_20160908T170707_20160908T170734_012964_014825_4CAE.SAFE
Targets DOI 001/0010 IN DLR Targets 02/10/2016 IW \$1A_IW_SLC_1SDV_20161002T170708_20161002T170735_013314_015387_B4AA.SAFE BAE CR 08/07/2016 to 03/10/2015 IW \$1A_IW_SLC_1SDV_20160708T061423_20160708T061450_012053_012A21_EAB4.SAFE S1A_IW_SLC_1SDV_20160718T174057_20160718T174125_012206_012F1A_560F.SAFE \$1A_IW_SLC_1SDV_20160718T174057_20160718T174125_012206_012F1A_560F.SAFE S1A_IW_SLC_1SDV_20160804T174929_20160804T174957_012454_01373F_14DF.SAFE \$1A_IW_SLC_1SDV_20160804T174929_20160804T174957_012454_01373F_14DF.SAFE S1A_IW_SLC_1SDV_20160811T174058_20160811T174126_012556_013AAC_7C7E.SAFE \$1A_IW_SLC_1SDV_20160813T061424_20160813T061452_012578_013861_7AB3.SAFE S1A_IW_SLC_1SDV_20160813T061424_20160813T061452_012578_013861_7AB3.SAFE \$1A_IW_SLC_1SDV_20160816T174929_20160816T174957_012629_013CFF_A644.SAFE S1A_IW_SLC_1SDV_20160813T061424_20160813T061452_012578_013861_7AB3.SAFE \$1A_IW_SLC_1SDV_20160901T060621_20160825T061452_012753_014144_SAPE S1A_IW_SLC_1SDV_20160901T061621_20160825T061425_013250_014552_012753_014144_A39D.SAFE \$1A_IW_SLC_1SDV_20160901T060621_20160901T060648_012855_014485_7D20.SAFE S1A_IW_SLC_1SDV_20160901T060621_20160901T060648_012855_014485_7D20.SAFE \$1A_IW_SLC_1SDV_20160901T060622_20160913T06049_01303_014A4A_8588.SAFE S1A_IW_SLC_1SDV_20160901T060621_20160913T060649_013030_014A4A_8588.SAFE \$1A_IW_SLC_1SDV_2016090170616425_20160916T174128_013026_015189_E751.SAFE <td></td> <td>16/09/2016</td> <td>IW</td> <td>S1A_IW_SLC1SDV_20160916T174100_20160916T174128_013081_014BFC_60C0.SAFE</td>		16/09/2016	IW	S1A_IW_SLC1SDV_20160916T174100_20160916T174128_013081_014BFC_60C0.SAFE
DER OE/10/2010 III Targets 08/07/2016 III S1A_IW_SLC_1SDV_20160708T061423_20160708T061450_012053_012A21_EAB4.SAFE BAE CR 08/07/2015 III S1A_IW_SLC_1SDV_20160708T061423_20160708T061450_012053_012A21_EAB4.SAFE S1A_IW_SLC_1SDV_20160718T174057_20160718T174125_012206_012F1A_560F.SAFE S1A_IW_SLC_1SDV_20160723T174928_20160723T174956_012279_01316F_D7C1.SAFE S1A_IW_SLC_1SDV_20160804T174929_20160804T174957_012454_01373F_14DF.SAFE S1A_IW_SLC_1SDV_20160804T174929_20160804T174957_012454_01373F_14DF.SAFE S1A_IW_SLC_1SDV_20160811T174058_20160811T174126_012556_013AAC_7C7E.SAFE S1A_IW_SLC_1SDV_20160813T061424_20160813T061452_012578_013861_7AB3.SAFE S1A_IW_SLC_1SDV_20160813T061424_20160813T061452_012578_013861_7AB3.SAFE S1A_IW_SLC_1SDV_20160823T174114_20160823T174143_012731_014082_27C0.SAFE S1A_IW_SLC_1SDV_20160825T061425_20160825T061452_012753_014144_A39D.SAFE S1A_IW_SLC_1SDV_20160901T060621_20160901T060648_012855_014485_7D20.SAFE S1A_IW_SLC_1SDV_20160901T060621_20160901T060648_012855_014485_7D20.SAFE S1A_IW_SLC_1SDV_20160901T060621_20160901T060648_012855_014485_7D20.SAFE S1A_IW_SLC_1SDV_20160901T060621_20160901T060648_012855_014485_7D20.SAFE S1A_IW_SLC_1SDV_20160901T060621_20160913T060649_01303_014A4A_8588.SAFE S1A_IW_SLC_1SDV_20160901T060621_20160913T060649_01303_014A4A_8588.SAFE S1A_IW_SLC_1SDV_20160913T060622_0160913T046049_013030_014A4A_8588.SAFE <t< td=""><td></td><td>20/09/2016</td><td>IW</td><td>S1A_IW_SLC1SDV_20160920T170708_20160920T170735_013139_014DEE_873F.SAFE</td></t<>		20/09/2016	IW	S1A_IW_SLC1SDV_20160920T170708_20160920T170735_013139_014DEE_873F.SAFE
to 03/10/2015 S1A_IW_SLC1SDV_20160718T174057_20160718T174125_012206_012F1A_560F.SAFE S1A_IW_SLC1SDV_20160723T174928_20160723T174956_012279_01316F_D7C1.SAFE S1A_IW_SLC1SDV_20160804T174929_20160804T174957_012454_01373F_14DF.SAFE S1A_IW_SLC1SDV_20160804T174929_20160804T174957_012454_01373F_14DF.SAFE S1A_IW_SLC1SDV_20160811T174058_20160811T174126_012556_013AAC_7C7E.SAFE S1A_IW_SLC1SDV_20160811T174058_20160811T174126_012578_013B61_7AB3.SAFE S1A_IW_SLC1SDV_20160816T174929_20160816T174957_012629_013CFF_A644.SAFE S1A_IW_SLC1SDV_20160823T174114_20160823T1741143_012731_014082_27C0.SAFE S1A_IW_SLC1SDV_20160825T061425_20160825T061452_012753_014144_A39D.SAFE S1A_IW_SLC1SDV_20160906T061425_20160901T060648_012855_0144B5_7D20.SAFE S1A_IW_SLC1SDV_20160906T061425_20160901T060648_012855_0144B5_7D20.SAFE S1A_IW_SLC1SDV_20160906T061425_20160906T061453_012928_014711_F9A4.SAFE S1A_IW_SLC1SDV_20160913T060622_20160913T060649_013030_014A4A_85B8.SAFE S1A_IW_SLC1SDV_20160908T061425_20160906T061453_012928_014711_F9A4.SAFE S1A_IW_SLC1SDV_20160928T174100_20160928T174128_013081_014BFC_60C0.SAFE		02/10/2016	IW	S1A_IW_SLC1SDV_20161002T170708_20161002T170735_013314_015387_B4AA.SAFE
03/10/2015 SIA_IW_SLCISDV_2016073T174928_20160723T174956_012279_01316F_D7C1.SAFE SIA_IW_SLCISDV_20160804T174929_20160804T174957_012454_01373F_14DF.SAFE SIA_IW_SLCISDV_20160811T174058_20160811T174126_012556_013AAC_7C7E.SAFE SIA_IW_SLCISDV_20160813T061424_20160813T061452_012578_013B61_7AB3.SAFE SIA_IW_SLCISDV_20160816T174929_20160816T174957_012629_013CFF_A644.SAFE SIA_IW_SLCISDV_20160823T174114_20160823T174143_012731_014082_27C0.SAFE SIA_IW_SLCISDV_20160825T061425_20160825T061452_012753_014144_A39D.SAFE SIA_IW_SLCISDV_20160901T060621_20160901T060648_012855_0144B5_7D20.SAFE SIA_IW_SLCISDV_20160901T060621_20160901T060648_012855_0144AE5TD20.SAFE SIA_IW_SLCISDV_20160901T060622_20160913T060649_013030_014A4A_85B8.SAFE SIA_IW_SLCISDV_20160913T060622_20160913T060649_013030_014A4A_85B8.SAFE SIA_IW_SLCISDV_20160913T060622_20160915T061453_013228_014711_F9A4.SAFE SIA_IW_SLCISDV_20160928T174110_20160928T174128_013256_0151B9_E751.SAFE SIA_IW_SLCISDV_20160928T174100_20160928T174128_013278_015268_6372.SAFE	BAE CR	08/07/2016	IW	S1A_IW_SLC1SDV_20160708T061423_20160708T061450_012053_012A21_EAB4.SAFE
S1A_IW_SLC1SDV_20160723T174928_20160723T174956_012279_01316F_D7C1.SAFE S1A_IW_SLC1SDV_20160804T174929_20160804T174957_012454_01373F_14DF.SAFE S1A_IW_SLC1SDV_20160811T174058_20160811T174126_012556_013AAC_7C7E.SAFE S1A_IW_SLC1SDV_20160813T061424_20160813T061452_012578_013B61_7AB3.SAFE S1A_IW_SLC1SDV_20160816T174929_20160816T174957_012629_013CFF_A644.SAFE S1A_IW_SLC1SDV_20160823T174114_20160823T174143_012731_014082_27C0.SAFE S1A_IW_SLC1SDV_20160825T061425_20160825T061452_012753_014144_A39D.SAFE S1A_IW_SLC1SDV_20160901T060621_20160901T060648_012855_014485_7D20.SAFE S1A_IW_SLC1SDV_20160901T060621_20160906T061453_012928_014711_F9A4.SAFE S1A_IW_SLC1SDV_20160906T061425_20160906T061453_012928_014711_F9A4.SAFE S1A_IW_SLC1SDV_20160906T061425_20160930T060649_013030_014A4A_85B8.SAFE S1A_IW_SLC1SDV_20160928T174100_20160928T174128_013256_0151B9_E751.SAFE S1A_IW_SLC1SDV_20160930T061426_20160930T061453_013278_015268_6372.SAFE				S1A_IW_SLC1SDV_20160718T174057_20160718T174125_012206_012F1A_560F.SAFE
S1A_IW_SLC1SDV_20160811T174058_20160811T174126_012556_013AAC_7C7E.SAFE S1A_IW_SLC1SDV_20160813T061424_20160813T061452_012578_013B61_7AB3.SAFE S1A_IW_SLC1SDV_20160816T174929_20160816T174957_012629_013CFF_A644.SAFE S1A_IW_SLC1SDV_20160823T174114_20160823T174143_012731_014082_27C0.SAFE S1A_IW_SLC1SDV_20160825T061425_20160825T061452_012753_014144_A39D.SAFE S1A_IW_SLC1SDV_20160901T060621_20160901T060648_012855_0144B5_7D20.SAFE S1A_IW_SLC1SDV_20160906T061425_20160906T061453_012928_014711_F9A4.SAFE S1A_IW_SLC1SDV_20160913T060622_20160913T060649_013030_014A4A_85B8.SAFE S1A_IW_SLC1SDV_20160916T174100_20160916T174128_013081_014BFC_60C0.SAFE S1A_IW_SLC1SDV_20160928T174110_20160928T174128_013256_0151B9_E751.SAFE S1A_IW_SLC1SDV_20160930T061426_20160930T061453_013278_015268_6372.SAFE		03/10/2015		S1A_IW_SLC1SDV_20160723T174928_20160723T174956_012279_01316F_D7C1.SAFE
S1A_IW_SLC1SDV_20160813T061424_20160813T061452_012578_013B61_7AB3.SAFE S1A_IW_SLC1SDV_20160816T174929_20160816T174957_012629_013CFF_A644.SAFE S1A_IW_SLC1SDV_20160823T174114_0160823T174143_012731_014082_27C0.SAFE S1A_IW_SLC1SDV_20160825T061425_20160825T061452_012753_014144_A39D.SAFE S1A_IW_SLC1SDV_20160901T060621_20160901T060648_012855_0144B5_7D20.SAFE S1A_IW_SLC1SDV_20160906T061425_20160906T061453_012928_014711_F9A4.SAFE S1A_IW_SLC1SDV_20160906T061425_20160913T060649_013030_014A4A_85B8.SAFE S1A_IW_SLC1SDV_20160913T060622_20160913T060649_0130381_014BFC_60C0.SAFE S1A_IW_SLC1SDV_20160928T174100_20160928T174128_013256_0151B9_E751.SAFE S1A_IW_SLC1SDV_20160930T061426_20160930T061453_013278_015268_6372.SAFE				S1A_IW_SLC1SDV_20160804T174929_20160804T174957_012454_01373F_14DF.SAFE
S1A_IW_SLC1SDV_20160816T174929_20160816T174957_012629_013CFF_A644.SAFE S1A_IW_SLC1SDV_20160823T174114_20160823T174143_012731_014082_27C0.SAFE S1A_IW_SLC1SDV_20160825T061425_20160825T061452_012753_014144_A39D.SAFE S1A_IW_SLC1SDV_20160901T060621_20160901T060648_012855_0144B5_7D20.SAFE S1A_IW_SLC1SDV_20160906T061425_20160906T061453_012928_014711_F9A4.SAFE S1A_IW_SLC1SDV_20160913T060622_20160913T060649_013030_014A4A_85B8.SAFE S1A_IW_SLC1SDV_20160916T174100_20160916T174128_013081_014BFC_60C0.SAFE S1A_IW_SLC1SDV_20160928T174100_20160928T174128_013256_0151B9_E751.SAFE S1A_IW_SLC1SDV_20160930T061426_20160930T061453_013278_015268_6372.SAFE				S1A_IW_SLC1SDV_20160811T174058_20160811T174126_012556_013AAC_7C7E.SAFE
S1A_IW_SLC1SDV_20160823T174114_20160823T174143_012731_014082_27C0.SAFE S1A_IW_SLC1SDV_20160825T061425_20160825T061452_012753_014144_A39D.SAFE S1A_IW_SLC1SDV_20160901T060621_20160906T061453_012928_014711_F9A4.SAFE S1A_IW_SLC1SDV_20160906T061425_20160906T061453_012928_014711_F9A4.SAFE S1A_IW_SLC1SDV_20160913T060622_20160913T060649_013030_014A4A_85B8.SAFE S1A_IW_SLC1SDV_20160916T174100_20160916T174128_013081_014BFC_60C0.SAFE S1A_IW_SLC1SDV_20160928T174100_20160928T174128_013256_0151B9_E751.SAFE S1A_IW_SLC1SDV_20160930T061426_20160930T061453_013278_015268_6372.SAFE				S1A_IW_SLC1SDV_20160813T061424_20160813T061452_012578_013B61_7AB3.SAFE
S1A_IW_SLC1SDV_20160825T061425_20160825T061452_012753_014144_A39D.SAFE S1A_IW_SLC1SDV_20160901T060621_20160901T060648_012855_0144B5_7D20.SAFE S1A_IW_SLC1SDV_20160906T061425_20160906T061453_012928_014711_F9A4.SAFE S1A_IW_SLC1SDV_20160913T060622_20160913T060649_013030_014A4A_85B8.SAFE S1A_IW_SLC1SDV_20160916T174100_20160916T174128_013081_014BFC_60C0.SAFE S1A_IW_SLC1SDV_20160928T174100_20160928T174128_013256_0151B9_E751.SAFE S1A_IW_SLC1SDV_20160930T061426_20160930T061453_013278_015268_6372.SAFE				S1A_IW_SLC1SDV_20160816T174929_20160816T174957_012629_013CFF_A644.SAFE
S1A_IW_SLC1SDV_20160901T060621_20160901T060648_012855_0144B5_7D20.SAFE S1A_IW_SLC1SDV_20160906T061425_20160906T061453_012928_014711_F9A4.SAFE S1A_IW_SLC1SDV_20160913T0606622_20160913T060649_013030_014A4A_85B8.SAFE S1A_IW_SLC1SDV_20160916T174100_20160916T174128_013081_014BFC_60C0.SAFE S1A_IW_SLC1SDV_20160928T174100_20160928T174128_013256_0151B9_E751.SAFE S1A_IW_SLC1SDV_20160930T061426_20160930T061453_013278_015268_6372.SAFE				S1A_IW_SLC1SDV_20160823T174114_20160823T174143_012731_014082_27C0.SAFE
S1A_IW_SLC1SDV_20160906T061425_20160906T061453_012928_014711_F9A4.SAFE S1A_IW_SLC1SDV_20160913T060622_20160913T060649_013030_014A4A_85B8.SAFE S1A_IW_SLC1SDV_20160916T174100_20160916T174128_013081_014BFC_60C0.SAFE S1A_IW_SLC1SDV_20160928T174100_20160928T174128_013256_0151B9_E751.SAFE S1A_IW_SLC1SDV_20160930T061426_20160930T061453_013278_015268_6372.SAFE				S1A_IW_SLC1SDV_20160825T061425_20160825T061452_012753_014144_A39D.SAFE
S1A_IW_SLC1SDV_20160913T060622_20160913T060649_013030_014A4A_85B8.SAFE S1A_IW_SLC1SDV_20160916T174100_20160916T174128_013081_014BFC_60C0.SAFE S1A_IW_SLC1SDV_20160928T174100_20160928T174128_013256_0151B9_E751.SAFE S1A_IW_SLC1SDV_20160930T061426_20160930T061453_013278_015268_6372.SAFE				S1A_IW_SLC1SDV_20160901T060621_20160901T060648_012855_0144B5_7D20.SAFE
S1A_IW_SLC1SDV_20160916T174100_20160916T174128_013081_014BFC_60C0.SAFE S1A_IW_SLC1SDV_20160928T174100_20160928T174128_013256_0151B9_E751.SAFE S1A_IW_SLC1SDV_20160930T061426_20160930T061453_013278_015268_6372.SAFE				S1A_IW_SLC1SDV_20160906T061425_20160906T061453_012928_014711_F9A4.SAFE
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S1A_IW_SLC1SDV_20160930T061426_20160930T061453_013278_015268_6372.SAFE				S1A_IW_SLC1SDV_20160916T174100_20160916T174128_013081_014BFC_60C0.SAFE
				S1A_IW_SLC1SDV_20160928T174100_20160928T174128_013256_0151B9_E751.SAFE
\$1A_IW_SLC1SDV_20161003T174931_20161003T174959_013329_0153FF_D84A.SAFE				S1A_IW_SLC1SDV_20160930T061426_20160930T061453_013278_015268_6372.SAFE
				S1A_IW_SLC1SDV_20161003T174931_20161003T174959_013329_0153FF_D84A.SAFE

Table	4:	Additional L1 Prod	ucts
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5.1. Amazon Rainforest Gamma profiles

Figure 15 shows an IW image acquired after the Tile 11 issue while Figure 16 shows a gamma profile across the image shown in Figure 15 and for an earlier acquisition and later acquisitions with the same relative orbit (105). The HV profiles indicate that the increase in gamma at the boundary of sub-swaths IW1 and IW2 are not related to the Tile 11 issue. Table 5 gives the mean gamma for the whole image. Between the acquisition just before and just after the Tile 11 issue and for HH polarisation there is a reduction of 0.09 dB while there is no reduction for HV polarisation. For the later acquisition on 07/09/2016 there is a further reduction of 0.30dB for HH polarisation and a reduction of 0.18dB for HV polarisation. The most recent acquisition on 01/10/2016 has a slightly higher gamma compared to the previous acquisition on the 07/09/2016 - the HV gamma is close to the pre Tile 11 issue acquisition.





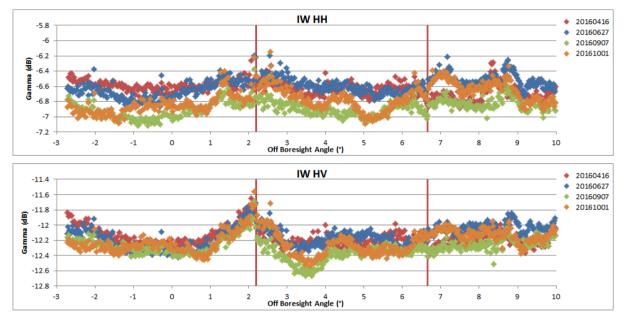
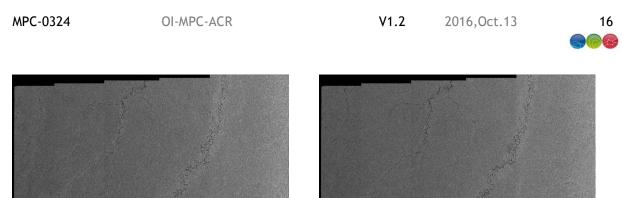


Figure 16 Amazon Rainforest IW Gamma Profiles

Acquisition Date	HH	HV	Before/After Failure
16/06/2016	-6.49 dB	-12.15 dB	Before
27/06/2016	-6.58 dB	-12.15 dB	After
07/09/2016	-6.88 dB	-12.33 dB	After
01/10/2016	-6.70 dB	-12.17 dB	After

Table 5: Mean Amazon Rainforest Gamma

Figure 17 and Figure 18 show an EW DH rainforest image and gamma profile for an acquisition acquired on 29th June 2016. Small gamma jumps can be seen but these cannot be confirmed as no previous acquisition with the same relative orbit has been found (due to the specific planning for the S1-B commissioning phase planning). Also the 01/07/2016 EW Amazon acquisition, for which there is a previous acquisition, do not give conclusive results due to the rather non-homogeneous nature of this scene (see in **RD-4**).



HH HV Figure 17 Amazon Rainforest EW Image from 29th June 2016.

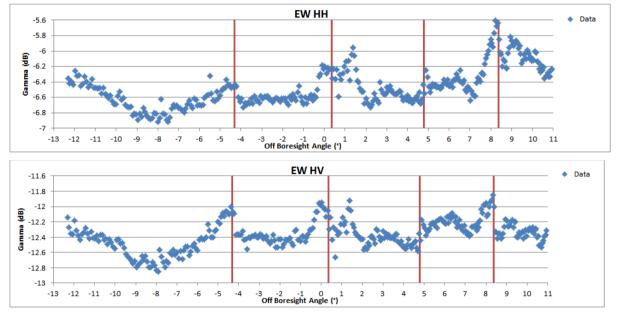


Figure 18 Amazon Rainforest EW Gamma Profiles from 29th June 2016

Figure 19 and Figure 20 show an EW DV rainforest image and gamma profile for an acquisition acquired on 17th September 2016 (over a different part of the Amazon from that shown above). A small gamma jump can be seen between EW1 and EW2 of about 0.2dB.

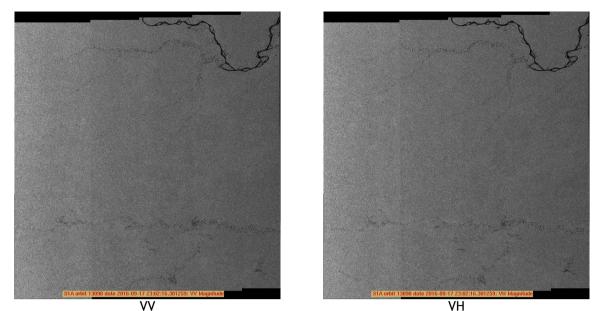


Figure 19 Amazon Rainforest EW Image from 17th September 2016

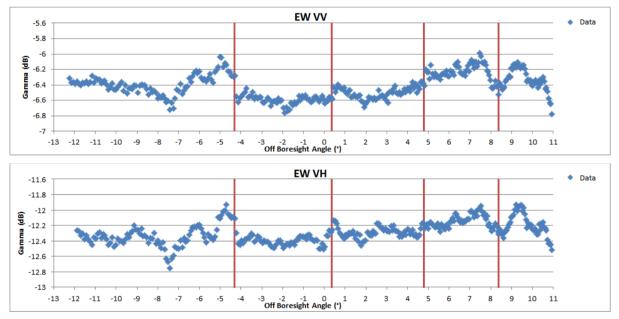
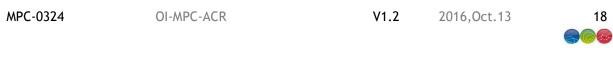


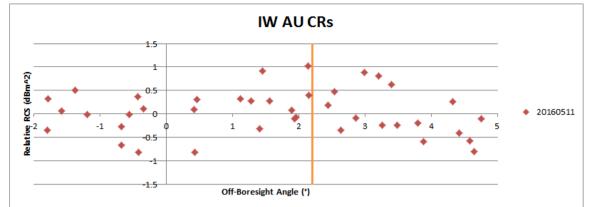
Figure 20 Amazon Rainforest EW Gamma Profiles from 17th September 2016

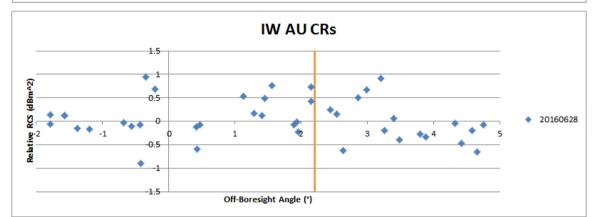
5.2. Calibration Point Targets

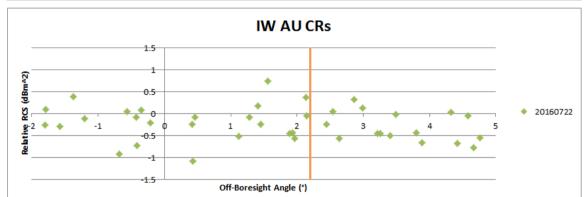
The Australian Corner Reflector array, the DLR transponders and corner reflectors and the BAE Corner Reflector have been used to assess the radiometric calibration of L1 product post the tile 11 issue. Results from before the failure have also been used as a comparison.

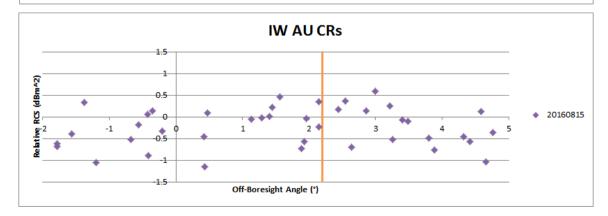
Figure 21 shows the relative RCS of the Australian CR array before and after the Tile 11 issue from an IW acquisition (IW1 and IW2 sub-swaths). The mean relative RCS pre & post the issue are given in Table 6 (results from three additional acquisitions before the issue have been included).











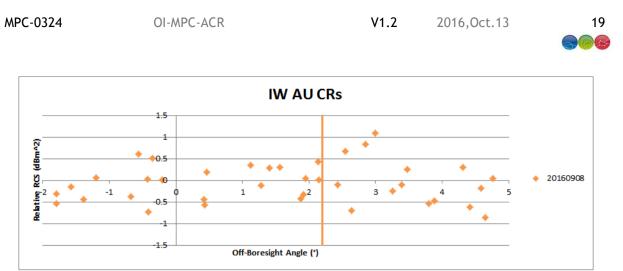


Figure 21 Australian CR relative RCS before (2016051) and after (20160628, 20160722, 20160815, 20160908) the Tile 11 Failure.

Acquisition Date	Mean Relative RCS	Before/After Failure
12/03/2016	-0.16±0.39dB	Before
24/03/2016	-0.16±0.51dB	Before
17/04/2016	-0.17±0.42dB	Before
11/05/2016	0.03±0.48dB	Before
28/06/2016	0.05±0.43dB	After
22/07/2016	-0.24±0.38dB	After
15/08/2016	-0.24±0.45dB	After
08/09/2016	-0.06±0.46dB	After

Table 6: Mean AU Corner Reflector Radar Cross-section

There is no significant difference in the mean relative RCS shown in the above table before and after the Tile 11 issue.

Figure 22 shows the relative RCS of the DLR transponders and corner reflectors based on IW products acquired during relative orbit 117 covering sub-swaths IW1 and IW2. The mean relative RCS pre & post the issue are given in Table 7 (results from three additional acquisitions before the issue have been included).

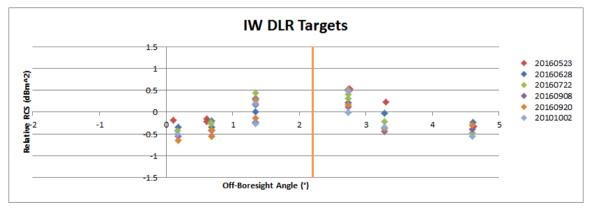


Figure 22 DLR Targets relative RCS

OI-MPC-ACR

MPC-0324

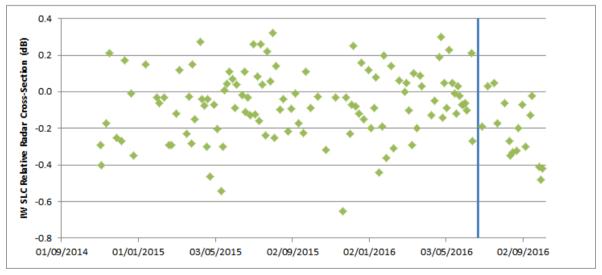
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Acquisition Date	Mean Relative RCS	Before/After Failure
17/04/2016	0.00±0.30dB	Before
29/04/2016	-0.02±0.33dB	Before
11/05/2016	-0.20±0.24dB	Before
23/05/2016	0.05±0.36dB	Before
28/06/2016	-0.06±0.32dB	After
22/07/2016	-0.02±0.37dB	After
08/09/2016	-0.20±0.38dB	After
20/09/2016	-0.16±0.40dB	After
02/10/2016	-0.14±0.38dB	After

Table 7: Mean DLR Target Radar Cross-section

There is no significant difference in the mean relative RCS shown in the above table before and after the Tile 11 issue, although measurements from September & October are slightly lower than earlier measurements.

Figure 23 shows the relative RCS for the BAE corner reflector pre and post the Tile 11 issue (to the left and right of the vertical blue line) based in IW products (IW1 and IW3). The mean relative RCS pre & post the issue is -0.06 ± 0.19 dB (114) and -0.21 ± 0.16 dB (17) respectively (the number of measurements are given in brackets).





There is a 0.15 dB drop in relative RCS before and after the Tiles 11 issue but the measurements post the Tile 11 issue are within the variation in relative RCS seen before the Tile 11 issue.

Sentinel-1A	A Tile #	11 Fai	lure
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6. Conclusions

The impact of the Tile 11 issue (reduced power for rows 1 to 10 in Tx H and Tx V) has been assessed using the S1A CFI Antenna Model through a comparison of the azimuth & elevation antenna patterns and the Doppler calibration profiles before and after the failures as summarised in Section 3.4. The main impact in terms of Level 1 product radiometry is small radiometric jumps at sub-swath boundaries between IW1 & IW2, EW1 & EW2 and EW2 & EW3.

Analysis of L1 products of the Amazon Rainforest and various calibration targets either show no or small (~0.1dB) changes in radiometry. This indicates that the internal calibration is correctly compensating for the reduction in transmit power caused by the Tile 11 issue. Results from various point targets (the Australian CR array, the DLR transponders and corner reflectors and the BAE corner reflector) do not show any systematic reduction in relative RCS. The only exception is for the BAE corner reflector where a drop of 0.15 dB drop in relative RCS before and after the Tiles 11 issue but the measurements post the Tile 11 issue are within the variation in relative RCS seen before the Tile 11 issue.

V1.2



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Appendix A - List of acronyms

To be confirmed
To be defined
Applicable Document
Reference Document
Noise Equivalent Sigma Zero
Antenna Model
Elevation Antenna Pattern
Azimuth Antenna Pattern
Transmit-Receive Module
Doppler Calibration Profile