Advanced L-Band Antenna for NG SMOS Missions (ALBA)

Final Review(FR)

DEFENCE AND SPACE

ALBA team

December 10th,2024

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Agenda

- ALBA objectives & activities
- ALBA antenna element description
  - Simulation performance
- TriHex description and breadboard definition
  - Simulation of TRIHEX performance (breadboard)
- ALBA test campaign
  - T1: Dimensional testing and mass
  - T2: S-parameter test (individual)
  - T3: radiation pattern test (individual)
  - T4: S-parameter vs temperature (2 individuals)
  - T5: insertion amplitude/phase vs temperature
  - T7:Breadboard S-parameters vs temperature
  - T8: Breadboard radiation patterns
- Image reconstruction analysis (UPC)
- Lesson learnt and Recommendation for further work.
- Conclusions
- AIs closure.
- AOB.

ALBA objectives & activities

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ALBA objectives & activities

- As per the ITT, the objective of this activity is to design, manufacture and experimentally demonstrate a representative part of an hexagonal L-band array antenna for next generation SMOS missions with a reduced element spacing, down to 0.577λ (at 1413.5 MHz), to allow an alias-free image.
- The activities consisted on:
    - ❑ Design , analyse , manufacture and test the ALBA antenna
    - ❑ Assess of the effect of mutual couplings between elements when integrated into the array.
    - ❑ Analyse the ALBA antenna elements integrated into the TriHex array structure, including the patterns and mutual coupling results of a portion of the TriHex S/C instrument that comprises a complete side of the structure and several elements of the neighbouring sides
    - ❑ Perform a complete test campaign to ALBA antenna breadboard.
    - ❑ Perform system level image reconstruction study
    - ❑ Perform with simulated and measured patterns system simulations to predict system performances (UPC activity).

ALBA antena element description

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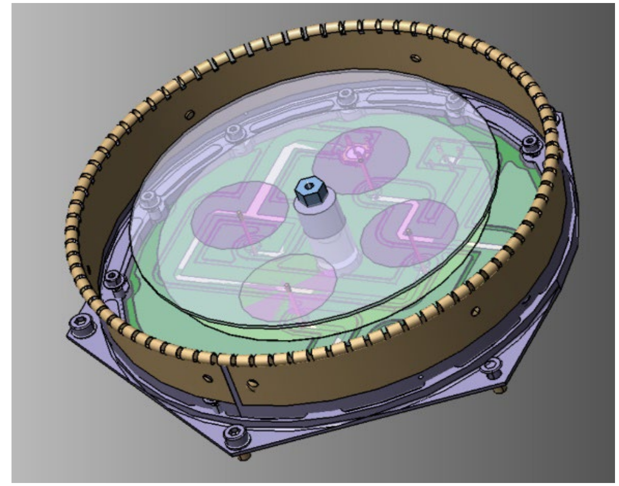
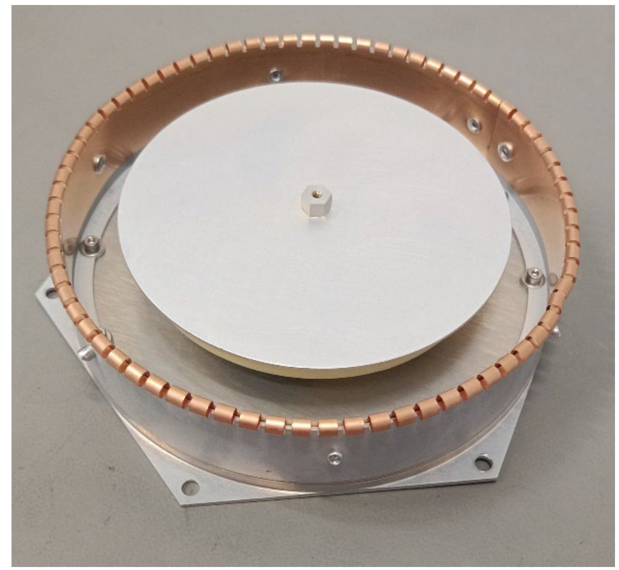
Antenna





- The antenna elements in TriHex are dual polarization elements operating in the L-band protected band (1404-1423MHz)
- The antenna is a dual polarization balanced feed (0º-180º) patch antenna element surrounded by a cavity.
- Balanced feed provides excellent isolation between polarizations and makes the phase center of the element to be aligned at the axis. The patch antenna uses air as dielectric to provide wide bandwidth. The feed network is designed in Duroid 6002 which is low loss and very temperature stable
- The surrounding cavity includes also a metal gasket to guarantee electrical contact with the surrounding ground plane around the antenna without gaps
- Antenna parts are built in aluminium to avoid any thermal mismatch

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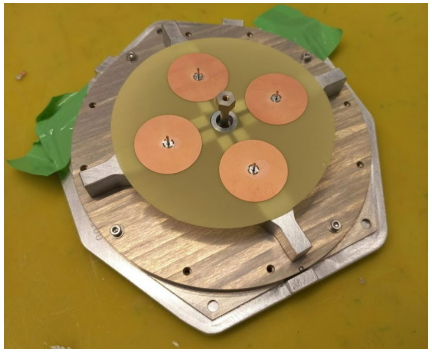
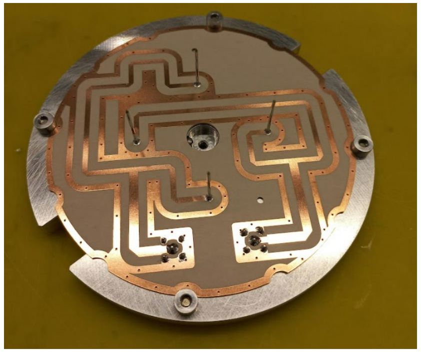
ALBA antena element description

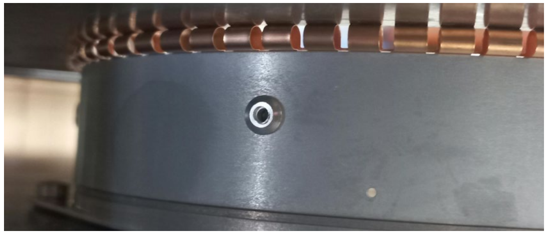


- Fed with four capacitive probes located at 90º one of the other.

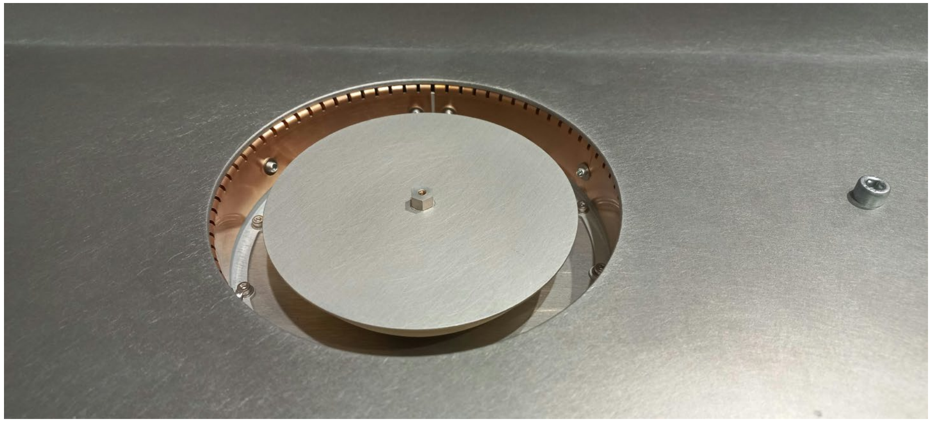


- Printed circuit, in microstrip technology, containing two independent circuits, each with 180º phase division.

- Metallic gasket to provide conductivity between antenna and ground plane.

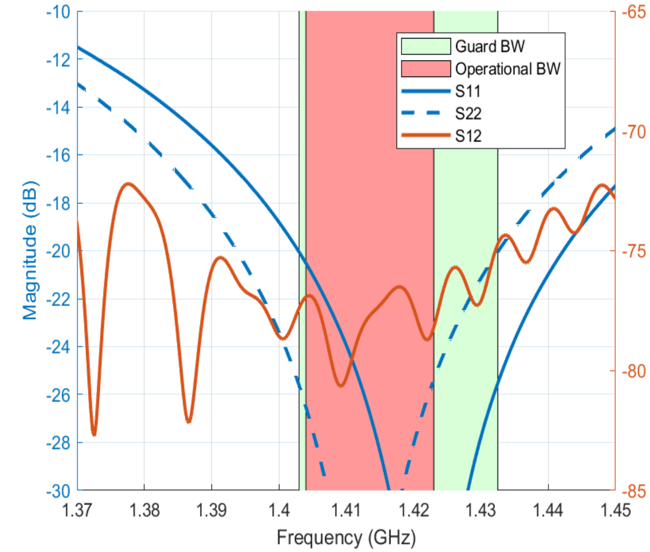


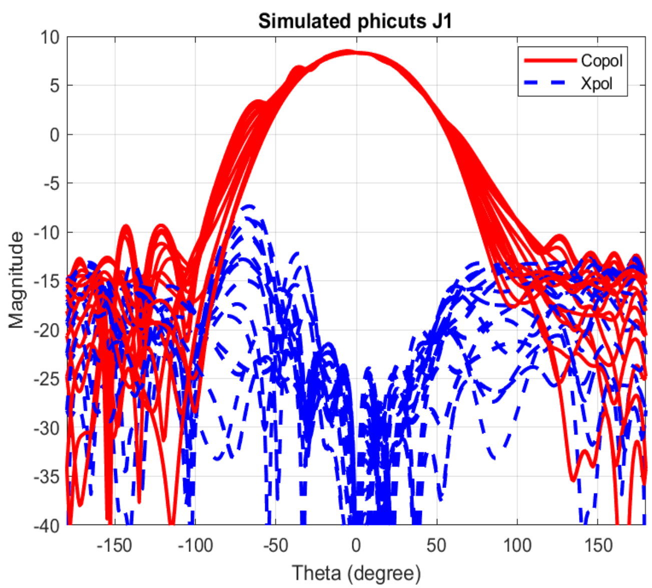
- Cavity size: 114mm in diameter
- Cavity height: 25mm.
- Disk patch diameter: 88.3 mm

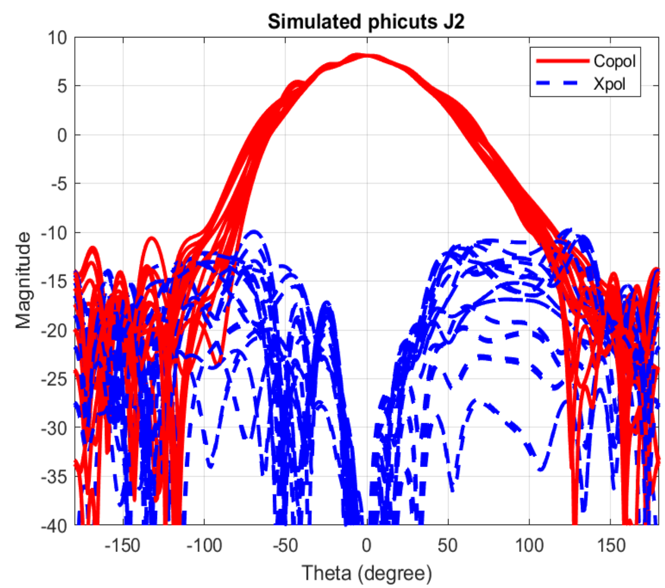


ALBA antenna element: simulation performance

- The effect of the ground plane position produces a variation in the current distribution in the antenna surroundings, varying both S-parameters and radiation pattern.
- A non-symmetrical diagram is obtained due to asymmetry in the location wrt the ground plane edge.
- The copolar component is affected with ripple.
- The current distribution of the antenna is affected → affects crosspolar pattern.







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ALBA antena element: simulation performance

- Different studies took place during the design process:
  - ❑ Effect of ground plane position (center vs edge and no ground plane)
  - ❑ Rotation of the antenna element at the edge of the ground plane
  - ❑ Ground plane height (bottom of the antenna vs top of the patch)
  - ❑ Tolerance analysis to verify the design robustness and possible detuning.

	Isolated	Edge GP (90cm)
Dir polH (dB)	7.7	7.84
Dir polV (dB)	7.7	8.33
XPD polH phi 45deg (dB)	33	22.3
XPD polV phi 45deg (dB)	33	26
HPBW phi 0 polH (deg)	76	74
HPBW phi 90 polH (deg)	84	72
HPBW phi 0 polV (deg)	84	72
HPBW phi 90 polV (deg)	76	78
Losses PolH (dB)	0.05	0.06
Losses PolV (dB)	0.08	0.09

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ALBA antena element: simulation performance

Design studies for the radiating element are covered in the supplied documentation:

Doc ref	iss	Doc name	Review
ALBA-ADSM-TN-1001172332	2.0	TN1: State of the art	PDR
ALBA-ADSM-TN-1001174596	1.0	TN2: Consolidated Requirements Review	PDR
ALBA-ADSM-TN-1001174597	2.0	TN3: Preliminary Design	PDR
ALBA-ADSM-TN-1001602782	1.0	TN4: Detailed Design	CDR
ALBA-ADSM-TN-1001799483	1.0	TN4: Detailed Design Addendum 1	CDR
ALBA-ADSM-TN-1001843223	1.0	TN4: Detailed Design Addendum 2	CDR

TriHex description and breadboard definition

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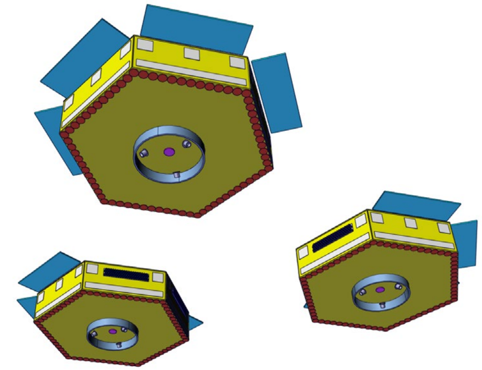
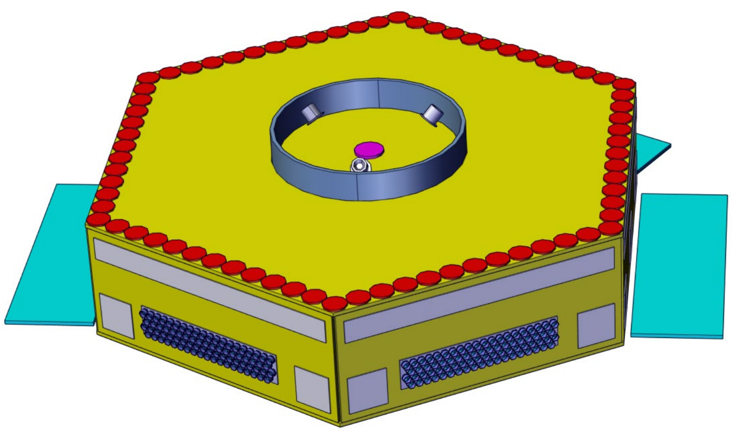
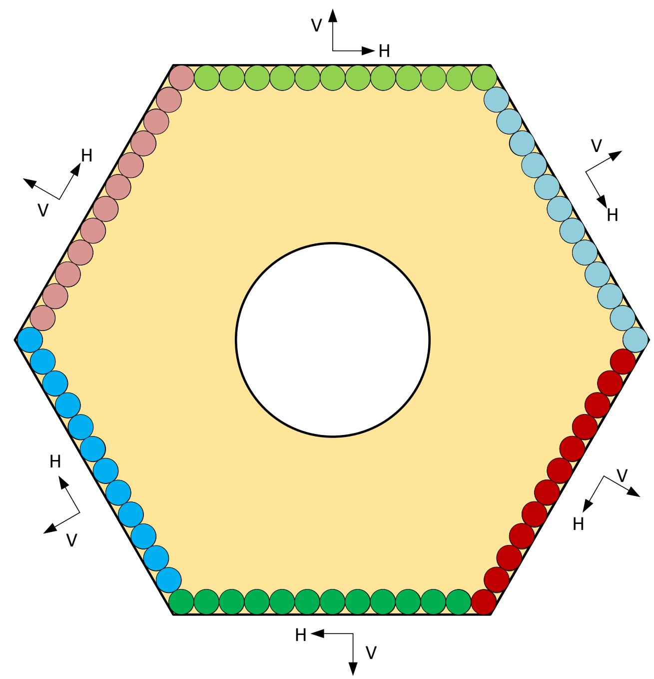
TriHex Instrument



- TriHex and is formed with 3 hexagonal spacecrafts of 3m in diameter.
- The hexagonal geometry provides better SLL performances against RFI, and the close spacing between radiating elements (0.577λ) provides a larger alias-free field of view (1200km) to the aperture synthesis instrument that permits reducing revisit time.
- Each spacecraft is formed by 72 antennas (+receivers) distributed in the periphery with 12 elements with the same polarization.





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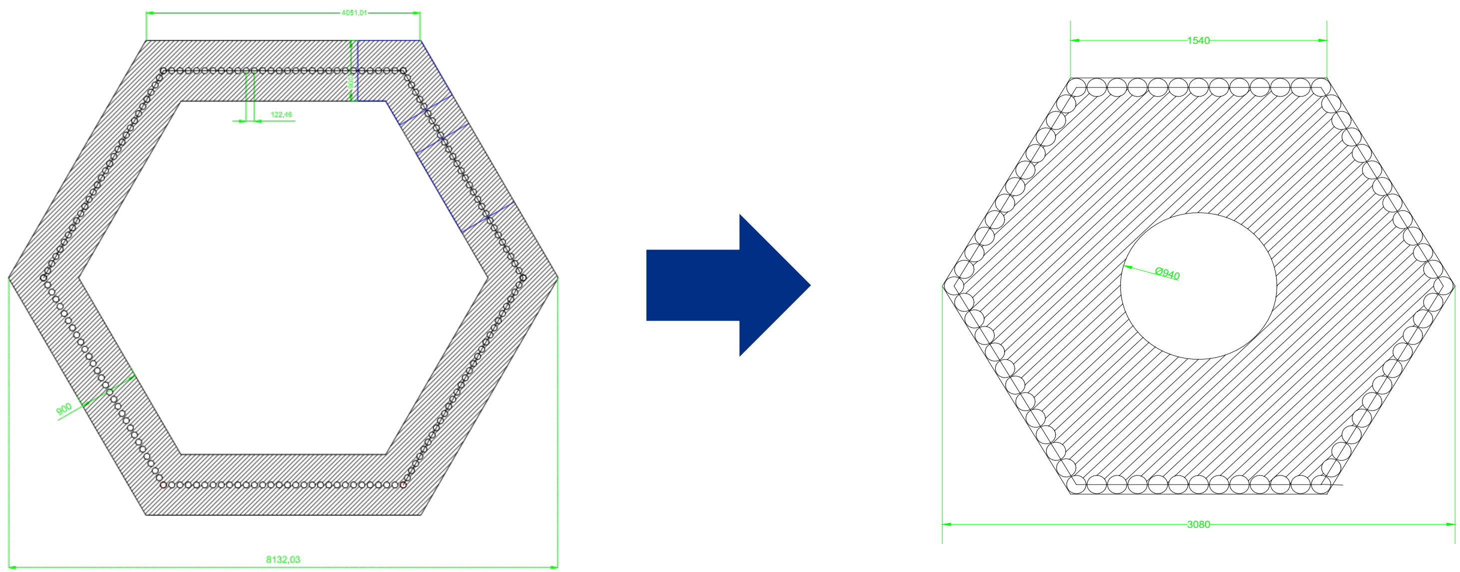
TRIHEX description and breadboard definition

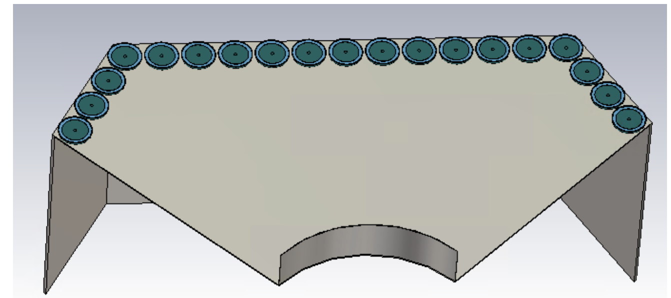
- Update of ALBA mission from one single hexagon with elements at the center to three spacecrafts instrument with flying configuration called TriHex, in which the antenna elements are located at the edge of each individual spacecrafts structure.

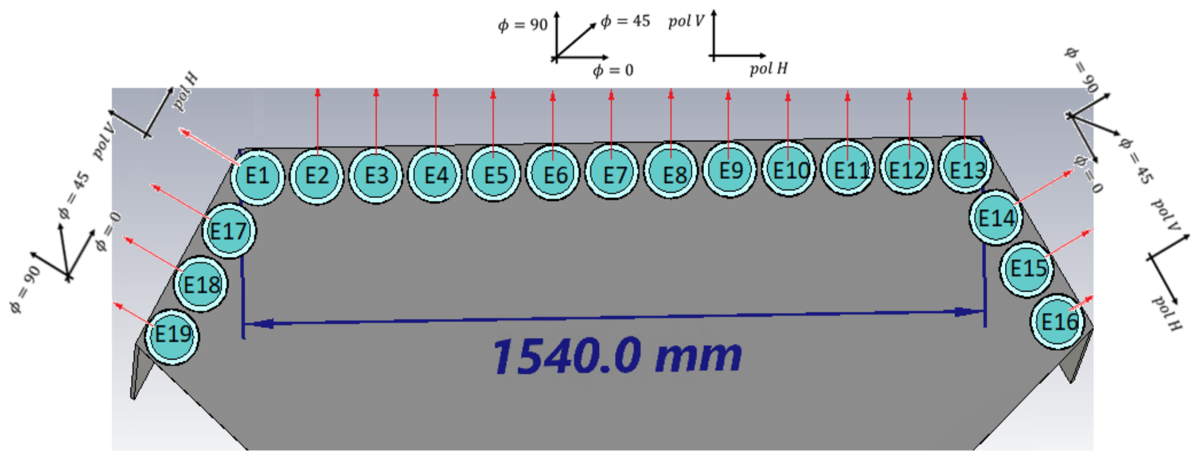


- Different setup simulations for the breadboard (BB) have been analysed (even the use of GRASP was considered to analyze the effects). Several meetings with CST technical personnel helped to solve the problems
- High computational efforts for full model mesh cells (742M)

Effect of antenna locations in TriHex structure

- A reduced S/C model with 19 antenna elements was defined, with 4 dummies (E15, E16, E18 and E19) to replicate the coupling effect of the other segments
- Straight arm elements (E1-E13) were analysed
  - ❑ Effects: ground plane truncation, couplings, metallic walls
  - ❑ The elements E14-E19 at the left and right sides are rotated +60 and -60 degrees.
  - ❑ The radiation pattern for each element has been calculated using a local coordinate system for each element.





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Simulation of TRIHEX segment performances

Element number	1	2	3	4	5	6	7	8	9	10	11	12	13
Directivity polH (dB)	6.94	7.15	7.39	7.24	7.16	7.23	7.38	7.23	7.16	7.24	7.39	7.15	6.77
GAIN IEEE polH (dB)	6.74	7.00	7.25	7.09	7.01	7.08	7.23	7.08	7.00	7.09	7.25	6.99	6.57
Realized Gain polH (dB)	6.71	6.96	7.20	7.04	6.97	7.04	7.19	7.04	6.97	7.04	7.20	6.96	6.53
HPBW polH phi 0 (deg)	96	92	91	91	97	95	95	95	97	91	90	92	87
HPBW polH phi 90 (deg)	96	76	80	82	83	82	72	82	83	82	80	76	95
XPD polH phi45 (dB) (1)	19.3	21.6	21.3	21.8	18.2	18.7	20.1	21.7	21.8	20.7	19.8	18.7	18.6
Directivity polV (dB)	6.84	7.12	7.15	7.08	7.09	7.15	7.17	7.15	7.09	7.08	7.15	7.13	6.79
GAIN IEEE polV (dB)	6.61	6.84	6.87	6.81	6.81	6.87	6.87	6.86	6.81	6.81	6.88	6.84	6.56
Realized Gain polV (dB)	6.59	6.81	6.84	6.77	6.78	6.84	6.86	6.84	6.78	6.77	6.85	6.81	6.53
HPBW polV phi 0 (deg)	105	100	102	104	102	103	105	103	102	104	101	100	101
HPBW polV phi 90 (deg)	92	68	72	72	64	66	64	66	64	72	71	67	86
XPD polV phi 45 (dB)1	21.9	26.9	24.4	24.7	20.6	22.4	29.9	20.5	22	24	21.6	21.8	22.4
Losses PolH (dB)	0.20	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.20
Losses PolV (dB)	0.23	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.23

(1) For the angular range -30< θ<30

The effect of coupling in V-pol elements in the gain was identified at DDR with the coupling level in V pol being responsable of 0.14dB $(\mathrm{dB}(1-2C^2))$ extra los wrt the H pol

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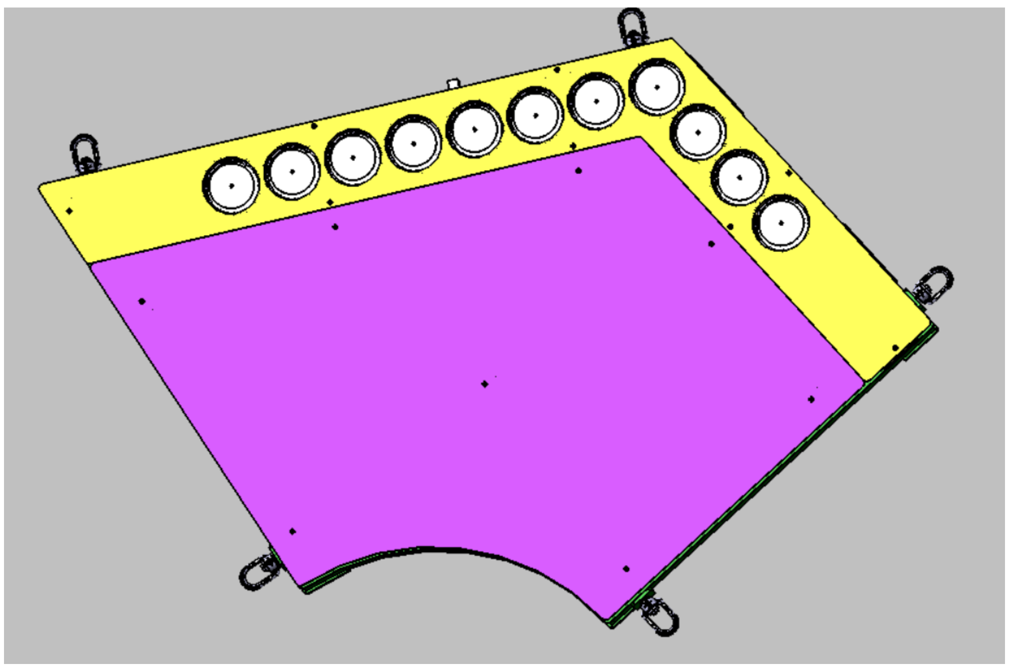
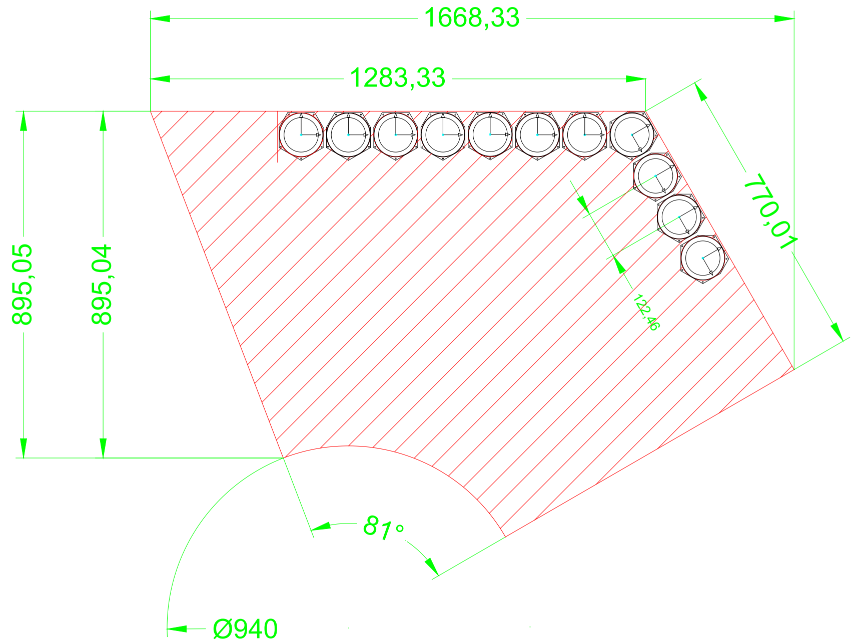
ALBA arrayed Breadboard definition

The analytical study of the segment was used to define a representative Breadboard, composed of 11 elements as initially required by the ITT





ALBA breadboard studies

- Different studies took place during the array definition process:
  - Different breadboard sizes analysed
    - High computation effort
    - Test over different solvers in CST 3D EM analysis tool.
  - Dummies inclusion to avoid edge effects due to truncation
  - Effect of ground plane position (ripple)
  - Coupling analysis between elements of the same and different arms.
  - Frequency behaviour in band
  - Phase center calculation

Test Plan Definition

Test Plan details were covered in the documentation and simulations were also conducted on the units under test

Doc ref	iss	Doc name	Review
ALBA-ADSM-PL-1001602783	3.0	TN5: Test Plan	CDR, TRR
ALBA-ADSM-TN-1001897313	1.0	TN8a: ALBA single antenna performances collection for test campaign	
ALBA-ADSM-TP-1001896010	2.0	TN8b ALBA Radiators Test Procedure	

ALBA test campaign

- The following test have been performed both at antenna and breadboard array level.
  - T1: Individual antenna ICD verification (mass, dimensional testing)
  - T2: Individual antenna S-parameter testing

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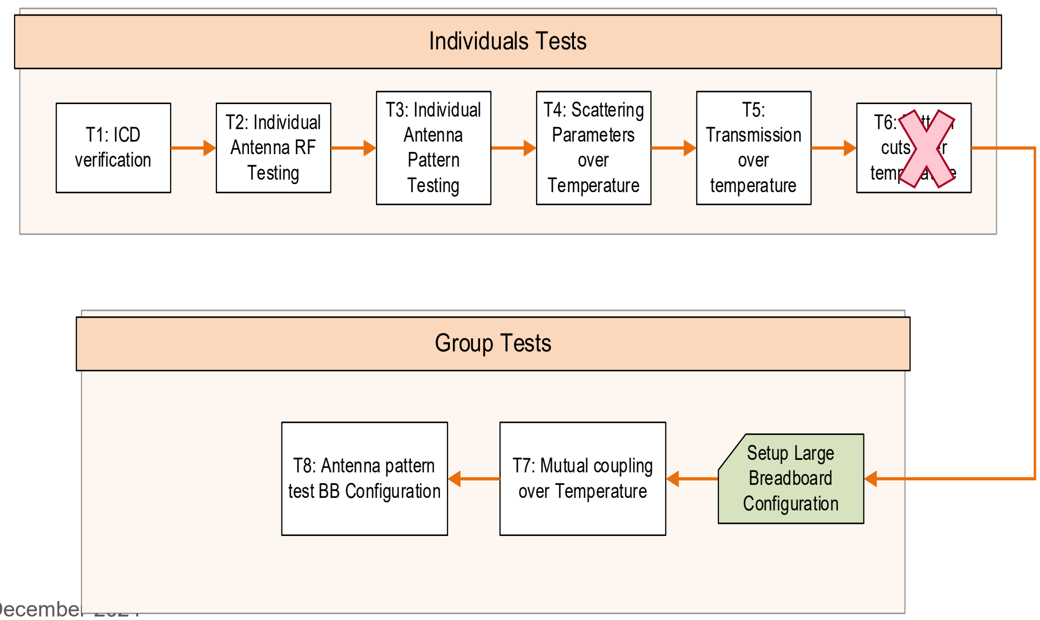
  - T3: Individual antenna pattern testing→ UPM facilities
  - T4: Individual antenna S-parameter testing over temperature
  - T5: Insertion amplitude/phase over temperature
  - T7: BB: Antenna mutual coupling over temperature

    Airbus
  - T8: BB: Antenna pattern test→ DTU facilities



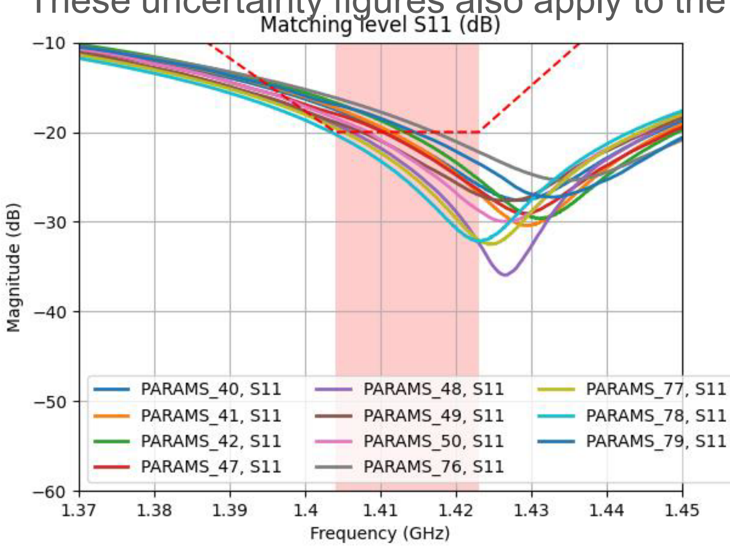
T1: Individual antenna ICD & mass verification

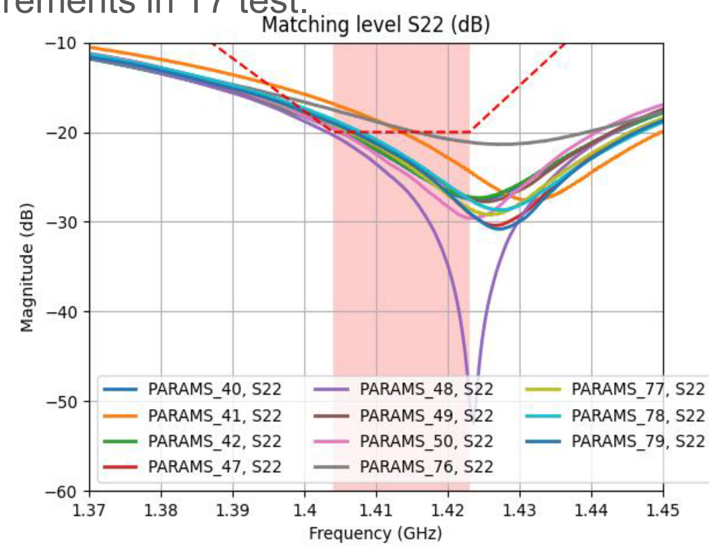
- ICD and mass verification of all antennas were performed
- Mass of elements 155,7g ± 0,58g are well in line with the expected values (154g)
- The review of the ICD opened an internal NCR related with the manufactured parts (the flatness) and the ‘generic’ tolerances required for the metallic parts. This is a lesson learnt that tight tolerances must be required for all representative elements

PN Description	Position in BB	Antena weight (g)
1404876 -SN76	1	154.95
1404877 -SN77	2	155.70
1404878 -SN78	3	154.95
1404879 -SN79	4	156.05
1404940 -SN40	5	156.50
1404941 -SN41	6	154.80
1404942 -SN42	7	155.70
1404947 -SN47	8	155.60
1404948 -SN48	9	156.10
1404949 -SN49	10	156.40
1404950 -SN50	11	155.65
Mean val		**155.67**
Standard dev		**0.58**

T2: Individual antenna S-parameter testing

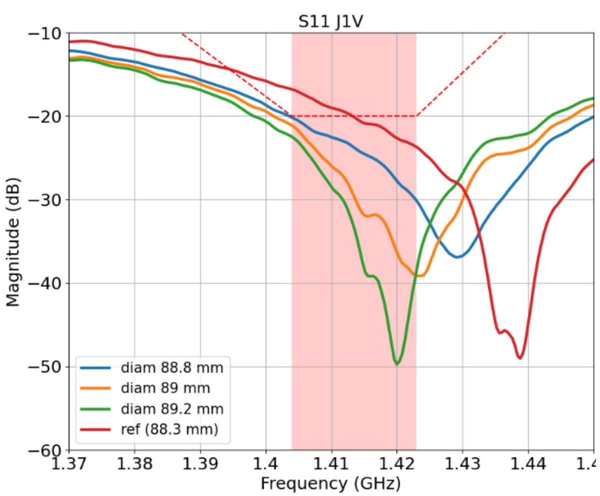
- Measured in ambient temperature
- Spread of the input match results that tend to shift to a slighter higher frequency.
- A patch antenna tolerance of +-0.3mm produces an spread of about 10MHz wrt the centre value.
- Uncertainty values:
  - For return loss: +/–0.35dB (1σ) in amplitude and +/–2º (1σ) in phase.
  - For transmission: +/-0.043dB (1σ) and +/-0.28º (1σ) for a reference S21 measurement of 0dB.
  - +/–2dB (1σ) for a reference S21 measurement of –40dB.
  - These uncertainty figures also apply to the measurements in T7 test.

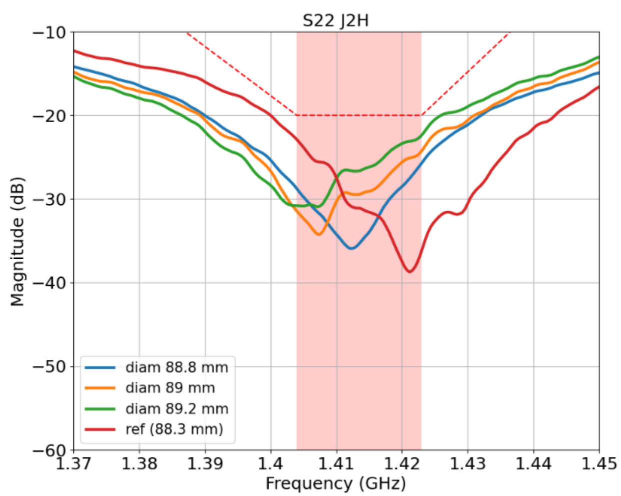


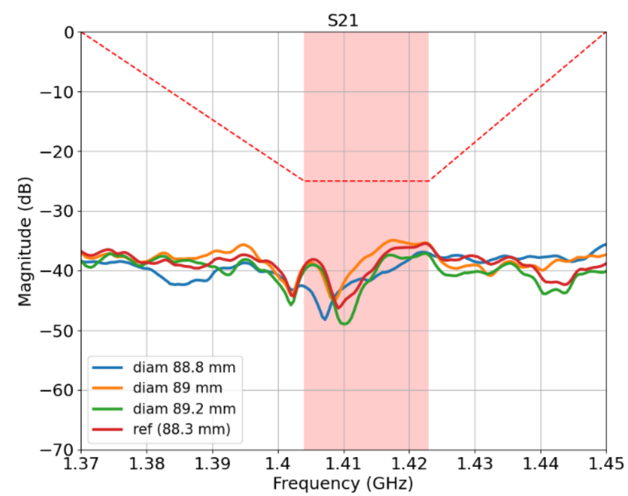


T2: Individual antenna S-parameter testing

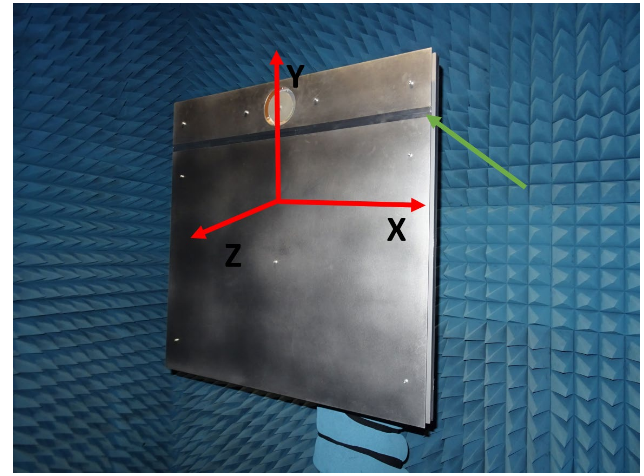
- The measurements revealed the deviation from CST simulations wrt the real results
- Study to tune/center the antenna BW.
- Manufacturing of different patch diameters.
- The reference patch is 88.3mm but a larger patch of around 89.2 mm would centre the frequency response of the return losses.







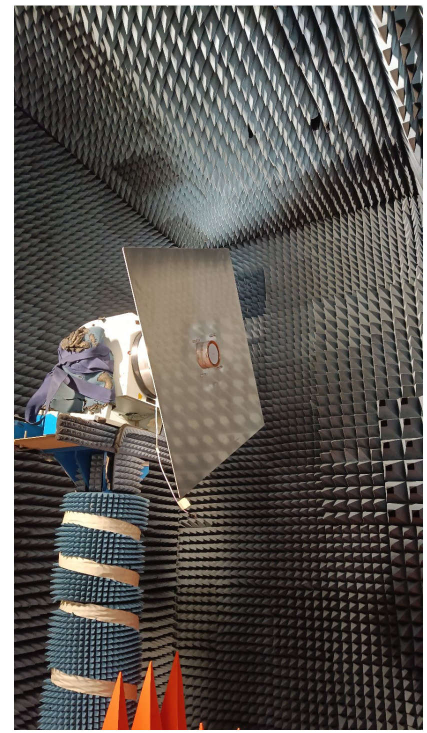
T3: Individual antenna pattern testing

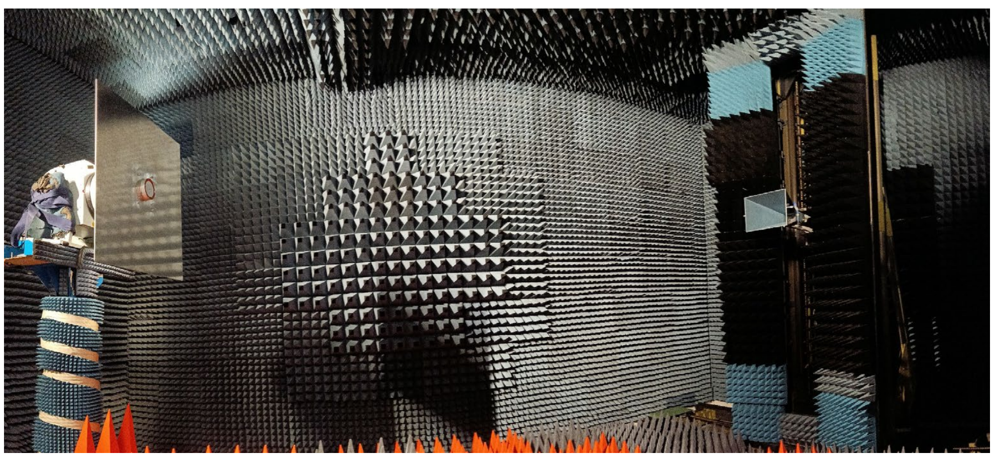


- Tested at UPM & Airbus facilities
- SNF anechoic chamber
- Deep study of losses computation when measuring an off-centred antenna pattern

- Radiation patterns measured at 1.404, 1.4135 and 1.423GHz.

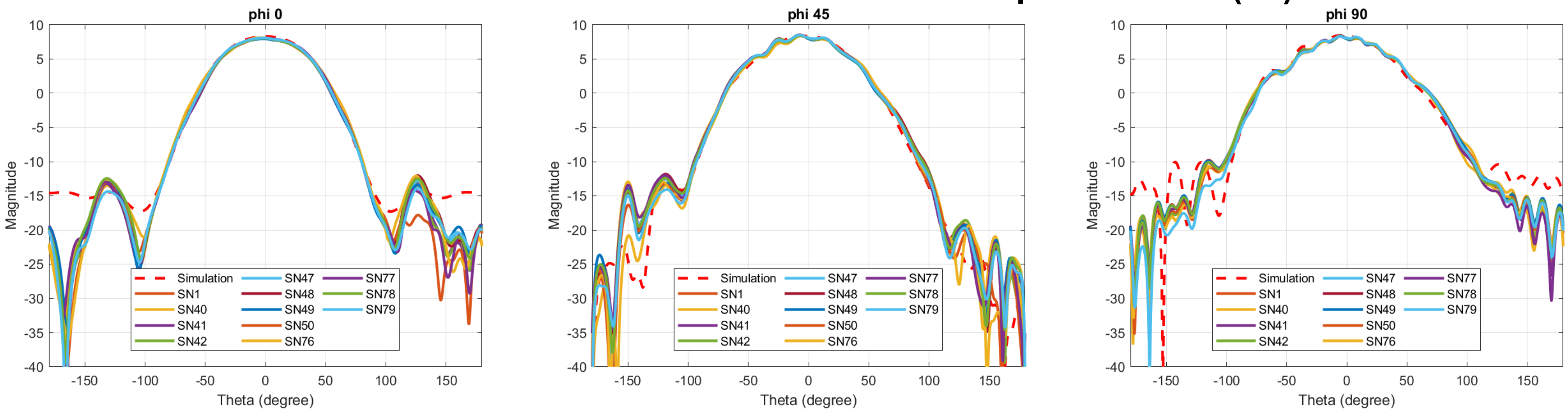
- Same coordinate axis in simulation and measurements
  - Vertical polarization along Y-axis (J1)
  - Horizontal polarization along X-axis (J2)



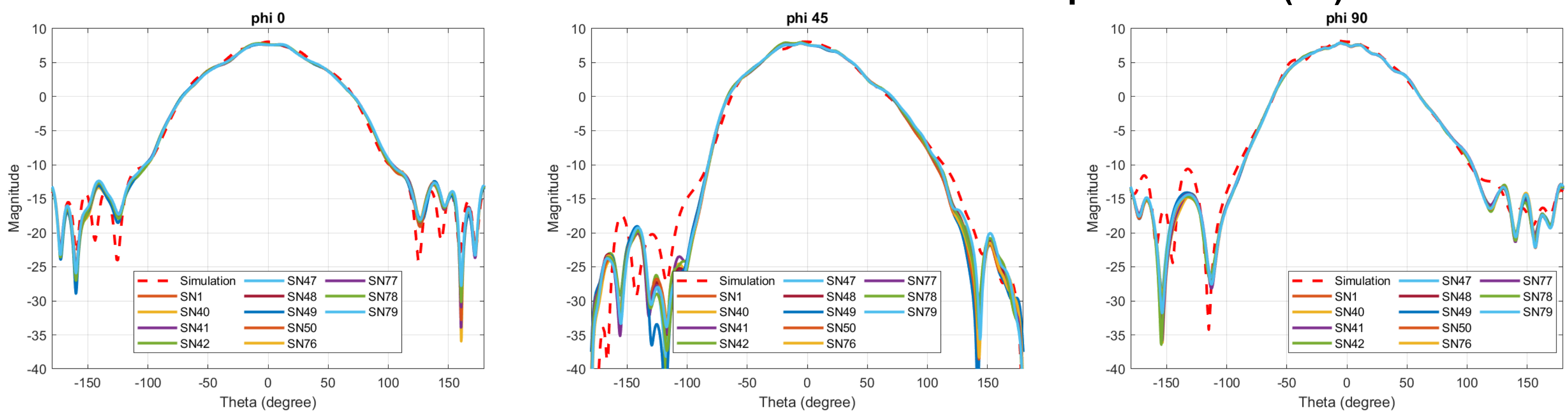


T3: Individual antenna pattern testing

Vertical polarization (J1)

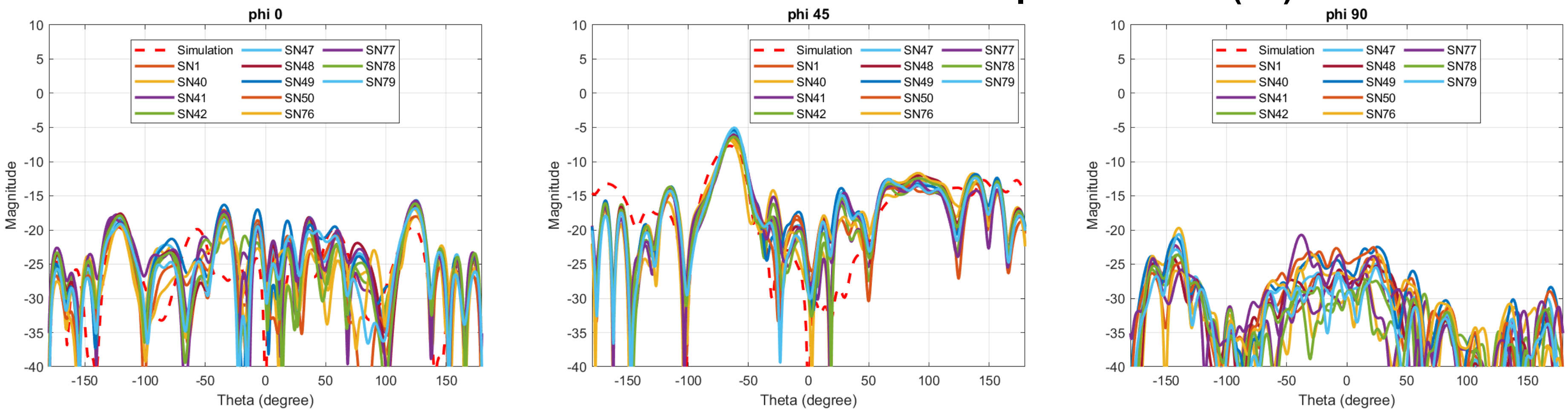


Horizontal polarization (J2)

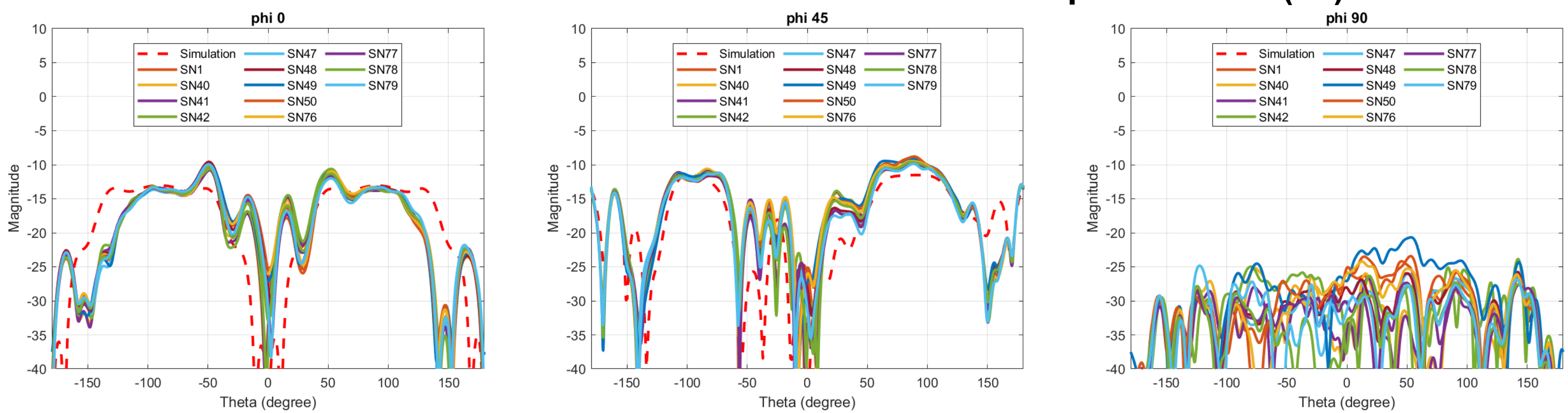


T3: Individual antenna pattern testing

Vertical polarization (J1)

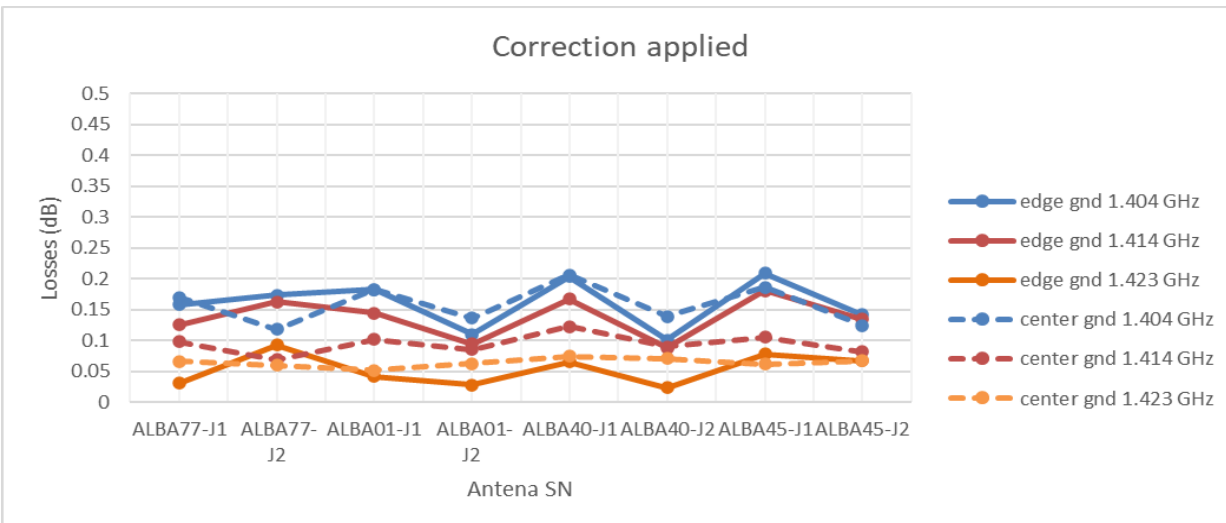


Horizontal polarization (J2)



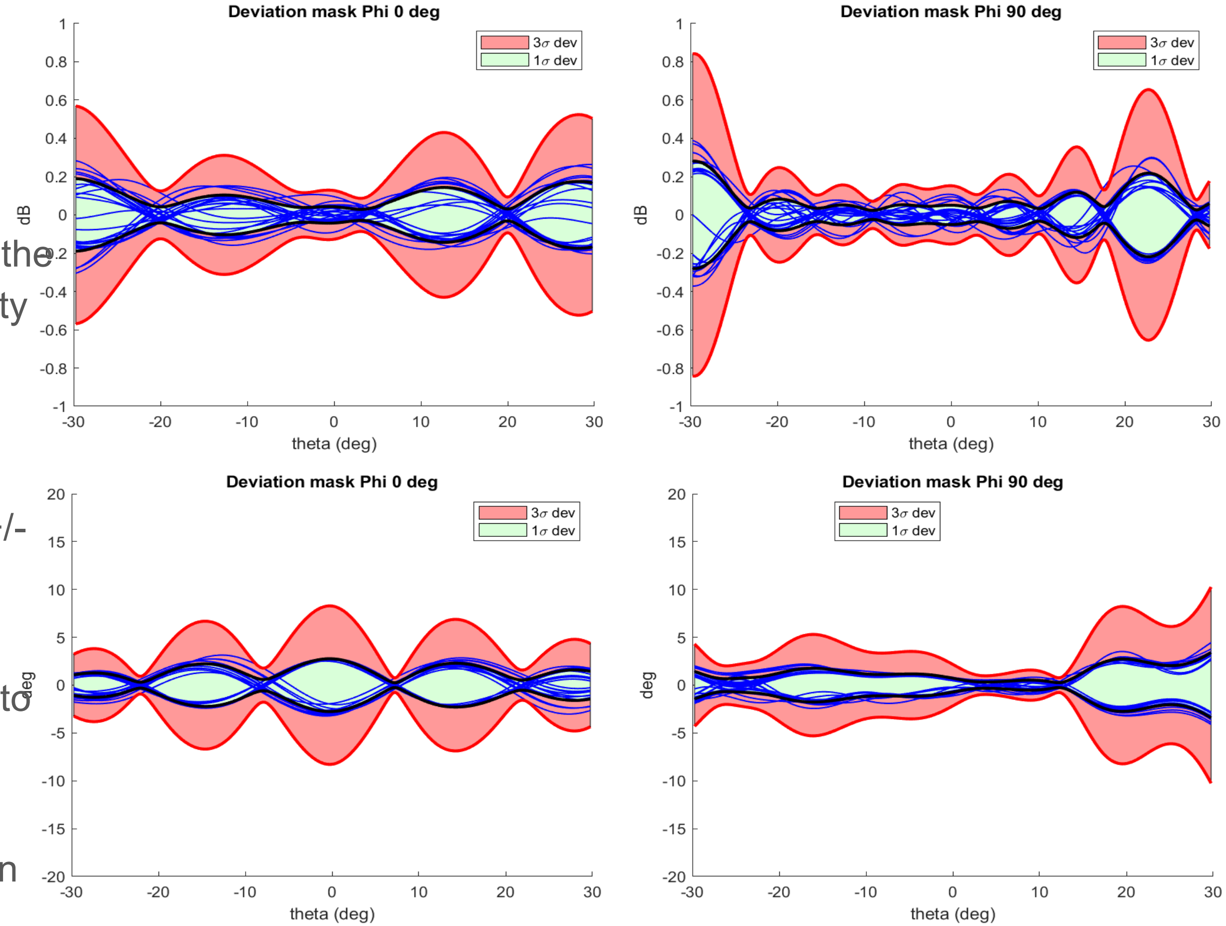
Efficiency (loss) measurements

- Issues were found when measurement of antenna losses were performed
- Gain Transfer method (Directivity-Gain) was the method used in this test
- The issue appeared due to the differences in broadside alignment between probe-AUT and probe-SGH.
- To solve the issue it was necessary to build a new ground plane mockup with antenna elements located at the centre so probe-AUT and probe-SGH had the same broadside alignment
- This confirmed the antenna loss expected from simulations (<0,25dB), inline with requirements



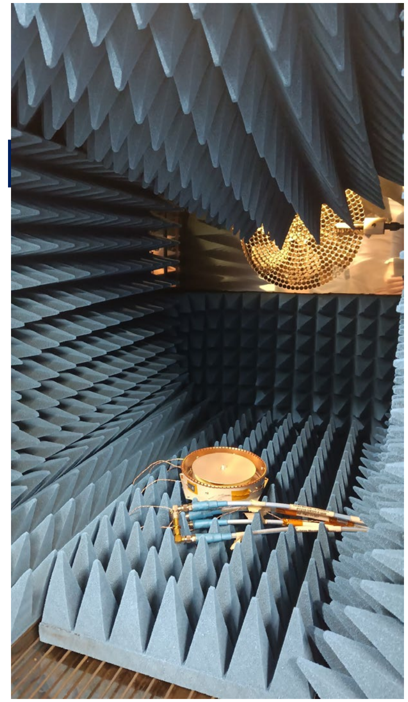
T3: Individual antenna pattern testing: deviation mask for H&V

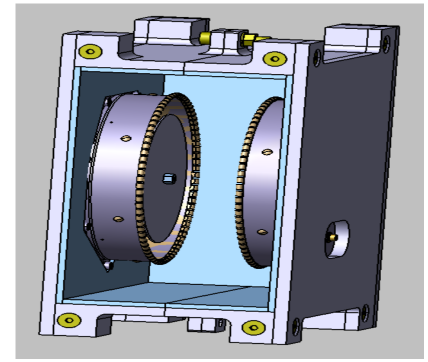
- Deviation masks were calculated for individual and arrayed elements
- The location of the antenna close to the edge GP has an effect in the similarity of elements, mainly in polarimetric (H+V) mode due to the effect of the edge
- Individual mask: +/-0.2dB (1σ) and +/-1deg (1σ) for Vpol and Hpol independently.
- Combined H&V mask: increases up to +/-0.4dB (1σ) and +/-5deg (1σ)
- The ground plane offers a different impact on each polarization→ pattern asymmetry.

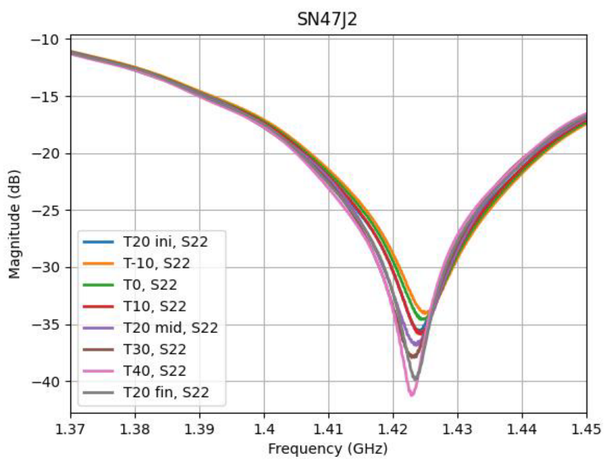


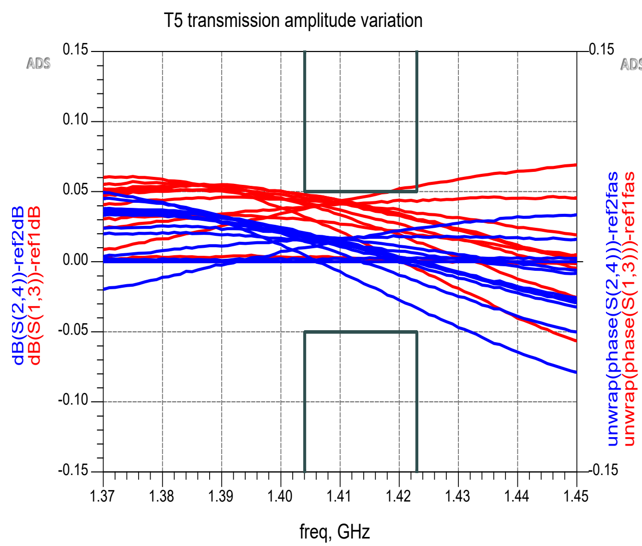
T4 & T5: S-parameter testing over tem

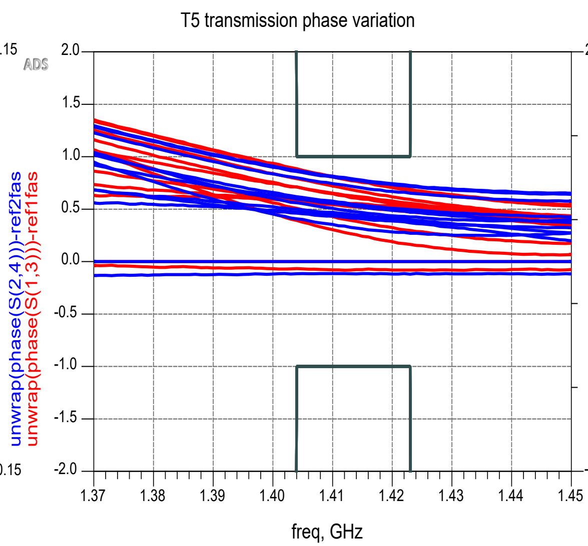
- Thermal tests were condiucted on the scattering parameters of the antennas and on a face to face test to verify the thermal stability of the design
- Thermal range was the corresponding to the SMOS antennas (–10ºC to +40ºC).
- The results confirmed the excellent thermal stability of the design





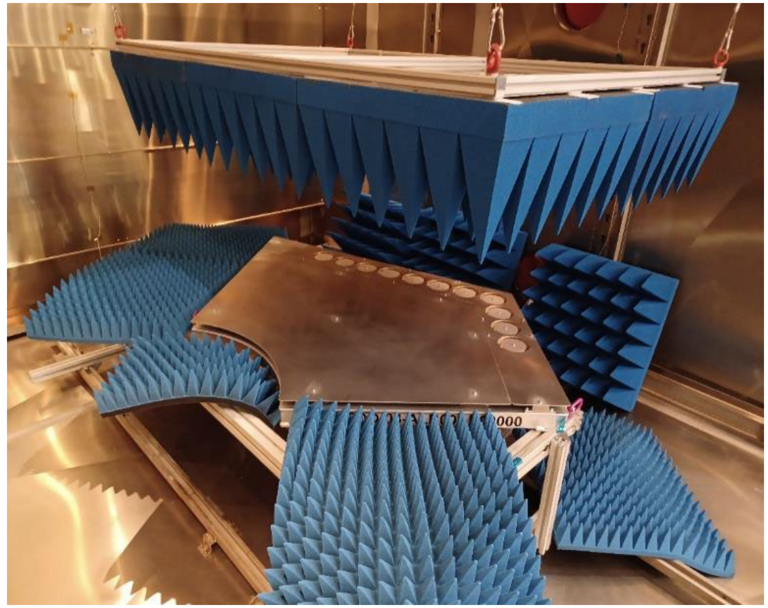


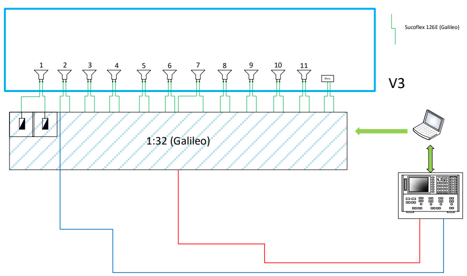


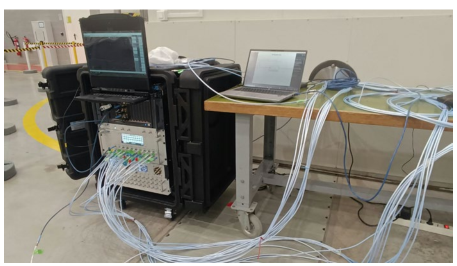


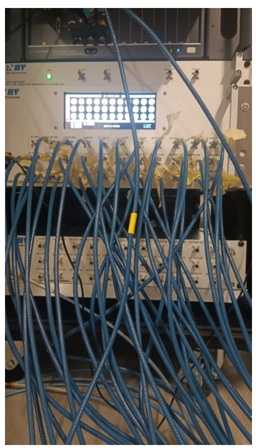
T7: Breadboard S-parameters over temperature

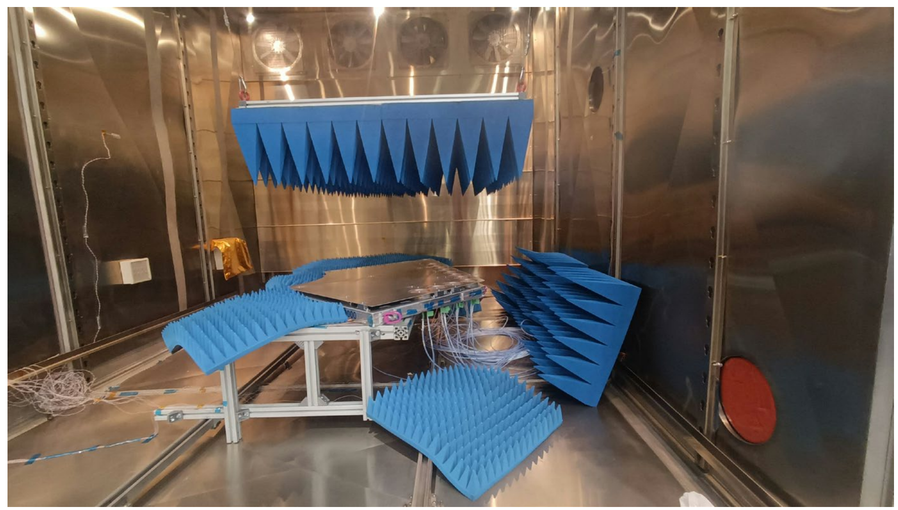
- The arrayed breadboard with 11 antennas was also submitted to the thermal scattering parameters test
- A 1:32 switch matrix was used to acquire the parameters btw all ports
- 8 thermal plateaux from –10ºC to +40ºC.



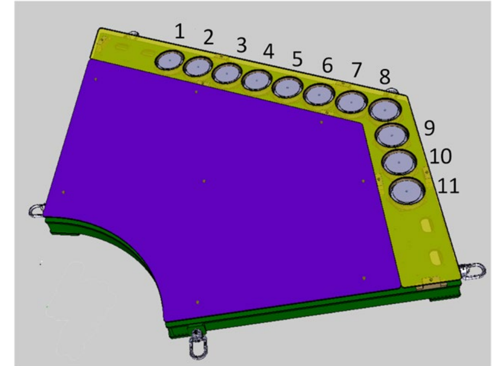


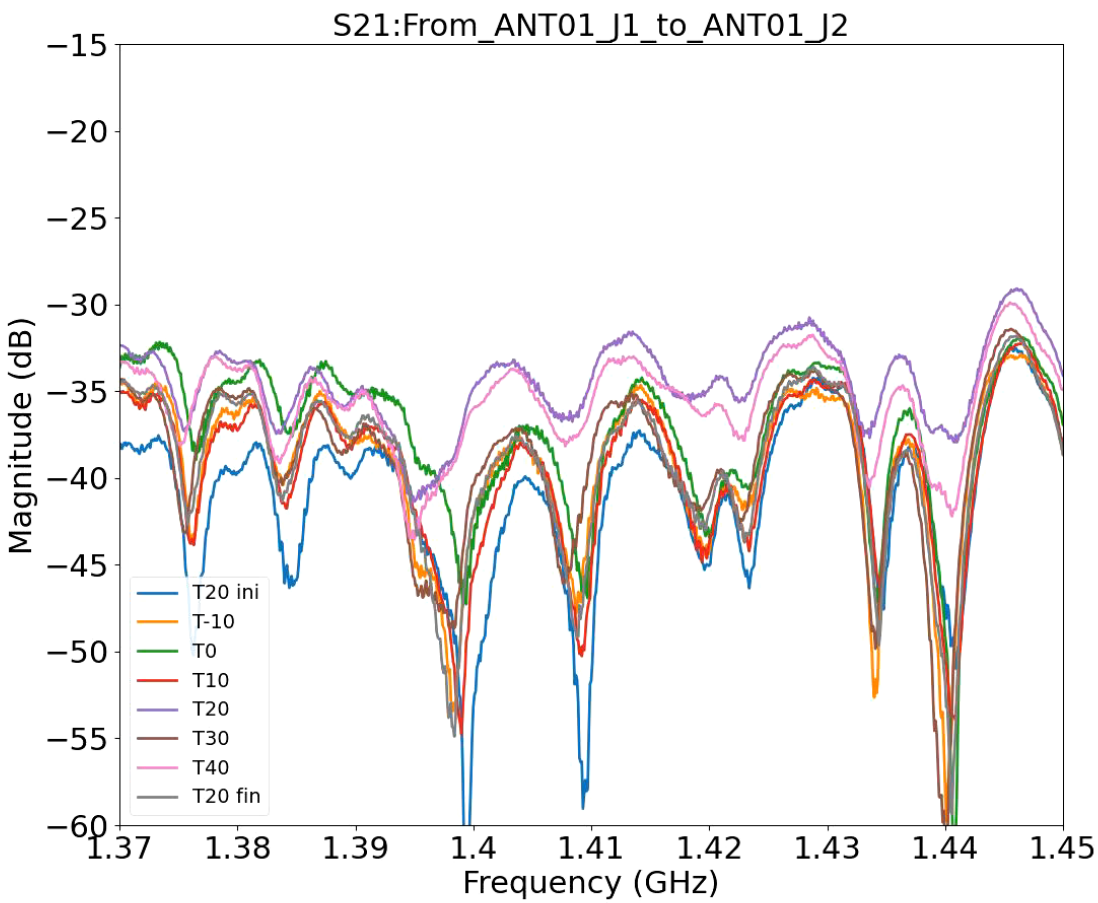






T7: Breadboard S-parameters over temperature

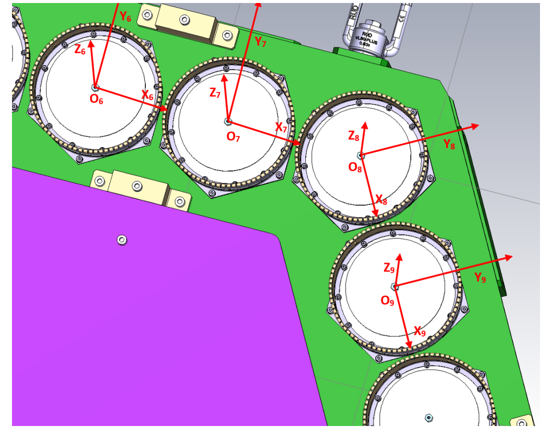


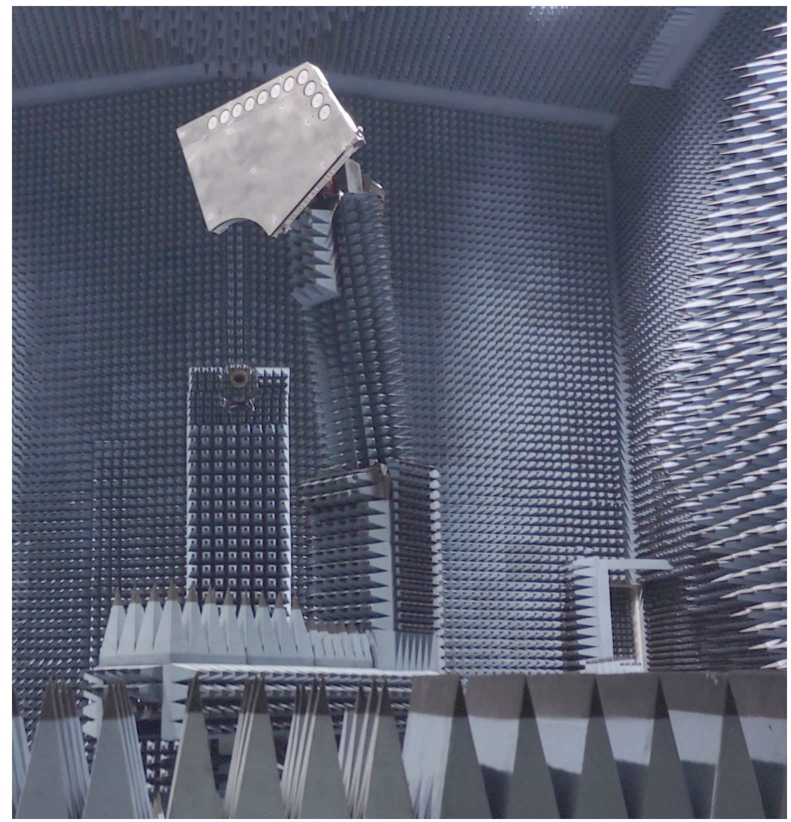


- **V-V :** 17dB coupling level between adjacent elements except at corner when two adjacent elements show different orientation (25dB).
- **V-H:** just show a lower value at the corner elements (7-8) with 17dB. Rest of elements >35dB
- **H-V:** just show a lower value at the corner elements (7-8) with 25dB . Rest of elements >30dB
- **H-H:** 25dB coupling level between adjacent elements except at corner when two adjacent elements show different orientation (30dB).
- No significant difference due to the Temperature appreciated. Good agreement with CST simulations

T8: Breadboard radiation pattern test

- Radiation patterns were conducted at DTU as per the proposal
- Spherical Ludwig-3 patterns for each of the 11 elements in both ports at 5 frequencies (Eco-Ecros)
- Positions of the elements in the structure wrt origin of coordinates was supplied by Airbus to DTU
- Patterns were transformed to the CoC of each radiating element





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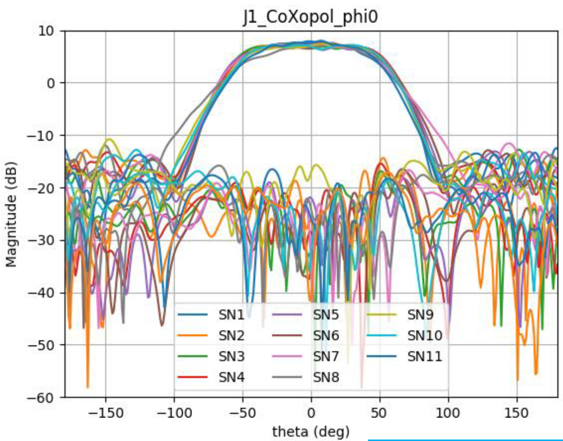
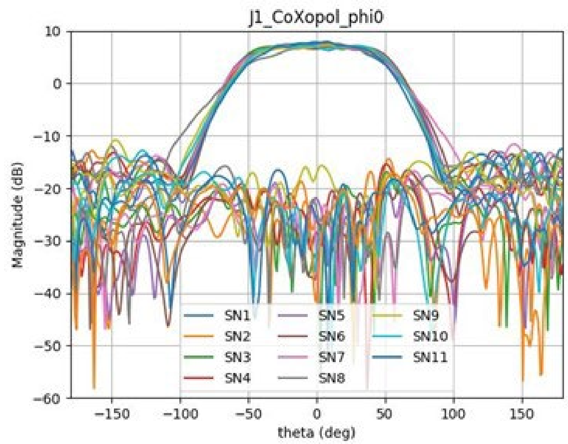
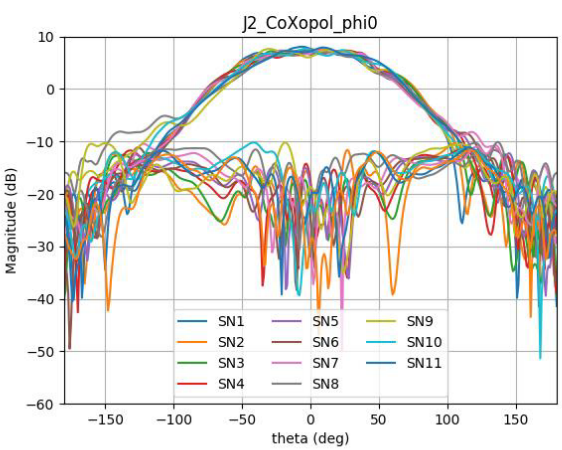
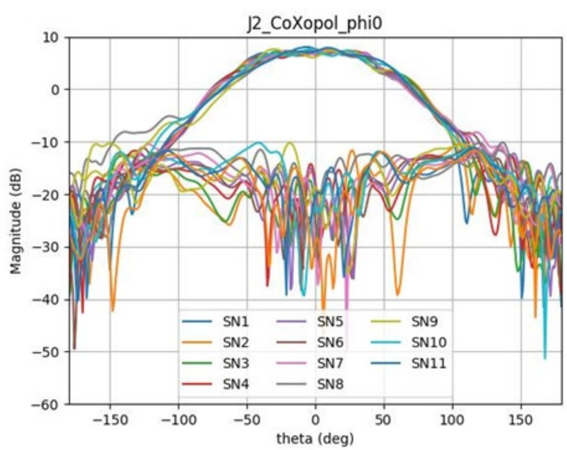
T8: Breadboard radiation pattern test





Vertical polarization





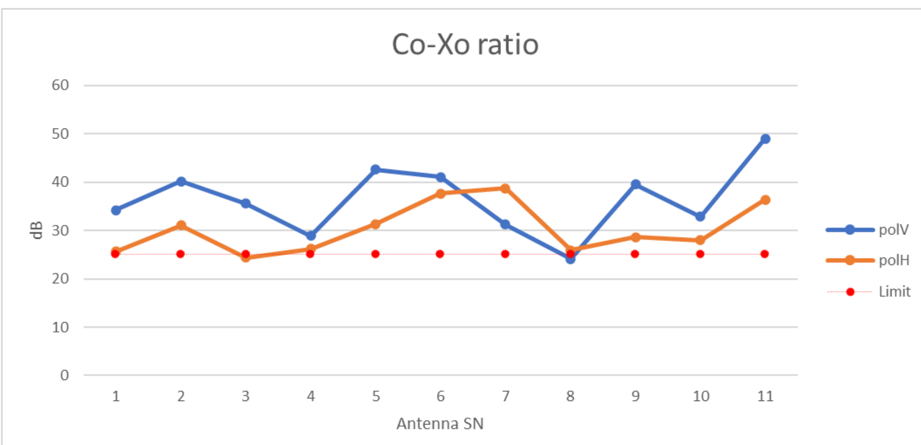
Horizontal polarization

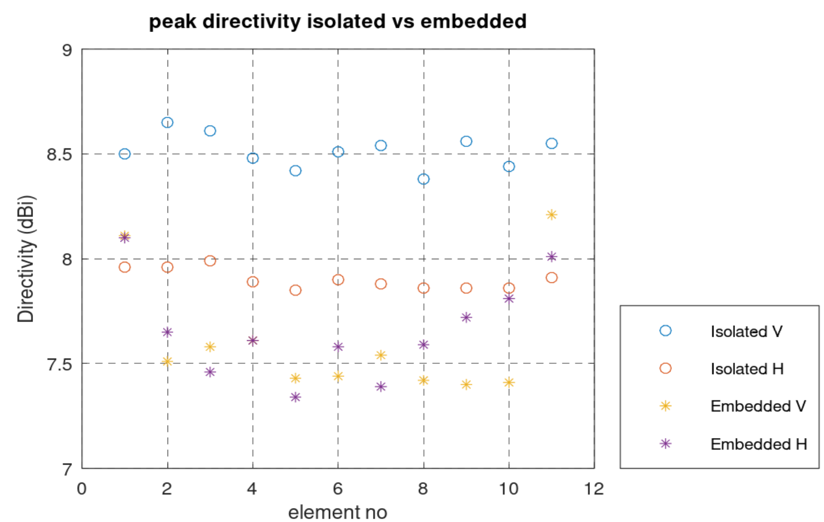
	Directivity at Boresight (dB)		Co(0,0)-Xpol (WC ±30deg) Ratio (dB)		BW3 phi=0 (deg)		BW3 phi=90 (deg)	
SN	polV	polH	polV	polH	polV	polH	polV	polH
1	7.96	7.69	24	19	89.10	88.59	67.99	74.51
2	6.80	7.19	20.7	20.9	103.86	97.73	73.50	73.86
3	7.13	6.86	21.5	19.9	104.55	94.84	67.38	75.06
4	7.02	7.58	22.3	20.1	105.97	87.93	68.58	72.02
5	7.19	6.61	24.6	20.3	107.92	93.46	69.22	74.48
6	6.63	7.37	24.4	19.2	104.80	95.44	77.62	74.44
7	7.25	6.97	23	17	102.65	95.64	65.57	73.75
8	6.89	7.24	19.1	15.4	96.08	82.00	87.23	87.12
9	7.12	6.27	25.7	16	102.09	84.95	71.44	76.40
10	6.92	7.49	23.1	19.9	101.65	91.28	72.53	69.19
11	7.62	7.32	24.1	19.7	89.34	88.43	71.00	77.61

Embedded patterns include the effect of mutual coupling

T8: Breadboard radiation pattern test

- Good agreement between simulation and measurements (copolar and crosspolar component).
- Isolated element exhibits different directivity in H and V polarization (due to GP edge effect in the current distributions).
- In the array, the coupling between elements mitigate this effect in the array configuration, as both H and V pol exhibit similar values.
  - ➢ V-pol coupling is high and this gives place to a reduction of the peak directivity

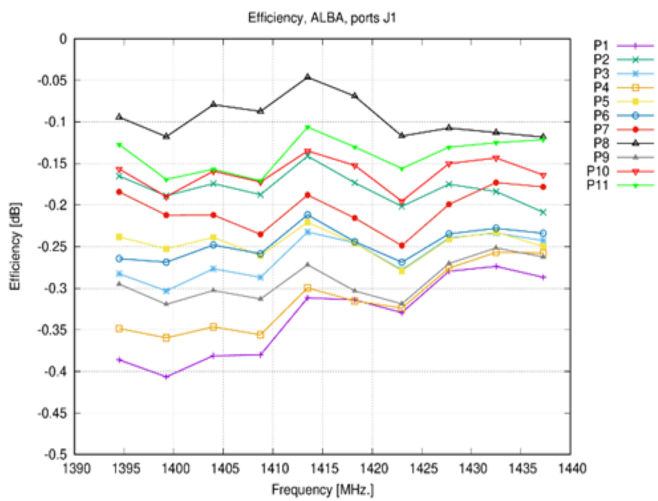


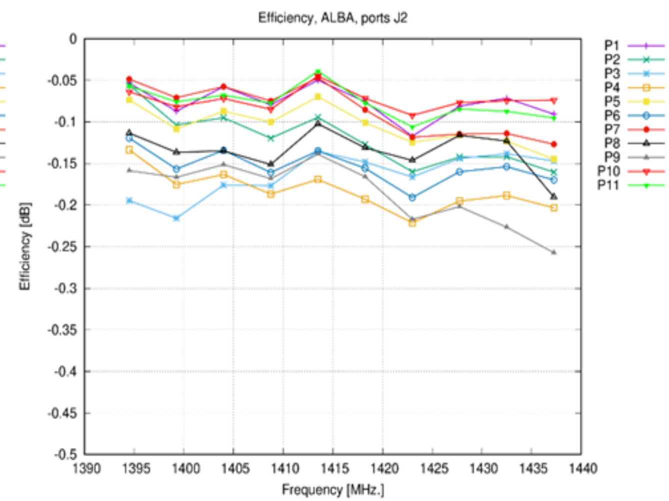


T8: Breadboard radiation pattern test: antenna efficiency

- The embedded conditions affect both the peak directivity as well as the efficiency with respect the isolated condition measurements.

- Efficiency values measured at DTU confirmed the results obtained at Airbus and also the simulated effect of coupling between elements:
  - ➢ This is related to the higher coupling terms for Vpol than in Hpol
    - –18 dB for Vpol between close terms→ $dB(\sqrt{1-2\times(10^{-18/20})^2}) = -0.14dB$
    - –25 dB for Hpol→ -0.028dB
    - *(assuming only the two neighbours)*





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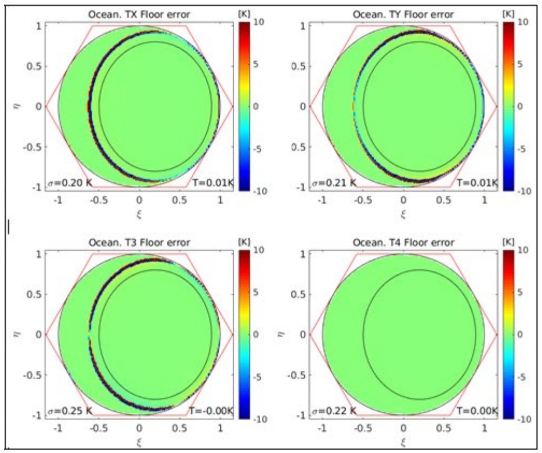
Results

- Test Results have been discussed in several meetings (TRB1 & TRB2).
- Pattern results have been provided to UPC for Instrument model imaging calculations
- The results have been collected in the corresponding test reports

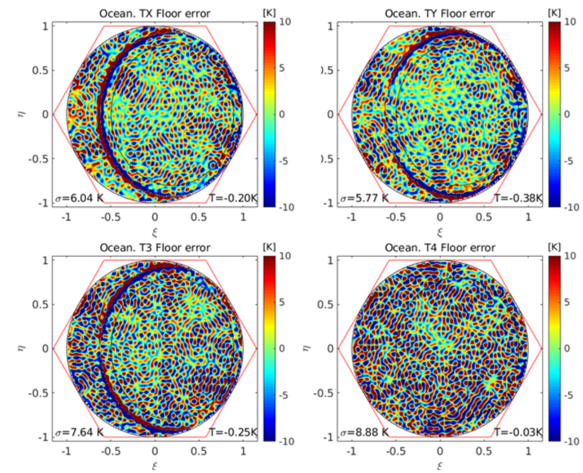
Doc ref	iss	Doc name	Review
ALBA-ADSM-TR-1001983557	1.0	TN6: Antenna Test Report	FR
ALBA-ADSM-TR-1002011047	1.0	TN6 Annex 1: Phase Centre Calculations	FR

Image reconstruction analysis (UPC)

- Radiometric performances at image reconstruction level (homogeneous, mixed and point source scenes) were derived by UPC considering TriHex and single hexagon topology
- Very small floor error regardless of the patterns set. Transition errors depend on spatial resolution



Configuration	T_x	T_y	T_3	T_4
Simulated antennas. Single Hex	0.53	0.47	0.62	0.48
Simulated antennas. TriHex	0.19	0.21	0.24	0.22
Measured antennas. Single Hex	0.49	0.47	0.55	0.39
Measured antennas. TriHex	0.20	0.21	0.25	0.22



- Point source and coastal transitions as expected resulting from side-lobes and spatial resolution
- Error-free forward-backward simulation in alias-free condition and polarization rotation of individual antennas in different arms has been successfully demonstrated
- Large condition number of G-matrix leads to high sensitivity to errors and large resulting radiometric errors. The effect is probably due to the singularities at the unit circle edge
- This effect of alias-free reconstruction has been identified as a follow-on research activity

Achieved results

REQ-RE	Parameter	Unit	Requirement	SoC	Comments
10	Bandwidth	MHz	1404 MHz – 1423 MHz	C	section 5.2 in RD5
20	Polarization		Simultaneous Linear H-V	C	section 4.1 in RD5
30	Cross-polarization discrimination	deg	–25 dB (within the HPBW)	NC	For the individual antennas shown in section 5.3 (RD5), the on-axis XPD is always in the range from –30dB to –40dB, and the XPD at EOC is in the range of –20dB to –25dB. This is associated to the edged GP test setup. This also occurs in the embedded arrayed pattern, where Xpol to be affected as shown in Section 0 (RD5). XPD values in the range of –20dB have been measured at EOC. At boresight XPD is always better than –25dB and use to be in the –30 to –40dB range
40	Directivity	Deg	>9 dBi	NC	This topic has been subject of several discussions from the beginning of the project and the measurement results confirm the analyses. In section 5.3 (RD5) are shown the directivities of the isolated antennas that are in the range between 7.6-8.2dBi (boresight), and the arrayed results shown in Section 0 (RD5) indicate arrayed directivity vales in the range of 7.3dBi as expected from the project start.
50	Efficiency	% dB	> 93.5 0.3 dB gain loss	C	Measurements included in section 5.3.5 and 5.7.7 in RD5. Gain/Directivity method has been used.
60	HPBW (Θ3dB)	deg	>65	C	Section 5.3 (individuals) in RD5 Section 0 (arrayed) in RD5
70	Input impedance	Ohm	50	C	
80	Return loss	dB	<–20 Target: –25	C	Section 5.2 in RD5

[RD05]	ALBA-ADSM-TR-1001983557	02	TN6: Antenna Test Report.

Achieved results

REQ-RE	Parameter	Unit	Requirement	SoC	Comments
90	Coupling between H-V ports	dB	<–25	C	Section 5.2 in RD5 Section 5.4 in RD5 Section 5.6 in RD5 In all cases requirement refers to the internal H-V coupling between antenna ports, that has been shown to be in the range of –35 to –40dB. Coupling between different elements is associated to spacing that has been updated to 0.577λ and coupling terms have been simulated and measured to be –18dB (V-V) and –25dB (H-H).
100	Phase centre accuracy	deg	0.0037 λ (x-y) 0.015 λ in z axis	C	Word 'accuracy' in this requirement is slightly misleading since it seems to refer more to the method of calculation than to the value itself. In any case the position in local X-Y antenna coordinates is strongly affected by the position of the antenna close to the edge of the structure, and the coupling between elements. Section 5.7.2 in RD5
110	Envelope	mm	0.577λ	C	By design section 5.1 in RD5
120	Mass	g	< 150 Target: 100	NC	NC by 5.7g (excluding attachment screws). Section 5.1 in RD5
130	Ground plane size (standalone)	cm	90 x 90	C	For individual testing purposes.
140	Ground plane embedded	cm	90	C	
150	Any electrical gap		Closed between the radiating element and ground plane	C	Section 4.1 in RD5 (by design)
160	Temperature range	deg	[–10,+40]	C	Section 5.4 in RD5 Section 5.5 in RD5 Section 5.6 in RD5

[RD05]	ALBA-ADSM-TR-1001983557	02	TN6: Antenna Test Report.

Achieved results

REQ-RE	Parameter	Unit	Requirement	SoC	Comments
170	Temperature stability of insertion phase		Amplitude: 0.05 dB stability variation Phase:1 deg stability variation	C	The measurement of stability included in section 5.5 in RD5 indicate amplitude and phase stability in the thermal range of +/-0.025dB and +/-0.5°, compliant to the specification
180	Pattern deviation (TBC)	dB deg	**Amplitude** < 0.25 dB for $0^\circ < \theta < 35^\circ$ < 0.3 dB for $35^\circ < \theta < 50^\circ$ < 0.5 dB for $50^\circ < \theta < 90^\circ$ **Phase** $< 0.5^\circ$ for $0^\circ < \theta < 35^\circ$ $< 1^\circ$ for $35^\circ < \theta < 50^\circ$ $< 2.5^\circ$ for $50^\circ < \theta < 90^\circ$	C	Section 5.3.3 in RD5 shows the individual patterns measured at the edge GP. The 1σ deviation is within requirements for H and V but combined H&V is not, due to different effect of diffraction. Compliance is stated as a guide of the similarity between the different manufactured elements. Section 0 in RD5 shows the arrayed deviation masks for H, V and H&V. It has been remarked that H&V is not similar to H and V alone, but the results are larger than the requirement as result of the combined effect of coupling and diffraction (0.5dB(1σ) in amplitude and 3°(1σ) in phase).
190	H-V pattern similarity (TBC)	dB deg	**Amplitude** < 0.25 dB for $0^\circ < \theta < 35^\circ$ < 0.3 dB for $35^\circ < \theta < 50^\circ$ < 0.5 dB for $50^\circ < \theta < 90^\circ$ **Phase** $< 0.5^\circ$ for $0^\circ < \theta < 35^\circ$ $< 1^\circ$ for $35^\circ < \theta < 50^\circ$ $< 2.5^\circ$ for $50^\circ < \theta < 90^\circ$	NC	Section 5.3.3 in RD5 shows the individual patterns measured at the edge GP. The 1σ deviation for H&V is not compliant due to different effect of diffraction Section 0 in RD5 shows the arrayed deviation masks for H&V. Results are not compliant as explained in previous requirement.
200	Orientation marking		Required to define polarization axis	C	Mechanical design in Section 4.1 in RD5 shows a corner hole that is used to perform polarization alignment in the integration process

[RD05]	**ALBA-ADSM-TR-1001983557**	**02**	**TN6: Antenna Test Report.**

Lesson learnt and Recommendation for further work.

Lesson learnt and Recommendation for further work.

- The metallic technology for the development of an L-band antenna for TriHex mission has been developed based on the lessons learnt from the SMOS-MIRAS project and also with the knowledge gained in other recent projects in this frequency band as Galileo and SMOS-IRMI
- The selection of the PCB laminate for the circuit has been based on a thermally stable material as Duroid6002 that was also a lesson learnt from SMOS. RC will improve losses even better
- Metallic pieces/parts of the design they have been assumed general tolerances, which has lead to some integration issues (mainly in the flatness requirement of the ground plane part). This gave place to an internal NCR and will be controlled to the required value for future developments
- The antenna has not a critical technology aspect as it is based on metal milling and PCB manufacturing
- Investigate a method of low loss antenna measurement (…based on radiometer methods?)
- In the image processing side done by UPC it has been identified the fact that the matrices involved in the alias-free reconstruction lead to a large condition number that generate large error. This has been identified as an interesting topic for follow-on image reconstruction research.

Conclusions.

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Conclusions

- The design of the ALBA antenna for a future SMOS follow-on has been performed
- The antenna design has been aimed to make a space-flight oriented design, and has been submitted to an extensive functional test campaign in the thermal range with excellent results.
- The thermal sensitivity & stability of the antennas has been addressed and fulfils the requirements
- A test campaign at element level and at array level has been performed with results aligned with the expected performances
- The effect of the close spacing (0,577λ) between elements has been shown, both in simulation and in measurement results
- The development of the antenna element has achieved TRL5 according ISO 1620
- Simulations of the Instrument performances and image reconstruction have been done showing the benefits of the TriHex configuration.
- Both image reconstruction in alias-free condition and polarization rotation of individual antennas in different arms have been demonstrated

AIs closure

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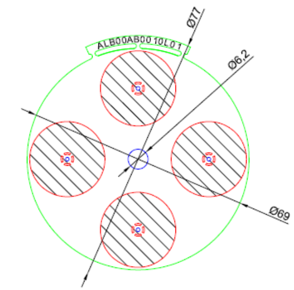
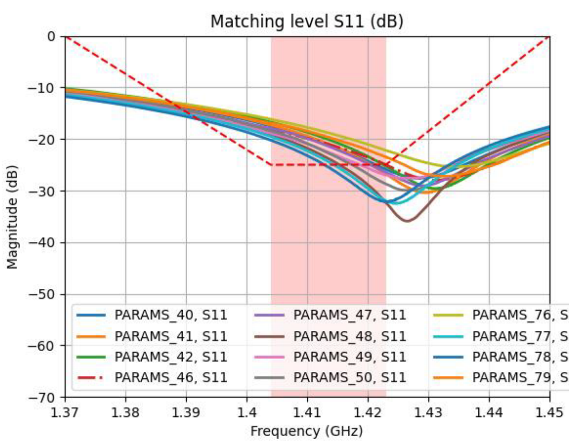
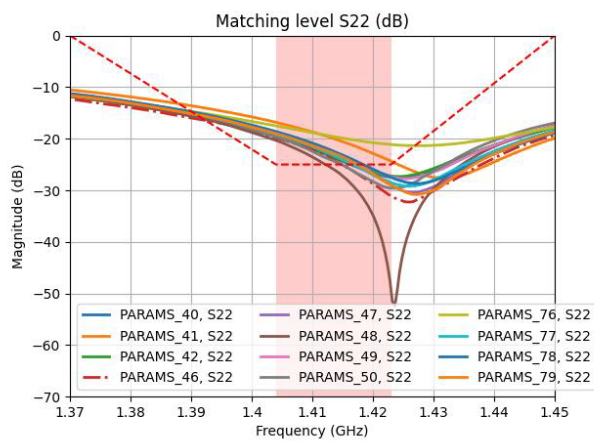
AIs closure.

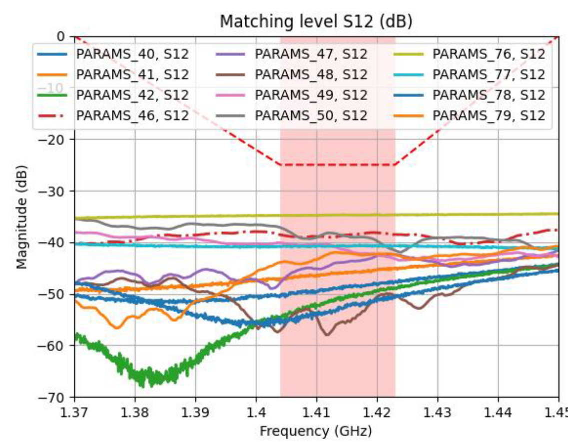


- All Ais are closed. Only TRB AI-4 are proposed for formally closure

AI-4	AIRBUS to ask for additional capacitive feed circuits correcting the diameter and to assemble and measure one ALBA antenna with this updated circuit.	TRB (Ap-2024)	*Proposed for closure*	*SN 46 has been manufactured with the new capacitive feed circuits.*







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Thanks!