

# HARMONY SAR INSTRUMENT ARCHITECTURE AND PERFORMANCE AT THE END OF PHASE B2

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# SUMMARY

/// Introduction to SAR Instrument for Harmony mission

/// Overview of the Instrument architecture – functional and physical architecture

/// Summary of SAR Instrument Performance

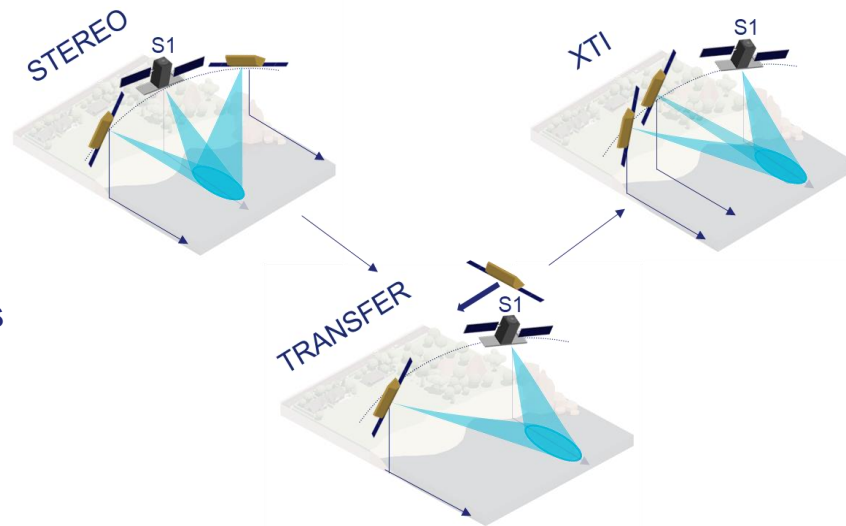
/// Current Development Status and TRL6 achievements

/// Conclusions

*This presentation has been prepared under a programme of and funded by the European Space Agency  
The view expressed herein can in no way be taken to reflect the official opinion of the European Space Agency.*

# INTRODUCTION TO SAR INSTRUMENT FOR HARMONY MISSION

- /// Harmony is a unique mission concept, introduced by the European Space Agency (ESA) in the frame of the Earth Explorer 10 missions in order to expand the Sentinel-1 applications.
- /// The Harmony system employs a **C-band passive SAR Instrument** working in **bi-static** configuration with Sentinel-1 and an Optical payload allowing to obtain enhanced products for the observation of oceans, cryosphere and solid Earth.



## Harmony satellites concept of operations

# INTRODUCTION TO SAR INSTRUMENT FOR HARMONY MISSION

/// In this framework, Thales Alenia Space Italia is the SAR Instrument Design Authority having in charge the design, development and verification of two SAR payloads, operating as the main subContractor of OHB as Harmony Satellite System Prime.

## /// The Harmony SAR Instrument shall guarantee:

### / **Compatibility with Sentinel-1** in terms of:

- Center frequency of 5.405GHz, C-band, with a maximum RF bandwidth about 100 MHz
- Acquisition modes: Stripmap Modes, Wave Modes (WM), TOPSAR Modes (Burst Modes with azimuth scanning) as Interferometric Wide Swath Modes (IW) and Extra-Wide Swaths Modes (EW)
- Radar nominal parameters as PRF, duty cycle, etc.

### / Enabling of multiple techniques from interferometric measurements, i.e. **Doppler Centroid Anomaly (DCA), Along-Track Interferometry (ATI) and Cross-Track Interferometry (XTI)**.

### / Enabling of **phase/frequency and coarse time synchronisation techniques** and implementation of **fine time technique** for synchronisation in order to solve issue intrinsically related to the bistatic nature of the mission exploiting on-board and on-ground processing techniques

- Dedicated presentations during this Workshop from TASI (E.Strazzer) and Aresys (D.Mapelli)

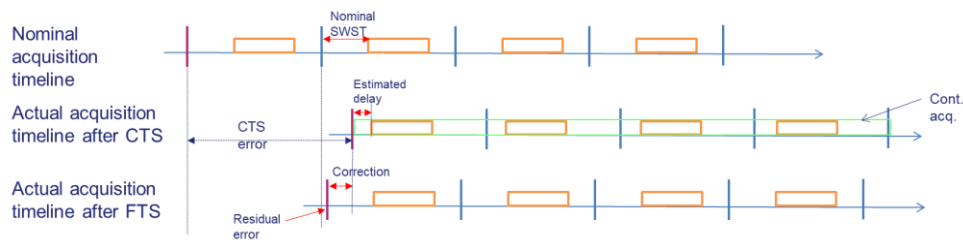
### / Enabling of the dual launch on VEGA C launcher



/// Fine Time Synchronization (FTS), i.e.: the alignment, to be maintained also during the datatake, of the Tx and Rx sampling windows. For Harmony mission, an accuracy of 50us is considered as driver.

- GNSS Common Clock (GNSS-CC) phase synchronization
- Data – driven refinement.

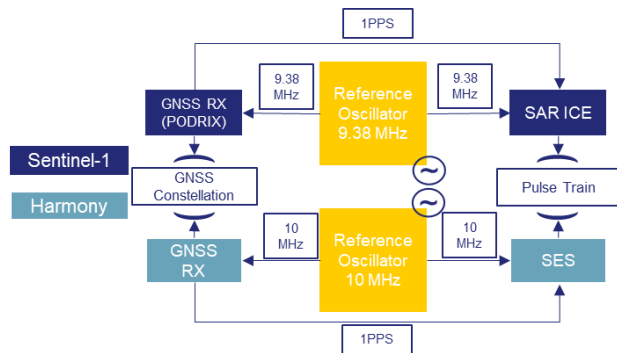
/// This technique exploits the GNSS receiver products (e.g. GNSS raw data) in order to estimate the frequency/phase mismatch between the two separated oscillators.



## Principles of Fine Time Synchronization Algorithm\*.

\*D.Mapelli et al., **Fine Time Synchronization for Bistatic and Multistatic Missions: the Harmony case, EUSAR 2024**

***Dedicated presentation for the latest results***

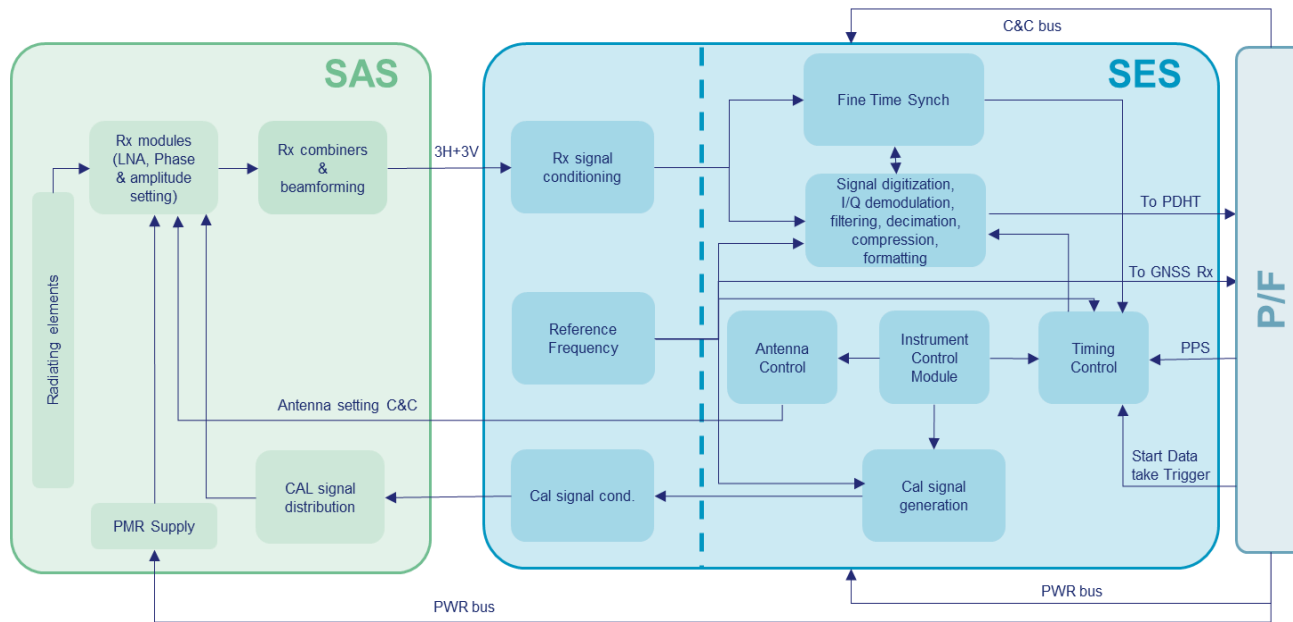


***Dedicated presentation for the latest results***

# SAR INSTRUMENT – FUNCTIONAL ARCHITECTURE

/// The architecture of the payload is broken down into two main sub-systems implementing:

- /// SAR Antenna Subsystem (SAS)
- /// SAR Electronics Subsystem (SES)



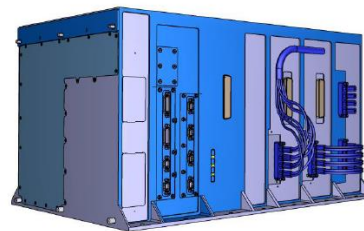
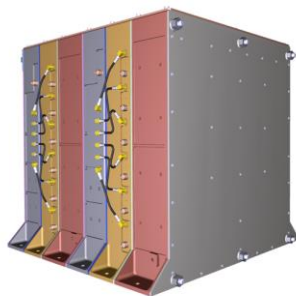
# SAR INSTRUMENT – PHYSICAL ARCHITECTURE – SES

/// The **SES** is able to manage 6 different RX channels (3 per polarisation) to be downlinked separately on ground enabling on-ground Digital Beam-Forming (DBF) and one for internal calibration purposes and is composed by:

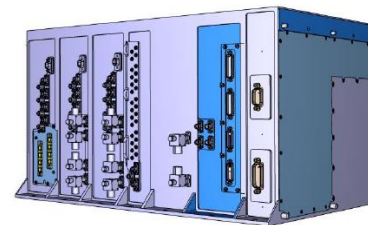
- 2 DiGital Units (DGUs, main and redundant) for digital functions
- 1 Radio Frequency Unit (RFU) internally redundant for RF functions
- Miscellanea and Harness that realizes the redundancy scheme between SES and SAS



RFU



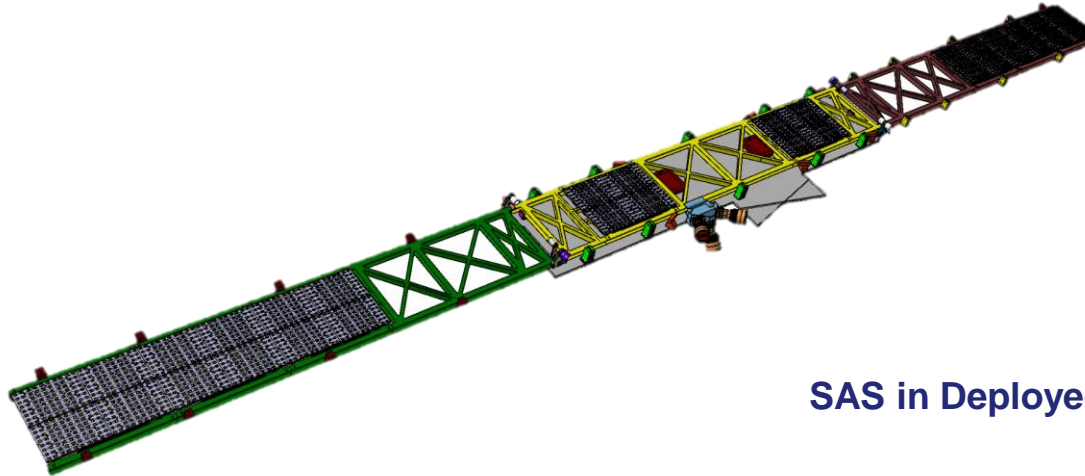
DGU





# SAR INSTRUMENT – PHYSICAL ARCHITECTURE – SAS

- /// **The SAS** is composed by three Antenna Assemblies, for a total antenna dimensions of about 13 m x 0.65 m (length x height), composed by 8 tiles with dimension of 0.88 m x 0.65 m, equipped with 64 Antenna Receiving module per polarisation.
- /// This modular architecture together with a distance between the Lateral Antenna assemblies about 10.5 m allows to exploit ATI from a single platform and DCA technique for the interested products, while the Central Antenna Assembly helps in order to reduce the ambiguities.



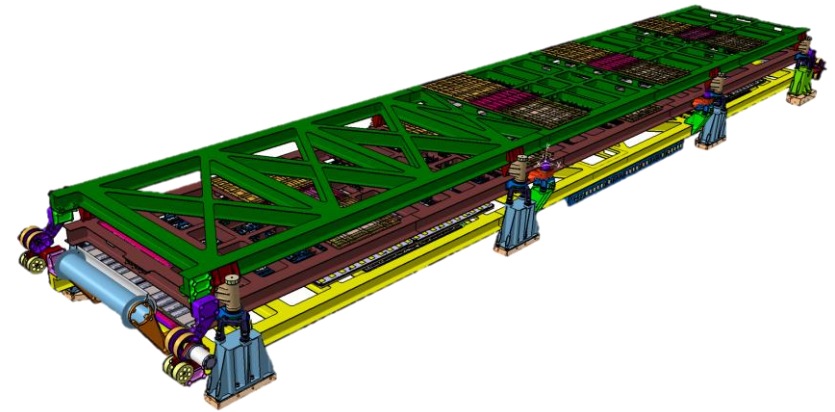
**SAS in Deployed Configuration**



# SAR INSTRUMENT – PHYSICAL ARCHITECTURE – SAS

## /// SAS Design configuration at the end of the Phase B2:

- / 1 fixed central frame
- / 2 deployable lateral wings
- / 1 Central Antenna Assembly composed by 2 Tiles (mounted on fixed frame)
- / 2 Lateral Antenna Assemblies composed by 3 Tiles (mounted on lateral wings)
- / Radiating Front End
- / SAS Electronic units as RMU, PSU, DCU
- / 2 couples of 180° hinges (allowing lateral wings deployment)
- / Double stage HDRMs
- / Single stage HDRMs
- / Mechanical Interfaces with Platform
- / SAS Harness



**SAS in Stowed Configuration**

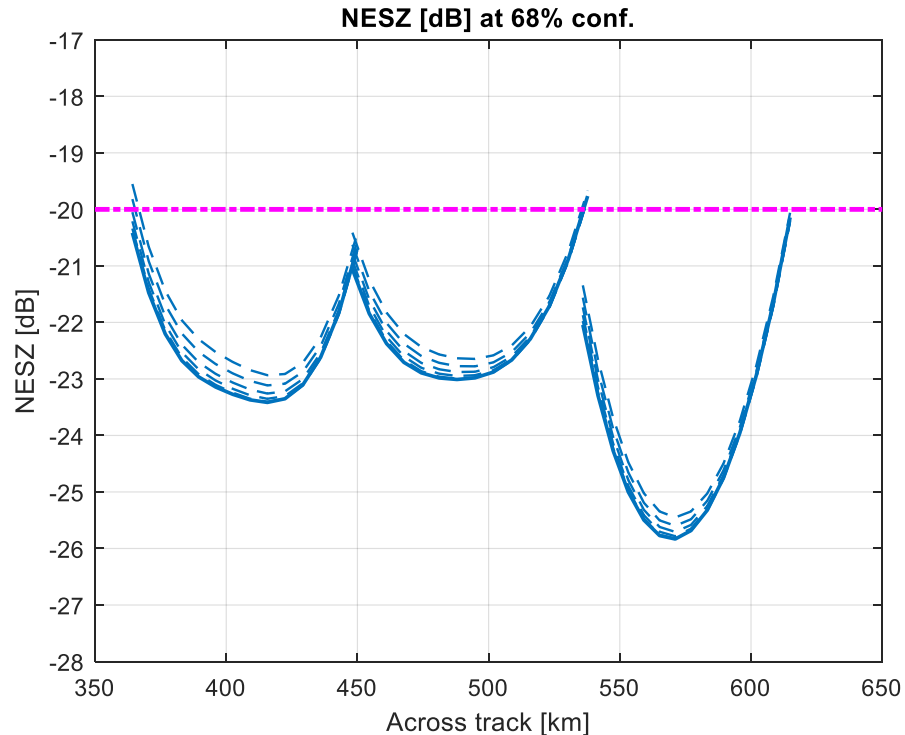
# L1A SLC-CPC NESZ – IW MODE

/// NESZ (OB-392: -20dB) TASR  
(OB-393: -17dB) are reported  
for SLC-CPC data

/// Compliance is fulfilled for all  
modes and swaths

Minor non compliance (< 4% of the  
total access) on NESZ @EW1  
does not compromise L1b  
performances.

/// Note: Multiple lines are for  
different azimuth positions for  
TOPS modes



# L1B – USV ATI

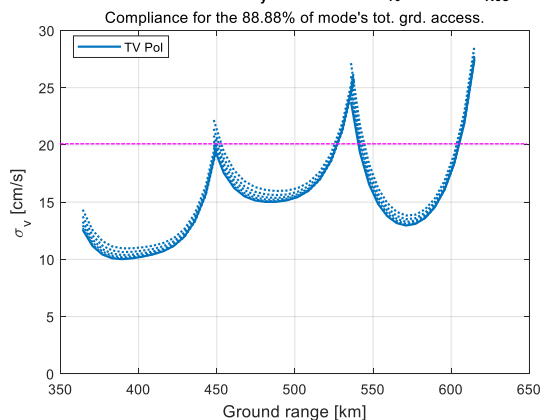
/// Here reported the RPE performance for IW mode using ATI for the USV (Geophysical equivalent surface velocity products).

Left: fine resolution

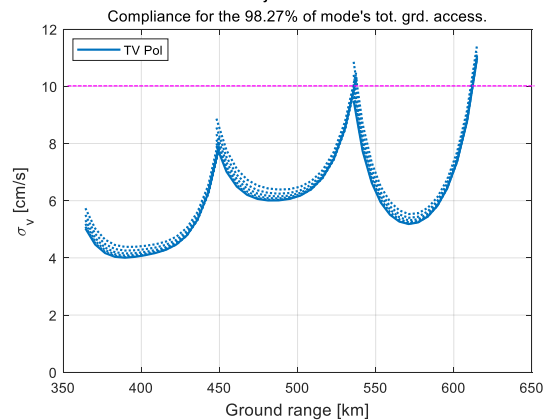
Right: coarse resolution

/// Required RPE is 10-20 m/s depending on the resolution

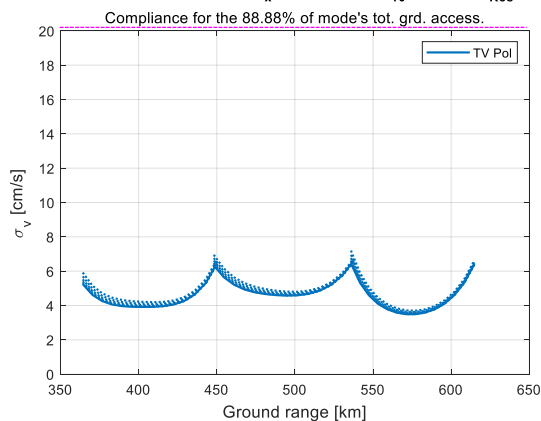
RPE [cm/s] on along-track vel. ( $V_y$ ) at 68% conf.  $U_{10}=8\text{m/s}$ ,  $L1b_{Res}=2\times 2\text{km}^2$



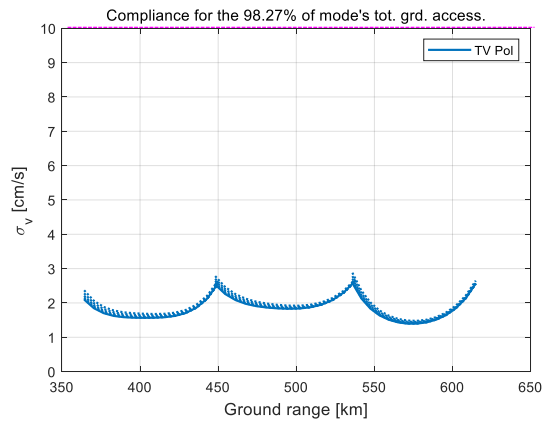
RPE [cm/s] on along-track vel. ( $V_y$ ) at 68% conf.  $U_{10}=8\text{m/s}$ ,  $L1b_{Res}=5\times 5\text{km}^2$



RPE [cm/s] on across-track vel. ( $V_x$ ) at 68% conf.  $U_{10}=8\text{m/s}$ ,  $L1b_{Res}=2\times 2\text{km}^2$



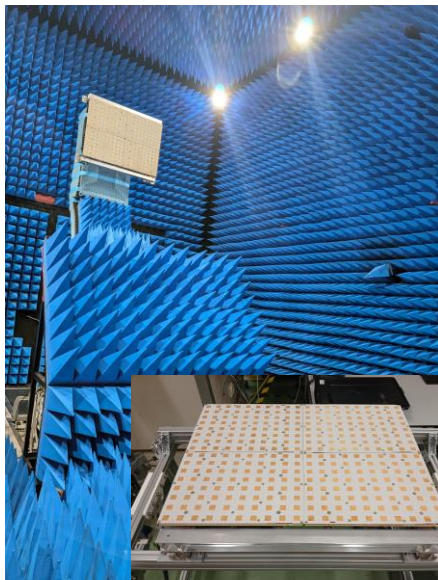
RPE [cm/s] on across-track vel. ( $V_x$ ) at 68% conf.  $U_{10}=8\text{m/s}$ ,  $L1b_{Res}=5\times 5\text{km}^2$



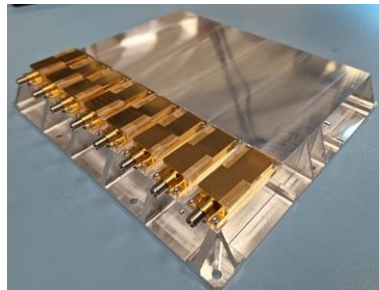
# CURRENT DEVELOPMENT STATUS AND TRL6 ACHIEVEMENTS

/// Successful SAR Instrument Preliminary Design Review, April 2025

/// TRL6 achieved for some functionalities deemed challenging

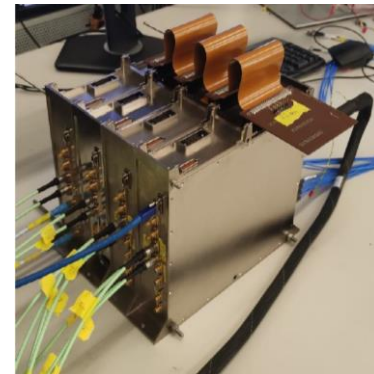
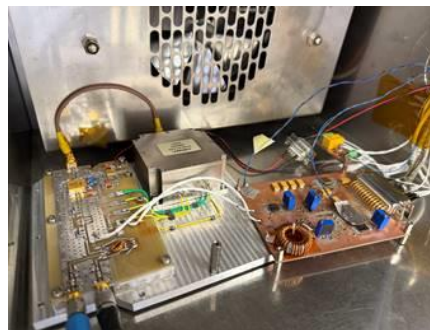


**RFE**



**RMU**

**OCXO Adjustability**



**DGU**

# CONCLUSIONS

/// In this presentation, the SAR Instrument architecture both in terms of logical and physical architecture conceived for the Harmony mission has been shown

/// It has been presented the development status and Performance of the SAR Instrument and the current development status at the end of the Phase B2

/// Next programmatic step: SAR CDR in Q1-Q2 2026

/// **Q&A**

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# THANK YOU FOR THE ATTENTION!

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