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Analysis Ready Data (ARD) is defined as EO data that has been processed in such a way that users can use it readily without any need for additional processing, allowing greater computation capabilities as well as utilisation of huge wealth of historic satellite data alongside recent missions.

This poster describes the development project that has been undertaken by IDEAS-QA4EO Service to ESA's SPPA (Sensor Performance, Products and Algorithms) Section, for the development of **CEOS-ARD NRB** processor prototype for the data from ERS-1/2 SAR and ENVISAT ASAR Instruments. The new ARD product outputs of this project align well with the current Sentinel-1 and Sentinel-2 ARD products thus demonstrating the 'Adding Value to Data' and 'Facilitation of Data Use' aspects of **Theme 2** of PV2023 conference.

## Overview

The Committee on Earth Observation Satellites (CEOS) has created a strategy that lays out a foundation for the creation of **Product Family Specifications (PFS)** for **Analysis Ready Data (ARD)** for Optical and Radar instruments (<https://ceos.org/ard/>). The PFS provide a framework of 'Threshold' (must comply) and 'Target' (nice to have) requirements for the ARD products in the following four generic areas:

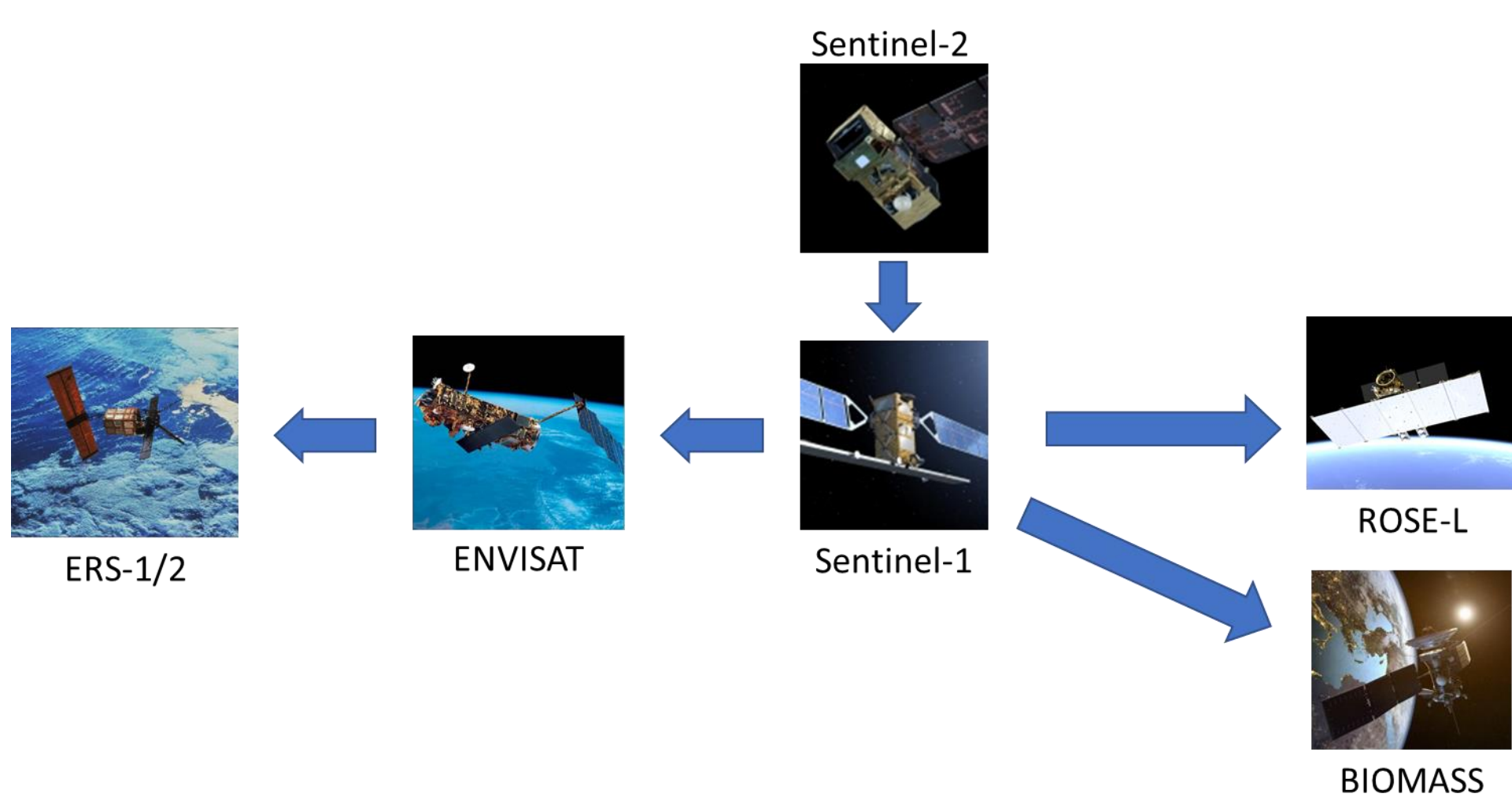
- General Metadata
- Per-pixel Metadata
- Radiometric and Atmospheric Corrections
- Geometric Corrections

The aim for creation of CEOS-ARD PFS is to provide an **internationally coordinated** and a **standardised approach** towards specification of ARD data. This would enhance the **usability** and **accessibility** of the ARD data for a wide variety of users.

This poster presents the latest status and outputs of the ARD Development project that is **led and managed by TPZ UK** under Instrument Data quality Evaluation and Analysis Service (IDEAS)-QA4EO service. The project aims to fulfil the needs of ESA's **Heritage Space Programme** to generate a **Synthetic Aperture Radar (SAR) ARD** product compliant with the CEOS requirements as well as aligned to Sentinel-1 and Sentinel-2 ARD outputs, for the historic ERS-1/2 and ENVISAT missions.

The baseline specification for the development of ARD outputs is the CEOS-ARD specification for SAR **Normalised Radar Backscatter (NRB)** PFS [1]. The SAR Quality Control (QC) Team within IDEAS-QA4EO service started the development of CEOS-ARD NRB processor prototype for ERS-1/2 SAR and ENVISAT ASAR products in 2022.

## CEOS-ARD NRB Definition Approach

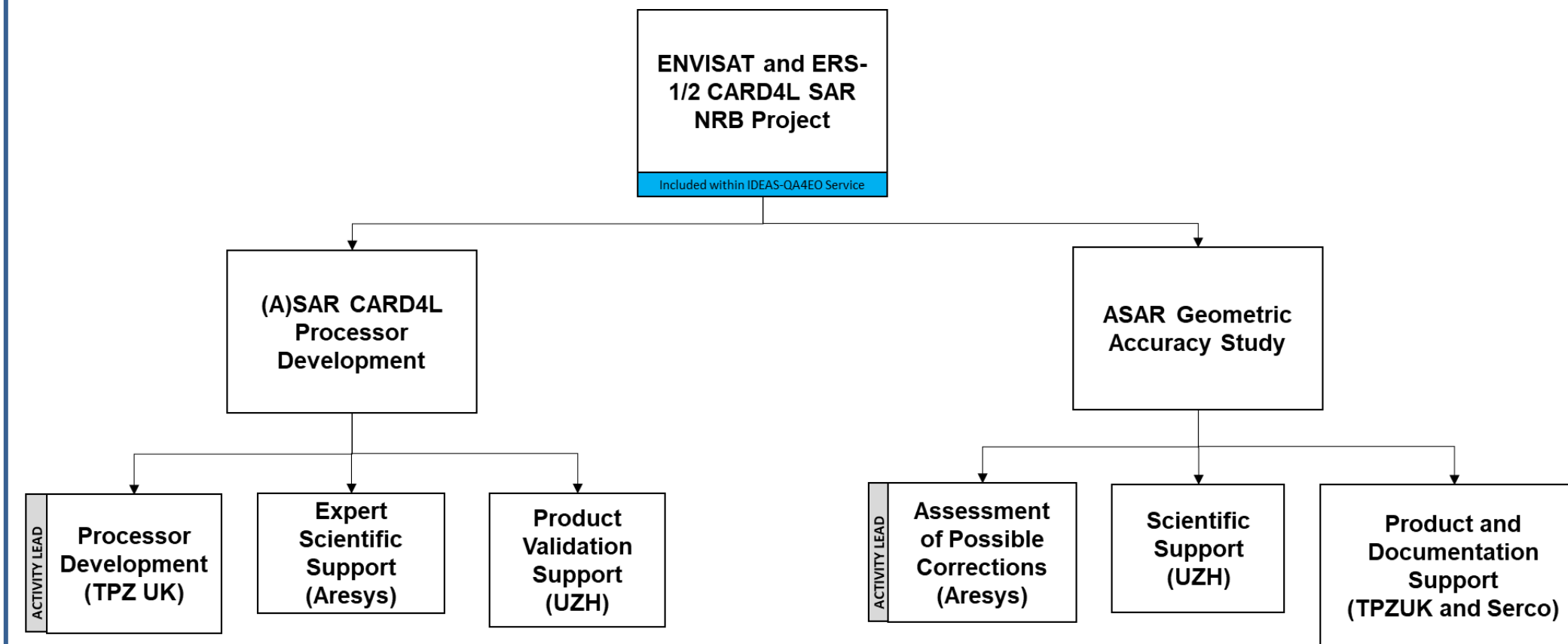


**Figure 1: ARD processor development approach to allow interoperability with Sentinel-2, Sentinel-1 and in turn reflect in future missions**

The processor development closely follows Sentinel-1 approach, with the aims as outlined below:

- **Immediate analysis and facilitation of data use:** By ensuring that CEOS-ARD requirements related to **Radiometric Terrain Correction (RTC)**, projection of **Digital Elevation Model (DEM)** etc. are implemented;
- **Interoperability:** By ensuring that the gridding and DEM are aligned with Sentinel-1, and future Sentinel-1 NG, ROSE-L and BIOMASS missions;
- **Cloud computation capability:** By developing the output product in the **Cloud-Optimised GeoTIFF (COG)** format;
- **Open science compliance:** By developing an open-source software for the processor.

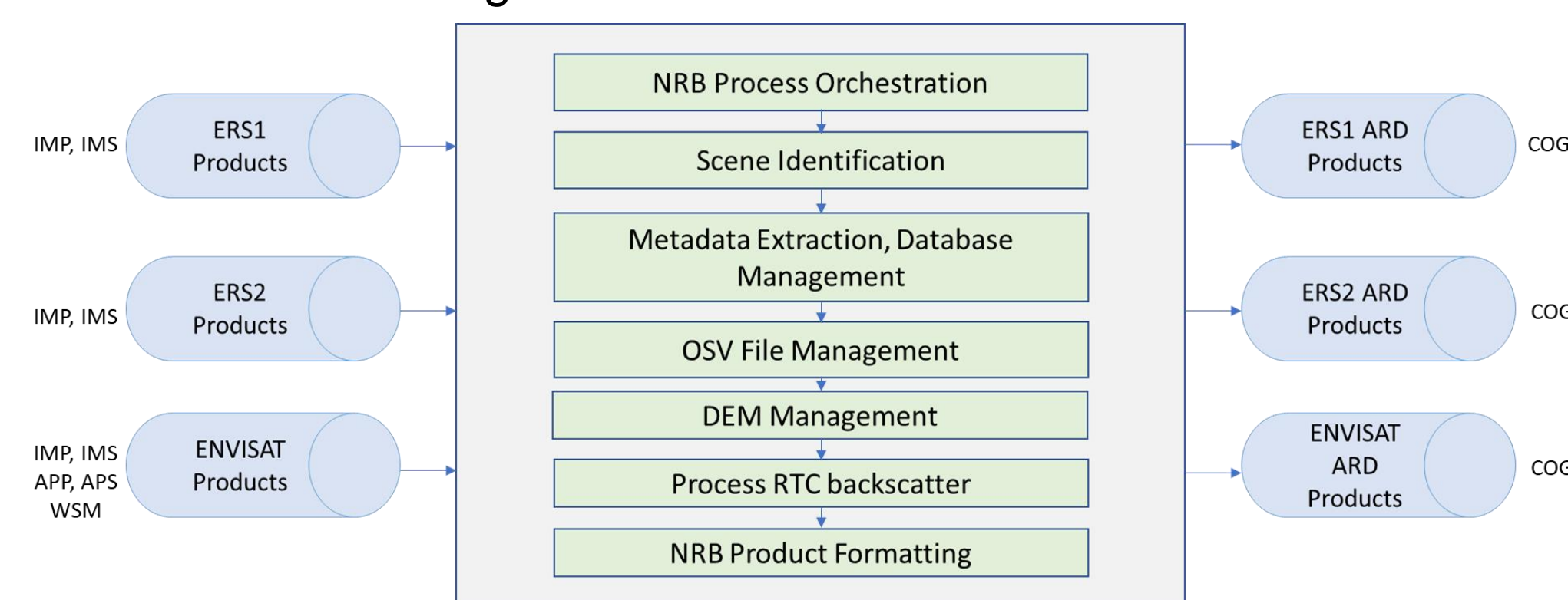
## Project Team and Current Status



**Figure 2: ERS-1/2 SAR and ENVISAT ASAR NRB ARD processor development team**

The project has been defined in two parts as follows:

- **Processor Development:**
  - Develop the ARD processor for ERS-1/2 SAR and ENVISAT Advanced SAR (ASAR) Imaging mode products
  - Focus on **L1 Single Look Complex (SLC)** and **PRrecision (PRI)** for **IM** and **AP** and **L1 Medium Resolution (MR)** for **WS**
  - **Output** -> COG format (including XML) ARD products for all three missions
- **Geometric Accuracy Study:**
  - Asses potential improvements to ENVISAT ASAR data to deliver the highest resolution ARD products that is practically possible
  - **Output** -> A set of recommendations with a description of identified algorithms

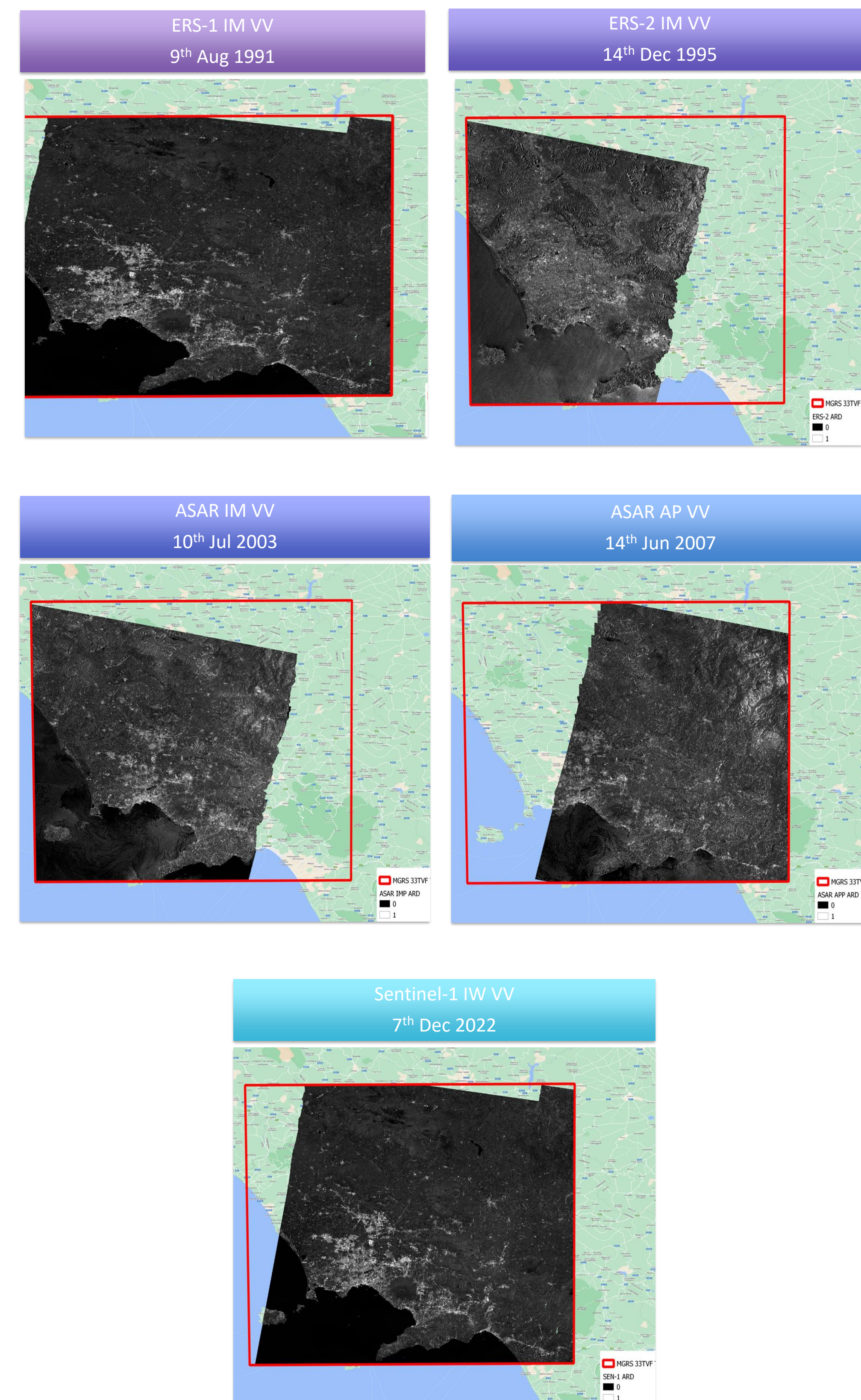


**Figure 3: ERS-1/2 SAR and ENVISAT ASAR NRB ARD processor design**

The current status of the project and processor is as follows:

- **Builds Upon:**
  - PyroSAR Library of Python -> Open Source
  - **SeNtinel Application Platform (SNAP)** -> Open Source
- **DEM:**
  - Copernicus DEM
    - EEA-10 (over EEA39 countries) and GLO-30 (over other countries)
  - Few areas with restricted access (Azerbaijan and Armenia) where GLO-90 is used
- **RTC:**
  - Flattening Gamma: Radiometric Terrain Correction for SAR Imagery [2]
- **Gridding:**
  - Aligned to **Military Grid Reference System (MGRS)**
  - Geometry and CRS of each tile read from a reference KML file provided by Sentinel-2 mission
  - Input pixel spacing is dependent on the image mode (ASAR IMP: 12.5m and ASAR WSM: 75m)
- **CEOS Requirement Traceability:**
  - 30/30 Threshold requirements implemented (**100% compliance**)
  - 7/14 Target requirements implemented (**50% compliance**)
- **Geometric Accuracy:**
  - Implement the **Azimuth Bi-static Delay** within ENVISAT ASAR ARD processor as bulk correction -> for the slant range time in the middle of the product

## Outputs and Next Steps



**Figure 4: CEOS-ARD NRB Products for ERS-1 (9th August 1991), ERS-2 (14th December 1995), ENVISAT (IM on 10th July 2003 and AP on 14th June 2007), Sentinel-1 (7th December 2022), spanning over 30 years, aligned to the same grid as Sentinel-2**

The outputs from three historic missions show promising alignment with the current Sentinel-1 mission. More detailed verification is being performed for all three missions. Any corrections required, shall be implemented before the delivery. The final date of delivery is expected to be **End April 2023**. Future activities include:

- Validate products using UZH internal RTC processor
- Implement noise removal in an intuitive manner
- Implement results from Geolocation Accuracy Study
- Improve RTC
- Implement dedicated processor for products for **Ocean Radar Backscatter (ORB)** (<https://ceos.org/news/ard-pfs-orb-nlsr/>)

## Acknowledgements and Contact

The team would like to extend their thanks to **John Truckenbrodt** (Geospatial Data Architect at DLR, formerly Research Associate at Friedrich Schiller University Jena) and **Clément Albinet** (Data Quality and Cal/Val Manager at ESA-GMQ) for their continued support throughout this project, including exchange of additional information about related activities which helped gain an overall understanding of the context of this development.

For further information on the project, contact: [sar@eo-sppa.org](mailto:sar@eo-sppa.org)

## References

1. Albinet C. et al, October 2021, Analysis Ready Data for Land – Product Family Specification: Normalised Radar Backscatter, V5.5
2. Small D., August 2011, Flattening Gamma: Radiometric Terrain Correction for SAR Imagery, IEEE Transactions on Geoscience and Remote Sensing, Vol. 49, No. 8