GENESIS New Combined Processing

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Overview

- Background, Motivation & Objectives
- The Navigation Support Office
- Co-Location of Geodetic Techniques
- PROcessing, Archiving and Distribution (PROAD)
- Summary

Background, Motivation & Objectives

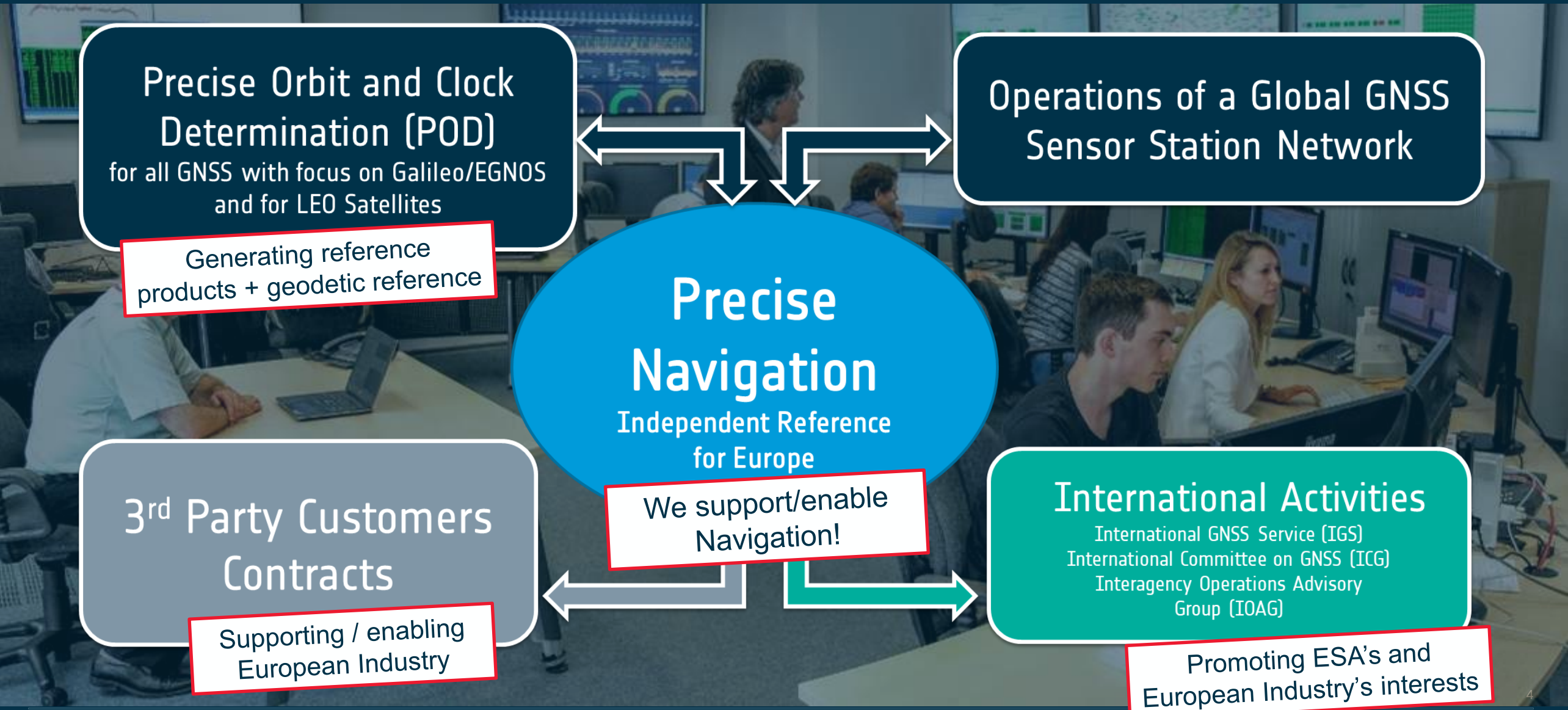
- GENESIS is ESA's future mission, expected in 2028, that will aim at contributing to a highly improved Earth reference frame with a target accuracy of 1 mm and a long-term stability of 0.1 mm/year, providing a coordinate system for the most demanding navigation applications on our planet.

- The baseline for the GENESIS satellite is to combine all four major space-geodetic techniques:
  - Global Navigation Satellite Systems (GNSS)
  - Satellite Laser Ranging (SLR)
  - Very Long Baseline Interferometry (VLBI)
  - Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS)

  while synchronising and cross-calibrating the instruments to determine the inherent biases of each technique, allowing to correct them for improved accuracy.

- The ESA Navigation Support Office at ESOC will be responsible for the Precise Orbit Determination of the GNSS satellites and GENESIS and, in preparation for this mission, is preparing the tools to process all observables from the four major space-geodetic techniques, in a combined and coherent manner.

The Navigation Support Office at ESA/ESOC



Precise Orbit and Clock Determination (POD)

for all GNSS with focus on Galileo/EGNOS and for LEO Satellites

Generating reference products + geodetic reference

Operations of a Global GNSS Sensor Station Network

Precise Navigation

Independent Reference for Europe

We support/enable Navigation!

3rd Party Customers Contracts

Supporting / enabling European Industry

International Activities

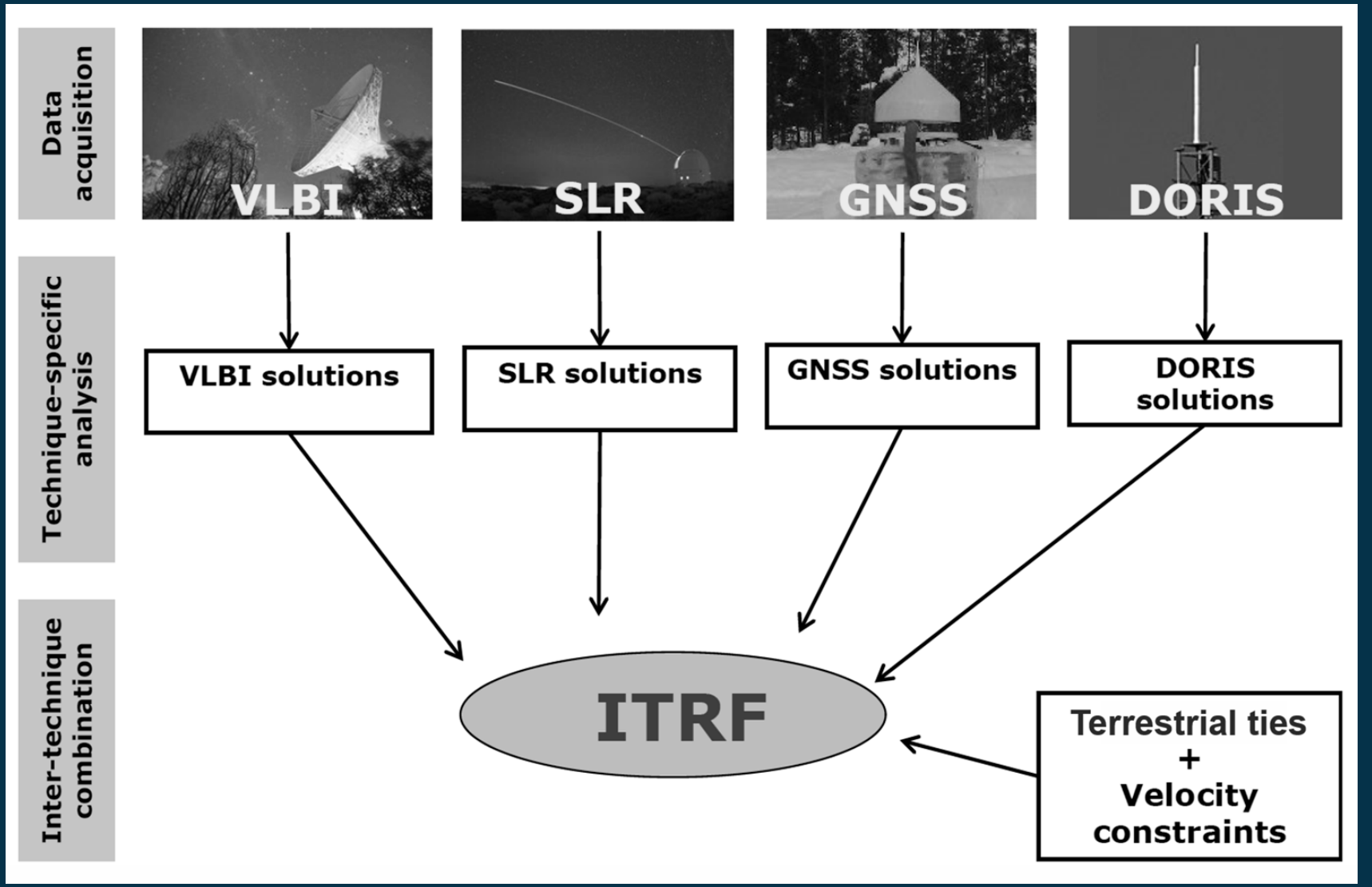
International GNSS Service (IGS)
International Committee on GNSS (ICG)
Interagency Operations Advisory Group (IOAG)

Promoting ESA's and European Industry's interests

International Terrestrial Reference Frame Realisation

Current Approach:

- Different geodetic techniques are used for the realisation of the ITRF.
- According to their peculiar observing principle and systematics,
- each technique plays a distinct role in the realisation of the ITRF.



Objective: Co-Location of Geodetic Techniques

Terrestrial ties:

- The local ties are the vectors connecting the reference points of the different space geodetic techniques co-located within the same ITRF site.
- They allow connecting the technique-specific frames into a unique common frame.

Limitations of the terrestrial tie approach:

- Inhomogeneous distribution
- Unfrequently updated
- Discrepancies with space geodesy estimates (likely due to systematic errors)

GENESIS satellite (a “flying laboratory” with well-calibrated payloads)**:**

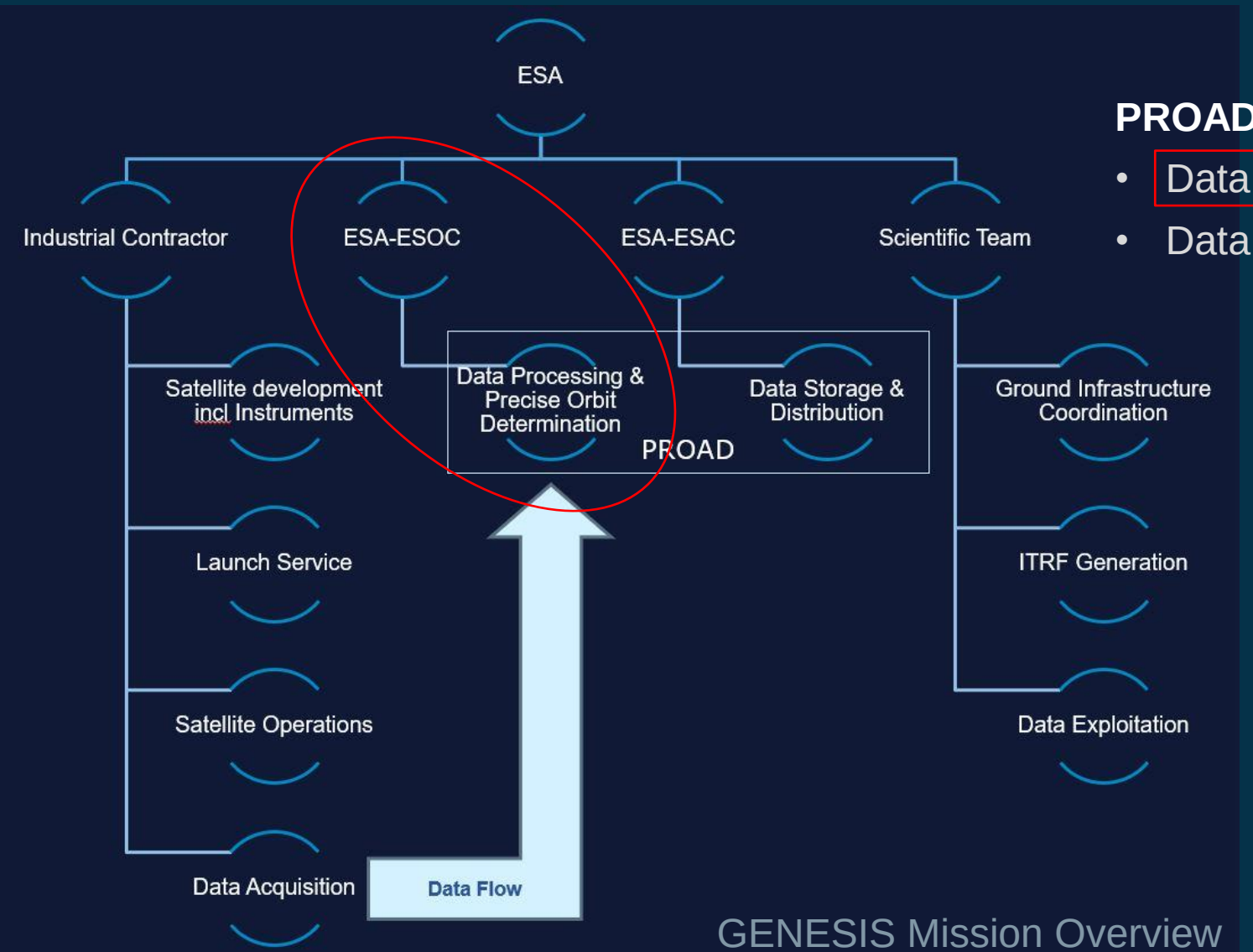
- Ideally trackable by ground stations contributing to the ITRF (SLR & VLBI), carrying DORIS & GNSS receiver
- Estimation of common parameters by means of the observations provided by the different techniques
- Identification of technique-specific systematic biases

Reference: GENESIS CDF Team, ESA-TECSYE-HO-2022-001182 (ESA UNCLASSIFIED – Releasable to the Public)

Summary: Co-Location of Geodetic Techniques

- GENESIS aims at establishing high precision and stable ties between all key geodetic techniques that are used to define and disseminate the ITRF, removing the systematic errors amongst them.
- GENESIS will also provide unification of the technique-specific reference frames and significant scientific benefits in Earth modelling.
- Currently there are small but significant differences between the reference frames as produced by the individual techniques.
- The “space-tie” does provide a continuous tie between the techniques with a homogeneous distribution all around the Earth. This will complement the current ground tie approach, and overcome some of its intrinsic limitations.
- GENESIS will strengthen the integration of the Earth geometry, rotation and gravitational field by co-locating in orbit, for the first time, VLBI and all satellite geodetic techniques.

Contribution of the Navigation Support Office



GENESIS Mission Overview

PROAD (Data **PRO**cessing, **A**rchiving and **D**elivery)

- Data Processing & POD (ESA-ESOC)
- Data Storage & Distribution (ESA-ESAC)

In addition to the PROAD activities, the ESA Navigation Support Office will also contribute to the generation of the ITRF by provision of individual solutions for all four geodetic techniques as an official Analysis Center (AC) to the IAG/IERS.

GENESIS - PROAD Collaborating Across ESA

Measurements and Ancillary Data

Data and Products

Data Processing
&
Precise Orbit Determination

esa ESOC

esa ESAC

Data Storage
&
Distribution

IGS

GNSS

Navigation Support Office

GNSS Science Support Centre (GSSC)

IVS

VLBI

POD Products and Additional Data

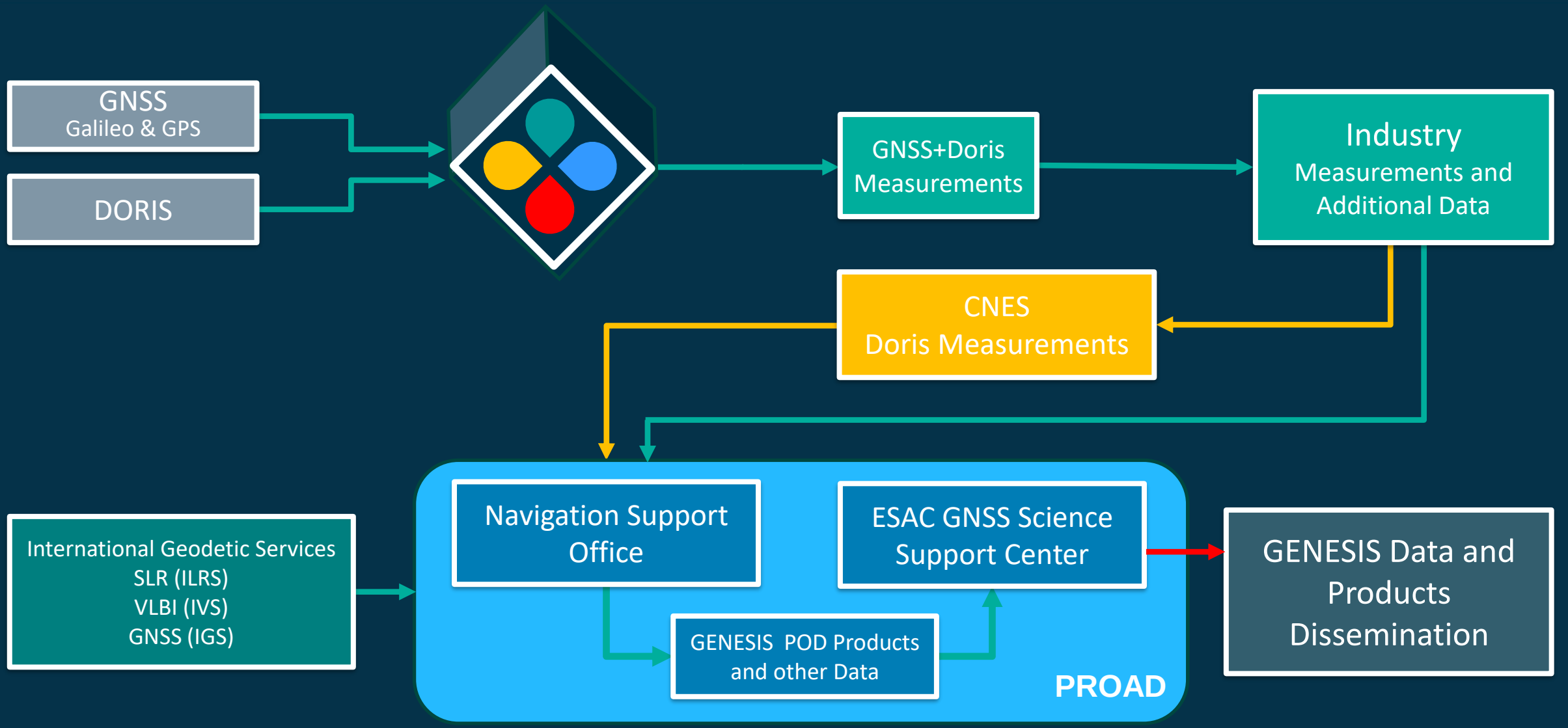
ILRS

SLR

PROcessing, Archiving and Distribution (PROAD)

esa genesis

GENESIS - PROAD Data Flow



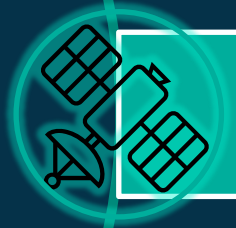
GENESIS - PROAD POD Data Products

- Precise Orbit Determination for Galileo and GPS satellites
- Precise Orbit Determination for GENESIS satellite
- In-Orbit validation of the pre-launch calibrated space ties between the different geodetic payloads on board the GENESIS satellite
- **Additional Products are possible, based on agreements with International Organizations**

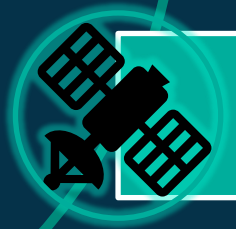
GENESIS - Potential New PROAD Products

Combined solutions

Solution A: coherent processing of all four geodetic techniques in a single least squares process



Solution B: Solution A including MEO satellites

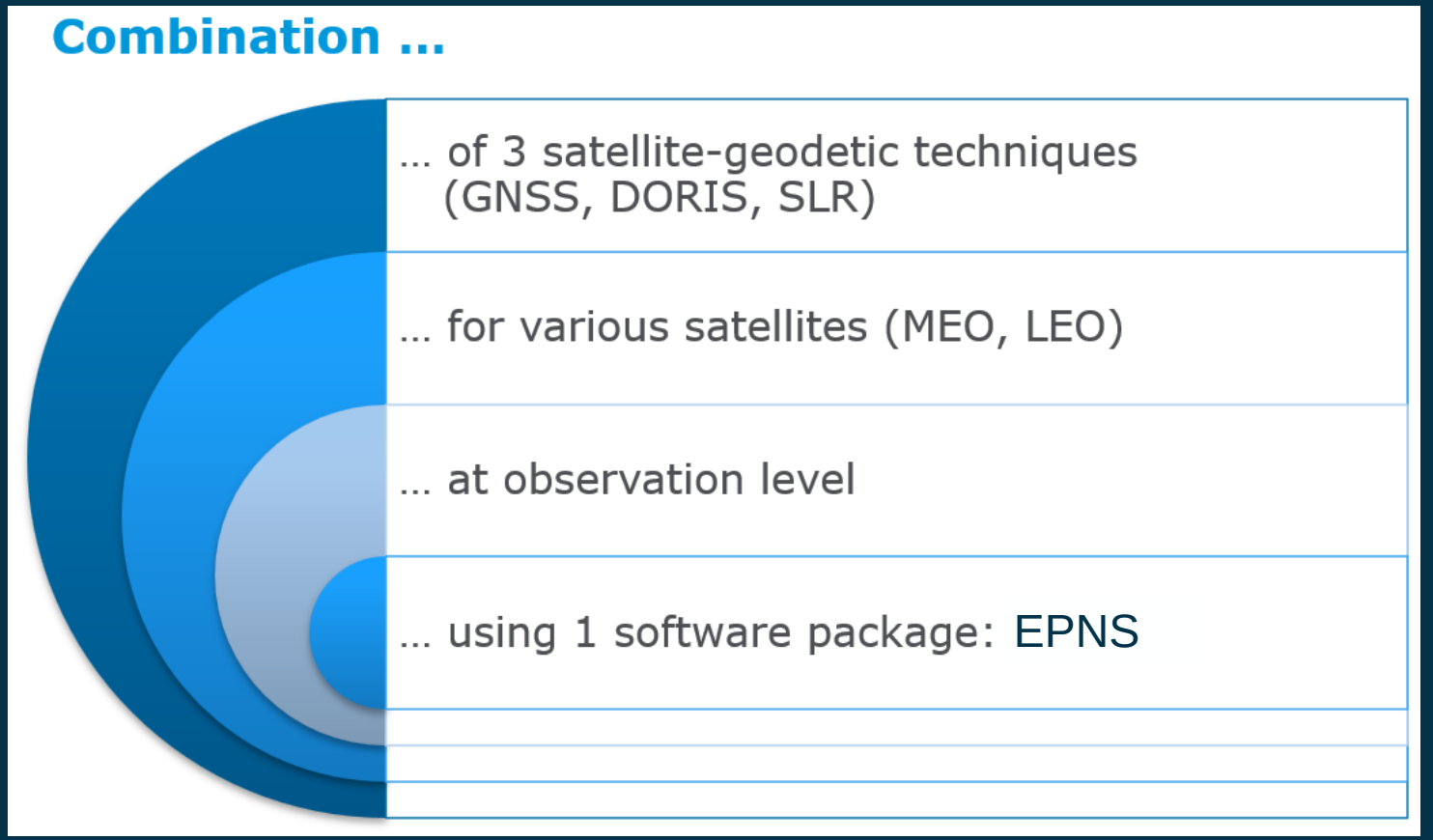


Solution C: Solution B including LEO satellites (e.g. Sentinel satellites, Lageos satellites, etc.)

Important: so far, no GNSS-based LEO contribution towards the ITRF

Combination On Observation Level (COOL)

- The ESA Navigation Support Office builds on extensive experience in multi-technique combination on observation level (GNSS, DORIS and SLR) and multiple satellite types (MEO & LEO).



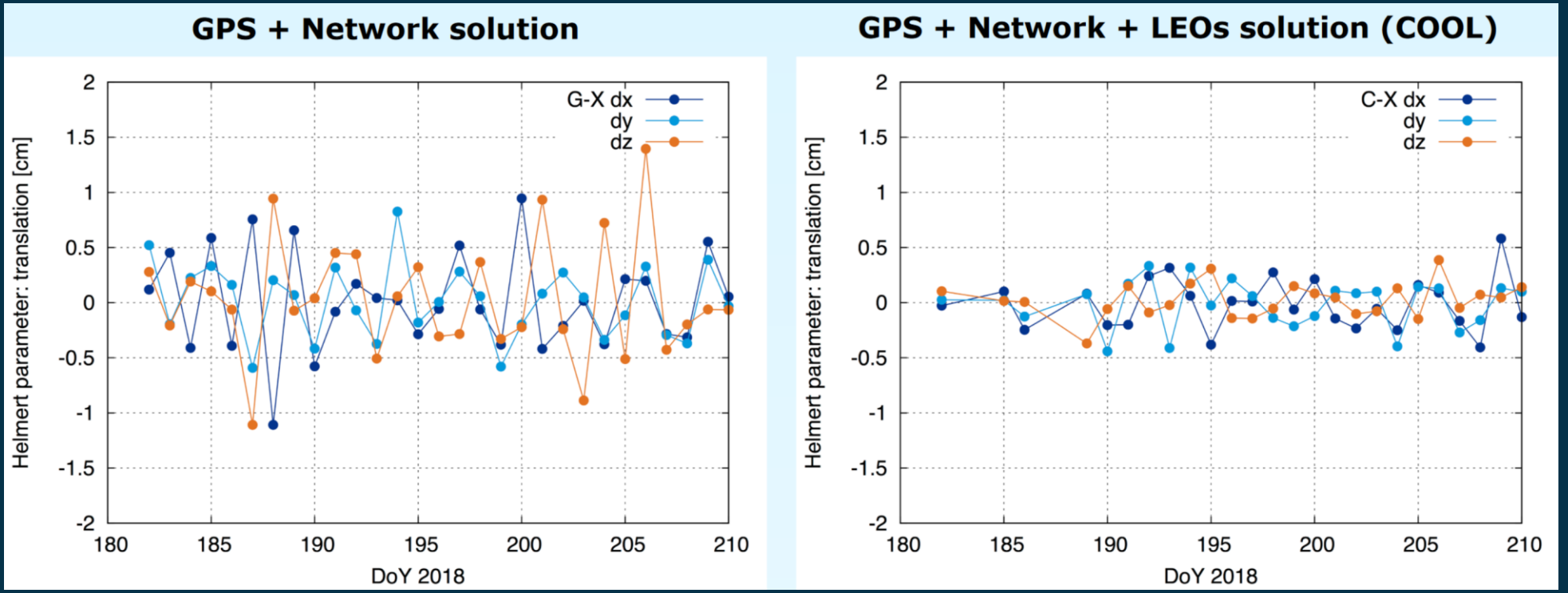
Reference: Multi-technique combination at observation level with NAPEOS, EGU General Assembly 2012, Vienna

Multi-technique combination:

- On observation level
- Process techniques together in one run
- Make use of different strengths and weaknesses
- Detect and reduce technique specific systematic behaviour

Combination On Observation Level (COOL)

- Example results for a combination of GPS satellites, a network of 60 GPS stations and 2 LEO satellites (Sentinel-3A & B, carrying GPS receivers) in one single process
- Comparions with a solution that involves GPS satellites only and a station network without LEOs
- Results show improvements in terms of station repeatability and GPS day-boundary orbit overlaps.



Reference: Integer ambiguity resolved orbits and the benefits of combined Sentinel and GPS processing, Gini at al., EGU 2019

Summary - Contributions from the Navigation Support Office

The ESA Navigation Support Office is an official Analysis Center (AC) for the following geodetic techniques and respective services:

- GNSS (IGS)
- SLR (ILRS)
- DORIS (IDS)

In addition, the Navigation Support Office is currently an Associated AC for:

- VLBI (IVS)

Over the past decades, the Navigation Support Office has continuously been contributing as an official AC to the ITRF generation, and this will continue in the future.

In the context of the GENESIS PROAD activities, the Navigation Support Office will provide new, additional products to support the evolution and improvements of the ITRF generation.

Thank you for your attention!