



EU SST Collision Avoidance Service in Real Operation Scenarios



Cristina Pérez (ES OC)/François Laporte (FR OC)

Outline

- What is EU SST?
- Overview of the CA Service
 - Key concepts to understand EU SST CA Service
- Real cases in operations
 - How to manage daily operations with exceptional cases?
 - Management of megaconstellations
 - How important is to have information in advance:
 - 1st GALILEO CAM
 - GEO S/C vs GEO debris
 - The importance of coordination: handover between ESA and EUMETSAT

What is EU SST?

EU SST is:

- A working example of multilateral cooperation at the intersection of space safety and space security
- A consortium of 7 Member States* expanding towards a new SST partnership composed of up to 15 Member States of the European Union

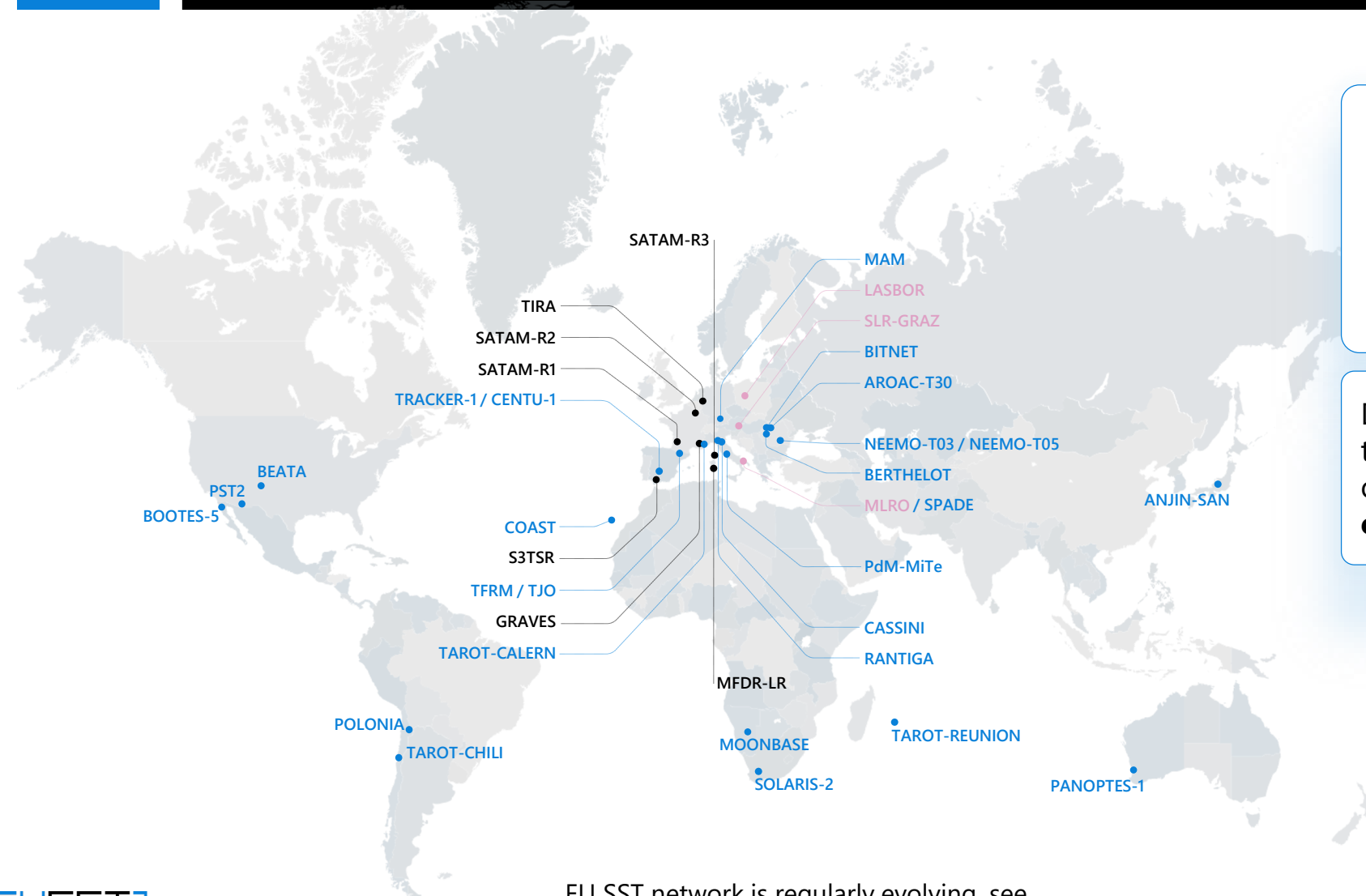
We:

- Are fully **operational 24/7**, we deliver high quality public services to users (CA, RE, FG)
- Perform **research and development** of capabilities to improve the level of performance and autonomy
- Foster innovation and **competitiveness** of the European industry and start-ups, we support the consolidation of a commercial ecosystem around SSA, strengthening strategic autonomy in Europe
- Are **security** relevant (e.g. data sharing) and we take into account the dual dimension
- Mature and expand as a fully-fledge security component of the **EU Space Programme 2021-2027**

*France, Germany, Italy, Poland, Portugal, Romania, Spain



Sensors for space surveillance and tracking



- **3 Lasers**
- **7 Radars**
(2 surveillance, 5 tracking)
- **26 Telescopes**
(15 surveillance, 11 tracking)

Dual approach which enables the use of sensors of different origins: **scientific, military and commercial**

EU SST network is regularly evolving, see
<https://www.eusst.eu/about-us/>



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SSA Operators workshop

Service provision - 3 Operational Services



Collision Avoidance (CA)

Risk assessment of collision and generation of collision avoidance alerts

Re-entry Analysis (RE)

Risk assessment of space objects re-entry into the Earth's atmosphere

Fragmentation Analysis (FG)

Detection and characterisation of in-orbit fragmentations

Key features

- User-tailored service (SCD)
- Hot redundancy scheme with a single service provider
- Enhanced Analysis & Risk Mitigation support (e.g. covariance estimations, HBR estimations, PoC sensitivity analysis, CAM support, support for exceptional operations)

- Long-term (within 30 days) re-entry predictions
- Short-term (a few days) overflight predictions with ground tracks over customizable areas of interest

- Short-term notification to confirm quickly an FG event
- Medium-term FG analysis based on the orbital parameters of the catalogued fragments e.g. Gabbard Diagram
- Long-term FG analysis (with simulations with breakup model)

Products

- Autonomous and enhanced CDMs
- CA Reports
- Monthly reports

- 30 days re-entry list
- RE reports

- Short-term notification
- Medium-term report
- Long-term report

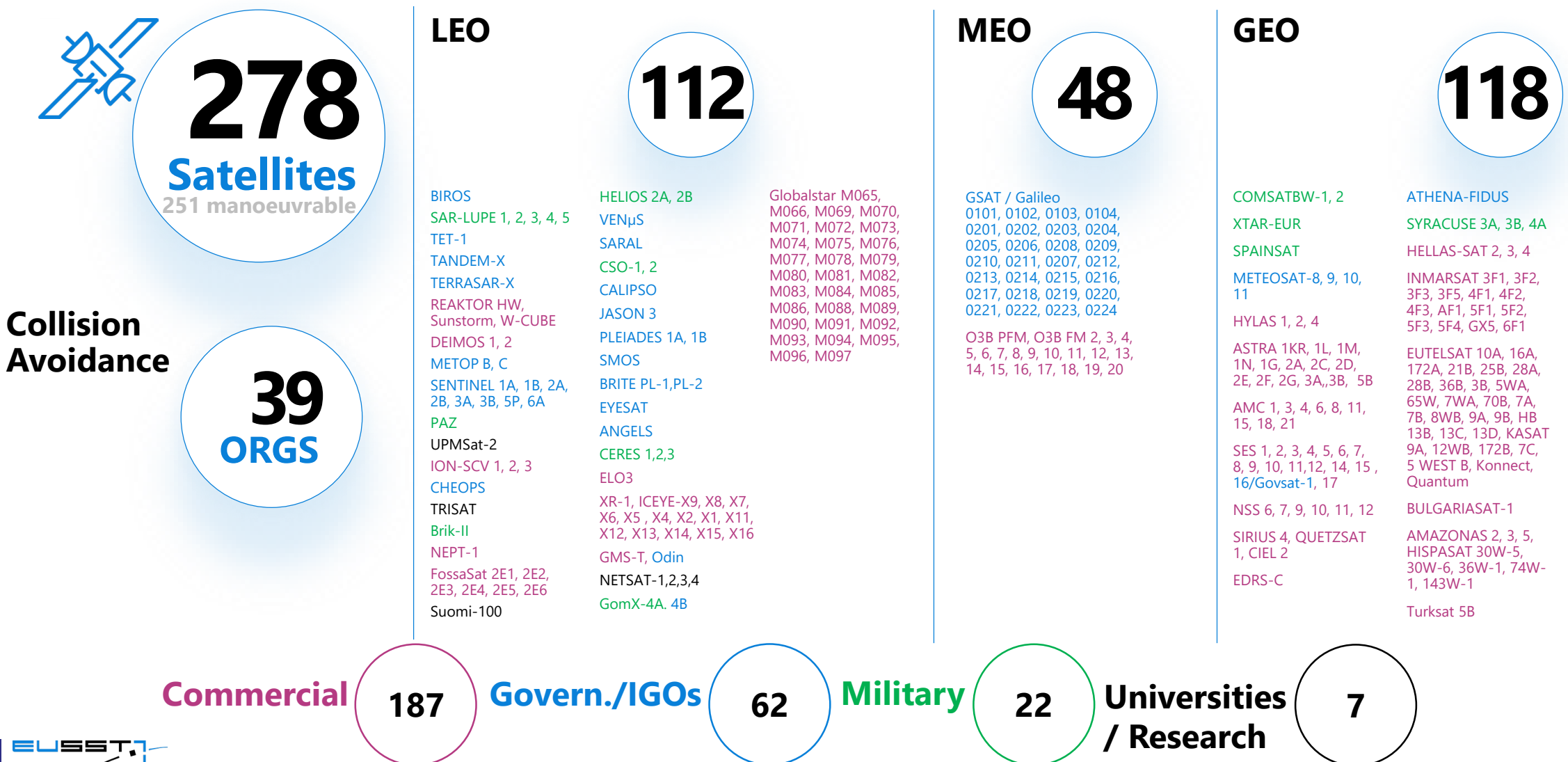
Portal

- Access, download and upload information (API and web interface)
- Access documentation, administer fleets and configure notifications alerts
- View evolution of key parameters e.g. PoC and interactive graphs

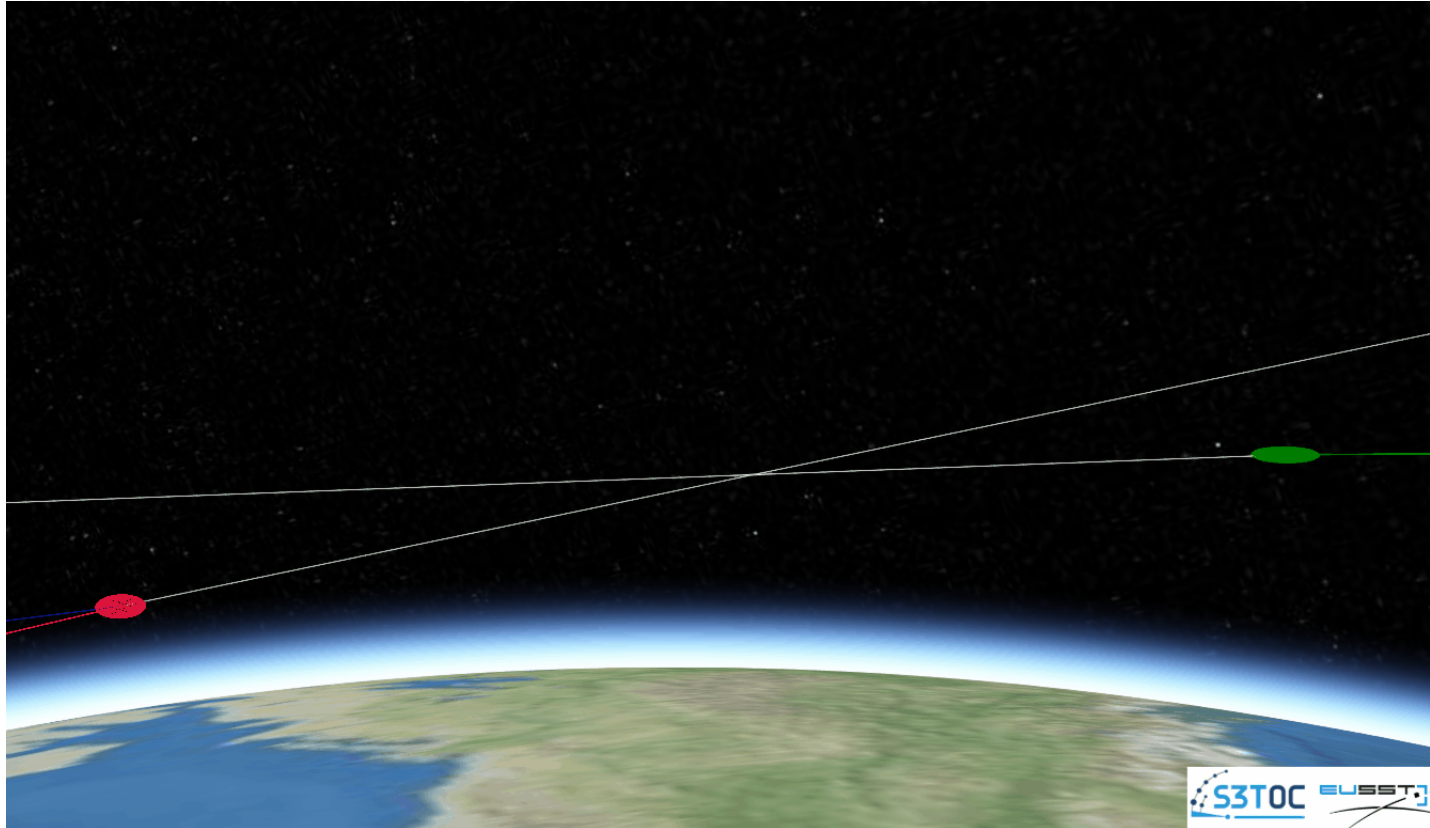
- Access and download information (API and web interface)
- Configure notifications
- View evolution of re-entry window, and interactive ground track plots

- Access and download information (API and web interface)
- Receive notifications
- Access interactive graphs, fragment viewer and other dedicated content

Overview of the EUSST CA users



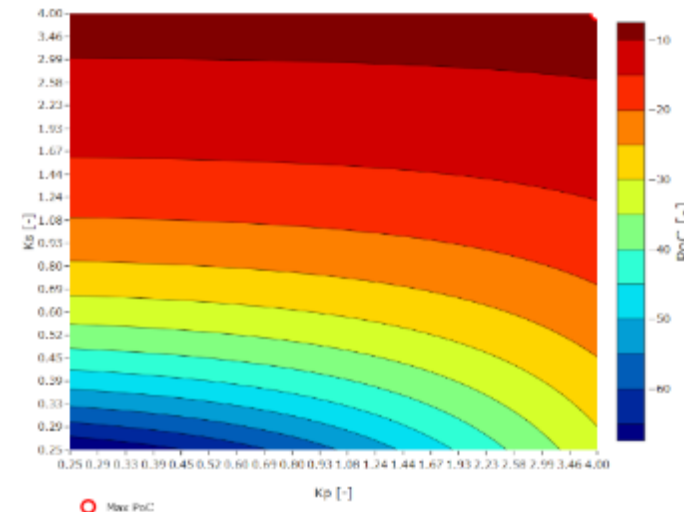
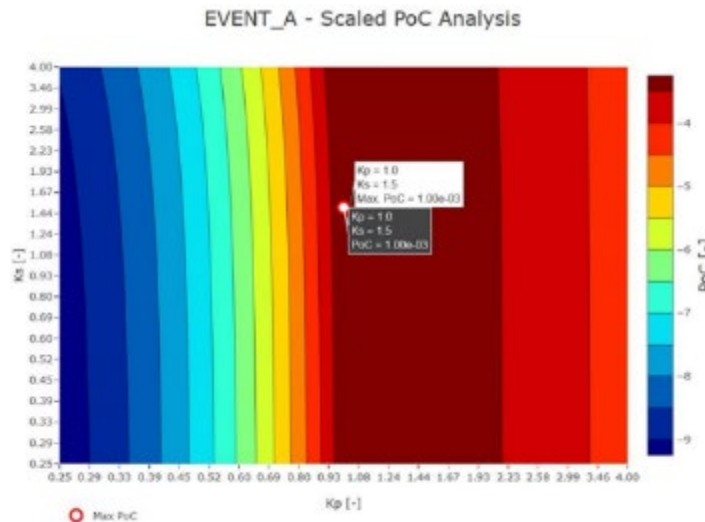
Key concepts to understand EU SST CA service



Key concepts to understand EU SST CA service (1/3)

■ EU SST uses the **Scaled PoC** to compute the level of risk

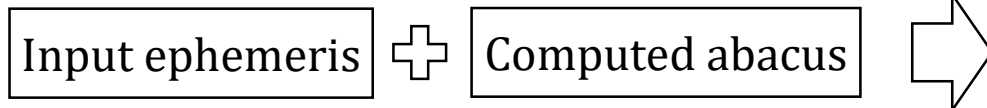
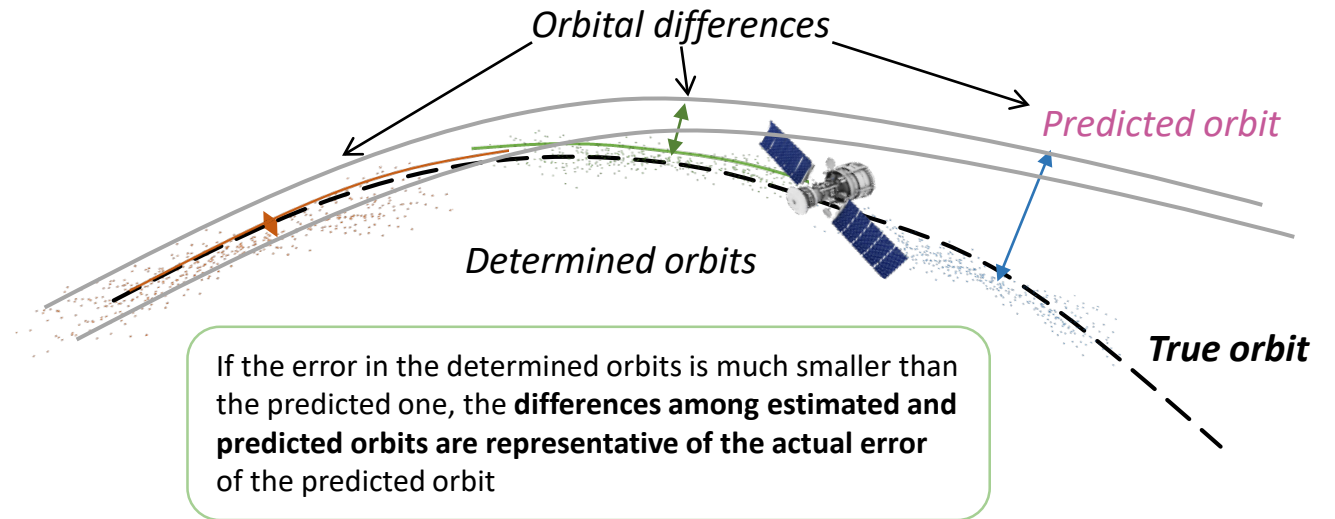
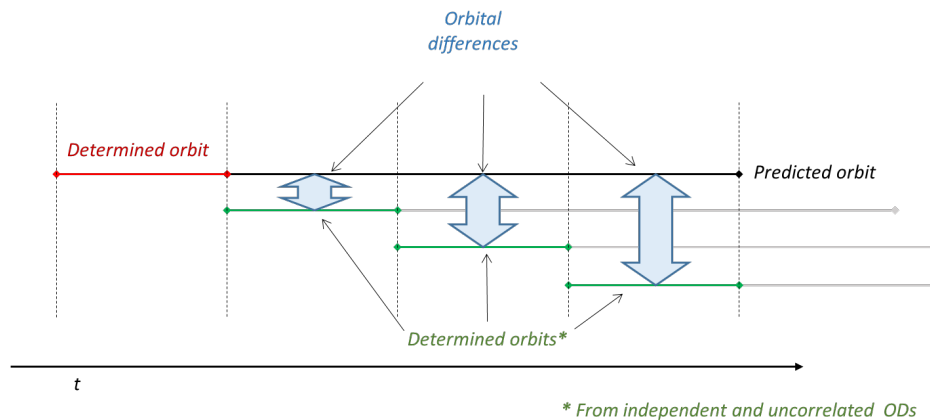
- **Covariance is the key factor** to compute Probability of Collision
- Coefficients k_p and k_s for magnitude of variation of dispersions for primary and for secondary have been chosen from a statistical analysis in the past.
- C (covariance) = $k_p C_p + k_s C_s$ with k_p and k_s independent scale factors applied to respective covariance
- Scaled PoC is defined as the maximum value of PoC when k_p and k_s are in a realistic interval chosen after statistical analysis in the past



Key concepts to understand EU SST CA service (2/3)

■ O/O ephemeris analysis to enhance quality of CA service

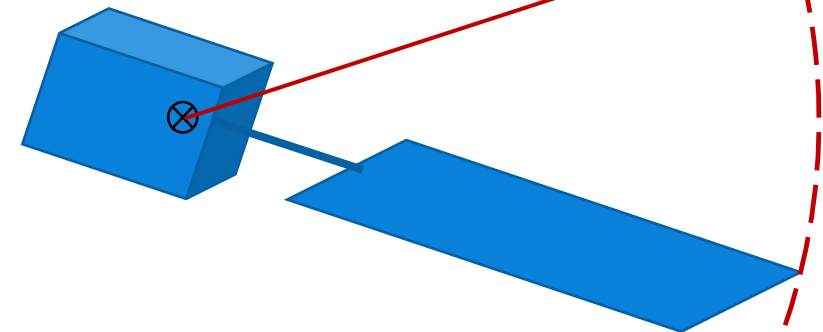
1. Computation of a covariance abacus: Covariance is **not usually provided** by most ephemerides sources or it might not be realistic, thus requiring methods to estimate it with no more information than sets of ephemerides



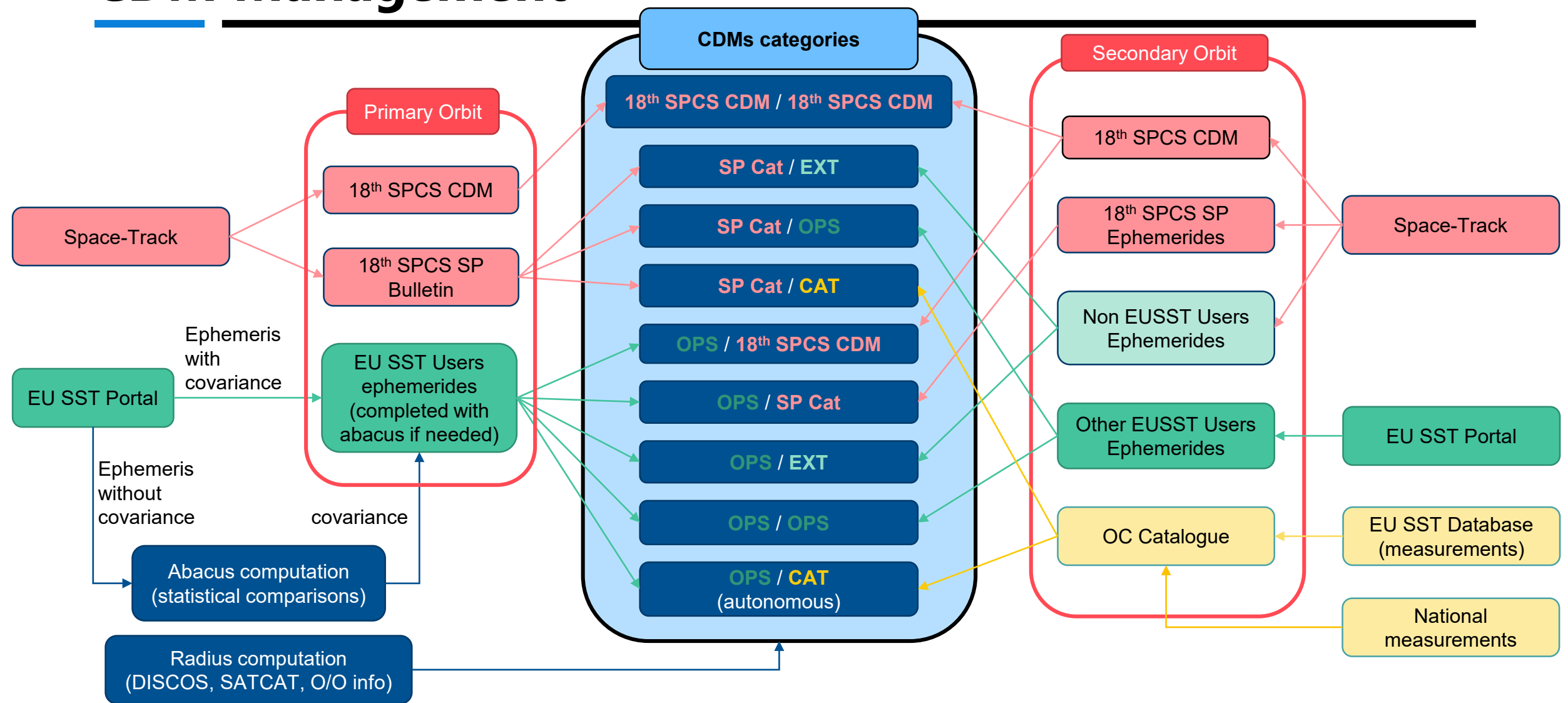
OEM with covariance used for the CA analysis

Key concepts to understand EU SST CA service (3/3)

- The concept of Hard Body Radius (HBR) is used to compute the Scale PoC, **HBR refinement leads to a higher quality of the CA service**
 - Too conservative HBR leads to higher PoC → Need to avoid unnecessary avoidance manoeuvres
 - HBR is defined as the radius of the minimum sphere centered at the centre of gravity of the S/C that contains the whole spacecraft when all deployable components, if any, are extended (e.g. the distance between the centre of gravity of the spacecraft to the outermost component).
 - HBR of S/C can be decreased if attitude is known
 - User can provide an attitude ephemerides or a look-up table
 - HBR of secondary objects may be computed from:
 - DISCOS database for payloads or R/B
 - Satcat information



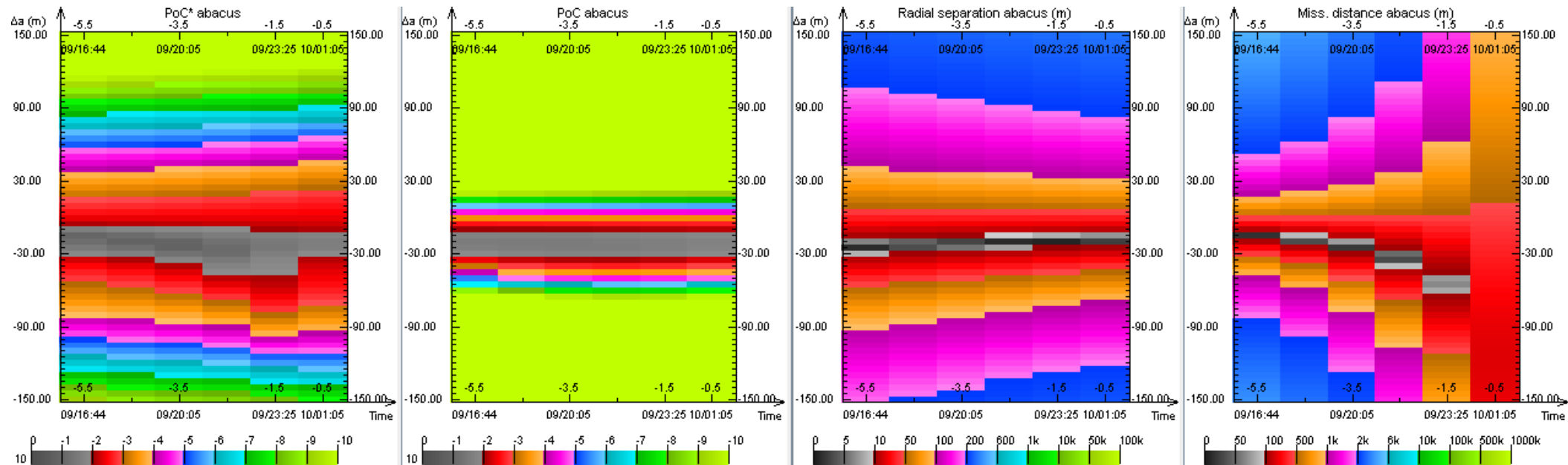
CDM Management



CA service characteristics: Support to Mitigation actions

■ Mitigation recommendation and manoeuvre support

- Triggered by HIE detection or at O/O request

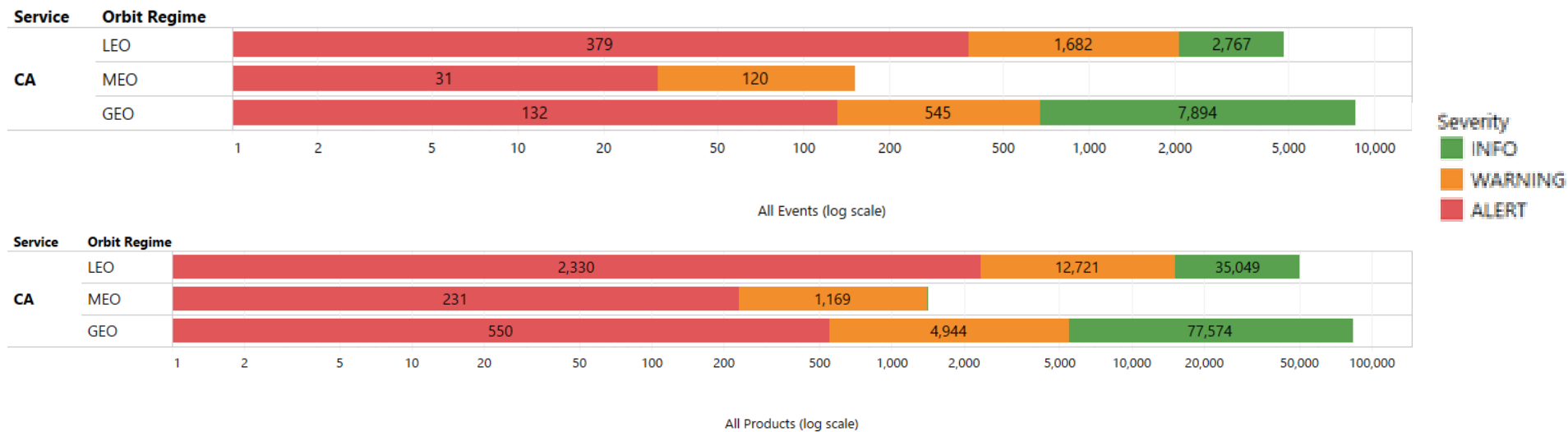


Real case in operations



How to manage in parallel daily operations and exceptional cases?

- From last year (01/04/2021 to 31/03/2022),
 - 4 millions+ CDMs managed by OCs, only the few relevant ones provided to the users

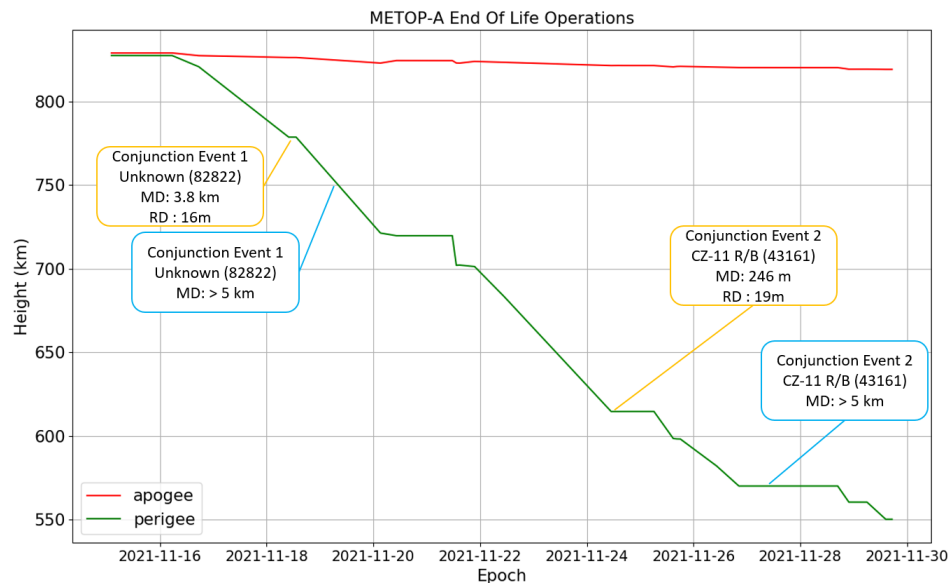


- Exceptional operations = specific needs + fast answers
 - Support provided to 5 S/C in Electric Orbit Phase, 7 S/C in chemical LEOP and 4 S/C relocations
 - Support to 7 S/C in the End of Life phase

➡ Process highly automated, adaptations may be required for exceptional operations

METOP A EOL support

After 15 years in Operations METOP A conducted from 15th November 2021 a series of EOL maneuvers for two weeks reaching a perigee of around 500Km



EUSST was requested to carry out the screenings risk analysis for clearance on 6 sequence of maneuvers:

- to generate screenings within a volume of 5km in all directions, and focus on secondaries with HBR larger or equal to 1m, or manoeuvrable objects
- screening against SP catalogue and EXT ephemerides (public ephemerides from spacetrack.org), EUSST also screened against CAT catalogue
- to forward the ephemerides to CARA, so they can upload to space-track and generate the nominal screening results.

Management of megaconstellations

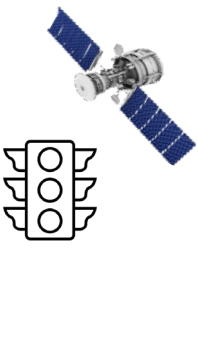
- EUSST in close contact with major megacons owners: Starlink and OneWeb
 - The use of operational ephemerides from spacetrack is key!
 - We provide confirmation about the maneuverability of the s/c monitored by EUSST
 - We ensure that the involved Starlink s/c is active and has its automated CA process turned on.
 - EUSST ensures that security relevant S/C are protected by routine screenings

However...

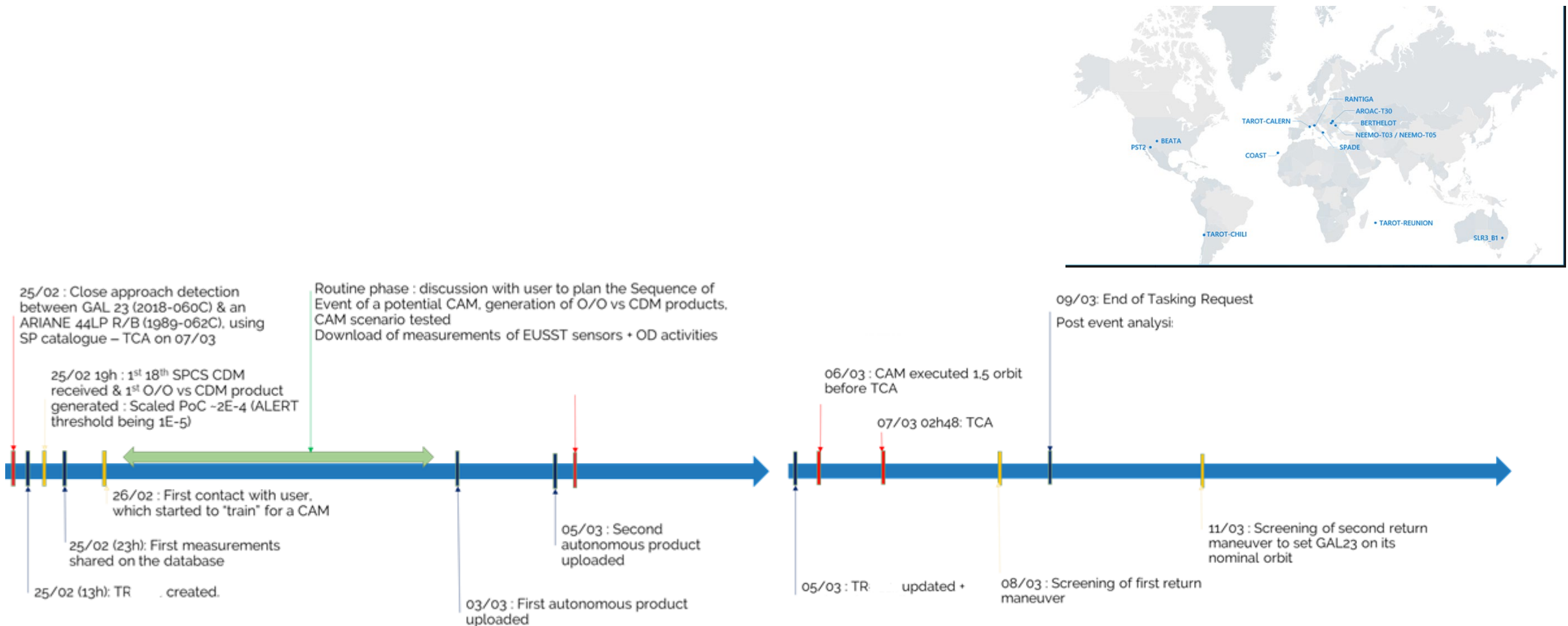


Some s/c are crossing recurrently the Starlink orbits leading to several HIE per month

- For those s/c, a procedure has been developed in agreement with both O/O:
 - For each event, EUSST OC check if involved Starlink s/c is Active and Maneuverable
 - If yes, agreement that the lead of maneuverability will be on Starlink side without contact between the two O/O, and EUSST
 - If no, coordination is required



How important is to have information in advance: 1st GALILEO CAM



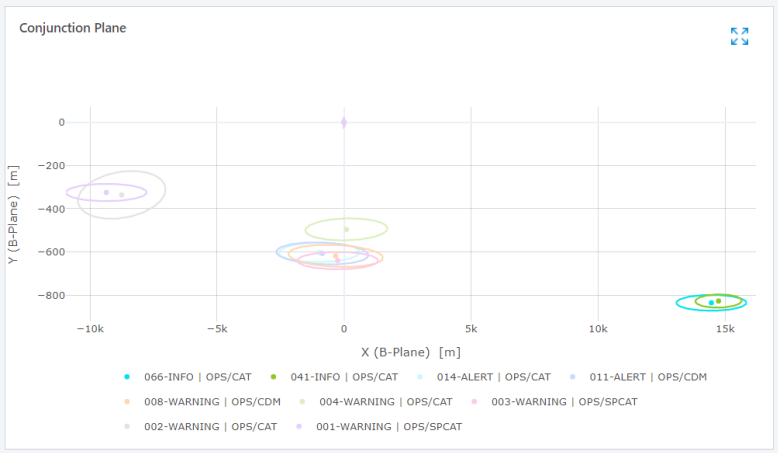
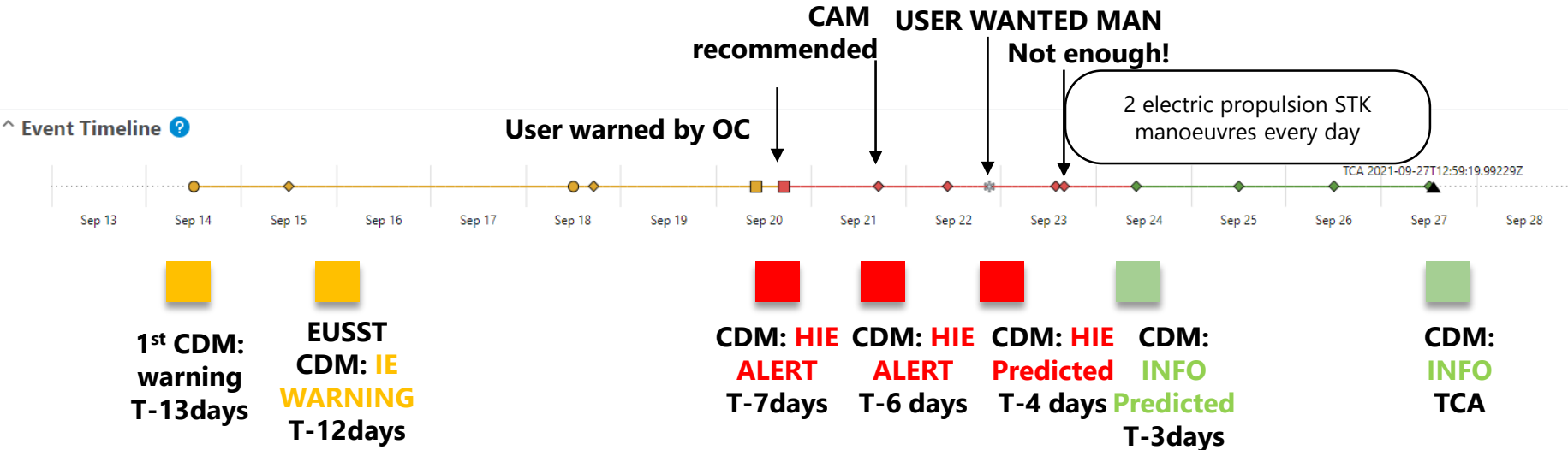
How important is to have information in advance

Primary: GEO object
Secondary: object abandoned in L2

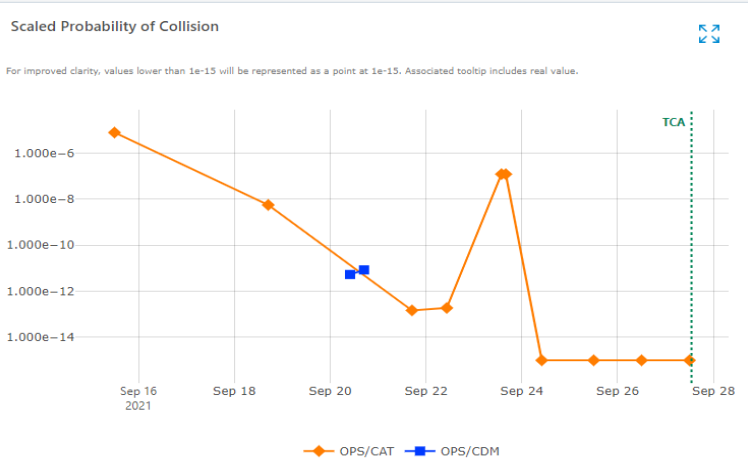
HIE with CAM support

MD&RD: ~ 500m

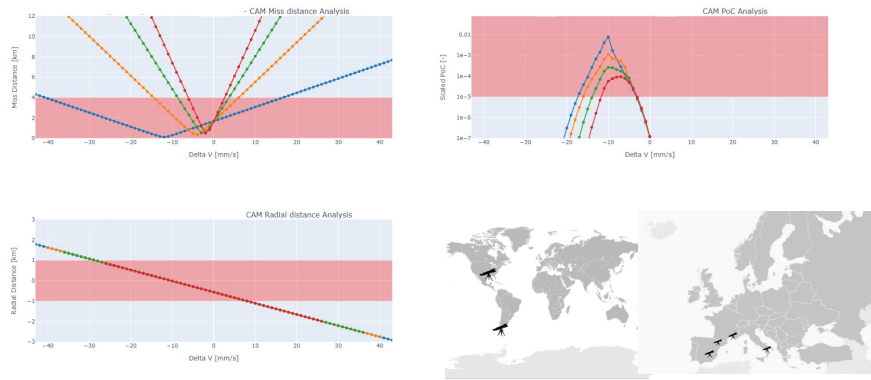
Scaled PoC ~ 7.8E-6



Conjunction Plane



PoC Analysis



CAM Analysis



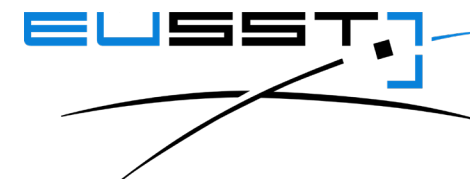
The importance of coordination: handover between ESA and EUMETSAT

- At the end of 2021, two S/C under ESA operational control from ESA was transferred to EUMETSAT
 - The importance of having procedures and protocols!
 - ...and to have the will to cooperate:
 - EUSST organize the handover by being transparent of the thresholds and configurations for each user
 - Both users agrees on share products regarding CA during three months
 - An end to end test was conducted to ensure 18th SPCS and NASA links were properly set up
 - The day before handover a list of potential conjunctions were made available with both thresholds
- Handover Procedure is ready to be used in other cases !





Thank you



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