Collaborative Ground Segment Workshop
Welcome

18 October 2021

Workshop Objectives

- Reconnect after a too long interruption
- Exchange on respective Ground Segment operational status and perspectives
- Plan for the coming years

Where we left…

Context

First elements of the ESA GS transformation being put in operation

Preparation of the Copernicus Long Term scenario

Concluding cycle

Oct. 2019: Collaborative workshop concluding the initial ESA program cycle

Preparation of potential follow-on

What has happened!

Collaborative Ground Segment activities supported at the ESA ministerial creating new perspectives and …

2020: Patatrac!!!

2021: Ready for reboot

Context :

ESA Ground Segment Operations transition to the cloud being finalized

Transition of the Copernicus Operations into the next European financial framework

ESA Earth Observation Framework

The ESA EO operation framework is evolving:

Moving Copernicus Ground Segment into Cloud is the most visible element

Supporting the creation of an open EO data space for operational services is an underlying dynamic

ESA Contributes to the setup of an ecosystem based on an IT infrastructure environment (public cloud) and supporting the development and operations of interacting services

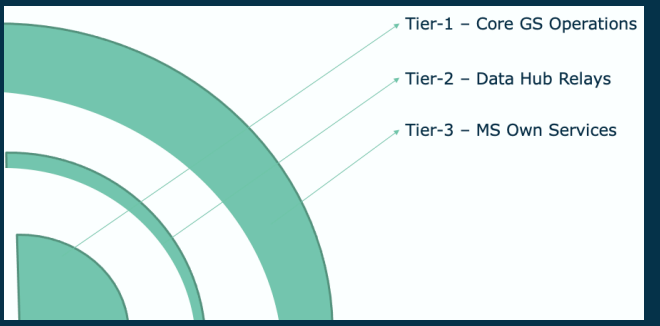
Autonomy associated to Interdependency

The self-standing services are benefitting from the surrounding environment (e.g. scalability) and establishing “Customer-Provider” relationships

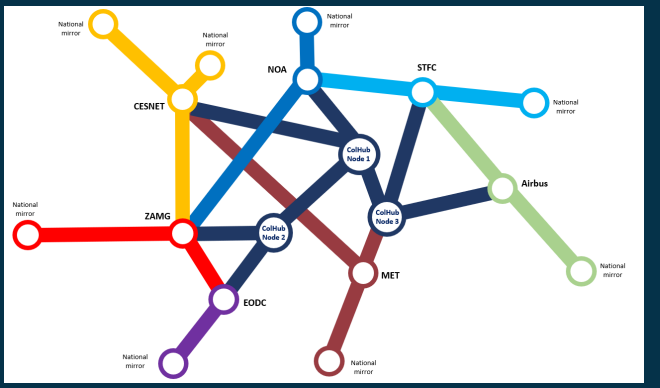
Next step : Data Access : ready to go

Role of the Collaborative Ground Segment ?

Collaborative GS Initiated as a “Plan B” to secure access to Copernicus Data



Collaborative Data Relays have been developing into a small ecosystem



⇒ It is proposed that the Network of Collaborative Data Relays benefit from the available ESA EO framework services to deliver new services and increase collaboration on new areas

Proposed Plan

Make use of existing services

- e.g. Traceability

Develop and integrate new component

- e.g. On-demand production

Reinforce collaboration

- Be capable of sharing resources / sharing results

Proposed Plan for Collaboration

2022:

- Maintain on-going operations
- Include new data sets
- Complete first cycle of updates for the collaborative hub software / environment

2023:

- Integrate the future data access services interfaces
- On-demand production services / streamlined data access

2024:

- Data relays fully functional as part of the ecosystem
- Supporting services like:
  - Large data bulk transfer
  - Dedicated streamlined access …

New Copernicus Data Access Available

Processors in Python

Sentinel Missions Status

Pierre Potin, *Sentinel-1*
Ferran Gascon, *Sentinel-2*
Anja Stromme. *Sentinel-3*
Claus Zehner, *Sentinel-5p*

7 Sentinel missions operated by ESA → nominal status

All Sentinel missions remain operational

All Sentinel missions are operated in full operations capacity

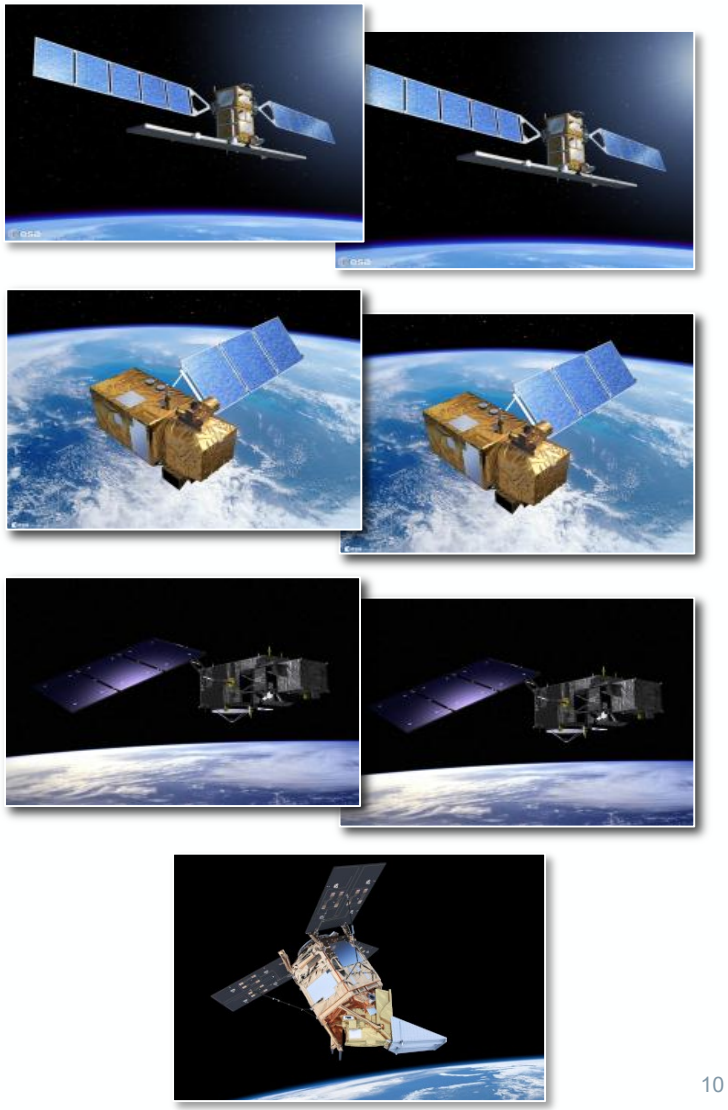
- *Sentinels operated via pre-defined observation plans*
  → see next slide on HLOP revision (for S-1 and S-2)

➢ **Sentinel-1A and Sentinel-1B → nominal operations**

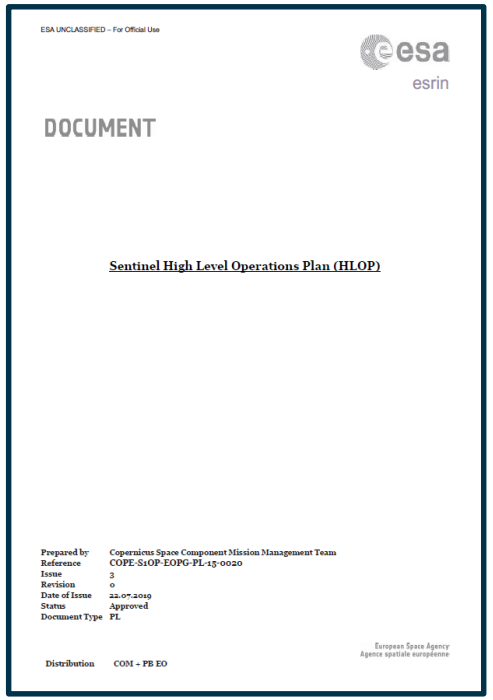
➢ **Sentinel-2A and Sentinel-2B → nominal operations**

➢ **Sentinel-3A and Sentinel-3B → nominal operations**
(managed together with Eumetsat)

➢ **Sentinel-5P → nominal operations**



Revision process of the Sentinel HLOP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DOCUMENT

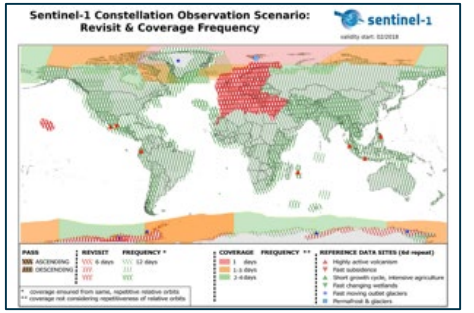
Sentinel High Level Operations Plan (HLOP)

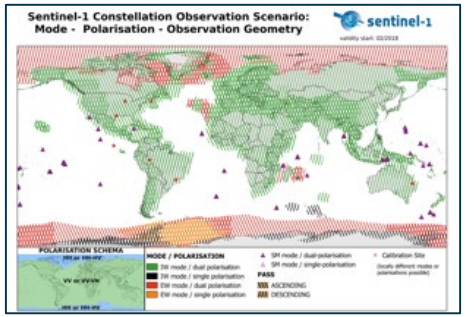
Prepared by	Copernicus Space Component Mission Management Team
Reference	COPE-S1OP-EOPG-PL-15-0020
Issue	3
Revision	0
Date of Issue	22.07.2019
Status	Approved
Document Type	PL

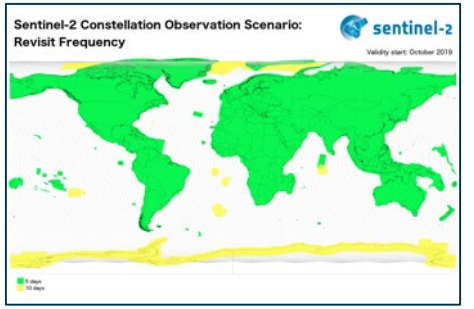
Distribution COM – PB EO

European Space Agency
Agence spatiale européenne

- ✓ The revision process of the Sentinel High Level Operations Plan has been launched at the April 2021 DOSTAG meeting and the June 2021 User Forum / Copernicus Committee meeting
- ✓ A limited number of new observation and operational needs related to the Sentinel-1 and Sentinel-2 missions have been received from Denmark, France, Germany and Norway
- ✓ These needs are under assessment or implementation and will be considered for the next release of the HLOP planned for Q4 2021, following endorsement by the European Commission
- ✓ Report to DOSTAG and User Forum will be provided during Q1 or Q2 2022.







Sentinel-1 Mission Status Highlights

- The Sentinel-1 mission is overall in a very good shape
- Sentinel-1A launched in April 2014, Sentinel-1B in April 2016

  ⇒ Sentinel-1A has reached 7 years (design lifetime) of routine operations:

ESA web news:
https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Sentinel-1/First_Copernicus_satellite_exceeds_design_working_life

- Despite the difficult situation in Europe due to the COVID-19 crisis, efforts have been and are still being made to ensure the continuity of the S1 mission operations, which remain nominal

Sentinel-1A: 7 years in operations !

Sentinel-1 Mission Status Highlights (cont'd)

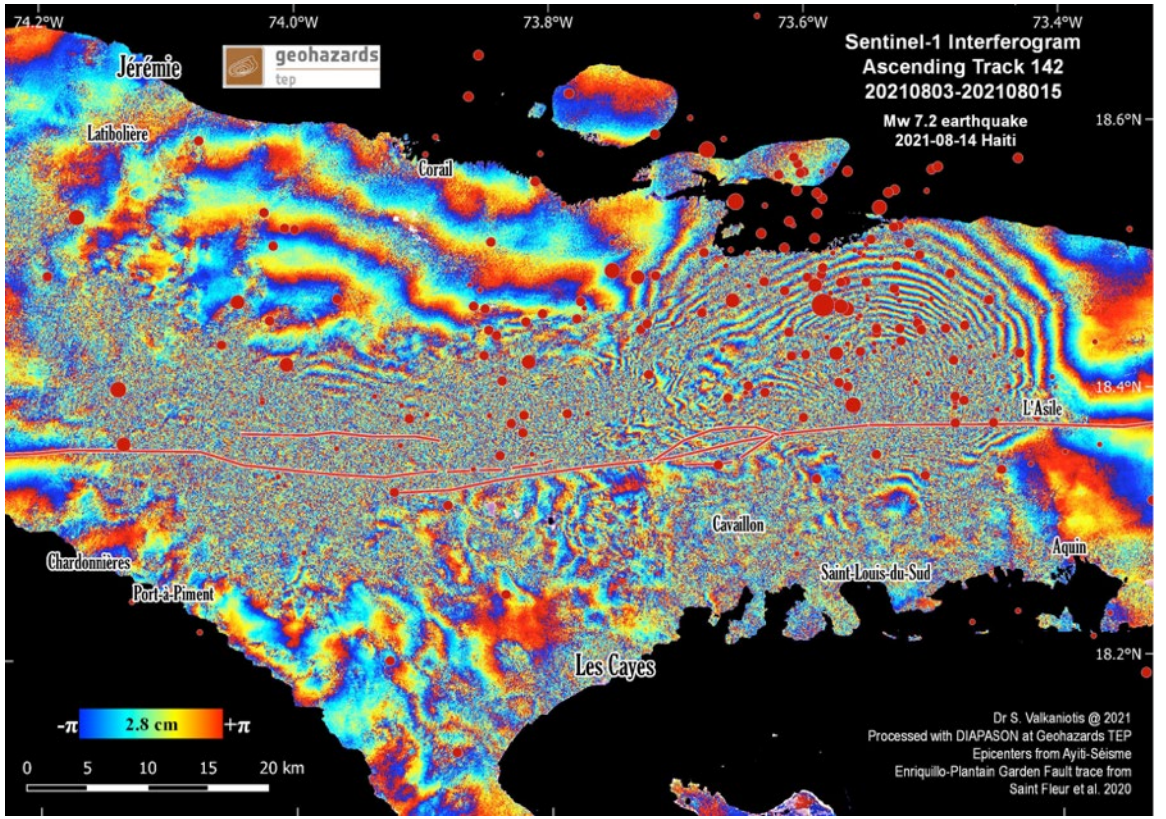
- Routine provision of Sentinel-1 data to operational services and users worldwide
- Sentinel-1 contribution to emergency activations continues to be very high
- Sentinel-1 is operated close to its full mission capacity (i.e. difficult to accommodate additional observations)

Sentinel-1 Mission Evolution (part of…)

- Preparation of the concept of "in-orbit standby" of a 3rd satellite
- Possibly, generation of S-1 Analysis Ready Data (ARD) product (Normalised Radar Backscatter - NRB)
  => Strong request from user community
  => Detailed specification on-going, potential operational implementation 2nd half 2023, subject to funding availability

M7.2 earthquake in Haiti, 14 August 2021

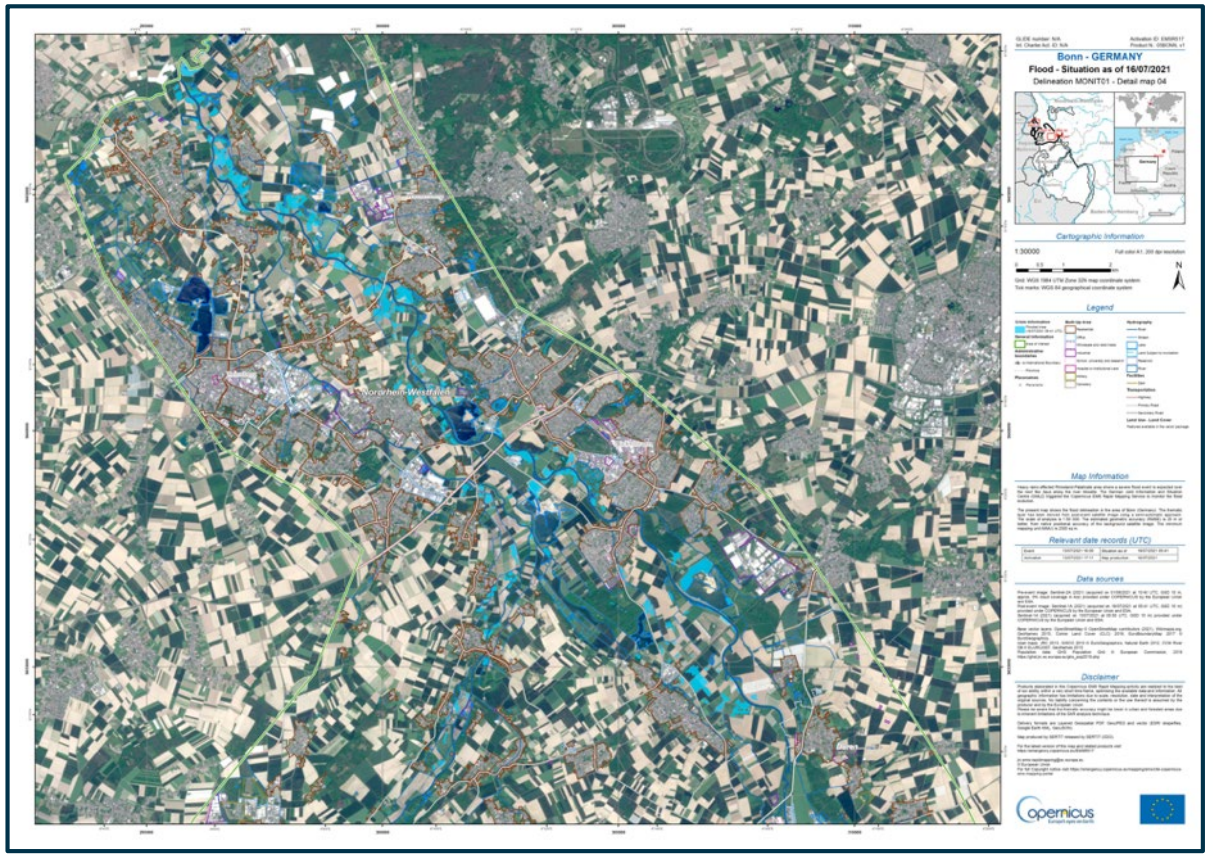
Rupture follows the sinistral Enriquillo-Plantain Garden Fault for ~ 70-80km



Examples of recent Sentinel-1 applications

Major floods in Germany and Belgium in July 2021

Example of flood map based on a Sentinel-1 images acquired on 15 and 16 July, area of Bonn



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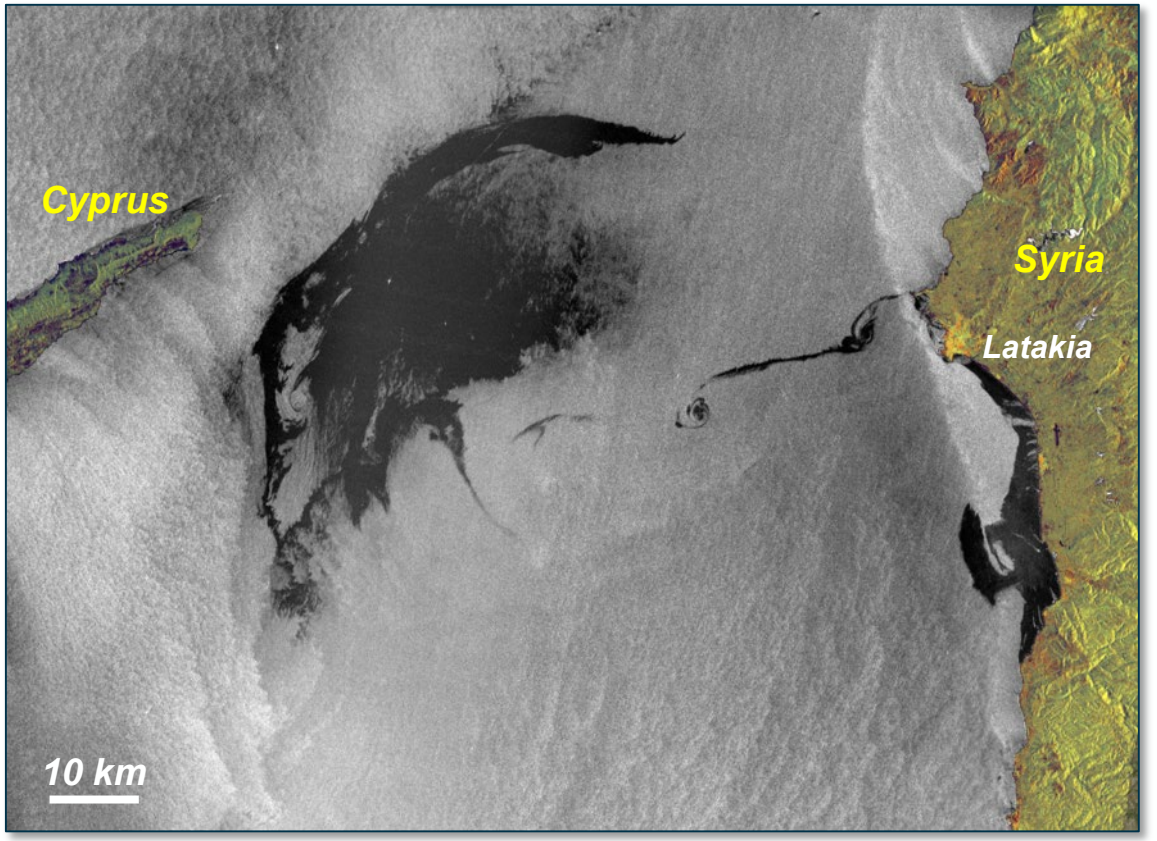
Oil spill in East Mediterranean in August 2021

Oil spill generated by a leak in a fuel tank of the Baniyas power plant on the Syrian coast (S1 image of 30 August 2021

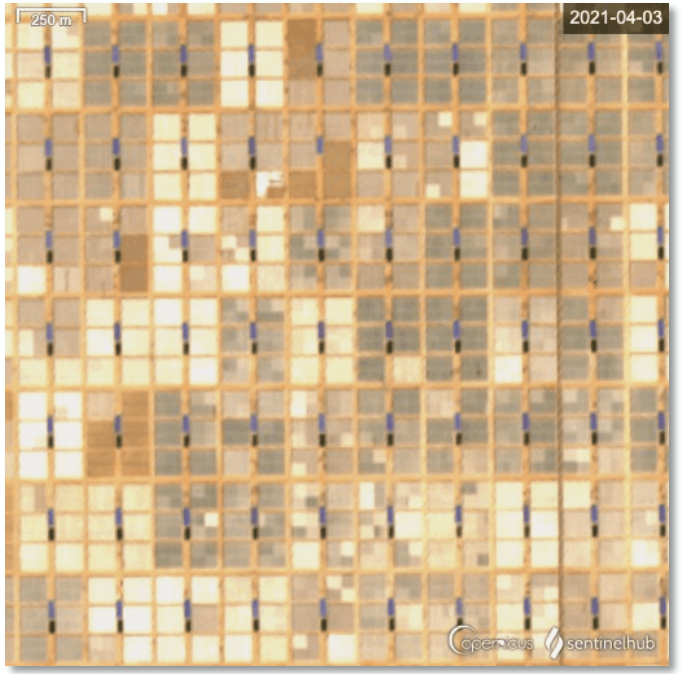


Copyright: Contains modified Copernicus Sentinel data (2021) / processed by Visioterra

Sentinel-2 Mission Status Highlights

- ✓ Sentinel-2 is being operated nominally implementing the Sentinel High-Level Operations Plan (HLOP).
- ✓ The geometric refinement of products has been deployed worldwide, improving the multi-temporal registration and absolute geolocation accuracies of Level-1C and Level-2A products.
- ✓ Copernicus DEM is being used for the orthorectification of products.
- ✓ New pilot products (Level-2H and Level-2F) harmonizing and fusing Sentinel-2 and Landsat-8/9 products. Processor available here:

  https://github.com/senbox-org/sen2like
- ✓ Top European EO mission (e.g. in terms of scientific peer-reviewed publications and data volume distributed).



Sentinel-2 images of greenhouses in Egypt's former desert

Mission Outlook (up to 2022)

✧ Sentinel-2 archive reprocessing to generate Collection-1 to start in Q1 2022 (pending EC approval).

✧ Major upgrade of Level-1C and Level-2A products featuring several improvements in the algorithms and modifying elements of the products format. Transfer to operations planned on 15 November 2021.

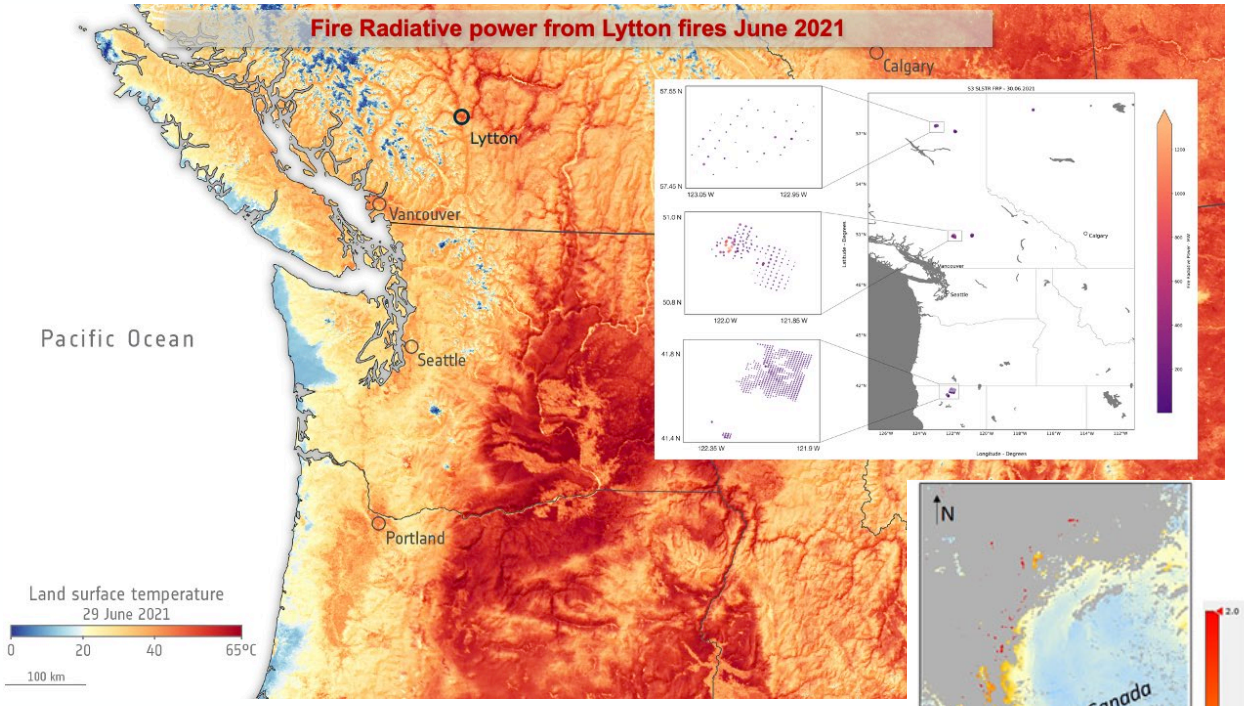
✧ Further expansion of the Observation Scenario as defined in the HLOP, considering requests received from Copernicus Services and Member States (feasibility analysis currently on-going).

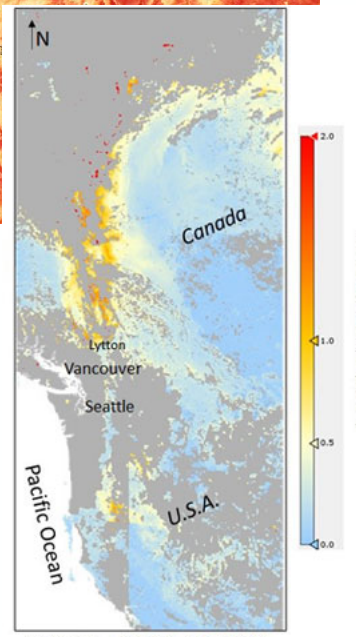
✧ Generation of Level-2H and Level-2F products (harmonizing/fusing S2 and Landsat) pilot productions for evaluation by users.

✧ Distribution of Sentinel-2 GRI (Global Reference Image) as a free & open product by mid-2022.

Sentinel-3 Mission Status Highlights

- The Sentinel-3 mission is overall in a very good shape
- All Sentinel-3A and -3B Level 1 and Level 2 core data products are operationally released to the user community and made available via the regular Data Hubs
- The SYN-AOD and the Fire Radiative Power (FRP) products are made available through the regular Data Hubs since 8th of April and 19th August 2021
- Reprocessing of Sentinel-3A SLSTR is completed, and the data will be distributed through the hubs Q4 2021. Corresponding products from Sentinel-3B already released.
- FRP file format update planned for end 2021. Sample products to be released by MPC in Q4 2021
- Split of SRAL L1b into thematic products ongoing. Release spring 2022



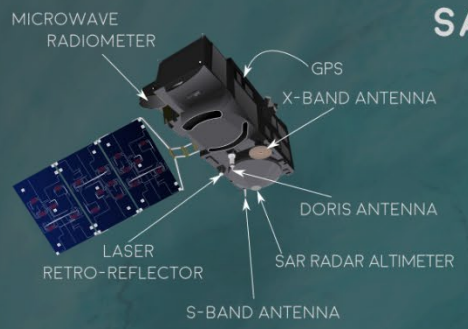


S3B_SY_AOD 01 July 2021

Land surface temperature, Fire radiative power and Aerosol optical depth from the heatwave and fires in Canada in June 2021.
Copyright: Contains modified Copernicus Sentinel data (2021)/processed by ESA

SENTINEL-3 ALTIMETRY CRYOSPHERE PRODUCTS

SATELLITE DESCRIPTION



ALTITUDE: **814.5 KM**

INCLINATION: **98.65°**

GROUND TRACK DEVIATION: **+/- 1KM**

REVISIT TIME: **27 DAYS**

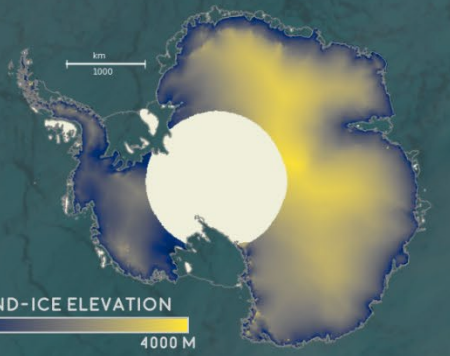
KU-BAND: **13.595 GHz - BANDWIDTH 350 MHz**

DATA AVAILABLE SINCE **2016** (S3A) AND **2018** (S3B)

LEVEL-2 THEMATIC LAND-ICE PRODUCTS

* Data products in netCDF4 format at 20Hz.
* TDPs are expected to be delivered by Q4 2021.
* **180 MB*** in size per pass for land-ice
* They contain the main geophysical variables:
  - **Ice surface elevation**
  - **Surface backscatter (roughness)**

* Product size to be confirmed



PERFORMANCE OF SENTINEL-3 ALTIMETER OVER LAND AND SEA ICE

SARM vs LRM: The Sentinel-3 improved along-track resolution (approximately 300m) in SAR mode improves the measurements over land ice and sea ice.

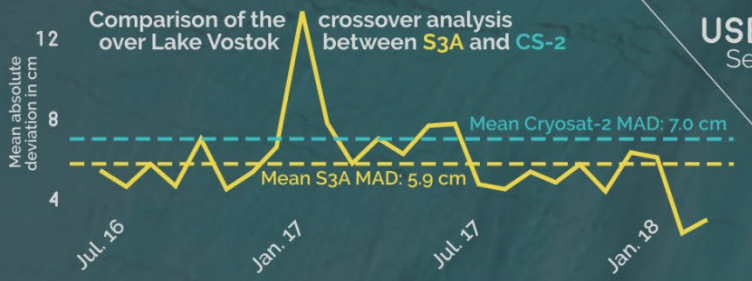
95% OF RETRACKABLE WAVEFORMS ARE AVAILABLE OVER ANTARCTICA

ICE SHEET ELEVATION ACCURACY COMPARED TO GROUND TRUTH FOR FLAT SURFACES **~8 CM**

ICE SHEET ELEVATION ACCURACY AT CROSSOVER LOCATIONS FOR HIGH SLOPE (ICESAT-2) **<50 CM**

PERCENTAGE OF VALID FREEBOARD MEASUREMENTS DURING WINTER **25%**

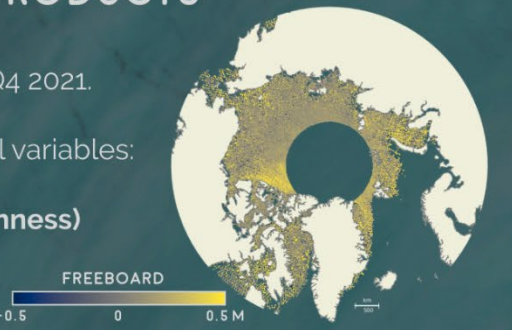
* SIMILAR RESULTS TO CRYOSAT-2



LEVEL-2 THEMATIC SEA-ICE PRODUCTS

* Data products in netCDF4 format at 20Hz.
* TDPs are expected to be delivered by Q4 2021.
* **90 MB*** in size per pass for sea-ice.
* They contain the main geophysical variables:
  - **Freeboard**
  - **Surface backscatter (roughness)**

* Product size to be confirmed



USEFUL LINKS

Sentinel Online: **sentinel.copernicus.eu**

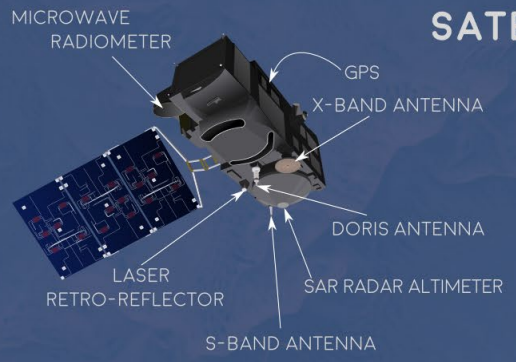
S3 Land Altimetry Product Handbook: **Under preparation**

DATA ACCESS

Scihub: **scihub.copernicus.eu**

ESA DIAS: **copernicus.eu/en/access-data/dias**

SENTINEL-3 ALTIMETRY INLAND WATER PRODUCTS



SATELLITE DESCRIPTION

ALTITUDE: **814.5 KM**

INCLINATION: **98.65°**

GROUND TRACK DEVIATION: **+/- 1KM**

REVISIT TIME: **27 DAYS**

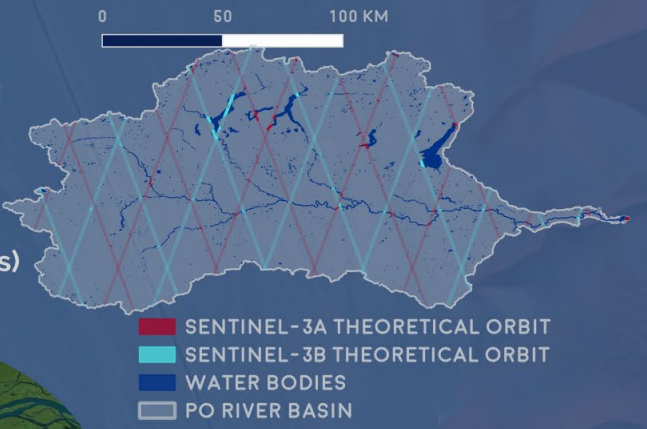
KU-BAND: **13.595 GHz - BANDWIDTH 350 MHz**

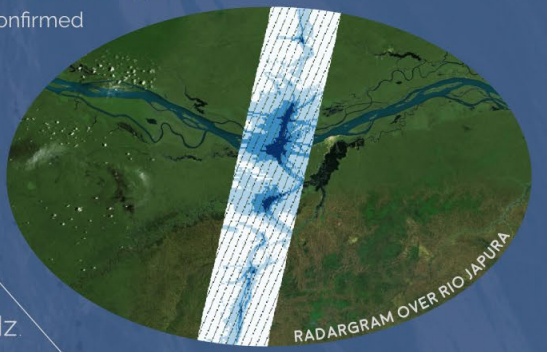
DATA AVAILABLE SINCE **2016** (S3A) AND **2018** (S3B)

LEVEL-2 THEMATIC DATA PRODUCTS

* Data products in netCDF format at 20Hz
* TDPs are expected to be delivered by Q4 2021.
* **225 MB*** in size per pass for inland water.
* They contain the main geophysical variables:
  - **Water level (including all the satellite corrections)**
  - **Surface backscatter (roughness)**

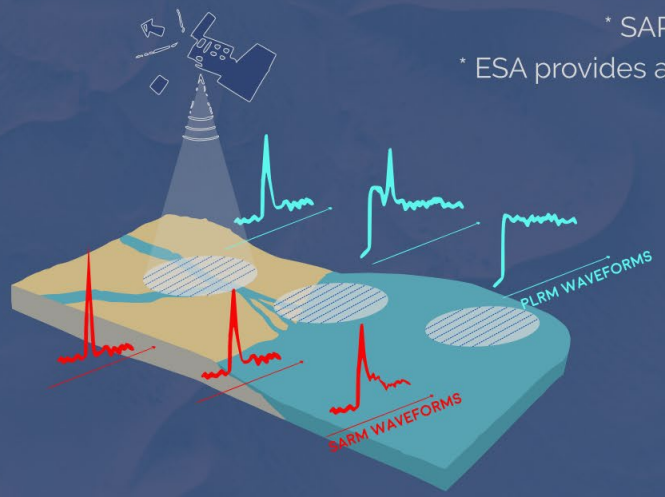
* Product size to be confirmed





PERFORMANCES OF SENTINEL-3 OVER RIVER AND LAKES

* SAR mode improves the measurements over inland water
* ESA provides a processing on demand platform to process data at 80Hz.



RIVER & LAKE DATA QUALITY

10-15 CM OF DISPERSION OBSERVED ALONG A RIVER OR A LAKE CROSSING

LAKE WATER HEIGHT ACCURACY COMPARED TO GROUND TRUTH

< 3 CM

80% OF RETRACKABLE WAVEFORMS ARE AVAILABLE OVER THE LARGE LAKES

DEFINE YOUR TARGET ONLINE

You can define your targets over inland water

https://www.altimetry-hydro.eu/

USEFUL LINKS

Sentinel Online: **sentinel.copernicus.eu**

S3 Land Altimetry Product Handbook: **Under preparation**

DATA ACCESS

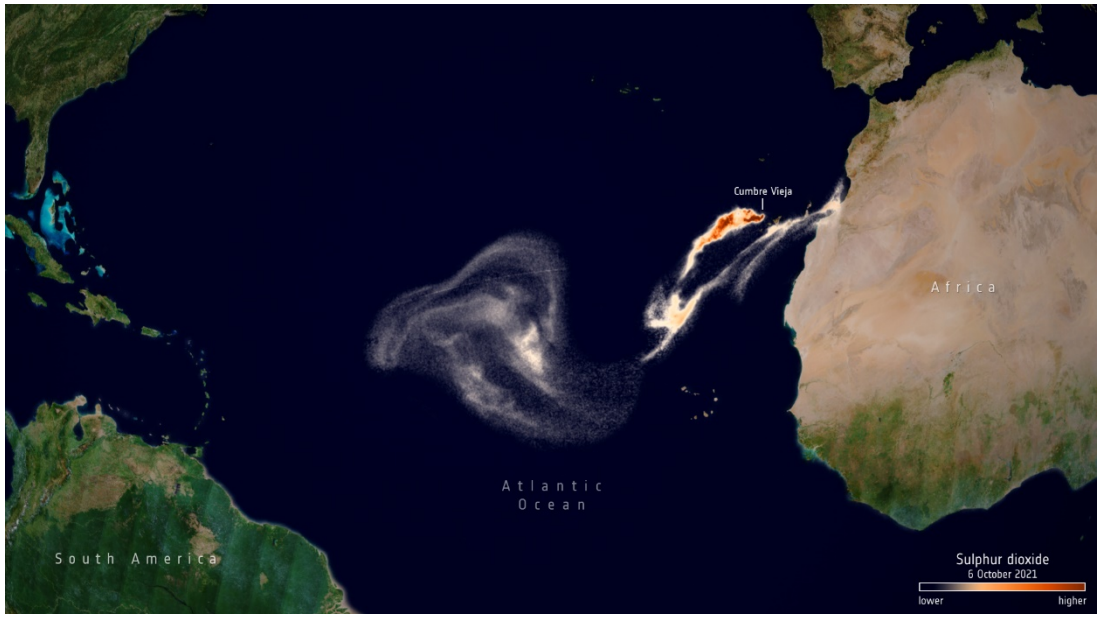
Scihub: **scihub.copernicus.eu**

ESA DIAS: **copernicus.eu/en/access-data/dias**

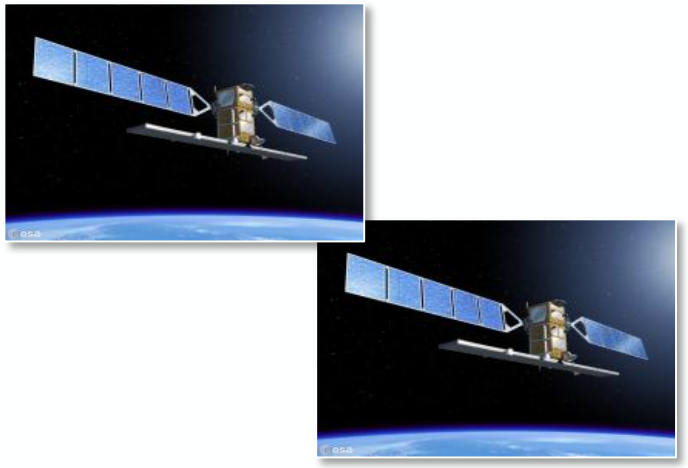
→ THE EUROPEAN SPACE AGENCY

Sentinel-5P Mission Status Highlights

- The mission is in routine operations phase since 05 March 2019.
- The products Level 1B Radiance/Irradiance, Methane, trop. Ozone (Offline); Aerosol Absorbing Index, Aerosol Layer Height, Carbon Monoxide, Formaldehyde, Nitrogen Dioxide, Sulphur Dioxide, Total Ozone, and Cloud products (Offline and NRT) are available to the public via the Copernicus Sentinel-5 Precursor Data Hub – s5phub.copernicus.eu.
- During early July a new Sentinel-5P Level 1 product version (that takes into account an offset in the low UV wavelength range and corrects for degradation in Irradiance measurements) was successfully implemented into the ground-segment (including also upgrades of all Level 2 products).
- Currently the public release of the Sentinel-5P Ozone Profile product and an improved Methane product (providing also measurements over the sea) is being prepared. The release is planned during Nov. 2021



Sentinel-5P Sulphur Dioxide concentrations on 6 October 2021 emitted by the Cumbre Vieja volcano – Kanary Island of La Palma



Thank you for your attention

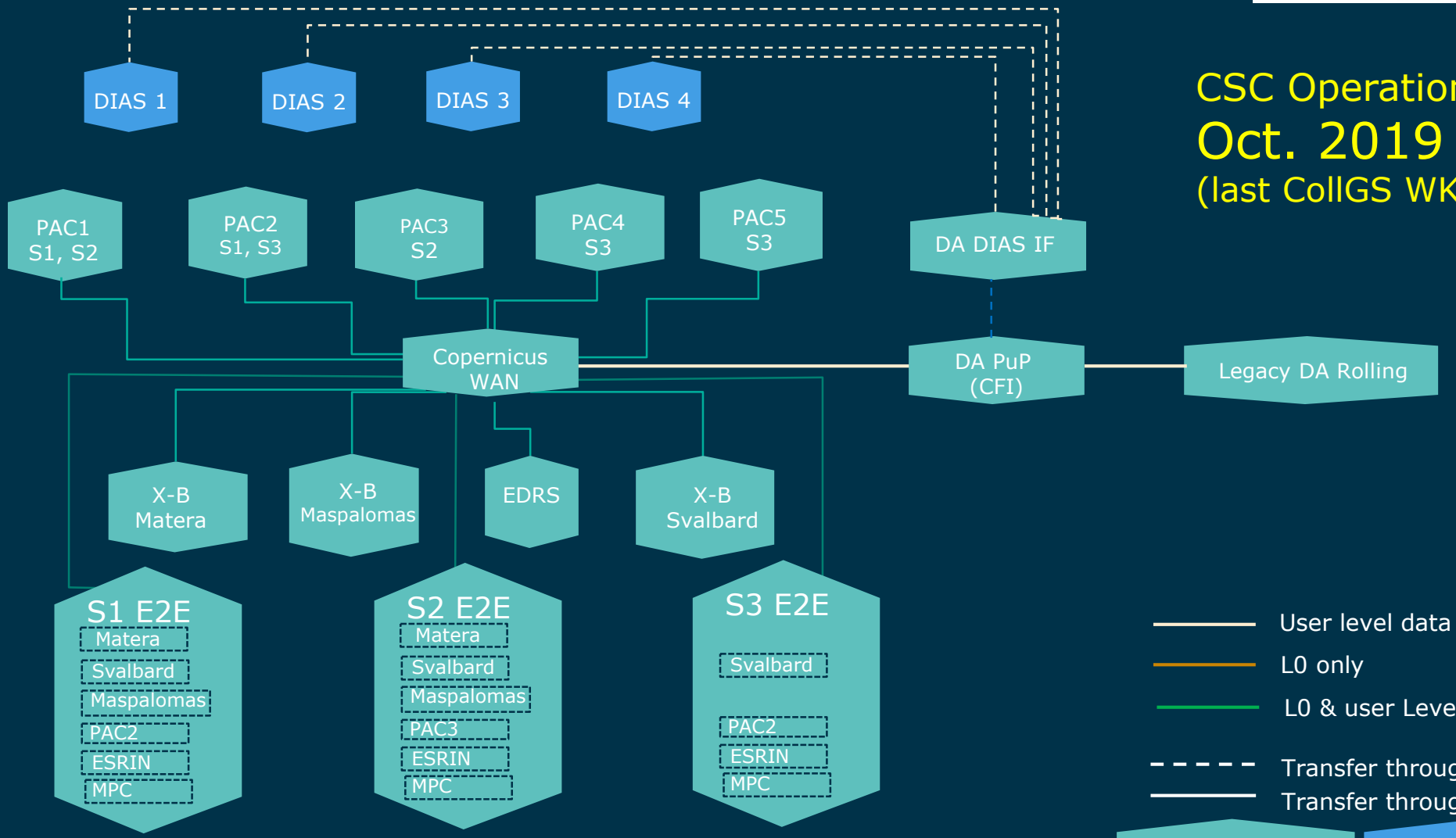
CSC Operations – ESA Framework

ESA Ground Segment Transformation Status

Collaborative Ground Segment Workshop

18-19 October 2021

Transforming…yes…but what?



CSC Operations context
Oct. 2019
(last CollGS WKS)

User level data
L0 only
L0 & user Level & Engineering level
Transfer through Internet
Transfer through Copernicus WAN

Legacy system and interfaces
New operations with internet access

Transforming…yes…but why?

2019: Highly successful Copernicus Ground Segment operations in place and smoothly deliverying top quality routine operations

…but….suitability for the future challenges is at stake…

Complex adaptation and long lead time for evolutions

Risk of operations sustainability with increasing data volume and user demand

Lack of flexibility to quickly and efficiently adapt to evolving user scenarios

Dedicated infrastructure and closed network connectivity

Risk of industrial /technical lock-in

Highly coupled interfaces & interdependent service operations

Transforming…yes…but for what?

Ensure competitive, cost effective, robust and flexible CSC Ground Segment operations capable to answer ever increasing challenges in user demand, data volumes and Copernicus programme ambitions

Rationalise archive volume growth for user level data while ensuring access to all mission data

Favour service approach and industrial competition

Prevent industrial and technical lock-in

Transforming…yes…but how?

Maximisation of the use of "standard services"

Gradual migration of operations to public cloud environment(s)

Minimise services inter-dependencies and disentangle services interfaces

Minimise data transfer and use public internet / GÉANT

Profit from the natural end of original service contracts to gradually implement the transition

Streamlining and harmonisation of interfaces

Transforming…yes…but were are we?

Transformation – Transition phase

Initial CSC Operations Phase

Operations in line with initial design & implementation drivers

7 new satellites in launched and reached steady routine operations

Transition Phase

Routine CSC Operations continuation

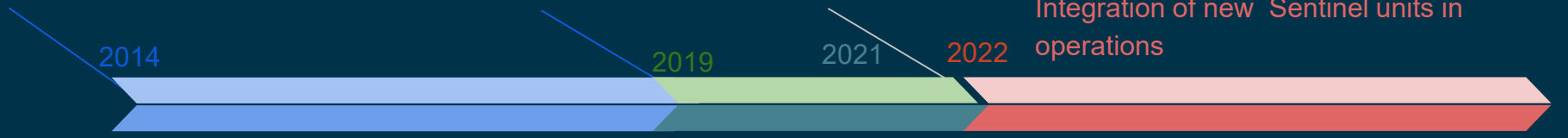
Gradual implementation of new scenario: target is to reach the new operations configuration by end 2021

CSC Operations beyond 2021

Routine Operations in line with target scenario

Continuation of Operational consolidation and evolutions for specific scenario in place

Integration of new Sentinel units in operations



2019-2021: transition phase

Implementation of the new scenario while maintaining the overall system under nominal operational conditions

Transformation – Fulfilling the planned roadmap

Reaching the end of the transformation phase…
& … close to completing the transformation objectives

Preparation of first versions of transformation project documentation baseline

First procurement actions initiated

First documentation baseline issued and 1st Checkpoint kicked-off

2020

- New S1/2/3 **Acquisition Services** procured and integrated in operations
- New S1/2/3 **Archiving Services** procured and integrated in operations
- New S1/2/3 production service procurement initiated
- New Reference System Service procurement initiated
- S1/2/3 legacy PDGS under final steps for cloud migration
- Copernicus WAN under final decommissioning steps
- **New Interfaces** largely implemented

2021

- S1/2/3 legacy PDGS fully operated on **public cloud**(s)
- Copernicus **WAN decommissioning** completed
- New S1/2/3 **production services** procured and integration in progress
- **Reference System** service started
- Processors **re-engineering** started
- **Coordination Desk** service started
- New Data Access in preparation

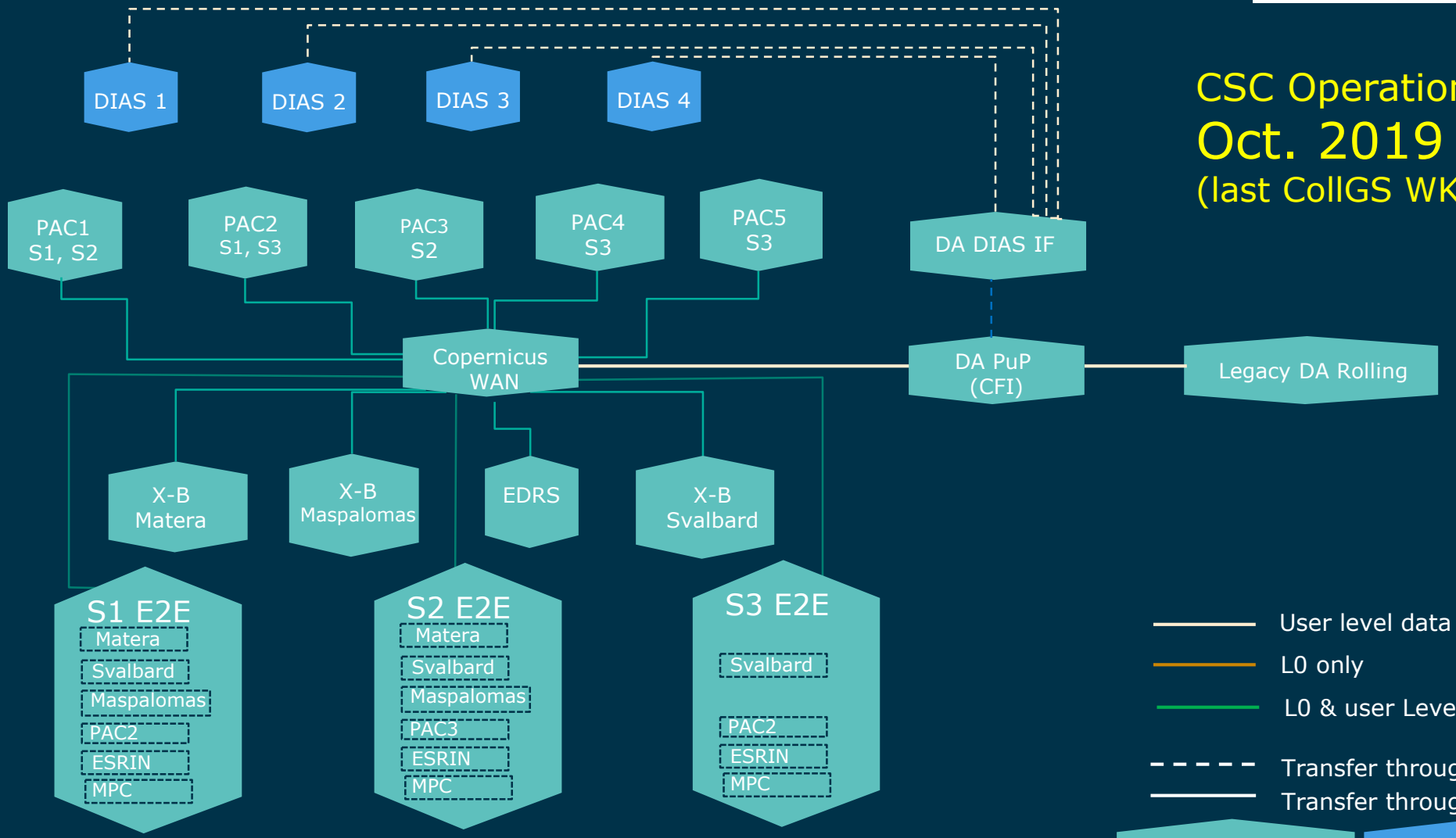
2nd Checkpoint kicked-off

2022

- S1/2/3 legacy PDGS decommissioning
- New S1/2/3 production services in operations
- New **Data Access** in operations

3rd Checkpoint KO planned Q1-2022

Transforming…yes…but what?



CSC Operations context

Oct. 2019

(last CollGS WKS)

User level data

L0 only

L0 & user Level & Engineering level

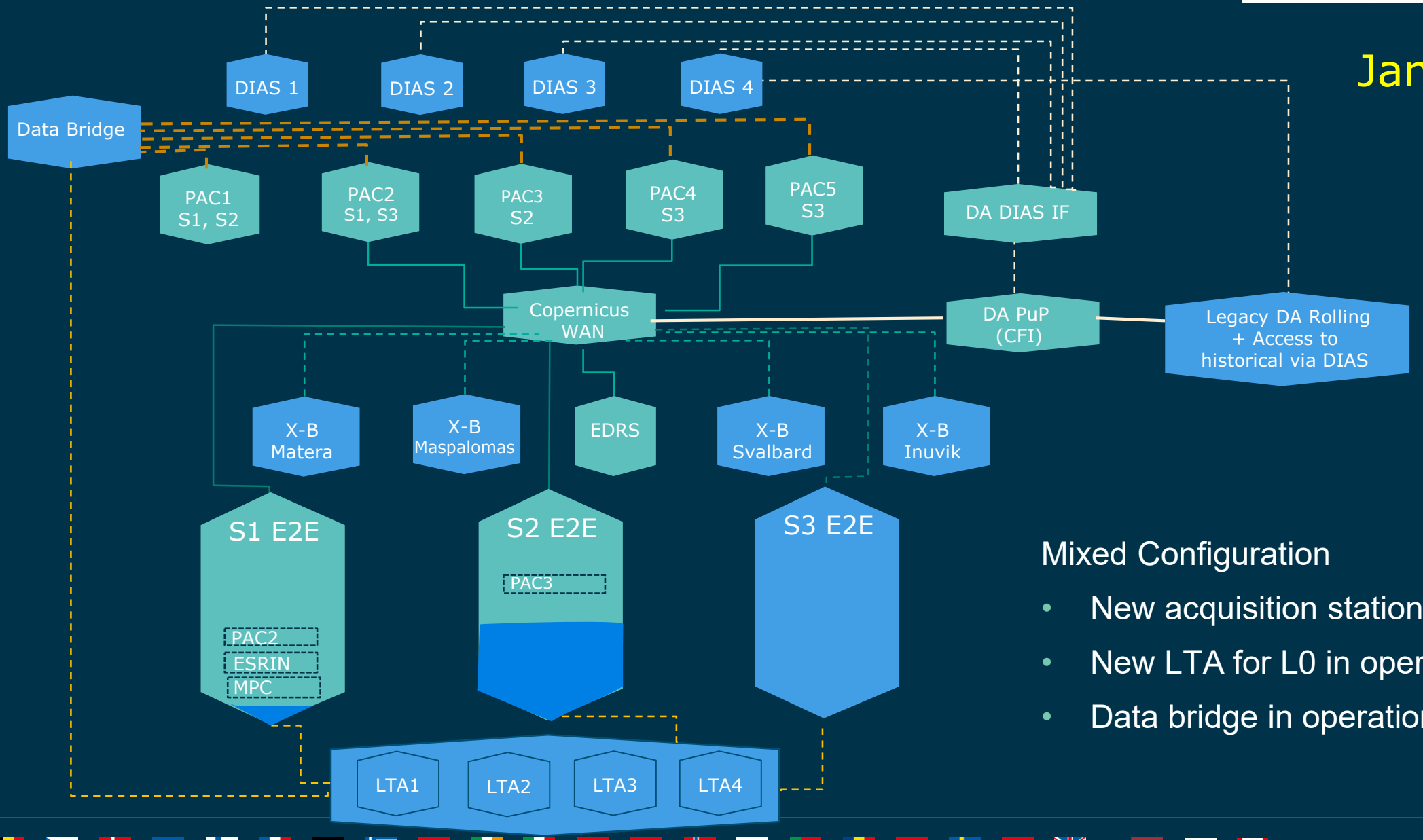
Transfer through Internet

Transfer through Copernicus WAN

Legacy system and interfaces

New operations with internet access

CSC Operations - Transition Phase

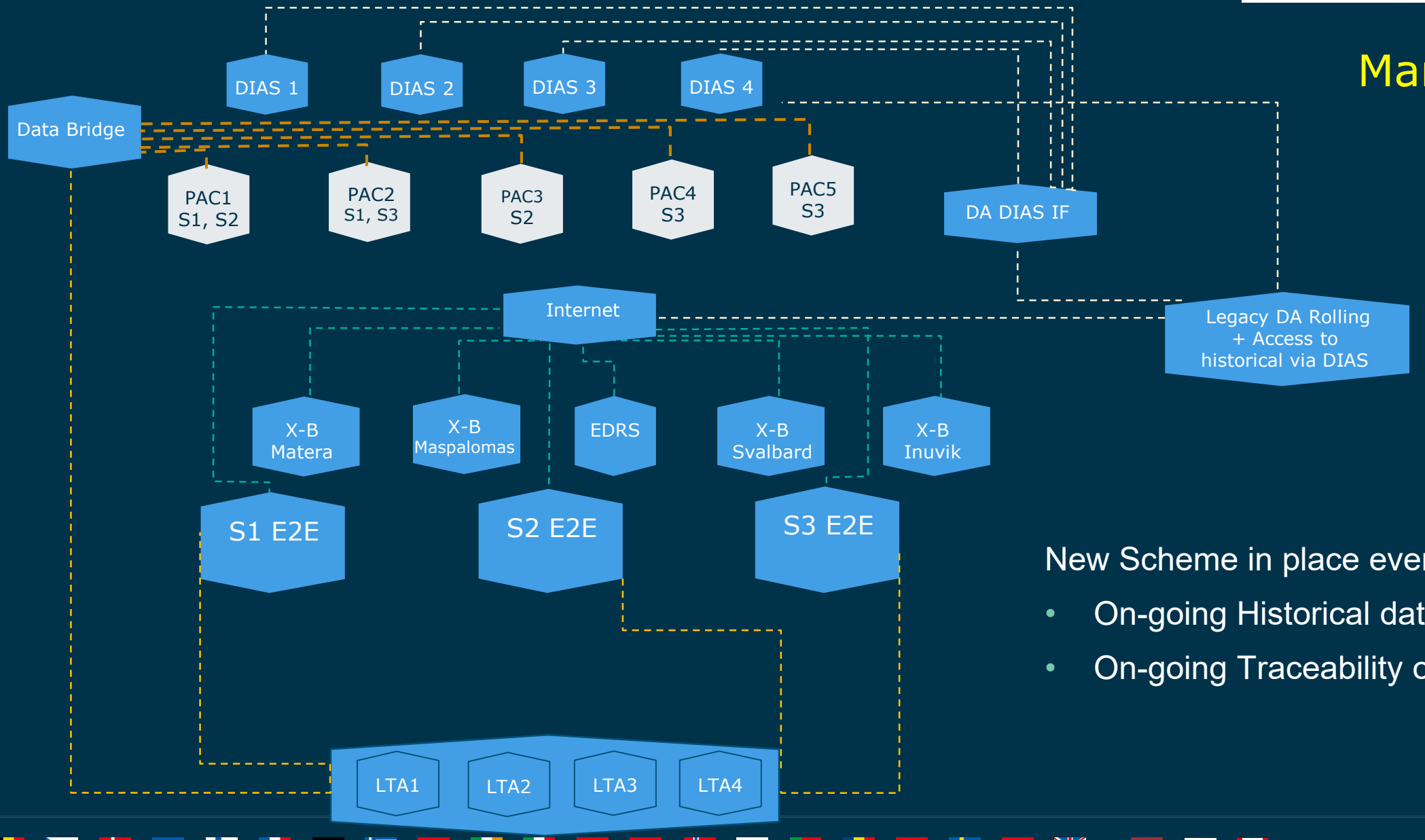


Jan. 2021

Mixed Configuration

- New acquisition stations in operation
- New LTA for L0 in operation
- Data bridge in operation

CSC Operations - Full cloud & Internet context

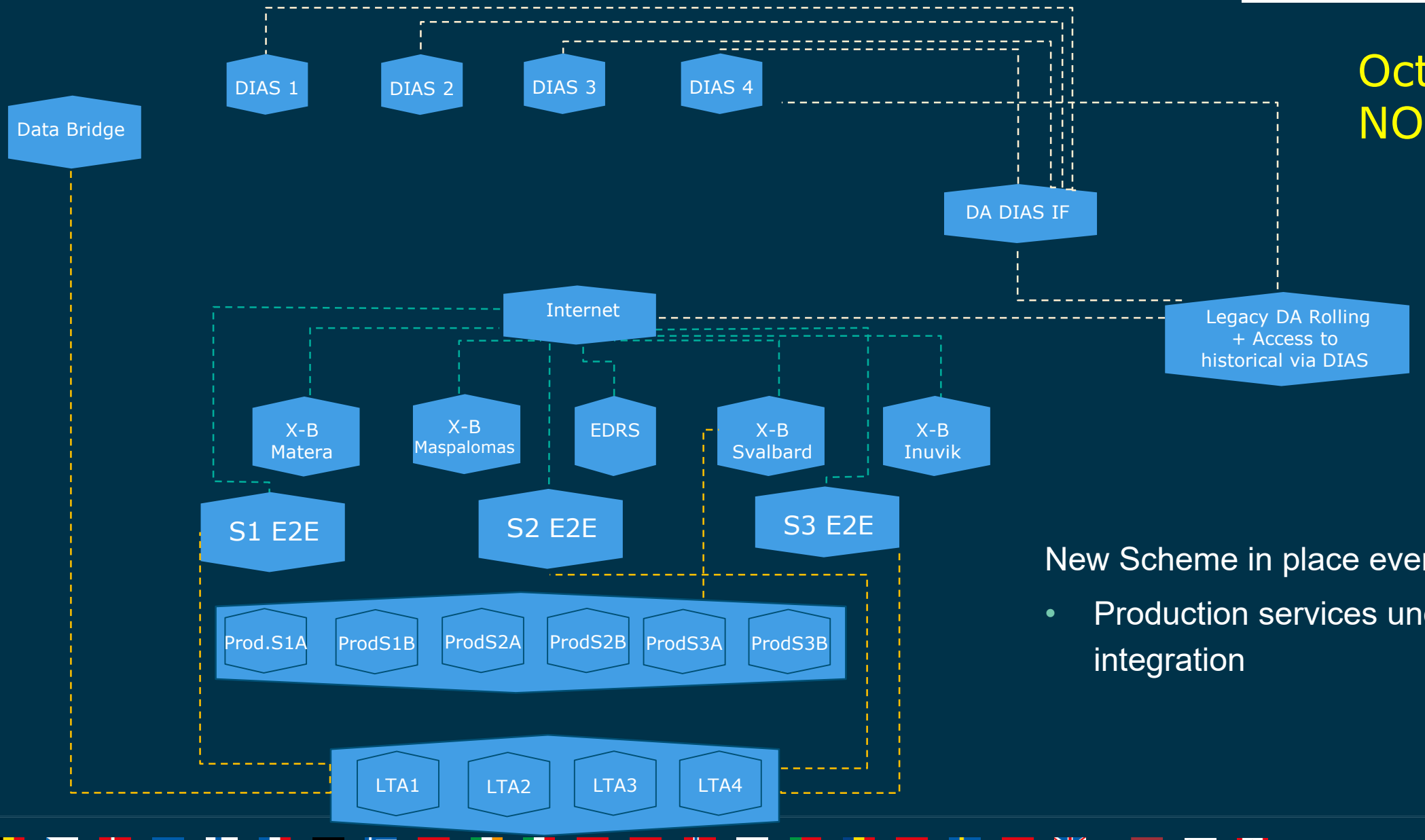


Mar. 2021

New Scheme in place everywhere

- On-going Historical data transfer
- On-going Traceability of all L0

CSC Operations - Full cloud & Internet context

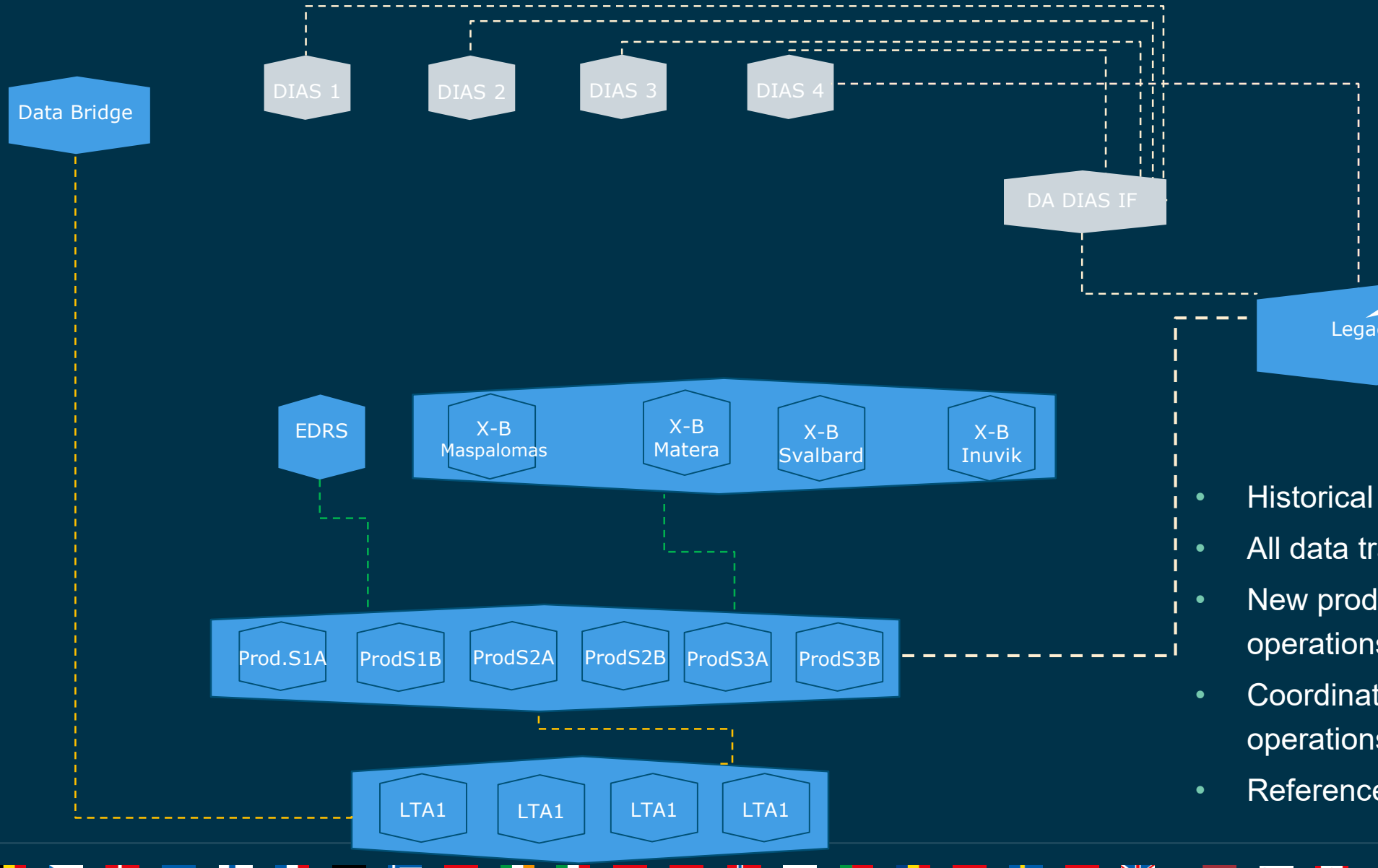


Oct. 2021
NOW

New Scheme in place everywhere

- Production services under integration

CSC Operations – Transformation completion

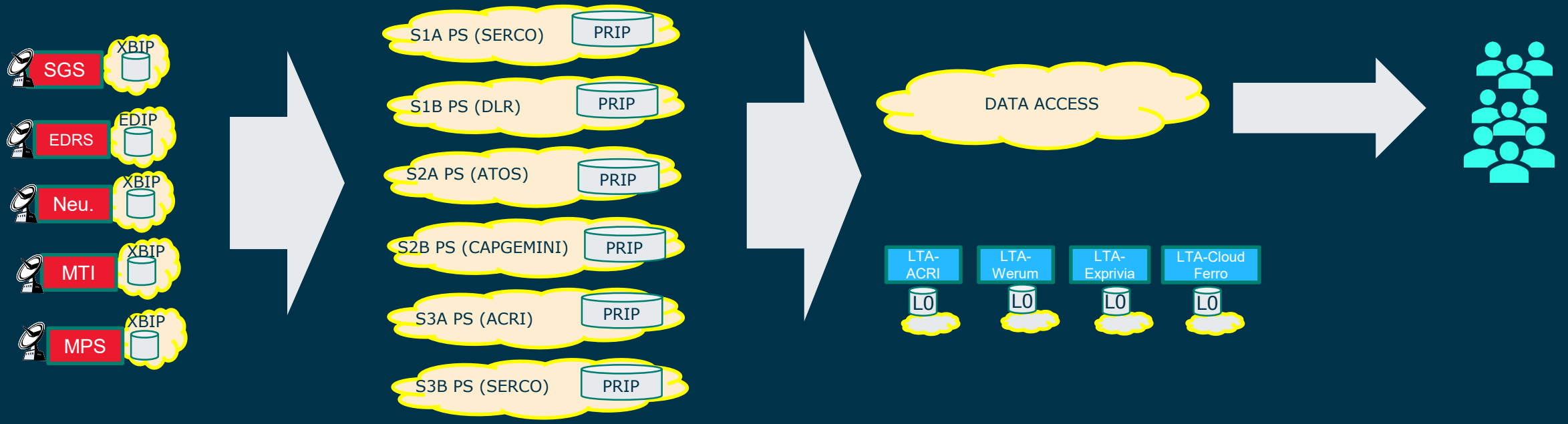


Mar. 2022

New Data Access procurement in preparation – Final element for transformation finalisation

- Historical data transferred
- All data traced
- New production services in routine operations
- Coordination desk service in operations – Dashboard availability
- Reference System in operations

CSC Operations – Transformation layout overview



Mission Planning

Traceability (Proof of Concept) (GAEL Systems)

End to end operations performance, dashboaard and operations coordination (TPZ-IT)

Procesors Re-engineering (CS)

Reference system (ADS)

What's next – short term highlights?

- Sentinel-2 mission data reprocessing – 2022 [pending final authorisation from EC]
- Access to a real time operations status dashboard - 2022
- Availability of an open-source reference solution for the Sentinels production orchestration - 2022
- On-demand production, allowing access to latest version of any data -2022
- A major evolution in data processors
  - A new set of modular and cloud optimised Sentinel data processors planned by end 2023/early 2024
    - Maximisation of open source availability
    - Optimisation of on-demand production

Transformation…yes…what's next?

The result of the transformation sets the basis for a further evolved ESA operation Framework concept

The EOF will consist in a set of standards and services allowing the setup of a decentralised and distributed and yet unified and coherent Ground Segment framework

In particular, ESA plans to:

- Operate newly deployed identity management services across all operations
- Offer open interfaces for end to end integration to MS services as part of the Collaborative activities
- Develop catalogue of services in-line with industrial architecture initiatives (e.g. Gaia-X, IDS, AARC,...)

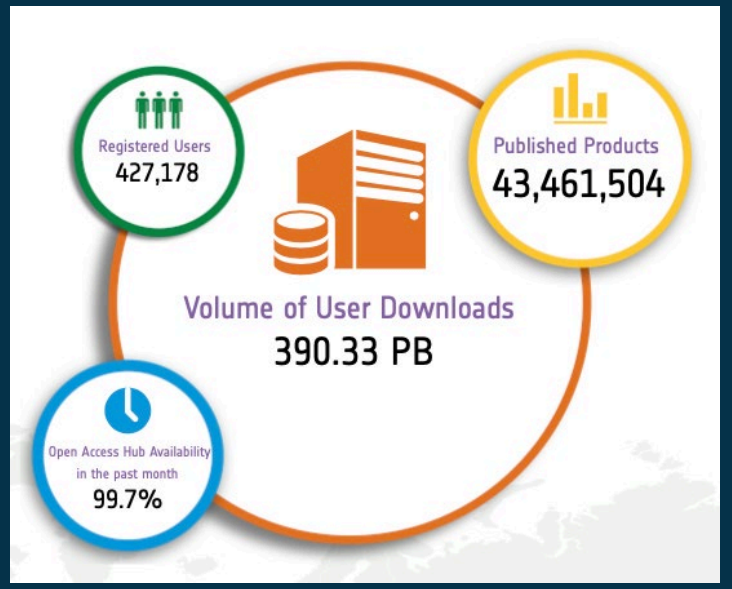
Data Access Status

Jolyon Martin
18 October 2021

Outline

- Data Access Operations Updates
- Data Relay Highlights and Evolution
- Benchmarking Update

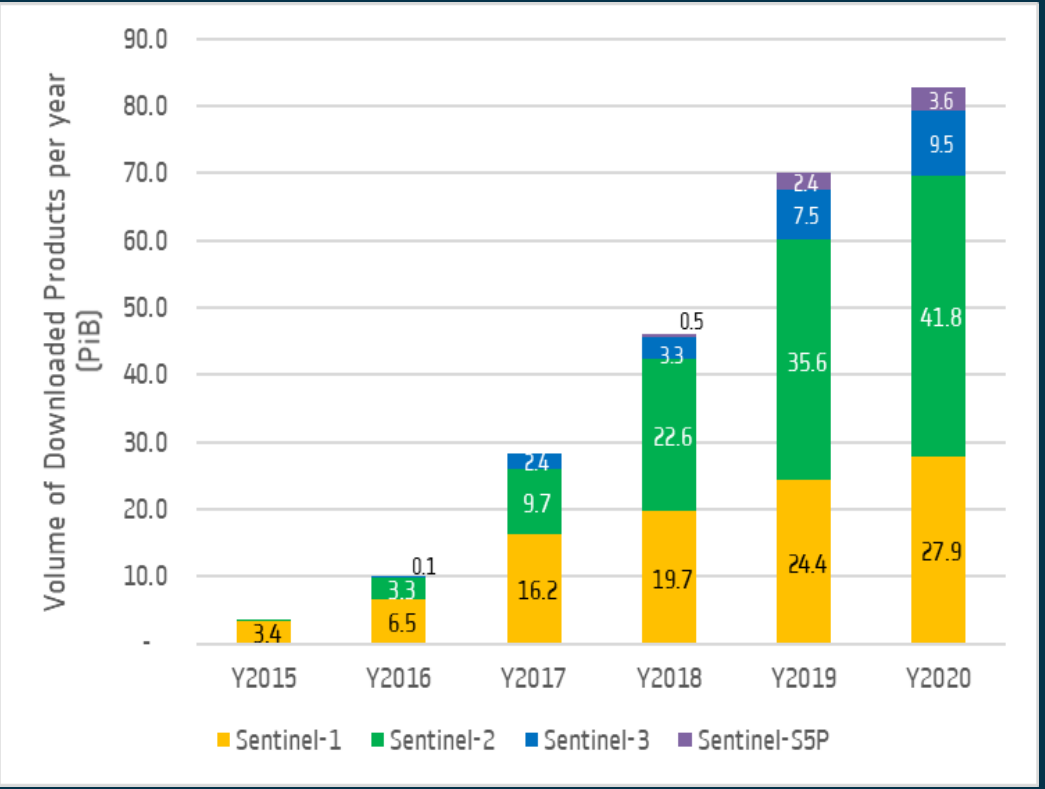
Data Distribution Highlights

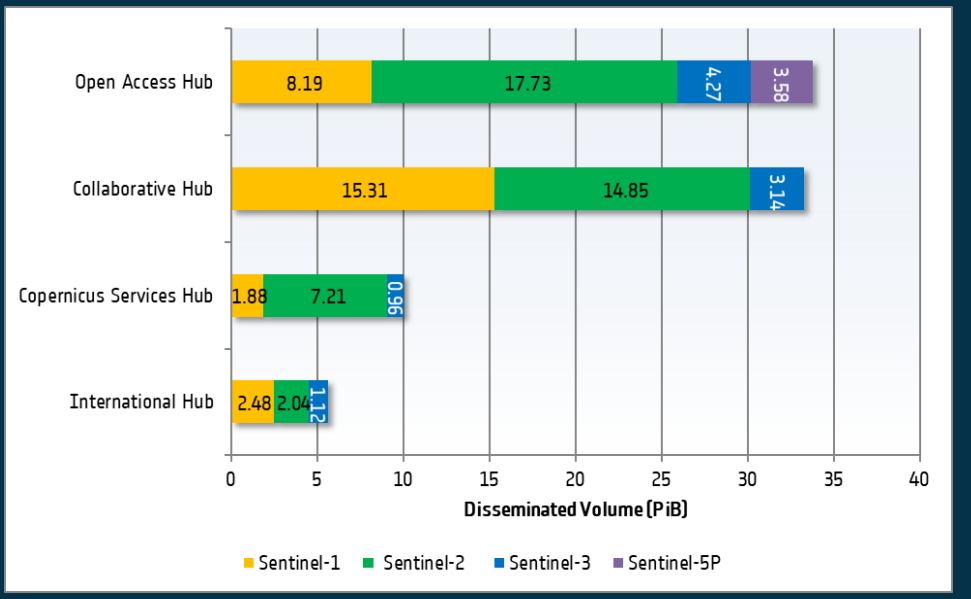


The Copernicus Sentinels Data Distribution - ESA component

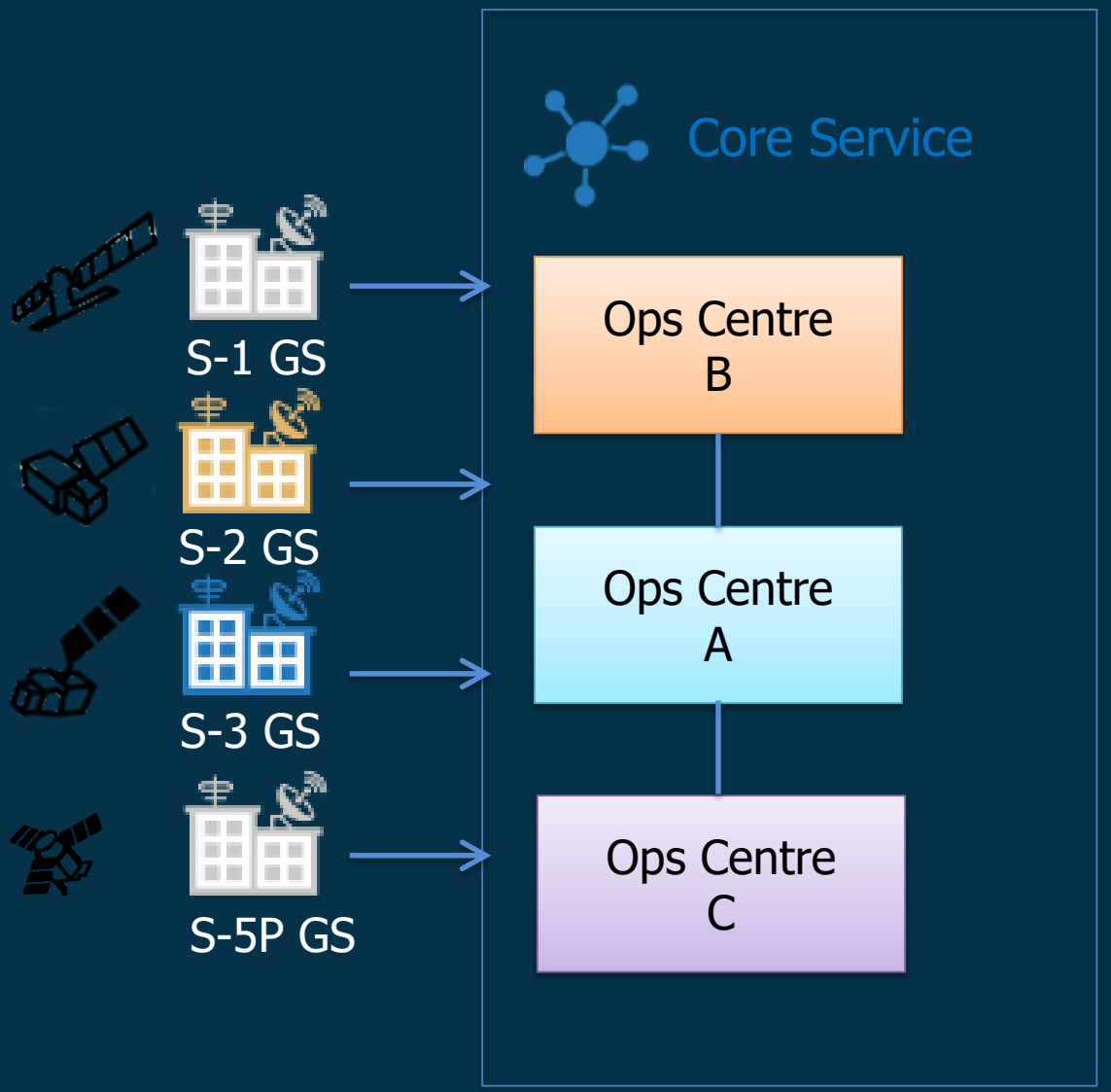
- Publishes ~20 TiB of user level data per day
- Distributes over 300 TiB per day
- With over 400,000 downloads per day
- Manages over 10,000 query requests per minute

Y2020 Dissemination Volumes

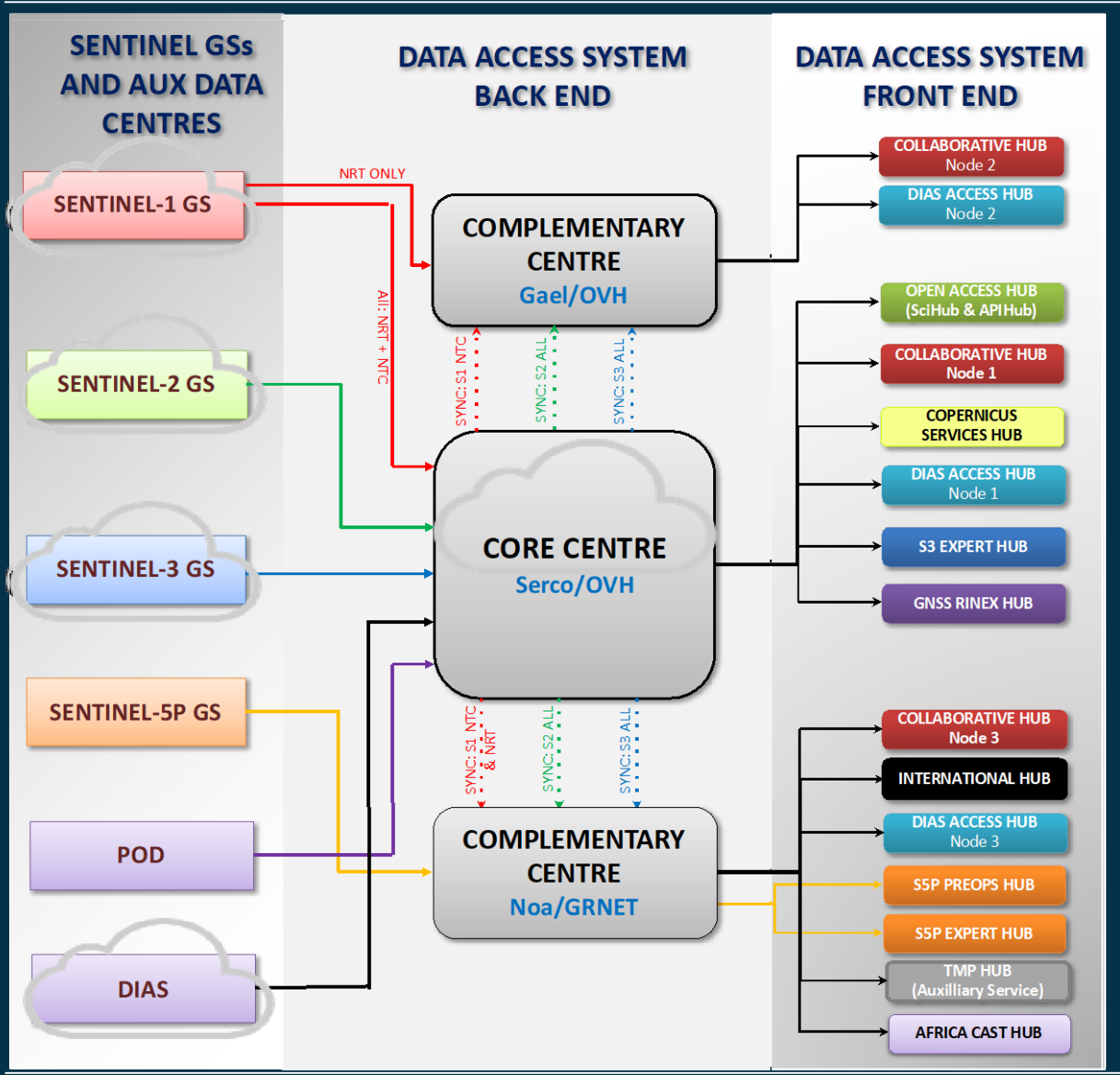




Main Service Scope



Main Evolutions Y2020 – Y2021



Main Evolutions

- Retirement of Mission Specific Long Term Archives
- Historic Data retrieval from DIAS
- Move of GS to cloud
- Retirement of Copernicus Wide Area Network
- Transfer of Core Centre to cloud

Collaborative Service Scope

Collaborative Hub

LATEST NEWS

19 Collaborative GS
8 Data Hub Relays

177,509,761 Products Downloaded
118.09 PB Volume Downloaded

Node1: S1, S2, S3 NTC 1 year
S1 NRT 1 month
S3 NRT/STC 1month
Node2: 2 weeks
Node3 3 weeks

LTA Yes

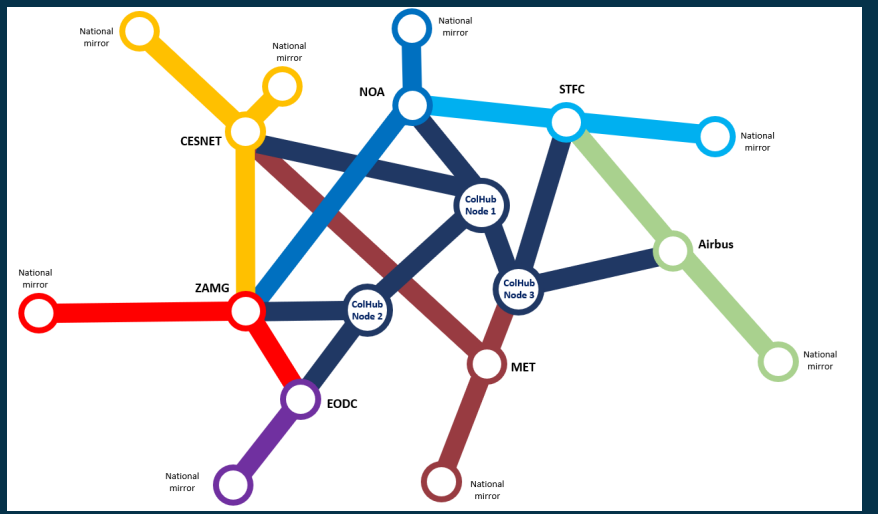
Sentinel-1 NRT & NTC
Sentinel-2
Sentinel-3 OLCI
Sentinel-3 SLSTR
Sentinel-3 SRAL
Sentinel-3 SYN

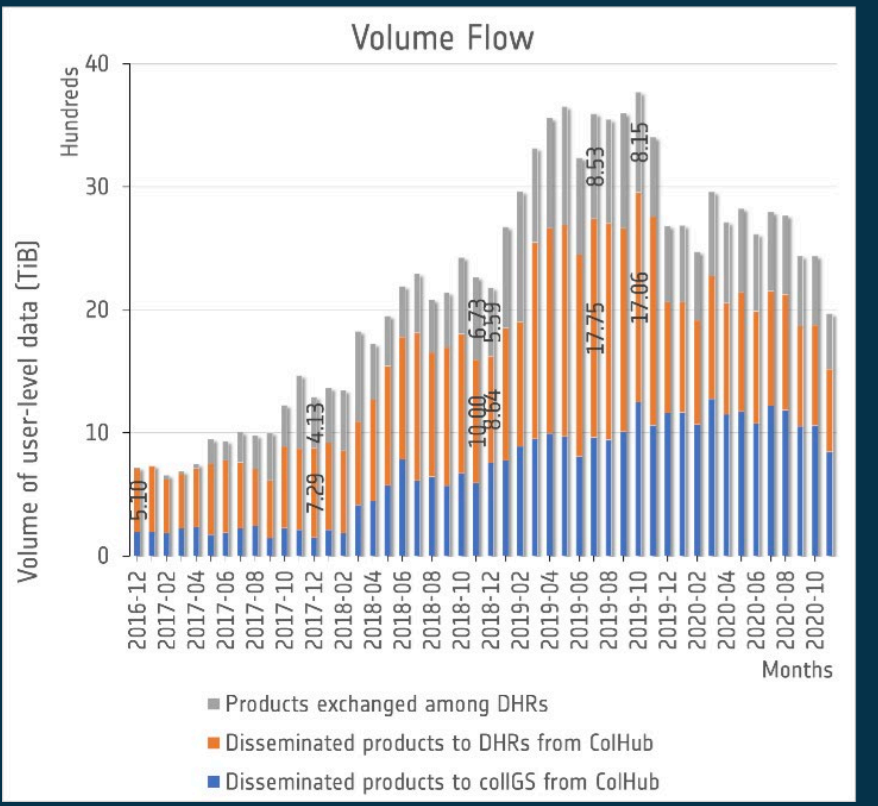
Max 10 concurrent downloads

Data Distribution to Collaborative Ground Segments

- Access to full Sentinel data series (including historic access) via 3 nodes

- Reinforced by network of Relays



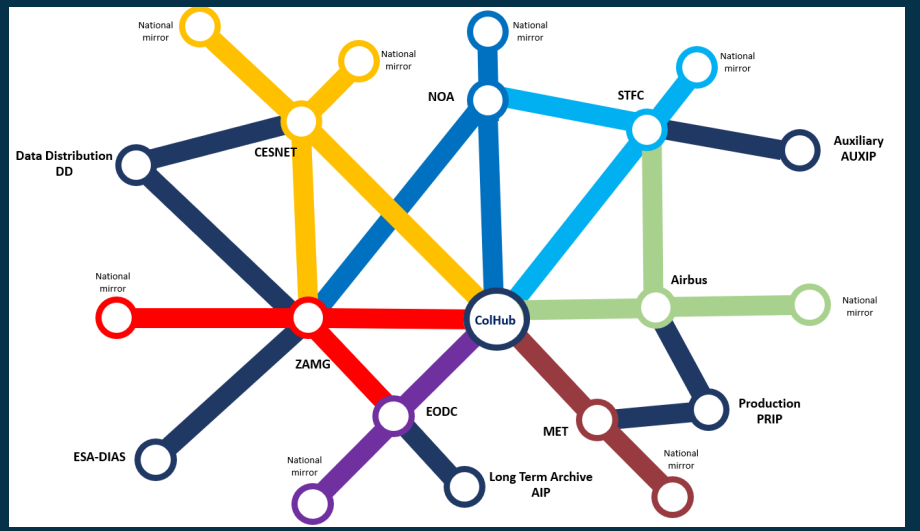


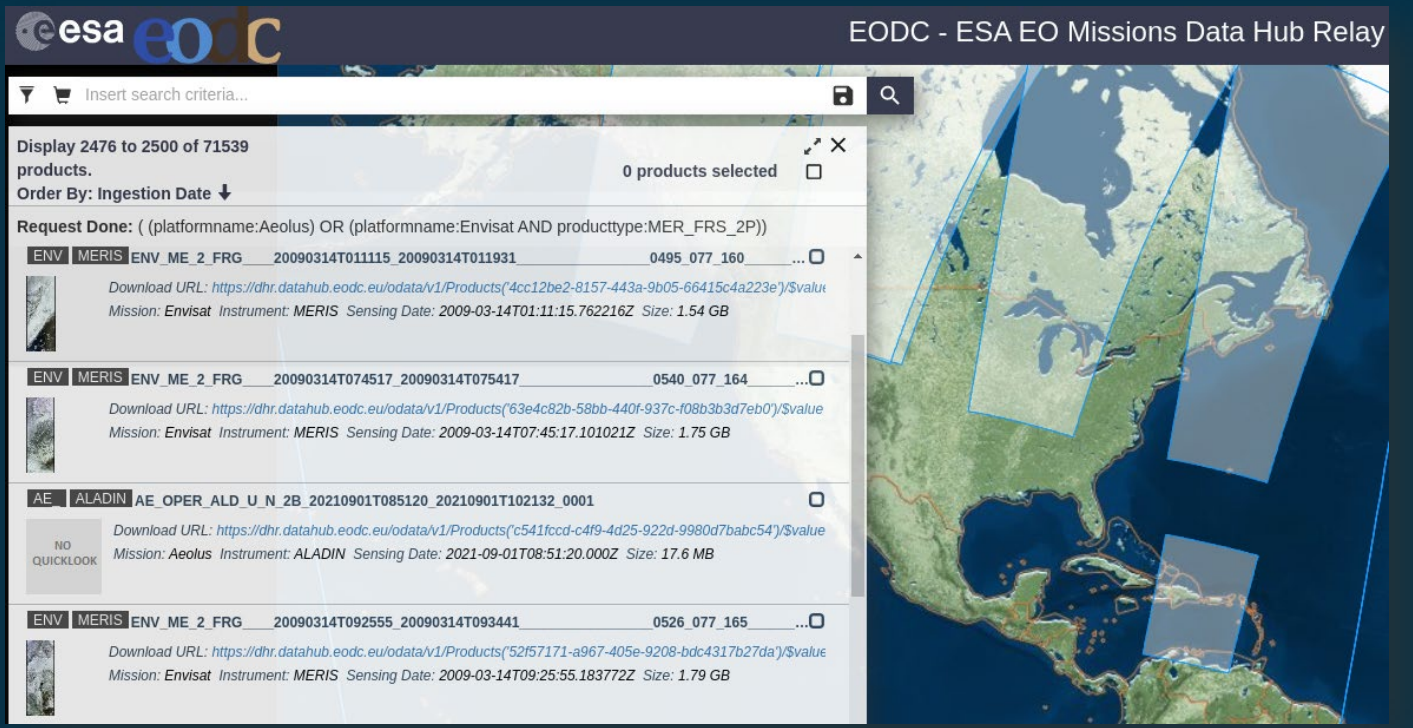
Evolution of the Relay Network

The Data Distribution to Collaborative Ground Segments

- Access to additional data sources for Collaborative Ground Segments (ESA missions, historic S2 Level-0)

- Towards new operations concepts

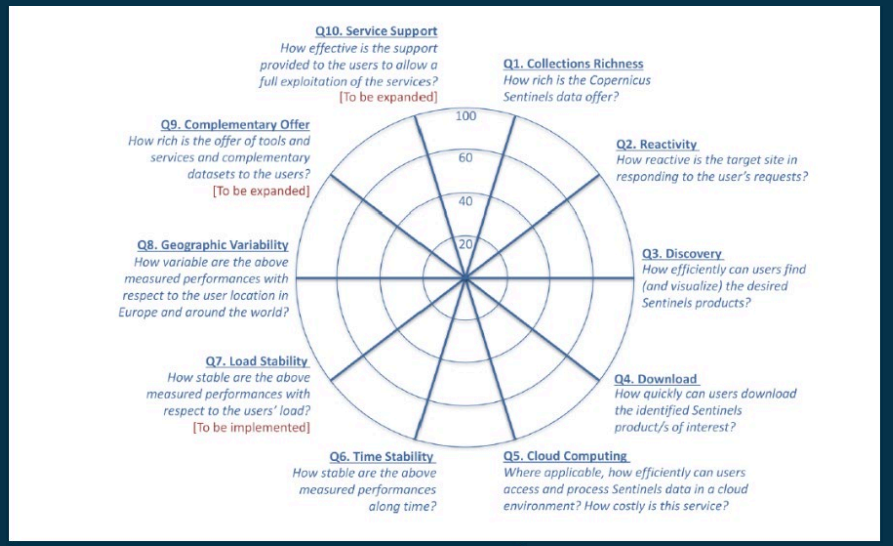


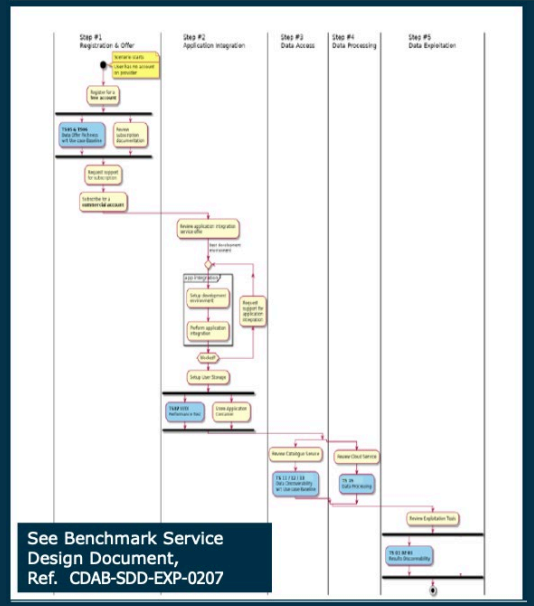


Collaborative Support – Current Topics

- Traceability Framework
- Transformations Framework
- User Management Framework
- Semantic Framework
- Benchmarking

Benchmarking Update





Benchmarking of

- Quality of Experience
- End to End Scenarios

Methodology and process now well established and expanded to include some CollGS target sites, as well as other international initiatives.

Workshop and Checkpoint held 21 Sept. ’21

- Benchmarking successful in providing indicators for improvement and inter-comparison
- Open Source Test Suite available for “Self Benchmarking”

https://github.com/esa-cdab/cdab-testsuite