NSTT Activities - Working Document

V0.0: 24 January 2023

This serves as a working document, to help refine and progress the topics proposed to the New Space Task Team. All members of the NSTT should contribute where possible to refining the topics proposed.

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1. CEOS & New Space White Paper

The objective of the White Paper is to provide a list of key findings & recommendations on the actions that should be undertaken by CEOS entities (working groups, VCs, ad hoc teams) to foster the development of the New Space sector in a neutral manner.

CEOS Group Responsible: New Space Task Team

Description of activity:

The starting point for developing the White Paper is the Think Piece document that further details the framework of the New Space Task Team (NSTT) and that includes a series of questions & topics to be addressed by NSTT in the coming months. Outcomes of the discussions related to the "questions & topics " will be used to develop the "Findings & Recommendations" of the White Paper.

- Reformat the Think Piece document and make it accessible online to allow each NSTT member to provide her/his own thoughts and suggestions for each question & topic listed in the Think Piece document.
- In parallel, the initial list of actions proposed in the present document in the following pages, shall be consolidated.
- The NSTT Lead person together with interested volunteers from the NSTT, will draft the series of Findings and Recommendations using the inputs from the NSTT members, described in the first bullet.
- A draft version of the White Paper will be presented at the 2023 SIT Technical Workshop, and a final version at the 2023 CEOS Plenary for endorsement,
- NSTT members will meet at the occasion of the monthly telcons (TBC) and of the New Space sessions at SIT-38, SIT Technical Workshop and CEOS Plenary.

2. CEOS & New Space Sessions

Organise the New Space sessions at the main 2023 CEOS events (SIT meeting, SIT Technical Workshop and the CEOS Plenary).

CEOS Group Responsible: New Space Task Team

Description of activity:

The two New Space sessions organised in 2022, at the occasion of the SIT-37, the SIT Technical Workshop and the 2023 CEOS PLenary (BIarritrz, France) have aroused a certain interest among CEOS agencies. The intention of the 2022-2023 SIT Chair team is to extend this series of New Space sessions in 2023, starting at SIT-38, then SIT Technical Workshop and finally, at CEOS Plenary.

3. Measures to optimise the availability and usability of public EO programme data

- Coordinated approach to cloud data availability, promotion of CEOS-ARD
- Collaboration on data systems, formats, discoverability

CEOS Group Responsible:

Context and Background:

Description of activity:

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Benefits to New Space:

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Benefits to CEOS:

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4. Calibration / Validation: Facilitating Sensor to Sensor Interoperability by Establishing a CEOS Post-Launch Cal/Val Reference and Increasing the Reliability of Data

The mission of the CEOS **Working Group on Calibration & Validation** (WGCV) is to ensure long-term confidence in the accuracy and quality of Earth Observation data and products and to provide a forum for the exchange of information about calibration and validation, including the coordination of cooperative activities. Of relevance to the New Space topic, the CEOS WGCV can provide support for calibration and validation of instruments, helping to increase confidence in measurements, providing traceability, and ensuring data is fit for purpose. CEOS WGCV aims to provide references for calibration, validation, and data quality, as well as methods and protocols for cal/val, access to tools and expertise for New Space.

The following chapters detail some of the opportunities that exist for WGCV to support the New Space industry.

4.1. Cal/Val References

CEOS Group Responsible: WGCV

CEOS WGCV provides:

- References for radiometric calibration/validation
- References for geometric and image quality calibration/validation
- References for SAR calibration (under development)
- References for thermal missions (under development)
- GHG Sensor calibration resources
- Best practices and references for cal/val

Description of activity:

- A number of sites are qualified as reference sites. CEOS WGCV follows a rigorous metrology approach to characterise these sites as fiducial reference measurements. A fiducial reference measurement (FRM) is defined as:
    - Ideally having ***documented SI traceability*** (e.g. via round-robin characterisation and regular pre-and post-deployment calibration of instruments) using metrology standards and/or community recognised best practices;
    - ***Independent*** of the satellite geophysical retrieval process;
    - Having an ***uncertainty budget*** for all FRM instruments, and derived measurements, is available and maintained;
    - FRM measurement ***protocols, procedures*** and community-wide management practices (measurement, processing, archive, documents, etc.) are defined, published and adhered to by FRM instrument deployments;

- FRM are ***accessible*** to other researchers allowing independent verification of processing systems;
- FRM are ***required*** to determine the on-orbit uncertainty characteristics of satellite geophysical measurements via independent validation activities.

The following reference sites are likely of particular interest to the New Space sector:

- **RadCalNet**: RadCalNet is a CEOS WGCV initiative. RadCalNet is a network of test sites providing, via a common portal, Top Of Atmosphere @ Nadir references with uncertainties in the range of 400 - 2500 nm (10 nm bands) every 30 mins. Test sites have to demonstrate their traceability and uncertainties. RadCalNet processing provides uncertainties for each data point. Several well characterised sensors were used to evaluate RadCalNet sites. SI-traceability allows users to combine data from multiple sites with confidence. There are a large number of possible calibrations that allow evaluation of temporal changes. RadCalNet provides fiducial reference measurements*. As of March 2023, the network is composed of five sites and is being extended to seven sites.*
  - **CEOS WGCV Land Product Validation (LPV)Supersites**: **CEOS WGCV LPV** has defined sites which are referred to as LPV Supersites. These sites: Follow well-established protocols useful for the validation of satellite land products (at least three types) and for radiative transfer modelling approaches. Have active, long-term operations supported by appropriate funding and infrastructural capacity. Are supported by airborne LiDAR and hyperspectral acquisitions (desirable). Were selected primarily from well known and established networks, and several were nominated by each LPV focus area team, and then all sites were evaluated for their suitability by ranking them first based on the availability of data (active site) and their spatial representation. After this, the variables were ranked based on the number of key variables that could be validated with a given site, whether structural information was available, and if atmospheric and other properties were measured.
  - There is an ongoing joint CEOS WGCV IVOS/LPV activity on the two rapidly growing domains, LST and Hyperspectral. This is a relevant activity for New Space. Additionally, Hypernet – a network of hyperspectral equipment that will facilitate the cal/val of hyperspectral instruments**.**
- **References for geometry and image quality calibration/validation**: CEOS WGCV has defined a reference dataset composed of edge images and corresponding MTF curves. Users can access the edge images through the CEOS CalVal Portal (http://calvalportal.ceos.org/). A reference paper associated with the reference dataset can serve as a new tool to either implement or check the MTF measurement that relies on the slanted edge method (see reference publication: ***"Comparison of MTF measurements using edge method: towards reference dataset".***

  CEOS WGCV is also working on reference ground control points for geometry. A step forward is achieved using the Sentinel-2 Reference Image (GRI), which serves as a reference for medium resolution sensors (around 10 m – 50 m resolution).

- **SARCalnet**: There is a demand for well-defined calibration targets for SAR instruments. Fixed targets are used to calibrate data from SAR missions. Traditionally these targets have been defined differently for each SAR mission. There are three main categories of targets
    - Natural Targets,
    - Artificial Passive Targets,
    - Artificial Active Targets

  The CEOS WGCV SAR subgroup is currently in the early stages of formulating SARCalnet - an established network of calibration sites that would ease mission calibration and facilitate collaboration between sensors by offering a network of consistent and open calibration references.

- **TIRCALNET (Thermal InfraRed Calibration Network**): The objective of TIRCALNET– is to provide ToA spectra for thermal infrared calibration/validation as an automated network. There are uncertainties arising from challenges related to site heterogeneity and emissivity estimates, with instrument radiometric uncertainty being less significant. The network requirement is to provide a spectrally sampled brightness temperature at ToA to 0.5K (or ToA radiance).

  The main customers/users for a ToA service are the space agencies including but not limited to NASA, ESA and CNES with their higher resolution future TIR missions, but also for commercial missions in the TIR domain that are being planned. In any case, the requirements being planned by space agencies should also be more than sufficient for commercial missions.

- **GHG Sensor Calibration**: CEOS WGCV provides a methodology of vicarious calibration for various size footprint and off-nadir GHG data as well 14-year annual joint campaign data for cal/val including surface albedo, radiosonde data, XCO2, CH4 by EM27-FTS, and alpha jet vertical profiles. Datasets for analysis include solar irradiance and molecule cross sections. In addition, analytical results from various types of spectrometers: GOSAT FTS, OCO and S5P TROPOMI are also available.

- **Best Practices**: CEOS WGCV provides a set of best practices documents that facilitate cal/val activities and allow comparison of results. The documents are available on the WGCV Cal/Val Portal.
- **Pseudo-Invariant Calibration Site (PICS):** Terrestrial sites used to monitor the long term in-flight radiometric calibration of Earth Observation optical sensors. They have been used intensively by space agencies and New Space for a long time as they are spatially uniform, spectrally stable and invariant with time. A long list of these sites has been identified. They are mostly located in the Sahara desert and Arabian Peninsula. Among these sites, six have been endorsed by CEOS as standard reference sites for the post-launch calibration of space-based optical imaging sensors. Other methods include the use of Deep Convective Clouds or Rayleigh scattering as a standard approach. CEOS WGCV and LPV (Land Product Validation) provide a set of protocols to correctly validate geo-physical and bio-physical products, e.g., *Global Surface Albedo Product Validation Best Practices Protocol* and the LAI / FAPAR protocols.

Benefits to New Space:

The New Space sector can find properly characterised references that can be used to anchor their own observations.. Therefore, they can be compared and used together with other missions and can demonstrate the fitness for purpose of these new data sources. SmallSat/NewSpace missions in general, cannot guarantee the same quality and reliability as CEOS/governmental agencies and the missions, thereby creating scepticism about their data quality in the user community. For Smallsats to become valuable for space science, they must meet the quality requirements set by the science community. SmallSat/NewSpace teams are interested in increasing the reliability of their data while ensuring a fast data delivery and return on investment. WGCV Cal/Val support can help to progress this. Providing such Cal/Val support will reduce their operating costs and add value to their end products. It will enhance their science/application/service capabilities and strengthen their competitiveness. It will also shorten their start-up time and time to market.

Interoperability between satellites/products will facilitate increased opportunities to use these new data sources for global societal benefit applications (agriculture, water use, forest and vegetation monitoring, pollution monitoring, climate, etc.).

Benefits to CEOS:

There are a growing number of public and commercial providers of high resolution space-borne Earth Observation data. Key to using data from these new sources is a good understanding of their characteristics, how they are calibrated, and their quality and technical capabilities. Interoperability between satellites/products will allow increased opportunities for global applications (agriculture, water use, forest and vegetation monitoring, pollution monitoring, climate applications, etc.). The data can be used together only if we can trust its accuracy and characterisation. Therefore, harmonisation in Calibration and Validation approaches is fundamental. The Global Earth Observation System of Systems can work only if quality standards and r*eferences* are put in place.

4.2. Intercomparison of New Space and CEOS datasets

WGCV can provide a:

- Framework for intercomparison exercises
- Match the database for New Space (satellite data + in-situ FRM coincident data) for radiometry and a database of ground control point or reference thumbnails for VHR geometry Cal/Val.

CEOS Group Responsible: WGCV

Description of activity:

CEOS WGCV has started a number of activities aimed at intercomparing algorithms or approaches for Cal/Val. The objective of these activities are to better understand the uncertainties component by comparing different outputs from different approaches and to propose further improvements to the

various algorithms. This comparison framework facilitates the understanding and knowledge of the various products from New Space and space Agencies allowing better harmonisation between missions.

The current intercomparison exercises include:

- ACIX: Atmospheric Correction scheme intercomparison
- CMIX: Cloud Masking scheme intercomparison
- DEMIX: DEM intercomparison and impact on orthorectification process
- BRIX: Intercomparison of Biomass algorithm retrieval
- SRIX4VEG: Intercomparison of Surface reflectance and vegetation parameter retrieval.

CEOS WGCV is also assessing the development of a “Match Up Database for New Space”. It will consist of coincident satellite data together with Fiducial Reference Measurements (FRM) for radiometry, typically over RadCalNet sites.

Benefits to New Space:

The New Space sector can benefit from these intercomparison frameworks by gaining knowledge in algorithms and their uncertainties. A better understanding of differences with existing algorithms will provide opportunities for improvements and confidence in quality and fitness for purpose.

Benefits to CEOS:

Similar to the previous chapter on references, intercomparison frameworks help improve understanding New Space characteristics and quality and therefore facilitate interoperability between satellites/products that allow increased opportunities for global applications. In addition, the participation of New Space in these intercomparison frameworks provides additional information that, in return will help to better understand space agencies’ core products and boost confidence in their quality.

5. Cal/Val Maturity Matrix

In 2030, it is projected that there will be over 8000 commercial satellites with the most explosive growth in the hyperspectral and hybrid sensor domains (source: the US National Geospatial Intelligence Agency). Space agencies identified a need for tools for the systematic evaluation of commercial satellite data to understand how it may be integrated into their programmes. NASA launched the CSDA (Commercial Smallsat Data Acquisition) Project and ESA the EDAP (Earthnet Data Assessment Project) in response. Mission success is dependent upon quality assurance. Evidencing data quality significantly increases the value of datasets. Many aspects of data quality are aimed at facilitating communication to users; In the past few years, CEOS has developed a comprehensive definition of mission quality through Analysis Ready Data (CEOS-ARD), interoperability, Fiducial Reference Measurements (FRM), uncertainty evaluation (e.g. Sentinel-2, Sentinel-3, Landsat 9) and traceability (e.g., CLARREO, TRUTHS, Libra missions). A framework brings together this work to define a combined quality assurance standard. The Cal/Val Maturity Matrix assessment framework is aimed at verifying claimed mission performance and adheres, where applicable, to community best practices to the extent that data is “fit for purpose”.

The assessment is divided into two parts:

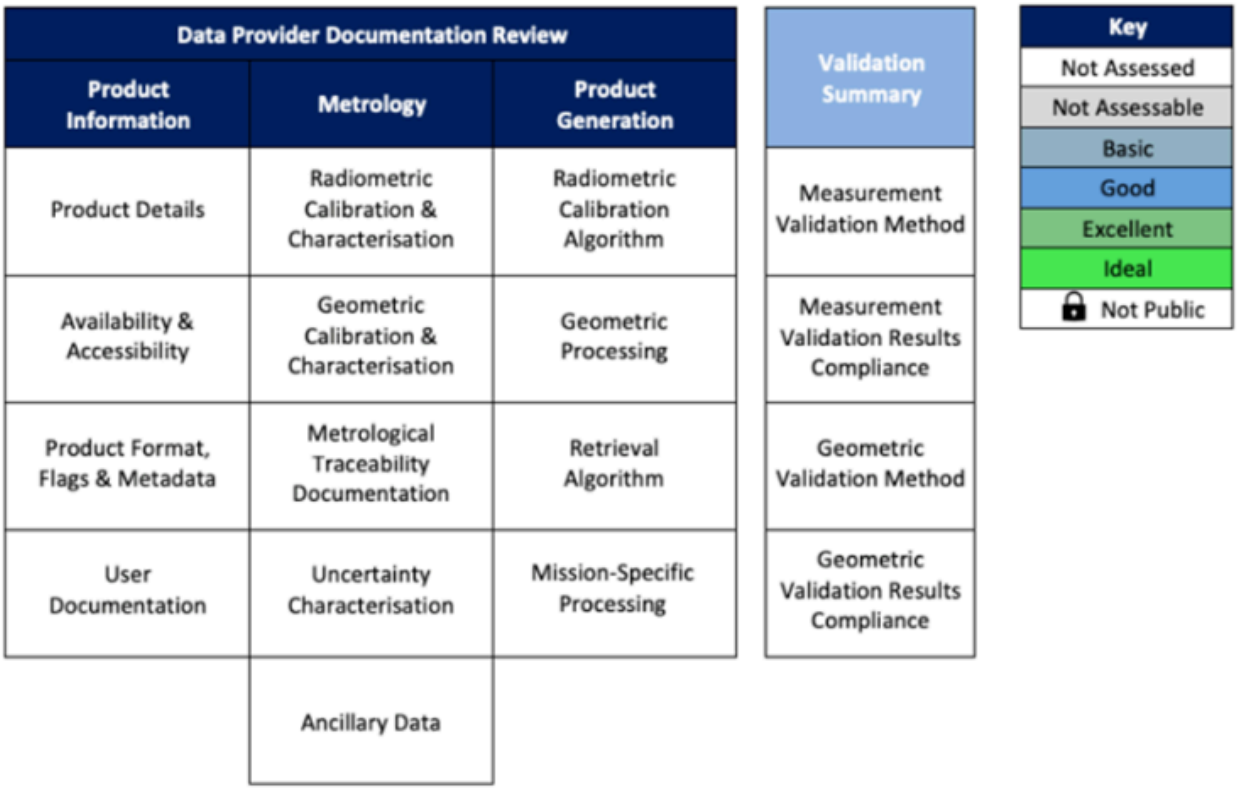
1) Review of mission quality as evidenced by its documentation

2) Validation analysis performed by mission quality assessor.

Data providers can refer to this framework as they define products and evidence themselves.

Having a common framework between ESA and NASA simplifies the process for vendors and makes results more comparable. The assessment process is an interactive activity between assessors and mission operators. The framework was structured by the development of a Cal/Val Maturity Matrix. The Maturity Matrix is composed of a Validation Summary that summarises validation activity undertaken by the assessor and by a Data Provider Documentation Review that reviews the mission quality as evidenced by its documentation. It comprises product information which is a review of descriptive information accompanying products, metrology information that underpins evidence for observation quality and product generation section, which is a review of “fitness for purpose” of the product generation.

- The structure of the Cal/Val Maturity Matrix is shown below:



Benefits to New Space:

Undertaking assessment through a standardised maturity matrix facilitates communication with data providers (New Space). The Assessment process is an interactive activity between assessors and missions; through this interactive process, New Space could gain knowledge on data quality and increase the reliability of their data while ensuring a fast data delivery and return on investment.

Benefits to CEOS:

The quality framework and Maturity Matrix facilitate data comparisons and help gain knowledge on data quality and fitness for purpose of New Space data, therefore facilitating synergies between New Space and CEOS missions.

5.1. SITSat Task Team

With the emergence of a number of SI-Traceable Satellite missions (SITSats), the CEOS WGCV has considered the need for a group to coordinate on issues of common interest and to foster mutual benefits. SITSats have great potential to increase the accuracy of climate records and can also serve as high quality references for both CEOS Agency missions and the commercial sector – including 'New Space'. Both of these topics are headline priorities for CEOS and the ESA SIT Chair. The WGCV has proposed the establishment of a joint Task Team with GSICS which will include representatives from

agencies operating and developing such missions, and others as interested, as a means to promote dialogue and coordination.

The Task Team will work on collaborative activities, discuss future developments, mission coordination, new technologies and spectral domains, interoperability topics, and serve as a forum for international coordination on SITSat missions, aiming to build an integrated system approach to their development and utilisation.

The Task Team will build on the findings of the workshop *"SI-Traceable Space-based Climate Observing System: a CEOS and GSICS Workshop"* hosted by the UK Space Agency at the National Physical Laboratory in London in September 2019. The goal of the workshop was to assess the benefits and requirements of a space-based climate observing system, summarising current measurement capabilities, climate-based needs, and future implementation plans, together with recommendations. More details are available in the published report.

The SITSat Task Team will provide an opportunity for mission coordination, gap analyses, efficient tasking and acquisition planning, etc., it will allow coordination on technical topics, reporting of uncertainty and traceability information, interoperability, methods of dissemination etc.. It will aim for a systems-based approach rather than having missions being developed and operated in isolation, along the lines of CEOS Virtual Constellations.

Benefits to New Space:

SITSats will provide absolute reference from space. It will be a Fiducial Reference Measurement in space. Therefore, New Space will be able to use it as an absolute reference; it will improve the data quality and ensure interoperability between missions.

Benefits to CEOS:

Acting as a quality reference, CEOS will play its role of coordinating international Earth observation efforts to benefit society.

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6. Analysis Ready Data

- Increased promotion and uptake (incl. by CEOS agencies), further industry engagement
- Connection with OGC ARD SWG

CEOS Group Responsible: ARD Oversight Group, LSI-VC

Context and Background:

Description of activity:

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Benefits to New Space:

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Benefits to CEOS:

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7. EO standards and frameworks

- FRM

CEOS Group Responsible:

Context and Background:

Description of activity:

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Benefits to New Space:

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Benefits to CEOS:

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8. CEOS Interoperability Framework

CEOS Group Responsible: WGISS

Context and Background:

Description of activity:

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Benefits to New Space:

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Benefits to CEOS:

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9. CEOS provision of highly calibrated and characterised reference EO missions of long duration

- Promote awareness, engage on calibration transfer
- SITSAT calibration transfer
- Potential WGCV/GSICS task SITSAT coordination Team

CEOS Group Responsible: WGCV

Context and Background:

Description of activity:

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Benefits to New Space:

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Benefits to CEOS:

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10. Observation gaps, commercial opportunities to fill CEOS priority requirements for climate, SDGs and disasters

- Utilise background missions

CEOS Group Responsible:

Context and Background:

Description of activity:

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Benefits to New Space:

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Benefits to CEOS:

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- Private mission not interfere with CEOS future missions
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Input from SDG team:

- Is New Space data used frequently in your field? Why / why not?
- What data features are most important for your field (resolution, revisit time, data access, etc.)? Can CEOS provide this? If not, could New Space fill this gap?
- Are there any observation gaps in the next 10-15 years which are not currently covered by CEOS missions? Could you see New Space filling these gaps? How can these gaps be filled?
- What trends do you anticipate around the application of commercial data in your field?

11. Combined and harmonised data streams

- Climate action, Global Stocktake, Methane (IMEO), biomass

CEOS Group Responsible:

Context and Background:

Description of activity:

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Benefits to New Space:

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Benefits to CEOS:

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12. EO QA measures - shared data quality metrics approach?

- Maturity Matrices (DMS, Cal/Val)
- ESA EDAP, NASA CSDA, joint NASA-ESA framework

CEOS Group Responsible:

Description of activity:

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Benefits to New Space:

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Benefits to CEOS:

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13. Data policies, data brokerage, multi-user licensing, block buying data and establishing end-user licensing agreements (EULAs)

CEOS Group Responsible:

Context and Background:

Description of activity:

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Benefits to New Space:

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Benefits to CEOS:

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14. Open Data Cube and other analytics/processing tools

CEOS Group Responsible: SEO

Context and Background:

Description of activity:

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Benefits to New Space:

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Benefits to CEOS:

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15. Method and result sharing for performing characterisation of commercial data

- Develop recommendations on best practices and collaboration efforts to improve the results of these efforts and to make the results more beneficial to the broader community.

CEOS Group Responsible:

Context and Background:

- ESA - NASA joint deliverables:
- OUT-23-05 (ESA - NASA Earth Observation Mission Quality Assessment Framework - Optical Guidelines)
- OUT-23-06 (ESA- NASA Earth Observation Mission Quality Assessment Framework - SAR Guidelines)
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Description of activity:

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Benefits to New Space:

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Benefits to CEOS:

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