

Copernicus Space Component
ESA-NOAA Technical Operating Arrangement

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Between:

the European Space Agency (ESA), established by the ESA Convention opened for signature in Paris on 30 May 1975, having its headquarters located at 8-10 rue Mario-Nikis, 75738 Paris Cedex 15 – France, represented by Mr Josef Aschbacher, Director of Earth Observation,

on the one part,

and

the National Oceanic and Atmospheric Administration (NOAA), an agency of the government of the United States of America, represented by Dr. Stephen Volz Assistant Administrator - Satellite and Information Services,

on the other part,

Hereinafter referred to individually as “Participant” or jointly as “Participants”,

1 INTRODUCTION

1.1 Background

Copernicus is a European programme, providing Earth Observation information for environmental monitoring and civil security. The dedicated Sentinel missions are being developed to meet the operational needs of the programme.

According to Article 9 of the Regulation establishing the Copernicus programme, the European Commission manages, on behalf of the European Union (EU) and in its field of competence, relationships with third countries and international organisations.

In line with this Regulation, the European Commission has concluded Agreements with the European Space Agency (ESA) and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) on the implementation of the space component of Copernicus.

These Agreements foresee that ESA and EUMETSAT provides support to the EU for the matters concerning the international technical cooperation of the Copernicus Programme. In particular, ESA and EUMETSAT assess the impact of international technical cooperation requests and implement and are responsible for technical actions with international partners subject to the prior approval of the European Commission and prerequisite funding provided by the European Union.

On this basis, the European Commission requests ESA and EUMETSAT to establish relevant technical operating arrangements with international partners, primarily focusing on the Sentinels operated by ESA and EUMETSAT and addressing issues such as liability and technical data interface specifications.

ESA and EUMETSAT will be responsible for the implementation of the technical operating arrangements, in coordination and subject to the prior agreement by the European Commission.

The implementation of the technical operating arrangements will be facilitated by a joint 'Copernicus Cooperation Group', involving the European Commission, ESA, EUMETSAT and the international partners, whose members meet whenever necessary, to oversee and stimulate cooperative activities (e.g. exchange of best practices, comparison of products, exchange of personnel).

1.2 Purpose and objectives

The European Union, represented by the European Commission, and the United States of America, represented by the U.S. Department of State, have signed a Cooperation Arrangement to ensure the access to Sentinel data for the United States of America. Specifically, the European Union and United States recognize full, open, and free access to each other's environmental satellite data is of mutual benefit and should follow the GEOSS Data Sharing Principles. U.S. agencies, including the U.S. National Oceanic and Atmospheric Administration (NOAA), the U.S. National Aeronautics and Space Administration (NASA), and the U.S. Geological Survey (USGS) are expected to continue to provide a wide range of observations and the European Commission intends to provide high bandwidth connections to U.S. agencies to access Sentinel data. In addition to data sharing, collaborations are being encouraged in areas of calibration/validation, development of societal applications and coordination on spectrum issues.

Based on this Cooperation Arrangement, ESA and NOAA intend to coordinate the technical implementation covering the Sentinel data access to NOAA by developing a technical operating arrangement signed by ESA and NOAA.

Based on this Cooperation Arrangement, ESA and NOAA cooperate on a voluntary basis for enabling Sentinel data access to NOAA, without any exchange of funds. In the event that either ESA or NOAA is unable to continue one or several of the activities described in this Technical Operating Arrangement, each may have the option of terminating the participation in the activity after consultation with the other and after giving reasonable advance notice.

The purpose of this Technical Operating Arrangement is to define ESA and NOAA's respective roles and responsibilities as well as the terms and conditions under which they intend to cooperate to implement the exchange of satellite data foreseen in the Cooperation Arrangement between the European Commission and the International

partner on Cooperation on Earth Observation data related to the Copernicus programme.

In this arrangement, both sides recognise that the European Union and United States of America are pursuing Earth Observation activities in a number of areas of common interest and that sharing each other's satellite data on the basis of reciprocity should provide mutual benefits. Both sides are committed to the principle for full, free and open access to European Sentinel and NOAA Earth Observation satellite data and information, subject to applicable security restrictions.

1.3 Scope

This document describes the technical arrangements (e.g. cooperative initiatives description, operational interfaces, ESA required support) between both agencies.

In case other entities (e.g. Universities, Institutes) are involved in the arrangement on NOAA's side, NOAA acts as an interface and contact point between ESA and the other entity.

1.4 References

An overview of the overall Copernicus dedicated Sentinel missions is available in the Sentinel Online portal at sentinels.copernicus.eu. In particular, the portal contains up to date information on:

- Mission description, including space and ground segment aspects, and operational news
- Product definitions, including contents and format specifications
- Detailed mission user handbook
- Link to data access hubs, including registration, user manuals, operational news

The following documents are referenced in this Technical Arrangement and provide further detailed information.

[RD-1] GMES Space Component Operations Concept, ref. GMES-GSEG-EOPG-PD-12-0056, Issue 1.1., dated 9 August 2013

[RD-2] "Legal notice on the use of Copernicus Sentinel Data and Service Information".

https://sentinel.esa.int/documents/247904/690755/Sentinel_Data_Legal_Notice

[RD-3] Sentinel-5P FDS-SNPP Orbit Data Interface Control Document, S5P-IC-ESC-FS-5013, Issue 2, Revision 0, 28/12/2015.

[RD-4] "Sentinel5P - Suomi NPP Loose Formation Flying Concept", S5P-TN-ESA-SY-0223, Issue 1, Revision 2, 12/11/2015.

[RD-5] “Sentinel5P – Reference Orbit Acquisition Strategy”, S5P-TN-ESC-FS-5015, Issue 1, Revision 1, 14-04-2016.

2 EUROPEAN ACCESS TO NOAA MISSION AND CALIBRATION DATA

In adherence to its full and open data policy, NOAA intends to continue to provide Earth observation data products to European users at no charge. This includes, but is not limited to data from (full list available from http://www.nesdis.noaa.gov/about_satellites.html; http://www.ospo.noaa.gov/Operations/satellite_operations.html)

- Geostationary Operational Environmental Satellites (GOES)-13
- GOES-14
- GOES-15
- GOES-16
- NOAA-15
- NOAA-18
- NOAA-19
- Suomi National Polar-orbiting Partnership (partnership with NASA)
- Deep Space Climate Observatory (DSCOVR) (partnership with NASA)
- Jason-2 (partnership with NASA, CNES, and EUMETSAT)
- Jason-3 (partnership with NASA, CNES, and EUMETSAT)
- Marine Optical Buoy (MOBY) observations (for in situ vicarious calibrations) available through NOAA CoastWatch/OceanWatch <http://www.star.nesdis.noaa.gov/sod/moby/>

These data are currently available in Europe through EUMETSAT via EUMETCast.

Requests for access to this data by ESA from NOAA can be made by using a data access request form, available here: <http://www.ospo.noaa.gov/Organization/About/access.html>. Furthermore, this information may be posted on ESA and EU Copernicus data access portals to inform European users.

3 ARRANGEMENT TECHNICAL INTERFACES

In the framework of Copernicus, technical operating arrangements aim, among others, at providing:

- a supplementary access to Sentinel Missions data, i.e. through specific data acquisition services (data hub to data hub), specific data products, mirror sites, etc, thus further valorising the Sentinel missions exploitation.
- access to relevant NOAA Missions data, i.e. through specific data acquisition services (data hub to data hub), specific data products, mirror sites, etc, thus further valorising the relevant missions exploitation.

3.1 Technical Arrangement Types

The technical operating arrangement provides a framework for specialised solutions in five main areas:

1. Data acquisition and Quasi Real Time production (direct downlink at International Local Stations – currently not foreseen)
2. Complementary collaborative data products and algorithms definition
3. Core data product dissemination and access (e.g. international mirror sites)
4. Development of innovative tools and applications
5. Complementary external validation support activities

Note that the above technical operating arrangement types address on one side the Sentinel missions, and on the other side relevant NOAA missions.

The following sections define the technical arrangements for the specific area of cooperation.

In the framework of this Technical Operating Arrangement:

- additional areas of technical cooperation may be included in the future, if relevant, agreed by ESA and NOAA, and has prior endorsement by the European Commission.
- regular technical meetings are intended to be held between the NOAA and ESA, e.g. within the Copernicus Cooperation Group, co-led by the European Commission for European partners and the U.S. Department of State. The European Commission will be invited as observer to all such meetings and all meeting documentation will be forwarded to the European Commission by ESA for information.

4 INTERNATIONAL ARCHIVING AND DISSEMINATION CENTRES, MIRROR SITE

4.1 Involved Entities

NOAA intends to be the sole entity to establish a direct operational interface to ESA (i.e. International Data Hub), under this Technical Operating Arrangement.

4.2 NOAA Activity

NOAA intends to use global Sentinel data for scientific study, to aid in the development of operational products from these data, and the production of operational products. Operational use includes both near real time use and non-time critical products (i.e. delayed-mode science data in NOAA terminology) in support of both research and applications.

4.3 ESA Support

4.3.1 Access to the Sentinel International Data Hub

ESA grants NOAA access to the International Data Hub (IntDH), a rolling archive, providing bulk dissemination capabilities for Sentinel data products. The IntDH will continuously store Sentinel data acquired during the previous month(s) at the processing levels agreed as part of the Sentinel core data product list and the associated timeliness as defined in the GSC Operations Concept, [RD-1]. It enables searching, browsing, previewing, and downloading the Sentinel data. The time interval covered by the IntDH rolling archive will be scalable and include at least the previous 30 days of data.

Access to the Sentinel archived data is provided via a separated data access infrastructure not subject to this Technical Operating Arrangement. If required in the future, a specific campaign could be put in place as a one-off activity to be coordinated with other international partners to transfer reprocessed or missing data. Such a campaign, including selected archived data publishing in the IntDH, may also apply in the future to make re-processed Sentinel data available.

Access to the IntDH is allowed via a web authentication module. ESA will provide NOAA with a username and password to access the IntDH. This username and password may be used only by NOAA (including its representatives, employees, and contractors involved in the initiative) for the purpose of the initiative and is not to be shared with other natural or legal persons.

NOAA intends to use the IntDH access only for the purpose of its activity in the initiative described above. Through registration at the IntDH, accessing and/or downloading available content, NOAA should not misuse or interfere with the service of the IntDH portal. In the event of file corruption, NOAA may request ESA support retransmission of files.

All functionalities and contents offered by the IntDH are provided by ESA on a best efforts-basis. The transmission of content from the IntDH may be interrupted or delayed by ESA in the event of technical constraints, such as the internet bandwidth. In such case, the download requested by NOAA may be enabled later taking into account other users' requests.

4.3.2 Data Transfer

ESA will provide appropriate interfaces, to transfer Sentinel data to NOAA via internet. If required, ESA supports network performance tuning to fully utilize available bandwidth. ESA intends to use reasonable efforts to provide operational support, such as notifying NOAA of a IntDH server outage or sensor data outage.

4.4 Time Schedule

The IntDH is intended to be available from the sentinels.copernicus.eu portal. ESA intends to provide Sentinel data sets as they become available in accordance with ESA data provision plan (e.g. after launch, commensurate with the ramp-up plan for data provision).

NOAA intends to be ready to accept data transfers after the in-orbit commissioning phase of each Sentinel.

4.5 Reporting

NOAA intends to keep the European Commission and ESA informed about the course and success of the activity.

The regular reports regarding the Sentinel data usage are intended to have at least annual frequency, and are intended to, at a minimum, contain information regarding:

- Sentinel data use and applications;
- Onward-dissemination of Sentinel data, including user statistics of the Sentinel data provided by NOAA to third parties;
- Any changes to the pre-agreed set up of activities that may have an impact on ESA's support to the partner's activities.

More specifically, as concerns Sentinel data NOAA and relevant third party usage statistics, the following minimum categories of information are intended to be provided to the European Commission and ESA as part of the annual reports.

User account statistics, including:

- Utilisation domain (i.e. research, commercial, education, other)
- Usage field (i.e. atmosphere, emergency, marine, land, security, climate, other)
- Country of the account user

Data dissemination statistics, including:

- Data delivered per utilisation domain and usage field
- Data volume per utilisation domain and usage field
- Total number of distinct users
- Total volume of data distributed
- Total volume of data distributed by product
- Statistics on the core product delivered

4.6 Sentinel Data Governance

Sentinel data made available via the IntDH are governed by the Legal notice on the use of Copernicus Sentinel Data and Service Information”, [RD-2]. NOAA accepts these conditions implicitly by using or distributing the Sentinel data.

In the event that in the future specific Sentinel data are assessed by the EU to be “sensitive”, the access to such Sentinel data through the IntDH and its use and distribution may be subject to different licensing conditions. This also applies for Sentinel data already received by NOAA, or a third party as indicated under 4.5 above through the IntDH, in the event Sentinel data are assessed to be “sensitive” after the time of data download.

5 INTERNATIONAL COMPLEMENTARY EXTERNAL VALIDATION SUPPORT

5.1 Involved Entities

NOAA intends to be the sole entity to establish a direct operational interface to ESA under this Technical Operating Arrangement.

5.2 NOAA Activity

NOAA plans to use Sentinel data as appropriate for scientific study of the environment, the development of operational products, and the production of operations products on a global basis. Near-real-time access to Sentinel data is critical to most of NOAA's planned activities.

Sentinel-1: NOAA intends to use all data modes and processing levels, but intends to generally use interferometric wide swath and extended wide swath data. The use of data from the polar regions, US coastal regions, as well as Gulf of Mexico areas within 450 km of shore are likely to be given higher priority.

Sentinel-2: NOAA intends to use all data modes and processing levels, but has special interests in coastal areas, select land surface areas, and data from the multispectral high-resolution imager.

Sentinel-3: NOAA intends to use all data modes and types and processing levels with a particular interest in global level-1 data. NOAA assets in place for calibration and validation activities for VIIRS SNPP are available for use by NOAA for calibration and validation of OLCI S3. These may include Marine Optical Buoy (MOBY) observations and observations from dedicated cal/val field activities and other field activities of opportunity. NOAA intends to provide access to ESA to the result of its own calibration and validation activities, as well as access to the available in-situ observations/data (e.g. MOBY, cal/val field activities, etc). NOAA also intends to use OLCI and SLSTR global level-1 data, land surface and atmospheric data products, as applicable, for product development, cal/val and product intercomparison, with foci on Land Surface Temperature, Active Fires, Vegetation Indices, Surface Reflectance, Surface Type / Land Cover and Aerosol Load.

Sentinel-5P: NOAA intends to use the TROPOMI data for product testing and evaluation, spatial gap filling and calibration, as well as validation activities for Ozone, NO₂, SO₂, aerosol and cloud products.

Additional uses for data from Sentinel satellites are still under development. NOAA anticipates using all modes available on a global basis. (See chapter 7 below.)

5.3 ESA Support

5.3.1 ESA technical support to complementary validation activity

ESA intends to provide sample data sets of the Sentinel 1, 2, 3 and 5p core products (e.g. L0, L1, L2) and satellite and sensor characterization data as they become available to support joint validation and calibration activities.

5.4 Time Schedule

NOAA plans to acquire Sentinel data from the IntDH as soon as it is available. At first, NOAA plans to validate these data for scientific and operational purposes. As appropriate, these data are intended to be used to help generate operational environmental products.

5.5 Reporting

NOAA intends to keep the European Commission and ESA informed about the course and success of the activity.

The regular reports regarding the complementary external validation activity are intended to have at least annual frequency, and are intended to, at a minimum, contain information regarding

- Summary of complementary validation results
- Sentinel data use and application;
- Any changes to the pre-agreed set up of activities that may have an impact on ESA's support to NOAA's activities.
- Onward-dissemination of Sentinel data (if relevant), including user statistics according to section 4.5 above.

Note: reporting on Sentinel data distribution is intended to be required only, if the initiative comprises systematically onwards distribution of Sentinel data. Distribution on a case-by-case basis is not expected to be subject to reporting.

5.6 Sentinel data governance

Sentinel data used by the complementary validation activity are governed by the "Legal notice on the use of Copernicus Sentinel Data and Service Information", [RD-2]. NOAA accepts these conditions implicitly by using or distributing the Sentinel data.

6 SENTINEL-5 PRECURSOR/SNPP LOOSE FORMATION FLIGHT

6.1 Activity Background

This section documents the technical arrangement between ESA and NOAA on the loose-formation flight of Suomi NPP (SNPP)/Sentinel-5 Precursor. This loose-formation flying will provide significant value to scientific research and operational forecasts, by allowing for the combination of observations close in time and space from the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument on SNPP and the TROPOspheric Monitoring Instrument (TROPOMI) on Sentinel-5 Precursor (S5P), thus significantly improving the data information and content.

ESA intends to use SNPP operational products as part of the processing for S5P data. Methane (CH₄), retrieved from the S5P short-wave infra-red (SWIR) channel, is a core product to be provided by the S5P mission for the Copernicus users. The retrieval requires accurate cloud information and screening in order to avoid excessive systematic error. While S5P alone can provide a certain level of cloud screening, the information provided by the VIIRS instrument (bands 7, 9 and 11) on-board SNPP is instrumental to improve the methane product significantly. In particular, the operational VIIRS cloud mask will be used as part of the S5P data processing.

Due to the dynamic nature of clouds, the temporal separation between the SNPP and S5P observations need to be as small as possible and not exceeding 5 minutes. Due to the significant larger across track swath of VIIRS on SNPP the complete S5P field-of-view still remains in the SNPP observations considering the shift resulting from the temporal separation.

6.2 Technical Coordination

The loose formation between S5P and SNPP technical and organisational aspects cover the following items:

- Operations concepts of the two spacecraft forming the constellation, including orbit control and manoeuvre scheduling strategies.
- Requirements for the nominal along-track, lateral and timely separation of the two satellites.
- Requirements for a minimum safe separation of the satellites, including scenarios with limited commandability or failed orbit control manoeuvres.
- Data exchange/communication requirements between the involved mission authorities and operations centres (European Space Operations Centre, ESOC, NOAA Office of Satellite Products & Operations, OSPO).
- Requirements for the pre-launch validation of interfaces between the SNPP and S5P operations centers.
- Strategy for the initial orbit injection of S5P and the acquisition of a steady state loose formation.
- Strategy for a termination of the formation operation, e.g. following a full or partial loss of an essential payload function or a phasing out of either mission.

The following technical documents describe the management of the related activities: “Sentinel-5P FDS-SNPP Orbit Data Interface Control Document” [RD-3], as well as the “Sentinel5P - Suomi NPP Loose Formation Flying Concept” [RD-4] and the “Sentinel5P – Reference Orbit Acquisition Strategy” [RD-5].

Data exchange (e.g. access to VIIRS data) is addressed in chapter 2 and 3.

6.3 ESA Support

ESA intends to routinely provide S5P orbit information to NOAA, this includes planned orbit and short notice manoeuvres as defined in the orbit data ICD [RD-3]. Further, ESA intends to provide information regarding S5P, in particular in case of issues impacting the constellation (e.g. platform anomalies) or the products (e.g. instrument degradation).

6.4 NOAA Support

NOAA intends to routinely provide SNPP orbit information to ESA, this includes planned orbit and short notice manoeuvres as defined in the orbit data ICD [RD-3]. Further, NOAA intends to provide information regarding SNPP, in particular in case of issues impacting the constellation (e.g. platform anomalies) or the products (e.g. instrument degradation).

6.5 Time Schedule

The technical meetings between ESA and NOAA regarding the S5P-SNPP loose formation should be conducted on a regular basis (as outlined in the ICD [RD-3]) until the start of the controlled deorbiting of one participating satellite plus an additional safety period ensuring no impact to the remaining mission. The exchange of orbit information according to the orbit data ICD [RD-3] will be tested by NOAA before the S5P launch and operationally in place for the LEO and following phases.

6.6 Reporting

ESA and NOAA intend to keep each other as well as the European Commission informed about the S5P-SNPP loose flying formation. Regular reports (e.g. yearly) regarding the formation flight operations are intended that include at minimum:

- Summary of the orbit control files exchanged;
- S5P-SNPP loose formation anomalies;
- Information on the S5P and SNPP missions that impact the aim of the loose formation flight (e.g., platform or VIIRS degradation).

6.7 Loose Formation flying with JPSS-1 or JPSS-2

Depending on the health of SNPP and the experience of flying in the loose flying formation, ESA and NOAA may agree to fly S5P in loose flying formation with JPSS-1 and/or JPSS-2. ESA and NOAA will perform studies on the technical and organizational aspects needed to fly S5P with JPSS-1 and/or JPSS-2 before making any decision to fly S5P in loose formation with JPSS-1 and/or JPSS-2.

7 NOAA CONTRIBUTION TO THE S5P VALIDATION TEAM

7.1 Activity Background

The Sentinel-5 Precursor Calibration and Validation Team Call (S5PVT) aims to engage leading expertise for supporting the independent Calibration and Validation of the Sentinel-5 Precursor.

The S5PVT will provide to ESA independent experimental data, analysis and recommendations to critically assess the end-to-end performance of the TROPOMI instrument and its products.

7.2 NOAA S5PVT Project

NOAA will contribute to the S5PVT through the project, 'Assessment and Applications of S5P TROPOMI Atmospheric Composition Products at NOAA' (ID 35343) lead by the Principal Investigator Dr. S. Kondragunta, and supported by the Co-Investigators L. Flynn and Dr. M. Goldberg (all NOAA staff).

Executive Project Summary:

The successful introduction of a new sensor into the global observing system involves three broad areas of work. The first is characterization of the measurements and instrument performance. The second is the development and application of algorithms to create estimates of useful products. The third is validation of those products and comparison of their performance to existing records.

The NOAA team will assist in all three areas by using comparisons with measurements, algorithms and products from the SNPP and JPSS-1 instruments as they overlap with those from S5P TROPOMI. The measurement and instrument performance evaluation will make use of satellite instrument comparison and trending techniques as developed by the Global Space-based Inter-Calibration System (GSICS) research working group including those for overpasses (LEO/LEO and LEO/GEO), Earth targets, measurement residuals with respect to forward models, and solar irradiance comparisons.

Level 2 product evaluation will make use of comparisons of TROPOMI retrievals with correlative products from instruments on SNPP and JPSS-1 to understand product performance globally and seasonally and determine applicability to NOAA user applications. NOAA team will engage its Climate Program Office (CPO), Office of Atmosphere Research (OAR) Air Resource Laboratory (ARL), operational air quality forecasters, and partner Naval Research Laboratory (NRL) in the assessment of S5P TROPOMI products for applications in science studies to understand atmospheric processes and air quality forecasting.

8 EFFECTIVE DATE, MODIFICATIONS, AND TERMINATION

8.1 Effective Date and Resolution of Previous Arrangements

This Technical Operating Arrangement will be effective upon its signature by both NOAA and ESA and will remain in force for eight years (8 years) unless terminated in accordance with Section 8.2 below. Upon signature, the previous Copernicus Technical Operating Arrangement entitled “Copernicus Space Component: ESA-NOAA Technical Operating Arrangement” signed on March 7, 2016 will be terminated and replaced by this Technical Operating Arrangement.

8.2 Modification, Extension and Termination

This Technical Operating Arrangement may be modified or extended for further one-year periods by written agreement of the Participants. Either NOAA or ESA may terminate this Technical Operating Arrangement during the first eight years of its duration after providing not less than one (1) year written notice to the other.

This Technical Operating Arrangement is not a legally binding commitment and the activities will be carried out on a best efforts basis.