

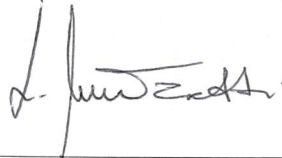




## ***CSC\_ EUMETSAT-NOAA\_Technical Operating Arrangement***

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## **1 INTRODUCTION**

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 EU Regulation establishing the Copernicus programme [AD-1], the European Commission shall manage, 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 Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) and the European Space Agency (ESA) on the implementation of the space component of Copernicus.

These Agreements foresee that EUMETSAT and ESA shall provide support to the EU for matters concerning the international technical cooperation of the Copernicus Programme. In particular, EUMETSAT and ESA shall assess the impact of international technical cooperation requests and shall implement and be 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 EUMETSAT and ESA to establish relevant technical operating arrangements with international partners, primarily focusing on the Sentinels operated by EUMETSAT and ESA and addressing issues such as liability and technical data interface specifications.

EUMETSAT and ESA 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, EUMETSAT, ESA and the international partners, whose members meet whenever necessary, to oversee and stimulate cooperative activities (e.g. exchange of best practices, exchange and comparison of products, exchange of personnel).

## **2 BACKGROUND AND OBJECTIVES**

### **2.1 Background**

EUMETSAT and NOAA have enjoyed a long-standing and fruitful cooperation in the field of Earth observation, witnessed by their cooperation in the operations of geostationary satellite systems, in the development and operations of polar-orbiting satellites as part of an Initial Joint Polar System, and in the development of the cooperative Ocean Surface Topography Mission implemented by the Jason-2 and Jason-3 satellites. The signature of the Long Term Cooperation Agreement in August 2013 provides a general policy framework to enhance the ability to plan for long-term space-based observation systems for operational meteorology and operational monitoring of the oceans, the composition of the atmosphere, and climate monitoring.

The cooperation on geostationary Earth observation satellite systems started through an Exchange of Letters in 1993 and was consolidated through the signature of the Agreement on Access to Images and Meteorological Data Distribution Material from EUMETSAT Meteosat Satellites, first concluded in July 1995 and most recently updated in July 2008.

On the polar-orbiting satellites, NOAA and EUMETSAT have established an integrated and shared Initial Joint Polar System (IJPS) by exchanging instruments and coordinating the operations of NOAA and EUMETSAT polar-orbiting satellites to provide and improve meteorological and environmental forecasting and global climate monitoring services worldwide. This was done through the signature of a series of agreements, starting with the Initial Joint Polar System Agreement signed in 1998, and followed by the Joint Transition Activities (JTA) Agreement signed in June 2003. The JPS and JTA Agreements ensure continuity of the IJPS system and provide long-term continuity of observations from polar-orbiting missions. NOAA and EUMETSAT signed the Joint Polar System (JPS) Agreement in December 2015 to continue this cooperation over the next decades, with their next generation polar-orbiting satellites.

Moreover, NOAA and EUMETSAT have the intention to secure reciprocal access to their Earth observation satellite data and products to support their activities and Copernicus services, in accordance with relevant Data Policies, and to implement the policy framework by establishing more detailed agreements covering specific cooperation programmes. NOAA's data and products are available to Copernicus in Europe through EUMETSAT via EUMETCast. The primary means of accessing this NOAA data for near-real-time applications in Europe is and shall remain through EUMETSAT.

EUMETSAT concluded in November 2014 a Copernicus Agreement with the European Union on the implementation of the Copernicus programme (hereinafter "Copernicus Agreement") [AD-3]. In accordance with Article 8 of the Copernicus Agreement, EUMETSAT shall implement and be responsible for subsequent technical actions with international partners on behalf of the European Commission.

The European Commission concluded in October 2015 a Cooperation Arrangement with the Government of the United States of America on Cooperation on Earth Observation data related to the Copernicus programme [AD-4], which may be complemented by separate "technical operating arrangements", as necessary, between implementation agencies on both sides, including EUMETSAT and NOAA.

## **2.2 Purpose and Scope**

The purpose of this Technical Operating Arrangement (TOA) is to define the EUMETSAT and NOAA respective roles and responsibilities on the delivery of Sentinel-3 marine data and products and other Sentinel data to users as agreed by the European Commission.

NOAA is responsible for serving as the interface between EUMETSAT and other involved entities in the United States, with a particular focus on the near real time user community, but also supporting researchers and other delayed mode science and applied users.

EUMETSAT and NOAA recognise that the European Union and NOAA 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. EUMETSAT and



NOAA are committed to the principle of full, free and open access to European Sentinel-3 marine data and products and to NOAA's environmental satellite data and information, subject to applicable security restrictions.

The scope of this TOA is to describe the technical and operational arrangements between EUMETSAT and NOAA for the transfer and reception of Sentinel-3 marine data and products and other Sentinel data distributed by EUMETSAT on behalf of the EU for redistribution to US users.

Furthermore, this TOA may address other relevant Sentinel and NOAA missions.

In the framework of this TOA:

- additional areas of technical cooperation related to delivery of Sentinel data and products, agreed by EUMETSAT and NOAA, may be included in the future, if relevant and prior endorsement by the European Commission.
- regular technical meetings related to the delivery of Sentinel-3 marine data and products are intended to be held between NOAA and EUMETSAT. The European Commission shall be invited as observer to such meetings and all relevant meeting documentation shall be forwarded to the European Commission for information.

EUMETSAT and NOAA intend to carry out their responsibilities under this TOA on a best efforts basis. In the event that either EUMETSAT or NOAA is unable to continue one or several of the activities described in this TOA, each may have the option of terminating the participation in the activity after consultation with the other and after giving reasonable advance notice.

### **2.3 Applicable Documents:**

- AD-1 Regulation (EU) No 377/2014 of the European Parliament and the Council of 3 April 2014 establishing the Copernicus Programme and repealing Regulation (EU) No 911/2010 (hereinafter "Copernicus Regulation")
- AD-2 Commission Delegated Regulation (EU) No 1159/2013 of 12 July 2013 supplementing Regulation (EU) No 911/2010 of the European Parliament and of the Council on the European Earth monitoring programme (GMES) by establishing registration and licensing conditions for GMES users and defining criteria for restricting access to GMES dedicated data and GMES service information.
- AD-3 Agreement between the European Union, represented by the European Commission, and EUMETSAT on the implementation of the Copernicus programme including the transfer of ownership of certain assets (Copernicus Agreement), signed on 7 November 2014
- AD-4 Cooperation Arrangement between the European Commission and the Government of the United States of America on Cooperation on Earth Observation data related to the Copernicus programme, signed on 16 October 2015.
- AD-5 Legal notice on the use of Copernicus Sentinel Data and Service Information from the European Commission
- AD-6 Interconnection Security Agreement Between NOAA/NESDIS and EUMETSAT

## 2.4 Reference Documents:

RD-1 Copernicus Space Component Product and Data List COPE-GSEG-EOPG-PD-14-0017

## 3 PROVISION OF NOAA'S MISSION AND CALIBRATION DATA AND PRODUCTS TO EUMETSAT

In adherence to its free-and-open data policy, NOAA will continue to provide Earth observation data products to European users. This includes, but is not limited to data from: (full list available from [http://www.nesdis.noaa.gov/about\\_satellites.html](http://www.nesdis.noaa.gov/about_satellites.html) - [http://www.ospo.noaa.gov/Operations/satellite\\_operations.html](http://www.ospo.noaa.gov/Operations/satellite_operations.html))

- Geostationary Operational Environmental Satellites (GOES)-13
- GOES-14
- GOES-15
- NOAA-15 (Polar-orbiting Environmental Satellites (POES))
- NOAA-18
- NOAA-19
- Suomi National Polar-orbiting Partnership (partnership with NASA)
- Deep Space Climate Observatory (DSCOVR) (partnership with NASA)
- Jason-2 (in partnership with NASA, CNES, and EUMETSAT)
- Jason-3 (in 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 (<http://www.eumetsat.int/website/home/Data/DataDelivery/index.html>).

Requests for access to these data through NOAA can be made by using a data access request form, available here: <http://www.ospo.noaa.gov/Organization/About/access.html>.

This information may be posted on EUMETSAT and EU Copernicus data access portals to inform European users.

## 4 SENTINEL MISSIONS EXPLOITED BY EUMETSAT ON BEHALF OF THE EU

### 4.1 Overview

As per [AD-3], EUMETSAT is the operator of the Sentinel-3 satellite, in cooperation with ESA, and delivers the Sentinel-3 marine mission, while ESA delivers the land mission.

EUMETSAT will also exploit the Sentinel-4 and Sentinel-5 atmospheric missions implemented as part of its Meteosat Third Generation and EPS-Second generation satellite systems.

EUMETSAT will also exploit the Jason-CS/Sentinel-6 cooperative mission in cooperation with the United States.



## 4.2 Sentinel-3 Mission

The Sentinel-3 mission will provide high-accuracy optical, radar and altimetry data for marine and land services. It will measure variables such as sea-surface topography, sea- and land-surface temperature, ocean colour and land colour with high-end accuracy and reliability.

The full Sentinel-3 mission will consist of two satellites simultaneously in orbit. Sentinel-3 is a low Earth orbit, sun-synchronous satellite, with an inclination of 98.65° and a repeat cycle of 27 days. The full coverage and revisit time will be achieved with both Sentinel-3 A and 3B being in orbit. The nominal mission life time is foreseen to be 7.5 years. The optical mission payload consists of the Ocean and Land Colour Instrument (OLCI) and the Sea and Land Surface Temperature Radiometer (SLSTR). The topography mission payload comprises the Ku-/C-band Synthetic Aperture Radar Altimeter (SRAL) and the Microwave Radiometer (MWR). These are complemented by three instruments for Precise Orbit Determination (POD): DORIS, a Doppler Orbit Radio positioning system, GNSS, a GPS receiver, providing precise orbit determination and tracking multiple satellites simultaneously, and LRR to accurately locate the satellite in orbit using a Laser Retro-Reflector system.

The European Union has approved four models of Sentinel-3 (Sentinel-3A, -3B, -3C and -3D). The first model, Sentinel-3A, was launched on 16 February 2016.

Following completion of in-orbit commissioning, EUMETSAT will operate the Sentinel-3 satellites and deliver the marine mission, starting with an operations ramp up phase followed by the routine operations phase.

## 5 EXCHANGE OF SENTINEL-3 MARINE DATA AND PRODUCTS AND OTHER RELATED DATA BETWEEN NOAA AND EUMETSAT

### 5.1 Operational Data

EUMETSAT will provide to NOAA Sentinel-3 Level 1 and Level 2 marine data and products and other Sentinel data distributed by EUMETSAT on behalf of the EU as described in the Copernicus Space Component Product and Data List [RD-1].

This includes, but is not limited to the following:

Sea surface temperature (SST) from the Sea and Land Surface Temperature Radiometer (SLSTR) in netCDF format
---

Ocean colour (OC) from the Ocean and Land Colour Instrument (OLCI) in netCDF format, at full and reduced resolutions
--

Ocean Altimetry Products from the Synthetic Aperture Radar Altimeter (SRAL) instrument in netCDF format
---

Aerosol Optical Depth (AOD) and Fire Radiative Power (FRP) to be available as Day 2 products in netCDF format
---

Further information on the list of products distributed by EUMETSAT and their formats is available from the EUMETSAT Product Navigator: <http://navigator.eumetsat.int>

## 5.2 Data to NOAA for Sentinel-3 Validation Support Activities

EUMETSAT will provide sample data sets of the Sentinel-3 core products (e.g. L0, L1, L2) as per [RD-1] and satellite and sensor characterisation data as they become available for the sole use of supporting joint validation and calibration activities.

## 5.3 Data to EUMETSAT for Sentinel-3 Validation Support Activities

NOAA assets in place for calibration and validation activities for the Suomi National Polar-Orbiting Partnership VIIRS instrument are available for use by NOAA for calibration and validation of the Sentinel-3 OLCI instrument. These may include Marine Optical Buoy (MOBY) observations and observations from dedicated cal/val field activities and other field activities of opportunity. NOAA will provide EUMETSAT with the results 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).

# 6 TECHNICAL OVERVIEW

## 6.1 EUMETSAT Mechanism of Data Access to NOAA

There are three EUMETSAT mechanisms to provide access to Sentinel-3 marine data and products to users, as described in Figure 1 below:

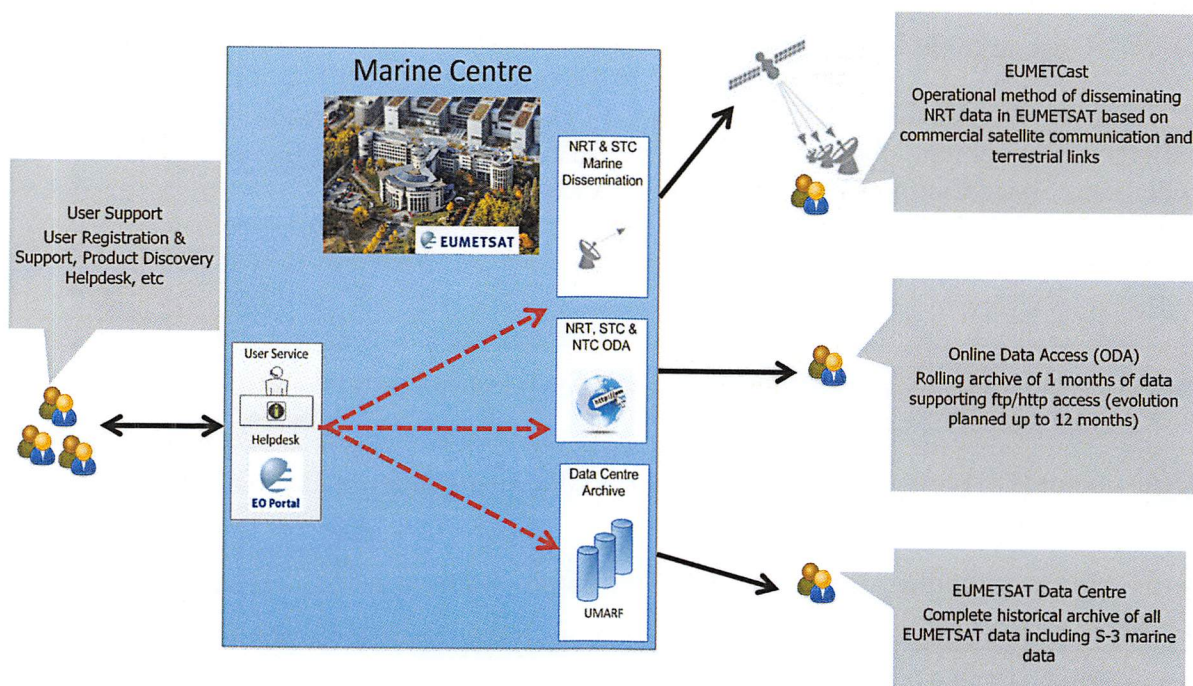
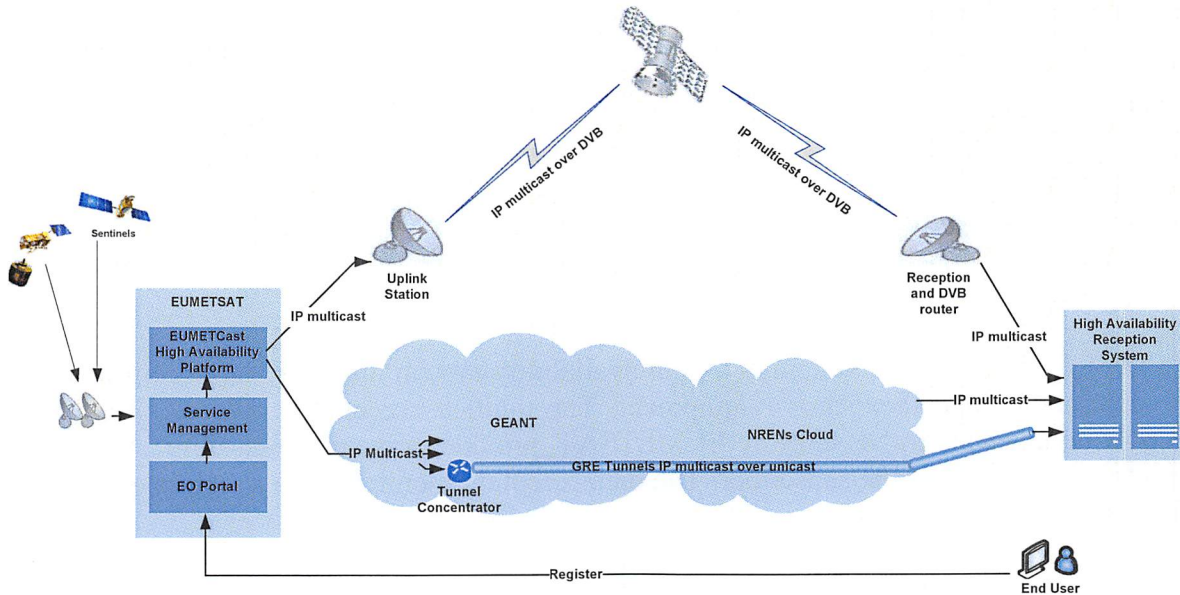


Figure 1: Access to Sentinel-3 marine data and products



The baseline mechanism for the transfer of Sentinel-3 marine data and products and other Sentinel data distributed by EUMETSAT on behalf of the EU is EUMETCast.

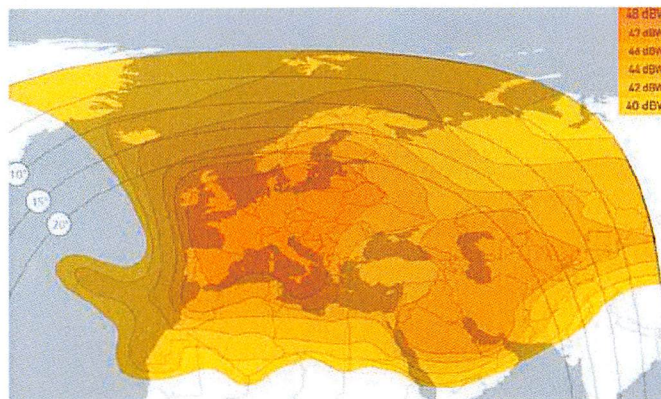
The architecture of the EUMETCast system is presented in Figure 2 below.



**Figure 2: EUMETCast System Architecture**

The baseline mechanism is EUMETCast-Terrestrial, using the mechanisms and terrestrial links described in section 6.3 below.

It is however acknowledged that US users located within the footprint of EUMETCast-Europe (see figure 3) can also access near real time data directly via the EUMETCast-Europe satellite broadcast service, if they are pre-registered on the EUMETSAT EO Portal and equipped with a suitable Very Small Aperture Terminal (VSAT) station. This possibility, offered to all users, is not further addressed in this TOA.



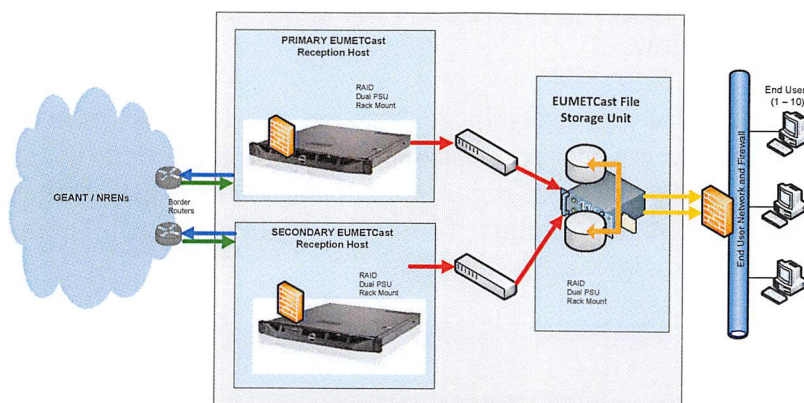
**Figure 3: Footprint of EUMETCast-Europe satellite broadcast service**

The data delivery is based on a Push model using Internet Protocol (IP) multicast allowing the users to receive the data at the end station as soon as it is available. Additionally, multicast has a one-to-many concept and is highly scalable on the number of users with a single transmission from the server.

The service is part of EUMETSAT operations and managed at EUMETSAT headquarters with the multicast server application hosted on a dedicated EUMETCast Platform, consisting of high-availability load sharing servers. The data is organized in multicast channels and the management of the bandwidth is achieved per channel and by the use of a priority scheme.

The files are disseminated by using Digital Video Broadcasting - Satellite - Second Generation (DVB-S/S2) encapsulation on commercial telecommunication satellite networks and native multicast on terrestrial IP networks. The terrestrial network service has an extensive worldwide connectivity based on Source Specific Multicast (SSM). Unicast tunnels can encapsulate multicast IP packets and in this way bridge non-multicast enabled network parts, based on Generic Routing Encapsulation.

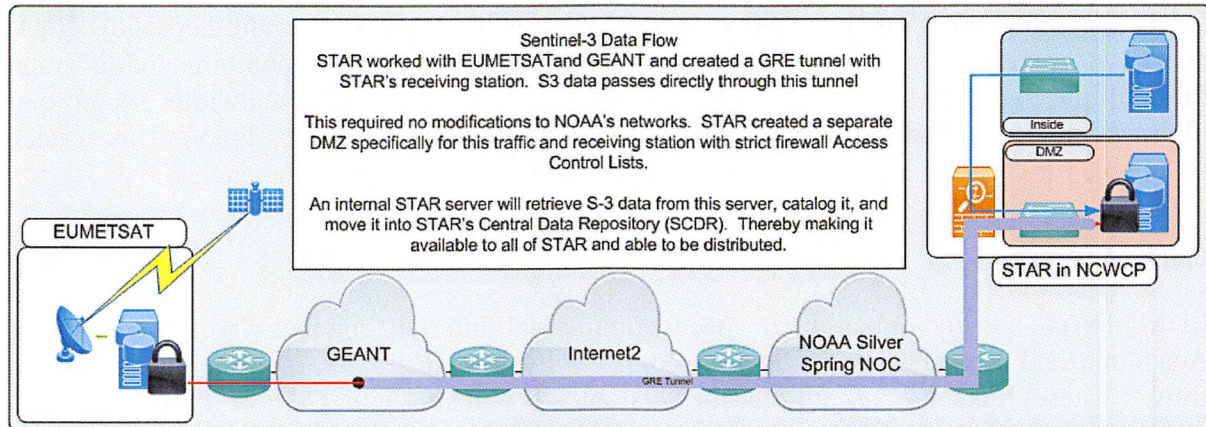
The EUMETCast reception system is a high-availability system allowing the use of off-the-shelf, commercial and inexpensive equipment. The multicast-reception software, TelliCast Client, made available to NESDIS by EUMETSAT, provides a means to customize the data reception to the needs of the subscriber. The data reception monitored via a web interface on the local reception host(s).



**Figure 4: EUMETCast operational reception system**



## 6.2 NOAA Mechanisms to Receive Data and Provide Data Access



**Figure 5 - Current Multicast Reception Configuration**

The Sentinel-3 multicast data flows and Generic Routing Encapsulation (GRE) tunnel are over the GEANT and Internet2 networks. Encryption is employed by EUMETSAT to ensure the integrity of the near-real-time Sentinel-3 marine data and products and confidentiality of actual data transferred.

Data successfully received by the NOAA/NESDIS/Center for Satellite Applications and Research (STAR) will be transferred to STAR's internal STAR Central Data Repository (SCDR) where it will be made available to STAR's scientists for processing and redistribution.

NOAA/NESDIS/STAR will use a combination of existing HTTPS and Anonymous-File Transfer Protocol (FTP) distribution systems to support limited internal redistribution of near real time Sentinel-3 marine data and products. STAR is planning on offering seven days of data via HTTPS and an additional 30 days via Anonymous-FTP.

Consistent with the terms of this arrangement, NOAA is recognized by EUMETSAT as the primary provider of Sentinel-3 marine data and products to users within the United States. In this regard, NOAA's CoastWatch/OceanWatch Program will provide routine and sustained access to and science support for Sentinel-3 marine data and products via STAR's infrastructure. Current distribution servers are limited to 2 Gigabits (Gbs), while the network is limited to 10Gbps. Solely because of the limited real-time technical support available, Sentinel-3 marine data and products provided by STAR should be considered non-operational even though active, sustained and timely support will be provided. STAR is planning on providing these services until such time as NOAA/NESDIS/Office of Satellite Products and Operations (OSPO) has the capability to assume the responsibilities of distribution and proceed with operational distribution of Sentinel-3 marine data and products to users in the United States.

## **6.3 Telecommunications**

### **6.3.1 Commercial Links and Dedicated Point-to-Point Tunnels**

EUMETSAT and NOAA are already supporting transfer of data products through multiple existing point-to-point communication links (largely with a per-programme heritage). These operational services are being evolved through a bilateral roadmap, to combine and leverage the multiple data flows onto a single communications service (high bandwidth, secure and high-availability, supported by multiple and separate underlying Comms links). This service is suitable for carrying all guaranteed point-to-point data flows between agencies.

### **6.3.2 Internet**

EUMETSAT has redundant high speed commercial Internet connectivity and redundant Academic and Research (AR) Internet connectivity that facilitates multiple types of data flow. These links are used both for guaranteed Transmission Control Protocol (TCP) connectivity (point-to-point) and non-guaranteed User Datagram Protocol (UDP) data flows (multicast – see EUMETCast Terrestrial). Multicast protocols are currently configured to utilise only the redundant AR links, and are thus available worldwide to any customer with AR connectivity (e.g. NOAA).

NOAA has multiple connections to AR throughout the United States and thus has options to place one or multiple NOAA reception points, from a Comms perspective. Collocating a NOAA multicast reception point at the same landing point as the separate VPN tunnel would allow this specific EUMETCast Terrestrial node to benefit from the unified underlying Comms support model planned (for support of the VPN).

## **6.4 Security**

Exchange of data by NOAA and EUMETSAT falling under the scope of this TOA shall comply with the provisions of the Interconnection Security Agreement between NOAA and EUMETSAT [AD-6].

## **7 OPERATIONAL ACTIVITIES**

### **7.1 EUMETSAT and NOAA Operational and Technical Support**

#### **7.1.1 EUMETSAT**

All data flows described above are under full technical support, including operational monitoring in the EUMETSAT control centre, reporting and coordinated 24/7 coverage for responding to any faults that may occur. The support also includes provision of operational information and notifications via the EUMETSAT Operational Service Status Indicator and User Messaging System and the access to EUMETSAT operational Helpdesk&User Support ([ops@eumetsat.int](mailto:ops@eumetsat.int)). The EUMETSAT User Helpdesk is also responsible for answering questions relating to Sentinel-3 marine data and products. If NOAA receives enquiries related to Sentinel-3 marine data and products, the NOAA helpdesk will forward these enquiries to EUMETSAT's User Support.



The new leveraged roadmap communications service described above is under the agreed coordinated support of a single agency from end to end (EUMETSAT). This delivers a simplified and more efficient progression of fault reporting and investigation.

Support is also in place for data flows described above, though it should be understood that for data flows using commercial Internet as the underlying transport mechanism is “best-effort” in terms of available bandwidth (for example). Commercial Internet links are typically highly leveraged by service providers and it is not generally possible to guarantee bandwidth availability for specific data flows. AR connectivity is generally managed with far lower congestion, and on highly meshed circuits (to support transfers of very large volumes of data at high speeds using multiple underlying link providers).

### **7.1.2 NOAA**

NOAA/NESDIS/STAR will provide routine and sustained access to and science support for Sentinel-3 marine data products via STAR’s infrastructure. STAR provides 8/5 technical support and best-effort for availability of data to users. The CoastWatch/OceanWatch Program maintains a user help desk ([info@coastwatch.noaa.gov](mailto:info@coastwatch.noaa.gov)). Both STAR and CoastWatch/OceanWatch have systems in place to routinely monitor data flow and will work together with EUMETSAT to address identified problems with Sentinel-3 marine data and products.

When NOAA/NESDIS/OSPO assumes operational responsibilities of data flows originating from EUMETCast Terrestrial, the NOAA Environmental Satellite Processing Center (ESPC) Help Desk will monitor data flow for interruptions. The ESPC Help Desk is the point of contact for service interruptions and issuing users notifications. The ESPC Help Desk will contact EUMETSAT in the event of outages or faults. This support, for systems, networks, and applications under NOAA control, is available on a 24/7 basis but could vary depending on the required support level of the applications using Sentinel-3 marine data and products.

The data flow support is limited to the systems, networks, and applications under NOAA control.

## **7.2 Reporting**

NOAA intends to provide EUMETSAT all the necessary details requested to ensure compliance with the reporting requirements agreed between EUMETSAT and the EC in section 3.9 of Annex I of the Copernicus Agreement.

In this regard, NOAA intends to keep EUMETSAT informed about the implementation of this Arrangement. Reporting should be done on a regular basis and contain, as a minimum, the following information:

- Copernicus user registrations and use;
- Onward-dissemination of Sentinel-3 marine data and products, including user statistics of the Sentinel-3 marine data and products provided by NOAA to third parties; and
- Any changes to the agreed mechanisms that may have an impact on EUMETSAT’s support to NOAA’s activities.

Regarding usage statistics related to NOAA and all relevant third parties, the following minimum categories of information should be provided to EUMETSAT as part of the regular reporting.

User account statistics, including:

- Utilisation domain (i.e. Copernicus Services, National Institutions, Researchers, Commercial-SMEs)
- Usage field (i.e. atmosphere, emergency, marine, land, security, climate, other)
- Estimated downstream users benefitting from the data downloaded: 0-10, 11-100, 101-1000, over 1000
- Country of the user

Data dissemination statistics, including:

- Volume of data provided to users in near real time
- Volume of data provided to users on delayed time
- Total volume of data distributed
- Data delivered per utilisation domain and usage field
- Total number of users registered

### **7.3 Sentinel-3 Marine Data and Products Governance**

Sentinel-3 marine data and products made available under the terms of this TOA are governed by the Copernicus data policy as defined in the Copernicus Regulation (EU) No. 377/2014 [AD-1] and the Commission Delegated Regulation (EU) No 1159/2013 [AD-2] and distributed in accordance with the Legal notice on the use of Copernicus Sentinel Data and Service Information from the European Commission [AD-5].

NOAA accepts these conditions implicitly by using or distributing the Sentinel-3 marine data and products.