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ICDs between the EUNADICS-AV Portal and the VAAC/NMS/SESAR-SWIM systems

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Author(s):
N. Theys, H. Brenot, V.-H. Peuch, M. Suttie, C.-H. Rokitansky, F. Zobl, K. Eschbacher, M. Kerschbaum, M. Pichler

Reviewer(s):
W. Som de Cerf, M. Steinheimer, A. Muscat, P. Hereil

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Abstract

This deliverable formalises the interface between EUNADICS-AV data portal and key user systems (VAAC / NMS / SESAR-SWIM). This document specifies interface requirements for the two following fields of information:

- Data description from provider
- Data transfer from EUNADICS-AV to key users

This document contains all the information required by key users in case future data products will be operationally delivered to them by EUNADICS-AV partners.

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Executive Summary

As part of the dissemination strategy of WP8 (i.e. data flows of EUNADICS-AV products to stake holders; see deliverable D40), this deliverable formalises the interfaces between EUNADICS-AV data portal and key user systems (VAAC / NMS / SESAR-SWIM). Two kinds of information are required by key users to perform their activities using products delivered by EUNADICS-AV data portal: description and transfer of data products. This document specifies interface requirements for the two following fields of information:

1. Data description:
    - Name of provider
    - Name and type of product
    - Processing level
    - Transfer timing
    - Format
    - Volume

2. Data transfer:
    - Detailed protocol
    - List of products
    - File name convention
    - Technical specifications
    - Notification and products change
    - Volume

Although operational data delivery is not part of EUNADICS-AV project (only a demonstration/pre-operational phase is planned), the present document aims at providing information at the description level required by key users in case data products would be operationally delivered by EUNADICS-AV partners in the future.

At the time of writing, a final and consolidated list of relevant EUNADICS-AV products is not yet established. Therefore, this deliverable will be updated in the course of the project with more completed description of products and data transfer. In this end-to-end version of this ICD deliverable, the example of one product has been chosen and filled in the tables of section 5.

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1. Introduction

As an introduction, Fig. 1 presents a sketch of EUNADICS-AV data flows and the links between WPs. This gives a clear and logic view how data products (WP3) triggered by notifications from the early warning system (WP5) and outputs from air space specific model (WP6) will be disseminated to stakeholders (key users and community at large) in WP8 (see deliverables D40 and D41).

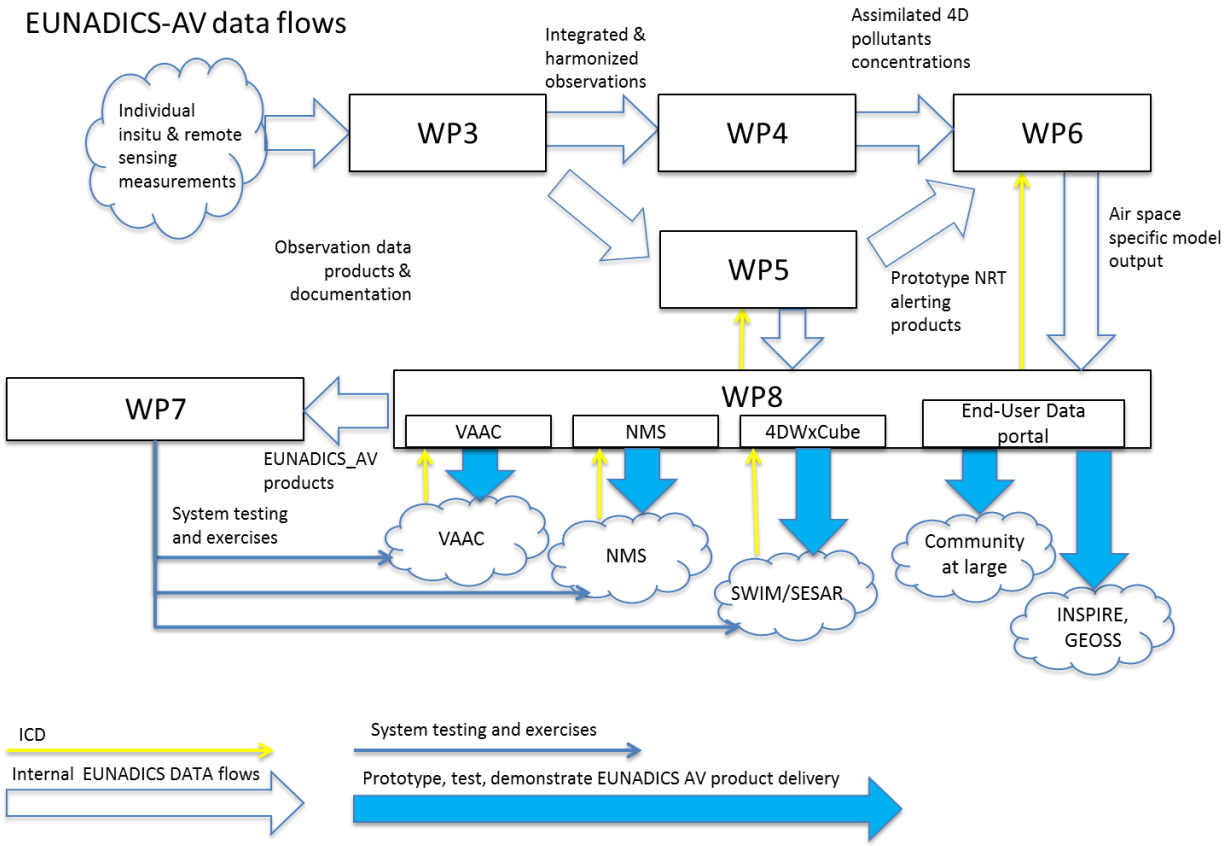

Figure 1 : Schematic diagram of EUNADICS data flow.

This deliverable concerns the tasks of WP8, specifically the dissemination of products from EUNADICS-AV data portal to the key user systems (i.e., VAAC / NMS / SESAR-SWIM).

1.1 Purpose of the document

The purpose of this Interface Control Document (ICD) is to formalise how data products are to be delivered from the EUNADICS-AV data portal to the key user systems, i.e., the Volcanic Ash Advisory Centres (VAAC), the National Meteorological Services (NMS) and the Single European Sky ATM Research and its System wide Information Management (SESAR-SWIM).

1.2 Structure of the document

This document follows the ICD structure established from the requirements of London and Toulouse VAACs (Météo-France is indeed partner of EUNADICS-AV as well), ECMWF partner (representing NMS protocol), and SESAR joint undertaking and EUROCONTROL.

Chapter 1 describes the purpose of this document, its structure and the intended readership.

Chapter 2 lists all the documents referenced in this ICD.

Chapter 3 describes the definitions used in this document.

Chapter 4 presents VAAC interface to EUNADICS-AV portal, identifying the specific interface requirements needed to deliver successfully to the International Airways Volcano Watch (IAVW) community of the International Civil Aviation Organization (ICAO).

Chapter 5 presents NMS interface to EUNADICS-AV portal, identifying the specific interface requirements needed to deliver successfully to NMS community which is part of the World Meteorological Organisation (WMO).

Chapter 6 presents SESAR-SWIM interface to EUNADICS-AV portal, identifying requirements needed to deliver successfully to the SESAR-SWIM community (via 4DWxCube MET-GATE).

1.3 Intended readership

This ICD is written for all data providers in the consortium and data providers outside the consortium, which will be delivering data products to the EUNADICS-AV data portal developed by WP8.

2. Applicable and reference documents

- EUNADICS-AV D40 (2017): *Dissemination plan*, 31/05/2017.
- EUNADICS-AV D41 (2017): *ICD between data providers and EUNADICS-AV Portal*, 31/10/2017.
- EUROCONTROL (2016): SWIM: Connecting the ATM world, https://www.eurocontrol.int/publications/what-swim, August 2016.
- SESAR (2011): Technical Specification 4DwxCube, MET Information Systems Development, Verification & Validation, 11.02.02-D41, SESAR, 2011, https://www.sesarju.eu/sites/default/files/solutions/06_TS_Solution_35_11.02.02-D41_Technical_Specification_4DWxCube_-_Ed_00.01.00.pdf.
- SESAR (2015) : 4DweatherCube, MET-GATE, http://www.sesarju.eu/sites/default/files/documents/concepts/Fact_sheet_on_METGATE.pdf.
- SESAR (2016) : DELIVERING TAILORED MET INFORMATION WITH THE 4DWXCUBE AND MET-GATE, http://www.sesarju.eu/highlights/Delivering%20tailored%20MET%20information%20with%20the%204DWxCube%20and%20MET-Gate.
- T11.2.2.2 – 4DWxC MET GATE (2015): How a MET provider can register a new kind of MET product in the MET-GATE catalogue? Dec 29, 2015, http://publicwiki.meteo.fr/confluence/pages/viewpage.action?pageId=7503923.

3. Terms, definitions and abbreviations

Acronyms/ Abbreviations	**Definition**
4DwxCube	Four dimensional weather cube
AIRM	ATM Information Reference Model
ATFCM	Air Traffic Flow and Capacity Management
ATM	Air Traffic Management
CAT	Clear Air Turbulence
DCPC	Data Collection or Production Centre
ECMWF	European Center for Medium-range Weather Forecasts
ECPDS	ECMWF Product Dissemination System
EMI	European Meteorological Infrastructure
EUMETNET	European Meteorological Network
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
EUNADICS-AV	European Natural Airborne Disaster Information and Coordination System for Aviation
GTS	Global Telecommunication System
HMI	Human Machine Interface
IAVW	International Airways Volcano Watch
ICAO	International Civil Aviation Organization
ICD	Interface Control Document
ID	Identification
ISRM	Information Service Reference Model
LLSWC	Low Level Significant Weather Chart
MET	Meteorological / Meteorology
MET-GATE	MET information services Generation, ATM Tailoring and Exchange
METAR	MET Aerodrome Report
METSP	MET Service Provider
NMS	National Meteorological Services
PIREP	PIlot weather REPort
RSMC	Regional Specialised Meteorological Centre
SCG	Service Coordination Group
SESAR	Single European Sky ATM Research
SIGMET	SIGnificant MET information/advisory
SIGWX	SIGnificant Weather forcasts
SWIM	System Wide Information Management
TAF	Terminal Aerodrome Forecast
TCA	Terminal Control Area
VAA	Volcanic Ash Advisories
VAAC	Volcanic Ash Advisory Centre
WIS	WMO Information System
WMO	World Meteorological Organisation

4. VAAC interface to EUNADICS-AV Portal

The role of this interface is to specify requirements needed to deliver successfully to the IAVW community of ICAO, of which Volcanic Ash Advisory Centres (VAACs) are part. The following description on the needs of the VAACs in terms of interfaces to EUNADICS-AV system is an output of a teleconference meeting held on November 15, 2017 between representatives of:

- **Toulouse Volcanic Ash Advisory Centre**: Philippe Hereil (Toulouse VAAC manager). Matthieu Plu of Météo-France (lead of EUNADICS WP6) also attended the meeting.
- **London Volcanic Ash Advisory Centre**: Anton Muscat (London VAAC operations manager).
- **Royal Belgian Institute for Space Aeronomy (BIRA-IASB):** Nicolas Theys and Hugues Brenot.
- **Royal Netherlands Meteorological Institute (KNMI):** Wim Som de Cerf and Saskia Wagenaar.
- **Zentralanstalt für Meteorologie und Geodynamik (ZAMG):** Marcus Hirtl.

The meeting started with a presentation of the EUNADICS-AV project objectives and proposed prototype products, followed by a discussion on the VAACs needs and suggestions for future work.

4.1 VAAC systems description

The Volcanic Ash Advisory Centres are the International Civil Aviation Organization (ICAO) centres that are mandated to issue advisories in case of volcanic eruptions affecting the airspace. There are nine VAACs worldwide, each of them having an area of responsibility as illustrated in Fig. 2.

Over Europe, there are two VAACs:

- **Toulouse VAAC** (http://www.meteo.fr/vaac) hosted by Météo-France. Toulouse VAAC has a large area covering all Africa, large parts of Europe, Middle East and Asia.
- **London VAAC** (https://www.metoffice.gov.uk/aviation/vaac) hosted by the United Kingdom Met Office. The London VAAC area is less extended than the one of

Toulouse VAAC and covers Iceland, the United Kingdom, Scandinavia and North Siberia.

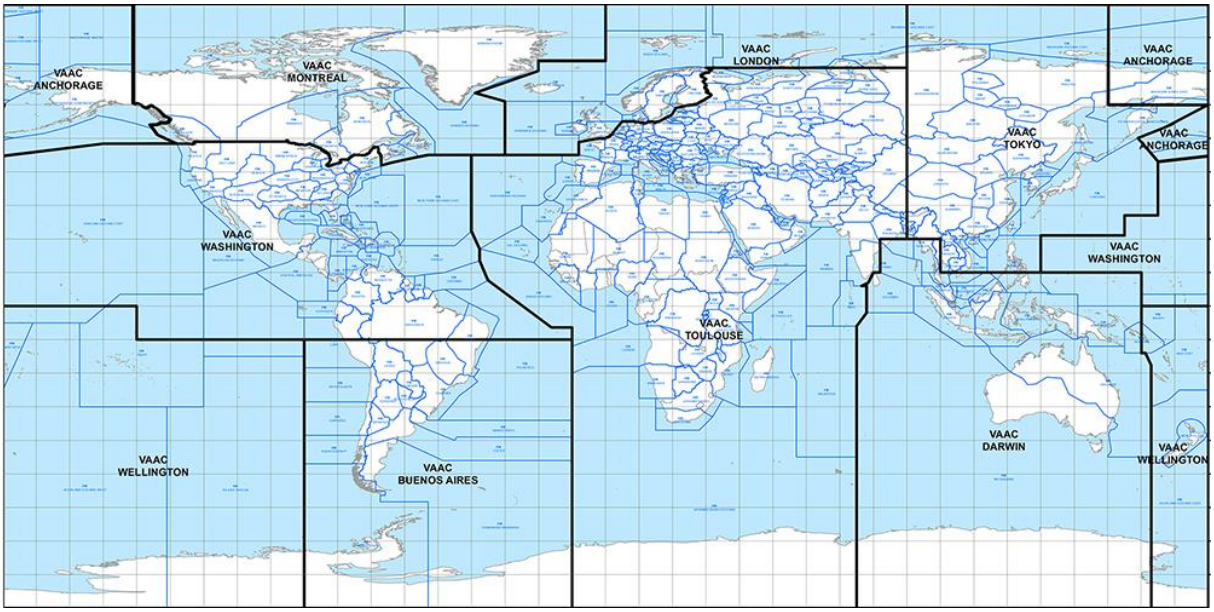

Figure 2 : Areas of responsibility for the nine VAACs worldwide.

For each volcano, depending on the region it is located in, one particular VAAC is in charge of providing atmospheric transport modelling and simulation products using a combination of:

- Volcano observatory data
- Satellite-based observations
- Ground-based observations
- Aircraft observations

An overview of the London VAAC process can be found at the following link: https://www.metoffice.gov.uk/aviation/vaac/process

London and Toulouse VAACs have specialist forecasters who produce volcanic ash advisories and guidance products using a combination of data from observations and models. For example, the Met Office NAME dispersion model or the Météo-France MOCAGE-accident model, are initialised with both meteorological and volcanic eruption data. This includes winds, temperature, humidity, height of plume, size of ash particles and more.

These model can also be run in “inverse” mode in order to provide information on the origin of an air-mass arriving at a given point in space and time. This configuration is used to perform backtracking simulations.

A strong cooperation between the different VAACs exists (especially between Toulouse and London VAACs which provides a reciprocal back-up facility) and is needed because volcanic ash plumes follow wind patterns and typically move from one area of responsibility to another.

4.2 VAAC general interface requirements

From the exchanges between VAACs and EUNADICS-AV representatives, several important points related to the VAACs needs in terms of products and interfaces have been addressed and discussed:

- Both London and Toulouse VAACs recognise that the project objective of having consistent and coherent observational data in a central repository is ambitious and a very good idea. However, the VAACs also clearly expressed a concern in that sensitive automatic products would become freely available to the general public, leading possibly to conflicts with the work performed by the designated entities.
  Hence, EUNADICS-AV shall coordinate with the VAACs (and other key users) what data products could be made freely available to the general public via the EUNADICS-AV data portal and what are the data products that would only be accessed by the VAACs via a protected specific interface.

- Generally speaking, London and Toulouse VAACs have similar needs and approaches. However, London VAAC area of responsibility is much smaller than the area of Toulouse and the vast majority of volcanoes are located in Iceland where the observational networks are very good (one volcano is located on Jan Mayen Island, approximately 800 km to the northeast of Iceland, and this is unmonitored). London VAAC already has access to all observational data in real time (or near real time).

- A general need expressed by the VAACs is to improve their situation awareness via a unique information source. The 9 VAACs meet regularly – they mention their interest for a shared platform to exchange data and products, currently this is done e.g. per email and should be optimised. A common platform is particularly relevant in case a volcanic plume gets transported into another area of responsibility and therefore, a common platform could reinforce the existing liaison between two different VAACs. If EUNADICS-AV can provide such a prototype e.g. for UK and Toulouse VAACs (importantly to share model data) this could raise attention also for the others on global scale.

- Requirements in terms of interfaces: London and Toulouse VAACs are mostly interested by a web interface (with an access restricted to the VAACs) where data could be visualised, e.g. satellite and lidar imagery and aircraft reports of Volcanic Ash are explicitly mentioned. This could possibly also include options to download the data displayed but a specific dissemination channel (e.g. ftp) is not a priority.

- Requirements in terms of products: among the three types of EUNADICS-AV products (alerting products, tailored observation data products, model products), the VAACs are most interested in tailored data products that could (possibly) improve situation awareness, as VAACs already deliver model products (concentration charts, volcanic ash graphics) on their websites.

- Time/performance requirements: the data products shall be operational or quasi-operational. The data shall be available in real-time or near-real-time otherwise the products will not be used.

- Communication requirements: the system shall provide an easy monitoring of data flows, and include information whether the data are present or not, and messages on possible errors.

- Data/file format requirements: preferred formats are netCDF[1], GRIB[2], kmz[3] (compressed google earth file). Toulouse VAACs also uses the open standard format GeoJSON[4]. London VAAC also mentioned that they would be very interested to have data on visual observations of volcanic ash from aircrafts (from pilots). Minimal information needed would be latitude, longitude, height and time of observations. This data could be overlaid with satellite and model data for instance.

- The option to use ECMWF Product Dissemination System (ECPDS[5]) to transmit read-time data is discussed. The London and Toulouse VAACs state it might be useful in the future but it is not a priority for them in the short run.

- Both UK and Toulouse mention they are also RSMC's and therefore also interested in nuclear aspects.

1 https://www.unidata.ucar.edu/software/netcdf

2 https://en.wikipedia.org/wiki/GRIB

3 https://developers.google.com/kml/documentation/kmzarchives

4 https://en.wikipedia.org/wiki/GeoJSON

5 https://www.ecmwf.int/en/forecasts/documentation-and-support/data-delivery/manage-your-data-transmission-ecpds

4.3 VAAC specific interface requirements

The purpose of this specific interface is to specify:

- The EUNADICS-AV products required by VAACs
- The data transfer protocol
- The notification and test data requirements
- The volume of data exchanged

The products for dissemination to VAACs will mainly consist of tailored products and data visualisation with the possibility to download the data displayed using a specific dissemination channel. The selected products cover the following airborne hazards:

- volcanic ash plumes
- volcanic SO_2 plumes

These products will be ingested and stored within the EUNADICS-AV portal.

At the time of writing this ICD, the exact specification of EUNADICS-AV products is not known. The following sections define the type of information that needs to be included, in general terms. The specific details of products (transfer protocols, timings, etc.) will need to be added once known. As an example, information about few products is provided.

4.3.1 Data Description

Table 1 : Description of all of the products required for dissemination to VAACs.

Product Name	Product type (measurement/analysis/prediction)	Processing Level (L2/L3/L4)	EUNADICS-AV Provider

4.3.1.1 Transfer Timing

Table 2 : Specification of the timing details of the of the product transfers to VAACs.

Product Name	Date created	Date issued	Date received	Data latency
	Daily product	Daily after	Within ten minutes after	Within one hour after production

	e.g. 2016-09-27T23:39:50Z	production time	Date issued	time

4.3.1.2 Data Format

Table 3 : Specification of the format and compression method (if any) for each product transferred to VAACs.

Product Name	Format	Data compression
	e.g. NetCDF Climate and Forecast (CF) Metadata Convention Standard Name Table v28	e.g. Compressed (gz)

4.3.1.3 Data Volume

Table 4 : Specification of the number and volume of files for each product transferred to VAACs.

Product Name	Number of Data files	File Volume
	e.g. Three files per day	e.g. Size varies (~ 6 Mbytes)

4.3.2 Data Transfer

4.3.2.1 From EUNADICS-AV to VAACs

EUNADICS-AV provides all the following groups of products for transfer to VAACs from the EUNADICS-AV portal:

[*List of product types*]

a.

b.

The detailed protocol is as follows:
[*Detailed steps in the transfer protocol adopted*]

a.
b. …

4.3.2.2 File name convention

Table 5 : Description of file naming convention (with example for each product transferred to VAACs).

Product name	File name convention

4.3.2.3 Technical specifications

This section details the technical specifications of the file transfer. These will differ depending on whether the VAAC is pulling data from the EUNADICS-AV portal or data is being pushed to the VAAC.

Table 6: Protocol of file transfer (data is pulling by VAACs or being pushed by EUNADICS-AV).

Product name	File transfer	Host server	Data path	User account
	pulling			
	pushed			

4.3.2.4 Notification and product change

4.3.2.4.1 Scope of the Service Level Agreement

This agreement concerns the following products (to be defined):

-
-

4.3.2.4.2 Incident and outage

In the case of any incident or planned outage impacting one of the products, an appropriate communication protocol needs to be set up to inform the VAACs of such disruption to service.

4.3.2.4.3 Change impacting one of the products

An appropriate mechanism for communicating and implementing changes in products needs to be agreed and adhered to.

In case of any change impacting any of the products listed in 4.3.2.4.1:

- Once a change is foreseen (from one year in advance to 1 month) an email is sent to VAACs contact points with a brief description of the foreseen change and the foreseen implementation date.
- If the change (previously announced) has a direct impact on the user (file name, product content, access):
  - It will be notified 2 months in advance,
  - After its entry into service, double dissemination (current and new products) will be ensured over a period of 2 months,
  - When appropriate sample datasets will be made available 1 month before.
- If the change (previously announced) has not a direct impact for the user (new secondary sensor, update of secondary sensor...):
  - It will be notified at least 2 weeks before
  - Sample datasets will be made available 2 weeks before when appropriate.

4.3.2.5 Contact points

Table 7: Designated contact points at VAACs for problems concerning this interface.

Contact name	Email address	Telephone number
London VAAC: Anton Muscat	anton.muscat@metoffice.gov.uk	+44 1392 886 033

Toulouse VAAC: Philippe Hereil	philippe.hereil@meteo.fr	+33 5 61 078 239

For administrative issues (ICD changes) please contact:

Table 8 : Designated contact point at EUNADICS-AV for problems concerning VAACs interface.

Contact name	Email address	Telephone number
Service Desk, EUNADICS-AV	eunadics-office@zamg.ac.at	+43 1 36026 2008

Note: *The requirements that cannot be implemented in this deliverable and the EUNADICS-AV Portal directly (too specific for VAAC) will be implemented within the existing infrastructure of the core data delivery system (Task 8.3). This task will provide a VAAC ICD and a prototype VAAC extension on the EUNADICS-AV Portal.*

5. NMS interface to EUNADICS-AV Portal

The role of this interface is to specify requirements needed to deliver successfully to the National Meteorological Services (NMS) community which is part of the World Meteorological Organisation (WMO).

5.1 NMS description

The European Meteorological Infrastructure (EMI) is composed of:

- ECMWF, the European Centre For Medium-Range Weather Forecasts, which provides global meteorological products, a High-Performance Computing and data archive facility as well as training services;
- EUMETNET, the European Meteorological Network, which provides a framework for organising cooperative programmes between NMS for a range of meteorological activities, including observing systems, data processing, basic forecasting products, research and development and training;
- EUMETSAT, which is in charge of operating the space component of the EMI;
- The National Meteorological Services (NMS) in the different European countries.

An interactive map of the NMS can be found on the EUMETNET website (http://eumetnet.eu/members-partners), with contact details and link to the main websites.

The NMS vary very much in size in Europe and so does the range and variety of the meteorological services that they provide, either as part of their public service mandate or as part of commercial consultancy activities. The civil and military aviation sectors are in general key users of the NMS, which are in general in charge of supporting the operations of airport in their country with meteorological services (observations, forecasts, ...).

Data provision to and from the NMS is organised under the framework of the WMO, namely though the so-called Global Telecommunication System (GTS), which is progressively replaced by the WMO Information System (WIS). Operational data exchanges are really at the core of the meteorological business. ECMWF and EUMETSAT are also key provider of numerical model outputs and satellite observations respectively. ECMWF and EUMETSAT are also Entrusted Entities for the implementation of the European Copernicus programme and are using the same channels to deliver Copernicus data and services as for their core meteorological mandate. Several Copernicus products and data from the Sentinels are (or will be) of interest for the aviation sector (volcanic ash, dust and biomass burning plumes).

5.2 NMS specific interface requirements

The purpose of this specific interface is to specify:

- The EUNADICS-AV products required by NMS
- The data transfer protocol
- The notification and test data requirements
- The volume of data exchanged

The products for dissemination to NMS will consist of early warning products (generated by WP5) and pilot implementation products (generated by WP6) covering the following airborne hazards:

- volcanic ash plumes
- dust clouds from desert storms
- airborne aerosols
- nuclear and chemical plumes

Comment from Anton Muscat (London VAAC): Once again it is important to understand that, currently, the VAACs and RSMCs send out information to users in NMSs relating to both Volcanic Ash plumes and nuclear plumes, as part of mandated services through ICAO and WMO respectively. In the future, RSMCs will also provide plume information relating to non-nuclear dispersion (e.g. chemical plumes, and potentially other airborne aerosols). Therefore, it is important that any such products provided through the EUNADICS-AV portal are issued through either the VAAC or RSMC so that a consistent product is offered to users.

The products will be ingested and stored within the EUNADICS-AV portal.

At the time of writing this ICD, the exact specification of EUNADICS-AV products is not known. The following sections define the type of information that needs to be included, in general terms. The specific details of products (transfer protocols, timings, etc.) will need to be added once known. As an example, information about few products is provided.

5.2.1 Data Description

Table 9 : Description of all of the products required for dissemination to NMS.

Product Name	Product type (measurement/analysis/prediction)	Processing Level (L2/L3/L4)	EUNADICS-AV Provider
Dust Aerosol (0.03 - 0.55 µm) Mixing Ratio forecast	Prediction	Model output	ECMWF/CAMS

5.2.1.1 Transfer Timing

Table 10 : Specification of the timing details of the of the product transfers to NMS.

Product Name	Date created	Date issued	Date received	Data latency
Dust Aerosol (0.03 - 0.55 µm) Mixing Ratio forecast	Twice daily product	Twice daily after production time: 00Z base time by 10UTC, 12Z base time by 22UTC		Within one hour after production time

5.2.1.2 Data Format

Table 11 : Specification of the format and compression method (if any) for each product transferred to NMS.

Product Name	Format	Data compression
Dust Aerosol (0.03 - 0.55 µm) Mixing Ratio forecast	GRIB/NetCDF	None

5.2.1.3 Data Volume

Table 12 : Specification of the number and volume of files for each product transferred to NMS.

Product Name	Number of Data files	File Volume
Dust Aerosol (0.03 - 0.55 µm) Mixing Ratio forecast	164 files per day: 2 base times x 41 forecast steps x 2 level types (model levels and pressure levels)	Individual model level file: 73 Mb (GRIB), 49 Mb (NetCDF) Individual pressure level file: 30 Mb (GRIB), 20 Mb (NetCDF) Total volume per day: 14.1 Gb

5.2.2 Data Transfer

5.2.2.1 From EUNADICS-AV to NMS

EUNADICS-AV provides all the following groups of products for transfer to NMS from the EUNADICS-AV portal:
[*List of product types*]

a.
b.

The detailed protocol is as follows:
[*Detailed steps in the transfer protocol adopted*]

a.
b.

5.2.2.2 File name convention

The file naming convention is as follows:

`z_cams_c_ecmf_yyyymmddhhmmss_vvvv_tt_lt_sss_param.[grib|nc]`

where:
`ecmf` is the WMO location indicators;
`yyyymmddhhmmss` is the base date and time of the forecast;
`vvvv` is a version or experiment identifier. `prod` will be used for operational products, `test` (or experiment ID) will be used for testing purposes, `rean` for reanalysis if needed;
`tt` is the type of data, `fc` - forecast, `an` - analysis;
`lt` is the type of level. `pl` for pressure level products, `sfc` for surface fields, `ml` for model level fields;
`sss` is the forecast hour time step. For accumulation and averages, it is the end time. This number must be zero padded to 3 digits, e.g. step 24 is given as 024;
`param` is the parameter short name;
`grib`, `nc` is the format of a file, GRIB or NetCDF.

Table 13 : Description of file naming convention (with example for each product transferred to NMS).

Product name	File name convention
Dust Aerosol (0.03 - 0.55 µm) Mixing Ratio forecast	`z_cams_c_ecmf_20171129000000_prod_fc_pl_012_ aermr04.grib` contains all the pressure levels of +12 step dust aerosol (0.03 - 0.55 µm) mixing ratio fields from a forecast started on 29 November 2017 at 00:00 UTC

5.2.2.3 Technical specifications

This section details the technical specifications of the file transfer. These will differ depending on whether the NMS is pulling data from the EUNADICS-AV portal or data is being pushed to the NMS.

Table 14: Protocol of file transfer (data is pulling by NMS or being pushed by EUNADICS-AV).

Product name	File transfer	Host server	Data path	User account
Dust Aerosol (0.03 - 0.55 µm)	FTP pull	dissemination.ecmwf.int	/DATA/CAMS_NREALTIME/${YYYYMMDDhh}	User needs to

Mixing Ratio				register
	pulling			
	pushed			

where YYYYMMDDhh is the base date/time of the forecast.

5.2.2.4 Notification and product change

5.2.2.4.1 Scope of the Service Level Agreement

This agreement concerns the following products (to be defined):

-
-

5.2.2.4.2 Incident and outage

In the case of any incident or planned outage impacting one of the products, an appropriate communication protocol needs to be set up to inform the NMS of such disruption to service.

5.2.2.4.3 Change impacting one of the products

An appropriate mechanism for communicating and implementing changes in products needs to be agreed and adhered to.

In case of any change impacting any of the products listed in 5.2.2.4.1:

- Once a change is foreseen (from one year in advance to 1 month) an email is sent to NMS contact points with a brief description of the foreseen change and the foreseen implementation date.
- If the change (previously announced) has a direct impact on the user (file name, product content, access):
    - It will be notified 2 months in advance,

- After its entry into service, double dissemination (current and new products) will be ensured over a period of 2 months,
- When appropriate sample datasets will be made available 1 month before.

- If the change (previously announced) has not a direct impact for the user (new secondary sensor, update of secondary sensor...):
  - It will be notified at least 2 weeks before
  - Sample datasets will be made available 2 weeks before when appropriate.

5.2.2.5 Contact points

Table 15: Designated contact points at NMS for problems concerning this interface.

Contact name	Email address	Telephone number

For administrative issues (ICD changes) please contact:

Table 16 : Designated contact point at EUNADICS-AV for problems concerning NMS interface.

Contact name	Email address	Telephone number
Service Desk, EUNADICS-AV	eunadics-office@zamg.ac.at	+43 1 36026 2008

Note: *The requirements that cannot be implemented in the core delivery system (are too specific for NMS) will be implemented within this task on the existing infrastructure of the core data delivery system (Task 8.3). The WMO Information System (WIS) can be seen as the possible candidate for realising the technical interface and the project aims to connect as a Data Collection or Production Centre (DCPC) to the WMO information system. Task 8.3 will deliver a NMS ICD and a prototype NMS extension on the EUNADICS-AV Portal.*

6. SESAR-SWIM interface to EUNADICS-AV Portal

The role of this interface is to specify requirements needed to deliver successfully to the SESAR-SWIM community (via 4DWxCube MET-GATE).

6.1 4DWxCube MET-GATE description

The four dimensional weather cube (4DWxCube) is the technical response to the MET challenges in SESAR (SESAR, 2011; SESAR, 2015; SESAR, 2016). Thus in the framework of SESAR, national meteorological service providers from EUMETNET are developing innovative MET solutions for air traffic management. The 4DWxCube is a (virtual) repository of shared, consistent and translated meteorological information, produced by multiple meteorological service providers and made available to ATM stakeholders via its SWIM compliant MET-GATE.

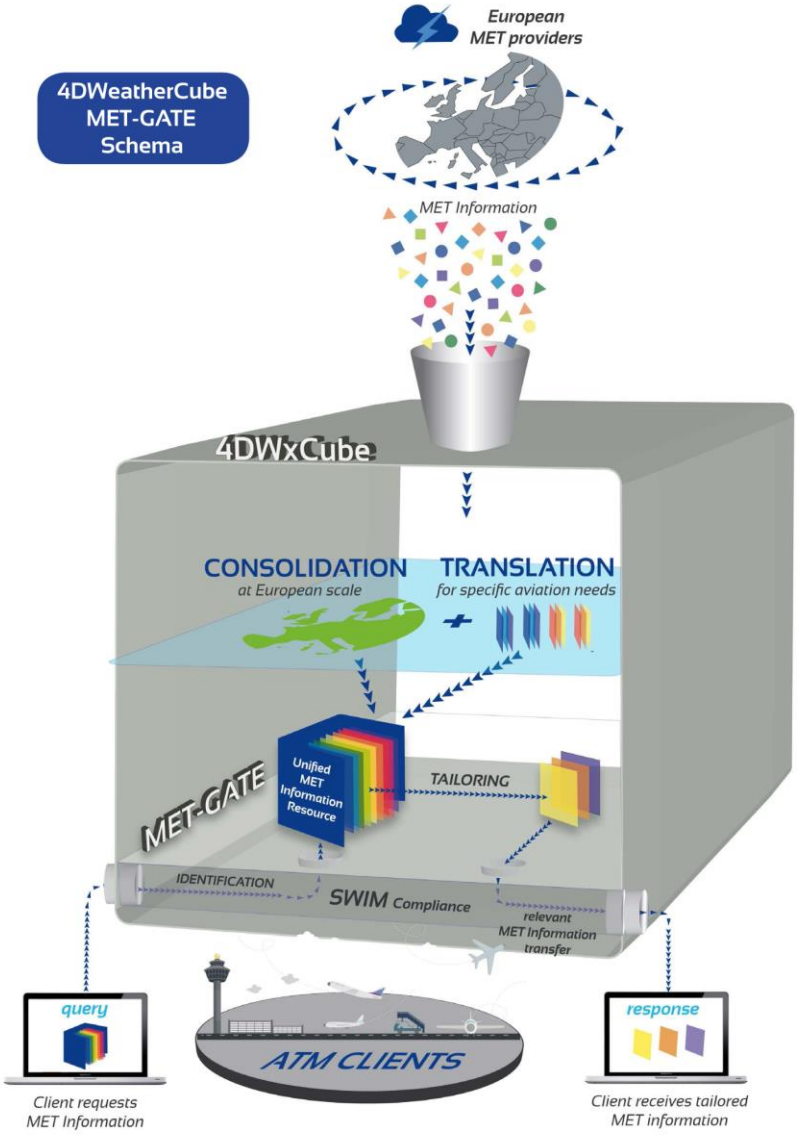

Figure 3: 4DWeatherCube MET-GATE framework; source: http://www.sesarju.eu

The 4DWxCube is a system of systems (see Fig. 3) made of:

- Functional blocks performing MET "Consolidation & Translation"
- The MET-GATE system

The 4DWxCube contains all the complexity of the weather forecasting and observation process and consolidates all the information in such a way that the user can extract the details relevant to their situation without having to concern themselves about which MET provider has produced the forecast.

The MET-GATE is designed as a one stop shop for MET, providing SWIM services from classical regulated products to innovative products related to the latest scientific fields such as convection, icing and clear air turbulence. This is the SWIM compliant user interface for ATM stakeholders.

The MET-GATE is the one stop shop for MET information. It accesses consolidated and translated MET information, performs the relevant data collection, selects and provides fit-for-purpose MET information for ATM stakeholders through MET-ATM SWIM services.

Facets of the MET-GATE are:

- Ensuring consistency among Europe by guaranteeing the same view sharing
- of the observed and forecasted MET situation
- Ensuring the SWIM compliance in term of SWIM data model AIRM, SWIM service model ISRM, SWIM technical infrastructure
- A unique access portal which guarantees the reliability of MET information
- supply and a high level of performance crucial for ATM Services
- Providing Smart Functionalities such as:
    - Build a collection of MET information according to a time-related criterion, a geographical criterion (cross section, vertical profile, 4D trajectory) and/or a list of physical parameters (wind direction, temperature, etc...)
    - Extract a contour from gridded data (isoline)
    - Provide alarm when a parameter exceeds a threshold
    - Convert data format

There are several types of 4DWxCube users, but four main categories can be distinguished, these are: governance contributors, administrators of the system, providers of MET Information and services and ATM system consumers.
The 4DWxCube Governance Board is the team of people who approves the addition or removal of new products, services and METSPs to the 4DWxCube. This team has no direct interaction with the system but can instruct the Administrator to carry out specific tasks.
The Service Coordination Group (SCG) is a team of people that coordinates the activities required to develop and approves new SWIM Services.
The 4DWxCube administrator is a human operator in charge of the 4DWxCube administration. This user is allowed to manage the list of access rights of ATM consumers and the list of available Product Definitions in the 4DWxCube though a dedicated Human Machine Interface (HMI) called "Administration portal". The Administrator is responsible for registering MET Product Definitions and service providers ensuring that the 4DWxCube contains approved and consistent information relating to the primary artefacts in the system. The Administrator is also responsible for publishing metadata for specific MET Services to the SWIM Registry.

Table 17 : List of expected products and transaction levels (list not exhaustive ; source : SESAR, 2011).

MET Product	Expected Transaction Levels
METAR	Every 30 minutes, for each aerodrome
TREND (modifier to TAF/METAR)	Ad-hoc (addition to TAF/ METAR)
SPECI	Ad-hoc (update of METAR)
TAF	4 times per day, for each aerodrome (planned/ near future : information out of model, supplemented with meteorologist expertise)
SIGMET	Ad-hoc - valid for max. 4 hours for a specific region of airspace (icing, turbulence & thunderstorm), - valid for max. 6 hours for volcanic ash
SIGWX	4 times per day, 13 PNG charts in total and in BUFR format
Radar (observations)	Update rate of 5-15minutes
Satellite (observations)	Update rate of 5min to 1h
Turbulence / CAT	1h update rate for nowcast
Convection	5 min update for nowcast for 0-3h nowcast
Icing	1h update rate for nowcast
Wind	1h update rate for nowcast
VAA	Ad-hoc
TCA	Ad-hoc
AIRMET	Issued 4 times daily (ad-hoc), normally
Aerodrome Observations	15 seconds – 10 minutes depending on MET parameter (instrument)
Aircraft Observations (PIREP)	Ad-hoc, normally not in areas with LLSWC (Low Level Significant Weather Chart)

A generic METSP provides meteorological information and services to the 4DWxCube. All MET Information and service providers shall be approved by the governance board (i.e., an

authority who gives permission about what data an identified provider can supply). NMS are specialist METSPs that offer a wide range of authoritative MET Products. Other METSPs that could have access to the 4DWxCube domain system include: local MET observations provided by ATM-dedicated aerodrome infrastructure, aircraft en-route MET information, commercial MET product and/or service providers, and potentially crowd-sourced MET information where this is deemed appropriate. METSPs are assumed to provide the listed MET products at the expected following transaction levels. Table 17 provides a list of expected products and transaction levels.
Exchanges between the 4DWxCube and its ATM system consumers are always done through SWIM compliant services. Consumers access MET product information only through the services advertised by the SWIM Registry. Consumers must be known to the system and must have permission to access the advertised services. The 4DWxCube does not present an HMI to its consumers as it cannot directly interact with a human user. Instead, it provides consumers with machine-to-machine services. An ATM system uses data supplied by the 4DWxCube (business-to-business operating) and advertised by the SWIM Registry. ATM systems are developed by ATM consumers and are specific to their type of activities.

The list below describes a typical information flow through the 4DWxCube highlighting the key information artefacts (*in red italics*), the key processes and the persistent stores (**in bold**). It describes how radar information is managed within the 4DWxCube to support the publication of a tailored convection product for an ATM consumer (SESAR, 2011):

1. The provider uploads the *radar information* with minimum *metadata* related to the specific instance of the *radar information*.
2. The *radar information* is validated to make sure that it is in the expected format etc.
3. The *metadata* is validated to make sure that it provides the minimum metadata information required.
4. The *radar information* and the *metadata* are processed. The metadata is extended to include *provider information* and *product definition* information obtained from the **4DWxCube Registry**. The *raw radar information* is stored in the MET Product Store. The *extended metadata* is stored in the **4DWxCube Registry**; the *extended metadata* shall contain information about the location of the *raw radar information* in the **MET Product Store**.
5. The *Metadata ID* and the *Product Definition ID* are passed to the broadcast process which broadcasts the information to any processes that may be interested in the fact that new data is available.
6. A consolidation monitoring process shall monitor for any new information (based on product definition ID) that is relevant to one or more of the consolidation processes. The *Metadata ID* is then transferred to the appropriate process(es).
7. The selected consolidation process (via Radar Composite) is informed of new information and retrieves the *radar extended metadata* from the **4DWxCube Registry**. The process itself may need to wait until *radar information* is available

from other providers. Using the information contained in the metadata the process shall retrieve all relevant *radar information* from the **MET Product Store** and then produce a *Consolidated Radar Reflectivity* product and store this in the **Consolidated MET Product Store**, *Consolidated Radar Reflectivity Metadata* associated with the consolidated product shall be stored in the **4DWxCube Registry**.

8. The *Metadata ID* and the *Product Definition ID* are passed to the broadcast process which broadcasts the information to any processes that may be interested in the fact that new data is available.
9. A translation monitoring process shall monitor for any new information (based on product definition ID) that is relevant to one or more of the consolidation processes. The *Metadata ID* is then transferred to the appropriate process(es).
10. The selected translation process (which characterises cloud convection) is informed of new information and retrieves the *Consolidated Radar Reflectivity Metadata* from the **4DWxCube Registry**. The process itself shall also need to may need to wait until new *Forecast and Observation metadata* is available. Using the information contained in the metadata the process shall retrieve the *Consolidated Radar Reflectivity* and *Forecast and Observation Products* from the **Consolidated MET Product Store** and then produce the *Convection Product* and store this in the **Translated MET Product Store**, *Convection Product Metadata* associated with the consolidated product shall be stored in the **4DWxCube Registry**.
11. The *Metadata ID* and the *Product Definition ID* are passed to the broadcast process which broadcasts the information to any processes that may be interested in the fact that new data is available.
12. A subscription monitoring process shall monitor for any new information (based on product definition ID) that is relevant to any of the active subscriptions. The *Convection Product Metadata* is retrieved from the **4DWxCube Registry** and passed to the specific tailoring service associated with the subscription.
13. Using the *Convection Product Metadata*, the service retrieves the *Convection Product* from the **Translated MET Product Store** and creates a *tailored ATM Product* that is published to the consumer.

Central to the data management of the system are the MET Product Stores (Raw, Consolidated and Translated) which store the meteorological information and the 4DWxCube Registry which stores the metadata associated with the MET Products and the providers. The Data Management functional block spans all the internal processes of the 4DWxCube. Upload and management of providers, product definitions and service descriptions are dealt with in the Administration functional block. Consolidated MET Products and Translated MET Products are managed in the same way as Raw MET Products.

In the context of SESAR, the development of the 4DWxCube and the MET-GATE systems will enable users across Europe to access MET information in SWIM formats for their

operations. By creating a consistent MET picture over Europe, i.e. consistent in location, time and user application, decision making will in turn be more consistent, reducing the potential for conflict and enhancing ATM predictability.

Through EUMETNET, the national MET service providers have collaborated in innovative ways to develop the 4DWxCube and MET-GATE. During the first quarter of 2016, tailored MET information has been used to support decision making in a number of SESAR validation exercises including: de-icing management at airports; ATFCM measures; and the use of ensemble weather forecasts in trajectory planning. TOPLINK project, a SESAR large scale demonstration, and the SWIM Global Demonstration will provide further opportunities to demonstrate the benefits of tailored MET information.

Detailed information on technical specifications of 4DWxCube (with MET information systems development, verification & validation) can be found in SESAR (2011).

6.2 4DWxCube general interface requirements

The general interface requirements are based on T11.2.2.2 – 4DWxC MET GATE (2015), in which registration of new kind of MET product in the MET-GATE catalogue is presented. The following services are used to manage the MET products supply:

- METSP Product Management Service
  - Register MET Product
  - Recall MET Product / Send alert
  - De-register MET Product
  - Request Met Product Usage Log
  - METSP Observation Retrieval Service
- Upload service

The MET provider has to provide a product description document to define its new kind of MET product. This document shall be approved by the 4DWxCube Governance Board and will allow the MET-GATE administrator to correctly configure the cache and the access services.

In this document will be specified:

- The name of the new kind of product and a free text description
- Information about data policy to apply to the new kind of product
- Information about data format

- The frequency of updates
- Description of data content (in order to correctly map the product to the AIRM model)

Once these points have been defined and agreed, the MET-GATE administrator updates the catalogue to allow external user to access the new type of product.

The MET provider publish its MET products to the 4DWxCube using the Upload service. Each time a new MET product is received, it is stored in the cache and the catalogue is updated accordingly (see Table 18 for the specifications of terms).

Table 18 : Specification of terms (T11.2.2.2 – 4DWxC MET GATE, 2015).

Term	Description
MET product	Provided MET information to the 4DWxCcube composed by data items and metadata.
MET product description	List of attributed product properties associated to a MET Product that ATM consumers shall use to access the MET Products. Each product property shall be attributed with values reflecting the content of the particular product item.
MET Product Definition:	Static metadata associated with a specific MET Product that MET Service Providers deliver to the 4DWxCube. This acts as a template for the generated Product Description.
Data item	Statement of observed and/or forecast meteorological conditions related to a specific time (or period) and location.
Data item metadata	Information which describes a data item.
Catalogue	Set of all the MET product descriptions accessible for ATM clients.

6.3 4DWxCube specific interface requirements

The products identified for dissemination via 4DWxCube will consist of data observations (provided by WP3), early warning products (generated by WP5) and pilot implementation products (generated by WP6) covering the following airborne hazards:

- volcanic ash plumes
- dust clouds from desert storms
- airborne aerosols
- nuclear and chemical plumes

The products will be ingested and stored within the EUNADICS-AV portal.

At the time of writing this ICD, the exact specification of EUNADICS-AV products is not known. The following sections define the type of information that needs to be included, in general terms. The specific details of products (transfer protocols, timings, etc.) will need to be added once known. As an example, information about few products is provided.

6.3.1 Data Description

Table 19 : Description of all of the products required for dissemination to 4DWxCube.

Product Name	Product type (measurement/analysis/prediction)	Processing Level (L2/L3/L4)	EUNADICS-AV Provider

6.3.1.1 Transfer Timing

Table 20 : Specification of the timing details of the of the product transfers to 4DWxCube.

Product Name	Date created	Date issued	Date received	Data latency
	Daily product e.g. 2016-09-27T23:39:50Z	Daily after production time	Within ten minutes after Date issued	Within one hour after production time

6.3.1.2 Data Format

Table 21 : Specification of the format and compression method (if any) for each product transferred to 4DWxCube.

Product Name	Format	Data compression
	e.g. NetCDF Climate and Forecast (CF) Metadata Convention Standard Name Table v28	e.g. Compressed (gz)

6.3.1.3 Data Volume

Table 22 : Specification of the number and volume of files for each product transferred to 4DWxCube.

Product Name	Number of Data files	File Volume
	e.g. Three files per day	e.g. Size varies (~ 6 Mbytes)

6.3.2 Data Transfer

6.3.2.1 From EUNADICS-AV to 4DWxCube

EUNADICS-AV provides all the following groups of products for transfer to 4DWxCube from the EUNADICS-AV portal:
[*List of product types*]

a.
b.

The detailed protocol is as follows:
[*Detailed steps in the transfer protocol adopted*]

c.
d.

6.3.2.2 File name convention

Table 23 : Description of file naming convention (with example for each product transferred to 4DWxCube).

Product name	File name convention

6.3.2.3 Technical specifications

This section details the technical specifications of the file transfer. These will differ depending on whether 4DWxCube is pulling data from the EUNADICS-AV portal or data is being pushed to 4DWxCube.

Table 24: Protocol of file transfer (data is pulling by 4DWxCube or being pushed by EUNADICS-AV).

Product name	File transfer	Host server	Data path	User account
	pulling			
	pushed			

6.3.2.4 Notification and product change

6.3.2.4.1 Scope of the Service Level Agreement

This agreement concerns the following products (to be defined):

-
-

6.3.2.4.2 Incident and outage

In the case of any incident or planned outage impacting one of the products, an appropriate communication protocol needs to be set up to inform 4DWxCube of such disruption to service.

6.3.2.4.3 Change impacting one of the products

An appropriate mechanism for communicating and implementing changes in products needs to be agreed and adhered to.

In case of any change impacting any of the products listed in 6.3.2.4.1:

- Once a change is foreseen (from one year in advance to 1 month) an email is sent to 4DWxCube contact points with a brief description of the foreseen change and the foreseen implementation date.
- If the change (previously announced) has a direct impact on the user (file name, product content, access):
  - It will be notified 2 months in advance,
  - After its entry into service, double dissemination (current and new products) will be ensured over a period of 2 months,
  - When appropriate sample datasets will be made available 1 month before.
- If the change (previously announced) has not a direct impact for the user (new secondary sensor, update of secondary sensor...):
  - It will be notified at least 2 weeks before
  - Sample datasets will be made available 2 weeks before when appropriate.

6.3.2.5 Contact points

Table 25: Designated contact points at 4DWxCube for problems concerning this interface.

Contact name	Email address	Telephone number

For administrative issues (ICD changes) please contact:

Table 26 : Designated contact point at EUNADICS-AV for problems concerning 4DWxCube interface.

Contact name	Email address	Telephone number
Service Desk, EUNADICS-AV	eunadics-office@zamg.ac.at	+43 1 36026 2008

Note: *The requirements that cannot be implemented in the core delivery system (are too specific for SESAR/SWIM) will be implemented within this task on the existing infrastructure of the core data delivery system (Task 8.3). Météo-France has expert knowledge in this field and will contribute to this task. PLUS will provide in-system SESAR/SWIM compliance Test*

support for development and unit/integration testing of the interface. System testing will be done in WP7. Task 8.3 will deliver a SESAR/SWIM ICD and a prototype SESAR/SWIM extension on the EUNADICS-AV Portal.