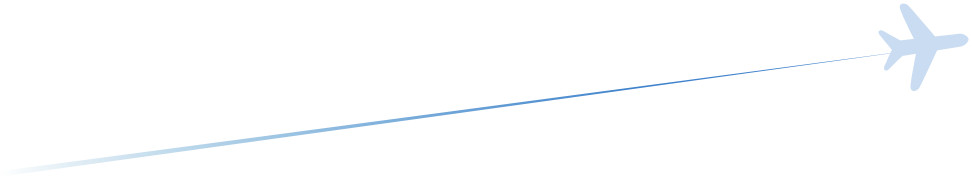

[SESAR 2020 Solution PJ.18-04b TRL 6 Technical Specification (TS/IRS)

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PJ.18-04b

IMPROVED MET INFORMATION

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Abstract

This document is the technical specification of PJ.18-04b Improved MET information. It provides an overview of MET developments and the requirement specifications, covering functional, non-functional, and interface requirements. It also contains architecture views covering the various functional blocks, systems, services and interfaces addressed.

Amongst all developments, PJ.18-04b proposes two TRL6 solutions at the end of Wave 1, these are:

- GWMS Enhancement and corresponding capability and information service;
- Cb-global capability and Cb-global service.

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1 Executive summary

PJ.18-04b aims to design and develop improved Meteorological (MET) services or capabilities that provide MET information contributing to enhanced situational awareness of information consumer. The activities of PJ.18-04b are organised with operational use in mind where most of the capabilities and information services are developed based on the need of operational solutions within the industrial research (IR) programme.

In line with the structure of the IR programme, the tasks of PJ.18-04b are broken down into a number of domains in support of different operational context (airport, network, aircraft, etc.). The tasks comprise the development of common components (CC) and information services (IS) and corresponding validation activities.

Amongst all activities undertaken by PJ.18-04b, the following developments are considered as mature enough for implementation, therefore proposed as TRL6 solutions of PJ.18-04b for Wave 1.

- Solution 1: GWMS enhancement capability coupled with Glide Wind Profile capability and METForTAM service
- Solution 2: Cb-global capability and Cb-global service

The remaining developments of PJ.18-04b are regarded as activities in support of other solutions and most of these are of lower maturity level that require further research.

This document presents the technical specification of activities undertaken by PJ.18-04b. It describes in detail the context, need, process of the component development. In parallel, the baseline architecture is enhanced with new functions, services and systems according to the specification of the components. The technical validation of these activities is detailed in the PJ.18-04b technical validation plan (TVALP) and results of the validation are collected in the PJ.18-04b technical validation report (TVALR).

PJ.18-04b has coordinated with solutions PJ.02-01, PJ03b-06, PJ.04-02, PJ.05-05, PJ.17-01, PJ.18-04c and PJ24 to identify MET needs, which were expressed as requirements for PJ.18-04b. Based on these requirements, PJ.18-04b has developed two TRL6 solutions and several other common components/information services, mostly in support of other solutions, with all activities delivering a common objective: to improve MET information provision.

These developments cover a wide range of MET information needs and multiple domains as defined in the project plan. The capabilities and information services provide information related to, inter alia, wind conditions on glide path, tracking of thunderstorm cells, specific category of wind information (Bora), runway surface conditions, enhanced weather observation for remote tower using enhanced imaging of weather camera, contrail formation, etc. Besides the TRL6 solutions, most of these developments aim to reach TRL4 maturity at the end of Wave 1, except METForWTS which is of lower maturity level and aims for TRL2.

PJ.18-04b focuses mature TRL6 solutions based on which the maturity should be assessed. These solutions have been validated by the associated TRL6 validation exercises. The TRL4 activities have also been validated by PJ18-04b, mostly in coordination with the solution they support.

The outcome of the validation exercises have shown that in general, it can be concluded that the capabilities and information services have proven their technical feasibility and provided output as expected. The TRL6 solutions have demonstrated high maturity that should be ready for future implementations.

2 Introduction

2.1 Purpose of the document

This document is the technical specification of PJ.18-04b Improved MET information. The purpose is to provide an overview of developments conducted by PJ.18-04b and the requirement specifications, covering functional, non-functional, and interface requirements. It also contains architecture views covering the various functional blocks, systems, services and interfaces addressed by the solution.

Furthermore, the technical specification intends to form the basis for industrialisation and deployment, thereby focusing on the functional description of the mature MET (sub)systems and services instead of physical design of the prototypes for implementation. The developed systems should also be considered as potential candidate to further standardisation development activities.

To this end, PJ.18-04b proposed two TRL6 solutions that are considered mature enough for implementation. This document focuses on the technical specifics of these solutions.

2.2 Scope

PJ.18-04b develops and validates enhanced or new MET concepts addressing the needs expressed by other SESAR 2020 solutions. This has resulted in a range of MET developments within the scope of PJ.18-04b. Amongst all activities, PJ.18-04b focuses on two groups of concept that have been matured in Wave 1 and proposed as two TRL6 solution of PJ.18-04b.

In order to present a complete view of all PJ.18-04b activities, this TS/IRS covers functional and non-functional requirements related to all PJ.18-04b MET developments. As a means to separate the solutions being proposed from other activities, the requirements of TRL6 solutions have been included in the body of this document, whereas the requirements of other activities with lower maturity levels can be found in the Appendix. These requirements could be further matured in the next research cycle.

2.3 Intended readership

The intended readership of the present document is as follows:

- Partner solutions that had established dependency with PJ.18-04b, i.e. PJ.02-01, PJ.03b-06, PJ.04-02, PJ.05-05, PJ.17-01, PJ.18-04c and PJ.24.
- In particular, Solution PJ18-04c uses the output of PJ18-04b , since results of 18-04b contribute to enhanced MET advisory information provision and 18-04c strives to develop solutions which make this information available in the cockpit.
- Solution PJ19 in charge of Content Integration activity, which follows a collaborative and iterative process involving all SESAR 2020 Solutions.
- Any other SESAR 2020 projects and solutions interested in the PJ.18-04b developments.
- SJU to assess this SESAR 2020 deliverable.

2.4 Background

Part of the activities presented in this document is based on previous work done in SESAR 1 in Projects 15.04.09.c and 11.02.02 from the MET perspective[37][38][39][40] .

Concerning the two TRL6 solutions:

- [Solution 1] GWMS enhancement is an activity following developments related 4DWxCube in SESAR 1, particularly in terms of adapting, prototyping and validating the MET-GATE functional block inside the Aerodrome ATM MET Capability Configuration; As such, it is not separable of new processing capabilities and service developments dedicated to Airport/Aerodrome MET developed in SESAR2020

- [Solution 2] Cb-global capability and Cb-global service are new concept in the context of SESAR.

2.4.1 Background and Wave 1 improvements of Solution 1:

Part of the concepts and requirements presented in this document is based on previous work done in SESAR 1 in Projects 15.04.09.c (Solution #21 Airport operations plan (AOP) and its seamless integration with the network operations plan (NOP) [37]) and 11.02.02 (Solution #35 MET information exchange [38][39][40]) from the MET perspective. In particular, the METForTAM service is based on work of OFA05.01.01[45], the IERs of which have been adopted by Solution PJ.04-02 in SESAR2020 wave 1, i.e. possibly new or changed requirements formulated in SESAR 2020 Wave 1 will be included as well.

These requirements are the driver for the service payload of METForTAM. Additionally, as the GMWS output satisfying these requirements had been provided in a proprietary manner in EXE669 of OFA05.01.01, the requirements on SWIM compliance for the 4DWxCube Technical System in the Aerodrome ATM-MET capability configuration that GWMS is prototyping had not been validated. Therefore, the development of METForTAM has a link to the task of GWMS Enhancement where the gap of the MET-GATE functional block inside the Aerodrome ATM-MET CC is closed and requirements still <in progress> are validated.

The provision of METForTAM by GWMS will be prototyped to be SWIM Yellow Profile (YP) compliant and will be included and validated in EXE-PJ.04-02-V2.04. METForTAM will reach TRL6 readiness compared to what was achieved in SESAR 1.

The METForTAM service has been designed as having six messages that can be individually subscribed to. Five of these messages contain the standard parameters and the sixth message on local phenomena is supposed to be a kind of wild card message that leave an open space for particular needs of airports. As an example for such local information, data elements describing the Bora phenomenon have been included in the service. Since this is completely new work, it has not the same TRL as the METForTAM service. It is necessary to take note of the fact that this is just exemplary and therefore not to be included in the assessment of the TRL, since it is the nature of this service to have an open structure with respect to local phenomena that can never be assessed in its entirety. Only the five standard messages should be regarded as being under TRL6 scrutiny. Therefore, separate exercises have been conducted to demonstrate the MET capability to detect Bora wind and to classify Bora wind events. Both these exercises have TRL 4 only.

In dependency with requirements derived for enhancing separation procedures, a glideslope wind profile product will be newly developed. Although the MET product is new, mature sources like Radar and Lidar sensors will be used. Therefore, is expected that the payload itself will reach TRL 6 whereas the corresponding METForWTS service for which this capability, although not exclusively, will be developed will reach likely TRL 2.

The new component of the GWMS (Ground Weather Management System) prototype will represent the MET-GATE functional block for the Aerodrome ATM-MET CC (the "local MET-GATE") as the payload tailoring component that has the right bindings to provide local MET services on Yellow and Purple Profile (Blue Profile is deemed not applicable for MET services), and will reach TRL 6.

2.4.2 Background and Wave 1 improvements of Solution 2:

Both Cb-global capability and Cb-global service were not part of SESAR Wave 1. However, outside of SESAR, previous work was performed within the EU FP6 project "FLYSAFE" (Airborne integrated systems for safety improvement, flight hazard protection and all weather operations, 2005-2009, http://cordis.europa.eu/projects/rcn/75794_en.html) and within DLR internal research projects. During these projects, both the Cb-global capability and the Cb-global yellow profile service have been intensively tested in cooperation with aviation stakeholders in several campaigns, e.g. at airports and in data link tests. Based on the feedback of the aviation stakeholders, the technologies have been further developed and had already reached TRL5 before the start of SESAR 2020.

Within SESAR2020 PJ18-04b the aim is to bring both the Cb global capability and the Cb-global yellow profile service to TRL6. For Cb-global capability this means that within SESAR2020 the detection and nowcasting of thunderstorm hazards will be optimized and also extended to the detection and nowcasting of high altitude icing conditions (HAIC) and convectively induced turbulence (CIT). For the Cb-global yellow profile service this means that the performance of the provision of the Cb-global data has been optimized with regard to SWIM compatibility, transmission times, and communication handling.

2.5 Structure of the document

PJ.18-04b activities are a collaborative effort of all task leaders and contributors, this is also reflected in the structure of the sections. In each Chapter, tasks and development results of different partners are presented in dedicated sections.

The document is organised as follows:

Chapter 1 presents the Executive summary

Chapter 2 introduces the technical specification

Chapter 3 presents an overview of the activities and the solution's impact on architecture.

Chapter 4 presents the functional architecture and technical requirements.

Chapter 5 contains implementation options.

Chapter 6 summarises the assumptions.

Appendix A contains the SDD of the services developed by the solution

Appendix C contains functional and non-functional requirements of prototypes of lower maturity levels

Appendix D provides more details about the MET products and sources

2.6 Glossary of terms

Term	Definition	Source of the definition
AIR-REPORT	A report from an aircraft in flight prepared in conformity with requirements for position, and operational and/or meteorological reporting.	*ICAO Annex 3*
Cb-global	hazard detection and nowcasting (=forecasting up to one hour) related to active thunderstorms (Cb), convective induced turbulence (CIT), and high altitude ice crystals (HAIC) based on satellite data	*AT-One(DLR)*
Cb	Cumulonimbus cloud (referring to active thunderstorm)	*Met community*
CCF	Climate change functions, providing a quantitative estimate of climate impact associated with aviation emissions, as established within ATM4E (Exploratory Research).	*AT-One (DLR)*
CIT	Convectively induced turbulence	*Met community*
HAIC	High altitude icing conditions	*Met community*

Table 1: Glossary

2.7 Acronyms and Terminology

Term	Definition
ADD	Architecture Description Document
ATM	Air Traffic Management
AWOS	Automated Weather Observing System

CC	Capability Configuration
EATMA	European ATM Architecture
E-ATMS	European Air Traffic Management System
FAA	Federal Aviation Administration
FMP	Flow Management Position
GWMS	Ground Weather Management System
IER	Information Exchange Requirement
INTEROP	Interoperability Requirements
IR	Infrared
IRS	Interface Requirements Specification
ISRM	Information Services Reference Model
MET	Meteorology
NAF	NATO Architecture Framework
NSOV	NAF Service Oriented View
NOV	NAF Operational View
NSV	NAF System View
NWP	Numerical Weather Prediction
OSED	Operational Service and Environment Definition
PIRM	Programme Information Reference Model
QoS	Quality of Service
RCAMS	Runway Condition Automated assessment System
SDD	Service Description Document
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SoaML	Service Oriented Architecture Modelling Language
SPR	Safety and Performance Requirements
SWIM	System Wide Information Management

TAM	Total Airport Management
TMA	Terminal Area
TRL	Technology Readiness Level
TS	Technical Specification
UML	Unified Modelling Language
V&V	Validation and Verification
VIS	Visible, Visibility
WSDL	Web Services Definition Language
WTS	Wake Turbulence Separation
XSD	XML Schema Definition

Table 2: Acronyms and terminology

3 SESAR Solution Impacts on Architecture

3.1 Target Solution Architecture

3.1.1 SESAR Solution(s) Overview

This section presents an overview of all tasks undertaken by the PJ.18-04b mainly from architecture point of view. It comprises technical specification of developed MET concepts and a view on the relevant architectural elements.

Architecture of MET information exchange have been designed to cover all 18-04b developments. Many elements (functional block, functions, systems, etc.) provide the required process or exchanges for multiple developments within PJ.18-04b, therefore the architecture is not divided according to the maturity level of the developments as it consider both TRL6 and TRL4 activities.

PJ.18-04b activities are defined in domains focussing on common component (CC) and information services (IS) development. The activities of the active domains are also described in this chapter.

OI Step		OI description	Open CR
POI-0008-MET		Provision of MET data as SWIM services (Yellow Profile) relevant for Aerodrome and TMA	
	EN code	EN description	Open CR
	METEO-03c	Provision and monitoring of real-time airport weather information for time-based separation and curved approaches	
	METEO-04c	Generate and provide MET information relevant for Airport and approach related operations at short notice ('time to decision' between 3 minutes and 7days) including rotorcraft and RPAS	
	METEO-10a	VIS Camera for visibility measurement and cloud monitoring	
	METEO-10b	IR Camera for cloud monitoring	
	METEO-11b	Wind monitoring in dry conditions using data from Scanning Doppler Lidar	

	METEO-12a	Compile data for METForTAM service	
	METEO-12b	Compile data for METForWTS service	
	SVC-037	METForTAM Service	
	SVC-040	METForWTS Service	
	EN code	EN description	Open CR
	SENA01221	Runway Sensors	CR 03736 Change Request for Creation - for new MET system enabler Runway Sensors
	SENA01222	C06 Local MET Information	CR 03737 Change Request for Creation - for new MET System Enabler C06 Local MET Information
	SENA01223	C07 Cb (thunderstorm) nowcasting	CR 03738 Change Request for Creation - for new MET system enabler C07 thunderstorm nowcasting
	SENA01224	RWYWeather Service	CR 03739 Change Request for Creation - for new MET Service RWYWeatherService
	SENA01225	Compile data for RWYWeather Service	CR 03740 Change Request for Creation - for new MET Function Compile RWYWeather
	SENA01226	Standard MET Parameter processing	CR 03741 Change Request for Creation - MET function Standard data processing
	SENA01227	Microwave Radiometer	CR 03742 Change Request for Creation - MET System Enabler Microwave Radiometer

	SENA01228	Precipitation processing	CR 03743 Change Request for Creation - MET System Enabler Precipitation processing
	SENA01229	Runway condition	CR 03744 Change Request for Creation - MET System Enabler Runway condition processing
	SENA01230	Temperature Inversion Detection	CR 03745 Change Request for Creation - Temperature Inversion Detection
	SENA01233	Processing of Convection Cell detection	CR 03748 Change Request for Creation - MET System Enabler Convection Cells
	SENA01237	(Ensemble) Forecast based on NWP model output	CR 03752 Change Request for Creation - MET System Enabler Numerical Weather Predicition
	METEO-07c	Integrated system of infrared and visual cameras to enable automatic detection of LVC	CR 03898 Update METEO-07c links to EATMA (PJ.18-04b)
	METEO-08c	Integrated system of 3D scanning Doppler X-Band radar and long range Doppler lidar for all-weather wind monitoring	CR 03899 Update METEO-08c links to EATMA (PJ.18-04b)
	METEO-11a	Precipitation and Wind monitoring in wet conditions using data from Doppler Weather Radar	CR 03909 Update METEO-11a title amendment
POI-0009-MET		Provision of MET data as SWIM services (Yellow Profile) relevant for En-route and Network operations	
	EN code	EN description	Open CR
	METEO-05c	Generate and provide MET information relevant for TMA and En-route related operations at short notice ('time to decision' between 3 minutes and 7days), including for low-level IFR operations.	
	METEO-06c	Generate and provide Meteorological information relevant at short notice ('time to decision' between 3 minutes and 7days)	

	EN code	EN description	Open CR
	SENA01223	C07 Cb (thunderstorm) nowcasting	CR 03738 Change Request for Creation - for new MET system enabler C07 thunderstorm nowcasting
	SENA01233	Processing of Convection Cell detection	CR 03748 Change Request for Creation - MET System Enabler Convection Cells
	SENA01237	(Ensemble) Forecast based on NWP model output	CR 03752 Change Request for Creation - MET System Enabler Numerical Weather Prediction

Table 3: Applicable POI and ENs

Following tables show new proposed and more specific POIs and related Enablers:

OI Step	OI description	Open CR
OIS01303	MET Service provision based on camera data	CR 03906

	EN code	EN description	Open CR
	METEO-07c	Integrated system of infrared and visual cameras to enable automatic detection of LVC	CR 03898 Update METEO-07c links to EATMA (PJ.18-04b)
	METEO-10a	VIS Camera for visibility measurement and cloud monitoring	
	METEO-10b	IR Camera for cloud monitoring	

OI Step	OI description	Open CR
OIS01304	MET Service provision for runway weather condition	CR 03907

	EN code	EN description	Open CR

	SENA01221	Runway Sensors	CR 03736 Change Request for Creation - for new MET system enabler Runway Sensors
	SENA01224	RWYWeather Service	CR 03739 Change Request for Creation - for new MET Service RWYWeatherService
	SENA01225	Compile data for RWYWeather Service	CR 03740 Change Request for Creation - for new MET Function Compile RWYWeather
	SENA01229	Runway condition	CR 03744 Change Request for Creation - MET System Enabler Runway condition processing

OI Step		OI description	Open CR
OIS01305		MET Service provision for all-weather 3D-wind information	CR 03908
	EN code	EN description	Open CR
	METEO-08c	Integrated system of 3D scanning Doppler X-Band radar and long range Doppler lidar for all-weather wind monitoring	CR 03899 Update METEO-08c links to EATMA (PJ.18-04b)
	METEO-11a	Precipitation and Wind monitoring in wet conditions using data from Doppler Weather Radar	CR 03909 Update METEO-11a title amendment
	METEO-11b	Wind monitoring in dry conditions using data from Scanning Doppler Lidar	
	SVC-037	METForTAM Service	
	SVC-040	METForWTS Service	

OI Step	OI description	Open CR

OIS01306		MET Service provision for precipitation (probability) information	CR 03910
	EN code	EN description	Open CR
	METEO-11a	Precipitation and Wind monitoring in wet conditions using data from Doppler Weather Radar	CR 03909 Update METEO-11a title amendment

OI Step		OI description	Open CR
OIS01307		MET Service provision for Temperature inversion information	CR 03911
	EN code	EN description	Open CR
	SENA01227	Microwave Radiometer	CR 03742 Change Request for Creation - MET System Enabler Microwave Radiometer
	SENA01230	Temperature Inversion Detection	CR 03745 Change Request for Creation - Temperature Inversion Detection

OI Step		OI description	Open CR
OIS01308		MET Service provision for Standardized MET Information	CR 03912
	EN code	EN description	Open CR
	SENA01226	Standard MET Parameter processing	CR 03741 Change Request for Creation - MET function Standard data processing

OI Step		OI description	Open CR

OIS01309		MET Service provision for Convection Cell Information	CR 03913
	EN code	EN description	Open CR
	METEO-11a	Precipitation and Wind monitoring in wet conditions using data from Doppler Weather Radar	CR 03909 Update METEO-11a title amendment
	SENA01223	C07 Cb (thunderstorm) nowcasting	CR 03738 Change Request for Creation - for new MET system enabler C07 thunderstorm nowcasting
	SENA01233	Processing of Convection Cell detection	CR 03748 Change Request for Creation - MET System Enabler Convection Cells

OI Step		OI description	Open CR
OIS01310		MET Service provision for NWP information	CR 03914
	EN code	EN description	Open CR
	SENA01237	(Ensemble) Forecast based on NWP model output	CR 03752 Change Request for Creation - MET System Enabler Numerical Weather Prediction

For the two TRL6 Solutions, the following ENs are considered:

- Solution 1:
    - EN from Sesar 1: METEO-03c, METEO-04c, METEO-07c (CR for DS20 pending), METEO-08c (CR for DS20 pending), SWIM-APS-06b
    - Endorsed for DS18: METEO-10a, METEO-10b, METEO-11a (CR for DS20 pending), METEO-11b, METEO-12a, METEO-12b, SVC-037, SVC-040
    - CR for DS20: SENA01221, SENA01222, SENA01226, SENA01227, SENA01228, SENA01230, SENA01233, SENA01237,

    Some Enablers can be linked directly to requirements; some are enabling Enablers for the SVC-037 or SVC-040 service enablers. Since most of the proposed EN have still the CR

status “pending”, we wait until they are endorsed before creating another CR to link these enabling ENs to SVC-037 or SVC-040.

- Solution 2: METEO 4c, METEO 5c, METEO 6c, SENA01223 and SENA01233

3.1.2 PJ18-04b Domains

The activities of PJ.18-04b are defined in Domains, which are described in PJ.18-04b TVALP [41]. The table below list the capabilities and information services developed by PJ.18-04b and their corresponding domains. The table is only meant to present the relationship between a PJ.18-04b MET concept and relevant domains the concept addresses.

The domains consolidate developments with a specific (MET) purpose and can contain developments of several MET products with different maturity levels. **The domains were only meant to better structure the activities and facilitate collaboration between partners, as the domains do not represent a specific MET solution or maturity.**

PJ.18-04b developments	**PJ18-04b domains**
Glideslope wind profile	IS.1 - MET Information Services to support High Performing Airport Operations CC.3.1 - Airport MET Information and Alert Generation Enhancement CC.4.2 - Enhanced Airport (surface-based & remote sensing) MET Observations
METForWTS	IS.1 - MET Information Services to support High Performing Airport Operations
Bora wind detection	CC.4.2 - Enhanced Airport (surface-based & remote sensing) MET Observations
Bora wind classification algorithm	CC.3.1 - Airport MET Information and Alert Generation Enhancement
GWMS SWIM Enhancement	CC.2.2 GWMS Enhancement IS.1 - MET Information Services to support High Performing Airport Operations
GWMS: Swapping MET providers	CC.2.2 GWMS Enhancement IS.1 - MET Information Services to support High Performing Airport Operations
Remote Tower MET (RemoteTWRMET) Service	IS.1 - MET Information Services to support High Performing Airport Operations

PJ.18-04b developments	PJ18-04b domains
Runway Weather Monitoring and Forecast Services (input-RWYWeather/output)	IS.1 - MET Information Services to support High Performing Airport
Cb-global capabilities	CC.2.3 - Cockpit-Ready MET
Cb-global yellow profile service	IS.5 - MET Information Services for aircraft information domain
Contrail formation (by algorithm)	CC.3.3 - MET Information Generation for Climate-optimised routing
Airport MET Camera	CC.4.2 - Enhanced Airport (surface-based & remote sensing) MET Observations
METForTAM	IS.1 - MET Information Services to support High Performing Airport Operations CC.2.2 GWMS Enhancement CC.3.1 - Airport MET Information and Alert Generation Enhancement CC.4.2 - Enhanced Airport (surface-based & remote sensing) MET Observations
Thales convection impact service	IS.2 - MET Information Services to support Optimised ATM Network Services

Table 4: PJ.18-04b developments links with domains

PJ.18-04b activities were undertaken by different partners developing various concepts. The next sections provide description of the developments per PJ.18-04b partner.

3.1.2.1 Activities in domain CC.2.2, CC.3.1, CC4.2 and IS.1

Solution 1 addresses the enhancement of GWMS, i.e. adapting prototyping and validating the MET-GATE functional block inside for Aerodrome ATM MET CC, the development of glide wind profile capability and the METForTAM service. These activities are mainly related to airport MET information which are distributed in several domains of the PJ.18-04b working structure.

Task PJ18-04b-TRL6-CC.4.2 “Enhanced Airport (surface-based & remote sensing) MET Observations” comprises two main types of developments and belongs to the “Consolidation” functional blocks of the 4DWxCube TS.

- Develop new MET capabilities; based on evolved information exchange requirements (IER) it is anticipated that new MET capabilities will have to be developed. For these new local sensors, integration with regional information and appropriate algorithms will be needed. It is clear that this has bearings on standardisation processes.

- Use pure MET capabilities for ATM relevant phenomena; phenomena detection relevant for ATM operational processes is the driving force for the development of MET capabilities. Phenomena are a further algorithmic abstraction from the pure MET information. Therefore, most of this activity will deal with development of such algorithms

The Task PJ18-04b-TRL6-CC.3.1 "Airport MET Information and Alert Generation Enhancement" belongs to the "Translation" working area. The activity includes the translation of pure MET information into parameters suitable to aviation users. It is strongly based on task PJ18-04b-TRL6-CC.4.2 "Enhanced Airport (surface-based & remote sensing) MET Observations" but also includes numerical weather prediction capabilities. This enables the generation of improved alerts[1].

Task PJ.18-04b-TRL6-CC.2.2 "GWMS Enhancement" deals mainly with the extension of the GWMS capability already developed in SESAR 1 to SWIM functionality. It shall cover Yellow and Purple Profile SWIM services. Therefore, also MET information will be provided as SWIM services.

Task PJ.18-04b-TRL6-IS.1 "MET Information Services to support High Performing Airport Operations" deals actually with the design and provision of services developed in the before mentioned tasks.

However, technical validation is not separated per task but rather per prototype and/or dependency with operational solutions as outlined in the PJ.18-04b TVALP document.

Following functional blocks (FB) are covered by the above-mentioned activities:

Consolidation:

- C01 Radar Composite
- C02 Aircraft Information Processing and QC
- C03 Very Short Term Forecast
- C04 Short Term Forecast

Translation:

- T01 Regulatory MET Information
- T02 Local MET Information and Alerts
- T03 Convection
- T06 MET Forecast Uncertainty

Tailoring:

- MET-GATE

[1] "Alert" in the context of describing this activity means event based information on a generic constraint to aviation defined on a global and/or regulatory level. In most, if not all, cases this will be a safety constraint, whereas performance based alerts shall be counted as impact assessment of MET and are dealt with by ATM systems. As such "Alert" here is a subcategory of threshold based translation of MET information based on common grounds (e.g. METAR precipitation classes, ICAO thresholds for wind shear).

A new Functional Block is proposed covering all the locally measured (within aerodrome area) MET data including development of capabilities and also consolidation if needed. All this was covered by FB T02 Local MET Information and Alerts in SESAR 1 but it belongs to the “Translation” part. The proposed new FB is:

- C06 Local MET Information

All these FBs are within the Technical System 4DWxCube. Based on SESAR 1 results, several instances of the 4DWxCube exist. Within the Capability Configuration “Aerodrome ATM-MET” the instance of the 4DWxCube is realised by the GWMS (Ground Weather Management System); a system developed in project 15.04.09.c in SESAR 1 and now further evolved in SESAR 2020 (e.g. FB MET-GATE is adapted for Aerodrome ATM MET CC and prototyped/validated GWMS in Wave 1).

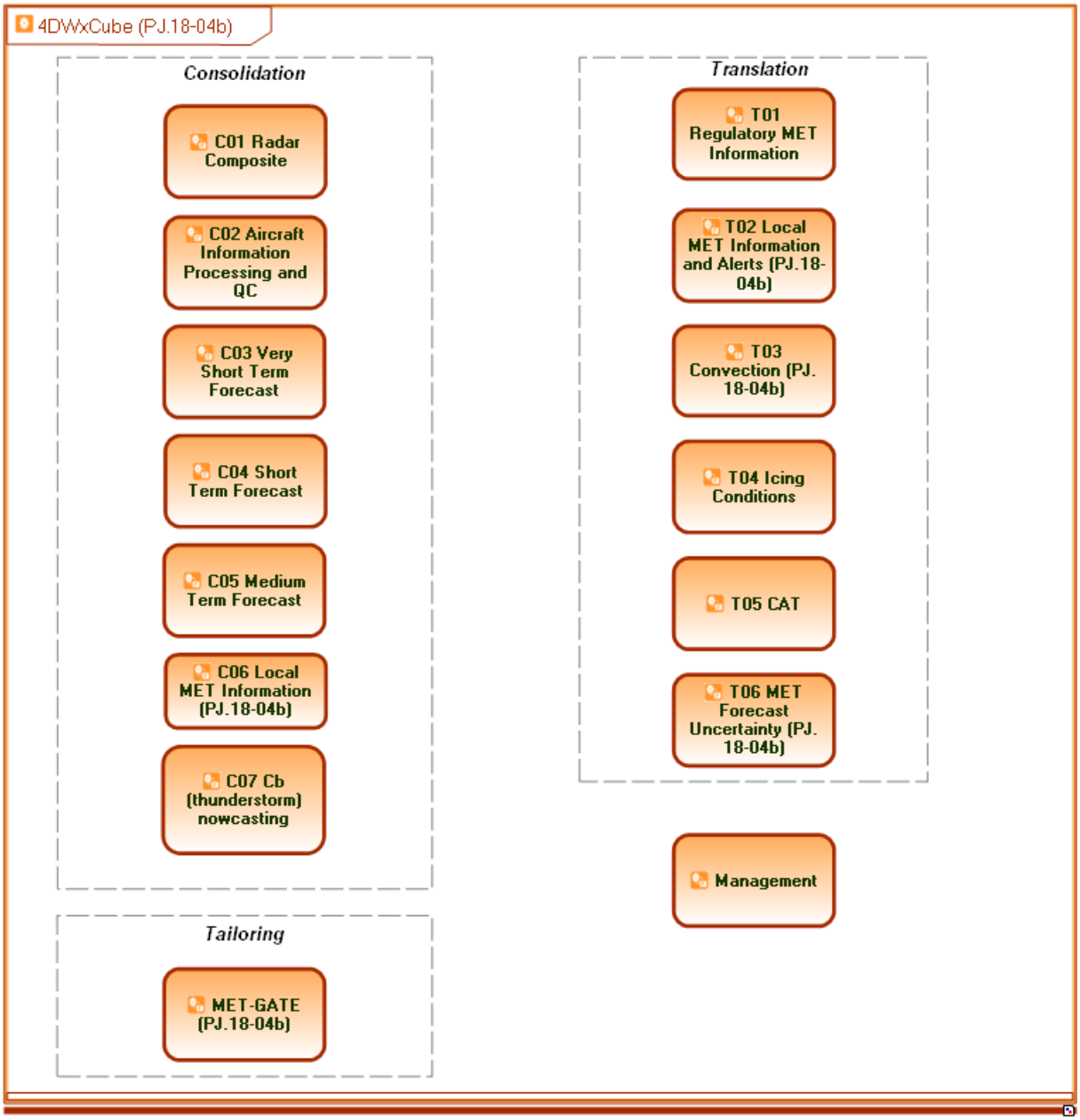

Figure 1: 4DWxCube Technical System and Functional Blocks (from EATMA), including the new proposed FB C06 Local MET Information and C07 CB (thunderstorm) nowcasting.

SESAR Solution ID and Title	Functional Blocks/Role impacted by the SESAR Solution (from EATMA)	Enabler ID (from EATMA)	Enabler Title (from EATMA)	Enabler coverage
PJ.18-04b Improved MET Information	VIS Camera	METEO-10a	VIS Camera for visibility measurement and cloud monitoring	• fully
PJ.18-04b Improved MET Information	IR Camera	METEO-10b	IR Camera for cloud monitoring	• fully
PJ.18-04b Improved MET Information	Runway Sensors	CR 03736	Runway Sensors	• fully
PJ.18-04b Improved MET Information	Doppler Weather Radar	METEO-11a	Wind monitoring in wet conditions using data from Doppler Weather Radar	• Fully
PJ.18-04b Improved MET Information	Scanning Doppler Lidar	METEO-11b	Wind monitoring in dry conditions using data from Scanning Doppler Lidar	• fully
PJ.18-04b Improved MET Information	Microwave Radiometer	CR 03742	Microwave Radiometer	• fully
PJ.18-04b Improved MET Information	C01 Radar Composite	-	-	• -
PJ.18-04b Improved MET Information	C02 Aircraft Information Processing and QC	-	-	• -
PJ.18-04b Improved MET Information	C03 Very Short Term Forecast	-	-	• -

SESAR Solution ID and Title	Functional Blocks/Role impacted by the SESAR Solution (from EATMA)	Enabler ID (from EATMA)	Enabler Title (from EATMA)	Enabler coverage
PJ.18-04b Improved MET Information	C06 Local MET Information	METEO-03c	Provision and monitoring of real-time airport weather information, Step 2	• Fully
		METEO-04c	Generate and provide MET information relevant for Airport and approach related operations, Step 2	• Partial (MET information for airport, covering observation and nowcast)
		METEO-07c	New remote sensing technologies supporting MET-ATM Systems for LVP Operations	• Fully
		METEO-08c	All-weather remote sensing of high resolution 3D Aerodrome wind field, Step 2	• Fully
PJ.18-04b Improved MET Information	T01 Regulatory MET Information	METEO-03c	Provision and monitoring of real-time airport weather information, Step 2	• Partial (only covering the regulatory part in accordance with the task content)
		METEO-04c	Generate and provide MET information relevant for Airport and	• Partial (only covering the regulatory part in

SESAR Solution ID and Title	Functional Blocks/Role impacted by the SESAR Solution (from EATMA)	Enabler ID (from EATMA)	Enabler Title (from EATMA)	Enabler coverage
			approach related operations, Step 2	accordance with the task content)
PJ.18-04b Improved MET Information	T02 Local MET Information and Alerts	METEO-03c Many new functions proposed, see Tables in section 3.2	Provision and monitoring of real-time airport weather information, Step 2	• Fully
PJ.18-04b Improved MET Information	T03 Convection	METEO-03c	Provision and monitoring of real-time airport weather information, Step 2	• Partial (only dealing with Convection aspects)
PJ.18-04b Improved MET Information	T06 MET Forecast Uncertainty	METEO-04c Many new functions proposed see Tables in section 3.2	Generate and provide MET information relevant for Airport and approach related operations, Step 2	• Partial (only dealing with forecast uncertainty)
PJ.18-04b Improved MET Information	MET-GATE	METEO-12a METEO-12b SVC-037	Compile data for METForTAM Compile data for METForWTS METForTAM service	• Fully • fully • fully

SESAR Solution ID and Title	Functional Blocks/Role impacted by the SESAR Solution (from EATMA)	Enabler ID (from EATMA)	Enabler Title (from EATMA)	Enabler coverage
		SVC-040	METForWTS service	• fully
		CR 03740	Compile RWYWeather	• fully
		CR 03739	RWYWeather Service	• fully

Table 5: SESAR Solution PJ.18-04b Scope and related Functional Blocks/roles & Enablers

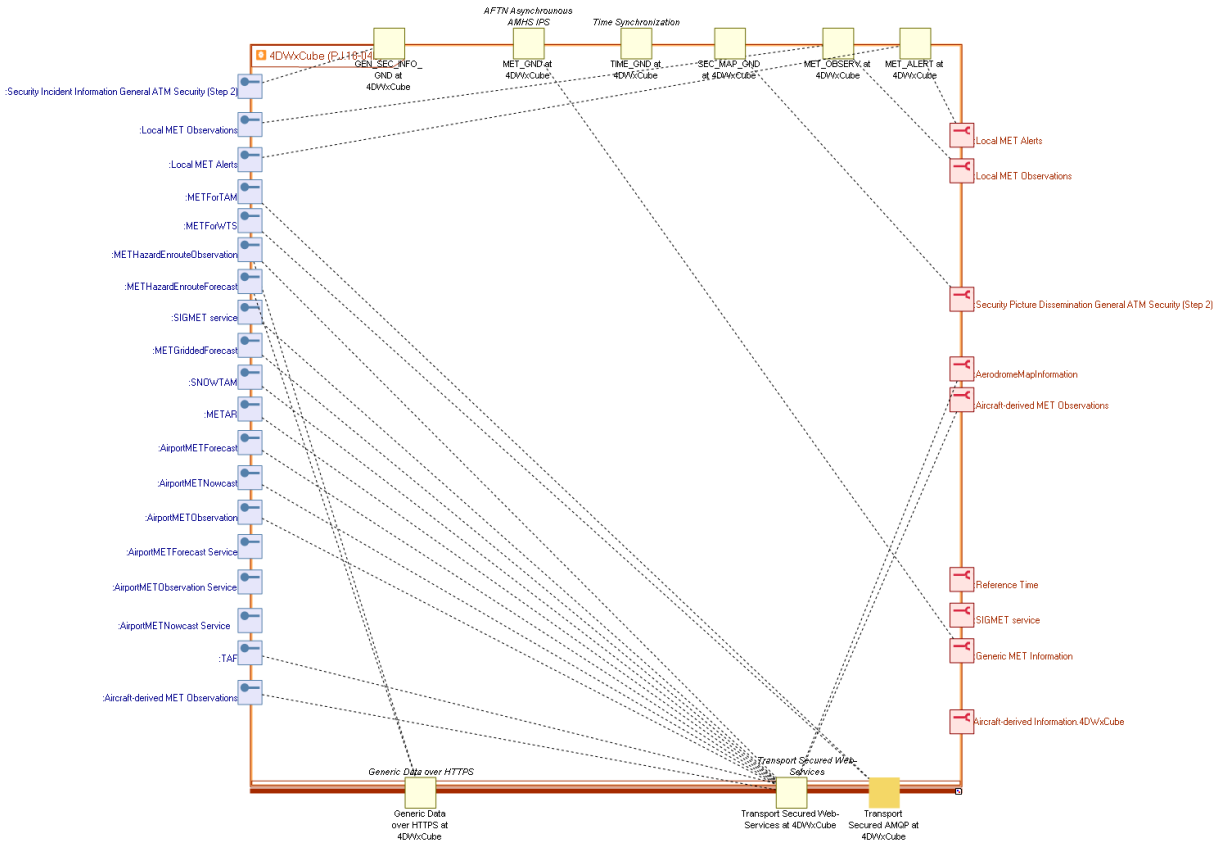

Figure 2: 4DWxCube assembly diagram

The assembly diagram shows service and request points for services and resource interactions and allocated ports. Transport Secured AMQP is newly introduced to the newly provided MET services.

Please note, the 4DWxCube TS can be instanced in several environments. We deal with the implementation in the Aerodrome ATM-MET CC. The GWMS prototype from Leonardo is an instance of the 4DWxCube in the Aerodrome ATM-MET CC. Not all service/request points and ports shown in Figure 2 are required for some instances.

Following ports of the 4DWxCube instanced in CC Aerodrome ATM-MET are mentioned in EATMA:

- MET_ALERT
- MET_GND
- MET_OBSERV
- TIME_GND
- Transport Secured Web-Services

MET_ALERT is used to provide alerts and warning obtained locally to the ATM-MET CC for further usage and data collection outside the aviation context.

Via MET_GND generic MET Information are provided available through MET services and not only dedicated for aviation purposes. These are for instance data from a national lightning detection or weather radar network.

MET_OBSERV was the port used for local MET observations provided by sensors installed at the aerodrome. MET sensors were regarded as infrastructure systems. In EATMA “Standard MET Sensors” and “Enhanced MET Sensors” are also Technical Systems and the data is provided as Resource Interaction to the 4DWxCube. Also this port is used to provide locally obtained observations from Aerodrome ATM-MET CC to the ATM-MET CC.

TIME_GND is the port for the provision of a common time reference.

Transport Secured Web-Services is a port for SWIM Yellow Profile.

Transport Secured AMQP is newly introduced also for SWIM Yellow Profile services.

3.1.2.1.1 Deviations with respect to the SESAR Solution(s) definition

All the enablers listed in Table 5 are required and are dealt with in the solution’s lifetime. In addition, Enablers in Table 11 are of relevance for the work conducted in the domains CC2.2, CC3.1, CC4.2 and IS.1.

3.1.2.1.2 Relevant Use Cases(UC)

System Process	Description	Exercise leader
[NSV-4] **METForTAM** ***Solution 1***	Function process diagram for the METForTAM service. Includes the FBs and Functions for acquiring MET data and product processing and the METGATE which prepares the final service for dissemination. Customer is the Airport Operations Centre TS, FB	PJ.04-02 (two exercises, one at Oslo airport, second at Bratislava airport)

System Process	Description	Exercise leader
	Alerting Configuration Support, Function Check against MET provision.	
[NSV-4] METForWTS	Function Context Diagram to realise the provision of the METForWTS service from the Aerodrome ATM-MET CC to the TWR CC. WTS stand for Wake Turbulence Separation. Service includes current and 10 min forecast wind information. Input resources (all modelled as Black boxes): ATM-MET_CC (Generic MET Information) Standard MET Sensors Enhanced MET Sensors All Translation and Consolidation FBs within the 4DWxCube TS are just including one function because the details of meteorological processing is of no interest for this function context diagram. Breakdown: Aerodrome ATM-MET CC --> 4DWxCube TS --> MET-GATE FB: realised by GWMS prototype (PJ18-04b) TWR CC --> Aerodrome ATC TS --> Departure Separation Management FB/Operational Supervision Aerodrome ATC FB: realised by operational prototype (PJ02-01)	PJ.18-04b
Airport Integrated Camera Images capability	Enhancement of automatic weather observations of visibility, clouds and phenomena by integration of dual visible/infrared camera (Enablers METEO-10a and METEO-10b). Capability ensures regular imaging of whole horizon, sky (including stitching images into single whole-sky image) and video capture.	PJ.05-05
[NSV-4] RWYWeather	Definition of the Runway Monitoring and Forecast Input Service, which shall be capable of providing all required data for RCAMS system (developed in Solution PJ03b-06).	PJ.18-04b
Remote Tower MET (RemoteTWRMET) Service (included in [NSV-4] Advanced Automated MET System)	Definition of the Remote Tower MET Service, which shall be capable of providing all required data for Advanced Automated MET system (developed in Solution PJ05-05), especially Airport Integrated Camera Images	PJ.18-04b
GWMS capability ***Solution 1***	Enhancement to GWMS developed in SESAR 1 with respect to new functions and MET-GATE functional block adapted for the Aerodrome ATM-MET CC	PJ.18-04b

Table 6 Relevant use cases of activities

Descriptions can be found throughout this document and in the PJ.18-04b TVALP.

3.1.2.1.3 Applicable standards and regulations

AMQP is the used standard for the provision of MET Services.

3.1.2.2 Activities in CC.2.3, CC.3.3 and IS.5

Solution 2 addresses activities in domain CC.2.3 and IS.5 representing the Cb-global capability and Cb-global service.

CC.2.3 Cockpit-Ready MET [Solution 2]
IS.5 MET Information Services for aircraft information domain [Solution 2]
CC.3.3 MET Information Generation for Climate-optimised routing [TRL4 activity]

The activities in CC.2.3 and IS.5 focus on the generation and uplink of MET information on thunderstorm hazards into the cockpit, whilst CC.3.3 addresses information related to contrail formation and their impact on flight trajectory, details about this activity can be found in Appendix D.

3.1.2.2.1 Cockpit-Ready MET

This activity entails the DLR system Cb-global that uses data from geostationary satellites to detect, track, and nowcast thunderstorms in order to provide pilots an overview of the current weather hazard situation beyond the limited view of the on-board radar. It is relevant for the upper airspace en-route and enables a pilot to strategically plan a safe and smart flight route around the thunderstorms well ahead in time instead of flying tactical manoeuvres and searching for gaps between the thunder cells.

Based on observations from ground weather radars the DLR thunderstorm tracking and nowcasting system “Rad-TRAM” detects and tracks cells of heavy precipitation related to thunderstorms and calculates the development and propagation of these cells up to one hour. The Rad-TRAM information is relevant for the lower airspace and gives ANSPs and Airports an overview of the thunderstorm situation enabling them to plan. With the Rad-TRAM information Airports can optimise their operations, and ANSPs can advise pilots to avoid thunderstorm cells during take-off and landing.

Information provided by both systems is fully tailored to aviation needs.

The technical specification details about these systems are further elaborated in Appendix D.

3.1.2.2.2 MET Information Services for aircraft information domain

This activity address the uplink of MET information on thunderstorm hazards into the cockpit. The MET Information needs to satisfy the specific requirements [44] of the airlines and the aircraft outfitters who provide the data uplink techniques. One of the approaches to provide weather data to the cockpit is to utilize the MET GATE which is an instance of the 4DWxCube.

The MET information service developed here will provide data from Cb-global (see section 3.1.2.2.1, capability CC.2.3 - Cockpit-Ready MET) to the flight management at the civil AU Operations Centre via a https platform and is called “Cb-global service”. The Cb-global service combines and utilises the following existing services from SESAR 1: METHazardEnRouteObservationService [43] and

METHazardEnrouteForecastService [42]. It is part of the 4DWxCube and covers the functional blocks (see Figure 1 in section 3.1.2.1):

C07: Cb (thunderstorm) nowcasting – a proposed new functional block where satellite data from an external non-ATM MET service provides are processed to identify, track and nowcast thunderstorms

T03: Convection

The resulting convection data are then tailored and provided via the MET-GATE instance.

Please note: In the EATMA portal NSV-4 diagram the “Cb-global service” has been renamed to “MetHazardEnRoute Service”. However, with both terms the same service is meant.

The technical specification about options for the uplink are further elaborated in Appendix D.

The following ENs are covered by the three activities above:

SESAR Solution ID and Title	Functional Blocks/Role impacted by the SESAR Solution (from EATMA)	Enabler ID (from EATMA)	Enabler Title (from EATMA)	Enabler coverage
PJ.18-04b Improved MET Information	C07 Cb (thunderstorm) nowcasting	METEO-05c	Generate and provide MET information relevant for TMA and En-route related operations at short notice ('time to decision' between 3 minutes and 7days), including for low-level IFR operations.	Fully
PJ.18-04b Improved MET Information	C07 Cb (thunderstorm) nowcasting	METEO-06c	Generate and provide Meteorological information relevant at short notice ('time to decision' between 3 minutes and 7days)	Fully

SESAR Solution ID and Title	Functional Blocks/Role impacted by the SESAR Solution (from EATMA)	Enabler ID (from EATMA)	Enabler Title (from EATMA)	Enabler coverage
PJ.18-04b Improved MET Information	T03 Convection	METEO-05c	Generate and provide MET information relevant for TMA and En-route related operations at short notice ('time to decision' between 3 minutes and 7days), including for low-level IFR operations.	Fully
PJ.18-04b Improved MET Information	T03 Convection	METEO-06c	Generate and provide Meteorological information relevant at short notice ('time to decision' between 3 minutes and 7days)	Fully
PJ.18-04b Improved MET Information	MET-GATE Aerodrome Weather Information Management	METEO-04c	Generate and provide MET information relevant for Airport and approach related operations, Step 2	**Fully**
PJ.18-04b Improved MET Information	MET-GATE Aerodrome Weather Information Management	METEO-05c	Generate and provide MET information relevant for TMA and En-route related operations, including low-	**Fully**

SESAR Solution ID and Title	Functional Blocks/Role impacted by the SESAR Solution (from EATMA)	Enabler ID (from EATMA)	Enabler Title (from EATMA)	Enabler coverage
			level IFR operations, Step 2	
PJ.18-04b Improved MET Information	MET-GATE Aerodrome Weather Information Management	METEO-6c	Generate and provide Meteorological information relevant for Network related operations, Step 2	**Fully**
PJ.18-04b Improved MET Information	C07 Cb (thunderstorm) nowcasting	CR 03738 SENA 01223	C07 Cb (thunderstorm) nowcasting	**Fully**
PJ.18-04b Improved MET Information	T03 convection	CR 03748 SENA 01233	Processing of Convection Cell detection	**Fully**

Table 7: ENs covered by AT-One(DLR) activities

3.1.2.2.2.1 Deviations with respect to the SESAR Solution(s) definition

All the enablers listed in Table 7 are required and are dealt with in the solution's lifetime.

3.1.2.2.2.2 Relevant Use Cases(UC)

System Process	Description	Exercise leader
[NSV-4] Cb-global service	Function process diagram for the Cb-global service. Includes the FBs and Functions for acquiring MET data and product processing and the METGATE which prepares the final service for dissemination. Customer is the Civil AU Operations Centre, Flight Management (PJ18-04c)	PJ.18-04b (DLR Cb-global yellow profile service EXE)
[NSV-4] AIMMETForFlightDeck	Function process diagram for the AIM and MET data provision for Flight Deck	PJ18-04c

3.1.2.2.2.3 Applicable standards and regulations

AMQP is the used standard for the provision of MET Services.

3.1.2.3 Activities in IS.2

This activity is considered as part of PJ24 with support of PJ.18-04b, therefore it is not part of the solutions being proposed by PJ.18-04b, and either it will be subject to be PJ.18-04b maturity assessment.

Task PJ18-04b.IS.2 – MET Information Services to support Optimised ATM Network services.

3.1.2.3.1 Relevant Use Cases(UC)

The METForFMP service includes the FBs and Functions for acquiring MET data from the MET providers. It deals with managing the weather hotspots in particular Convection phenomena. It computes the different areas with different convection forecast probabilities. Customer is the FMP CC, FB Meteorological Operations Translation, Function MET Alerting.
The FB Meteorological Operations Translation and the Function MET Alerting are not yet modelled in PJ.04-02.

The above mentioned UC with [NSV-4] is modelled in MEGA. There are additionally developed capabilities and services within the scope of tasks where Thales Air Systems has the lead (Exercise 5 for the PJ24 demo). Other use cases are yet to be modelled, or they will be only validated internally or they are related to only internal developments and improvements.

Descriptions can be found throughout this document and in the PJ.18-04b TVALP[41].

3.1.2.3.2 Applicable standards and regulations

Web services and XML are the used standards for the provision of MET Services.

3.1.3 Capability Configurations required for the SESAR Solution

The table below is directly extracted from the TS document generated by MEGA:

[Context] Aerodrome ATM-MET PJ.18-04b				
CC	**Op Env**	**Capability**	**Node**	**Stakeholder**
Aerodrome ATM-MET (PJ.18-04b)	Airport;	Aeronautical and Meteorological Information Management; Meteorological Observation and Forecasting Provision;	Meteorological Service Provision;	Civil MET Service Provider; Military MET Service Provider
Airport (PJ.18-04b)	Airport;	Airport Operations Management;	Airport Ops Support; Airport Vehicle; Network Operations;	Civil Airport Operator; Military APT operator

[Context] Aerodrome ATM-MET PJ.18-04b				
ATM-MET (PJ.18-04b)	Airport; En-Route; Network;	Aeronautical and Meteorological Information Management; Meteorological Observation and Forecasting Provision;	Meteorological Service Provision;	Civil MET Service Provider; Military MET Service Provider
Communication Infrastructure (PJ.18-04b)	Airport;	Communication;		Civil CNS Service Provider
TWR (PJ.18-04b)	Airport;	Wake Turbulence Separation Provision; Weather-Dependent Separation Provision;	Aerodrome ATS; Network Operations;	Civil ATS Aerodrome Service Provider
Aerodrome ATM-MET (Step 2)	En-Route and TMA	-Weather Hazard Detection (TMA) -Weather Hazard Detection (aerodrome)	Meteorological Service Provision	Airlines, Air Navigation Service Provider

Table 8: Required CC for CC.2.1, CC.3.1, CC4.2 and IS.1

[Context] ATM-MET PJ18-04b				
CC	**Op Env**	**Capability**	**Node**	**Stakeholder**
ATM-MET (PJ.18-04b)	Airport; En-Route; Network;	Aeronautical and Meteorological Information Management; Meteorological Observation and Forecasting Provision;	Meteorological Service Provision;	Civil MET Service Provider; Military MET Service Provider

[Context] ATM-MET PJ18-04b				
Civil AU Operations Centre (PJ18-04b)	Airport; En-Route;	Airspace User Operations; Airspace User Situational Awareness;	Airspace User Ops Support; Flight Deck;	Airspace User; Civil Flight Operations Centre;
Communication Infrastructure (PJ.18-04b)	Airport;	Communication;		Civil CNS Service Provider; Military CNS Service Provider
Non-ATM MET Service Providers (External) (PJ18-04b)	Airport; En-Route;	Meteorological Observation and Forecasting Provision;		Civil MET Service Provider;

Table 9: Required CC for CC.2.3, CC.3.3 and IS.5

3.2 Changes imposed by the SESAR Solution on the baseline Architecture

Enabler ID (from EATMA)	Enabler Title (from EATMA)	Changes
METEO-03c	Provision and monitoring of real-time airport weather information, Step 2	New products and services will be developed based on IER.
METEO-04c	Generate and provide MET information relevant for Airport and approach related operations, Step 2	New products and services will be developed based on IER.
METEO-5c	Generate and provide MET information	The Cb-global service is introduced. However, it is not a new service, but utilises METHazardEnrouteObservation Service and METHazardEnrouteForecast Service without

Enabler ID (from EATMA)	Enabler Title (from EATMA)	Changes
	relevant for TMA and En-route related operations, including low-level IFR operations, Step 2	any changes. The new FB C07-Cb (thunderstrorm) nowcasting has been newly generated
Meteo-6c	Generate and provide Meteorological information relevant for Network related operations, Step 2	The Cb-global service is introduced. However, it is not a new service, but utilises METHazardEnrouteObservation Service and METHazardEnrouteForecast Service without any changes. The new FB C07-Cb (thunderstrorm) nowcasting has been newly generated
METEO-07c	New remote sensing technologies supporting MET-ATM Systems for LVP Operations	New sensors may be required, influence on system "Enhanced MET Sensors".
METEO-08c	All-weather remote sensing of high resolution 3D Aerodrome wind field, Step 2	No title and description is proposed via CR to focus more on the functions and processing and not on the sensors themselves. See also Table 11 below.
SWIM-APS-06b	Provision of Meteorological Information services for Step 2	New services will be developed based on IER.

Table 10: List of changes due to the SESAR Solution based on already existing enablers.

Following table is extracted from MEGA and includes Change requests done for DS19 and recently for DS20 (CR not yet endorsed):

Enabler	Element type	Element name	Impact	Change
METEO-10a	VIS Camera for visibility measurement and cloud monitoring			
	FB	VIS Camera (PJ.18-04b)	Introduce	
	Function	Visibility monitoring	Introduce	
	Function	Visible Cloud Monitoring	Introduce	

METEO-10b	IR Camera for cloud monitoring			
	FB	IR Camera (PJ.18-04b)	Introduce	
	Function	Infrared Cloud Monitoring	Introduce	
METEO-11b	Wind monitoring in dry conditions using data from Scanning Doppler Lidar			
	FB	Scanning Doppler Lidar (PJ.18-04b)	Introduce	
	Function	Wind monitoring in dry conditions	Introduce	
METEO-12a	Compile data for METForTAM service			
	Function	Prepare METForTAM Service	Introduce	
	Function	Tailoring METForTAM Service	Introduce	
METEO-12b	Compile data for METForWTS service			
	Function	Prepare METForWTS Service	Introduce	
	Function	Tailoring METForWTS Service	Introduce	
SVC-037	METForTAM Service			
	Service	METForTAMService	Introduce	
SVC-040	METForWTS Service			
	Service	METForWTSService	Introduce	
SENA01221 (CR)	Runway Sensors			
	FB	Runway Sensors (PJ.18-04b)	Introduce	
	Function	Runway condition monitoring	Introduce	
SENA01222 (CR)	C06 Local MET Information			
	FB	C06 Local MET Information (PJ.18-04b)	Introduce	
	Function	Consolidate local MET Information	Introduce	
SENA01223 (CR)	C07 Cb (thunderstorm) nowcasting			

	FB	C07 Cb (thunderstorm) nowcasting	Introduce	
	Function	thunderstorm nowcasting based on satellite data	Introduce	
SENA01224 (CR)	RWYWeather Service			
	Service	RWYWeatherService	Introduce	
SENA01225 (CR)	Compile data for RWYWeather Service			
	Function	Prepare RWYWeather Service	Introduce	
SENA01226 (CR)	Standard MET Parameter processing			
	FB	T02 Local MET Information and Alerts (PJ.18-04b)	Update	
	Function	AWOS Parameters Processing	Introduce	
	Function	Bora wind classification	Introduce	
	Function	Precipitation and Precipitation probability processing	Introduce	
	Function	Runway condition processing	Introduce	
	Function	Weather Phenomena detection	Introduce	
	Function	Wind condition change	Introduce	
SENA01227 (CR)	Microwave Radiometer			
	FB	Microwave Radiometer (PJ.18-04b)	Introduce	
	Function	Vertical Temperature Profile monitoring	Introduce	
SENA01228 (CR)	Precipitation processing			
	FB	T02 Local MET Information and Alerts (PJ.18-04b)	Update	

	Function	Precipitation and Precipitation probability processing	Introduce	
SENA012 29 (CR)	Runway condition			
	FB	T02 Local MET Information and Alerts (PJ.18-04b)	Update	
	Function	Runway condition processing	Introduce	
SENA012 30 (CR)	Temperature Inversion Detection			
	FB	T02 Local MET Information and Alerts (PJ.18-04b)	Update	
	Function	Temperature Inversion detection	Introduce	
SENA012 33 (CR)	Processing of Convection Cell detection			
	FB	T03 Convection (PJ.18-04b)	Update	
	Function	Convection cell detection	Introduce	
SENA012 37 (CR)	(Ensemble) Forecast based on NWP model output			
	FB	T06 MET Forecast Uncertainty (PJ.18-04b)	Update	
	Function	Ensemble forecast post-processing	Introduce	
	Function	Nowcast glide/climb path wind	Introduce	
	Function	Precipitation probability forecast	Introduce	
	Function	Runway condition forecast	Introduce	
	Function	Wind aloft probability forecast	Introduce	
METEO-07c (CR)	Integrated system of infrared and visual cameras to enable automatic detection of LVC			

	FB	T02 Local MET Information and Alerts (PJ.18-04b)	Update	
	Function	Visibility and Cloud Processing	Introduce	
METEO-08c (CR)	Integrated system of 3D scanning Doppler X-Band radar and long range Doppler lidar for all-weather wind monitoring			
	FB	T02 Local MET Information and Alerts (PJ.18-04b)	Update	
	Function	Bora wind classification	Introduce	
	Function	Current glide/climb path wind	Introduce	
	Function	Nowcast glide/climb path wind	Introduce	
	Function	Turbulence Cell detection	Introduce	
	Function	Wind aloft processing	Introduce	
	Function	Wind condition change	Introduce	
	Function	Wind shear detection	Introduce	
METEO-11a (CR)	Precipitation and Wind monitoring in wet conditions using data from Doppler Weather Radar			
	FB	Doppler Weather Radar (PJ.18-04b)	Introduce	
	Function	Precipitation monitoring	Introduce	
	Function	Wind monitoring in wet conditions	Introduce	

Table 11: New change requests for ENs

Furthermore, the following changes could be envisaged:

For implementation of MET service on climate optimised trajectories a corresponding standard MET dataset is required to be available. One option for the corresponding MET service is to rely on 3-dimensional fields of meteorological field data, which can be used to calculate overall impact along a trajectory. For an uplink, the information within the relevant flight corridor is selected and transmitted. A second option, is to establish a ground system which only provides relevant contours within the flight corridor. This second option requires less exchange of data. For an efficient implementation of this MET service a translation of more comprehensive MET data by an adequate system should be envisaged. Such a system would be responsible of extracting relevant contours for e.g. pre-fixed levels of climate change functions.

4 Technical Specifications

4.1 Functional architecture overview

The functional architecture presents a complete view of all activities performed by PJ.18-04b and it consolidates all architecture elements addressed by PJ.18-04b. Therefore, **the TRL6 solutions are not separated from other PJ.18-04b activities in this context**.

Role	Functional Block	Function
[NSV-4] METForTAM		
	Alerting Configuration Support (PJ.18-04b)	Check Against MET Provision;
	C01 Radar Composite	C01 Radar Composite;
	C03 Very Short Term Forecast	C03 Very Short Term Forecast;
	C04 Short Term Forecast	C04 Short Term Forecast;
	C06 Local MET Information (PJ.18-04b)	Consolidate local MET Information;
	MET-GATE (PJ.18-04b)	Prepare METForTAM Service; Tailoring METForTAM Service;
	T02 Local MET Information and Alerts (PJ.18-04b)	AWOS Parameters Processing; Bora wind classification; Precipitation and Precipitation probability processing; Temperature Inversion detection; Turbulence Cell detection; Visibility and Cloud Processing; Weather Phenomena detection; Wind aloft processing; Wind shear detection;
	T03 Convection	T03 Convection; Convection cell detection;
	T06 MET Forecast Uncertainty (PJ.18-04b)	Ensemble forecast post-processing; Precipitation probability forecast; Runway condition forecast; Wind aloft probability forecast;

Role	Functional Block	Function
	VIS Camera (PJ.18-04b)	Visibility monitoring;
	Meteorological Operational Translation (PJ.18-04b)	Receive MET Forecasts and Observations;
[NSV-4] METForWTS		
	C03 Very Short Term Forecast	C03 Very Short Term Forecast;
	C06 Local MET Information (PJ.18-04b)	Consolidate local MET Information;
	Departure Separation Management (PJ.18-04b)	Assess Wind
	Doppler Weather Radar (PJ.18-04b)	Wind monitoring in wet conditions;
	MET-GATE (PJ.18-04b)	Prepare METForWTS Service; Tailoring METForWTS Service;
	Operational Supervision Aerodrome ATC (PJ.18-04b)	Display Wind Conditions
	Scanning Doppler Lidar (PJ.18-04b)	Wind monitoring in dry conditions;
	T02 Local MET Information and Alerts (PJ.18-04b)	Wind condition change; Current glide/climb path wind
	T06 MET Forecast Uncertainty (PJ.18-04b)	Nowcast glide/climb path wind;
[NSV-4]RWYWeather (Runway weather Monitoring and Forecast Input Service)		
	C03 Very Short Term Forecast	C03 Very Short Term Forecast;
	C06 Local MET Information (PJ.18-04b)	C06 Local MET Information (Consolidate local MET Information);
	Doppler Weather Radar (PJ.18-04b)	Precipitation monitoring;
	MET-GATE (PJ.18-04b)	Prepare RWYWeather Service;
	Runway Sensors (PJ.18-04b)	Runway condition monitoring;

Role	Functional Block	Function
	Runway Surface Condition Computing System (PJ.18-04b)	RWYCC computation (built-in sensors); RWYCC computation (Weather based model);
	T02 Local MET Information and Alerts (PJ.18-04b)	Runway condition processing;
	T06 MET Forecast Uncertainty (PJ.18-04b)	Runway condition forecast;
Remote Tower MET (RemoteTWRMET) Service (included in [NSV-4] Advanced Automated MET System)		
	C06 Local MET Information	C06 Local MET Information (Consolidate local MET Information);
	VIS Camera (PJ.18-04b)	Visibility monitoring; Visible Cloud Monitoring;
	IR Camera (PJ.18-04b)	Infrared Cloud Monitoring;
Airport Integrated Camera Images capability		
	VIS Camera (PJ.18-04b)	Visibility monitoring; Visible Cloud Monitoring;
	IR Camera (PJ.18-04b)	Infrared Cloud Monitoring;
GWMS capability		
	C01 Radar Composite	C01 Radar Composite;
	C02 Aircraft Information Processing	C02 Aircraft Information Processing
	C03 Very Short Term Forecast	C03 Very Short Term Forecast
	C04 Short Term Forecast	C04 Short Term Forecast;
	C06 Local MET Information	Consolidate local MET Information
	MET-GATE	Prepare METForTAM Service; Tailoring METForTAM Service; Prepare METForWTS Service; Tailoring METForWTS Service;
	T01 Regulatory MET Information	T01 Regulatory MET Information

Role	Functional Block	Function
	T02 Local MET Information and Alerts	AWOS Parameters Processing; Bora wind classification; Precipitation and Precipitation probability processing; Temperature Inversion detection; Turbulence Cell detection; Visibility and Cloud Processing; Weather Phenomena detection; Wind aloft processing; Wind shear detection; Wind condition change; Current glide/climb path wind
	T03 Convection	Convection Cell detection
	T06 MET Forecast Uncertainty	T06 MET Forecast Uncertainty;
[NSV-4] Cb-global service		
	C07 Cb (thunderstorm) nowcasting	thunderstorm nowcasting based on satellite data;
	Flight Management (PJ18-04b)	Receive MET data;
	MET-GATE (PJ.18-04b)	Prepare Cb-global service; Tailoring Cb-global service;
	T03 Convection	Convection Cell detection

Table 12: Functional blocks and their functions needed to realise the solution

Please note, that the FBs within the Consolidation and Translation part of the 4DWxCube TS are internal blocks and further breakdown e.g. how data is acquired and further processed is of no specific interest to the aviation community. Therefore, only one function with the same name is defined within these FBs in Wave 1. To enhance transparency and to clarify what the stakeholder (MET Service Provider) later needs to deploy and implement, a further breakdown would be necessary to state the required functions. The period of this task does not allow incorporation in DS19, but it could be covered in Wave 2 where work is ongoing.

The related activities can be found in the NSV-4 diagrams in chapter 4.1.2. The activities are only linked to functions of the MET-GATE FB, not to the supporting functions within the 4DWxCube TS.

4.1.1 Resource Connectivity Model

This View shall describe the context view of Aerodrome ATM-MET CC including a local instance of 4DWxCube (named GWMS from 18-04b Leonardo perspective) serving airport operations. The Aerodrome ATM-MET CC from Common libraries were duplicated and will be modified to adjust for S2020 requirements. Following Use cases apply:

UC 1:Link to PJ04-02 Total Airport Management: METForTAM service

UC 2:Link to PJ02-01 Wake Vortex decay: .METForWTS service

UC 3: Link to PJ.05-05: Airport Integrated Camera Images, RemoteTWRMET service

UC 4: Link to PJ.03b-06: RWYWeather Service

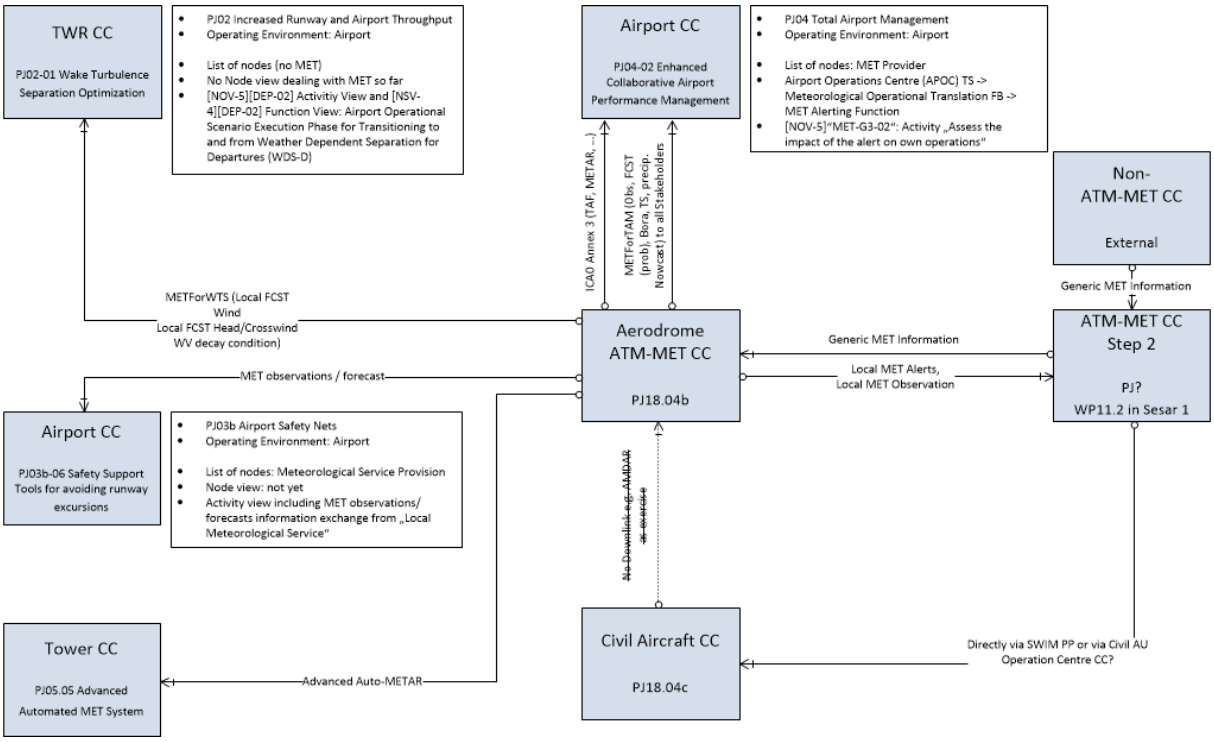

Figure 3: Context view of Aerodrome ATM-MET CC from PJ.18-04b perspective.

Figure 3 provides the overview of relationships of project PJ.18-04b with solution projects and the anticipated work covered in SESAR 2020 Wave 1.

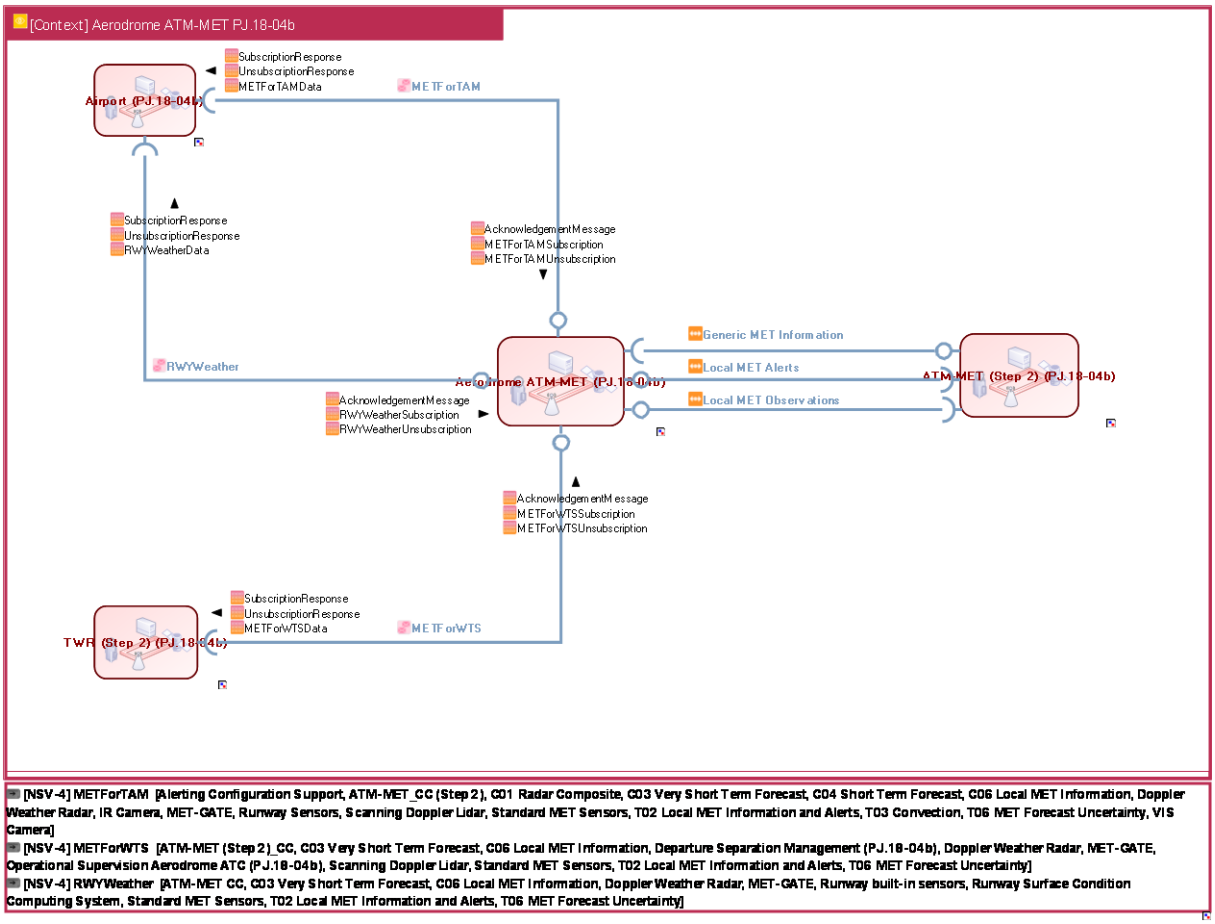

Figure 4: Context diagram for Aerodrome ATM-MET CC (PJ.18-04b)

New items include:

- METForTAM service provision via AMQP1.0 to Airport_CC
- METForWTS service provision also via AMQP to TWR CC
- RWYWeather service provision to Airport CC
- Receiving Generic MET Information (RI) via MET_GND from ATM-MET_CC

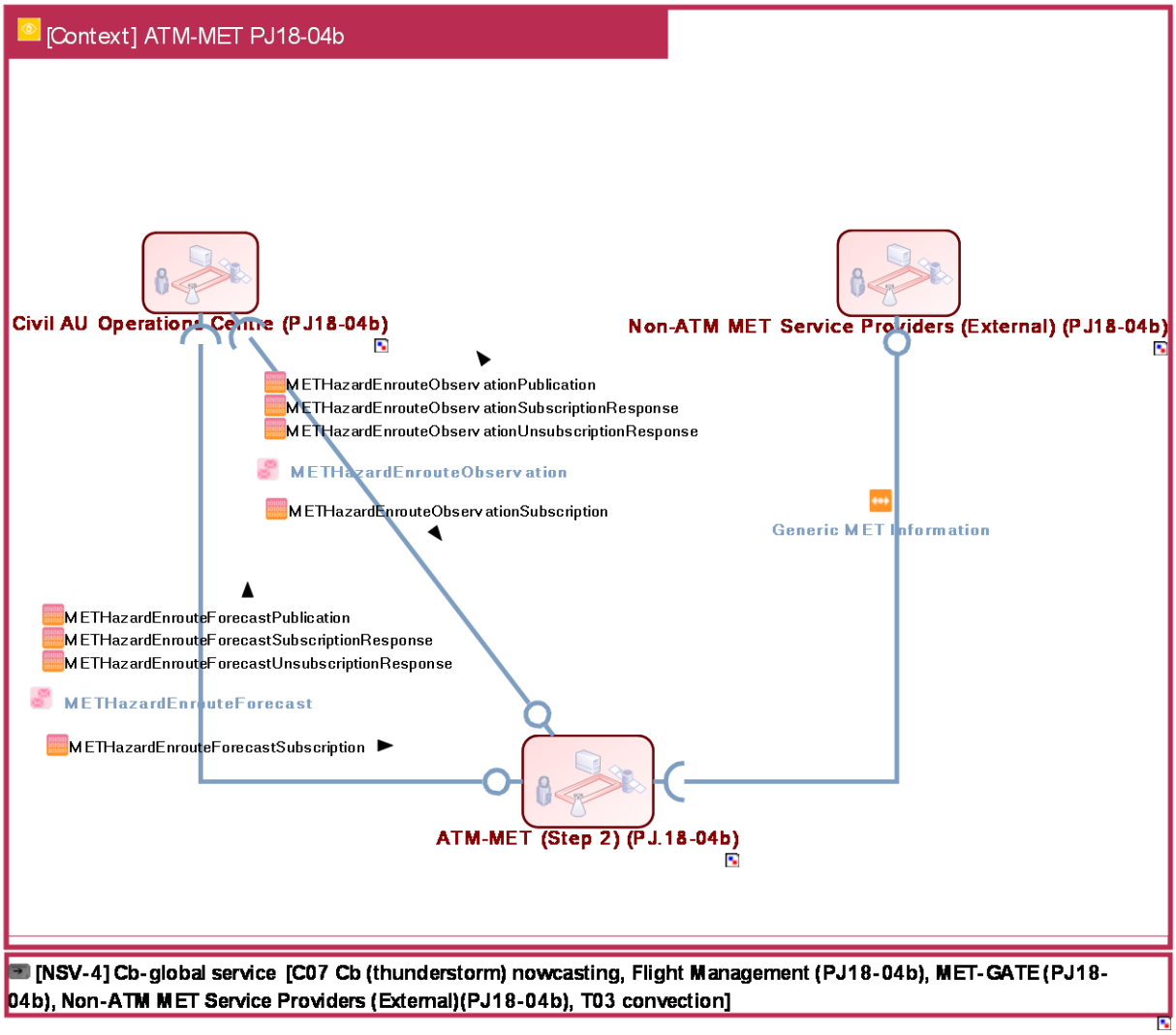

Figure 5: Context diagram for ATM-MET CC (PJ.18-04b)

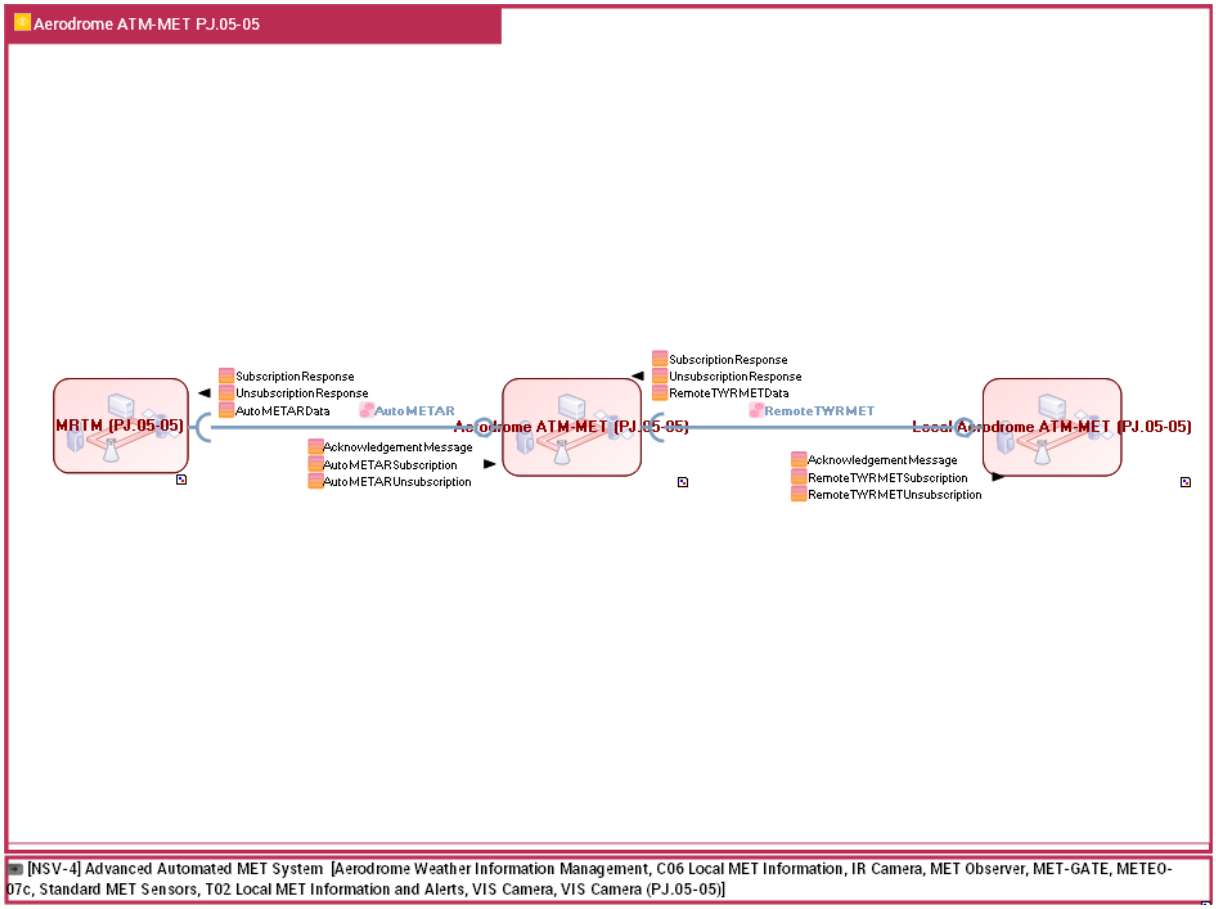

Figure 6: Context diagram for ATM-MET (PJ.05-05) with RemoteTWRMET Service

4.1.2 Resource Orchestration view

4.1.2.1 [NSV-4] METForTAM

Function process diagram for the METForTAM service. Includes the FBs and Functions for acquiring MET data and product processing and the MET-GATE which prepares the final service for dissemination. Customer is the Airport Operations Centre TS, FB Alerting Configuration Support, Function Check against MET provision.

Input resources:

ATM-MET_CC (Generic MET Information)

Standard MET Sensors

Enhanced MET Sensors

Breakdown:

Aerodrome ATM-MET CC --> 4DWxCube TS --> MET-GATE FB: realised by GWMS prototype (PJ.18-04b)

Airport CC --> Airport Operation Centre TS --> Alerting Configuration Support FB: realised by prototype in PJ.04-02.

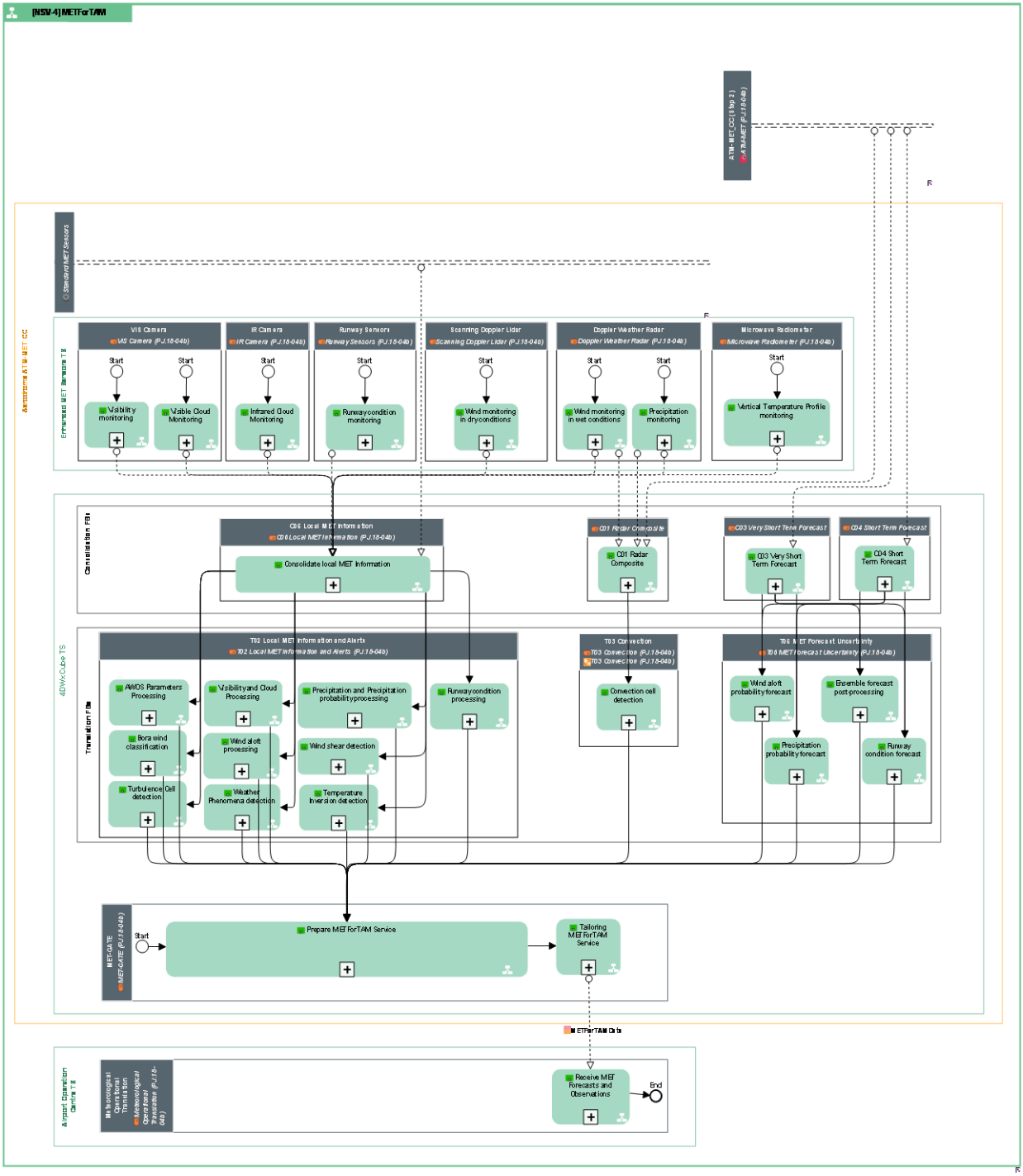

Figure 7: Function context diagram for METForTAM service

Function	Description
AWOS Parameters Processing	Reception of basic MET parameters (e.g. temperature, humidity) and consolidation to provide one representative value per parameter.
Bora wind classification	Classification of Bora wind types with the help of algorithm, depending on their speed and direction characteristics, based on the measurements from available infrastructure at the airport.
C01 Radar Composite	Via Interface MG00, FB C01 receives the Time Reference. Via the FB "Management", this functional block collects "Raw Radar Data" from the radars of the European network (Interface MG01.2) to build a harmonized mosaic of 2D and 3D reflectivity fields over Europe, referred to as the "Consolidated Radar Reflectivity". Via Interface C01, this "Consolidated Radar Reflectivity" field is returned to the FB "Management".
C03 Very Short Term Forecast	Via Interface MG00, FB C03 receives the Time Reference. Via the FB "Management", this functional block collects "Very Short Term Forecast" (both "Deterministic" and "Ensemble Forecast") from the "General MET Infrastructure" (Interface MG01.3). Consolidation involves projection of the MET gridded information on a common European grid and a statistical compositing of the MET products in the overlap areas of their respective domains to constitute a super-ensemble. Via Interface C03, the "Consolidated VST Forecast" is returned to the FB "Management".
C04 Short Term Forecast	Via Interface MG00, FB C04 receives the Time Reference. Via the FB "Management", this functional block collects "Short Term Forecast" (both "Deterministic" and "Ensemble Forecast") from the "General MET Infrastructure" (Interface MG01.4). Consolidation involves projection of the MET gridded information on a common European grid and a statistical compositing of the MET products in the overlap areas of their respective domains to constitute a super-ensemble. Via Interface C04, the "Consolidated ST Forecast" is returned to the FB "Management".

Function	Description
Consolidate local MET Information	New Functional Block "C06 Local MET Information" proposed: Collecting and consolidating local MET Information is also necessary for e.g. 3D wind field (Radar+Lidar), rain estimates (Radar+rain gauge), or if more than one sensor is available for one MET parameter (e.g. temperature). In PJ.05-05 collection and consolidaton of particular enhanced MET Sensors was added: VIS camera and IR camera (e.g. sky dome images stitching and projection from half-sphere to plane.).
Convection cell detection	Abstraction of input sources like radar, satellite, lightning data to derive convection cells.
Ensemble forecast post-processing	Taking the results from ensemble forecasts and translating them for aviation specific purposes with probabilities.
Infrared Cloud Monitoring	IR camera imagery supports MET observer especially in observation of cloud cover during night and cloud base height at the airport and enhances automatic means of observation for these MET parameters. These parameter are difficult to observe nowadays and using of IR camera imagery can significantly improve and ease the MET Observer job. Single whole-sky-image in IR spectrum provides information about cloud coverage even during night, when visual observation of clouds is almost impossible. Brightness temperature based on IR imagery helps to estimate cloud base height during both daytime and night, which provides objective criterion for cloud base assessment missing in current operating methods. IR Camera can be used advantageously by MET Observer at the airport, but optionally also by remote observer.
Precipitation and Precipitation probability processing	Deriving products related to precipitation and precipitation probability, e.g. rain cells identification and tracking and estimation of rain amount.
Precipitation monitoring	Derivation of precipitation products from radar-based measurements
Precipitation probability forecast	Precipitation probability forecast based on NWP model output.
Prepare METForTAM Service	Take all the incoming MET data and products and prepared the METForTAM service.

Function	Description
Receive MET Forecasts and Observations	METForTAM service from PJ.18-04b supports this function in PJ.04-02.
Runway condition forecast	Runway condition forecast based on NWP model output.
Runway condition monitoring	Dedicated measurements of sensors located at or around the runway to monitor the runway condition.
Runway condition processing	Derivation of runway condition products based on runway sensors' measurements.
Convection cell detection	This FB translates observations and forecast of convection to assess convection hazards for aviation and manages the consistency of the hazard assessment (severity thresholds) with the forecast range, from each cell description on the very short term to a coarser characterization of the convective risk on the short and medium terms. Via Interface MG00, FB T03 receives the Time Reference. To support these functionalities, this FB collects from the FB "Management" "Generic MET Observations" (Interface MG01.1), "Local MET Observations" (Interface MG02), "Consolidated Radar Reflectivity" (Interface MC01), "Aircraft-derived MET Observations" (Interface MC02), "Consolidated VST Forecast" (Interface MC03), "Consolidated ST Forecast" (Interface MC04), and "Consolidated MT Forecast" (Interface MC05). Via Interface T03, "Convection" is returned to the FB "Management".
Tailoring METForTAM Service	According to operational needs or filtering requirements the METForTAM service will be adjusted and transferred via YP to the customer.
Temperature Inversion detection	Analysis of temperature profiles for the detection of inversions.
Turbulence Cell detection	Analysis of respective input data for the detection of turbulence cells in the aerodrome area.
Vertical Temperature Profile monitoring	Determining the vertical temperature profile based on measurements from Microwave Radiometer.

Function	Description
Visibility and Cloud Processing	Analysis of respective data for the provision of visibility and cloud parameters.
Visibility monitoring	Monitoring of all visibility points (in system internal database) around the airport at regular intervals by camera working in visible spectrum.
Visible Cloud Monitoring	VIS camera imagery supports MET observer especially in observation of cloud cover (in daylight), prevailing visibility and significant phenomena at the airport and enhances automatic means of observation for these MET parameters. Assessment of cloud coverage using single whole-sky-image in VIS spectrum decreases subjectivity of the observation. While current automatic observation of visibility is based on extrapolation of point measurement (optical characteristics of limited air volume), using VIS camera imagery for prevailing visibility enables automatic observation in all direction with possible identification of minimal visibility in specific directions. Video sequences from camera supports MET observer in identification of significant phenomena (e.g. type of precipitation) at the airport. VIS Camera can be used advantageously by MET Observer at the airport, but optionally also by remote observer.
Weather Phenomena detection	Based on sensor measurements detection of present weather elements like sand storm, wet snow, etc.
Wind aloft probability forecast	Based on NWP model output probabilities for wind aloft are derived.
Wind aloft processing	Analysis of respective measurements for the derivation of wind aloft information.
Wind monitoring in dry conditions	Ground-based Scanning Doppler Lidar is used for wind monitoring in dry conditions.
Wind monitoring in wet conditions	Ground-based Doppler Weather Radar used for wind monitoring in wet conditions.
Wind shear detection	Based on Radar/Lidar wind measurements, applying algorithm for the detection of hazardous wind shear along runway and glide/climb paths.

Table 13: Functions and their descriptions used in METForTAM context diagram.

Please note that the descriptions from FBs already defined and described in SESAR 1 (C01-C05, and T01-T06) are sometimes outdated in terms of used ports. Also not all ports are applicable to the local instance of a 4DWxCube in Aerodrome ATM-MET CC context.

4.1.2.2 [NSV-4] METForWTS

Function Context Diagram to realise the provision of the METForWTS service from the Aerodrome ATM-MET CC to the TWR CC. WTS stand for Wake Turbulence Separation. Service includes current and 10 min forecast wind information for head- and crosswind components.

Input resources:

ATM-MET_CC (Generic MET Information)

Standard MET Sensors

Enhanced MET Sensors

Breakdown:

Aerodrome ATM-MET CC --> 4DWxCube TS --> MET-GATE FB: realised by GWMS prototype (PJ18-04b)

TWR CC --> Aerodrome ATC TS --> Departure Separation Management FB/Operational Supervision Aerodrome ATC FB: realised by operational prototype (PJ02-01).

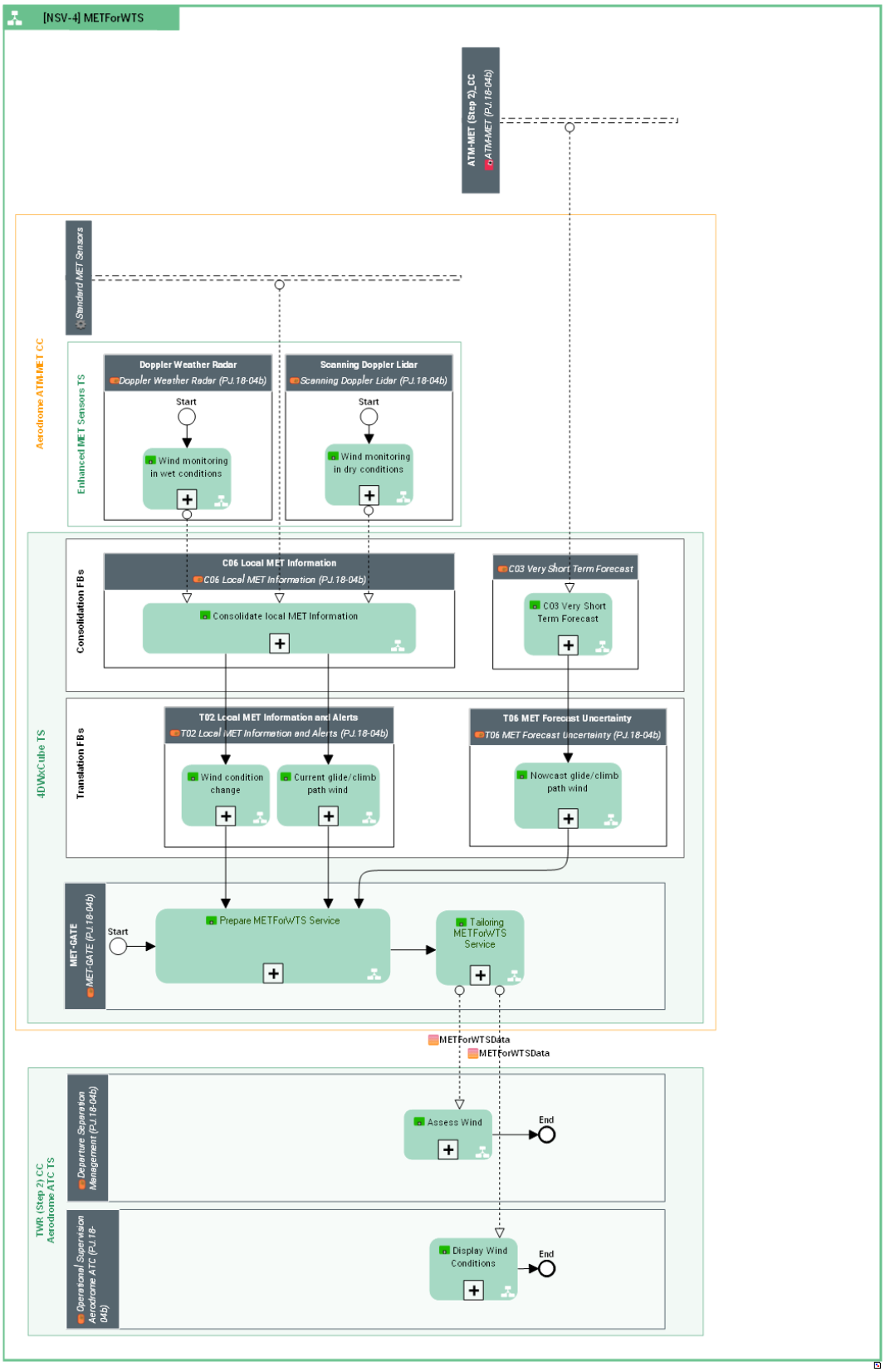

Figure 8: Function context diagram for METForWTS service.

Function	Description
Assess Wind	Function from PJ.02-01, [NSV-4][DEP-02] concept. METForWTS service is linked to this function in TWR CC, Aerodrome ATC TS, Departure Separation Management FB.
C03 Very Short Term Forecast	Via Interface MG00, FB C03 receives the Time Reference. Via the FB "Management", this functional block collects "Very Short Term Forecast" (both "Deterministic" and "Ensemble Forecast") from the "General MET Infrastructure" (Interface MG01.3). Consolidation involves projection of the MET gridded information on a common European grid and a statistical compositing of the MET products in the overlap areas of their respective domains to constitute a super-ensemble. Via Interface C03, the "Consolidated VST Forecast" is returned to the FB "Management".
Consolidate local MET Information	New Functional Block "C06 Local MET Information" proposed: Collecting and consolidating local MET Information is also necessary for e.g. 3D wind field (Radar+Lidar), rain estimates (Radar+rain gauge), or if more than one sensor is available for one MET parameter (e.g. temperature).
Current glide/climb path wind	Based on Radar and/or Lidar measurements derived current wind for the glide/climb path.
Display Wind Conditions	Function from PJ.02-01, [NSV-4][DEP-02] concept. METForWTS service is linked to this function in TWR CC, Aerodrome ATC TS, Operational Supervision Aerodrome ATC FB.
Nowcast glide/climb path wind	Based on NWP models output derived nowcast wind for the glide/climb path.
Prepare METForWTS Service	Take all the incoming MET data and products and prepare the METForWTS service.
Tailoring METForWTS Service	According to operational needs or filtering requirements the METForWTS service will be adjusted and transferred via YP to the customer.

Function	Description
Wind condition change	Based on Radar and/or Lidar measurements, notifcation about wind condition change according to local definitions.
Wind monitoring in dry conditions	Ground-based Scanning Doppler Lidar is used for wind monitoring in dry conditions.
Wind monitoring in wet conditions	Ground-based Doppler Weather Radar used for wind monitoring in wet conditions.

Table 14: Functions and their descriptions used in METForWTS context diagram.

Please note that the descriptions from FBs already defined and described in SESAR 1 (C01-C05, and T01-T06) are sometimes outdated in terms of used ports. Also not all ports are applicable to the local instance of a 4DWxCube in Aerodrome ATM-MET CC context.

4.1.2.3 [NSV-4] RWYWeather

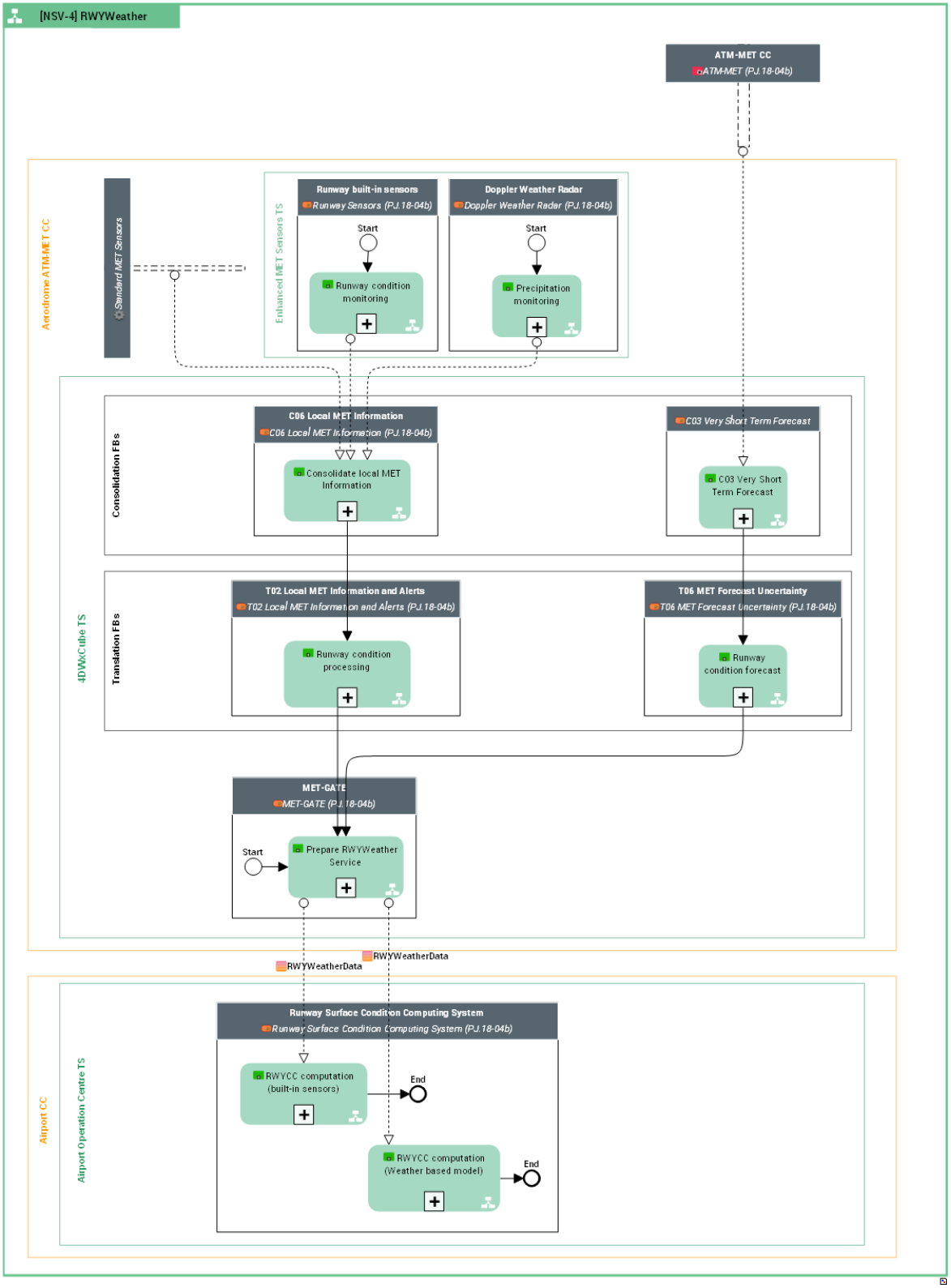

Figure 9: Function context diagram for the RWYWeather service

Function	Description
C03 Very Short Term Forecast	Via Interface MG00, FB C03 receives the Time Reference. Via the FB "Management", this functional block collects "Very Short Term Forecast" (both "Deterministic" and "Ensemble Forecast") from the "General MET Infrastructure" (Interface MG01.3). Consolidation involves projection of the MET gridded information on a common European grid and a statistical compositing of the MET products in the overlap areas of their respective domains to constitute a super-ensemble. Via Interface C03, the "Consolidated VST Forecast" is returned to the FB "Management".
Consolidate local MET Information	New Functional Block "C06 Local MET Information" proposed: Collecting and consolidating local MET Information is also necessary for e.g. 3D wind field (Radar+Lidar), rain estimates (Radar+rain gauge), or if more than one sensor is available for one MET parameter (e.g. temperature).
Precipitation monitoring	Derivation of precipitation products from radar-based measurements.
Prepare RWYWeather Service	Take all the incoming MET data and products and prepare the RWYWeather service.
Runway condition forecast	Runway condition forecast based on NWP model output.
Runway condition monitoring	Dedicated measurements of sensors located at or around the runway to monitor the runway condition.
Runway condition processing	Derivation of runway condition products based on runway sensors' measurements.
RWYCC computation (built-in sensors)	Function from PJ.03b-06 using the RWYWeather service as input.
RWYCC computation (Weather based model)	Function from PJ.03b-06 using the RWYWeather service as input.

Table 15: Functions and their descriptions used in RWYWeather context diagram

4.1.2.4 [NSV-4] METHazardEnroute

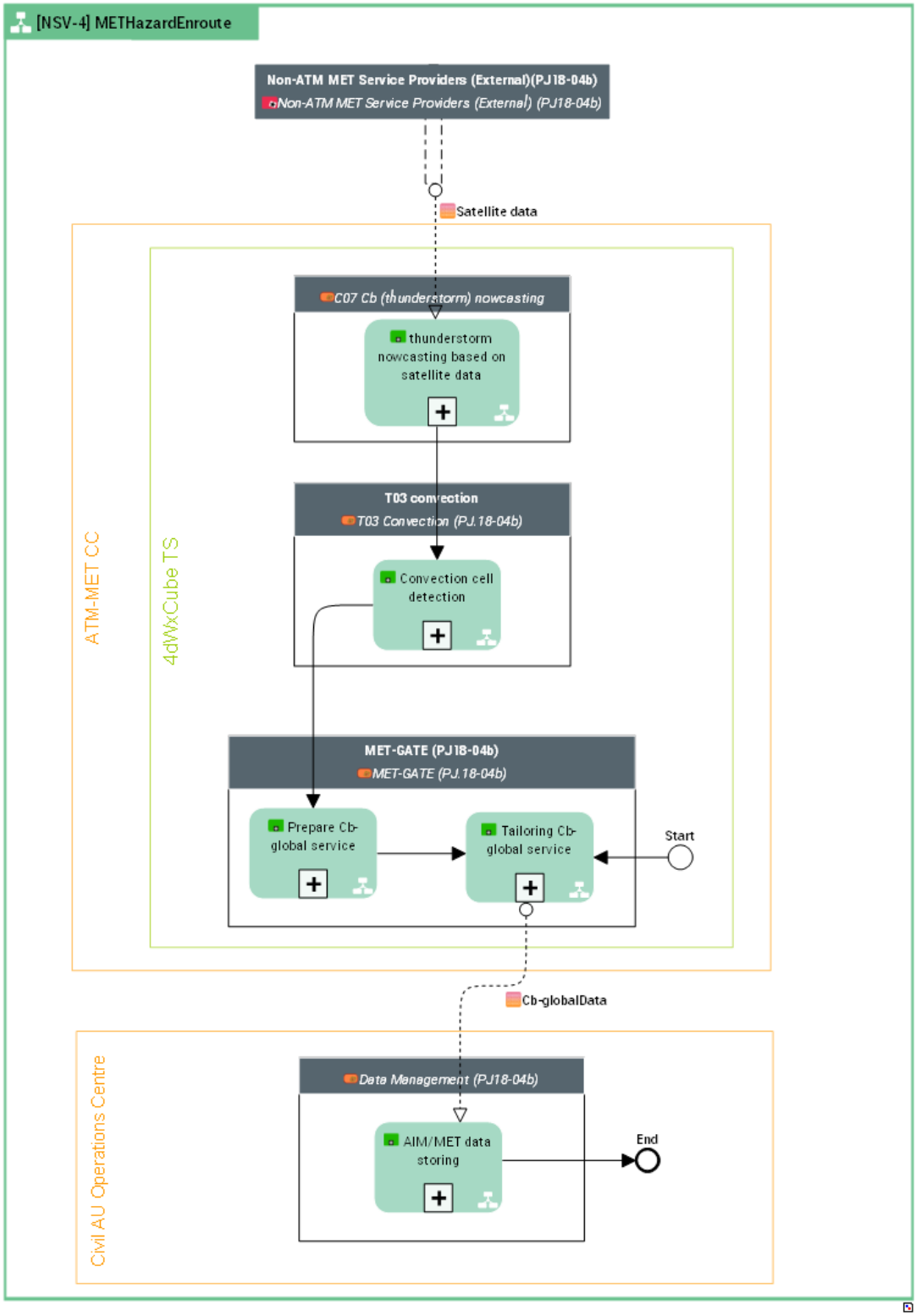

Figure 10: Function context diagram of Cb-global service

Function	Description
AIM/MET data storing	Function from PJ.18-04c. CB-global service is linked to this function in Civil AU Operations Centre CC, Civil AU Flight Operations Centre (FOC) TS, Data Management FB.
Convection cell detection	Abstraction of input sources like radar, satellite, lightning data to derive convection cells.
Prepare Cb-global service	Take all the incoming MET data and products and prepare the Cb-global service.
Tailoring Cb-global service	According to operational needs or filtering requirements the Cb-global service will be adjusted and transferred via YP to the customer.
thunderstorm nowcasting based on satellite data	Satellite data used as input for the detection and tracking of convection phenomena (thunderstorms).

Table 16: Functions and their descriptions used in Cb-global context diagram.

4.1.2.5 [NSV-4] Advanced Automated MET System (RemoteTWRMET Service)

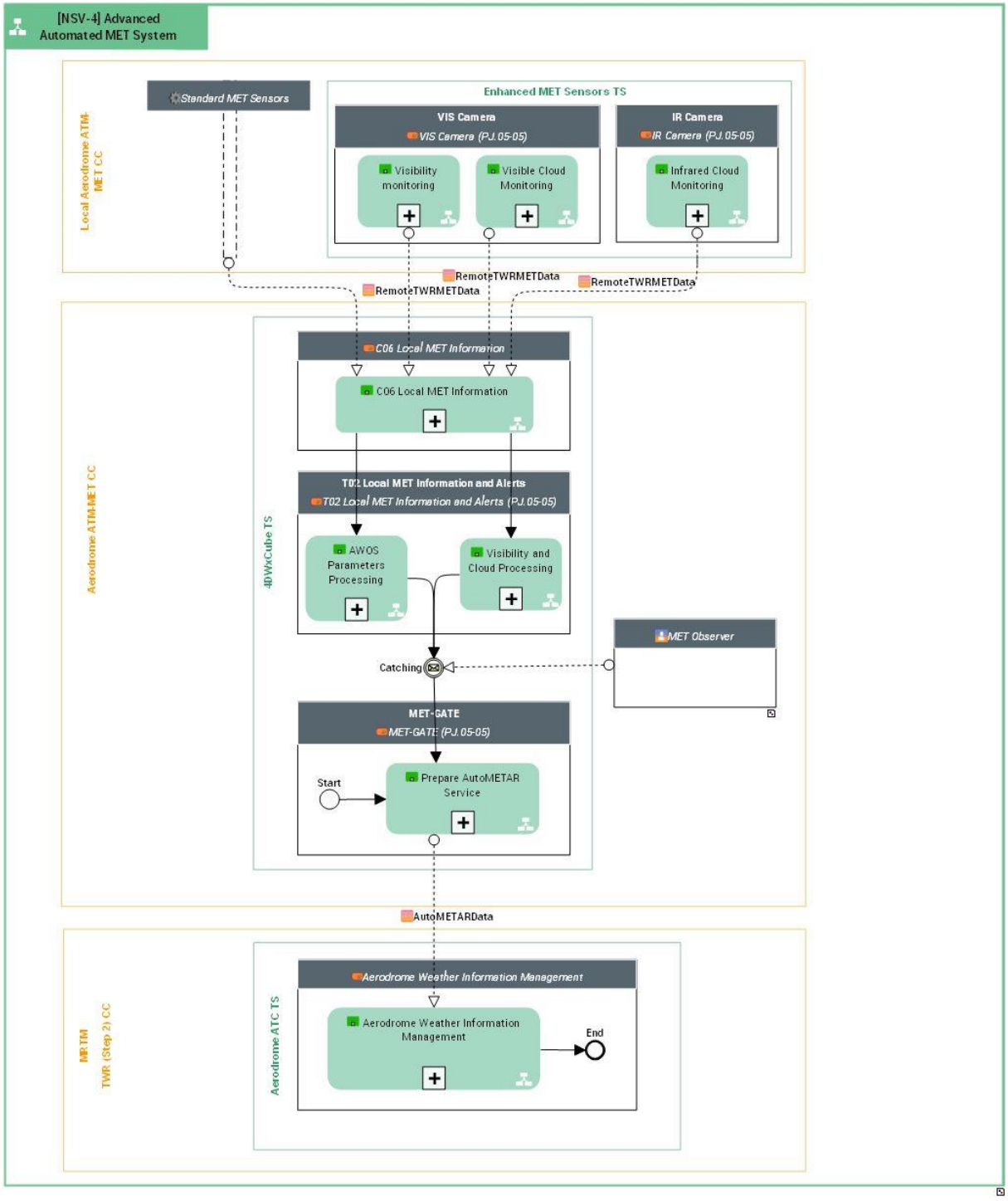

Figure 11:Function context diagram of RemoteTWRMET service (included in Advanced Automated MET System)

Function	Description
Visibility monitoring	Monitoring of all visibility points (in system internal database) around the airport at regular intervals by camera working in visible spectrum.
Visible Cloud Monitoring	Monitoring of sky dome at regular intervals by camera working in visible spectrum.
Infrared Cloud Monitoring	IR camera imagery supports MET observer especially in observation of cloud cover during night and cloud base height at the airport and enhances automatic means of observation for these MET parameters. These parameter are difficult to observe nowadays and using of IR camera imagery can significantly improve and ease the MET Observer job. Single whole-sky-image in IR spectrum provides information about cloud coverage even during night, when visual observation of clouds is almost impossible. Brightness temperature based on IR imagery helps to estimate cloud base height during both daytime and night, which provides objective criterion for cloud base assessment missing in current operating methods. IR Camera can be used advantageously by MET Observer at the airport, but optionally also by remote observer.
C06 Local MET Information	Collecting and consolidating local MET Information as Function is necessary for e.g. 3D wind field (Radar+Lidar), rain estimates (Radar+rain gauge), or if more than one sensor is available for one MET parameter (e.g. temperature). In PJ.05-05 collection and consolidaton of particular enhanced MET Sensors was added: VIS camera and IR camera (e.g. sky dome images stitching and projection from half-sphere to plane.).
AWOS Parameters Processing	Processes standard AWOS data like temperature, pressure, humidity, etc... Cooperates with Visibility and Cloud Processing function.
Visibility and Cloud Processing	An integrated system of IR and VIS cameras monitors and recognizes the visibility and cloud situation around the airport in wide range of weather conditions from good to adverse. The novelty here is not in the sensors themselves, but in their mutual integration to perform a common function utilizing artificial intelligence algorithms. Cooperates with AWOS Parameters Processing function to integrate measured parameters into cloud, visibility and potentially other weather phenomena recognition. The system finally calculates prevailing visibility also in inhomogeneous conditions (when visibility in one specific direction is different from visibility in other directions) and cloud information also in inhomogenous conditions (different cloud layers over different airport area parts).

Table 17: Functions and their descriptions used in Advanced Automated MET System context diagram related to RemoteTWRMET Service

4.1.3 Infrastructure connectivity model

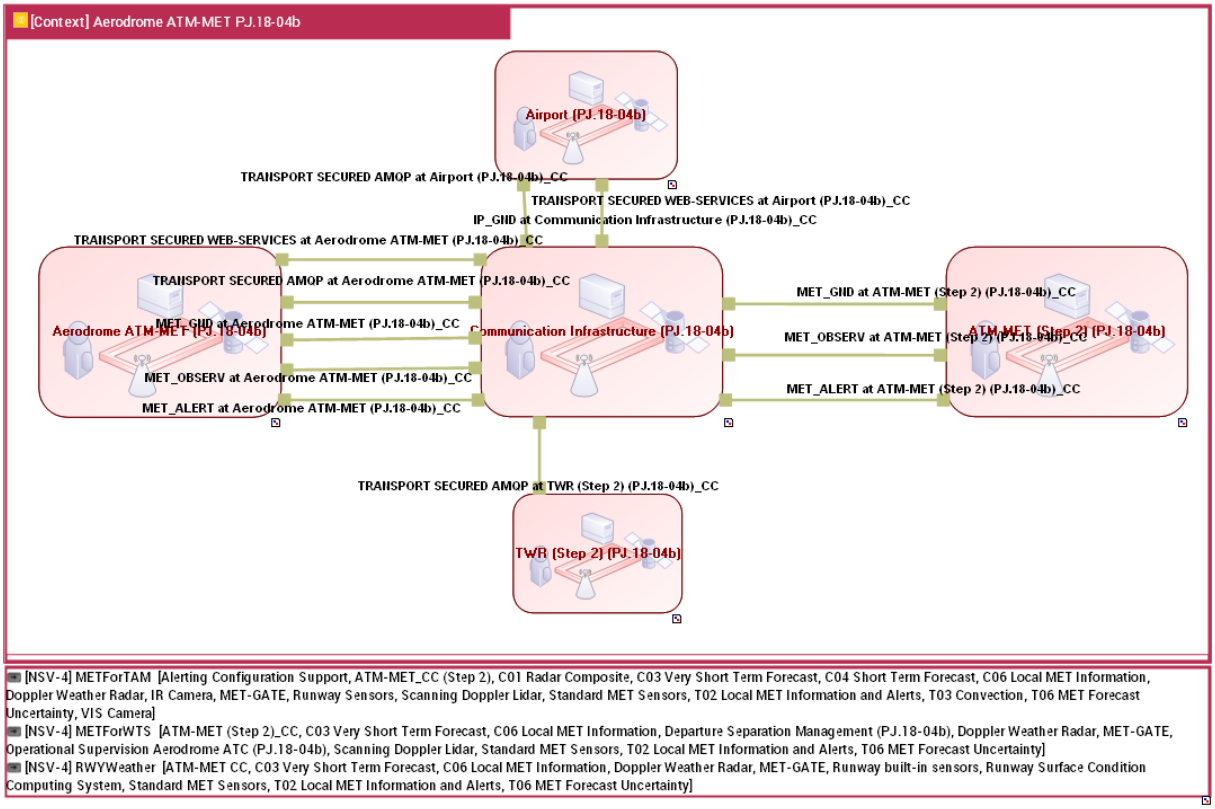

Figure 12: Infrastructure diagram for the Aerodrome ATM-MET (PJ.18-04b) CC context including ports and system port connectors.

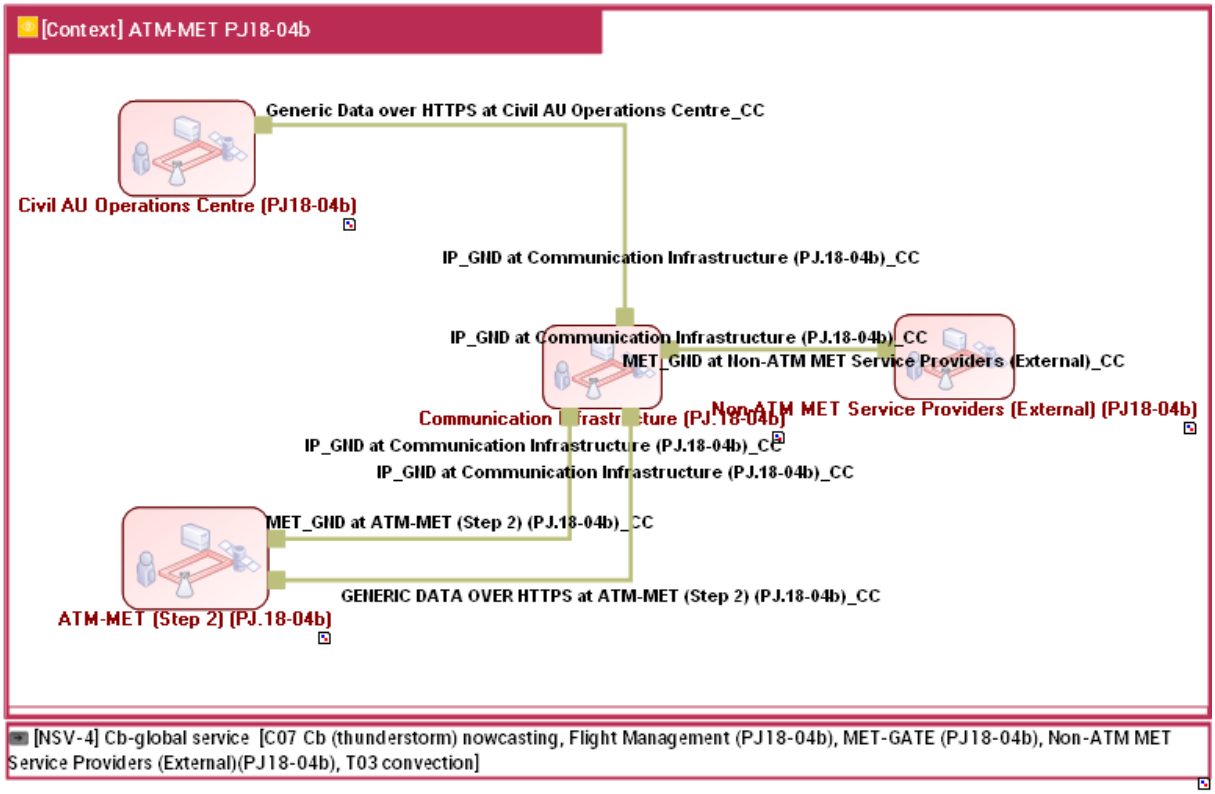

Figure 13: Infrastructure diagram for the ATM-MET (PJ.18-04b) CC context including ports and system port connectors

4.1.4 Service view

4.1.4.1 Service description

Service	Service description
METForTAM	METForTAM Service for the exchange between Aerodrome ATM-MET CC and the Airport CC. Provision is based on requirements to support Total Airport Management (TAM) concept. In total, the service consists of six payloads: CurrentWeather, CurrentWindRVR, ForecastWeather, ForecastWindRVR, LocalPhenomena and PolygonWeatherTypes.
METForWTS	This service addresses the needs for detailed wind information. Wind information comprises head- and crosswind components along the glidepath which will be used for optimising the runway throughput by addressing new arrival and departure concepts. Therefore, a glidepath wind profile will be provided as service inlcuding current, nowcast and forecast wind information.
RWYWeather	Runway condition information service to provide necessary input data for RCAMS system as a SWIM service. The service includes data from ground

Service	Service description
	sensors (embedded in runway), other measured data at the airport (e.g. AWOS) and data necessary for preparation of the runway condition forecast.
Cb-global service	This service comprises the two existing services METHazardEnrouteForecast and METHazardEnrouteObservation
METHazardEnrouteForecast	Service handling Nowcast (D -2hours, 3D, Probability factor) and Forecast(d-2 hours to 7days, 3D, Probability factor) of significant weather phenomena for assessment by consumers.
METHazardEnrouteObservation	Service handling actual significant weather phenomena for immediate assessment by consumers.
Remote Tower MET Service (RemoteTWRMET)	This service addresses dependency with 'Advanced Automated MET System' in order to provide all input data necessary for enhanced automated weather observation at the airport in a standardized way (especially Airport Integrated Camera Images – new capability, which has not been addressed yet).

Table 18: Service descriptions.

4.1.4.2 Service Provisioning

Interaction	Consumer CC	Consumer System	Provider CC	Provider System
METForWTS.TWR (Step 2) (PJ.18-04b)_CC and Aerodrome ATM-MET (PJ.18-04b)_CC	TWR (Step 2) (PJ.18-04b)	Aerodrome ATC;	Aerodrome ATM-MET (PJ.18-04b)	4DWxCube;
Generic MET Information	ATM-MET (Step 2) (PJ.18-04b)	4DWxCube;	Non-ATM MET Service Providers (External) (PJ18-04b)	Non-ATM MET (External);
METHazardEnroute Forecast	Civil AU Operations Centre (PJ18-04b)	Civil AU Flight Operations Centre (FOC);	ATM-MET (Step 2) (PJ.18-04b)	4DWxCube;
METHazardEnroute Observation	Civil AU Operations Centre (PJ18-04b)	Civil AU Flight Operations Centre (FOC);	ATM-MET (Step 2) (PJ.18-04b)	4DWxCube;
Local MET Observations.ATM-MET (Step 2) (PJ.18-04b)_CC and Aerodrome ATM-MET (PJ.18-04b)_CC	ATM-MET (Step 2) (PJ.18-04b)	4DWxCube;	Aerodrome ATM-MET (PJ.18-04b)	4DWxCube; Standard MET Sensors; Enhanced MET Sensors;

Interaction	Consumer CC	Consumer System	Provider CC	Provider System
Generic MET Information.Aerodrome ATM-MET (PJ.18-04b)_CC and ATM-MET (Step 2) (PJ.18-04b)_CC	Aerodrome ATM-MET (PJ.18-04b)	4DWxCube;	ATM-MET (Step 2) (PJ.18-04b)	4DWxCube;
Local MET Alerts.ATM-MET (Step 2) (PJ.18-04b)_CC and Aerodrome ATM-MET (PJ.18-04b)_CC	ATM-MET (Step 2) (PJ.18-04b)	4DWxCube;	Aerodrome ATM-MET (PJ.18-04b)	4DWxCube;
METForTAM.Airport (PJ.18-04b)_CC and Aerodrome ATM-MET (PJ.18-04b)_CC	Airport (PJ.18-04b)	Airport Operations Centre;	Aerodrome ATM-MET (PJ.18-04b)	4DWxCube;
RWYWeather.Airport (PJ.18-04b)_CC and Aerodrome ATM-MET (PJ.18-04b)_CC	Airport (PJ.18-04b)	Airport Operations Centre;	Aerodrome ATM-MET (PJ.18-04b)	4DWxCube;

Table 19: Service provisioning table.

4.1.4.3 Service Realization

Please note, some of the mentioned ports below are related to services or Resource Interactions which have been defined in SESAR1. We do not have any information about protocol or standards which may apply to these interfaces and ports if not already described in EATMA or MEGA. Therefore, it exists a lack of descriptions for technical specifications done in SESAR1. We only describe items which have been newly defined in SESAR2020 and belong to our responsibility or are of essential knowledge for providing services in operational validation exercises.

4.1.4.3.1 Interaction Generic MET Information.ATM-MET (Step 2) (PJ.18-04b) CC and Aerodrome ATM-MET (PJ.18-04b)_CC

System Port: MET_GND at ATM-MET (Step 2) CC

Protocol Stack	Protocol
AFTN Asynchrounous	
	AFTN
AMHS IPS	
	X.400

	TCP
	IP

System Port: IP_GND at Communication Infrastructure_CC

Protocol Stack	Protocol
IP	

System Port: IP_GND at Communication Infrastructure_CC

Protocol Stack	Protocol
IP	

System Port: MET_GND at Aerodrome ATM-MET_CC

Protocol Stack	Protocol
AFTN Asynchrounous	
	AFTN
AMHS IPS	
	X.400
	TCP
	IP

4.1.4.3.2 Interaction Local MET Alerts.Aerodrome ATM-MET (PJ.18-04b)_CC and ATM-MET (Step 2) (PJ.18-04b)_CC

System Port: IP_GND at Communication Infrastructure_CC

Protocol Stack	Protocol
IP	

System Port: MET_ALERT at Aerodrome ATM-MET

Protocol Stack	Protocol

System Port: MET_ALERT at ATM-MET (Step 2)

Protocol Stack	Protocol

4.1.4.3.3 Interaction Local MET Observations.Aerodrome ATM-MET (PJ.18-04b)_CC and ATM-MET (Step 2) (PJ.18-04b)_CC

System Port: IP_GND at Communication Infrastructure_CC

Protocol Stack	Protocol
IP	

System Port: MET_OBSERV at Aerodrome ATM-MET

Protocol Stack	Protocol

System Port: MET_OBSERV at ATM-MET (Step 2)

Protocol Stack	Protocol

4.1.4.3.4 Interaction METForTAM.Aerodrome ATM-MET (PJ.18-04b)_CC and Airport (PJ.18-04b)_CC

System Port: IP_GND at Communication Infrastructure_CC

Protocol Stack	Protocol
IP	

System Port: Transport Secured AMQP at Aerodrome ATM-MET_CC

Protocol Stack	Protocol
Transport Secured AMQP	
	Generic Data (MIME)
	AMQP
	SSL/TLS
	TCP

System Port: Transport Secured AMQP at Airport_CC

Protocol Stack	Protocol
Transport Secured AMQP	
	Generic Data (MIME)
	AMQP
	SSL/TLS
	TCP

Service Interface Definition	
serviceInterfaceDefinitionMETForTAMPublication	
Standard	**MEP, Security Configuration, Interface Bindings**
AMQP	Publish/Subscribe

Service Interface Definition	
serviceInterfaceDefinitionMETForTAMPublication	
Standard	**MEP, Security Configuration, Interface Bindings**
AMQP	Publish/Subscribe

4.1.4.3.5 Interaction METForWTS.Aerodrome ATM-MET (PJ.18-04b)_CC and TWR (Step 2) (PJ.18-04b)_CC

System Port: IP_GND at Communication Infrastructure_CC

Protocol Stack	Protocol
IP	

System Port: Transport Secured AMQP at TWR (Step 2)_CC

Protocol Stack	Protocol
Transport Secured AMQP	
	Generic Data (MIME)
	AMQP
	SSL/TLS
	TCP

Service Interface Definition	
serviceInterfaceDefinitionMETForWTSPublication	
Standard	**MEP, Security Configuration, Interface Bindings**
AMQP	Publish/subscribe

Service Interface Definition
serviceInterfaceDefinitionMETForWTSSubscription

Standard	MEP, Security Configuration, Interface Bindings
AMQP	Publish/Subscribe

4.1.4.3.6 Interaction RWYWeather.Airport (PJ.18-04b)_CC and Aerodrome ATM-MET (PJ.18-04b)_CC

System Port: IP_GND at Communication Infrastructure (PJ.18-04b)_CC

Protocol Stack	Protocol
IP	

System Port: TRANSPORT SECURED WEB-SERVICES at Aerodrome ATM-MET (PJ.18-04b)_CC

Protocol Stack	Protocol
Transport Secured Web-Services	
	XML
	SOAP
	HTTP
	TLS
	TCP

System Port: TRANSPORT SECURED WEB-SERVICES at Airport (PJ.18-04b)_CC

Protocol Stack	Protocol
Transport Secured Web-Services	
	XML
	SOAP
	HTTP
	TLS
	TCP

System Port: IP_GND at Communication Infrastructure (PJ.18-04b)_CC

Protocol Stack	Protocol
IP	

Service Interface Definition
serviceInterfaceDefinitionRWYWeatherPublication

Standard	MEP, Security Configuration, Interface Bindings
Generic Data over HTTPS	

Service Interface Definition	
serviceInterfaceDefinitionRWYWeatherSubscription	
Standard	**MEP, Security Configuration, Interface Bindings**
Generic Data over HTTPS	

4.1.4.3.7 Interaction METHazardEnrouteForecast

System Port: IP_GND at Communication Infrastructure (PJ.18-04b)_CC

Protocol Stack	Protocol
IP	

System Port: GENERIC DATA OVER HTTPS at ATM-MET (Step 2) (PJ.18-04b)_CC

Protocol Stack	Protocol
Generic Data over HTTPS	
	Generic Data (MIME)
	HTTP
	TLS
	TCP

System Port: IP_GND at Communication Infrastructure (PJ.18-04b)_CC

Protocol Stack	Protocol
IP	

System Port: Generic Data over HTTPS at Civil AU Operations Centre_CC

Protocol Stack	Protocol
Generic Data over HTTPS	
	Generic Data (MIME)
	HTTP
	TLS
	TCP

Service Interface Definition	
METHazardEnrouteForecastPublisher	
Standard	**MEP, Security Configuration, Interface Bindings**
METHazardEnrouteForecastInterface.Generic Data over HTTPS	MEPs Supported: SRR Security Configuration: Interface Binding Traceability: REQ-14.01.04-TS-0901.0310

Service Interface Definition	
METHazardEnrouteForecastSubscriber	
Standard	**MEP, Security Configuration, Interface Bindings**
METHazardEnrouteForecastInterface.Generic Data over HTTPS	MEPs Supported: SRR Security Configuration: Interface Binding Traceability: REQ-14.01.04-TS-0901.0310

4.1.4.3.8 Interaction METHazardEnrouteObservation

System Port: IP_GND at Communication Infrastructure (PJ.18-04b)_CC

Protocol Stack	Protocol
IP	

System Port: GENERIC DATA OVER HTTPS at ATM-MET (Step 2) (PJ.18-04b)_CC

Protocol Stack	Protocol
Generic Data over HTTPS	
	Generic Data (MIME)
	HTTP
	TLS
	TCP

System Port: IP_GND at Communication Infrastructure (PJ.18-04b)_CC

Protocol Stack	Protocol

IP	

System Port: Generic Data over HTTPS at Civil AU Operations Centre_CC

Protocol Stack	Protocol
Generic Data over HTTPS	
	Generic Data (MIME)
	HTTP
	TLS
	TCP

Service Interface Definition	
METHazardEnrouteObservationPublisher	
Standard	**MEP, Security Configuration, Interface Bindings**
METHazardEnrouteObservationInterface.Generic Data over HTTPS	MEPs Supported: SRR Security Configuration: Interface Binding Traceability: REQ-14.01.04-TS-0901.0310

Service Interface Definition	
METHazardEnrouteObservationSubscriber	
Standard	**MEP, Security Configuration, Interface Bindings**
METHazardEnrouteObservationInterface.Generic Data over HTTPS	MEPs Supported: SRR Security Configuration: Interface Binding Traceability: REQ-14.01.04-TS-0901.0310

4.2 Functional and non-Functional Requirements

This section presents details of the requirements. As means to separate requirements based on the target maturity level, only of the requirements of TRL6 solutions are listed in this section. Other requirements can be found in Appendix C.

The SESAR1 baseline of this technical specification of the local instance of the 4DWxCube called Ground Weather Management System (GWMS) comprised two strands of work conducted in two different work packages in SESAR1, namely WP11 and WP15. The respective projects responsible for technical specifications of MET systems were 15.04.09c and 11.02.02. Therefore, their requirements build the basis for the GWMS. In order to better illustrate this, the GWMS functional blocks are mapped onto the 4DWxCube functional blocks, since the 4DWxCube is the overarching concept. But only requirements will be described here, which support the work in SESAR2020 and contribute to the working tasks CC.2.2, CC.3.1, CC.4.2 and IS.1.

As the relevant documentation for this task, the following references have to be taken into account:

15.04.09c final technical specification [37]

11.02.02 Technical Specification LOCAL [38]

11.02.02 Technical Specification 4DWxCube [39]

11.02.02 IRS 4DWxCube MET-GATE [40]

The major functional blocks of the 4DWxCube are expounded as follows in [39]:

- Management
    - Administration

      This capability refers to activities performed by the 4DWxCube administrator, such as managing access rights, registering MET Services, and managing new MET Product Descriptions in the 4DWxCube. It also supports the monitoring and control of the system to ensure that the data and services are operating at acceptable levels.

    - Data management

      The 4DWxCube provides the capability to manage the various persistent data artefacts that support the provision of MET information to end users. The 4DWxCube shall also be able to accept and store MET Products from registered MET Service Providers to support the Consolidation and Translation processes.

- Consolidation

  The purpose of the Consolidation functional block is to create consistent, common harmonized and seamless MET Information at the European scale from the collection of MET Products delivered by the METSPs.

- Translation

The purpose of the Translation functional block is create MET Products that meet specific aviation end user needs from the consolidated MET Information generated by the Consolidation functional block.

- MET-GATE

  One of the main functions of the 4DWxCube is to serve MET Products to ATM systems via the MET-GATE as SWIM services. In this section are described the functionalities needed to serve the ATM consumers the required data set.

4DWxCube FB	Functions/FB	GWMS FB(s)	Task
4DWxCube Management	Administration	Configurability	
	Data management	Data Collection and Product Generation (Data Storage)	CC.4.2 Enhanced Airport MET Observations
Consolidation	C01, C02, C03, C04, C05, C06	Data Collection and Product Generation (Input Data Check)	CC.4.2 Enhanced Airport MET Observations
Translation	T01, T02, T03, T04, T05, T06	Data Collection and Product Generation (Data Formatting, Product Generation, Product Generation Quality Check)	CC.4.2 Enhanced Airport MET Observations CC.3.1 Airport MET Information and Alert Generation Enhancement
MET-GATE	Tailoring	Data Dissemination	IS.1 MET Information Services
MET-GATE	MET Product Retrieval	Ports obsolete; SWIM to be developed for Step 2.	CC.2.2 GWMS Enhancement IS.1 MET Information Services

Table 20: Mapping of 4DWxCube FB to former GWMS FBs and working tasks defined in PJ.18-04b

4.2.1 CC.2.2 GWMS Enhancement [Solution 1]

[REQ]

Identifier	REQ-18-04b-TS-CC22.0010
Title	SWIM Interface
Requirement	The local 4DWxCube shall have an interface to SWIM to provide MET data for aerodrome area.
Status	<Validated>
Rationale	MET access via SWIM. This has been derived from REQ-15.04.09.c-TS-03920.0010.
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<Enabler>	SWIM-APS-06b
<ALLOCATED_TO>	<Functional block>	MET-GATE
<ALLOCATED_TO>	<System Port>	Transport Secured AMQP

[REQ]

Identifier	REQ-18-04b-TS-CC22.0020
Title	Subscriptions – notification of users
Requirement	The local MET-GATE shall make users aware when a MET Product inside a service is not available to enable the ATM users to react accordingly.
Status	<In Progress>
Rationale	ATM clients require to know when a MET Product they are subscribed to is no longer supplied by the local 4DWxCube. This has been derived from REQ-11.02.02-TS-4DWC-0071. This amounts to a general design time requirement for services. Not implemented for any exercise.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<Enabler>	SWIM-APS-06b
<ALLOCATED_TO>	<Functional block>	MET-GATE
<ALLOCATED_TO>	<System Port>	Transport Secured AMQP

[REQ]

Identifier	REQ-18-04b-TS-CC22.0030

Title	Subscription – service update
Requirement	The local MET-GATE shall be always in possession of the latest MET products available and process subscriptions accordingly.
Status	<Validated>
Rationale	In order to accomplish the subscription requirement on event. This has been derived from REQ-11.02.02-TS-4DWC-0073.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<Enabler>	METEO-03c, METEO-04c; SWIM-APS-06b
<ALLOCATED_TO>	<Functional block>	MET-GATE
<ALLOCATED_TO>	<System Port>	Transport Secured AMQP

[REQ]

Identifier	REQ-18-04b-TS-CC22.0110
Title	MET Service Description via SWIM Registry
Requirement	The MET-GATE shall provide access to the MET Service Descriptions through the SWIM Registry to allow the ATM user to configure requests according to the capabilities of the respective services
Status	<In Progress>
Rationale	ATM clients need service information to configure their requests. This has been derived from REQ-11.02.02-TS-4DWC-1165. SWIM registry not in use currently.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<Enabler>	SWIM-APS-06b

<ALLOCATED_TO>	<Functional block>	MET-GATE
<ALLOCATED_TO>	<System Port>	Transport Secured AMQP

[REQ]

Identifier	REQ-18-04b-TS-CC22.0140
Title	Integration of new services
Requirement	The local MET-GATE FB shall be able to accommodate new Services without major redesign to support the integration of new services more easily.
Status	<Validated>
Rationale	New capabilities will be required as the 4DWxCube evolves. This has been derived from REQ-11.02.02-TS-4DWC-1177.
Category	<Design>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<Enabler>	SWIM-APS-06b
<ALLOCATED_TO>	<Functional block>	MET-GATE
<ALLOCATED_TO>	<System Port>	Transport Secured AMQP

REQ

Identifier	REQ-18-04b-TS-CC22.0160
Title	Number of subscriptions
Requirement	The 4DWxCube shall support 10000 subscriptions simultaneously.
Status	<Deleted>
Rationale	Expected performance. This has been derived from REQ-11.02.02-TS-4DWC-0096. This is part of SWIM TI.
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b

REQ

Identifier	REQ-18-04b-TS-CC22.0200
Title	User – password – authentication
Requirement	The local MET-GATE shall provide user/password based scheme for authentication.
Status	<Deleted>
Rationale	Local MET-GATE users need to be register in the system to use its services. This has been derived from REQ-11.02.02-TS-4DWC-0083. Done via SWIM TI.
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<ALLOCATED_TO>	<Functional block>	MET-GATE

REQ

Identifier	REQ-18-04b-TS-CC22.0210
Title	Authentication: trusted networks
Requirement	The local MET Gate authentication by users shall be done between SWIM nodes.
Status	<Validated>
Rationale	Due to security reasons. This has been derived from REQ-11.02.02-TS-4DWC-0087.
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<Enabler>	SWIM-APS-06b
<ALLOCATED_TO>	<Functional block>	MET-GATE

[REQ]

Identifier	REQ-18-04b-TS-CC22.0220
Title	Configuration of SSL-based transport
Requirement	The MET-GATE shall allow the configuration of SSL-based transport protocol (AMQPS) for metadata and data transfer to maintain data security.
Status	<Validated>
Rationale	Adherence to SWIM service description regulates this. This has been derived from REQ-11.02.02-TS-4DWC-0089.
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<Enabler>	SWIM-APS-06b
<ALLOCATED_TO>	<Functional block>	MET-GATE
<ALLOCATED_TO>	<System Port>	Transport Secured AMQP

REQ

Identifier	REQ-18-04b-TS-CC22.0230
Title	SOA principles
Requirement	The local 4DWxCube system shall be designed according to Service-oriented architecture (SOA) principles.
Status	<Validated>

Rationale	Loosely coupled services, increased competitions, and enhancement of business capabilities. This has been derived from REQ-11.02.02-TS-4DWC-0090.
Category	<Maintainability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b

REQ

Identifier	REQ-18-04b-TS-CC22.0240
Title	MET information alerts.
Requirement	The design of the local MET Gate shall allow issuing alerts to indicate that part or all of the MET Information of a MET Information service is not available, out of date or cannot be generated, to be used in case required by a specific service.
Status	<In Progress>
Rationale	This has been derived from REQ-11.02.02-TS-4DWC-0008. Not implemented in any exercise.
Category	<Reliability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<Enabler>	SWIM-APS-06b
<ALLOCATED_TO>	<Functional block>	MET-GATE

REQ

Identifier	REQ-18-04b-TS-CC22.0250
Title	Non-regulatory products – complex services

Requirement	Local ATM Users require complex, non-regulatory services to support their operations. The local MET Gate shall allow for such non-regulatory, complex services.
Status	<Validated>
Rationale	Design constraints. This has been derived from REQ-11.02.02-TS-4DWC-2114.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<ATMS Requirement>	REQ-PJ.04.02-SPRINTEROP-0819-0010
<SATISFIES>	<ATMS Requirement>	REQ-PJ.04.02-SPRINTEROP-0819-0020
<SATISFIES>	<ATMS Requirement>	REQ-PJ.04.02-SPRINTEROP-0819-0030
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-ARR0.0130
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-ARR2.1160
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-ARR2.1170
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-ARR2.1210
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-DEP2.0004
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-DEP3.0028
<SATISFIES>	<Enabler>	SVC-037
<SATISFIES>	<Enabler>	SVC-040
<ALLOCATED_TO>	<Functional block>	MET-GATE
<ALLOCATED_TO>	<Service>	METForTAMService
<ALLOCATED_TO>	<Service>	METForWTSService
<ALLOCATED_TO>	<Information exchange>	[NOV] MET Forecast and Observations Provision
<ALLOCATED_TO>	<System Port>	Transport Secured AMQP

[REQ

Identifier	REQ-18-04b-TS-CC22.0260
Title	WXXM format

Requirement	The local MET Gate shall provide standardized services according to standardized data models and formats (IWXXM within AIXM, based on XML) using offline schema validation.
Status	<Validated>
Rationale	Derived from REQ-15.04.09.c-TS-03910.0010. Offline does not require connection to the free internet and is much quicker as well as a self-contained solution.
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<Enabler>	SWIM-APS-06b
<ALLOCATED_TO>	<Functional block>	MET-GATE

REQ

Identifier	REQ-18-04b-TS-CC22.0280
Title	ATM consumers - maximum delivery time
Requirement	MET data items shall be delivered to local ATM consumers within a maximum delivery time - of 10 to 30 minutes for Medium Term Planning purposes - of 3 to 15 minutes for Short Term Planning purposes - of 30 seconds to 5 minutes for Execution purposes - of 15 seconds to 1 minute for alerts depending on the MET products.
Status	<In progress>
Rationale	Performance criteria are necessary for the users to know to ensure safe operations. Derived from REQ-11.02.02-IRS-4DWC.2033. Not checked for any exercise because different target environments not part of validation exercises.
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<Enabler>	SWIM-APS-06b
<ALLOCATED_TO>	<Functional block>	MET-GATE

REQ

Identifier	REQ-18-04b-TS-CC22.0290
Title	ATM consumers - connection via SWIM
Requirement	The communication between the local MET-GATE and ATM consumers shall use the SWIM "Yellow", "Blue" or "Purple" profile as required by the respective services.
Status	<Validated>
Rationale	Separation of concerns between product providers and distributers. Less complex interfaces. This has been derived from REQ-11.02.02-IRS-4DWC.2041.
Category	<Interoperability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<Enabler>	SWIM-APS-06b
<ALLOCATED_TO>	<Functional block>	MET-GATE

REQ

Identifier	REQ-18-04b-TS-CC22.0300
Title	ATM consumers - SWIM compliance

Requirement	The services supporting exchanges between the local MET-GATE and ATM consumers shall be compliant with the latest releases of SESAR AIRM and ISRM except when duly justified.
Status	<Validated>
Rationale	Mandatory to ensure interoperability with SWIM. This has been derived from REQ-11.02.02-IRS-4DWC.2042.
Category	<Interoperability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<Enabler>	SWIM-APS-06b
<ALLOCATED_TO>	<Functional block>	MET-GATE

REQ

Identifier	REQ-18-04b-TS-CC22.0310
Title	Request/Reply - specification of request - API
Requirement	The local MET Gate shall provide ATM consumers with APIs enabling to specify the requests of MET products for each service.
Status	<Deleted>
Rationale	This has been derived from REQ-11.02.02-IRS-4DWC.2067. This is done via SWIM nodes.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<Enabler>	SWIM-APS-06b
<ALLOCATED_TO>	<Functional block>	MET-GATE

[REQ]

Identifier	REQ-18-04b-TS-CC22.0340
Title	Subscription - update of data item delivery
Requirement	The local MET Gate shall be capable of providing services periodically or event triggered, depending on the properties of the respective MET service.
Status	<Validated>
Rationale	Basis for routine inherently event triggered applications like severe weather warning. This has been derived from REQ-11.02.02-IRS-4DWC.2079.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<Enabler>	SWIM-APS-06b
<ALLOCATED_TO>	<Functional block>	MET-GATE

[REQ]

Identifier	REQ-18-04b-TS-CC22.0360
Title	MET Subscription – defining subscription
Requirement	The local MET Gate shall provide ATM consumers with an API enabling them to define their profiles for subscriptions.
Status	<Deleted>
Rationale	Functional requirement for subscriptions –definition. This has been derived from REQ-11.02.02-IRS-4DWC.2080. This is part of the SWIM TI.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier

<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<Enabler>	SWIM-APS-06b
<ALLOCATED_TO>	<Functional block>	MET-GATE

[REQ]

Identifier	REQ-18-04b-TS-CC22.0380
Title	ATM consumers - subscription - validity - yes
Requirement	In response to a request for subscription, the local MET Gate shall allow for services that return to ATM consumers, if the subscription is valid and compatible with the service description.
Status	<Deleted>
Rationale	Basic functional requirement for client/server type metadata/data retrieval system. This has been derived from REQ-11.02.02-IRS-4DWC.2087 Part of the SWIM TI.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<ALLOCATED_TO>	<Functional block>	MET-GATE

[REQ]

Identifier	REQ-18-04b-TS-CC22.0390
Title	ATM consumers - subscription - validity - no
Requirement	The local MET Gate shall allow for services that return to ATM consumers, if the subscription is not valid or not compatible with the service description.
Status	<Deleted>
Rationale	Basic functional requirement for client/server type metadata/data retrieval system. This has been derived from REQ-11.02.02-IRS-4DWC.2088. Part of the SWIM TI.

Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<ALLOCATED_TO>	<Functional block>	MET-GATE

[REQ]

Identifier	REQ-18-04b-TS-CC22.0420
Title	ATM consumer - authentication before communication
Requirement	Any ATM consumer shall be registered and provided with a certificate having a given validity period, before enabling any communication with the local 4DWxCube.
Status	<Validated>
Rationale	Flexible way to manage clients with different capabilities. This has been derived from REQ-11.02.02-IRS-4DWC.2034.
Category	<Functional><Maintainability><Metadata>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b

4.2.2 CC.3.1 Airport MET Information and Alert Generation Enhancement [Solution 1]

[REQ]

Identifier	REQ-18-04b-TS-CC31.0020
Title	Glidepath Wind Profile
Requirement	An algorithm for a glidepath wind profile based on Doppler Lidar or Doppler Weather Radar measurements shall be provided.
Status	<Validated>

Rationale	Arrival and departure concepts for time based and/or weather dependent sequencing need headwind and crosswind components along the glidepath. The MET Service provider shall develop an algorithm based on sensors' data to provide information about wind in the glidepath to ATM consumers.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-ARR0.0130
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-ARR2.1210
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-DEP2.0004
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-DEP3.0028
<SATISFIES>	<Enabler>	METEO-08c
<SATISFIES>	<Enabler>	SENA01222
<SATISFIES>	<Enabler>	METEO-11a
<SATISFIES>	<Enabler>	METEO-11b
<ALLOCATED_TO>	<Functional block>	C06 Local MET Information
<ALLOCATED_TO>	<Functional block>	T02 Local MET Information and Alerts
<ALLOCATED_TO>	<Function>	Consolidate local MET Information
<ALLOCATED_TO>	<Function>	Wind condition change
<ALLOCATED_TO>	<Function>	Current glide/climb path wind

[REQ]

Identifier	REQ-18-04b-TS-CC31.0030
Title	Glidepath Wind Profile Forecast
Requirement	An algorithm for a glidepath wind profile short term forecast with focus on the first 10 minutes shall be provided.
Status	<In Progress>

Rationale	Arrival and departure concepts for time based and/or weather dependent sequencing need headwind and crosswind components along the glidepath with lead-time in line with A/C approaching or departing. So far, only persistence forecast has been checked in terms of error bars when testing the algorithm based on REQ-18-04b-TS-CC31.0020 which seems not enough and more work is needed. The forecast, however has been included in the METForWTS data model.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-ARR2.1160
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-ARR2.1170
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-ARR2.1210
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-DEP2.0004
<SATISFIES>	<Enabler>	METEO-08c
<SATISFIES>	<Enabler>	SENA01237 (CR)
<ALLOCATED_TO>	<Functional block>	C03 Very Short Term Forecast
<ALLOCATED_TO>	<Functional block>	T06 MET Forecast Uncertainty
<ALLOCATED_TO>	<Function>	C03 Very Short Term Forecast
<ALLOCATED_TO>	<Function>	Nowcast glide/climb path wind

[REQ]

Identifier	REQ-18-04b-TS-CC31.0060
Title	A/C based MET observations such as Mode-S derived- observations
Requirement	The local 4DWxCube shall produce from A/C based MET observations products for - wind speed aloft - wind direction aloft - headwind aloft

	- crosswind aloft - temperature for an area of minimum 10 nautical miles around the airport extending from the surface up to 5000ft, with vertical resolution of 500ft up to 2000ft and 1000ft up to 5000ft, slant resolution of 0,5 nautical miles and an update rate of 10 minutes.
Status	<Validated>
Rationale	Local stakeholders require observed wind speed aloft in support of their operations. This has been derived from REQ-11.02.02-TS-LOC2.1105. The requirement was already validated in Sesar 1 but it is kept here because it is adopted to PP service.
Category	Functional

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<Enabler>	METEO-08c
<SATISFIES>	<Enabler>	SENA01237 (CR)
<SATISFIES>	<Enabler>	SENA01230 (CR)
<ALLOCATED_TO>	<Functional block>	T02 Local MET Information and Alerts
<ALLOCATED_TO>	<Functional block>	T06 MET Forecast Uncertainty
<ALLOCATED_TO>	<Function>	Wind aloft processing
<ALLOCATED_TO>	<Function>	Wind aloft probability forecast
<ALLOCATED_TO>	<Function>	Temperature Inversion detection

[REQ]

Identifier	REQ-18-04b-TS-CC31.0070
Title	Extend to new MET Service Providers or Products
Requirement	The local 4DWxCube Management FB shall be extensible to new MET Service Providers, new MET Products to expand the capabilities of the system.
Status	<Validated>

Rationale	Local specificities may have it that MET raw data or tailored products must be integrated from other parties. This has been derived from REQ-11.02.02-TS-4DWC-0078.
Category	<Design>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<Enabler>	METEO-03c
<SATISFIES>	<Enabler>	METEO-04c
<SATISFIES>	<Enabler>	METEO-05c
<SATISFIES>	<Enabler>	METEO-06c
<ALLOCATED_TO>	<Functional block>	T02 Local MET Information and Alerts
<ALLOCATED_TO>	<Functional block>	T03 Convection
<ALLOCATED_TO>	<Functional block>	T06 MET Forecast Uncertainty
<ALLOCATED_TO>	<Function>	Convection Cell detection

4.2.3 CC.4.2 Enhanced Airport (surface-based and remote sensing) MET Observations [Solution 1]

[REQ]

Identifier	REQ-18-04b-TS-CC42.0030
Title	Very short term forecast wind field near the airport
Requirement	The wind field around the airport shall be forecast with high temporal and spatial resolution high enough to be applicable to sequence management.
Status	<In Progress>
Rationale	Weather dependent and/or time based operations need to have certainty about the glide slope wind during landing of an aircraft. Since wind is a flow phenomenon, it requires forecast of sufficient surroundings of the airport. So far, only persistence forecast has been checked in terms of error bars when testing the algorithm based on REQ-18-04b-TS-CC31.0040 which seems not

	enough and more work is needed. The forecast, however has been included in the METForWTS data model.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-ARR2.1160
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-ARR2.1170
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-ARR2.1210
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-DEP2.0004
<SATISFIES>	<Enabler>	METEO-11a
<SATISFIES>	<Enabler>	METEO-11b
<SATISFIES>	<Enabler>	SENA01237
<SATISFIES>	<Enabler>	SENA01222
<ALLOCATED_TO>	<Functional block>	Doppler Weather Radar
<ALLOCATED_TO>	<Functional block>	Scanning Doppler Lidar
<ALLOCATED_TO>	<Functional block>	C06 Local MET Information
<ALLOCATED_TO>	<Functional block>	C03 Very Short Term Forecast
<ALLOCATED_TO>	<Functional block>	T06 MET Forecast Uncertainty
<ALLOCATED_TO>	<Function>	C03 Very Short Term Forecast
<ALLOCATED_TO>	<Function>	Consolidate local MET Information
<ALLOCATED_TO>	<Function>	Wind monitoring in wet conditions
<ALLOCATED_TO>	<Function>	Wind monitoring in dry conditions
<ALLOCATED_TO>	<Function>	Nowcast glide/climb path wind
<ALLOCATED_TO>	<Function>	Wind aloft probability forecast

[REQ]

Identifier	REQ-18-04b-TS-CC42.0040
Title	Glidepath real time wind monitoring

Requirement	Glidepath winds shall be monitored in real time. This can be done using a dedicated Doppler WxRadar/Lidar combinations that has no other duties or by real time relay of AMDAR data.
Status	<Validated>
Rationale	During TBS and/or Weather dependent separation supervisors and controllers need to be alerted automatically when the applicable wind goes below the minimum threshold
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-ARR0.0130
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-ARR2.1210
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-DEP2.0004
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-DEP3.0028
<SATISFIES>	<Enabler>	METEO-11a
<SATISFIES>	<Enabler>	METEO-11b
<SATISFIES>	<Enabler>	METEO-08c
<SATISFIES>	<Enabler>	SENA01222
<ALLOCATED_TO>	<Functional block>	Doppler Weather Radar
<ALLOCATED_TO>	<Functional block>	Scanning Doppler Lidar
<ALLOCATED_TO>	<Functional block>	T02 Local MET Information and Alerts
<ALLOCATED_TO>	<Function>	Wind monitoring in wet conditions
<ALLOCATED_TO>	<Function>	Wind monitoring in dry conditions
<ALLOCATED_TO>	<Function>	Current glide/climb path wind
<ALLOCATED_TO>	<Function>	Wind aloft processing
<ALLOCATED_TO>	<Function>	Wind condition change
<ALLOCATED_TO>	<Function>	Consolidate local MET Information

4.2.4 IS.1 MET Information Services to support High Performing Airport Operations [Solution 1]

[REQ]

Identifier	REQ-18-04b-TS-IS1.0010
Title	Total Airport Management weather service METForTAM
Requirement	The Ground Weather Management System (GWMS) as the local instantiation of the 4DWxCube technical system inside the Aerodrome ATM-MET CC shall provide a service tailored for the operational concept “Total Airport Management”.
Status	<Validated>
Rationale	The total airport management concept requires a specially tailored MET service in order to support their weather related impact assessment of meteorological events
Category	<Data>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.04-02
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<ATMS Requirement>	REQ-PJ.04.02-SPRINTEROP-0819-0020
<SATISFIES>	<ATMS Requirement>	REQ-PJ.04.02-SPRINTEROP-0819-0030
<SATISFIES>	<Enabler>	SVC-037
<SATISFIES>	<Enabler>	METEO-12a
<ALLOCATED_TO>	<Functional block>	MET-GATE
<ALLOCATED_TO>	<Function>	Prepare METForTAMService
<ALLOCATED_TO>	<Function>	Tailoring METForTAM Service
<ALLOCATED_TO>	<Service>	METForTAMService
<ALLOCATED_TO>	<Information exchange>	[NOV] MET Forecast and Observations Provision
<ALLOCATED_TO>	<Data>	METForTAMData
<ALLOCATED_TO>	<System Port>	Transport Secured AMQP

4.2.5 CC.2.3 Cockpit- Ready MET and IS.5 MET Information Services for aircraft information domain [Solution 2]

The following requirements of CC2.3 are also applicable for IS.5.

[REQ]

Identifier	REQ-18-04b-TS-CC23.0010
Title	MET Hazards Observation & Forecast along the flight plan
Requirement	MET Hazards in particular thunderstorm observations and nowcasts up to one hour shall be provided in order to raise situational awareness and facilitate the flight planning
Status	<validated>
Rationale	Phenomena detection and forecast relevant for ATM operational processes is the driving force for the development of MET capabilities.
Category	<Data>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ18-04b
<SATISFIES>	<SESAR Solution>	PJ18-04c
<SATISFIES>	<Enabler>	METEO-05c
<SATISFIES>	<Enabler>	METEO-06c
<SATISFIES>	<Enabler>	SENA01223
<SATISFIES>	<Enabler>	SENA01233
<ALLOCATED_TO>	<Functional block>	MET-GATE
<ALLOCATED_TO>	<Function>	Prepare Cb-global service
<ALLOCATED_TO>	<Function>	Tailoring Cb-global service
<ALLOCATED_TO>	<Functional block>	C07 Cb (thunderstorm) nowcasting
<ALLOCATED_TO>	<Function>	Thunderstorm nowcasting based on satellite data
<ALLOCATED_TO>	<Functional block>	T03 convection
<ALLOCATED_TO>	<Function>	Convection cell detection
<ALLOCATED_TO>	<Service>	Cb-global service

<ALLOCATED_TO>	<Data>	SatelliteData
<ALLOCATED_TO>	<Data>	Cb-globalData
<ALLOCATED_TO>	<System Port>	Transport Secured AMQP

4.2.6 IS.5 Met Information Services for aircraft information domain [Solution 2]

[REQ]

Identifier	REQ-18-04b-TS-IS5.0010
Title	Coverage area & Temporal and spatial resolution of MET hazard data
Requirement	The hazardous weather (observation and nowcast) datalink service shall be provided with thunderstorms, convectively induced turbulence (CIT), and potential icing areas (HAIC) with global coverage and a spatial resolution of ~15''
Status	<validated>
Rationale	Phenomena detection and forecast relevant for ATM operational processes is the driving force for the development of MET capabilities.
Category	<Data>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ18-04b
<SATISFIES>	<SESAR Solution>	PJ18-04c
<SATISFIES>	<ATMS Requirement>	D4.3.070 PJ18-04c TS/IRS Technical Specification, V1, 8. November 2019
<SATISFIES>	<Enabler>	METEO-05c
<SATISFIES>	<Enabler>	METEO-06c
<SATISFIES>	<Enabler>	SENA01223
<SATISFIES>	<Enabler>	SENA01233
<ALLOCATED_TO>	<Functional block>	MET-GATE
<ALLOCATED_TO>	<Function>	Prepare Cb-global service
<ALLOCATED_TO>	<Function>	Tailoring Cb-global service

<ALLOCATED_TO>	<Functional block>	C07 Cb (thunderstorm) nowcasting
<ALLOCATED_TO>	<Function>	Thunderstorm nowcasting based on satellite data
<ALLOCATED_TO>	<Functional block>	T03 convection
<ALLOCATED_TO>	<Function>	Convection Cell detection
<ALLOCATED_TO>	<Service>	Cb-global service
<ALLOCATED_TO>	<Data>	SatelliteData
<ALLOCATED_TO>	<Data>	Cb-globalData
<ALLOCATED_TO>	<System Port>	Transport Secured AMQP

[REQ]

Identifier	REQ-18-04b-TS-IS5.0020
Title	Temporal resolution of MET hazard data
Requirement	The hazardous weather (observation and nowcast) datalink service shall be provided with thunderstorms, convectively induced turbulence (CIT), potential icing areas (HAIC) in a temporal resolution of ~10…30 min
Status	<validated>
Rationale	Phenomena detection and forecast relevant for ATM operational processes is the driving force for the development of MET capabilities.
Category	<Data>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ18-04b
<SATISFIES>	<SESAR Solution>	PJ18-04c
<SATISFIES>	<ATMS Requirement>	D4.3.070 PJ18-04c TS/IRS Technical Specification, V1, 8. November 2019
<SATISFIES>	<Enabler>	METEO-05c
<SATISFIES>	<Enabler>	METEO-06c
<SATISFIES>	<Enabler>	SENA01223
<SATISFIES>	<Enabler>	SENA01233
<ALLOCATED_TO>	<Functional block>	MET-GATE

<ALLOCATED_TO>	<Function>	Prepare Cb-global service
<ALLOCATED_TO>	<Function>	Tailoring Cb-global service
<ALLOCATED_TO>	<Functional block>	C07 Cb (thunderstorm) nowcasting
<ALLOCATED_TO>	<Function>	Thunderstorm nowcasting based on satellite data
<ALLOCATED_TO>	<Functional block>	T03 convection
<ALLOCATED_TO>	<Function>	Convection cell detection
<ALLOCATED_TO>	<Service>	Cb-global service
<ALLOCATED_TO>	<Data>	SatelliteData
<ALLOCATED_TO>	<Data>	Cb-globalData
<ALLOCATED_TO>	<System Port>	Transport Secured AMQP

[REQ]

Identifier	REQ-18-04b-TS-IS5.0030
Title	Weather hazard data format
Requirement	Weather hazard observation and nowcast products shall be provided to support strategic decisions. Refresh rate < 30 min, validity period < 1...3 h Output shall be in a fixed geographical domain, with a list of objects (xml contours), with labels indicating details such as severity, cloud top, and displacement velocity vector.
Status	<validated>
Rationale	Consistent data standards are essential for data exchange interfaces like SWIM
Category	<Data>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ18-04b
<SATISFIES>	<SESAR Solution>	PJ18-04c
<SATISFIES>	<ATMS Requirement>	D4.3.070 PJ18-04c TS/IRS Technical Specification, V1, 8. November 2019

<SATISFIES>	<Enabler>	METEO-05c
<SATISFIES>	<Enabler>	METEO-06c
<SATISFIES>	<Enabler>	SENA01223
<SATISFIES>	<Enabler>	SENA01233
<ALLOCATED_TO>	<Functional block>	MET-GATE
<ALLOCATED_TO>	<Function>	Prepare Cb-global service
<ALLOCATED_TO>	<Function>	Tailoring Cb-global service
<ALLOCATED_TO>	<Functional block>	C07 Cb (thunderstorm) nowcasting
<ALLOCATED_TO>	<Function>	Thunderstorm nowcasting based on satellite data
<ALLOCATED_TO>	<Functional block>	T03 convection
<ALLOCATED_TO>	<Function>	Convection cell detection
<ALLOCATED_TO>	<Service>	Cb-global service
<ALLOCATED_TO>	<Data>	SatelliteData
<ALLOCATED_TO>	<Data>	Cb-globalData
<ALLOCATED_TO>	<System Port>	Transport Secured AMQP

5 Implementation Options

The GWMS as presented in this document acts as a local instance of a 4DWxCube installed in the Aerodrome ATM-MET CC. Therefore, it supports with its capabilities and services primarily operations at the airport Nevertheless, MET information is required for each flight phase as indicated by the Enablers METEO-03c, METEO-04c, and METEO-05c and METEO-06c. The 4DWxCube can be installed locally (at the airport), on regional as well as network level. Accordingly, there are demands for different MET services with different temporal and spatial coverage.

6 Assumptions

No specific assumption have been made that have an impact on the technical specification.

7 References and Applicable Documents

7.1 Applicable Documents

Content Integration

[1] B.04.01 D138 EATMA Guidance Material

[2] EATMA Community pages

[3] SESAR ATM Lexicon

Content Development

[4] B4.2 D106 Transition Concept of Operations SESAR 2020

System and Service Development

[5] 08.01.01 D52: SWIM Foundation v2

[6] 08.01.01 D49: SWIM Compliance Criteria

[7] 08.01.03 D47: AIRM v4.1.0

[8] 08.03.10 D45: ISRM Foundation v00.08.00

[9] B.04.03 D102 SESAR Working Method on Services

[10]B.04.03 D128 ADD SESAR1

[11]B.04.05 Common Service Foundation Method

Performance Management

[12]B.04.01 D108 SESAR 2020 Transition Performance Framework

[13]B.04.01 D42 SESAR2020 Transition Validation

[14]B.05 D86 Guidance on KPIs and Data Collection support to SESAR 2020 transition.

[15]16.06.06-D68 Part 1 –SESAR Cost Benefit Analysis – Integrated Model

[16]16.06.06-D51-SESAR_1 Business Case Consolidated_Deliverable-00.01.00 and CBA

[17]Method to assess cost of European ATM improvements and technologies, EUROCONTROL (2014)

[18]ATM Cost Breakdown Structure_ed02_2014

[19]Standard Inputs for EUROCONTROL Cost Benefit Analyses

[20]16.06.06_D26-08 ATM CBA Quality Checklist

[21]16.06.06_D26_04_Guidelines_for_Producing_Benefit_and_Impact_Mechanisms

Validation

[22]03.00 D16 WP3 Engineering methodology

[23]Transition VALS SESAR 2020 - Consolidated deliverable with contribution from Operational Federating Projects

[24]European Operational Concept Validation Methodology (E-OCVM) - 3.0 [February 2010]

System Engineering

[25] SESAR 2020 Requirements and Validation Guidelines

Safety

[26]SESAR, Safety Reference Material, Edition 4.0, April 2016

[27]SESAR, Guidance to Apply the Safety Reference Material, Edition 3.0, April 2016

[28]SESAR, Final Guidance Material to Execute Proof of Concept, Ed00.04.00, August 2015

[29]SESAR, Resilience Engineering Guidance, May 2016

Human Performance

[30]16.06.05 D 27 HP Reference Material D27

[31]16.04.02 D04 e-HP Repository - Release note

Environment Assessment

[32]SESAR, Environment Reference Material, alias, “Environmental impact assessment as part of the global SESAR validation”, Project 16.06.03, Deliverable D26, 2014.

[33]ICAO CAEP – “Guidance on Environmental Assessment of Proposed Air Traffic Management Operational Changes” document, Doc 10031.

Security

[34]16.06.02 D103 SESAR Security Ref Material Level

[35]16.06.02 D137 Minimum Set of Security Controls (MSSCs).

[36]16.06.02 D131 Security Database Application (CTRL_S)

7.2 Reference Documents

[37] Solution #21, 15.04.09c D17, Final System Specifications update after Validation, Edition 00.01.06

[38] Solution #35, 11.02.02 D38, Technical Specification LOCAL, Edition 00.02.00

[39] Solution #35, 11.02.02-D41, Technical Specification 4DWxCube, Edition 00.01.00

[40] Solution #35, 11.02.02-D42, IRS 4DWxCube MET-GATE, Ed 00.02.00

[41] PJ.18-04b Technical Validation Plan, V2.1, 13 June 2019.

[42] SESAR 1 D.0528 European ATM Service Description for the METHazardEnrouteForecast Service, Edition 2.1, 20/07/2016.

[43] SESAR 1 D.0529 European ATM Service Description for the METHazardEnrouteObservation Service, Edition 2.1, 20/07/2016.

[44] D4.3.070 PJ18-04c TS/IRS Technical Specification, V1, 8. November 2019

[45] DEL 15.04.09c D13, Report on support to validation exercise VP-669 of OFA 05.01.01, Edition 00.01.00

Appendix A Service Description Document (SDD)

This appendix contains the SDDs of the services developed by PJ18-04b.

METForTAM:

METForTAMService (1_0).pdf

RWYWeatherService:

RWYWeatherService

METForWTS:

METForWTSService_ SDD.docx

Cb-global service is developed based on two services created in SESAR 1, MetHazardEnrouteObservationService and MetHazardEnrouteForecastService, these services have been reused and described in [42][43].

Appendix B Service Technical Design Document (STDD)

N/A.

Appendix C Functional and non-functional requirements for TRL4&TRL2 prototypes

This Appendix lists the requirements that have been developed by the solution but are not matured through TRL6 mature assessment or considered as support activities fully in support of other solutions. These requirements could be further researched and validated to achieve higher maturity levels.

[REQ]

Identifier	REQ-18-04b-TS-IS1.0020
Title	Glide slope wind profile service (METForWTS)
Requirement	The Ground Weather Management System (GWMS) as the local instantiation of the 4DWxCube technical system inside the Aerodrome ATM-MET CC shall provide a service tailored for the operational concept of wake turbulence separation.
Status	<In Progress>
Rationale	The wake turbulence separation concept requires a specially tailored MET service in order to support their weather related assessment what separation concepts shall be applied for arrivals and departures.
Category	<Data>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.02-01
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-ARR0.0130
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-ARR2.1160
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-ARR2.1170
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-ARR2.1210
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-DEP2.0004
<SATISFIES>	<ATMS Requirement>	REQ-02.01-SPRINTEROP-DEP3.0028
<SATISFIES>	<Enabler>	SVC-040
<SATISFIES>	<Enabler>	METEO-12b

<ALLOCATED_TO>	<Functional block>	MET-GATE
<ALLOCATED_TO>	<Function>	Prepare METForWTSService
<ALLOCATED_TO>	<Function>	Tailoring METForWTSService
<ALLOCATED_TO>	<Service>	METForWTSService
<ALLOCATED_TO>	<Data>	METForWTSData
<ALLOCATED_TO>	<System Port>	Transport Secured AMQP

[REQ]

Identifier	REQ-18-04b-TS-CC31.0010
Title	Bora Wind Classification is Needed
Requirement	A classification product for the Bora wind event based on locally available MET infrastructure shall be run by the translation functional block of the local 4DWxCube at airports that suffer from this phenomenon.
Status	<in progress>
Rationale	Airports near the eastern coast of the Adriatic sea suffer from strong, gusty seaward winds during the winter months.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ18-04b, PJ04-02
<SATISFIES>	<ATMS Requirement>	REQ-PJ.04.02-SPRINTEROP-0819-0010
<SATISFIES>	<Enabler>	METEO-03c
<SATISFIES>	<Enabler>	METEO-04c
<SATISFIES>	<Enabler>	METEO-11b
<SATISFIES>	<Enabler>	SENA01226 (CR)
<ALLOCATED_TO>	<Functional block>	T02 Local MET Information and Alerts
<ALLOCATED_TO>	<Function>	Bora wind classification

[REQ]

Identifier	REQ-18-04b-TS-CC31.0011
Title	Bora Wind Classification Scheme
Requirement	Bora wind shall be categorized according to the following scheme: • Standard Bora • Deep Bora • Nocturnal Gap Flow • Unclassified
Status	<in progress>
Rationale	Airports near the eastern coast of the Adriatic sea suffer from strong, gusty seaward winds during the winter months.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ18-04b, PJ04-02
<SATISFIES>	<ATMS Requirement>	REQ-PJ.04.02-SPRINTEROP-0819-0010
<SATISFIES>	<Enabler>	METEO-03c
<SATISFIES>	<Enabler>	METEO-04c
<SATISFIES>	<Enabler>	METEO-11b
<SATISFIES>	<Enabler>	SENA01226 (CR)
<ALLOCATED_TO>	<Functional block>	T02 Local MET Information and Alerts
<ALLOCATED_TO>	<Function>	Bora wind classification

[REQ]

Identifier	REQ-18-04b-TS-CC33.0010
Title	Contrail forming regions
Requirement	Regions where contrails form are identified.
Status	<in progress>
Rationale	Aircraft produce contrails which have a potential impact on climate
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ18-04b

[REQ]

Identifier	REQ-18-04b-TS-CC33.0020
Title	Persistent contrail forming regions
Requirement	Regions where contrails form and where those contrails are persistent need to be identified.
Status	<in progress>
Rationale	Aircraft produce contrails which have a potential impact on climate in particular those contrails which are persistent
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ18-04b

[REQ]

Identifier	REQ-18-04b-TS-CC42.0010
Title	Observation of dangerous cross winds
Requirement	Dangerous cross winds like the Bora observed in the Adriatic shall be observed with Doppler Lidar upstream measurements to facilitate tactical warning.
Status	<in progress>
Rationale	Dangerous cross winds like the Bora observed in the Adriatic present a large safety risk for landing aircraft.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ18-04b, PJ04-02
<SATISFIES>	<ATMS Requirement>	REQ-PJ.04.02-SPRINTEROP-0819-0010
<SATISFIES>	<Enabler>	METEO-03c
<SATISFIES>	<Enabler>	METEO-04c
<SATISFIES>	<Enabler>	METEO-11b
<ALLOCATED_TO>	<Functional block>	T02 Local MET Information and Alerts
<ALLOCATED_TO>	<Function>	Bora wind classification

[REQ]

Identifier	REQ-18-04b-TS-CC42.0020
Title	Observation of dangerous cross wind and wind shear
Requirement	Dangerous cross wind shear like during the Bora observed in the Adriatic shall be observed with Doppler Lidar upstream measurements to facilitate tactical warning.
Status	<in progress>
Rationale	Dangerous cross wind shear like during the Bora observed in the Adriatic present a large safety risk for landing aircraft.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ18-04b, PJ04-02
<SATISFIES>	<ATMS Requirement>	REQ-PJ.04.02-SPRINTEROP-0819-0010
<SATISFIES>	<Enabler>	METEO-03c
<SATISFIES>	<Enabler>	METEO-04c
<SATISFIES>	<Enabler>	METEO-11b
<ALLOCATED_TO>	<Functional block>	T02 Local MET Information and Alerts
<ALLOCATED_TO>	<Function>	Wind shear detection

[REQ]

Identifier	REQ-18-04b-TS-CC42.0060
Title	Camera controller
Requirement	Camera controller shall exist, which provides the capability to rotate/tilt/zoom the camera in predefined repeatable cycles, non-regular scans and extracts both video and imagery.
Status	<in progress>
Rationale	It is necessary to schedule and control camera.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b, PJ.05-05
<SATISFIES>	<Enabler>	METEO-10a
<SATISFIES>	<Enabler>	METEO-10b
<ALLOCATED_TO>	<Functional block>	VIS Camera
<ALLOCATED_TO>	<Functional block>	IR Camera
<ALLOCATED_TO>	<Function>	Visibility monitoring
<ALLOCATED_TO>	<Function>	Visible Cloud Monitoring
<ALLOCATED_TO>	<Function>	Infrared Cloud Monitoring

[REQ]

Identifier	REQ-18-04b-TS-CC42.0070
Title	Image pre-processing - image stitching
Requirement	A software shall exist, which pre-processes the raw images and prepares them for subsequent recognition. The system shall compose cloud imagery into a single sky picture (so called image “stitching”).
Status	<in progress>
Rationale	Raw images processing is necessary precondition for successful recognition.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b, PJ.05-05

[REQ]

Identifier	REQ-18-04b-TS-CC42.0080
Title	Image pre-processing - blurring/removal of sensitive content
Requirement	According to local law requirements, a software for recognition of human faces and car identification plates shall be applied and the software shall blur/remove these parts of image from pictures.
Status	<in progress>
Rationale	As far as camera can capture public space partially, it shall meet the law.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b, PJ.05-05

[REQ]

Identifier	REQ-18-04b-TS-CC42.0090
Title	Regular imaging of visibility points
Requirement	The system shall take photos of all visibility points at regular intervals. The intervals shall be configurable to 30 or 60 minutes according to ICAO Annex 3.
Status	<in progress>
Rationale	System needs photos of visibility points to be able to distinguish if they are visible or not. To provide true awareness of prevailing visibility and its directional variations, camera shall regularly scan points in all directions and distances.

Category	<Functional>, <Data>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b, PJ.05-05
<SATISFIES>	<Enabler>	METEO-10a
<SATISFIES>	<Enabler>	METEO-10b
<SATISFIES>	<Enabler>	METEO-07c
<ALLOCATED_TO>	<Functional block>	VIS Camera
<ALLOCATED_TO>	<Functional block>	IR Camera
<ALLOCATED_TO>	<Functional block>	T02 Local MET Information and Alerts
<ALLOCATED_TO>	<Function>	Visibility monitoring
<ALLOCATED_TO>	<Function>	Visible Cloud Monitoring
<ALLOCATED_TO>	<Function>	Infrared Cloud Monitoring
<ALLOCATED_TO>	<Function>	Visibility and Cloud Processing

[REQ]

Identifier	REQ-18-04b-TS-CC42.0100
Title	Regular imaging of sky
Requirement	The system shall take the photos of the whole sky at regular intervals. The intervals shall be configurable to 30 or 60 minutes according to ICAO Annex 3.
Status	<in progress>
Rationale	System needs photos of sky to be able to recognize cloud coverage. To provide true awareness of sky conditions also in inhomogeneous conditions, the camera shall regularly scan the whole sky. .
Category	<Functional>, <Data>

[REQ Trace]

Relationship	Linked Element Type	Identifier

<SATISFIES>	<SESAR Solution>	PJ.18-04b, PJ.05-05
<SATISFIES>	<Enabler>	METEO-10a
<SATISFIES>	<Enabler>	METEO-10b
<SATISFIES>	<Enabler>	METEO-07c
<ALLOCATED_TO>	<Functional block>	VIS Camera
<ALLOCATED_TO>	<Functional block>	IR Camera
<ALLOCATED_TO>	<Functional block>	T02 Local MET Information and Alerts
<ALLOCATED_TO>	<Function>	Visibility monitoring
<ALLOCATED_TO>	<Function>	Visible Cloud Monitoring
<ALLOCATED_TO>	<Function>	Infrared Cloud Monitoring
<ALLOCATED_TO>	<Function>	Visibility and Cloud Processing

[REQ]

Identifier	REQ-18-04b-TS-CC42.0110
Title	Regular video capture of phenomena (Semi-automated mode)
Requirement	Thy system shall capture short videos (5-10 sec) of phenomena at regular intervals. The intervals shall be configurable to 30 or 60 minutes according to ICAO Annex 3.
Status	<in progress>
Rationale	Videos are important for the remote MET Observer to be able to recognize precipitation type, obscuration or other phenomena defined in METAR message (ICAO Annex 3, WMO Manual No. 306, FM-15)
Category	<Functional>, <Data>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b, PJ.05-05
<SATISFIES>	<Enabler>	METEO-10a
<SATISFIES>	<Enabler>	METEO-10b
<ALLOCATED_TO>	<Functional block>	VIS Camera
<ALLOCATED_TO>	<Functional block>	IR Camera

<ALLOCATED_TO>	<Function>	Visibility monitoring
<ALLOCATED_TO>	<Function>	Visible Cloud Monitoring
<ALLOCATED_TO>	<Function>	Infrared Cloud Monitoring

[REQ]

Identifier	REQ-18-04b-TS-IS1.0030
Title	Runway Weather Monitoring and Forecast Service (input)
Requirement	The Runway Weather Monitoring and Forecast Service (input) shall be capable of providing all the required data (with SWIM dissemination functionality) for RCAMS system (AWOS, ground sensor, etc.).
Status	<in progress>
Rationale	RCAMS system developed in PJ03b-06 requires dedicated service in order to receive necessary input data (e.g. from ground sensors) in standardized way.
Category	<Data>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b, PJ03b-06
<SATISFIES>	<ATMS Requirement>	REQ-03b.06-SPRINTEROP-ATSS.0009
<SATISFIES>	<Enabler>	SENA01224 (CR)
<SATISFIES>	<Enabler>	SENA01225 (CR)
<SATISFIES>	<Enabler>	SENA01221 (CR)
<SATISFIES>	<Enabler>	SENA01229 (CR)
<ALLOCATED_TO>	<Functional block>	MET-GATE
<ALLOCATED_TO>	<Functional block>	Runway Sensors
<ALLOCATED_TO>	<Functional block>	T02 Local MET Information and Alerts
<ALLOCATED_TO>	<Function>	Prepare RWYWeather Service
<ALLOCATED_TO>	<Function>	Runway condition monitoring
<ALLOCATED_TO>	<Function>	Runway condition processing
<ALLOCATED_TO>	<Service>	RWYWeather
<ALLOCATED_TO>	<Information exchange>	[NOV] MET Info Provision

<ALLOCATED_TO>	<Data>	RWYWeatherData
<ALLOCATED_TO>	<System Port>	Generic Data over HTTPS

[REQ]

Identifier	REQ-18-04b-TS-IS1.0031
Title	Runway Weather Monitoring and Forecast Service (output)
Requirement	The Runway Weather Monitoring and Forecast Service (output) shall be capable to disseminate RCR as well as any additional information generated by RCAMS system
Status	<in progress>
Rationale	RCAMS system developed in PJ03b-06 requires dedicated service to disseminate outputs in a standardized way in order to each stakeholder has the same information at the same time.
Category	<Data>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b, PJ03b-06
<SATISFIES>	<ATMS Requirement>	REQ-03b.06-SPRINTEROP-ATSS.0010

[REQ]

Identifier	REQ-18-04b-TS-IS1.0040
Title	Remote Tower MET Service
Requirement	Remote Tower MET Service shall be capable to provide all required data for Advanced Automated MET system (developed in Solution PJ05-05), especially Airport Integrated Camera Images
Status	<in progress>
Rationale	Advanced Automated MET system developed in PJ05-05 requires dedicated service in order to receive necessary input data (e.g. Airport Integrated Camera Images) in standardized way.
Category	<Data>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b, PJ.05-05
<SATISFIES>	<Enabler>	METEO-10a
<SATISFIES>	<Enabler>	METEO-10b
<ALLOCATED_TO>	<Functional block>	VIS Camera
<ALLOCATED_TO>	<Functional block>	IR Camera
<ALLOCATED_TO>	<Function>	Visibility monitoring
<ALLOCATED_TO>	<Function>	Visible Cloud Monitoring
<ALLOCATED_TO>	<Function>	Infrared Cloud Monitoring

Climate-optimized trajectories MET service contrail formation

[REQ]

Identifier	REQ-18-04b-TS-CC33.0010
Title	Contrail formation
Requirement	MET Service on contrail formation needs to inform on those regions of the atmosphere where an aircraft forms contrails.
Status	<Deleted>
Rationale	
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ.18-04b
<ALLOCATED_TO>	<Functional block>	MET-GATE

MET Information Services to support FMP

[REQ]

Identifier	REQ-18-04b-TS-IS2.0010
Title	Convection phenomena detection for ATC FMP
Requirement	Detect convection phenomena for ATC ATM MET
Status	<in progress>
Rationale	Phenomena detection relevant for ATM operational processes is the driving force for the development of MET capabilities.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<SATISFIES>	<SESAR Solution>	PJ18-04b
<SATISFIES>	<SESAR Solution>	PJ24

Appendix D Detailed description of MET products and sources

D.1 DLR's Cb-global and RadTram

D.1.1 Satellite-based Thunderstorm tracking and nowcasting (DLR)

The DLR system Cb-global uses data from geostationary satellites to detect, track, and nowcast thunderstorms up to one hour. Four different thunderstorm development stages can be distinguished by the system: 1.) potential thunderstorm development, 2.) rapid vertical cloud growth, 3.) mature thunderstorm, and 4.) areas with convectively induced turbulence (CIT). In addition, Cb-global is also able to identify regions favourable for icing conditions, in particular high altitude ice crystal icing. If uplinked into the cockpit, Cb-global information provides pilots an overview of the current weather hazard situation beyond the limited view of the on-board radar. It enables a pilot to strategically plan a safe and smart flight route around the thunderstorms well ahead in time instead of flying tactical manoeuvres and searching for gaps between the thunder cells.

Cb-global can be run with data from different geostationary satellites (METEOSAT, HIMAWARI, and GOES), i.e. it has global coverage with update rates of the detections and nowcasts between 5 and 15 minutes depending on the availability of the satellite data.

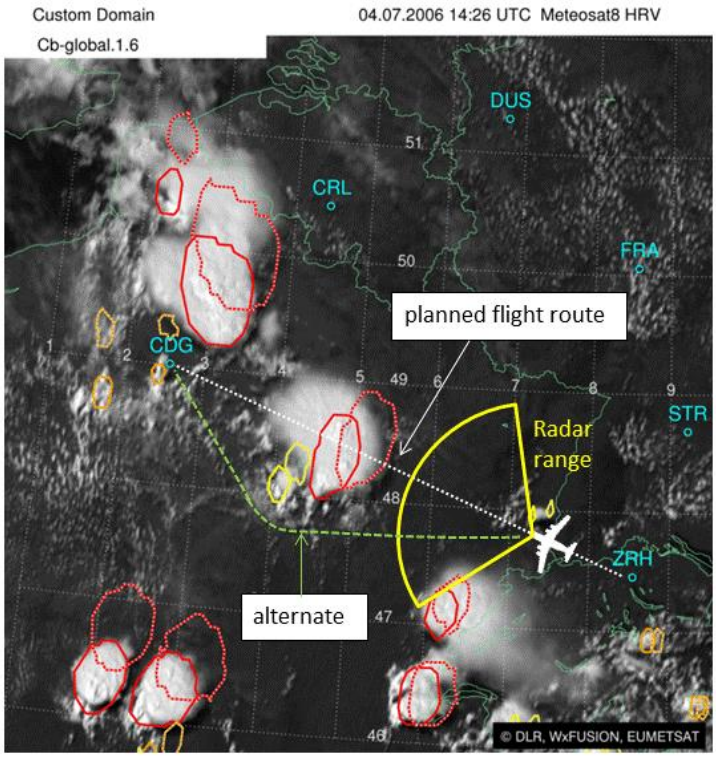

Figure 14:Cb-global example for a flight from Zurich (ZRH) to Paris Charles de Gaulle (CDG)

Radar Tracking and nowcasting of thunderstorms (DLR)

Based on observations from ground weather radars the DLR thunderstorm tracking and nowcasting system “Rad-TRAM” detects and tracks cells of heavy precipitation and calculates the development and propagation of these cells up to one hour. A reflectivity threshold of 37dBZ is used in order to identify hazardous precipitation areas which are relevant for air traffic in the lower air space where take-off and landing procedures take place (TMA and airports). The threshold has been chosen due to the fact that precipitation with reflectivity ≥ 37dBz exhibit good correspondence to lightning activity within the most active parts of thunderstorms. In addition, experience has shown that pilots often avoid flying through precipitation regions with reflectivity ≥ 37dBZ.

Different weather radar composites can be used for Rad-TRAM (e.g. the European Weather Radar Composite EURADCOM from the DWD), and it is also possible to run Rad-TRAM on data from single weather radars e.g. located close to or at an airport. Updates of the detections and nowcasts can be provided in 5 – 15 minute steps depending on the availability of the radar data.

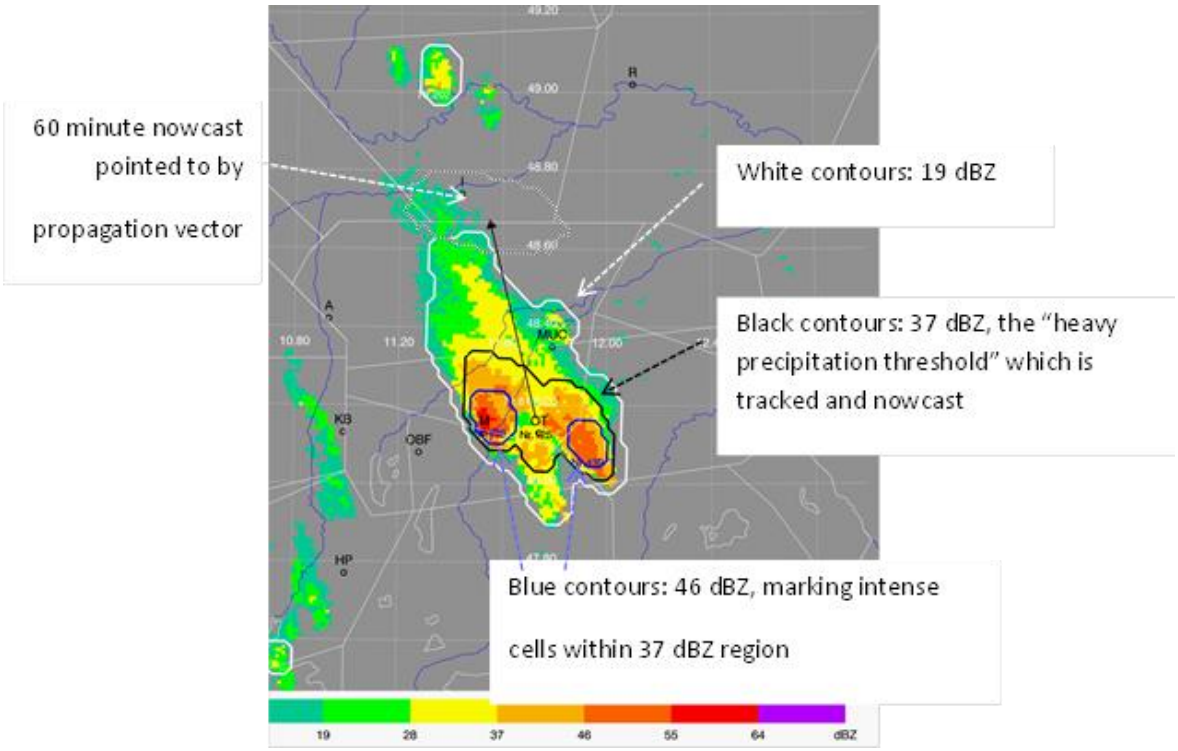

Figure 15:Rad-TRAM example for the TMA Munich (MUC)

Tracking and nowcasting of rain cells (LEONARDO Germany)

Complete precipitation fields will be tracked and forecasted. Convective as well as stratiform precipitation patterns are supported. Actual rain rate, expected position and intensity in near future, and expected total rain amount within forecast time can be derived.

In addition, if it is deemed valuable, probability forecasts of total rain within the specified forecast period to exceed a set of particular rain thresholds can be derived.

Lightning overlays (LEONARDO Germany)

Lightning data can be provided presenting it as single lightning strikes or as frequency distributions. Cloud-to-cloud or cloud-to-ground can be differentiated.

Wind shear information (LEONARDO Germany)

Wind shear information within 3 NM of the airport in approach and departure paths can be provided and presented as simple text strings to the cockpit.

D.1.2 Tailoring of Met Info

Thunderstorm tracking and nowcasting (DLR)

Both DLR systems, Cb-global and Rad-TRAM (see sections 3.4.1 and 3.4.2), provide their output in near real time in the form of standard GML/XML files containing the geo-referenced positions of the thunder cells, their nowcasts, and their specific characteristics like track history, trend, moving speed, moving direction, intensity etc. This information is unambiguous, precise, and interpretation-free, i.e. tailored to aviation needs. An ICD (interface control document) provided by DLR describes the details of the file format. The format can easily be made SWIM compatible, as it is based on an international standard. In addition, it comprises only small data volumes, is extendable, enables fast selectable reading, and is highly compressible, i.e. data can easily and cost-effectively be uplinked into the cockpit.

Tracking and nowcasting of rain cells (LEONARDO Germany)

Information can be adjusted to serve the aviation needs in terms of forecast period, rain amount thresholds, probability thresholds, etc.

Wind shear information (LEONARDO Germany)

Since we provide wind shear information according to ICAO Annex 3 and DOC 9817, also using the naming convention recommended by FAA, the wind shear information is already tailored to aviation needs.

D.2 Options for the uplink of MET information into the cockpit

This section describes the options for the uplink of MET information on thunderstorm hazards addressed by DLR's activity IS.5 MET Information Services for aircraft information domain.

D.2.1 Direct uplink of Met Information (Option 1)

- The Met Provider e.g. DLR generates up-to-date information of weather hazards in real time. This information is converted into a format suitable for tailoring with regard to aircraft specific requirements like aircraft position, heading, speed etc. (Service 1)

- Aircraft specific information of the individual aircraft (aircraft position, heading, speed etc.) is downlinked by an up- and downlink service provider (Service 3) and sent to the Met

Provider who tailors the weather hazard information in accordance with the available flight- and aircraft-specific information (Service 2).

- The aircraft-specific tailored information is then transferred back to the up- and downlink service provider (Service 2) and uplinked back to the aircraft (Service 3).

The following graphic illustrates the service option 1 with the DLR system Cb-global as example weather hazard information.

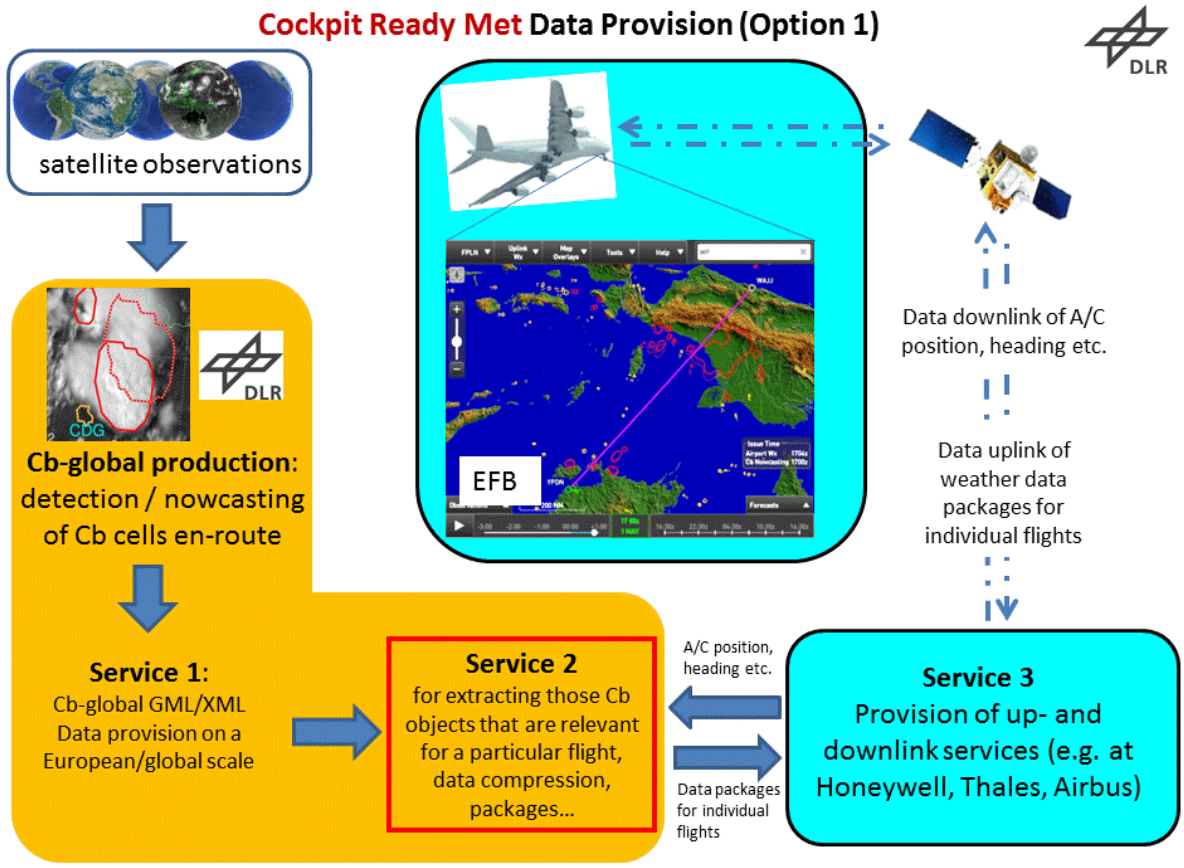

Figure 16:Illustration of service option 1 with DLR Cb-global as example weather hazard information

D.2.2 Uplink of Met Information via an Aircraft and Flight Specific MET Integration System (Option 2)

- The Met Provider e.g. DLR generates up-to-date information of weather hazards in real time. This information is converted into a format suitable for tailoring with regard to aircraft specific requirements like aircraft position, heading, speed etc. and then sent to a provider of up- and downlink services who operates an Aircraft and Flight Specific Met Integration System (Service 1)
- The Aircraft and Flight Specific Met Integration System tailors the weather hazard information (Service 2) in accordance with the flight- and aircraft-specific information that has been downlinked from the aircraft (Service 3).

- The aircraft-specific tailored weather information is then transferred back to the aircraft (Service 3).

Option 2 provides the advantage that downlinked aircraft-specific information does not have to be sent to each individual Met Service Provider, but stays with the provider of the up- and downlink service. In addition, Service 2 does not have to be installed at each individual Met Provider, but is only located at the provider of the up- and downlink services. This approach increases bandwidth efficiency and eliminates the need for synchronization of aircraft originated data among various Met service providers.

The following graphic illustrates the service option 2, again with the DLR system Cb-global as example weather hazard information.

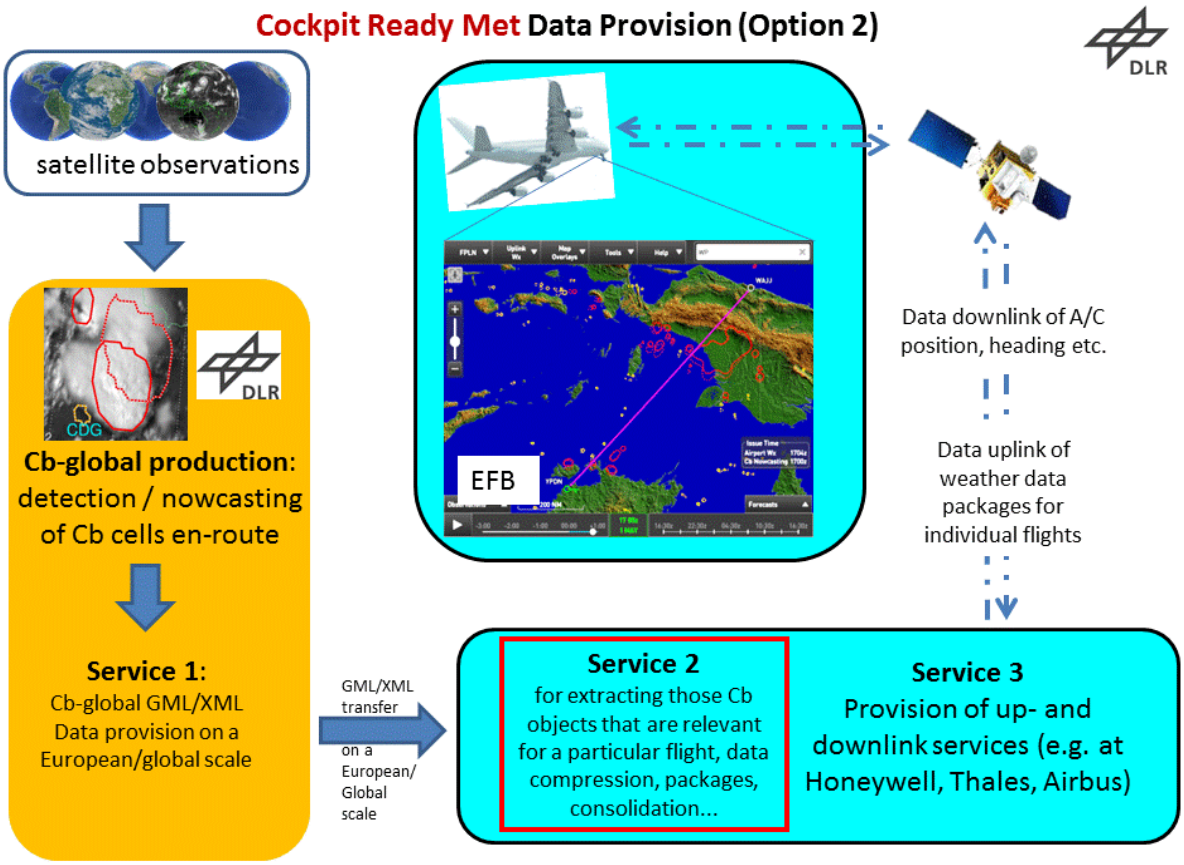

Figure 17:Illustration of service option 2 with DLR Cb-global as example weather hazard information

D.3 DLR's MET service on Contrail formation

This section provides in detail the TRL4 activity on Contrail formation. This activity was performed in the domain 'MET information generation for climate-optimised routing'.

This activity deals with establishment of advanced MET-service which enables climate impact assessment and optimisation of aircraft trajectories. The activity includes definition and provision of prototypic advanced MET data and formulation of an expanded objective function.

The concept developed relied on the usage of the MET interface in order to pass on information relating to climate impact of aviation emissions. Such information is required during the flight planning process as a requisite for enabling an environmental performance assessment during trajectory optimisation, as proposed within Wave 1 Exploratory Research project (2016-2018). From this overall concept, PJ18-04b reuses the approach on how to establish an interface between air traffic management and the environmental and climate impact of aircraft operations. Hence, within PJ18-04b, the same approach is applied by using the MET interface for providing information, which is relevant for environmental performance of operations.

The MET data provided are functions which enable to provide a direct link between aviation emission and associated climate impact, relying on standard climate change metrics. Such climate change metrics result from an associated impact on radiative balance in the atmosphere. Typical units are taken from international initiatives on climate change, e.g. average temperature response, or a global warming potential. MET service on climate impact is a prerequisite for establishing quantitative performance data for the key area environment. Is it intended that MET data will be provided via MET-GATE.

A user requiring assessing overall climate impact of aircraft operations uses that metric in order to translate aircraft emission to its associated climate impact, using standardized metrics, e.g. as also required from regulatory side. Here MET service also needs to enable metrics similar to a carbon dioxide equivalent emission, which allows direct translation to units used in current emission trading schemes. MET service climate change function enables the functional blocks to get a clear vision of the situation with regards to climate impact of aviation emissions and regions with low sensitivity which are favourable when user aims to mitigate climate impact of aviation.

Relevant Use Cases

For the MET service for generation of climate-optimized trajectories the relevant use cases are “Environmental assessment of aircraft trajectories” and “Climate-optimisation of aircraft trajectories” is the user requesting to provide performance data on key area environment. The technical system, or more generally speaking, the MET data available in an adequate technical system allows to calculate from the actual aircraft performance data during flight planning, directly the associated climate impact. Such information is key both when assessing or when optimising aircraft trajectories.

In the earlier case, climate assessment, data will be calculated in order to enable to calculate e.g. the overall climate impact of a business trajectory, for that specific day, under those specific meteorological conditions. In the latter case, climate optimisation, the calculation will be used as input to an optimisation routine, in order to provide an optimal solution, satisfying the overall objective function, which will is expected to be a combination of weighting from economic impacts and environmental impacts. Relevant use case descriptions are a result from expertise of DLR/AT-One, from earlier activities on e.g. climate-optimisation of aircraft trajectories. Hence, MET service for climate-optimized trajectories is required for a climate impact assessment and for climate-optimisation of aircraft trajectories.

Applicable standards and regulations

The plan for carbon-neutral growth from 2020 adopted by ICAO in 2016 – known as CORSIA –can be used as a reference for emission and associated impact assessment and offsetting.

Aviation currently accounts for some 2% of global CO2 emissions, with further increase projected for the coming decades. Domestic aviation has been subject to emission trading in Europe for some five years now. In addition, IATA, the industry's leading association, announced in 2009 a set of three sequential goals for air transport: (1) a 1.5 % average annual improvement of fuel efficiency from 2009 to 2020, (2) carbon neutral growth from 2020 onwards and (3) a 50% absolute reduction in carbon emissions by 2050. To further these initiatives, the International Civil Aviation Organization adopted in October 2016 a global market based measure to help achieve carbon neutral growth, known as the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

CORSIA provides a framework for offsetting emissions from flights between participating countries above the 2020 baseline. In its first phase from 2021–2026, participation in the scheme will be voluntary, but the most important countries have already indicated their intention to engage. From 2027 onwards, participation will be mandatory for most countries. At the same time evaluation of representing climate impact correctly is going on, as it is known that beside carbon related climate impact of aviation, non-CO2 impact amount for the same order of magnitude of climate impact (e.g. IPCC, 2010). To respond to this need from standardisation and regulation, a MET service is required which enables calculation of overall climate impact.

D.3.1 MET Information service on contrail formation and contrail persistency (DLR)

The DLR MET service provides information on formation of contrails and on their persistence establishing an initial step towards assessment and optimisation of aviation's climate impact at a specific aircraft position. Aviation is contributing to climate change by emissions of CO_2, nitrogen oxides (NO_x) impacting ozone and methane in the atmosphere, formation of contrail and contrail cirrus, as well as particulate matter and by aviation induced changes to cloudiness, hence by its CO_2 and non-CO_2 effects. This activity represents an initial step towards enabling an assessment of aviation non-CO_2 effects along aircraft trajectories flown. Within task PJ18-04b-CC3.3 a MET service on contrail formation has been developed which informs whether (1) at a specific position (and time) a contrail is formed, and whether (2) this contrail is persistent.

Both criteria on contrail formation can be calculated with an algorithm relying on a set of atmospheric parameters and aircraft engine characteristics. Meteorological parameters comprise pressure, temperature, and relative humidity.

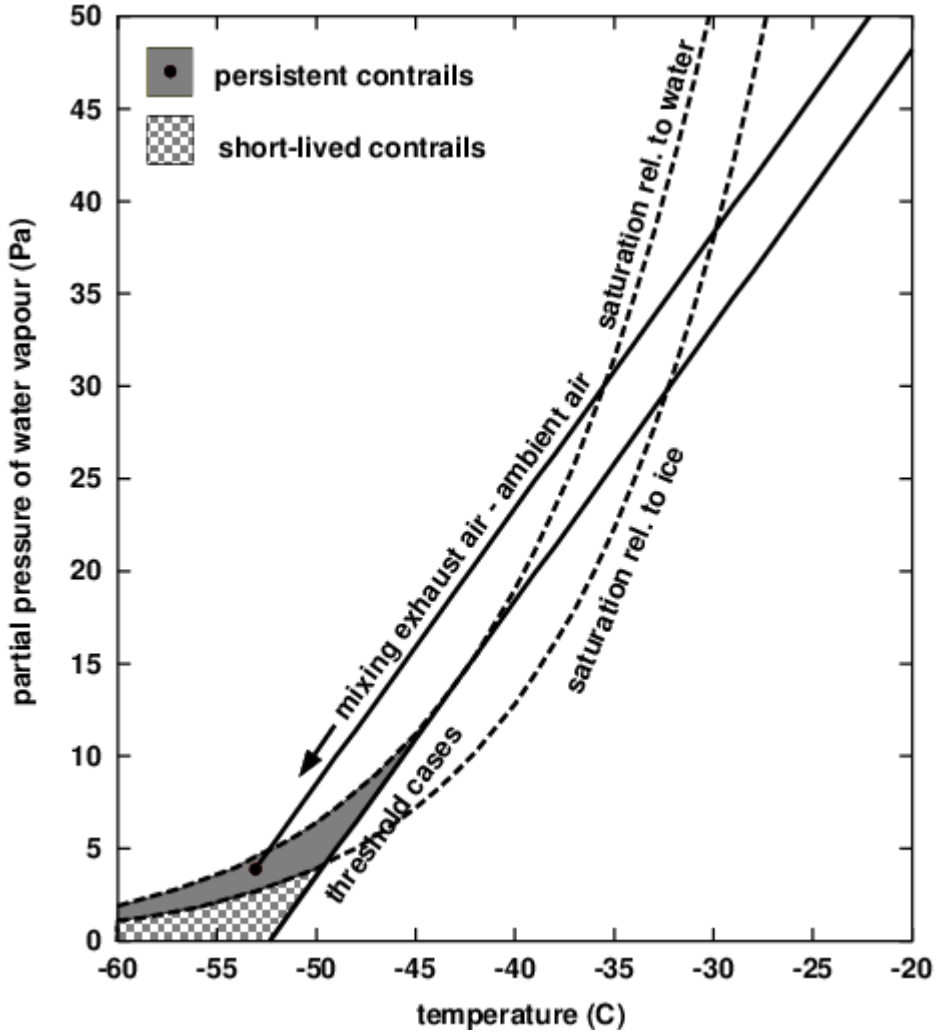

Figure 18: Schmidt-Appleman diagram explaining thermodynamic contrail formation and contrail persistence showing individual mixing lines.

Figure 18 shows the so-called Schmidt-Appleman diagram which explains the thermodynamic contrail formation criterion as well as the persistence criterion. The straight lines present two sets of thermodynamic properties of exhaust air while it is mixed with ambient air (mixing lines). These mixing lines begin at high temperatures (directly after the engine) and end somewhere in the lower left corner of the diagram at a point that represents the temperature and water vapour partial pressure of the ambient air. Whether a contrail is formed or not depends on the location of the mixing lines end point (atmospheric conditions) and on the slope of the mixing line (fuel and engine properties). In the figure, a mixing line endpoint in the chequered area implies that a short-living contrail is formed. As short-lived contrails evaporate quickly after formation, such contrails are unimportant from a climate impact point of view. A mixing line endpoint in the solid grey area implies that a persistent contrail is formed. The area above the curve labelled “saturation rel. to ice” is the domain of ice supersaturation which is required for contrail persistence. Contrails are not formed if the mixing line ends right of the line labelled “threshold cases”.

Thus, the calculation needs, apart from the technical data, in detail,

1) fuel lower heating value (energy content of the fuel per unit mass)
2) overall propulsion efficiency

also thermodynamic data that describe the state of the ambient air, in detail,

1) atmospheric (ambient) temperature
2) relative humidity (with respect to liquid water or ice)
3) air pressure.

From the atmospheric temperature we compute, respectively,

1) water saturation pressure rel. to liquid water
2) water saturation pressure rel. to ice

From relative humidity, pressure and the saturation pressures we compute the water vapour partial pressure, and we know whether the relative humidity with respect to ice exceeds 100% or not.

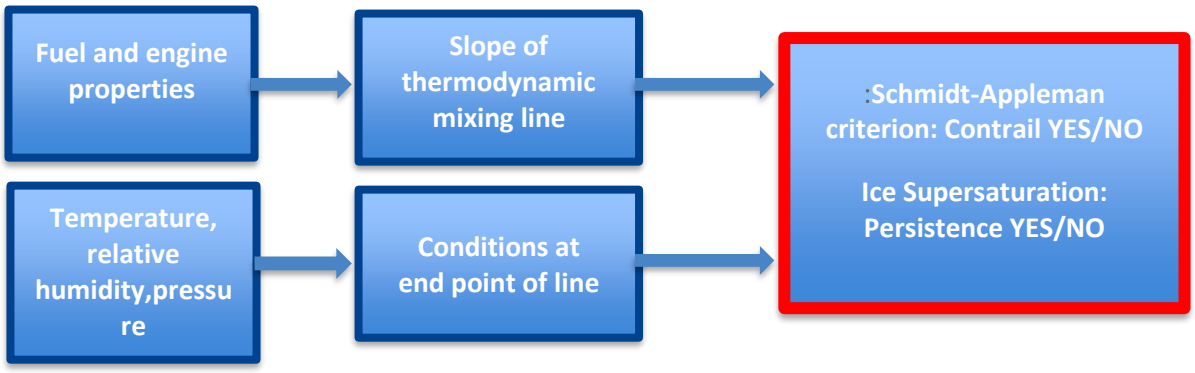

Figure 19: Flow chart describing how input data is used in algorithm in order to calculate criteria on contrail formation and contrail persistence.

Applying this algorithm along an aircraft trajectory by using above mentioned meteorological data, originating either from aircraft sensors or meteorological forecast (and hindcast) data, following the flow chart (Figure 19) enables to compute both the formation condition of contrails as well as the persistence condition.

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