Nationaal Lucht- en Ruimtevaartlaboratorium

National Aerospace Laboratory NLR

Executive summary

Applications of SWIM

Final report

Problem area

This document describes the final results of the "KDC Applications of SWIM" project as executed by NLR for KDC from December 2014 to September 2015. It is the result of a literature study of SWIM and iSWIM and the PCP. In addition various interviews with stakeholders have taken place to determine the implications iSWIM has on current systems and future plans. The result is an overview of the aspects iSWIM (as required by the PCP), an overview of the impacted systems and planned activities of the Dutch stakeholders. The implications of iSWIM on the existing systems and planned activities are described together with an identification of opportunities that emerge because of the introduction of iSWIM.

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Summary

This document describes the final results of the "KDC Applications of SWIM" project as executed by NLR for KDC from December 2014 to September 2015. It is the result of a literature study of SESAR results of SWIM and iSWIM, the SESAR deployment plan and the PCP. In addition various interviews with Dutch stakeholders have taken place to determine the implications iSWIM has on current systems and future plans. The result is an overview of SWIM, and overview of the impacted systems and mandatory activities related to the PCP for the Dutch sector. In addition opportunities related to the introduction of iSWIM are identified and translated to recommendations to the Dutch stakeholders.

Contents

1 Introduction

The SESAR programme, started in 2004, aims to modernize the air traffic management system in Europe. The key objectives of SESAR are to restructure European airspace, to create additional capacity and to increase efficiency. The implementation of SESAR is guided by EU implementing regulations. As the implementing regulations affect several key stakeholders of the Dutch sector, it is important to have a proper overview of the impact of the regulation on the Dutch sector. This study focusses on one aspect of the regulation, namely the foundation on which all other technologies are built: the information exchange network called System Wide Information Management (SWIM).

This document is the final result of the KDC study “Applications of SWIM” which provides an overview of the regulation, a description of SWIM, the impact of the regulation on the Dutch sector and identifies opportunities taking into account current and future developments with the Dutch stakeholders.

1.1 SESAR

SESAR is the research dimension of the Single European Sky (SES). It is now often referred to as SESAR 1 as it is superseded by SESAR 2020. SESAR is composed of three phases: definition, development and deployment. As SESAR has now reached deployment phase, future research is conducted in the successor of SESAR called SESAR 2020. The proposed SESAR solutions (the results from the development phase) rest on 6 pillars aimed to make the ATM system more efficient, safer and with a decreased environmental impact. The pillars comprise of the following solutions:

- Moving from airspace to 4D trajectory management: *“the systematic sharing of aircraft trajectories between various participants in the ATM process to ensure that all partners have a common view of a flight and have access to the most up-to-date data available to perform their tasks.”*
- Traffic synchronization: *“all aspects related to improving arrival/departure management. It aims to achieve an optimum traffic sequence resulting in significantly less need for air traffic control (ATC) tactical intervention, and the optimisation of climbing and descending traffic profiles.”*
- Network collaborative management and dynamic/capacity balancing: *“successive phases of operation planning from long to medium and short term. All involved ATM stakeholders progressively share more and more precise data to build a common traffic and operational environment picture called the Network Operations Plan (NOP). This NOP is updated in real time to reflect any changes in ATM operations.”*

- Airport integration and throughput: *"achieving a full integration of airports into the ATM network, ensuring a seamless process through Collaborative Decision Making."*
- Conflict management and automation: *"substantially reducing controller task load per flight through a significant enhancement of integrated automation support, whilst simultaneously meeting the safety and environmental goals of SESAR."*
- System wide information management (SWIM): *"a complete change in paradigm of how information is managed along its full lifecycle, involving stakeholders from across the whole European ATM network."*

SWIM is a prerequisite for many of the other pillars by providing the right information at the right time and right place. SWIM is a broad term covering a large part of the information management that is used in the ATM process. SESAR describes SWIM to: *"...enable the Air Navigation Service Providers (ANSP), airports, airlines, and air defence operators to intensify their cooperation to an unprecedented level, scope, and detail."*

1.2 Pilot Common Projects

To ensure proper and timely uptake of SESAR results with the stakeholders, the European Commission has created two implementing regulations.

1. The EU Implementing regulation 409/2013 [1] has been created to deploy in a timely, coordinated and synchronised way ATM functionalities that will achieve the essential operational changes as defined in the SESAR project. The regulation defines the common projects, the establishment of governance and the identification of incentives supporting the implementation of the European Air Traffic Management Master Plan.
2. Further, the EU implementing regulation 716/204 [2] defines the establishment of the *first* common project, referred to as Pilot Common Project (PCP) that identifies 6 ATM functions (in line with the 6 solutions) that should be implemented at relevant stakeholders before 2025. The establishment of initial SWIM (iSWIM) is one of them. iSWIM can be seen as a version of SWIM with initial functionality that can be implemented within the timeframe.

Although the adoption of the implementing regulation was the direct motive to conduct the study, other important motives can be found by looking at trends in information technology such as big data, clouds, security and automation in data collection and analysis. These have the potential to impact information management in ATM as well. Some initial developments have already started and examples include Collaborative Decision Making (CDM), the increasing availability of digital information (e.g., weather) and increased use of data exchange between ANSP's (e.g., the LVNL-MUAC AMA message). As SWIM can be seen as a major enabler for further developments in this area, for the Dutch sector, it is recommendable that the development of SWIM concepts is closely monitored such that timely action can be taken if necessary.

Developments in the data sharing area are expected while a fully functioning European wide SWIM network is not expected before 2025. The need for data exchange among Dutch stakeholders is expected to increase in the time period before 2025. Dutch developments will therefore partially take place in parallel with the finalization of SWIM. It is important that future data management developments are aligned with SWIM to prevent inefficiencies and doing work twice. Knowledge of the current status of SWIM, its expected developments and the pros and cons of specific parts of SWIM will decrease the probability of such misalignment. A good overview of SWIM and its expected developments will enable the creation of a roadmap and the definition of next steps for data management in the Dutch sector.

This study addresses several aspects each contributing to the above goals. Identification of the *opportunities and possibilities* that SWIM brings, with a specific attention for the Dutch sector, will enable the sector to determine focus. A description of the information flows within a SWIM network provides insight in the general picture of SWIM. An overview of the necessary infrastructure and some initial ideas about how to connect legacy systems to SWIM can be used for some first rough cost estimates. Having a proper overview of SWIM provides the opportunity to identify opportunities and assess the risks surrounding the introduction of SWIM and sharing data.

1.3 Scope, Assumptions & Prerequisites

The study addresses iSWIM, its expected developments and its implications in a broad sense. The study provides a broad overview with specific attention to implications and opportunities for the Dutch sector. To ensure the team aligns properly with stakeholder interests, the team has talked with strategy managers at LVNL, KLM and AAS.

The scope of the study is in the first place defined by the current status of SWIM and the current status of the (legacy) systems of the Dutch sector. Nevertheless, some judgements were made about the expected further development and deployment of both SWIM and legacy systems. To address the subject of connection to legacy systems, several meetings were organized with system experts of the various stakeholders.

The study will not describe detailed technical architectures but will provide clear directions for implementation including identification of relevant technologies and protocols taking into account Dutch sector needs, both functional and non-functional requirements.

1.4 Project activities

To accomplish the aforementioned goal, the NLR team has conducted several activities that can be divided in three main steps: information collection, consultation and evaluation (see Figure 1).

The *information* step consisted of a study of relevant documentation and the consultation of (external) SWIM experts. In the *consultation* step, strategy experts and systems experts of the Dutch stakeholders were interviewed. The information and consultation results together formed the basis for the *evaluation* to draw conclusions.

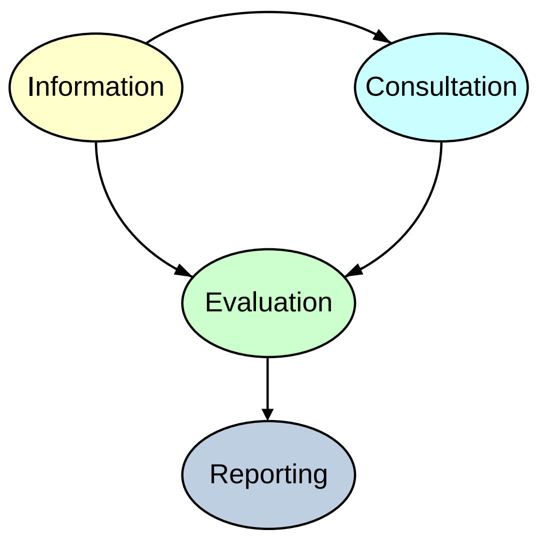

Figure 1: High-level overview of the approach to the study.

In order to create a proper overview of current system capabilities and to identify architectural opportunities and drawbacks in the deployment of the SWIM technology, several meetings with architectural experts of existing systems of the Dutch stakeholders have been organized. The table below provides an overview of those meetings.

Date	Stakeholder	External participants
25-03-2015	LVNL	Paul de Kraker Ron Slootbeek
10-04-2015	AAS	Erik Derogee
22-04-2015	AAS	Frans Duivenvoorde Eric van Leeuwen
11-08-2015	KLM	Ceriel Janssen Martin Dijkzeul Caroline Koenderinck-Bok

2 SWIM overview

This chapter provides an overview of (i)SWIM and the standards and technologies it uses.

2.1 What is SWIM?

Within the scope of SESAR, SWIM can be characterised as a set of data, services and protocol definitions and the technical infrastructure for the secure *exchange of data* between stakeholders in ATM. This includes Airport Operations Plans (AOP) and Network Operations Plans (NOP). An AOP can be characterised as a local airport information system with airport (airside) operations and planning information. An NOP can be characterised as a central information system with network (flight/ATM) operations and planning information. Industries like Indra, Frequentis, Selex and Thales are currently involved in the development of SWIM, AOP, NOP and communication tools and technical infrastructure within the SESAR programme and under supervision of the SESAR Joint Undertaking (SJU) and Eurocontrol.
SWIM is the enabler for most of the technical solutions that SESAR has developed and that are currently moving towards implementation. The initial idea of SWIM goes back to the 90s when Eurocontrol presented the idea to the FAA. In 2005 ICAO adopted the idea which now forms a central pillar in both SESAR and NextGen. The main goals of SWIM are to advance the development of the ATM system by promoting data exchange through:

- cheaper design;
- easier adoption;
- re-use of information;
- enabling innovation.

SWIM aims to minimize impact to legacy systems when connecting to SWIM by adopting the Service Oriented Architecture (SOA) approach. Within this approach, applications provide services to other applications via a common communication protocol.
Relevant examples of legacy systems in the Dutch sector include the AAA system of LVNL, the (new) CCIS system of LVNL, the CISS system of AAS and the FIRDA system of KLM. For these systems/companies it is of vital importance to anticipate the introduction and the further development of the SWIM technology. An overview of the layered structure of SWIM is depicted in Figure 2.

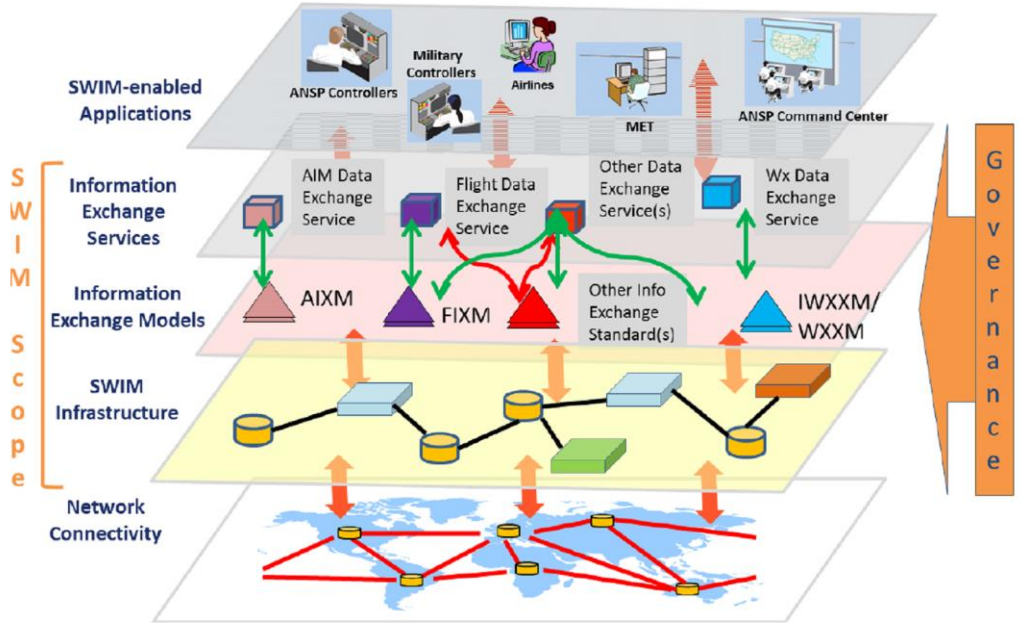

Figure 2: Overview of SWIM and its components.

The SWIM layers consist of the following:

- **Network Connectivity:** The bottom layer of SWIM is formed by the internet/VPN network. It consists of the regular internet network upon which several dedicated Virtual Private Networks (VPN) are deployed. In Europe, the Pan European Network Service (PENS) network or the public internet forms the backbone of SWIM (see Section 2.3).
- **SWIM Infrastructure:** The second layer of SWIM is formed by the SWIM infrastructure. This consists of centralised databases for data and service registration purposes and centralised facilities for entity identification, entity authentication, and SWIM/PENS management purposes.
- **Information Exchange Models:** The third layer of SWIM is formed by the SWIM data exchange models (see Sections 2.2.2, 2.2.3 and 2.2.4) and the SWIM data reference model (see Section 2.2.5). All data exchanged over SWIM is defined in these models to standardise the data structures and their interpretations as much as possible. Modern UML and XML based language technologies are used for this.
- **Information Exchange Services:** The fourth layer of SWIM is formed by the SWIM service reference model (see Section 2.2.6). With these services the data of the third layer can be provided and accessed easily. All services offered over the SWIM system are defined in this model to standardise the service profiles and their interpretations as

much as possible. Modern internet based protocol and service technologies are used for this.

- **SWIM-enabled Applications:** The top layer of SWIM is formed by the SWIM enabled applications of the stakeholders. This can be adapted legacy systems as well as new systems and applications that may offer new services to their users. These are the applications that the stakeholders use/develop as the result of the mandatory activities (Chapter 5) and the opportunities (Chapter 6).

The potential impact of SWIM on the ATM system is large but SWIM also provides many opportunities for innovation. It is therefore important to have the Dutch sector properly aligned with the development of SWIM in order to be prepared. This alignment includes provision of current status, expected development, regulation and timeline.

The maturing of SESAR concepts and SWIM in particular is shown by the recent adoption by the European Commission of a regulation for the implementation of the Pilot Common Project [2] which consists of the first set of ATM functionalities that were developed within SESAR. The aim is to ensure these functionalities are "*deployed in a timely, coordinated and synchronised way.*" The adoption shows once more that information exchange within ATM is becoming increasingly important in the years to come.

2.1.1 SWIM versus iSWIM

The implementation of iSWIM can be seen as the necessary foundation for full SWIM that can be implemented within the foreseen timeframe. It is an essential infrastructure to support information exchanges that are built on standards and delivered through a network by SWIM enabled systems. One distinct difference is the fact that the aircraft is not in the loop in iSWIM. Therefore the purple data exchange profile is not part of iSWIM, only the blue and yellow profiles are used (see next section for more information about the profiles). The main focus of iSWIM is on the exchange of aeronautical, meteorological and flight & network information services.

2.2 SWIM data exchange standards

Within the SESAR1 programme, several work packages have developed technical enablers for (i)SWIM. The foundations of those are formed by the data models that enable data exchange. These enablers and the exchange processes are detailed in this section.

2.2.1 Introduction

Within the European SESAR1/SESAR2020 programmes SWIM consists of the following reference models:

- ATM Information Reference Model (AIRM);
- Information Service Reference Model (ISRM).

In addition, within the international ICAO organisation SWIM consists of the following data exchange models:

- Aeronautical Information Exchange Model (AIXM);
- Flight Information Exchange Model (FIXM);
- Weather Information Exchange Model (WXXM).

The AIRM is a common reference that ensures proper interoperability on the *logical* level. It ensures semantic interoperability that ensures the precise meaning of exchanged information is preserved and understood by all parties. Semantic interoperability ensures that:

- The meaning of exchanged information is unambiguously understood by all interoperating parties, including parties in different ICAO regions.
- The meaning of exchanged information is not lost or altered as it travels through the end-to-end data chain (from the point of origin to the point of destination).

In contrast, AIXM, WXXM and FIXM ensure proper interoperability on a *technical* level. These models provide the XML based data structures for a subset of the AIRM that ensure that technical systems of stakeholders are able to exchange information.

The ISRM model is built on top of the AIRM model. It provides services to *access* to the AIRM information and services to *control* this access. These services are grouped into the following categories:

- Common services to control the access;
- Yellow profile services for flexible/affordable ground/ground data communications;
- Blue profile services for fast/secure/reliable ground/ground data communications;
- Purple profile services for air/ground data communications;
- Green profile services for civil/military ground/ground data communications.

Some common services, the purple profile services and the green profile services are still subject of R&D within the SESAR2020 programme.

The AIRM and ISRM models are supported by an access-restricted internet-based network using the TCP/IP protocol family. Within Europe this is the Pan-European Network Services

(PENS) network or any of its future follow ups. It is expected that it will gradually replace all existing European aeronautical data networks. Figure 3 provides an overview of the models.

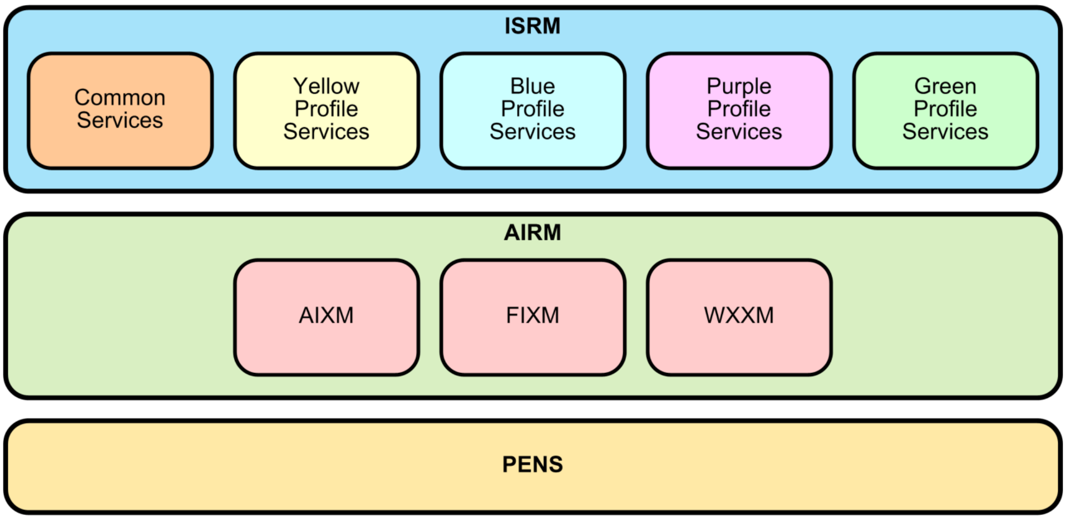

Figure 3: SWIM model layers. Note that information exchanged using the yellow profile can also be exchanged using the public internet instead of PENS.

The models are supported by an increasing number of ANSP's. Currently these include:

- Airservices Australia;
- Air Traffic Management Bureau (ATMB; China);
- Civil Aviation Authority of Singapore (CAAS);
- Direction des Services de la Navigation Aérienne (DSNA; France);
- European Organisation for the Safety of Air Navigation (Eurocontrol; Europe);
- Federal Aviation Administration (FAA; USA);
- Japan Civil Aviation Bureau (JCAB);
- National Air Traffic Services (NATS; UK);
- NAV Canada.

Other ANSP's including meteorological service providers are following.

The SWIM models are based on modern publicly available standard information technologies. In principle, no new dedicated information technology will be developed for SWIM. Amongst others, the following technologies are used:

- Protocols:
  - Advanced Message Queuing Protocol (AMQP);
  - Hypertext Transfer Protocol (HTTP);
  - Real Time Publish/Subscribe (RTPS) protocol;
  - Simple Object Access Protocol (SOAP);

- Services:
  - Data Distribution Service (DDS);
  - Web Service (WS);
- Languages:
  - Extensible Mark-up Language (XML);
  - Geography Mark-up Language (GML);
  - Unified Modelling Language (UML);
  - XML Schema Definition (XSD).

In principle, the data and services offered by the providers on the SWIM/PENS network are not available to the general public. Users/stakeholders (i.e., entities in the SWIM terminology) must be granted access to the SWIM/PENS network in general and must be granted access to the data and services of the specific providers. This can be done on a personal basis, but also on a company, department, group or system basis. Basically, there is no difference with the current day practices although in SWIM there will be standard facilities for local and federated access: entity identification and entity authentication. The charging of the access and use of data and services is not part of SWIM. It is expected that if charging is necessary the current day practices will be applied.

The data access itself is modelled in several service protocols implementing the following so-called message exchange patterns:

- Publish/subscribe: A provider publishes his data when available and the subscribers will receive this data subsequently.
- Request/reply: A user issues a data request to a provider and the provider will answer with a data reply.
- Provide/acknowledge: A provider sends his data when available and the receiver will acknowledge the reception of this data.

These patterns have various variants, characteristics and levels of service.

2.2.2 The FIXM Model

The FIXM data exchange model consists of all kinds of digital flight and flow data:

- Air Traffic Services (ATS) data;
- ANSP boundary crossing data;
- EUROCAE Document ED-133 data;
- Fleet prioritisation data;
- Flight CDM and A-CDM data;

- Flight plan data;
- Flight route data;
- Flight trajectory data;
- Globally Unique Flight Identifier (GUFI) data.

The FIXM model is developed by Eurocontrol and FAA in coordination with organisations like Airservices Australia, DSNA, IATA, ICAO, JCAB, NATS and NAV Canada. It complies with the applicable ICAO standards and will become an ICAO Standard and Recommended Practice (SARP) in 2016.

The current version of the FIXM model is Core v3.0.1 of February 2015. There are separate FAA and Eurocontrol A CDM extensions available. Eurocontrol and SJU are busy with the development of the next FIXM model Core v4.0 with flight trajectory extensions that will probably be released in February 2016.

Maturity of technology can be expressed using the so-called TRL (Technology Readiness Level) scale. Appendix B provides a description of the 9 TRL levels. The maturity of the FIXM model is estimated to be on TRL-6 level (technology demonstrated in an industrial relevant environment) or TRL-7 level (system prototype demonstrated in an operational environment) in 2015. There are various commercial FIXM compliant products available. Several ANSP's are busy with the deployment of the FIXM model into their systems and practices.

Note that FIXM is **not** the same as the *Flight Object*. The Flight Object is more than a data model. It is the concept of a single common source of flight data to be used as a common reference, and its implementation involves defining an architecture of Flight Object Servers, requirements for how those servers must interact, plus the definitions of a set of services to be offered, and the payload they carry. FIXM is a data format, and as such is much narrower in scope than the concept of the Flight Object. ICAO Doc 9965 provides a vision *"specifically for flight information that relies on SWIM as a mechanism for exchange of flight information while managing the consistency and timeliness of the information"*. Several SESAR projects have dealt with the flight object, most distinctively project 13.2. EUROCONTROL states that the Flight Object *"is a concept to support the sharing of consistent flight data between all stakeholders. Its purpose is to ensure that all systems have a consistent view of the flight and that the data is widely and easily available, subject to appropriate access controls"*.
The Flight Object is therefore not a fixed definition, but rather a concept in which flight data is shared in a consistent way, using a prescribed data format (i.e. FIXM). The PCP describes various operations on the Flight Object that should be implemented.

2.2.3 The AIXM Model

The AIXM data exchange model consists of all kinds of digital Aeronautical Information Service (AIS) data:

- Aerodrome Mapping Database (AMDB) data;
- Aeronautical Information Publication (AIP) data;
- Electronic Flight Bag (EFB) data;
- Notice to Airmen (NOTAM) data.

The AIXM model is developed by Eurocontrol and FAA in coordination with organisations like ACI, ARINC, CANSO, EUROCAE, IATA, ICAO, NATO and RTCA. It complies with the applicable ICAO standards and is an ICAO Standard and Recommended Practice (SARP) for Aeronautical Information Management (AIM) systems.

The current version of the AIXM model is v5.1 of February 2010. A new version is not foreseen.

The maturity of the AIXM model is estimated to be on TRL-6 level (technology demonstrated in an industrial relevant environment) or TRL-7 level (system prototype demonstrated in an operational environment) in 2015. There are various commercial AIXM compliant products available. Several ANSP's are busy with the deployment of the AIXM model into their systems and practices.

2.2.4 The WXXM Model

The WXXM data exchange model consists of all kinds of digital meteorological data:

- Airmen's Meteorological Information (AIRMET) data;
- Gridded meteorological data;
- Meteorological Aerodrome Report (METAR) data;
- Significant Meteorological Information (SIGMET) data;
- Special METAR (SPECI) data;
- Terminal Aerodrome Forecast (TAF) data;
- Volcanic Ash Advisory (VAA) data.

The WXXM model is developed by Eurocontrol and FAA in coordination with organisations like ARINC, EUROCAE, ICAO, OGC, RTCA and WMO. It is an ICAO Standard and Recommended Practice (SARP) for meteorological information.

The current version of the WXXM model is v2.0 of March 2015.

The maturity of the WXXM model is estimated to be on TRL-6 level (technology demonstrated in an industrial relevant environment) or TRL-7 level (system prototype demonstrated in an operational environment) in 2015. There are commercial WXXM compliant products available. Several meteorological service providers are busy with the deployment of the WXXM model into their systems and practices.

2.2.5 The AIRM Model

The comprehensive AIRM data reference model is based on the AIXM, FIXM and WXXM data exchange models and consists of all kinds of digital ATM data:

- Aircraft data
- Airspace data: Airspace volumes and infrastructure
- Air traffic operations data
- Base infrastructure data: Identity, location, description and configuration of physical facilities, systems, terrain and obstacles
- Common data: ATM specific topics
- Environment data: Environmental impact and measures
- Flight data
- Meteorological data: Meteorological observations, reports, analyses and forecasts
- Surveillance data: Flight position, vector, identity and path intent
- Stakeholder data

The AIRM model is developed within the SESAR1 programme by various European ANSP's and aerospace industries under supervision of SJU and Eurocontrol. The requirements for the AIRM model stem from the various SESAR1 work package projects and concepts. Partial implementations of the AIRM model are used in the validation exercises of the various SESAR1 work package projects and concepts in conjunction with partial implementations of the ISRM model.

The current version of the AIRM model is v3.2.0 of September 2014. New improved and extended versions may be expected within the SESAR1 programme (up to 2016) but are certainly expected within the SESAR2020 programme (2016-2021).

The maturity of the AIRM model is estimated (assumed by SJU) to be up to TRL-6 level (technology demonstrated in an industrial relevant environment) in 2015. But this does not account for the complete AIRM model. There are no commercial AIRM compliant products available yet. But the aforementioned aerospace industries are developing prototypes within the SESAR1 programme. The future deployment of the AIRM model by the ANSP's in Europe will be supervised by the SESAR Deployment Manager (SDM).

2.2.6 The ISRM Model

The comprehensive ISRM service reference model consists of the following services:

- Common services to control the access:
    - Registry services to publish and discover data and services;
    - Public Key Infrastructure (PKI) services for signing, issuing and maintaining certificates for entity (i.e., user) identification, entity authentication and data encryption.
    - Bridge Certification Authority (BCA) services for interconnecting trust domains (i.e., organisations) via cross signed certificates for entity authentication;
- Yellow profile services for flexible/affordable ground/ground data communications:
    - Ground/ground data request/reply WS-based services;
    - Ground/ground data publish/subscribe WS-based services;
- Blue profile services for fast/secure/reliable ground/ground data communications:
    - Ground/ground data request/reply WS-based services;
    - Ground/ground data publish/subscribe DDS-based services;
- Purple profile services for air/ground data communications:
    - Air/ground data request/reply AMQP-based services;
    - Air/ground data publish/subscribe AMQP-based services;
- Green profile services for civil/military ground/ground data communications.

The following services are available:

- Airport management services (including Network Operations Plan (NOP) services);
- Airport CDM services;
- Trajectory management services;

- Network management services (including Airspace Management (ASM) services);
- Aeronautical information management services;
- Flight information management services;
- Meteorological information services;
- Shared information management services;
- Traffic sequencing services.

The ISRM model is developed within the SESAR1 programme by various European ANSP's and aerospace industries under supervision of SJU and Eurocontrol. The requirements for the ISRM model stem from the various SESAR1 work package projects and concepts. Partial implementations of the ISRM model are used in the validation exercises of the various SESAR1 work package projects and concepts in conjunction with partial implementations of the AIRM model.

The current version of the ISRM model is v1.2 of December 2014. New improved and extended versions may be expected within the SESAR1 programme (up to 2016) but are certainly expected within the SESAR2020 programme (2016-2021). Especially, some common services, the purple profile services and the green profile services are subject of R&D within the SESAR2020 programme.

The maturity of the ISRM model is estimated (assumed by SJU) to be up to TRL-6 level (technology demonstrated in an industrial relevant environment) in 2015. But this does not account for the complete ISRM model. There are no commercial ISRM compliant products available yet. But the aforementioned aerospace industries are developing prototypes within the SESAR1 programme. The future deployment of the ISRM model by the ANSP's in Europe will be supervised by SDM.

2.3 PENS

The Pan-European Network Services (PENS) is the network that has been selected to serve as the basis for the exchange of SWIM information with the blue profile. PENS is an IP-based network service that is able to service voice and data communication. PENS allows the exchange of aeronautical information in a seamless and integrated manner. It aims to significantly reduce the costly fragmented networks implemented using the legacy communication protocols (such as X.25) that are still widely used by the ANSP's.

PENS supports the key services provided by the Network Manager Operations Centre (NMOC) of Eurocontrol to various remote locations such as Flow Management Positions within ACC's, Aeronautical Information Services and Central data centres. The present services include the Flow Management Services, the European AIS Database (EAD) service and exchange of trajectory information through the ETFMS Entry Nodes and the AFTN / AMHS network.

PENS currently supports the following ANSP services between various Air Traffic Services Units (ATSUs)[1]:

- Flight Message Transfer Protocol (FMTP) - for the exchange of coordination and transfer messages (On-Line Data Exchange - OLDI);
- ATS Message Handling System (AMHS) - for the exchange of aeronautical information such as flight plans;
- Surveillance - for the exchange of radar data between ANSP's;
- Voice over IP (VoIP) - for voice communications between Air Control Centres (ACC's).

For SWIM, PENS will be used to exchange data with the blue profile services, that is, data that need a high security/reliability level. Exchange of yellow profile service data through PENS is optional. For this purpose, the public internet may be used as well.
In 2010, Eurocontrol signed a contract with SITA to launch the service. The contract is worth up to €50m for eight and a half years. Therefore the contract will end in 2018. After 2018 it is the intention that PENS will be superseded by future PENS (see Section 3.4 for details). Figure 4 provides an overview of current PENS users.

[1] PENS website: http://www.pens.aero/.

Figure 4: PENS users as of 2013.

2.4 NMOC

The Network Manager Operational Centre (NMOC) of Eurocontrol is the central coordinating entity in Europe for ATM purposes (formerly known as CFMU). It has connections with all European ANSP's and all major European airports in order to perform its network, flow and capacity management and coordination tasks. For this purpose NMOC has several messages, message exchange mechanisms, protocols and networks. NMOC will gradually transfer and extend all these facilities and operations to the SWIM/PENS technology. Some important messages for the Dutch sector are described below.

The Slot Allocation Messages (SAM) and the Slot Revision Messages (SRM) are important Air Traffic Flow and Capacity Management (ATFCM) messages for CDM purposes. The SAM and SRM messages are sent from NMOC to the Tower System (via the AAA system) of LVNL to keep them informed about the planning of the departure flight. The messages contain, amongst other parameters, the (new) Calculated Take-Off Time (CTOT) of departure flights. The SAM and SRM messages are sent in the ATS Data Exchange Presentation (ADEXP) format with the X400 protocol over TCP/IP.

The Departure Planning Information (DPI) messages and the Flight Update Messages (FUM) are important flight progress messages for CDM purposes. It is the intention (as of end of 2016) to send DPI messages from A-CDM to NMOC to keep them informed about departure flights. The DPI messages may contain parameters like Estimated Take-Off Time (ETOT), Target Take-Off Time (TTOT), Estimated Taxi-Out Time (EXOT), aircraft type, aircraft registration and Standard Instrument Departure (SID) route information. With this information the NMOC may re-compute the CTOT times of departure flights. The DPI messages are sent in the ADEXP format with the X400 protocol over TCP/IP.

The FUM messages are sent from NMOC to the Tower System (via the AAA system) of LVNL and the CISS system of AAS to keep them informed about arrival flights. The FUM messages may contain parameters like Estimated time at FIR entry point, Estimated Landing Time (ELDT), the Standard Arrival Route (STAR) Entry Point (SEP) or the Estimated Time Over (ETO) for the Initial Approach Fix (IAF). The FUM messages are sent in the ADEXP format with the X400 protocol over TCP/IP.

Eurocontrol has stated that the AFTN/X.25 network is outdated, complex and too costly to maintain. As a successor, ICAO has specified the ATS Message Handling System (AMHS). The AMHS is an integral part of the CNS/ATM concept, and it is associated to the Aeronautical Telecommunication Network (ATN) environment. PENS implementations have already been developed as well.

It is expected that all message services of NMOC will be upgraded to comply with the internet/VPN-based SWIM/PENS technologies using AMHS. This will be a gradual transition as not to disturb current operation. Eurocontrol states the following about the transition:

"During transition from AFTN/CIDIN to AMHS, messages will be exchanged seamlessly between users of all networks. The end-to-end communication path between a source and a destination may involve any combination of path segments within the three networks."

Some NMOC services are already available on the PENS network. Furthermore, it is expected that the definitions and formats of the ATFCM and flight progress messages will be upgraded to comply with the SWIM AIRM model.

Within the SESAR1 programme, validation exercises have been and will be executed for the dynamic Demand/Capacity Balancing (dDCB) concept. Within this concept Short-Term ATFCM Measures (STAM) are taken to balance the European ATC sector workloads. Measures such as small ground delays, flight level capping and small re-routings can reduce the traffic complexity, prevent overloads and congestions, and eventually improve the capacity and safety. As a result of the dDCB processes, STAM messages for individual flights are sent by NMOC to ANSP's and airlines to coordinate the taken short-term flow and capacity measures. KLM participated in the dDCB validation exercises. Also the STAM messages will become part of the SWIM AIRM model and will become available on the PENS network.

2.5 Eurocontrol Centralised Services

The Centralised Services (CS) aim to reduce fragmentation of the European ATM network by implementing several services for data handling on a central level instead of a national level. The expected benefits include reduced cost, improved performance and an improved level of interoperability. The development of centralised services is further expected to create a Europe-wide ATM market by tendering these services to consortia. The European Commission co-finances several feasibility studies and demonstrators. The CS programme is coordinated and aligned with the PCP and the deployment programme (see section 3.2).

The implementation of the CS is divided in two phases. Phase 1 (2014-2016) develops demonstrators and conducts feasibility studies. Phase 2 (from 2015) aims to operate the CS that passed phase 1.

3 Towards implementation

This chapter will describe how the EC adopted SWIM and implemented a regulation to ensure proper and timely implementation.

3.1 EU implementing regulation/PCP

In 2013, the European commission established the implementing regulation 409/2013 [1] on the definition of common projects, the establishment of governance and the identification of incentives supporting the implementation of the European Air Traffic Management Master Plan. This non-legislative act led to the implementing regulation 716/2014 on the establishment of the Pilot Common Project supporting the implementation of the European Air Traffic Management Master Plan [2]. This regulation is often referred to as *the* Pilot Common Project (PCP). The implementing regulation is an EU initiative to move forward the deployment of SESAR. The final standards are expected to be published in 2016 and beyond. The PCP comprises of six ATM functionalities that should be implemented throughout the European Union on 1 January 2015. The functionalities are:

1. *Extended arrival management and Performance Based Navigation (PBN) in the high density TMA* improves the precision of the approach trajectory and facilitates air traffic sequencing at an earlier stage. Extended AMAN supports the extension of the planning horizon to a minimum of 180-200 nautical miles. PBN covers the development and implementation of fuel efficient and/or environmental friendly procedures.
2. *Airport integration and throughput* facilities the provision of approach and aerodrome control services. It consists of several sub-functionalities.
3. *Flexible airspace management and free route* enable airspace users to fly as closely as possible to their preferred trajectory.
4. *Network collaborative management* improves the ATM network performance, capacity and flight efficiency through exchange, modification and management of trajectory information.
5. *Initial System Wide Information Management (iSWIM)* concerns the development of services for information exchange by ground-ground integration and aeronautical data management & sharing, which consists of a set of services that are delivered and consumed through an IP-based network by SWIM enabled systems, enabling significant benefits in terms of ANSP productivity. SWIM comprises of standards, infrastructure and governance.

6. *Initial Trajectory Information Sharing (i4D)* consists of the improved use of target times and trajectory information, including where available, the use of on-board 4D trajectory data by the ground ATC system and network manager.

This study focusses on the 5th improvement, the introduction of iSWIM. iSWIM is an enabler of many of the other improvements as it facilitates the information exchange for the ATM functionalities. The mandate identifies 6 building blocks that iSWIM comprises of, the first two ensure a proper information exchange through an IP-based network:

1. Common infrastructure components;
2. SWIM technical infrastructure (TI) and profile services.

The other four comprise of the actual exchange of:

3. Aeronautical information;
4. Meteorological information;
5. Cooperative network information;
6. Flight information.

The *common infrastructure components* comprises of the registry that is used for publication and discovery of information regarding service consumers and providers. Other components are the logical information model, the SWIM enabled services and information about business, technical and policy information. It also ensures a secure information transfer by implementing a Public Key Infrastructure (PKI).

The *SWIM Technical Infrastructure and Service Profiles* is based on existing standards and ensures a proper information exchange by defining different data exchange profile services (see Section 2.2 for more details).

The *Aeronautical Information Exchange* mandates the operational stakeholders to implement a set of services which support the exchange of aeronautical information. This information includes:

- Airspace Reservation/Restrictions;
- aerodrome mapping and airport maps;
- airspace usage;
- D-NOTAM's (digital NOTAM's);

Service implementations shall be compliant with the applicable version of Aeronautical Information Reference Model (AIRM), the AIRM Foundation Material and the Information Service Reference Model (ISRM) Foundation Material.

The *Meteorological Information Exchange* ensures proper exchange of:

- Weather information at airports for a small interval in the future;
- Volcanic ash mass;

- Information supporting Aerodrome, en-route, approach ATC and the network information management. The system capability should target a horizon between 20 minutes and 7 days.

The *Cooperative Network Information* exchange consists (among others) of the exchange of:

- actual airport capacity (based on actual weather);
- slots;
- restrictions;
- structure, use and availability of airspace.

Finally, the *Flight Information Exchange* request for information exchange and manipulation during the pre-tactical and tactical phases. These include various operations on the flight objects and the ability to share the information of the flight objects. In addition the following services should be implemented:

- validate flight plan and routes;
- exchange flight plans, 4D trajectories, performance data and flight status;
- flight lists;
- flight update messages.

The functionality listed above should lead to an operational iSWIM as of 1 January 2025. The geographical scope is the European Air Traffic Management Network (EATMN) and applies to the network manager and the ANSP's, airports, airspace users and MET providers.
Civil-military coordination is also part of the geographical scope. However, The Netherlands does not need to take action because of regulation 552/2004 [3] which defines civil-military coordination as: "*... the EATMN, its systems and their constituents shall support the timely sharing of correct and consistent information covering all phases of flight, between civil and military parties.*" According to the PCP, The Netherlands already complies with this regulation.

The implementing rule further emphasizes the importance of synchronization of (technical) activities among stakeholders. There are multiple service profiles defined for data exchange, the most important being the blue and yellow profiles. An important prerequisite is that high capacity centres shall be connected to the Pan-European Network Services (PENS) for exchange information with the blue profile. Information that is exchanged using the yellow profile can be either transferred using PENS or the public internet. More information about the profiles can be found Section 2.2.1.

3.2 SESAR Deployment Manager

The SESAR Deployment Manager (SDM) is the body, defined in EU regulation 409/2013, article 9 [1] that will develop and execute the Deployment Programme (DP), a project view strictly drawn from the Pilot Common Project (PCP) set by Commission Implementing Regulation (EU) No 716/2014 [2], as well as any subsequent Common Projects in future regulations. The DP provides a comprehensive and structured work plan of all activities necessary to implement technologies, procedures and best practices required to implement common projects. It organises these activities in implementation projects identifying the associated risks and mitigation actions, the geographical scope, the timeframe and the operational stakeholders responsible for carrying out the implementation projects. The DP will be submitted to the EC for approval first.

The SESAR deployment alliance has been appointed by the EC to fulfil the role of SDM. This alliance consists of:

- A6: 5 ANSP members and a group representing the COOPANS alliance;
- A4: 4 bodies representing the airlines (Air France-KLM, easyJet, IAG group and Lufthansa)
- SDAG airports: a group of 25 airports.

SDM is responsible for steering the Connecting Europe Facility (CEF) Transport calls through the DP. The CEF transport calls run from 2014 to 2020. The total budget from CEF earmarked for transport related projects is €26.2bn in this period[2]. From this budget approximately €3bn is available for SESAR implementation up to 2020. The first version of the DP has been delivered to the EC for approval and will be the specification for the next CEF Transport calls for proposal (expected end of 2015). These calls are managed by the Innovation and Networks Executive Agency (INEA) which is responsible for implementation of these calls. INEA can be seen as the successor of the Trans-European Transport Networks (TEN-T). The establishment of SESAR deployment phase structure is depicted in Figure 5. The detailed governance map is shown in Figure 6.

The first version of the DP has been submitted for approval to the EC on the 25th of June 2015. An update (version 1.1) is expected 30th September 2015 and version 2 is expected 30th of June 2016. Version 2 will target the INEA call for 2016 and will be preceded by a consultation period for stakeholders. The DP defines (just as the PCP) 6 different ATM Functionalities which are further divided into 20 sub-functionalities. These are turned into 44 families of implementation projects. The DP will be the main reference document for INEA to specify the

[2] http://www.icb-portal.eu/index.php/funding-financing

priorities in the successive calls for proposals for the Implementation Projects (IP) that will be launched from September 2015. In addition the 110 project submitted to INEA as part of the CEF Transport Call for Proposals in 2014 are also included in the project view of the DP. The DP further defines the activities that need to be performed for each of the 44 families of projects including an indication for timing. The families all have assigned a priority (either high, medium or low). The high and medium priority families are ready for implementation, the low priority families are not (yet). The urgency for implementation is higher for the high priority families because they are considered to be more on the critical path for PCP implementation and deliver earlier benefits. However, the PCP states that *each* of the 44 families needs to be fully implemented. The DP therefore prioritises families of projects on the basis of optimization, not on the basis of importance.

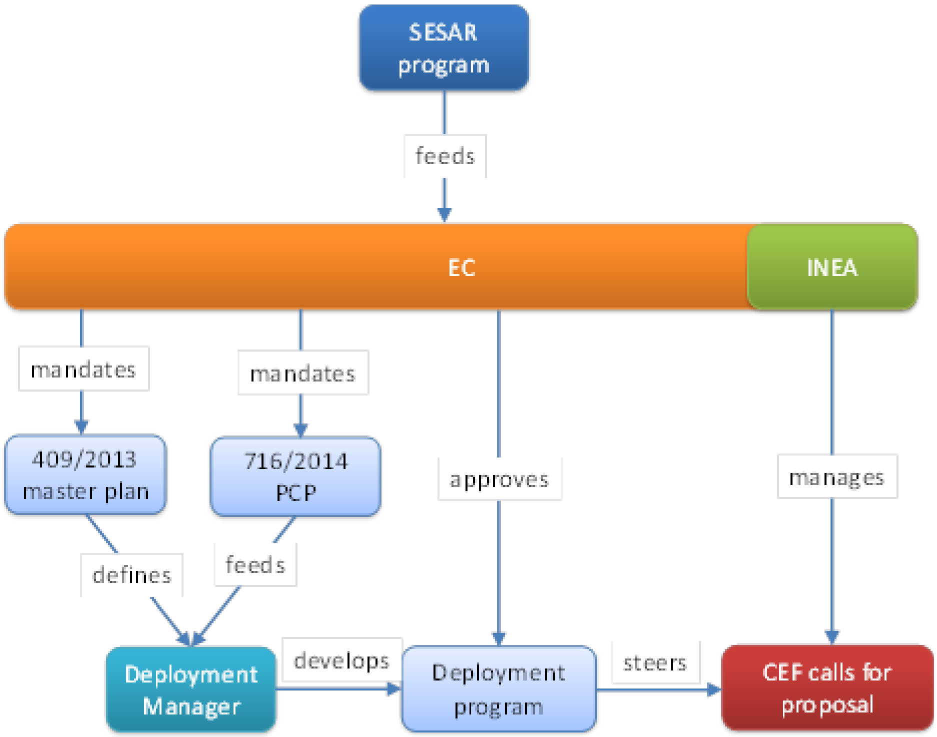

Figure 5: Overview of the establishment of SESAR deployment.

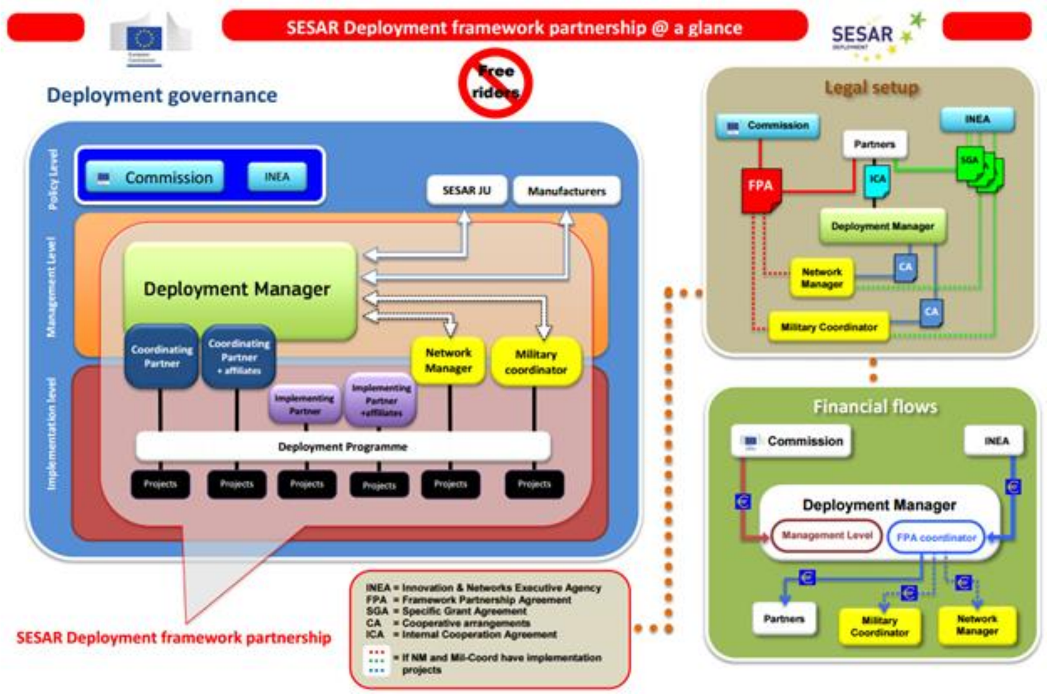

Figure 6: SESAR deployment governance structure.

3.3 Implementation details and roadmap

The implementing regulation for the PCP provides (in article 4) a list of references to related SESAR projects in which the implementation details can be found (supporting material article 4a).

Parts of the standardization process run in parallel with the implementing rule. For iSWIM the following standardisation procedures are on-going:

- Flight information exchange: the specification for the FIXM message format, including the flight object. The initial standard is expected in 2015; the final standard is expected in 2017.
- Meteorological information exchange: the WXXM standard has been delivered in 2014.
- Aeronautical information exchange: planned for 2015.
- Standards and specifications on the SWIM registry: planned for 2015.
- Standards and specifications on the SWIM profile definitions: planned for 2015.

3.4 SWIM project families and timeline

For SWIM, the DPv1 defines 6 ATM Functionalities (AF). These are further subdivided into 44 families of projects. One of those AFs is AF-5: Initial SWIM. Within AF-5 there are 6 sub AFs defined with the following project families:

Sub-AF 5.1: Common Infrastructure Components

- 5.1.1 PENS 1 (High priority family)
- 5.1.2 Future PENS (Medium priority family)
- 5.1.3 Common SWIM Infrastructure Components (PKI, registry, governance) (High priority family)

Sub-AF 5.2: SWIM Technical Infrastructure and Service Profiles

- 5.2.1 Stakeholders' compliance to IP (High priority family)
- 5.2.2 Stakeholders' SWIM Infrastructure components (Medium priority family)

Sub-AF 5.3: Aeronautical Information Exchange

- 5.3.1 Upgrade / Implement Aeronautical Information Exchange system/service (High priority family)

Sub-AF 5.4: Meteorological Information Exchange

- 5.4.1 Upgrade / Implement Meteorological Information Exchange system/service (Medium priority family)

Sub-AF 5.5: Cooperative Network Information Exchange

- 5.5.1 Upgrade / Implement Cooperative Network Information Exchange system/service (High priority family)

Sub-AF 5.6: Flights Information Exchange

- 5.6.1 Upgrade / Implement Flight Information Exchange system/service (Medium priority family)

For the implementation of the families, SDM has created a preliminary roadmap (Figure 7). This figure shows that first PENS should be operational at each relevant stakeholder. Relevant stakeholders are stakeholders that exchange information using the blue profile. In addition, all stakeholders should have the option to exchange information over IP-based networks, i.e., the public internet. The other families are then run in parallel some ending in 2022 and some in 2025.

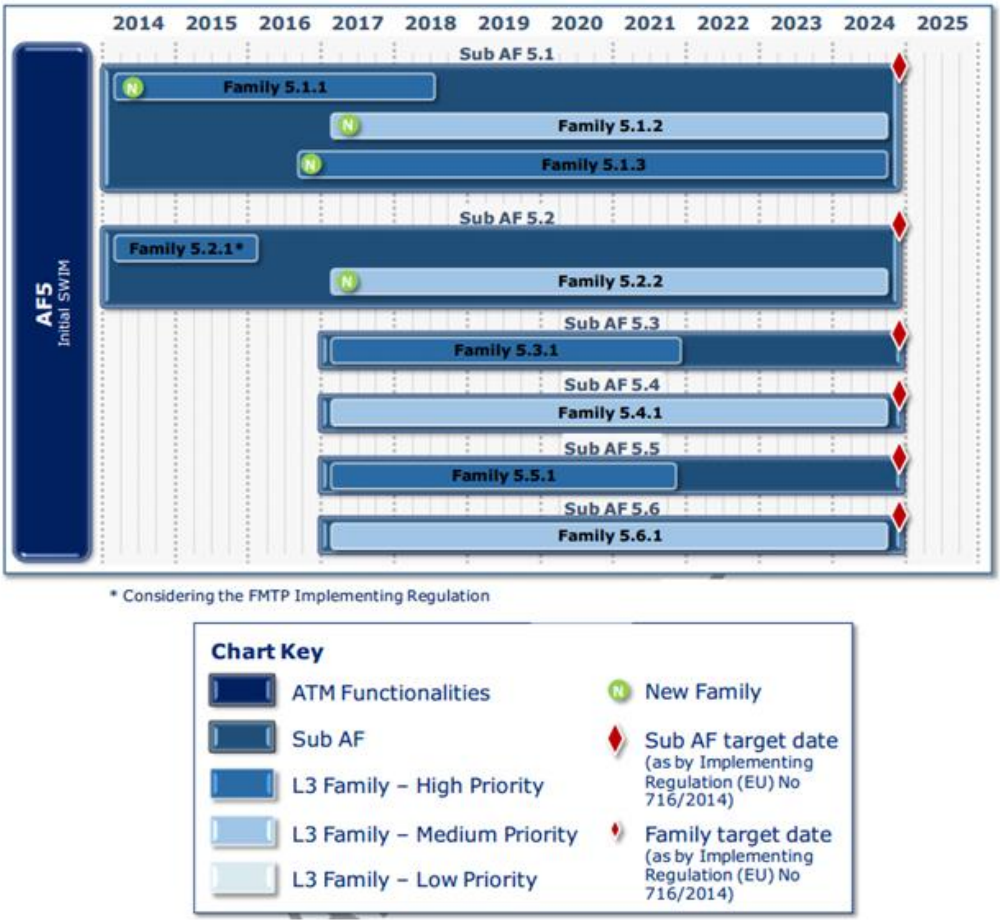

*Figure 7: **Preliminary** Gantt chart.*

4 Current and future data exchange demands for the Dutch sector

For each stakeholder, relevant current and future developments have been identified that could potentially have a relation with the PCP and iSWIM. These developments are defined on the basis of company needs, sector needs, external (e.g., market) developments etc. Some developments are already mature and on-going, some are part of a roadmap and some are expected in the next decade through proper judgement of experts. This chapter describes and orders the most important (and relevant) developments for each stakeholder. As many developments have a strong link with ICT systems, an overview is provided of the most important systems currently in use with the stakeholders.

4.1 LVNL current systems

This section provides an overview of the most important systems currently in use at LVNL.

4.1.1 ATM suRveillance Tracker And Server (ARTAS)

The ARTAS system is a surveillance tracker system of LVNL that tracks all flights in and near the Amsterdam FIR and Dutch TMA's. LVNL has several ARTAS systems with different purposes: Area control, approach/departure control, tower control, back-up system and contingency system. These systems are connected with several surveillance sensors, i.e. primary, SSR, Mode-S radars and multilateration sensors in the Netherlands and neighbouring countries. The flight tracks are provided in the ASTERIX format by the track services for which several characteristics can be specified: the tracking area, the update rate, the radar synchronisation, etc.

4.1.2 Amsterdam Advanced ATC system (AAA)/iCAS

The Amsterdam Advanced ATC system (AAA) is the central ATC/FDPS system of LVNL to manage and control in which the flights to/from/in the Amsterdam FIR and several Dutch TMA's. It is used for area control, approach/departure control and is connected with the Tower System at Schiphol airport. AAA is connected to the ATC/FDPS systems of the adjacent ATC centres of MUAC, BelgoControl, DFS and NATS, and NMOC. AFTN is used to exchange flight plan information with NMOC. Flight objects and flight data are exchanged with the FDPS systems of these adjacent centres with OLDI messages, Flight Update Messages (FUM) using the Aeronautical Fixed Telecommunication Network (AFTN).

The management and control of flights (e.g., military flights and low-level general aviation flights) in some zones below FL195 of the Amsterdam FIR and some Dutch TMA's by the Air Operations Control Station (AOCS) military ATC centre will be integrated into the AAA system in the future. For this purpose the AAA system will need to be adapted and extended.

4.1.3 Tower System

The Tower System is the central tower ATC system of LVNL at Schiphol airport. It is used for tower control, ground control, delivery control, start-up/push back control and runway management purposes. Its flight data processing is currently taking care of by the AAA system but may become integrated in the Tower System in the future. The Tower System is connected with the CISS system of AAS and the FIRDA system of KLM for gate management and CDM purposes.

4.1.4 CPDSP

The Collaborative Pre-Departure Sequence Planning (CPDSP) system of LVNL is an important subsystem of the Tower System at Schiphol airport. It determines the best pre departure sequence of departure flights per runway based on parameters such as the runway planning and capacity, and the scheduled/target/coordinated take off time, taxi out time, stand, aircraft type and departure route (SID) of the flights. It is an essential system for efficient turnaround and outbound traffic management and A CDM.

4.1.5 Closed-Circuit Information System (CCIS)

The Closed-Circuit Information System (CCIS) is an airport, aeronautical and meteorological information presentation system of LVNL for ATC controllers and a limited number of stakeholders such as AAS and KLM. It is used as a secondary information source in the ATC and tower control operations of LVNL. Examples of the presented information are the status of the landing systems and runways, the ATS routes, the radio frequencies, the weather conditions and weather forecasts such as the Schiphol Kansverwachting (SKV).

4.2 Relevant LVNL issues and (expected) developments

1. Improve planning through better predictions, most importantly for inbound traffic. An increased reliability of predictions may lead to higher efficiency, better use of capacity and better predictability of flight times. Current developments include the definition of

fixed arrival routes and improvements of *arrival management*. Fixed arrival routes encompass the definition of RNAV routes from the TMA border to the runway. The advantage is that fixed arrival routes will lead to less vectoring in the TMA. As this limits the possibilities for the TMA controller to influence traffic, it is important that the delivery of aircraft to the TMA is done orderly and timely.
With extended arrival management the planning horizon for inbound traffic is increased. The earlier aircraft are planned, the more time there is to realize this planning which is expected to lead to less interference in the planned flight paths. With the introduction of a new arrival manager at LVNL, the potential for increasing the planning horizon is created.

2. There is a trend to shift from the static use of airspace (based on agreements) to a more dynamic use of airspace that is based on current need. Dynamic use of airspace leads to a better balance between demand and capacity but requires careful coordination between stakeholders. Airspace can even by dynamically allocated cross-border. The most important development in that light is the FABEC project Central West. Within this project airspace, partially in The Netherlands, partially in Germany can be dynamically allocated as either military training area or be used for civil aviation. Besides the civil and military stakeholders, also general aviation and (in the future) RPASs could play a role in dynamic use of airspace as well.
The use of airspace is coordinated by Eurocontrol through a so-called *use plan*. Such plan is "*an ASM message of NOTAM status notifying the daily decision of an Airspace Management Cell on the temporary allocation of the airspace within its jurisdiction for a specific time period, by means of a standard message format*." The use plan is distributed by the Airspace Management Cell which is a joint civil/military cell responsible for the day-to-day management of airspace.
A recent development is the Local and sub-Regional Airspace Management (LARA) system. LARA is a software package to support and enhance airspace management. It provides the possibility to reserve airspace and enables coordination. The tool is an enabler for seamless cross-border coordination. There are currently 18 participating states in Europe. LVNL is implementing the LARA system which is currently in a pre-operational state.
3. Recently, activities have started to modernise the Tower System. The two most important developments in this light include the introduction of Electronic Flight Strips (EFS) and the Tower2020 project that aims to modernize the Tower Systems itself. The current Tower System is a joint development of HITT (currently Saab) and LVNL. The next generation Tower System will be bought off-the-shelf. The Tower System has several connections to external systems. The Tower System is an active part of the

Schiphol CDM process and Collaborative Pre-Departure Sequence Planning (CPDSP). The Tower System receives most of its information from AAA, for the gate planning there is communication with the CISS of AAS. Most flight data is received from AAA. Communication to KLM is mostly done through CDM.

4. The network manager sends Flight Update Messages (FUMs) to LVNL. This is a one-directional communication. Most airports deliver Departure Planning Information (DPI) to the network manager. The DPI messages supply the Network Manager Operations Centre with airport situational information direct from the airport CDM systems in order to update the real-time flight situation prior to take-off. In a symmetric process, the FUMs sent by the network manager provide CDM airports with an accurate estimated landing time of arriving flights, thus improving the planning of outbound flights. The Tower System uses the FUMs for slot allocation and trajectory prediction. The precision of FUMs is not very high. Improvements in the quality of the information contained in the FUMs could lead to better planning and prediction.
5. The Aeronautical Information Publication (AIP) contains all (lasting) information that is essential for air navigation. It contains, for example, Standard Instrument Departures and Standard Arrival routes. Updates are implemented on a fixed cycle, usually every 28 or 56 days. There is a wish from LVNL to be able to update the AIP more frequently.
6. Increase the use of weather information in the arrival process. For example, weather information from outside the Amsterdam FIR could be used in the (extended) arrival management tool to better predict arrival times.
7. At LVNL a workload tool has been developed that is able to estimate the expected workload for air traffic controllers. The tool uses flight information, information from the network manager and historical data to make an estimation of the workload. The output of the tool is used in the process of deciding when to merge or split sectors. The tool could be further improved by making use of other information sources.
8. In line with the previous point, also for the Tower System a better prediction for necessary human resources could be an improvement as well.
9. In the (near) future the cooperation between civil and military air traffic control will be intensified. A major factor in this process is the sharing of the same location of civil and military air traffic controllers. New information needs may emerge in this process. An example is the need for departure information from military airports.
10. Currently information with adjacent centres is exchanged through the On-Line Data Interchange (OLDI) interface. This interface was designed to automate the coordination process between ATC centres. It is a relatively old interface using the X.25 packet switching protocol. The OLDI interface is used to coordinate with adjacent centres by

exchanging (among others) COP times. In the future the OLDI interface is expected to be replaced by more modern systems such as PENS which is SWIM compatible.

4.3 AAS current systems

This section provides an overview of the most important systems currently in use at Schiphol airport.

4.3.1 Central Information System Schiphol (CISS)

The Central Information System Schiphol (CISS) is the central airport, flight, aeronautical and meteorological information management system of AAS for ground handling, passenger management/control, baggage management/control and other terminal processes. CCIS receives input from:

- FIRDA (KLM system) which generates flights in CCIS;
- Other handlers also provide data;
- KNMI (weather) through a live connection;
- Gate Management System (AAS);
- Seasonal schemes;
- Times, registrations;
- FIR entry times (LVNL);
- Landing times.

In addition, it provides output to:

- Handlers;
- Gate Management System for planning;
- Information screens in the terminals (FIDS);
- External parties such as BAS or Teletekst.

4.3.2 Gate Management System (GMS)

The Gate Management System (GMS) is the central airport stand management system of AAS at Schiphol airport. It is used for the planning and management of the stands (connected/quick gates as well as remote aircraft parking positions) of Schiphol airport. The allocation of stands to flights is based on the Regulation Aircraft Stand Allocation Schiphol (RASAS) set of rules to ensure efficiency, punctuality, robustness and fairness between airlines and ground handlers. The stand plan data is provided to the CISS for further information distribution and CDM purposes.

4.3.3 Collaborative Decision Making (CDM) portal

The Collaborative Decision Making (CDM) Portal is a central internet-based airport, flight, aeronautical and meteorological information distribution system of AAS for a limited number of stakeholders at Schiphol airport that are involved in the A CDM process. For example, the ground handlers at Schiphol airport, the airlines at Schiphol airport, the Civil Aviation Authority (CAA) of the Netherlands (ILT) and the National Supervisory Authority (NSA) of the Netherlands (ILT). Furthermore, some flight data may be provided to third parties such as broadcasting companies (NOS and RTL) for public information distribution purposes (teletext services).

4.3.4 Flight Information Display System (FIDS)

The Flight Information Display System (FIDS) is a flight information distribution system of AAS to inform air travellers and their supporters about the status of the flights at Schiphol airport: arrival time, arrival hall, baggage reclaim belt, departure time, check-in desks, departure lounge, gate number and flight status. Everywhere in the Schiphol terminal buildings the public FIDS displays can be found.

4.4 Relevant AAS issues and (expected) developments

1. Schiphol airport is on the threshold of introducing CDM at the airport. CDM allows many stakeholders that are active at the airport to exchange information. Information for the CDM process is delivered by the CDM portal. This information consists of weather, runway usage and flight information. The flight information provides TOBT and TSAT updated with flight progress information. In addition there is frequent contact by phone.
2. AAS would like to have better information about the runways in use.
3. At several places there are issues with the proper connection of IATA call signs and ICAO call signs. Currently AAS is talking to KLM to also communicate ICAO call signs.
4. There are opportunities if information could be easily exchanged with other airports. Currently information with other airports is exchanged through the telex-based Aeronautical Fixed Telecommunication Network (AFTN) network.
5. CDM information could be further unlocked for other processes such as passengers, security, luggage handling etc.

6. It could be interesting to distribute alerts generated by CDM to relevant stakeholders.
7. Progress concerning flight plan handling:
    a. Delay should be introduced by the stakeholder operating the flight plan;
    b. More accurate flight progress information could be useful;
    c. Better communication of airline induced changes of the flight (e.g., number of passengers, amount of luggage, cancellations) would be welcome;
8. Departure Planning Information (DPI) is sent to flow management 3 hours before departure. Flow management checks the availability of a slot.
9. The development around Lelystad airport as a satellite airport besides Schiphol airport could benefit from SWIM.

4.5 KLM current systems

This section provides an overview of the most important systems currently in use at KLM.

4.5.1 Flight Information Royal Dutch Airlines (FIRDA)

The Flight Information Royal Dutch Airlines (FIRDA) system is the central flight information system of KLM mainly used by KLM Ground Services including the KLM Hub Control Centre (HCC) at Schiphol airport and the aircraft, passenger and baggage services.

4.5.2 LIDO

The LIDO system is a tool suite provided/supported by Lufthansa Systems (formerly called LIDO) and used as the Computerised Flight Plan Service Provider (CFSP) by the KLM Operational Control Centre (OCC). It consists of several flight dispatching modules, for example, for flight planning (LIDO/FPLS), flight trajectory optimisation (LIDO/Flight) and flight position following (LIDO/Winds) through Aircraft Communications and Reporting System (ACARS) system. All KLM flight plan data is entered and managed in the LIDO system. The LIDO system provides the KLM flight plan data to NMOC (via LVNL) and to the FIRDA system of KLM for further distribution.

4.6 Relevant KLM issues and (expected) developments

1. FIRDA communicates with different handlers and KLM's own stations abroad. The communication is about KLM movements and can be used for planning.

2. It is to be expected that on the longer term, FIRDA will be replaced by the system that is also in use with Air France.
3. Flight plans are forwarded by the LIDO system to LVNL which then forwards them to Eurocontrol. This is for historic reasons; LVNL does not manipulate the flight plans, it just forwards them.
4. The first version of the flight plans is sent automatically, later manual updates can be made with a human-in-the-loop to optimize the operation.
5. LIDO allows for optimization of the flights and flight following.
6. FIRDA delivers flight information to CISS, KLM handlers and KLM departments.
7. KLM uses ground radar images from the CDM portal of AAS.
8. During a flight, progress messages are exchanged between FIRDA and the aircraft using ACARS. These messages contain position and remaining fuel information.
9. The Winds module of LIDO allows KLM to follow its operation worldwide. Winds allows KLM to speed-up or slow down aircraft based on (for example) available capacity and expected cost. Winds receives information from various sources such as weather information from Delta airlines.
10. In the CDM development process at Schiphol airport, KLM has the feeling it does not have sufficient influence on the process.
11. KLM participates in a flow management project of Eurocontrol. Within this project Short Term ATFCM Messages (STAM) are exchanged to prevent sector loads. This is done by dividing small delays over several airlines. The system works through the NOP portal.
12. User-Driven Prioritisation Process (UDPP). This is a major element in SESAR. During the trial period, the slot of a flight could be swapped multiple times. Now this has been reduced to a maximum of one swap per flight. KLM is able to save a serious amount of money. Deals have been made with other airlines to be able to swap inter-airline as well.

4.7 Overview of NL data distribution architecture

Figure 8 outlines important parts of the current data distribution architecture in the Dutch sector. It shows that there are many dedicated data interfaces between the various systems of the stakeholders in the Dutch sector. This architecture works (of course) but it has serious limits with respect to scalability, efficiency and costs. Furthermore, some of the older data interface technologies are reaching the end of their supported life in the modern internet world.

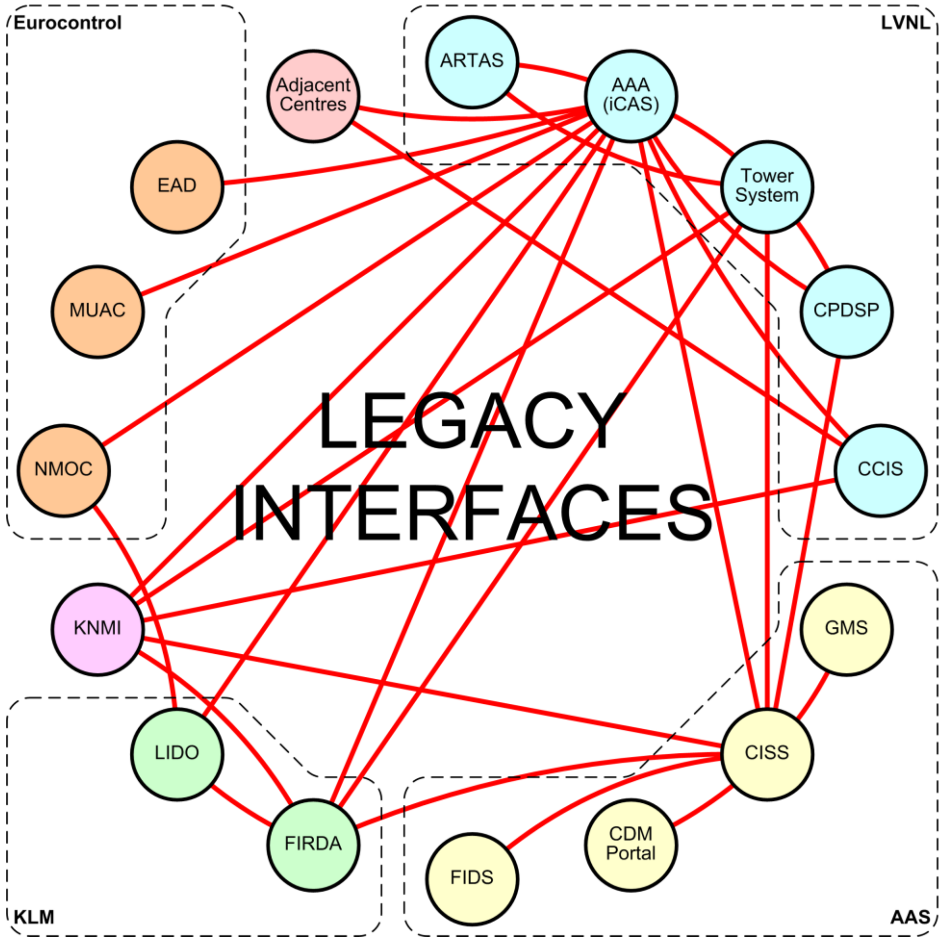

Figure 8: Current data distribution architecture in the NL sector.

4.8 Potential future data distribution architecture

To illustrate the potential of SWIM, the following figure shows a possible future architecture.

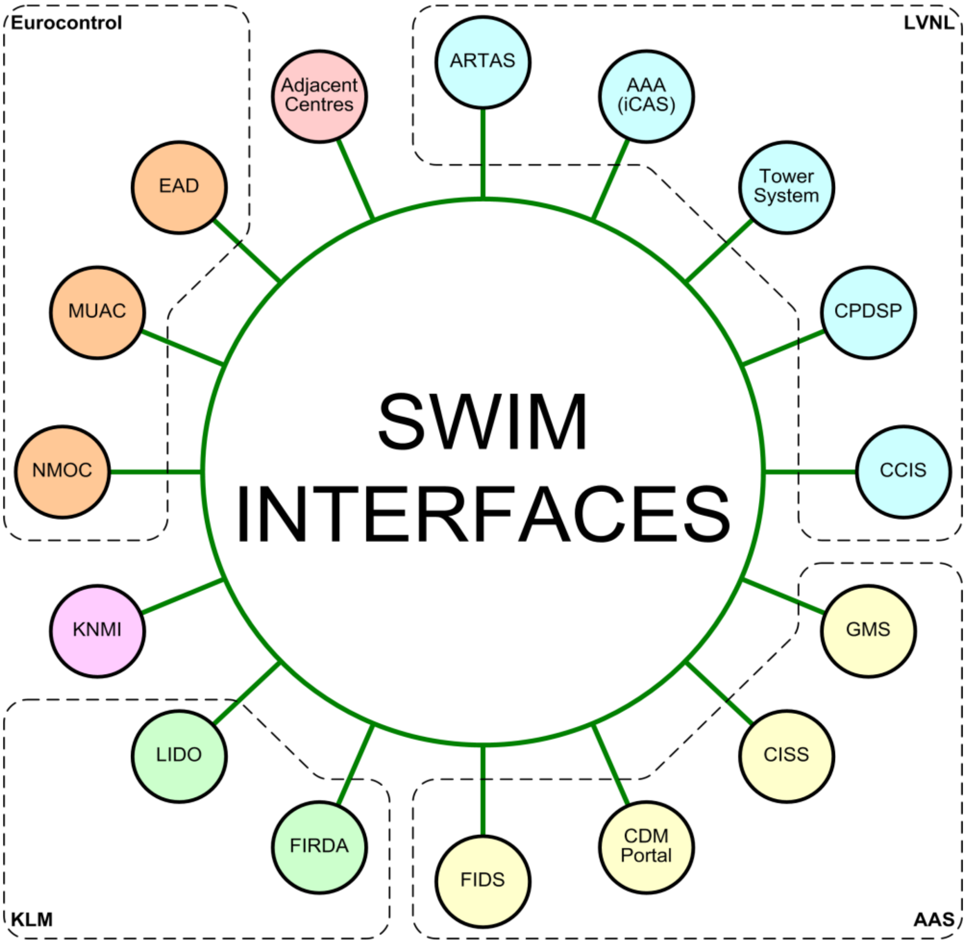

Figure 9: Proposed SWIM-based data distribution architecture in the NL sector.

The figure shows that each system of the stakeholders has basically only one data interface with the rest of the world. All data supply and demand is based on the same SWIM/PENS technology that is scalable, efficient and (in relation to the current situation) more cost effective.

The transition from the current data distribution architecture to the proposed SWIM-based data distribution architecture cannot be realised overnight. The SWIM/PENS technology has to be introduced in a gradual way where new SWIM-based data interfaces are implemented and provided next to the existing data interfaces. This enables other (consuming) systems to adopt and make use of the new SWIM-based data interfaces in a gradual way. Thereafter the existing data interfaces may be phased out.

Especially systems with many (different) data interfaces (e.g., AAA, CISS and FIRDA) may benefit from the SWIM-based data distribution architecture. It is much cheaper to maintain a limited set of data interfaces using the same SWIM/PENS technology than a larger set of data interfaces using dedicated legacy technologies. But the investments in the SWIM/PENS technology precede the benefits. And the benefits can only be realised when the usage of the older technologies is terminated.

5 Mandatory activities

The PCP and the deployment programme (DP) describe the mandatory functionalities that the member states need to implement. The deployment program divides the sub-ATM functionalities into a set of families. For each family, the DP describes the recommended actions to ensure compliance with the PCP. In Table 1, these are summarized. Next, specific tables are presented that translate the general actions to specific actions per Dutch stakeholder.

Table 1: Project families and recommended actions

Family/ Name	Description	Applicable to	Initial/Full Operational Capability	DP recommended actions for stakeholders
5.1.1 PENS-1	To support flight object exchange, ANSP's planning to implement IOP FO, have to be or become PENS user.	LVNL	Before 2014 30/06/2018	All PCP ANSP's not already PENS1 user and planning to implement IOP FO before mid-2018, are invited to present a project to become a PENS1 user.
5.1.2 Future PENS	The future PENS will replace PENS1 terminating in June 2018.	LVNL	01/01/2017 01/01/2025	A Call For Tender is expected to be released by Eurocontrol by the end of 2015.
5.1.3 Common SWIM Infrastructure components	SWIM authority for management, registry and other common components. This family ensures that stakeholders are able to provide and consume SWIM services.	LVNL, KLM, AAS, KNMI	01/06/2016 01/01/2025	It is recommended that pioneering stakeholders (NMOC, ANSP's …) launch an IP to set-up a first SWIM Governance to be able to manage as soon as possible the SWIM Registry, its content, the evolution of SWIM elements required during deployment, SWIM compliance assessment, all together allowing the start of SWIM implementation.
5.2.1 Stakeholder Internet Protocol (IP) Compliance	The scope of this Projects Family aims mainly at implementing on civil and military stakeholder side IP network connectivity to be able to exchange ATM information.	LVNL, KLM, AAS, KNMI	Before 2014 01/01/2016	Each stakeholder not yet IP compliant should plan to transition to IP connectivity in order to be in a position to exchange information with other stakeholder in the near future
5.2.2 Stakeholder SWIM Infrastructure Components		LVNL, KLM, AAS, KNMI	01/01/2017 01/01/2025	The scope of this Projects Family aims at implementing in each Stakeholder the following SWIM components: - Blue profile - Yellow profile - Any other components necessary for

				stakeholder SWIM implementation
5.3.1 Upgrade / Implement Aeronautical Information Exchange system / service	Operational stakeholders shall implement services which support the exchange of aeronautical information using the yellow profile.	LVNL, KLM, AAS	01/01/2017 01/01/2022	Be able to exchange aeronautical information data using AIRM as stated in the PCP. This includes Airspace Reservation/Restriction (ARES) information and D-NOTAM's. Implementation of services shall be compliant with AIRM and ISRM.
5.4.1 Upgrade/Implement Meteorological Information Exchange	Operational stakeholders shall implement services which support the exchange of meteorological information using the yellow profile.	LVNL, KLM, AAS, KNMI	01/01/2017 01/01/2025	The systems shall be upgraded or implemented to support the exchange of Meteorological Information in WXXM/IWXXM formats in compliance with the yellow profile, either through the public internet or over PENS.
5.5.1 Upgrade/Implement Cooperative Network Information exchange	The Network Information will be freely exchanged between the systems of the Operational stakeholders by means of defined cooperative network information B2B services, using the yellow profile.	LVNL, KLM AAS	01/01/2016 01/01/2025	The systems shall be upgraded to support the B2B exchange of information in compliance with the yellow profile, either through the public internet or over PENS.
5.6.1 Upgrade / Implement Flights Information Exchange system /service	Deal with the Flight Object (Share Flight Object and various operations on a flight object) between ACC and TMA and NMOC supported by the blue profile. Deal with various exchanges of Flight Information between operational stakeholders supported by the yellow profile.	LVNL, KLM AAS	01/01/2017 01/01/2025	The civil systems shall be upgraded or implemented to support the Flights Information exchange in compliance with the yellow/blue profiles, either through the public internet or over PENS. PENS shall be used for Flight Object Information using blue profile.

The actions defined by SDM can be split and translated to specific recommended actions for the Dutch stakeholders. In the following tables, for each of the 4 applicable Dutch stakeholders (LVNL, KLM, AAS and KNMI) specific actions coming from the project families are identified.

Table 2: LVNL recommended actions per project family

Family	Action
5.1.1: PENS-1	Ensure that the process of becoming a PENS-1 user is completed by 30/06/2018. IP network connectivity is a prerequisite for PENS-1.
5.1.2: Future PENS	Decide involvement in the Eurocontrol tender process. Ensure continuation of operation after termination of PENS-1 on 01/01/2018.
5.1.3: Common SWIM infrastructure components	These comprise of the basic necessities to connect to SWIM. Ensure to stay in-the-loop of developments. Determine which role to play in the definition process. This step requires strong coordination between all stakeholders. Cooperation with other Dutch stakeholders could be beneficial here.
5.2.1: IP compliance	Check IP compliance of iCAS, Tower System, future Tower System and CCIS. Ensure not to upgrade to systems that are not IP compliant.
5.2.2: Stakeholder SWIM Infrastructure Components	Ensure that all components necessary for SWIM are implemented (in particular the blue and yellow profiles). Coordinate with other stakeholders. Ensure that existing systems are able to use these profiles. This can be either directly or through an adapter (translating between existing legacy applications and the target infrastructure).
5.3.1: Upgrade / Implement Aeronautical Information Exchange system / service	Ensure that ARES, airspace usage plans and D-NOTAM information can be exchanged through SWIM using the AIRM and ISRM models. The latter is defined in the registry. In addition, as LVNL is the AIS provider, it should provide aeronautical information such as aerodrome mapping data and airport maps. The yellow profile is used for this exchange. Monitor the development of the AIRM and ISRM models. Ensure security by conducting a risk assessment and by establishing security monitoring.
5.4.1: Upgrade/Implement Meteorological Information Exchange	Ensure that iCAS/Tower System/CCIS will be able to consume weather information using the WXXM data format (yellow profile). Because of the increased system interactions: ensure security by conducting a risk assessment and by establishing security monitoring.
5.5.1: Upgrade/Implement Cooperative Network Information exchange	Ensure that iCAS/Tower System will be able to exchange network information as described in the PCP (yellow profile). This comprises of the exchange of B2B information between operational stakeholders using the yellow profile and the public internet. NMOC will provide the different communication paradigms. NMOC should be consulted for details. Because of the increased system interactions: ensure security by conducting a risk assessment and by establishing security monitoring.
5.6.1: Upgrade / Implement Flights Information Exchange system /	Ensure that iCAS/Tower System will be able to use, manipulate and exchange flight information (flight object) using the blue profile over PENS. Information should be exchanged between ACC and TMA and NMOC. In addition, the yellow profile should be used to exchange flight information between operational stakeholders. During the transition period, both legacy messaging and

	yellow/blue information exchange should exist simultaneously. FAB could be used to synchronize FO distribution and consumption. The recommended strategy should be first intra FAB and then be extended inter FAB. Because of the increased system interactions: ensure security by conducting a risk assessment and by establishing security monitoring.

Table 3: KLM recommended actions per project family

Family	Action
5.1.1: PENS-1	No action required as PENS is used for the blue profile and AOCs do not need to exchange information using this profile.
5.1.2: Future PENS	No action required as PENS is used for the blue profile and AOCs do not need to exchange information using this profile.
5.1.3: Common SWIM infrastructure components	These comprise of the basic necessities to connect to SWIM. Ensure to stay in-the-loop of developments. Determine which role to play in the definition process. This step requires strong coordination between all stakeholders. Cooperation with other Dutch stakeholders could be beneficial here.
5.2.1: IP compliance	IP compliance is a strong prerequisite for SWIM. Verify IP compliance of LIDO/FIRDA to ensure foundation for information exchange with SWIM. Ensure that future systems are IP compliant.
5.2.2: Stakeholder SWIM Infrastructure Components	Ensure that all components necessary for SWIM are implemented (in particular yellow profile). Coordinate with other stakeholders. Ensure that existing systems are able to use these profiles. Decide on architecture to connect the existing systems. This can be either directly or through an adapter (translating between existing legacy applications and the target infrastructure).
5.3.1: Upgrade / Implement Aeronautical Information Exchange system / service	LIDO/FIRDA needs to be adapted to support simultaneously legacy messaging exchanges and yellow profile information (ARES, AUP, UUP, D-NOTAM). Because of the increased system interactions: ensure security by conducting a risk assessment and by establishing security monitoring.
5.4.1: Upgrade/Implement Meteorological Information Exchange	Ensure FIRDA will be able to communicate with meteorological services using the yellow profile and the WXXM/IWXXM data formats. Because of the increased system interactions: ensure security by conducting a risk assessment and by establishing security monitoring.
5.5.1: Upgrade/Implement Cooperative Network	This comprises of the exchange of B2B information between operational stakeholders using the yellow profile and the public internet. NMOC will provide the different communication paradigms. NMOC should be consulted for details. Communication with

Information exchange	NMOC should be migrated to SWIM. There will be a transition period in which both legacy and SWIM message exchange exist simultaneously. Coordinate with other stakeholders when deploying these services. Because of the increased system interactions: ensure security by conducting a risk assessment and by establishing security monitoring.
5.6.1: Upgrade / Implement Flights Information Exchange system /	Only the flight information part applies to Airspace Users such as KLM. It deals with the exchange of flight information between operational stakeholders. FIRDA/LIDO should be able to exchange flight plans, flight lists, detailed flight data and departure information.

Table 4: AAS recommended actions per project family

Family	Action
5.1.1: PENS-1	No action required as PENS is used for the blue profile and airports do not need to exchange information using this profile.
5.1.2: Future PENS	No action required as PENS is used for the blue profile and airports do not need to exchange information using this profile.
5.1.3: Common SWIM infrastructure components	These comprise of the basic necessities to connect to SWIM. Ensure to stay in-the-loop of developments. Determine which role to play in the definition process. This step requires strong coordination between all stakeholders. Cooperation with other Dutch stakeholders could be beneficial here.
5.2.1: IP compliance	IP compliance is a strong prerequisite for SWIM. Verify IP compliance of CISS to ensure foundation for information exchange with SWIM. Ensure that future systems are IP compliant.
5.2.2: Stakeholder SWIM Infrastructure Components	Ensure that all components necessary for SWIM are implemented (in particular yellow profile). Coordinate with other stakeholders. Ensure that existing systems are able to use these profiles. Decide on architecture to connect the existing systems. This can be either directly or through an adapter (translating between existing legacy applications and the target infrastructure).
5.3.1: Upgrade / Implement Aeronautical Information Exchange system/service	Coordinate with LVNL to what extent AAS needs to provide aeronautical information as most items seem to apply to LVNL.
5.4.1: Upgrade/Implement Meteorological	CISS information exchange with MET providers should migrate to SWIM. Using the yellow profile and the WXXM/IWXXM data formats, CISS needs to be able to exchange meteorological information using SWIM. Because of the increased system

Information Exchange	interactions: ensure security by conducting a risk assessment and by establishing security monitoring.
5.5.1: Upgrade/Implement Cooperative Network Information exchange	Coordinate with LVNL to what extent AAS needs to provide cooperative network information as most items seem to apply to LVNL.
5.6.1: Upgrade / Implement Flights Information Exchange system /	Most information exchanges seem to apply to ANSP's, airlines and NMOC. Coordinate with the other stakeholders to what extend AAS needs to implement additional information exchange services to comply with the PCP.

Table 5: KNMI recommended actions per project family

Family	Action
5.1.1: PENS-1	No action required as PENS is used for the blue profile and airports do not need to exchange information using this profile.
5.1.2: Future PENS	No action required as PENS is used for the blue profile and airports do not need to exchange information using this profile.
5.1.3: Common SWIM infrastructure components	These comprise of the basic necessities to connect to SWIM. Ensure to stay in-the-loop of developments. Determine which role to play in the definition process. This step requires strong coordination between all stakeholders. Cooperation with other Dutch stakeholders could be beneficial here.
5.2.1: IP compliance	IP compliance is a strong prerequisite for SWIM. Verify IP compliance of systems to ensure foundation for information exchange with SWIM. Ensure that future systems are IP compliant.
5.2.2: Stakeholder SWIM Infrastructure Components	Ensure that all components necessary for SWIM are implemented (in particular yellow profile). Coordinate with other stakeholders. Ensure that existing systems are able to use these profiles. Decide on architecture to connect the existing systems. This can be either directly or through an adapter (translating between existing legacy applications and the target infrastructure).
5.3.1: Upgrade / Implement Aeronautical Information Exchange system/service	Not applicable to MET providers.
5.4.1: Upgrade/Implement	The PCP mandates that KNMI is able to provide a long list of meteorological information through SWIM using the yellow profile. Data can be exchanged either by

Meteorological Information Exchange	using PENS or the public internet. Ensure existing systems are able to exchange data using the services and data standards according to SWIM principles. The WXXM/IWXXM formats should be supported. Because of the increased system interactions: ensure security by conducting a risk assessment and by establishing security monitoring.
5.5.1: Upgrade/Implement Cooperative Network Information exchange	Not applicable to MET providers.
5.6.1: Upgrade / Implement Flights Information Exchange system /	Not applicable to MET providers.

6 Opportunities and points of interest

Besides the mandatory activities, the introduction of iSWIM provides opportunities and things to take into account for planned and future activities of the Dutch sector. With every future activity that relates to data exchange, a PCP check should be performed to check any relation to the PCP and/or SWIM. Using the information about stakeholder activities and the list of mandatory activities, the information from the previous chapters has been translated into a long list of opportunities and points of interest for each stakeholder.

6.1 Opportunities for LVNL

- As LVNL is in the process of a major system renewal process, it is important to map the needs for data exchange on the possibilities of the new systems. It should therefore be verified that iCAS provides the necessary interfaces for a proper connection to SWIM not only to comply with the PCP but also to ensure a safe basis for future developments. Joining forces with other users of iCAS is could accelerate the PCP compliance development of iCAS. The replacement of the Tower System (which will be COTS as much as possible), provides an opportunity to ensure SWIM compatibility by adding this to the list of requirements for the tender process. SWIM compatibility could be either ensured through internal standard or through a gateway.
- As LVNL is an information provider for en-route centers and the network manager, it is useful to discuss future information provision with these stakeholders. Their need for information can change over time and there may also be a need for information that is currently only available internally at LVNL. iSWIM may provide opportunities to unlock such information. Actively seeking for (business) opportunities to improve information provision through iSWIM could become part of the LVNL strategy.
- A vision on the use of the flight object and how LVNL could benefit from it may be useful in the light of the system replacement process of the coming years. Such vision could be used to provide overview.
- With Schiphol airport being a major European airport that is served by a relatively small airspace, extended arrival management is a promising solution to contribute to better planning of the arrival stream. The higher the quality of the information about the aircraft that need to be planned, the better the planning process can take place. SWIM may open new opportunities to require information that can be used for the benefit of this process. An example is the use of flight objects with better progress information; being able to better predict arrival times opens the possibility to the creation of a more

efficient arrival stream. Another example is the use of departure information from nearby airfields to ensure a smooth inclusion of pop-up traffic in the arrival stream.

- As Eurocontrol is actively promoting the use of SWIM, all kinds of communication with Eurocontrol are candidates for use of SWIM. It is important to be aware of the plans of Eurocontrol and NMOC for migration to SWIM.
- KNMI is already in the process of implementing several requirements of the PCP. In the near future, SWIM can be used to consume weather information from multiple sources. This provides opportunities which should be identified. Examples include better anticipation to disturbances due to bad weather at other airports or anticipating disturbances in flight schedules of certain airlines due to bad weather at their home airports that have adverse effects on the Schiphol operation.
- More generally, in each new project the role of iSWIM (and the PCP as a whole) should be a part of the considerations.
- SWIM could bring benefits on the side of the distribution of AIP information. In the future updates to the AIP will be executed through SWIM, which will create opportunities for cooperation and potentially for a higher update frequency and using AIP information as a basis for system configurations/adaptations.
- ARTAS could be improved and/or enriched with information from SWIM. Multiple sources with the same information have the potential to reduce uncertainty.
- A uniform way of communication with adjacent centres paves the way for an extension of the amount of information that is exchanged. An implementation of SWIM can be re-used for communication with other centres, lowering the amount of work involved. Legacy systems such as OLDI could be phased out. Having one type of interface supporting several data exchanges is expected to lead to lower maintenance cost than having multiple interfaces each for one specific purpose.
- The creation of an Airspace Use Plan (AUP) is a laborious and daily recurring activity. LVNL may automate this with the use of a tool such as the Local and sub-Regional Airspace Management (LARA) system of Eurocontrol. The use of LARA for the AUP will guarantee compliance with all relevant EU regulations including that of (initial) SWIM. LARA will become part of the Central Services of NMOC. It is expected that all Central Services of NMOC will be standardised on the SWIM/PENS technologies.

6.2 Opportunities for AAS

- It is interesting to investigate the opportunities that arise from the connection of CDM with SWIM. Other airports may already have started initiatives in this direction, AAS could benefit from these developments by communication to other airports about delays, capacity, weather etc. Another opportunity could be to improve communication with other stakeholders about CDM related matters.

- The Airport Operations Centre (APOC) could benefit from SWIM through a better and more efficient data provision. Examples include better anticipation of disturbances due to bad weather at other airports or anticipating disturbances in flight schedules of certain airlines due to bad weather at their home airports that have adverse effects on the Schiphol operation. The airport operation plan (a shared rolling plan to provide a common situational awareness to stakeholders) could also benefit from the introduction of iSWIM as more and more accurate data could be integrated into the plan.
- (Part of) CDM information could be unlocked to, e.g., passengers, security, luggage handling and general public.
- The development of Lelystad airport provides an opportunity to re-think the information flows. Making the technical systems of Lelystad airport less dependent on those of AAS might provide benefits for things like contingency. SWIM could play are role here by providing independent flows of information to different airports instead of a centralized system.
- Correlating flight related data that is exchanged between ANSP's, airports, airlines and ground handlers is a laborious and daily recurring activity of AAS. ANSP's use and exchange flight data with ICAO flight identifiers while airports, airlines and ground handlers mainly use and exchange flight data with IATA flight identifiers. Correlating ICAO-based flight data with IATA-based flight data or vice versa is automated to a large extent but anomalies are always left over for further investigation.
  The Globally Unique Flight Identifier (GUFI) is an essential part of the FIXM model as well as the AIRM model. GUFI is a reference that uniquely identifies a specific flight. It unifies ICAO, IATA and other flight identifiers and is independent of any particular system. It enables the stakeholders in the Dutch sector to correlate flight related data of ANSP's, airports, airlines and ground handlers in a consistent and unambiguous way.
- There is also an opportunity to better communicate changes in flights (e.g., number of passengers, amount of luggage, cancellations) through SWIM. This could be implemented either by communicating directly to the stakeholder or through the network manager.

6.3 Opportunities for KLM

- Both FIRDA and LIDO have many interfaces to the outside world. Connecting to SWIM may provide opportunities to improve planning and standardize communication.

FIRDA may be superseded in the future. An interface to SWIM could be an important requirement for such transition.

- The consumption of weather information could be an important driver for SWIM compatibility. SWIM provides the opportunity to integrate weather information from multiple sources. Also switching between weather predictions providers could be made transparent. Therefore, SWIM provides flexibility and prevents a lock-in.
- Flight plans are currently filed through LVNL. It may beneficial to do this directly to Eurocontrol for flexibility and (fail) safety. LVNL will then receive the information back from Eurocontrol.
- If CDM information could be received not only from AAS but from all airports that KLM services. Combining CDM information about delays or predicted take-off times could lead to better planning for example for new developments such as STAM messages or UDPP.
- Information provision towards passengers could also benefit from SWIM for the same reasons.
- The introduction of iSWIM and its services provide opportunities for a better and more optimal inbound priority sequencing of flights. Various criteria are currently used to optimize such sequence, such as fuel cost, work hour restrictions, passenger transfers etc. The use of iSWIM services may provide opportunities to further optimize this process.

6.4 Opportunities for KNMI

- Being a pure data provider, early adoption of SWIM could strengthen the business case for KNMI. SWIM could remove barriers for stakeholders to consume more weather information from different providers, this provides opportunities for KNMI.

7 Conclusions and Recommendations

The PCP describes a list of mandatory activities that European ATC stakeholders should undertake in the coming 10 years. These activities are a direct result of the SESAR project. With a large airport within its boundaries, the Dutch sector is affected in all aspects of this PCP. The introduction of iSWIM is one of the main activities from the PCP that enables many of the other activities. This document provides an overview of the impact on the Dutch sector of the introduction of iSWIM as described in the PCP. This includes both mandatory activities as opportunities that arise from the PCP. This study provides an overview of current and future developments for Dutch stakeholders in the light of the introduction of iSWIM.

The PCP is aimed to ensure a coordinated implementation of a part of the results of SESAR. The cost related to the implementation of the PCP can be lowered in two ways:

1. Take the PCP and its implications into account with every future data related activity to prevent double work and coordinate activities with other stakholders.
2. Use the funding from INEA to implement necessary changes.

The first point is something to embed in each stakeholder’s organization. For each development a PCP check should be performed that looks not only at the obligations, but also to the opportunities related to the PCP. Cost/benefit analysis is important here when considering additional activities.
For the second point, the first round of funding through INEA has already been closed, with more rounds to come. 110 projects have been submitted in this first round. LVNL, KLM, Schiphol and KNMI have submitted one or more projects. The list of potential developments that may be eligible for funding is large and proper and timely action should be taken.

For stakeholders to be able to benefit from iSWIM developments and to ensure a proper implementation, it is highly recommended that each stakeholder creates a roadmap. The starting point of the roadmap should not be the mandatory PCP developments but should show how intended stakeholder developments are foreseen over time. It should contain all developments of the stakeholder that may be affected by iSWIM. Next the intended implementation of the PCP can be added to the roadmap using the information from Chapter 5. The combination of intended developments and PCP activities allows for the identification of opportunities that are created by iSWIM (see Chapter 6 for an overview) to the roadmap.
When creating the roadmap, it is important to choose what the strategy towards PCP implementation will be. For example, when becoming a front runner in PCP implementation, new opportunities can be implemented quickly. But because many iSWIM developments need

some critical mass before they can become effective, this may also be counterproductive. A careful, well thought out strategy towards iSWIM implementation is therefore necessary. The strategy should also include the identification of projects that are eligible for INEA funding. The creation of the roadmaps at each stakeholder should be coordinated with other stakeholders in order to maximize the use of synergy and to coordinate activities.

The deployment manager will continue to update the deployment plan. This study has only looked at one pillar of the PCP; other aspects all have their own impact. Expertise is necessary to create sufficient knowledge about the PCP, its implications and to keep up with developments. The appointment of a PCP coordinator could be useful in coordinating PCP work at each stakeholder. Coordination among Dutch stakeholders could further contribute to the sharing of knowledge and experience and the coordination of activities.

For each stakeholder it is highly recommended to verify that current developments (new functionality, new services, new systems etc.) comply with PCP requirements.

The PCP requests for new functionality that is currently often unavailable or only partially available. When adding new functionality to existing systems or when unlocking information and sharing it with he outside world, it is very important to timely consider security risks. Especially legacy systems that may not have been designed for information sharing may expose security risks when adding new functionality to share information. It is therefore highly recommended that information security is given a high priority in the design process for new functionality.

The implication of the changes that the PCP foresees on human factors has been assessed in various SESAR exercises. However, the dependence of the impact is often highly dependent on local (stakeholder) circumstances. It is recommended not to underestimate the human factors side of the foreseen changes. This is especially true for air traffic controllers as they already work under pressure and small changes of systems may have a large impact on the (perceived) workload. A careful balance between safety, workload and service provision needs to be maintained. This should be one of the focal points when developing an implementation plan.

8 Bibliography

[1] European Commission, "On the definition of common projects, the establishment of governance and the identification of incentives supporting the implementation of the European Air Traffic Management Master Plan," Commission Implementing Regulation (EU) No 409/2013, Brussels, 3 May 2013.

[2] European Commission, "On the establishment of the Pilot Common Project supporting the implementation of the European Air Traffic Management Master Plan," Commission Implementing Regulation (EU) No 716/2014, Brussels, 27 June 2014.

[3] European Commission, "On the interoperability of the European Air Traffic Management network," Regulation (EC) No 552/2004 of the European Parliament and of the Council, Brussels, 10 March 2004.

Appendix A Acronyms

4D	**Four Dimensional (trajectory)**
AAA	**Amsterdam Advanced ATC system**
AAS	**Amsterdam Airport Schiphol**
ACARS	**Aircraft Communications and Reporting System**
ACC	**Area Control Centre**
A-CDM	**Airport CDM**
ACI	**Airports Council International**
ADEXP	**ATS Data Exchange Presentation**
AF	**ATM Family**
AFTN	**Aeronautical Fixed Telecommunication Network**
AIM	**Aeronautical Information Management**
AIP	**Aeronautical Information Publication**
AIRM	**ATM Information Reference Model**
AIRMET	**Airmen's Meteorological Information**
AIS	**Aeronautical Information Service**
AIXM	**Aeronautical Information Exchange Model**
AMA	**Arrival Management Message**
AMAN	**Arrival Management**
AMDB	**Aerodrome Mapping Database**
AMHS	**ATS Message Handling System**
AMQP	**Advanced Message Queuing Protocol**
ANSP	**Air Navigation Service Provider**
AOC	**Airline Operations Centre**
AOCS	**Air Operations Control Station**
AOP	**Airport Operations Plan**
APOC	**Airport Operations Centre**
ARES	**Airspace Reservation**
ARINC	**Aeronautical Radio Incorporated**
ARTAS	**ATM suRveillance Tracker And Server**
ASM	**Airspace Management**
ASTERIX	**All Purpose Structured Eurocontrol Surveillance Information Exchange**
ATC	**Air Traffic Control**
ATFCM	**Air Traffic Flow and Capacity Management**
ATM	**Air Traffic Management**

ATMB	**Air Traffic Management Bureau (China)**
ATSU	**Air Traffic Service Unit**
ATS	**Air Traffic Services**
AUP	**Airspace Use Plan**
BAS	**Bewoners Aanspreekpunt Schiphol**
B2B	**Business to Business**
BCA	**Bridge Certification Authority**
CAA	**Civil Aviation Authority**
CAAS	**Civil Aviation Authority of Singapore**
CANSO	**Civil Air Navigation Services Organisation**
CCIS	**Closed-Circuit Information System**
CDM	**Collaborative Decision Making**
CEF	**Connecting Europe Facility**
CFMU	**Central Flow Management Unit**
CFSP	**Computerised Flight Plan Service Provider**
CISS	**Central Information System Schiphol**
COOPANS	**Cooperation of Air Navigation Service Providers**
COP	**Coordination Points**
COTS	**Commercial off the Shelf**
CPDSP	**Collaborative Pre Departure Sequence Planner**
CR	**Contract Report**
CTOT	**Calculated Take-Off Time**
DCB	**Demand/Capacity Balancing**
dDCB	**Dynamic DCB**
DDS	**Data Distribution Service**
DFS	**Deutsche Flugsicherung (Germany)**
D-NOTAM	**Digital NOTAM**
DP	**Deployment Programme**
DPI	**Departure Planning Information**
DSNA	**Direction des Services de la Navigation Aérienne (DSNA)**
EAD	**European AIS Database**
EATMN	**European ATM Network**
EC	**European Commission**
ED	**EUROCAE Document**
EFB	**Electronic Flight Bag**
EFS	**Electronic Flight Strips**
ELDT	**Estimated Landing Time**

ETFMS	**Enhanced Tactical Flow Management System**
ETO	**Estimated Time Over**
ETOT	**Estimated Take-Off Time**
EU	**European Union**
EUROCAE	**European Organisation for Civil Aviation Equipment**
Eurocontrol	**European Organisation for the Safety of Air Navigation**
EXOT	**Estimated Taxi-Out Time**
FAA	**Federal Aviation Administration**
FABEC	**Functional Airspace Block Europe Central**
FDPS	**Flight Data Processing System**
FIDS	**Flight Information Display System**
FIR	**Flight Information Region**
FIRDA	**Flight Information Royal Dutch Airlines**
FIXM	**Flight Information Exchange Model**
FL	**Flight Level**
FMTP	**Flight Message Transfer Protocol**
FO	**Flight Object**
FPLS	**Flight Planning System**
FUM	**Flight Update Message**
GML	**Geography Mark-up Language**
GMS	**Gate Management System**
GUFI	**Globally Unique Flight Identifier**
HCC	**Hub Control Centre**
HITT	**Holland Institute of Traffic Technology**
HTTP	**Hypertext Transfer Protocol**
i4D	**Initial 4D (trajectory)**
IAF	**Initial Approach Fix**
IAG	**International Airlines Group**
IATA	**International Air Transport Association**
ICAO	**International Civil Aviation Organisation**
iCAS	**iTEC Centre Automation System**
ILT	**Inspectie Leefomgeving en Transport**
INEA	**Innovation and Networks Executive Agency**
IOP	**InterOperability**
IP	**Implementation Project**
IP	**Internet Protocol**
ISRM	**Information Service Reference Model**

iSWIM	**Initial SWIM**
iTEC	**Interoperability Through European Collaboration**
IWXXM	**ICAO WXXM**
JCAB	**Japan Civil Aviation Bureau**
KDC	**Knowledge and Development Centre**
KLM	**Koninklijke Luchtvaartmaatschappij**
KNMI	**Koninklijk Nederlands Meteorologisch Instituut**
LARA	**Local and sub-Regional Airspace Management**
LIDO	**Lufthansa Systems**
LVNL	**Luchtverkeersleiding Nederland**
MET	**Meteorological information service**
METAR	**Meteorological Aerodrome Report**
MUAC	**Maastricht Upper Area Control**
NATO	**North Atlantic Treaty Organisation**
NATS	**National Air Traffic Services (UK)**
NL	**The Netherlands**
NMOC	**Network Manager Operations Centre**
NOP	**Network Operations Plan**
NOS	**Nederlandse Omroep Stichting**
NOTAM	**Notice to Airmen**
NSA	**National Supervisory Authority**
OCC	**Operations Control Centre**
OGC	**Open Geospatial Consortium**
OLDI	**On-Line Data Interchange**
PBN	**Performance Based Navigation**
PCP	**Pilot Common Projects**
PENS	**Pan-European Network Services**
PKI	**Public Key Infrastructure**
R&D	**Research and Development**
RASAS	**Regulation Aircraft Stand Allocation Schiphol**
RPAS	**Remotely Piloted Aircraft System**
RTCA	**Radio Technical Commission for Aeronautics**
RTL	**Radio Television Luxembourg**
RTPS	**Real Time Publish/Subscribe protocol**
SAM	**Slot Allocation Message**
SARP	**Standard and Recommended Practice**
SDAG	**SESAR-related Deployment Airport Group**

SEP	**STAR Entry Point**
SESAR	**Single European Sky ATM Research**
SID	**Standard Instrument Departure**
SIGMET	**Significant Meteorological Information**
SITA	**Société Internationale de Télécommunications Aéronautiques**
SJU	**SESAR Joint Undertaking**
SKV	**Schiphol Kansverwachting**
SOA	**Service Oriented Architecture**
SOAP	**Simple Object Access Protocol**
SPECI	**Special METAR**
SRM	**Slot Revision Message**
STAM	**Short-Term ATFCM Measures**
STAR	**Standard Arrival Route**
SWIM	**System Wide Information Management**
TAF	**Terminal Aerodrome Forecast**
TCP	**Transmission Control Protocol**
TENT	**Trans-European Transport Networks**
TI	**Technical Infrastructure**
TMA	**Terminal Control Area**
TOBT	**Target Off-Block Time**
TRL	**Technology Readiness Level**
TSAT	**Target Start Up Approval Time**
TTOT	**Target Take-Off Time**
UDPP	**User-Driven Prioritisation Process**
UK	**United Kingdom**
UML	**Unified Modelling Language**
USA	**United States of America**
UUP	**Updated Use Plan**
VAA	**Volcanic Ash Advisory**
VoIP	**Voice over IP**
VPN	**Virtual Private Network**
WMO	**World Meteorological Organisation**
WS	**Web Service**
WXXM	**Weather Information Exchange Model**
X.25	**Packet Switching Exchange Protocol**
XML	**Extensible Mark-up Language**
XSD	**XML Schema Definition**

Appendix B : overview of TRL levels by the European Commission

TRL level	Description
1	basic principles observed
2	technology concept formulated
3	experimental proof of concept
4	technology validated in lab
5	technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
6	technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
7	system prototype demonstration in operational environment
8	system complete and qualified
9	actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)