PENS/SWIM/AMHS - Concepts

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Scope of the Document

This document provides a formal reference about PENS; SWIM and AMHS based on the presentation carried out during the PG M40 within the framework of PENS roll-out.

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References

[1] ICAO Annex 10 – Aeronautical Telecommunications, Volume II and Volume III

[2] ICAO Doc 9880-AN/466: Manual on Detailed Technical Specifications for the Aeronautical Telecommunication Network (ATN) using ISO/OSI Standards and Protocols, Part II – Ground-Ground Applications - ATS Message Handling Services (ATSMHS), First Edition – 2010

[3] ICAO Doc 9880-AN/466: Manual on Detailed Technical Specifications for the Aeronautical Telecommunication Network (ATN) using ISO/OSI Standards and Protocols, Part III – Upper Layer Communications Service (ULCS) and Internet Communications Service (ICS), , First Edition – 2010

[4] ICAO Doc 9880-AN/466: Manual on Detailed Technical Specifications for the Aeronautical Telecommunication Network (ATN) using ISO/OSI Standards and Protocols, Part IV – Directory Services, Security and Systems Management, First Edition – 2010

[5] ICAO Doc 9896-AN/469: Manual on the Aeronautical Telecommunication Network (ATN) using Internet Protocol Suite (IPS) Standards and Protocols, First Edition – 2010

[6] ICAO EUR Doc 020, EUR AMHS Manual, latest Edition

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1 Introduction

1.1 The purpose of this document is to clarify the concepts of PENS, SWIM, AMHS and their interrelation. These concepts are sometimes used in a broad and often interchangeable manner leading to confusion and potentially wrong assumptions and conclusions.

1.2 Furthermore, the document provides information on current implementations and strategies for the deployment of PENS, SWIM and AMHS aiming to familiarise the reader on the intended use of these technologies within the European framework.

1.3 This document also identifies the most important stakeholders and their roles in the environments defined by PENS, SWIM and AMHS.

2 Document overview

2.1 The document includes the following Chapters:

- The first four Chapters deal with the scope, structure, terminology and abbreviations used in the document.

- The fifth Chapter provides an overview of PENS, which is a common IP based network service across the European Region able to support voice and data communications. It also introduces some notions about the use of VPNs for different services and applications.

- The sixth Chapter describes the concept of SWIM and the functionalities that SWIM intends to provide to the users.

- The seventh Chapter describes the ATS Messaging Handling System, i.e., AMHS. The intention of this chapter is to present this aeronautical messaging system as the logical evolution within Europe of current aeronautical messaging systems, which are AFTN and CIDIN.

- The eighth Chapter describes the different types of communication services explaining the differences between all of them.

- The ninth Chapter raises operational considerations that impact on deployment, inter-working and transition.

- Finally, Chapter 10 provides some useful conclusions about the next steps within the framework of PENS, SWIM and AMHS implementation.

3 Terminology

3.1 All definitions in this document are based on the EUR AMHS Manual, Appendix A.

3.2 The term ATSU (air traffic service unit) is used as synonym for an ACC ground system.

4 Abbreviations

4.1 The following main abbreviations are used in this document:

ACC	Area Control Centre
ACP	Aeronautical Communications Panel (ICAO)
AFSG	Aeronautical fixed service Group (ICAO EANPG)
AFTN	Aeronautical fixed telecommunication network
AI	Aircraft identifier
AIDC	ATS inter-facility data communication
AINSC	Aeronautical industry services communication
AIRAC	Aeronautical Information, Regulation and Control
AIS	Aeronautical information services
AMC	ATS Messaging Management Centre
AMH	Application (profile) Message Handling
AMHS	ATS message handling system
ANSP	Air Navigation Service Provider
ATC	Air Traffic Control
ATN	Aeronautical Telecommunication Network
ATSC	Air Traffic Services Communication
ATSU	Air Traffic Service Unit
CDM	Collaborative Decision Making
DSP	Domain Specific Part
EAMTP	European Air Traffic Management Programme
EANPG	European Air Navigation Planning Group (ICAO)
ES	End System
EUR	ICAO Region Europe
EUR/NAT	ICAO Regions Europe and North Atlantic
FIR	Flight Information Region
IATA	International Air Transport Association

ICAO	International Civil Aviation Organisation
IDI	Initial Domain Identifier
IDP	Initial Domain Part
IDRP	Inter-domain Routing Protocol
MIB	Management Information Base
MSB	Most Significant Bit
MT	Message Transfer
MTP	Message Transfer Protocol
OLDI	On-Line Data Interchange
PICS	Protocol Implementation Conformance Statement
SES	Single European Sky
SNMP	Simple Network Management Protocol
SSL	Secure Socket Layer
SUT	System Under Test

5 PENS Concept

5.1 Current data communications in the air traffic management domain heavily rely on X.25, a technology that is obsolete and phased out (OLDI, ASTERIX, AFTN/X.25 and CIDIN).

5.2 States are promoting the decommissioning of X.25 systems because the technology is difficult to maintain, expertise is hard to find, and, at the end of the day, it is expensive according to those that have this technology widely deployed.

5.3 Nowadays, there are still many inter-ANSP links that are bilateral point-to-point circuits, managed on a bilateral basis.

5.4 PENS is a common facility that allows ANSPs two different IP interconnection possibilities. In those cases where the ANSPs have their own IP networks, they can connect their national IP networks to PENS. In those others where the ANSPs don't have their own IP network, the PENS project can install an access point, consisting of a PENS router, at each location where an IP connection needs to be implemented, in order to provide connectivity with the PENS network.

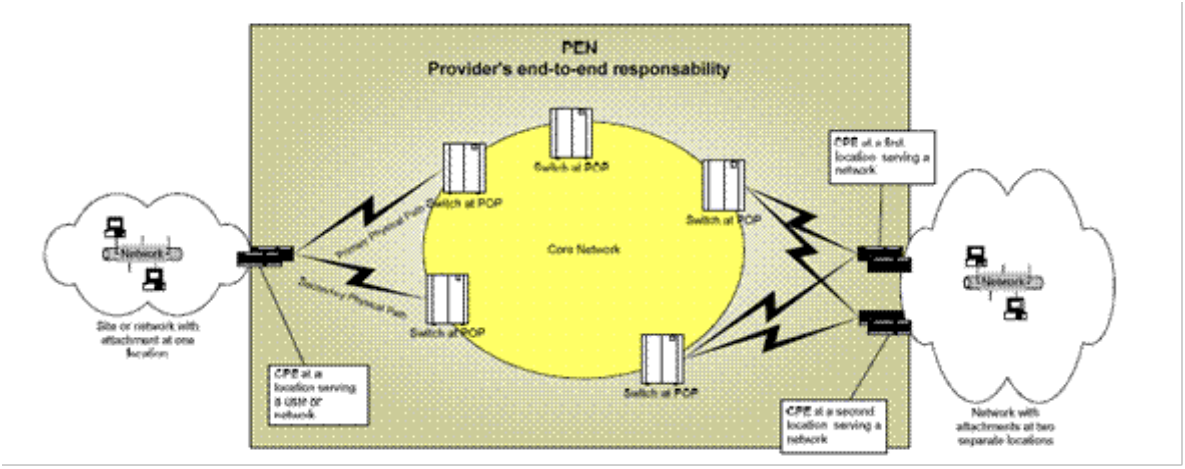

Figure 1 - Possible network lay-out for ANSPs connection to PENS.

5.5 PENS provides a common IP based managed network service across the European Region.

5.6 PENS provides an efficient support to operational data and potentially voice communications: existing services and new requirements from future Air Traffic Management (ATM) concepts including SESAR.

5.7 The objective of PENS is to provide the required infrastructure to guarantee end-to-end IP connectivity for a variety of aeronautical users and applications. In this sense, PENS has been deployed to support existing and future services. Currently three categories of users/services have been defined - CFMU, EAD and ANSPs - and their migration to PENS is ongoing.

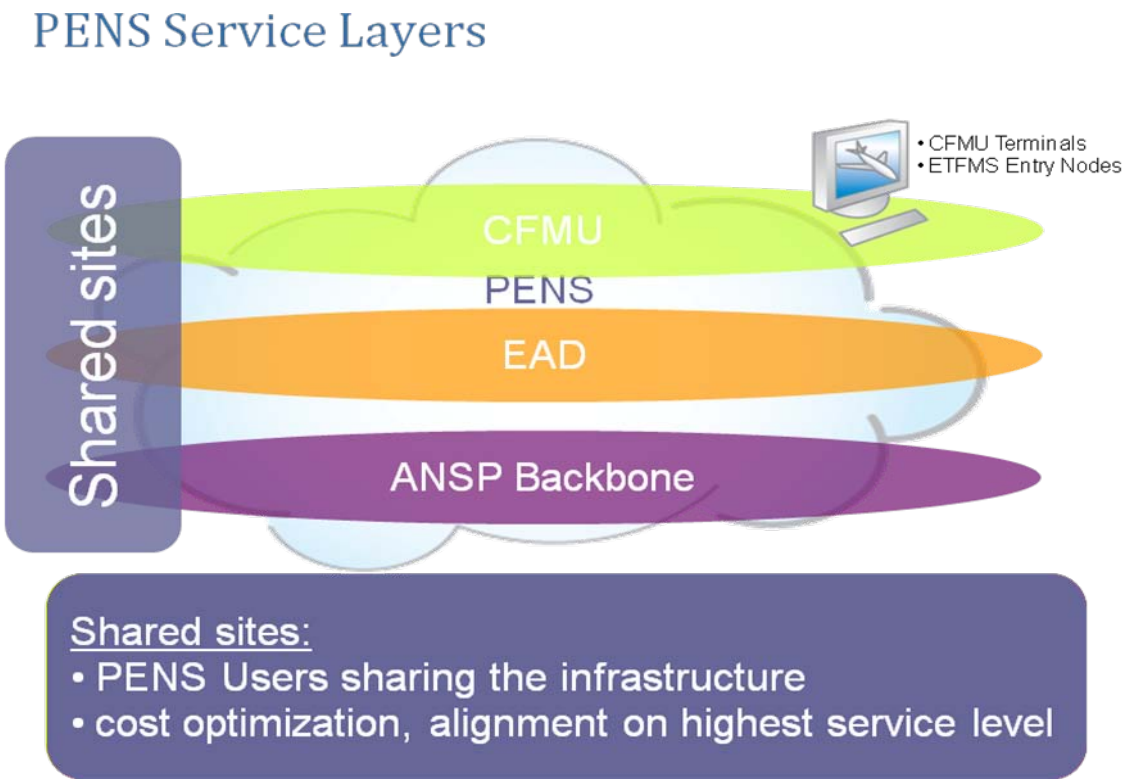

Figure 2.- PENS Services layers with different VPNs: CFMU, EAD and ANSP Backbones.

5.8 The ANSP Backbone service supports among others the AMHS, RADAR and FMTP applications. It is also planned to use the PENS for SESAR validation and testing. Due to the different needs of the various services and users, several VPNs have been defined over PENS. According to the requirements (real time or not) and the purposes (operational or test) demanded by the ANSPs, different classes of service have been implemented.

5.9 Even though it is in the first implementation stages, the future of the PENS seems to be very promising. Already there are requests for the project to expand so as to accommodate ANSPs in the entire EUR Region and beyond. Airlines have also expressed a strong interest to get connected to PENS. In this sense, SITA and ARINC support the idea of the connection with PENS through the specific network devices. This way, ANSPs and airlines would get connected to exchange valuable information strengthening the concept of CDM.

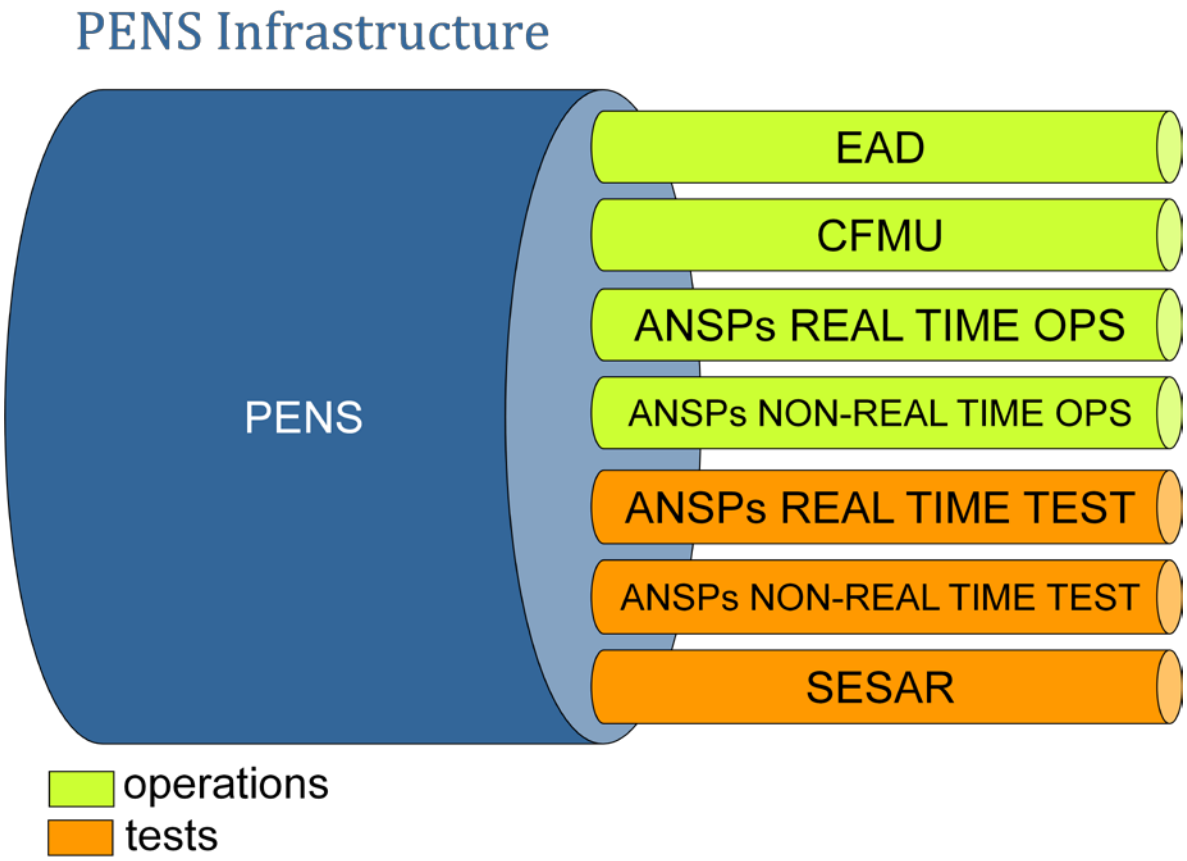

Figure 3 - VPNs foreseen within PENS framework.

5.10 Figure 3 depicts all the VPNs foreseen for PENS. It is essential to notice that there are two sorts of VPNs: Operational purpose VPNs and Testing purpose VPNs. EAD, CFMU and operational ANSP VPNs (real and non-real time) belong to the first class while SESAR and testing ANSP VPNs (real and non-real time) belong to the second class.

5.11 The performance requisites for these VPNs vary depending on each specific service and must be agreed with the consensus of these VPN users.

6 SWIM Concept

6.1 SWIM is a broad global conception currently being analyzed by ICAO. SWIM, as it should be implemented in Europe, in terms of information as well as systems and protocols, is currently being defined in the context of SESAR. FAA as for the USA is also analyzing the concept of SWIM in the context of NEXTGEN.

6.2 SWIM is envisaged as a seamless infrastructure which will accommodate the conveyance of all types of ATM information to users world-wide. In this sense ICAO is supporting the joint efforts that SESAR and NEXTGEN are doing to come up with a global solution.

6.3 SWIM just defines the architecture of a pan-European warehouse identifying the possible users as well as the logical connections that there should be among them.

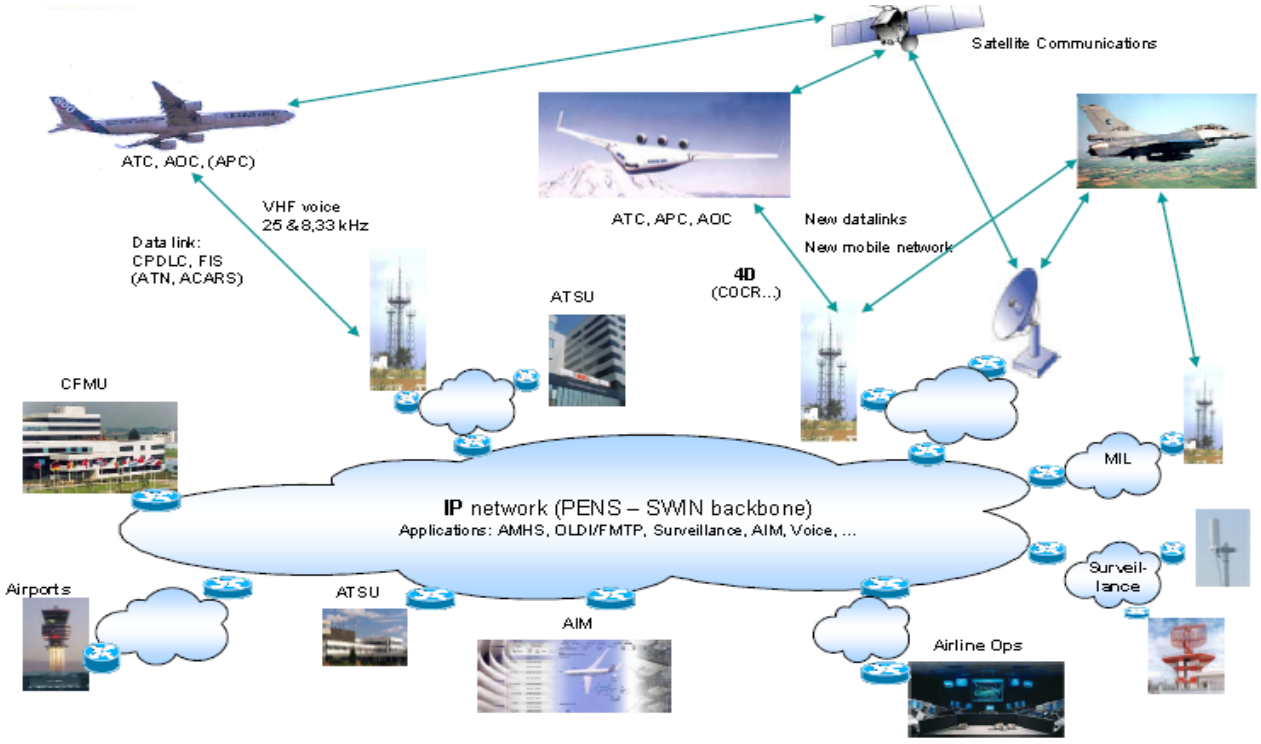

Figure 4 - SWIM potential users.

6.4 As depicted in the diagram above, all the users within the aeronautical environment could potentially access this large information database: ANSPs, aircraft, AOC clients (airlines, airports, etc.), military users, specific ATM service providers (CFMU, EAD), etc.

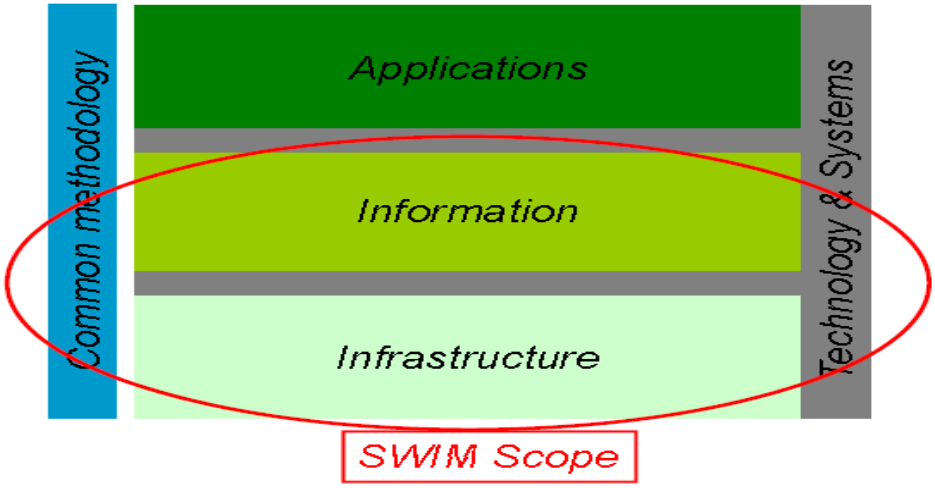

Figure 5 - SWIM stack displaying the interrelation among applications, information and infrastructure.

6.5 SWIM transforms the ATM network into a messaging network, where information is exchanged among the involved entities (airspace users and other ATM users) using two message exchange mechanisms: publish/subscribe or request/reply.

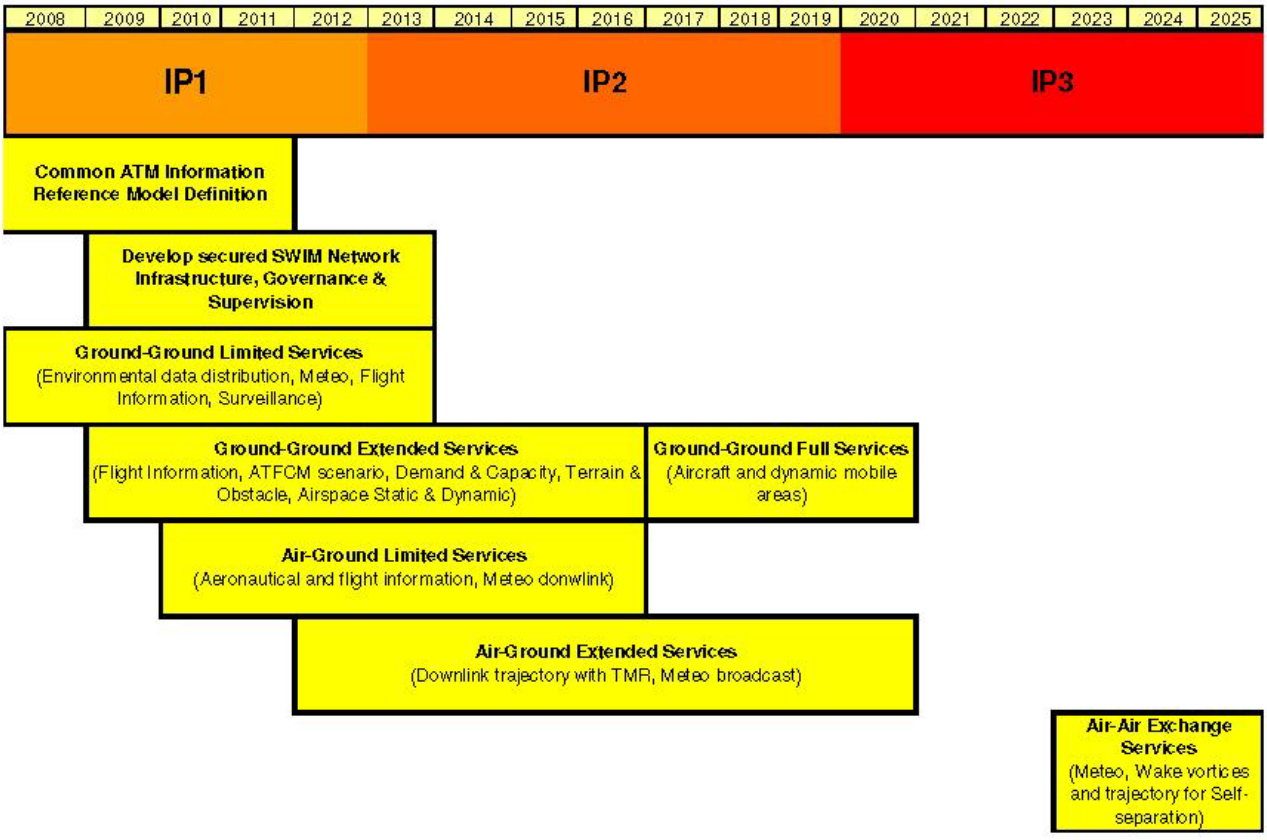

Figure 6 - SWIM roadmap within SESAR framework planning.

6.6 In the publish/subscribe message exchange mechanism users interested in obtaining this information have to subscribe to the system and will receive the required information whenever it is available.

6.7 On the contrary, in the request/reply message exchange mechanism, the client explicitly requests the information it needs at the time it is needed.

6.8 It must be noted that SWIM just explains the potential users and logical connections that should exist among them. Protocols under the application layer should be completely defined.

6.9 Figure 6 depicts SWIM's roadmap within the framework of SESAR.

7 AMHS Concept

7.1 ATS Message Handling System is a message oriented technology designed to support ICAO-based message exchange in line with particular formats and handling requirements as defined by ICAO.

7.2 The exchanged messages include:

- Flight regularity messages, including those exchanged for ATFM purposes;
- Aeronautical information service (AIS) messages, e.g. NOTAMs, SNOWTAMs, ASHTAMS;
- Meteorological messages concerning reports and forecasts (such as TAF, METAR, SPECI);
- Flight safety messages, e.g. movement and control messages, messages originated by an aircraft operating agency concerning an aircraft in flight or about to depart, specific meteorological messages (e.g. SIGMET, AIRMET, etc.);
- Distress messages (including SAR related traffic);
- Urgency messages;
- Aeronautical administrative messages, and;
- Service messages.

7.3 ATSMHS defines a store and forward messaging service used to exchange ATS messages between users over the ATN network.

7.4 The ATS Message Handling System technical specifications are compliant with mature message handling systems standards such as ISO/IEC 10021 and ITU-T X.400.

7.5 Additionally, AMHS is able to support the exchange of binary data – a need already identified in the AIS and MET environment.

7.6 AMHS is the logical evolution of CIDIN in the EUR Region and of the AFTN worldwide. In the case of Europe, the implementation of AMHS will be fostered by the existence of PENS.

7.7 The message switches forming the nodes of the ATS Messaging infrastructure are currently deployed in international COM Centres and operated by the staff of these COM Centres.

7.8 The operational and technical role of the international COM Centres includes:

- Monitoring and operation of the ATS Messaging infrastructure;
- Oversight of the proper conveyance and delivery of message flows;
- On-line network management;
- Specific handling of messages and potential reaction when required; [limited applicability in an AMHS environment];
- Focal management point for adjacent COM Centres and users;
- Traffic logging.

7.9 The precise role of international COM Centres in the future information exchange environment (SWIM after 2020) will probably need to be re-examined, however it would be

safe to assume that the services provided by store and forward messaging and AMHS in particular will be required for the foreseeable future.

8 Types of communication services

Nowadays, three different types of communication services have been identified: message oriented communication services, publish/subscribe communication services and communication services based on the concept of Collaborative Decision Making (CDM).

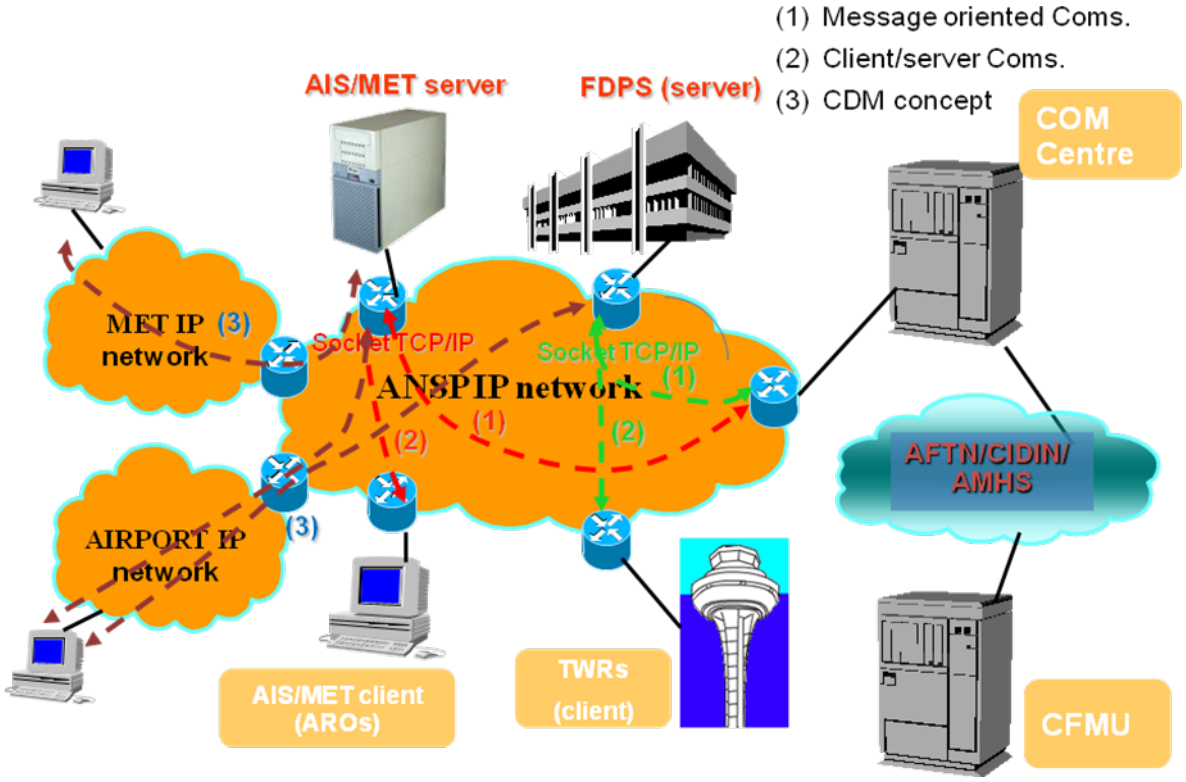

Figure 7 - Different types of communication services introducing the concept of CDM.

8.1 Message oriented communication services

8.1.1 The message oriented communication services have the following characteristics:

8.1.2 Very well known message formats defined by ICAO.

8.1.3 This kind of communication services ensures interoperability on a global basis regardless of user size and technical sophistication.

8.1.4 Some representative examples of this technology are AFTN, CIDIN and AMHS, which are used all over the world.

8.1.5 There are a big number of aeronautical applications based on this approach. The main advantage of this kind of communication services is that since they are message oriented, whenever the message format is compliant with the standard, both entities can understand each other without major difficulties. The associated problem this kind of communication presents is that end national applications have to implement messaging clients - that can be quite complicated.

8.2 Publish/subscribe communication services

8.2.1 The publish/subscribe communication services have the following characteristics:

- They are more efficient solutions used for the exchange of information between systems.
- They can also be applicable to real-time applications.
- Some very well known examples would be web-based solutions and SWIM.

8.3 Communication services for CDM

8.3.1 The Collaborative Decision Making concept requires that all involved ATM entities share the same necessary information to make their decisions:

8.3.2 The concept of CDM consists of two high level elements: the sharing of information related to progress of flights and priorities, and acting on the shared information.

8.3.3 The benefits of CDM are:

- Better use of resources
- Enabling partners to set priorities
- Improvement of the predictability of operations

8.3.4 SWIM is a platform to support CDM, because it enables the information available at each ATM entity to be shared by other entities using standardised interfaces.

8.3.5 Air/Ground CDM could take place in case tactical intervention during flight is considered necessary.

8.3.6 Ground/ground CDM process and information sharing through SWIM would allow sufficiently high accuracy for many processes to be available at the aircraft before the flight.

8.4 Services utilised by EAD

8.4.1 The above services as utilised by EAD are depicted in Figure 8 below:

8.4.2 Two different types of traffic are identified: message oriented and publish/subscribed communications service.

8.4.3 The former is mainly used for message exchange with other ICAO Regions while the latter establishes a publish/subscribed architecture using PENS.

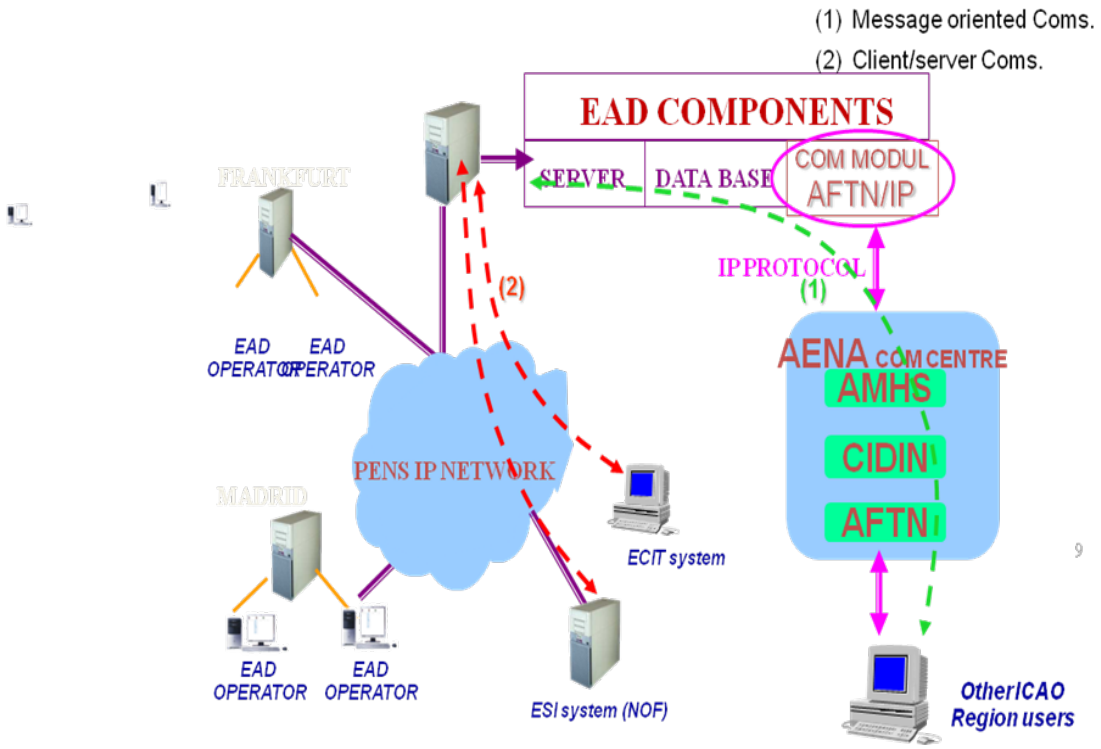

Figure 8 - Type of communication services used by EAD.

9 ATS Messaging and transition to SWIM

This chapter highlights the topics expected to be addressed in the framework of transition from the current ATS Messaging concept towards a communication architecture based on SWIM.

9.1 Functional areas:

9.1.1 The ATS network currently conveys messages mostly related to flights before they are active, but also some messages related to active flights.

9.1.2 In the framework of SESAR, the requirements for ATS/ATFM, AIS and MET related information exchange will be taken into account in the SWIM architecture.

9.1.3 Considering that ATS Messaging is generic by nature and can be used to exchange any kind of message, service continuity for the exchange of other messages, including distress messages, urgency messages, administrative and service messages is expected to be addressed as part of the transition to SWIM.

9.2 Geographical coverage

9.2.1 ATS Messaging based on AFTN/CIDIN/AMHS is a globally adopted standard for ICAO Member States and ANSPs. It provides a common and single interface to all users, hiding the potential heterogeneity of lower layers to the service users. The Regional networks linked by means of inter-Regional connections, provide a global seamless messaging infrastructure.

9.2.2 There is no indication at present that SWIM would be implemented outside the EUR SES and US FAA environment. Furthermore, ICAO is assessing a global solution taking into consideration the outputs from FAA/NEXTGEN and SESAR.

9.2.3 The implementation of a seamless IP infrastructure, such as PENS, to serve as an ICAO global network backbone, would be desirable but not easily achievable within the 2020 SESAR timeframe.

However, the types of message identified in section above and included in SWIM are also utilised outside the EUR/US geographical area (e.g. flight plans, NOTAMs, MET etc.). This means that the systems in Europe communicating via SWIM will also need to communicate directly or indirectly with systems in other Regions which are not “SWIM-capable”, but are presumably still exchanging messages/data using ATS Messaging. Inter-working will be required between the European SWIM environment and the ATS Messaging environment in other Regions.

9.3 Communication model:

9.3.1 ATS Messaging operates with several major characteristics:

A store-and-forward messaging model from one source to multiple recipients;

a) Each message is sent independently of other messages. The system does not provide any “request/response mechanism”;

b) Distribution is based on collective addresses / distribution lists (DLs) which can be operated in a recursive manner: a collective address may contain individual addresses which themselves are collective. This allows collective addresses to operate at various levels, typically one international level for “wide distribution” and one national level

for “local distribution”. Participating in one of these DLs may be seen as the subscription to a service.

c) No need for “synchronous exchanges” (messages are held in case of recipient system being not available).

9.3.2 In the framework of SWIM transition, the major differences in scope and nature between the communication models of ATS Messaging and of SWIM are expected to be analysed. The current information distribution mechanism based on DLs (collective addresses) may form a starting point for the SWIM subscription mechanism.

9.4 Message formats

9.4.1 ATS Messaging being a flexible, multi-purpose communication system, it can convey practically any kind of message format and syntax. In the considered scope, this includes:

d) for character-oriented formats:

i) Structured syntaxes and formats specified in ICAO or other applicable (e.g. WMO) Documents (Doc 4444, Annex 15, etc.) for flight plans, MET, AIS, etc.

ii) Regional or national structured syntaxes and formats (ADEXP, etc.);

iii) Unstructured or free text;

iv) Syntaxes such as XML can be included in a message body, subject to a few constraints (e.g. supported character set);

e) Message body containing binary data:

i) The support of binary data, combined with the absence of restriction on message size or length, makes it possible to convey any kind of data message. The only limit is related to network/system design in terms of capacity and performance.

9.4.2 As part of a transition strategy, it should be possible, if needed, to exchange AIS and MET data in their XML format using ATS Messaging. Although technically possible, such a solution is not expected to be optimal. The co-existence and/or conversion between the formats identified above are expected to be addressed as part of SWIM transition.

9.5 The transitional systems:

9.5.1 Transition approaches for communication systems, when needed, often include conversion gateways, encapsulation techniques and/or dual/multiple stack implementations (co-existence approach). It is obviously too early at this time to identify the most appropriate approach to be adopted during the transition to SWIM period.

9.5.2 However the answers to the following questions should be included in the SWIM transitional work:

ii) Assuming that ATS Messaging is still required for communication with other Regions, to what extend will it need to be maintained within the Region in parallel or as part of the SWIM environment?

iii) Does it make sense to consider multi-stack architecture so that there must be some kind of "conversion gateways" between ATS Messaging environment and SWIM environment? How and where should these gateways be implemented?

iv) If "conversion gateways" are not chosen as transitional systems, this may mean that there is some geographical and functional overlapping between the residual ATS Messaging environment and the SWIM environment. This implies that connected end systems (FDPS, etc.) would be required to maintain dual connectivity. Could this be adopted as a general solution?

v) How SWIM should be protected in terms of legacy when it comes to protocols and messages?

9.6 The role of international COM Centres

9.6.1 The role of international COM centres as foreseen by ICAO and implemented globally will most probably be impacted during the transition to SWIM. It is difficult to assess the magnitude of this impact at this time. The operational and technical role of the COM Centres and of their staff should be analysed when implementing the future SWIM environment, taking into account the need for service continuity, seamless interoperability, inter-regional traffic exchange, requirements at the national level and volume and criticality of residual traffic.

9.6.2 Furthermore, the role of a COM Centre is likely to vary depending on its actual position within the network, and the level of integration to SWIM of the ATS units, airports, originators of ATS, AIS and MET data and other entities it directly serves, as well as the level of integration of its neighbouring environment.

9.6.3 However, if this transition is implemented through the "conversion gateways", the potential impact mentioned above should not be so critical. Indeed, these "conversion gateways" should remove this complexity from the COM Centres.

10 Interworking between ATS Messaging and SWIM

10.1 It is expected that, in order to properly cover the topics identified in this paper, transition work will be performed in close coordination between experts of the target technology (SWIM) and experts of the existing ATS Messaging.

10.2 Although is not likely that SWIM replaces ATS Messaging as a whole and in one single operation, this paper has presented the need of some kind of interworking between current ATS Messaging systems and SWIM.

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