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ALGORITHM OF GUARANTEED-AND-ADAPTIVE CONTROL OF AEROSTATIC VEHICLE UNDER UNDETERMINED EXTERNAL TURBULENCES

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Abstract. *The article is devoted to the analysis of current information management systems and System Wide Information Management. The limitations of current systems and benefits of the new system were revealed. The European experience of System Wide Information Management implementation has been investigated in the scope of Ukrainian information management system.*

Keywords: air traffic management; information management; interoperability; System Wide Information Management; System Wide Information Management architecture.

1. Introduction

In the modern world with the continuously growing intensity of air traffic flow the information is to be delivered timely and accurately.

Today's Air Traffic Management (ATM) system comprises a wide variety of applications.

These applications were developed for specific purposes and exist separately of each other.

Each of them has its own information systems: on board the aircraft, in the air traffic control centre, etc.

Each of these interfaces is custom designed, developed, managed, and maintained individually and locally at a significant cost.

That is why the current ATM system is complex and information exchange is ineffective.

One of the major weaknesses of current system is considered to be the limited interconnectivity of services and systems.

Moreover, the limited data sharing and bad interoperability of the systems all contribute to airspace capacity not being optimally used.

To solve this problem both the SESAR and NextGen have developed the concept of System Wide Information Management (SWIM).

2. Analysis of researches

By the definition SWIM is an enabler that facilitates interoperable information exchange in the European ATM system and consists of standards, infrastructure and governance enabling the management of ATM information and its exchange between qualified parties via interoperable services [3].

The goal of the SWIM program, according to the program acquisition lead, is to "operate in the background to provide seamless information to users who have a valid need for the data."

The implementation of SWIM is a rather evolutionary process that is based on a gradual transition towards a service-oriented European ATM system.

The objective of information management is to collect, organise, control, process and deliver information in order to provide the decision makers and information users with the right information at the right time and in the right place.

3. The drawbacks of current information sharing in ATM

The main weaknesses can be classified into 4 categories:

– interoperability and information exchange;

– standardised information models;

– availability, sharing and management of information;

– new technologies.

Interoperability and information exchange. Any air navigation systems organisation has individually worked on solving their own information management problems, and the information exchange between domain systems significantly improved.

But this has been done without considering the need for global interoperability.

The current level of interoperability between domain systems in Europe is extremely low.

This occurs because of the fragmentation of systems and overall lack of a common understanding of what needs to be standardised.

It limits the coordination between the parties in prioritising the allocation of resources.

The result is inefficient and non-collaborative use of the available capacity, and a lack of flexibility to cope with unusual occurrences.

Standardised information models. The current European ATM system lacks a standardised (digital) information format and model (Fig. 1).

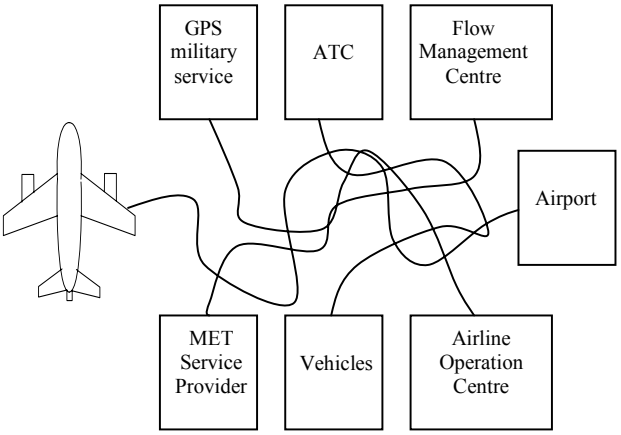

Fig. 1. Current information sharing in the ATM system

This is due the lack of consistency of the information contained in various databases.

It is also a severe weakness for a network which aims to share information to improve services and introduce advanced automation.

A well-defined, consistent information structure which enables a cohesive set of databases to be used is needed.

Availability, sharing and management of information. Poor information sharing and management prevents proper coordination between all stakeholders, resulting in less effective use of available assets and thereby hidden costs to the airspace users in the form of operational inefficiencies (Fig. 2).

New technologies. The current technologies in operation can support growth within the current Air Traffic Control (ATC) paradigm, but the implementation of new technologies, together with a change of paradigm for the performance of ATM, is considered essential to support traffic growth of the forecast level.

The legacy information architecture and technology cannot easily adapt to the use of up-to-date methods for data exchange, and will need to evolve bearing in mind the security requirements considered necessary to meet emerging cyber security threats.

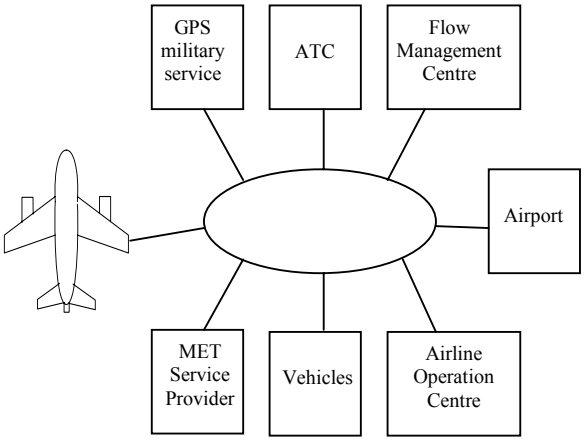

Fig. 2. Information sharing with implementation of SWIM

The following figures show the current information exchange and the future information sharing with implementation of SWIM.

4. Building swim

According to Eurocontrol's documentation, in order to build SWIM it necessary to define such elements of the system:

– standards;
– governance;
– infrastructure;
– SWIM-enabled applications.

Standards. This element will represent the standard definitions of all ATM information, through harmonized conceptual and logical data models.

As it is stated in SESAR Programme, this will be instantiated in the ATM Information Reference Model.

That is an ATM services model, which represents the logical breakdown of required information services and their behavioral patterns.

The SESAR Program has decided to instantiate these services in the Information Service Reference Model.

Governance. This element is the information management functions.

For example: operational and organizational functions for the management of user identities, discoverability of resources, security solutions for aspects such as authentication, encryption and authorization, notification services and registration.

These functions need to be defined to support information sharing.

The SWIM governance functions affect almost all of the roles and their interactions within the European ATM system.

Infrastructure. The element is represented be the SWIM technical infrastructure and is the interoperable (runtime) infrastructure (ground/ground and air/ground) over which SWIM services are provided and ATM data are distributed, shared and consumed.

Depending on the specific needs profile, its implementation may differ from one stakeholder to another in terms of scope and type of implementation.

SWIM Air/Ground will allow aircraft to access ground-based SWIM.

It will complement the existing datalink applications that provide end-to-end data exchange capabilities between aircraft and the ground. SWIM Air/Ground will enable information sharing between aircraft and multiple ground SWIM enabled systems.

SWIM-enabled applications. The application of SWIM standards and principles to the interfaces of ATM applications enables ATM business benefits by assuring the provision of commonly understood high quality information to the right people at the right time [3].

5. SWIM architecture

The Fig. 3 graphically shows the architecture of SWIM .

The reference model for ATM information will provide harmonized conceptual and logical data models.

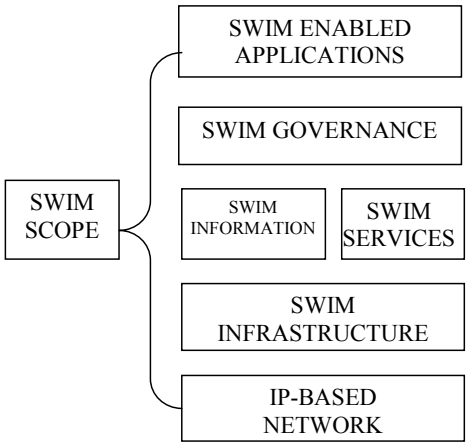

Fig. 3. SWIM architecture

This will cover all domains of ATM operations: aeronautical information, flight, meteorology and surveillance.

The reference model for information services will provide the logical breakdown of required information services and their behavioural patterns.

The principles of governance and information management functions: such as user identity management, discoverability of resources, security aspects including authentication, encryption and authorization, notification services, registration need to be defined to support information sharing.

SWIM governance affects almost all the roles and their interactions within the ATM system.

In addition, the management of information requires that policies related to the access and uses of information are developed.

Rules, roles and responsibilities need to be defined, per stakeholder, taking into account the functional criticality of the information they handle.

Data ownership, data provision and data usage rules will need to be redefined and harmonized. Issues such as liability, charging and copyright principles should be managed.

SWIM infrastructure is the interoperable (runtime) technical infrastructure (ground/ground and air/ground) over which the data will be distributed.

Its implementation may, depending on the specific needs profile, differ from one stakeholder to another, both in terms of scope and way of implementation. It will offer SWIM technical services based as much as possible on mainstream IT technologies. It will preferably be based on commercial off-the-shelf products and services, but it is possible that in some cases specific software may need to be developed.

Typically dedicated and secured IP networks and the Internet will provide the underlying basic ground/ground connectivity; and ground/air (up and down).

Furthermore, SWIM enabled applications are applications that make use of or share information and information services provided through SWIM.

Fig. 4 shows which exactly characteristics of SWIM are expected to be in the future.

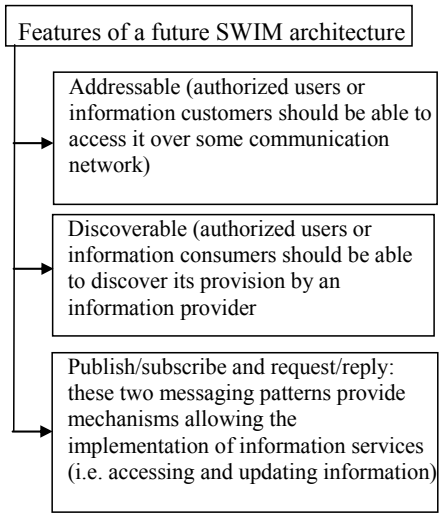

Fig. 4. Features of future SWIM architecture

6. SWIM Registry Service

Alongside the SWIM concept – the SWIM Registry Service aims at improving the visibility and accessibility of ATM information and services available through SWIM. It describes the complete set of services enabled by SWIM with qualitative, consolidated and structured information.

The registry is also the source of reference for other service related information such as standards, policies and certifications.

Safety considerations and the respect for integrity, confidentiality and availability of information are key elements of the registry's design [2].

The Fig. 5 above shows us the interaction between the participants of the Registry service.

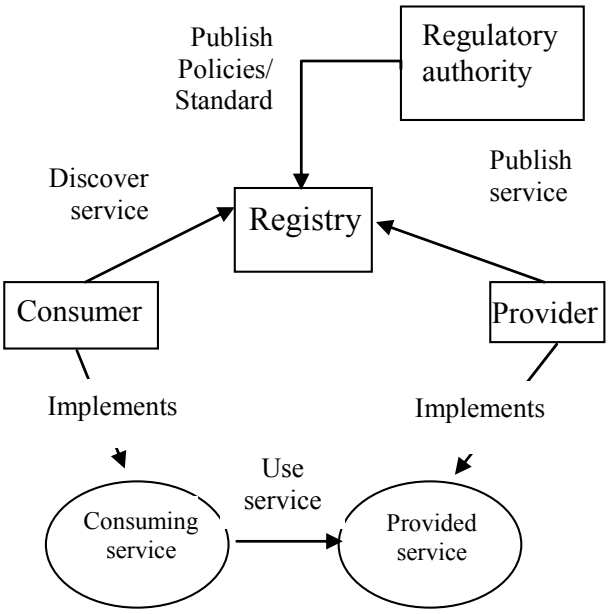

Fig 5. The Diagram of the Registry Service

Accordingly to it the Registry is the database, where the services enabled by the provider and the policies and standards set by the authority are published.

The consumer can discover those services and find anything hat he needs to use those services.

7. European experience

A SWIM Concept of Operations has been created which includes:

– SWIM Definition
– SWIM principles
– the rationale for change
– the associated benefits.

It also captures practical examples of SWIM pioneers that explain their gradual evolution towards SWIM.

Since 2011, live SWIM demonstrations have been organised annually to demonstrate that the supporting technologies are sufficiently mature to make SWIM a reality.

In an effort to truly engage with a wide stakeholder community a SWIM Masterclass has been created.

Its objective is to further develop and demonstrate the added value of the latest advances in information technology for ATM.

At the present time, the SWIM Masterclass has gathered the support of almost a hundred organisations and their experts and is trying to begin connecting the whole air traffic management community.

An important aspect of the SWIM developments is a fully integrated service orientated architecture approach which will use services as the mechanism to support the ATM stakeholders sharing, visualising and processing ATM information.

The basis of this principle is to split the consumers of information and the procedures of it.

This decoupling makes it easier to define concerns and responsibilities and consequently increases the flexibility and agility of the ATM system.

In spite of the good progress made, the work is far from being finished.

The actual integration of SWIM into the different ATM components can only take place in an evolutionary manner and further development of SWIM governance, compliance, and deployment aspects will still take a considerable amount of time and effort [4].

In terms of Pan-European stakeholder coordination and consultation, an AIM/SWIM Team has been established.

The AIM/SWIM Team is a technical and operational, specialist advisory body, established within the framework of Eurocontrol, which provides a direct means of consultation between all stakeholders involved in activities pertaining to performance and delivery aspects under the tactical (technical) development/deployment level for SWIM [4].

8. Conclusions

The SWIM is a new system that will, as a result, improve the shortcomings of the current provision and management of ATM related information.

The system is being under development by both the SESAR and the NextGen organizations that will lead to a better standardization and globalization of information exchange in ATM system.

The global improvements in information management are intended to integrate the ATM network in the information sense, not just in the system sense, and are envisioned to be applied as a system-wide information management concept.

The implementation of SWIM will bring the benefits to all the parties in the information exchange process by the more accurate and easy access to information.

So, it is possible to say that the Europe has made a good progress with the implementation of SWIM.

Ukraine as a country with constantly increasing intensity of air traffic should also be involved in the implementation and development of SWIM for the sake of better ATM.

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М. М. Богуненко[1], Ю. В. Радченко[2]. Упровадження концепції організації всеосяжної системи інформації SWIM в систему управління інформацією України

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Проведено аналіз систем обміну даними і концепції організація всеосяжної системи інформації SWIM**.** Виявлено недоліки теперішньої системи і переваги нової системи. Досліджено європейський досвід упровадження SWIM. Виконано огляд системи організації інформації в Україні.

Ключові слова: архітектура SWIM; обмін інформацією; організація повітряного руху; сумісність; SWIM.

Н. Н. Богуненко[1] , Ю. В. Радченко[2]. Внедрение концепции организации всеобъемлющей системы информации SWIM в систему управления информацией

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Проведён анализ современных систем обмена данными и концепции организации всеобъемлющей системы информации SWIM. Выявлены недостатки нынешней системы и преимущества новой системы. Исследован европейский опыт внедрения SWIM. Выполнен обзор системы организации информации на Украине.

Ключевые слова: архитектура SWIM; обмен информацией; организация воздушного движения; совместимость; SWIM.

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