Somosi Vilmos

INFORMATION INFRASTRUCTURES IN AIR TRAFFIC MANAGEMENT

The Air Navigation Service Providers (ANSPs) are facing new challenges of air transportation demand as a consequence of the global economic growth. The new concepts and developments however are envisaging a centralised environment of Air Traffic Management (ATM), where roles, responsibilities of critical infrastructure elements will definitely change. The envisaged integration and regionalization of services will also alter the information infrastructure of ATM.

Keywords: *data service provision, virtual centre, remote tower, liberalization of ATM, disruptive technologies*

INTRODUCTION

The Air Navigation Service Providers are facing new challenges of air transportation demand as a consequence of the global economic growth. According to the annual global statistics of the International Civil Aviation Organization (ICAO), 3.8 billion passengers travelled on scheduled flights in 2016, 53 million tonnes of freight were carried and 35.4 million aircraft movements were registered. As stated by ICAO long-term air traffic forecasts, cca. 10 billion passengers are expected to travel, while the number of aircraft departures is projected to 95 million by 2040. These estimates seem realistic, especially if we consider the fact that the world's major airframe manufacturers delivered 1520 new commercial aircraft in 2016 and recorded 1555 new orders from the airlines [1].

Moreover, the most compelling counterpoint is the raising demand pushing against the limits of the already saturated sky by the rapidly growing drone operations and unmanned passenger and freight transport, not only in en-route environment but also in the lower segments of the airspace [2].

This continuous augmentation is experienced in the European region, and this challenge can only be handled by developments of Air Navigation Service Providers (ANSPs) contributing to several programs to satisfy the extra capacity demand. These concepts and projects however are envisaging a new environment of Air Traffic Management (ATM) infrastructure, where ANSPs roles, responsibilities and their interrelations will definitely change when giving answers to these industrial challenges. The industrial reforms also raise the questions e.g. how the new players will fulfil the requirements of the critical infrastructures, will the new centralised systems be interoperable with all national assets, how the civil and military standards would accommodate to the new demand, and last but not least, what kind of contingency measures should be taken in order to provide service continuity for the European air traffic.

UNIFYING THE EUROPEAN AIRSPACE

The Single European Sky (SES) is an EU initiative launched in 2004 in order to improve Europe's airspace capacity and enhance the ATM services in a structured way. Its purpose is to modernise the European airspace structure, standardize and develop Air Traffic Management infrastructure (technologies, procedures, protocols, human resources competences etc.) so as to ensure forecast growth in air traffic can be met safely and sustainably, operational costs are reducing while environmental performance is improved. The SES ensures better usage of the saturated airspace and Europe's aviation industry can remain globally competitive. [3]

According to the latest statistics of the European Network Manager (EUROCONTROL) of 2017, 4500 airspace users generated 29.057 aircraft movements (3.49 million passengers) daily (average), operating in 43 states and 530 airports, and handled by 68 air traffic control centres. The annual 10.6 million flights (which is a 4.4% increase compared to 2016 statistics) suffered the average 0.88 minute/flight ATFM[1] en-route delay that should be further minimised or even eliminated [4].

The European Commission, in accordance with the major European airlines association[2], urges operational changes in Air Navigation Services and in particular Air Traffic Management, hence it is setting regulations to enforce member states and their ANSPs for enhanced service provision and, where applicable, to create unified environment. One example of this kind of compulsory collaboration is the Functional Airspace Block (FAB) "*where provision of air navigation services and related functions are performance-driven and optimised with a view to introducing, in each functional airspace block, enhanced cooperation among air navigation service providers or, where appropriate, an integrated provider*" [5].

Establishment of nine FABs (seen on Figure 1) raises the question to be answer foremost: what is the geographical scope where capacity enhancement is expected by implementation of regional and centralised functions and services. The Network Manager (EUROCONTROL) develops and runs the European ATM network (covering 43 countries) which is larger Area of Responsibility than the geographical scope of EU regulated FABs. Ukraine, Turkey and other Partner States of EUROCONTROL, who are also inevitable players of the pan-European en-route network and play significant role if harmonised ATM infrastructure consolidations is envisaged.

Unifying the European Airspace also means that procedures have to be standardized and systems should be integrated. There are different views and interpretations about services related to air navigation, namely whether these functions could ever be liberalized in a formulating competitive environment which also can result reduction of ANSPs as well as reforms of information infrastructure. The Air Navigation Service Provision and Air Traffic Management will change anyway as new players and challenges are already seen in the horizon: due needs of passengers (commuting in long distance, urban mobility) and the global economy growth, in the near future air vehicles will be more autonomous, more inter-connected and more intelligent, with faster speed and longer endurance. New assets such as drones (or as we should call

[1] Air Traffic Flow Management

[2] Airlines for Europe (A4E) founded by Europe's five largest airline groups (Air France KLM, easyJet, International Airlines Group, Lufthansa Group, Ryanair) that assures cca. 75% of the Europe's passenger journeys by 2,700 airplanes and 300,000 employees

them “robots with wings”) will also claim their share of the airspace. New technologies e.g. Internet of Things, quantum computing, big data or artificial intelligence are opening a new epoch with many opportunities and challenges of the European aviation industry. [6] The present form of the ATM industry seem to face with a drastic (r)evolution by turning its services towards remote technologies or centralization.

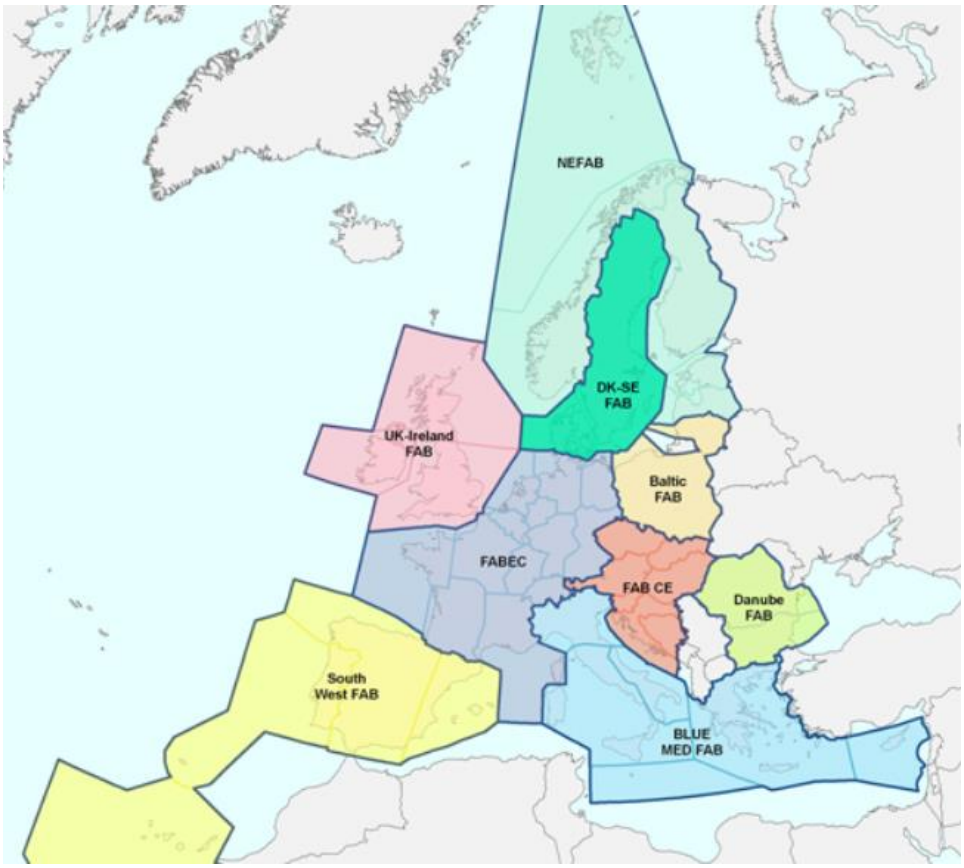

Figure 1. Functional Airspace Blocks [(Source: European Commission)

LIBERALIZATION OF EUROPEAN AIR NAVIGATION SERVICES

Expansion of the above mentioned new technologies and European Commission’s reform intentions with more and more strict EU legislation (which is binding only for member states and countries who are committed to achieve SES goals) are changing the monopolistic Air Traffic Management industry to a competitive environment. Due to the slow progress and different behaviour of the member states, there are several scenarios how the aviation value chain would transform in the next 5-15 years. The challenges of ATM evolution seem to transform into a few possible scenarios (or theoretically, evolutional steps/milestones) in the next 25-35 year timeline.

Status quo

Number of ANSPs do not or slightly change (due to majority of the States opposing the EU ambition, only some company-fusion on a voluntary basis might occur), but the requested capacity development will be assured by investments of technology developments. Considering the slight air traffic growth rate in the next 10-20 years, ANSPs can gain extra capacity by

implementing new technologies and procedures (e.g. regional free route implementations) as well as harmonized ATCO and ATSEP trainings.

Regional consolidation

Several bi/multilateral collaboration where the number of stakeholders are reduced. This step would be achieved either by law enforcement (e.g. upgraded SES regulations, top-down legal environment for functional airspace blocks) or on a voluntary basis (as a deliberate 'runaway' of stakeholders who want to stabilize their position in their Area of Responsibility or even in the new market environment). The regional air traffic service provision projects consolidation of airspace architecture and procedures. There are already some international examples to the joint service provision in an integrated airspace:

- **United States of America**: the Federal Aviation Administration (FAA) provides Air Navigation Services in 22 Area Control Centres, 123 airport control towers and more than a hundred TRACONs[3] (133 TWR/TRACON, 27 TRACON) [7];
- **Africa**: an international public institution called ASECNA has been providing air navigation service provision since 1959 in 6 Flight Information Regions (FIRs) covering the territory of 16 African member countries[4] and Madagascar to establish a single African sky. ASECNA is managed with an active contribution of France [8];
- **Central America**: COCESNA is a non-profit public service organisation established by Costa Rica, Honduras, Guatemala, El Salvador and Nicaragua in 1960 (Belize acceded to COCESNA in 1995). It holds the exclusive rights for air traffic service provision, aeronautical telecommunications, NAVAIDS and Aeronautical Information Services over the territories of the member states and contracting parties [9].

It is important to highlight that the above mentioned examples are fundamentally different than the European progress: those working environments were developed as a joint service provision since the beginning, therefore the participating partners don't have the political or financial reason to position themselves due to lack of competition. However, the collaborating European states and their ANSPs are just about to find the way for the consolidation (so called liberalization) progress.

Nevertheless, to give European example, NUAC[5] establishment by Denmark and Sweden, where both parent ANSPs operations (LFV and NAVIAIR) were integrated into the joint enterprise in 2012. [10] However this entity still use the 3 centres of the parent companies, it is the first and very remarkable step towards consolidation.

In summary, the regional consolidation most likely can give a boost to the expansion of disruptive, remote or centralised technologies, since the joint service provision has to cover wider

[3] Terminal Radar Approach Control Facilitiy

[4] Benin, Burkina, Cameroon, Central Africa Republic, Congo, Ivory Coast, France, Gabon, Guinea, Guinea Bissau, Equatorial Guinea, Madagascar, Mali, Mauritania, Niger, Senegal, Chad, Togo, Union of Comoros

[5] from 1 july 2012 Nordic Upper Area Centre (NUAC) is running the three Air Traffic Control Centres in Copenhagen, Malmoe and Stockholm and provides en-route operations to DK-SE Functional Airspace Block

geographical scope by increased number of data sources transferred via multiple telecommunication links. This liberalized European ATM service chain would result reduction of providers i.e. ATS units (air traffic control centres) [11].

Expansion of disruptive technologies

Airframes are to be responsible for self-separation as well as auto-navigation, consequently fewer providers are to operate in the new service environment. Roles and responsibilities (operational profile) of service providers will also change significantly: satellite and (standalone or standby) ground based NAVAID providers[6], ATM data providers, Virtual Centres as new Air Traffic Service Providers would remain on the scene. This new stakeholder-classification definitely change playing field and re-position today's stakeholders (ANSPs), if they ever can remain. As a result of remote and centralised technologies, service provision will be independent from its original location. Air Traffic Management units will change their monolithic ATM system to service oriented architectures. In the future Virtual Centres controller working positions will be decoupled and separated from the ATM Data Service Provision (ADSP). ATM Data Service Provider hosting services will provide the necessary information one or more ANSPs' Virtual Centre. Virtual Centres subsequently will operate as ATM Data users [12]. Remote solutions in the future can replace the 'local' tower, approach or en-route air traffic services [13].

As an example, in the re-opened Kosovo upper airspace HungaroControl is providing en-route services since April 2014 by using surveillance, radio and flight data from the adjacent ANSPs. This solution can be used only with high number of available assets (providing redundancy in a certain region) and requires secured communication network. The telecommunication network is provided by commercial actors as it is the most convenient solution, while data encryption is the responsibility of the ANSPs [14].

Automated aviation and Air Traffic Management

The self-driven aircraft and auto-separation will eliminate today's ordinary Air Traffic Services. Only regional Air Traffic Flow Manager(s) would monitor and supervise the continental air traffic stream with a close cooperation of contingency units who would be responsible to handover the control of air traffic in a certain area in case of emergency situation (signal outage, loss of communication, on-board malfunction, etc.).

Automation in safety critical Air Traffic Management, and in particular Air Traffic Control, generates many advantages such as capability increase, workload reduction, complex computations and sophisticated conflict prediction, that overall can lead to an increased performance reliability. On the other hand, automation applications can have disadvantages e.g. partial or full loss of situation awareness for the air traffic controller. "*Being aware of the delicacy required to implement automation in the safety critical ATM environment, the understanding of the operators' acceptance mechanism in terms of which elements are actually driving the acceptance of automation and where along the various levels of automation user support 'tips' into scepticism or even refusal to cooperate, is seen as a critical contribution to automation implementation*" [15].

[6] companies providing Communication, Navigation, Surveillance services

The envisaged steps towards displacement, centralisation and automation will require proper change management in order to get a full support from involved staff. The new working environment will need secured and redundant data-communication network which is a high performance functional information infrastructure [16]. As of today, these systems and datalinks are often operated jointly (civil-military) due to economic and national security interests. Most likely the communication lines will be operated in the same way in the future. Consequently, stakeholders have to fulfil the civil and military requirements as well in case of centralised service provision.

INTERCONNECTIVITY, HYPERNET, DATA PROCESSING

These new technologies e.g. centralised functions, quantum computing, big data analysis, 4D flight trajectory management, artificial intelligence and remote control positions are fundamentally reforming the aviation sector as well as Air Traffic Management. The new solutions will require tremendous amount of data gathered from different (international) sources and high speed intra/internet connectivity with adequate cyber security protocols.

Nowadays, ANSPs usually operate a monolithic ATM system with few information services and infrastructure. Information is generated mainly individually, only the necessary data is shared and forwarded to the partners, like neighbouring ANSPs, the Network Manager (centralised unit located at EUROCONTROL Headquarters in Brussels responsible for the system-wide Air Traffic Flow and Capacity Management) and also the military (e.g. Command and Reporting Centre responsible for national/NATO Air Defence and Air Policing duties). Recognized air picture in the NATO Integrated Air Defence System is built up by using data received from military and civil sensors and flight information provided by ANSPs.

The very simple block diagram in Figure 2. shows the three main elements of a national ATM environment i.e. data sources, ATM data processing system and controller working positions.

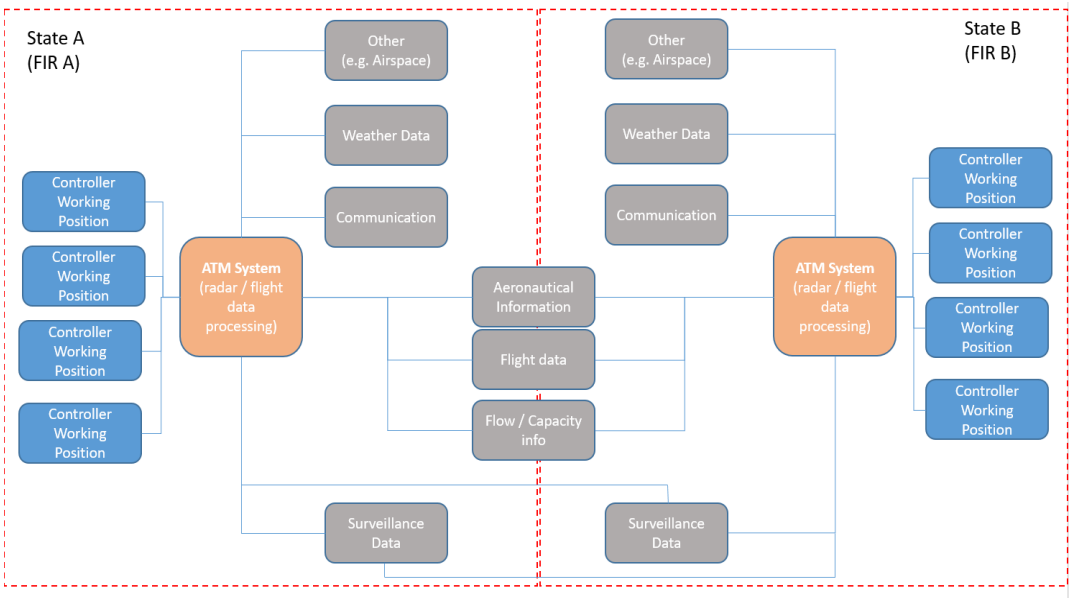

Figure 2. Monolithic civil ATM environments [Author]

As the Hungarian example of service provision in the relatively small Kosovo upper airspace demonstrates, multiple data sources (sensors) from the adjacent ANSPs, tripled air-ground radio

connectivity assure full coverage of the airspace and grant the non-stop (24/7/365) service continuity for the operations.

Duplicated ground-ground coordination lines between the designated ANSP (HungaroControl) and the adjacent area control units are also indispensable for the smooth traffic flow management and transfer of responsibility. [14] This solution shows in reality, that there is no limitation in distance between data sources and ATM data processing elements.

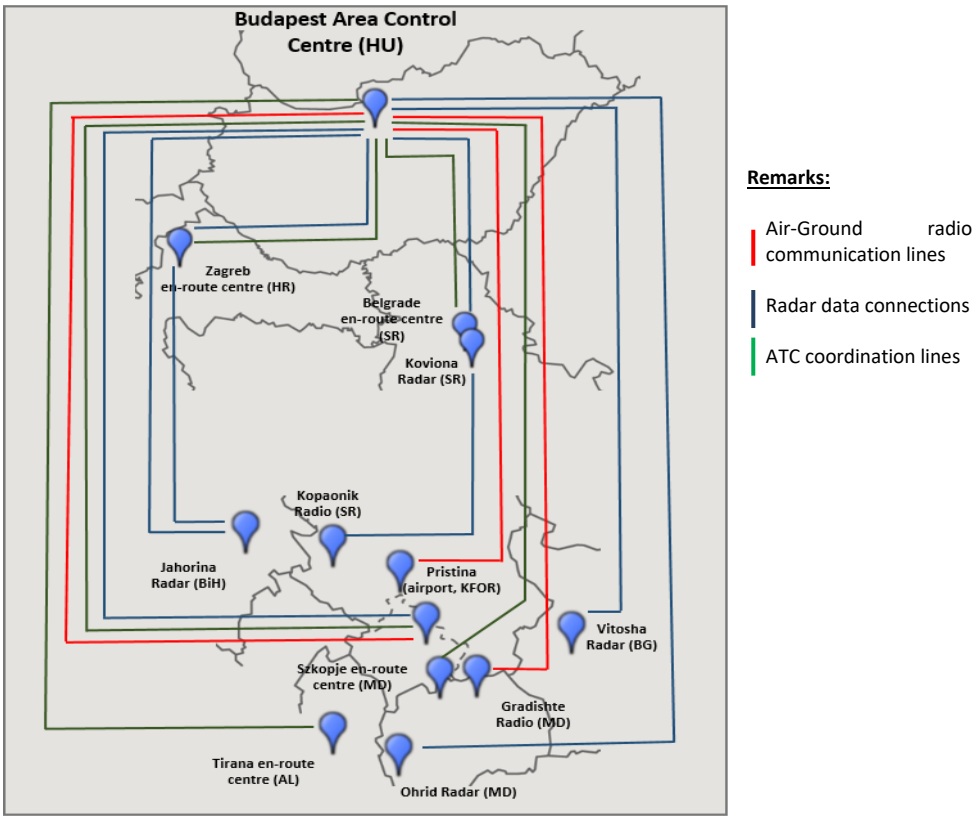

Figure 3: Datalinks for Kosovo Upper Area service provision [14]

Virtual Centre model is also focusing to geographical decoupling of ATM Data Service Provision (ADSP) from Air Traffic Service Units (ATSUs). In this concept ATM Data Service Provider hosts services by providing the necessary information to Virtual Centres (ATM Data users) and is responsible for ATS in their Area of Responsibility. [12] The first Virtual Centre demonstration[7] held in 2016 verified that necessary data (surveillance and correlation, flight data distribution and management, coordination and transfer by NATS[8] and EUROCONTROL) can be exchanged between different data service systems (i.e. ADSP) and controller working positions (CWPs in Brétigny) through a System-Wide Information Management broker (SWIM) [18].

Another virtual centre R&D activity is the EU co-financed[9] AdaaS (ATM Data as a Service) project with the collaboration of Slovenia Control and EUROCONTROL Maastricht Upper

[7] Project partners: EUROCONTROL (Brétigny), NATS (Southampton), Skyguide and SkySoft-ATM (Geneva and Vienna), Frequentis (Vienna)

[8] ANSP of the United Kingdom

[9] The 3 year long project (2015-2018) is co-financed by the European Union's Connecting Europe Facility (CEF)

Area Centre (MUAC). This activity also justifies that data processing can be decoupled from its original location (domestic data source and data usage). The study investigates the extent to which ATM data services can be provided by an ATM Data Service Provider's interoperable ATM system to one or more civil Air Traffic Service Units. Furthermore, the project aims to deploy new technologies and best practices to the concept of ATM Data Centres [17].

The AdaaS study focused to the assessment how an ANSP's information and communications infrastructure should be upgraded to receive data from an ATM Data Service Provider which is located from a long distance (in a non-neighbouring country). The demonstrator (Slovenia Control) received data from local radars, used tracking and safety net services, but these functions and systems were fed by remote flight data processing system services operated in the Netherlands (MUAC). In addition, the MUAC controller working positions and HMI (Human-Machine Interface) were also installed in Slovenia Control to demonstrate independency of the data sources, data processing and controller positions by using commercial communication network to establish interconnectivity among the essential parts of the system.

The remote Tower solution of HungaroControl demonstrates that Air Traffic Service provision can be independent from the local environment, with the support of a digital platform for visualization. Augmented reality is built up by information received from cameras located in the pre-identified hot spots around the airport. Air traffic controllers can monitor real-time images on a video wall that utilizes latest technologies: some cameras have a pan-tilt-zoom function and able to transit information in extreme weather conditions as well using infrared technology that provides enhanced visibility. In addition, the live picture is labelled with graphic symbols and data. These innovations can improve the situational awareness of air traffic controllers, thus aviation becomes even safer [19].

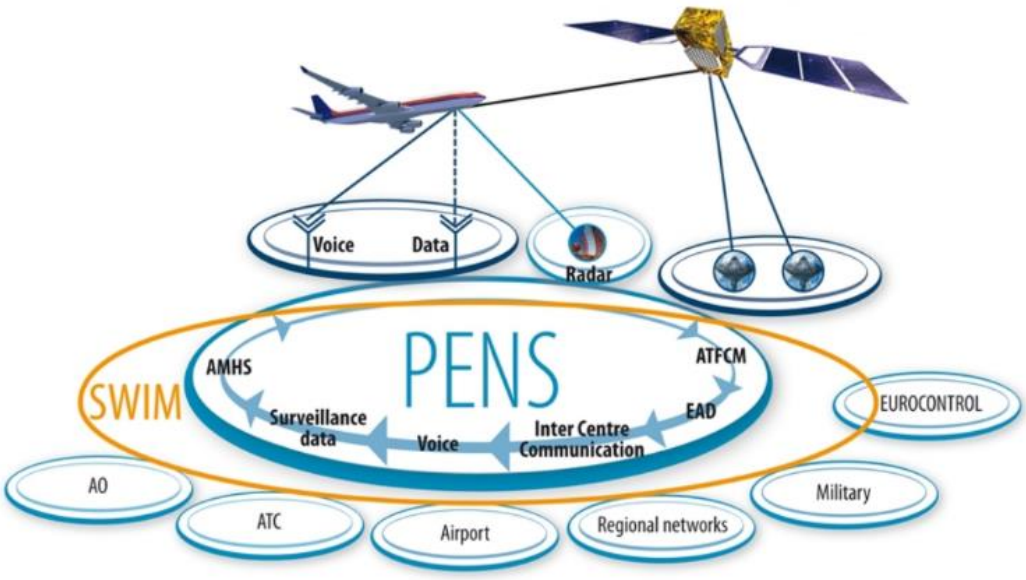

Figure 4: PENS and SWIM [21]

with 2.45 mioEUR and monitored by the Innovation and Networks Executive Agency (INEA)

Using the above mentioned technologies require secured and redundant intra/internet connections to share relevant, up-to-date and standardized data among stakeholders (in this context pilots, airport and airlines operations centres, ANSPs, meteorology service providers, military). The concept of the previously referred System Wide Information Management (SWIM) should cover a complete paradigm change of information management of the pan-European ATM environment (ATM systems, data domains and business trajectory phases (planning, execution, post-execution) managing aeronautical data, flight trajectory, aerodrome operations-related or meteorological information, air traffic flow, capacity and also surveillance data [20].

Together with SWIM concept, the pan-European network service (PENS) is an international ground/ground communications infrastructure initiative jointly implemented by EUROCONTROL and the European ANSPs with the aim to meet air traffic communication requirements. PENS will provide a common IP-based network service in Europe including voice and data communication and efficient support to existing and also to the new services [21].

RISKS AND CHALLENGES OF REMOTE TECHNOLOGIES

As of the European Council Directive 2008/114/EC on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection, air transport (thus the ATM systems too) are part of the national critical infrastructures. [22] By its definition critical infrastructure' means assets, systems which are substantial for maintaining the vital societal functions such as health, safety, security, economic or social well-being of people, and any destruction or disruption would cause a significant impact to the Member State. Disruption or destruction of the European Critical Infrastructure (ECI) would have a significant impact in a wider dimension (at least on two Member States). Therefore protection of national and Eureopan critical infrastructure shall ensure the functionality, continuity and integrity in order to deter, mitigate and neutralise a threat, risk or vulnerability [16].

Critical infrastructures catalyse economy and grant basic functions and service continuity that essential for a state's vitality. Furthermore, critical infrastructures shall contribute to public security and national defence [16].

Based of the above mentioned definitions exclusion of Air Navigation and Air Traffic Services from the scope of critical infrastructures is inconceivable, however it might be an antecedent of the market liberalization.

ATM environment ought to be considered as critical infrastructure, regardless of the configuration; whether it is monolithic or a centralised/decoupled structure as it is envisaged in the future system constellation. Any failure, outage or impact (natural disaster) to the ATM systems or air traffic service provision have serious consequences in the transportation and even the EU economy. For instance, the volcanic ash crisis in 2010 pinpointed the vulnerability of the pan-European air traffic network. According to the estimation of the International Air Transport Association (IATA), the airline industry worldwide lost €148 million a day during the disruption, and the total industry loss was aprox. €1.3 billion. [23] More than 95,000 flights were cancelled all across Europe during the travel ban but some figures suggested 107,000 flight cancellation in the eight-day period, accounting for 48% of total air traffic and roughly 10 million passengers [24] [25].

Another example is Zagreb Area Control Centre outage in 2014 (due to thunderstorm activity with heavy rain) when the lack of air traffic service provision caused capacity reduction of the Croatian airspace for 2 days. [26] This (very rare) situation also shows that any outage of a system (even if it is redundant) can cause a long-term capacity decrease in a large geographical area, not only in the affected zone, but also in the neighbouring Flight Information Regions as well, who had to take over the responsibility of the bypassing air traffic. This threat would increase the effects if it happens in centralised ATM data processing environment or at an integrated Air Traffic Service Provider.

The recent system error in EUROCONTROL's Enhanced Tactical Flow Management System on 3th April 2018 caused serious flight delays over Europe. The testing problem of the Network Managers' system – that originally helps to manage air traffic by comparing demand and capacity of air traffic control sectors – delayed aprox. 15.000 flight operations out of cca. 29.500 planned flights. [27] However it was only the second system failure in 20 years (the last happened in 2001) and EUROCONTROL Contingency Plan was immediately activated, this event also highlights that any malfunction or error in safety critical ATM can cause serious problems in the pan-European dimension.

The above mentioned situations emphasise that the future centralised ATM Data Provision and remote technologies have to be developed with appropriate redundancy and contingency, while the elements of the system (data sources, intra/internet connections, data processing computers, server centres and controller working positions), and all elements also shall be secured and protected (against cyberattacks and physical threats or even natural disasters). Expansion of centralised ATM data processing or integration of air traffic services in wider area of responsibility will increase the complexity (number of stakeholders i.e. involved countries and industrial partners, robustness of the system) of the new ATM infrastructure and also raise the risk of the system vulnerability. The potential threats shall be pre-assessed and corrective measures have to be adopted accordingly.

It is also important to recall the European Council Directive 2008/114/EC in the reforms of ATM domain, namely "*since various sectors have particular experience, expertise and requirements concerning critical infrastructure protection, a Community approach to critical infrastructure protection should be developed and implemented taking into account sector specificities and existing sector based measures including those already existing at Community, national or regional level, and where relevant cross-border mutual aid agreements between owners/operators of critical infrastructures already in place*" [22].

CONCLUSIONS

Remote and centralised ATM services will spread in the mid-term future around the World and catalyse the integration of (partially) independent national Air Traffic Services. The introduced new technologies and concepts definitely support the EU rule makers to change regulations and enforce stakeholders for a consolidation. However, instead of changing the status of air transport and the supporting ATM/ANS, specifications shall be defined.

However, Air Traffic Management should be kept as critical infrastructure, and the new service provision (whether it is remotely available or centralised) should accomplish the same requirements as for today's monolithic ATM systems. Nations who are favouring the new solutions (due to legal obligations or financial benefits) should receive grants and safeguards for service continuity in case of system malfunction, outage, or any times of crisis. As of the EU Directive and the above mentioned examples, any damage of ATM systems (which are essential for the maintenance of vital societal functions such as air transport), destruction or disruption by natural disasters, criminal activity, malicious behaviour or even terrorism would have a significant negative impact for the security of the nation and EU, as well as for the economy and well-being of its citizens.

REFERENCES

[1] ICAO: Annual Report 2016. Source: https://www.icao.int/annual-report-2016/Pages/the-world-of-air-transport-in-2016.aspx Downloaded: 04.2016

[2] Vas T., Palik M.: UAV operation in aerodrome safety and ACS procedures. The 7th International Scientific Conference "DEFENSE RESOURCES MANAGEMENT IN THE 21st CENTURY". Braşov, 15.11.2012

[3] European Commission: Single European Sky.: https://ec.europa.eu/transport/modes/air/single_european_sky_en

[4] EUROCONTROL: About the Network Manager. Source: https://www.eurocontrol.int/articles/about-network-manager Downloaded: 02.2018

[5] REGULATION (EC) No 1070/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 October 2009 amending Regulations (EC) No 549/2004, (EC) No 550/2004, (EC) No 551/2004 and (EC) No 552/2004 in order to improve the performance and sustainability of the European aviation system

[6] SESAR Joint Undertaking: Digitalizing Europe's Aviation Infrastructure. Downloaded: 08.11.2017

[7] About FAA. Source: https://www.faa.gov/about/ Downloaded: 08.07.2017

[8] ASECNA. Source: https://www.asecna.aero/index.php/en/2014-03-31-16-47-52-fr/2014-03-31-16-53-9-en/etats-membres-en Downloaded: 02.02.2018

[9] CANSO: Corporacion Centroamericana de Servicios de Navegacion Area (COCESNA). Source: https://www.canso.org/cocesna

[10] LFV/NAVIAIR: NUAC. Source: http://www.lfv.se/en/partnership/nuac Downloaded: 01.07.2012

[11] IATA: A Blueprint for the Single European Sky (IATA-AEA-ERA). Source: https://www.iata.org/pressroom/pr/Documents/blueprint-single-european-sky.pdf

[12] Szepessy K.: HungaroControl Disruptive technologies in Air Traffic Management. 8th Florence Air Forum 21.10.2016 Firenze

[13] Somosi V.: Questions of ANS industry liberalization. INAIR Conference. 10-11 Nov 2016 Vienna

[14] Pokoradi L., Somosi V.: A Koszovói magaslégtéri irányítási rendszer gráf-modellezése. Hadmérnök XII. évfolyam 4. szám 2017. december

[15] Bekier, M.: Automation Acceptance in Air Traffic Management. University of New South Wales Sydney, Australia, March 2013

[16] Haig Zs., Kovács L.: Kritikus infrastruktúrák és kritikus információs infrastruktúrák. Nemzeti Közszolgálati Egyetem 2012.

[17] EUROCONTROL: ATM Data as a Service (AdaaS) - Towards the concept of data centres. Source: http://www.eurocontrol.int/publications/atm-data-service-adaas-towards-concept-data-centres

[18] EUROCONTROL: A demonstration of the world's first Virtual Centre. Source: http://www.eurocontrol.int/news/demonstration-world-first-virtual-centre Downloaded: 29.07.2016

[19] Hangyál Gy.: HungaroControl Remote Tower Project. World ATM Congress 2018 Madrid. Source: http://en.hungarocontrol.hu/download/50c2d4610e416cc91db5d2b9cc609027.searidge-panel-discussion-hc-rtwr.pdf

[20] EUROCONTROL: System Wide Information Management (SWIM). http://www.eurocontrol.int/swim

[21] EUROCONTROL: Pan-European Network Services (PENS). Source: http://www.eurocontrol.int/articles/pan-european-network-services-pens

[22] COUNCIL DIRECTIVE 2008/114/EC of 8 December 2008 on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection

[23] BBC News: Flight disruptions cost airlines $1.7bn, says IATA. 21.04.2010

[24] BBC News: Ash cloud chaos: Airlines face huge task as ban ends. 21.04.2010
[25] Bye, B.L.: Volcanic eruptions: Science and Risk Management. Science 2.0. 27.05.2011
[26] Network Manager: Monthly Network Operations Report. Analysis – July 2014.: https://www.eurocontrol.int/sites/default/files/publication/performance/201407/network-operations-report-july-2014-analysis.pdf
[27] BBC: Half of European flights delayed due to system failure Source: http://www.bbc.com/news/world-europe-43633094
[28] EUROCONTROL: What are the FAB (Functional Airspace Blocks), (oline) url: https://www.eurocontrol.int/faq/what-are-fab-functional-airspace-blocks

A légiforgalom-szervezés információs infratrsuktúrái

A globális légiközlekedési igények új kihívásokat jelentenek a léginavigációs szolgáltatóknak (ANSP-k). Az új elgondolások és fejlesztések a légiforgalom-szervezés (ATM) egyes szolgáltatások központosítását is vizionálja, amelyben várhatóan megváltozik a kritikus infradtruktúra elemek felelősségi köre, funkciója. A bekövetkező integráció és regionalizáció ennek megfelelően az ATM információs infrastruktúra is hatást gyakorol majd.

Keywords: *légiforgalmi szolgáltatások integrációja, helyfüggetlen légiforgalmi szolgáltatások, remote torony*

Somosi Vilmos FAB program menedzser és polgári-katonai együttműködési koordinátor HungaroControl Magyar Légiforgalmi Szolgálat Zrt vilmos.somosi@hungarocontrol.hu orcid.org/0000-0002-4763-2174	Somosi Vilmos FAB Program manager and civil-military cooperation coordinator HungaroControl Hungarian Air Navigation Services vilmos.somosi@hungarocontrol.hu orcid.org/0000-0002-4763-2174

http://www.repulestudomany.hu/folyoirat/2018_2/2018-2-18-0483_Somosi_Vilmos.pdf