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Chapter 1. Introduction to Air Navigation Services

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1.1 The fundamentals of Air Navigation Services

Airlines and airports rely on the Air Navigation Services for the management of air traffic. Hence, Air Navigation Services (ANS) provision is considered as a core element for air transportation. Air Navigation Services include five broad categories of services provided to air traffic during all phases of operation (area control, approach control and aerodrome control). These services are the following: Air Traffic Management (ATM), Communication services, Navigation services and Surveillance services (CNS), Meteorological services for air navigation (MET), Aeronautical Information Services (AIS) and Search and Rescue (SAR). These services are provided to air traffic during all phases of flight (e.g. planning, execution) and operations (approach, aerodrome and en-route).

<Insert Figure 1.1 here>

Figure 1.1 The Air Navigation Services

Aeronautical Information Services (AIS) provide information on the availability of air navigation services and their associated procedures necessary for the safety, regularity and efficiency of air navigation (i.e. AIP, AIC, NOTAM, etc.). Communications, Navigation and Surveillance (CNS) includes communication facilities, navigation services and surveillance systems. Communication facilities have two main categories: aeronautical fixed service and aeronautical mobile service.

Under Article 1 of the ICAO Chicago Convention, States have the sovereignty over the airspace above their territory. However, States are also required to establish the provision of ANS within their airspace. The dimension of the national airspace and its organisation into Flight Information Regions (FIR) is published in the respective Aeronautical Information Publication (AIP).

Air Traffic Management (ATM) comprises three main services (Skybrary, nd):

- **Air traffic services (ATS)**, with the general purposes of ensuring safe and orderly traffic flow (facilitated by the air traffic control (ATC) service) as well as providing the necessary information to flight crews (flight information service, FIS) and, in case of an emergency, to the appropriate (e.g. SAR) bodies (alerting service). ATS is mostly performed by air traffic controllers. Their main functions are to prevent collisions by e.g. applying appropriate separation standards and issue timely clearances and instructions that create orderly flow of air traffic (e.g. accommodate crew requests for desired levels and flight paths, ensure continuous climb and descent operations, reduce holding times in the air and on the ground). ATS relies on tactical interventions by the controllers and direct communication with the flight crews usually during the entire flight.
- **Air traffic flow management (ATFM)**, the primary objective of which is to regulate the flow of aircraft as efficiently as possible to avoid the congestion of certain control sectors. The ways and means used are increasingly directed towards ensuring the best possible match between

supply and demand by staggering the demand over time and space and by ensuring better planning of the control capacities to be deployed to meet the demand. Supply and demand can be managed by imposing various restrictions on certain traffic flows (e.g. assigning CTOTs or requiring flights matching certain criteria to use specific routes). Also, supply can be increased by appropriate sector management (e.g. increasing the number of controllers working at the same time). AFTM measures can be seen as pre-tactical, as they do not affect the current situation but rather the near future.

- **Airspace management (ASM)**, the purpose of which is to manage airspace - a scarce resource - as efficiently as possible to satisfy its many users, both civil and military. This service concerns both the way airspace is allocated to its various users (by means of routes, zones, flight levels, etc.) and the way in which it is structured to provide air traffic services.

There are three main types of Air Traffic Control (ATC), Aerodrome Control (also known as Tower Control) Approach Radar Control and Area Radar Control. ATC is used to manage the safe and orderly flow of aircraft into, out of, and across the airspace. There are two categories of air traffic services, en-route services that control traffic during the cruise phase of the flight, and the Terminal Air Navigation Service (TANS) that relate to “radar approach and departure” (approach) service and the aerodrome service (Efthymiou, 2020). The approach service typically controls the aircraft within 40-50 nautical miles from the airport. The aerodrome service relates to the visual control provided by the ATC tower. The general categories of airspace are the following:

- Controlled Airspace. This is an airspace of defined dimensions within which air traffic control services are provided to Instrument Flight Rules (IFR) flights and to Visual Flight Rules (VFR) flights in accordance with the airspace classification. VFR aircraft operating in controlled airspace are responsible for separating themselves from all other aircraft and are permitted so long as the weather conditions are sufficient to enable pilots to “see and avoid” other aircraft.
- Positive Controlled Airspace. Flights in this type of airspace are conducted normally under IFR. This airspace is reserved for either very high-altitude flights at or above 18,000 feet mean sea level (MSL) or around high-density airports.
- Uncontrolled Airspace. In uncontrolled airspace, ATC separation services are not and all aircraft, whether IFR or VFR, must provide their own separation, regardless of the weather conditions.
- Special Use Airspace. This is airspace wherein activities must be confined because of their nature, or wherein limitations are imposed upon aircraft operations that are not a part of those activities, or both. Some examples of this airspace types are prohibited airspace and restricted areas.

While airspace can be simply classified as controlled and uncontrolled, ATS airspace is classified and designated in accordance with the following (ICAO, 2018):

Class A. IFR flights only are permitted, all flights are provided with air traffic control service and are separated from each other.

Class B. IFR and VFR flights are permitted, all flights are provided with air traffic control service and are separated from each other.

Class C. IFR and VFR flights are permitted, all flights are provided with air traffic control service and IFR flights are separated from other IFR flights and from VFR flights. VFR flights are separated from IFR flights and receive traffic information in respect of other VFR flights.

Class D. IFR and VFR flights are permitted, and all flights are provided with air traffic control service, IFR flights are separated from other IFR flights and receive traffic information in respect of VFR flights, VFR flights receive traffic information in respect of all other flights.

Class E. IFR and VFR flights are permitted, IFR flights are provided with air traffic control service and are separated from other IFR flights. All flights receive traffic information as far as is practical. Class E shall not be used for control zones.

Class F. IFR and VFR flights are permitted, all participating IFR flights receive an air traffic advisory service, and all flights receive flight information service if requested.

Class G. IFR and VFR flights are permitted and receive flight information service if requested.

The services provided and flight requirements for different classes of airspace are shown in the table below.

Table 1.1: Services provided and flight requirements for different classes of airspace (Source: ICAO Annex 11, 2018)

Class	Type of flight	Separation Provided	Service Provided	Speed limitation *	Radio communication requirement	Subject to an ATC clearance
A	IFR only	All aircraft	Air traffic control service	Not applicable	Continuous two-way	Yes
B	IFR	All aircraft	Air traffic control service	Not applicable	Continuous two-way	Yes
	VFR	All aircraft	Air traffic control service	Not applicable	Continuous two-way	Yes
C	IFR	IFR from IFR IFR from VFR	Air traffic control service	Not applicable	Continuous two-way	Yes
	VFR	VFR from IFR	1) Air traffic control service for separation from IFR 2) VFR/VFR traffic information service (and traffic	250 kts IAS below 10000 ft amsl	Continuous two-way	Yes

Class	Type of flight	Separation Provided	Service Provided	Speed limitation *	Radio communication requirement	Subject to an ATC clearance
			avoidance advice on request)			
D (1)	IFR	IFR from IFR	Air traffic control service, traffic information about VFR flights (and traffic avoidance advice on request)	250 kts IAS below 10000 ft amsl	Continuous two-way	Yes
	VFR	Nil	IFR/VFR and VFR/VFR traffic information (and traffic avoidance advice on request)	250 kts IAS below 10000 ft amsl	Continuous two-way	Yes
E (2)	IFR	IFR from IFR	Air traffic control service and, as far as practical traffic information about VFR flights	250 kts IAS below 10000 ft amsl	Continuous two-way	Yes
	VFR	Nil	Traffic information as far as practical	250 kts IAS below 10000 ft amsl	No	No
F	IFR	IFR from IFR as far	Air traffic advisory service;	250 kts IAS below	Continuous two-way	No

Class	Type of flight	Separation Provided	Service Provided	Speed limitation *	Radio communication requirement	Subject to an ATC clearance
		as practical	flight information service	10000 ft amsl		
	VFR	Nil	Flight information service	250 kts IAS below 10000 ft amsl	No	No
G	IFR	Nil	Flight information service	250 kts IAS below 10000 ft amsl	Continuous two-way	No
	VFR	Nil	Flight information service	250 kts IAS below 10000 ft amsl	No	No

* When the height of the transition altitude is lower than 10,000 ft amsl, FL100 should be used in lieu of 10000 ft

Important Notes:

(1): In Class D airspace, both IFR and VFR traffic are required to follow ATC clearances; however, ATC are only responsible for IFR against IFR separation.

(2): In Class E airspace, ATC does not provide separation between IFR and VFR traffic; IFR traffic shares responsibility for separation from uncontrolled VFR traffic with that traffic.

1.2 The transition to a competitive environment for Air Navigation Service Providers (ANSPs)

An Air Navigation Service Provider (ANSP) is an organisation that provides the service of managing the aircraft in flight or on the manoeuvring area of an and which is the legitimate holder of that responsibility. An air navigation service provider (ANSP) must be able to adjust service provision dynamically to the heterogeneous performance requirements of the airspace users (both civil and military (Bourgois et al., 2018).

The aircraft movements increase has created significant pressure to managing the airspace and has highlighted the inefficiencies in the provision of ANS. The European sky is one of the busiest skies in the world; yet air traffic management is organised in a fragmented way. In fact, the European airspace system covers an area of 10.8 million km2 managed by 37 Air Navigation Service Providers (ANSPs) and 62 Area Control Centres (ACCs), 262 Approach Control units (APPs), 56,300 staff. This fragmentation impacts adversely on flight safety, limits capacity, increases costs and slows down the decision-making process. Thus, better coordination for transferring the responsibility of an aircraft among Air Traffic Control (ATC) sectors in Europe is needed. Such an initiative to reform the architecture of the Air Traffic Management (ATM), known as Single European Sky (SES), was first launched by the European Commission in 1999 (Efthymiou, 2016).

The reform of the ANSPs is one of the most important issues for Aviation and it is closely related to the ownership type and business model of the ANSP. Most of the ANSPs are government-owned, but there are few that are a Private Public Partnership (PPP), e.g. NATS in the UK, and private companies, e.g. ACR in Sweden (Table 1.2). All the different ownership and organisational forms that exist have the potential according to ICAO (Doc 9161, 2013) to deliver excellent service under the condition of an appropriate government structure. Moreover, Air Navigation Service Providers after 2010 started forming alliances and cooperating. ANSPs may cooperate for different reason, the most important are a) a good cost benefit business case; b) synergies in technologies and expertise; c) optimisation in the production and achievement of economies of scale or scope; and d) forced by government regulation or legislation.

Table 1.2: Organisation and Corporate arrangements of selected states (Source based on Eurocontrol, 2021)

ANSP	Country	Organisational & Corporate Arrangements
Albcontrol	Albania	Joint-stock company (State-owned)
ANS CR	Czech Republic	State-owned enterprise
ANS Finland	Finland	State-owned enterprise
ARMATS	Armenia	Joint-stock company (State-owned)
Austro Control	Austria	Limited liability company (State-owned)
Avinor	Norway	Joint-stock company (State-owned)
BULATSA	Bulgaria	State-owned enterprise
Croatia Control	Croatia	Joint-stock company (State-owned)
DCAC Cyprus	Cyprus	State body
DFS	Germany	Limited liability company (State-owned)
DHMI	Turkey	Autonomous State enterprise
DSNA	France	State body (autonomous budget)
EANS	Estonia	Joint-stock company (State-owned)
ENAIRE	Spain	State-owned enterprise
ENAV	Italy	Joint-stock company (State-owned)
HCAA	Greece	State body
HungaroControl	Hungary	State-owned enterprise
AirNav	Ireland	Joint-stock company (State-owned)
LFV	Sweden	State-owned enterprise
LGS	Latvia	Joint-stock company (State-owned)
LPS	Slovak Republic	State-owned enterprise
LVNL	Netherlands	Independent administrative body
MATS	Malta	Joint-stock company (State-owned)
M-NAV	F.Y.R.O.M.	Joint-stock company (State-owned)
MOLDATSA	Moldova	State-owned enterprise
MUAC	-	International organisation
NATS	United Kingdom	Joint-stock company (part-private)
NAV Portugal	Portugal	State-owned enterprise
NAVIAIR	Denmark	State-owned enterprise
Oro Navigacija	Lithuania	State-owned enterprise

ANSP	Country	Organisational & Corporate Arrangements
PANSA	Poland	State body (acting as a legal entity with an autonomous budget)
ROMATSA	Romania	State-owned enterprise
Sakaeronavigatsia	Georgia	Limited liability company (State-owned)
Skeyes	Belgium	State-owned enterprise
Skyguide	Switzerland	Joint-stock company (part-private)
Slovenia Control	Slovenia	State-owned Enterprise
SMATSA	Serbia	Limited liability company
	Montenegro	
UkSATSE	Ukraine	State-owned Enterprise

Regulation and market form have made ANSPs' management more complicated than ever. Compared to other areas of aviation management, only a very small number of scholars have researched the area of managing ANSPs. Nava-Gaxiola and Barrado (2016) studied the expected benefit in saving flight distance after introducing the Free Route Airspace in the Southwest FAB using traffic simulation models. Baumgartner and Finger (2014) provided a brief overview of the SES. Button and Neiva (2013) using Data Envelopment Analysis estimated the potential economic efficiency of functional airspace blocks. Pellegrini and Rodriguez (2013) made a comparison of the Single European Sky and Single European Railway Area. Button and McDougall (2006) discussed the institutional and structure changes in air navigation service-providing organizations. Comendador, Valdés and Sanz, (2012) researched the liberalisation of Air Traffic Services in Spain. Efthymiou and Papatheodorou (2018, 2020) investigated the environmental area of Single European Sky and Efthymiou (2017) researched the governance of the ATM reform. Bilotkach et al (2015) performed a cost-efficiency benchmarking of European ANSPs, whereas Grebenšek and Magister (2013) discuss the suitability of benchmarking as a measure method for ANSPs performance. Tomova (2016) discussed the commercial revenues of ANSPs. Buyle et al. (2021) discussed the ANSPs business models. Blondiau et al (2016) developed economic models to analyse the performance of ANSPs. Nevertheless, there are not many books written about management issues of an ANSP and on the ATC reform. This edited book fills this important gap with a comprehensive, in-depth study of the issues related to Air Navigation Service Providers business.

1.3 Aim and Structure of the book

The book aims to be a unique repository of current knowledge and critical debate on the Air Navigation Service Providers business with an international focus. There are a total of 13 written by a team of 16 leading researchers, scholars and industry experts based at universities, research institutes, governance authorities and ANSPs across the world. Focused on Air Traffic Management and the principles, performance and markets of Air Navigation Service Providers, the book has the following chapters:

Chapter 2: The legal environment of ANSPs by François Huet, Policy and Regulatory Director, Borealis Alliance

There is a wide variety of legal setups for ANSPs. However, air traffic service provision, at least for en route services, is characterised by the designation of national monopolies, operating within national borders, which contributes to the fragmentation of the European ATM network. With the

COVID pandemic following several years of traffic and delays growth, the ATM industry is now expected to carry out its digital transformation to negotiate a “green” and future-proof return to growth, meeting public opinion expectations, and able to absorb future crises and traffic variations upwards or downwards through more agility, scalability and resilience. Such is the claimed purpose of the new Single European Sky initiative (“SES2+”) and the associated roadmap towards a “Digital European Sky”. This digital transformation may be accelerated by the arrival of “new entrants” in the airspace, drones in particular. The Single European Sky initiative is gradually trying to decouple en route (or area) air traffic service provision, which would remain monopolistic (and thus economically regulated), from the other, “auxiliary”, services (terminal air traffic services for aerodrome and for approach, CNS, AIS, ADS and MET), which are encouraged to be opened to market conditions. However, there is resistance from a large number of Member States who want to make sure that this evolution remains fully in their hands and is not imposed on them. The evolution of the legal environment of air navigation services provision will largely depend on the adoption of the SES2+ legislative package, expected in 2022. It is for the time being difficult to predict where the cursor will stop between the protection of services that pertain to “*the exercise of the powers of a public authority*” on the one hand, and the opening to market of the other services on the other hand.

Chapter 3: From NextGen to SES: Structural reform in the ANSP industry by Anna Tomová, Department of Air Transport, University of Žilina, the Slovak Republic

While many infrastructure industries in the world have undergone structural reforms, the provision of air navigation services as a part of aviation infrastructure was out of the trend for a long time. However, gradually, also the provision of air navigation services in several countries have been changed and structural reforms have been carried out. Due to structural changes, the historical model based on statutory multi-product monopolies in public ownership was changed, and third parties were allowed to participate in the provision of air navigation services and compete. Moreover, some air navigation service providers were (partially) privatised. Structural reforms could be utilised when achieving the goals of seamless single sky within the international groupings of countries for their single markets with air services.

Chapter 4: Air Traffic Control Officers (ATCOs) Recruitment and Training by Gary McIlroy, Irish Aviation Authority, Ireland and Marina Efthymiou, Dublin City University, Ireland

This chapter outlines the recruitment, training and licencing requirements of the Air Traffic Control sector as prescribed by ICAO Annex 1, Annex 11 and ICAO Doc 4444 PANS-ATM, ICAO Doc 9868 PANS-Training. These SARPs are then transposed by regional regulations where applicable (specifically Europe and EU 2015/340) and incorporated into state regulation. Specifically, this chapter will discuss the impact of those requirements on the people who operate within that sector, i.e., the ATCOs, from their recruitment to training and certification as licenced ATCOs operating in the live traffic environment. The chapter also researches a sample of ANSPs recruitment practices and makes some recommendations.

Chapter 5: Safety Management in ANSPs by Markus Biedermann, Director Operational Support DFS GmbH

Air Traffic control has been introduced as the most important safety net for aviation. From the early days up until now, air traffic controllers provide airspace users around the globe with high quality service, that allows a safe, orderly, fluent and environmental flow of air traffic. Without continuous technical advancements and ongoing development on safety procedures, this complex as well as complicated system would not sustain. Therefore ANSPs grew into highly reliable organisations, which operate relatively error free over prolonged periods of time even in an environment of constant stress. This is supported by a robust framework from world wide organisations such as ICAO but also on pan-national or national levels such as through EASA or the CAAs. The framework on the one hand and the organisation on the other hand support each other in developing and introducing constant improvements for safety of air traffic either through technological means or organisational development to maintain safety of air travel at the highest standards.

Chapter 6: ANSPs Capacity and delays by Radosav Jovanović, University of Belgrade –Faculty of Transport and Traffic Engineering, Serbia

The capacity of an airspace sector is influenced by several factors, including separation standards, traffic complexity, airspace design, availability of systems for communication, navigation and surveillance, human factors, weather, etc. A distinction should be made between capacity in nominal and actual, often degraded conditions. Suppose an imbalance between capacity and demand is foreseen. In that case, actions need to be taken, first by acting on the capacity side, i.e. making the best use of available capacity, and only then, if needed, acting on the demand side.

Air Traffic Flow Management (ATFM) measures are techniques used to manage air traffic demand according to system capacity, i.e., ensure that available airspace capacities can accommodate traffic loads safely, efficiently, and non-discriminatory. Flight delays caused by demand-capacity imbalances in ATM may have significant cost implications for the affected airspace users. For example, the costs of en-route imposed delays in the European system were estimated at about 1.9 billion EUR in 2018.

Chapter 7: Air Navigation Service Providers and Environmental Performance by Marina Efthymiou, Dublin City University Business School, Ireland

Environmental performance is a significant aspect of aviation. Apart from reducing the emissions of the ANSP, it is important to consider the airspace structure. The Single European Sky (SES) aims to organize the airspace uniformly, with air traffic control areas based on operational efficiency rather than national borders. One of the main aspects of SES is performance evaluation in four areas: cost efficiency, capacity, safety, and environment. In the Key Performance Area (KPA) of environmental, targets aiming at climate change mitigation have been set for flight efficiency and airspace structure. This chapter discusses the various measures and considers some challenges for improved environmental performance.

Chapter 8: ANSP charges by Frank Fichert, Worms University of Applied Sciences, Germany

The costs of ANS provision are to a large degree covered by the airspace users, mostly via user charges (and ‘earmarked’ aviation-related taxes in the U.S.). Usually, there are different charging schemes for the en route phase and for approach and aerodrome services (also referred to as terminal services). Within the framework set by ICAO, many variants of user charges exist. For en route services, charges are in many cases depending on flight distance and aircraft weight. Whereas weight-dependent charges (en route as well as approach and aerodrome) might be seen as some kind of Ramsey pricing, incentives (e.g. peak-load pricing) are hardly used within actual charging schemes.

Chapter 9: Regulation of Air Traffic Control Services: Principles and European Experience by Hans-Martin Niemeier, University of Applied Sciences, Bremen, Germany and Peter Forsyth, Department of Economics, Monash University, Australia.

This chapter focusses on the regulation of Air Traffic Control (ATC): how it is done, and how it can be improved. The analysis is general, but it pays specific attention to Europe, which is a region which is dominated by public but regulated suppliers. Major parts of ATC systems, especially the en-route systems, are characterised by natural monopoly. Worldwide, most ATC systems are publicly owned and operated, though there are significant exceptions, such as those of the United Kingdom and Canada. In the EU ATC systems are government owned, though many are corporatized. With ATC systems there is a short run problem of achieving productivity, and in some cases, there are also quality problems, which are manifested in delays. In the long run there are problems of achieving efficient levels of investment. In the EU there is strong evidence of productive inefficiency in many countries' systems, and pricing often involves traffic risk sharing mechanisms, which dampen incentives for efficiency. Questionable incentives for efficiency in government owned systems are an issue. Turning to the long run, in Europe there have been chronic problems of achieving adequate investment, made more complex by the difficulties in achieving interoperability between the systems of different countries. The EU system of regulation is such that incumbent operators are shielded from risks (very evident in the Covid crisis), leading to weak incentives for efficiency.

CHAPTER 10: The Business Framework for Air Navigation Service Providers (ANSP) by Marek Bekier, University of New South Wales (UNSW), Sydney

In the past, Air Navigation Service Providers (ANSP) have traditionally been owned, controlled and sometimes operated by their respective governments. In recent years, along with an overall reduction of public ownership in public utilities, a trend towards separation from the government and an +increased commercialisation of the ANSP could be observed (Dempsey-Brench and Volta, 2018). Rooted in the agreements and architecture of the Chicago Convention (1944), each state organized and regulated the ANS provision under a national monopoly through dedicated ANS Providers. In recent years, a trend towards a cautious opening of the monopoly markets and a partial liberalization of the industry is observable and is also recommended by the European Commission through adjustment proposals to its Single European Sky (SES) regulatory framework (European Commission, 2020) However, the development towards a more commercialized and competitive ANS industry requires a transition towards a more commercial management, governance and administration of the ANSP, a process commonly referred to as commercialization. An introduction describing the origins of the vertically integrated ANSP is at the beginning of this chapter. To understand the underlying business structure of the ANS industry, the next section then introduces the cost-recovery concept and provides an overview on the key economic elements – the revenue generation and cost-structures - of an ANSP. This is followed by an overview on the various governance models of ANSP, as ownership and governance often determine the degree of commercialization. How commercialization impacts on the overall business models of ANSP and how a liberalization of the ANS market is expected to change the dynamics in the industry is discussed and demonstrated through a case study from the private Terminal ANS (T-ANS) Provider ACR. This chapter, which has its focus on the European ANS market, will then conclude with a summary and an outlook on expected developments that can change the physiognomy of the ANSP business framework.

Chapter 11: The potential of Unbundling ATM Services in Europe by Keith McEvoy, AirNav Ireland, Dublin ACC, Ireland and Marina Efthymiou, Dublin City University Business School, Ireland

European ATM network reform has been a continual challenge for all European aviation organisations. Its fragmentation has led to cost-inefficiencies and delays, which airline groups are continually scrutinising and pushing to streamline and defragment the ATM network. Some reform initiatives, such as the Single European Sky, have been deemed, for the most part, ineffective. While the SES reform is still ongoing and modifications are taking place, a new reform theory has emerged in the guise of airspace unbundling. Although there are small pockets of unbundled terminal airspaces around Europe, the push is to unbundle en-route services. This chapter explores the current European ATM system and outlines the different approaches to reform the ATM network. It also presents the current business models of ANSPs, an aspect that influences ANS unbundling. It discusses unbundling at a terminal and en-route level and concludes with the barriers to reform.

Chapter 12: Multiple Remote Tower Operations: Air Traffic Controllers' Attention Distributions and Task Performances by Peter Kearney, Chief Executive Officer, Irish Aviation Authority, Wen-Chin Li, Safety and Accident Investigation Centre, Cranfield University, U.K and Graham Braithwaite, Safety and Accident Investigation Centre, Cranfield University, U.K

The innovative concept of multiple remote tower operation (MRTO) is where a single air traffic controller (ATCO) provides air traffic services to two or more different airports from a geographically separated virtual Tower. Effective visual scanning by the air traffic controller is the main safety concern for human-computer interaction, as the aim of MRTO is a single controller performing air traffic management tasks originally carried out by up to four ATCOs, comprehensively supported by innovative technology. Thirty-two scenarios were recorded and analyzed using an eye tracking device to investigate the above safety concern and the effectiveness of multiple remote tower operations. The results demonstrated that ATCOs' visual scan patterns showed significant task related variation while performing different tasks and interacting with various interfaces on the controller's working position (CWP). The development of Augmented Vision Video-panorama technologies has increased the monitoring capabilities of air traffic controllers. During the trials no safety occurrence was reported nor did any operational safety issue arise during the provision of air traffic services to 500 aircraft in the live exercises. ATCOs were supported by new display systems equipped with pan tilt zoom (PTZ) cameras allowing enhanced visual checking of airport surfaces and aircraft positions. Therefore, one ATCO could monitor and provide services for two airports simultaneously. The factors influencing visual attention include how the information is presented, the complexity of that information, and the characteristics of the operating environment. ATCO's attention distribution among display systems is the key human-computer interaction issue in single ATCO performing multiple monitoring tasks.

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