Science, Engineering and Technology *Vol. 2, No. 2, pp. 7-13*
www.setjournal.com *https://doi.org/10.54327/set2022/v2.i2.44*

Application of ICT as a Key Element for Airport Safety and Security Operations

Adnan Šahić[1,2], Džemal Cinac[2]

[1]*Bosnia and Herzegovina Air Navigation Services Agency (BHANSA), Sarajevo 71000, Bosnia and Herzegovina*

[2]*University of Sarajevo, Faculty of Traffic and Communications,, Srajevo 71000, Bosnia and Herzegovina*

Abstract

Airport risk management is a demanding task as several different areas have to be monitored including outer edges, car parks, terminals, and other passenger facilities. Information and communication technologies (ICT) are key elements for airport operation safety and security. One of the advantages of ICT based systems is they can react better and faster in real time and perform certain tasks at airports. This paper aims to present a safety overview of ICT and multi-agent systems (MAS) usage in the implementation of various airport operations. This paper aims to present a safety overview of ICT and MAS systems usage in the implementation of various airport operations. This paper summarizes a multi-agent concept that highlights their applications at airports such as passenger transfer, baggage management, aircraft handling, and field service through a detailed and extensive literature review on related topics. Much of the information on processes within the airport, processes in air traffic, and the processes of operators, i.e. airlines, is the result of monitoring work on a software development project for individual airports that serves to manage all processes in airports. The analysis led to the conclusion that safety and security in airports can be additionally improved by greater use of ICT as well as greater use of MAS, which ultimately contributes to the optimization of the airport.

Keywords*: Airports, Multi-agent systems, Airport safety, Airport security, Risk management, Airport operations, Airport ground services*

1. Introduction

Safety is a condition in which the risk of danger to road users or objects is reduced and maintained at or below an acceptable level of safety (*ALoS*) through a continuous process of hazard detection and risk management. Safety is a condition in which the risks associated with aviation activities related to or directly supporting aviation operations are reduced and controlled to an acceptable level. The terms (domains) safety and security are generally viewed separately in aviation. While the safety treats risks associated with aviation activities, the latter safeguards civil aviation against acts of unlawful interference [1]. However, ICT-based systems are used in both areas. Air traffic safety regulations have evolved in step with the emergence and development of new technologies. The aim of the regulation was to influence the quality and safety of transport by adopting rules. Flight safety today is an imperative in modern air traffic. Numerous terrorist threats and, on the other hand, the aspiration to achieve maximum technical reliability of aircraft require the application of information technologies that must ensure easy monitoring and decision-making in air traffic management. The constant growth of the volume of traffic in aviation requires the implementation of ICT in order to raise the level of flight safety to a higher level.

Today, usage of agents has considerably increased in computer systems. Objectification methods are not able to meet the needs of agent-based software and require essential equipment, which is why software engineering developed from object-oriented to agent-oriented [2]. As a service platform, airports have several types of clients or customers. From the aeronautical perspective, the main airport clients are airlines of all types: traditional airlines, low cost airlines, but also freight airlines and integrators [3]. Airports provide them with infrastructure (e.g. runways, taxiways and aprons) and services (e.g. refuelling and handling).

Flight safety today is an imperative in modern air traffic. The aspiration to achieve maximum technical

Corresponding author: *Adnan Šahić (addo_saha@yahoo.com)*
Received: *21 September 2022*; Revised: 15 *October 2022*; Accepted: 25 *October 2022*; Published*: 31 October 2022*

reliability of aircraft require the application of information technologies that must ensure easy monitoring and decision-making in air traffic management. The constant growth of the volume of traffic in aviation requires the implementation of information and communication technologies - ICT in order to raise the level of flight safety to a higher level.

2. Safety Aspect: Activities and Resources

At the very beginning, it is important to point out that in1945 the "International Air Transport Alliance" (IATA) was established in Cuba for the purpose of standardizing the necessary safety processes in airports in order to ensure the best possible service when processing passengers, their luggage, freight transport and aircrafts at airports [4]. IATA has, among other things, issued an (Airport Handling Manual – AHM and Passenger Services Conference Resolutions Manual - PSCRM). AHM is listing the most important processes such as the care of transit passengers, the disposal of luggage, the disposal of shipments, the control of boarding, organization of the aircrafts on the runway and the ground service [5]. PSCRM, on the other hand, deals with passengers, passenger luggage, travel documents, electronic tickets, booking systems, payment methods, allocation of seats on the aircraft, denoting the operator and the flight number of that operator, prescribes the standard format for all outgoing and incoming messages from the airport and much more. Airports become essential actors in the air transport market with a growing independence in strategic decision-making [6].

The airport infrastructure in today's conditions is very difficult to expand, so to increase capacity and system efficiency, existing operations should be optimized. With the optimization of flight operations, the complexity of the airport system also increases, and the security system needs to be adjusted [7]. In order for airports to provide service to airlines and safety of the passengers, they need resources. The physical resources at the airport are:

1. Runway according to safety standards– for landing and take-off aircrafts. The length of the runway determines the size of the aircraft that can land at that airport (a larger aircraft takes a longer runway). In addition to the runway, there are other factors that affect the take-off/landing performance of the aircraft, such as the mass of the aircraft, weather conditions, landing procedures, etc.
2. Parking spaces safe– the aircraft parks here on the unloading and boarding of passengers and luggage and during all other ground service services. The number of parking spaces also determines the capacity of the aircraft, which the airport can receive in a period of time.
3. Various vehicles – such as a fire truck, a shuttle for passenger transport, a fuel tanker, a food and water delivery vehicle (catering), a luggage trolley, a cleaning vehicle, a tractor for towing an aircraft, a vehicle with stairs, etc.
4. Terminal – this is the building where passengers and their luggage are processed.
5. Check-in counters – are used for check in of passengers and takeover of luggage.

The presentation of potential safety risks at airports that affect operations is shown in Figure 1.

Figure 1. Potential airport safety risks.

The number of check-in counters determines the number of passengers that can be checked in a period of time. If there are too few check-in counters, there may be delays. Body checks counters and X-rays – this is used for passenger safety control and their luggage. A large number of X-rays at body check counters ensures rapid passage of passengers. Otherwise, this is a potential stop and possible cause of flight delays. From the point of view of safety, gates– are physical exits through which passengers leave the terminal and get on the bus that leads them to the aircraft, but also to the place where safety checks are completed.

On the basis of ICAO Doc 9859 Safety Management Manual (SMM), a recommended process of designing safety performance indicator system is proposed. In this process, [8] four main establishment steps are given: design safety performance indicator, make safety action plan, monitor actual safety performance, and improve safety performance system. In order to design safety performance indicator, some management objectives should be defined, such as reduction of incidents and accidents, improving safety management capacity, etc. Operations for employees are especially important. These are all jobs such as: check in personnel, mechanics, sorter employees, employees on the runway, firefighters, cargo service employees, dispatchers, balancer of aircrafts, traffic coordinator, ramp agents, information workers, commercials, etc [9].

2.1. Passenger processing

Passengers are considered to be especially airline clients but they are also direct clients of airports as they must be processed before/after their flight. The range of non-aeronautical services depends on the airport size and type and they usually include shops, restaurants and bars providing services to the passengers, visitors and employees and bringing revenues to the airport [10]. In order for airlines to save money and not to have their own representatives (and rented space) at each airport, they pay airports to take care of their passengers and their luggage. Thus, the airport is in charged to check-in passengers, safety control of passengers (body check) and inspection of luggage using X-rays, and conducting passengers to the aircraft a. After the passenger has passed the safety inspection enters the so-called ″clean zone" [11]. The check-in process itself is actually recording that the passenger actually came to the airport and wants to get on the aircraft and that one (or more) seats are reserved to his name. After the aircraft departures from the airport, airline is getting information about all passengers on that flight so that the airline knows the status of the tickets sold. This exchange of data is very important and must be correct, otherwise, for example, a passenger who was on a flight may subsequently request a refund for an unused ticket (when in fact he used it).

From the view of the airport, there are three basic types of passengers, namely:

- domestic,
- transit, and
- transfer fee.

Safety aspects are essential in this segment. Namely, local passengers are passengers who begin their journey at that airport. Transit and transfer passengers are those who came to the airport on some flight. The difference between transit and transfer passengers is that transit passengers continue their journey with the flight they came with and the transfer passengers do not. They arrived on one flight to the airport and transfer to another flight.

Security control, which limits the possibility of unlawful interferences on board an airplane, is the key airport safety element. [12] The aim of scanning passengers and cabin luggage is to make it impossible to bring forbidden objects to restricted areas within an airport. Also for this purpose different models of passenger transport process can be used at airports where we need to distinguish business passengers from casual ones. Moreover, passengers can arrive from different sources. For example, there may be transit passengers arriving at the gate together with departing passengers, thus creating a single profile of arrival at the gate [13].

2.2. Processing of domestic and international travelers

The safety aspect is significant when processing local and transit passengers, which can be domestic or international. International travelers are those who leave the country and unlike domestic travelers, who do not leave the country, enter the international and duty-free zones and can shop in shops with vat-free prices. All of the carriers required services such as passenger checking, passenger and luggage safety screening and boarding of passengers are performed over this type of passenger. The services provided by the airport to passengers, on behalf of the carrier, are charged by the airport to the carrier.

2.3. Processing of transit and transfer passengers

Transit passengers are passengers who arrive at the airport on an aircraft and continue on the same aircraft with which they arrived at the airport. Depending on the laws of the country where the airport is located, these passengers must or may not leave the aircraft while refueling [14].

If they have to leave the aircraft, airport employees take them out of the aircraft and take them by bus to the

airport where they are waiting for the refueling to be completed. After the refueling of the aircraft has been completed, airport employees again take the passengers to the aircraft. When passing through the airport building, transit passengers do not have to undergo a safety check again since they carried out this when they initially boarded the flight they arrived on and did not leave the "clean zone" at any time.

Transfer passengers are those who, like transit passengers, arrived at the airport on some flight, but at that airport they transfer to another flight. Unlike transit passengers, they have the option of leaving the clean zone and, if they exit, they will have to undergo a safety check again. Transfer passengers can be domestic (arriving from the domestic airport and continuing to the domestic airport) and international (continue the flight to the airport outside the country). If they are international travelers, they also have the opportunity to enter the international zone at the airport and shop in the "duty free" store.

2.4. Baggage processing as a safety challenge

Baggage Handling means safety checking of luggage and transporting to the aircraft and boarding luggage. After the passenger is checked, he hands over his luggage to a check-in employee who puts the luggage on the conveyor belt. This tape of luggage is transported by sorters. Baggage Reconciliation (BRS) that looks like the Figure 2.

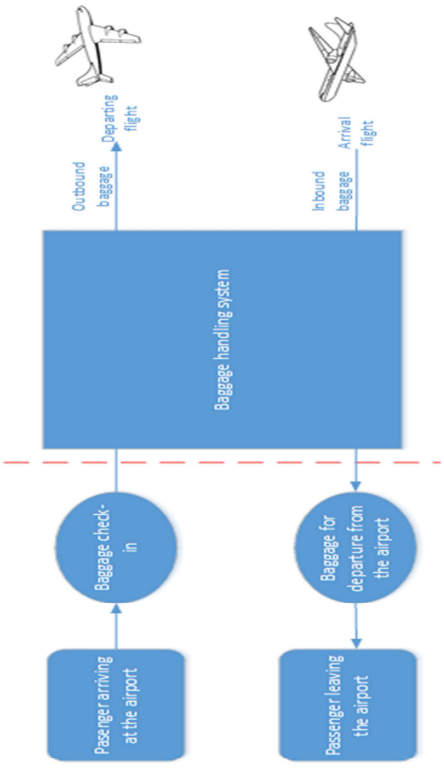

Figure 2. Display of the baggage processing room Baggage reconciliation.

The conveyor belt that brings the luggage to the sorter first passes through the X-ray machine where the luggage is inspected. It is then driven to the carousel where airport staff determine which trolleys to load their luggage on according to the inscription on their luggage. For one flight, as many trolleys are taken as necessary to transport the luggage. The trolley is always right for one flight and there is never a baggage shuffle. Figure 3. shows the transport of luggage over the conveyor belt.

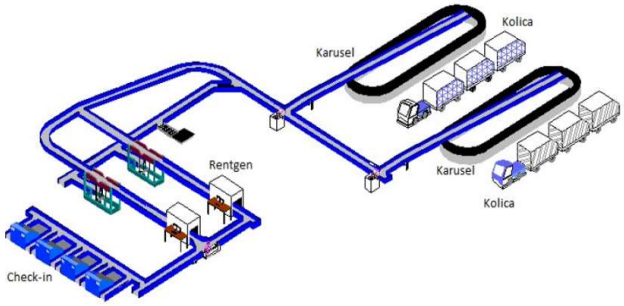

Figure 3. View of the baggage handling room via the conveyor belt [15].

The passenger can have hand luggage that he carries with him on the aircraft. Hand luggage must also be checked and the agreed rules that determine what can be brought on board as hand luggage must be observed. Some things, for example, must be in special bags (various liquids such as perfume, alcohol, tobacco, cosmetics) and should be entered in limited quantities. There are also items that should not be brought on the aircraft as hand luggage, but are allowed to be placed in luggage that must go in the luggage compartment on the aircraft in like nail clippers, etc. PSCRM states exactly how to handle luggage that uses batteries and luggage confiscated by airport employees [15].

3. Safety aspect of boarding control

Load Control is setting standardized codes and message formats. United Nations/Electronic Data Interchange for Administration, Commerce and Transport - (UN/EDIFACT) format which are used to communicate between different airports to notify cargo, passengers and their luggage which aircraft is heading to that airport [16]. Airports communicate with each other through SITA (fran. Société Internationale de Télécommunications Aéronautiques) network by sending standardized messages in EDIFACT format to exchange information about arriving and departing flights, lost luggage, etc [17].

Example of messages in SITA format:

- PROL Message
- SKO7102/29AUG DBV PART1
- CFOG/141M
- RBOD M/MY
- -OSOL073M
- 1WIONTHER/SVEINCATOMR-AO1
- .W/KO/3/40
- .N/0About000140618001/OSL
- .N/0000140621001/OSL
- .N/0About000140622001/OSL
- .R/EOTLP HK1 11799999999999999999

Through check-in message used to check passengers

- UNAB+IATA:1+OU+LH+150812:1210+DBVNIKO'
- UNAH+1+DCQCKU:03:1:IA+DBVNIKO'
- LOAR+XH:DBV'
- FDAQ+OU+0470+150514+ZAG+CDG'
- PPAD+NAKACHE+F+16+REBECCA++1019+1:1'
- PRAD+N+OK'
- UPAD+A+NAKACHE+N+REBECCAAAMS'
- UNAT+8+1'
- UNZA+1+DBVNIKO'

3.1. Safety in the disposal of aircrafts on the runway

Ramp Handling is including all necessary processes for situations such as directing the aircraft on the runway, determining the parking space for the aircraft, hand signs that are serving for the communication between the agent on the runway and the pilot, loading and unloading passengers, passenger luggage and cargo, ignition of the engine of the aircraft, etc. It is about processes that begin with the landing of the aircraft on the runway up to the parking of the aircraft, engine shutdown and disembarkation of passengers, luggage and cargo [18]. Then follows the work of the ground service that supplies the aircraft. When this part is finished, the process of disposing of the aircraft begins again on the runway where the agent on the runway must direct the aircraft to the prescribed airfield.

3.2. Safety and field service

Ground Handling takes care of all the needs of the aircraft, such as refueling, beverage and food supply for passengers and crew (catering), technical inspection of the aircraft, cleaning of the aircraft (interior of the aircraft and external windows), use of technical items such as starter, power generator, tractor for landing and take-off, unscrewing the runway for take-off and landing, transporting injured passengers and those in wheelchairs, processing passengers and their luggage at check-in counters, VIP lounge services, etc [19]. Since it is goal for the aircraft to spend as little time in the parking lot as possible, to pay less to the airport, these services must be carried out as quickly as possible [20]. For all delays caused by airport employees, the airport must be held accountable to the operator of the aircraft and in most cases pay the agreed penalties. The second consequence of the delay in the supply of the aircraft is the disruption of the order of take-off and landing of the other aircrafts. The above activities or needs are best illustrated in Figure 4.

There is an agreed sequence of execution of ground handling services that must be followed, whether for organizational reasons or legal reasons. For example, you cannot start cleaning the aircraft and before disembarking passengers. Also, by law, fuel must not be refueled until the passengers have boarded and a fire truck has arrived at the aircraft as a safety measure. The steps for provisioning the aircraft before take-off are shown in Figure 5.

Political sensitivities between countries may require attention from an airline, especially when the airline flies to disputed areas. [22] Monitoring flight safety is currently the task of flight dispatch. Castro (2013) proposes that flight dispatch's responsibilities should also include uploading information on disruptions to the MAS based tool (e.g. weather updates). This task might lead to an increased workload and hence could interfere with monitoring flight safety.

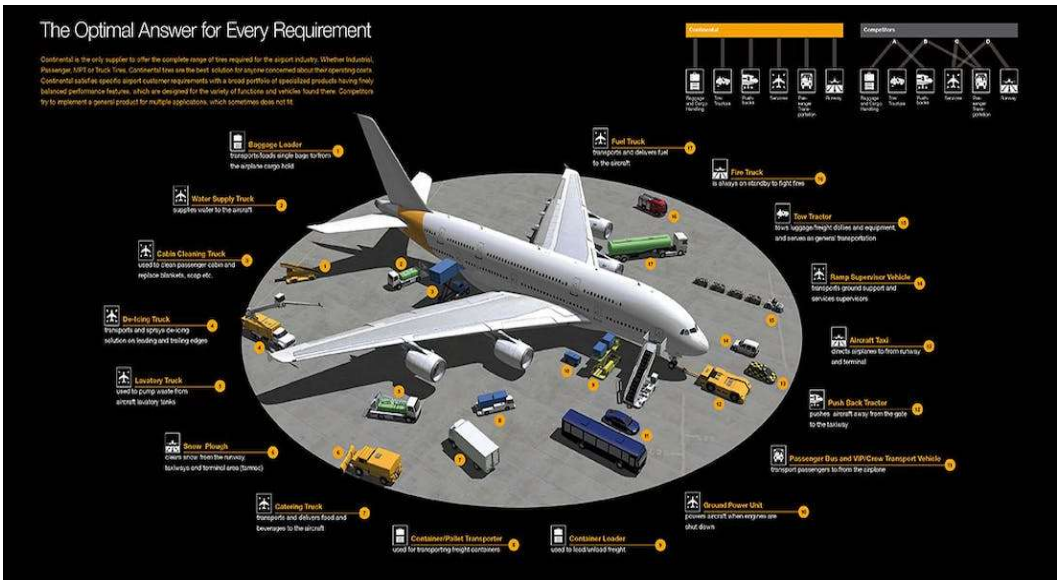

Figure 4. Overview of aircraft requirements at the airport [21].

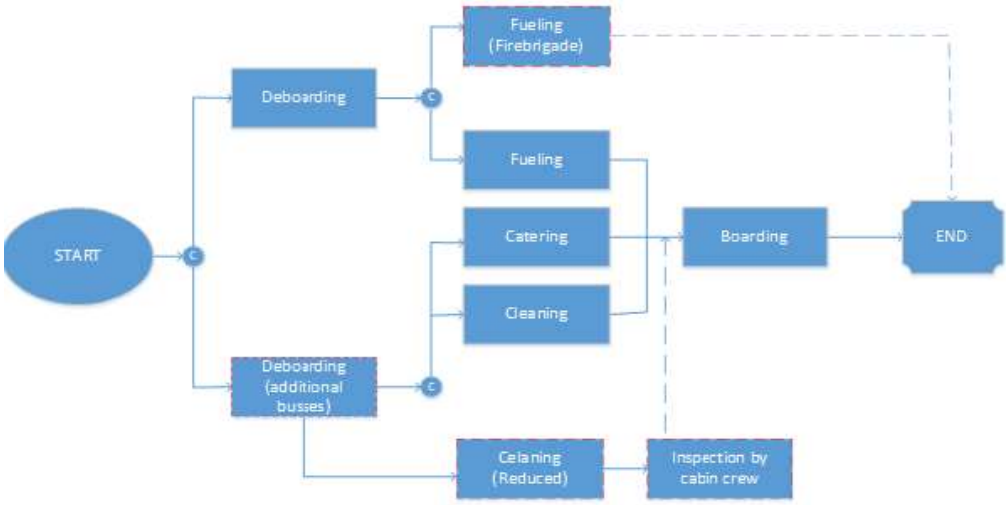

Figure 5. The process for the disposal of aircraft.

4. Conclusion

Safety in air traffic is one of the highest priorities. ICT systems find more and more applications in airports, either during the process of arranging flight schedules, optimizing flight control or optimizing the processes themselves at the airport. One of the main reasons for using multi-agent systems, besides efficiency and speed of operation, is the ability to quickly adapt to changes and emergencies such as changes in flight schedules, delays and making the right decisions in a short period of time.

In order to be able to make the right decisions, it is necessary to have accurate and timely information about the state of the situation. To this end, the European Aviation Safety Organisation (EASA) has started several projects to achieve faster data exchange between airports, airlines, air traffic control and governments of individual countries. This is especially accelerated after the emergence of COVID-19. EASA and the European Centre for Disease Prevention and Control (ECDC) have developed protocols for the measures airports, airlines and operators should adopt to ensure a safe return to normal operations. To strengthen the implementation of these measures, Airlines for Europe (A4E), the European Business Aviation Association (EBAA), the European Regions Airline Association (ERA) and the International Air Transport Association (IATA) have signed a cooperation agreement with EASA to promote the harmonised and coordinated implementation of the EASA/ECDC protocols by industry, governments and travellers

Despite numerous studies so far, no research has attempted to connect the passenger to the aircraft and optimize the processes by proposing a model that will cover the two. The aim of future research should be combination of all processes related to the aircraft (e.g. flight control, ground service, etc.) with passenger-related processes (e.g. check-in, safety screening, baggage care, etc.) since these are two closely related processes. The passenger will not arrive at the airport without planning to use it, and the aircraft will not land unless it plans to board passengers.

Competing Interest Statement

The authors declare no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

Data Availability Statement

No data or additional materials were utilized for the research described in the article.

5. References

[1] H. Wipf, "Safety Versus Security in Aviation," in *The Coupling of Safety and Security. SpringerBriefs in Applied Sciences and Technology()*., Springer, Cham., 2020.

[2] H. S. B, Agent-based Software Development Methodologies What is an Agent?, Sydney, 1997.

[3] L. I. L. N. M. E. T. A. K. A. Badanik B, "Future strategies for airports," in *27th Congress of the International Council of the Aeronautical Sciences*, Zilina, 2010.

[4] "IATA," [Online]. Available: http://www.iata.org.

[5] ICAO, 2014. [Online]. Available: https://www.icao.int/environmental-protection/CarbonOffset/Documents/Methodology%20ICAO%20Carbon%20Calculator_v7-2014.pdf.

[6] Kazda A; Badanik B; Tomova A; Laplace I; Lenoir N, "Future airports development strategies," *Komunikacie,* pp. 19-24, 2013.

[7] E. Šimić and M. Begović, "Airport delay prediction using machine learning regression models as a tool for decision making process," in *2022 45th Jubilee International Convention on Information, Communication and Electronic Technology (MIPRO)*, Opatija, 2022.

[8] C. M, C. Y and M. S, "Identifying Safety Performance Indicators for Risk Assessment in Civil Aviation," in *IOP Conf. Series: Materials Science and Engineering*, Beijing, 2021.

[9] EUROCONTROL, "Performance Review Commission: Performance Review Report," EURO, Brussels, 2012.

[10] Laplace I; Kazda A; Tomova A; Badanik B; Lenoir N; and M. E, "FAST:Future airport strategies," *8th Innovative Research Workshop and Exhibition, Proceedings,* pp. 19-28, 2009.

[11] J. Reason, Managing the Risks of Organizational Accidents, London: Ashgate Publishing Limited, 1997.

[12] K. A and T. K, "Simulation model of security control system functioning: A case study of the Wroclaw Airport terminal," *Journal of Air Transport Management,* vol. 64, no. B, pp. 173-185, 2017.

[13] Matas M; Novak A, "Models of processes as components of air passenger flow mode," *Komunikacie,* pp. 50-54, 2008.

[14] M. Janić, "A model of Air Traffic Control sector capacity based on air traffic controller workload," *Transportation Planning and Technology,* pp. 311-335, 1997.

[15] J. Vogt, T. Hagemann and M. Kastner, "“The Impact ofWorkload on Heart Rate and Blood Pressure in En-Route and Tower Air Traffic Contro," *Journal of psychophysiology : an international journal,* pp. 297-314, 2006.

[16] ICAO, "ICAO," 17 11 2020. [Online]. Available: http://www.icao.int/sustainability/pages/factsfigures.aspx.

[17] SITA, "SITA," 2020. [Online]. Available: http://www.sita.aero/aboutsita.

[18] J. M. Histon and R. J. Hansman, "THE IMPACT OF STRUCTURE ON COGNITIVE COMPLEXITY IN AIR TRAFFIC CONTROL," MIT International Center for Air Transportation, Cambridge, MA 02139 USA , 2002.

[19] E. S. Stein, "Air traffic controller workload: An examination of workload probe Report DOT/FAA/CT-TN84/24," FAA, Atlantic City, 1985.

[20] M. W. Hurst and R. M. Rose, "Objective job difficulty, behavioral response, and sector characteristics in air route traffic control centres," *Ergonomics Edition 21,* pp. 697-708, 1978.

[21] S. B, J. M and H. B, "Evaluation of a Multi-Agent System approach to airline disruption management," *Journal of Air Transport Management,* 2018.

[22] Aviationpros, "Aviationpros," 2016. [Online]. Available: https://www.aviationpros.com/gse/article/12246865/10-questions-withcontinental-specialty-tires.