Artificial intelligence to benefit the passenger experience at the airport

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The aviation industry has made significant strides in integrating artificial intelligence, resulting in the development of smart airports. These airports use the Internet of Things to offer improved services and systems, enhancing their development, sustainability, and efficiency. Artificial intelligence has also greatly aided in the management of smart airports by enabling real-time monitoring and analytics. Smart airports utilize intelligent sensors to manage conditions within the airport and provide automatic support services for passengers and security personnel. This study tells how AI is used at airports, what benefits it offers and how passenger safety is improved. The research also examines how the passenger's seamless travel improves thanks to AI applications.

This study was conducted as a qualitative desk-based study to understand the current AI-based solutions, especially at the smart airports how they impact passenger safety, and how they help in creating a seamless journey. Data was collected using already existing secondary sources. The study reveals the essential features expected from a smart airport, along with the systems and technology employed to offer passengers a comfortable and hassle-free journey. Smart airports prioritize travel comfort and efficiency while leveraging various sensors to perform analytics and create a safer environment. AI technology ensures seamless collaboration between all airport systems, resulting in a functional entity that combines AI technology, travel safety, and hassle-free travel.

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1 Introduction

Passengers are increasingly connected and looking for a safe, secure, and seamless journey to reach their destination. Smart airports want to offer their customers a better travel experience through the possibilities offered by artificial intelligence, in which case the passenger's experience would be highly personal, but especially safe and seamless. Smart airports have paid special attention to passenger safety and smooth travel, and the introduction of digital processes and procedures after the COVID-19 epidemic has especially accelerated this development.

The purpose of this desk-based study was to find out what kind of artificial intelligence-based applications airports use and what benefits they have for the passenger's travel safety. In addition, this thesis focused on at how AI improves seamless travel in airports. The research method of this thesis was desk-based research, which was a realistic research method for the data to be acquired. Since the topic was AI-based solutions for airports, this research method was a cost-effective and realistic way to carry out research using secondary data sources. The secondary data sources used in this work are mainly publications by experts in the field or publications by educational institutions.

Seamless travel is a special personal experience for every traveller, and it is suitable for everyone. Seamless travel is the use of technology that enables security checks as efficiently and quickly as possible. Seamless travel requires the use of AI technology, and more and more airports want to pay attention to ensure that every passenger has a unique seamless travel experience.

2   Purpose and aim of the thesis

The purpose of this qualitative desk-based study is to be of help to future and current operators and stakeholders in the airport and hospitality industry, who are faced with applications implemented with the help of artificial intelligence for passengers in the airport environment. This research helps to understand what kind of applications can be created for airports with the help of artificial intelligence and how all this together improves the travel experience, safety, and seamless travel. The purpose is also that the research would be useful for professionals in the field and for various parties and stakeholders operating in the aviation sector.

2.1   Scope of the study

The focus of the research is on the passenger's point of view. Initially, it was necessary to investigate the use of artificial intelligence at airports and identify the smart airports that have implemented this technology. Since AI offers benefits to airports, airlines, and passengers, it was important to limit the perspective and center the research around the passenger. To achieve this, research questions have been formulated to examine the phenomenon from the passenger's point of view.

From the passenger's point of view, the focus was particularly on how AI has improved passenger safety at airports because many AI-based applications at airports have improved passenger safety and that is a key issue in the aviation industry. In addition to travel safety, smart airport emphasizes seamless travel made easier by artificial intelligence, so the work discusses how artificial intelligence has made seamless travel easier. Smart airport's seamless travel applies to all passengers to guarantee a safe and smooth flow of customers. Therefore, passenger safety or seamless travel at work is not dealt with from the point of view of a specific type of passenger.

2.2   The research questions

The leading research questions of the thesis are:

- How has artificial intelligence been applied at the airports?
- What advantages does it have in terms of safety for the passenger?
- How does the application of artificial intelligence at airports improve the passenger's seamless travel and how?

This study first aims to answer how has artificial intelligence been applied at the airports and at the same time define key terms that are present throughout the study.

After this, the study focuses on what advantages AI has in terms of the passenger's safety and how the application of artificial intelligence at airports improves the passenger's seamless travel.

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Due to the vastness of the topic, the research questions were narrowed down to focus on airports. Artificial Intelligence (AI) has a wide range of benefits, so the topic was limited to passenger travel safety and how AI can enhance the seamless travel experience. This work will specifically address the safety of travelers, rather than the overall seamless travel experience, by examining a specific type of traveler. At smart airports, all passengers use AI-based applications on their customer path, and the seamless travel experience provided by these AI applications is available to every passenger.

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3   Methodology and analyses of the thesis

3.1   Research method

A research method is the process by which data is collected for a study. The method of obtaining research data varies based on the goals of the study, and the method should always be chosen on a case-by-case basis. In general, research methods can be categorized as desk-based research and field research. (Barbara Bassot 2022, 4–5.)

Qualitative research is not simply straightforward. A simple way to define that qualitative research doesn't involve numbers. Qualitative research is empirical research where the data is not in the form of numbers. In general, qualitative research is about exploring information to gain understanding via interpretation. Qualitative research involves exploring data and interpreting phenomena to gain insights rather than to get straight answers or solutions. (Barbara Bassot 2022.)

The desk-based research is defined as research where the data is gathered, and the collected data is organized to examine and interpret relevant theory. Secondary research involves using the data collected by others and interpreting that data to have new insights about research questions.

Desk-based research involves gathering information from secondary sources that already exist. This method involves finding and obtaining materials through various means and planning how to use them effectively. The data is frequently obtained from the internet or other existing documents without any direct contact with people. In her publication, Barbara Bassot explains that the term "desk-based research" is used as a distinct approach from secondary research and library-based research. (Barbara Bassot 2022.)

Table 1. Different terms for research (Barbara Bassot 2022.)

DESK-BASED RESEARCH – finding your own data via indirect sources, often via the internet, without having direct contact with people.

SECONDARY RESEARCH – using data from previous studies to gain new insights and interpretations through a new research question.

LIBRARY-BASED RESEARCH – often an alternative term for secondary research.

In addition, it is necessary to evaluate the gathered existing information. It is often the case that the necessary information is already available, but it must be evaluated to obtain relevant information for use in research. Defining the term desk-based research applies a wide range of ways to collect data from already existing sources. In general, three types of data sources are used in research projects. Those three sources are primary sources, secondary sources, and tertiary sources. (Barbara Bassot 2022.)

Primary data sources contain original material which is often written. They can be poems historical recordings and diaries. These sources can be also visual such as paintings, photos, and diagrams but also visual or recorded material such as podcasts, documentaries, and films.

Secondary data sources describe or analyze the primary sources. Secondary sources can include textbooks, dictionaries, encyclopedias, or other written material that review or evaluate the sources. Secondary sources can also include academic journal articles that are based on primary research.

Tertiary data sources compile and organize secondary sources to make them easier to find. The tertiary sources can guide to relevant academic articles and publications. (Barbara Bassot 2022.)

3.2 Search process

The research was conducted as qualitative desk-based research. In this desk-based re-search, I explored information via secondary sources such Internet from already existing documents and studies to gather specific information on the topic without having direct contact with people. I felt that there is no need to organize the acquisition of new research data since there exists plenty of accurate sources to gather information. The advantage of desk-based research is that it is a quick and cost-effective method to get more knowledge and understanding to answer research questions. In terms of material procurement, the material must be obtained from reliable and up-to-date information sources. Conducting research and collecting my data. The selection of the research method was also influ-enced by the abundant material that is already available, its easy utilization, and cost-ef-fectiveness.

Since I am using secondary sources for my thesis, it is appropriate to consult a data col-lection professional, for example in a library. In this way, it is possible to get more versatile and comprehensive information on the subject, so that I can get as much information as possible on the subject for my desk-based research.

3.3 Data collection and criteria

Research based on secondary sources should always be approached with a critical eye. When selecting sources, it is important to assess the reliability of the publisher and the timeliness of the information. Additionally, it is crucial to compare sources to determine the accuracy of the information. By comparing and analyzing data from multiple sources, it is possible to make informed conclusions and observations based on secondary sources.

I had to be critical in choosing which sources to use for this research. I first considered the criteria to be whether the source directly describes my topic and whether it answers my research questions. The source also needed to be directly useful for my research or whether it is mainly information that supports the topic.

The aviation industry has experienced a big change after COVID-19, and in addition to that, artificial intelligence has changed a lot of operating methods at airports in recent years, which I focus on in this work. Because of this, I tried to stick only mainly to similar sources that were published in 2019 or later. In this way, I can ensure that the material I use in this work is as up to date as possible and considers the change in the field, where artificial intelligence has greatly influenced the operation of airports.

In this research, the sources for the theoretical part were mostly English-language publications, which were guides on how to do a qualitative desk-based study, to get an idea of how the theoretical part of this kind of research progresses. Otherwise, the sources chosen for the study were largely English-language publications of aviation professionals on the internet, and English-language publications of some educational institutions, which deal directly with the subject and can be considered reliable and fresh. In addition, electronic articles and sites related to the topic were used as sources when published by relevant sources. As written English sources, I used the printed publications of Airport Report magazine aimed at aviation professionals. All the material I use is already publicly available and I do not need separate permission to use the material.

Throughout my thesis, I have utilized printed specific magazines that I have intentionally accumulated over the course of my studies. I have subscribed to the Airport Review magazine in paper form and have diligently saved each printed edition for future reference. To expand my research, I have taken advantage of the Google Scholar option in the Google search engine to purchase or read online e-books. These e-book sources have diversified my sources and proved to be invaluable. To delve deeper into specific research queries, I have utilized the Google Scholar feature to search for pertinent PDF files. Additionally, I have come across various e-books that have provided me with a wealth of general information on a range of topics.

As I conducted research for my study, I encountered some challenges in sifting through the material to find articles and texts that dealt with the perspective on accessibility, which was the focus of my study. For instance, I came across a lot of information on how artificial intelligence has transformed air traffic in numerous ways, such as making things easier in the aircraft itself or air traffic control. However, I had to carefully filter my topic and focus on sources that specifically discussed the achievements of artificial intelligence in airports and how it can facilitate seamless travel.

While reading through the materials, I also paid attention to whether the authors used keywords that were relevant to my thesis. These included terms such as artificial intelligence, applications, seamless travel, customer experience, technology, and many others that were related to my topic. I've noticed that the same content gets published in various places on the internet, but it's often reported or interpreted differently by different people. This made it quite challenging for me to locate the original and complete publication. Additionally, I came across some excellent articles and publications on university websites, but unfortunately, they were only available to students at that University.

I was willing to pay for some good publications that cover my topic, but I couldn't find any. Some online materials were available for purchase, I ended up buying some e-books to assist me in my research.

3.4   Analysis of the data

Analyzing is a critical aspect of desk-based research. It's normal to collect a significant amount of material that includes various studies, articles, and other documents that must be compiled and analyzed.

Studying secondary data is an essential part of the research process, and it's crucial to collect the material carefully, review it, and check it to eliminate any possible deficiencies. and ambiguities. Sometimes it is also necessary to supplement the material. In this desk-based study, ready-made existing material has been used, which has been tried to be used as an effective tool to deepen the knowledge of matters for which there is already ready-researched information and results. It is therefore secondary research, i.e. research of research data. (Sarajärvi.Tuomi 2017, 160-168.)

In general, content analysis in a desk-based study is only an aid for organizing the material and not an actual analysis tool. The difference is clear in qualitative research, where content analysis is a tool for data analysis. When content analysis is an aid, subcategories and superior categories are made from the collected material. This allows the material to be organized and grouped. (Sarajärvi.Tuomi 2017, 160-168.)It is also possible to approach the analysis of the material through a thematic analysis. Both analyses, content analysis, and thematic analysis, can be done either based on material or theory. In practice, the same principles and logic apply to the form of thematic analysis as to content analysis. (Sarajärvi.Tuomi 2017,160-168.)

In both the content analysis and the thematic analysis, the starting point is the collected material, but in the content analysis, the material is classified into subgroups and supergroups, and the description takes place in the form of a table. In the thematic analysis, the most important and leading ideas are initially extracted from the collected material, around which a mind map is outlined, and an entity related to the theme can be created.

In the content analysis, procedure is with the help of a table, but in the thematic analysis, we draw a mind map, which becomes more and more detailed around the topic into a clear whole. In the thematic analysis, each theme must be clear, and coherent in terms of content, and different themes to be discussed.

Normally, there are several mind maps, and, in the end, there are only a few concepts in them. In the literature, when dealing with thematic analysis, it is emphasized that the researcher must actively work on the material he has collected and interpret the material in the right way. (Anneli Sarajärvi, Jouni Tuomi 2017, 160-168.)

3.5   Thematic data analysis

For this work, I used thematic analysis as it was the most suitable method for analysing the material I gathered and the kind of answers and information I was seeking. My main objective was to identify the most significant topics and content from the data I had collected to answer my research questions. I created various topics based on the relevant content that was most central to my research.

In this study, I used thematic analysis because I felt it fit well with my research questions and the secondary data, I was able to gather for this study. In addition, considering the amount of material I collected, a mind-map type of review seemed like the most logical option. In addition, the data I used for this analysis was as simple as possible to categorize, since I did not produce my research data.

In general, thematic analysis is also a relatively easy and quick way to analyze data, especially for a person who does not have much experience in qualitative research.
With the help of thematic analysis, it was easy to keep clear exactly what information was relevant to me and thus gather information relevant to my research question and topics that support my research questions around my theme. (Guest. Mac Queen. Amey 2012.)

Table 2. The general progression of content analysis and thematic analysis. (Sa-rajärvi.Tuomi 2017.)

CONTENT ANALYSIS	THEMATIC ANALYSIS
A strong decision on what you are interested in	
Get to know the material, make notes	Get to know the material, make notes
Collect the marked things together and separately from the rest. reduction of subjects Forming subclasses Formation of upper classes Forming a gathering concept for the whole	Collect interesting facts together. Simply collect the facts Organize the material into potential themes. Think about the relationship between the themes: for example, what is the connection between the different themes and between the different levels of the themes? Are some more relevant than others? Check that the material fits the themes and make a mind map. Define the themes, and their content and name the themes.
Write a report	Write report

The secondary data I collected includes the following type of material: Internet publications that are from educational institutions or written by professionals in the field. E-books purchased on the Internet. A printed aviation magazine with a lot of current industry publications and a few video documentaries.

I read through all the publications on the Internet and selected only those that were most useful in terms of my research questions and those that could contain information supporting my topic. Among these, I still had to drop those whose publisher was not reliable enough in my opinion, or a source that seemed to only refer to the original writing in its style. Finally, I only included the publications that were from the original publisher.

In the periodical publications, I picked out articles that supported the Internet publications I had chosen, but which brought some new information to the matter, and I could link them to support the themes I had already outlined. I looked through the video material to get an idea of how I could better visually illustrate seamless travel to the reader in my work and I looked for ideas on how to present it. I sorted these video materials into data supporting the seamless travel topic.

After I had outlined all my main themes, I started to think about their relationship to my research questions and whether the content of my data corresponds to my research questions. Do I need to add data or change some things. After that, I started thinking about different levels of the themes and how to structure them all into a logical entity around my research questions and what would be a clear structure.

Although in the thematic analysis, a final report is written on the analysis of the data used, this time I did not feel it necessary to write a separate report. Instead, I outlined the structure of my research and the order of presentation of things. I continued to read through my data and marked the order of priority in the data I collected, and at which points in the research I would use the data I collected. This was a sum up that was just right for this secondary desk-based study that I am doing alone.

4   Artificial intelligence technology transforming airports

Artificial intelligence has a lot of positive effects on efficiency, safety, and smooth travel when you learn to use the advantages it offers. Customer satisfaction and customer service have a high importance to the airport industry and nowadays AI technologies are likely to impact operations over the next decade. Artificial intelligence (AI) could be a game changer in the future for airports and airlines which are now embracing new technologies and turning to artificial intelligence (AI) to support their customer service. (International airport review, 2021.)

Technology is changing how companies and customers communicate, and airports are no exception. Data is now being used to enhance the entire passenger experience from buying tickets and selecting seats to boarding and ground transportation. This data can be collected at every stage of the journey, allowing airports to improve their operations and provide a better customer experience. Artificial intelligence is being embraced by airports as it offers an opportunity to provide personalized service and meet customer expectations. This desire to enhance customer service is a significant driver for airports to adopt AI technology in their operations. (International Airport Review, 2021) (International airport review, 2021.)

The introduction of artificial intelligence at the airports is also associated with an interest in efficiency. "According to McKinsey's study on artificial intelligence reports the global travel industry will gain $400 billion in increased efficiency annually through the adoption of artificial intelligence. (Mc Kinsey& Company).

Artificial intelligence enables the automation of routine tasks previously performed by humans. For example, as the aviation industry is applying AI there are concerns about AI systems replacing humans in the workplace. AI will support human decision-making and assist in repetitive tasks that are too challenging and boring for humans. AI is a branch of computing in which a system is capable of not only intuiting a decision based on its inputs but also making the correct recommendations more likely than humans based on the same information given. For example, routine customer service tasks at airports are performed by widely used chatbots, which are a good example of artificial intelligence technology. Such chatbots already exist, for example, at Frankfurt and Berlin airports. Practically AI systems and the human world collectively achieve a mission. (International airport review, 2021.)

To remain competitive in the aviation industry, airports need to explore new technologies and collaborate with partners and stakeholders to integrate these technologies into their daily operations. Artificial intelligence is a constantly evolving field, and machine learning is being increasingly used to improve applications, resulting in noticeable enhancements. For example, Internet of Things (IoT) devices on airplanes or in airport hangars generate vast amounts of data, which organizations can use to implement predictive analytics to optimize everything from safety waiting times to maintenance tasks, thereby improving customer experience and safety. The algorithms are at the core of an AI system or platform, and they are typically designed to solve or support a specific problem. (International airport review 01/2020, s40).

Finding applications for AI in an airport environment is relatively easy because airports are willing to test for example baggage tugs, semi-autonomous boarding bridges, and the drone has flown aircraft inspections. Key areas in this new development include robotics and artificial intelligence (AI) As in many industries airports need to stay on top of the development. Now the possibilities and limitations of AI are currently intensive subjects in the media. There are questions such as how many airport processes can be automated, how to simplify them, and what kind of role the robots will play at the airport. All these together mean changes to airport operations. (International airport review 03/2018,48).

AI applied to be a seismic technology at the airport must achieve at least some goals and benefit the airport and the passengers. According to Ian Law (01/2020), AI must play a leading role in tackling one or more key industry issues, it must realize the significant potential to create a viable commercial market and it must command industry-wide use not just at a small subset of top-tier airports. (International Airport review 01/2020,40).

4.1   Airport industry preparing for AI

Getting AI solutions right in action will take preparation and the quality of AI-based decisions is a function of the quality of its inputs. AI-based solutions must be very accurate and have comprehensive knowledge of their environment. Accurately detecting an environment through sensors and other means will require capital investment.
Making the right decisions at critical points requires AI algorithms that possess the capability to process those complex inputs and considerable investment in training and algorithms to learn responses to all possible scenario algorithms require considerable processing resources to operate in the real-time airport environment.
The current capabilities of cloud technology allow algorithms to scale to simultaneously serve the biggest and smallest airports, each paying for their use.

Airport Council International (ACI) and the World's IT Standing Committee are developing data hub designs for airports of all sizes to capture and store other data. They are also creating common data standards that ensure that data inputs to algorithms are uniformly common across the industry. AI has considerable potential to be a change for the good in the airport sector. Algorithms will be the new software and will command the highest price. The get most out of the value airports must work to develop common standards to capture the data to develop algorithms and commercial concords that allow ongoing research and development of algorithms in a vibrant AI algorithm marketplace that tackles the aviation sector's issues. (International Airport Review 01/2023).

4.2   Smart airports

New technological developments have forced airports to develop and become smart airports. New technological solutions are smart departure gates, check-in, baggage control, facial recognition, and biometric identifiers, the airport is navigated using a mobile device. Passenger behavior is studied by data mining and data analytics. Airport operations use AI adaptations and many other solutions based on artificial intelligence. These AI solutions and improvements provide better customer satisfaction for passengers and an efficient work environment for airport staff. (Smart Airports 2020.)

A smart airport is an airport that uses bid data and open data to improve its operations. At smart airports, to make operations more efficient, operators create value by collecting information on real-time passenger flows and at the same time analyzing the passenger profile. To have a better look at smart airports, it is necessary to define a smart airport. Nagy, E., & Csiszár, C define the smart airport in their publication Airport Smartness. The airport using AI technology is defined as a smart airport or Airport 4.0. They have added the definition of a smart city to this definition of a smart airport. These smart cities apply technology to urban life to create a comfortable and sustainable environment. In this context, the smart airport is only a part of this whole system, and they are completely connected. Information is exchanged Information is exchanged between urban traffic and air traffic. In this way, the best possible performance is achieved to guarantee customer satisfaction (Nagy & Csiszár, 2016).

Flight safety: Flight safety requirements must always be followed to guarantee a safe journey for passengers. Flight safety must also be guaranteed by aircraft personnel and everyone who uses and operates at the airport. Smart airports improve the safety standards of the aviation industry with modern technology to reduce inconvenience to passengers by complying with regulations and requirements.

At the airport, security screening processes are challenging, as they take a lot of time, and passengers find it an unpleasant experience. However, the security check ensures the safety of the flight. At the smart airport, the Internet of Things (IoT) is used as a smart application to mobilize, identify, and process tasks to identify passengers together with RFID to provide advanced security service (Aruna Rajapaksha & Dr. Nisha Jayasuriya, 2020.) The Internet of Things can offer a lot of opportunities at airports, especially when using AI technology. In addition to efficiency, the Internet of Things can offer better passenger knowledge generate new revenues and improve profitability.

Munich Airport is a good example of an application based on artificial intelligence for security checks. Munich Airport has a CT, computer tomography, scanner terminal that can detect both solid and liquid explosives. In this terminal, passengers do not need to bring out their laptops, smartphones, and the permitted liquids they contain. Baggage only needs to be declared and it can be easily screened through the scanner. (Business Traveler 2023.)

In general, a smart airport provides a safer environment for passengers as well as everyone else who operates at the airport. If a security incident were to occur at a smart airport, it would be immediately reviewed with the integration of IoT. In the future, airports will have to respond to rapid growth and the challenges it brings, such as increasing the capacity of airplanes and expanding airports. It is necessary to continuously use smart technology to support the development of airports. The use of biometrics is also one of smart airports' key IT applications, which can be used to identify passengers during security checks, check-in, or at the border at the airport. (Aruna Rajapaksha & Dr. Nisha Jayasuriya 2020.)

4.3   AI Applications at the Smart Airport

Managing an airport is a responsible task because the airport as an operating environment is limited, but there is a lot of responsibility. Airport management must manage available resources, deal with internal and external agencies, maintain timely service delivery, maintain the security of passengers and visitors, and safe operation of the airport while complying with aviation regulations. AI offers different applications to airports, the purpose of which is to meet the challenges of airports when passenger flows increase and ease rush hours. In this chapter, we go through which applications airports offer that are based on artificial intelligence.

Smart check-in

Passengers are offered several check-in methods, such as mobile phones, in-person, and computer-based service kiosks. These practices reduce the number of personnel at the airport and human errors are reduced. At Smart airports, the passenger can check in for the flight he booked in the terminal through any service counter for his airline. Smart check-in There are different ways for the passenger to check in; he can do it on the Internet, by mobile phone, or on the spot at the airport. Computer-based kiosks are available at airports, which are cost-effective as they do not require staff and reduce human error. In the past, airlines offered such self-service check-in kiosks to their customers. Smart airports can offer such kiosks to customers of all airlines, and check-in can be done through any self-service kiosk. In this way, the terminal space can be used more rationally and efficiently, and at the same time, it is possible to offer a service to everyone. (Aruna Rajapaksha & Dr. Nisha Jayasuriya 2020.)

Self-boarding

It is expected from a smart airport that digitalized systems and processes offer an efficient and pleasant travel experience. The access process to the international terminal is an unpleasant experience for the passenger, as it involves a lot of security checks and manual processes. A smart airport is expected to use AI technology to connect different digitalized systems and processes to offer a more efficient and convenient travel experience. The boarding process is thought to be an unpleasant experience for the passenger in addition to security checks and other usual manual processes. Smart airport boarding pass scanning gates are positioned so that the passenger scans the passport himself and boarding pass at the self-service check-in counter before boarding the plane. This self-service check-in counter uses the latest RFID technology.
When boarding the plane, the passenger scans the boarding passes by placing them in the reader, which is at the gates before boarding the plane. The self-service check-in counter checks the boarding pass and the passenger's passport. Thus, the passenger can go on board without human contact or the inspection process at the gates. The self-service check-in counter uses the late RFID methodology. (Aruna Rajapaksha & Dr. Nisha Jayasuriya 2020.)

Indoor navigation

Mobile phone applications can provide a wide range of information such as flight times, airport locations, boarding times, and gates. The mobile phone application can contain navigation instructions in the terminal or generally how to arrive at the airport. Also, all the services offered by the terminal are usually included in the travel plan of the phone application. The application also provides information about the terminal, where there may be congestion peaks, information is also available about the speeds of different processes, and the application provides notifications and alerts to the passenger.

With the help of smart applications, the passenger gets directions to his destination, and the airport's processes and formalities are handled easily without ground handling staff and the placement of points at the airport. (Aruna Rajapaksha & Dr. Nisha Jayasuriya 2020.)

Biometric services

Biometric services in many airports have implemented automatic personal identification based on physiological characteristics. These identification systems are usually placed carefully at the control points at the airport. The biometric features that the system detects are face recognition, fingerprints, hand geometry, handwriting, retention, and vein, which are important identifiable biometric features.

The sterile area at the airport means the space after the security check. Into this area only ticketed and screened passengers are allowed to enter or the staff with the identification badge. These are services that guarantee passenger comfort in the airport process, improve security, and reduce the possibility of human errors. With the help of biometric identifiers, it is possible to improve and facilitate access to the airport, security checks, processing of tasting documents becomes easier, e-gates, and easier entry to sterile gates.

The use of biometric identifiers also facilitates the identification of luggage and the border inspection process, thus making the trip to the airport seamless and smooth. When a passenger boards the plane, it is very important to identify the passenger with the help of a biometric identifier, as this way a safe flight can be guaranteed. There are already existing fully biometric travel documents that offer more precise identification of passengers, with a very high level of accuracy. By utilizing this technology, it is possible to check whether the holder of the travel documents is the same person who boarded the plane.

With the help of AI technology, it is possible to take biometric data such as fingerprints and faces at the check-in point. The passenger can be monitored, and his condition mapped using smart CCTV cameras which prevents crimes while the border control checks his documents. The idea is that passengers have easy access to the departure gates with a valid passport and biometric identifier. In this way, many airports can improve passenger comfort, and the efficiency of the entire terminal process, reduce the number of staff, and the possibility of human errors, and thus a lot of information can be entered to support artificial intelligence decision-making. (Aruna Rajapaksha & Dr. Nisha Jayasuriya 2020.)

Smart wearable

To be able to explain the technological solutions of smart airports precisely enough, the next point is a direct quote from Smart Airport: A Review on the Future of the Airport Operation. The review explains very precisely how AI technology has been used in combination with other technologies.

> With modern technology wearable hardware solutions are in use and an embedded microsystem is the core structure. The physical interaction module shares environmental sensors to measure temperature and humidity, scanners, and remote controller modules. Passenger-centric modules operate touch screens, cameras, audio features, and motion sensors. Communication systems include WiFi, Bluetooth, GPRS, IOT & other latest communication methods (Aruna Rajapaksha & Dr. Nisha Jayasuriya, 2020).

Smart devices such as watches, electronic hand-held accessories, Bluetooth headgear, smart headphones, and other electronic devices with sensors give notifications and alerts to passengers on how to coordinate their timing and activities at the airport. In other words, the equipment worn over this informs the conditions of boarding times, changing departure gates, locations of check-in counters, duty-free shops, and restaurant services. The passenger starts receiving real-time travel information when he enters the terminal door or when the aircraft starts sending travel information to arriving passengers. (Aruna Rajapaksha & Dr. Nisha Jayasuriya 2020.)

RFID luggage tags

RFID identification refers to radio frequency identification technology, which is mainly used at airports for baggage identification in the handling process. This technology facilitates the handling of luggage remotely from different locations between different people. The immediate benefit for the passenger is that the passengers will receive an RFID-based luggage tag that can be used to track the goods. With a baggage ticket, you can get information about loading or unloading baggage or about their journey during a layover. Airports benefit from the fact that RFID technology reduces the risks of misuse of luggage. Additional information about the luggage is entered into the system, such as the manufacturer, brand, and dimensions of the goods. The number of ground-handling personnel is less, and the explosive detection system can reduce the risk of damages that occur. Lost luggage can be reported easily by scanning the boarding pass and baggage check card when the customer contacts their airline. The airline can quickly locate the luggage using RFID technology and deliver the luggage to the right place where the customer is. (International Airport Review, 2021.)

Bags ID

Passengers' luggage can be used with BagsID, which is shaping the future of traveling with bags at airports. This technology uses high-speed computer vision and artificial intelligence to identify bags in a system that makes traveling with all bags at the airport much more direct for a passenger. The BagsID reading rate is 99.4 percent and more and the price per bag is significantly cheaper than the previously used RFID technology. This allows airports to make financial savings and it does not require major operational changes to airport operations or ground handling operations. (International Airport Review, 2021.)

Self-baggage tagging

Conventional airlines and low-cost airlines are both pursuing growth and low costs. The number of self-connecting passengers is on the rise, especially in Asia than in Europe. South Korea's Incheon Airport in particular plays a key role in self-service at the airport, which makes it possible to handle large numbers of passengers. At smart airports, the number of staff is reduced, and resources are not needed as much as before. Passengers tag their pieces of luggage using baggage tags provided by the machines in the departure terminal. The machines print baggage tickets for the customer and this way the airline can reduce fixed and operating costs. Passengers can monitor the status of the luggage from a smartphone.

Digital baggage tags bring an advantage because ground handling can change the digital barcode if there are changes to the trip. (International Airport Review 2024.)

4.4 AI benefits at airports

Passengers expect a comfortable and smooth journey in the terminal, despite the terminal formalities. At a smart airport, passengers do not have to wait for long periods compared to a traditional airport. Sensors using the Internet of Things produce information about the shortest line, parking spaces, and reliable luggage.

For example, Changi Airport has introduced automated baggage handling machines in Terminal 4 that work entirely with facial recognition technology. There is absolutely no need for manual procedures or identity checks during the security check during the entire departure screening process, which is fully automated taking passengers' comfort into account. In addition, At Changi Airport, artificial intelligence has already been implemented, especially in terminal four, and the use of artificial intelligence and machine learning compatible applications for various functions. In this way, it is possible to sense, analyze, and predict better what is happening at the airport to make operations more efficient. (Changi Airport Group 2021.)

Airstar robots have been developed in Korea to guide passengers in terminals. These robots are placed in crowded passenger areas, such as the arrivals hall, tax-free stores, and luggage belts in the arrivals area. Robots improve the comfort of passengers and thus services such as transportation, parking, and self-driving vehicles are more accessible. This ensures a good intelligent passenger experience and indoor terminal positioning technology with the help of robots. (Smart Airports 2022.)

Efficiency

To improve the efficiency of airport operations, passenger data collection is important. Big data analysis is an inexpensive and very useful advantage for the airport. It can be used to identify passenger behavior, get more revenue, locate passenger gathering places, and calculate average waiting times for passengers. This intelligent data processing and big data can be used to determine the passenger's behavior.

In Distilling Managerial Insights and Lessons from AI projects at Singapore's Changi Airport Lee, S., & Miller, S. present that modern airport operators are keen to detect and network infrastructure, data management infrastructure, data analytics, and artificial intelligence and machines. This enables continuous learning at the airport so that the efficiency of operations can be improved and developed.

In South Korea, Incheon Airport has improved its operations through smart technology by utilizing real-time data. The airport has real-time flight delay tracking, flight waiting times can be estimated and the passenger transfer process in the terminal can be predicted. These functions improve airport performance and passenger comfort. The South Korean airport also takes advantage of the opportunity to manage airport operational delays with digital display boards and smart CCTVs. This is a video surveillance system that uses video cameras to send signals to a limited audience. Other working dashboards automatically update and alert at the required level resources and performance levels using big data analysis (Incheon Airport, 2019.)

Optimizing limited resources

Airports must get more space for commercial operations and thus must be able to optimize the limited terminal space. By using modern technology, the operating costs of airports can be lowered. When a passenger's customer trip at the airport is thought of as a priority, passengers' comfort and smooth travel are the most important. The smart airport does not want passengers to pack into one area. The idea is to reduce the number of passengers by managing the waiting area in the terminal. It is important to manage passenger flows and use terminal resources efficiently at different times to keep passenger flow flowing smoothly. Thus, it is also possible to reduce the operating costs of the terminal and improve the efficiency of the operation with the right methods.

The Smart airport concept is an effective solution, as it optimizes the use of limited resources at the airport. Smart airports can implement IoT-based real-time information systems when predicting the future. This system suggests, for example, the best resource for the exchange arrangement during the terminal's peak hours. This is based on AI analysis. It is possible to allocate resources and manage the airport also by allocating manpower, in which case most of the processes are automated and personnel are not needed as much for passenger processes. Robotics, personal mobile phone directives, smart information panels, and the airport. Collaborative Decision Making (A-CDM) systems can optimize the available limited resources that prevail in the terminal.

In South Korea, for example, Incheon Airport introduced an A-CDM system in 2017 to integrate real-time data with the air traffic control tower and apron control tower. The result was improved responsiveness with departure times and runway queues managed in advance. with the A-CDM system. In addition, intelligent technology helps reduce energy consumption by handling lighting and air conditioning systems (Aruna Rajapaksha & Dr. Nisha Jayasuriya).

Growing passenger volume

Effective passenger flow is essential for the operation of the airport. Airports use passenger analytics, which monitors the number of passengers and movement through the airport using video and IoT (Internet of Things). The machine learning models offered by artificial intelligence are applied to this data and thus airports can optimize queue management and manage checkpoint resources by reacting to changing situations. In this way, it is also possible to predict peak periods, so that airport retailers can make the necessary sales actions.

In general, the predicted passenger volume and the demand that this will put on airport efficiency and effectiveness will be the unifying issue for the whole sector. Algorithms that will take a myriad of airfield inputs and support real-time or just-in-time gate allocation and airfield management decision support will prove valuable to aviation industry leaders.

As airports add more gates and runways, airport revenues will need to cover the long-term costs of expansion during this growth. AI-based solutions will be used, new sources of revenue must be invented, and airports' commercial utilization of assets has to be optimized. (Smart Airports 2019.)

4.5   AI improves passenger's security

Airports want to significantly improve their passengers' security due to the new threats. At the same time, passengers' expectations of air travel have changed and grown, which has pressured airports to develop better transit, speed up queues, and make the journey as seamless as possible from the airport entrance to the departure gate.

For many governments, AI offers solutions that can improve the travel safety of passengers. For example, in 2019, the United Kingdom invested 1.8 pounds in the development of new AI systems to improve safety through AI systems. Aviation security officials have also introduced new computed tomography scanners that use artificial intelligence to target threats at Los Angeles International Airport, J.F. Kennedy Station, and Phoenix Airport.

The more information that is fed into artificial intelligence systems, the more useful they are in terms of passenger safety. The airports, using AI machine learning, potential threats can be identified and analyzed much more accurately and faster than humans. In the past, for example, objects such as liquids and electronics had to be scanned separately at security, but thanks to artificial intelligence technology, these items can be kept packed in luggage when they pass through security. For example, for Helsinki-Vantaa airport, Finavia has invested in the airport's security check and acquired transillumination and liquid analysis equipment. Passengers no longer must separate goods from carry-on luggage, and the device can identify security risks in luggage even better. (Airport Technology 2019.)

Passengers go through checkpoints at the airport, the technology of which improves the safety of passengers and airport staff at airports in addition to checkpoints, artificial intelligence can also improve security in the ground area of airports. There is the Evolv Edge system used to scan people. This system uses a combination of a camera, facial recognition, and millimeter wave technology to scan people walking through a security gate. Such technology is based on machine learning and improves the more data is fed into it. Machine learning technology can be used to analyze data for various security threats. This Evoly Edge technology is applied at the Oakland International Airport. Evoly Edge technology detects, for example, explosives firearms, and other dangerous objects and substances affecting passengers' travel safety and flight safety. (Airport Technology 2019.)

With the help of Evol Edge technology based on artificial intelligence, about 900 people can pass through the security gate in an hour, which is significantly faster than the traditional X-ray scanner at the airport. At the Oakland airport, the purpose of Edge is to scan airport employees before and during their shifts at the airport. The intention is that the same technology would be introduced in other parts of the United States to screen not only employees but also passengers. This helps manage future risks at the airports and improves passengers 'safety at the airport and in the aircraft. (Airport Technology 2019.)

One of the emerging applications of artificial intelligence in airports is computer vision. This technology utilizes cameras and machine learning algorithms to monitor complex ground maintenance operations and detect safety issues in real time. It can also sound alerts when services are taking longer than expected. Gatwick Airport in London is one of the pioneer airports to make use of computer vision to increase aircraft turnaround times and provide better security conditions for ground staff. The ability of AI to learn, observe, look for patterns, and raise awareness of specific situations such as human behavior can add significant value to an airport's security and safety posture. AI can immediately detect and alert about a passenger collapsing in a terminal, a child at risk of injury, or a victim of human trafficking. This technology will be invaluable to the public and the sector. The airport's cameras use AI video analytics that can detect immediately if a passenger or anyone at the airport suffers an injury or another health issue. The AI camera technology immediately warns the airport security team about the accident, and they can react promptly to assist the spot. (Skylla 2024.)

Due to the COVID-19 pandemic, airports are considering the adoption of AI computer vision technology to prevent the spread of potential pandemics and diseases. Computer vision-based AI cameras can be used to scan passengers for increased skin temperature, observe social distancing, and check if passengers are wearing mandatory face masks. If regulations are not followed, security personnel will intervene. Automated passenger heat screening is performed to avoid congestion at airports, and this technology can help prevent the spread of diseases while managing other health risks. By monitoring a passenger's temperature, the system can also detect if the passenger is nervous or potentially unwell, in which case they can be further checked before they pass through security. (Scylla 2020.)

AI computer vision technology also enables real-time monitoring of luggage and, above all, timely detection of unattended luggage. Unattended baggage can pose a threat at the airport and endanger the safety of everyone at the airport.
Unspecified baggage may contain explosives or other security threats. Computer vision can automatically detect objects, bags, or other goods that appear to be without an owner or abandoned at the airport for a long time. With the help of technology, it is possible to trace the potential owner.

Another baggage-related problem at airports is baggage theft. If luggage is reported as stolen, AI systems can be used to carry out a forensic search of luggage and persons. The operator can monitor the passengers' activities before and after the reported event, quickly identify the location of the stolen item, and track down the suspect. Computer vision is highly implemented at the Gatwick International Airport and Toronto Pearson International Airport. (Scylla 2020.)

With airport security in mind, facial recognition is widely used at various airports to scan passengers as they pass through customs at several major airports. Border control Immigration agencies, customs, smart services, and quarantine are required to fulfill all the conversions and regulations. The International Airport Council insists on using international standard methods in biometrics and uniformity. Not all border control systems have the necessary face recognition systems that could be sure that the passenger who gets on the plane is the same as in the travel documents. Therefore, in addition to facial recognition, biometric readers should be introduced at border checkpoints with electronic immigration gate which uses biometric recognition known as e-gate systems. (Airport Technology 2019.)

The most important thing when using this technology is accuracy. In the USA, Hartsfield-Jackson Airport is launching a fully biometric terminal. The passenger uses the facial recognition scanner at the self-service check-in kiosk, at various checkpoints, and the entrance gates. (Airport Technology 2019.) Using this technique requires particularly good precision. In 2019, Hartsfield-Jackson Airport in the United States started the first biometric terminal. Passengers use facial recognition scanners at self-service kiosks, checkpoints, and boarding gates. The biometric terminal uses fingerprints, facial recognition, and retinal scanning to minimize potential security threats to pre-empt security threats. (Airport Technology 2019.)

4.6   Future AI solutions

Thanks to artificial intelligence, it has been possible to create diverse security systems for airports. For example, in Great Britain, an AI system has been developed at the University of Manchester, which can measure a passenger's walking speed or step pattern when the passenger steps on the pressure pad. (EE Times 2018.)

The intelligent portable border control system project has been launched in the European Union, the purpose of which is to facilitate border crossing and whose technology is completely AI-based. In this project, the plan is a virtual border control that asks passengers questions about the contents of their suitcases and other questions. At the same time, a camera that monitors facial micro-expressions analyzes expressions.

If the virtual border guard thinks that the passenger is lying, the system takes more information about the passenger before the passenger is checked by a human border guard. (Airport Technology, 2020.)

The airports that have implemented AI-based applications are the largest in Europe, the United States, and Asia, with a high passenger volume. All the time, different governments in different countries are developing different strategies and studies on how AI-based technology can be utilized in different methods to improve the safety of airports and make passenger flow smoother.

4.7 Conclusions

The smart airport is the future model of the airport and the airports have already implemented many AI-based uses for passenger operations, baggage handling, and security checks. The most important applications of artificial intelligence at airports are determined to offer better passenger experience, the efficiency and profitability of the airport operation, considering limited resources, and above all, flight safety. The use of each AI application, Internet of Things, big data analysis, and the latest RFID technology in baggage handling guarantees a better customer experience. The use of all these technologies enables a smooth process at the airports at the different touchpoints. These points include smart check-in, self-service boarding, the use of various smart devices, RFID baggage tracking and bag tagging, automatic kiosks for finding lost baggage, border control, and mobile phone applications that provide air travelers with navigation.

Strategic challenges at a smart airport are limited space and the growing number of passengers, information security also creates its challenges that can be facilitated with the help of AI. The digital transformation of airports is very expensive, and the planned investment would also be a future product. Future studies it is recommended to identify the required level of intelligence adaptation of technology in the airport operations.
It is important that expert personnel receive training, and they have a positive mindset for digital change together with all stakeholders. A lot of attention is paid to the functionality of airports and a lot of research is done about the future.

New insights are to be discovered and special solutions on how to get functioning smart airports in countries with emerging economies and countries with great tourism attractions, but AI has not yet been able to be utilized. One direction of development matters to everyone between countries, creating a functioning flight infrastructure. (Research Gate 2019.)

In the future, ensuring the safety of passengers with the help of AI technology solutions will be crucial. These AI-based solutions can be used at airports to improve travel safety, speed, and efficiency. Fast passenger flows at the airport rely on maintaining continuous security and minimizing security risks. Achieving this goal requires regularly updating and maintaining security procedures, as well as feeding AI systems with new information to ensure machine learning. AI technology solutions need to constantly communicate to predict, analyze, and anticipate passengers and other operators at the airport. This involves analyzing foot traffic, behavior, check-in and boarding times for individuals driving around the airport. By incorporating AI technology, airports can offer a safer and improved operating environment, which prioritizes the safety of customers but also enhances the travel experience. (Matt Powell 2022.)

Airports use different AI applications and machine learning is a key part of AI technology, which can be used to predict potential security threats at airports. By utilizing AI and machine learning together, data can be collected automatically throughout the passenger's journey. The passenger's journey starts at check-in and ends at the boarding plane. To be analyzed are the passenger's foot traffic, micro-expressions at different points, body temperature measurement, and other end-use situations where the passenger's behavior is monitored.

Airports strive to ensure a high level of safety, efficiency, and comfort for their passengers. To achieve these goals, they are increasingly turning to advanced technologies such as AI, automation, and security systems. In particular, the use of analysis technology helps to improve travel safety and streamline passenger flow.
By adopting these new technologies, airports can gain a competitive advantage, offer a more personalized travel experience, and create a secure environment for their passengers. According to Matt Powell in 2022, these technological advancements are critical for airports to maintain their position as leaders in the travel industry. (Matt Powell 2022.)

5 Customer journey -seamless travel

The integration of artificial intelligence has enabled the creation of a seamless travel experience for passengers at the airport. Seamless journey begins from the check-in process to the boarding gates. The primary goal is to improve passenger flow at the airport by providing digital AI-based solutions at checkpoints for travel documents and implementing computer vision solutions for security checks. This eliminates the need for passengers to separately remove items from their bags or take off accessories and outerwear during security checks, making queues shorter and flowing quickly. This, in turn, reduces security risks and ensures a smooth start to the customer journey. (IDEMIA. Seamless travel experience.2022.)

The seamless customer journey utilizes AI-based biometric recognition technology, allowing passengers to check in for their flight and have their travel documents verified without human contact. This not only reduces the time spent in queues but also ensures a hygienic journey where passengers travel in minimal contact with each other, thus preventing the spread of infectious diseases.AI-based technology has the potential to provide a safer and more pleasant travel experience for passengers while also making the tasks of airport and aviation crew members easier. Thanks to AI, security checks can be conducted in advance using biometric facial recognition devices, automated travel document checks, and various sensors that collect information at airports. All these measures help to ensure a seamless journey for travellers. (IDEMIA. Seamless travel experience.2022.)

Passengers nowadays demand more comfort and speed when traveling. In 2023, IATA conducted a global survey of passengers, which revealed that travellers expect a smooth and seamless experience at the airport with minimal wait times. The research also showed that passengers have confidence in biometric identification and are eager to use it to speed up their journey, especially during the check-in process before arriving at the airport. (IATA. Global. Passenger survey.2023.)

Using single identity tokens to unlock the full potential of a seamless travel experience based on biometric data has become possible thanks to the use of AI technology. This has resulted in a decrease in traffic congestion and has made it easy for passengers to monitor peak traffic times from their phones, enabling them to plan their schedules accordingly. A stress-free travel experience is guaranteed, leaving enough time for passengers to relax in the airport cafes and restaurants. The seamless and fast travel experience ensures a comfortable and enjoyable customer experience. (IDEMIA. Seamless travel experience.2022.)

The air travel industry faces challenges in ensuring smooth and seamless travel experiences for passengers. As the number of passengers increases and their expectations grow, airports need to carry out more security-related inspections as smoothly as possible. While airports should aim to offer a seamless travel experience, security checks must be enhanced to address possible new threats, and contacts at airports should be minimized. This is where the use of AI technology becomes increasingly important. However, it is essential to keep costs moderate. One of the challenges in creating a seamless travel experience is that airport infrastructure and models can significantly vary depending on the location and size of the airport. For instance, smaller airports may not have enough space to accommodate the technology required at checkpoints, making it challenging to expand their airport model. Airports across the globe vary in terms of their technological capabilities. While some older airports may require expensive upgrades to accommodate AI technology, smaller local airports may not prioritize seamless travel and AI integration. Nevertheless, these airports play a vital role in their immediate communities by providing essential transportation services.

5.1   Touchpoints and customer journey

I have created a visual presentation that showcases how easy it can be for a passenger to navigate at the airport. The presentation features circles that represent the various touchpoints a passenger may encounter while at the airport, including departing, transit, and returning passengers.

Additionally, the presentation features arrows that illustrate the passenger's journey through the airport, emphasizing the use of cutting-edge technology that streamlines the passenger's experience. The descriptions of each customer journey also consider the specific needs of different types of passengers, such as those departing for their trip, transit passengers, and those returning from their journey.

Table 3. Outgoing passenger touchpoints at the airport.

Table 4. Returning passenger's touchpoints at the airport. A smaller circle outlines the transit passenger touchpoints.
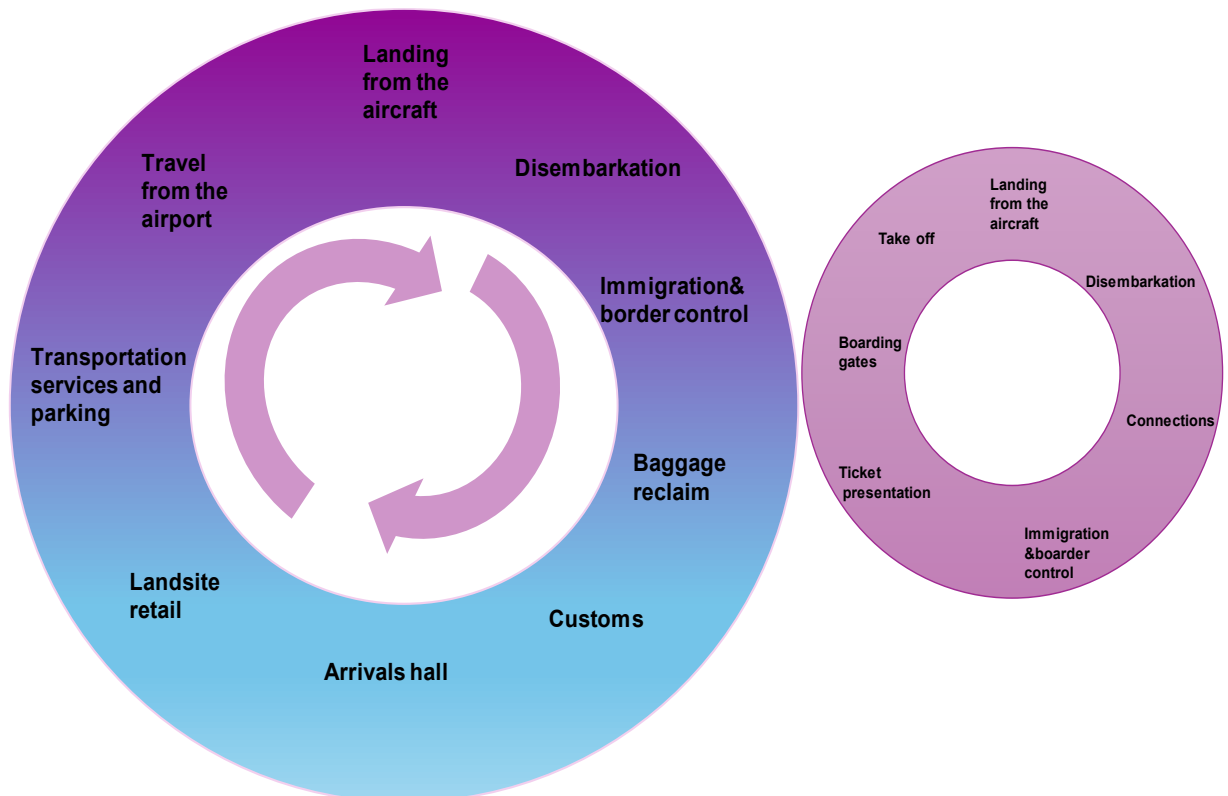
Table 5. Below is a representation of air passenger touchpoints, denoted by purple arrows. The first arrow signifies the touchpoints of departing passengers, the second arrow shows those of returning passengers, and the third arrow denotes the touchpoints of transit passengers.

In addition, I have attached a document describing the seamless passenger journey powered by AI technology, represented by green arrows. It explains how AI technology has been implemented to ensure a hassle-free airport experience for passengers.

Check in	Baggage drop	Security	Departure hall	Airside retail stores shopping	Departure boarding gates	Boarding to the aircraft	Take off
e-gates, biometric pre register walk thorough experience	Self service digital bag tag and drop mobile tracking	Biometric recognition, infra red cameras for walk thorough	Digital screens & wayfinding, mobile device personalized content	Mobile or biometric payment, mobile applications, personalized shopping proposals	Sensors, health status, location based services, digital screens and wayfinding	Queue management, digital document checking at the borading for walk thorough	

Landing from the aircraft	Disembarkation	Immigration & border control	Baggage reclaim	Customs	Arrivals hall	Landsite retail	Transportation services and parking

Landing from the aircraft	Disembarkation	Connections	Immigration & boarder control	Ticket presentation	Airside retail stores shopping	Boarding gates	Take off
e-gates, biometric pre register walk thorough experience	Digital screens and wayfinding, personalized notification for the mobile	Visa document & checking seamless biometric identity management	Computer vision detects lost bags. Mobile tracking	Customs: Automatic threat detection systems Tickets: mobile, digital ticket scanning	Common-use payment, mobile applications, personalized shopping proposals	Queue management, digital document checking at the borading Parking: smart parking, automated licence plate recognition	

Virtual queuing and check-in

AI technology at the airports makes possible to avoid surfaces that need to be touched at the airports. A seamless travel experience also allows to avoid queues and thus the passenger can enjoy a fast and effortless journey. There are various applications on the phone for seamless travel. With the application, the passenger can buy an e-ticket to the airport, which allows the passenger to access the airport's so-called fast list. Such applications include Contactless Fast Track and Queless Journeys. The e-ticket enables the passenger to reserve an arrival time at the airport from which his flight departs.

The passenger queues at the airport virtually on his smartphone and delays and arrives at the airport when it is his arrival time. Airlines and airports also encourage passengers to digitally check-in in advance via mobile applications to avoid queue times and traffic jams. (Finnish border guard, 2020.)

The option of virtual queuing and seamless technology can offer a safer and more convenient experience for passengers. This means that passengers can avoid touching surfaces and eliminate the need to wait in long queues at the airport. As a result, there is less chance of the spread of diseases and passengers have more time to shop, dine, and relax in the airport lounge. Completely contactless airport experiences are therefore for those who are ready and open to new technology and who decide to share their biometric data. Fast and fluent seamless travel also helps airports generate non-aeronautical revenue as passengers have more time to spend in restaurants and shopping areas. Additionally, phone applications can assist passengers throughout their customer journey, making their trip more stress-free. (International Airport Review.2019.)

Travel documents

The step towards seamless travel is digitization, but people still rely so much on the physical passport as a travel document that the challenge is real. This is why the Digital Travel Credential (DTC) has been developed and is an accurate representation of a biometric passport or other electronic passport. This means a machine-readable travel document. The document contains the passenger's personal information, such as a facial image, and security features. This document is on the passenger's device for example mobile and can be read at airports only with the passenger's consent using public key infrastructure encryption. This guarantees a higher level of security, especially for reading biometric data. (Ideamia.2022.)

Digital empowerment provides a seamless travel experience as well. The passenger can do DTC (Digital Travel Credential himself. He scans his passport information with his country's mobile ID application, and the application combines the biometric data and the trip information. After this, the airline's check-in application creates a temporary unique identifier for the trip, which corrects the passport and boarding pass. When the passenger is at the airport, he uses this identifier at all checkpoints where identity is verified. The smartphone is placed on the contactless reader, or the passenger looks only straight directly at the facial recognition device. (ICAO, 2020.)

An e-passport is a digital version of a standard passport that comes with a chip containing identical information. To boost security, fingerprints and iris data are added, which are unique to an individual, making it easy to verify their identity. Moreover, the chip can be read without contact, and all the information can be retrieved within a second. This is also another alternative way to identification. Passengers can conveniently store their digital passport in their digital wallet, which automatically shares their nationality information and necessary travel document details when required. British Airways, for example, utilizes a secure login system where passengers can easily share their digital passport and flight ticket information with the airline. Upon doing so, passengers receive a confirmation via text message that they are all set for their upcoming flight. And for those who prefer a completely contactless travel experience, traditional boarding passes are no longer necessary.

Passengers can also save time in obtaining a visa by applying for an e-visa, which can be applied for online using an e passport and flight information. The visa is usually issued within a few days. In countries where passengers are exempted from a visa, they can obtain an electronic travel permit in place of an e-visa. To obtain a journey permit, passenger can also apply online, which provides a seamless travel experience for the passenger from the very beginning.

Some countries have developed a program called Trusted Traveler to ensure passenger flows move quickly and efficiently at airports. The program focuses on identifying and assessing the risk levels of passengers, allowing security checks and control points to concentrate on the riskiest individuals. By participating in the Trusted Traveler program, passengers can enjoy reduced waiting times at various airport checkpoints. The program also eliminates passengers who do not pose a risk, making the process even faster. The United States is one country that has implemented such a program. (Eulisa, 2022.)

Baggage handling

The aviation industry today is highly digitized and generates a lot of information about airplanes, passengers, luggage, and various functions of the airport. Managing this information efficiently is crucial to ensure smooth airport operations and passenger satisfaction. IoT technology is used to collect and analyses this data in real time. The Internet of Things refers to systems that rely on data transfer from various technical devices. IoT technology helps in collecting and analysing data in real time, enabling better decision-making and improvements in various aspects of airport operations, such as flight schedules and airport resources.

The Internet of Things has improved baggage handling. When a passenger checks in, a laser light system measures the dimensions and weight of each piece of luggage. Based on the flight information, weight, and size of the luggage, the computer assigns a specific location inside the airplane container for the baggage. The luggage is also given an identifier with an antenna for a narrow frequency band, allowing for quick removal from the plane if the passenger doesn't board for any reason. Thanks to this new technology, physical tags with ten-digit bar codes are no longer necessary. (BagsID, 2024.)
However, passengers may suffer from tremendous inconvenience if their suitcase is sent without any form of physical tag. The downside is that if the destination airport doesn't have AI technology for luggage handling, finding the luggage can be a challenge without the bar code tag.

A baggage handling system which has been installed at London Gatwick Airport enables full traceability and pre-clearance of baggage up to 18 hours before the scheduled departure time. This system has improved the handling of luggage, but at the same time, it has also increased the energy efficiency of luggage by up to 50 percent. This fits in with the seamless travel concept of future airports because airports want to be cost- and energy-efficient. (BagsID, 2024.)

Passengers can now benefit from the latest baggage handling and security screening technology. During the security screening process, they no longer need to remove all liquids and electronic items from their carry-on bags, as well as shoes and other accessories that they wear. The use of AI technology in security checks has greatly reduced the hassle and time of the screening process. The system checks both the carry-on goods and the passenger, allowing for a faster and smoother experience. Additionally, the computer vision used in this technology can detect security risks that might otherwise go unnoticed. This technology is already in use at Helsinki Vantaa Airport in Finland.

Shopping at the airport growing non-aeronautical revenue

A smooth customer experience means a travel where every traveller's step takes is seamlessly integrated with their digital identity and biometric data. Shopping at airports will also become effortless and more convenient, as the idea of seamless travel is to give passengers more time to shop while at the airport.

Passengers are now receiving personalized purchase offers through the social media channels they use, applications, or other engagement platforms. Travelers can even get customized offers from travel agencies by sharing information about their loyal customers, which can be integrated with their smartphone's digital wallet. Airlines can use passengers' purchase behaviour and history to tailor offers that are unique to them. This makes the purchasing process more convenient and streamlined for everyone involved.

The process of placing orders has been simplified and streamlined. The passenger can choose any product or service from the available options and create an order. This order is then saved as a verifiable credential in the passenger's digital wallet. There is no longer any need to present the passenger register, electronic ticket, or any other travel documents while making a purchase, for instance, at the airport's tax-free shop. All the necessary travel details are saved in the verifiable credentials, which can be easily read through a QR code. (IATA, 2023.)

Automated boarder control and boarding eGates

Electronic gates, known as eGates, are found at the airports using biometric technology to automate the process of checking passports at the border security and boarding to the aircraft. This technology is very efficient and speeds up not only the security and customs process but also boarding process. The expansion of eGates means that more airports will introduce electronic gates that use biometric technology to automate the inspection of passports and boarding passes, therefore making the customs and boarding process faster to the aircraft. This technology allows citizens from different countries to travel more smoothly at the airport.

Automated border checks help border guards to process travellers more efficiently and reduce waiting times at airports. The use of e-gates is made possible by the performance of passport technology. When using an e-gate, the passenger simply places their e-passport in the reader and looks at the camera. The chip in the passport and the information page are read in just one second. The signature of the passenger is verified, and the passenger's face is compared to the photo on the chip. The system can also check Interpol's databases and international watch lists. If the facial recognition matches, the passenger is allowed to pass through the e-gate. (International Journal of Business and Management,2020.)

To come back to the earlier chapter the e-passport is an electronic version of a regular passport that comes equipped with a chip containing the same information. To enhance security, fingerprints and iris data are also added. This biometric information is unique to an individual, generating it an efficient way of verifying identity. Additionally, the chip can be read without contact and all the information can be retrieved within a second

During the boarding phase, passengers reach the e-gates where their journey at the airport comes to an end. From there, their customer journey may continue as a transit passenger, or they may leave the plane and become a returning passenger at the airport, or they may proceed to their destination.

5.2   Dubai International airport DXB

In my thesis, I used Dubai Airport as an example to discuss the concept of a seamless passenger experience. I chose this airport because it has implemented three fully AI technologies in its terminal three for all passengers. From a tourism perspective, Dubai International Airport is an excellent example of efficiency, innovative utilization of AI technology, and forward-thinking.To understand the technologies offered by artificial intelligence at Dubai Airport (DXB) AI technology has been applied to create a smooth and seamless customer journey, considering all the location-specific needs, requirements, and possibilities.

The UAE, United Arab Emirates and General Civil Aviation Authority (GCAA) are investigating the use of artificial intelligence in the air traffic control process at the UAE airport in collaboration with Canadian Seabridge Technologies. This led to the conclusion that the UAE's strategy is to explore how artificial intelligence and other technologies can improve the aviation industry. The goal is especially airport and air traffic safety and efficiency. Arab Emirates is actively developing airport AI solutions with the support of the government in the Dubai Future Accelerators facility. (Dubai airports, 2023.)

The upcoming chapter and graphics provide some interesting insights into the potential customers of the airport. Here are some facts:

> - In 2022, the airport served 66.1 million passengers annually, making it the busiest airport in the world with approximately 200,000 passengers per day.
> - The DXB airport offers access to 229 destinations across 99 countries through 88 international airlines.

- Out of the 62.2 million pieces of luggage handled by the airport in a year, 99.8 percent were successfully handled with an error rate of only two bags per thousand passengers.

- Additionally, 92 percent of the luggage was delivered within 45 minutes of the passenger's arrival after the plane landed at the airport.
- In terms of security services, 96.2% of passengers queued for 5 minutes at the passport check upon departure, while 95.5% of arriving passengers waited less than 13 minutes.

- In 2022, a total of 343,339 flights flew through the DXT. (Dubai Airports Main Fact File, 2023.)

Travel experience in Dubai airport.2022.

In 2023, at Dubai Airport, passengers traveling in terminal three can consent to the use of their biometric data in the Emirates application, service kiosks, or in person with a customer service representative at the check-in point. This enables a completely contactless and fast customer experience at several points in the airport at Dubai International Airport in terminal three.

The areas where AI is being used in terminal three are check-in, lounges, boarding, and immigration. At all points, artificial subsystems are biometric innovations that recognize passengers' unique facial features and link their passports for instant identity verification. The first biometric airport terminal number three is already operational at Dubai International Airport and now has AI-based systems in place for all the passengers flying from terminal three.

The Smart Gates at Dubai Airport are cutting-edge biometric technology that precisely identifies passengers by their facial features. By expediting the immigration process and reducing waiting times, these automated border control systems significantly enhance the overall travel experience. To take advantage of these benefits, passengers must fulfill the requirements of the gates. (Dubai International airport DXB, 2024.)

In addition, AI-based solutions, and services at the DXB airport can help passengers choose their meals, schedule a taxi from the airport, and achieve a completely personalized travel experience throughout the journey, which would be completely seamless and queue-free.

Self-driving cars run at Dubai Airport, using fully artificial intelligence and 100 percent solar and electric energy. In the longer term, the idea is that these vehicles will enhance the daily operations of Dubai airport and help improve traffic between ground and air traffic. At the airport, there has also been talking for a long time about baggage handling that relies on artificial intelligence and would work under robots. (Forbes, 2020.)

Eligibility for Smart Gate access operated by Dubai Airport only serves a select group of individuals whose flight departs from terminal three. Citizens of the United Arab Emirates and GCC citizens, which means Gulf member countries, meet smart gates requirements. The smart gate function is also available for citizens of the United Arab Emirates, and citizens of the member nations of the Persian Gulf Cooperation Council. Those individuals who have established residency in the United Arab Emirates can also travel through Terminal Three gates, meaning that long-term residents of the country can take advantage of this completely seamless and streamlined travel benefit.

Upon arrival at Dubai International Airport, passengers are required to register automatically at the entry touch point. To determine if they are eligible to use Smart Gates, passengers must check their eligibility on the General Directorate of Residency and Foreigners Affairs (GDRFA) website. If the passenger is eligible, they will receive immediate confirmation and can use the smart gates when traveling in terminal three. The purpose of this feature is to provide a smooth and comfortable travel experience for eligible passengers. However, it is important to note that this feature is currently only available to certain nationalities at DXB airport.

It's worth noting that the smart gates at Dubai International Airport are only available to UAE and GCC nationals, UAE residents, and visa holders with a biometric passport. This means that many regular tourists who don't meet the criteria for smart gates, as well as transit passengers who don't meet the eligibility requirements, cannot use this service. However, traditional entry checkpoints are still available throughout the airport. (Dubai International airport DXB, 2024.)

In conclusion, it seems that a truly seamless travel experience is only possible for those eligible travelers who belong to specific nationalities, visa statuses, or hold a biometric passport which is also known as e-passport. Therefore, a completely seamless travel experience is not possible for all passengers. Despite this, Dubai International Airport is an excellent example of how AI technology can be utilized in airports, with significant investments being made in this area. While a seamless travel experience may not be possible for all nationalities, AI technology is still being used to enhance the airport experience.

5.3 Seamless travel is important for several reasons

Traveling can be made seamless by reducing waiting times and eliminating extra processes, which can make the travel experience smoother and more efficient. With advancements in technology, it has become easier for passengers to book a flight and board it seamlessly. This can save a lot of time and effort for travelers, making their journey more comfortable and hassle-free.

Seamless travel is beneficial in multiple ways - it enhances the customer experience, increases passenger satisfaction, and provides an opportunity for a more personalized customer journey. Travelers value hassle-free travel, individualized services, and an uninterrupted passenger experience. Seamless travel creates positive experiences at various stages of travel lead to customer loyalty, which ultimately benefits businesses.

Individuals have different travel preferences, and the various stages of travel can be quite burdensome and stressful for everyone. However, seamless solutions can help to reduce stress and anxiety, making the trip less burdensome and more enjoyable. With such solutions, passengers can focus more on enjoying their trip rather than worrying about airport luggage or the smoothness of their travel experience, including whether they will make their flight or not.

AI technology has made it possible to integrate better systems with the entire airport security system. This allows for better monitoring of the flow of people at the airport, as well as monitoring of various situations and enhanced control and communication. With the help of these integrated systems, airport personnel can obtain up-to-date information about flight delays and changes in departure gates, thus enabling passengers to be kept informed. All of this contributes to a safer airport environment.

Efficient and seamless processes at airports can significantly reduce the costs of airlines, improve non-aeronautical revenue for airports, and lower the overall costs of airports. Other stakeholders such as passengers also benefit from the cost-effectiveness of a seamless travel process. The cost savings resulting from streamlined operations can be passed on to passengers in the form of lower prices.

Airports and airlines that have integrated AI technology and invested in a seamless travel experience gain a competitive edge over other players in the industry. Travelers tend to prefer airlines and airports that offer stress-free and hassle-free travel while prioritizing comfort and efficiency. A seamless travel experience is beneficial for all the parties involved, including the airports, airlines, and passengers. (Idemia, 2022.)

5.4 AI can make traveling smarter and more seamless.

The use of AI in aviation has led to several benefits that meet current and future market demands. These benefits include improved planning, targeted decision-making, and complete understanding and monitoring of the most important performance factors of all airports and airlines. When Big Data is correctly monitored, it can help calculate operating costs, improve customer service, maintain a competitive marketplace, and increase profit margin and shareholder value.

Artificial intelligence has become increasingly important in the travel industry, not just to improve business profitability, but also to enhance travelers' experience throughout their journey. By implementing AI at airports, it is possible to identify passengers' needs and solve problems to create a seamless travel experience for all involved parties, including travelers, service providers, and airport staff. Airports host people, airplanes, and luggage from all over the world, which makes it crucial to ensure seamless movement of all entities involved. The implementation of AI at airports can help achieve this goal by streamlining processes and identifying potential issues before they become problems, thereby enhancing the overall travel experience. (International Airport Review, 2024.)

I am aware that the pandemic has had a considerable influence on the integration of AI technology in airports, particularly in enhancing travel convenience. The pandemic has underscored the importance of secure travel, with a decreased reliance on contact-intensive surfaces. Consequently, the travel process has been optimized, with some physical stages of the journey either simplified or eliminated, rendering the entire experience more hassle-free.

Since the outbreak of the pandemic, both airports and airlines have suffered significant financial losses. However, the implementation of seamless travel has provided a financial boost for both parties. Seamless travel shortens the various stages of a passenger's travel process, allowing them more time to explore retail stores and shop on their phones while onboard. This results in an increase in non-aeronautical revenue. It's worth noting that seamless travel doesn't only benefit passengers; it's also an efficient way to increase sales revenue, which is crucial for both airports and airlines.

The COVID-19 pandemic has also had a significant impact on the integration of AI technology in airports, particularly in enhancing travel convenience and security. The pandemic has highlighted the importance of secure travel, with a reduced dependence on contact-intensive surfaces. As a result, the travel process has been streamlined, with some physical stages of the journey either simplified or eliminated, making the whole experience more hassle-free.

Different terms are used to describe seamless travel, which is made possible by AI technology. These terms refer to the change in the customer journey brought about by using technology. For example, some sources refer to it as biometric travel, which means that biometric identification takes care of all stages of the journey. However, this is not yet possible in all stages of every customer journey at all airports. Others refer to it as smart travel, which is more descriptive, as it implies that digital applications make traveling easier and eliminate the need for physical or paper documents. Additionally, some publications mention the digital journey. Although the use of different terms in various sources can be confusing, the important point is that they all refer to seamless travel, which is a customer journey realized using AI technology. This type of travel is effortless, quick, and easy from the customer's perspective, thanks to digital services.

Based on my research from multiple sources, I have concluded that having some level of familiarity with various applications and digital solutions can help to create a smooth travel experience. It is my belief that frequent travelers are more likely to benefit from a seamless travel experience, whereas those who travel once or twice a year for vacation may not find the seamless travel option as valuable.

Seamless travel is the future, and AI technology will be applied first at the world's largest and busiest airports to create seamless travel. These airports are several terminal airports, and passenger flows are high. Therefore, it's crucial to guarantee travel safety and provide a great customer experience for every air passenger, which is the most critical aspect of seamless travel. The passenger's satisfaction and unique experience during the entire trip also benefit the airports and airlines, as a satisfied passenger will probably travel through the same airport or airline in the future. In essence, the integration of seamless travel undoubtedly results in heightened effectiveness and revenue, specifically for airlines and airports. For the traveler, seamless travel diminishes anxiety, saves considerable time, augments safety through AI technology, and delivers a more tailored and enjoyable customer experience at the airport. Ultimately, an improved passenger journey at the airport benefits all stakeholders in the aviation industry.

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