UNIVERSITY OF THE AEGEAN

SMART AIRPORT ATHENS INTERNATIONAL AIRPORT “ELEFTHERIOS VENIZELOS” CASE

MASTER THESIS

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ABSTRACT

As air traffic grows, airports need to adapt to the requirements and to become more entrepreneurial and proactive to changing aviation dynamics. Most of the airports, nowadays are considered ‘’multi-nodal’’ transportation hubs for people, information and trade. The goal of the smart airport is to make systems and processes digitally aware, interconnected, infused with intelligence and simple to access by everybody. Smart airports will have to use multiple intersecting digital and automation technologies that have to converge in solving the new technology challenges. To deliver a genuinely customer-centric experience, the smart airport partners will need to go beyond data sharing and ensure extended collaboration, from strategic planning through to operation decision-making. The same data will be shared and enriched by various users – including the passengers themselves – who will control the level of access to their personal information. On the whole, no airport of the future will be truly smart without exploiting IoT (Internet of Things) capabilities. In short, it means that physical objects are connected to the Internet via an IP address, enabling everything that connectivity entails: tracking, data collection, analysis, control and more.

This project is about smart technologies that have been developing for the last years and their implementation in the airport field. The report is divided into two parts: the first part deals with a theoretical study, whereas the second one is about the practical application of the previous analysis. In the first place, the concepts of smart technology and smart airport are defined as well as every aspect that this implementation, in a certain area, involves. Next, some examples of the considered as the best airports in the world are shown. This list is based on either the technologies development or the passengers' point of view. Also, the fields in which these technologies are mainly implemented are exposed. As it is shown along the report, the use of these technologies improves and eases the experience of both passengers and workers. But the fact that they are new means that the security to protect them from intruders' attacks is still being developed. This is the reason why the possible attacks that could happen to communication network are analyzed, too.

The airport chosen for the second part of the project is the Athens International Airport, “Eleftherios Venizelos”. First of all, the actual existing technologies in this airport are analyzed and it is studied if this airport could be considered smart or not. Therefore, a visit to the airport was necessary. Secondly, a new application of smart technology is thought and developed at the mentioned airport. The proposal application is a beacon network deployed along the terminal able to locate via application where the passengers are at real time. So, the passengers have the ability to navigate within the airport to destination of their choice (e.g. from check-in counters to departure gate). After this, the network is designed and finally the approximate budget needed to invest is calculated.

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TABLE OF CONTENTS

INDEX OF TABLES

INDEX OF FIGURES

1 INTRODUCTION

1.1 DESCRIPTION OF THE RESEARCH

The aim of this project is to do a study of smart technologies and to analyze which ones of them are currently in the airport field, especially at Athens International Airport (AIA) “Eleftherios Venizelos” and which new applications could be implemented with the objective of improving the users experience, either passengers or workers.

The project is separated into two parts. The first part consists in a theoretical study of smart technologies and the use of this intelligence at the airports, an analysis of the fields in which they are used and some of the most attractive characteristics of the considered the twelve best airports in the world will be commented. Besides, the technologies that passengers with local and international destination crosses will be exposed since they leave their home until they leave the destination airport.

In the second part of the project an intelligence analysis will be carried out at Athens International Airport (AIA) “Eleftherios Venizelos”. After a visit, it will be determined if these technologies are present at this airport and whether it can be considered smart or not. A new idea of application will be chosen to be implemented at it and the beacon network to be deployed along the terminal will be designed. In the design of the network it must be taken into account how the sensors will be distributed and what type they will be, that is, it will be necessary to differentiate between fixed and mobile nodes, if they will be capable of analyze obtained data and where the Gateway will be. It should also be considered whether the sensors will be powered by batteries or if they will be connected to electrical power. The most technologically challenging point though, is the design and implementation of the mobile app. There are several different technologies that must be combined in order to work properly.

Finally, an approximation of the needed budget to implement the application will be calculated.

1.2 SMART TECHNOLOGY AND IOT (INTERNET OF THINGS)

It is understood as smart technology all devices that after receiving and external stimulus through their sensors, they will realize a concrete purpose. Each one of the devices consists of a microprocessor which after analyzing the obtained datum will respond just as it has been programmed. The group of these technologies being used in a concrete space allows the interaction between the objects that surrounds us and the users. It is a physic world composed by sensors and actuators integrated in daily life objects and that are all connected between them.

Nowadays, the first electrical appliances that used this intelligence, for example, are televisions or freezes. In these two cases, the television could detect if there is or there is not anyone watching it and turn itself off. This action would suppose energy savings while the refrigerator could detect if there is any food about to expire and could inform the user.

Figure 1: The Smart Airport features

What could happen if, in addition, we would connect these objects to the Internet? This concept is known as Internet of Things (IoT). They are a group of services, networks and devices which collect, transmit, store, analyze and present the collected datum in different ways (voice, images and datum) improving the quality of users' life in a concrete environment. They compose a system that connects different services in the same space avoiding all type of obstacles.

The IoT will reach the moment in which every object around us will be connected to Internet, and they will be able to provide us information depending on the function of each one of them and be controlled from the distance with our personal devices.

The Internet of Things, nevertheless, does not have just house applications. In the case that is being studied, it has useful applications. Terminal buildings thank to the application of smart technologies are able to managing themselves. This means that a reduction in the energy used and an increment in comfort and security can be achieved. [27]

1.3 Introduction to smart technologies

For the application of these technologies it is necessary the properly functioning of network sensors, responsible for the development of their purpose.

The sensors that compose these networks perform different phases depending on the actuation they are doing. It is a total of four phases: the first one is the collection of datum from the surround, for example, in the case of a system responsible for the temperature regulation, a group of sensors capable of measuring the temperature in a room will be needed. The second phase is the transmission of the information collected. In the application of the example the value of temperature obtained will be transported through the sensor network until the main node. [30] The third phase is the storage and/or the analysis of the data. If the recollection of different information is needed, to avoid an overload of the network as well as and increment of the energy consumption, each one of the sensors can storage the information and send it at the same time. The actuation phase is the last of the phases. Once the main node or Gateway receives the datum it will have to give an order depending on that information. In this example, air conditioning will be turned on or turned off according to the environment temperature. Another example of IoT is the ability to predict whether a flight actually take off on time. To achieve this, airlines are working hard in the background. Systems like ACARS [airport communications addressing and reporting systems], [10] which include sensors on planes, automatically communicate flight status changes to air traffic control via SMS message to the passengers.

The main purpose of their implementation at airports is to improve in sustainability and effectiveness fields and at the same time to achieve a reduction in costs. Using them, it is easier to make decisions in a collaborative way, as well as the interchange of information between passengers and airlines so they are able to know the status of the airport and the flights continuously. [26]

2 SMART AIRPORT DEFINITION

An airport resembles a small city. The majority of the applications and the technologies used are the same or similar. The concept of airports has changed a lot in the recent years. Ten years ago, the passenger experience at airports used to be a simple process, the least uncomfortable, considered by passengers as a dull procedure. It was thought as a loss of time before their flight. Today, the time before the flights became a time which is used by passengers to relax and have fun. It now has become a fundamental part of the travel experience. Airports are seen as places of entertainment or even doing business, as they can offer all those services to the passengers. [6]

A lot of effort is put in the reduction of the overall costs and in the transformation of the airports into smart environment, problems can be solved dynamically or even in advanced, in order to prevent them from appearing. The key is to maintain the proper communication between the different fields on the airport area: luggage/ passenger handling, airlines, security, logistics and commerce. The main issues are the delayed flights and the lost luggage. An airport must know the flights status anytime and at the same time to communicate them to the passengers. Furthermore, passengers should be informed about the status of their flights, luggage, etc., through applications (which must be developed). Another possible enhancement would be the ability to approximately calculate the time in the check-in queue. Finally, the new systems would enable the possible reallocation of the airport resources, applying changes wherever needed. [11]

Figure 2: The smart airport assets

2.1 IN WHICH FIELDS AT AIRPORTS ARE THESE TECHNOLOGIES USED?

There are distinctions of the smart technologies which are applied at airports. For example, there are technologies used by passengers and other used by the personnel.

The implementation of such technologies can be directed to guarantee the security at the airport and its surroundings or oriented to the passengers, so they are able to use them for their needs.

Also, technologies are applied at the gates to accelerate the processes through which the passengers must go through, such as the check-in process, or the security and passport controls, guaranteeing the security that is required at airports.

At the airside, using such technologies, mean the simplification of work, more speed, and in consequence, client satisfaction.

They turn airspace into a more secure place since they allow quick responses due to early alarming systems. They also allow better time slots allocation, because the algorithms used, give the maximum efficiency. Due to the use of cameras, the observation of the area, is possible. In consequence, planning and controlling increases air and land security. In addition, the intelligent administration of the terminals decreases both costs and energy consumption; Hence, the airport becomes a place, friendlier to the environment. [27]

2.2 NOWADAYS, WHICH AIRPORTS ARE CONSIDERED THE MOST ADVANCED ONES

The task to determine whether an airport is smart or not, is a difficult one, as the “smart” components can have different applications, as mentioned above. The list below, has taken into account airport facilities, processes’ speed, passengers’ opinions, international benchmarks etc.

2.2.1 SINGAPORE CHANGI AIRPORT

Changi is one of the biggest airports in Asia given the number of passengers and cargo it can serve. It has been noticed, by people who participated in surveys that its comfortable facilities and its services, along with entertaining areas such as cinemas or butterfly gardens are unparalleled. There can be found resting places, an external swimming-pool, gyms, massage rooms and beauty treatments, as well as a big variety of duty free shops. [5]

2.2.2 SACRAMENTO INTERNATIONAL AIRPORT, UNITED STATES

Sacramento International Airport's three-story Terminal B, which opened in November, was designed with energy efficiency in mind at every turn. It includes a heat-reflecting cool roof, high-efficiency boilers, and energy-efficient evaporation and convection-based cooling to keep travelers in the baggage-claim and ticketing areas comfortable. There's also glass that lets in light while minimizing heat, a cogeneration plant (fueled by natural gas) that uses reclaimed heat to produce heat and power simultaneously, and dimmable fluorescent and LED lighting. The terminal is expected to reduce CO2 emissions by 793 metric tons per year—equivalent to taking 165 cars out of commission. Another high-tech highlight is the terminal's "common-use gate system," in which any airline can operate any gate or ticket position of the airport's 160 workstations simply by accessing a central database. Passengers flying any airline out of SMF can also use these kiosks to print their boarding pass. [24]

2.2.3 DÜSSELDORF INTERNATIONAL AIRPORT, GERMANY

Constructed in just eight weeks, the advanced 8400-panel solar array at Düsseldorf International Airport in Germany covers an area as big as six soccer fields. It's the largest ground-mounted solar-power plant within the security zone of a German airport, and it is easily visible for passengers in flight arriving at or departing from Düsseldorf. Beginning in 2012, the plant is expected to generate 2 megawatts of energy per year—not nearly enough to meet all the airport's energy needs, but a start. And just so air travelers appreciate the array, the airport has a large monitor that displays how much energy the panels are creating and the mass of carbon emissions they are preventing. [12]

2.2.4 CARRASCO INTERNATIONAL AIRPORT, MONTEVIDEO, URUGUAY

Uruguay's Carrasco International Airport, is a stunning mixture of architectural beauty and eco-friendliness. While relatively small, the airport's carbon footprint might be even smaller. In 2016, Carrasco became home to nearly 10 acres of solar panel arrays that, together with wind turbines, produce enough energy to power the airport in full. This even includes the electric buses running between the gates and the airplanes. [4]

2.2.5 MELBOURNE INTERNATIONAL AIRPORT, AUSTRALIA

To streamline the enormous amount of baggage (up to 20,000 pieces daily) that comes through its three busiest terminals, Melbourne International Airport uses a high-speed, tilt-tray baggage-sortation system. This system sends luggage through the airport on individual trays before "tipping" each bag off at the correct loading location. It's equipped with an energy-efficient linear synchronous motor (LSM) that reduces carbon dioxide emissions by 75 percent while also eliminating contact between moving parts. That minimizes wear and tear and lets the machines run quieter. [23]

2.2.6 ZÜRICH AIRPORT, SWITZERLAND

The thing that does the Zurich airport unique, is the introduction of a new information management system at the airport called “ZEUS”. ZEUS is a software-based, real-time airport activity monitoring and amendment system. ZEUS integrates technologies to process information and provide an understandable interface; the system was developed as a smart client application. The software is installed on a number of workstations around the airport giving access to the ZEUS database, which is constantly updated with information from around the airport. For example, users can use CCTV to recognize and track aircraft and get a range of information from flight and boarding data to baggage handling status. ZEUS is also fully integrated with the airport digital message boards. Airport status reports may be provided in minutes instead of taking a whole day.[17]

2.2.7 LONDON HEATHROW AIRPORT, UNITED KINGDOM

At most airports, the highlight of the check-in process is either waiting in a long line for your respective airline or, if you're lucky, using a common-use system where you just drop your bags and go. In Heathrow Airport they took one step further, doing something truly innovative. In the Airport's Terminal 2, designed by Luis Vidal, travelers can use a "truly common check-in," as Neil Clark, Heathrow's CIO, has called it. Regardless of which of the 26 airlines in Terminal 2 they're flying, travelers can leave their bags with any agent they choose. That means a single attendant can service several airlines at once. The result is that one of the busiest international airports in the world efficiently moves its 79 million annual passengers through the terminal. [16]

2.2.8 HANEDA AIRPORT, TOKYO, JAPAN

Tokyo's Haneda Airport is another example of the way robotics are shaping passenger check-in experiences. Japan Airlines has teamed up with Nomura Research Institute, Ltd. (NRI) to show how NAO, —a 58 cm robot located at the carrier's check-in counter— in addition to engaging in interactive dialogue, provides passengers with useful tips on the airport's facilities, flight information and what weather to expect at their destination. This makes Haneda Airport truly innovative, and it is a first idea of how robotics could further contribute to the technologic advancements of airline industry. [15]

2.2.9 KANSAI INTERNATIONAL, JAPAN

Built on a man-made island in the middle of Osaka Bay, airport engineers had to deal with the high risk of earthquakes, typhoons, storm surges, sinking of the reclaimed land and the construction of a 3km long bridge to link the airport to the mainland. The airport has sunk 8 meters already, so architects have placed adjustable columns under the terminal to compensate for the shifting land. Despite that sinking feeling, the airport has emerged unscathed from several severe earthquakes that have hit the region in recent years. [21]

2.2.10 INDIANAPOLIS INTERNATIONAL AIRPORT, USA

This airport boasts with a customer-service robot, which puts it right up there regardless of their other tech-savvy features. Apart from the robot, however, there are also touch-screen kiosks for calling local hotels and attractions, Uber and Lyft vehicle service, and QR codes in parking lots that email you location info. This airport will also be like a safehouse for responsible travelers, who should know that the entire airport is LEED (leadership in Energy and Environmental design) certified. Sustainable. [19]

2.2.11 AMSTERDAM AIRPORT SCHIPHOL, NETHERLANDS

Boasting one of, if not the, most advanced robot customer service projects, Schiphol is widely considered Europe's most technologically advance hub. The SPENCER (Social situation-aware Perception and action for Cognitive Robots) project is a European Union-funded research project aimed to advance technologies for intelligent robots that operate in human environments. While the robot is actually an innovation by KLM, Schiphol's best feature is perhaps its exemplary collaboration between airport, airline and the Dutch government. In order to solve issues facing the industry, strengthening security for example, communication between these three parties will be imperative. Schiphol has also released a new tailored mobile app and website rebrand in 2016 to celebrate its 100th birthday. [25]

2.2.12 COPENHAGEN AIRPORT, DENMARK

Extremely well-advanced in the IT department, Copenhagen announced last year successful collaboration with Amadeus to install an Airport Collaborative Decision-Making facility – or A-CDM. The implementation of Amadeus Airport Sequence Manager and A-CDM Portal solutions, which provide the airport, its airline customers, ground handlers and air traffic controllers with accurate and synced information on aircraft departures is thought to radically improve the overall passenger experience by enabling instantaneous communication between all parties. Furthermore, Copenhagen have pledged to a goal of CO2-neutral growth to 30 million passengers – and the ambition to maintain that goal while expanding to 40 million passengers. The Danish number one, as well as being among the European leaders with respect to technology, is extremely ecologically conscious. [8]

3 SMART TECHNOLOGIES APPLICATIONS AT AN AIRPORT

Technology makes huge progresses and every moment there are new applications that can be implemented at airports. Next, they will be detailed explained, from the used in the smallest airports to the leading ones.

The steps of a passenger who arrives from his home to the airport, with international destination, until the arrival when he picks up his luggage and leaves the destination airport will be followed. For each one of the applications it will be shown an existing example of airport in which they are currently functioning.

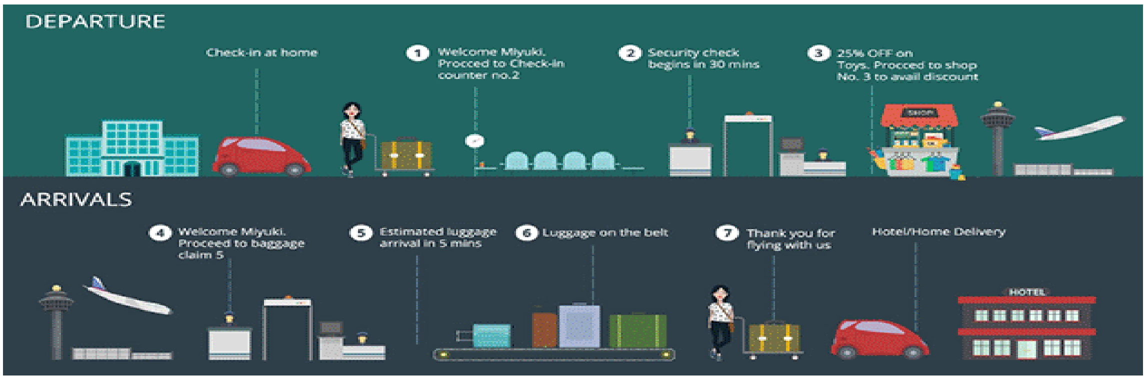

Figure 3: **The passengers journey**

First of all, the passenger must arrive to the airport via public transport or private transport. In the case of the public transport, in his mobile phone he will be able to know timetables and the needed time to get there. In the opposite case, also using an application he will know the condition of roads, this means, it will be possible to know if there are retentions or not, and the most direct route from the departure place. Once there a robot will park the car automatically. [10]

At the terminal the passenger must walk to the check-in area of the company with which he will fly. He will receive a notification at his personal device about flight information and the waiting time at the security control zone. To find the check-in desks, smart phones will be used as GPS what will allow locating yourself anywhere at any time before the security filter and at the airside to find the boarding gate or the smoking area, for example. In addition, to be connected to the internal airport network the passengers will receive advertisements about shops and restaurants even personalized.

Every person can do the check-in in an autonomous way, the procedure can be done at the automatic check-in desks. By a lector they can read the passport or ID card and once the flight datum has been introduced they print the boarding pass.

The next step is one of the longest procedures, the security and the passport controls. However, there is no need to take off electrical devices such as laptops, phones, liquid containers from carrying luggage or belts and watches as there are new scans able to analyze every type of object. The passport control is not a long process due to intelligent facial recognition systems reducing not only time but the possibility of losing personal documents.

By camera networks distributed along the terminal the passenger's movement is monitored. This allows knowing the more congested areas and the time needed to pass them.

Once the controls have been passed, the passenger can enjoy some entertaining time visiting shops or restaurants. Some airports such as Changi, in Singapore or Incheon in South Korea, have spas, gardens, swimming-pools and cinemas. While enjoying any of these services, it is possible that the passenger forgets the departure time or the boarding gate. In this case, he may need quick help. He can turn to small humanoids (60 cm) distributed along the building who offer boarding gates and timetables information. If the origin airport has various terminals, using an internal train, which goes to all the buildings, guarantees the fast transport to any of them.

At the boarding moment, the passenger must go to the boarding gates, which are automatic. The gates have a lector where the passenger must show the printed code in the boarding pass or in the smart phone.

At the destination airport, the main worry for many of the passengers is to know if their luggage arrived with them or it has been lost. But this is easy to know just checking personal devices as luggage add a locating chip. Now, the passenger must go to conveyor belts to pick up the suitcase. This is the last step before leaving the airport and also one that takes some time. This chip also will allow the workers to locate the owner and accelerate the delivery process. This system is used in connection flights, as well. [10]

The transport of suitcases is done by conveyor belts to the place where staff load them into vehicles that take them to the airplane, where automatically they are put into the airplanes' hold.

The examples of the airports that have these smart technologies are:

1. At **Düsseldorf Airport, Germany**, an **automatic parking service** has been implemented. This robot scans vehicles to obtain the measures and parks it. In addition, it reads the number plate and links it to the owner flight so it knows the arrival time and can have the vehicle ready at that certain time. [12]

Figure 4: The automatic parking service

2. At **Taoyuan Airport, Taiwan**, the **check-in** can be done at the **train** and **subway stations** in the city where the train to the terminals is taken. Therefore, it is not necessary to load with the luggage in the journey. [29]

Figure 5: Check-in at the train and the subway stations in the city

3. At **San Francisco Airport, USA**, by the use of **localization beacons**, personal devices with internet connection to the airport network or Bluetooth connection are able to locate yourself in the airport terminal map as well as knowing all the establishments around you. This airport is also testing auditory indications for people with visual difficulties. [13]

Figure 6: The Indoor navigation app

4. At **Helsinki Vantaa Airport, in Finland** incorporate **automatic desks** in which it is possible to do the **check-in**, even when carrying big luggage, in an autonomous way. In the case of carrying check-in luggage, the screen of the desks shows the number of the left-luggage office where it must be taken, avoiding this way long queues. [17]

Figure 7: The automatic desks for check-in, even when carrying big luggage

5. At **Schiphol Airport, Amsterdam, Holland**, in which are the **new scans**. They analyze the interior of bags without need to take off metal or electrical objects. Nowadays, it is being studied the possibility of a scan able to analyze passengers in movement to determine what type of objects they are carrying in their pockets. These scans will be able to recognize if the objects are just coins, or on the contrary they can be dangerous. In this case, the airport staff would be alerted to do an exhaustive inspection. [25]

Figure 8: The new scans which analyze the interior of bags without need to take off metal or electrical objects.

6. At **Dallas International Airport, USA**, new passports implement chips in which all the personal information is kept. The **facial recognition systems** read this information and compare the facial characterises between the passport picture and the scan lecture. [9]

Figure 9: The facial recognition systems

7. At **London City Airport, United Kingdom**, the **camera network** controls the movements in the whole terminal, that is why it is possible to warn passengers in advance so they can avoid congested areas or reorganize their activities in order to be on time for the flight departure. [7]

8. At **Haneda Airport in Tokyo, Japan**, the **humanoids** which are in testing phase are able to answer seven different questions as the boarding gate location or the weather at the arrival city in Japanese, and soon in English and Chinese, too. The third version of this robot can also move and it is capable of cooperating with another robot by their sensors for a better actuation depending on the passengers' requests. [15]

Figure 10: The humanoids

9. At **McCarran Airport in Las Vegas, USA**, incorporate fourteen **automatic boarding gates** in which passengers can realize the process by themselves. These gates have a lector which reads the code and in case of a last moment seat number change, they can print a new boarding pass. [22]

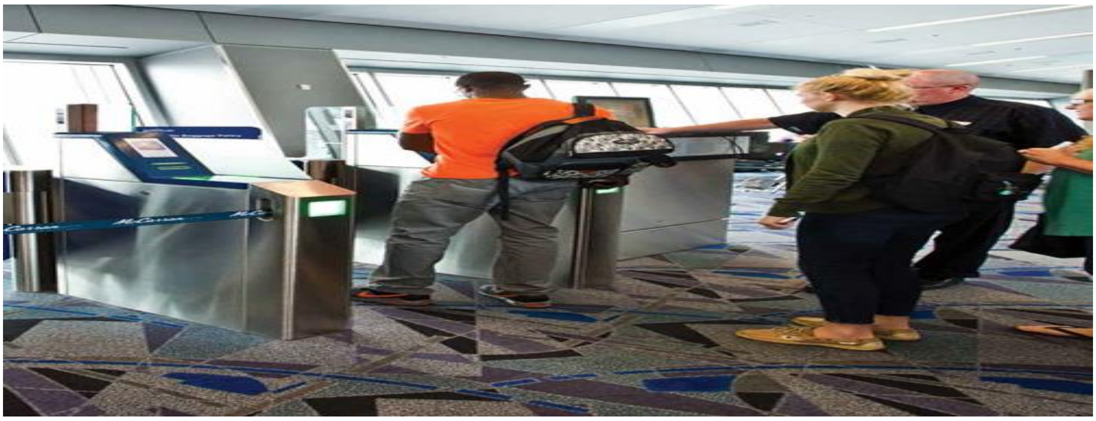

Figure 11: The automatic boarding gates

10. At **Calgary International Airport, Alberta, Canada**, uses a **location luggage system** based on a microchip that speeds up the delivery of suitcases reducing the waiting

time, and in addition, it eases the work in scale flights, guaranteeing more flow in the process [3]

11. At **Zürich Airport, Switzerland**, an **automated baggage loading system** reduces manual work, costs and time, as the number of workers needed for process is reduced at the same time improves safety and quality. [17]

Figure 12: The automated baggage loading system

3.1 Smart airport basic elements (Benchmarks-Level)

Given the above, it would be helpful to try to categorize the levels of "smart airports" given some standard benchmarks. To achieve that, the major "smart" airport facilities were collected and a benchmark table was created. The creation of a four-level system was decided, so as to depict the level of each airport in a clear and discrete way. The corresponding table and the explanation of the levelling can be found below:

	Smart Application
1	Automatic parking service
2	Check-in at the train and subway
3	Automatic desks to do the check-in
4	New scans that analyze the interior of bags without need to take off metal or electrical objects.
5	Facial recognition systems
6	Camera network which controls the movements in the whole terminal
7	Humanoids which are able to answer questions
8	Automatic boarding gates
9	Location luggage system
10	Automated baggage loading system
11	Passenger wi-fi
12	Indoor Navigation (Localization Beacons)
13	Kiosk devices (e-ticketing)
14	Stationery devices

Table 1: The Benchmarks of a Smart airport

Airport 1.0: the typical “traditional” airport where all processes are done manually. The IT penetration is limited to certain solutions such as CUTE or basic resources anagement solution. These types of airports normally run a B2B business without any service marketed directly to the passenger. (0 till 2)

Airport 2.0: the main factor defining this type of airport is self-service and massive CUTE deployment. Airports 2.0 are adopters of partial self-service, limited just to check-in process and Wi-Fi technology being deployed in these airports. (3 till 6)

Airport 3.0: self-service is deployed across the passenger journey at all levels. Operations management is automated and predictive and mobility solutions are largely used on terminal side and air side (particularly in apron areas). (7 till 10)

Airport 4.0: the 4.0 airport leverages big data and open data to enhance its innovation. Operators try to create value out of data, by adapting processes to real-time passenger flow, anticipation and by knowing the customer profile better. This family of airports clearly sees its business shifting from B2B to B2C. (11 till 14)

Using the aforementioned system, it will be easier for the responsible parties to determine the level of an airport, and to decide which upgrades they should apply to the existing facilities and which new technologies to implement, in order to elevate the level of the airport and to boost the passengers’ satisfaction.

3.2 PROBLEMS OF SMART TECHNOLOGIES IMPLEMENTATION

Along with the technology advance, the threats also multiply. In places where everything is automated and is based mainly on wireless technologies, the risk of networks being hacked or illegal users can have access to confidential data and process it, is high. The main vulnerability of such systems is that the intruders may have access to a local network and cause major problems to the services such as DDoS (Denial of Service) attacks, or data interception. Such methods could possibly make a network virtually useless.

In an airport concept, these threats could mean that unauthorized individuals could gain access to the confidential data of passengers and airport users. A big threat is Data leak. In that case the intruder could have access to data stored in the airlines’ databases, such as personal information of passengers, or flight information and store it.. Airports that make use of IOT (Internet of Things) have even bigger attack surfaces. So, it is vital that security is guaranteed. To achieve that, it is very important that interested parties know how to identify those threats and to be proactive. Although, if such attacks take place, the main goal is to ensure that they will affect the fewer functionalities possible, and not the entire network.

A major factor, which could become a big problem is the compliance with GDPR, which enforces significant changes in the way that Airlines handle personal Data. GDPR outlines six principles that businesses need to follow when processing personal data.

Broadly, “personal data” for airlines means any information which relates to an identified or identifiable individual, principally a passenger in this context. It will include, for example, the passenger’s name and contact details. It will also sometimes include information about travel patterns, vehicle usage, the dates and times passengers enter or exit a transport network, and fares or toll information. Whether or not those types of information constitute “personal data” in a particular context (so as to be caught by the GDPR) is often the first (and sometimes the most difficult) question. Usually, it will depend on how that information is going to be used. [14]

As mentioned above, in keeping with these principles, airlines must comply with 6 general rules:

- Process all personal data fairly and lawfully
- Only process personal data for specified and lawful purposes
- Endeavour to hold relevant and accurate personal data, and where practical, we will keep it up to date
- Will not keep personal data for longer than is necessary
- Keep all personal data secure
- Endeavour to ensure that personal data is not transferred to countries outside of the European Economic Area without adequate protection

To summarize, it can be easily understood that every new implementation or change to the existing functionalities will be far more complicated, given the new regulations.

4 ATHENS INTERNATIONAL AIRPORT (AIA)

Figure 13: The Athens international Airport

A major airport for the city of Athens was planned for many years as a replacement for the 60-year-old Ellinikon International Airport. In 1997, the city's new airport moved a step further towards reality when Athens was announced to be the host of the 2004 Olympic Games. By March 2001, Athens International Airport (AIA) “Eleftherios Venizelos” was fully operational after just 51 weeks of construction work and at the cost of more than €2 billion. Its major features include two parallel runways being 4 km and 3.8 km long respectively. The airport has received approval from the European Aviation Safety Agency and the Federal Aviation Administration for take-offs and landings of the biggest passenger jet worldwide, the A380. [1]

4.1 AIA History

AIA is located between the towns of Markopoulo, Koropi, Spata and Loutsa, about 20 km to the east of central Athens. The airport is named after Elefthérios Venizélos, the prominent Cretan political figure and Prime Minister of Greece, who made a significant contribution to the development of Greek aviation and the Hellenic Air Force in the 1930s. As to-date, ownership is divided between the Hellenic Republic (Greek State) and Private Sector in a 55%-45% stake following a PPP scheme for the airport company. Currently, private investors include the Copelouzos Group (5%) and PSP Investments of Canada (40%), following purchase of Hochtief's shares. [18]

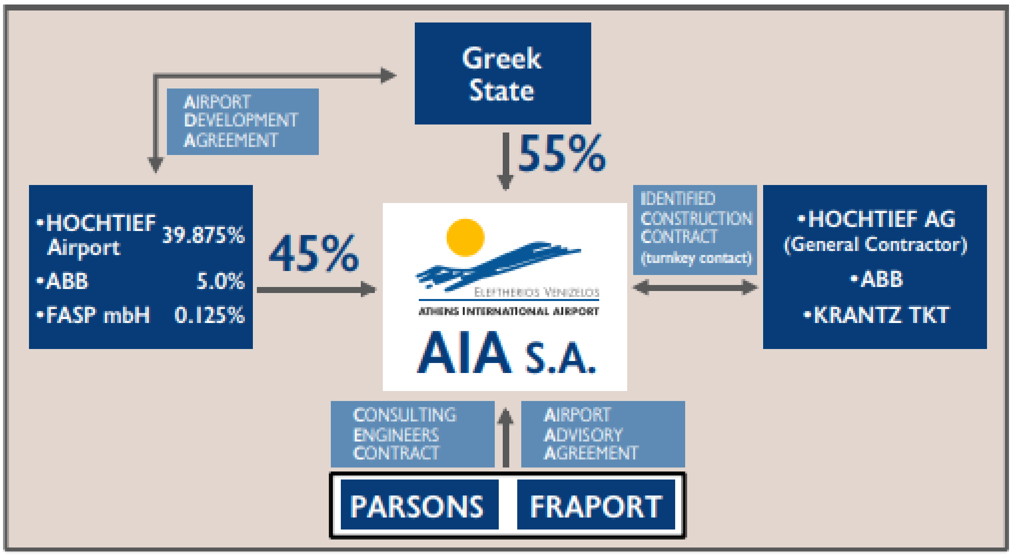

Figure 14: The AIA's ownership (2018)

The airport was constructed to replace the now-closed Athens (Ellinikon) International Airport, as the latter had reached its saturation point with no physical space for further growth. Studies for a new airport had been carried out from as early as the 1970s, with as many as 19 different locations being looked at before an area close to the town of Spata was chosen as suitable. Athens Airport SA, a state-owned company, was established in 1978 to proceed with the plans. However, after delays and slow development, the project was revived in 1991 with the then government launching an international tender for the selection of a build-own-operate-transfer partner for the airport project, with Hochtief of Germany being selected. [18]

In 1996, Athens International Airport S.A. (AIA) was established as a Public–private partnership with a 30-year concession agreement. That same year, the €2.1 billion development finally began with an estimated completion date of February 2001. The airport construction was completed five months before schedule but was delayed opening a month due to surface connections to Attiki Odos not being completed. The airport officially opened on March 28th 2001. The first arrival was Olympic Airways OA424 from Toronto, via Montreal. The second arrival was Olympic Aviation from Kythira which departed Ellinikon Airport earlier and the first departure was a KLM flight to Amsterdam. [18]

The first ever A380 to visit 'Eleftherios Venizelos' Athens International Airport made an emergency landing on 13 April 2011 for emergency medical reasons. The first scheduled A380 flight took place on 26 October 2012 by Emirates. [18]

Year	Passenger annual traffic	Passenger % change	Cargo handled (kg.)	Cargo % change	Aircraft movements	Aircraft % change
2002	11,827,448	n/a —	106,813,249	n/a —	159,467	n/a —
2003	12,352,394	3.6 ▲	109,741,122	2.7 ▲	170,129	6.7 ▲
2004	13,662,332	11.5 ▲	118,999,247	8.4 ▲	191,048	12.3 ▲
2005	14,281,020	4.5 ▲	115,942,974	2.6 ▼	180,936	5.3 ▼
2006	15,079,708	5.6 ▲	120,174,745	3.6 ▲	190,872	5.6 ▲
2007	16,538,043	9.7 ▲	118,972,376	1.0 ▼	205,295	7.6 ▲
2008	16,466,491	0.4 ▼	**122,195,965**	2.7 ▲	199,418	2.9 ▼
2009	16,225,589	1.5 ▼	104,520,932	10.5 ▼	**210,147**	5.4 ▲
2010	15,411,099	5.0 ▼	96,676,103	7.5 ▼	191,766	8.7 ▼
2011	14,446,971	6.3 ▼	85,831,845	11.2 ▼	173,296	9.6 ▼
2012	12,944,041	10.4 ▼	76,424,557	11.0 ▼	153,295	11.5 ▼
2013	12,536,057	3.2 ▼	74,874,633	2.0 ▼	140,448	8.4 ▼
2014	15,196,369	21.2 ▲	77,337,956	3.3 ▲	154,530	10.0 ▲
2015	18,087,377	19.0 ▲	80,475,761	4.0 ▲	176,156	14.0 ▲
2016	20,016,998	10.7 ▲	88,477,196	9.9 ▲	189,137	7.4 ▲
2017	**21,737,787**	8.6 ▲	90,176,471	1.9 ▲	195,951	3.6 ▲
2018 (to-date)	5,877,730	9.7 ▲	TBA	▲	53,831	7.8 ▲

Figure 15: Passenger, aircraft movement and cargo statistics at "AIA" airport: 2002-2018 [18]

The Greek government-debt crisis reduced the overall passenger traffic of the airport for six consecutive years (2009-2013). Many long-haul airlines outright terminated service to the airport, while others chose to operate on a seasonal basis only, opting to terminate service during the winter months. Moreover, these problems were further exacerbated by the closure of Olympic Airlines, which operated many long-haul flights to and from the airport. In 2013, the airport handled just above 12.5 million passengers, 3.2% fewer than in 2012 and lower by approximately 25% when compared to 2007's traffic, which was the all-time-high at that time. [18]

2014 signaled a strong recovery for the airport's passenger traffic and all statistical figures. More than ten new airlines started new flights to and from Athens. Aegean Airlines strengthened its network by 30% (with many more destinations scheduled for 2015) while Ryanair established a new base in the Athens Airport and added eight destinations. The airport company recorded an increase in passenger traffic in excess of 21% during 2014, reaching 15.1 million passengers, resulted both by new destinations but also by increased capacity offered on established ones. [18]

4.2 AIA CHARACTERISTICS

The airport currently has two terminals, the main terminal and the satellite terminal accessible by an underground link from the main terminal. It is designed to be extended in a modular approach over the ensuing years in order to accommodate increases in air travel. These extensions are planned in a six-phase framework. The first phase allowed the airport to accommodate 26 million passengers per year. When the airport originally opened, the current phase called for a capacity of only 16 million passengers per year, however, the capacity was able to increase without progressing to the next phase thanks to advanced IT logistics. The final expansion phase will allow the airport to accommodate an annual traffic of 50 million passengers, with the current layout leaving enough space for five more terminals to be added. As such, the parallel runway system currently in place has been designed to accommodate flight traffic with this high equivalent annual passenger load upon completion of the final expansion phase.

The main terminal building handles the all intra-Schengen flights, as well as several non-Schengen flights. All of airport's 144 check-in desks are located in the Main Terminal and it has three separate levels, one for arrivals, one for departures and a food court level complete with a view of the eastern runway. Finally, the terminal is equipped with fourteen jet bridges and eleven belt conveyors for luggage.

Hall A is used for flights to Non-schengen countries and Non-European countries.

Hall B handles flights to Intra-schengen countries as well as domestic services.

As of March 2018, the Athens International Airport has issued a tender for its first physical expansion, concerning the south wings of the main terminal. The tender calls for a building expansion with a total area of approximately 14,950 square meters over five levels (levels 0 to 4). The expansion should be completed by mid-2019 and add 18 more counter check-in decks as well as additional space for arrivals, departures, security and automated control gates but also expanded shopping area and new lounges.

The satellite terminal has two levels, one for arrivals and the other for departures. It is easily accessible through an underground link complete with moving walkways. The terminal is equipped with ten jet bridges and is capable of handling annual traffic of six million passengers.

In recent years its parking stands were utilized for long term storage of airliners, specifically two ex-Olympic Airways Airbus A340-300s (both aircraft were transferred to its new owner in February 2017) and a Boeing 767-300ER of defunct Greek start-up carrier Sky Greece Airlines. However, as of June 2017, the parking space of the satellite terminal is in full use for both Schengen and non-Schengen area flights and to accommodate increased traffic. From June 2017. Ryanair, Easyjet, Vueling and Eurowings are some of airlines that are using it. [1]

4.3 Analysis of smart technologies at AIA, could it be considered as a smart airport?

	Smart Application	Yes	No
1	Automatic parking service		✔
2	Check-in at the train and subway		✔
3	Automatic desks to do the check-in	✔	
4	New scans that analyze the interior of bags without need to take off metal or electrical objects.		✔
5	Facial recognition systems		✔
6	Camera network which controls the movements in the whole terminal	✔	
7	Humanoids which are able to answer questions		✔
8	Automatic boarding gates		✔
9	Location luggage system		✔
10	Automated baggage loading system	✔	
11	Passenger wi-fi	✔	
12	Indoor Navigation (Localization Beacons)		✔
13	Kiosk devices (e-ticketing)	✔	
14	Stationery devices	✔	

Table 2: The Benchmarks of a Smart airport and which of them there are at AIA

As it was already mentioned, the table above shows the benchmarks that are critical for the categorization of the airports' levels. The two columns on the right (yes/ no), indicate which facilities exist at AIA. In our example, AIA fulfils 6 out of 14 benchmarks. So it is a **"Level 2 smart airport".** This measurement will be useful in the later stages, to determine how AIA could be upgraded to a higher level.

5 IMPLEMENTATION OF A NEW SMART APPLICATION AT AIA

Indoor Navigation is a new trend in transportation, and air transportation industry is not an exception. More and more airports try to adopt indoor navigation, so as to make it easier for the airport guest and passengers to navigate inside the airports. AIA, as a leading airport in innovation, should include indoor navigation in its facilities as soon as possible. In the section below, there is an analysis on how the implementation of such an application could be accomplished.

5.1 INDOOR NAVIGATION APP

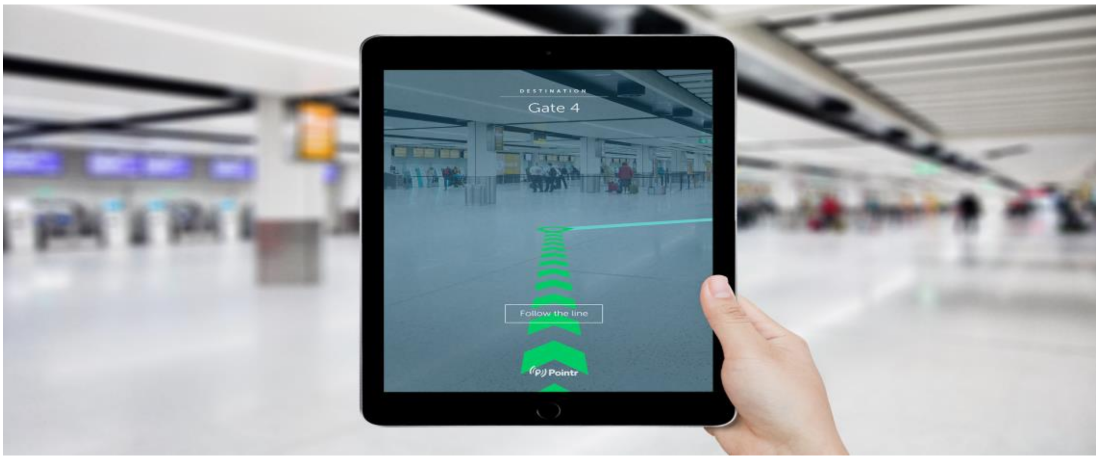

Figure 16: The Indoor navigation app

5.1.1 High level Description (Indoor Navigation and Localization Beacons)

Indoor navigation deals with navigation within buildings. Because GPS reception is normally non-existent inside buildings, other positioning technologies are used here when automatic positioning is desired. Wi-Fi or beacons (Bluetooth Low Energy, BLE) are often used in this case to create a so-called "indoor GPS". Contrary to GPS, however, they also enable you to determine the actual floor level. Most applications require an "indoor routing" functionality that guides people precisely through a building using an indoor navigation app and, in this way, automatically determines their position – very similar to the navigation systems that are used in cars. A typical application is turn-by-turn navigation in an app (displaying directions on a digital map) used for train stations, airports, shopping centers and museums. This kind of application can also include many other useful services. However, indoor navigation is not possible without automatic positioning - for example, when a digital building map is integrated into a website or in a digital signage system (multi-touch kiosk/interactive terminal). In this case, no location hardware is required (Wi-Fi, beacons). [20]

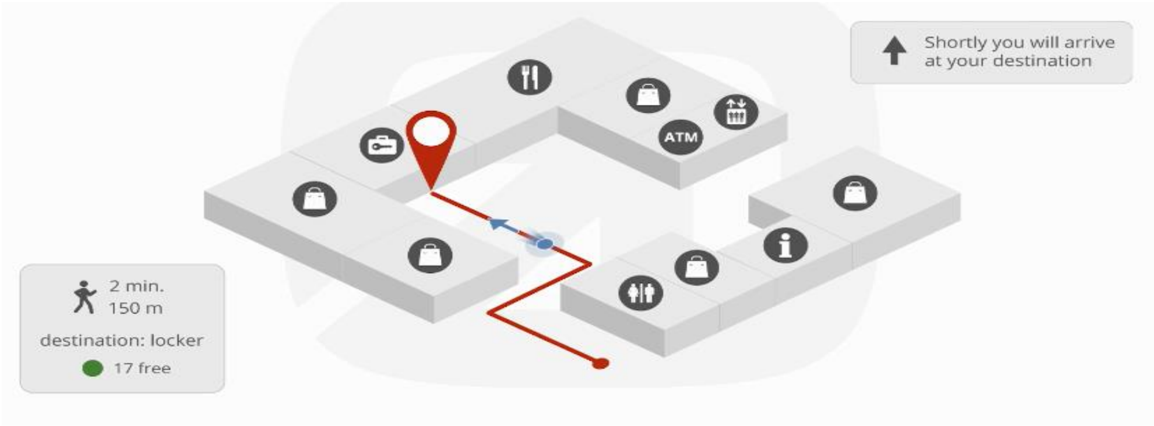

Figure 17: How the app works

5.1.2 Components and Infrastructure

Before the implementation of such an application, there should exist a certain infrastructure.

First of all, a third-party partner should take over the GIS mapping of the airport. This should be done, in a similar way that external mapping is done. All the inside places of the airport should be mapped, in a detailed and precise GIS map. [30]

Then, another engineering partner, should take over the structural and engineering study, in order to determine the best way to place the beacons and the routers, for maximum functionality and minimum cost.

After all these prerequisites have been accomplished, a mobile application should be developed.

5.1.3 Indoor Navigation App

The main functionality of the proposed application, will be to navigate the connected guests inside the airport, acting as a traditional GPS application. Two forms will be filled, one with the location of the passenger, and the other with the final destination. Then the application will propose the fastest route to the desired destination.

However, the proposed mobile application could take the navigation one step further. The user/ passenger, will scan the QR codes in their boarding pass and the application will propose to them all the routes they should take, in order to embark successfully. For example, the application will send the passengers to the check in counter, then to the luggage drop etc., until finally it sends them to their gate.

Lastly, the application could have some more functionalities, of commercial use. There could be a widget, with a list of all the shops which are situated inside the airport, and a navigation system for them too. Also, the passengers could receive inside-app notifications for probable offers from the shops, depending on their searches in the application.

5.1.4 Costs and maintenance

Although there will not be a detailed cost analysis in this paper, there will be some rough estimations, in order to indicate that the implementation of the proposed app is feasible and cost effective for an organization like AIA. The main cost is the cost of the beacons and their maintenance.

The cost of a single beacon is about 10-20 euros on average (in 2018), depending on the battery capacity of each beacon. Given the size of the airport it is roughly estimated that about 350-400 beacons should be installed in order to cover every inch of its inside areas in both buildings (arrivals and departures). So, it can be understood that the initial cost could be 6000-8000 euros on average.

Now, given that the expected battery life of each beacon is 3-7 years on average it is easily understood that the maintenance costs will be of none importance. The only case that the IT support team of the airport should step in, is when a beacon malfunctions and it needs to be replaced.

A huge organization like AIA should take advantage of this cost effective and innovative chance, to firstly increase the passengers' satisfaction, and also to upgrade its status as a leading power in innovation and smart technology implementations.

5.2 VISUALIZATION OF THE FUNCTIONALITY (INDOOR NAVIGATION APP)

Figure 18: The menu of the app

Figure 19: The navigation interface of the app

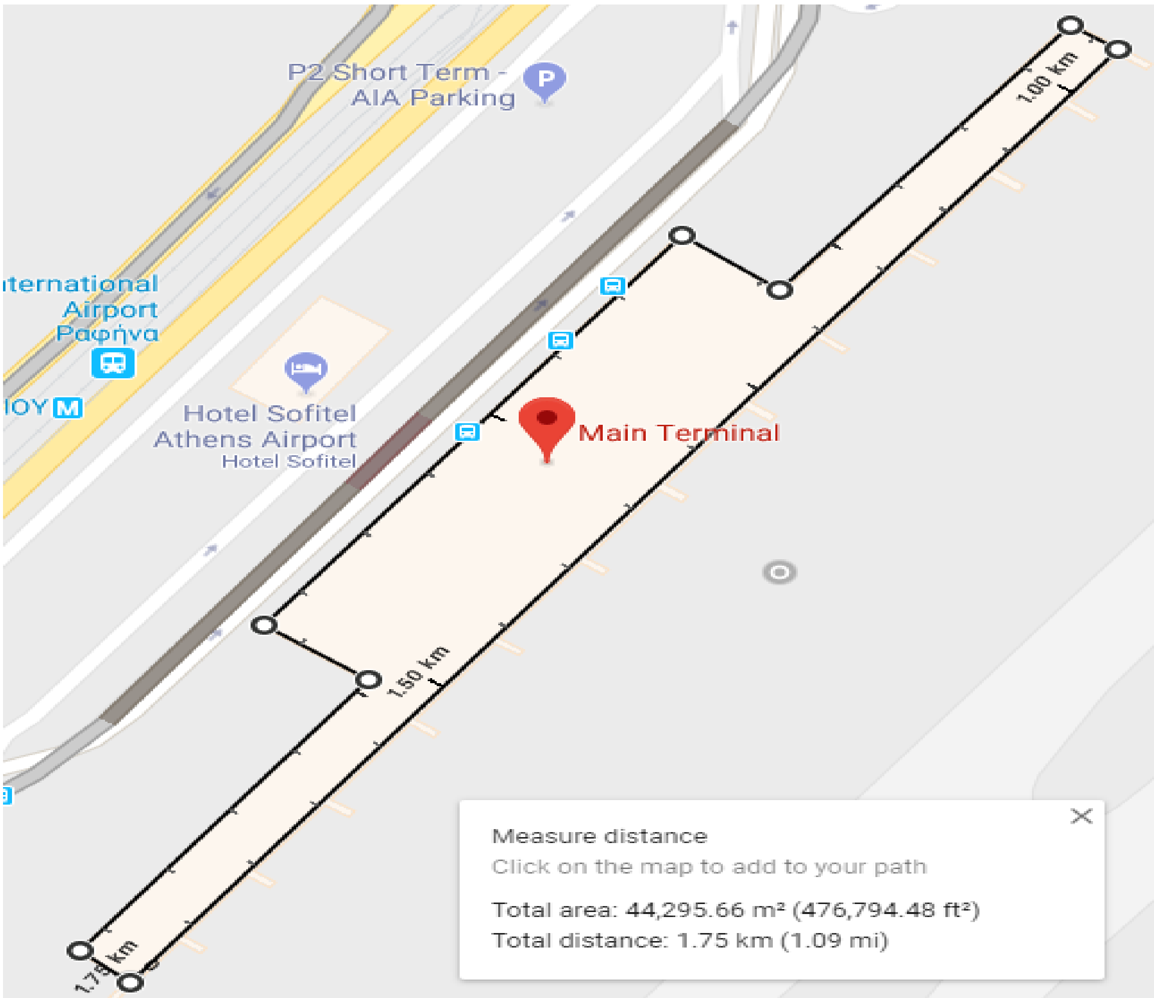

Figure 20: The total area of AIA main Building

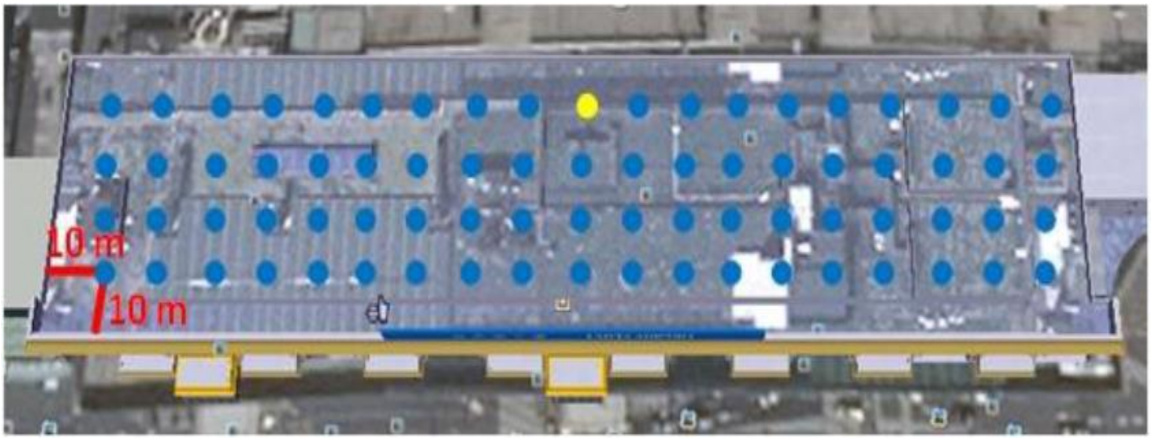

Figure 21: The position of the beacons

6 CONCLUSION

Assuming that the proposed application is implemented, we will try to depict the expected results. Using the aforementioned benchmarking system, it is clear that AIA will instantly level up as a smart airport. Now it fulfills 6 out of 14 basic "smart" benchmarks and it is "**Level 2".** After the implementation it will fulfill 7 out of 14, and it will become a **"Level 3.0 smart airport".**

Figure 22: The levels of an Airport

The indoor navigation application, will help passengers a lot, and especially passengers that travel for business reasons. In most cases, they do not have the time to wander in the airport, searching for their gates. It will help the passengers who travel for leisure also, given that the application will navigate them to the leisure facilities of the airport. So they will spend their free time in a funny way.

Also, it will certainly help, passengers who travel via connecting flights. Usually they do not have much time between flights, and in case they get lost for a while, wandering in the airport there is a high probability that they lose their flights.

To conclude, it will become one of the first airports to adopt the trend of indoor navigation, globally. This will be a huge boost to the airport's fame as an innovative airport, which has its passengers' satisfaction and needs in high regard.

7 FURTHER DISCUSSION

Given the almost unlimited potential of technology, there are plenty of possible new functionalities that could be implemented to the airport.

A feasible future functionality, could be for example, facial recognition of the airport visitors. Using facial recognition could ideally lead to the minimizing of check in time, time of waiting in front of the gate, etc. Also, it would be a huge boost for the airport's security. Given that every visitor will have been identified, the airport's security will know if there are people inside the airport who pose possible dangers(terrorists etc).

Though, such a feature is not feasible at the moment. It requires the launch of the new ID cards, which will store biometrical data of the ID holder. So, it will be a very interesting project in the next few years.

Such implementations, not only will improve the passengers' satisfaction, but they will also help the airport to climb the highest level of the benchmarking system.

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