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AEROSPACE VEHICLES BACHELOR DEGREE

Viability and Preliminary Design of an Airport in Europe

Final Report

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Abstract

An airport is the infrastructure from where the vast majority of air operations start. Planes begin their journeys by taking off at one airport and ending them landing at another. In this study, the feasibility of locating said infrastructure in an exact country and area of Europe has been analyzed in order to carry out a preliminary design based on the demand that this location generates and the previous conditions to which it is subjected.

The first thing that has to be investigated is the location of the airport. To this end, the European countries have been analyzed using two comparative methods that assess aspects of interest for the study and it has been possible to obtain that Hungary, specifically, in the city of Sárbogárd, is the country considered with the greatest potential to locate the airport.

The next point to be discussed is the Traffic Demand Analysis. In any project based on the construction or creation of a new platform or a new business, it is necessary to estimate the demand it will have. To design the airport, a study of both passenger and aircraft traffic has been, first, carried out to obtain the capacity it will cover and to be able to carry out the preliminary design. The definition of the capacity in a horizon scenario, that will support the infrastructure, is obtained by investigating the area where it will be located as well as the Budapest Airport taken as a reference for the analysis. The purpose established has been to absorb part of the air traffic at the Hungarian capital airport. After analyzing the traffic and deciding which complete low-cost airlines would be accommodated in a realistic scenario, different data of interest is obtained, such as the month and the peak day, the busy day and the peak hour, and the number of operations and passengers per year, from the base year that would be 2027 to a horizon scenario.

Finally, to obtain a preliminary design of the airport, the so-called year of design, 2036 (intermediate scenario) has been taken as a reference. Based on the annual, peak day and peak hour traffic results in this design year, the air side and the ground side of the airport can be designed using the Airbus A321 Neo (ACF) as the reference aircraft. The design is governed by what the ICAO dictates in Annex 14, for the design of the runway, taxiways and parking aprons (air side) and, for the land side, it has been used the IATA established manual, where the organization explains how to estimate passenger flows and thus be able to define the areas that make up the terminal building and the terminal as a whole. It should be noted that a preliminary design of the main aircraft and passenger movement areas is carried out, elements such as easements, visual aids and other airport buildings would be defined in a more complete design of the airport.

In summary, carrying out a feasibility study and a preliminary design of an infrastructure, as such, is a squared process, in which everything must be justified in detail. But, apart from the difficulties encountered, being able to study everything that the construction of an airport infrastructure implies is of great interest because, in the end, all the factors that affect and determine the future, of the designed airport, are analyzed.

Resumen

Un aeropuerto es la infraestructura desde donde parten la gran mayoría de operaciones aéreas, las aeronaves inician su recorrido despegando en un aeropuerto y terminan aterrizando en otro. En este estudio se ha analizado la viabilidad de ubicar dicha infraestructura en un país y zona exacta de Europa para realizar un diseño preliminar en base a la demanda que esta localización genera y las condiciones previas a las que está sometido.

La primera investigación realizada es sobre la ubicación del aeropuerto. Para ello, se han analizado los países europeos mediante dos métodos comparativos que valoran aspectos de interés para el estudio y se ha podido obtener que Hungría, concretamente, en la ciudad de Sárbogárd, es el país considerado con mayor potencial para localizar el aeropuerto.

El punto siguiente tratado es el análisis de demanda de tráfico. En todo proyecto basado en la construcción o creación de una nueva plataforma o un nuevo negocio, es preciso estimar la demanda que tendrá. Para diseñar el aeropuerto, inicialmente se ha realizado un estudio de tráfico tanto de pasajeros como de aeronaves para conocer la capacidad que abarcará y poder llevar a cabo el diseño preliminar. La definición de la capacidad en un escenario horizonte que soportará la infraestructura, se obtiene investigando el área donde se ubicará así como el Aeropuerto de Budapest-Ferenc Liszt, tomado como referencia para el análisis. La finalidad establecida ha sido absorber parte del tráfico aéreo en el aeropuerto de la capital húngara. Después de analizar el tráfico y decidir qué aerolíneas completas de bajo costo se alojarían en un escenario realista, se obtienen diferentes datos de interés, como el mes y el día pico, el día tipo y la hora punta, y el número de operaciones y pasajeros por año, desde el año base, que sería 2027, hasta un escenario horizonte de 18 años (2045).

Finalmente, para obtener un diseño preliminar del aeropuerto, se ha tomado como referencia el llamado año de diseño, 2036 (escenario intermedio). En base a los resultados de tráfico anuales, de día pico y hora punta en este año de diseño, se puede diseñar el lado aire y el lado tierra del aeropuerto tomando el Airbus A321Neo ACF como avión de referencia. Este diseño se rige por lo que dicta la ICAO en el Anexo 14, para el diseño de la pista, las calles de rodaje y las plataformas de estacionamiento (lado aire) y, para el lado tierra, se utiliza como base el manual establecido por la IATA donde explica como estimar flujos de pasajeros y así poder definir las zonas que forman el edificio terminal. Destacar que se realiza un diseño preliminar de las zonas de movimiento de aeronaves y de pasajeros principales. Elementos como las servidumbres, ayudas visuales y otras edificaciones aeroportuarias se definirían en un diseño más completo del aeropuerto.

En conclusión, realizar un estudio de viabilidad y un diseño preliminar de una infraestructura como tal es un proceso muy cuadriculado, en el que se debe de justificar todo al detalle. Pero, aparte de las dificultades encontradas, poder estudiar todo lo que implica la construcción de una infraestructura aeroportuaria, como se verá a lo largo de este proyecto, es de gran interés porque, al final, se terminan analizando todos los factores que afectaran y determinaran el futuro uso del aeropuerto diseñado.

Appreciation

All effort and dedication have their reward.

This project will end my undergraduate studies and I want to thank my family, friends and professors who have placed all their trust and support in me. Especially my grandfather. Wherever he is, he will always give me all the strength, spirit and confidence that I need to overcome everything I set out to do. Thank you.

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List of Symbols and Abbreviations

This list of symbols and abbreviations relating to the parameters that are used throughout the document.

CI Total number of check-in counters

CIJ Check-in servers including business class counters

CIY Number of economy class check-in servers

SC Number of security check servers

α Magnetic orientation

δ Magnetic declination

ψ Geographical direction

$A_{capacity}$ Capacity of the aircraf

AH Arrival Hall area

AOP Average occupacy time per passenger

AOV Average occupacy time per visitor

ARC Airport Reference Code

$ARFL$ Aeroplane reference field length

$ASDA$ Accelerate-stop distance available

b Wingspan

BCU Baggage Claim Units

C Medium aircrafts

C_H Elevation correction

C_T Temperature correction

$CAGR$ Compound annual growth rate

CAT Precision approach runway category

CDN Time that the baggage claim unit is destined for an aircraft

Cl Lift coefficient

CWY No obstacle free zone

D Specific distance

$F1$ % of the PHP in the peak 30-min

$F2$ traffic generated by flights 1 hour before and after peak hour

G Standard thermal gradient

g Importance values

g_{air} Density of air

GHR Gate Hold Room

H Specific heigh

H_{SL} Sea level elevation

i Mix index

IFR Instrumental Flight Rules

J Percentage of business class passenge

L Lift

LDA Landing distance available

M Million

MLW Maximum Landing Weight

MQT Maximum queue time

$MTOW$ Maximum Take-Off Weight

NNB Number of passengers at 80 % load factor

p Value of each option

pax Passengers

$PC_{10\ min}$ Peak 10-min demand at check-in

$PC_{30\ min}$ Peak 30-min demand at check-in

PCD Number of passport control desks

$PCD_{arrivals}$ Number of passport control desks (arrivals)

$PCD_{departures}$ Number of passport control desks (departures)

PHP Peak hour passengers

PNB Proportion of the number of passengers arriving in a narrow-body airplane

PT_{ci} Time it takes for a passenger to check-in

PT_{pca} Time it takes for a passenger to pass the passport control - arrivals

PT_{pcd} Time it takes for a passenger to pass the passport control -departures

PT_{sc} Time it takes for a passenger to review the passport

R Radius

S Intermediate factor

S Surface

S_{TOTAL} Total surface of the terminal building

SCH Schengen Area

SPP Space required per person

SWY Stop zone

T_H Temperature in an especific heigh

T_{ref} Reference temperature

T_{SL} Sea level temperature

$TODA$ Take-off distance available

$TORA$ Take-off run available

v Velocity

VFR Visual Flight Rules

VPP Number of visitors per passenger

W_T Wheel Track

Chapter 1

Introduction

1.1 Aim of the Project

The main purpose of this project is to study the feasibility of a new airport in Europe. It is intended to be sustainable both competitively and technically. To do this, a study will be carried out to determine the most appropriate location of the infrastructure, the traffic demand will be analyzed and a preliminary design of the air side and the ground side of the airport will be implemented.

1.2 Scope of the Project

As the main point of a project, the limits and the means must be marked to fulfill with its objectives. This is called scope. Next a series of tasks or points to be carried out will be defended to reach the main objective, previously determined, of designing a completely viable airport. For this, it will be considered that the project will consist of seven main parts, apart from this introduction.

- **Regulatory Framework**.
  The organizations that dictate the regulations applied to the design of an airport infrastructure will be detected. In addition to the legal documents necessary to evaluate and design the airport.

- **General Location of the Airport**.
  The region of Europe where the airport will be located will be studied and decided by comparing different countries, using some criteria and decision making methods.

- **Demand Analysis**.
  Through this analysis, the traffic forecast, in the determined area, will be carried out. The concept of airport to be designed, the type of airlines that will fly and the annual, monthly, daily and hourly number of passengers and flights will also be determined.

- **Specific Location**.
  In the next block it will be possible to detail in which area, within the previously chosen region, the airport will be located. This will be determined thanks to the traffic forecast, the definition of the type of airport and a topological and meteorological analysis.

- **Preliminary Infrastructure Design**.
  Pre-design considerations will be determined and the main landside and airside components will be studied and designed.

- **Environmental and Social Impact**.
  Assess the effects of the study resulting in a real project and estimate how the construction of the airport would affect society and the environment.

- **Conclusions and Recommendations**.
  It will be attempted to summarize the entire project in a series of final conclusions in which the results and decisions taken during the development of the project will appear.

1.3 Basic Requirements

In the next point, we will try to name the general specifications that will be reflected in the result of this project, which will conduct and delimit the process. The purpose, location and design of the airport, the regulations and some general conditions will be delimit.

- It will be a commercial passenger airport that complements another or that solves an unresolved need.
- It will be located somewhere in Europe.
- The traffic forecast must be justified at all times and found with an analysis that is as close to reality as possible.
- At all times of design and decision, the International Civil Aviation Organization (ICAO) and International Air Transport Association (IATA) rules and recommendations must be followed.
- The airport design will be based on ICAO Annex 14 and the following manuals: Airport Planning Manual (Doc. 9184), Aerodrome Design Manual (Doc. 9157) and the IATA Aiport Development Reference Manual.
- The airport will be environmentally and socially sustainable.

1.4 Project Justification

Currently, there are thousands of airports across Europe. It is true that there are areas excessively saturated by these infrastructures, but we also know for sure that if they continue operating it means that they are profitable. But this has not always been the case, times have changed, and with it, mobility patterns. Nowadays, the population moves a lot by plane, either for tourism or work. Consequently, practically all areas of Europe are covered by an airport.

In the following image, although it is not recent and not all airports appear, it can be seen this airport saturation in Europe that is being talked about.

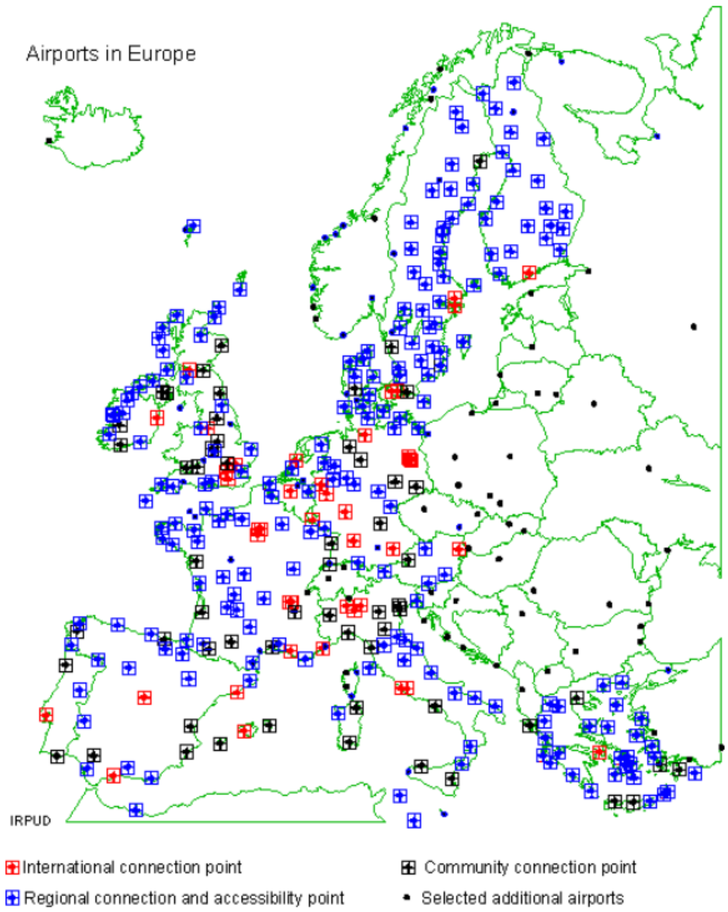


Fig. 1.1. European Airports. Source: [1]

Therefore, there are excessively saturated airports that need the support of others to reduce their air traffic, on the other hand, there are other areas that do not have an airport and it could be very useful. Specifically, this project will seek which area could have the potential to introduce a new airport and study its viability, it would be of great interest if it turns out to be acceptable.

In other words, a study should be carried out on the existence of airports in Europe in order to select a tactical area so that it would be beneficial to establish an infrastructure of such characteristics.

In relation to this importance of location, if we read the article *Regional airports and regional growth in Europe. Which way does the causality run?* one of most outstanding ideas in relation to the choice of the location is the following: "In peripheral regions, air traffic may decrease the negative effects of long distances. Easy accessibility attracts firms, investments and other economic activity to the region and stimulates employment and production at established firms" [2].

If a strategic location is chosen to position the airport, it can be of great help to the economy of the country or region. It has been studied that many companies decide to establish or change their location depending on the type of access they have to air transport.

Another point to take into account is that due to the pandemic the airport infrastructure model has been rethought, in this times the spaces must be adapted with strict hygiene and distance measures. The idea of designing a new airport could be interesting as it would already be built with these new constraints in mind, although this would already be defined in a full airport design.

Furthermore, leaving aside the current health crisis and the importance of location, there are other critical points, but they are also crucial, in this project. Determining other factors such as air traffic, the dimensions of the air side and the ground side are key points also because everything must meet a series of specifications marked by a strictly defined regulation.

In short, despite having everything against it, experiencing an economic crisis due to a pandemic, if the inhabitants and members of the government of an area are interested in locating an airport in it, everything will be easier. If a territory is not exploited, airport speaking, it could be very attractive because in terms of land it could be easier to find free hectares to build that around and existing airport and it could attract more business opportunities in it by creating new links or air routes, something of great importance in these times of recovery. In addition, when designing a new airport, a more sustainable approach can be given to the project, within what can be achieved in an infrastructure of the aeronautical sector, a plus thanks to the great awareness that currently exists regarding caring for the environment.

Therefore, this justification of the project could be summarized as the need to design a new airport infrastructure looking for a sustainable airport that covers any need either due to lack of airports or excessive demand in the area and that is adapted to the current situation.

Chapter 2

Regulatory Framework

The regulations, in any project, are essential to give it credibility. If they are not followed, in projects like this one for the design and construction of a new infrastructure, it would be impossible to carry it out.

In addition, the regulations are adapted to the activities. They are updated according to the times that are lived. Therefore, it is important to have some basic notions of the regulatory framework that governs this project.

2.1 Legislative Framework

There are different organizations, made up of different countries, which establish all the regulations and guidelines of international and European civil aviation.

2.1.1 ICAO (International Civil Aviation Organization).

ICAO is an international organization whose mission is "to serve as the global forum of States for international civil aviation"[3].

It can be said that it controls everything related to aviation to create an international unit. The existence of this organization is crucial for the creation of an airport since, in an infrastructure as such, airplanes arrive from different countries.

This organization works by drafting some annexes that must be followed and that deal with different aspects related to aviation such as meteorology, aircraft operations, aeronautical telecommunications, etc [4]. In this project, as will be discussed later, Annex 14 that talks about aerodromes and heliports will be followed.

In addition to these Annexes, ICAO also drafts a series of technical manuals with all kinds of more detailed information. For example, the Airport Planning Manual (Doc. 9184), Aerodrome Design Manual (Doc. 9157), Doc. 9859 and Doc. 9774 will be of great interest in the subject in question.

2.1.2 European Directives and Regulations.

ICAO, as already mentioned, is an international organization. And, within each continent, there are other organizations that also try to organize aviation in their respective territories. The regulation of interest for this study is the European one, specifically, we refer to three important organizations so that aviation in the continent is regularized.

i. JAA (Joint Aviation Authorities): These authorities take on aviation matters within the EU, at the European level, and cooperate with other regulatory authorities such as the Federal Aviation Administration North American (FAA).

   "Each JAR is a code, that is, a systematic collection of standards that refer to a specific aeronautical topic"[5]. In the project in question, the most interesting topics are maintenance, certification and operations.

ii. EUROCONTROL: Is another European organization that manages air traffic around the single European sky. Manages the network of flight plans, plans and seeks the compatibility of airport capacity [6].

iii. EASA (European Union Aviation Safety Agency): Finally, this organization is of utmost importance when dealing with issues related to the aeronautical sector in Europe. It has two great functions [7]:

   - Establish a high and uniform level of safety ("safety" concept) in European civil aviation, as the basis for a future European "single sky" (Regulations (EC) 1592/2002 and 104/2004; Directives 2003/42 / EC, 2004/36 / EC).
   - Harmonize the legal framework of National Security in Airports ("security" concept) between the different European States (Regulations (EC) 230/2002, 622/2003, 1486/2003, 1138/2004).

   This organization dictates a series of security regulations that must be followed by the so-called airside, the part of the airport used by aircraft, that is, the well-known aerodrome which is part of the airport.

   This regulation will be applied in this project since it seeks to design an airport which is "open to the public use, serve commercial air transport and have a paved instrument runway of 800 metres or more"[8].

2.2 Annex 14: Regulations for the design and operation of airports

The Annex 14 [9] is part of the regulations issued by ICAO. It consists of 2 volumes: the first on aerodromes and the second on heliports. In this project, it is interesting to use the first volume of ICAO Annex 14 as it is about designing an airport.

When designing the airside of the airport, this series of mandatory rules must be followed. In addition, there are also some recommendations that are not mandatory but should be followed. If not, the reason why they are not used should be properly justified.

It should be noted that this Annex focuses on the design of the airside, talks about the area of activity of the aircraft such as runways, taxiways and parking platforms.

In summary, what this annex seeks is to provide standards and recommendations so that the design and construction project of the airport is carried out from the point of view of operational safety.

2.3 Regulations Applied to the Landside of the airport

Regarding the land side of the airport, the applicable regulations depend on each country's own development ministry. The General Secretary for Transport of the area where the airport will be located must approve a program that talks about the infrastructures through which passengers move such as the terminal building, the parking lot, etc.

Even so, the regulations that would apply to design the landside are determined by IATA in its Airport Development Reference Manual [10].

2.4 Hungarian Air Transport Regulations

As will be seen later, the country of location of the new airport will be in Hungary. Therefore, it is useful to gather information on the Hungarian air transport regulatory framework.

First, the National Transport Authority is in charge of all types of regular transport in Hungary, be it air transport or other. This organization "had replaced the General Inspectorate of Transport, the Central Inspectorate for Transport, the Local Transport Inspectorates in the counties of Hungary, and the Civil Aviation Authority"[11].

On the other hand, we find HungaroControl [12] that does not exactly regulate Hungarian air transport but it does provide air navigation services (ANSP) in the country's airspace. What's more, "on 5 February 2015, HungaroControl became the first air navigation service provider (ANSP) in Europe to abolish its entire air traffic services (ATS) route network, enabling aircraft to use Hungarian airspace freely, without any restrictions" [13]. HUFRA (Hungarian Free Route Airspace) is the new concept that this organization introduced. This term provides freedom in Hungarian airspace that is, aircraft can fly more optimally by choosing the shortest direct route between entry and exit points without having a fixed route, not time and space limitation in Hungary.

Finally, the Ministry of National Development responsible of transport matters in Hungary could be included since, as a general objective, it has to control "that development in various sectors should operate in harmony with each other" [14].

In the event that the project becomes a reality, it should follow and act on the basis of what all these organizations in the country govern.

Chapter 3

General Location of the Airport

In this section, a study will be carried out to choose the country where the airport will be located. Previously, it will start with the 51 autonomous countries, islands and archipelagos that make up Europe. A first selection of 15 countries will be carried out, carrying out a study with data on the number of inhabitants of each country, the number of commercial airports with international flights and the GDP per capita of each of them. Finally, the country of location of the airport will be decided using two decision methods that will be presented later, which basically find an index for each country after evaluating each option (country) with a series of interesting requirements.

3.1 Previous Selection between European Countries

Making decisions when you have many options can be complicated, since each of them has specific characteristics that can give them a special appeal. The objective of this point is the choice of 15 potential countries to locate a new airport. An attempt will be made to assess 51 European countries, directly ruling out all those that are also part of Asia except Turkey (Georgia, Azerbaijan, Armenia and Kazakhstan) and ruling out Kosovo since it is a partially recognized state [15].

Fig. 3.1. European countries. [Own elaboration (Google Earth and Word)]

Table 3.1: 51 European countries to analyze first.

Number	Country	Number	Country
1	Albania	26	Liechtenstein
2	Germany	27	Lithuania
3	Andorra	28	Luxembourg
4	Austria	29	North Macedonia
5	Belgium	30	Malta
6	Belarus	31	Moldova
7	Bosnia and Herzegovina	32	Monaco
8	Bulgaria	33	Montenegro
9	Cyprus	34	Norway
10	Vatican City	35	Netherlands
11	Croatia	36	Poland
12	Denmark	37	Portugal
13	Feroe Islands	38	United Kingdom
14	Slovakia	39	Gibraltar
15	Slovenia	40	Guernsey
16	Spain	41	Man Island
17	Estonia	42	Jersey Island
18	Finland	43	Czech Republic
19	France	44	Romania
20	Greece	45	Russia
21	Hungary	46	San Marino
22	Ireland	47	Serbia
23	Iceland	48	Sweden
24	Italy	49	Switzerland
25	Latvia	50	Turkey
-	-	51	Ukraine

Initially, the main thing to evaluate is the number of airports, with characteristics similar to the one to be designed in this study, that each country already has. The airport to be designed is a commercial passenger airport. To better visualize these commented data, the cities of each country that have a commercial airport were marked on the following map, made with Google Earth [16].

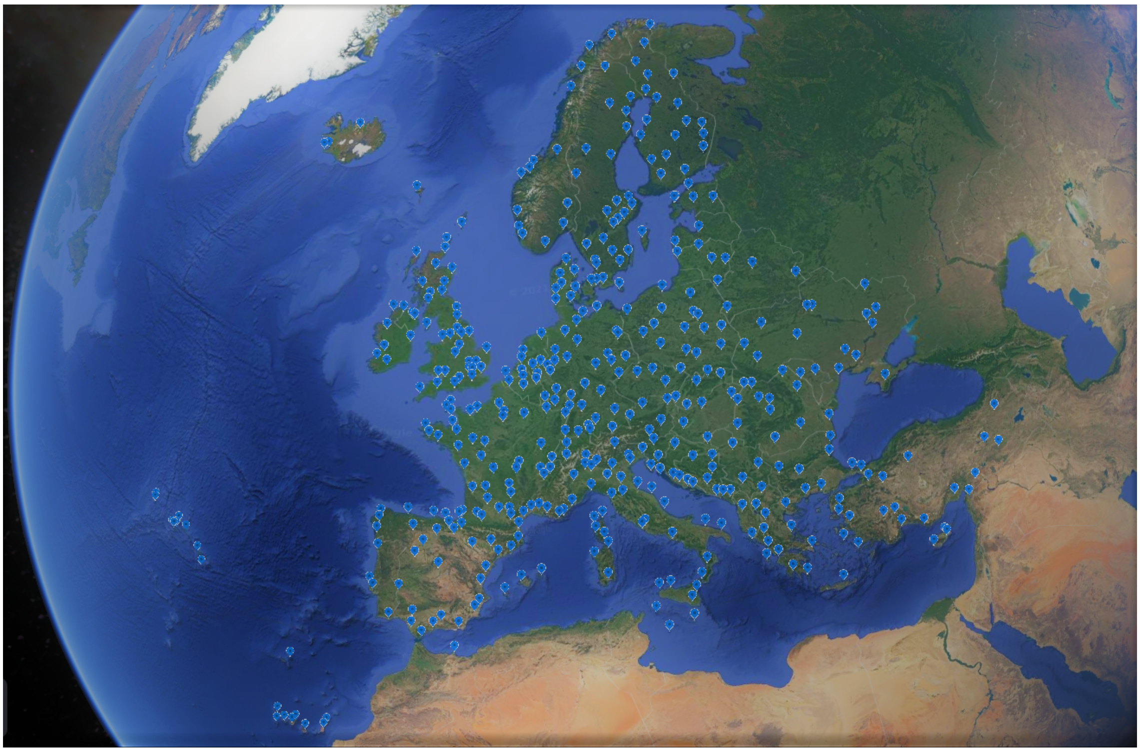


Fig. 3.2. European cities with an airport. [Own elaboration (Google Earth)]

As these locations were placed, each country was analyzed and the areas that were detected less covered by airports in the country were noted, which are presented in **Appendix A** because they only simply sign up to find out if the country has, at first glance, the need to build a new airport. This was assessed by measuring distances and times between some cities and airports or directly if it was very clear. In some countries it was already observed that there was no potential area to locate the airport, carrying out this initial analysis.

3.1.1 Selection in terms of the necessity of an airport.

In order to evaluate each region, the number of inhabitants they have will be taken as a reference, since it seeks to design a commercial airport and for this it is necessary to have passengers, that is, the inhabitants of each country are possible passengers of this new airport infrastructure in question. Therefore, the following table is made with the commented data: country, number of inhabitants and number of airports.

Table 3.2: Number of population and airports of each country.

Country	Population (M) [17]	Airports [18]	Country	Population (M) [17]	Airports [18]
Albania	2,875	1	Liechtenstein	0,038	0
Germany	83,082	28	Lithuania	2,792	4
Andorra	0,073	0	Luxembourg	0,615	1
Austria	8,875	6	North Macedonia	2,077	2
Belgium	11,459	5	Malta	0,492	1
Belarus	9,478	4	Moldova	3,56	1
Bosnia and Herzegovina	3,436	4	Monaco	0,039	0
Bulgaria	7,004	4	Montenegro	0,623	2
Cyprus	0,872	3	Norway	5,333	15
Vatican City	0,001	0	Netherlands	17,29	5
Croatia	4,080	9	Poland	38,447	15
Denmark	5,814	10	Portugal	10,252	14
Faroe Islands	0,048	1	United Kingdom	66,636	36
Slovakia	5,449	4	Gibraltar	0,034	1
Slovenia	2,077	2	Guernsey	0,066	2
Spain	46,791	42	Man Island	0,084	1
Estonia	1,323	5	Jersey Island	0,098	1
Finland	5,523	18	Czech Republic	10,64	5
France	65,236	49	Romania	19,413	13
Greece	11,314	31	Russia	147,043	591
Hungary	9,759	4	San Marino	0,033	0
Ireland	4,902	6	Serbia	6,971	4
Iceland	0,357	3	Sweden	10,236	24
Italy	60,466	33	Switzerland	8,549	6
Latvia	1,92	2	Turkey	81,821	17
			Ukraine	42,169	15

Next, an estimate was made of how many inhabitants should leave per airport.

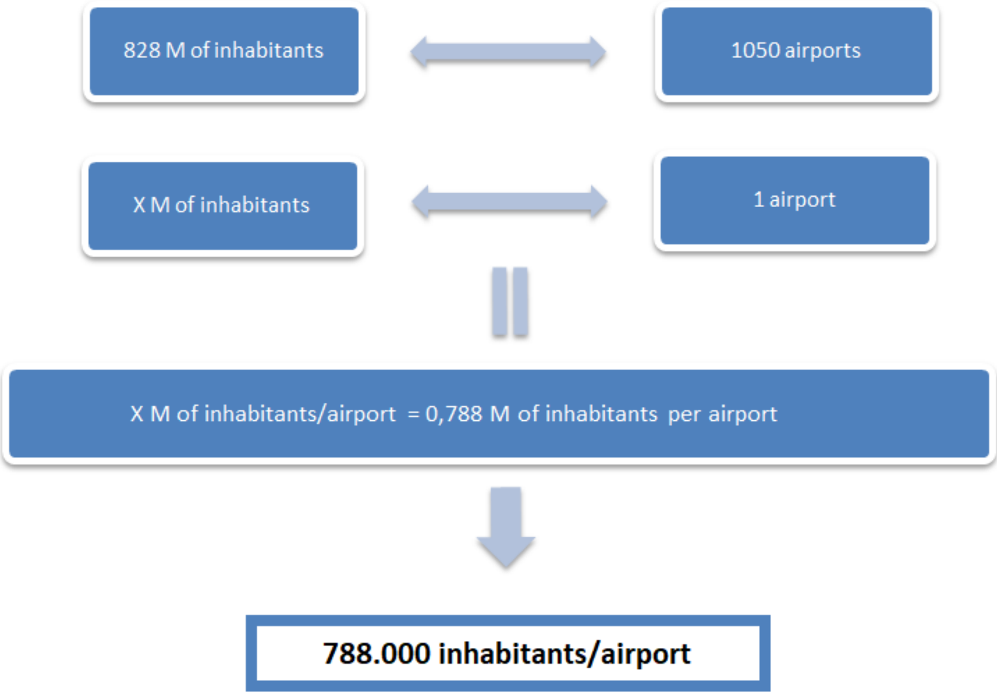


Fig. 3.3. Estimation of the number of inhabitants per airport. [Own elaboration (Word)]

It is observed that the result is approximately 788.000 inhabitants/airport. Therefore, taking into account that there are many airports that do not have international flights, the following will be used as a reference:

$$1 \; airport \rightarrow 500.000 \; inhabitants$$

This means that if a country has 1 airport for every 500.000 inhabitants, it is more than served and, in principle, it would not have much need to create a new one.

Once this is determined, countries can begin to be evaluated and discarded taking into account the relationship between inhabitants and airports.

Calculating the Population/Airports relationship it can be seen the following:

Table 3.3: Relation between populations and airports.

Country	Population (M) [17]	Airports [18]	M inhabitants/Airports
Albania	2,875	1	2,875
Germany	83,082	28	2,967
Andorra	0,073	0	-
Austria	8,875	6	1,479
Belgium	11,459	5	2,292
Belarus	9,478	4	2,370
Bosnia and Herzegovina	3,436	4	0,859
Bulgaria	7,004	4	1,751
Cyprus	0,872	3	0,290
Vatican City	0,001	0	-
Croatia	4,080	9	0,453
Denmark	5,814	10	0,581
Faroe Islands	0,048	1	0,048
Slovakia	5,449	4	1,362
Slovenia	2,077	2	1,039
Spain	46,791	42	1,114
Estonia	1,323	5	0,265
Finland	5,523	18	0,307
France	65,236	49	1,331
Greece	11,314	31	0,365
Hungary	9,759	4	2,440
Ireland	4,902	6	0,817
Iceland	0,357	3	0,119
Italy	60,466	33	1,832

Country	Population (M) [17]	Airports [18]	M inhabitants/Airports
Latvia	1,92	2	0,960
Liechtenstein	0,038	0	-
Lithuania	2,792	4	0,698
Luxembourg	0,615	1	0,615
North Macedonia	2,077	2	1,039
Malta	0,492	1	0,492
Moldova	3,56	1	3,560
Monaco	0,039	0	-
Montenegro	0,623	2	0,312
Norway	5,333	15	0,356
Netherlands	17,29	5	3,458
Poland	38,447	15	2,563
Portugal	10,252	14	0,732
United Kingdom	66,636	36	1,851
Gibraltar	0,034	1	0,034
Guernsey	0,066	2	0,033
Man Island	0,084	1	0,084
Jersey Island	0,0987	1	0,098
Czech Republic	10,64	5	2,128
Romania	19,413	13	1,493
Russia	147,043	591	0,249
San Marino	0,033	0	-
Serbia	6,971	4	1,743
Sweden	10,236	24	0,427
Switzerland	8,549	6	1,425
Turkey	81,821	17	4,813
Ukraine	42,169	15	2,811

- **Relation $<$ 1:** The country has more than 1 airport for every 1 million inhabitants.
- **Relation $\approx$ 1:** The country has 1 airport for every million inhabitants.
- **Relation $>$ 1:** The country has more than 1 M inhabitants for each airport.

Next, observing these tables and the conclusions found, an analysis will be made of all the countries, classifying them according to whether or not they need to build a new airport.

To begin with, the countries that will be discarded directly due to three specific reasons will be presented:

- **Reason A:** Countries that have twice or more airports than millions of inhabitants.
- **Reason B:** Countries that have less than 500.000 inhabitants and already have an airport.
- **Reason C:** Countries with a number of inhabitants close to 500.000 and that with an airport already cover the entire territory due to its small surface area and low population.

Table 3.4: Reasons for direct discard from some countries.

Country	M inhabitants/Airports	Reason for discarding
Cyprus	0,290	Reason A
Croatia	0,453	Reason A
Denmark	0,581	Reason A
Faroe Islands	0,048	Reason B
Estonia	0,265	Reason A
Finland	0,307	Reason A
Greece	0,365	Reason A
Iceland	0,119	Reason A
Luxembourg	0,615	Reason C
Malta	0,492	Reason C
Montenegro	0,312	Reason A
Norway	0,356	Reason A
Gibraltar	0,034	Reason B
Guernsey	0,033	Reason A
Man Island	0,084	Reason B
Jersey Island	0,098	Reason B
Russia	0,249	Reason A
Sweden	0,427	Reason A

Once the countries to be ruled out directly have been detected due to their little need to build a new airport infrastructure, we proceed to assess the countries that have as many airports as millions of inhabitants or more airports than millions of population but not twice as much.

Table 3.5: Countries with a number of airports similar to that of millions of inhabitants.

Country	M inhabitants/Airports	Condition
Bosnia and Herzegovina	0,859	Uncertain
Slovenia	1,039	Uncertain
Ireland	0,817	Uncertain
Latvia	0,960	Uncertain
Lithuania	0,698	Uncertain
North Macedonia	1,039	Uncertain
Portugal	0,732	Uncertain

At this point, the countries with the most potential to build a new airport will be presented below, since, in principle, their need is greater because they have more millions of inhabitants than airports and let us remember:

$$X \; million \; inhabitants \rightarrow 2 \cdot X \; airports$$

In other words, these missing countries, even considering 1M inhabitants for every 1 airport, will need one or more new airports to cover their population. As the tables are presented, it will be seen that, each time, countries have more need to build a new airport to cover the entire population that lives in them.

Table 3.6: Countries with more M inhabitants than airports, but not twice as many.

Country	M inhabitants/Airports	Condition
Austria	1,479	Uncertain
Bulgaria	1,751	Accepted
Slovakia	1,362	Accepted
Spain	1,114	Accepted
France	1,331	Accepted
Italy	1,832	Accepted
United Kingdom	1,851	Accepted
Romania	1,493	Accepted
Serbia	1,743	Accepted
Switzerland	1,425	Uncertain

Table 3.7: Countries with more than double M inhabitants than airports but not triple.

Country	M inhabitants/Airports	Condition
Albania	2,875	Accepted
Belgium	2,292	Accepted
Belarus	2,370	Accepted
Hungary	2,440	Accepted
Poland	2,563	Accepted
Czech Republic	2,128	Accepted
Ukraine	2,811	Accepted

Table 3.8: Countries with three or more M inhabitants than airports.

Country	M inhabitants/Airports	Condition
Netherlands	3,458	Accepted
Moldova	3,560	Accepted
Turkey	4,813	Accepted
Germany	2,967	Accepted

In these countries finally presented, it would be very interesting to build new air transport infrastructures to remove the flow of passengers.

Before determining the conclusions of this first selection, countries with less than 500.000 inhabitants that do not have an airport will be assessed. Let us remember that these are: Andorra, Vatican City, Liechtenstein, Monaco and San Marino.

Vatican City is ruled out outright because it has so little population. The others also have little population and, therefore, it would not be too interesting to build an airport in these countries, in principle. If the distances from these countries to the nearest airport are analyzed, it is observed that Liechtenstein is the only one with the greatest distance. In addition, it has topologically potential sites for the construction of the airport; therefore, the only country analyzed that would proceed to the next phase of the selection is Liechtenstein.

Table 3.9: Countries with less than 500.000 inhabitants without an airport.

Country	Condition
Andorra	Dismiss
Vatican City	Dismiss
Liechtenstein	Accepted
Monaco	Dismiss
San Marino	Dismiss

To finish this first analysis, a diagram will be presented where the inhabitants will appear according to the number of airports in each country. Emphasize that the data of all countries have been represented except those that do not have an airport, not those that have a very low number of inhabitants and not Russia, for example, which has many millions of inhabitants and many airports.

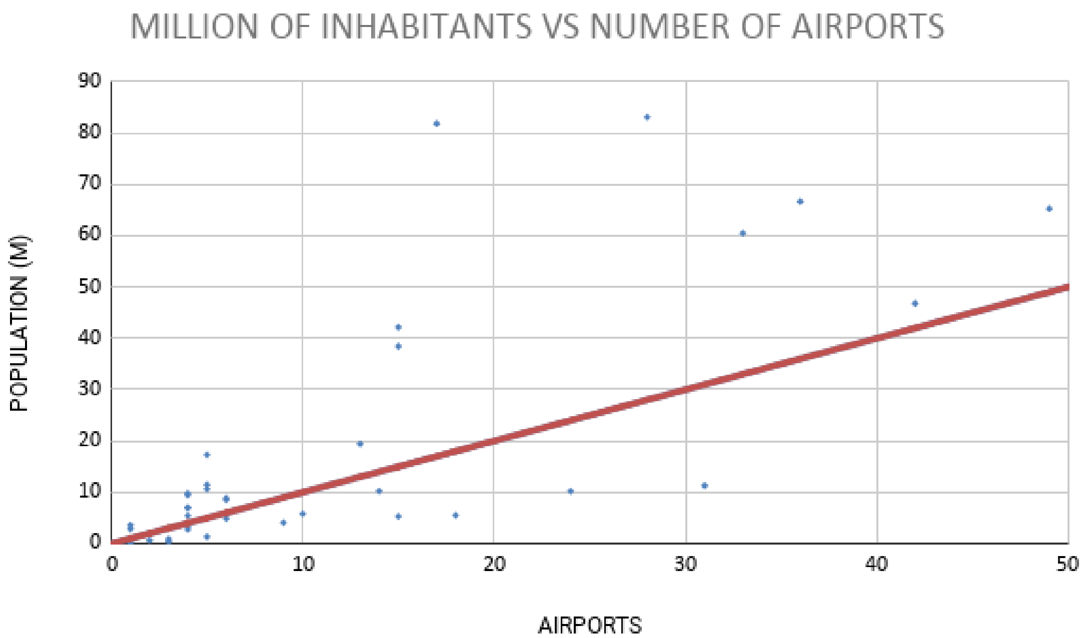


Fig. 3.4. Graphic about the relation between million of inhabitants and number of airports. [Own elaboration (Excel)]

If we look at the following graph we see that the countries that have the greatest need to build a new airport infrastructure are those that are above the line that passes through the points estimated as ideal, that is, this line represents that the ideal if a country has 5 million inhabitants is that it has 5 airports, 1 airport per 1 million inhabitants, since previously it has already been explained that it was estimated that the fair thing would be 1 airport for every 500.000 inhabitants.

After this analysis, the countries with **more inhabitants than airports and those marked as doubtful** would go to another selection.

But, before continuing with the group selection, we detected several cases of countries that we could eliminate now.

First, we see in **Table** 3.2 that Switzerland has approximately 9 million inhabitants and 6 airports.

If we use Google Earth [16], it can be seen that in this country, Lausanne would be the most needy area as it takes 1 hour by car and 1 hour and 30 minutes by public transport to the airport in Sion, so it is not so badly covered. In addition, the other area without an airport is already the Alps, which due to topological and meteorological conditions is ruled out because it would be very difficult to build there.

Then we have Austria. Its least covered areas are in the west and northwest. The one to the west is an area of the Alps and very mountainous and it would not be a good place to position an airport. On the other hand, the one in the northwest has close (approx. 1 hour and 30 from the most remote place) the Vienna airport to which it could support but it would not be worth it. In addition, Austria has almost 9 M inhabitants and 6 airports, which if we consider that the ideal is to have an airport every 1 M, it would be more or less well served. There is not much difference in this case since the airports are well distributed throughout the country.

Consequently, Austria and Switzerland will be left out of the selection. Once these two countries have been discarded, we are left with the following:

Table 3.10: Countries moving to the next phase.

Country	Condition
Bosnia and Herzegovina	Accepted
Slovenia	Accepted
Ireland	Accepted
Latvia	Accepted
Lithuania	Accepted
North Macedonia	Accepted
Portugal	Accepted
Bulgaria	Accepted
Slovakia	Accepted
Spain	Accepted
France	Accepted
Italy	Accepted
United Kingdom	Accepted
Romania	Accepted
Serbia	Accepted
Albania	Accepted
Belgium	Accepted
Belarus	Accepted
Hungary	Accepted
Poland	Accepted
Czech Republic	Accepted
Ukraine	Accepted
Netherlands	Accepted
Moldova	Accepted
Turkey	Accepted
Germany	Accepted
Liechtenstein	Accepted

3.1.2 Selection using groups in terms of millions of citizens.

A spreadsheet has been made that includes the country, the inhabitants and the 2019 GDP (in M €), the variation in this year, the GDP in 2020 and the variation in this year, and it is presented in **Appendix B**.

Once these data is collected, an assessment is made by grouping the countries not ruled out even by number of inhabitants. That is, for example, Bosnia and Moldova were grouped together because they both had between 3 and 4 million inhabitants. Once they had all been grouped, they were compared by groups, assessing the previous results on the number of airports and inhabitants and also assessing the GDP and its variations.

Table 3.11: Grouping countries by number of inhabitants.

Group	Population	Countries
1	< 1 M	Liechtenstein
2	> 1 M and < 2 M	Latvia
3	> 2 M and < 3 M	Albania, Slovenia, Lithuania and North Macedonia
4	> 3 M and < 4 M	Bosnia and Moldova
5	> 4 M and < 5 M	Ireland
6	> 5 M and < 6 M	Slovakia
7	> 6 M and ≤ 7 M	Serbia and Bulgaria
8	> 9 M and < 10 M	Belarus and Hungary
9	> 10 M and < 11 M	Portugal and Czech Republic
10	> 11 M and < 20 M	Belgium, Netherlands and Romania
11	> 20 M and < 50 M	Spain, Poland and Ukraine
12	> 50 M and < 80 M	France, Italy and United Kingdom
13	> 80 M	Germany and Turkey

Finally, to finish deciding, these groups of countries were compared one by one, assessing the need for an airport and, the annual and per capita GDP of 2019 and 2020 and its variation to see how the countries functioned economically. This aspect has been considered important since if the economy of a country does not work too well it will not interest to create a new infrastructure and less an airport because capital is needed for it and for it to work. The inhabitants are possible passengers of the airport and if they do not have capital they will not fly in it.

The idea is to rule out those countries that have practically the same number of inhabitants and their country or population has a lower GDP, that is, they have fewer economic resources.

Table 3.12: GDP per capita (M euros / M inhabitants).

Country	Population (M inhabitants) [17]	PIB 2019 (M€) [19]	PIB per cápita (€/ inhabitant)
Albania	2,875	13.645	4.746,087
Germany	83,082	3.449.050	41.513,806
Belgium	11,459	476.203	41.557,117
Belarus	9,478	57.538	6.070,690
Bosnia and Herzegovina	3,436	18.046	5.252,037
Bulgaria	7,004	61.240	8.743,575
Slovakia	5,449	93.865	17.226,097
Slovenia	2,077	48.393	23.299,470
Spain	46,791	1.244.772	26.602,808
France	65,236	2.425.708	37.183,580
Hungary	9,759	146.093	14.970,079
Ireland	4,902	356.051	72.633,823
Italy	60,466	1.790.942	29.618,992
Latvia	1,92	30.421	15.844,271
Lithuania	2,792	48.797	17.477,436
North Macedonia	2,077	11.209	5.396,726
Moldova	3,56	10.680	3.000
Netherlands	17,29	810.247	46.862,175
Poland	38,447	532.329	13.845,788
Portugal	10,252	213.949	20.869,001
United Kingdom	66,636	2.526.615	37.916,667
Czech Republic	10,64	223.950	21.047,932
Romania	19,413	222.998	11.487,045
Serbia	6,971	45.970	6.594,463
Turkey	81,821	679.510	8.304,836
Ukraine	42,169	137.468	3.259,930
Liechtenstein	0,038	5.972	57.157,895

As seen in the table above, the €/inhabitant vary greatly depending on the country. Even countries with a similar population differ greatly in terms of GDP per capita, which means that it is interesting to compare them based on this aspect. If two countries have a similar number of inhabitants, it is important to observe the resulting euros per person since if this value is higher, it means that the country, even having the same population, is much richer economically than the other with a lower value. And if one country has fewer inhabitants than another and has a higher GDP, it will turn out to be better off economically.

Now the relevant comparisons are made. But first, comment that Slovakia, Ireland, Latvia and Liechtenstein have no one to compare themselves with since countries with similar numbers of inhabitants have already been eliminated. Therefore, they would proceed to the next phase, to **Point** 3.2.

Also comment on two aspects, if the percentage of variation in GDP is positive it is interesting because it means that the country's economy works and is growing from one year to the next. And, if this variation is maintained, it means that it would be interesting to stimulate the economy, that is, making some change or creating new business opportunities in the country would be very favorable for this variation to increase.

3.1.2.1 Comparison to determine the 15 countries that pass the phase.

- **GROUP 3**
  - **Lithuania *vs* Albania**
    Lithuania economically is better than Albania as it has more or less the same number of inhabitants and a higher GDP. In addition, the variation of GDP in 2019 in Lithuania is greater but in 2020 this variation is negative but very low and Albania remains. Once these parameters have been evaluated, it is decided to choose the two countries. Albania because it is in great need of a new airport, according to the results of the **Point** 3.1.1 and Lithuania because in terms of economy it is much better than Albania and it would be fair to choose it as well.
  - **Slovenia *vs* Macedonia**
    Slovenia and Macedonia have practically the same number of inhabitants and Slovenia has much more GDP. And the decline of both countries in 2020 is similar, so of these two it is decided which Slovenia is better.
  - **Lithuania *vs* Slovenia**
    Lithuania is better than Slovenia in GDP since it has more or less the same number of inhabitants and euros, but the variation of Lithuania in 2019 is greater and its decrease in 2020 is less.

  Group 3 result: Lithuania and Albania

- **GROUP 4**
  - **Bosnia and Herzegovina *vs* Moldova**
    Bosnia is richer but has less growth variation in 2019 than Moldova. Therefore, also considering that Moldova needs an airport more than Bosnia, we will choose Moldova because if it manages to continue growing economically, it could reach Bosnia's GDP.

  Group 4 result: Moldova

- **GROUP 7**
  - **Serbia *vs* Bulgaria**
    Bulgaria is considerably richer in GDP but Serbia has a greater variation and in 2020 it held out and increased its wealth by 1 %. But if we look at Serbia, it has more inhabitants than Lithuania and has a lower GDP, so it could be ruled out, therefore, it was decided to choose Bulgaria.

  Group 7 result: Bulgaria

- **GROUP 8**
  - **Belarus *vs* Hungary**
    Hungary has much higher GDP, twice as much, and in 2019 it grew more but in 2020 it declines a lot (5 %) and Belarus does not do so but as has happened before, if we compare Belarus and Bulgaria, we see that Belarus has more inhabitants and lower GDP so clearly we choose Hungary.

  Group 8 result: Hungary

- **GROUP 9**
  - **Czech Republic *vs* Portugal**
    The slightly richer Czech Republic grew less in 2019 but had a smaller decline than Portugal in 2020. In addition, the Czech Republic has a greater need to build new airports.

  Group 9 result: Czech Republic

- **GROUP 10**
  - **Belgium *vs* Netherlands**
    Then the Netherlands has a larger population, 6 M more inhabitants and is twice as rich. Although in 2019 both increased by 1,7 %, in 2020 Belgium declined a lot. For all these reasons, it was decided to choose Netherlands.
  - **Romania *vs* Netherlands**
    Romania is out because it is much less rich than the Netherlands and has more than millions of inhabitants.

  Group 10 result: Netherlands

- **GROUP 11**
  - **Poland *vs* Ukraine**
    These two countries have the same starting conditions, both have more than twice the million inhabitants than airports, but looking at the GDP, we see that Ukraine has approximately 4 million more inhabitants, and its GDP is less than that of Poland. In addition, although Poland grew more in 2019 but fell in 2020, it still had a higher GDP than Ukraine and has more difference between inhabitants and airports, therefore, it has a greater need than Ukraine. In addition, Ukraine has war problems and this is not very convenient to create a new structural project.

- **Poland *vs* Spain**
  Spain has almost 10 million more inhabitants than Poland and twice the GDP. On the other hand, Poland grew more in 2019 than Spain and did not fall as sharply as Spain, which did in 2020 by 10.8 %. Poland has a greater difference between millions of inhabitants and airports but, in this case, we discard Poland because of its low GDP and if we calculate the GDP per capita for 2019 of both countries, we see that Spain far exceeds Poland, it has twice as much million euros per person than Poland.

Group 11 result: Spain

- **GROUP 12**
  - **France *vs* United Kingdom**
    These two countries have roughly the same number of inhabitants and were previously assigned the same level of need for a new airport. France grew more in 2019 and declined less in 2020 than the UK.

    We could say that they are fairly even due to the result of their GDP per capita, since if we calculate it, for both it is 37.000 €/inhabitant.
  - **Italy**
    Italy, compared to the aforementioned countries, has about 5-6 million fewer inhabitants, but if we calculate the GDP per capita it is clear which of the three countries should be discarded.

Table 3.13: GDP per capita (M euros / M inhabitants)

Country	Population (M inhabitants)	GDP per capita (€/inhabitant)
France	65,236	37.183,580
Italy	60,466	29.618,992
United Kingdom	66,636	37.916,667

Italy is ruled out, because it has a lower GDP per capita.

Group 12 result: France and United Kingdom

- **GROUP 13**
  - **Germany *vs* Turkey**
    Germany is chosen because it has more or less the same inhabitants as Turkey and has a much higher GDP.

Group 13 result: Germany

Finally, a table is presented with the results obtained throughout this point.

Table 3.14: Analysis Results (15 countries accepted).

Country	Condition
Liechtenstein	Accepted
Latvia	Accepted
Albania	Accepted
Lithuania	Accepted
Slovenia	Dismiss
Macedonia	Dismiss
Bosnia and Herzegovina	Dismiss
Moldova	Accepted
Ireland	Accepted
Slovakia	Accepted
Bulgaria	Accepted
Serbia	Dismiss
Hungary	Accepted
Belarus	Dismiss
Czech Republic	Accepted
Portugal	Dismiss
Netherlands	Accepted
Belgium	Dismiss
Romania	Dismiss
Spain	Accepted
Poland	Dismiss
Ukraine	Dismiss
France	Accepted
United Kingdom	Accepted
Italy	Dismiss
Germany	Accepted
Turkey	Dismiss

3.2 Decision Making - Final General Location of the Airport

This final selection aims to choose the country where the new airport will be located.

To do this, two multi-criteria methods will be used to make the final decision. We will use the selected countries and a series of requirements that will be defined below.

3.2.1 Assessments and decisions prior to the methods.

First, it will be assessed whether or not Liechtenstein will enter the final selection.

3.2.1.1 Is Liechtenstein a good option to locate the new airport?

We know that this country does not have an airport with commercial flights. In principle, it seems a very good option to locate the infrastructure but if its characteristics are analyzed, it turns out that not so much.

This country in 2019 had 38.000 inhabitants, approximately, and 5.972 million euros of GDP in 2019. Therefore, it turns out that in 2019 it obtained about 157.157 euros per inhabitant.

These GDP values are very positive, which means that the economy of this country works very well but, in this particular case, this is in the background.

This country, having very little population, does not have much need to have an airport with its own international flights, since at first, the potential passengers would only be 38.000 and as has been remarked throughout this explanation, the ideal would be one airport each about 500.000 or 1 M inhabitants.

Ultimately, Liechtenstein would be a good option economically and geographically, but not demographically, and in the end, that last one, is the most interesting for an airport because it would significantly increase passenger and aircraft traffic at the new infrastructure.

So we already have 14 definitive options with which the last analysis will be carried out.

Now it would be necessary to define the requirements.

3.2.1.2 Requisites.

Finally, the requirements to be used were determined after thinking about what is important to assess when building a new airport in a country.

Some of them have already been discussed throughout the previous points.

- **Need for a new airport.**
  In this requirement, what is intended is to assess the variation between millions of inhabitants and airports that the country has. Those with three times as many inhabitants as airports will have the highest score.

  In other words, if the number of inhabitants is divided by the number of airports, the higher the result of this division, the better because it means that there are more inhabitants than airports, which is the same as saying that there is more need to build an airport.

  The data to assess this requirement can be found in **Table** 3.3.

- **Transported passengers in 2019.**
  This requirement refers to studying, on average, how many passengers were transported by air in 2019 per airport in the country (Transported passengers in 2019/Number of airports).

  The following table presents the necessary data.

Table 3.15: Relation between population and airports.

Country	Transported passengers (Thousands of passengers) [20]	Airports
Albania	307,74	1
Germany	109.633,75	28
Bulgaria	832,83	4
Slovakia	5,449	4
Spain	88.237,17	42
France	71.289,28	49
Hungary	39.803,37	4
Ireland	170.161,85	6
Latvia	4.976,41	2
Lithuania	40,61	4
Moldova	1.408,17	1
Netherlands	46.358,46	5
United Kingdom	142.392,53	36
Czech Republic	5.446,16	5

- **GDP (Gross Domestic Product).**
  Looking at the GDP of a country means valuing its economy. What interests us most to compare between countries is to look at the GDP generated per capita, that is, per inhabitant. Therefore, in this requirement the M €GDP / M inhabitants (the same as €/inhabitant) will be valued in 2019, since this year is prior to the pandemic and it is of greater interest to study the country in a stable situation and not in an economic crisis such as the current.

Table 3.16: GDP per capita of each of the 14 countries.

Country	GDP per capita (€/inhabitant)
Albania	4.746,087
Germany	41.513,806
Bulgaria	8.743,575
Slovakia	17.226,097
Spain	26.602,808
France	37.183,580
Hungary	14.970,079
Ireland	72.633,823
Latvia	15844,271
Lithuania	17477,436
Moldova	3000
Netherlands	46862,175
United Kingdom	37916,667
Czech Republic	21047,932

- **Surface.**

  This requirement values the surface that the country has, since if it is larger, there will be more space to create new infrastructures. If we calculate the square kilometers by number of airports adding the new one, we will know, on average, how many km^2 each airport in the country would cover, an important fact since if the result of this calculation is high it means that each airport in the country covers more territory and, therefore, there is more need to cover this space with this airport of more and all this new airport would be of great help to cover all areas of the country.

Table 3.17: Relation between surface and number of airports.

Country	Surface (km^2) [21]	Airports	Surface per airport (km^2/airport)
Albania	28.748	1	14.374
Germany	357.021	28	12.311,069
Bulgaria	110.910	4	22.182
Slovakia	48.845	4	9.769
Spain	504.645	42	11.735,930
France	547.104	49	10.942,080
Hungary	93.030	4	18.606
Ireland	70.280	6	10.040
Latvia	64.589	2	21.529,667
Lithuania	65.200	4	13.040
Moldova	33.843	1	16.921,500
Netherlands	41.526	5	6.921
United Kingdom	244.820	36	6.616,757
Czech Republic	78.866	5	13.144,333

- **Meteorological conditions.**

  If the territory where the airport is located has good weather conditions, it is favorable since passengers will feel safer and there will be a better performance of the flow of aircraft and thus, the airport will be more efficient.

  Good weather conditions would be:

  - Moderate temperatures: If there are no strong frosts or snow, better, as these two meteorological phenomena could cause flight cancellations due to ice or snow on the runways.
  - Low rainfall: Since if it rains a lot, the runways could be flooded and the planes would skid, and visibility would be unfavorable.
  - Reduced wind: If there are strong air currents, takeoffs and landings would be more complicated and the stability of the aircraft would be put at risk.

  This requirement will be assessed by gathering the data of these three phenomena for each country, taking as a reference the capital of each one of them and the month of January, which is generally the worst weather conditions in Europe.

Table 3.18: Meteorological conditions data [22].

Country	Temperature (°C)		Precipitation (mm)	Wind (km/h)
	Minimum	Maxim		
Albania	0	4	70	14
Germany	-1,9	2,9	42,3	20
Bulgaria	-4,9	2,2	28	4
Slovakia	-2,8	3,1	37,4	14
Spain	2,7	9,8	32,8	23
France	2,5	6,9	53,7	8
Hungary	-3	2,6	30,5	10
Ireland	2,4	8,1	62,6	14
Latvia	-7,8	-2,3	34	7
Lithuania	-6,4	-1,6	48	11
Moldova	-6	0	40	4
Netherlands	0,5	5,4	62,1	14
United Kingdom	3,1	8,1	41,6	10
Czech Republic	-2,4	2,6	20,4	7

Then, each of the countries will be given a value from 0 to 13 according to temperature, rainfall and wind, to classify them from worst to best in each type of phenomenon.

Table 3.19: Meteorological conditions points.

Country	Temperature	Precipitations	Wind	Total points
Albania	8	0	2	10
Germany	7	5	1	13
Bulgaria	3	12	12	27
Slovakia	5	8	4	17
Spain	12	10	0	22
France	11	3	9	23
Hungary	4	11	8	23
Ireland	10	1	3	14
Latvia	0	9	11	20
Lithuania	1	4	6	11
Moldova	2	7	13	22
Netherlands	9	2	5	16
United Kingdom	13	6	7	26
Czech Republic	6	13	10	29

Therefore, the one with the highest score will be the one with the best weather conditions.

- **Member of the different Organizations.**

  This requirement will assess the importance of belonging to the following organizations: the European Union and the Schengen Area (SH).

  Logically, when a country maintains more relations with others it has some advantages. Having relationships of this type facilitates air transport as there are fewer restrictions and, therefore, it is much more fluid.

The European Union, according to its website [23], maintains firm objectives that are the following:

- "Promote peace, its values and the well-being of its citizens".
- "Offer freedom, security and justice without internal borders".
- "Promote sustainable development based on balanced economic growth and price stability, a highly competitive market economy with full employment and social progress, and environmental protection".
- "Combat social exclusion and discrimination".
- "Promote scientific and technological progress".
- "Strengthen economic, social and territorial cohesion and solidarity among the Member States".
- "Respect the richness of its cultural and linguistic diversity".
- "Establish an economic and monetary union with the euro as its currency".

That is, the countries that are within this organization seek economic, social and territorial union. Furthermore, they have a common goal of maintaining stability, security and prosperity among themselves and internationally as a union.

Then we have the Schengen Area that aims to unify the movement of citizens of the countries that make it up to facilitate transport between nations with a common visa policy [24]. For connections between countries that are part of this organization, it is not required to establish a passport control at the airport.

After seeing this importance of belonging to these organizations, the countries will be presented and to which organization they belong, if they are part of either of these two.

Table 3.20: Country - Organizations [23].

Country	EU	Schengen Space
Albania	±	X
Germany	✓	✓
Bulgaria	✓	X
Slovakia	✓	✓
Spain	✓	✓
France	✓	✓
Hungary	✓	✓
Ireland	✓	X
Latvia	✓	✓
Lithuania	✓	✓
Moldova	X	X
Netherlands	✓	✓
United Kingdom	X	X
Czech Republic	✓	✓

Once the information has been gathered, this requirement will be assessed by giving certain points according to the organization to which they belong:

Table 3.21: Points depending on the organizations.

Points	EU	Schengen Space
5	✓	✓
3	✓	X
3	X	✓
2	$\pm$	X
1	X	X

- **Least amount of CO_2 emitted in year 2019.**

  Here, the main idea is that a country that emits less CO_2 will be better when it comes to building an airport since these infrastructures already provide a level of CO_2 emission as low as possible. Therefore, if an airport is built in a country with a lot of pollution to start with, it would increase its pollution even more and it should not be done.

  Once this aspect has been clarified, the assessment of this requirement will be divided in two.

  First, according to the European Aviation Environmental Report 2019 [25]. On pages 69 and 70 of the document, there is a map that classifies the most important airports in each country by pollution levels. Then a bar chart is made that we will see below where the amount of CO_2 emitted per passenger is specified.

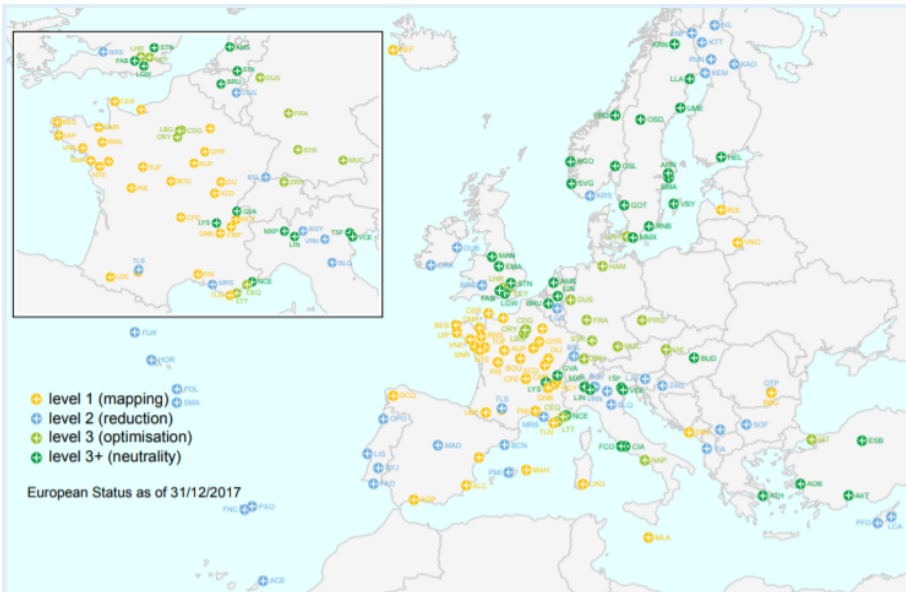


Fig. 3.5. European airports participating in the Airport Carbon Accreditation program. Source: [25]

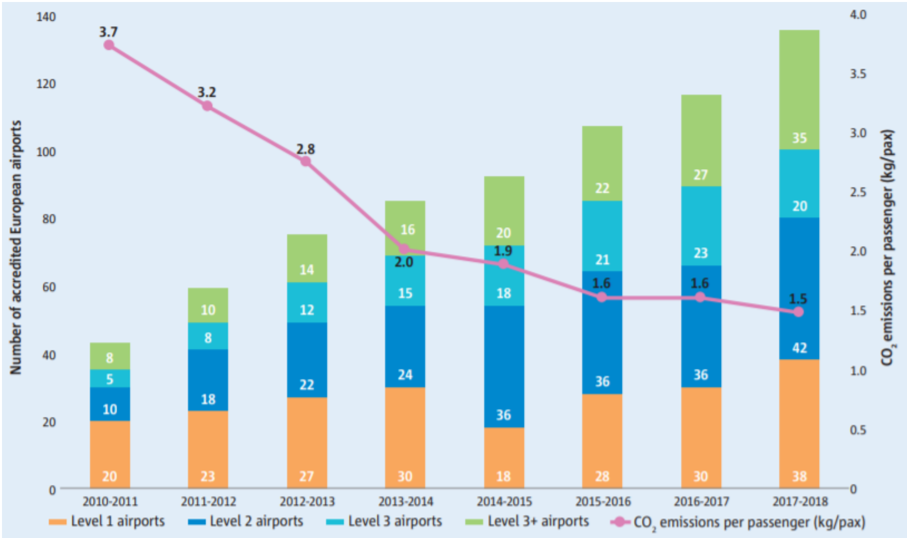


Fig. 3.6. Increasing number of accredited European airports and stabilised CO_2 emissions per passenger. Source: [25]

Each country will be assigned a score according to the level of pollution at its capital airport, as a reference.

Table 3.22: Points depending on the pollution level.

Level	Points
Level 1	5
Level 2	3,5
Level 3	2,5
Level 4	1

Table 3.23: Points assigned to the pollution level of each country.

Country	Level	Points A
Albania	Level 2	3,5
Germany	Level 3	2,5
Bulgaria	Level 2	3,5
Slovakia	Level 3	2,5
Spain	Level 2	3,5
France	Level 3	2,5
Hungary	Level 4	1
Ireland	Level 2	3,5
Latvia	Level 1	5
Lithuania	Level 1	5
Moldova	Level 1	5
Netherlands	Level 4	1
United Kingdom	Level 3	2,5
Czech Republic	Level 3	2,5

Once these levels have been defined and assigned, the country's level of contamination will be analyzed. Specifically, it will be classified according to the total kts of CO_2 that each country emitted in 2019 [26] and will be assigned points from 0 to 13 each one from more to less CO_2 emission.

Table 3.24: CO_2 emissions assigned points.

Country	CO_2 [kts]	Points B
Albania	5.659	13
Germany	702.600	0
Bulgaria	43.314	7
Slovakia	35.985	9
Spain	25.9310	3
France	314.736	2
Hungary	53.183	6
Ireland	36.548	8
Latvia	8.379	12
Lithuania	13.772	10
Moldova	9.229	11
Netherlands	156.415	4
United Kingdom	364.906	1
Czech Republic	105.693	5

Finally, to obtain the total points, evaluating both classifications, the points will be added and each country will be given a final score to perform the methods. And, the one that will obtain the most points will be the one that least pollutes of the others, that is, the country that will obtain the highest score in this requirement.

Table 3.25: Total points of CO_2 emissions evaluation.

Country	Points A	Points B	Total points
Albania	3,5	13	16,5
Germany	2,5	0	2,5
Bulgaria	3,5	7	10,5
Slovakia	2,5	9	11,5
Spain	3,5	3	6,5
France	2,5	2	4,5
Hungary	1	6	7
Ireland	3,5	8	11,5
Latvia	5	12	17
Lithuania	5	10	15
Moldova	5	11	16
Netherlands	1	4	5
United Kingdom	2,5	1	3,5
Czech Republic	2,5	5	7,5

3.2.2 OWA (Ordered Weighted Average).

This method follows the next methodology:

i. Give importance values to each requirement according to the importance they give to the decision (g).
ii. Value each option (country) from 1-5 (p) according to type of requirement. For this point, the data and results previously presented in **Point** 3.2.1.2 will be used.
iii. Calculate the product $p \cdot g$ that corresponds to the relative grade.
iv. Finally the OWA formula will be applied:

$$OWA = \frac{\sum_{i=1}^{n} p_i \cdot g_i}{p_{max} \cdot \sum g_i}$$

v. OWA results.

1) Level of importance of each requirement for the decision (g).

Table 3.26: Weight of each requirement.

Requisite	Weight (g)
Need for a new airport	70
Transported passengers in 2019	60
GDP (Gross Domestic Product)	40
Surface	50
Meteorological conditions	20
Member of different organizations	30
Least amount of CO_2 emitted in 2019	10

2) Valuation of each option according to requirement (p).

The OWA method points have been given by assessing the maximum and minimum value of each parameter to be assessed. From these, the biggest has been given a score of 5 points (highest score) and the smallest one of 1 point. From these values, the mean score of 3 has been assigned the mean value of the parameter. And then the other scores have been estimated by calculating average values.

This will be seen in the first requirement. In the others the same method has been used but the calculations will not be presented.

- **REQUISITE 1: Need for a new airport.**
  After performing the means between values, the assignments of values to the OWA points have resulted as follows:

Table 3.27: Assignment of values.

M inhabitants/airport	OWA points
3,560	5
3,200	4,5
2,843	4
2,484	3,5
2,125	3
1,800	2,5
1,408	2
1,050	1,5
0,690	1

Once we have the following numerical references, the score for each option can be estimated, evaluating requirement 1.

Table 3.28: Points requirement 1.

Option	Country	M inhabitants/airport	Method points
Option A	Albania	2,875	4
Option B	Germany	2,967	4,1
Option C	Bulgaria	1,751	2,5
Option D	Slovakia	1,362	1,8
Option E	Spain	1,114	1,5
Option F	France	1,331	1,7
Option G	Hungary	2,440	3,4
Option H	Ireland	0,817	1,2
Option I	Latvia	0,960	1,3
Option J	Lithuania	0,690	1
Option K	Moldova	3,560	5
Option L	Netherlands	3,458	4,8
Option M	United Kingdom	1,851	2,6
Option N	Czech Republic	2,128	3

- **REQUISITE 2: Transported passengers in 2019 per number of airports.**

Table 3.29: Points requirement 2.

Option	Country	Miles transported passengers/airport	Method points
Option A	Albania	307,740	1,1
Option B	Germany	3.915,491	1,6
Option C	Bulgaria	208,208	1,1
Option D	Slovakia	1,980	1
Option E	Spain	2.100,885	1,4
Option F	France	1.454,883	1,2
Option G	Hungary	9.950,8425	2,5
Option H	Ireland	28.360,308	5
Option I	Latvia	2.488,205	1,4
Option J	Lithuania	10,153	1
Option K	Moldova	1.408,170	1,2
Option L	Netherlands	9.271,692	2,4
Option M	United Kingdom	3.955,348	1,6
Option N	Czech Republic	1.089,232	1,2

- **REQUISITE 3: Gross Domestic Product 2019.**

Table 3.30: Points requirement 3.

Option	Country	Euros/inhabitant	Method points
Option A	Albania	4.746,087	1,1
Option B	Germany	41.513,806	3,3
Option C	Bulgaria	8.743,575	1,4
Option D	Slovakia	17.226,097	1,8
Option E	Spain	26.602,808	2,3
Option F	France	37.183,580	3
Option G	Hungary	14.970,079	1,7
Option H	Ireland	72.633,823	5
Option I	Latvia	15.844,271	1,7
Option J	Lithuania	17.477,436	1,8
Option K	Moldova	3.000	1
Option L	Netherlands	46.862,175	3,5
Option M	United Kingdom	37.916,667	3
Option N	Czech Republic	21.047,932	2,1

- **REQUISITE 4: Surface per airport.**

Table 3.31: Points requirement 4.

Option	Country	km^2/airport	Method points
Option A	Albania	14.374,000	3
Option B	Germany	12.311,069	2,5
Option C	Bulgaria	22.182,000	5
Option D	Slovakia	9.769,000	1,7
Option E	Spain	11.735,930	2,2
Option F	France	10.942,080	2,1
Option G	Hungary	18.606,000	4,1
Option H	Ireland	10.040,000	1,9
Option I	Latvia	21.529,667	4,8
Option J	Lithuania	13.040,000	2,7
Option K	Moldova	16.921,500	3,6
Option L	Netherlands	6.921,000	1,2
Option M	United Kingdom	6.616,757	1
Option N	Czech Republic	13.144,333	2,8

- **REQUISITE 5: Meteorological conditions.**

Table 3.32: Points requirement 5.

Option	Country	Total points evaluated	Method points
Option A	Albania	10	1
Option B	Germany	13	1,7
Option C	Bulgaria	27	4,6
Option D	Slovakia	17	2,5
Option E	Spain	22	3,6
Option F	France	23	3,7
Option G	Hungary	23	3,7
Option H	Ireland	14	1,8
Option I	Latvia	20	3,1
Option J	Lithuania	11	1,3
Option K	Moldova	22	3,6
Option L	Netherlands	16	2,2
Option M	United Kingdom	26	4,4
Option N	Czech Republic	29	5

- **REQUISITE 6: Member of different organizations.**

Table 3.33: Points requirement 6.

Option	Country	Points
Option A	Albania	2
Option B	Germany	5
Option C	Bulgaria	3
Option D	Slovakia	5
Option E	Spain	5
Option F	France	5
Option G	Hungary	5
Option H	Ireland	3
Option I	Latvia	5
Option J	Lithuania	5
Option K	Moldova	1
Option L	Netherlands	5
Option M	United Kingdom	1
Option N	Czech Republic	5

- **REQUISITE 7: Least amount of CO_2 emitted in 2019.**

Table 3.34: Points requirement 7.

Option	Country	Total points evaluated	Method points
Option A	Albania	16,5	4,8
Option B	Germany	2,5	1
Option C	Bulgaria	10,5	3,3
Option D	Slovakia	11,5	3,5
Option E	Spain	6,5	2,1
Option F	France	4,5	1,5
Option G	Hungary	7	2,3
Option H	Ireland	11,5	3,5
Option I	Latvia	17	5
Option J	Lithuania	15	4,5
Option K	Moldova	16	4,8
Option L	Netherlands	5	1,8
Option M	United Kingdom	3,5	1,3
Option N	Czech Republic	7,5	2,4

3) Calculate the product $p \cdot g$ that corresponds to the relative grade.

4) Finally, the OWA formula will be applied

The results of the OWA indices found will be presented. The table with all the corresponding operations (3), 4) and 5)) are presented in **Appendix C**.

5) OWA results.

Table 3.35: OWA Method table for criteria country selection.

Country	OWA index
Albania	0,48
Bulgaria	0,54
Czech Republic	0,56
France	0,47
Germany	0,60
Hungary	0,65
Ireland	0,60
Latvia	0,53
Lithuania	0,40
Moldova	0,57
Netherlands	0,64
Slovakia	0,41
Spain	0,45
United Kingdom	0,41

It is seen that with this method the most favourable one becomes Hungary followed by Netherlands.

3.2.3 PRESS Method.

This method is similar to the previous one but much more precise, therefore, once we have the results of this, they are compared with the previous ones and the final result will be found.

i. Same as OWA, assign a given weight to each requirement and obtain the relative weight by dividing that of each requirement by the sum of all the weights.

ii. Give scores from 1 to 5 to all the options according to each requirement (same values as in the OWA).

iii. Valuation matrix:

$$Q_{ij} = \frac{Y_{ij}}{Y_{jmax}} \cdot W_j$$

iv. Domination matrix:

$$T_{ij} = \sum (Q_{ik} - Q_{jk}) \rightarrow when\ Q_{ik} > Q_{jk}$$

v. Then, equal rows D_i and columns d_i and calculate index $\frac{D_i}{d_i}$.

vi. Results.

1) Level of importance of each requirement for the decision (g).

2) Valuation of each option according to requirement (p).

These points are exactly the same as in the OWA.

3) Valuation matrix.

To find this matrix, the formula presented above must be applied.

4) Domination matrix.

Like the valuation matrix, it will be found by applying a formula.

5) Calculation of the index.

From the results obtained from the domination matrix, the values of D_i and d_i, can be found, adding the sum of the values of each row and each column of the matrix, respectively.

Finally, the index is calculated by dividing: $\frac{D_i}{d_i}$

All these results are presented in **Appendix D**.

6) PRESS results

Table 3.36: PRESS Method table for criteria country selection.

Country	PRESS index
Albania	0,433
Bulgaria	0,696
Czech Republic	0,847
France	0,334
Germany	1,105
Hungary	1,810
Ireland	0,823
Latvia	0,579
Lithuania	0,173
Moldova	0,713
Netherlands	1,202
Slovakia	0,171
Spain	0,272
United Kingdom	0,244

3.2.4 Decision making results.

As seen in the previous points, using the two decision methods it appears that Hungary is the best country to locate the airport.

Using the OWA only, the result was not very accurate as Hungary came out as the "winning" country with 0,65; but followed by Netherlands with an index of 0,64.

For this reason, performing both methods the result is much more reliable since with the PRESS it is possible to adjust the decision further, since Hungary has an index of 1,810 and Netherlands of 1,202.

3.3 Final Location Result

As a conclusion to this point, from general location, we obtain that the country where the airport will be located will be Hungary.

Finally, this choice will be argued by presenting the data and results gathered on this country.

Table 3.37: Hungary Results.

Parameter	Value
Population (M)	9,759 M of inhabitants
Number of airports	4 airports
M inhabitants/Airport	2,440 M inhabitants/airport
GDP/person	14.970,079 €/inhabitant
km^2/airport	18.606 km^2/airport
Meteorological conditions	Moderates (23 points)
Organizations	EU and Schengen Area
Pollution level	High

We see that Hungary would need an airport since this country has more than twice, but not three times, millions of inhabitants than airports. Therefore, one more airport would do well to accommodate the population of other airports and remove the flow of passengers that can become excessive.

Then, if we look at the 2019 GDP values, we see that the country has a lot of money and its GDP did not stop growing. On the other hand, in 2020 it decreased by 5,00 % due to the pandemic. This last data is not worrying because due to the pandemic, most countries have declined economically. Economically, if we look at GDP per capita, we see that 14.970,079 € per inhabitant, quite high value.

Then, in terms of the surface area, we see that the km^2 per airport that appear is 18.606. This means that each of the 4 airports that currently exist in Hungary plus the new one, cover, as well say it, 18606 km^2 each. If a new one were not built, each of the 4 existing ones would cover 23.258 km^2. A considerable amount of km^2. It is interesting to have 5 and thus better cover the areas of Hungary.

Therefore, the weather in this country is quite regular as in Spain. It is true that the temperatures in the winter months are quite minimal but the rainfall, compared to other countries, does not fall too many mm. And the wind there is not excessively strong either, about 10 km/h. Having good weather conditions helps a lot to the fluidity of the airport since there will be no cancellations of flights due to storm, snowfall or frost or heavy rain or flooding.

In addition, Hungary belongs to the two organizations of special interest to build a new airport infrastructure in the country, the European Union and the Schengen Area.

Finally, if we look at the data collected on pollution in this country we see that the capital's airport, Budapest, pollutes a lot and in total, the country in 2019 emitted 53.183 kts. Therefore, it would be interesting to add an ecologically sustainable airport to reduce the level of pollution at the capital's airport and thus that of the country in general.

In short, after having analyzed different requirements for each country in Europe, the study carried out concludes that Hungary is the country with the greatest potential to build the new airport.

Fig. 3.7. General Location: Hungary. [Own elaboration (Google Earth)]

Chapter 4

Demand analysis

This section will try to study the potential traffic generator in Hungary at a general and more detailed level. The purpose is to estimate, according to the objective of the new airport to be designed, the number of operations and passengers that it will have in the starting year and in a horizon scenario, in order to later be able to design it according to the expectations taken. To do this, this section will be divided a in different points of interest for this study of air traffic demand in the country and, specifically, in the area of Hungary where the new airport will be located. Issues of traffic generation, absorption of airlines and their respective routes, traffic growth and traffic forecasts such as estimation of busy day or peak hour will be dealt with.

4.1 Introduction to the Demand Analysis

In order to plan an airport, it is fundamentally necessary to carry out a traffic demand in order to assess different parameters for its subsequent design. Traffic demand forecasts will be established in different planning horizons: short (5 years), medium (10 years) and long term (20 years).

There are different demand forecasts: demand for passenger traffic, aircraft, cargo and others such as demand for worker traffic, etc. In addition, depending on the type of traffic, different units of measurement will be used. In this case, the traffic to be studied will be passenger traffic and aircraft traffic, the units of which would be: for passenger traffic, units of pax departure, pax arrival and total pax are used, and for aircraft, number of total departures, arrivals and operations.

In addition, it is interesting to have traffic information for each period of time like annual (parameter/year), monthly (parameter/month) and hourly (parameter/hour) information.

Peak values will also be measured: peak month, peak and busy days and peak hour.

Finally, it is important to segregate the data according to:

- O/D or connection: arrivals and departures.
- Flight character: National/Domestic and International.
- Traffic segment: Regular, Charter, Airlift, “Seat-only” and Non-commercial.
- Airlines.

4.1.1 Methodologies for preparing forecasts.

IATA recommends three methods for calculating the traffic forecast [27]:

i. Historical traffic series: from existing airports, historical trends are extrapolated to the study horizons.
ii. Causal methods based on econometric models, regressions and weighting models: for existing or new airports, identify the socio-economic variables that influence the growth or decrease of traffic.
iii. Qualitative techniques (estimation of the potential market): for new airports, the potential passenger traffic will be estimated based on the target air market (emitter, receiver), the strategies of the airlines, development of the area of influence, competitiveness with other means of transport and nearby airports, etc.

In this project, there will be a mix between traffic forecasts based on historical series and regressions and qualitative techniques. And, airports with characteristics similar to the one proposed or airports that affect the future new airport (either by proximity or for another reason) will be taken as reference. It will be seen later.

4.2 Type of Airport

The airport to be designed will have national and international flights since its objective is to cover the center and southern part of the country and hopefully northern Serbia. Therefore, it would mainly absorb flights from the nearest airport, which is Budapest.

The idea is that the airport is low-cost tourist, that is, that the lowest-cost companies offer international flights. It will be decided whether the flights will be scheduled, charter or both, depending on the results of the study that will be carried out on the traffic demand.

The final adjustment of the type of traffic that the airport will have, as will be seen later, is made based on the analysis of air traffic in Hungary and the reference airport, Budapest-Ferenc Liszt Airport.

4.3 Influence Area of the Airport

It is crucial to study the viability of a new airport to understand the environment or area of influence around it as well as to evaluate the volume of sender, receiver and intermediate traffic that it may generate. The term area of influence refers to any area or territory that is within a temporary distance of 1-2 hours by road from the airport in question.

At this point, the area where the new airport will be located will be more or less defined, but not yet the exact location. This approach will serve to analyze the environment that will surround the airport.

To do this, as we want the Budapest airport to be close, and therefore within the area of influence of the new one, we will make a circumference with a center in Budapest and with a radius of about 145-150 km.

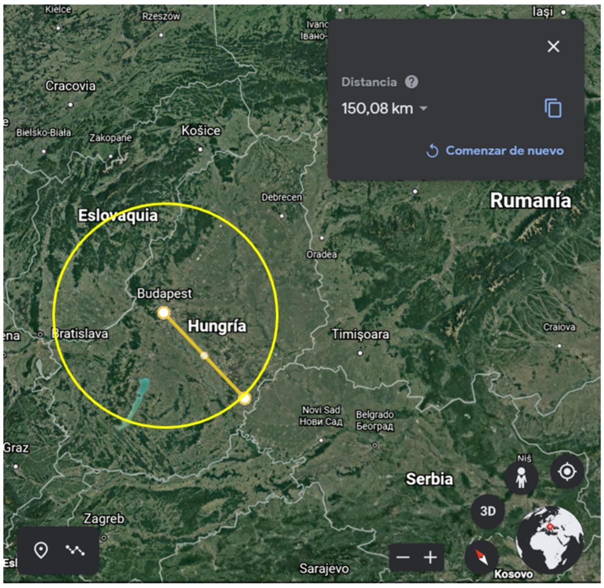


Fig. 4.1. First estimate of the area of influence. [Own elaboration (Google Earth & Word)]

As we can see in the **Figure** 4.1, the new airport should be at the very edge of the circumference but, if possible, within it. The most powerful area to locate the airport will be studied later.

4.4 Country Airports Analysis

A period of 10 years must be defined that will be used to analyze the airports. This period will be from 2010 to 2020, despite the fact that the pandemic began in 2020 and it is not convenient to analyze the data for this year because they are very altered, since air traffic has fallen a lot from that year until now.

On the other hand, for all the demand parameters to be estimated, values from a current scenario, as recent as possible, will be needed. It has been decided to use the year 2019 since it is prior to the pandemic and previous decisions have been made using data from this year. Once everything will be analyzed in 2019, a future forecast estimate will be made.

It will also be necessary to choose a reference airport within the area of influence and the Budapest airport, as already specified, is chosen.

4.4.1 General analysis of Hungarian airports.

To analyze the Hungarian airports at a general level, the values that interest us will be found from a database called *Eurostat* [28].

An airport is based on the number of passengers it carries and the number of flights it performs. Therefore, if the total number of passengers transported and the total number of aircraft are analyzed, from 2010 to 2020, the following numerical and graphical results are obtained.

But first, we will introduce the CAGR term.

The CAGR is the compound annual growth rate, that is, it is a percentage that indicates the growth of certain parameters over a period of time. It is interesting for this study because if we calculate this growth from 2010 to 2019 we can see how the air traffic in Hungary has increased, on average, year after year.

The formula for this parameter will be presented below:

$$CAGR = (\frac{V(t_n)}{V(t_0)})^{\frac{1}{t_n - t_0}} - 1 \tag{4.1}$$

Table 4.1: Total passengers on board data per years in Hungary [28].

Year	Total passengers on board
2010	8.174.510
2011	8.884.837
2012	8.429.843
2013	8.441.204
2014	9.054.848
2015	10.228.352
2016	11.694.505
2017	13.379.836
2018	15.212.355
2019	16.730.494
2020	3.965.443

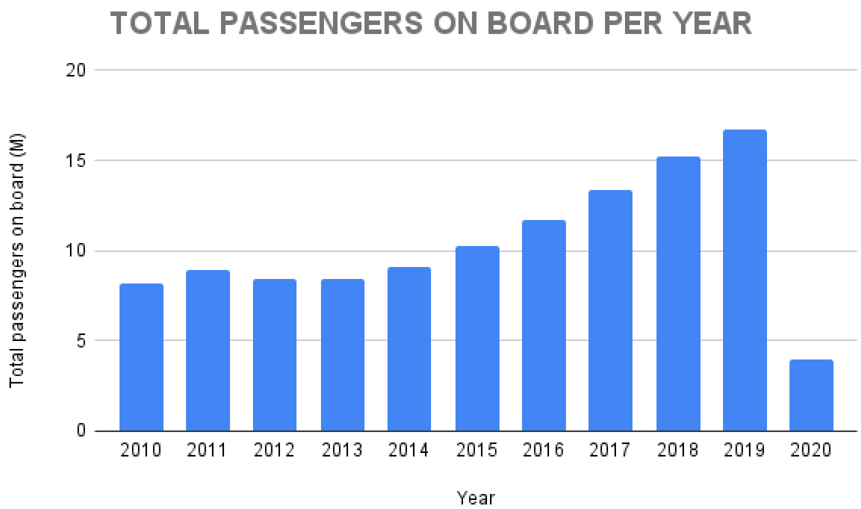


Fig. 4.2. Evolution of passengers on board in Hungary. [Own elaboration (Excel)]

Using the values from the **Table** 4.1, we obtain the CAGR for the number of passengers:

$$CAGR\ (2010 \rightarrow 2019) = ((\frac{V(2019)}{V(2010)})^{\frac{1}{2019-2010}} - 1) \cdot 100\% = 8,28\%$$

If we analyze these annual results of the number of total passengers that flew to or from Hungary, we see that the CAGR is approximately 8% from 2010 to 2019, that is, the number of air passengers in the country has increased on average by 8% year after year, with its ups and downs, reaching 16 million passengers in 2019.

Starting in 2013 or, rather, since 2014, a fairly linear growth is seen, which would be interesting to repeat from 2027 (a year that will be considered with the same traffic data as in 2019) until at least 2045. Throughout the study, it will be seen why the importance of these data.

Table 4.2: Total commercial passenger air flights data per year in Hungary [28].

Year	Total commercial passenger air flights
2010	93.752
2011	98.140
2012	75.716
2013	71.756
2014	74.832
2015	80.184
2016	86.292
2017	92.968
2018	104.884
2019	113.059
2020	36.646

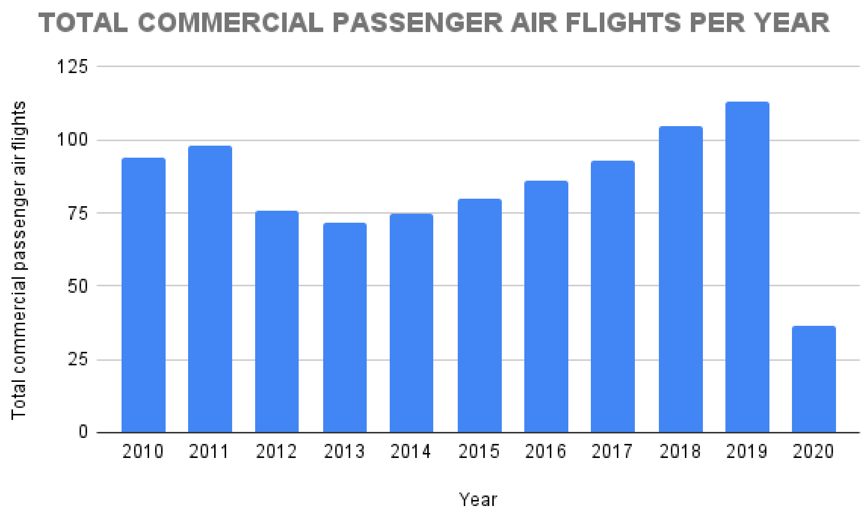


Fig. 4.3. Evolution of commercial passenger air flights (thousands) in Hungary. [Own elaboration (Excel)]

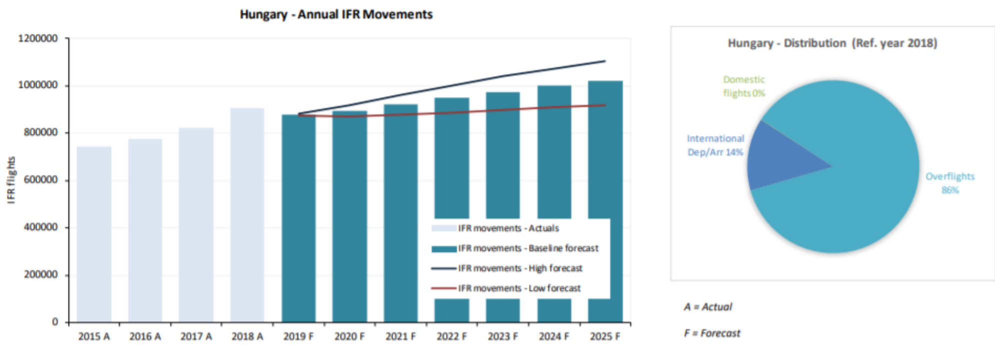
Using the values from the **Tabla** 4.2, we obtain the CAGR for the number of commercial passenger air flights:

$$CAGR\ (2010 \rightarrow 2019) = ((\frac{V(2019)}{V(2010)})^{\frac{1}{2019-2010}} - 1) \cdot 100\% = 2,10\%$$

We see that the number of operations has not varied as much as that of passengers, in addition, the growth in the number of flights began to be linear from 2013 after a fall from 2012 to 2013 in the number of air operations.

Then, in both graphs, what is most striking is the large drop in the number of passengers and flights in 2020. But, we once again emphasize that we will be based on the 2019 data as a reference because if the pandemic had not occurred, in principle, the parameters would continue to increase as seen from 2013 to 2019.

For example, in the year 2018-2019 EUROCONTROL drew up the document "Lssip 2019 - Hungary - local single sky implementation" [29] where an estimate of the evolution of air traffic in Hungary was made.



EUROCONTROL Seven-Year Forecast (Autumn 2019)											
IFR flights yearly growth		2016 A	2017 A	2018 A	2019 F	2020 F	2021 F	2022 F	2023 F	2024 F	2025 F
Hungary	H				-2.3%	3.8%	4.8%	4.2%	3.8%	3.2%	2.7%
	B	4.3%	5.9%	10.0%	-2.7%	1.8%	2.8%	3.1%	2.6%	2.7%	2.1%
	L				-3.2%	-0.4%	0.6%	1.3%	1.3%	1.3%	0.6%
ECAC	B	2.8%	4.0%	3.8%	1.1%	2.3%	1.9%	2.2%	1.8%	1.9%	1.4%

Fig. 4.4. Evolution of traffic in Hungary. Source: [29]

The graph shows that the organization estimated that in 2020 the country's air traffic would continue to increase and thus until 2025 they found an estimate of more than 1 million IFR flights in 2025, taking into account domestic and international flights and overflights. That is, more than 860.000 overflights and 140.000 international flights were estimated for 2025. This gives us to understand that in 2018-2019 Hungary's air traffic was valued very positively, the idea was that air movements were constantly growing.

4.4.2 Reference airport analysis.

To continue with the analysis, a reference airport must be chosen that is within the area of influence of the new one.

Although the exact location of the new airport is not yet known, we know that the one in the capital, Budapest, will be within the area of influence since the main function of the new airport will be to absorb and remove the flow of passengers from the airport in the capital of Hungary.

To analyze the reference airport, the values from the *Eurostat* database [28] have been used again, but this time searching for the reference airport: **Budapest-Ferenc Liszt airport (Budapest, Hungary)**.

First, all data on the number of flights and passengers from 2015 to 2020 are presented. These results are classified by regular and non-scheduled flights and within, by national and international flights. The evaluation will be carried out from 2015 to 2020 since we are interested in seeing the traffic of the last years.

Table 4.3: Air passenger transport by main airport reporting Budapest airport.

PERIOD	Number of commercial passenger flights		Number of passengers	
	International	National	International	National
SCHEDULED SERVICES				
2015	77.390	0	9.859.974	0
2016	81.935	0	11.101.716	0
2017	88.270	0	12.701.562	0
2018	98.776	0	14.329.026	0
2019	105.962	0	15.689.791	0
2020	34.998	0	3.790.854	0
NON-SCHEDULED SERVICES				
2015	2.793	1	368.378	0
2016	1.987	1	273.553	141
2017	2.187	0	330.125	0
2018	3.120	1	471.426	66
2019	2.774	0	409.728	0
2020	455	3	48.537	554

If we analyze these data to find what types of flights abound at the Hungarian capital airport, we will obtain a series of conclusions.

Table 4.4: Results of Budapest airport considering the sum of scheduled and non-scheduled services.

PERIOD	Number of commercial passenger flights		Number of passengers	
	International	National	International	National
SCHEDULED + NON-SCHEDULED SERVICES				
2015	80.183	1	10.228.352	0
2016	83.922	1	11.375.269	141
2017	90.457	0	13.031.687	0
2018	101.896	1	14.800.452	66
2019	108.736	0	16.099.519	0
2020	35.453	3	3.839.391	554

If the sum of scheduled and unscheduled flights is considered, it is clear that very few domestic flights are carried out at the reference airport. Not to say that the highest national activity was obtained in 2020, a year of pandemic in which it was not possible to fly to other countries. It can be concluded that the activity of the Budapest airport at the national level is almost non-existent.

The results are presented below, separating scheduled flights and unscheduled flights, but considering the sum of national and international flights.

Table 4.5: Results of Budapest airport considering the sum of national and international services.

PERIOD	Number of commercial passenger flights	Number of passengers
SCHEDULED SERVICES		
	International + National	International + National
2015	77.390	9.859.974
2016	81.935	11.101.716
2017	88.270	12.701.562
2018	98.776	14.329.026
2019	105.962	15.689.791
2020	34.998	3.790.854
NON-SCHEDULED SERVICES		
	International + National	International + National
2015	2.794	368.378
2016	1.988	273.694
2017	2.187	330.125
2018	3.121	471.492
2019	2.774	409.728
2020	458	49.091

If the sum of national and international flights is considered, but separating the results by scheduled and unscheduled flights, we can find what percentage of the total flights at the reference airport are scheduled and unscheduled flights.

Only the analysis for the year 2019 will be presented, as it is the reference taken throughout the project.

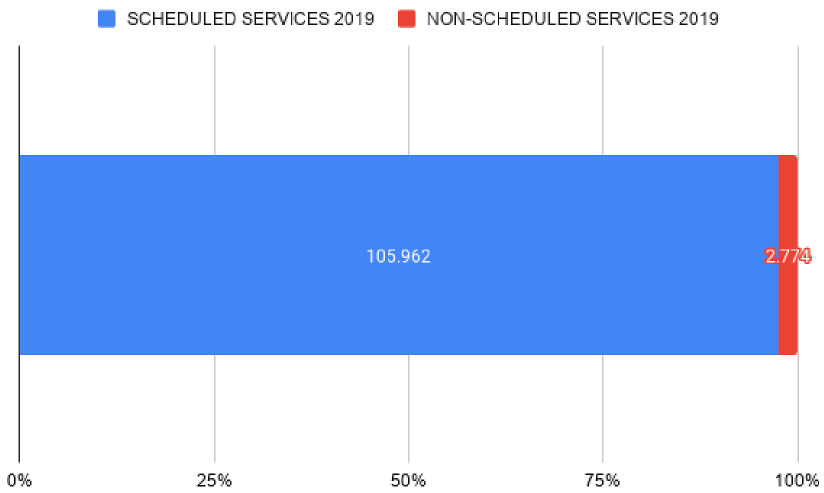


Fig. 4.5. Proportion of commercial passenger flights in scheduled and non-scheduled flights in 2019 over the total (100%). [Own elaboration (Excel)]

We see that there is a big difference: scheduled flights correspond to 97,4% of the total and unscheduled flights to 2,6%. Obviously, the same occurs with the number of passengers transported, where there is 97,5% for scheduled and 2,5% for non-scheduled.

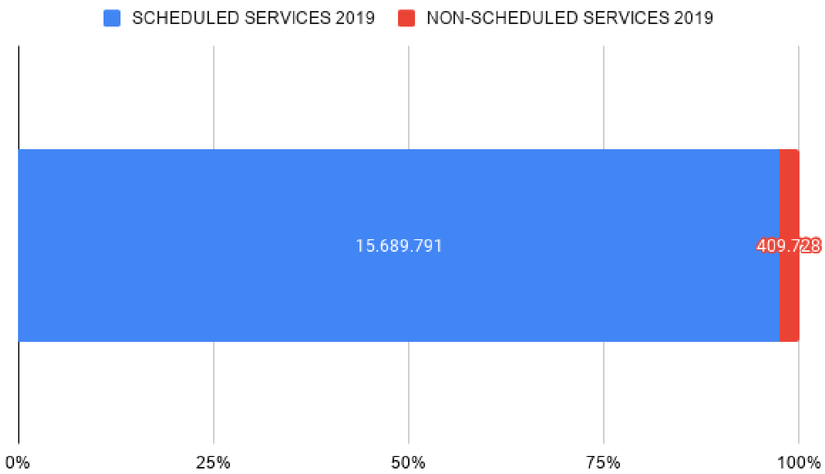


Fig. 4.6. Proportion of number of passengers in scheduled and unscheduled flights in 2019 over the total (100%). [Own elaboration (Excel)]

In conclusion, at the Budapest airport in 2019 there was activity, mainly, of international scheduled flights. Therefore, we will consider that, currently and in the coming years as well.

Finally, adding for each year all operations and all passengers transported on scheduled, unscheduled, national and international flights, the total results for Budapest will be presented in a table, in **Appendix E**. And, at the same time, the percentage of the total of Hungary.

If we look at the results for 2019, the year taken as a reference, we see that the percentage of activity at the Budapest airport is, approximately, a 96% of the 100% in Hungary. In other words, practically all flights arriving and departing from Hungary do so at the Budapest-Ferenc Liszt airport. For this reason, the idea of absorbing flights from the reference airport, that of the Hungarian capital, is a good idea since air traffic is very high and would require additional support, which will be the new airport to be designed.

4.5 Potential Generation of the Air Traffic

Air traffic is generated thanks to different variables that influence the generation of demand at an airport.

Some interesting variables to analyze would be the following:

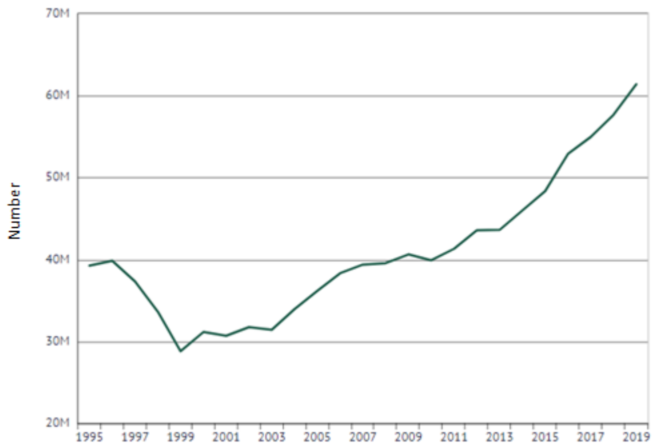
- Tourist attraction in the area of influence.
- Number of inhabitants in the area, their age and their economic level.
- Business activity.
- Transport networks.
- Tourism development.
- Offer of accommodation places.
- Macroeconomic variables.

We will only focus on two of them: tourism and transport.

4.5.1 Arrivals and departures by air on total inbound and outbound tourism in Hungary.

To study the number of possible passengers at the new airport, it is interesting to analyze the number of people who arrived by air in Hungary compared to the number of total tourist arrivals to the country.

In Hungary, in recent years, the number of arrivals of non-residents in the country has grown considerably.



YEAR	VALUE	%
2019	61.397.000	6,47
2018	57.667.000	4,92
2017	54.962.000	3,92
2016	52.890.000	9,40
2015	48.345.000	5,13

Fig. 4.7. Arrivals of non-resident tourists to Hungary's national borders. Source: [30]

This is a good sign to create this new airport since if the number of arrivals increases, the air traffic will also increase. If we see the following table, the results of three reference years (2017, 2018 and 2019) of the total arrivals by air are shown, the three reasons for the highest generation of this air traffic and the same but on the ground in order to present the percentage of arrivals by air over total arrivals.

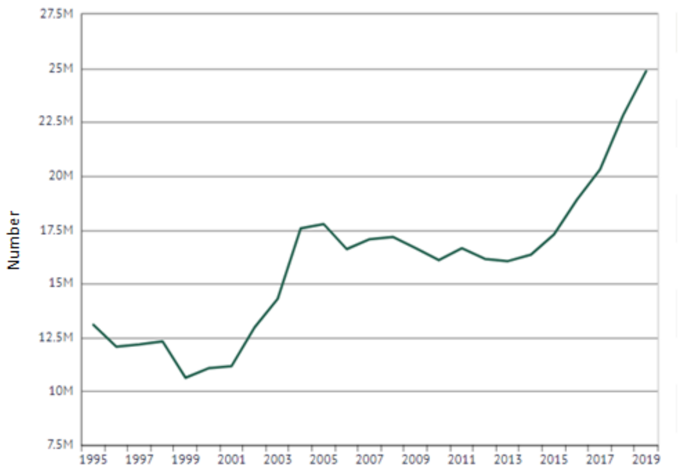
Table 4.6: Inbound trips to Hungary by mode of transport [31]

Year	Total arrivals	Arrivals by type of transport			% over the total arrivals
		Type of arrival	Three major purposes of travel	Total inbound trips	
2017	54.962.000	Visitors arrived by air	Holiday, leisure and recreation	5.441.000	9,899566974
			Business tourism, conference, congress, cross border trading		
			Visiting friends and relatives		
		Visitors arrived by road	Transit	49.521.000	90,10043303
			Holiday, leisure and recreation		
			Shopping		
2018	57.667.000	Visitors arrived by air	Holiday, leisure and recreation	6.113.000	10,60051676
			Business tourism, conference, congress, cross border trading		
			Visiting friends and relatives		
		Visitors arrived by road	Transit	51.554.000	89,39948324
			Holiday, leisure and recreation		
			Shopping		
2019	61.397.000	Visitors arrived by air	Holiday, leisure and recreation	7.029.000	11,44844211
			Visiting friends and relatives		
			Business tourism, conference, congress, cross border trading		
		Visitors arrived by road	Transit	54.368.000	88,55155789
			Shopping		
			Holiday, leisure and recreation		

It can be seen that air traffic has increased over the years since the number of arrivals to the country is increasing and, in addition, the number of arrivals by air has been increasing since it can be seen that the percentage of total arrivals by Air has been increasing and, on the contrary, the number of arrivals by land has decreased.

To continue, it is also equally interesting to see how many Hungarians, mostly, left the country by air with respect to the outbound tourism that was generated in total.

If we look at the following data, in approximately 2013, Hungarian residents traveled more outside the country. This aspect also leads to generating more air traffic as there would be more departures.



YEAR	VALUE	%
2019	24.860.000	9,01
2018	22.805.000	12,36
2017	20.297.000	7,42
2016	18.895.000	9,37
2015	17.276.000	5,73

Fig. 4.8. Trips abroad by resident Hungarian tourists. Source: [32]

Anyway, it can be seen with the result of the graphs of **Figures** 4.7 and 4.8 that there are many more arrivals by foreign tourists than non-departures by residents of the country.

At the same time, looking at the number of round trips from Hungary, by mode of transport, it is concluded that the number of annual trips abroad lasting one night or more by tourists from Hungary by air does not differ exaggeratedly from trips by land . On the other hand, the number of overnight trips from Hungary to another country may differ more and the number of land traffic more than air.

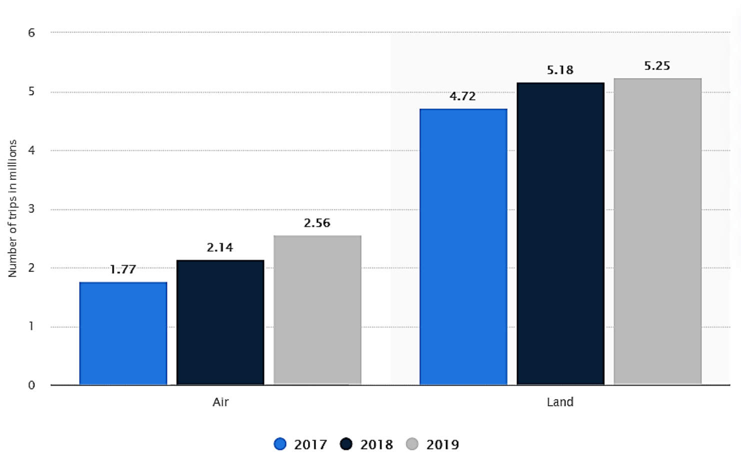


Fig. 4.9. Number of outbound trips from Hungary 2017-2019, by mode of transport. Source: [33]

4.5.2 Analysis of the situation at Budapest airport.

As already analyzed at the country level in the previous **Point** 4.5.1, it has been seen that Hungary's tourism was in full growth, an aspect that leads to an increase in the number of arrivals and departures by air. Similarly, tourism in the Hungarian capital would also grow as Budapest is the most important city in the country and this is confirmed by the data collected in the **Point** 4.4.2 since it is observed that almost 100 % of the air movements in Hungary occur at the reference airport.

The fact that Budapest hosts the majority of Hungary's air transport can cause an overload at the airport as all arriving tourists or residents who want to leave the country for another generate air traffic at this capital's airport.

On the other hand, if we analyze the current situation at Budapest airport, leaving aside the effects caused by the pandemic, in a recent news item (05/05/2021) from *euronews*, whose headline reads as follows: " A new Air Silk Road between China and Hungary will increase freight traffic to Europe" [34], it is said that it will increase freight traffic at Budapest airport. If there was already a high flow of passengers and commercial flights in 2019 and, now, cargo traffic will increase, it could lead to a large saturation at the airport when the situation returns to normal. Therefore, it is important to reduce the passenger traffic of the reference airport so that it can be more efficient and not over-saturated.

4.6 Estimation of Air Mode Recruitment

In the previous point, we will find much of the information that will be needed in this section, the objective of which is to find the routes that the new airport could absorb or complement and thus estimate the number of operations and passengers at the new airport.

4.6.1 Analysis of air operators and air link network in Budapest.

A very interesting point about the analysis of the reference airport is to analyze the routes that operate in it and that may be interesting for the new one.

First, all the data of the different airlines that operate in the reference airport and their destinations (country and city) will be collected. Then, by carrying out a series of searches and estimates, the number of operations and passengers corresponding to each destination-airline group has been calculated. This will look better later.

These results presented in **Appendix F** have been determined according to the following aspects:

- The data on the destinations that have a connection with the Budapest airport have been found from the Excel (BUD City Traffic Report 2019 _2020.xlsx) taken from the Budapest airport website [35]. And the airlines that fly to each of them, mainly, from a flight search engine [36] and also from some captures (**Appendix G**) made during current days of departures and arrivals at the reference airport.
- To give a percentage, of the total data collected in the spreadsheet, four cases have been distinguished for each airline-destination group:

  i. For a destination, if with all the data collected with the captures and with the flight search engine there were only results from one airline, 100% of the data was assigned to it.

ii. If of all the possible airlines for a destination they appeared in the departures or arrivals at the airport (captures), the total flights (arrivals and departures) of each were counted and the portion of the total (sum of all arrivals and departures to that specific destination) that corresponded to him, based on current activity, was found.

iii. If with the search engine more than one airline appeared for a flight and only one airline appeared in the captures, those with no current activity were assigned 20% of the total data to each one and the rest (as long as it was greater than 20%) was applied to the airline with current operations.

iv. If for some destinations there was no current data, only those found by the search engine were considered and the data was distributed equally.

- For some destinations, no data was found and, therefore, no results were obtained. The vast majority of them, if not all of them, had data assigned by the Budapest airport but, according to what was found, there are no direct flights to or from them, from Budapest, so no airline could be assigned to them.

In addition, if we look the following table (**Table** 4.7), we see that the destinations with the highest number of annual passengers from the airport of the Hungarian capital are in Europe (United Kingdom, Germany, Italy, Spain, France and Netherlands) and in Asia.

We are more interested in the named countries because if there is more air traffic it is more interesting to absorb flights to these destinations to support the main airport, Budapest.

Table 4.7: Commercial passenger traffic at Budapest-Ferenc Liszt International Airport by continents and European countries [37].

Continent - Country	**Number of passengers**					
	2015	2016	2017	2018	2019	2020
Commercial flights total	**10.228.352**	**11.409.543**	**13.061.494**	**14.829.726**	**16.129.263**	**3.843.255**
Of which:						
Europe	9.530.152	10.585.547	12.010.283	13.407.799	14.484.763	3.515.086
of which:						
United Kingdom	1.634.709	1.901.390	2.017.821	2.109.792	2.404.498	661.731
Germany	1.498.922	1.663.677	1.957.890	2.144.710	2.212.990	510.723
Italy	924.191	1.008.856	1.153.103	1.251.888	1.424.285	311.745
Netherlands	596.068	747.517	779.464	760.937	750.376	234.687
Spain	503.930	653.486	740.227	928.773	1.005.830	224.587
France	546.995	611.626	693.456	694.628	760.888	196.711
Switzerland	375.563	388.607	434.888	527.233	597.068	150.487
Greece	254.962	279.551	298.98	369.241	431.067	132.474
Belgium	491.794	496.527	553.788	566.747	541.604	117
Russia	273.171	267.712	318.751	464.047	509.555	100.913
Poland	197.233	212.719	239.109	284.026	346.726	86.633
Turkey	481.183	374.910	385.807	475.322	507.545	86.351
Other European countries	1.751.431	1.978.969	2.436.999	2.830.455	2.992.331	701.044
Asia	602.046	731.75	878.338	1.008.014	1.230.008	302.475
America	13.844	41.091	53.226	203.650	215.660	5.940
Africa	82.297	51.155	119.647	210.263	198.832	19.754
Non-commercial flights	**70.611**	**32.456**	**35.729**	**37.765**	**44.226**	**16.124**
Altogether	**10.298.963**	**11.441.999**	**13.097.223**	**14.867.491**	**16.173.489**	**3.859.379**

It is true that these commented destinations would be of interest to the new airport but at the same time, it must be valued that an airline would move completely, therefore, not all operations to or from these destinations could be absorbed since airlines such as Wizz Air or Ryanair have many flights at the reference airport.

To make a first airlines estimate, it will be interesting to choose airlines with a series of characteristics:

- Low-cost airlines as it is easier for them to move and be successful in a new airport close to the main one.
- Airlines that cover the main destinations with the most activity to reduce the flow of passengers and flights to Budapest airport.
- The destinations to be searched are international because, as has already been seen during the analysis of the previous points, the new airport is not interested in adopting domestic flights since there are not many at Budapest airport and it is already close to both Szeged airport which is exclusively domestic.

In this way, once the number of annual passengers and operations has been calculated for each airline-destination group, only low-cost airlines results will be selected. These are presented in **Appendix H**.

We see that the European countries with the most air traffic with connection to Budapest airport (**Table** 4.7) with low-cost airlines are covered almost 100% of these. Aspect that can be of great support to reduce air flow at the capital's airport.

4.6.2 Calculation of passenger absorption in three scenarios.

Once the first selection has been made, gathering the data that interests us now, we see the airlines with which three possible scenarios that the new airport could host will be built.

Visualizing the results of the previous analysis, at first glance it can be seen that the airlines Wizz Air and Ryanair are the ones that make the most flights. Therefore, these two airlines will be combined with each other or with the other low-cost to form the scenarios discussed below.

Table 4.8: Total results per low-cost airline in Budapest airport in 2019.

Airlines	Commercial passenger flights	Passengers
Ryanair	27.686	4.482.089
Wizz Air	25.189	4.135.677
easyJet	4.623	735.157
Eurowings	4.261	495.412
Norwegian Air Shuttle	3040	487488,3
Jet2.com	1.012	168.856
TOTAL LOW-COST	**65.811**	**10.504.679**

Then, analyzing the data in the **Table** 4.8 and the countries where there are more flights from Budapest, we found three possible combinations of airlines for three different scenarios: pessimistic, realistic and optimistic. In each of them, the percentage of absorption of passengers from the airport of the capital will be calculated.

Table 4.9: Pessimistic scenario - Airlines and destinations.

Airlines	Country	City	2019 values	
			ATM	PAX
easyJet	France	Lyon	286	42.582
		Paris	188	29.479
	Netherland	Amsterdam	877	136.254
	Switzerland	Basel	1.253	200.435
		Geneva	686	110.673
	United Kingdom	London	1.107	175.850
		Manchester	226	39.884
Eurowings	Germany	Cologne	609	76.598
		Dusseldorf	1.332	152.439
		Hamburg	686	84.094
		Stuttgart	1.634	182.281
Norwegian Air Shuttle	Denmark	Copenhagen	703	115.736
	Finland	Helsinki	319	45.827
	Norway	Oslo	653	105.717
	Sweden	Stockholm	259	44.359
	United Kingdom	London	1.107	175.850
Jet2.com	United Kingdom	Birmingham	155	25.623
		Nottingham	233	37.700
		Glasgow	210	36.485
		Leeds	188	29.165
		Manchester	226	39.884
TOTAL			**12.937**	**1.886.915**

Table 4.10: Realistic scenario - Airlines and destinations.

Airlines	Country	City	2019 values ATM	2019 values PAX
Wizz Air	Albania	Tirana	316	52.871
	Azerbaijan	Baku	183	30.341
	Belgium	Brussels	741	108.321
	Bosnia-Hercegovina	Sarajevo	206	30.203
	Bulgaria	Bourgas	89	14.310
		Sofia	93	15.016
	Canary Islands - Spain	Fuerteventura	24	3.689
		Tenerife	210	35.081
	Cyprus	Larnaca	362	60.992
	France	Nice	218	37.203
		Paris	188	29.479
	Georgia	Kutaisi	256	40.026
	Germany	Berlin	504	82.725
		Dortmund	485	80.629
		Frankfurt	300	43.542
		Hanover	330	54.263
	Greece	Athens	441	72.985
		Corfu	117	19.807
		Heraklion	215	34.425
		Rhodes	94	15.217
		Thessaloniki	181	29.057
		Zakynthos	75	12.672
		Chania	34	5.830
	Iceland	Reykjavik	286	56.270
	Israel	Tel Aviv	861	152.811
	Italy	Alghero	54	8.923
		Bari	312	59.477
		Bologna	106	21.261
		Catania	170	33.531
		Milan	493	88.862
		Naples	317	54.673
		Rome	525	90.184
	Kazakhstan	Astana	172	25.208
	Kosovo	Pristina	207	29.819
	Macedonia	Skopje	218	33.616
	Malta	Malta	220	37.431
	Montenegro	Podgorica	240	37.681
	Netherland	Eindhoven	1.410	295.990
	Norway	Bergen	21	3.025
		Oslo	653	105.717
	Poland	Warsaw	843	62.728
	Portugal	Faro	54	9.220
		Lisbon	427	64.543
		Porto	125	20.947
	Romania	Bucharest	430	34.014
		Tirgu Mures	301	48.125

Wizz Air	Russia	Kazan	36	5.712
		Moscow	684	84.228
		St.Petersburg	455	82.381
	Spain	Alicante	186	37.527
		Barcelona	400	76.066
		Ibiza	30	5.943
		Madrid	503	89.762
		Malaga	195	33.917
		Palma De Mallorca	77	13.038
		Castellon	54	8.819
	Sweden	Gothenburg	195	35.693
		Malmo	393	74.869
		Stockholm	777	133.076
	Switzerland	Basel	313	50.109
	Ukraine	Kiev	1.184	178.972
		Odessa	37	6.096
	United Arab Emirates	Dubai	413	107.297
	United Kingdom	Birmingham	155	25.623
		Edinburgh	288	51.061
		Liverpool	284	49.353
		London	4.428	703.399
	France	Lyon	286	42.582
		Paris	188	29.479
	Netherland	Amsterdam	877	136.254
	Switzerland	Basel	1.253	200.435
		Geneva	686	110.673
	United Kingdom	London	1.107	175.850
		Manchester	226	39.884
	Germany	Cologne	609	76.598
		Dusseldorf	1.332	152.439
		Hamburg	686	84.094
		Stuttgart	1.634	182.281
	Denmark	Copenhagen	703	115.736
	Finland	Helsinki	319	45.827
	Norway	Oslo	653	105.717
	Sweden	Stockholm	259	44.359
	United Kingdom	London	1.107	175.850
	United Kingdom	Birmingham	155	25.623
		Nottingham	233	37.700
		Glasgow	210	36.485
		Leeds	188	29.165
		Manchester	226	39.884

easyJet	France	Lyon	286	42.582
		Paris	188	29.479
	Netherland	Amsterdam	877	136.254
	Switzerland	Basel	1.253	200.435
		Geneva	686	110.673
	United Kingdom	London	1.107	175.850
		Manchester	226	39.884
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		Dusseldorf	1.332	152.439
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	Sweden	Stockholm	259	44.359
	United Kingdom	London	1.107	175.850
Jet2.com	United Kingdom	Birmingham	155	25.623
		Nottingham	233	37.700
		Glasgow	210	36.485
		Leeds	188	29.165
		Manchester	226	39.884
TOTAL			**38.131**	**6.022.596**

It has been decided to set up this realistic scenario using the airline Wizz Air, combined with those of the pessimistic scenario, and discarding Ryanair because it is more likely that Wizz Air, being Hungarian, will trust the new projects in the country, it also flies to all destinations with greater traffic in Budapest, and in some destinations it shares traffic with one of the other airlines.

Table 4.11: Optimistic scenario - Airlines and destinations.

Airlines	Country	City	2019 values ATM	2019 values PAX
Wizz Air	Albania	Tirana	316	52.871
	Azerbaijan	Baku	183	30.341
	Belgium	Brussels	741	108.321
	Bosnia-Hercegovina	Sarajevo	206	30.203
	Bulgaria	Bourgas	89	14.310
		Sofia	93	15.016
	Canary Islands - Spain	Fuerteventura	24	3.689
		Tenerife	210	35.081
	Cyprus	Larnaca	362	60.992
	France	Nice	218	37.203
		Paris	188	29.479
	Georgia	Kutaisi	256	40.026
	Germany	Berlin	504	82.725
		Dortmund	485	80.629
		Frankfurt	300	43.542
		Hanover	330	54.263
	Greece	Athens	441	72.985
		Corfu	117	19.807
		Heraklion	215	34.425
		Rhodes	94	15.217
		Thessaloniki	181	29.057
		Zakynthos	75	12.672
		Chania	34	5.830
	Iceland	Reykjavik	286	56.270
	Israel	Tel Aviv	861	152.811
	Italy	Alghero	54	8.923
		Bari	312	59.477
		Bologna	106	21.261
		Catania	170	33.531
		Milan	493	88.862
		Naples	317	54.673
		Rome	525	90.184
	Kazakhstan	Astana	172	25.208
	Kosovo	Pristina	207	29.819
	Macedonia	Skopje	218	33.616
	Malta	Malta	220	37.431
	Montenegro	Podgorica	240	37.681
	Netherland	Eindhoven	1.410	295.990
	Norway	Bergen	21	3.025
		Oslo	653	105.717
	Poland	Warsaw	843	62.728
	Portugal	Faro	54	9.220
		Lisbon	427	64.543
		Porto	125	20.947
	Romania	Bucharest	430	34.014
		Tirgu Mures	301	48.125

Airlines	Country	City	2019 values	
			ATM	PAX
Wizz Air	Russia	Kazan	36	5.712
		Moscow	684	84.228
		St.Petersburg	455	82.381
	Spain	Alicante	186	37.527
		Barcelona	400	76.066
		Ibiza	30	5.943
		Madrid	503	89.762
		Malaga	195	33.917
		Palma De Mallorca	77	13.038
		Castellon	54	8.819
	Sweden	Gothenburg	195	35.693
		Malmo	393	74.869
		Stockholm	777	133.076
	Switzerland	Basel	313	50.109
	Ukraine	Kiev	1.184	178.972
		Odessa	37	6.096
	United Arab Emirates	Dubai	413	107.297
	United Kingdom	Birmingham	155	25.623
		Edinburgh	288	51.061
		Liverpool	284	49.353
		London	4.428	703.399
	France	Lyon	286	42.582
		Paris	188	29.479
	Netherland	Amsterdam	877	136.254
	Switzerland	Basel	1.253	200.435
		Geneva	686	110.673
	United Kingdom	London	1.107	175.850
		Manchester	226	39.884
	Germany	Cologne	609	76.598
		Dusseldorf	1.332	152.439
		Hamburg	686	84.094
		Stuttgart	1.634	182.281
	Denmark	Copenhagen	703	115.736
	Finland	Helsinki	319	45.827
	Norway	Oslo	653	105.717
	Sweden	Stockholm	259	44.359
	United Kingdom	London	1.107	175.850
	United Kingdom	Birmingham	155	25.623
		Nottingham	233	37.700
		Glasgow	210	36.485
		Leeds	188	29.165
		Manchester	226	39.884
Ryanair	Belgium	Brussels	2.223	324.962
	Bulgaria	Bourgas	89	14.310
		Sofia	93	15.016
	Canary Islands - Spain	Las Palmas	109	19.706
	Cyprus	Paphos	270	46.971
	Czech Republic	Prague	2.642	233.067
	Denmark	Billund	314	54.638
		Copenhagen	703	115.736

Ryanair	Finland	Tampere	170	29.290
		Lappeenranta	38	6.413
	France	Bordeaux	210	32.519
		Marseille	198	34.013
		Paris	376	58.957
	Germany	Berlin	2.017	330.901
		Nuernberg	620	105.048
	Greece	Argostólion	32	5.317
		Athens	441	72.985
		Corfu	117	19.807
		Rhodes	94	15.217
		Thessaloniki	181	29.057
		Zakynthos	75	12.672
		Chania	34	5.830
		Preveza	28	4.674
	Ireland	Cork	156	28.011
		Dublin	1.198	206.040
	Israel	Tel Aviv	1.723	305.623
		Eilat	106	16.055
	Italy	Bari	312	59.477
		Bologna	106	21.261
		Cagliari	142	24.581
		Catania	170	33.531
		Milan	1.973	355.449
		Naples	317	54.673
		Palermo	222	38.194
		Pisa	276	48.177
		Rimini	102	17.662
		Rome	1.574	270.551
		Treviso	312	53.344
	Jordan	Amman	189	31.808
	Luxembourg	Luxembourg	29	4.509
	Malta	Malta	220	37.431
	Poland	Poznan	39	5.991
	Portugal	Lisbon	427	64.543
		Porto	125	20.947
	Spain	Barcelona	1.598	304.265
		Madrid	587	104.723
		Malaga	292	50.876
		Palma De Mallorca	77	13.038
		Santander	208	36.411
		Sevilla	141	25.194
		Valencia	220	38.715
	Sweden	Gothenburg	195	35.693
	Ukraine	Odessa	37	6.096
	United Kingdom	Bristol	338	60.942
		Nottingham	233	37.700
		Edinburgh	288	51.061
		London	2.214	351.700
		Manchester	226	39.884
		Doncaster/Sheffield	246	40.833
TOTAL			**52.886**	**8.617.776**

Once these first combinations of airlines and destinations have been collected, the absorption percentage of the three scenarios will be calculated.

These results will be obtained using the total number of passengers for each scenario and finding the proportion of Budapest's total annual passengers in 2019 (16.129.263) and the total number of commercial passenger flights in the same year (108.734). The total data of the Budapest airport has been obtained from its website [35].

$$\%\ takeover = \frac{Scenario\ total\ results}{Total\ data\ Budapest\ airport} \tag{4.2}$$

Table 4.12: Percentage of air traffic absorption - Number of commercial passenger flights.

Scenario	Total number of operations	Absorption percentage
Pessimistic	12.936	11,90 %
Realistic	38.125	35,06 %
Optimistic	52.875	48,63 %

Table 4.13: Percentage of air traffic absorption - Number of passengers.

Scenario	Total number of passengers	Absorption percentage
Pessimistic	1.886.913	11,70 %
Realistic	6.022.590	37,34 %
Optimistic	8.617.766	53,43 %

4.6.3 Results extrapolated to the start year of the new airport.

Finally, the air traffic of the new airport will be estimated in which it will be its estimated start-up year (2027).

4.6.3.1 Recovery year and base year of the new airport.

The CEO of EUROCONTROL, Eamonn Brennan, said on May 21:"By the end of next year, traffic will only have recovered to 72% of 2019 levels, and will only get back to close to where we were pre-pandemic by 2025" [38].

In the image below you can see the development of air traffic. As the organization says, the first scenario that considers that 100% of 2019 traffic will recover in 2024 is optimistic. Then, the second and the one that according to EUROCONTROL "remains most likely" [38] estimates that 95% of the 2019 results will recover in 2024 and, finally, the most pessimistic scenario considers that it recovers 74% in 2024 and that until 2029 air activity does not return to normal.

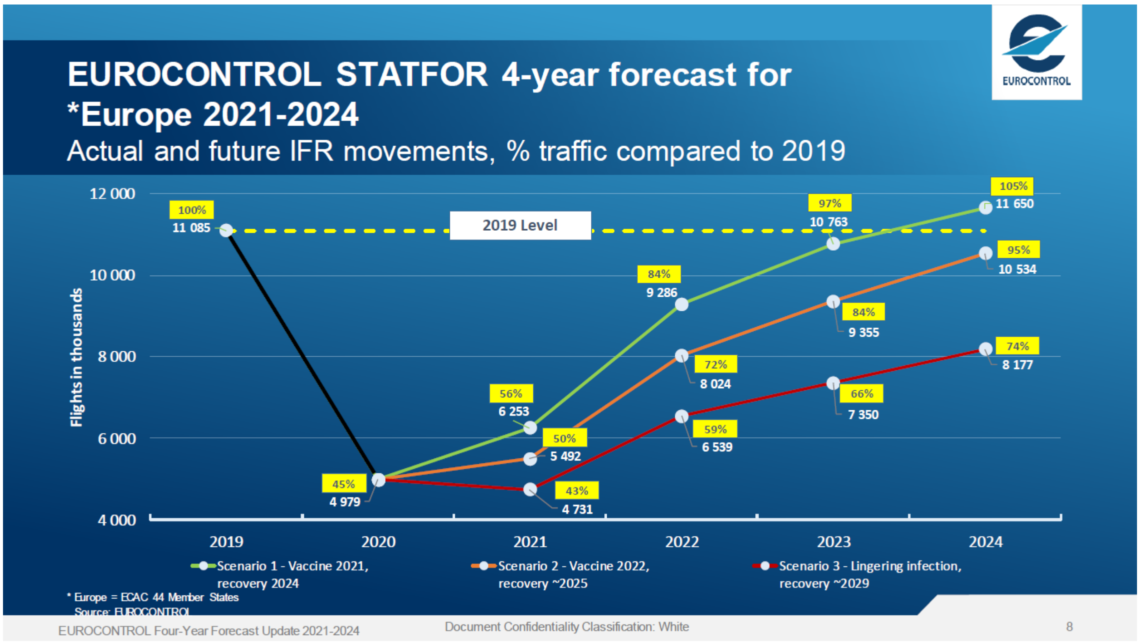

Fig. 4.10. European Flight Movements and Service Units - Three scenarios for recovery from COVID-19. Source: [38]

In this study, it will be considered that in 2025 100% of 2019 traffic will be recovered, as it is the most reasonable decision. We would choose the most likely scenario according to the organization, in 2024 it would recover 95% of 2019 and in 2025 100%, according to the comments of the director of EUROCONTROL, Mr. Brennan.

Therefore, it will be considered that in 2027 the new airport would be put into operation.

4.6.3.2 Percentage increase in annual traffic since the year of recovery.

By not having scope to the results of the estimation of traffic growth from 2025, to be able to extrapolate the traffic results for the new airport found according to data from the Budapest airport in 2019, the CAGR calculated according to the annual data for Hungary form 2017 to 2019 will be used. That is, this annual growth rate will be applied to the results of the three estimated scenarios.

It should be noted that from 2025 to 2027 there are the same number of years as from 2017 to 2019, the CAGR of these two years will be considered as traffic will be in full growth. The growth after the pandemic is considered higher compared to that which will later apply from a few years after the start-up of the new airport in 2027.

Annual percentage increase of the number of commercial international passenger flights:

$$\boxed{CAGR_{flights} = 10,28\%}$$

Annual percentage increase of the number of international passengers:

$$\boxed{CAGR_{pax} = 11,82\%}$$

4.6.3.3 Estimated traffic of the new airport in its inception year in three scenarios.

Below, as a summary of what will be considered to present the results, the following clarifications are presented:

- It will be considered as explained, that in 2025 world air traffic will equal the traffic results of 2019, the year with which the previous analysis of absorption has been based. Therefore, the data that will be used as starting data are those of **Tables** 4.12 and 4.13.
- The percentages of increase in traffic considered of 11,82% for the number of passengers and 10,28% for the number of flights for each year that passes since 2025 will apply the same for both scheduled and unscheduled flights.
- 2027 will be estimated as the starting year of the new airport because traffic in Hungary and in the world will have already been established and it will be estimated that it will increase as it has done before the pandemic. Therefore, the CAGR will be applied twice to extrapolate the results in 2025 to 2027.

Now, the final results of the estimated traffic in both airports, the reference airport and the new airport, for the year 2027 will be presented. Point out that, as already mentioned in previous points, the new airport is intended to absorb scheduled and unscheduled international flights, so are presented the results of the total international flights.

Table 4.14: Estimated air traffic in 2027.

Scenario	Commercial passenger flights	Number of passengers
NEW AIRPORT 2027		
Pessimistic	15.732	2.359.342
Realistic	46.366	7.530.473
Optimistic	64.305	10.775.407
BUDAPEST 2027		
Pessimistic	116.509	17.771.034
Realistic	85.875	12.599.902
Optimistic	67.936	9.354.969

4.6.4 Considered traffic results and link network of the new airport in 2027 (basis year).

Finally, the **realistic scenario** will be taken to carry out the final traffic forecast. This scenario is the most standard and, therefore, the most likely. This is clearly seen in the results of the **Table** 4.14: in the pessimistic scenario, very little traffic is absorbed and the air flow from Budapest airport is hardly reduced; in the optimistic scenario, there would be more traffic at the new airport than in the Hungarian capital and, in the realistic scenario, the new airport continues to have fewer operations and passengers, but it already has considerable traffic that helps the reference airport.

Therefore, the final results that are estimated for the new airport in its starting year, 2027, are as follows:

Table 4.15: Air traffic results of the new airport in 2027.

2027	
Commercial passenger flights	**Number of passengers**
46.366	7.530.473

Once the traffic of the new airport has been estimated in its beginning, the airlines which will offer their services to the new airport and to which destinations they will fly are the ones in **Table** 4.10).

4.7 Traffic Forecast

It is clear that the traffic forecast for the new airport will not be as realistic as it would be for an existing and operating airport. Even so, different parameters of interest will be estimated to study the traffic of the new airport in the year of its start, 2027. In the end, this is a long-term traffic forecast since data for 2019 are taken and the results are estimated for 2027.

4.7.1 Calculation of the parameters of interest for the study of air traffic.

4.7.1.1 Monthly analysis.

Peak month calculation

The peak month is the month with the highest number of operations and passengers. This calculation will be made based on the 2019 monthly data for Budapest and the current data (2021). But, previously, if we analyze the total commercial flights from Budapest airport in the first quarter of 2019 and in the first quarter of this year 2021, we see the following:

Table 4.16: First quarter total commercial operations in Budapest airport during 2019 and 2021 [28][35].

Year	Month	Total number of commercial flights	Total number of passengers
2019	January	7.555	1.002.863
	February	7.013	968.519
	March	8.136	1.170.772
	April	8.989	1.334.123
2021	January	1.520	224.960
	February	1.391	205.868
	March	1.619	239.612
	April	1.754	259.592

It can be seen that the monthly traffic forecast for this year, 2021 is varying in the same way as in 2019. We see that from January to February the activity at the airport declines but then in March it increases again, exceeding the operations of January and April this air traffic continues to increase. Therefore, we deduce that the variation in traffic year after year varies in the same way. Therefore, the peak month will be decided from the 2019 data, which throughout the project, has been estimated to be the same in 2025.

Below, these 2019 data are presented considering the total international flights from Budapest airport. The percentage of each month over the total has been calculated, both for the number of operations and passengers.

Table 4.17: Monthly data of Budapest airport in 2019 (2025) [35].

Year	Month	Commercial passenger flights	% of the total	Number of passengers	% of the total
2019	January	7.555	6,948	1.002.863	6,218
	February	7.013	6,450	968.519	6,005
	March	8.136	7,482	1.170.772	7,258
	April	8.989	8,267	1.334.123	8,271
	May	9.543	8,776	1.409.325	8,737
	June	9.645	8,870	1.471.409	9,122
	July	10.326	9,497	1.600.683	9,924
	August	10.414	9,578	1.613.239	10,002
	September	10.004	9,200	1.510.126	9,363
	October	9.701	8,922	1.472.666	9,130
	November	8.497	7,814	1.267.923	7,861
	December	8.911	8,195	1.307.615	8,107
TOTAL (ANNUAL)		**108.734**	**100**	**16.129.263**	**100**

Using these percentages, it will be possible to calculate an estimate of the variation by months of the new airport in 2027.

Table 4.18: Monthly data of the new airport in 2027.

Year	Month	Total commercial passenger flights	Total number of passengers
2027	January	3.222	468.219
	February	2.990	452.185
	March	3.469	546.613
	April	3.833	622.879
	May	4.069	657.989
	June	4.113	686.975
	July	4.403	747.331
	August	4.441	753.193
	September	4.266	705.052
	October	4.137	687.562
	November	3.623	591.971
	December	3.800	610.503
TOTAL (Annual)		**46.366**	**7.530.473**

If we analyze the **Table** 4.18, we see that the month in which the highest air traffic is estimated at the new airport is August, both in terms of number of passengers and air operations.

Table 4.19: Peak month results (Year 2027).

Peak month	Commercial passenger flights	Number of passengers
August	4.441	753.193

Average monthly results

Table 4.20: Average movements per month (Year 2027).

Average commercial flights per month	Average number of passengers per month
3.864	627.539

4.7.1.2 Daily analysis.

Calculation of the typical or busy day

The typical day is the second busiest day of the average calendar week (7-day period) of the peak month, August in this case.

Budapest airport busy day will be estimated first in 2019.

To calculate this busy day, it will be done using the number of operations and then the number of passengers will be estimated. First, the operations for the average week of August must be calculated.

$$Operations\ for\ the\ average\ week = \frac{Total\ August\ Flights}{August\ Number\ of\ Weeks} \tag{4.3}$$

$$Operations\ for\ the\ average\ week = \frac{10.414}{4+\frac{3}{7}} = 2.352\ flights$$

Then, once we have this average week, we need to calculate the number of operations for each calendar week (7 days) of 2019 at the Budapest airport. For this, we will need the number of daily operations of the reference airport in 2019. We find these data from a spreadsheet issued by EUROCONTROL on daily air traffic [39]. We'll look at IFR flights. In any case, the total of monthly operations does not quite coincide with those found on the Budapest airport website since, surely, they will consider other types of flights and not only commercial passenger flights. Therefore, the data will be extrapolated later.

Table 4.21: Daily flights for August 2019 at Budapest airport [39].

Year	Date	Departure IFR flights	Arrival IFR flights	Total IFR flights	Total IFR flights per WEEK (7 days)
	31/08/2019	153	154	307	-
	30/08/2019	206	206	412	-
	29/08/2019	185	186	371	-
	28/08/2019	203	205	408	
	27/08/2019	182	183	365	
	26/08/2019	193	189	382	
	25/08/2019	181	186	367	2.603
	24/08/2019	157	156	313	
	23/08/2019	201	201	402	
	22/08/2019	183	183	366	
	21/08/2019	207	198	405	
	20/08/2019	171	179	350	
	19/08/2019	180	178	358	
	18/08/2019	192	192	384	2.585
	17/08/2019	160	156	316	
2019	16/08/2019	199	195	394	
	15/08/2019	188	190	378	
	14/08/2019	199	195	394	
	13/08/2019	178	179	357	
	12/08/2019	189	189	378	
	11/08/2019	196	195	391	2.612
	10/08/2019	167	164	331	
	09/08/2019	196	196	392	
	08/08/2019	187	182	369	
	07/08/2019	205	204	409	
	06/08/2019	181	184	365	
	05/08/2019	195	192	387	
	04/08/2019	211	195	406	2.707
	03/08/2019	156	166	322	
	02/08/2019	209	205	414	
	01/08/2019	195	209	404	
	TOTAL	**5.805**	**5.792**	**11.597**	**11.597**

It is observed that the week with weekly traffic most similar to that of the calculated average week is the one formed from August 15 to 21, 2019.

Once the average week has been chosen, looking at the number of departures and arrivals and the total number of flights, the following results are obtained:

$$Busiest\ day\ of\ the\ week\ (Budapest) \rightarrow Wednesday\ August\ 21,\ 2019$$

$$Second\ busiest\ day\ of\ the\ week\ (Budapest) \rightarrow Friday\ August\ 16,\ 2019$$

Once we have the results of the 2019 busy day of the Budapest airport, we will extrapolate them to those of the new airport in 2027.

First, the same 7-day period of 2027 (15/08/2027-21/08/2027) will be considered for the middle week.

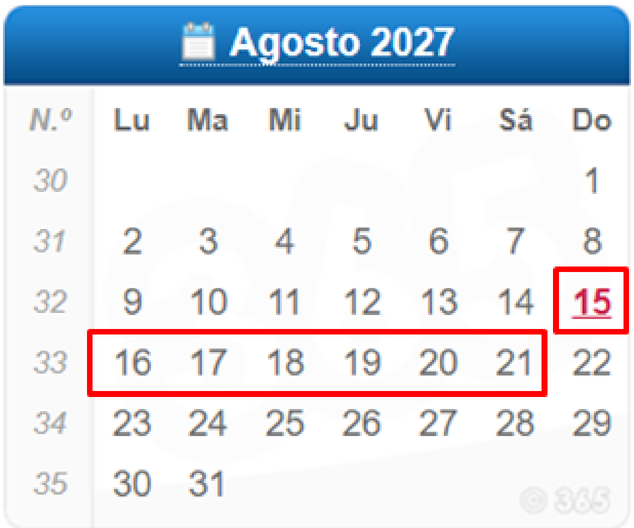

Fig. 4.11. Medium week of August 2027. Source: [40] [Own elaboration (Word)]

And the days with the highest traffic will remain as they are reasonable. On the 21st many people finish their vacations and return to their places of residence and, on the 16th, others begin their vacation period in the second half of August. In addition, in 2019 these days in Budapest airport were the ones with the highest traffic and it is estimated that this will be the case at the new airport.

Therefore, the busy day of the new airport in 2027 will be:

$$\boxed{Busy\ day\ 2027\ \rightarrow\ Monday\ August\ 16\ (Week\ 33)}$$

Next, in order to estimate the number of operations and passengers for this day, a proportion will be obtained using the data presented in the **Table** 4.21 of the reference airport in 2019 and will be extrapolated to the new airport in 2027.

But previously, the extrapolation will be carried out to the estimated number of operations and passengers at the Hungarian capital airport in the month of August (**Table** 4.17). That is, we have the data for the medium week from 11.597 total operations for the month of August and we want the relationship for the number of passenger flights for the month of August 2019 at the Budapest airport.

$$11.597\ total\ IFR\ flights \rightarrow 2.585\ IFR\ flights\ in\ the\ average\ week$$

$$10.414\ total\ passenger\ flights \rightarrow X\ flights\ in\ the\ average\ week$$

$$\boxed{2.321\ flights\ in\ the\ medium\ week\ in\ Budapest\ airport\ (2025)}$$

$$2.585\ IFR\ flights\ in\ the\ average\ week\ \rightarrow 394\ flights\ in\ the\ busy\ day$$

$$2.321\ flights\ in\ the\ medium\ week\ in\ Budapest\ airport\ (2025) \rightarrow X\ flights\ in\ the\ busy\ day$$

$$\boxed{354\ flights\ in\ the\ busy\ day\ in\ Budapest\ airport\ (2025)}$$

Now, we calculate the percentage of the number of flights for the medium week over the total number of flights for the month of August at the reference airport.

$$\%\ medium\ week\ over\ the\ monthly\ total = \frac{2.321\ weekly\ flights}{10.414\ monthly\ flights} = 22,29\% \approx 22\%$$

And when we have this result, we calculate the portion of the total flights of the average week that corresponds to the busy day.

$$\%\ 2nd\ day\ of\ most\ activity\ of\ the\ medium\ week = \frac{354\ daily\ flights}{2.321\ weekly\ flights} = 15,25\% \approx 15\%$$

Finally, if we apply these percentages to the results of the month of August of the new airport in 2027 (**Tabla** 4.18), we obtain the following results:

Table 4.22: Calculation of the busy day of the new airport in 2027.

2026	Commercial passenger flights	Number of passengers
August	4.441	753.193
Medium week	977	165.700
Busy day	147	24.900
Departures on the busy day	74	12.575
Arrivals on the busy day	73	12.325

The following results are obtained for the busy day:

Table 4.23: Estimated busy day of the new airport in 2027.

Busy day	Commercial passenger flights	Number of passengers
Monday August 16 (Week 33)	147	24.900

Calculation of the peak day

It is necessary to clarify that the peak day is not necessary to be in the peak month but it can be estimated that it will be in the months of greatest activity, therefore we will study which period of 3 or 4 months has greater activity and we will deduce that the peak day will be within those months.

If we find a graph to see the variation by months of the estimated air traffic data for the new airport in 2027, we see that the months with the highest activity are June, July, August and September, therefore, the peak day will have more tendency to be in any of them.

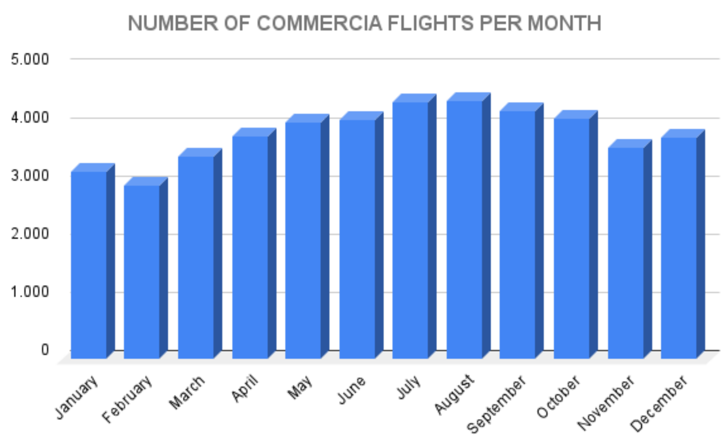

Fig. 4.12. Estimated evolution by months of the number of commercial passenger flights at the new airport in 2027. [Own elaboration (Excel)]

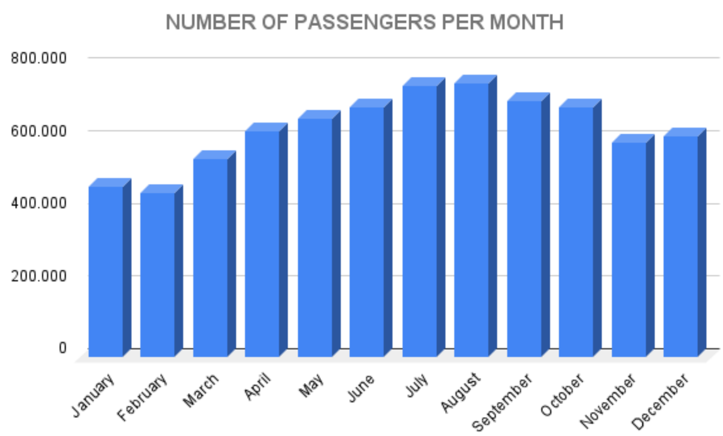

Fig. 4.13. Estimated evolution by months of the number of passengers at the new airport in 2027. [Own elaboration (Excel)]

To find this peak day, we need to base ourselves on daily data from the Budapest airport and then extrapolate the results for the new one.

If we look for the daily traffic in 2019 for Hungary in general, we get the following diagram:

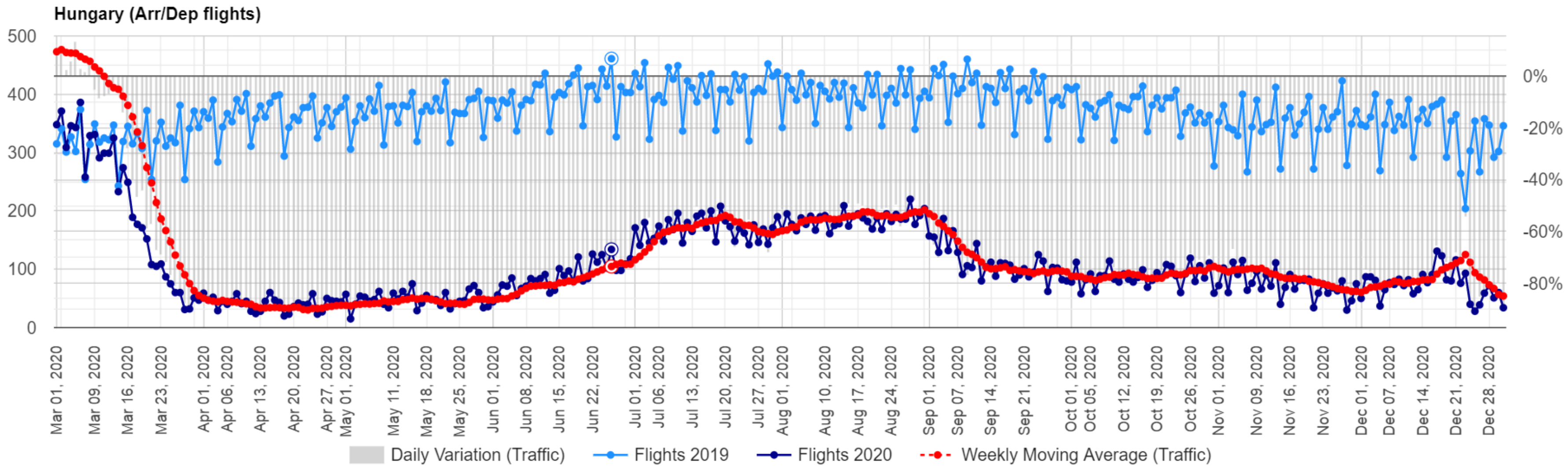

Fig. 4.14. Daily traffic variation in Hungary in 2019. Source: [41]

Here we see the evolution of daily air traffic in Hungary in 2019 and 2020 and their respective variation. For this study, we will only be interested in that of 2019 (considered the same as that of 2025).

The peak day in 2019 in Hungary was Friday June 28. As already mentioned, the Budapest airport is the one that generates the highest traffic in Hungary, therefore, the peak day will be the same. But anyway, if we use the EUROCONTROL Airport Traffic data [39] and order more operations in 2019, we see that the peak day coincides with that of Hungary. Therefore, the results of the peak day are as follows:

$$Peak\ day\ at\ Budapest\ airport \rightarrow Friday\ June\ 28\ (Week\ 26)$$

It can be seen that the maximum number of operations that took place at the Budapest airport in 2019 was 428 flights.

It will be considered that what was the peak day at the Budapest airport in 2019 will be the same in 2027. That is, in order to estimate the peak day of the new airport we will look at the week of the year to which Friday June 28 corresponds of 2019 and we will look for the Friday of that same week in the year 2027.

According to the 2019 calendar, the peak day corresponded to Friday of week 26. Therefore, if we consult the 2027 calendar, we find the day corresponding to the estimated peak day:

$$\boxed{Peak\ day\ in\ 2027 \rightarrow Friday\ July\ 02\ (Week\ 26)}$$

Finally, we will need to extrapolate the number of operations on this peak day at the Budapest airport to get the number of operations and passengers on the peak day at the new airport in 2027.

We will perform the extrapolation by calculating what proportion corresponds to the 428 flights on the peak day of the total flights in June 2019 (**Tabla** 4.17) in Budapest airport.

$$Percentage\ of\ the\ total\ flights\ (New\ airport) = \frac{428}{9.645} = 4,44\%$$

And, knowing the total flights estimated in 2027 in July (**Tabla** 4.18), we can find the following result:

$$Operations\ of\ the\ peak\ day = 194\ flights$$

We performed the same procedure for the number of passengers, directly applying the estimated percentage for the number of operations.

$$Passengers\ of\ the\ peak\ day\ (New\ airport) = 32.883\ passengers$$

Table 4.24: Estimated peak day of the new airport in 2027

Peak day	Commercial passenger flights	Number of passengers
Friday July 02 (Week 26)	194	32.883

The results, as we will see in the following table, make sense since they are higher than those of the busy day (**Tabla** 4.23), an aspect that corroborates that the peak day does not have to be in the month peak.

4.7.1.3 Hourly analysis.

Calculation of the peak hour

The idea is to construct the standard hourly day and find what will be the rush hour of the new airport in its starting year, 2027. We know that the rush hour is found from the busy day. In our case, the busy day corresponds to a Monday in August. Therefore, it will be taken as a reference on Monday, May 17 of this year 2021, mainly, and the others also to be more precise with the number of operations that usually exist on Monday. Anyway, the idea is to estimate a current standard day that would correspond to a Monday, therefore the following will be considered:

- Destinations are assumed to remain the same day (Monday).
- All the hours and all the flights in those hours will be valued considering all the destinations that appear in those 3 days (Monday). In the end they are practically the same every Monday.

This estimate is made to try to reproduce the Monday that would have the highest activity since, currently, all the information that can be obtained from this 2021 is affected by the effects of the pandemic. For this reason, the departures and arrivals at Budapest airport in 2021 (**Appendix G**) of the estimated current busy day are presented below in order to be able to base ourselves on real data of hourly activity.

Table 4.25: Departures on Mondays in Budapest airport in May 2021 (**Appendix G**).

	Time period	Hour	Country	Destination
DEPARTURES	06:00 am-07:00 am	06:10	Sweden	Stockholm
		06:15	Italy	Milan
		06:35	Netherlands	Amsterdam (3 flights)
			United Kingdom	London
	07:00 am-08:00 am	07:00	Germany	Frankfurt (8 flights)
	08:00 am-09:00 am	-		
	09:00 am-10:00 am	09:05	Turkey	Istanbul
		09:15	Germany	Dusseldorf
		09:55	Russia	Barnaul
	10:00 am-11:00 am	10:10	Germany	Dusseldorf
	11:00 am-12:00 pm	11:50	Germany	Stuttgart
	12:00 pm-01:00 pm	12:10	Poland	Warsaw
		12:15	France	Paris (4 flights)
		12:35	Germany	Dusseldorf
		12:50	Russia	Moscow
	01:00 pm-02:00 pm	01:00	United Kingdom	London
		01:25	Germany	Munich (3 flights)
	02:00 pm-03:00 pm	02:00	Spain	Malaga
		02:10	Poland	Warsaw
		02:20	Israel	Tel Aviv
		02:40	Germany	Frankfurt (3 flights)
	03:00 pm-04:00 pm	03:15	South Korea	Seoul
		03:20	Italy	Rome
	04:00 pm-05:00 pm	04:40	Poland	Warsaw
		04:45	Qatar	Doha
		04:55	Qatar	Doha
	05:00 pm-06:00 pm	05:05	Netherlands	Amsterdam (3 flights)
	06:00 pm-07:00 pm	06:00	Russia	Barnaul
	07:00 pm-08:00 pm	-		
	08:00 pm-09:00 pm	08:40	Switzerland	Basel
		08:55	Ireland	Dublin
	09:00 pm-10:00 pm	-		
	10:00 pm-11:00 pm	-		

Table 4.26: Arrivals on Monday in Budapest airport in May 2021.

	Time period	Hour	Country	Destination
ARRIVALS	06:00 am-07:00 am	-		
	07:00 am-08:00 am	-		
	08:00 am-09:00 am	08:10	Turkey	Istanbul
		08:40	Italy	Milan
		08:50	Germany	Dusseldorf
	09:00 am-10:00 am	09:10	Poland	Warsaw
		09:35	Germany	Dusseldorf
		09:45	Italy	Milan
	10:00 am-11:00 am	-		
	11:00 am-12:00 pm	11:00	Sweden	Stockholm
		11:10	Germany	Stuttgart
		11:30	France	Paris (5 flights)
		11:50	United Kingdom	London
	12:00 pm-01:00 pm	12:00	Russia	Moscow
			Germany	Dusseldorf
		12:45	Germany	Munich (2 flights)
		12:55	Qatar	Doha
	01:00 pm-02:00 pm	01:05	South Korea	Seoul
		01:30	Poland	Warsaw
		01:55	Germany	Frankfurt (8 flights)
	02:00 pm-03:00 pm	02:50	Italy	Rome
	03:00 pm-04:00 pm	-		
	04:00 pm-05:00 pm	04:05	Poland	Warsaw
		04:20	Netherlands	Amsterdam (3 flights)
	05:00 pm-06:00 pm	-		
	06:00 pm-07:00 pm	06:50	United Kingdom	London
	07:00 pm-08:00 pm	-		
	08:00 pm-09:00 pm	08:10	Switzerland	Basel
		08:30	Ireland	Dublin
	09:00 pm-10:00 pm	-		
	10:00 pm-11:00 pm	10:00	Israel	Tel Aviv
		10:35	Germany	Frankfurt (3 flights)
		10:55	Netherlands	Amsterdam (3 flights)

Once this data is collected, the number of total operations can be calculated hour by hour.

Table 4.27: Total operations per hour in Budapest airport (May 2021).

Time period	Departures and Arrivals		Total flights
06:00 am-07:00 am	Arrivals	0	6
	Departures	6	
07:00 am-08:00 am	Arrivals	0	8
	Departures	8	
08:00 am-09:00 am	Arrivals	3	3
	Departures	0	
09:00 am-10:00 am	Arrivals	3	6
	Departures	3	
10:00 am-11:00 am	Arrivals	0	1
	Departures	1	
11:00 am-12:00 pm	Arrivals	8	9
	Departures	1	
12:00 pm-01:00 pm	Arrivals	4	12
	Departures	8	
01:00 pm-02:00 pm	Arrivals	10	14
	Departures	4	
02:00 pm-03:00 pm	Arrivals	1	7
	Departures	6	
03:00 pm-04:00 pm	Arrivals	0	2
	Departures	2	
04:00 pm-05:00 pm	Arrivals	4	7
	Departures	3	
05:00 pm-06:00 pm	Arrivals	0	3
	Departures	3	
06:00 pm-07:00 pm	Arrivals	1	2
	Departures	1	
07:00 pm-08:00 pm	Arrivals	0	0
	Departures	0	
08:00 pm-09:00 pm	Arrivals	2	4
	Departures	2	
09:00 pm-10:00 pm	Arrivals	0	0
	Departures	0	
10:00 pm-11:00 pm	Arrivals	7	7
	Departures	0	
11:00 pm-12:00 am	Arrivals	0	0
	Departures	0	
TOTAL			**91**

As can be seen in the table above, the current busy day rush hour in Budapest is estimated to be from 1:00 p.m. to 2:00 p.m. with 14 operations (arrival and departure flights). And it is appreciated that the results, being based on current data affected by the pandemic, are not very high, there is a small number of operations at rush hour. In addition, the number of operations is not too distributed.

Therefore, to estimate the hourly traffic of the busy day of the new airport in 2027, it will be estimated by finding a proportion of the current hours, of the estimated as the reference busy day, over the total operations. Once we have the percentage, it will be applied to the total operations of the busy day of the new airport (**Table** 4.23) and we will know the number of operations that would correspond to the new airport on its busy day in 2027.

Table 4.28: Percentage of the number of flights per hour over the total flights of the current reference busy day (Monday May 2021) in Budapest airport.

Time period	Total flights	% over the total number of flights
06:00 am-07:00 am	6	6,593406593
07:00 am-08:00 am	8	8,791208791
08:00 am-09:00 am	3	3,296703297
09:00 am-10:00 am	6	6,593406593
10:00 am-11:00 am	1	1,098901099
11:00 am-12:00 pm	9	9,89010989
12:00 pm-01:00 pm	12	13,18681319
01:00 pm-02:00 pm	14	15,38461538
02:00 pm-03:00 pm	7	7,692307692
03:00 pm-04:00 pm	2	2,197802198
04:00 pm-05:00 pm	7	7,692307692
05:00 pm-06:00 pm	3	3,296703297
06:00 pm-07:00 pm	2	2,197802198
07:00 pm-08:00 pm	0	0
08:00 pm-09:00 pm	4	4,395604396
09:00 pm-10:00 pm	0	0
10:00 pm-11:00 pm	7	7,692307692
11:00 pm-12:00 am	0	0
TOTAL	**91**	**100**

The reconstruction of the busy day of the new airport with data on the number of operations per one hour period is presented in the following table.

Table 4.29: Hourly operations on the busy day of the new airport in 2027.

Time period	Total flights
06:00 am-07:00 am	10
07:00 am-08:00 am	13
08:00 am-09:00 am	5
09:00 am-10:00 am	10
10:00 am-11:00 am	2
11:00 am-12:00 pm	14
12:00 pm-01:00 pm	19
01:00 pm-02:00 pm	23
02:00 pm-03:00 pm	11
03:00 pm-04:00 pm	3
04:00 pm-05:00 pm	11
05:00 pm-06:00 pm	5
06:00 pm-07:00 pm	3
07:00 pm-08:00 pm	1
08:00 pm-09:00 pm	5
09:00 pm-10:00 pm	1
10:00 pm-11:00 pm	11
11:00 pm-12:00 am	0
TOTAL	147

To represent this busy day the previous data will be used (**Table** 4.29).

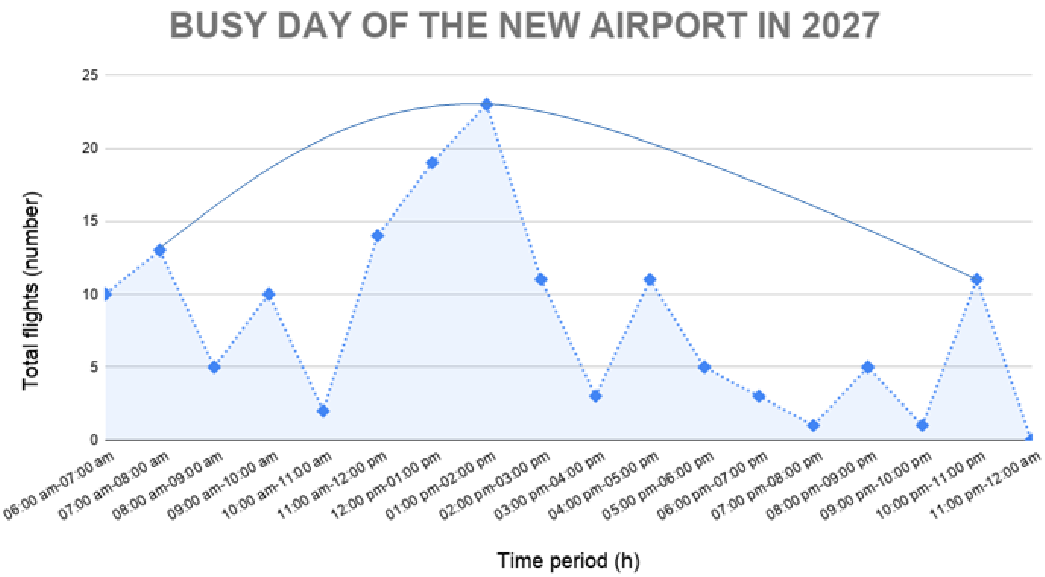

Fig. 4.15. Evolution of the busy day peak hours of the new airport in 2027. [Own elaboration (Excel & Word)]

Exponential jumps are seen in the diagram due to the large difference between peak hours and off-peak hours.

Finally, the results of the hourly analysis on the busy day of the new airport in its starting year are presented.

Table 4.30: Estimated peak hour in the busy day of the new airport in 2027.

Peak hour	Commercial passenger flights	Number of passengers
01:00 pm - 02:00 pm	23	3.896

4.8 Extrapolation to the Horizon Scenario

Although throughout the traffic study it has been based on the realistic scenario, of the three proposed in **Point** 4.6.2, a study of the number of operations and passengers of the typical day and of the rush hour will finally be presented for these three scenarios for a few years. The results of a starting horizon (2027), a medium horizon (2036) and a distant horizon (2045) will be analyzed.

To do this, different graphs will be made, using MATLAB (**Appendix I**), showing the evolution of traffic over the years, taking as a basis the number of operations and passengers for the busy day and the number of operations and passengers for the busy hour of the new airport in 2027 .

Table 4.31: Starting scenario data (2027) - Busy days and peak hours.

Scenario	Busy day		Peak hour	
	Flights	Pax	Flights	Pax
Pessimistic	50	7.800	8	1.220
Realistic	147	24.900	23	3.896
Optimistic	203	35.600	31	5.436

To estimate traffic growth, the CAGR of the total Hungarian airports from 2010 to 2019 will be used, calculated at the **Point** 4.4.1. This CAGR was obtained by comparing the traffic in a period of 9 years, therefore, as from 2027 to 2036 there are the same number of years, it will be estimated that the annual traffic of the new airport in its first years will grow the same as it did in Hungary during the named years. In addition, it will be considered that the daily traffic grows the same as the annual one, and in the same way for the hourly traffic that would grow according to the daily traffic.

These commented percentages will be applied year to year from 2027 to 2036. But, as of 2036, it will be considered that traffic does not grow so much annually since it is estimated that it will accommodate, it will grow more moderately. Consequently, the CAGR used during the first years will be cut in half.

In addition, the growth rate of air operations will be used and not that of passengers, since the latter is quite high (8 %).

The following are the CAGRs to use, rounded:

Table 4.32: Estimated CAGRs.

CAGR	Flights	Pax
CAGR (2027-2036)	2 %	2 %
CAGR (2036-2045)	1 %	1 %

Finally, making a loop in the code to calculate the operations and the number of passengers year by year, the following diagrams are obtained:

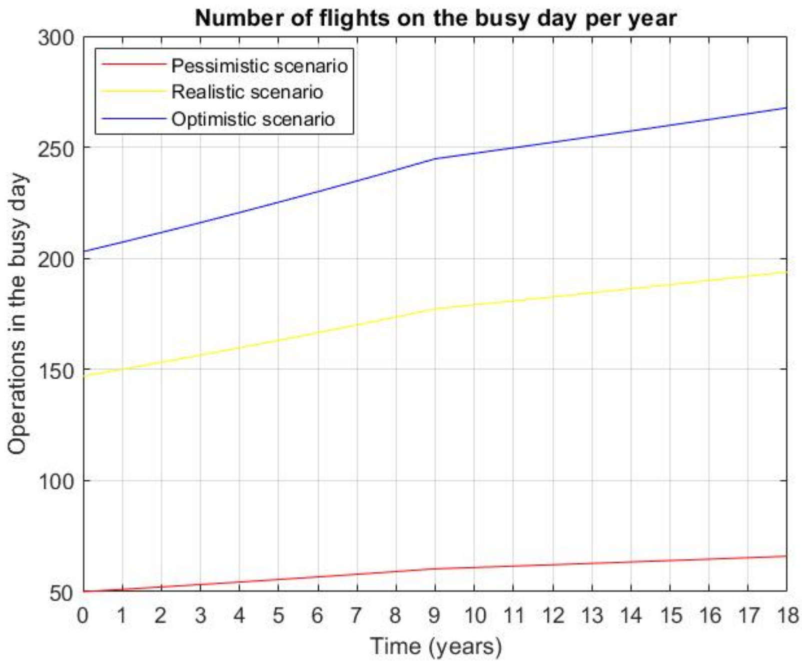

Fig. 4.16. Number of flights on the busy day per year (2027-2045) in three scenarios. [Own elaboration (MATLAB)]

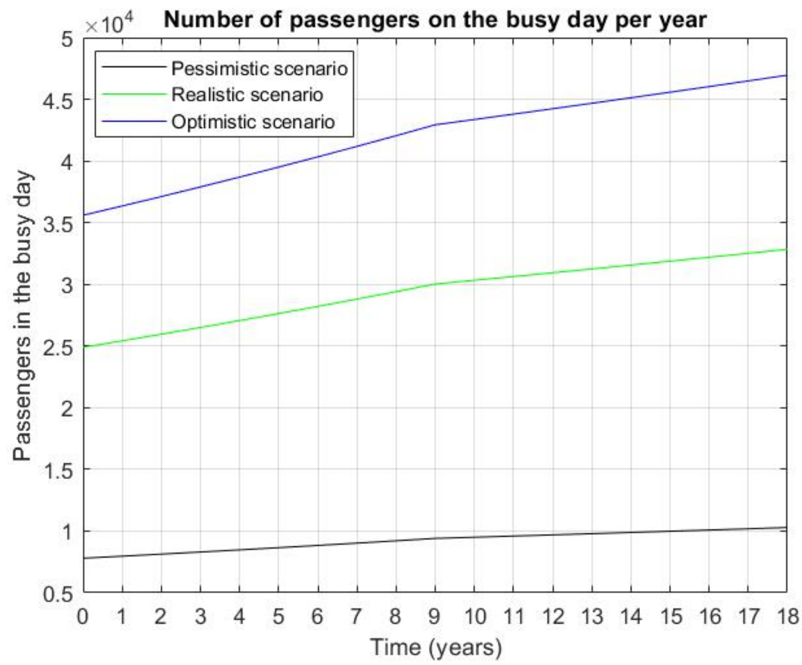

Fig. 4.17. Number of passengers on the busy day per year (2027-2045) in three scenarios. [Own elaboration (MATLAB)]

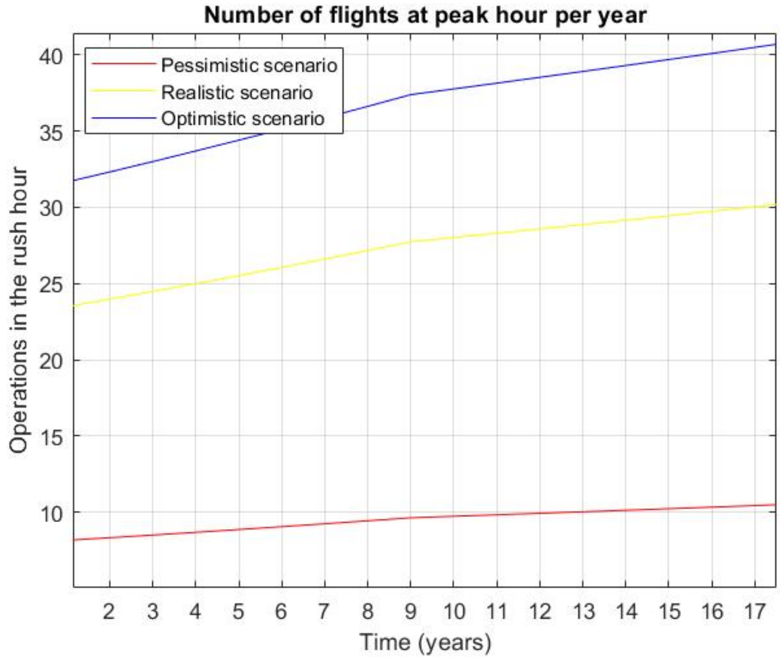

Fig. 4.18. Number of flights at peak hour per year (2027-2045) in three scenarios. [Own elaboration (MATLAB)]

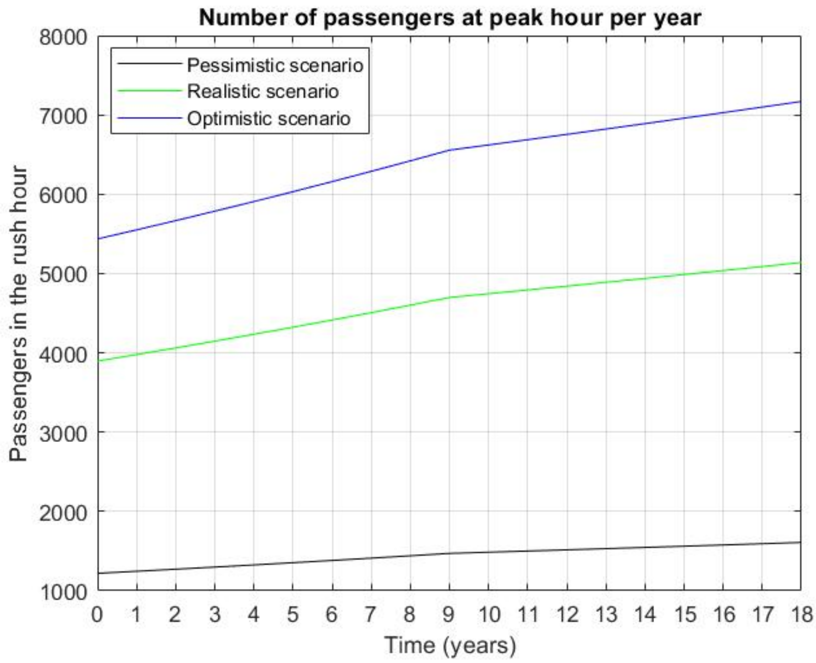

Fig. 4.19. Number of passengers at peak hour per year (2027-2045) in three scenarios. [Own elaboration (MATLAB)]

And the results that interest us the most would be the following:

Table 4.33: Results of the horizon scenario from 2027 to 2045 assessing the busy day and peak hour at the new airport.

Horizon Scenario	Scenarios	Busy day		Peak hour	
		Flights	Passengers	Flights	Passengers
Preliminary (2027 - Year 0)	Pessimistic	50	7.800	8	1.220
	Realistic	147	24.900	23	3.896
	Optimistic	203	35.600	31	5.436
Medium (2036 - Year 9)	Pessimistic	59	9.213	9	1.441
	Realistic	174	29.410	27	4.602
	Optimistic	240	42.047	37	6.420
Long (2045 - Year 18)	Pessimistic	65	10.186	10	1.593
	Realistic	192	32.516	30	5.088
	Optimistic	265	46.488	40	7.099

As we can see in the results tables and in the diagrams, the traffic has been estimated as increasing. From 2027 to 2036 it is estimated that it grows more annually than from 2036 to 2045. It is concluded that traffic at the new airport will grow more in the first years and then this growth will slow down.

Finally, a table is presented of how the annual traffic would look over the years, estimating that it grows in the same way as the busy day and peak hour.

Table 4.34: Results of the horizon scenario from 2027 to 2045 assessing the annual data at the new airport.

Horizon Scenario	Scenarios	Annual Traffic	
		Flights	Passengers
Preliminary (2027 - Year 0)	Pessimistic	15.732	2.359.342
	Realistic	46.366	7.530.473
	Optimistic	64.305	10.775.407
Medium (2036 - Year 9)	Pessimistic	18.972	2.845.218
	Realistic	55.914	9.081.276
	Optimistic	77.548	12.994.461
Long (2045 - Year 18)	Pessimistic	20.749	3.111.773
	Realistic	61.153	9.932.057
	Optimistic	84.813	14.211.851

For the final air side and ground side design, you will need these results. Estimated data for 2027 because it is the starting year and the airport must provide enough service to cover this typical day and rush hour traffic. And, the results for the year 2036 are also interesting because the airport should be able to manage traffic 5-10 years from now and then already consider whether an extension is convenient (more number of runways, more than one terminal...) but now for a longer horizon such as the year 2045.

Chapter 5

Specific Location

Once the traffic monitoring of the new airport has been carried out, using Budapest as a reference, it will be determined exactly where or in Hungary it will be located. In the Demand Analysis, at the point of the area of influence, the possible location of this new airport was delimited, since when using the Budapest airport as a reference and since the objective of the new airport is to absorb flights from the capital, it is advisable that the two are within the other's area of influence.

To do this, this area of Hungary will be detected and where the infrastructure should be located will be studied.

5.1 Study of Potential Areas

Previously, at the **Point** 4.3, the area where the new airport should be located was delimited.

In order to be able to analyze this zone, we divide Hungary into their respective areas and mark the first estimated zone.

Fig. 5.1. Hungary regions. Source: [42] [Own elaboration (Word)]

We see that the possible regions to locate the new airport are the east of Central Transdanubia, the north-west of the Southern Great Plain and Pest.

In the following points, these three areas will be analyzed but it is necessary to comment that the Pest region would be eliminated from the selection since the capital's airport is located there.

5.2 Topography

Topography is an essential part of studying the location of the new airport. It is convenient to study the terrain when building an infrastructure. In addition, the elevation of an airport is important since it influences the efficiency of action in the takeoff and landing of airplanes.

If we mark on a topographic map (**Figure** 5.2) the altitudes of the areas that are of interest to this study, already named above, we will see the average altitude at which the airport would be built in each region, considering the lowest elevations.

The height at sea level of the airport affects its actions. If the height is high, as determined by the standard conditions of the atmosphere, it causes a decrease in pressure that is determined by a low density. In turn, an increase in height causes less power from the aircraft engine that reduces takeoff efficiency and the payload or payload that the aircraft could carry. These effects can be seen in the airplane's lift formula.

$$L = \frac{1}{2} \cdot g_{air} \cdot v^2 \cdot S \cdot C_l \tag{5.1}$$

The density of the air (g_{air}), decreases at a higher altitude and this leads to an increase in speed in order to maintain stable lift. If the aircraft needs more speed and angle of attack to act, it will also require more runway length at the airport to land and take off.

Therefore, an area with the lowest possible height above sea level will be sought so that the power of the engines of the aircraft operating in the new airport is greater and they can land and take off with a more stable lift and not have to use so much speed and angle of attack.

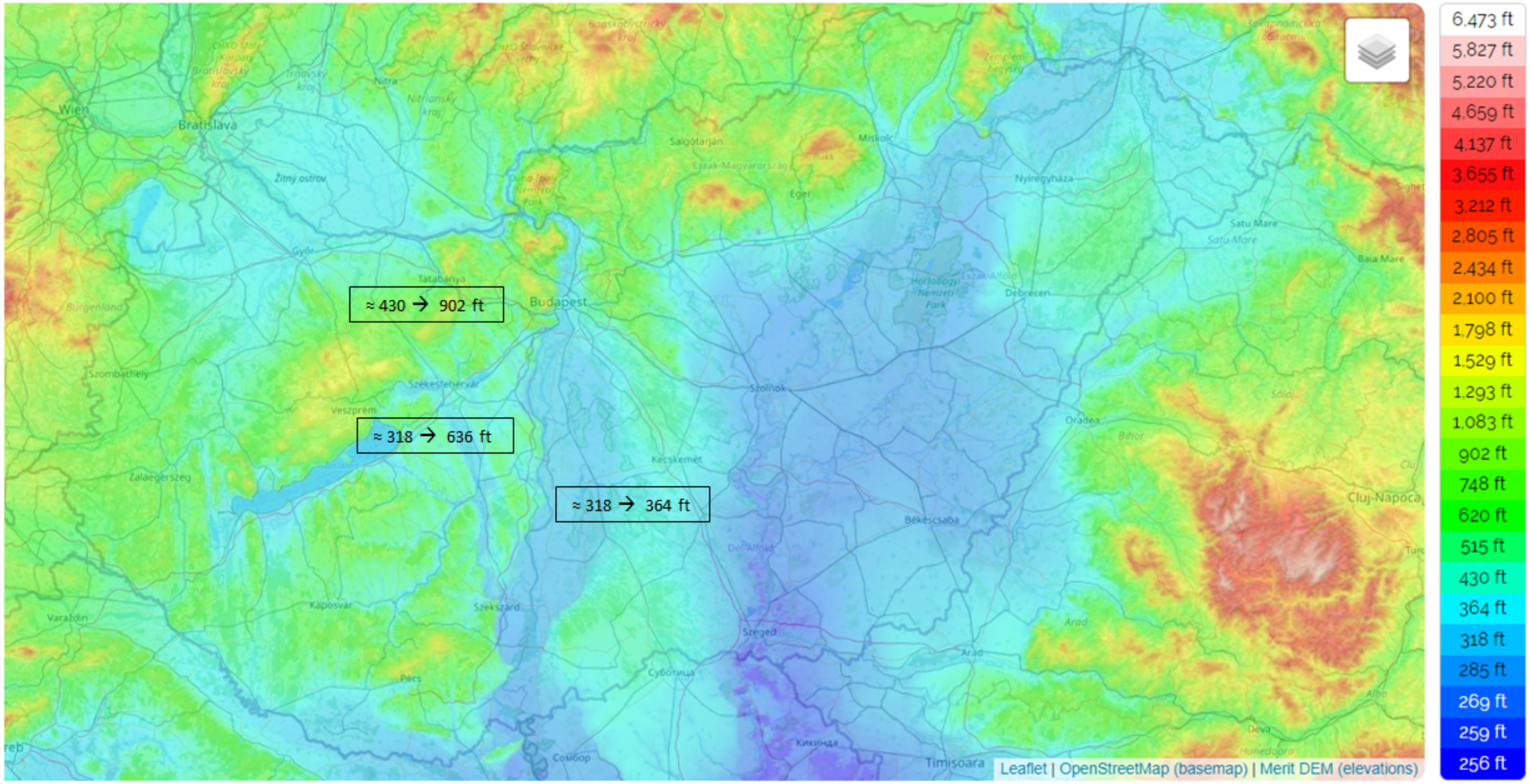

Fig. 5.2. Topographic map of Hungary. Source: [43]

5.3 Meteorology

When choosing an area to build an airport, it is also important to study the meteorological conditions of each area.

The main city of each area will be taken as a reference. In the following map you can see each region of Hungary divided by its corresponding areas.

Fig. 5.3. Division of each region by areas. Source: [44]

After making the first approximation (**Figure** 5.1), the areas and their main cities that are within the marked area would be:

- Bács-Kiskun → Kecskemét
- Fejér → Székesfehérvár
- Komárom-Esztergom → Tatabánya

To study the general meteorology of the possible zones, that of each main city will be studied. The temperature, rainfall and wind of each city taken as a reference will be analyzed.

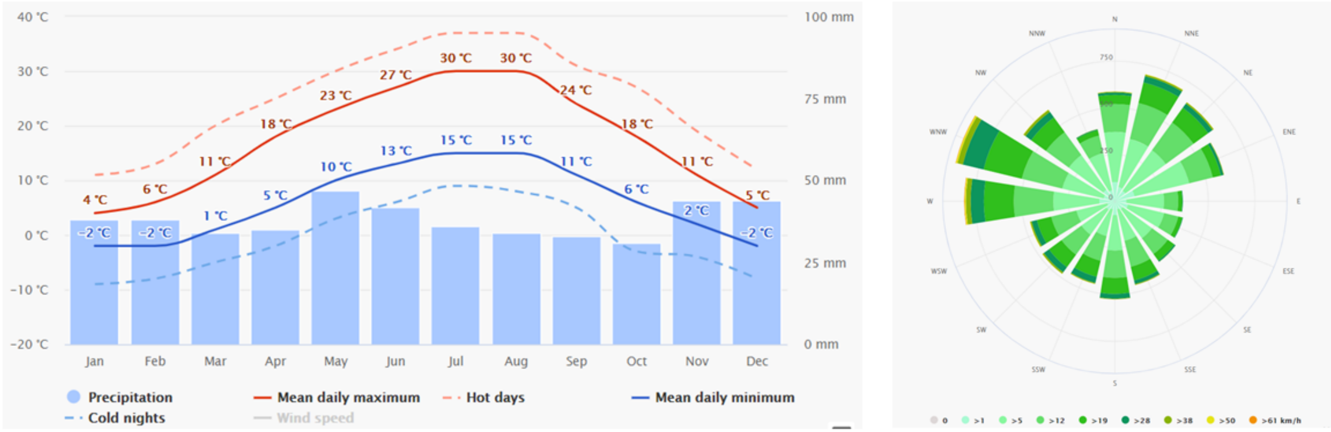

Fig. 5.4. Kecskemét meteorological conditions. Source: [45]

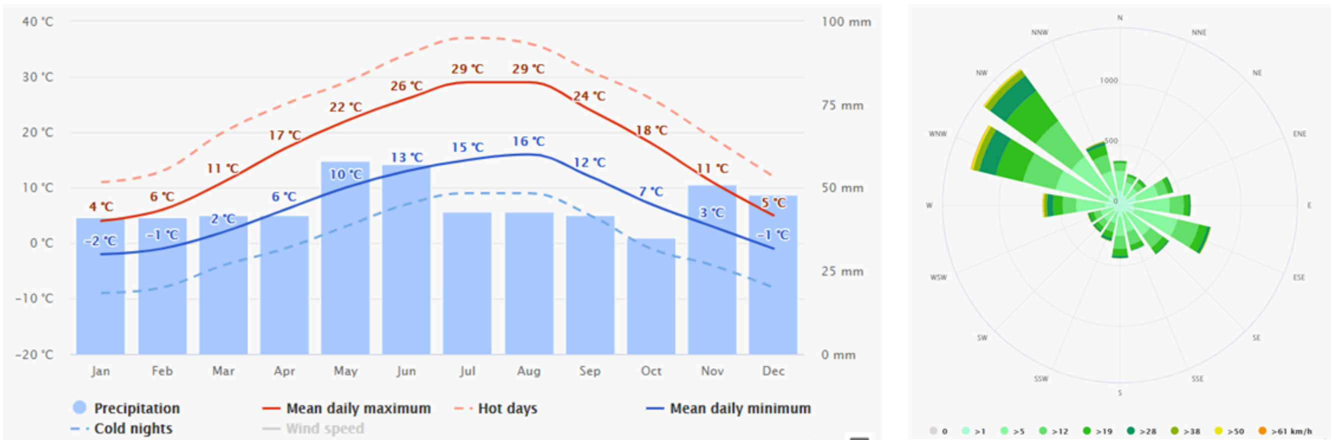

Fig. 5.5. Székesfehérvár meteorological conditions. Source: [45]

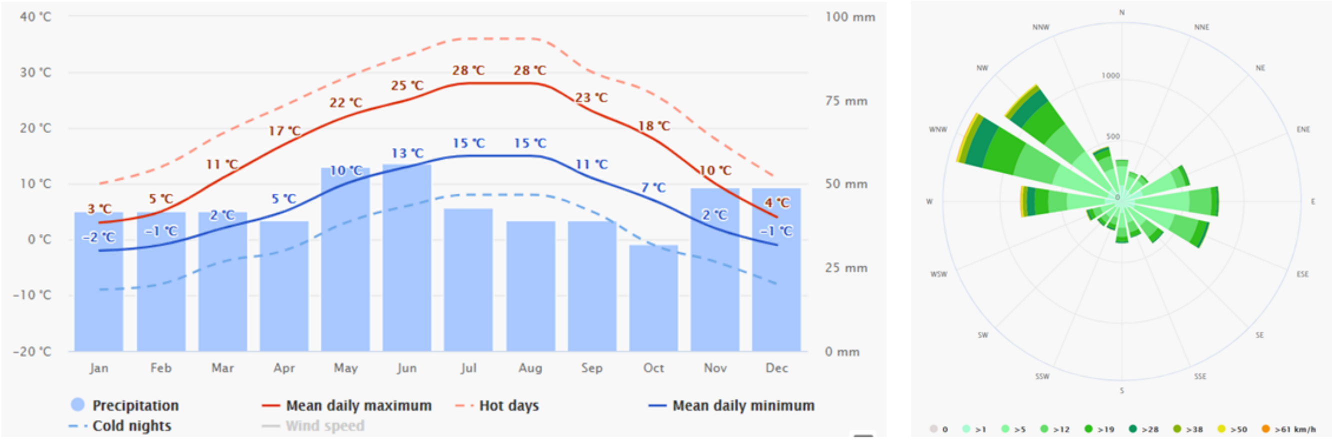

Fig. 5.6. Tatabánya meteorological conditions. Source: [45]

The weather at the airport is important when landing and taking off. If there is a high temperature the efficiency of the aircraft engine decreases because the density of the air would be lower and this causes a drop in power and combustion of the engine. In addition, as before, if this engine thrust is lower, more is needed to be able to take off and land and that determines that the runway length is greater because it would cost more to take off and land.

Obviously, if there are very low temperatures it is not good either as frost can occur and the slopes would slip. The same happens if there is abundant rainfall, visibility is reduced and the wheels of the aircraft can skid and destabilize the landing mostly.

If we analyze the three graphs of temperature and precipitation, we obtain the following conclusions:

- The maximum temperatures occur in July and August and in Kecskemét they are more extreme (30ºC) but they do not differ much from the others.
- The minimum temperatures are in January, February and December. These, in Székesfehérvár and Tatabánya are a little less low but those of the three cities are between -1ºC and -2ºC. And, in Tatabánya, the maximums in these months of minimum temperatures are lower.
- The precipitations in Kecskemét, in general, are lower, the abundance of precipitation does not exceed 50 mm.

Based on these conclusions, we see that in practically the three cities, temperatures and rainfall change in the same way and give similar values.

Lastly, the wind. Later, this will be studied in detail in the exact area in which the airport is located but, now, it can be analyzed in a general way. Through the wind rosette you can see all the directions that the wind follows, the hours per year that these coordinates follow and the speed that it has during the year in the cities analyzed. As we can see, in Kecskemét the wind "blows" in each direction for more hours a year, that is, its direction changes more frequently and this would cause more instability in the aircraft operating at the airport since the runway or runways will be positioned in a specific address. In the other two cities, more or less, the wind goes in the same directions and during the same time of the year, only two directions are the most differentiated. It can be said that the wind is more regular in these last two and that can ensure more stability of the aircraft because the runway would already be directed in such a way that these directions are favorable and thus operations at the airport are more efficient.

5.4 Exact Location

Finally, we will choose which will be the exact positioning zone.

After analyzing the topology and meteorology of the regions that would have within the area of influence from the airport to the Budapest airport, we can conclude the following.

Regarding topography, it has been seen that the flattest region with the lowest elevation is the Southerns Great Plain where the Bács-Kiskun area is located. The eastern part of Central Transdanubia has some areas with altitudes above sea level similar to the averages of the Bács-Kiskun region. However, the Komarom-Esztergomsi region, which is very elevated and, as explained, does not interest to build a type of infrastructure such as the one studied.

And, in reference to the meteorological conditions, it has been seen that where the regions differ the most is in the behavior of the wind. Taking into account that in the Bács-Kiskun area the wind acts more irregular.

Ultimately, the chosen region and area are the **Central Transdanubia region and Fejér area**.

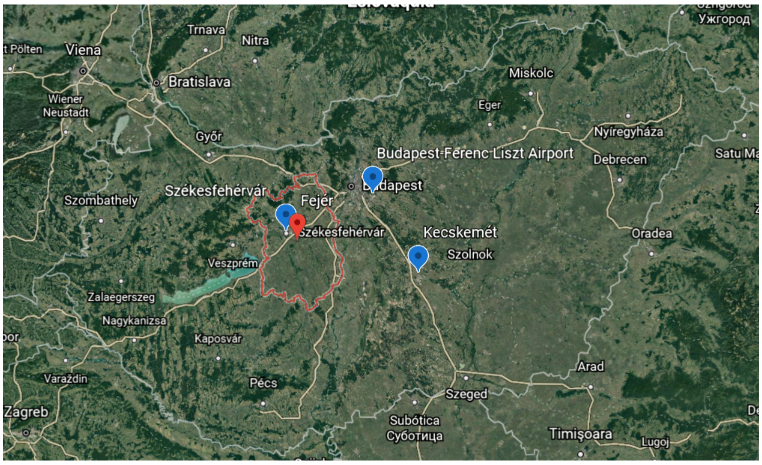

Fig. 5.7. Fejér (Central Transdanubia region) - Selected area. Source: [16]

Observing the previous topological map (**Figure** 5.2) it can be seen that the most convenient thing is to locate the new airport between Sárbogárd and Sárhatvan since the height above sea level is low (about 300-400 ft).

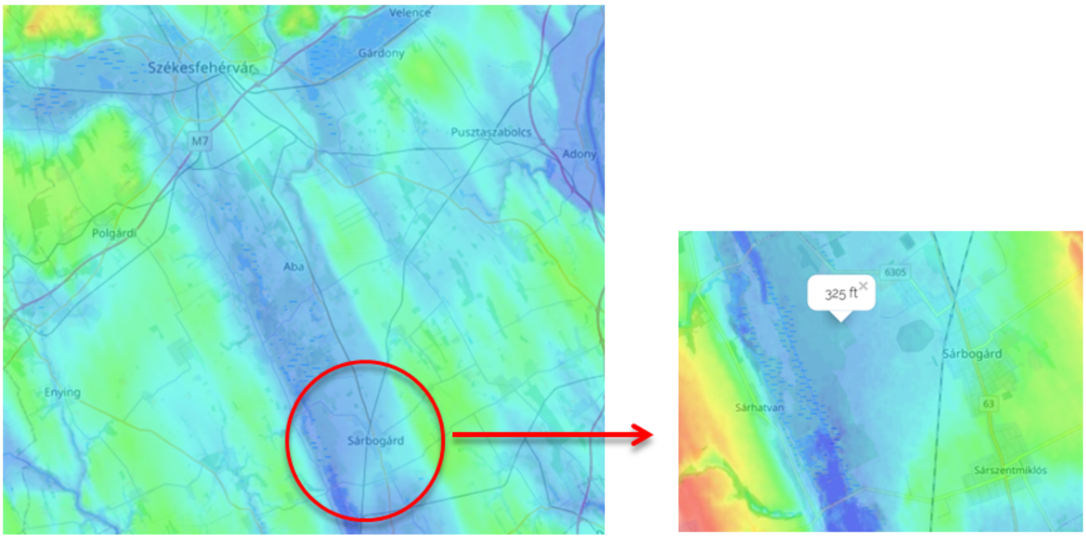

Fig. 5.8. Exact location of the new airport - Sárbogárd-Sárhatvan. Source: [43] [Own elaboration (Word)]

Furthermore, the weather conditions are similar to Székesfehérvéar (**Figure** 5.5). However, they will be analyzed in more detail later.

Therefore, the city of Sárbogárd and its surroundings will be taken as a reference as the location of the new airport. This new airport, therefore, will be called:

Sárbogárd-Sárhatvan Airport

Chapter 6

Complete Infrastructure Design

This chapter will try to design the entire airport. That means, both the air side and the land side and general aspects of the airport. To do this, a preliminary analysis will begin with which different parameters of interest that every airport needs for organizational and regulatory issues will be found. Then each part of the land side and the air side will be exposed based on the reference regulations (ICAO Annex 14 [9]) to design an infrastructure as such.

6.1 Prior to Design Considerations

Before designing an airport, it is necessary to define the Airport Reference Code (ARC). This code is composed of a number, which depends on the airplane reference field length, and a letter given based on the wingspan of the aircraft chosen as the reference or the outer main gear wheel span. During this point you will see how it is obtained and what this code is for.

First the necessary parameters to obtain this reference key of the Sárbogárd-Sárhatvan Airport, will be find.

6.1.1 Design reference airplane.

To choose the reference aircraft for the design, different possibilities of aircraft operating in the airlines of the new airport will be analyzed and the one with the highest or most extreme values will be chosen.

This has an explanation. If the airplane with larger dimensions, greater capacity and greater performance is used, everything designed on the air side would be useful for the other airplanes as they would be of smaller dimensions and capacities.

It is true that the same type of aircraft does not operate at an airport for all destinations, but here an estimate of the aircraft will be made to generalize the design.

In the beginning, the airplanes that operate in the airlines that opened the airport were selected [46]. But, it must be taken into account that the analysis is of interest to be carried out in the long term so that the airport is assured the possibility of continuing to function well.

Therefore, if we calculate approximately the number of passengers per flight in the realistic scenario in year 2036 4.34, an average of **170 passengers per plane** or operation leaves.

Then, we will choose a design aircraft that covers this number of passengers in order to put ourselves in the most extreme operating conditions to be able to design the air side based on this reference aircraft.

To select the aircraft, we first gather all the aircraft models belonging to the fleet of the airlines operating at the new airport.

Analyzing that data (**Appendix J**), different conclusions ate obtained:

- On average, an aircraft is needed that can carry at least 170 passengers, therefore some of them can already be ruled out (A319-100, B737-800 and B737-300).
- All aircraft are narrow-body (fuselage width is less than 5 m).
- The Boeing 757-200 will be scrapped as it only operates on one airline and the one with the least traffic at the new airport.
- Of the Airbus models that remain in the selection, the ones with the highest MTOW will be chosen. These are the A321-200 and the A321neo.
- The final decision is obtained by analyzing the MTOW of the two aircraft that remain in the selection because if we want the runways to serve any aircraft that operates at the airport, we must choose the one that needs the longest runway length to operate. The one with the maximum takeoff weight is the A321neo.
- There are two A321neo models so we will choose the one with the highest weights (**Table** 6.1) to take the whole analysis to the most extreme case. This is the WV072 model.

Table 6.1: Aircraft weight characteristics A321neo [47].

Weights	WV071 (ACF)	WV072 (ACF)
Maximum Ramp Weight (MRW) Maximum Taxi Weight (MTW)	97.400 kg (214.730 lb)	97.400 kg (214.730 lb)
Maximum Take-Off Weight (MTOW)	97.000 kg (213.848 lb)	97.000 kg (213.848 lb)
Maximum Landing Weight (MLW)	77.300 kg (170.417 lb)	79.200 kg (174.606 lb)
Maximum Zero Fuel Weight (MZFW)	73.300 kg (161.599 lb)	75.600 kg (166.669 lb)

En conclusión, se escogerá la siguiente aeronave para el diseño:

$$\boxed{Design\ aircraft \rightarrow A321\ Neo\ WV072\ (ACF)}$$

Fig. 6.1. A321neo (ACF). Source: [48]

In addition, this aircraft belongs to the fleet of the two airlines that produce the most traffic at the Sárbogárd-Sárhatvan Airport. Its dimensional and performance characteristics are presented in **Appendix K**.

6.1.2 Aeroplane reference field length (ARFL).

Analyzing this parameter (ARFL) we will obtain the number that makes up the ARC of the new airport. The maximum value of this parameter will be needed among all the airplanes operating at the airport.

That is, the minimum field length necessary to take off is required with the following characteristics [9]:

- At the maximum certified take-off mass (MTOW).
- At sea level (0 ft).
- In standard atmospheric conditions (ISA).
- Without considering air speed.
- Considering that the track has no slope.

We should take into account that "the determination of the aeroplane reference field length is solely for the selection of a code number and is not intended to influence the actual runway length provided"[9].

This will be seen later, when the runway length is determined.

Using the following graph to analyze the runway length as a function of the take-off weight of the design aircraft, we will obtain the minimum runway length the aircraft would need to take off with the maximum take-off weight.

$$MTOW\ design\ aircraft = 97\ Tonnes$$

We must analyze the results on the zero line since we are in conditions at sea level. A modification will be made to the graph taken from the *Aircraft Characteristics airport and maintenance planning (A321)* [47].

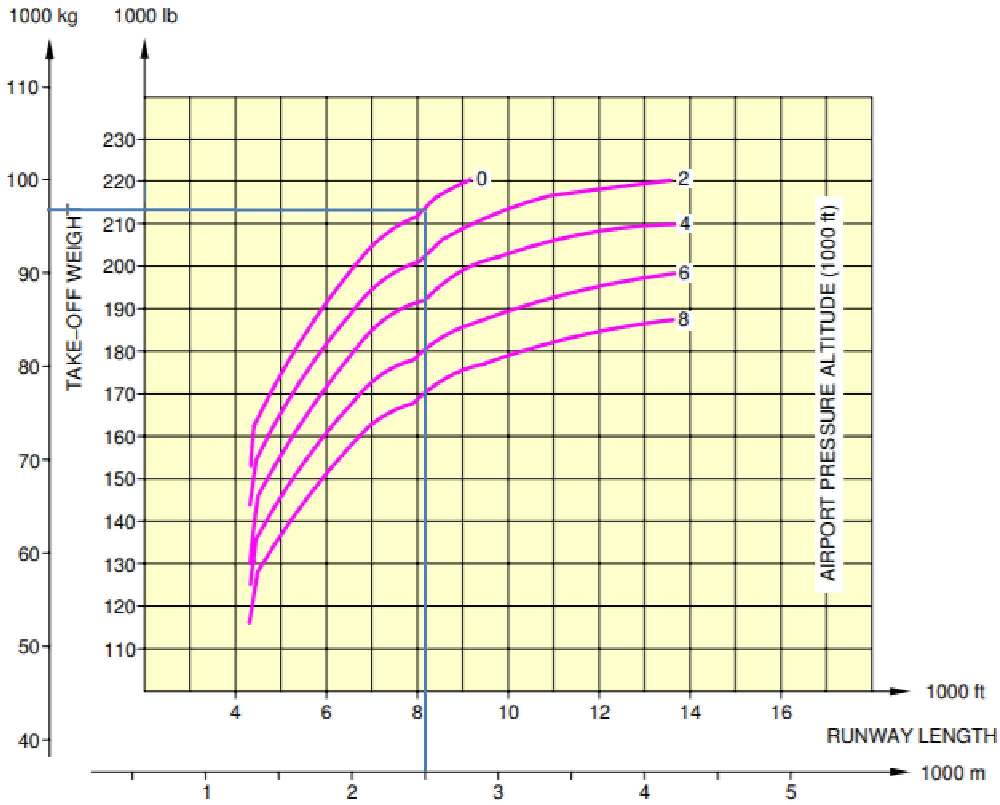

Fig. 6.2. Take-off Weight Limitation - ISA Conditions (A321neo - LEAP-1A Series Engine). Source: [47] [Own elaboration (Word)]

Therefore, the Airplane reference field length is:

$$\boxed{ARFL = 2.500\ m}$$

6.1.3 Airport Reference Code (ARC)

Finally, the following assignment defined by ICAO in Annex 14 will be used to give an ARC to the design airport.

Table 1-1. Aerodrome reference code
(see 1.6.2 to 1.6.4)

Code element 1		Code element 2		
Code number (1)	Aeroplane reference field length (2)	Code letter (3)	Wingspan (4)	Outer main gear wheel span[a] (5)
1	Less than 800 m	A	Up to but not including 15 m	Up to but not including 4.5 m
2	800 m up to but not including 1 200 m	B	15 m up to but not including 24 m	4.5 m up to but not including 6 m
3	1 200 m up to but not including 1 800 m	C	24 m up to but not including 36 m	6 m up to but not including 9 m
4	1 800 m and over	D	36 m up to but not including 52 m	9 m up to but not including 14 m
		E	52 m up to but not including 65 m	9 m up to but not including 14 m
		F	65 m up to but not including 80 m	14 m up to but not including 16 m

a. Distance between the outside edges of the main gear wheels.

Fig. 6.3. Aerodrome reference code, Annex 14, Chapter 1. Source: [9]

Based on the results obtained in the previous points (**Point** 6.1.1 and **Point** 6.1.2), the airport reference code (ARC) will be determined.

The design aircraft, the A321neo (ACF), is already known. From **Appendix K**, we get its wingspan and the outer main gear wheel span (wheel track):

Table 6.2: Data to obtain the number of the ARC [47].

Description	Symbol	Value (m)
Wingspan	b	35,8
Wheel Track	W_T	8,97

We see in the **Figure** 6.3 that the letter assigned for the ARC, although it is at the limit, is the **letter C**.

Finally, using the results of the **Point** 6.1.2, we obtain that the assigned number will be the **number 4**, since the ARFL exceeds 1.800 m in length.

The new airport is therefore assigned the following Airport Reference Code:

$$\boxed{ARC \rightarrow 4C}$$

This reference code will serve to define the ICAO regulations that will be used to plan and design the air side of the airport.

6.2 Airside Design

In this part, everything related to the aircraft movement space, the air side, will be defined. Basically, it is made up of three components: the runways, the taxiways and the parking platform.

6.2.1 Runways.

Runways could be defined as the most important part of an airport, since without them, airplanes would not be able to take off or land. Therefore, it is necessary to study the number of runways that the new airport would need, their orientation and their dimensions.

6.2.1.1 Runway operational capacity.

To determine the number of runways needed at the airport, the method proposed by the FAA in report RD-74-124 will be used.

The idea is to calculate the hourly capacity from some graphs or a table.

First of all, we must calculate what the mixing ratio is according to the type of aircraft that will fly at the new airport.

The expression for the mix index is as follows:

$$i = \%C + 3 \cdot (\%D) \tag{6.1}$$

In other words, the percentage of medium-sized aircraft (more than 5.670 kg and less than 136.000 kg) that operate at the airport is added three times the percentage of large aircraft (more than 136.000 kg).

As seen in textbf Point **Point** 6.1.1 and **Point** 6.1.3, the aircraft taken as reference is medium (C), therefore, it will be considered to operate at 100 % of medium-sized aircraft at the new airport and, therefore, 0 % of large aircraft (D).

$$i = 100 + 3 \cdot (0) = 100$$

$$\boxed{i = 100}$$

Once this result of the mixing index has been obtained, the number of runways that the new airport would need can be analyzed using the classification obtained from the *Airport Engineering notes (UPC)* [49] and which can be found in **Appendix L**. Initially, only the one and two-runway configurations will be analyzed.

We see that for a mix index of 100, the new airport could operate with a single runway. The index is between 81 and 120 so, the maximum capacity of operation per hour VFR are 55 op/h and IFR 53 op/h. According to the results obtained, at the peak hour of our airport in the reference year for the design (2036) there would be about 27 operations (**Table** 4.33), result within the mentioned margin. Therefore, with a runway it could already operate

Runways configuration	Mix Index %(C+3D)	Capacity Operations/hour VFR	IFR	Annual Service Volume Operations/hour
	0 to 20	98	59	230.000
	21 to 50	74	57	195.000
1.	51 to 80	63	56	205.000
	81 to 120	55	53	210.000
	121 to 180	51	50	240.000

Fig. 6.4. Runways configurations - One runway results. Source: [49] [Own elaboration (Word)]

In the next point, this conclusion that only one runway is needed will be reinforced.

6.2.1.2 Runway approach category.

To determine the category of approximation, we will go to the most conservative extreme. The approximation will be **precision instruments**.

Defining an airport with visual approximations could only be said to be very optimistic. In the end, in Europe there is good visibility in most airports, but in order to give greater landing efficiency when there are adverse conditions, it is more appropriate to declare instrumental approaches, with visual aids.

Within this type of runway approach there are non-precision approach runways and precision approach runways. They will be designed as precision tracks. This type of runway approach receives both visual and non-visual aids since they consist of radio aids through antennas such as ILS or VOR. Thus, aircraft can receive radio aid to align themselves with the runway center line during landing, an aspect that gives greater operational safety when visibility is reduced or null.

Finally, within precision there are different categories. A summary table and the decision of the type of category of the new airport will be presented below. The category is important to give different dimensions to the runway and its surroundings and to determine the type of aids necessary to carry out the approach.

Table 6.3: Precision approach runway categories. Source: [9]

Category		Decision Height (DH)	Visual Range (VR)
CAT I		$\geq$ 60 m (200 ft)	$\geq$ 550 m
CAT II		30 m (100 ft) $\leq$ DH $<$ 60 m (200 ft)	$\geq$ 300 m
CAT III	**CAT III A**	$<$ 30 (100 ft) m	$\geq$ 175 m
	CAT III B	$<$ 15 m (50 ft)	50 m $\leq$ VR $<$ 175 m
	CAT III C	0 m	0 m

As not enough information can be obtained to estimate the most convenient type of category, we will go to the most conservative, category III and, within this to the most "permissive", Category III A.

In addition, we know that the location of the airport is a fairly suitable area in terms of meteorology. For example, Budapest airport has two runways, one of category II and one of category III B [50]. This airport in the Hungarian capital has been the reference throughout the project so it will also be used as an indication to choose a category.

$$\boxed{Runway\ approach\ category \rightarrow CAT\ III\ A}$$

Therefore, the airport allows VFR operations, Nighttime VFR operations and IFR operations (CAT III A).

6.2.1.3 Landing and Take-off distances of the aircraft.

To determine these distances, the maximum weights in each phase of the plane will be used. In addition, correction factors for elevation, temperature and slope will be applied in case the distances cannot be found directly to the altitude and the corresponding temperature.

Following the *Aerodrome Design Manual* [51], we obtain the pertinent corrections that will be applied on the base distances calculated at ISA conditions at sea level (D).

- **Elevation correction**: "The basic length selected for the track should be increased at the rate of 7% for each 300 m elevation" (3.5.2) [51].

$$C_H = D + (D \cdot 0,07 \cdot \frac{H}{300}) \tag{6.2}$$

- **Temperature correction**: "The runway length determined in accordance with 3.5.2 should in turn be increased at a rate of 1 % for every 1°C that the aerodrome reference temperature exceeds the standard atmospheric temperature corresponding to the aerodrome elevation." (3.5.3) [51].

$$C_T = C_H + C_H \cdot 0,01 \cdot (T_{ref} - T_H) \tag{6.3}$$

- **Slope correction**: This correction will not be applied since the runway is considered flat, its longitudinal slope will be 0 %.

Next, the data necessary to apply these corrections will be presented.

Table 6.4: Data to apply corrections to declare runway lengths.

Conditions	Sea Level	Airport	
Altitude (ft)	0	325	
Temperature (°C)	15	T_H= 14,35	T_{ref}= 29
Runway Slope (%)	-	0 %	

-Altitude: We know the altitude at sea level to be 0 m and, at the airport, we know it because the approximate location of the airport has already been determined before, whose altitude is about 325 ft (≈ 100 m) according to **Figure** 5.8.

-Temperature: The temperature at 0 meters of altitude is also predefined [51] and the temperature at 100 meters of elevation of the airport is obtained using the following expression that we also know:

$$T(H) = T_{SL} + G \cdot (H - H_{SL}) \tag{6.4}$$

$$T(100\ m) = 15\ °C - 6,5 \cdot 10^{-3}\ °C/m \cdot (100\ m - 0\ m) = 14,35\ °C$$

(G: Standard thermal gradient).

And the reference temperature of the airport is estimated according to **Figure** 5.5 since it is the average temperature of the area in the hottest months, which are the ones that interest us, as recommended in Annex 14 (2.4.2) [9]: " The aerodrome reference temperature should be the monthly mean of the daily maximum temperatures for the hottest month of the year (the hottest month being that which has the highest monthly mean temperature)".

- Slope: Obtaining the value of the runway slope will be explained in **Point** 6.2.1.7.

Landing distance

To determine the landing distance, the characteristics and performance document of the airport chosen as the design aircraft will be used, the A321Neo WV072 (ACF) [47], at **Point** 6.1.1.

Using the Maximum Landing Weight (MLW) value from the **Table** 6.1 we can obtain the landing field length at 325 ft, with an approach, and it is obtained the following diagram:

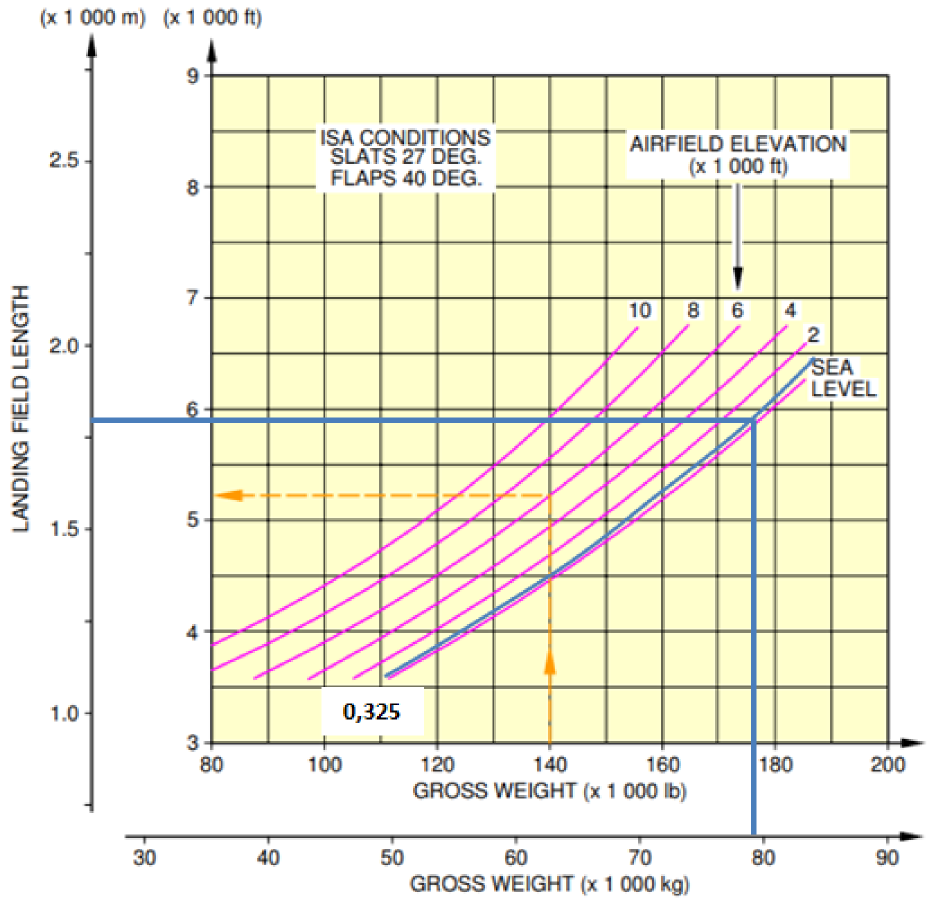

Fig. 6.5. Landing Field Length A321Neo WV072 (ACF) - ISA Conditions (CFM56 Series Engine). Source: [47] [Own elaboration (Word)].

Therefore, an MLW of 79.200 kg gives a landing field length at 325 ft of approximately **1.800 m**. Now it would only be necessary to carry out the pertinent temperature correction.

$$C_T = 1.800,00 + 1.800,00 \cdot 0,01 \cdot (29 - 14,35) = 2.063,70 \ m$$

The landing field length will be the one found through the corrections since there is no graph in conditions other than the ISA. And, the landing distance, is the same as the landing field length so it is not necessary to increase the length by 65%. The result obtained is:

$$\boxed{Landing \ distance \ = \ 2.064 \ m}$$

Take-off distance

On the other hand, to calculate this distance, unlike before, a diagram provided by the manufacturer of the aircraft chosen as the design aircraft will be used directly, since it will always be more precise than the general correction method applied in the previous case. As already seen, the reference temperature of the new airport is 29 °C so the commented diagram can be used under ISA conditions +15°C (≈ 29°C). In addition to the already determined MTOW of 19.700 kg and the altitude of 325 ft.

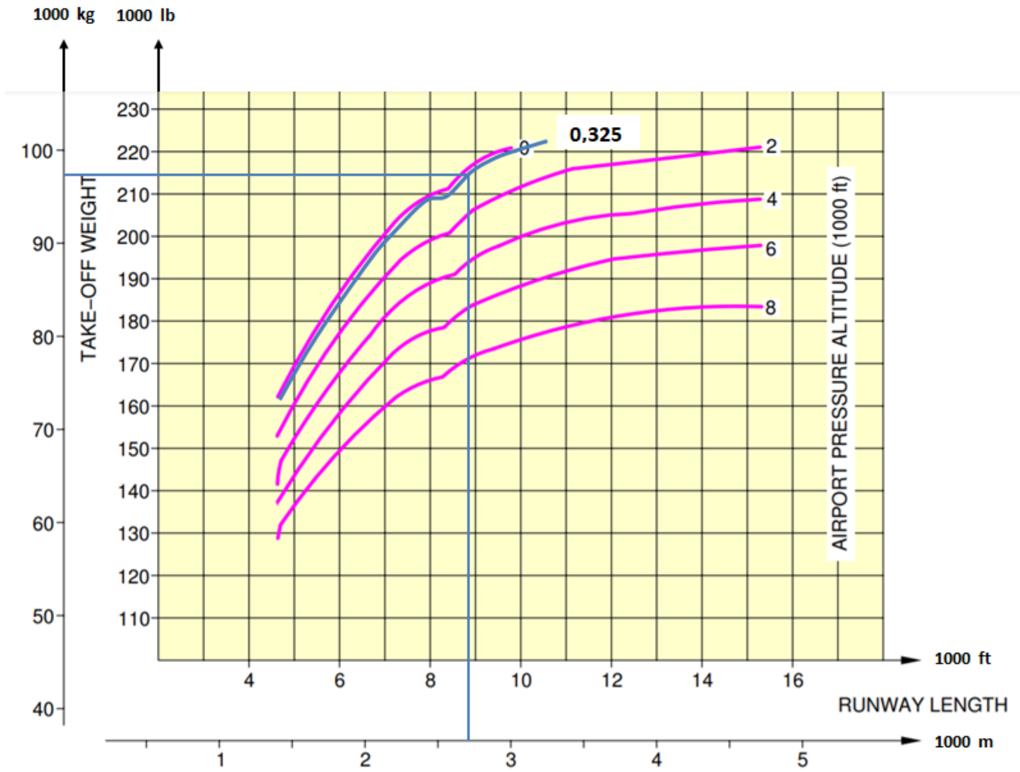

Fig. 6.6. Take-Off Weight Limitation - ISA +15°C (+27°F) Conditions. Source: [47] [Own elaboration (Word)]

With the estimation on the graph of the 325 ft curve, we find that runway length is 2.700 meters. But this will not be the take-off distance, is the distance traveled at take-off from rest until the airplane is 50 ft above the ground, considering the MTOW. So, to find the final take-off distance without considering engine failure, the found of 2.700 meters will be increased by 15 % [52].

$$\boxed{Take - off\ distance\ =\ 3.105\ m}$$

6.2.1.4 Runway orientation.

According to ICAO Annex 14 - Volume 1 [9]: "The number and orientation of runways at an aerodrome should be such that the usability factor of the aerodrome is not less than 95 per cent for the aeroplanes that the aerodrome is intended to serve". This usability factor is the percentage of the total annual hours that the wind acts in all directions except in the direction of the cross wind to the runway that exceeds a certain speed. ICAO says the following verbatim:

Recommendation.— *In the application of 3.1.1 it should be assumed that landing or take-off of aeroplanes is, in normal circumstances, precluded when the crosswind component exceeds:*

— *37 km/h (20 kt) in the case of aeroplanes whose reference field length is 1 500 m or over, except that when poor runway braking action owing to an insufficient longitudinal coefficient of friction is experienced with some frequency, a crosswind component not exceeding 24 km/h (13 kt) should be assumed;*

— *24 km/h (13 kt) in the case of aeroplanes whose reference field length is 1 200 m or up to but not including 1 500 m; and*

— *19 km/h (10 kt) in the case of aeroplanes whose reference field length is less than 1 200 m.*

Fig. 6.7. Choice of maximum permissible crosswind components. Source: [9]

In other words, to calculate the usability factor, the speed from which the chosen design aircraft could not operate at the airport must be determined.

As has already been determined, the ARFL is 2.500 m, therefore we would be in the first case. We could choose 37 km/h (20 kt) as the transverse wind speed of operation limitation, but since we want to analyze and design taking the most restrictive characteristics, we will also analyze the results for a transverse limit speed of 24 km/h (13 kt).

Once these limit speeds have been determined, the wind will be analyzed in the airport location area. The city of **Sárbógárd** will be taken as a reference for the analysis.

Analysis of wind performance

To analyze the wind activity in the positioning area of the new airport, the wind rose of the city of Sárbogárd will be presented. This wind rosette shows the average number of hours per year that the wind "blows" in each direction and at each speed.

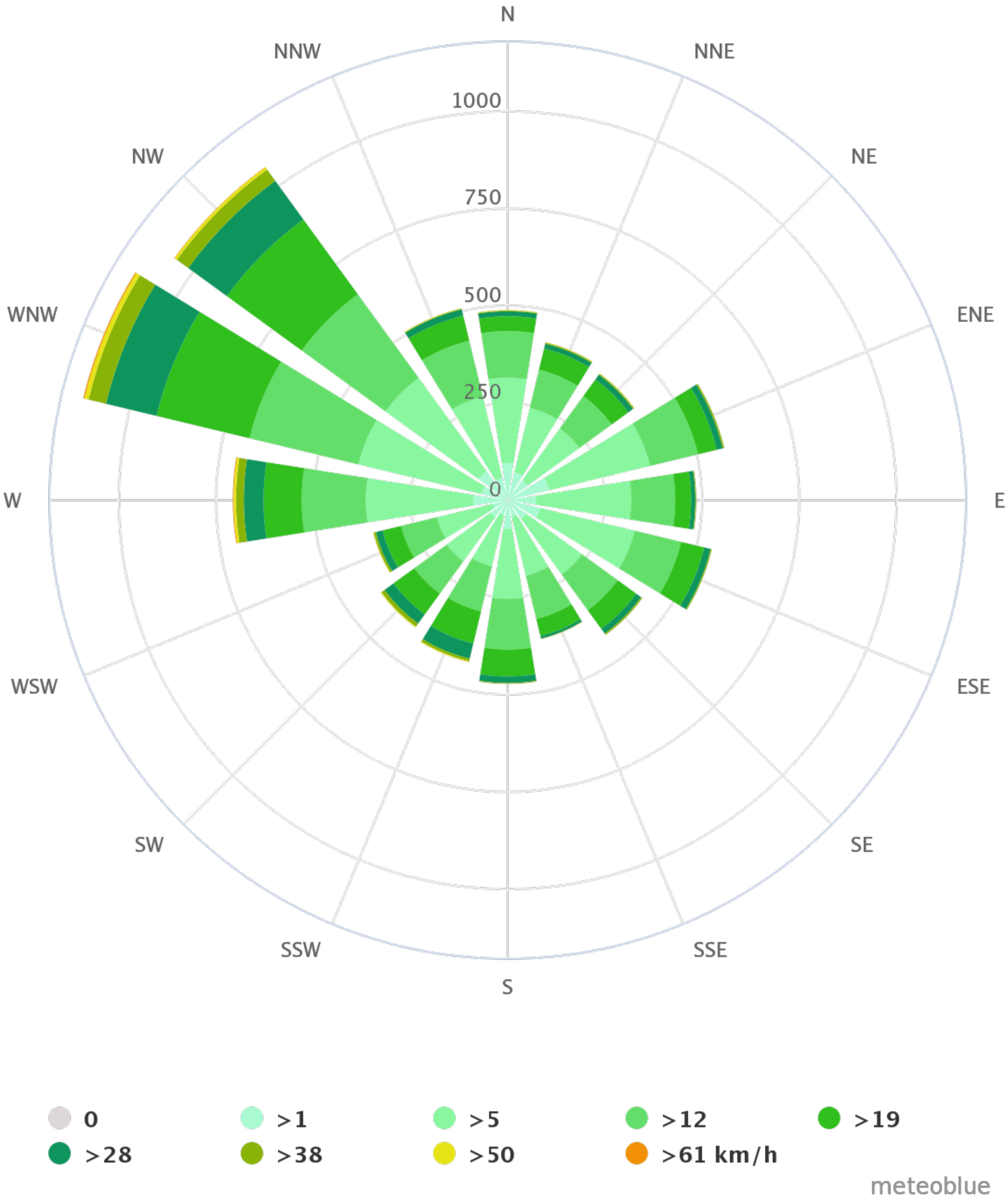

Fig. 6.8. Sárbogárd Wind Rose. Source: [22]

Extrapolating the results of this wind direction and frequency study diagram, the following table is presented, which we will need later.

Table 6.5: Direction, speed and frequency of the wind in Sárbogárd.

Wind direction	Wind velocity (kt)									T direct. (h/y)
	0 - 1 kt	**1 - 5 kt**	**5 - 12 kt**	**12 - 19 kt**	**19 - 28 kt**	**28 - 38 kt**	**38 - 50 kt**	**50 - 61 kt**	**> 61 kt**	
N	5	91	219	120	38	13	2	1	0	489
NNE	4	70	170	101	56	13	3	1	0	418
NE	1	63	164	103	53	15	3	1	0	403
ENE	4	106	267	127	49	16	4	0	0	573
E	0	73	245	113	41	11	2	0	0	485
ESE	3	83	250	123	61	17	3	0	0	540
SE	1	58	177	114	59	15	4	0	0	428
SSE	0	45	155	114	45	7	1	0	0	367
S	9	65	180	130	69	17	2	0	0	472
SSW	1	39	135	119	85	40	7	2	0	428
SW	3	51	140	103	66	29	10	2	0	404
WSW	0	40	147	95	49	18	6	1	0	356
W	4	85	276	165	98	51	20	6	2	707
WNW	1	68	326	288	246	134	46	11	3	1.123
NW	4	89	296	266	238	123	36	7	1	1.060
NNW	0	60	214	148	66	17	2	1	0	508
T vel. (h/y)	40	1.086	3.361	2.229	1.319	536	151	33	6	**TOTAL (h/y)** **8.761**

Frequency diagram

To find out the direction of the runway at the new airport, we will use the frequency diagram and the previous wind rosette.

The idea is to find the two contiguous directions with less wind frequency at a speed greater than the speed defined as the limit. That is, if we find the directions with this that meet the previous requirement, we will know the directions where the track will be oriented since they will be perpendicular. The idea is to achieve the maximum possible utilization coefficient and, taking into account, that it must be greater than 95 % as indicated in Annex 14 in point 3.1.1 [9]: “Recommendation: The number and orientation of runways at an aerodrome should be such that the usability factor of the aerodrome is not less than 95 per cent for the aeroplanes that the aerodrome is intended to serve”.

Therefore, we calculate the percentage of frequency in each direction and for each wind speed. Then, we add for each pair of addresses (NS, NNE-SSW, NE-SW, ENE-WSW, EW, ESE-WNW, SE-NW and SSE-NNW) the percentage of hours/year (h/y) with speeds above the limit speed.

As already mentioned, the performance of the wind will be analyzed for two limit speeds, one more restrictive and the other more permissive.

Table 6.6: Frequency with which the wind speed exceeds the limit speed of each pair of directions.

Directions	**Sum of speeds above the limit speed (%)**	
	Restrictive case (Limiting speed: 13 kt)	**Least restrictive case (Limiting speed: 20kt)**
N-S	4,474	1,621
NNE-SSW	4,874	2,363
NE-SW	4,394	2,043
ENE-WSW	4,166	1,632
E-W	5,810	2,637
ESE-WNW	10,638	5,947
SE-NW	9,850	5,513
SSE-NNW	4,577	1,587

If we find the graph of frequency with respect to direction, we will see in which pairs of directions the minimum is located.

Let’s emphasize that we want the minimums since this percentage is the frequency with which the track could not be used to operate. It will be subtracted from 100 % of hours per year that are operated at the airport (utilization coefficient).

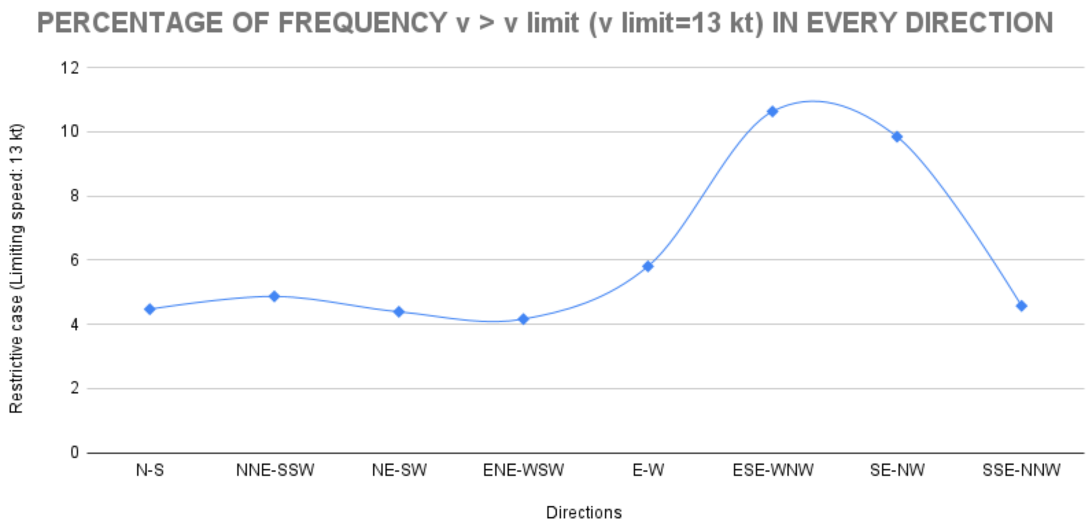

Fig. 6.9. Wind frequency restrictive case analysis. [Own elaboration (Excel)]

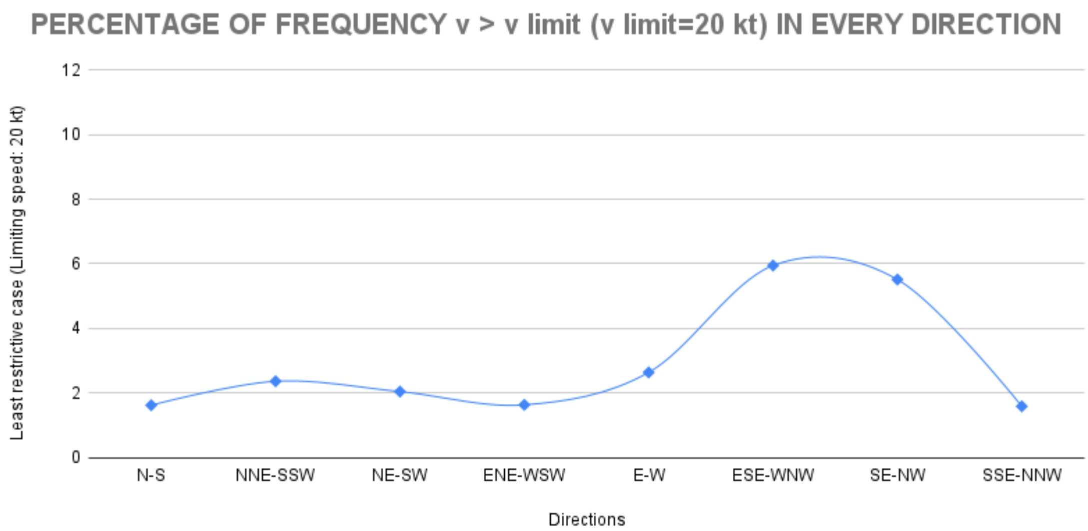

Fig. 6.10. Wind frequency less restrictive case analysis. [Own elaboration (Excel)]

- **Restrictive case:** minimums in ENE-WSW, NE-SW, N-S and SSE-NNW.
- **More permissive case:** minimums in SSE-NNW, N-S, ENE-WSW and NE-SW.

Consequently, the 4 directions perpendicular to those named will be analyzed, since the percentages found above would be the percentage of hours per year in which the runway could not be used due to a speed greater than the limit in these directions transverse to the runway. One of the following will be the orientation of the runway of the new airport.

These addresses will be: E-W, SE-NW, ENE-WSW and SSE-NNW. The wind rosette and the tracks drawn in each of these directions will be presented below.

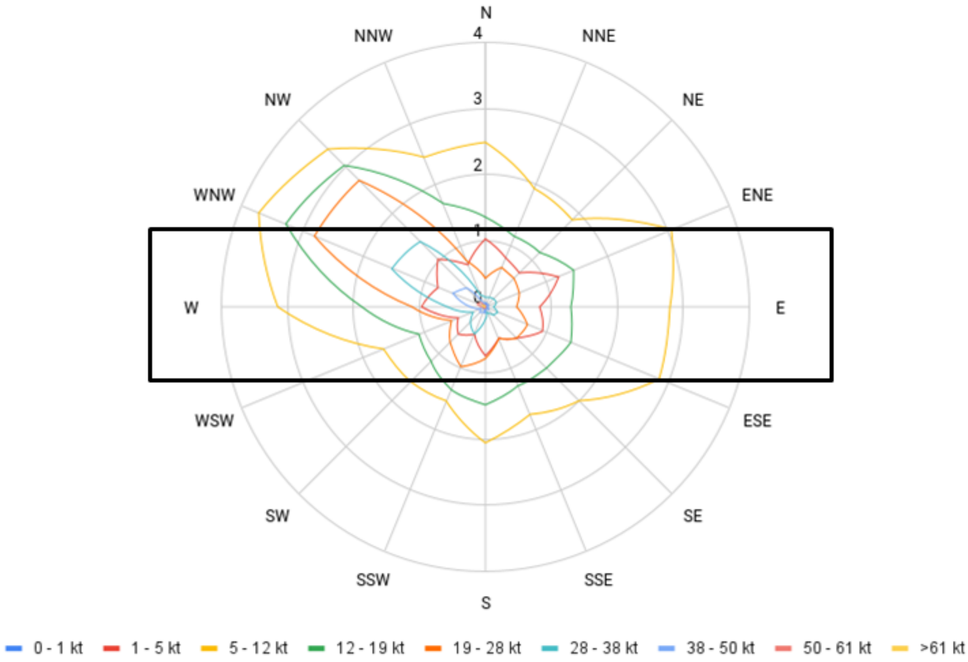

Fig. 6.11. Runway direction E-W. [Own elaboration (Excel & Word)]

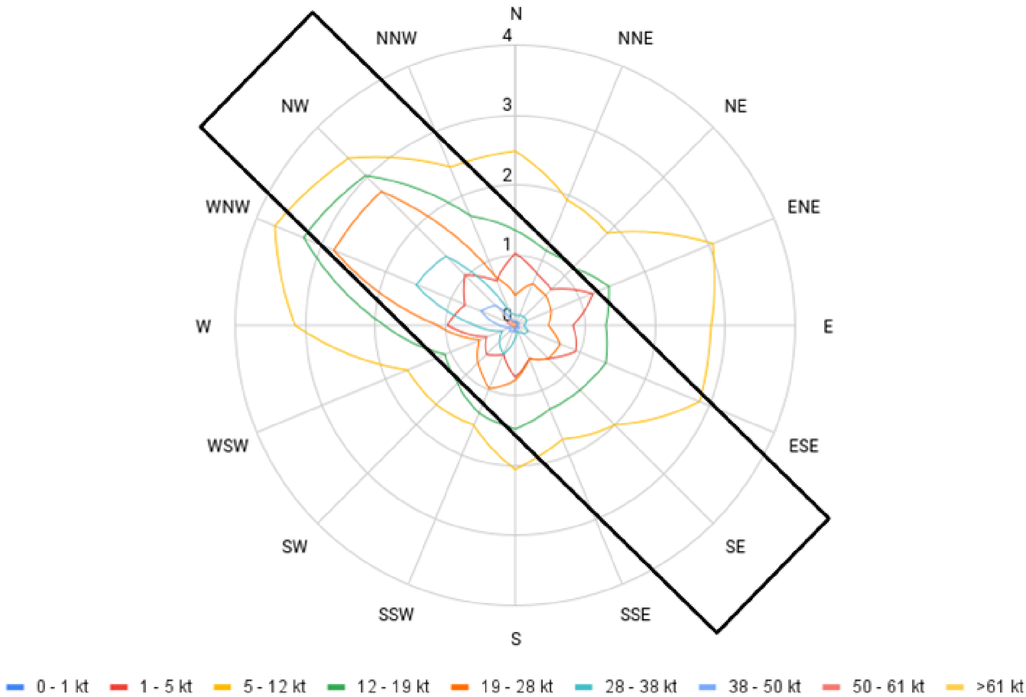

Fig. 6.12. Runway direction SE-NW [Own elaboration (Excel & Word)]

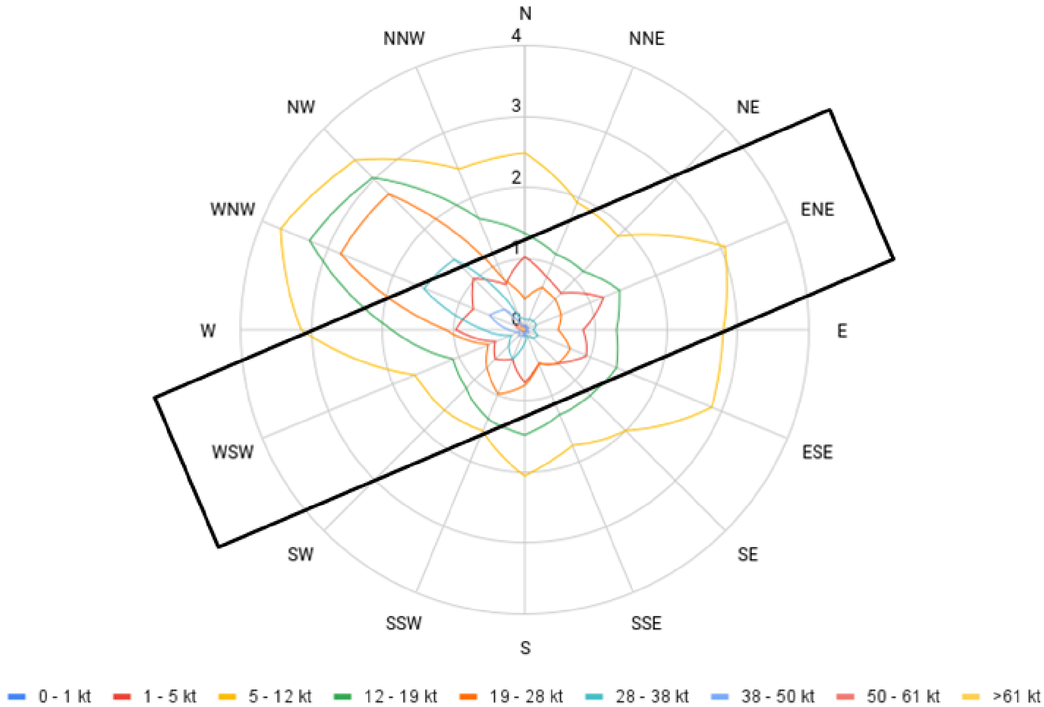

Fig. 6.13. Runway direction ENE-WSW [Own elaboration (Excel & Word)]

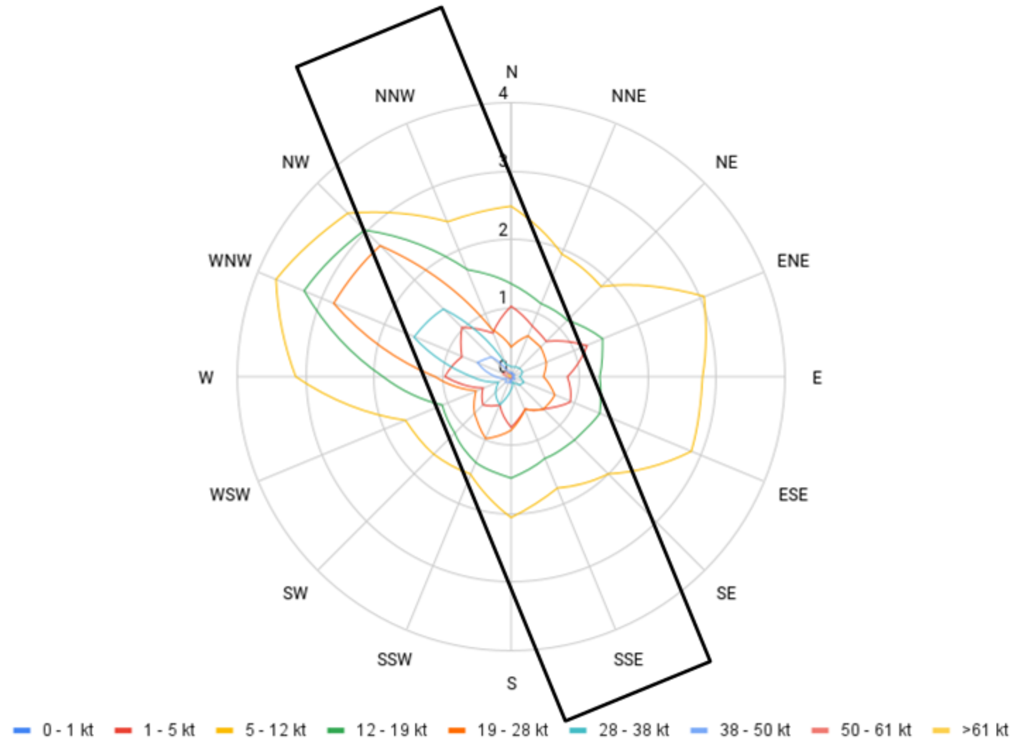

Fig. 6.14. Runway direction SSE-NNW [Own elaboration (Excel & Word)]

First, finding the diagram of the wind frequency in each direction we see that there is a maximum in WNW but this direction has already been discarded, therefore, we look at the second direction in which more wind "blows" and it is NW. If there is a lot of wind in this direction during the year it can decrease the efficiency in runway operations because if it is very strong and the plane is going against it, it needs a lot of power and if it is going in favor it could accelerate it excessively and increase its lift a lot. Therefore, this SE-NW address will be discarded. Furthermore, in neither of the two cases of limiting speed considered is the direction with which we obtain the maximum utilization coefficient.

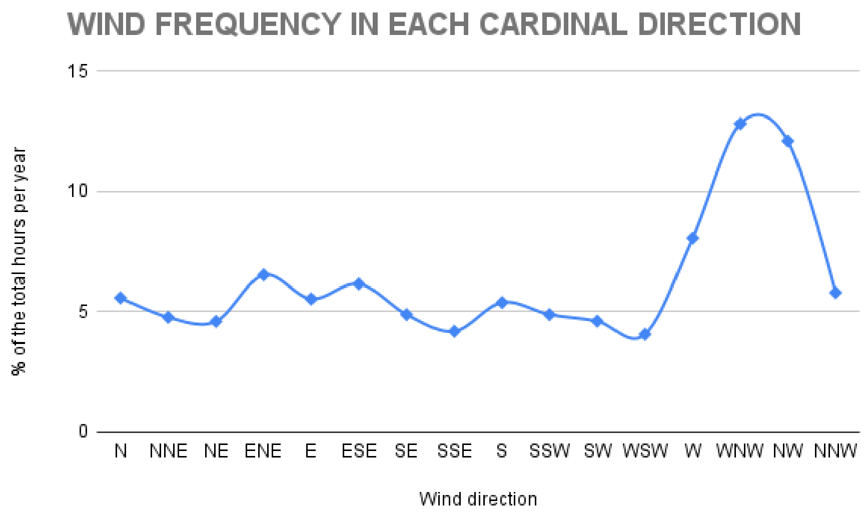

Fig. 6.15. Total percentage of wind over the total in each cardinal direction [Own elaboration (Excel)]

Then, we see that the minimum of the graph is in the WSW direction and this, from what was commented above, is a point in favor. Furthermore, this is one of the addresses of the address pair with which the highest utilization coefficient would be obtained (in the least restrictive case).

On the other hand, if we analyze the frequency with which each velocity occurs in each direction, the following diagram of stacked areas is obtained:

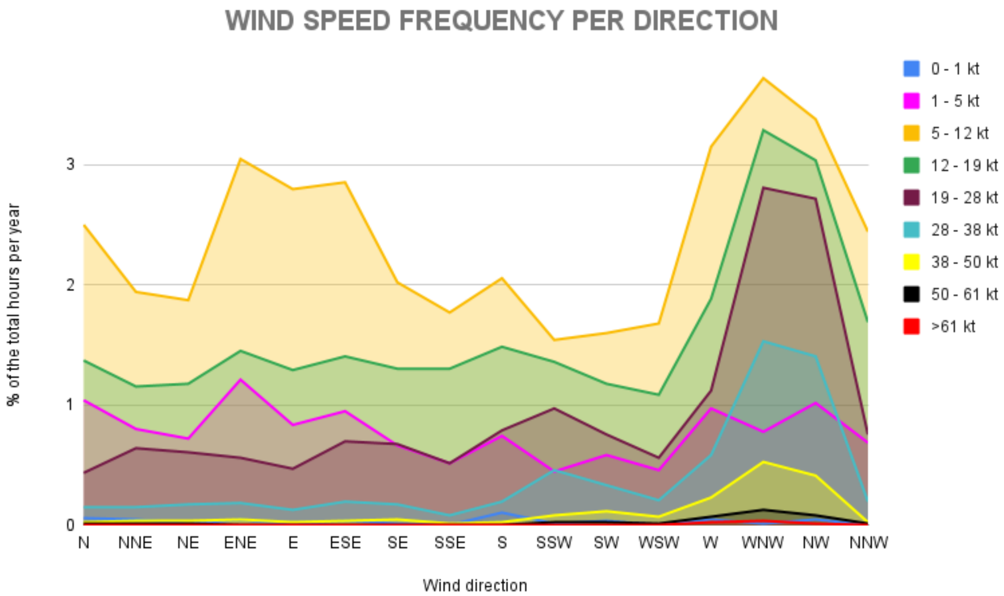

Fig. 6.16. Frequency with which each velocity occurs in each cardinal direction. [Own elaboration (Excel)]

In this diagram it can be seen that the minimum in the speeds above the limit speeds are in a direction of the potentials to select. In the 19-28 kt range, the minimum is in the cardinal N direction and in the E. We are interested in the percentage of wind action in this speed range in the E direction, which is 0,43 %. We see that this percentage is not significant (it does not even reach 1 %), and this direction does not give the maximum utilization coefficient in either of the two cases analyzed. Therefore, the E-W address is also discarded.

If we give the graph a higher resolution, we will obtain the final conclusions.

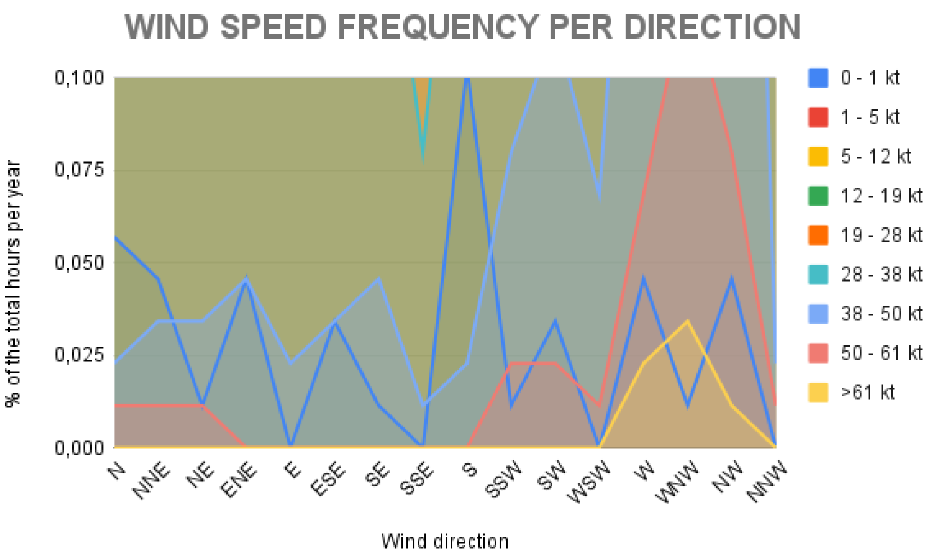

Fig. 6.17. More resolution - Frequency with which each velocity occurs in each cardinal direction. [Own elaboration (Excel)]

The diagram shows the minimums for the higher speed ranges (28 kt-38 kt, 38 kt-50 kt, 50 kt-61 kt,>61 kt). These minim points are in the SSE direction. Here it is the same as with the E direction since the speed percentage is so low that it would not be considered significant either.

On the other hand, if we go back to the diagram (**Figure** 6.17), we see that the minimum of the 12 kt-19 kt range is in WSW with 1,08 %. Compared to the previous ones, this one is significant.

Final orientation

If we see the results of the utility coefficient of the final addresses SSE-NNW and ENE-WSW, we see the following:

Table 6.7: Usability factor for the two final directions in the two analysis cases.

Direction	Usability factor (%)	
	Restrictive case (Limiting speed: 13 kt)	Least restrictive case (Limiting speed: 20kt)
SSE-NNW	95,83 %	98,37 %
ENE-WSW	95,42 %	98,41 %

For the least restrictive case, the utilization coefficient is very high and the maximum is given in ENE-WSW, but we see that it does not differ too much with the SSE-NNW direction (difference of 0,05 %). On the other hand, in the most restrictive case it is 0,41 %. Furthermore, in the least restrictive case the utilization coefficient is very high so this variation is not as important as it would be in the more restrictive case where the result is adjusted ($\approx$ 95%).

Ultimately, as we are interested in studying the most restrictive case, we will choose the direction **SSE-NNW**.

In addition, this chosen orientation is suitable in terms of topographic area and noise emissions. The following image shows the area where the new airport would be built and we see that there are no obstacles that could affect the use of the airport, such as urban centers, mountains, etc.

Fig. 6.18. More detailed location of the airport [16].

Furthermore, if we observe the compass rose (**Figure** 5.5) in the airport area, it can be seen that in the runway orientation directions, the wind does not blow too frequently, so that much noise pollution would not be emitted.

Therefore, it is decided to choose the commented orientation as the most "usable", the one with SSE-NNW orientation, that if we change it to degrees (Each quadrant (90º) has 4 portions so from direction to direction they will add 22,5º):

$$\boxed{Runway\ Orientation \rightarrow 112,5^\circ/292,5^\circ}$$

6.2.1.5 Runway designation.

To define the number to the track we must take into account the address previously found. We know that the meteorological directions are based on geographic north (azimuth), instead, the tracks are oriented according to magnetic north (bearings).

Therefore, to convert this azimuth orientation, the magnetic declination of the airport must be subtracted from the azimuth if it is in the East and added if it is in the West.

We will analyze the magnetic data of Sárbogárd (location of the airport).

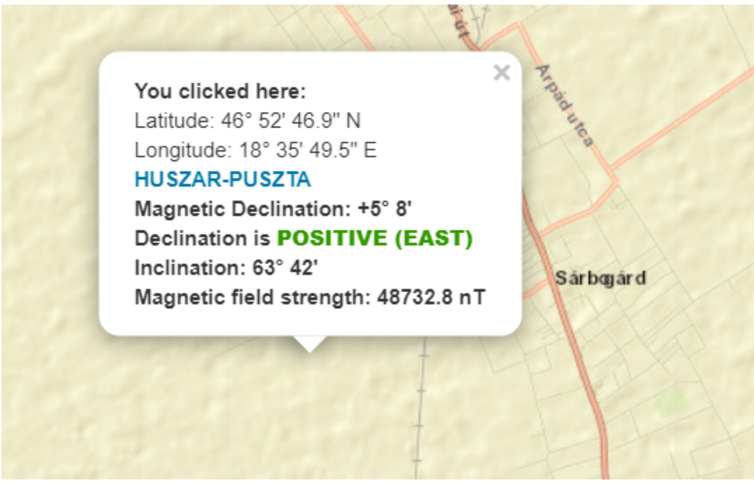

Fig. 6.19. Magnetic declination of the location of the airport using the World Magnetic Model WMM2020. Source: [53].

And, according to NOAA (National Centers for Environmental Information) [54], the same data is obtained with a redacted document (**Appendix M**).

We will thus obtain the magnetic orientation (heading) of the runway by subtracting the magnetic declination (δ) from the geographical direction (azimuth (ψ)) since the airport is located in the East.

$$\alpha = \psi - \delta \tag{6.5}$$

$$\alpha = 112,5^\circ - 5,13^\circ = 107,37^\circ$$

Therefore, to name the track, the magnetic orientation is approximated to the nearest ten sexagesimals. To find the denomination of the other head, add 180 degrees to the magnetic angle found ($180^\circ + 107^\circ = 287^\circ$).

Runway definition:

- **Runway 10**: magnetic orientation 107° (headland in the northeast, track orientation southwest).
- **Runway 28**: magnetic orientation 287° (headland in the southwest, northeast runway orientation).

The explanatory scheme of this denomination is presented below.

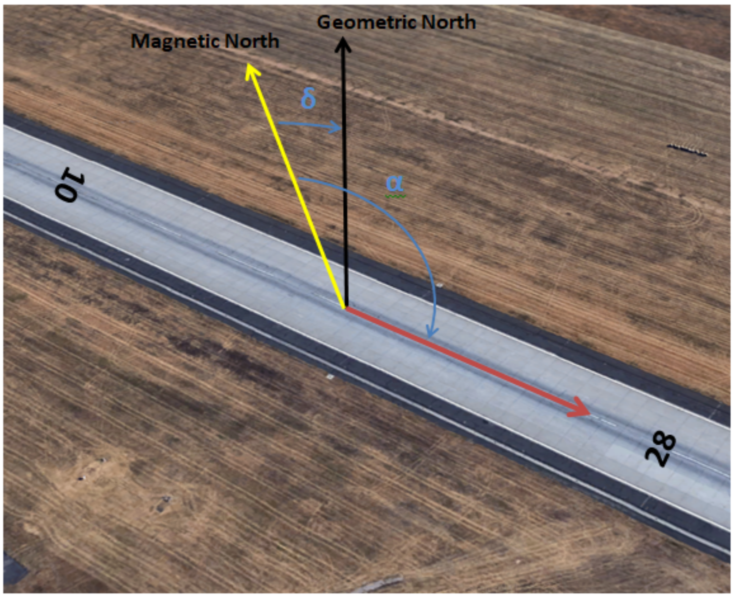

Fig. 6.20. Explanatory diagram of the runway name of the new airport. [Own elaboration (Word & Google Earth [16]].

It will not be necessary to define a letter since we only have one runway.

6.2.1.6 Declared runway distances.

Next, prior to the study runway dimensions, the distances declared in both directions of the new airport runway will be specified. These are the following:

- **Take-off distance available (TODA):** It corresponds to the entire length that an aircraft can use for take-off, whether it is a paved runway (TODA) or an obstacle-free zone (CWY).
- **Take-off run available (TORA):** This distance is equal to the distance that the airplane travels during takeoff from the beginning of this operation from the ground until it reaches 50 ft in height. Therefore, it is decided to asphalt the runway and the entire take-off distance, which, as already mentioned, is the run distance plus 15% of it. By paving all this take-off distance, it is being said that the TODA will be equal to the TORA. Therefore, no obstacle free zone (CWY) will be defined.
- **Accelerate-stop distance available (ASDA):** It is the length that an aircraft will have at its disposal to land at the new airport. To define this distance, the following hypothesis is defined, the ASDA. With the type of airport defined and the type of flights and airplanes that will operate in it, it is considered that any airplane that takes off will have a margin of error to brake in case of engine failure

or any inconvenience since the asphalt runway will be sufficient. In the end, with this consideration, the landing is also being made safe as there is a good range of distances and it will not be necessary to define a stop zone (SWY) either.

- **Landing distance available (LDA):** This distance will be considered equal to that available for take-off (TODA) since it is greater than the landing distance found. In addition, the runway threshold will not be defined as offset.

All this explanation will be reflected in the following table and the diagrams of the runway and its declared distances.

Table 6.8: Declared distances - Runways 10 and 28.

Runway	TORA (m)	ASDA (m)	TODA (m)	LDA (m)
10	3.105	3.105	3.105	3.105
28	3.105	3.105	3.105	3.105

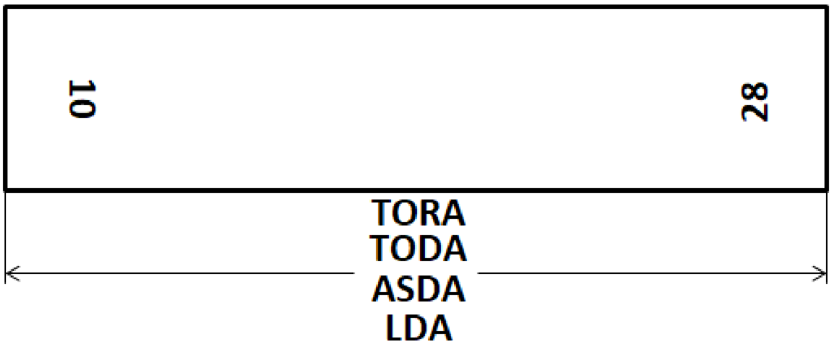

Fig. 6.21. Declared distances - Runway 10 and 28. [Own elaboration (Word)]

6.2.1.7 Runway and their surrounding dimensions.

<u>**Runways**</u>

- **Width:** The runway width is determined by a table, already established by ICAO in Annex 14 [9], based on the airport's ARC.

Code number	Code letter A	B	C	D	E	F
1[a]	*18 m*	*18 m*	*23 m*	–	–	–
2[a]	*23 m*	*23 m*	*30 m*	–	–	–
3	*30 m*	*30 m*	*30 m*	*45 m*	–	–
4	–	–	*45 m*	*45 m*	*45 m*	*60 m*

a. The width of a precision approach runway should be not less than 30 m where the code number is 1 or 2.

Fig. 6.22. Width of runways. Source:[9]

We see that in the case of this airport it must be 45 meters (ARC → 4C).

- **Slopes:**

  -Longitudinal slopes: According to ICAO, "The slope computed by dividing the difference between the maximum and minimum elevation along the runway centre line by the runway length should not exceed: 1 per cent where the code number is 3 or 4" [9]. In addition, in the first and last quarter of the runway length, this slope should not exceed 0,8 %. So, as has already been estimated at the point of landing and take-off distances (**Point** 6.2.1.3), the longitudinal slope is considered 0% on the runway.

  -Sight distance: If there is no choice but to design the track with a change in slope, it should be noted that the visibility from any point 3 m above the track can be seen from another at the same height.

  -Transverse slopes: This slope is important so that flooding does not occur on the track, therefore, when the letter of the ARC is a C, the slope must be 1,5 %. This should be maintained along the runway except when there is an intersection with a taxiway.

Table 6.9: Runway dimensions.

Parameter	Value
Length	3.105 m
Width	45 m
Transverse slope	1,5 %
Longitudinal slope	0 %

Runway shoulders

These margins are essential to "protect" the aircraft and the ground around the runway. Sometimes due to wind or heavy rain the aircraft can deviate from the runway and therefore it is important to establish this runway margin.

- **Width:** As determined by ICAO [9]:"The runway shoulders should extend symmetrically on each side of the runway so that the overall width of the runway and its shoulders is not less than 60 m where the code letter is D or E". In the case of this airport, the runway width is 45 m, so the ideal would be to determine margins of about 10 meters each so that the runway and the margins have a total width of 65 meters.
- **Slopes on runway shoulders:** The margins will be designed so that the end in contact with the runway is at the same level and the cross slope must not exceed 2,5 %.

Table 6.10: Runway shoulders dimensions.

Parameter	Value
Length	3.105 m
Width	10 x2 m
Transverse slope	1,5 %
Longitudinal slope	0 %

Runway turn pads

"Where the end of a runway is not served by a taxiway or a taxiway turnaround and where the code letter is A, B or C, a runway turn pad should be provided to facilitate a 180-degree turn of aeroplanes" (3.3.2) [9].

These platforms are required in the case where the runway does not have raceways at both ends. In this case, as will be seen later, the airport does have taxiways at both ends.

Runway strips

This is a safety zone. Runway strips are obstacle-free areas that are used in the event that the plane has a problem and goes off the runway. Therefore, these strips are parallel to the tracks and their margins.

- **Length:** The length of the strip must be greater than or equal to 60 meters from the end of the runway, in the case of the new airport. It is decided that this strip will be 65 meters from the end of the runway. No more will be given since the track is intended to have a stop zone and, therefore, an obstacle-free zone from each end.
- **Width:** The width of the strip must be such that from the runway center line it extends laterally at least 150 meters, therefore, it will be decided to give this lateral length from the runway center line to each side, since for airports with code number 4 it's enough.
- **Objects:** As far as possible, no objects shall be placed within this strip, except visual aids necessary for air navigation.
- **Slopes:**

  - Longitudinal slopes: As on the runway and on the margins, this slope must not exceed 1.5 %. It will be defined as 0 %.

  - Transverse slopes: Must be less than or equal to 2,5 % and will be set to 1,5 %.
- **Graded portion:** A level strip 150 meters wide will be designed (75 meters on each side from the runway center line).

Table 6.11: Runway strips dimensions.

Parameter	Value
Length	65 m
Width	300 m
Transverse slope	1,5 %
Longitudinal slope	0 %
Graded portion widths	(75 & 115) x2 m

Runway and safety areas (RESA)

These areas should be added to the design since the airport's ARC number is 4. It is desirable to have one at each end of the runway strip.

- **Length:** It must reach a length of 240 meters or more from the end of the runway and will be defined as a length of 265 meters from it. In other words, the runway strip extends longitudinally 65 meters from the end of the runway and the RESA starts from the end of the strip and extends 200 meters from it, thus between the two it reaches 265 meters in length from the end of the runway.

- **Width:** ICAO recommends the following: "The width of a runway end safety area should, wherever practicable, be equal to that of the graded portion of the associated runway strip (3.5.6)" [9]. Therefore, it will be defined as width of 150 meters for the RESA.
- **Slopes:**

  - Longitudinal slopes: It must have a downward slope of less than 5 %. It is determined as 0 %, like any slope of this type defined.

  - Transverse slopes: Upward or downward slope of less than 5 %. It is defined as 1,5 %.

Table 6.12: Runway and safety areas dimensions.

Parameter	Value
Length	200 m
Width	150 m
Transverse slope	1,5 %
Longitudinal slope	0 %

Finally, the dimensions of the runway and its surroundings are illustrated.

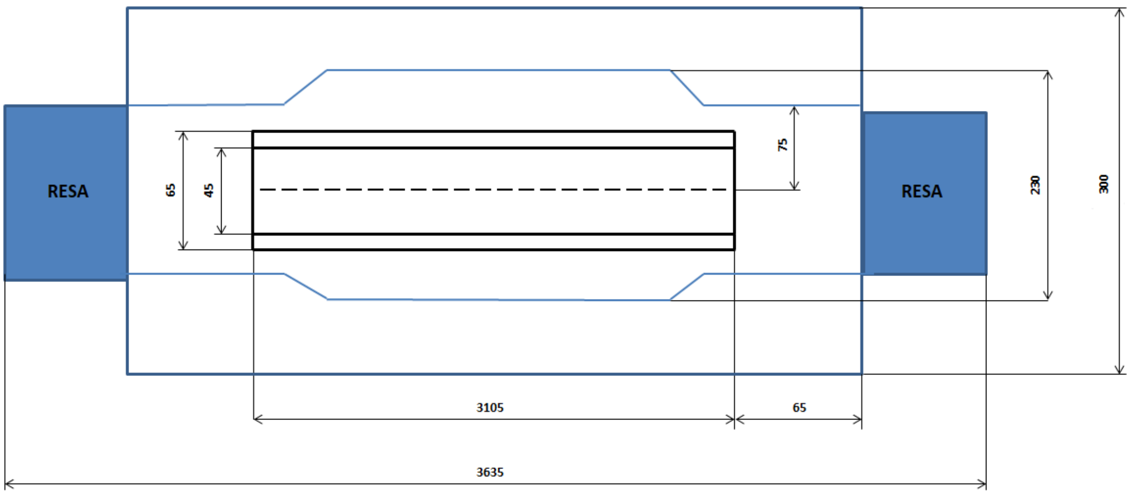

Fig. 6.23. Runway and their surroundings dimensions (m). [Own elaboration (Word)].

6.2.2 Taxiways.

These additional "runways" are required at an airport so that aircraft can access from the parking apron to the runways, and vice versa. They allow the plane to move quickly and safely.

As already determined, the design aircraft is class C and all aircraft operating at this airport will be considered to be of this class. On the other hand, the flow of air traffic is abundant, so it will be necessary to specify different taxiways, each one destined to a function. Based on these clarifications, the type and number of taxiways that the new airport will have will be exposed.

- **1 central taxiway, perpendicular to the runway:** This type of connection is available to practically all airports since aircraft can use it to exit the runway or to access it and, in addition, in case of emergency, this taxiway provides direct access from the terminal building and the taxi platforms. parking to the track and vice versa. This is an essential and basic element in terms of airport security.
- **2 rapid exit taxiways:** These taxiways are used so that the aircraft can leave the runway, once it has landed, in a faster and more efficient way. Therefore, a fast exit lane will be located near each end of the runway so that, depending on the wind gusts, an airplane, even landing on one side or the other, can quickly clear the runway.
- **2 holding bays:** These components will also be determined since ICAO recommends that an airport have these positions if its traffic is medium or high. As the new airport only has one runway and it is estimated that it will have a fairly dense annual traffic, it has been decided to add one holding bay to each end of the runway. They will be located at the intersection between the runway and the taxiways.
- **2 taxiways parallel to the runway:** Ultimately, in any runway design, if some are determined perpendicular or not parallel to the runway, parallel taxiways must also be designed to be able to access the parking aprons and flow airside traffic. In this case, two taxiways are designed parallel to the runway because having a considerably dense traffic, this design allows more aircraft movement at the same time and this results in a greater number of operations.

The dimensions of these taxiways will then be determined and their layout will be specified at **Point** 6.2.3.

6.2.2.1 Taxiways dimensions.

General taxiway dimensions

- **Clearance distance on straight points:** This is the distance between the outer main wheel and the edge of the taxiway and it is defined that it should not be less than 3 meters for ARC with letter C, according to Annex 14 [9]. Therefore, a distance of 5.5 meters will be given since the design aircraft has a wheel base of 8,97 meters, thus it will have room for maneuver.
- **Clearance distance on curved points:** In curved points, for the most extreme case of aircraft type, with a wheel base greater than 18 m this distance must be greater than 4,5 meters. Although the chosen design aircraft model (A321neo) has a wheel base of 16,90 m, it is chosen to give 5,5 meters (the same as for the straight sections) so that the aircraft can make a more efficient turn.
- **Width:** For a letter C airport the width of the taxiways must be greater than 15 meters. It will be defined as 20 meters.

  Next, comment that the following diagram is an "ideal" scheme on the distances that must be defined in the curves and in the straight areas of the taxiways for a 135 degree turn. Obviously, the plane is not always centered on the taxiway, therefore, more extreme distances have been defined, especially in the curved parts.

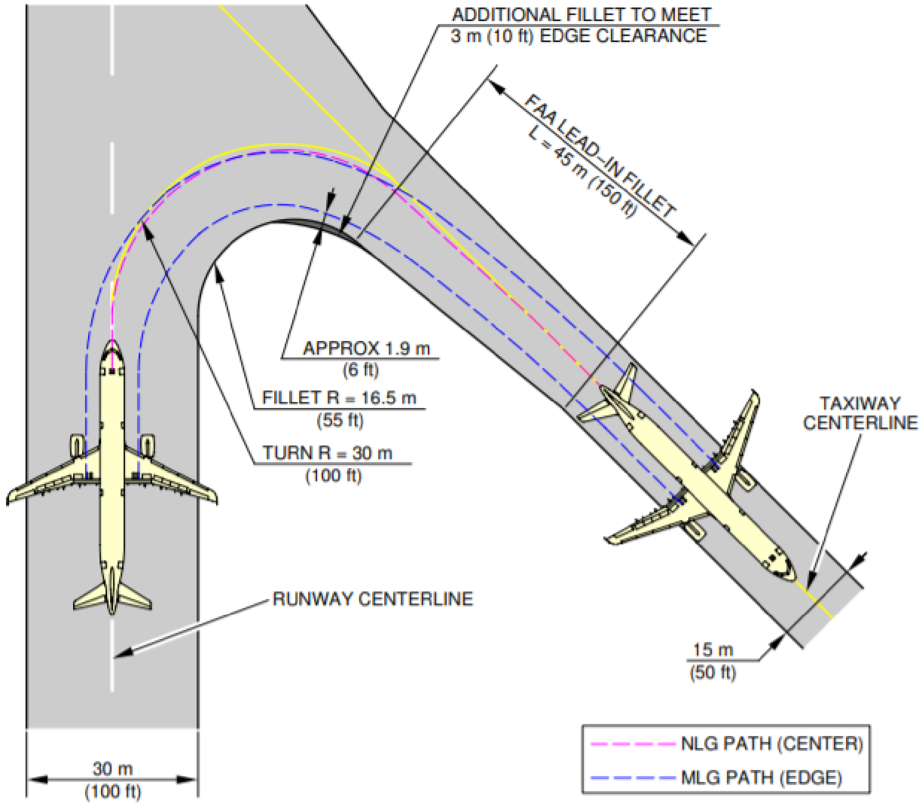

Fig. 6.24. 135° Turn - Runway to Taxiway (Cockpit Over Centerline Method). Source: [47]

- **Slopes:**

  -Longitudinal slopes: It must not be greater than 1.5 %. It is determined to be 0 %, as the slope of the runway.

  -Transverse slopes: The maximum of 1.5 % is chosen.

- **Taxiway minimum separation distances:** Of the distances in the following table, exactly 2 of the most important for the design will be defined.

Table 3-1. Taxiway minimum separation distances

Code letter	Distance between taxiway centre line and runway centre line (metres) — Instrument runways Code number 1	2	3	4	Non-instrument runways Code number 1	2	3	4	Taxiway centre line to taxiway centre line (metres)	Taxiway, other than aircraft stand taxilane, centre line to object (metres)	Aircraft stand taxilane centre line to aircraft stand taxilane centre line (metres)	Aircraft stand taxilane centre line to object (metres)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A	82.5	82.5	–	–	37.5	47.5	–	–	23	15.5	19.5	12
B	87	87	–	–	42	52	–	–	32	20	28.5	16.5
C	–	–	168	–	–	–	93	–	44	26	40.5	22.5
D	–	–	176	176	–	–	101	101	63	37	59.5	33.5
E	–	–	–	182.5	–	–	–	107.5	76	43.5	72.5	40
F	–	–	–	190	–	–	–	115	91	51	87.5	47.5

Note 1.— The separation distances shown in columns (2) to (9) represent ordinary combinations of runways and taxiways. The basis for development of these distances is given in the Aerodrome Design Manual *(Doc 9157), Part 2.*

Note 2.— The distances in columns (2) to (9) do not guarantee sufficient clearance behind a holding aeroplane to permit the passing of another aeroplane on a parallel taxiway. See the Aerodrome Design Manual *(Doc 9157), Part 2.*

Fig. 6.25. Taxiway minimum separation distances. Source: [9].

-Distance between taxiway and runway center lines: It is defined as 250 meters since between these there will be a holding bay.

-Distance between taxiway and another taxiway center lines: This distance will be ed 45 meters.

Table 6.13: Taxiways general dimensions.

Parameter	Value	
Clearance distance	5,5 x2 m	
Width	20 m	
Transverse slope	1,5 %	
Longitudinal slope	0 %	
Distance between taxiway	Taxiway	45 m
	Runway	250 m

Taxiways shoulders

- **Width:** The straight parts of the taxiways must have margins wide enough to give a total width (street and margins) equal to or greater than 25 meters. If the width of the streets of the new airport is 20 meters, the margins will be determined as 5 meters on each side of the taxiway. That is, the total width between taxiway and shoulders is 30 meters. In the curved parts these margins of 5 meters will be maintained.

Table 6.14: Taxiway shoulders dimensions.

Parameter	Value
Width	5 x2 m
Length	The same as the taxiway

Taxiways strips

- **Width:** From the center line of the taxiway, this strip must be 26 meters or more. The taxiway margin ends at 15 meters from the center of the street, so the strip will be established at just 26 meters from the axis.
- **Graded portion:** As for the slopes, the strip has a graded area. The distance from this to the street axis is defined as 15 meters on each side of the central axis. According to ICAO this area should be greater than 12,5 meters in each part of the axis if the OMGWS distance (Outer width between wheels of the main landing gear) is between 6 meters and 9 meters not included, in the case of the design aircraft. It is 8,97 meters, so 12,5 meters are not fair.
- **Slopes:** The strip surface is designed level with the taxiway edge by margin (0 %). And, the upward transverse slope of the graded portion, will be 1,5 % (it must be less than 2,5 %).

Table 6.15: Taxiway strips dimensions.

<table>
<tr><th>Parameter</th><th colspan="2">Value</th></tr>
<tr><td>Width</td><td colspan="2">26 x2 m</td></tr>
<tr><td>Graded portion widths</td><td colspan="2">15 x2 m</td></tr>
<tr><td rowspan="2">Slopes</td><td>Strip</td><td>0 %</td></tr>
<tr><td>Graded portion (upward transverse)</td><td>1,5 %</td></tr>
</table>

Rapid exit taxiways

Its basic measurements coincide with those established for the taxiways in general.

- **Radius of turn-off curve:** It will be the minimum required, 550 meters.
- **Exit speeds under wet conditions:** With a radius of curvature of 550 meters, a departure speed of 97 km/h is allowed.
- **Intersection angle with the runway:** The recommended 30° is chosen.

Table 6.16: Rapid exit taxiway dimensions.

Parameter	Value
Radius of turn-off curve	550 m
Exit speeds under wet conditions	$\leq 97\ km/h$
Intersection angle with the runway	30°

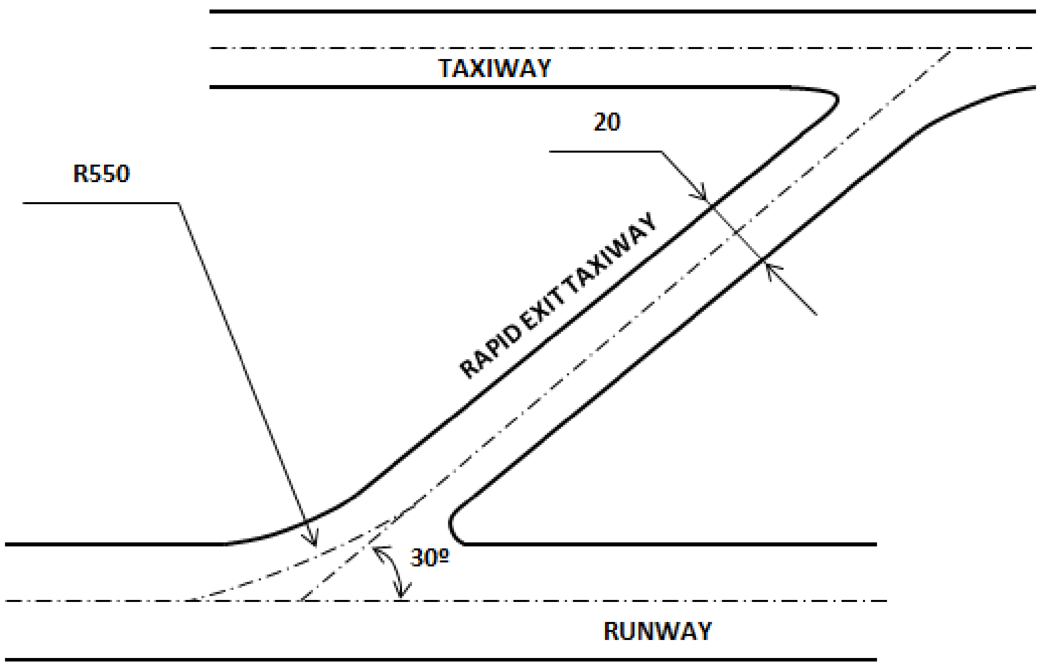

Fig. 6.26. Rapid exit taxiway dimensions (m). [Own elaboration (Word)]

Holding bays

- **Distance to the runway center line:** It is decided that it will be the established minimum of 90 meters since the design aircraft fully complies with the measures established as standard for this distance between axes.

Table 3-2. Minimum distance from the runway centre line to a holding bay, runway-holding position or road-holding position

Type of runway	Code number 1	2	3	4
Non-instrument	30 m	40 m	75 m	75 m
Non-precision approach	40 m	40 m	75 m	75 m
Precision approach category I	60 m[b]	60 m[b]	90 m[a,b]	90 m[a,b,c]
Precision approach categories II and III	—	—	90 m[a,b]	90 m[a,b,c]
Take-off runway	30 m	40 m	75 m	75 m

Fig. 6.27. Minimum distance from the runway centre line to the holding bay. Source: [9].

- **Length:** It must be about 180 meters.
- **Maximum point width:** From the extreme closest to the taxiing point to the closest to the holding point, it will be defined about 110 meters in width.

Table 6.17: Holding bays dimensions.

Parameter	Value
Distance to the runway center line	90 m
Length	≈155 m
Maximum point width	≈110 m

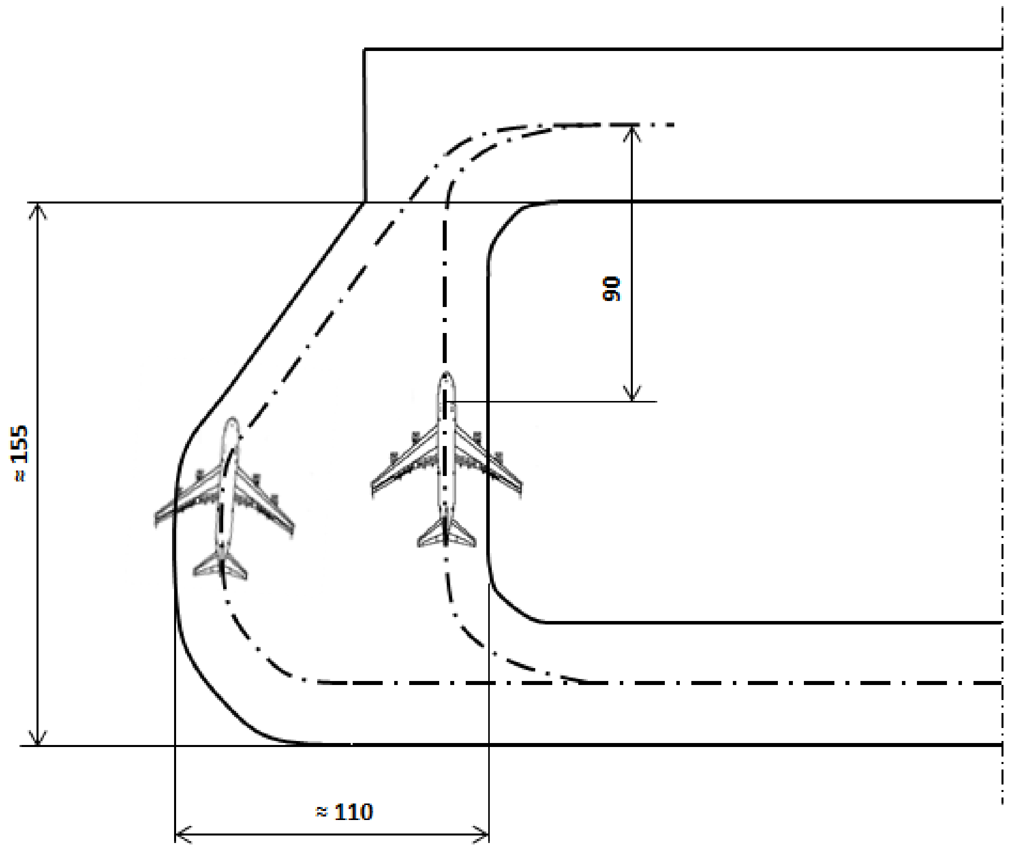

Fig. 6.28. Holding bay dimensions (m). [Own elaboration (Word)].

6.2.3 Runway and taxiways arrangement.

The following illustration shows the decisions made regarding the number of taxiways and their layout.

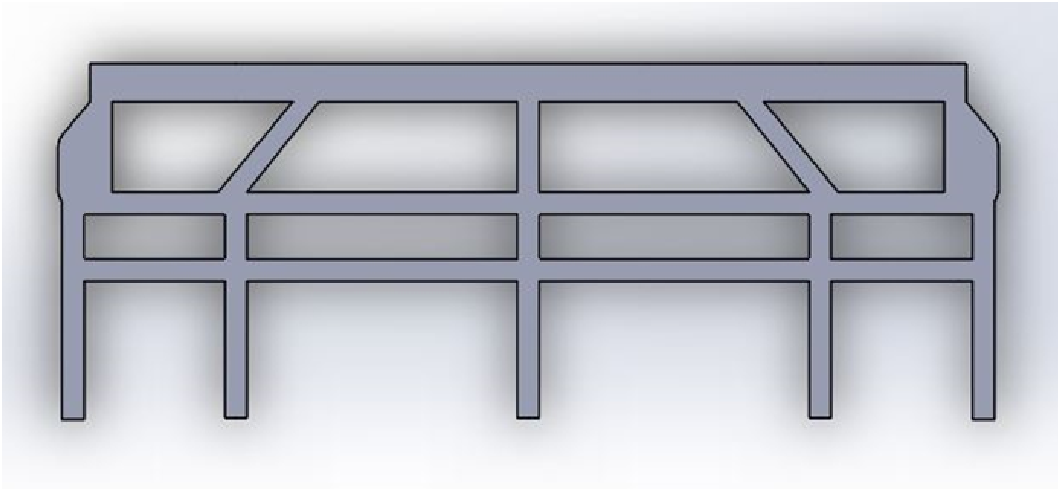

Fig. 6.29. Runway and taxiway arrangement. [Own elaboration (Solidworks)]

6.2.4 Parking platforms.

The use of these platforms is recommended in Annex 14 as it streamlines air operations at the airport since aircraft can be prepared and passenger loading is streamlined.

As we already know, the airport is intended for commercial passenger flights and type C aircraft, therefore these platforms will be designed based on it.

They will be designed so that passengers can access, the majority, directly from the terminal (terminal parking platforms, finger distribution), but this will be seen in the land side design.

Next, the dimensions of the parking spaces for each aircraft will be defined.

6.2.4.1 Apron dimensions.

General apron dimensions

The two main dimensions that are, the length and the width, will be determined based on a table that assigns a numerical code to each aircraft family [55]. In the case of the new airport, the aircraft defined as the design aircraft is part of the Airbus A320, as seen in the **Appendix J**.

- **Type of apron:** The V code will be chosen since the dimensions of the VI (A320 family) are quite adjusted to the A321neo design aircraft since its length is 44,51 meters and that of the VI code post is 46,5 meters.
- **Width:** 44 meters.
- **Length:** 54,5 meters.
- **Slopes:** In the aircraft stands the slope less than or equal to 1%.

Clearance distances on aircraft stands

ICAO recommends designing parking stalls leaving minimum distances between the aircraft when entering or exiting it and the buildings, other aircraft, stalls or others that are nearby. In the case of this airport, being the letter C, the declared minimum distance is 4,5 meters.

Table 6.18: Apron dimensions - Type V [55].

Parameter	Value
Width	44 m
Length	54,5 m
Slopes	$\leq 1\%$
Clearance distances	$\geq 4,5\ m$

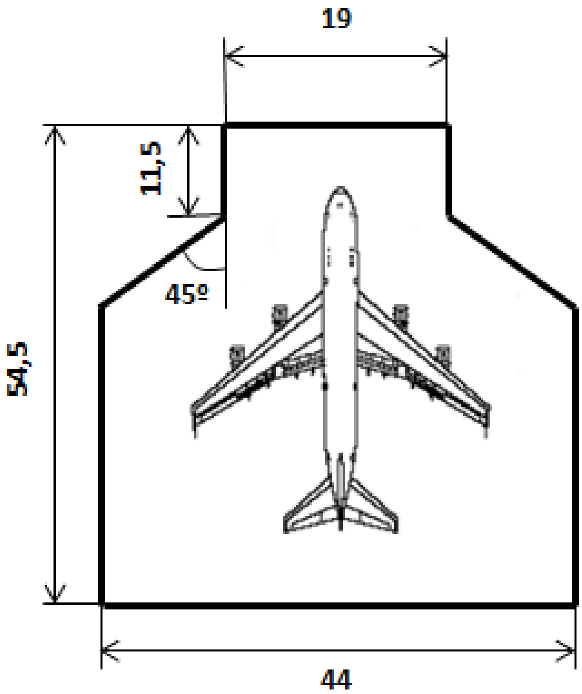

Fig. 6.30. Apron type V dimensions (m). Sources: [56] (plane) and [55] (data) [Own elaboration (Word)]

As will be seen later, the number of parking spaces and their disposition will influence the type of in-plant terminal to be designed.

To deduce this number of parking platforms, the results obtained in the Demand Analysis on the number of operations at rush hour will be used. This most extreme case will be studied since the decisions and parameters obtained are sure to be used for all other hours of the year. That is, if we design based on the maximum number of operations in one hour, we make sure that in no case will there be a problem of aircraft parking space or collapse, in no case would there be more than 27 operations in one hour, because that is why this is the time tip of the year 2036.

If we consider that of the 27 operations at rush hour, a maximum of 15 of them are departures (take-offs), we see the following:

$$15\ departures \rightarrow 60\ minutes\ (One\ hour)$$

$$1\ departures \rightarrow 4\ minutes$$

Rotations of 60 minutes would be carried out at the airport, being very conservative, since they are usually 30-45 minutes. In these rotations, at most, there would be one takeoff every 4 minutes to allow 15 operations in the 60 minutes of rotation. This means that if there are fewer takeoffs in 60 minutes, there would be a considerable time between operations. This margin has been given to be put in the most extreme case. Based on this decision, it is established that the total number of aprons must be 15 or more. As will be explained later, it was decided to put 6 remote accesses to the aircraft and 12 finger accesses, direct from the terminal building. A total of 18 since they would be just enough to cover the traffic at the airport's rush hour (15) plus some extras to give more fluidity to the traffic and, in case of expansion of the airport and increase in the number of operations and passengers, that the airport can cover it with the same efficiency.

$$\boxed{Number\ of\ aprons = 18\ aprons}$$

6.2.4.2 Parking platform arrangement

The distribution of this area of the airport is basic to define the subsystems within the terminal building. Logically, a basic principle is that the planes are parked on the side of the terminal that faces the taxiways and the runway. And, always, the determined measures of the aprons (**Figure** 6.30) must be considered for their distribution along the front of building.

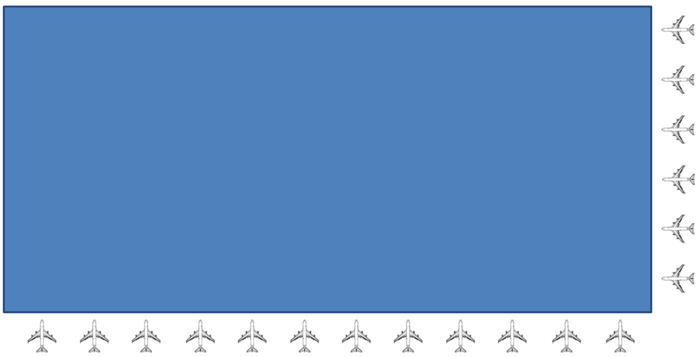

Fig. 6.31. Parking platform distribution. Source: [56] (plane) [Own elaboration (Word)]

As we can see, another aspect to point out is that all the finger connections are located in the front part of the terminal building facing the runway and on one of the sides, the remote parking platforms would be located, to which passengers must walk directly or by bus. In this case they would arrive on foot as it is a fairly safe area and close to the passenger terminal. In the drawing it is not fully appreciated that the lateral parking platforms are remote, but in the explanation it has already been determined.

Furthermore, this layout allows aircraft to access the taxiways safely, quickly and easily since there is plenty of room to maneuver.

6.2.5 Other airside components.

In this project, in reference to the airside, the aircraft's movement zones have been analyzed and designed.

At the same time, there are the easements and the visual aids that are also part of this area of the airport. These components are also essential in an infrastructure as such because they help aircraft to conduct their operations safely and efficiently.

The visual aids are divided into three groups, which are governed by their location and dimensioned by Annex 14 [9]. These are [57] the horizontal markings (runway markings, taxiway and aircraft stand), aeronautical lights (general, aeronautical beacons and lighting systems, runway lighting system, street lighting system). taxiing and stop lights, platform lighting and visual berthing guidance system) and aeronautical signs (general, mandatory instruction and information signs, VOR, aerodrome and aircraft stand identification signs and roadside waiting sign) .

Then, the easements are divided into 4 groups, according to the way in which they provide continuity and security or the signal they use (physical, radio, operational and acoustic). These easements are also determined according to Annex 14 [9]

6.3 Landside Design

The land side or terminal area is intended for passenger movements at the airport. As well as on the air side, the typology, distribution and different circulation flows in some important areas to be defined in the terminal building will be determined.

An airport consists of different infrastructures located on the land side. These are: the terminal building, aircraft maintenance and repair areas, cargo treatment areas, commercial and industrial areas, parking and access points and aeronautical auxiliary buildings such as the control tower.

In this project, we will focus on the terminal building and analyze its most important features.

6.3.1 Passenger terminal.

It will be explained what form and how the building will be dosed. It will be analyzed in plan, elevation and internally, through the subsystems that are part of it.

6.3.1.1 Terminal building typology.

Here, based on the type of airport that has been defined throughout the study, the plan and elevation form of the passenger terminal will be defined.

6.3.1.2 Factors to consider.

- **Traffic segment:** The type of traffic that the new airport will have is international. Among the destinations with which all but one destination is connected, they are part of Europe. But, within Europe, as already studied, some countries belong to the SCH space and to the EU and others do not. The following countries are not part of the

Schengen area and have a connection to the airport: Albania, Azerbaijan, Bosnia-Herzegovina, Cyprus, Bulgaria, Georgia, Israel, Kazakhstan, Kosovo, Macedonia, Montenegro, Romania, Russia, Ukraine and United Kingdom. Then, the following are not part of the EU: Albania, Azerbaijan, Bosnia-Herzegovina, Georgia, Iceland, Israel, Kazakhstan, Kosovo, Macedonia, Norway, Russia, Switzerland, Ukraine and United Kingdom. This will be important to consider when distributing spaces in the airport since to travel to or come from countries that are outside the SCH area, a passport is required.

- **Type of traffic:** Based on the results obtained during the traffic study, the predominant flights at the new airport are international scheduled flights. And, mostly, they will be defined as **short-haul international flights** (less than six hours of travel).
- **Traffic demand:** It will also be important to consider the estimated traffic demand in the Demand Analysis chapter (**Chapter** 4) As the hourly, daily and annual results in the year of design, 2036.

6.3.1.3 Typology in plant.

It is decided that the airport will have a single terminal because based on the estimated traffic, it follows that with a terminal building of considerable dimensions, it is enough to cover the flow of passengers obtained.

Then, regarding the type of design, a **linear structure** will be determined. This is decided based on the passenger traffic obtained. In the end, with an estimated annual number of passengers in the design year (2036) of 9 million passengers, approximately, enough contact positions are needed so that the flow of passengers does not collapse and they can board directly to the plane, establishing a finger configuration that will later be seen.

In **Figure** 6.31 this type of shape is seen in a linear plan, specifically, it will be rectangular. This configuration afford enough space to establish sufficient contact positions to cover the traffic of this airport and so that the planes can maneuver perfectly.

The idea is the following, represented in a very basic way to see only the situation and the linear shape of the terminal building. The parking platforms still need to be drawn as the airside taxiways just end.

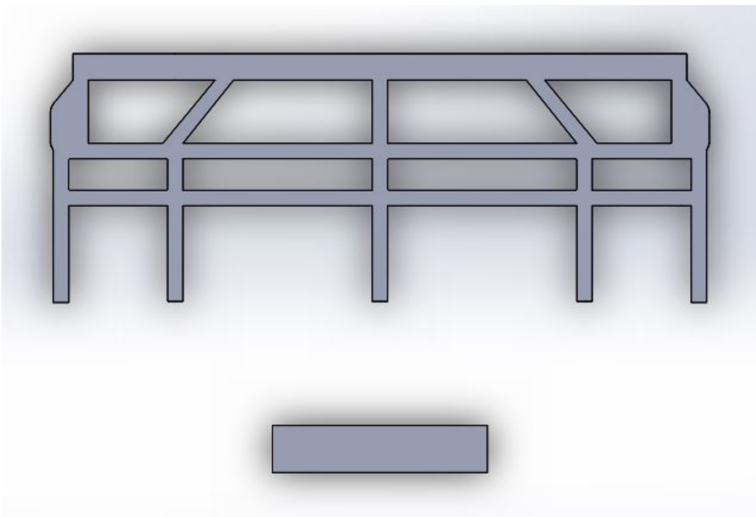

Fig. 6.32. Typology in plant of the terminal. [Own elaboration (Solidworks)]

6.3.1.4 Elevation typology.

Regarding the estimated annual traffic flow (it far exceeds one million passengers per year), it is decided to give it **two levels**. But, it will be considered that all passengers enter and leave through level 0, therefore, it is defined as a building with a **floor and a half**. In addition, as a linear plan typology has been determined, there will be a lot of capacity for parking platforms and connections may be one-way, direct from the terminal to the aircraft, an aspect that makes traffic flow more at the airport. And, it will also have additional remote platforms lateral to the building.

Furthermore, another point in favor of having two levels is that the building can be better organized and divisions can be made between departures and arrivals or connections UE, not UE, SCH or not SCH.

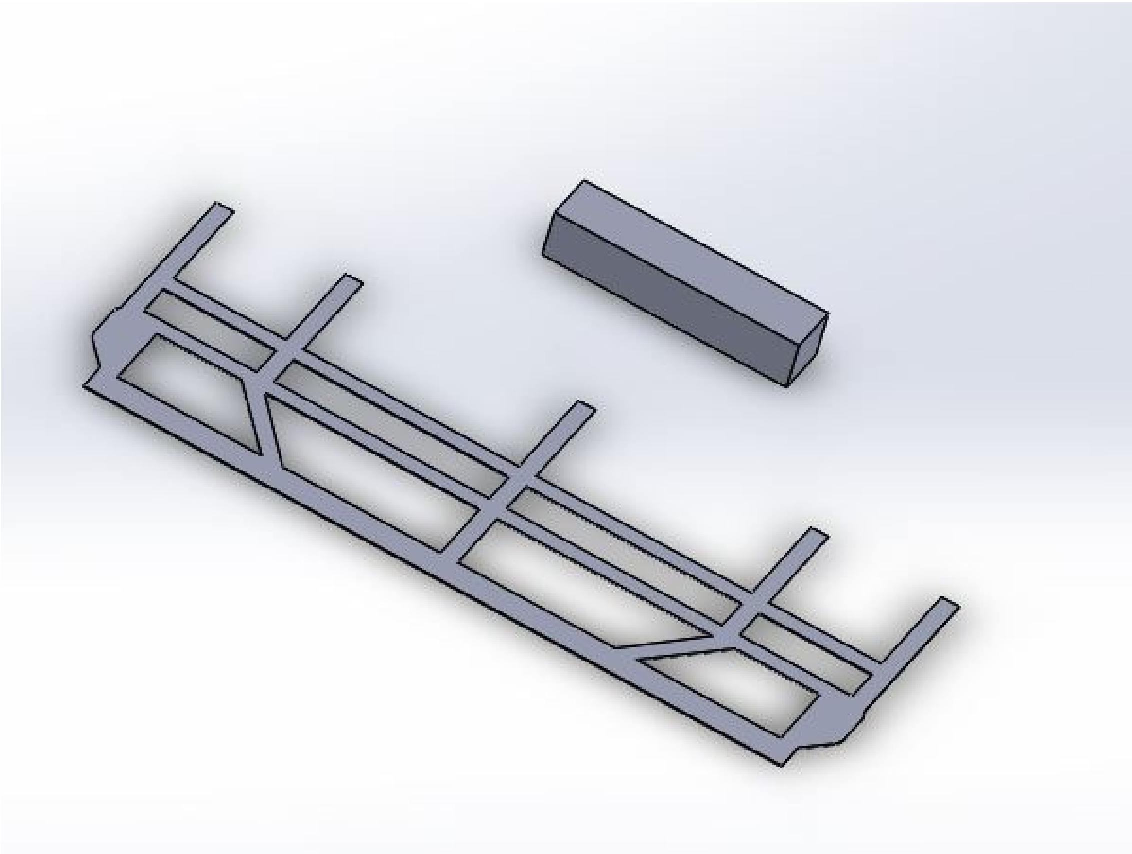

Fig. 6.33. Terminal building elevation and the preliminary airside (3D). [Own elaboration (Solidworks)]

These two commented levels (level 0 and level 1) and the distribution, in general, of the phases within the airport are presented below.

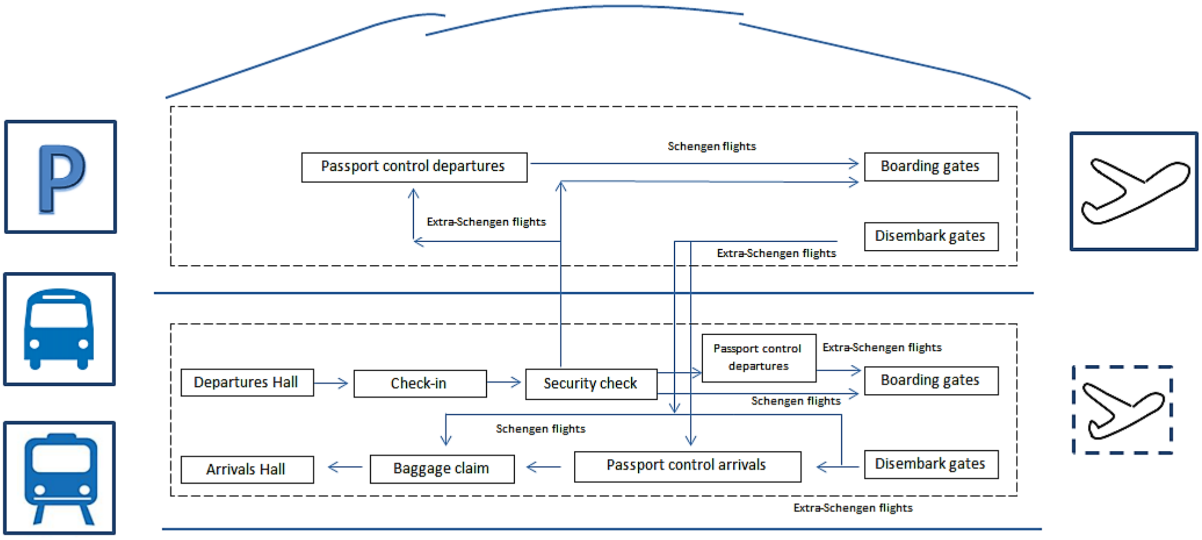

Fig. 6.34. Main layout of the terminal building, levels 0 and 1. Sources: [58] (bus) and [59] (train) [Own elaboration (Word)]

It is necessary to clarify that the distribution presented is at a general level, only the subsystems and their distribution appear. The entrance would be on the left side, where the symbols of the parking lot, bus and train entrances are specified. Then, on the other side there are two airplane symbols that mean, the upper one, flight departures within the Schengen area and Extra-Schengen and arrivals, and the bottom one designates that some departures within and outside the Schengen area and some Arrivals would be on level 0 and at the back of the terminal, seen from the opposite side of these aprons located on the side.

6.3.2 Terminal building subsystems.

The terminal building has different components or subsystems necessary to organize passenger traffic and achieve greater efficiency. These subsystems determine the phases of the departure and arrival process.

These departures and arrivals process and these subsystems that compose them are:

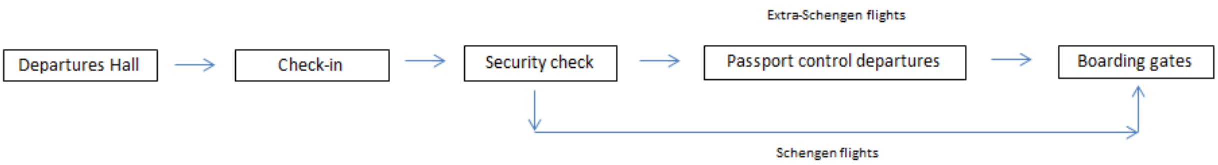

Fig. 6.35. Departures process. [Own elaboration (Word)]

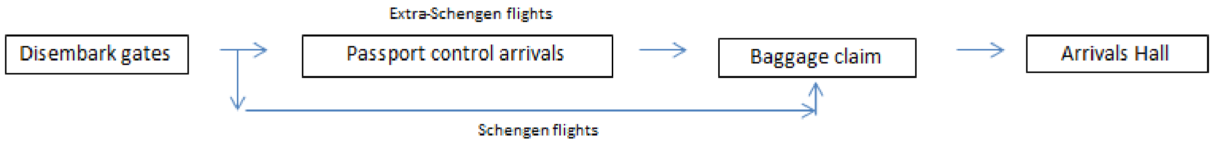

Fig. 6.36. Arrivals process. [Own elaboration (Word)]

- Subsystems in departures:
  - Check-in counters.
  - Security controls.
  - Passport controls.
  - Boarding gates.
- Subsystems in arrivals:
  - Passport controls.
  - Baggage Claim Units.

Throughout this point, the necessary design parameters will be determined to define the subsystems and, thus, subsequently, the general dimensions of the terminal building. But first, some aspects prior to this analysis of the subsystems and this commented capacity estimate will be considered.

6.3.2.1 Previous determinations.

First, the quality and level of service at the terminal will be defined.

Previously, to determine the quality of service that the Sárbogárd airport will provide, the maximum queue time (MQT) must be analyzed since this is one of the factors that determines the level of quality because if the processes are carried out quickly, air traffic will increase its efficiency.

Next, the time table established by the IATA will be presented to assess the service that will be provided.

	Short to acceptable	Acceptable to long
Check-in Economy	0 — 12	12 — 30
Check-in Business Class	0 — 3	3 — 5
Passport Control Inbound	0 — 7	7 — 15
Passport Control Outbound	0 — 5	5 — 10
Baggage Claim	0 — 12	12 — 18
Security	0 — 3	3 — 7

Fig. 6.37. Queuing times guideline. Source: [10]

The IATA in the *Airport Development Reference Manual* [10], defines some levels of service that are the following:

- A: Excellent level of service.

- B: High level of service.
- C: Good level of service.
- D: Adequate service level.
- E: Inadequate service level.
- F: Unacceptable level of service.

Within these, the new airport will be defined with a service level between level C and B since C is the minimum objective determined by IATA ("Level of Service C is recommended as the minimum design objective, as it denotes good service at a reasonable cost" [10]).

Therefore, it is being considered that the flow conditions are stable, the delays are acceptable and the comfort levels are good.

This decision is also made in conjunction with the MQT of each subsystem. Therefore, the MQTs that are established are the following, most of them take the acceptable times since the level of service chosen is C:

- Check-in Economy Class MQT: 20 minutes.
- Check-in Business Class MQT: 3 minutes.
- Passport Controls MQT: 5 minutes.
- Baggage Claim MTQ: 12 minutes.
- Security MQT: 3 minutes.

Based on this quality, the IATA defines standard measures such as for the check-in for single queue, the passport control, the baggage claim system, etc.

Then, another consideration must be specified. It will be determined that the flow of departures and arrivals at the airport is 50 % / 50 %. Since, according to **Table** 4.22, the number of arrivals and departures on the busy day of the new airport are practically the same.

6.3.2.2 Terminal service levels.

These service levels will determine the overall dimensions of the terminal building subsystems. To estimate them, the IATA dictates will be followed [10].

DEPARTURES

Check-in counters

The number of counters is important to speed up movements on the ground side of the airport since when passengers arrive they must check-in and some check-in prior to the flight and if this is not done efficiently, flight delays could occur.

- **Step A: Calculate the peak 30-min demand at check-in:**

  It is essential to study the demand during a specific time at the counters since this way the flow that these components should cover can be analyzed.

  The following expression will be used since such information is not available:

  $$PC_{30\ min} = PHP \cdot F1 \cdot F2 \qquad (6.6)$$

  This demand ($PC_{\ 30\ min}$) is determined based on the estimated rush hour passengers (PHP) for the design year only of economy class, by the factor F1 (% of the PHP in the peak 30-min from table 1) and the factor F2 that corresponds to the traffic generated by flights 1 hour before and after rush hour.

- It is considered that the number of economy class passengers at peak time will be 90 % of the total, also, remember that the number of departures (people who will go to the counter) is 50 % of the total: If we are going to **Table** 4.33 (year 2036, realistic scenario), and we apply 90 % and 50 % to the 4.602, 2.071 passengers are obtained during the rush hour of departures.
- For factor 1, as already mentioned, the flights from the new airport are mostly short-haul international. As the airport in its rush hour exceeds 4 operations, a factor F1 = 0,3 (F1 = 3 %) will be used.

Table 1 — F1: Peak 30-Minute at Check-In as a Percentage of the Peak Hour Period

Number of flights during the peak hour period	Domestic/Schengen/ Short-haul International	Long-Haul International
1	39%	29%
2	36%	28%
3	33%	26%
4 or more	30%	25%

Fig. 6.38. Table to estimate F1. Source: [10]

- Analyzing the bad hours of the base of the analysis that has been carried out to find the busy hour (**Table** 4.27), it is considered that the average percentage of the operations in the previous hour over the operations in rush hour and of the operations in the later hour over those of the rush hour will be the one that will be used to find the parameter F2 considering short-haul with the table international. This factor is F2 = 1,35 (average = ≈ 70%).

Table 2 — F2: Additional Demand Generated by the Flights Departing Before and After the Peak Hour Period

Average passenger load in the hour before and after the peak hour period in % of the PHP	Domestic	Schengen/Short-haul International	Long-haul International
90%	1.37	1.43	1.62
80%	1.31	1.40	1.54
70%	1.26	1.35	1.47
60%	1.22	1.30	1.40
50%	1.18	1.25	1.33
40%	1.14	1.20	1.26
30%	1.11	1.15	1.19
20%	1.07	1.10	1.12
10%	1.03	1.06	1.06

Fig. 6.39. Table to estimate F2. Source: [10]

$$PC_{30\ min} = 2.071 \cdot 0,3 \cdot 1,35 = 838,76\ passengers$$

- **Step B: Determinate the intermediate result (S), taking into account the Maximum Queuing Time (MQT)**

  Using the following diagram where X is the peak 30-min check-in obtained and, since the passenger traffic is high, it will be considered that MQT is considered 20 minutes (**Point** 6.3.2.1).

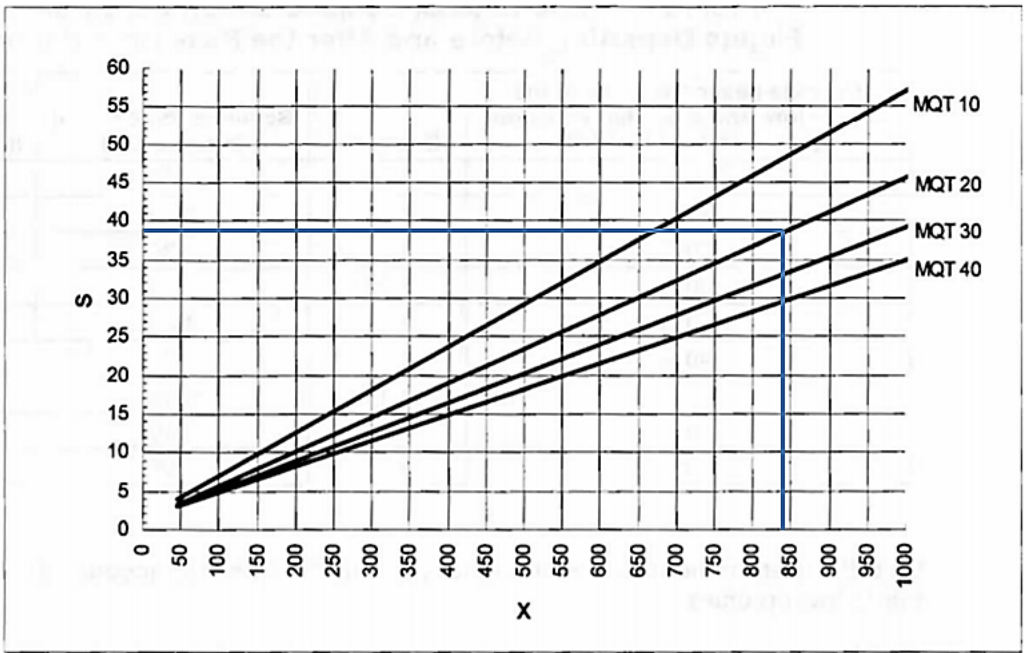

Fig. 6.40. Graphic to estimate the intermediate factor S - Check-in counters. Source: [10]

  It is obtained that the factor S is: S=39.

- **Step C: Calculate the number of check-in servers of the economy class.**

  Using the following expression, the number of economy class check-in servers assuming common use (#CIY) can be obtained.

$$\#CIY = S \cdot (\frac{PT_{ci}}{120}) \tag{6.7}$$

  The parameter PT_{ci} is the time (s) it takes, on average, for a passenger to check-in. It is considered 100 seconds.

  Thus, you get a number of counters for the economy class of:

$$\boxed{\#CIY = 39 \cdot (\frac{100}{120}) = 32,50 \approx 32 \ economy\ class\ counters}$$

- **Step D: Calculate the number of check-in servers including business class counters.**

  This parameter is also predefined with a formula provided by IATA. But, as previously estimated, the percentage of passengers flying business class is 10 % of the total, due to the type of airlines that operate at the new airport are low-cost and this means that they do not offer so many business seats. Therefore, it is obtained directly with the following expression:

$$\#CIJ = \#CIY \cdot 10\% \tag{6.8}$$

$$\boxed{\#CIJ = 32 \cdot 0,1 = 3,20 \approx 3 \; business \; class \; counters}$$

And, adding both results of the number of counters, the total number of check-in counters (#CI) at Sárbogárd airport is obtained.

$$\boxed{\#CI = 35 \;\; total \; counters}$$

Security check

Security controls are essential in any public infrastructure in which there is a high flow of people.

The calculation of the number of security checks is also made by IATA.

- **Step A: Calculate the peak 10-minute check-in counters.** This expression is almost the same as the one found in the passport control departures and the same data will be used.

$$PC_{10 \; minutes \; (security)} = \#CIY \cdot (\frac{600}{PT_{ci}}) + \%J \tag{6.9}$$

$$PC_{10 \; minutes \; (security)} = 32 \cdot (\frac{600}{100}) + 0,1 = 192,10 \; counters \; throughput$$

- **Calculate the number of security check servers (#SC).** Finally, the desired result is also obtained by means of an expression very similar to those of the departure passport control posts.

$$\#SC = PC_{10 \; minutes \; (security)} \cdot (\frac{PT_{sc}}{600}) \tag{6.10}$$

If an average of 15 seconds per person have been considered to review the passports, in the security controls more seconds will be estimated because in this process there is always some other mishap and the flow of passengers who are in this security phase stops . It is considered a time PT_{sc}=25 seconds.

$$\boxed{\#SC = 192,10 \cdot (\frac{25}{600}) = 8 \; security \; servers}$$

Passport control departures

Passport control on departures from Hungary is an important point due to the control of the country to check who leaves it and where it goes. Both for the safety of the community and the flight and the passengers themselves.

In this case, the peak 10-minute number of passengers who exit check-in is analyzed because they will pass through passport control.

The steps to follow will be explained below.

- **Step A: Calculate the peak 10-minute check-in throughput ($PC_{10\ minutes}$).** The following expression will be used in which the number of check-in positions for economy class is considered ($\#CIY = 32$), the average time that the check-in has been considered to last ($PT_{ci} = 100\ s$) and the percentage of business class passengers considered (%J=10%).

$$PC_{10\ minutes} = \#CIY \cdot (\frac{600}{PT_{ci}}) \cdot (1 + \%J) \tag{6.11}$$

$$PC_{10\ minutes} = 32 \cdot (\frac{600}{100}) \cdot (1 + 0,1) = 211,20\ counters\ throughput$$

- **Step B: Calculate the number of passport control desks (#PCD).** To determine the final result, use is also made of an expression established by the IATA [51]. The average time per person assigned to the control in question is considered to be 15 seconds as it gives enough time to review the documentation in this time or even less.

$$\#PCD = PC_{10\ minutes} \cdot (\frac{PT_{pcd}}{600}) \tag{6.12}$$

$$\boxed{\#PCD_{departures} = 211,20 \cdot (\frac{15}{600}) = 5,28 \approx 5\ passport\ control\ departures\ desks}$$

Gate Hold Room

This space is where passengers wait before boarding the corresponding plane. To estimate it, the IATA establishes percentages of passengers who will be standing and others seated and establishes a relationship between these and between the capacity of the aircraft.

The capacity of the aircraft ($A_{capacity}$) is found from the A321neo (ACF), the design aircraft of this airport that is 244 passengers (it is considered the maximum) and its 80 % (percentage considered by IATA to apply to this capacity) is 195 pax. Then, the IATA considers that 80 % of people will be seated and 20 % standing. GHR will be the gate hold room space (m^2).

$$GHR = 80\%\ of\ A_{capacity} \cdot 80\%(pax_{seated}) \cdot 1,7 + 80\%\ of\ A_{capacity} \cdot 20\%(pax_{standing}) \cdot 1,2 \tag{6.13}$$

$$\boxed{GHR = 195 \cdot 0,8 \cdot 1,7 + 195 \cdot 0,2 \cdot 1,2 = 312\ m^2}$$

And, as has been determined in point X, this area must be multiplied by 18, which is the number of aprons that the airport will have. Each gate is remotely or not remotely connected to an apron.

$$\boxed{GHR_{total} = 18 \cdot 312\ m^2 = 5.616\ m^2}$$

ARRIVALS

Passport control arrivals

As with the control of exit passports, it is essential to control entry passports and more because despite the fact that the new airport mainly allows intra-European flights, it could be that passengers come using a stopover to get to Hungary or to go to another country.

Arrival passport controls have a higher flow than departure controls or at least more concentrated. This is due to the fact that once the plane arrives at the new airport, the passengers it transports go directly to the terminal building and not as in the departures, since in these the passengers arrive at the airport in stages.

- **Step A: Determine S using a diagram.** Using the following expression that relates the variable X with the number of passengers at peak hour (in this case it would be the arrival totals, $PHP_{arrivals} = 2.301$) and the number of passenger exit doors that the design aircraft has, which are 4 in total, 2 FWD and 2 AFT in addition to the emergency doors that are not considered, this can be seen in **Appendix K**.

$$X = \frac{(PHP_{arrivals} \cdot \#exit\ doors)}{100} \tag{6.14}$$

$$X = \frac{2.301 \cdot 4}{100} = 92,04$$

Using the maximum queue time already established (MQT = 5 min) and the result of X, we obtain the value of the factor S which is $S_{arrivals}$=8.

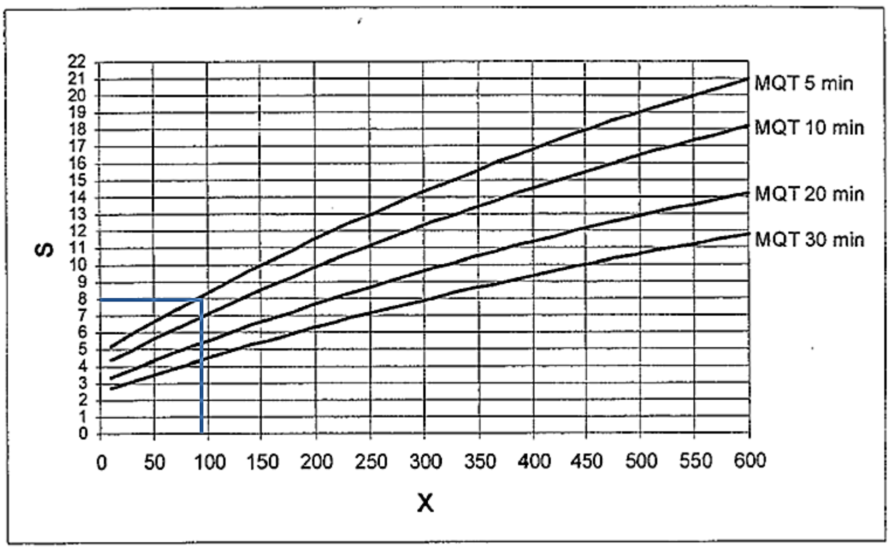

Fig. 6.41. Graphic to estimate the intermediate factor S - Passport control arrivals. Source: [10]

- **Step B: Number of passport control desks required**
  To finish and find the result in question, a last expression will be applied.

$$\#PCD_{arrivals} = S_{arrivals} \cdot (\frac{PT_{pca}}{20}) \tag{6.15}$$

The parameter PT_{pca} is considered equal to the previous one, of 15 seconds.

$$\boxed{\#PCD_{arrivals} = 8 \cdot (\frac{15}{20}) = 6 \textit{ passport control arrivals desks}}$$

Number of Baggage Claim Units (BCU)

These stations are used for passengers to collect their luggage when they arrive at the reference airport.

As the design aircraft and all those that would operate at Sárbogárd airport are narrow-body aircrafts, as already explained, the following expression will be used:

$$BCU = \frac{PHP \cdot PNB \cdot CDN}{60 \cdot NNB} \tag{6.16}$$

Where the parameters refer to: PHP, it will be the number of passengers arriving at rush hour ($PHP_{arrivals} = 2.301\ passengers$); PNB, is the proportion of the number of passengers arriving in a narrow-body airplane (PNB = 100 %); CDN, is the time that the baggage claim unit is destined for an aircraft (arrival flight) and the IATA recommends assuming about 20 minutes and, finally, the NNB, which is the number of passengers at 80 % load factor, which is 195 passengers .

$$\boxed{BCU = \frac{2.301 \cdot 1 \cdot 20}{60 \cdot 195} = 3,93 \approx 4 \textit{ baggage claim units}}$$

Arrival Hall (AH)

This area is intended for people who arrive at the airport to leave and move through another area other than the departures, so there is a better organization.

The formula to use will be:

$$AH = SPP \cdot \frac{AOP \cdot PHP}{60} + SPP \cdot \frac{AOV \cdot PHP \cdot VPP}{60} \tag{6.17}$$

If we define the values of the new parameters, the following results are obtained based on the values recommended by the IATA: AOP, the average occupacy time per passenger is assumed as 5 minutes; the AOV, the average occupacy time per visitor is assume as 30 min; SPP, is the space required per person (level C) is assumed as 2,00 m^2 and the VPP, the number of visitors per passenger is estimated as an average of 1,5 visitors.

$$\boxed{AH = 2 \cdot \frac{5 \cdot 2.301}{60} + 2 \cdot \frac{30 \cdot 2.301 \cdot 1,5}{60} = 3.835\ m^2}$$

6.3.2.3 Main areas of the terminal building sizing.

Before estimating the total area and dimensions of the terminal building, it is possible to go into more detail regarding the dimensioning of each phase or subsystem discussed.

Through the determined distribution and the results of the **Point** 6.3.2.2, the measurements of each part of the terminal building will be defined. All these dimensions will be based on what the IATA dictates [10]. The illustrations that will accompany the results and determinations are presented in plan (from above).

Arrivals and Departures Halls

The minimum area of the arrival waiting area, 3.835 m^2, has already been determined. This will be the minimum that should be defined. In the same way, a surface similar to that of the arrivals hall would be defined for the departure hall since many people also bring companions to the airport before taking off and they cannot pass beyond the security control, therefore, this would be defined entrance and waiting area.

Table 6.19: Arrivals and departures halls minimum area.

Dimension	Value
Arrivals Hall	$\geq$ 3.835 m^2
Departures Hall	$\geq$ 3.835 m^2

Check-in lobby

As already determined, there will be 32 economy class and 3 business class counters. The same dimensions will be considered for all, for the 35 check-in counters. For a counter that remains alone, only the width of 1 counter (1,50 meters) plus the width of the belt (1,00 meter) will be defined.

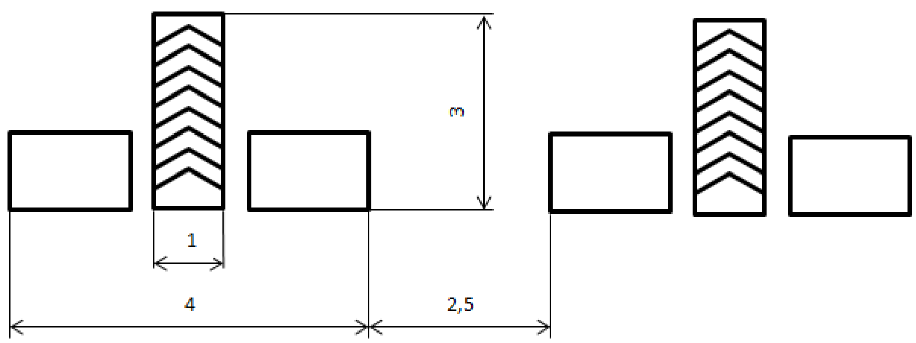

Fig. 6.42. Check-in counters dimensions (m). [Own elaboration (Word)]

Based on these measurements, considering the 35 counters and that the distance between the entrance to the check-in area and the entrance hall will be 15 meters, the general measurements of the check-in area are specified below.

Table 6.20: Check-in lobby general dimensions.

Dimension	Value
Length	18 m
Width	113 m
Surface	2.034 m^2

Security control

The security control is made up of the magnetic arc and the X-ray tape. Between these two they are 3,70 meters wide and 8,00 meters long, as established by IATA. Therefore, directly, considering the 8 security posts already determined, the final dimensions of the security control are:

Table 6.21: Security control dimensions.

Dimension	Value
Length	8 m
Width	30 m
Surface	240 m^2

Passport controls

There are two types of passenger controls. First, the overall dimensions of each "cabin" and the space between passport controls are determined. It should be noted that 2 passport controls departures will be defined at level 0 and 3 at level 1. This is because on both levels there will be boarding gates for flights within the Schengen area and for Extra-Shcengen flights.

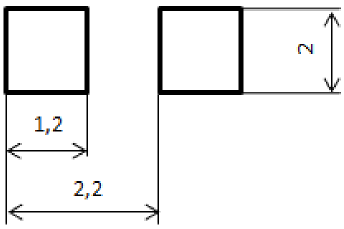

Fig. 6.43. Passport control dimensions (m). [Own elaboration (Word)]

On the other hand, as there are 5 controls for departures and 6 for arrivals, two tables are shown with the general dimensions of each space. It has been taken into account that these controls only serve as allowed access to the boarding area or at the exit, therefore, a length of this space of 2,00 meters is established. It is a space almost considered passing through, in which not much time is spent.

Table 6.22: Departures passport control dimensions.

Dimension (Level 0)	Value (Level 0)	Dimension (Level 1)	Value (Level 0)
Length	2 m	Length	2 m
Width	3,4 m	Width	5,6 m
Surface	6,8 m^2	Surface	11,2 m^2

Table 6.23: Arrivals passport control dimensions.

Dimension	Value
Length	2 m
Width	12,2 m
Surface	24,4 m^2

Boarding gates

The area for each of the boarding gates has already been previously determined in **Point** 6.3.2.2 and was 312 m^2. Therefore, the minimum general area of the boarding gates in the upper zone will be 3.744 m^2 since there are 12 aprons and for those of level 0 lateral, it will be 1.872 m^2. It should be noted that these surfaces are the minimum necessary, the length and the width will not be defined exactly because it would depend on the complete distribution of the space of each level, an aspect that will not be fully defined in this project.

Table 6.24: Boarding gates minimum area.

Dimension	Value
Surface Level 0	$\geq$ 1.872 m^2
Surface Level 1	$\geq$ 3.744 m^2

Baggage claim

The new airport will have 4 baggage claim areas. In each one of them a tape is established with the typical shape established by the IATA [10], the oval shape. This form is chosen because it covers a large luggage capacity. Also, in the following table in the IATA manual, the length of the tape is determined. In the case of this airport, we will use those of narrow-body aircraft.

Aircraft Type and Flight(s) Serviced	Passenger Reclaim Presentation Length (X4,X5,X6)	Loader Staff Reclaim Bag Loading Length (X2)	Com ments/Recom mendations
(1 Off) Wide Body Aircraft	> 70m < 90m	> 20m < 40m	Upper limits should be used where the bag to passenger ratio are often > 1.5 Bags / Passenger
(1-2 Off) Narrow Body Aircraft	> 40m < 70m	> 20m < 30m	Upper limits should be used where the bag to passenger ratios are often > 1.5 Bags / Passenger Upper limits should be used where two business type flights are allocated to a single reclaim.

Fig. 6.44. Required presentation length of the baggage claim. Source: [10]

In the following figure, you will see the chosen measurements. Established intermediate measures are used as a large amount of luggage.

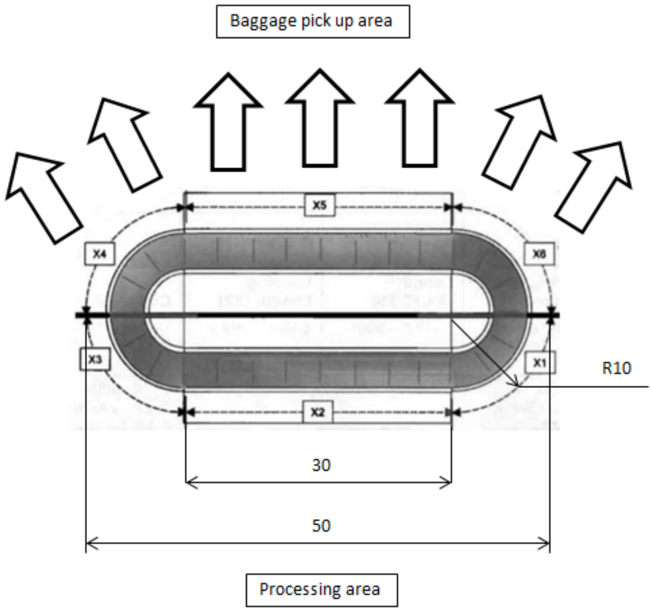

Fig. 6.45. Baggage claim dimensions (m). Source: [10] [Own elaboration (Word)]

In addition, having 4 tapes, they would be placed in 2 rows and 2 columns. And, a space would be left around them, both parallel and perpendicular of 5,00 meters because the passenger circulation is estimated high because it is also a passage area to access the arrival hall and the exit of the terminal building. Therefore, the overall dimensions and total area of this zone would be as follows:

Table 6.25: Arrivals passport control dimensions.

Dimension	Value
Length	55 m
Width	115 m
Surface	6.325 m^2

6.3.3 Capacity estimation.

Finally, the total area of the terminal building will be defined.

In the end, this project tries to carry out a pre-design of the airport so a series of general parameters have been used. For this design to be more realistic, you should have real data and make more precise measurements and not so many estimates or forecasts. In addition, it should be clarified that the dimensions have been roughly determined, that is, an estimate of the shape and measurements of the main areas of the terminal building will be found, without going into detail with very specific internal measurements such as the commercial area, restaurants and food stalls, passageways or bathrooms, have not been analyzed.

First, an initial estimation of the total area of the terminal building will be found. As already mentioned, the flights are international and most are scheduled.

Therefore, the following expression will be used, considering international flights:

$$S_{TOTAL} = 16 - 24\ m^2/php \tag{6.18}$$

This expression calculates the total area of the terminal using the number of passengers at rush hour (php), which, for the study airport in 2036, is 4.602 passengers. For each type of flight there is a range, the range of values by which the final result will be "moved", accoring to IATA, will be defined.

$$Total\ terminal\ surface\ (IATA) \rightarrow \boxed{73.632\ m^2 \leq S_{TOTAL} \leq 110.448\ m^2}$$

Once this range has been established, the total area of the building will be calculated based on the results that have been obtained.

The logical thing would be to define each of the areas that make up the building and size them but, it is repeated, this is going into much detail and it will not be done in this project. Therefore, to define the general measurements of the terminal we base ourselves on the number of parking platforms that have already been determined. In the end, as these are located one on the front of the building and the others on the side, based on the measurements of these aprons defined in the **Point** 6.2.4.1, we know that they must be at least the following:

$$Length \rightarrow 6 \cdot 44\ m = 264\ m$$

$$Width \rightarrow 12 \cdot 44\ m = 528\ m$$

If we round these measurements to the highest ten, the dimensions of the terminal building are obtained.

Table 6.26: Terminal building total dimensions.

Dimension	Value
Length	270 m
Width	530 m
Surface	143.100 m^2

It is seen that the area exceeds that estimated by the expression established by IATA. This was to be expected since in the design of the terminal building, when considering 18 aprons, we considered quite a lot of traffic since to determine this number of aprons, we went to the most extreme and optimistic case.

Finally, a drawing will be presented where these general measurements of the terminal building will be specified, as well as the distribution of the subsystems within it and their defined areas. Obviously, the scale of the drawing and the distribution of the areas within the building are estimates and these are only presented to see the way, more or less, with which each main area will be located.

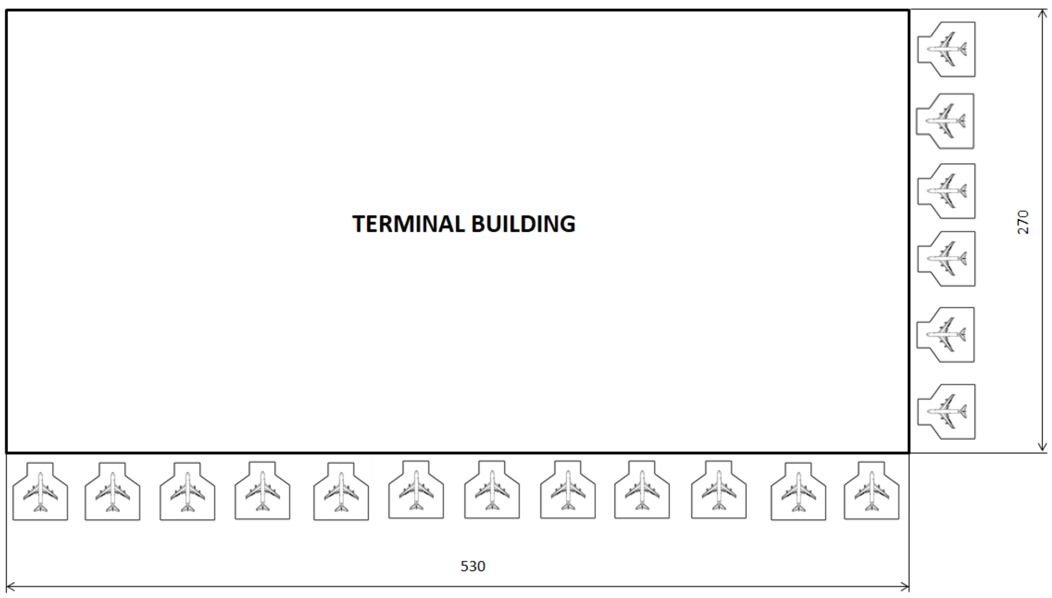

Fig. 6.46. General terminal building dimensions (m). [Own elaboration (Word)]

Regarding the interpretation of the distribution of the zones, it should be noted that the arrows that end at the edge of the level is because they pass or arrive from the other level if there is a stair symbol, or they pass to board or disembark an aircraft.

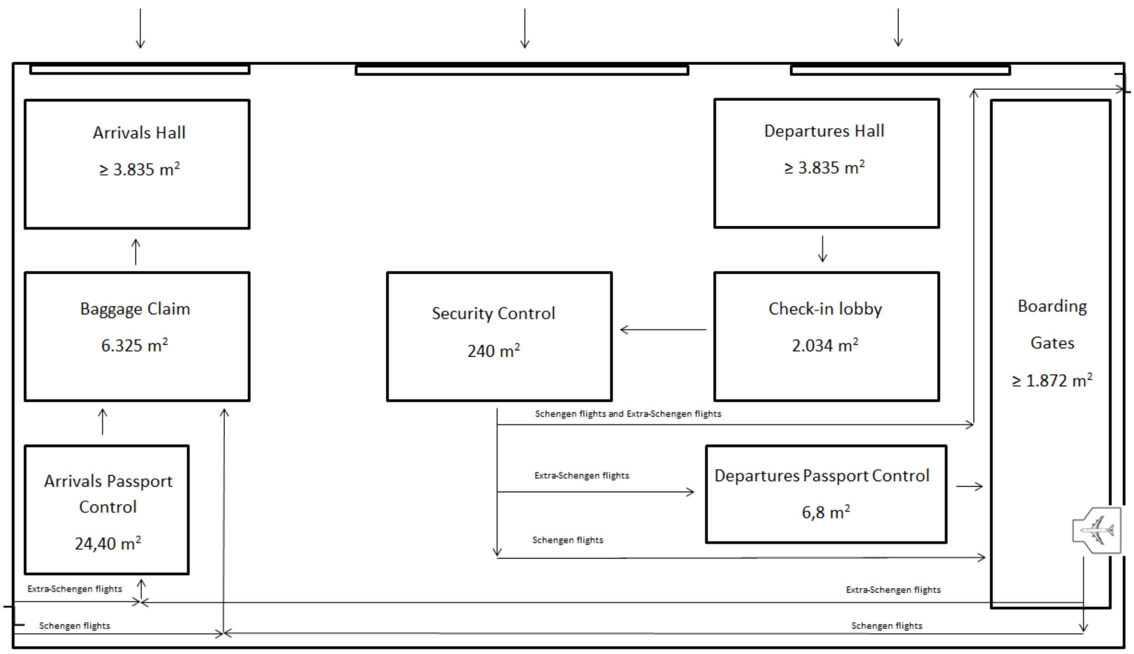

Fig. 6.47. Level 0 - surfaces and distribution [Own elaboration with Word].

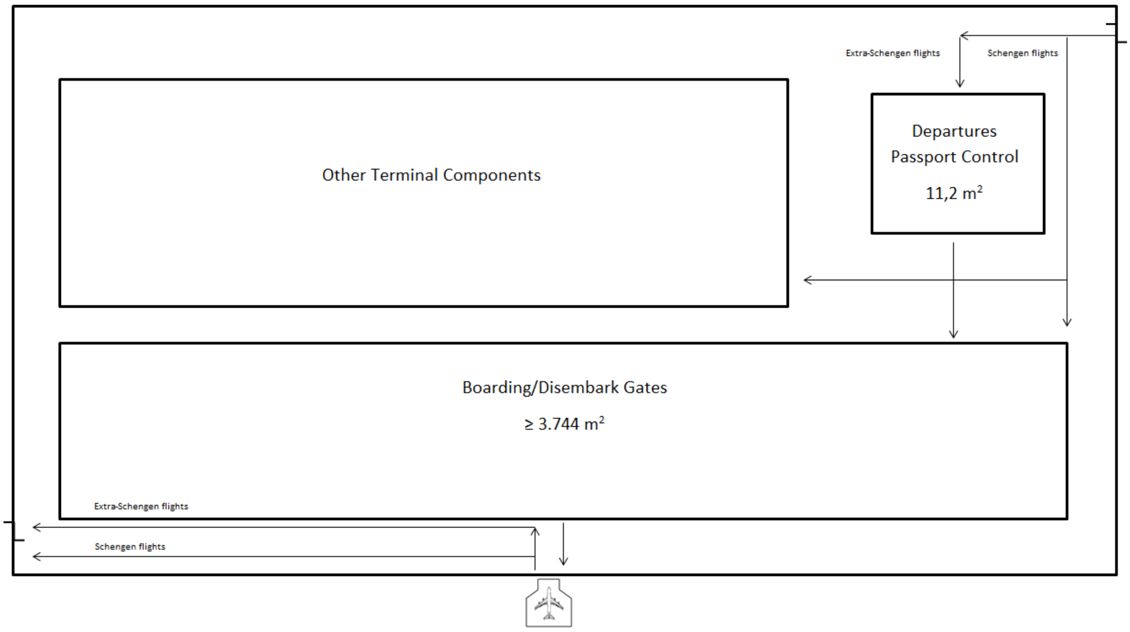

Fig. 6.48. Level 1 - surfaces and distribution. [Own elaboration (Word)]

6.3.4 Access areas to the terminal building.

To access said airport building, a vehicle parking area and an access area to the train station are defined. In addition, there would be different connections with the road so that these private vehicles, buses and taxis can access, but they will not be defined in this study. We once again comment that access to the terminal will only be through level 0. For this reason, roads should be designed for taxis and for short-term parking for cars. But here only the distribution is presented

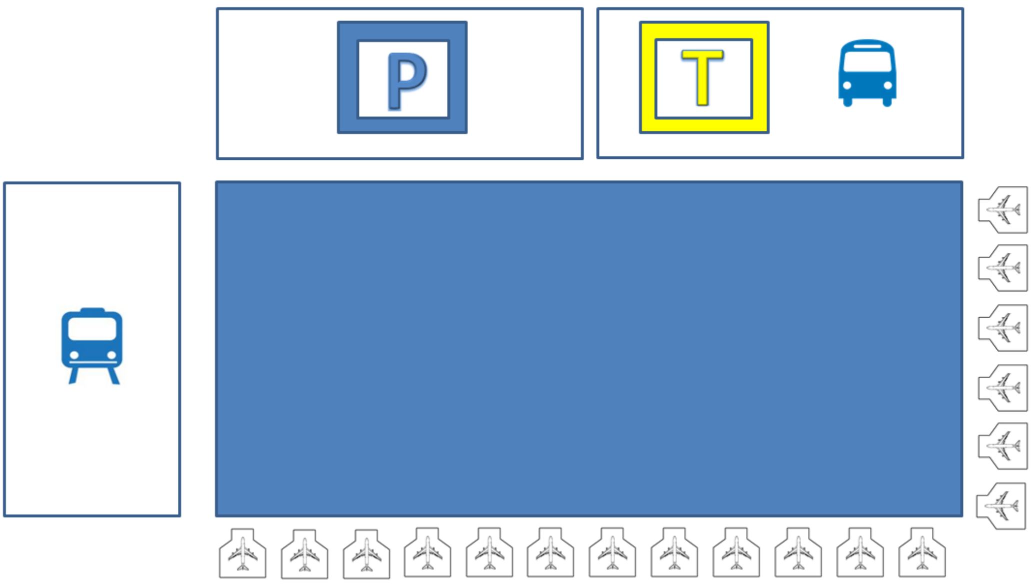

Fig. 6.49. Access to the terminal building. [Own elaboration (Word)]

The IATA establishes two general formulas to estimate the number of vehicle parking spaces that the new airport should offer. These expressions are based on the annual and daily traffic of the airport.

$$Parking\ spaces\ (pax-year\ estimation) = 500\ spaces/M\ pax-year \tag{6.19}$$

$$Parking\ spaces\ (pax-day\ estimation) = 265\ spaces/1.000\ departure\ pax-day \tag{6.20}$$

If both are calculated according to the data from the **Tables** 4.34 and 4.33, we see that the number of seats should be defined between 3,898 and 4,540 seats. It has been considered that 50 % of the total passengers are departing passengers.

$$Parking\ spaces\ (pax-year\ estimation) = 500\ spaces \cdot 9,08\ M\ pax = 4.540\ spaces$$

$$Parking\ spaces\ (pax-day\ estimation) = 265\ spaces \cdot 14,71\ thousands\ pax = 3.898\ spaces$$

$$\boxed{3.898\ spaces \leq Parking\ spaces \leq 4.540\ spaces}$$

6.3.5 Other airport buildings.

Following what the IATA dictates in its aerodrome design manual [10], other buildings other than the terminal building and access areas should be determined. In this project they will not be analyzed but they will be exposed, at least, to know and take into account the buildings that should exist at the airport. These are [60] the air cargo area, the control tower and the rescue and fire fighting areas. Each of them has a specific function within the airport, whether it is to offer service and assistance to the aircraft, give them directions and organize air traffic or ensure security at the airport.

6.4 Preliminary Design

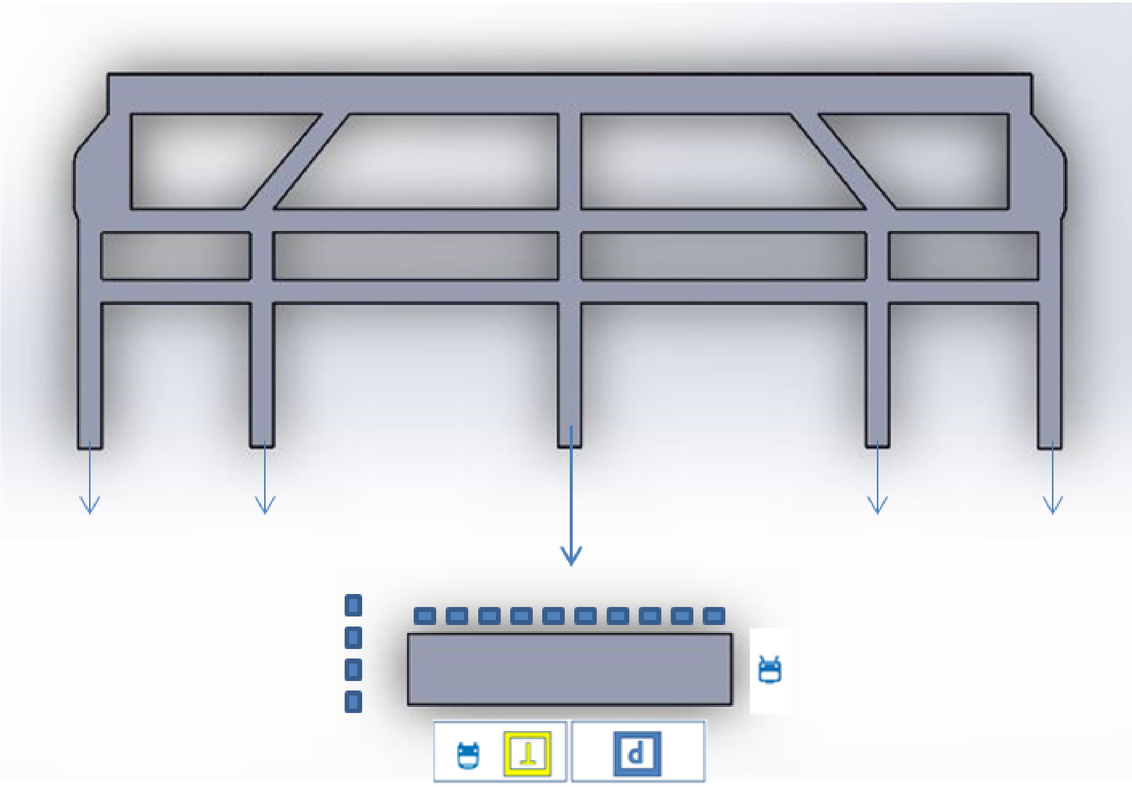

Fig. 6.50. Airside and Landside Preliminary Design (Top view). [Own elaboration (Solidworks)]

(The number of aprons in the following figure is not the estimate.)

Environmental and Social Impact

Studying the feasibility and carrying out a preliminary design of any infrastructure, even aeronautical, does not imply any considerable effect on the environment or on society since it is still an analysis. It is true that the step before any project is its preliminary design but until it results in something physical, it has no direct environmental or social impact.

It could be said that environmentally, the fact of working with electricity, Wi-Fi network and paper does produce effects on the environment, but not as negative as the actual construction of an airport could do. An infrastructure like the one that has been studied has different effects on the environment and, two of them, would be the following:

- **Deforestation and land modification:** Placing an airport requires having a lot of land of many hectares both in length and width since they operate planes of 45 meters long and 36 meters wide, approximately, as for example the one taken as the design in this study or even of bigger. If this airport were to be built, it would take almost 4 kilometers long and 1 kilometer or more wide. This means that a lot of ground would be flattened in a fairly green area of Hungary.
- **Pollution:** An infrastructure as such produces many CO2 emissions due to the fuel from the aircraft that operate in it. In addition, a lot of energy is used for an airport to function since all systems on the ground and air sides use light, radio signals, X-rays, etc. Another type of pollution they produce is acoustics. This affects the population due to its proximity. It is true that there are acoustic limits that every airport must comply with, but it also has effects on people who live near an airport. And, another type of pollution that it would produce is light, due to the size and number of systems it has that emit a lot of light.

Regarding the social impact, the study does have one and it is the proposed idea of a new project that can be very useful for Hungary, for its economy and international relations. If this idea were to be implemented and lead to the construction of the proposed new airport, as has been analyzed, it would imply an increase in tourism and business in the country of location. In addition, it would support the main airport that covers a lot of air movements since it almost only covers all the current traffic in the country. Absorbing traffic from the main airport could lead to an increase in commercial cargo and passenger flights in this as well as a more economical transport option (low-cost) for Hungarian citizens and for people coming from outside the country. Furthermore, the new airport would give more potential to the southern and central part of Hungary as all traffic is concentrated in the north of the country.

It is observed that the social impact is positive, despite the fact that the aforementioned environmental impact results, in many cases, originates in a negative impact on society due to stress, illnesses, noise nuisance, etc.

Conclusions and recommendations

This project based on the feasibility study and the realization of the preliminary design of a new airport in Europe has come to an end. As it has been seen throughout the document, many variables condition the final result in addition to the fact that it is obtained through a very detailed study.

In order to reach the final result and objective, different aspects have been analyzed. In any infrastructure construction project, one must begin by determining the regulatory framework by which it is governed. In this case, being an aeronautical infrastructure, the ICAO is the main one in charge of defining guidelines that must be followed to obtain a correct and viable preliminary design.

To arrive at this design, the first thing that has been carried out is the study of the location and the traffic demand that is estimated to have both in the starting year, which has been taken in 2027, and for a considerable later time, for the year of design, 2036.

The location at a general level, as has already been seen, is directly related to traffic demand. This is because if the country chosen to locate the airport has the potential to generate traffic, it will increase the viability of the infrastructure.

Therefore, in this project a forceful study has been carried out to decide that the country with the most potential to locate the airport would be Hungary. This decision is achieved by comparing different characteristics that would have an effect on the airport or its design and start-up. Some of these are the gross domestic product, the country surface, the number of existing airports, the meteorological conditions, the type of organizations that each country is in, the pollution and the number of inhabitants, who would be potential airport passengers. For the final decision, two decision methods have been used, the OWA and the PRESS method. These methods, which they do in, based on a weight that is given to each characteristic according to the level of importance, evaluate each country and find a numerical result. The highest result would be the place with the greatest potential for the parameter evaluated, in this case, the general location of the airport. Hungary obtained an index of 0,65 with the OWA and, more precisely, with the PRESS ony had a result of 1,810. In both cases, this country outperformed the others that were evaluated.

Once the location country had been chosen, the demand analysis could be carried out. The first thing was to determine the type of airport to be designed, a low-cost airport. This decision was decisive for the subsequent absorption of airlines from Budapest airport, which was determined as the reference airport. The conclusion that was taken based on the analysis of the traffic in Hungary was that all the air traffic in the country was generated by the capital airport, therefore, it was a logical decision to design the new airport as a support to the main one, to give greater efficiency and fluidity to the country's air traffic. These absorbed low-cost airlines were determined by collecting information on the number of passengers and annual operations, in 2019 (year taken as a reference throughout the project due to the subsequent and current effects of the pandemic), from the reference airport and posing three scenarios: one pessimistic, one realistic and one optimistic. Of these, it was decided to use the most realistic, with which a base traffic of 46.366 operations and 7.530.473 million passengers was obtained (**Table** 4.15).

Once the annual results of the base year were obtained, the traffic forecast was carried out in which an exhaustive monthly analysis was made, obtaining that August was the peak month (**Table** 4.20), daily in which the busy day (Monday August 16 (Week 33)) was determined with a traffic made up of 147 operations and 24.900 passengers (**Table** 4.23) and the peak day (Friday July 02 (Week 26)) with 194 flights and 32.883 passengers ((**Table** 4.24)). And finally, an hourly analysis was made in which a result of 23 flights was obtained at rush hour and 3.896 passengers.

Finally, the results were extrapolated to the horizon scenario, thus obtaining the most interesting results for the airport design. These are the annual, busy day and peak hour results in 2036. To obtain them, a code was programmed in which the traffic was increased with a reduced CAGR of 2 % for the number of flights and 1 % for the number of passengers, because the base traffic was already abundant and it was decided to choose to make it grow more moderately, to be realistic since the traffic, once it is quite high, remains more constant.

After the demand analysis, the preliminary design could be made, but first the exact location area of the airport had to be determined, since it is also of interest for the design of the airside of the airport. Through a topological and meteorological analysis within the area of influence of the Budapest airport, and therefore, the one determined, approximately for the new airport, it was determined that the exact location of the new airport was next to the city of Sárbogárd (Fejér area) .

And, the last chapter of this project, the complete infrastructure design. Different conclusions and results are obtained from this chapter. First, it was decided to use the A321 Neo WV072 (ACF) as the design aircraft since it was the one that best suited the traffic results obtained and the one with the highest MTOW. The MTOW interests us to submit the study to the most extreme aircraft, with which the longest runway would be obtained, so that all other type C aircraft could operate at the new airport. Based on this aircraft, the ARC of the airport was found to be 4C. This code is needed to define some dimensions in the preliminary design.

Once these preliminary considerations were determined, the design of the air side and the ground side has already been entered.

For the air side, the main decisions taken have been the following, always following what is established and recommended by the ICAO [9]:

- The new airport will have 1 runway with approach category CAT III A, geographic orientation SSE-NNW (112,5 ° / 292,5 °) corresponding to Runway 10 and Runway 28.
- It is decided to consider that all the declared distances are equal and 3.105 meters, and therefore, there will be no obstacle free zone (CWY) or a stopping zone (SWY) since the entire track is paved.
- The air side will have 1 central taxiway, 2 express exit streets, 2 holding bays and 2 taxiways parallel to the runway.
- The parking platforms will be established of type V based on the dimensions of the design aircraft. And, studying the traffic in the rush hour in 2036 that would be 27 operations, it is determined that to cover it, 18 aprons would be needed, putting us in the most extreme case. And these aprons will be 12 finger (directly connected to the terminal building) and 6 remote (located on the side of the terminal building).

To finish with the preliminary design, a set of conclusions and final decisions about the terminal building and the ground side are also obtained, these are the ones presented below, taken following the IATA Manual [10]]:

- The terminal building on the ground floor will be linear in structure and with general dimensions of at least 530x270 meters.
- In elevation, the building will be organized in two levels (Level 0 and Level 1). In this way, passenger traffic within the terminal and access to aircraft can be better organized.
- Within the terminal building, the subsystems that make up the departure and arrival processes at the airport are determined. These are the check-in counters, the security controls, the passport controls, the boarding gates, the baggage claim units and the halls. All these are dimensioned in the project following what the IATA dictates in its manual [10].
- Different access areas to the terminal building and the parking spaces necessary to cover the traffic at this airport are determined.

As it has been seen, creating an infrastructure of such dimensions and analyzing everything that it entails, from scratch, is a very expensive process. Due to this, it has not been possible to finish defining the entire land side and the air side as it would already be for projects with more hours of work and not on a preliminary design.

Another point that would have been interesting to evaluate in this project is the business plan. But, as this work is a study, estimating the exact economic investment required to carry it out requires a complete design of the airport and this was not the objective.

In short, it has been seen that locating this new airport in Hungary would be viable since the air traffic that would be obtained is abundant enough for the infrastructure to function and it can become, together with the Budapest-Ferenc Liszt airport, the center of all air operations in the country and potential generator of tourism and business. In addition, the preliminary design drawn up is consistent and may be feasible. Therefore, it would be recommended to complete the entire design in the future.

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