SUPERSONIC WORLDPORT

Bodies & Building Berlin

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ABSTRACT

Airports serve as vital gateways in global connectivity, demanding efficient and climate-conscious solutions due to the escalating demand for air travel. This research explores the paradigm shift needed in airport design, emphasizing technological innovations and collaborative spaces to address environmental challenges and support the dynamic growth of the aviation industry. The emergence of smart airports, propelled by advancements such as supersonic travel, hydrogen fuels, biometrics, self-check-ins, and automated baggage handling, is a focal point.
The theoretical foundation of this research is based on theories of future aviation that guide and support the research.
Employing methods like literature research, fieldwork, and interviews establish well-rounded research. As a consequence, the research aims to yield outcomes that will inform and support design decisions.

01 INTRO

Airports play a pivotal role in global connectivity, serving as gateways to the world. These gateways are complex structures where passenger flows must be watched, journey times shortened, high standards of security maintained and many different needs catered for all under one roof. Due to a substantial increase in the demand for airport capacity, driven by a rising number of passengers, air travel has become more common to billions of travellers. In 2012, 2.8 billion passengers utilized air travel. In the International Air Transport Association 2050 report, experts anticipate that by 2050, aviation transport will accommodate 16 billion passengers with a continuous upward trend (IATA 2011). Meeting this demand poses a significant challenge, necessitating efficient and climate-conscious organization of the entire operational process involved in aircraft activities. Considering that the aviation industry is at the forefront of technological innovation and aerospace engineering breakthroughs it seems that this demand can be met. However, in a world where sustainable, efficient, and effective innovations become a reality, the megastructure airport designs focused on passing the time need to be reimagined. Additionally, the integration of knowledge about technology across various disciplines has become increasingly vital in advancing innovation. (Abbas et al., 2013) Airports, as dynamic and complex hubs of transportation, can benefit immensely from adopting a multi-disciplinary approach to foster technological advancements. That is why airports should not only cater to travel but also become innovation hubs, where various specialists from around the world can exchange knowledge.

1.1. PROBLEM STATEMENT

The modern aviation industry is experiencing rapid growth, evident in the alarming increase in passenger volumes. Meeting the demand of increasing air passengers by implementing new technologies not only necessitates a meticulous reorganization of the operational processes within airports but also demands a conscientious approach toward climate-conscious practices. The emergence of smart airports, integrating technologies like supersonic travel, hydrogen fuels, biometrics, self-check-ins, and automated baggage handling are transforming the industry (Rajapaksha & Jayasuriya, 2020).
Various companies are developing commercial planes that travel faster than the speed of sound. According to Destinus, their airplanes will fly 'At velocities more than 5 times the speed of sound' people will be able to reach the other side of the world within 3 to 4 hours. The aircraft will be more compact compared to traditional intercontinental planes, accommodating 100 passengers instead of the typical 500-600 passengers. Additionally, this will be made possible on Co2-neutral, green hydrogen fuel by the year 2032 (Destinus, 2023). Another company claiming to develop supersonic airplanes, which are already ordered by various airlines, like American Airlines or Japan Airlines, is BoomSupersonic. They are developing commercial airplanes that fly two times faster than the speed of sound and can accommodate up to 88 passengers (Boom - Supersonic Passenger Airplanes, 2023).
To make these innovations environmentally responsible hydrogen is often proposed as a new aviation fuel. Hydrogen can be used as a clean fuel, and it has the advantage of producing water vapor as the primary byproduct when burned, making it a potentially environmentally friendly option. However, using hydrogen in aviation also poses significant technical challenges. As described by Jacobs (2022) there are three potential airport infrastructure scenarios for the supply and storage of hydrogen for use in fuelling hydrogen-powered aircraft:

- the delivery of liquid hydrogen directly to the airport by truck;
- the use of a hydrogen gas pipeline with on-site liquefaction;
- the use of electrolysis for hydrogen production on-site at the airport.

The last option being the most fitted for a global international airport, because the power can be also used to provide power to the terminal building and ground handling, creating a self-sufficient airport. Of course, this kind of infrastructure needs space, and according to the Aerospace Technology Institute (2022) an airport with a flow of ca. 135 million passengers a year needs to provide 325.000m2 of space to implement this strategy.

At the moment all airports are designed to accommodate the long waiting times with various duty-free shops and restaurants. These are also a big part of the airport's profit, which will be not discussed in detail in this research. This can be seen in the latest designs like Beijing Daxing International Airport or Jewel Changi Airport, each including around 300 shops and restaurants. (Phoon, 2019) The current waiting and check-in times at airports, averaging around three hours, appear excessively prolonged in light of the supersonic speeds associated with future air travel. Since the future is all about environment, efficiency, and effectiveness, technological innovations regarding check-ins and baggage handling are relevant topics that can influence the architecture of future airports.

Micro-X has developed a highly promising check-in system in terms of both time efficiency and safety. They assert that their system ensures a secure check-in process within just 30 seconds, it includes baggage screening, and their check-in stations occupy only one-seventh of the space required by traditional check-in setups (Bogaisky, 2023). This could mean that a much larger number of passengers could be handled in a smaller area of an airport. Another highly promising advancement in airport baggage handling technology is the Unipack automated baggage loading cell. Its capabilities include alleviating workers from physically demanding tasks, improving flight security, monitoring luggage until it's loaded into the aircraft, and optimizing the quality and packing density with its patented picking unit. (Automated baggage loading, n.d.) This automated handling of baggage could result in a space with no people so for example there would be no need for daylight.

Lastly, as mentioned by Abbas et al. (2013) a key to successful innovations is a multi-disciplinary approach. At the moment aviation companies are often competing with each other instead of working together for a better future. (Proponent, 2018) That is why it is important to create a space where various experts from around the world can work together.

Considering all the aviation innovations, it is clear that there is a need for a new approach in airport design, where new flows based on future capacity of airplanes and the speed of flows are taken into consideration. Additionally, a yet-to-be-designed multi-disciplinary space for innovative growth should be implemented in an airport design.

1.2. RESEARCH QUESTIONS

Taking into account the challenges posed by a growing number of passengers and technological innovations, the following main question should be asked regarding the future architecture of airports:

- How to develop design principles for highly energy-efficient airports?

Supported by the following sub-questions:

- What will change in airport design based on the anticipated increase in passenger volumes?
- What processes at airports will be changed due to new flows based on technological innovations and different aircraft capacities and speeds?
- How do the environmental implications impact airport design considering challenges associated with the adoption of supersonic travel, hydrogen fuels, and other technological innovations in airport operations?
- How can airports effectively implement hydrogen infrastructure for aviation, considering the technical challenges?
- Which architectural strategies can be employed to create multi-disciplinary spaces within airports, fostering collaboration among experts from various fields in the aviation industry?

02 RESEARCH FRAMEWORK

The conceptual framework is based on two scientific articles describing the main aspects of future airports, followed by innovations regarding airplanes, hydrogen fuel, check-in and baggage handling systems in the commercial aviation industry.

2.1. THEORETICAL FRAMEWORK

The theoretical framework is based on an article published in Aviation Journal in 2017 written by Alexander Medvedev, Professor head of the Chair of Aviation transport, member of the TTI Research committee, member of the Latvian Operation Research Society, member of the Latvian Association, professor at institutions of higher education, manager of theoretical training and examination of the EASA Part-147 training Centre at TTI Academic and professional aviation centre TSI/APAC, Iyad Alomar, MSc in engineering, training manager and Deputy of Quality manager of the EASA Part-147 training Centre at TSI/APAC (TTI Academic and professional aviation centre) and Slawomir Augustyn, Assistant Professor, an assistant Professor at the National Defence University (Warsaw, Poland). Where they describe how, airlines, airport operators, and businesses are collectively aiming to offer uninterrupted services and support to passengers and airport visitors, with the terminal building serving as a crucial facilitator. According to Medvedev et al. (2017), future visions of modern airports revolve around three main elements:

- Enhancing passenger comfort during the handling process;
- Increasing capacity and quality with heightened air operations efficiency;
- Minimizing the environmental footprint through initiatives such as clean energy projects to reduce CO2 emissions

Additionally, from the perspective of Professor De Neufville, an expert in Engineering Systems and Civil and Environmental Engineering at the Massachusetts Institute of Technology, in his article "Airports of the Future: The Development of Airport Systems." he outlined the global evolution of airport systems, emphasizing emerging trends that point towards a focused specialization in airport operations. De Neufville (2003) categorizes major airport types as follows:

- Short-haul airports: These airports aim to provide cost-effective services, particularly for short-haul flights;
- Cargo airports: Dedicated to serving integrated freight operators, these airports prioritize the efficient handling of cargo operations to meet the demands of the industry (de Neufville, 2003);
- Day and night intercontinental airports: These airports cater to global international passenger traffic, operating around the clock to meet the demands of huge passenger flows.

Given Europe's objective to promote high-speed train travel within the continent, designing an airport focused on short-haul flights would not fit the vision of the future (European Court of Auditors, 2018). Cargo airports, being specialized for freight, do not align with the human-focused nature of commercial airports and, therefore, fall outside the established framework. The most reasonable focus lies on intercontinental airports, as the innovation in supersonic travel is geared towards long-haul flights. Moreover, Europe's plans for train travel within the continent reinforce the strategic importance of intercontinental airports, making them a pertinent goal within the broader context of Europe, Germany, and Berlin.
That is why the researched innovations need to be related to at least one of the topics described by Medvedev et al. and fall into the context of intercontinental commercial travel.
The following aviation innovations are used as a framework for this research: supersonic air travel, hydrogen fuel, biometric security, self-check-in stations, automated baggage handling systems, and online duty-free shopping.

2.2. RELEVANCE

Airports stand as crucial nodes in global connectivity, functioning as gateways to the world. With a growing air travel demand, reaching 16 billion passengers by 2050, the aviation industry faces the challenge of efficiently accommodating this growth while trying to minimize its effects on the environment. 'Technological innovation is a "double-edged sword" and is considered a significant contributor to issues, such as climate change, ecological imbalances, and worsening pollution, and an effective means to solve environmental and sustainable development problems' (Fan & Shahbaz, 2023). Therefore it is important to rethink airport design to facilitate new efficient, effective, and environment-conscious technologies and collaborative spaces for airport staff, airlines, and technology partners encouraging innovation. These spaces can serve as hubs for collaborative efforts in advancing airport technologies, improving operational processes, and minimizing the contribution to climate change.

03 RESEARCH METHODS

To conduct this research, field, literature and interview methodologies are used. Field and interview methodologies are used to verify, support, and complement the literature methodology.

3.1. PROGRAM

In order to create a program for a new type of airport, the already existing airport programs need to be analysed. The case study approach will be applied. Airports consist of a landside, a terminal and an airside, these general aspects can be researched in a less detailed way. After that considering area-yearly passenger flow, a ratio can be determined and the program of the most efficient airports can be researched in more detail. This will be done by using the existing floor plans and calculating the percentages of different spaces. This will ensure a list of necessary spaces is established. Then according to the described possibilities of various technological innovations, the program can be adapted. Next, the new spaces that are needed to support an intercontinental innovation hub can be added. After completing this process architectural specialist should be consulted.

3.2. CLIENT

Literature, online resources, and interviews will support the research of the possible client. Finding out what parties own the airports around the world is the first step to get an understanding of the possible client. Additionally, since this research is not about a general airport, companies investing and creating applicable technological innovations in the field of aviation need to be researched. This way it can established what other companies could be a part of this project. Contacting the companies by email or phone is a possibility. Finally, to verify if the innovations of various companies are realistic an interview with a professor of aerospace engineering at TU Delft should be held.

3.3. SITE

The fitting site for such a huge and important structure as an airport is crucial. To establish if the site is suitable for an airport, research based on mapping and field visit is necessary. Finding out the connectivity and identifying surrounding areas is needed. Additionally, analysing possible future scenarios regarding expansions are important. Based on this calculations about noise impact on the surroundings should also be made.

04 DESIGN BRIEF

This design brief gives an overview of the current state of the process regarding the program, the client, and the site of the project.

4.1. PROGRAM

The program is developed as shown in the figures 1 to 5. To further develop this program the main spaces need to be divided into more detailed smaller spaces/rooms. This will be done for example for the innovation centre part by analysing the aviation centre reference projects program in more detail.

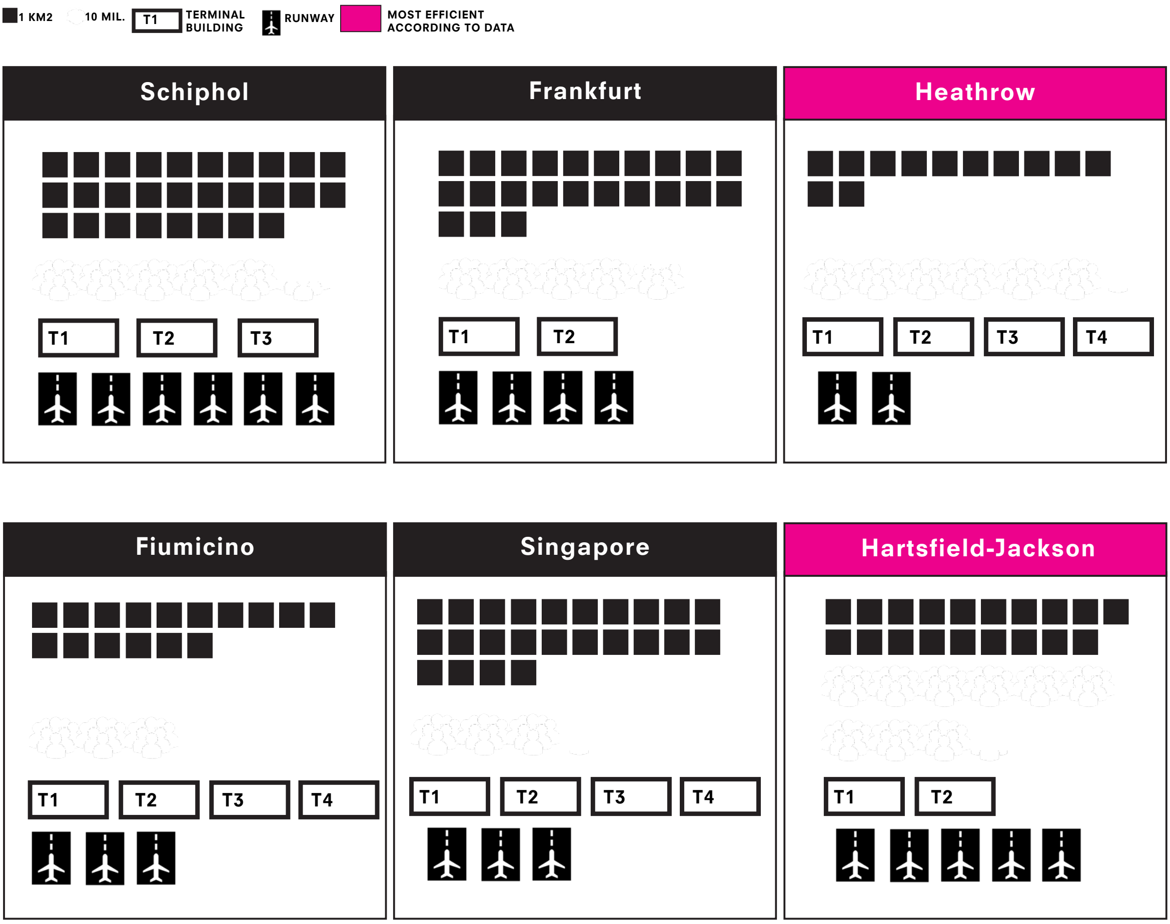


Figure 1. Data of different airports

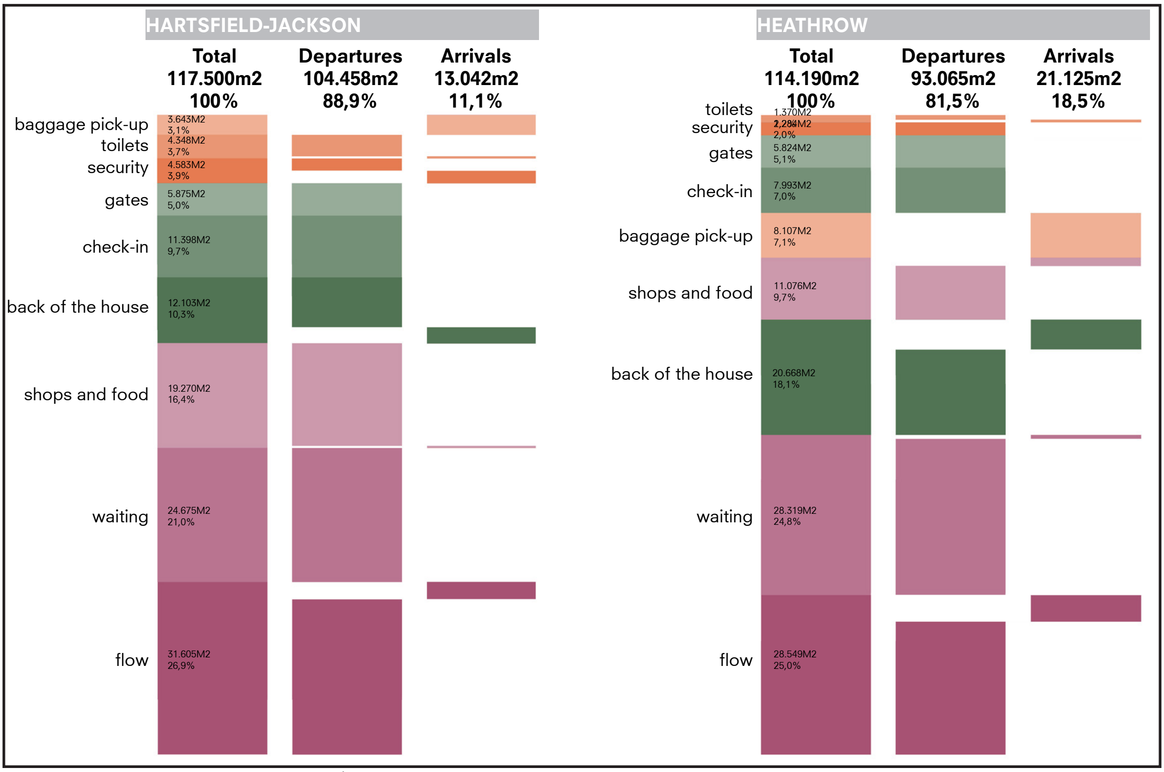


Figure 2. Program of reference projects

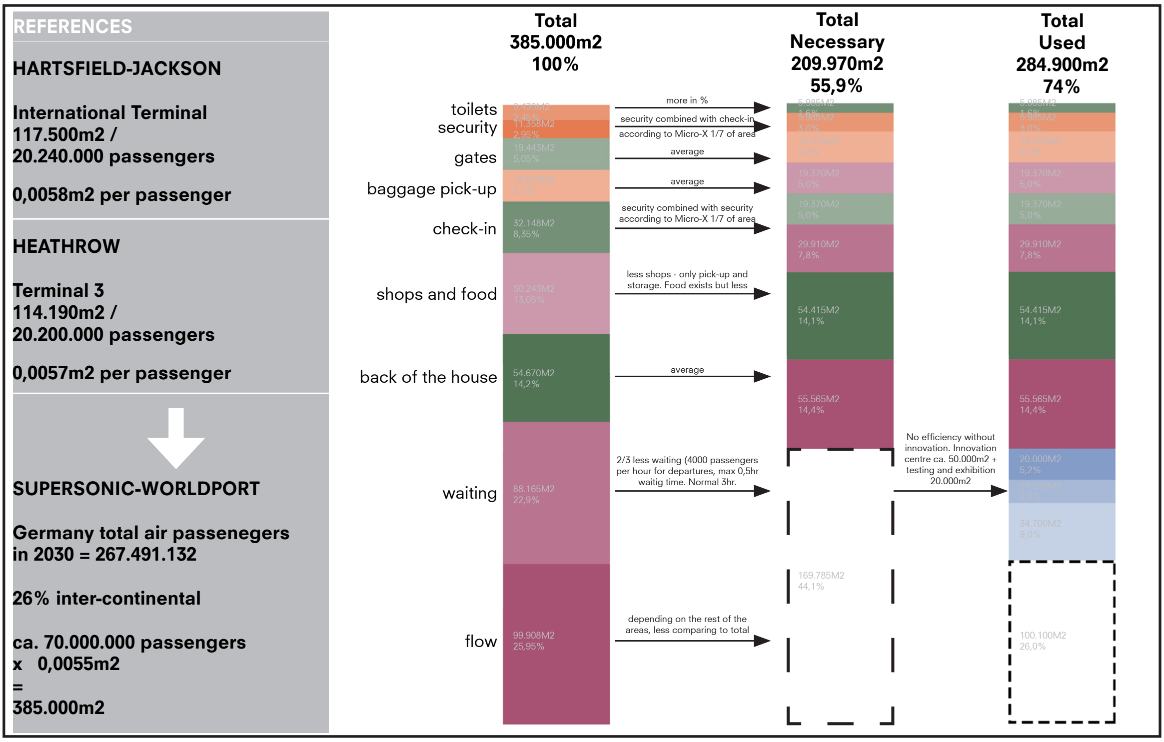


Figure 3. Process of making the program for the Supersonic Worldport based on reference projects

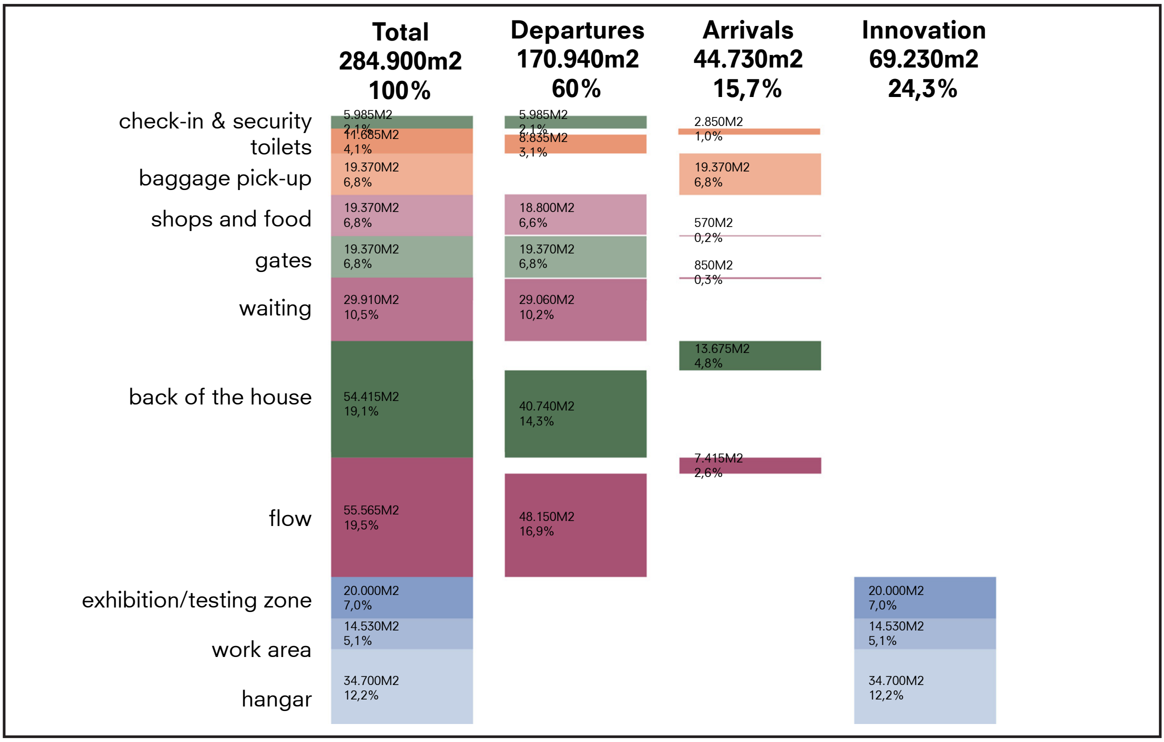


Figure 4. Program of the Supersonic Worldport

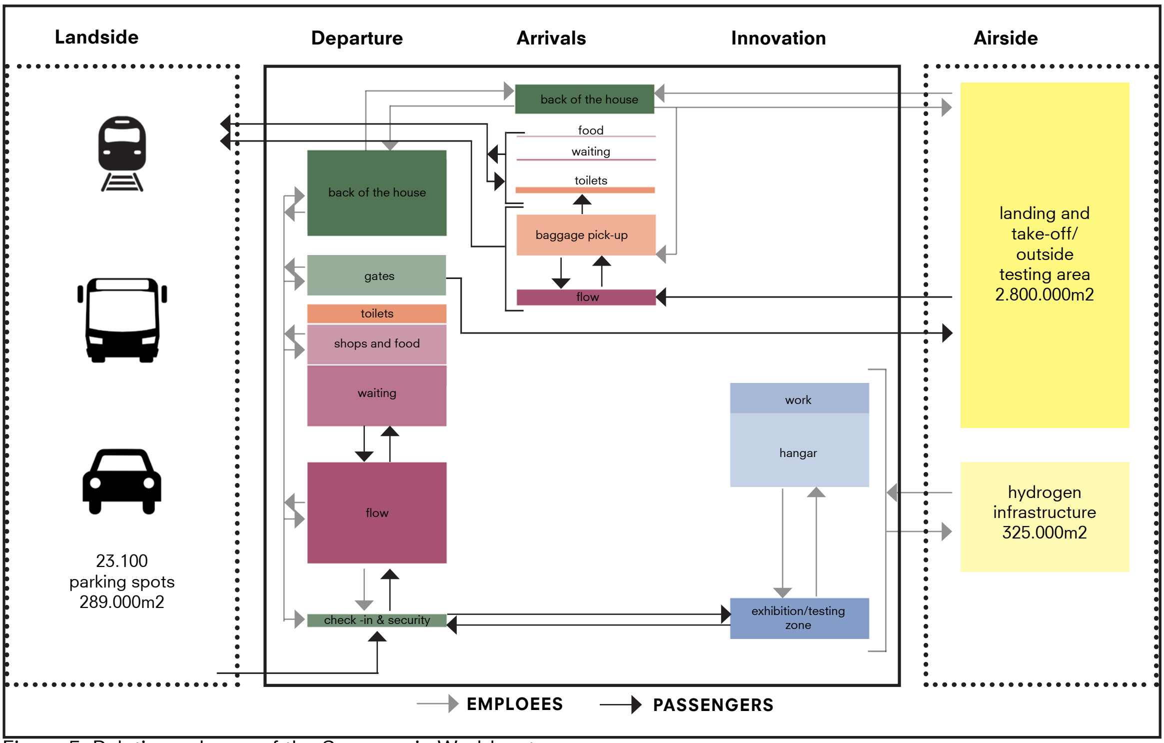


Figure 5. Relation scheme of the Supersonic Worldport

4.2. CLIENT

Based on how the European Union is invested in reducing climate change and supports innovation, this project seems to fit their agenda perfectly. Additionally, various companies from around the world that strive for innovation can be a part of this project to promote cooperation. This needs further investigation.

Figure 6. Potential cliets

4.3. SITE

This huge airport will need a good connection through various modes of transportation and a lot of space. Additionally, it will need runways for the airplanes. Since building runways cost a lot of material and energy, reusing already existing infrastructure seems like a justifiable choice. That is why area of the BER airport is chosen as a possible site for the Supersonic Worldport. This with an assumption that the already existing airport will be transformed into a train station for high speed trains, so European and intercontinental travel can be connected to each other.

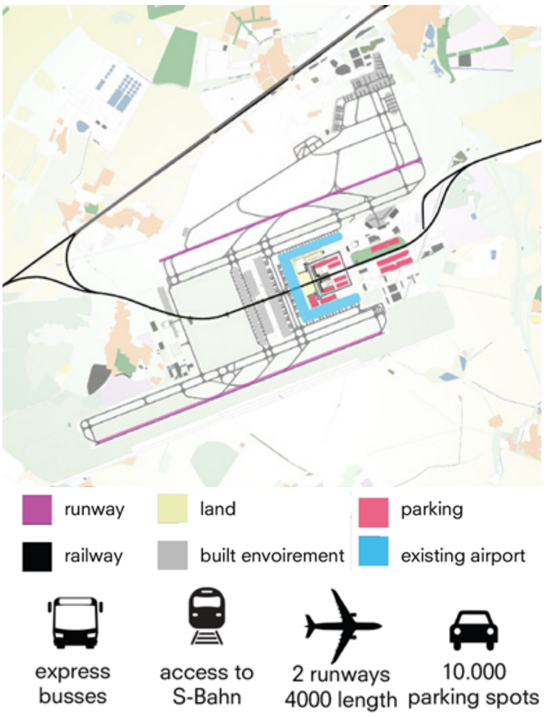
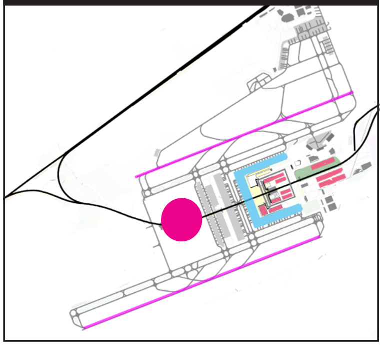


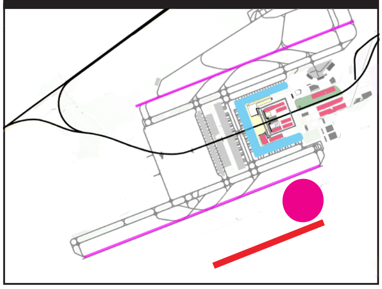
Figure 7. Mapping of possible location

Option 1



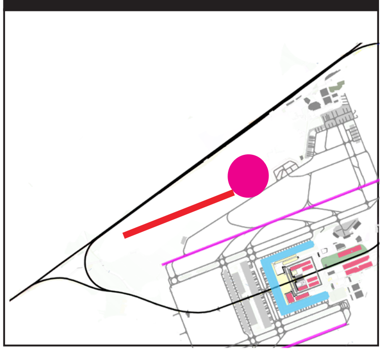
+ **Access to all of the exisitng runways**
+ **Easy acces by public transport**
+ **No additional land use**
- **Hard access by car**

Option 2



+ **Easy acces by public transport**
+ **Easy access by car**
+ **Possibilities to grow**
- **Hard access to one runway**
- **Additional land use**

Option 3



+ No additional land use
+- If additional station, easy acces by public transport
- Hard access to one runway
- Hard access by car

Figure 8. Options at the possible location

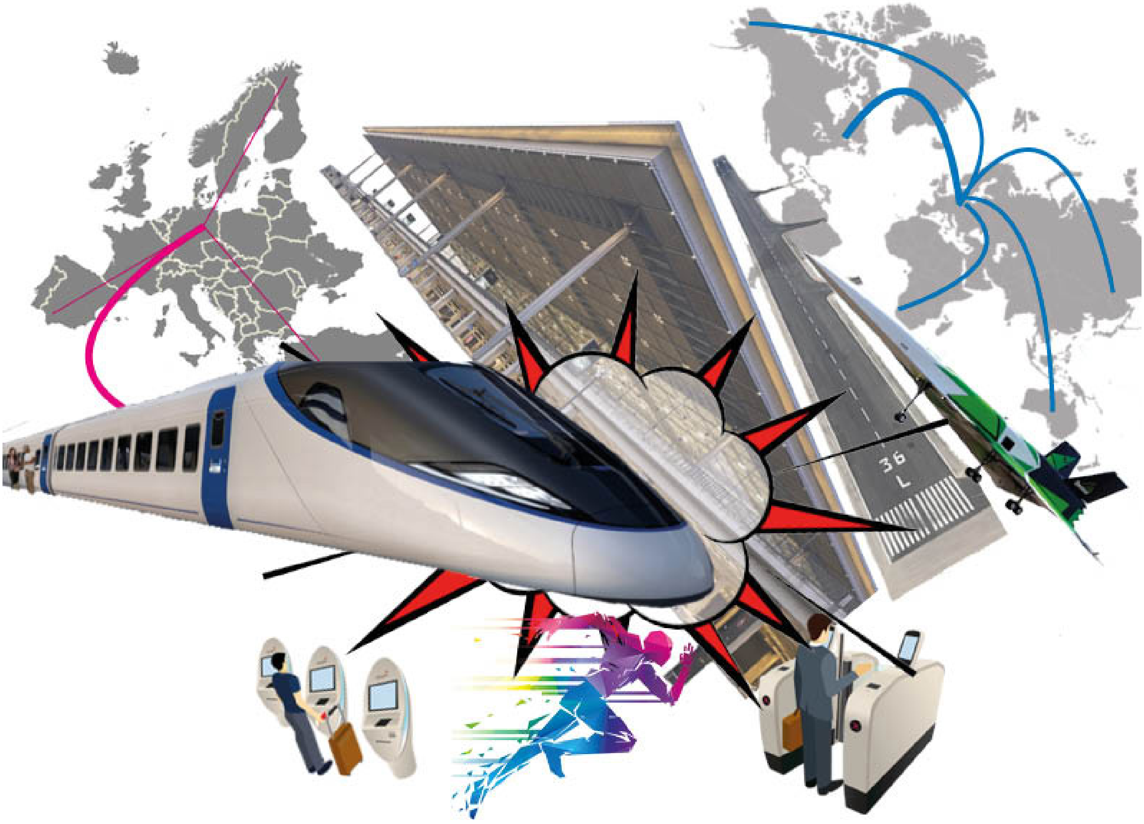


Figure 9. Collage reflecting the ambition of the project

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FIGURES

2. Made by author. Based on maps from www.atlanta-international-airport.com and www.heathrow.com
1,3 - 5, 7-9 . Made by author.
6. Logos from: destinus.ch, mirco-x.com, iconarchive.com and airbus.com