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## Challenges in Replacing More European Short Haul Flights by Rail



**Abstract:** - Within the European Union 18% of all flights cover a distance shorter than 500 kilometres. 67% of these flights are domestic and the remaining 33% is international. When looking in further detail at all short haul (< 500 km) flights in the EU, it has been found that on average, taking the train takes twice as long compared to taking the plane. However, almost 20% of these short haul flights, rail offers a faster or similarly fast alternative compared to taking the plane. This suggests that almost 20% of all short haul air routes in Europe can be replaced by rail.

However, this research has proven that it is not that easy as it seems. During the case study interviews several challenges have been identified, providing potential reasons why such short haul flights are retained. It seems like the largest challenge is to convince passengers to take the train instead of the plane. Flights are often still preferred because of among others: the bad reputation of railways, the lack of good luggage check-in facilities at train stations and the absence of direct high-speed rail connections to the airport.

On the other hand, the case study research on short haul flights for which no fast rail alternative is present has shown that geographical issues are the largest factor causing long travel times. This makes the introduction of high-speed rail extremely cost intensive and is therefore often not present. However, the EU is supporting several initiatives to improve the travel time for (parts of) these routes. In the coming decades travel times for these routes should slowly improve, bringing Europe one step closer in realising a modal share shift from air to rail

**Keywords:** - Transportation, Sustainability, Short haul flights, High speed rail, Replacing flights by rail, Modal share shift.

### I. INTRODUCTION

#### 1.1 Problem statement

Europeans travel a lot, on average in 2018 more than 2.500 kilometres are covered by plane per European per year [1]. Many of these movements are relatively short. In 2020 the average flight distance within Europe was 981 kilometres, a distance which could often also be covered by train in one day when good high-speeds lines are present [2,5,33]. The short average flight distance in Europe suggests that travelling with other more sustainable modes should be possible. This brought up the idea of investigating whether it would be possible to replace more of these short haul flights by sustainable modes of transport, such as trains.

Research has shown that for international aviation, the energy consumption has more than doubled since 1990, while for rail it has been decreasing in the past few decades [12]. Besides that, the type of energy used per mode also differs a lot. While trains use overall mainly electricity, aviation relies mainly on kerosine, resulting in the fact that trains emit five times less CO<sub>2</sub> per passenger per kilometre [44].

Even though rail is by far the most sustainable mode of transport, rail demand has only increased with 20% between 2000 and 2019 while air travel has increased with 86% [45]. This indicates the presence of many challenges in convincing more passengers to take the train and realizing a modal share shift from air to rail.

On top of that, research has shown that environmentally related travel mode decision priorities, like air quality impact and CO<sub>2</sub> emissions are of secondary importance for Europeans. Within Europe many people think that environmental impacts are overstated and are unwilling to do anything about the environment if others do not do the same [3]. Providing additional proof that it is very challenging to convince passengers to take the train instead of the plane.

All in all, this indicates that within Europe many improvements can be made in the field of sustainable transport and convincing passengers to take the most sustainable mode of transport. Especially when knowing that transport is the second sector in terms of emissions, representing 25% of total GHG emissions, after the energy supply sector [12]. As a result, the following problem statement has been formulated:

*“There are still many short haul passenger flights in Europe nowadays even though sustainable alternatives, such as trains, exist. To protect our climate and achieve the SDG targets, it will be necessary to replace these polluting flights with the much more sustainable high-speed trains. It will however be a Grand Challenge to convince passengers to fully stop taking these short distance flights and use the train instead.”*

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So, a drastic shift in the individual's decision making is needed to make travel in Europe more sustainable. Without a green shift within Europe's transport industry, it will be hard to achieve the targets set in SDG 13.2 and 9.1. A lack of improvements could have dramatic impact on the earth's climate with unforeseen future effects.

### 1.2 Research questions

In this section the main research question and related sub research questions will be discussed. As highlighted in the previous section there still remain major challenges in the field of sustainable travel within Europe, so as a result the following main research question has been formulated:

*“To what extent can passenger trains currently replace very short haul passenger flights within Europe when looking at price, travel time and CO2 emissions, and what can be done by train operators, aviation companies and European policy makers to support this?”*

However, to be able to answer this main research question, additional supporting material is necessary. So that is the reason why the following sub research questions have been formulated:

#### 1. Short haul flights

- a. Which very short haul (<500 km) passenger flights do currently exist within Europe?
- b. What is the total travel time from city centre to city centre for these flights?

#### 2. Passenger train alternatives

- c. Which passenger train routes currently exist as an alternative for these flights?
- d. What is the travel time from city centre to city centre for these train routes?

#### 3. Comparison

- e. How do the train alternatives compare to the flights when looking at ticket price, CO2 emissions and travel time?
- f. Which of these flights can potentially be replaced by train connections when looking at travel time? And why aren't they being replaced yet?
- g. Which of these train connections need significant improvements in travel time to be able to compete with aviation? And what kind of (policy) improvements are necessary?

#### 4. Concluding

- h. To what extent is Europe on its way to achieving SDG 13.2 (Climate Action) and SDG 9.1 (Industry, Innovation and Infrastructure) when looking at sustainable passenger transport?

It is expected that the combination of these sub research questions can eventually contribute to the answer to the main research question. Eventually a conclusion can be drawn on to what extent we can replace passenger flights by trains in the short term and what needs to be done in the long term to support this.

## II. THEORY

Different case studies have proven that when travel time is being drastically reduced by introducing High-speed Rail (HSR), competition between HSR and short haul flights is very strong. This often results in a drastic reduction of aviation passenger kilometres (see figure 1), sometimes air connections are even being abandoned. So it is possible to realise this modal share shift from air to rail when good HSR infrastructure is build [12, 13]. Also, a simulation study based on the London-Paris market where HSR has served a majority of the market, has shown that the introduction of HSR has been very beneficial to Green House Gas emissions [7]. This is mainly due to the green electricity that is being used by trains, resulting in 33 grams CO2 per passenger kilometre for trains compared to 160 grams CO2 per passenger kilometre for flights [14]. According to ERA, when looking at the whole journey, the HSR connections emit roughly 10% of what the flight alternatives emit [12]. The most shocking fact is that still many of these very polluting short haul fights run daily, even though very good HSR connections are present. This suggests that still many improvements can be made in the field of realizing a modal share shift from air to rail, something which will be further investigated in this paper.

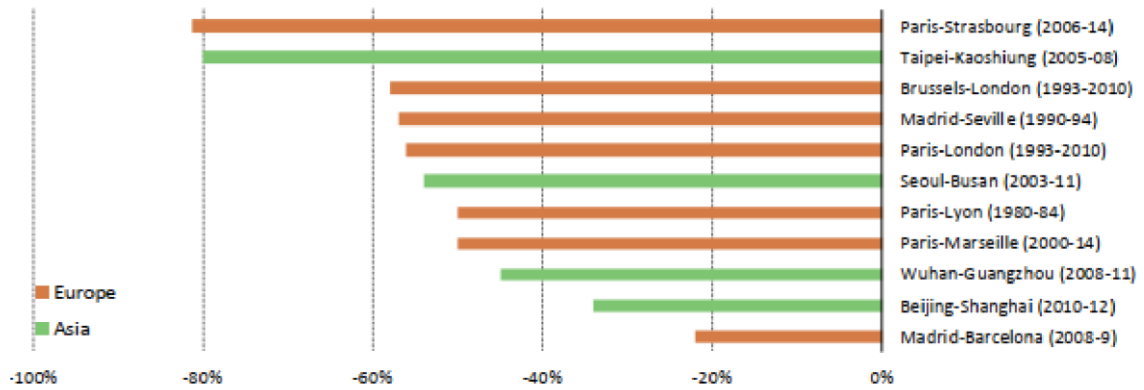


Fig. 1. Change in aviation passenger kilometres [12]

On the other hand, rail also has its negative externalities. One of them is high noise-related costs especially over large distances [10]. Also, the environmental pressures related to the construction and maintenance of the infrastructure can have a negative impact on the climate [10]. However, when you compare this to other modes of transport such as road transport, aviation and maritime, rail still has by far the lowest external costs. Namely, 18 billion for rail as compared to 820 billion for road, 48 billion for aviation and 98 billion for maritime [12].

Even though rail transport is the most sustainable and has the lowest external costs, it is still hardly able to compete against aviation within Europe when looking at ticket prices. On 79 out of 112 routes analysed by Greenpeace, flights are less expensive than rail. A train ticket can sometimes cost up to 30 times the price of the flight. Some really effective high-speed train routes, such as Amsterdam-London and Toulouse-Paris are still among one of the most popular short-haul flights in Europe. On these routes, flights remain much cheaper, which is very surprising when looking at the large amount of emissions. The price of the negative side effects of air is namely much higher compared to rail, meaning that a plane ticket should cost significantly more than a train ticket [8,10]. So, despite air transport being the most environmentally damaging form of transport per passenger-kilometre, the prices often do not include a compensation for negative externalities such as climate damage [9].

On the other hand, the European Green Deal objective to reduce GHG from transport by 90% by 2050 compared with 1990, highlights the willingness of European policy makers to take action. Facilitating this a shift from air to rail travel plays a key role, because travelling by air causes more than six times higher emission costs than travelling by HSR [10]. This research paper will focus on which improvements can be made by both European policy makers, railway operators and aviation companies to further support this modal share shift from air to rail as well as what the challenges are in realizing this.

### III. METHODOLOGY

This research will focus on a top-down approach, diving into what nowadays can be done by European policy makers, train operators and aviation companies to make train travel more attractive within Europe. This top-down approach has been chosen, because previous research has indicated that European citizens are only willing to make compromises in their current lifestyle when significant financial commitment from product and service providers is done [3]. Also, research has shown that a bottom-up approach will be very challenging due to the large influence of society on the individual. In order to change decision making of an individual, a change of the whole population is needed [3], which is outside the scope of this research due to limited time availability. So therefore, the focus will be on a top-down approach looking specifically at policy makers, train operators and aviation companies.

#### 3.1 Data analysis

First of all, a literature and data analysis will be done to find an answer to research question a, b, c and d. This is because much information relating to these research questions can be found by looking into online databases and other existing literature. It is important to notice that short haul flights will include flights which cover shorter distances than 500 kilometres. These flights are categorised by literature as very short haul flights and therefore have substantial potential to be replaced by sustainable alternatives [4].

#### 3.2 Case studies

To find an answer to sub research question e, f and g, a case study approach will be applied [46]. This case study will focus on certain train routes which provide a very good or very bad alternative compared to aviation. These routes follow from the literature and data analysis from the previous section. The case studies will compare

routes on price, emissions and travel time. Good train alternatives will be characterized as trainlines which have a relatively short travel time compared to flights and vice versa. So, to rate the alternative train connections from good to bad there will mainly be looked at total travel time from city centre to city centre. This is because the total travel time gives a good indication on whether the train routes are a somewhat comparable alternative for the short haul flights.

### 3.3 Interviews

After the data analysis on travel time a selection will be made about very good train alternatives. These very good alternatives will be further investigated in a case study. This case study will include interviews with corresponding organisations. The aim is to conduct at least 3 till 6 interviews in total. These interviews will be semi-structured, meaning that a fixed set of approximately five questions will provide the basis for the interview, however additional questions and discussions are also allowed. The outcome of the interviews will be qualitative data which will be analysed and summarised as objective as possible. Analysing the interviews includes both transcribing the interview recordings as well as highlighting important and repetitive parts. After analysing a detailed summary can be made. This summary will be shared with the corresponding organisations to verify its correctness.

### 3.4 Literature review

Additionally, next to this primary data coming from the interviews, also secondary data will be used. Secondary data includes data coming from for example existing academic reports and research papers. For questions f and g, literature research will be conducted to support the interview and case study findings by academic literature. This can help with extracting the investigated case studies in a broader context. Also, this can give a better understanding of the potential challenges for European policy makers, railway operators and aviation companies in the field of sustainable transport. The outcome of all these different research approaches will be synthesised to get to the answer of research question g and the main research question.

## IV. RESULTS

This section presents the detailed results of the field study including results from the data analysis, literature review, case studies and interviews. The detailed results of the data analysis (including intermediate steps) can be accessed on request.

### 4.1 Very short haul passenger flights key findings (data analysis)

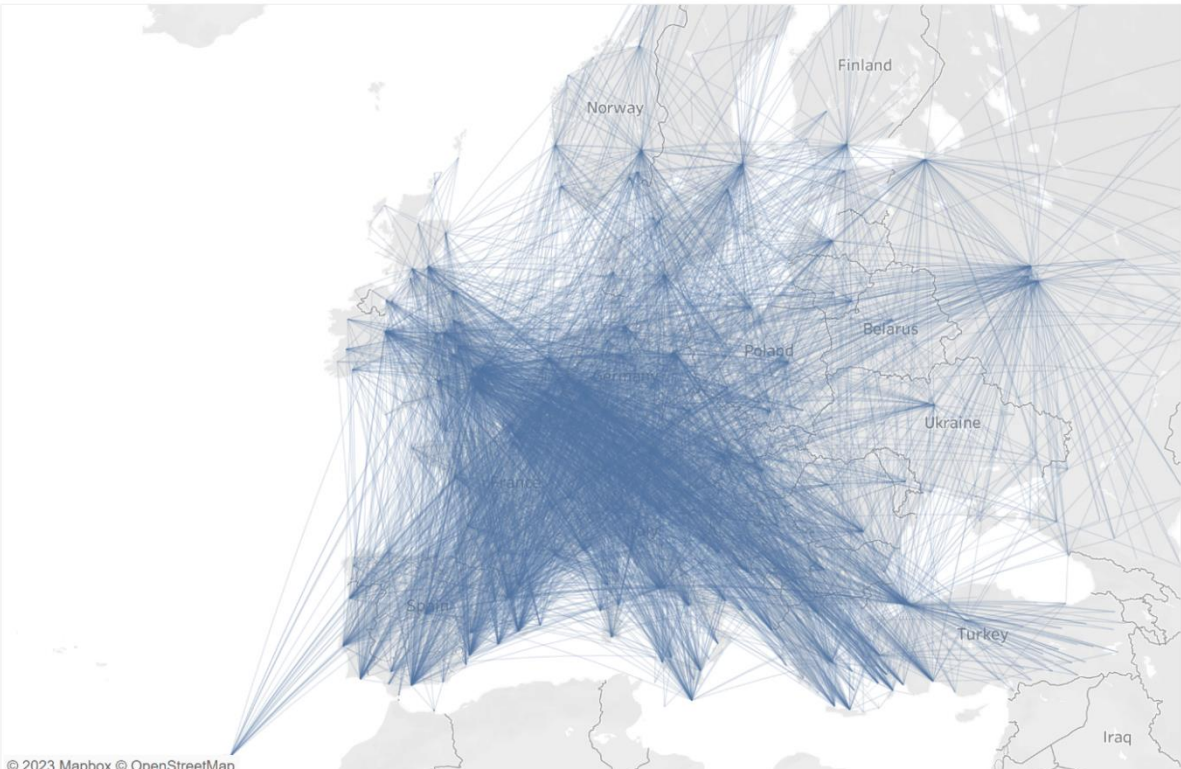
- In 2019 there were 66.629 different flights all over the world. The average flight distance was 4.490 kilometres (see figure 2);
- 15.919 out of 66.629 flights was within Europe which is approximately 24% of all flights. The average distance of flights within Europe was 1.183 kilometres (see figure 3);
- In 2019, the shortest flight within Europe only was 2,8 kilometres connecting the two Islands Westray and Papa Westray in the United Kingdom. The longest flight within Europe in 2019 covered approximately 3.900 kilometres and connected Moscow with Lisbon;
- 2.852 out of 15.919 flights cover a distance smaller than 500 kilometres and can be considered as very short haul, which is approximately 18% of the flight routes in Europe (see figure 4);
- These 2.852 flights include the same routes by different airlines, when removing duplicates, 1.762 different flight connections remain. However, this list still counts two way connections double. For example, Amsterdam-Paris is a different connection compared to Paris-Amsterdam. That means that these 2.852 flights connect roughly  $1.762/2=881$  different city centres with each other;
- 1.305 out of these 1.762 different city to city connections currently have a public transport alternative, which is approximately 74% of all very short haul flights in Europe. Most of the other routes are blocked by large areas water (for example remote islands) which makes them unreachable by public transport;
- For these 1.305 flights, the average travel time by car from city centre to airport is approximately 24 minutes. With London being one of the worst connected cities with an average travel time of more than one hour.

Each line represents one direct flight connection between two airports



**Fig. 2.** Flights across the world in 2019

Each line represents one direct flight connection between two airports



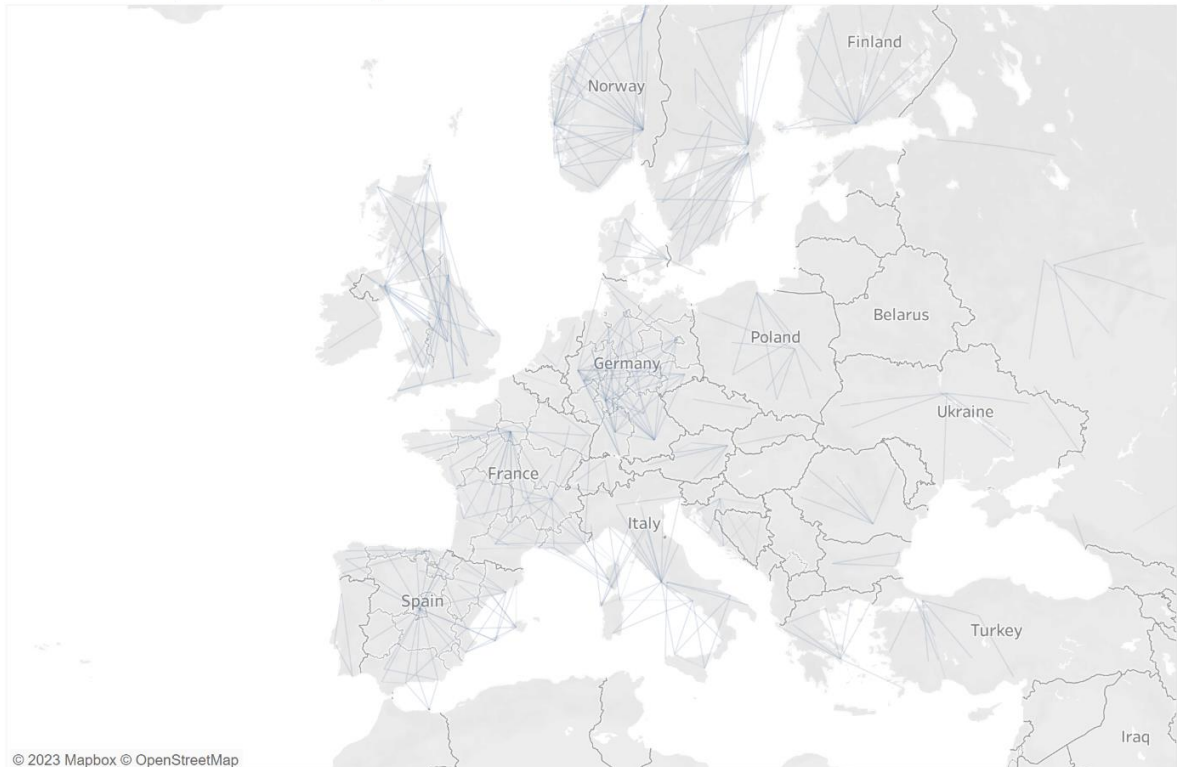
**Fig. 3.** Flights in Europe in 2019

Each line represents one direct flight connection between two airports



**Fig. 4.** Short haul flights in Europe in 2019

Each line represents one direct flight connection between two airports with a distance shorter than 500 kilometers



**Fig. 5.** Domestic Short haul flights in Europe in 2019 with a transit alternative

4.2 Train alternatives key findings (data analysis)

- On average, taking the plane is almost four times more polluting than taking the train;
- On average, taking the train is more than twice as expensive as taking a plane;
- Approximately 67% (1.174 out of 1.762) of all short haul flights is domestic, meaning that the flight stays within one country. The remaining 33% (588 out of 1.762) is international (see figure 5);

- On average, taking the train takes twice as long compared to taking the plane (minimum = 0,29, lower quartile = 1,07, median: 1,52, upper quartile = 2,48, maximum: 14,44);
- However, for 312 out of the 1762 different routes, rail offers a faster or similarly fast alternative compared to taking the plane, this corresponds to almost 18%. So that this suggests that when looking at travel time, almost 20% of all short haul air routes in Europe can already be replaced by rail;
- The transit journeys which take considerably longer than taking the plane are often blocked by large areas of water (such as lakes or seas). Most of these are peninsulas which are located in the north of Norway and the rest of Scandinavia. These peninsulas often don't have a good rail connection with the rest of the country. Also, within the United Kingdom, especially from and to Belfast, this often is an issue. For such journeys where rail has a geographical disadvantage (e.g. water blocking the route), it currently is still a better option to opt for flight alternatives instead. Realising a modal share shift and similar travel times on these routes would be extremely difficult;
- The top eight best and worst train alternatives which currently still have a direct flight between the two cities are presented in the next section.

4.3 Case study comparison

The train connections of table 2 can be considered to be good alternatives to currently still existing flights, because the train is more than twice as fast compared to taking the plane. It does have to be noted that this is only a fraction of all rail alternatives which are faster than taking the plane. Overall, there are much more routes on which rail offers a faster alternative. But due to limited time availability only routes which are more than twice as fast have been selected.

Table 2: Good rail alternatives following from data analysis

Source city	Destination city	Travel time by air	Travel time by rail	Plane is x times faster	Plane is x times more polluting	Plane is x times cheaper
Florence	Rome	241 mins	79 mins	0,33	4,9	1,5
Naples	Rome	222 mins	78 mins	0,35	5,2	1,4
Frankfurt	Stuttgart	219 mins	83 mins	0,38	4,7	1,5
Paris	Brussels	239 mins	92 mins	0,38	4,4	1,6
Duesseldorf	Frankfurt	222 mins	86 mins	0,39	4,8	1,5
Marseille	Lyon	244 mins	102 mins	0,42	4,4	1,6
Rome	Bologna	262 mins	123 mins	0,47	5,0	1,5
			Average	0,39	4,8	1,5

Additionally, it does have to be mentioned that the numbers presented above are estimations and might slightly deviate from reality. The journeys between Paris/Brussel and London have been excluded from this list because Google maps did not include the passport control time in the total travel time by train. Also, only one way routes are used (the fastest of the two) and the journey in the opposite direction is excluded.

It can be seen that all city-to-city connections from table 2 are much faster by rail as compared to the air alternatives (on average 2,5 times faster). These routes currently all have a fast direct train connection as well as a direct flight connection. Therefore, they have a large potential to be replaced by rail due to the significant reduction in travel time. The presented numbers of table 2 on emissions and price are still a rough estimation which made use of a price and emission per kilometre. They will be investigated in more detail in the next sections in order to make more accurate statements on them.

Table 3: Lowest ticket prices by plane according to corresponding airline website

Source city	Destination city	Price one day in advance (9-12-2023)	Price one week in advance (16-12-2023)	Price one month in advance (9-1-2024)	Price 5 months in advance (9-5-2024)
Florence	Rome	€ 61,0429	€ 108,0429	€ 61,0429	€ 61,0429
Naples	Rome	€ 62,3829	€ 62,3829	€ 62,3829	€ 62,8329
Frankfurt	Stuttgart	€ 169,1428	€ 114,1428	€ 82,3728	€ 82,3728
Paris	Brussels	€ 900,8631	€ 568,8631	€ 292,8631	€ 254,8631
Duesseldorf	Frankfurt	€ 144,2128	€ 99,2128	€ 79,9728	€ 79,9728
Marseille	Lyon	€ 280,0030	€ 137,0030	€ 131,0030	€ 107,0030
Rome	Bologna	€ 64,9629	€ 64,9629	€ 64,9629	€ 64,9629
	Average	€ 240,37	€ 164,94	€ 110,66	€ 101,86

**Table 4:** Lowest ticket prices by train according to corresponding train operator site

Source city	Destination city	Price one day in advance (9-12-2023)	Price one week in advance (16-12-2023)	Price one month in advance (9-1-2024)	Price 5 months in advance (9-5-2024)
Florence	Rome	€ 55,0024	€ 27,9024	€ 14,9024	€ 14,9024
Naples	Rome	€ 52,0024	€ 24,9024	€ 14,9024	€ 14,9024
Frankfurt	Stuttgart	€ 45,9025	€ 14,9025	€ 14,9025	€ 14,9025
Paris	Brussels	€ 109,0027	€ 59,0027	€ 29,0027	- 27
Duesseldorf	Frankfurt	€ 45,9025	€ 25,9025	€ 14,9025	€ 14,9025
Marseille	Lyon	€ 10,0026	€ 10,0026	€ 10,0026	€ 10,0026
Rome	Bologna	€ 67,0024	€ 29,9024	€ 18,9024	€ 18,9024
	Average	€ 54,97	€ 27,50	€ 16,79	€ 14,75

**Table 5:** Ticket price comparison

Source city	Destination city	Average price train	Average price plane	Plane is x times more expensive
Florence	Rome	€ 28,18	€ 72,79	2,5
Naples	Rome	€ 26,68	€ 62,50	2,3
Frankfurt	Stuttgart	€ 22,65	€ 112,01	4,9
Paris	Brussels	€ 65,67	€ 504,36	7,7
Duesseldorf	Frankfurt	€ 25,40	€ 100,84	4,0
Marseille	Lyon	€ 10,00	€ 163,75	16,4
Rome	Bologna	€ 33,68	€ 64,96	1,9
	Average	€ 30,32	€ 154,46	5,1

From the ticket price comparison of table 2.3 it can be concluded that for all flight routes the ticket prices by rail are cheaper than the ticket prices by air. This in combination with the shorter travel times, makes these journeys much more attractive by rail as compared to air. This highlights the question why these flights are still retained and why they aren't replaced by rail yet. Something which will be further investigated during the interviews of section D.

**Table 6:** CO2 emissions comparison

Source city	Destination city	CO2 emissions by train per passenger in grams	CO2 emissions by plane per passenger in grams <sup>16</sup>	Plane is x times more polluting
Florence	Rome	019	42.000	∞
Naples	Rome	019	40.000	∞
Frankfurt	Stuttgart	020	36.000	∞
Paris	Brussels	1.60017	39.000	24,4
Duesseldorf	Frankfurt	020	40.000	∞
Marseille	Lyon	89018	57.000	64,0
Rome	Bologna	019	44.000	∞
	Average	356	42.571	120

Also, the comparison on CO2 emissions of table 2.4 makes clear that the rail journeys are by far much less polluting than the flight alternatives. This is because trains in general use fewer fossil fuels, but also because many of the train operators on these routes only use green energy. This makes the impact of these rail journeys on the climate much lower and often even zero, providing additional evidence that realizing a modal share shift from air to rail is important.

**Table 7:** Number of air passengers according to Eurostat15 and the frequency

Source city	Destination city	Q4 2022	Q1 2023	Q2 2023	Average	Flight frequency
Florence	Rome	23.688	21.323	43.741	29.584	4 per day <sup>22</sup>
Naples	Rome	36.795	31.877	43.967	37.546	4 per day <sup>23</sup>
Frankfurt	Stuttgart	62.928	50.457	59.689	57.691	3-5 per day <sup>23</sup>
Paris	Brussels	69.865	58.716	75.993	68.191	2 per day <sup>22</sup>
Duesseldorf	Frankfurt	67.142	53.943	67.111	62.732	3-5 per day <sup>23</sup>
Marseille	Lyon	23.750	20.367	20.523	21.546	0-3 per day <sup>22</sup>
Rome	Bologna	-	-	-	-	2-3 per day <sup>22</sup>
	Average				46.215	3 per day

Even though the train alternatives are much faster, much cheaper and much less polluting as compared to the flight journeys, these flights still exist with an average frequency of 3 times per day (see table 2.5) transporting approximately 46.000 passengers per month. This clearly raises the question why such flights are still being

retained and why it would not be possible to replace them by rail. This is something that will be further investigated in the next section.

#### 4.4 Interview results

##### 4.4.1 Deutsche Bahn and Lufthansa

According to DB, the main challenges in replacing short haul domestic flights in Germany by rail alternatives, includes issues related to baggage handling, convincing passengers that rail is a more comfortable alternative, and convincing airlines to suspend flights on routes where comparable rail options were available. DB clearly expressed readiness to replace more flights, emphasizing that the infrastructure and technical setups are in place, especially in Frankfurt. DB currently provides a Rail&Fly offer for all their 5600 railway stations. Challenges primarily revolved around convincing passengers to choose rail and persuading airlines to suspend flights.

Lufthansa made clear that they are really willing to replace the domestic flights by rail: "If we don't find anything better to fly with our aircrafts than short flights, we don't do our job right, but we first need to convince the passengers." However, for Lufthansa it is not possible to stop the flights and use the train instead, because they expect to lose a vast majority of their passengers when introducing such an alternative. The strong competition between airlines is slowing down this transformation to more sustainable modes of transport. Secondly, having both the flight and rail journey at the same time, makes it very cost intensive for Lufthansa. This is because they have to pay DB per seat, while if this passenger would occupy the now empty seat in the airplane, this would not cost them anything extra. As a result, these flights are still being retained.

##### 4.4.2 Brussels Airlines and Eurostar

Brussels Airlines is mainly operating flights from and to Africa, introducing challenges such as political instability and large amounts of baggage handling. But also the Diabolo fee makes it difficult to offer affordable train alternatives from Brussels. This is a fee of 6,40 euro which every train passenger needs to pay when entering or exiting the train station at Brussels Airport Zaventem. Additionally, the direct train service between Brussels Airport and Amsterdam Airport will be cancelled from 2024. Highlighting the political support that airports in the Netherlands receive, while Brussels Airport lacks similar support from the Belgium government.

The airline also stresses the need for a direct train connection from Brussels Airport to Paris Charles de Gaulle Airport, where they are currently flying an almost always fully booked plane with a frequency of two times per day. There was a collaboration with Eurostar in the past, but it unfortunately has been stopped due to profitability issues. According to Brussels Airlines this was mainly due to the complexities of integrating baggage handling in the rail system and ensuring a smooth passenger flow for intermodal travel. This is mainly caused by the large numbers of passengers going to Africa, usually taking a lot of luggage with them while travelling with large families. "

Eurostar cannot facilitate a direct connection between Paris and Brussels Airport in short term. They currently do not have enough rolling stock available to add this additional stop. "This means that we would have to sacrifice a connection from our timetable, which is not desired". Eurostar expects to have more trainsets available at the end of this decade, but this it is still too far in the future for them to give any promises on adding this extra stop in the future.

##### 4.4.3 ÖBB and Austrian airlines

All in all, from the interview with ÖBB and Austrian it can be concluded that Austria is already doing a very good job in replacing short haul flights by rail. It is the first country who introduced a minimum price for flight tickets. On top of that, it is one of the rare countries in the EU that invests more in rail than in aviation. All in all, this results on only very few domestic and short haul flights. The air routes which do exist will be very likely replaced by rail in the next decade due to large infrastructural improvements. As was highlighted by both the DB and Lufthansa as well as Austrian, rail connectivity to Munich Airport remains a large bottleneck for both domestic and international short haul flights. An improvement on the infrastructure on this airport could potentially replace many short haul flights by rail. Austrian also agrees with Lufthansa that strong competition between airlines play a role. Stopping these short haul feeding flights will open up slots at the airport which might be taken over by the competition.

##### 4.4.4 ITA Airways and Trenitalia

All in all, the interviews with ITA Airways and Trenitalia highlighted that the largest issue in replacing more flights by rail is the lack of a good and efficient intermodal product. In many cases direct high speed rail connections

to the airports are missing as well as lacking check-in facilities at the airport's train station. Especially in the hub model of ITA Airways with many transferring passengers on short haul flights, efficient air-rail intermodality is of great importance.

#### 4.4.5 ALLRAIL's Secretary General "Nick Brooks"

The interview with ALLRAIL made clear that in order to realise a modal share shift from air to rail, market opening and liberalization in the passenger rail sector is needed. Market opening is according to ALLRAIL not only beneficial for operators but for various companies in the passenger rail value chain such as the infrastructure managers. "The strong competition which started 30 years ago, made the aviation industry so successful. This is also needed in the rail industry to drive efficiency, better services and lower prices." As an example, ALLRAIL mentioned the success market opening had in Italy: "A new entrant operator starting services in Italy in 2012, has led to 120% growth of passengers over the course of 11.5 years. And on certain specific parts of the Italian high-speed network, there's been a growth of more than 500% [43]. So, four times as many passengers as beforehand, which is huge modal shift." Additionally, ALLRAIL criticizes plans (supported by the EU) to build new mega airports in Portugal and Poland. The argument is that the stated environmental reasons for these projects are flawed, as new airports would likely lead to increased short haul flights and thus modal shift to air travel instead, rather than promoting sustainability.

#### 4.4.6 European Union Agency for Railways (five non-official representatives)

In short, the interview highlighted that the primary competitors for long-distance rail travel (beyond 500 kilometres) are road transport options, including coaches, but in particular cars. High-speed rail is for ERA also considered to be competitive even on routes up to 800 kilometres, with ongoing infrastructure projects aimed at increasing rail speeds in regions like Sicily and the Baltic states. Ticket prices for rail compared to aviation depend on the level of competition in the rail market. In regions with high-speed rail competition, ticket prices tend to be lower. However, in areas with less rail competition, prices may be higher. The European Union supports rail through financing infrastructure projects, with a strategic goal to double passenger numbers on rail. Policies focus on sustainability, and there are efforts to connect core airports with rail links.

Collaboration between rail and air travel is encouraged, but the EU does not have the authority to forbid flights. Incentives, such as carbon pricing policies, are seen as more effective than regulations in encouraging a shift from air to rail. Infrastructure challenges, such as gauge differences and technical rules, are identified as barriers to smooth and efficient rail travel. The EU's role is perceived as providing subsidies to upgrade infrastructure, harmonize technical rules, and address obstacles like gauge differences. Overall, the interview highlighted the importance of infrastructure development, competition, and incentives to enhance the competitiveness and attractiveness of rail travel compared to short-haul flights.

#### 4.4.7 Two European Commission representatives from the Directorate-General for Mobility and Transport (DG MOVE) department

From the interview it became clear that the EU's approach can be described as creating an enabling framework rather than favouring one mode over another. The EU also does not play an active role in approaching airlines or railways to become more sustainable. As said earlier, their primary focus is on facilitating a framework and providing fundings within existing programmes, in collaboration with the Member States. With this framework and fundings they eventually should convince more passengers to take the most sustainable travel mode. The representatives also mentioned that they are aware of the unfair taxation between airlines and railway operators. They said that this is currently under discussion within the European Commission but that there is no final decision being made yet.

The possibility of implementing regulations restricting short-haul flights within Europe, especially where there is a faster train alternative, was rejected by the representatives. They highlighted that there still many challenges to overcome. "It would be forbidding flights, instead of making rail more attractive, that's one aspect we do not favour." Secondly, they highlight that such regulations will become quickly too complex and detailed. "In instead of three articles, you could end up with 30 articles in legislation." Thirdly, it was mentioned that it will be difficult to treat all airlines the same, some might have more transferring passengers while others serve more point-to-point traffic. On the other hand, the EU should not make the situation more complex than it is. Implementing the following rule could already be very efficient: "It is not allowed to sell (connecting) flight tickets on routes where a faster or similarly fast city to city rail alternatives exist." The EU prefers to not use such hard rules to make this

modal share shift happen, they rather convince the passenger with for example better infrastructure or the universal ticketing system.

#### 4.4.8 Summary of results

Below you can find the summarized answer per sub research question following from the results section A till D.

- a. Which very short haul (<500 km) passenger flights do currently exist within Europe?

*The list of all short haul flights in Europe can be accessed on request.*

- b. What is the total travel time from city centre to city centre for these flights?

*The total travel time per flight can be accessed on request.*

- c. Which passenger train routes currently exist as an alternative for these flights?

- d. What is the travel time from city centre to city centre for these train routes?

*C+D: The alternative train routes including their travel time can be accessed on request.*

- e. How do the train alternatives compare to the flights when looking at ticket price, CO2 emissions and travel time?

*For all short EU haul flights, on average, taking the plane is almost four times more polluting than taking the train. Taking the train is more than twice as expensive and takes twice as long compared to taking the plane. During the more detailed investigation of the case studies it was seen that for the bad rail alternatives, taking the plane is 1,6 times more expensive, 2,8 times more polluting and 3,7 times faster than taking the plane. For the good rail alternatives it was found that on average taking the train is more than 2,5 times faster, 5,1 times cheaper and 120 times less polluting than taking the plane.*

- f. Which of these flights can potentially be replaced by train connections when looking at travel time? And why aren't they being replaced yet?

*The routes Florence-Rome, Naples-Rome, Frankfurt-Stuttgart, Paris-Brussels, Duesseldorf-Frankfurt, Marseille-Lyon and Rome-Bologna were identified as routes which have the largest potential to be replaced by rail since they were all more than twice as fast (from city centre to city centre) by rail as compared to air. The largest issue in replacing these flights by rail is the lack of an efficient intermodal product. For that reason passengers still opt to take the plane.*

- g. Which of these train connections need significant improvements in travel time to be able to compete with aviation? And what kind of (policy) improvements are necessary?

*The routes Rome-Trapani, Oradea-Bucharest, Sofia-Bucharest, Lisbon-Malaga, Alexandroupolis-Athens, Bari-Catania, Bari-Palermo and Warsaw-Vilnius were identified as routes which take more than three times longer by rail as compared to air. Therefore these routes need significant improvements in travel time to become able to compete with aviation. The most effective way to reduce travel times on these routes is by investing in HSR infrastructure as well as better cross-border connectivity*

Sub research question h will be answered in the last paragraph of the conclusion.

## V. DISCUSSION

Every effort is made to conduct this research as objectively and accurately as possible. However, as for every research project, this research is not perfect. This section will highlight some of the potential pitfalls of the conducted research.

First of all, the most recent flight database available was dated from 2019, meaning that when comparing with the current situation, some flights might not exist anymore, or new flight might have been introduced. The routes of the case studies have all been checked on their existence. However, some flights could be missing in this database, which means that for the 2023 situation different case studies might be identified. This could have led to potentially different outcomes.

Secondly, the statements made about CO2 emissions and prices are sometimes based on rough estimations, making them not always very accurate. Also, the flight distance and duration have been estimated and not real time fetched from a database or travel planner. Of course, many efforts have been made to make these estimations as accurate as possible. This has for example been done by comparing the estimated numbers with reality. However, still these estimations could lead to small deviations in outcome.

Thirdly, the train distance and duration have been planned by Google Maps, which could sometimes give inaccurate outcome. This is because, construction works could be present on certain lines at the moment of researching, resulting in longer travel times by train. Also, other uncertainty factors such as delays and punctuality

are not being taken into account in the travel time for both air and rail. Eventually this might lead to small deviations in outcome.

Fourthly, another uncertainty is that the flight routes have been identified based on city names and not on airport names. This means that for example different airports of Paris to the same airport of Brussels are all considered as one flight route from Paris to Brussels. This has been chosen because the time comparison is being made on city-to-city travel time and not airport to airport travel time. However, it could be the case that the different airports of Paris have a slightly different travel time to Brussels. Also, the travel time from city centre to different airports of Paris might deviate. This could potentially also lead to slightly different outcomes.

Fifthly, the use of primary data, especially the conducted interviews, could cause a bias in the research outcome. However, by verifying the interview summaries with the interviewees, one has tried to avoid having any misunderstandings or mistakes in the qualitative data. Also a larger sample size per organisation could help getting more accurate data. Due to limited time availability this was not possible for this research.

Lastly, it was not possible to have interviews with Trenitalia on their routes as well as SNCF and AirFrance on the Marseille-Lyon case study. They did not respond in time to the different contact attempts. This could potentially cause some missing insights in the case study section.

All in all, these relatively small uncertainties are being considered insignificant for the general outcome of the research. It is assumed that the mentioned deviations only have a small, probably neglectable, effect on the final outcome. Still, it would be a recommendation for future research to try to cope with these uncertainties. Due to limited time availability this was not possible for this research.

## VI. CONCLUSION

When looking at all short haul (< 500 km) flights in the EU, it has been found that on average, taking the train is twice as expensive, four to six times less polluting and twice as slow compared to taking the plane. However, almost 20% of these short haul flights, rail offers a faster or similarly fast alternative compared to taking the plane. Highlighting that still large efforts can be made to make travel in Europe more sustainable and to achieve the set climate targets.

The case study on the top 8 slowest rail journeys proved that for many routes still infrastructural improvements are needed. For most of these routes efforts (mainly in the form of fundings) are being made by the EU as well as national authorities to realise this.

When investigating the top 7 fastest rail alternatives it could be seen that still many challenges remain in the field of realizing this modal share shift from air to rail. First of all, a good city to city connection does not mean a good city to airport connection. Many of these short haul flights are namely being used as transferring or so-called feeding flights. This means that passengers do not want to travel from one city centre to another. Instead, they want to go from one city centre to the airport of another city centre to connect there to another flight.

For such journeys it seemed to be difficult to convince passenger to opt for the train, especially when the city to airport rail journey is not that good as compared to the city-to-city rail journey. One of the reasons for this is the lack of direct high-speed rail connections to airports. As a result, passengers would have to transfer from one train to another. In this situation passengers often prefer to still take the direct short haul flights. Also, the lack of luggage check-in facilities at train stations is identified as one of the contributing issues. Especially passengers who are carrying large amounts of luggage have a strong preference for direct flights where luggage can be dropped off at the start of their journey and collected at the end.

All in all, the lack of a good intermodal product in combination with the strong competition between airlines, makes it difficult to convince passenger to take the train. If one airline would replace their short haul feeding flights by rail (so introducing an air rail combination), there is a chance that they will lose a vast majority of their passengers to the competitors who still offer an air only service. Therefore, the key solution can be found in developing a good intermodal product which convinces passengers to take the train as well as infrastructural improvements, making airports such as Munich better connected with high-speed rail lines. There is a strong need for an efficient intermodal product which convinces passengers that rail is the more sustainable, more comfortable and faster alternative. Future research could focus on how passengers can be convinced to take the train as well as how such an intermodal product should look like.

Unfortunately, the EU does neither want to favour one mode over another nor ban certain flight routes. Their focus is on providing a framework which passengers, airlines and railway companies could use to become more sustainable. The EU says to be working on fairer taxation between different modes of transport for over 23 years now. However, as of today there have not been implemented any measures yet. The EU is also building a

multimodal travel planner which should encourage people to choose for the most sustainable transport modes. This is expected to be finished within several years.

It does have to be mentioned that in most cases there will still remain some demand for air passengers. This means that even if the train route is extremely efficient, probably one or two flights a day will remain. This can be seen on routes such as Marseille-Lyon and Paris-Brussels. The only way to fully stop these flights is by governmental, preferably European regulations. This seemed to be the most effective way to fully ban unnecessary short haul flights and achieve the set targets of the European Green Deal, SDG 13.2 (Climate Action) and SDG 9.1 (Industry, Innovation and Infrastructure).

Overall, there still remain many challenges in achieving the set SDG and Green Deal climate targets. Even though efforts are being made, it remains a Grand Challenge to make EU's passenger transport sector more sustainable. The lack of an effective intermodal product as well as the lack of efficient high speed cross border connectivity make it difficult to replace more flights by rail. Enhanced European policies, adopting a clear vision, favouring the most sustainable modes of transport, could play a key role in tackling these challenges and achieving the set climate targets.

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Fig. 6. The partner organisations in this research project.

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