• Adobe PDF
• Google Earth KMZ

We generated a 3D PDF with the program. In addition, it is possible, for example, to read and save the points, save the tiled model independently, or even share it online within the program.

The software can even generate a report on modeling, producing a few pages of PDF. This document includes camera calibration, camera positions, control points, and other processing parameters.

III. RESULTS AND CONCLUSIONS

We needed to get photos taken by an UAV, and we needed to do a geodetic survey to have data for an accuracy check of the 3D model. The photos were taken by using a DJI Phantom 3 UAV, and we used a Foif total station with its necessary accessories for the geodetic surveying. The UAV flight took place in 3 setups, in different heights and towards 3 separate directions. At the end of the day, 127 photos were taken.

In the geodetic survey we used 3 instrument setups, and we chose 21 control points on the site to measure. We took the measurements with extra care, in a specific way to be able to create a network and adjust errors at the same time. In order to minimize instrument errors in the surveying, we measured each points at twice permits. The deviation of coordinates of each points in the network are far less than 1 cm.

The accuracy test was performed with the help of Agisoft Photoscan as well. We placed the 'Markers' on the images of the textured model, which correspond to the ground control points measured in the field with Foif RTS 332 measuring total station.

After carrying out the error assessment the greatest residual was about 4 cm. The overall RMS value was 2.6 cm.

As a conclusion we can say that the UAVs can be used effectively for 3D modeling even indoors. The Agisoft Photoscan software (the latest name is Agisoft Metashape) is a perfect choice to go through the whole process.

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The Effect of High Speed Trains on Air Transport

J. Vagner *, E. Jenčová**, R. Rozenberg*, P. Kaľavský*, S. Ďurčo*, M. Antoško* and J. Sabo*
* Faculty of Aeronautics, Technical University of Košice/Department of Flight preparation, Košice, Slovakia
** Faculty of Aeronautics, Technical University of Košice/Department of Air Traffic Management, Košice, Slovakia
juraj.vagner@tuke.sk, edina.jencova@tuke.sk, robert.rozenberg@tuke.sk, peter.kalavsky@tuke.sk,
stanislav.durco@tuke.sk, matej.antosko@tuke.sk, jozef.sabo@tuke.sk

***Abstract* — The aim of the contribution titled The effect of high speed trains on air transport has a theoretical and practical character. The work deals with a survey of the current state of shared transport lines between air carriers and high-speed train operators in Europe. In the article is analysed the factors, that have the greatest influence in the decision-making of the passengers of the transport. We have highlighted the advantages of high-speed trains for short-to-medium distance transport and selected particular transport lines shared by both operators, which are analysed in more detail. Suggestions and advices are proposed for air carriers.**

I. INTRODUCTION

The development of high-speed rail (HSR) services throughout the last decades has gradually blurred the concept of competition and cooperation with air transportation. The spectacular growth in air transport increasingly poses the question of its impact on the environment. It is for this reason that public authorities and researchers are counting on high-speed trains (HST), whose efficiency is said to make possible a modal shift to the detriment of the airplane. The work deals with a survey of the current state of shared transport lines between air carriers and high-speed train operators in Europe. We show, as well, that for a given city pair, the actual decline in number of flights depends on various conditions, including length of the HST journey and the strategies adopted by the airlines. Some carriers reduce their offer in terms of number of seats but increase the number of flights in order to compete more effectively with the HSTs.

II. HIGH – SPEED LINES

High-speed trains (HSR) are a type of rail passenger service that works much faster than conventional rail. European Union Directive 96/48 / EC, Annex 1 defines a high-speed line in terms of:

• Infrastructures: a line specially designed for high-speed driving or specially adapted for high-speed driving.

• Minimum speed limit: minimum speed of 250 km / h (155 mph) on lines specially built for high speed and speed of approximately 200 km / h (124 mph) on existing lines that have been specially refurbished. This applies to at least one part of the line. Rolling stock must be capable of reaching a speed of at least 200 km / h (124 mph) in order to fit into a group of high-speed trains.

• Operating conditions: rolling stock must be designed with infrastructure for full compatibility, safety and quality of service

The UIC identifies three categories of high-speed lines:

• Category I - New tracks specially designed for high speeds, allowing a maximum driving speed of 250 km / h (155 mph).

• Category II - Existing tracks specially upgraded for high speeds, allowing a maximum driving speed of at least 200 km / h (124 mph).

• Category III - Existing tracks specially upgraded for high speeds, allowing a maximum driving speed of at least 200 km / h (124 mph). Some sections have a lower permissible speed (due to topographical constraints or passing through urban areas) [1, 2].

High-speed trains are an important part of transport networks in several European countries. Even with the normal view of the map below, it is clear that Slovakia is far behind. In Slovakia, the fastest railway sections pass trains at a speed of around 160 km / h, which is almost twice as low compared to the fastest sections in Europe.

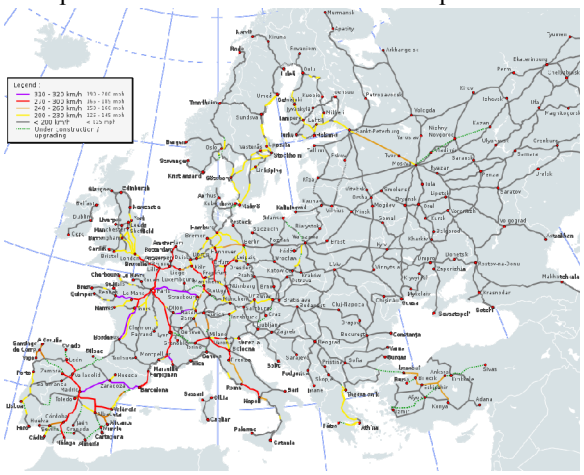

Figure 1. High speed lines in Europe

III. HIGH – SPEED LINES IN EUROPE

High-speed rail in Europe took off after the 1974 petrol crisis. Europe's energy dependency threatened internal mobility, so several Member States decided to develop a safe, fast, comfortable and ecological mode of transport in the form of high-speed rail lines. Italy was the first European country to inaugurate a high-speed rail line: the line from Florence and Rome opened in 1977. Shortly afterwards, France inaugurated its own "Trains à Grande Vitesse" lines. Germany's first high-speed lines, served by "Intercity Express" (ICE) trains, opened in the early 1990s, whereas Spain's "Alta Velocidad Española" (AVE) high-speed service commenced operations in 1992 [3].
There is currently no single European sky or single European high-speed rail network in Europe. Instead, there are a number of operating models in different Member

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States. For example, there are mixed high-speed systems (in France, Spain and Italy) and fully mixed high-speed lines (Germany, Austria and two sections in Italy).
At the end of 2017, 9067 km of high-speed lines were built in the European Union:

- Spain: 2,760 km
- France 2725
- Germany: 1,843 km
- Italy: 1013 km
- Other EU countries: 726km

The network is constantly expanding and at this moment an additional 1,671 km is being constructed. After completing all design plans, Spain will become the world's second longest high-speed rail network in China. Between 2000 and 2017, the European Union provided € 23.7 trillion to co-finance the construction of high-speed rail infrastructure [4].

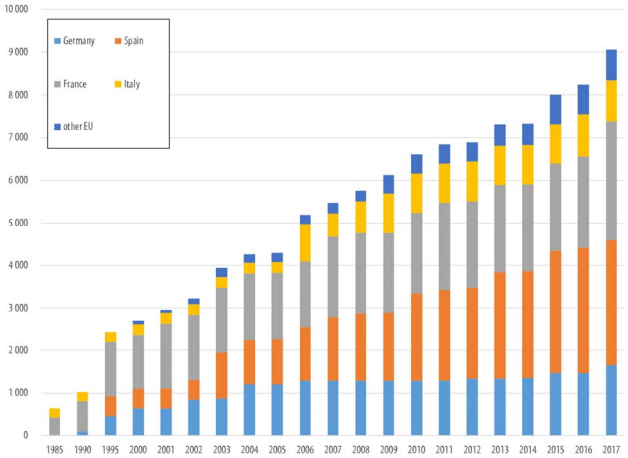

Figure 2. Length of national high-speed rail networks in the EU – growth over time

IV. COMPARSION HSR WITH AIR TRAVEL

In this article we want to point out that passengers use air-rail transport or HSR transport between metropolises. Thus, the outflow of passengers or their fragmentation would help overloaded airport and ATM capacities. HSR traffic is particularly useful when replacing short-haul flights. This would contribute to lightening the ATC, airspace or have a positive impact on the environment. In general, a larger number of passengers would be able to reach their destination without unnecessary waiting or delaying overload.

In the case of air travel, passengers spend at least 3 hours only on the way to the airport, waiting at the airport, wanting to check-in, boarding, etc. Airports cause high noise and occupy large areas, so they are located outside city centers. This fact is a weakness in the competition. Each city has different public transport and also transport infrastructure. The time it takes to move from city center to airport can range from 40 to 120 minutes in extreme cases (Paris CDG) that means high-speed trains can replace flights up to 750 km. Of the 20 busiest routes in Europe, there are 9 lines over 1000 km, 3 lines are between 800-900 km and 8 lines are less than 800 km. According to these lengths, high-speed trains can theoretically replace 40% of the busiest routes. For passengers whose time is not preferred, this percentage will rise to 55%. Of course, with increasing length, the time advantage is lost but time is not the only factor that affects passengers in deciding which transportation they choose. Not only is the simple equation of time, distance and speed important when traveling. Other factors include, for example, the amount of luggage, the ability to exchange or cancel tickets, the quality of transportation and the services provided passenger comfort, safety, etc. The most important attributes for passengers affecting the choice between airline and high-speed trains:

- ticket price
- travel time
- access to the airport or station
- the schedule of the connection and its frequency
- accuracy and reliability
- on-board comfort
- luggage service

We could divide the individual attributes when deciding which passengers to choose from into three categories:

1. Very important attributes - were determined by respondents themselves (more than 60%): ticket price, travel time, access to airport or station
2. Important attributes - on-board convenience, flight frequency and frequency, walking and availability, and waiting time

Little affecting attributes - on-board services provided luggage service [4].

V. INTERMODAL IN EUROPE

Intermodality: coordinated / organized use of more than one transport while traveling. Interested operators of individual modes of transport cooperate with each other on the basis of a pre-signed commercial contract in the design of transport links, planning the sale of tickets. The main objective of the above-mentioned cooperation is to ensure a coherent and best time travel. High-speed trains connect major urban areas with the busiest airports. This could contribute to relieving pressure and capacity at strategic airports within air networks. Air transport plays an essential role in the European economy for the citizens and industry of the European Union. By supporting 5.1 million jobs and contributing EUR 365 billion or 2.4% to European GDP, it contributes extensively to economic growth, employment, tourism, people-to-people contacts, as well as EU regional and social cohesion. There are over 400 airports with regular flights and 253 commercial airlines in the European Union. Every year, the top 10 airlines carry nearly 53% of passengers in Europe and 31% of European passengers handle the 10 largest airports in the European Union. In 2035 airports are not expected to cover the demand for air transport with a deficit of 1.9 million flights. Intermodality

and cooperation between air and high-speed rail can have a positive impact on the future. The figures below illustrate the planned delays in the European network, the increase from 2 min / years to 5 to 6 min / years in 2035.

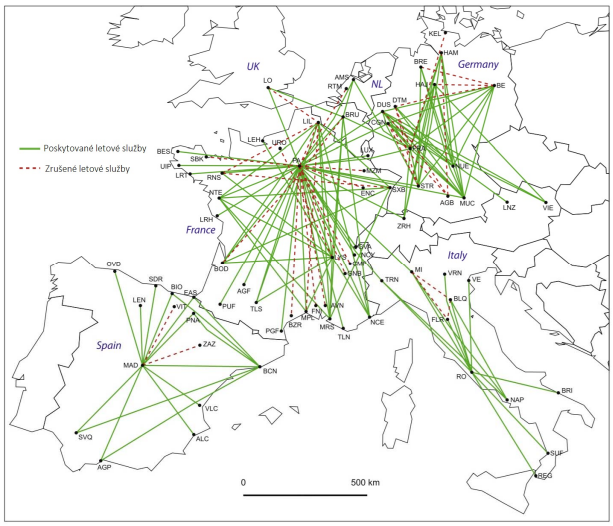

Figure 3. Shared traffic lines

The lack of airport capacity will be most significant in Turkey, the UK, the Netherlands, Bulgaria, Hungary, Germany, Poland, and Italy and will cause serious difficulties in Europe. The average delay and congestion of the entire airport network will increase. Despite plans to increase capacity at airports, after 2030, the total expected demand will not be met. Of the current more than 400 commercial European airline airports, five new airports, twenty-nine new runways, the expansion of aerodrome movement areas (TWY runways, aprons) and ground (terminals) at 106 airports are expected. Measures will increase capacity by only 17% by 2035.

The enclosed figures clearly show the potential for cooperation between air and high-speed rail. There are currently more than 250 lines on which both air carriers and high-speed trains operate simultaneously. In order for HS trains to work with airports, at least the following conditions must be met:

- Airport size: Size and population in the catchment area. Sufficient frequency of flights at a given airport to accommodate train capacities ranging from 500-1000 seats.
- Location: Location of the airport with respect to the HS train route. Thus, the HSR carrier can take the passengers being carried from the airport and continue to other destinations.

Travel time: The ability of HS trains to compete with air traffic times. If the time difference is greater than 3 hours, HS traffic becomes unattractive for passengers.

VI. EUROPEAN FLIGHTS THAT ARE CURRENTLY SLOWER THAN HIGH-SPEED TRAINS

Although currently the fastest means of transport are airplanes, the weaknesses when traveling with airlines are the airports themselves, where we lose a lot of time. The length of travel is clearly influenced by congestion and congested roads, shopping malls in terminals, long waiting times and the transition between checkpoints (want-in, safety, passport control ...), baggage delay after arrival. The aforementioned points contribute to making the fastest shipment the slower one. Increasing delays cause European passengers to look for alternatives to air travel. We chose 10 European hiking trails to get to the destination faster with a high-speed train.

TABLE I
COMPARISON TRAVELING WITH HSR OR PLANE

	HST		Plane	
	Time	Price (€)	Time	Price (€)
Brusel -> Paris	1:22	60	2:55	230
Brussel-> London	2:18	110	2:40	160
Brussel -> Amsterdam	1:50	85	2:30	180
Brusel -> Lyon	3:29	108	3:50	160
London -> Paris	2:16	116	3:57	75
Barcelona -> Madrid	2:30	55	3:35	90
Madrid-> Sevilla	2:20	52	3:25	105
Rome -> Milano	2:51	40	3:50	65
Paris -> Amsterdam	3:26	115	4:05	200
Paris -> Frankfurt	3:48	50	4:00	85

From the Table I, it is observable that high-speed rail transport is on a competitive advantage in terms of ticket / ticket prices as well as the total travel time. In other sub-chapters, we will focus on transport lines in Italy and Spain, as the high-speed infrastructure in these countries is high and high-speed train operators are a major competition for commercial air transport.

Italy

The increase in the popularity of HSR trains can be observed in Italy since the launch of the Turin-Naples line in 2002, this trend has increased even more with the arrival of the new operator Italo. As a result of the continual development of the lines, competition between transport sectors is increasing and the market share of airlines is decreasing. Competition is the reason why airlines have started to have trouble on lines operated in parallel with HSRs.

Alitalia has seen a noticeable decline in the number of airline passengers at the Rome hub and spoke airport Fiumicino (FCO). Like Alitalia, EasyJet has reduced its line-of-competition with HSR trains and has ceased operations on the Milan Linate - Rome Fiuminico route.

Fig. 4 shows the effects in terms of the evolution of the number of air passengers on the Milan-Naples, Turin-Rome, Rome-Naples routes served by both means of transport. For each track, the time spent on HS trains is also listed. This figure describes the situation since 2009 when HS

infrastructure has not yet been fully completed and the airline's market share has been controlled by the airlines.

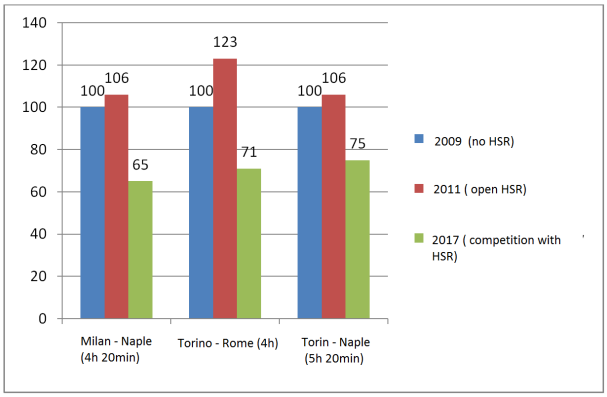

Figure 4. Development of air traffic in Italy

After analyzing the Milan-Naples route from 2009 to 2011, we can see the growth of air passengers by 6%. The opening of HS lines had no major impact on air transport. The big difference is seen since the arrival of Italo in 2016. In 2017, four years after liberalization, air transport lost 35% in 2009 and just over 40% in 2011 when we saw the peak of air traffic on the line. Thanks to this analysis, we can observe the impact of the HS track and the competitive struggle with air carriers. Turin - Rome points to a significant increase in the number of air passengers between 2009 and 2011, where the time spent traveling by HS with the HS train was between four and four and a half hours. In this case, the increase in air passengers was 23%. In 2017, there is a strong loss in the number of air passengers with a decrease of 27% compared to 2009 and 50% compared to 2011. On the Turin-Naples route, despite train duration of about 5 hours, a significant number of passengers favour the use of HS rail instead of air. This trend was similar to the case of Milan-Naples, where an increase of 6% between 2009 and 2011 followed, with a subsequent drop in air traffic by the Italian operator Italo.

In the following chart, we analysed the Rome-Milan route in more detail, which was considered to be the most important passenger route in the Italian aviation market for years. This fact demonstrates the popularity of HS trains and the ability to meet the needs of passengers who prefer HSR traffic over air [3, 5].

On the chart above, we can see how the competitive struggle between carriers has seriously affected the Rome-Milan route, with the proportion of passengers carried over the years. The graph clearly shows a decrease in the number of passengers carried by airlines. Overall, the number of passengers on the Rome-Milan line has decreased by more than 63.2%.

Overall, we think that HS lines, together with Italo, have helped to reduce the congestion of airports and airspace in the area, which will certainly help to keep air traffic flowing, reduce delays and also contribute to the European Commission's requirements. Air Italy and Alitalia should consider the prospect of the Milan-Rome airline and recommend moving them to destinations with greater distance.

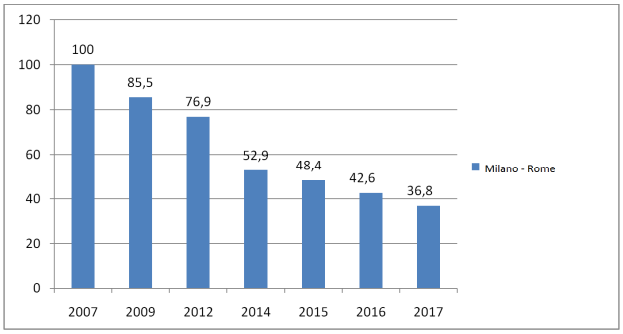

Figure 5. Development of HSR market share in Milan-Rome route

Spain

The route from Madrid to Barcelona has been one of the busiest routes in Europe for several years. This title deserves mainly due to the uniqueness of these two Spanish cities. Cities have the same distribution in tourism and business travel. This phenomenon has resulted in a desire for passengers to move between cities as quickly as possible, and airlines also have room for transport. After the launch of the high-speed railway lines and in particular the arrival of AVE trains, the market for passengers has moved to the aforementioned high-speed line. The advantage of HS trains were train stations located in the city center, "want-in" checks were not required and no luggage fees were charged. The total travel time from Barcelona to Madrid takes about 2.5 hours with a high-speed train. The flight time added to the airport takes more than 3.5 hours, which means that the high-speed train service will reduce travel time by 1 hour. Ticket / ticket prices for purchase one week in advance:

- 55 € by train and
- 90 € by air

Even when comparing prices, HS transport has a significant competitive advantage and therefore in recent years the demand for high-speed rail transport has been steadily increasing at the expense of air transport.

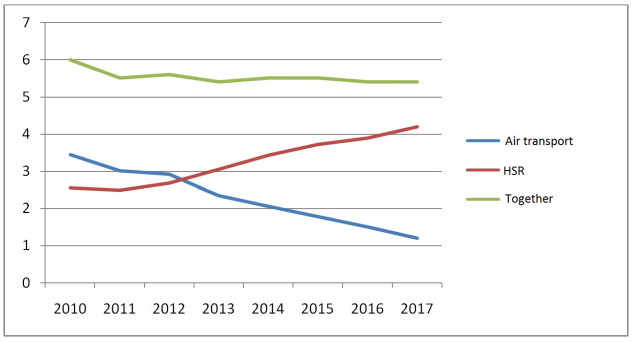

Figure 6. Development of market share in Madrid-Barcelona route

The 408 km Madrid-Valencia transport link is provided by both modes of transport. Like on the Madrid-Barcelona route following the opening of high-speed lines between Madrid and Valencia, air travel has begun to lose its

supporters. HSR services have a great advantage in the total time of the shipping process and in the ticket / ticket price:

- HS train 30 €
- Airplane 95 €

Therefore, the market share is clearly dominated by high-speed rail transport at 85% to 15%.

On the line, we would advise passengers to use high-speed rail services and leave Iberia and Air Europa to the HS by air on a train that competes in most critical factors. Released capacities could redirect to longer-haul or non-high-speed lines [4, 8].

CONCLUSION

It is not always possible to say with certainty that the operation of air services should be suspended or even discontinued on shared routes after an overall analysis of the individual joint lines. We think that high-speed rail has the potential to help reduce the increasing congestion of the largest airports and the busiest airlines on the European continent. Therefore, the different transport sectors should not deepen the competition between each other, but instead look for cooperation and improve the overall interconnection of individual infrastructures in Europe.

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