The effects of Hyperloop on the long-range personal and freight transportation industry in Europe

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ABSTRACT

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By Filipe Alves

The transportation industry has experience little disruptive technologies since the introduction of airplane, over 100 years ago. Nevertheless, the sector is of extreme importance in connecting people and businesses together. Hyperloop technology brings the promise of a new, faster and cleaner mode of transport that could disrupt current transportation modes. To understand the potential effects of the disruptive technology, the author analyses the current long-range freight and personal transportation industry, the modes and its characteristics and the competition between them. Hyperloop has more potential to affect the personal segment, and particularly airlines. On the freight side, the impact will be confined to the road and air modes of transport, and its degree will be lower. Once the technology is fully operational, airlines should focus on intercontinental routes where air transportation is the only mode available. LCC, relying solely on continental routes, will have difficulties in making the transition and many will leave the market. FSA and LCC will engage in M&A for operational efficiency and enlargement of hub-and-spoke networks. Air freight carriers rely mostly in intercontinental routes and should not experience a business model change. Road transportation is increasingly focusing on the "last-mile" of transportation services and may benefit from decongestion of roads caused by a shift to Hyperloop in the long-range freight transportation in Europe. Environmental impact of mode shift is considerable and is mostly caused by a shift in domestic and continental routes from air to Hyperloop transportation.

O setor de transporte tem experienciado poucas tecnologias disruptivas desde a introdução do avião, há mais de 100 anos. Contudo, o setor é muito importante para conectar pessoas e empresas. O Hyperloop traz a promessa de um novo modo de transporte mais rápido e limpo que pode perturbar os modos de transporte atuais. Para entender os seus efeitos potenciais, a atual indústria de transporte pessoal e mercadorias de longo alcance, os modos, suas características e concorrência entre elas é analisada. O Hyperloop tem mais potencial para afetar o segmento de passageiros, principalmente as companhias aéreas. No lado das mercadorias, o impacto será limitado aos modos de transporte rodoviário e aéreo, e o grau será menor. Quando a tecnologia estiver operacional, as companhias aéreas concentrar-se-ão em rotas intercontinentais nas quais o transporte aéreo é monopolista. As LCC, operando apenas rotas continentais, terão dificuldades em fazer a transição e algumas deixarão o mercado. As FSA e as LCC envolver-se-ão em fusões e aquisições para eficiência operacional e ampliação de redes hub-and-spoke. As transportadoras aéreas de mercadorias dependem principalmente de rotas intercontinentais e não devem sofrer alterações no modelo de negócios. O transporte rodoviário concentra-se cada vez mais na "última milha" do transporte e pode beneficiar do descongestionamento de estradas causada pela mudança no transporte de mercadorias de longo alcance na Europa para Hyperloop. O impacto ambiental da mudança de modo é considerável, sendo causado principalmente por uma mudança nas rotas domésticas e continentais do transporte aéreo de passageiros para Hyperloop.

Key Words: European transportation industry; Freight transportation industry; Hyperloop; Intermodal transport; Long-range transportation industry; Personal transportation industry.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ABREVIATIONS

EU	European Union
FSA	Full-service airlines
HSR	High-speed rail
IA	Interview A
IB	Interview B
IC	Interview C
ID	Interview D
LCC	Low-cost carriers
LR	Literature review
M&A	Mergers and acquisitions
OSS	Other secondary sources
USTD	United States Transportation Department

1-INTRODUCTION

Hyperloop is a new mode of transportation that moves freight and people quickly, safely, on-demand and direct from origin to destination. Passengers or cargo are loaded into the hyperloop vehicle and accelerate gradually via electric propulsion through a low-pressure tube. The vehicle floats above the track using magnetic levitation and glides at airline speeds for long distances due to ultra-low aerodynamic drag. It's autonomous, avoiding possibility for pilot error. Additionally, it's a safe and clean technology (Virgin Hyperloop One website 2019).

The present dissertation aims at exploring a new transportation technology, Hyperloop, and assess its potential impact on the long-range personal & freight transportation industry.

The academic relevance of the topic is understanding how a new, faster way of transportation can impact existing industries and cities by shorten relative distances, one hundred years after the last transportation technology was invented, and the application of theoretical frameworks to this specific topic, thus creating a structured literature of a topic where research is yet taking its first steps.

For managers, relevance lies on understanding the potential of the new technology, how it can shape businesses and threaten established industries, and the possibilities that will emerge with such changes.

The research questions addressed are the following:

1. What impact does Hyperloop have on the long-range personal & freight transportation industry in Europe?
2. How will this industry look like in Europe, given Hyperloop's full adoption?

The analysis begins with an overview of the European transportation market and analyses the freight and personal long-range transportation industries separately, as well the characteristics of different competing modes, the dynamics and competition in each industry. A separate section analyses Hyperloop, the principal companies developing the technology and its potential competitive advantages and disadvantages. Expert interviews allow for complementing analysis of consolidated academic literature and other secondary sources.

2-LITERATURE REVIEW

2.1-TRANSPORTATION INDUSTRY IN EUROPE: AN OVERVIEW

In the European Union, the industry employs 10.5 million people and is constituted by a network of around 1.2 million firms. The sector is paramount to the UE, as an efficient transport service and infrastructures are vital, not only to the economy but to boost social cohesion. Furthermore, the industry is also heavily related to environmental issues. (EU, Current Trends and Issues 2018).

The challenges for the transport sector in Europe for the upcoming years are the following:

- Creating a well-functioning Single European Transport Area, connecting Europe with modern, multi-modal and safe infrastructure networks;
- Shifting towards a low-emission mobility. (UE, 2017)

It is estimated that around 13% of European's final consumption is due to transportation. The current situation, a fragmented transport market in EU, will leave its growth potential untapped (EU, Current Trends and Issues 2018).

Dealing with the negative externalities is also a key issue in the European Union. The main external costs are:

- Greenhouse gas emissions;
- Local air pollution;
- Capacity bottlenecks;
- Accidents;
- Noise.

In 2015, transport was responsible for 33% of final energy consumption and 24% of greenhouse gas emissions in EU. There is a growing trend towards more cooperative intelligent transport systems and driverless piloting activities. Hence, increasing investment from the private sector in strategic transport infrastructure will be essential (EU, Current Trends and Issues 2018). New concerns, such as energy consumption and climate change, can drive governments to match their words into action (Michel Savy 2009).

2.2-FREIGHT INDUSTRY

The transportation services industry consists of the air, marine, rail, and road freight sectors and, in 2016, it generated 482.6 billion dollars in revenues in Europe, (Marketline Global Transportation Industry Summary 2017). In 2017, 76.7% of all inland freight was transported by road, followed by rail which accounted for 17.6%, and inland waterways which was responsible for transporting 6% of inland freight. These statistics refer only to inland freight transportation and thus does not include maritime and air freight transportation (Eurostat 2019).

2.2.1- FREIGHT TRANSPORTATION MODES: AN OVERVIEW

Road transportation allows to carry the cargo on a door-to-door basis, but it is also popular on long-range freight transportation across borders. In 2017, international laden road transportation accounted for over 25% of all road freight transportation (Eurostat 2019).

The rail freight transportation industry has reached its post-crisis peak in 2017, transporting 416 million tonne-kilometers. The industry has been growing steadily since 2012 but experienced a growth peak of 3.2% in 2017. In EU, international transport accounted for over 70% of all rail freight transportation, measured by tonne-kilometers or tonnes. Geographical location seems to play a key role in the share of international rail freight traffic (Eurostat 2019). Rail services, however, continue to be perceived as one of the poor performing services by EU consumers, scoring the 4th higher incidence of problems. Rail freight services are of low quality and reliability, mostly because there is a lack of coordination in cross-border capacity offer, traffic management and planning of infrastructure works. Lack of competition can also explain its poor performance (EU Current Trends and Issues, 2018). Rail is more likely to capture long-haul shipments (Kawamura, Mohamadian, Samimi 2011; Oum 1979). In addition, rail is also preferred for larger and heavier shipments (Kawamura, Mohamadian, Samimi 2011), but it's not dominant in the segment. Big shipment allows important economies of scale, on the haulage and fixed costs. The consolidation of freight and rationalization of supply chain are crucial for rail competitiveness (Michel Savy 2009).

In 2017, intra-EU and extra-EU air freight and mail transport registered growths of 1.6% and 9.8%, respectively, which illustrates the rising importance of the international transport segment. Domestic flight also increased in 2017 by 4.9% (Eurostat 2019). 27 % of EU air freight was carried through German airports in 2017 (Eurostat 2019), followed by the United Kingdom and France, who together totalize over 50% of Europe's air freight transportation (Eurostat 2019). Air transport is alternative for highly deteriorating goods, where transport time

is critical (Behrens & Berquist 2011) and courier traffic on continental long distances, after which the freight is carried by road. Carrying only 0.3% of total tonnage, it is worth 25% of the total trade value (Michel Savy 2009).

After a strong last quarter in 2016, global shipping seems to be recovering and has shown steady growth. Strong performance expectations for container shipping support a sustained momentum for trade growth. The shipping sector must shed weight and become more efficient. While building fewer ships and scrapping more, shared economy seems to be the panacea to most, with economies of scale coming from increased volumes of mergers & acquisitions or the creation of mega alliances (KPMG Transport Tracker 2017). Maritime is by far the dominant mode in tonnes carried on international transport, usual carrying large shipments over intercontinental distances (Michel Savy 2009).

2.2.2- INTERMODAL FREIGHT TRANSPORT MARKET DYNAMICS AND COMPETITON

Intermodal freight transport is the movement of goods in a single loading unit/vehicle that successfully uses two or more modes of transport without handling the goods themselves in changing modes (UN/ECE 2001), and where most of the route is traveled by rail, inland waterways or ocean going vessel (Bontenkoning & Macharis 2004). Its promotion was identified as critical in order to achieve a competitive transport system (Hanssen, Jorgensen & Mathisen 2012), as economic performance improves with the most suitable mode being used on each part of the trip (OECD 2011). The core of intermodal networks is the terminals where goods and logistic providers physically meet and interact (Netland,Stokland & Sund 2010).

The predominant modes of transport for the longer hauls in the intermodal transport chain are rail, inland waterways and short sea/ocean shipping, where units are consolidated, and economies of scale apply (Janic 2007).

Modes have very different characteristics, considering type of commodity, size of shipment, distance and geographical coverage. Each mode is focused on one specific market. There is little overlap between the realms on which different modes compete, as each mode is better suited for one specific segment. Competition occurs mostly within modes and less between modes (Michel Savy 2009).

In 2009, intermodal transport represented only 5% of total freight in Europe. The low value reflects the insufficient performance of the operators, tampered by fragmentation of intermodal

organization among many autonomous operators. Intermodal transport requires internal coordination rather than external market driven cooperation, and integration rather than vertical competition (Michel Savy 2009).

Shipment specific variables such as commodity type, value, weight and/or special handling needs influence mode choice. These groups of variables are interdependent (Kawamura, Mohamadian & Samimi 2011), as there is a close link between the size of the shipments, the value of goods and the length of haulage (Michel Savy 2009). Speed is a more important criterion for industries producing goods with high value/kilogram ratio and short life cycles. Pharmaceutical companies are therefore more likely to ship by air, whereas construction companies are more likely to ship by rail (Hinkka &Punakivi 2006).

The choice for rail is price-sensitive when compared to the choice for truck, however the choice for truck is more sensitive to haul time than that of the choice for rail (Kawamura, Mohamadian & Samimi 2011). As volume of loads increase, the break-even distance between road or rail transport shortens at a decreasing rate (Janic 2007). The breakeven point is estimated at 500km, although it is shorter in Europe- about 240km (Michel Savy 2009). The distance transported by truck in pre and post-haulages does not influence intermodal preference (Hanssen, Jorgensen & Mathisen 2012).

The external cost of intermodal train is 28% of those of general freight truck, without accounting for congestion costs (Hanssen & Mathisen 2014; Kawamura, Mohamadian & Samimi 2011; Forkenbrock 2001). The use of other transport modes than road for long haul freight transport can therefore help achieving a more efficient transportation system (Hanssen & Mathisen 2014). If Europe charges only for transport costs and does not include environmental costs, road and air modes are favored in comparison with rail transport (kpmg, Friedrick, Link, Stewart & Nash 2006). Considering new concerns, such as energy consumption and climate change, governments can be expected to match their words into action. Perspectives are that there will be no absolute modal shift, but a relative one. Road will still be dominant, with proportions in various modes benefiting the alternatives to roads (Michel Savy 2009).

Knowledge about factors determining choice of transport services is key to understanding the freight market and design competitive transport systems (Floden, Bärthel & Sorkina 2010).

Literature on transport mode decision-making provides valuable insights regarding the match between shipper's demands and transport mode characteristics, although it is not consensual.

Price is the most important determinant when choosing transportation mode (Danielis & Marcucci 2007; Hinkka et al. 2006). Water transport is the cheapest transport mode, followed by rail, three times higher, truck, thirty-five times higher and finally air, eighty-three times higher (Ballou 2004). The development of logistics emerged non-cost factors to play a significant role (Arunotayanun & Polak 2007), and there is a growing proportion of shippers seeking to optimize their comprehensive logistics cost, which means that sometimes a more expensive transport translates into a lower inventory volume (Michel Savy 2009). Average delivery time and delivery time reliability were regarded as the most important drivers (Balou 2004). Reliability, flexibility and safety also enter choice analysis (Norojons, Young 2003). Transport cost, delivery time, quality and flexibility of service were found to be significant determinants of the decision-making (Arunotayanun & Polak 2007). The importance of transport cost depends on the time cost of cargo, as highly perishable goods loose immense value if its delivery is delayed (Lervåg, Meland & Wahl 2001). Reliability and availability of each mode were considered the most important drive on transportation mode choice (Evers, Harper & Needham 1996). Haul time and reliability tend to be more important than cost (McGinnis 1979). Accessibility, reliability, cost time, flexibility and past experience with each mode are significant characteristics influencing the decision-making process. Familiarity with the mode, especially trucking, has a strong influence on mode choice behavior (Kawamura, Mohamadian & Samimi 2011).

2.3-PASSENGER INDUSTRY

Passenger transport refers to the total movement of passengers using inland transport on a given network (Eurostat 2019). According to the Eurostat, the principal mode of passenger transport is passenger car which accounted for 82.9% of inland passenger transport in EU in 2016 (Eurostat 2019).

2.3.1- PASSENGER TRANSPORTATION MODES: AN OVERVIEW

The passenger car main advantages are a greater mobility and flexibility, especially within cities (Eurostat 2019).

The rail passenger transport performance in 2017 increased by 3%, maintaining the growth trend it has been having since 2013. International transportation in the majority of analyzed countries accounted for less than 8% of the total rail transportation. Only three countries (France, Czech Republic and Luxembourg) accounted for more than 100 passenger-kilometers per inhabitant. It reflects the proximity of international borders, the importance of cross-border

commuters within the workforce, access to high-speed train links and whether international transport corridors run through a country (Eurostat 2019).

Air passenger transport performance followed the growth observed in previous years, increasing 7.2% between 2016 and 2017. It is worth to indicate that five countries, namely the United Kingdom, Germany, Spain, France, and Italy, represented two thirds of all air transportation across EU (Eurostat 2019). Intra-EU flights represented 47% of all flights, followed by extra-EU transport which accounted for 36%. National transport has the lightest weigh in air passenger transportation with only 17% of all air passenger traffic. Although most of the flights are destined to an EU destination, it seems international flights congest airport traffic in the biggest European airports (Eurostat 2019; KPMG Transport Tracker 2017). Low cost carriers have become increasingly popular, accounting for 48% of EU market seat capacity in 2015. Airlines have already begun to take steps to embrace green initiatives and may consider further efforts to enhance fleet fuel efficiency (KPMG Transport Tracker 2017).

2.3.2- LONG-RANGE PASSENGER TRANSPORT MARKET DYNAMICS AND COMPETITON

In the competition for passengers are full-service airlines (FSA), low-cost carriers (LCC) and high-speed rails (HSR), which compete indirectly between themselves (Lijesen & Behrens 2016).

FSA are airlines that focus on providing a wide range of pre-flight and onboard services, including different service classes, and connecting flights (Reichmuth 2008).

LCC focus on cost reduction in order to implement a price leadership strategy on the markets they serve (Reichmuth 2008).

Competition between established airlines is weak even if offering similar flights, with price responses to price changes of other airlines being very low (Van Den Dogaard & Lijesen 2019). Incumbent airlines respond to threats of entry of other airlines by dropping fares, before the airline starts operating that route and after it has entered (Goolsbee &Syverson 2005).

After exogenous shocks as the economic downturn of 1999 or the tragedy of 9/11, which prompted a demand shift to cheaper or safer modes, pressure for consolidation on the aviation market increased (Reichmuth 2008). Other exogenous shocks, as airports constraints, allow a

greater degree of concentration with an open market access safeguard. M&A of airlines with different business model, LCC and FSA, is also trendy in the industry (Reichmuth 2008).

Each group of stakeholders reacts differently to the HSR competition. FSA respond much stronger to HSR threats than LCC, since the latter usually competes from secondary airports (Lijesen & Behrens 2016). High response to an increase of seats offer by HSR may lead some FSA to reduce the number of seats offered even further, resulting in a smaller number of seats available in total (Lijesen & Behrens 2016). Some airlines decided to leave some routes after the optimal number of seats fell shorter than the optimal capacity (Behrens & Pels 2010). Some airlines experiencing high frequency elasticity of market share may leave the market as they cannot maximize profits (Lijesen & Behrens 2016).

The HSR can be competitive with air transport services for distances that can be covered in a maximum of 3 hours (González-Souvignat 2004), as its longer travel time is offset by higher frequency and lower fares (Behrens & Pels 2010).

Hence, different characteristics of each mode shape the competition between them and lead the demand towards a specific mode, thus it is paramount to comprehend the most valued characteristics for passengers. Connectivity and access time are the most important features of the competition between HSR and aviation in the London-Paris route (IATA 2003). When choosing whether to travel by car, train or plane in the Toronto-Montreal route, the most important determinant for passengers is total travel time (Koppelman & Wen 2000), which is intimately connected with the characteristics proposed by IATA: connectivity and access time. In addition to the travel time characteristic proposed by Koppelman & Wen, the travel time, the fares, frequency and trip purposes also play a major role on the passenger's choice of transportation (González-Savignan 2004).

It is important, therefore, to distinguish between leisure and business passengers, as each of these groups values each commodity differently. Business passengers' most valued characteristics are fares, road distance, weekly frequency, destination within the country, the use of electronic devices, and most important of all, total travel time (Behrens & Pels 2010). On the other hand, on-time arrival had little significance in business passenger's choices. Leisure passengers are more heterogeneous as a group in valuing prices. Unlike business passengers, they give little importance to total travel time. Road distance, weekly frequency and fares are the most valued characteristics for this group (Behrens & Pels 2010).

Population density is also found to shift passengers from FSA to HSR, making the HSR more effective in cities with a compact development (Clewlow, Sussman & Balakrishnan 2014). In fact, the HSR should locate in city centers and complete air transport service rather than compete with it (González-Savignan 2004). This way, the HSR could be an effective alternative for air transport, especially in airports with capacity constraints where the demand cannot be properly addressed (Lijesen & Behrens 2016).

Some airlines, which network rely on a particular route, will survive the HSR competition. LCC will compete with HSR for leisure passengers, although they might choose to leave in less dense markets (Behrens & Pels 2010).

Airlines are also the most polluting mode of transportation. In order to reduce aviation emissions by over 20% in 2024, there had to be a total demand shift in short-haul passenger transportation of 60% to non-polluting modes (Sgouridis, Bonnefoy &Hansman 2010).

2.4-HYPERLOOP

Hyperloop consists of a low-pressure tube with capsules that are transported at both low and high speeds throughout the length of the tube (Musk 2013). The capsules are supported on a cushion of air, featuring pressurized air and aerodynamic lift. The capsules are accelerated via a magnetic linear accelerator affixed at various stations on the low-pressure tube with rotors contained in each capsule. Passengers may enter and exit Hyperloop at stations located either at the ends of the tube, or branches along the tube length (Musk 2013).

Virgin Hyperloop One, founded in 2014, is a privately held company out to create fast, effortless journeys that expand possibilities and eliminate the barriers of distance and time, catalyzed by Elon Musk's white paper. It defines the Hyperloop as a new mode of transportation that moves freight and people quickly, safely, on-demand and direct from origin to destination. Virgin Hyperloop One systems will be built on columns or tunneled below ground to avoid dangerous grade crossings and wildlife. It will be fully autonomous and enclosed, eliminating pilot error and weather hazards. It will also be safe and clean, with no direct carbon emissions. The top speed is estimated to be at 1080 kilometers per hour (Virgin Hyperloop One website 2019).

DP World Cargospeed was created through a partnership between DP World and Virgin Hyperloop One, to provide hyperloop-enabled cargo systems to support the fast, sustainable and efficient delivery of palletized cargo. The first initiative of its kind in the world, DP World

Cargospeed will provide exceptional service for high-priority, on-demand goods, delivering freight at the speed of flight and closer to the cost of trucking. DP World Cargospeed systems, enabled by Virgin Hyperloop One technology, will transport high-priority, time-sensitive goods including fresh food, medical supplies, electronics, and more. It will expand freight transportation capacity by connecting with existing modes of road, rail and air transport (DP World website 2019). The current market for air freight, Hyperloops' prospect market, accounts for just 2 percent of ton miles but represents 40 percent of freight value. Not having a fixed guideway facilitates air transport hub-and-spoke system, which requires massive investments for Hyperloop (USTD 2016).

Hyperloop Transportation Technologies is using a crowdsourcing model, in which 100 core technical researchers work part-time for equity in the company. They have announced plans to construct a five-mile, demonstration test track along Interstate I-5 in Quay Valley, California, a privately-owned planned community (USTD 2016).

Transpod is a Canadian start-up with plans to implement Mr. Musk's hyperloop idea (USTD 2016).

The Hyperloop consists of several distinct components. Sealed capsules carrying 28 passengers each that travel along the interior of the tube depart, on average, every 2 minutes but has the capacity to departure every 30sec during rush hours. A larger system has also been sized that allows transport of 3 full size automobiles with passengers to travel in the capsule. The capsules are separated within the tube by approximately 37 km on average during operation and are supported via air bearings that operate using a compressed air reservoir and aerodynamic lift. The tube is made of steel. Two tubes will be welded together in a side-by-side configuration to allow the capsules to travel both directions. Pylons are placed every 30 m to support the tube. Solar arrays will cover the top of the tubes in order to provide power to the system. Linear accelerators are constructed along the length of the tube at various locations to accelerate the capsules. Rotors are located on the capsules to transfer momentum to the capsules via the linear accelerators (Musk 2013).

The Hyperloop transport system predicted characteristics are being on-demand and inexpensive as road transportation, fast as air transportation and environmentally friendly like rail or electric cars (Musk 2013).

Hyperloop is “the right solution for high-traffic city pairs that are less than 1500km apart” (Musk 2013), although it has been narrowed to distances between 320km and 800km (USTD 2016).

For a trip between San Francisco and Los Angeles of roughly 640 kilometers, the resulting time savings over air or maglev would be about 45 minutes, considering only the effective time in transit from departure to arrival. However, all three modes would likely have stations that locate at the outskirts of the major city and thus require additional time on local transit for travelers or freight to reach their destination. The time savings over HSR is more substantial at 2 hours, but HSR stations are generally found downtown which provides savings in access and egress time (USTD 2016). The Stockholm-Helsinki journey current travel time is estimated at 3.5hours by plane, including transport from and for the city from and for the airport and luggage and security screening, while ferry travel times last 17.5hours. Hyperloop takes 28 minutes to complete the 500km trip (KPMG Transport Tracker 2017).

The Hyperloop could facilitate offshore port facilities and relieve port constraints, where its main advantage would not be the speed itself, but the higher throughput for a given tube size (USTD 2016).

Many different cost estimates were carried since the Hyperloop Alpha White Paper, that estimated a cost of 17 million dollars per 1.6 kilometers (Musk 2013). Subsequent to the Alpha white paper, Virgin Hyperloop One gave a presentation citing 25 -27 million dollars per 1.6 kilometers for just the technology, excluding land acquisition. For an almost entirely underwater track specifically from Helsinki to Stockholm, Virgin Hyperloop One estimates a cost of 64 million dollars per 1.6 kilometers including vehicles (USTD 2016). For an approximate frame of reference, California HSR faces costs of 63-65 million dollars per 1.6 kilometers and in Europe the cost is 43 million dollars per 1.6 kilometers, although those figures include costs of land acquisition but exclude train sets. Thus, cost estimates for a land-based hyperloop system may appear lower than other modes (USDT 2016).

Amortizing the total cost of $6 billion of constructing the San Francisco-Los Angeles line over 20 years gives a ticket price of $20 for a one-way trip for the passenger version of Hyperloop (Musk 2013). With 15 million trips per year as the maximum capacity, that suggests $300 million per year in farebox revenue. Those calculations assume average 2 departures per minute over 24 hours. Very few people would want to travel in the middle of the night (USTD 2016), but in rush hours Hyperloop could leave every 30sec (Musk 2013). Fares would cover operating

costs (Musk 2013; USTD 2016). Bibop Gresta, Hyperloop Transportation Technologies' COO, states explicitly that government subsidies will be required (USTD 2016).

The technology has not yet been fully tested, rather is being tested in smaller tracks. Whereas Hyperloop Transportation Technology has already developed certification guidelines for the new transportation technology (Hyperloop Transportation Technologies website 2019), Virgin Hyperloop One has successfully accelerated a pod in a short track, achieving speeds of 384km/h in a 500m test track (Virgin Hyperloop One website 2019). However, for competitive reasons, further deadlines or prediction of test-runs are not disclosed or communicated.

3. METHODOLOGY

In order to answer the research questions, primary and secondary data collection were collected and analyzed.

RQ1 was answered through the assessment of the important characteristics in the industry and comparison of each mode with Hyperloop on those dimensions. Each characteristic was ranked 1 to 5, 5 being "Hyperloop much better than current mode" and 1 being "current mode much better than Hyperloop". Ranks were inferred after analysis of primary and secondary data collection, with expert insights weighting 70% and secondary sources weighting 30%, divided between consolidated academic review (20%) and other secondary sources (10%).

RQ2 was answered through analysis of past reactions of stakeholders to disruptions and historical competition between them, calibrated with insights from industry experts.

3.1. PRIMARY DATA COLLECTION

Primary data collection consists of four semi-structured expert interviews, two orientated for the freight side and two orientated to Hyperloop developing companies. The objective is complementing secondary research with insights from managers with experience and capabilities, to better understand the dynamics of the industry, the competition occurring between modes and the possible impact of Hyperloop over those industries.

José Costa Faria is an independent consultant with many years of experience in the logistics and transportation industry, including nine years at DHL where he worked as vice-president of Business Development in Southern Europe and Business Development Director Portugal.

Nelson Sousa is administrator at JLS, a road transportation company, and is vice-president of ANTRAN, the national associate of public road freight transportation companies of Portugal since 2014.

Thierry Boitier is Director of Supply Chain at Transpod, a Canadian company developing Hyperloop. Thierry has over ten years of experience as supply chain manager and has worked across Europe, Africa, Asia and America.

Cristian Santibanez is a manager at Hyperloop Transportation Technologies currently working as Urban Mobility Lead and Marketing Operations. He has ten years of experience working on urban innovation and mobility industries.

INTERVIEW ID	NAME	TYPE OF COMPANY	RANGE OF REVENUES(euros)
A	José Costa Faria	DHL (freight)	>25.000.000
B	Nélson Sousa	JLS (freight); ANTRAN	>25.000.000
C	Thierry Boitier	Transpod (Hyperloop tech.)	>1.000.000
D	Cristian Santibanez	HTT (Hyperloop tech.)	>1.000.000

Table 1- Interviewees Identification

3.2. SECONDARY DATA COLLECTION

Secondary data collection consists of consolidated academic review and consolidated insights from other reputable sources. This data is summarized in chapter two, and further divided into four main sections corresponding to the challenges and trends in the European transportation industry, the long-range personal segment, the long-range freight segment and the Hyperloop technology. The objective of this chapter is providing information regarding to which are the competing modes in each segment, their characteristics, the relative importance of each characteristic in the industry, how those characteristics shape competition and market share in the industry and how the stakeholders behave when the market is disrupted by a new mode or other external factor.

4-ANALYSIS AND FINDINGS

In the following section, a brief resume and analysis of the literature review and the data collected will be presented. Based on those analysis, a conceptual framework will be developed to assess the overall impact of the Hyperloop technology in the long-range personal and freight transportation industry, and its landscape once the disruption has become effective. As in previous chapters, the industry for personal transportation is analyzed separately from the industry for freight transportation, after an overview of the industry and its challenges as a whole.

4.1-HYPERLOOP POTENTIAL ON THE LONG-RANGE PERSONAL AND FREIGHT TRANSPORTATION INDUSTRY

The European Union has clear-defined goals for its transportation industry, among which are the creation of a Single European Transport Area and a shift toward environmentally friendly modes. The road and air transportation, both on freight and personal segments, benefit from low restriction or fees on carbon emissions and are the most threatened by a shift to low-emission modes or the internalization of external costs such as noise or air pollution (Bickel et al., 2006). However, environmental concerns appear to be somewhat short to shift transportation to different modes (Interviews A and B).

A different problem also common to both passenger and freight segments is airport constraints, that have been rising as demand grows at a faster speed than capacity. On the passenger side, the problem is bigger and the EU estimates by 2035 there will be an annual unattended demand of 2 million flights (Eurostat 2019). 5 countries are responsible for over two thirds the European air traffic, indicating investment in airport capacity or alternative transportation modes are vital in these areas to avoid, or minimize, the unattended demand predicted by the EU for the upcoming years.

4.1.1-LONG-RANGE PERSONAL TRANSPORTATION

Air passenger transportation in Europe is concentrated in five countries that account for over two thirds of all air passenger traffic, including UK, Germany, Spain, France and Italy. International flights, including intra and extra-EU flights, represent the majority of these flights, around 47% and 36% respectively, and are responsible for airport congestion in Europe, which is predicted to increase and reach an annual unattended demand of 2 million flights by 2035 (Eurostat 2019). Airport constraints also cause airlines dependent on frequency of flights to

leave routes where profits cannot be maximized (Lijesen & Behrens 2016). Environmental concerns also hunt the industry, as there is an increasing will of public authorities to internalize the environmental costs of transportation (EU Current Trends and Issues 2018). Aviation emissions are the highest of all modes of transportation and the hardest to achieve further fuel emission efficiency. The air transportation main competitive advantage is the speed or reduced total travel time when compared to other transportation modes, like rail or road. Consequently, air passenger transportation becomes more competitive as the distance increases, proportionating lower total travel times. This is important for another reason that the ones already stated, as air transportation requires time consuming boarding protocols that occupy a considerable percentage of the total travel time when the travelling distance is short.

Air transportation can be subdivided into two different segments, FSA such as Fly Emirates and LCC like Ryanair. The market is equally divided between these two segments of air passenger transportation as LCC accounted for 48% of market share in 2015 (KPMG Transport Tracker 2017), that present different characteristics. FSA compete from airports usually located close to the city center, reducing total travel time. Comfort and service are other strategic advantage of FSA. LCC compete from airports located on the outskirts of major cities, like Stanstead located 100km from London. Service and passenger comfort are kept low to enhance operational efficiency and reduce costs, culminating in lower prices when compared to FSA.

Competition between established airlines is weak, even when offering competing flights. Price changes from one airline does not trigger a response from its competitor (Van Den Dogaard & Lijesen 2019). This happens because competition in similar routes often occurs between FSA and LCC, that by presenting different characteristics attract different types of costumers. The situation is different when an operating airline faces threats of entry of a different airline in an operating route, which lead incumbent operators to reduce fares in the period before and during the beginning of operations in that route (Goolsbee & Syverson 2005). Responses may be stronger in this occasion to prevent the entry, making the incumbent a monopolist in that specific route.

Rail transportation services have kept a sustained growth over the past few years, but it's almost exclusively used for national transportation. Its main disadvantages are its poor infrastructure, alongside its poor operational performance (Eurostat 2019, Interviews A and B). Differences in rail or trains specifications, lack of international corridors or poor international coordination are the HSR main competitive disadvantages. National transportation suffers from poor services,

as rail scored 4th higher incidence of problems in the European Union (Eurostat 2019). The HSR main competitive advantages are its lower fares, comfort, location at city centers, the possibility of using electronic devices for work or leisure, and a higher frequency over air transport. Its lower speed means the HSR competitive advantage situates at distances long enough to be preferable to road transport, but not long enough so that air transport becomes preferable. In the long-range personal transportation, the HSR is competitive to distances that can be covered in a maximum of three hours (González-Savignan 2004). Consequently, an increase in HSR maximum speed through technological evolution would enlarge the areas where the HSR would have the necessary competitiveness to start operating the route.

FSA respond stronger to the HSR than LCC as both present similar characteristics: location closer to the city center and better quality of service. An increase of seats offered by the HSR on a particular route can cause airlines to reduce offered number of seats even further, reducing total number of seats offered in a particular route in total (Lijesen & Behrens 2016). This problem is amplified for airlines dependent on high frequency of flights for market share, that often decide to leave the market. Hub-and-spoke networks are crucial for FSA facing HSR competition.

LCC compete from secondary airports and offer a poorer service, but a greater total travel time. Hence, they don't react to the HSR threat as strong as FSA, but they can leave a route served by HSR when market density is low, as example of Ryanair in Porto-Lisbon route, citing alternative transportation companies, like HSR or FSA like TAP with strong hub-and-spoke networks in those areas, as the main reason (Expresso, "Ryanair encerra rota Porto-Lisboa", 18-09-2019).

After summarizing and interpreting what each mode can offer to passengers, it's paramount to understand what passengers are looking for in transportation and how those demands culminate in the choice of a specific mode of transport. The most valued characteristics for passengers are connectivity, access time, total travel time, fares, frequency, use of electronic devices and trip purposes, the latter divided between business and leisure passengers as these segments seek different transportation solutions. Road distance, frequency and fares are important for both segments, but unlike business passengers, leisure passengers give little importance to on-time arrival and total travel time. They are also more heterogeneous as a group, which leads to the assumption that leisure passengers can have very diverse preferences over the choice of transportation mode (Behrens & Pels 2010). Destination within the country and the use of

electronic devices also play a role in business passenger's choice of transport mode (Behrens & Pels 2010).

Road distance, frequency, and fares are the common characteristics both segments are demanding, but each player offer a different combination of these. Road distance is the main competitive advantage of the FSA, as it combines the speed of air travelling and arrives at airports close to the city center. LCC, competing from distant airports, add distance from the airport to the city center as makes road distance increase, while offering lower fares than FSA. Road distance is also the main disadvantage of the HSR, compensated by a higher frequency of departures when compared both to LCC and FSA, and lower fares when compared to FSA. By not demanding a reduced total travel time, leisure passengers are more likely to choose HSR or LCC transportation, although it's important to remember that, being a more heterogeneous group, leisure passengers have a wide range of value for each of the different transportation alternatives. Business passengers' most important demand is a reduced total travel time, making them prefer the FSA over other transportation modes. However, the use of electronic devices and the destination within the country give the HSR a competitive advantage in this segment. On-time arrival is also an FSA and LCC disadvantage, as flights have larger probability of being delayed due to higher exposure to airport traffic constraints or weather variations.

FSA are the right solution for business passengers, whereas LCC are the right solution for leisure passengers. Being the fares important to both types of passengers, dropping the fares may lead leisure passengers to FSA depending on the value each passenger places on fares and total travel time. The HSR is a viable solution for both types of passengers, in destinations that could be covered in a maximum of three hours (González-Savignan 2004). As distance increases, the competitiveness of HSR over air transportation decreases. HSR competition is also confined to areas where the infrastructures actually exist, limiting the routes where HSR is an alternative to air transportation. As air transportation demand increases and leads to airport congestion, the HSR is a viable alternative to complement air transport, especially in developed cities where passengers are more likely to switch from air to HSR transport (González-Savignan 2004).

4.1.2-LONG-RANGE FREIGHT TRANSPORTATION

Road transportation is popular in long-range and international freight transportation, as opposed to the personal transportation segment. Environmental concerns in this segment have been rising over time, with intermodal transportation being appointed as a viable alternative to long-

range road transportation in order to reduce gas emissions. The industry has, however, increased its fuel efficiency over time with margin to increase further, and developed various logistics solutions to tackle the problem (Interviews A and B). Public authorities often fail to communicate with the industry, and initiatives do not reach the execution phase or take considerable time to be approved. The road transportation competitive advantages are its flexibility, reliability, and a good cost-average delivery time trade-off, as this mode is neither the cheapest nor the fastest but offers a powerful combination of both characteristics.

Rail freight transportation has experienced a growth over the past few years, with most of its services being performed on international routes. Rail is one of the most popular modes of intermodal transport, and the one that could most contribute to the reduction of gas emissions as it is the most efficient mode of transport. However, the use of rail for intermodal transport is harmed by several structural problems (Eurostat 2019). The rail can only be used in routes where there are infrastructures, which lack investment, and often road is the only mode available in particular routes (Michel Savy 2009). Poor services performance also makes intermodal transport by rail inefficient while causing delays, and the inoperability while switching modes often make this option economically unviable (Interview B). International rail transport also requires international coordination, that is often not the case. Some countries, like Portugal and Spain, are isolated from the European rail network due to differences in rail infrastructures. This mode main competitive advantages are its capacity in volume of transportation and the price, although it needs to consolidate cargo to achieve economies of scale and travel big distances to disperse fixed costs and become more competitive.

Air freight transportation have also experienced a growth in the past years. Being the most polluting mode of transportation has little importance in this segment, as its market share measured in tonne-kilometers is almost insignificant. The air transportation main advantage is its speed or reduced total delivery time.

Maritime transportation is the only mode that has not experienced sustained growths in the past years. As the rail, maritime transportation needs to achieve economies of scale and disperse fixed costs to be competitive. The industry has achieved further efficiency with the creation of alliances or through M&A that allowed companies to reduce excess capacity. Port constraints and offshore operations overload are infrastructural problems the industry is yet to resolve. In addition, maritime transportation is highly subject to weather conditions, making it less reliable then the other modes. The maritime transportation main competitive advantages are the volume

capacity in transportation, the capacity to serve long intercontinental routes separated by sea where road or rail are not available, and the price despite the need to achieve economies of scale in cargo and serve long routes to reduce fixed costs (Michel Savy 2009).

Competition between modes is rather weak, and it occurs mainly within modes (Interviews A and B; Michel Savy 2009). As each mode of transportation presents different characteristics, there is little overlap on the realms where they compete. Air transport is the only one capable of delivering goods at intercontinental distances with speed, whereas road is the only mode combining a good price-delivery time trade-off, more reliable and more flexible. Rail and maritime transportation become cheaper than road over long distances, and therefore there is sometimes a competition between these modes. It's important to stress that, in order to be competition between modes, shippers are waiving the possibility of flexibility and reliability, in order to seek a lower transportation cost. In Europe, the break-even distance between road and rail transportation happens at 240 km, where prices of rail become competitive enough to overshadow the flexibility and reliability offered by road transport. In conclusion, shippers using rail or maritime transport have bigger concerns about price, whereas shippers using road transport have more concerns about the delivery time (Mohamadian et. al 2011).

Shippers desired characteristics for freight transportation allows us to better understand the decision-making process when choosing a mode of transportation. The cost of the haulage, average delivery time, reliability, flexibility, safety, availability, accessibility and past experience with each mode all influence the decision-making process of shippers (Mohamadian et. al 2011). In addition, cost of inventory volume also plays a role, as a more frequent transportation allows for a lower inventory volume.

The type of cargo and the length of haulage also influence the choice of mode of transportation. Large consignments with low value over intercontinental distances usually travel by maritime shipping, whereas continental distances are serviced by rail or road. Over large intercontinental distances, high-value goods travel by plane, whereas road is the preference for continental distances. The highest the cost value of cargo more important the average delivery time and reliability, hence the more likely shippers are to choose air or road transportation over rail or maritime transportation. The lowest the cost value of cargo, more likely are rail and maritime transportation to be chosen. However, even when these conditions are met, rail and maritime transportation need to consolidate cargo to achieve price competitiveness over road, making it less flexible, and road transport is still more reliable then both these modes. In conclusion, these

modes need to meet several conditions to be preferred over road transportation, specifically large distances, large and low-value cargo with a cost time low enough to make delivery time a less important aspect then cost. Maritime is often the only choice available for large consignments over intercontinental distances, but rail on the other hand is not available for all routes where there would be demand for it.

Environmental concerns are not enough to shift more long-range freight transportation from road to intermodal transportation. Although environmental savings would be considerable, constraints imposed by intermodal inefficiency and absence of governmental action mean that shippers do not consider environmental costs when choosing a mode of transport (Interviews A and B).

4.1.3-HYPERLOOP TECHNOLOGY

Hyperloop is a "generic term for tube transportation" (Thierry Boitier, Transpod) currently being developed by several companies around the world. The technology is still being developed, and there are questions that are yet unanswered. Among them, safety and regulatory issues, technological concerns and business development are still under planning and execution. Therefore, several assumptions are made in this chapter to allow for comparison with existing modes and analysis, based on the foreseeable results expected to make the technology feasible. The assumptions are the follow:

- Hyperloop technology is possible to achieve, reaching the proposed speed of over 1000km per hour, making it the fastest mode of transportation;
- Hyperloop speed will not produce G-forces that will make journeys uncomfortable for passengers;
- Hyperloop is a safe technology, and it's regarded as such by both legislators and passengers;
- The capacity for passengers is of 28 passengers per pod, whereas the capacity for freight is of three cars as first proposed by Elon Musk;
- Pods departure on average every 2 minutes, with possibility to departure every 30sec at rush hours;
- Cost is lower than that of air transportation, for both passengers and freight, as advocated by companies developing Hyperloop;
- Hyperloop does not stop at intermediate stations;
- Stations will be located close to the city center;

- Procedures regarding security and luggage handling will be similar to those of rail;
- Lines will be used for passenger and cargo, prioritizing the first and only using the latter during low-peak hours to enhance operational efficiency.

Hyperloop is the fastest mode of transportation, capable of reaching 1000km per hour, with an average speed of over 900 km per hour (USTD 2016). Air transportation current average speed is around 400km per hour, and the California proposed HSR, which prompted Musk to write the white paper on Hyperloop, has an average speed of 263km per hour. Therefore, hyperloop presents substantial speed gains over current existing modes. It is estimated time savings of 48 minutes in the LA-SF route over air transportation accounting only for average speed (USTD 2016). In addition, security screening at airports add to the total travel time, which will not be necessary at Hyperloop stations (Interview C). Also, as these stations are located close to the city center, there is no need for longer commute from airport to the city center, as secondary airports are often located further away from city centers. Overall, Hyperloop technology offers a substantial reduction in the total travel time.

Frequency is another of Hyperloop's competitive advantage. With possibility of departing every 30sec, and 2min on average, Hyperloop transportation is more frequent than any other long-range transportation system, making it virtually available at all times and with no need to plan transportation with advance, which makes Hyperloop more flexible than other modes.

Cost is lower than existing modes and provide Hyperloop transportation an important competitive advantage over other modes (Interviews C and D). An air ticket from LA-SF costs between $68 and $200, whereas an Hyperloop ticket costs 20$. The proposed HSR for the same track is 86$ per passenger (USTD 2016).

Therefore, Hyperloop's main competitive advantage when compared to existing modes of transportation are its flexibility, availability and affordability, only provided by road transportation, the speed that can only be compared to air transportation, and the fact that is a clean mode of transportation like rail (Musk 2013).

Hyperloop's need for new infrastructure for every operating route is a competitive disadvantage, because tubes will only be placed in routes where there is demand for a high-speed transportation that justifies such an investment (USTD 2016). Transpod's short-term approach is a construction of lines that "will bring passengers from point A to point B, hopefully with a few stations along the way. The long-term vision is a subway, but at a scale of a country"

(Thierry Boitier, Transpod). The maximum extension of a route is at 500km, whereas a route shorter than 300km wouldn't allow for speed advantages (Interview C). Hence, the solution would be a starting line, comprehended in the interval of 300-500km, to which other lines would be added as the network develops (Interview C). By developing the network continuously, more connections and routes will be possible, and one extension of route would lead to a utility increase for all stakeholders while allowing a creation of an extensive network.

Therefore, Hyperloop seems to be a viable solution for responding to the UE's challenges, since it is a clean transportation mode with no carbon emissions and no infrastructures in place yet, allowing the creation of a network using the same standards for technology and infrastructure and expanding the range of Hyperloop connections and utility.

Cargospeed focuses on delivering "high-priority, time-sensitive goods including fresh food, medical supplies, electronics, and more", and Transpod also focuses cargo services on consignments with high ratio cost-weight like that of air. As road is the most transversal mode of transport, there is some cargo transported by road that could be transported by the Hyperloop, although it represents a small fraction of the cargo usually carried by road.

The cost of haulage is cheaper using Hyperloop over air transport, with the price being "closer to the cost of truck" (DPWorld Cargospeed website 2019). The average delivery time is also shorter using Hyperloop, as it achieves greater speeds. Hyperloop transportation, less subject to weather conditions, is also more reliable and safer than air transport. However, Hyperloop relies on a fixed guideway for transport, making it less flexible than air transport. Air cargo services rely on hub-and-spoke networks for decreasing costs and increasing flexibility, which is difficult to replicate with Hyperloop due to "enormous investments" (USTD 2016) to achieve the same geographical reach. Availability is dependent on demand on a specific route: "some lines will be only for passengers, some lines mainly for cargo, and for some it will be probably 50/50, passengers during rush hours and cargo during low peak hours" (Thierry Boitier, Transpod). DPWorld Cargospeed also mentions using the lines in a "mixed-use system that fully utilizes system capacity and maximizes economic and social benefits" (DPWorld Cargospeed website 2019). Therefore, the likely scenario is that tubes are used for both passenger and cargo pods, adjusting the departure of cargo pods to low activity hours.

4.1.4-WHAT IMPACT WILL HYPERLOOP HAVE ON THE LONG-RANGE PERSONAL AND FREIGHT TRANSPORTATION INDUSTRY?

4.1.4-1- IMPACT OF HYPERLOOP ON THE LONG-RANGE PERSONAL TRANSPORTATION INDUSTRY

FSA	LR	OSS	IC	ID	Overall Impact
Connectivity	4	3	4	3	**3,55**
Access time	3	3	N/A	N/A	**3**
Total travel time	4	5	5	4	**4,45**
Fares	5	5	5	5	**5**
Frequency	5	5	5	N/A	**5**
Use of electronic devices	3	N/A	N/A	N/A	**3**
Overall impact					**4**

Table 2- Impact of Hyperloop on FSA

LCC	LR	OSS	I3	I4	Overall impact
Connectivity	4	3	4	3	**3,55**
Access time	4	4	N/A	N/A	**4**
Total travel time	5	5	5	5	**5**
Fares	4	4	4	5	**4,35**
Frequency	5	5	5	N/A	**5**
Use of electronic devices	3	N/A	N/A	N/A	**3**
Overall impact					**4,15**

Table 3- Impact of Hyperloop on LCC

HSR	LR	OSS	IC	ID	Overall impact
Connectivity	3	4	4	3	**3,45**
Access time	2	2	N/A	N/A	**2**
Total travel time	5	5	5	5	**5**
Fares	4	4	4	4	**4**
Frequency	4	4	4	N/A	**4**
Use of electronic devices	2	N/A	N/A	N/A	**2**
Overall impact					**3,41**

Table 4- Impact of Hyperloop on HSR

1-Current mode of transport is much better than Hyperloop

2-Current mode of transport is somewhat better than Hyperloop

3-Current mode of transport is similar to Hyperloop

4-Hyperloop is somewhat better than current mode of transport

5-Hyperloop is much better than current mode of transport

Hyperloops' main competitive advantages regarding the HSR are the total travel time, fares and frequency. Its main disadvantages are access time and the use of electronic devices. The overall impact of Hyperloop over the HSR is medium (3,41/5).

LCC are the most impacted stakeholder. Hyperloop has competitive advantages regarding access time, total travel time, fares and frequency. The overall impact of Hyperloop over LCC is high (4,15/5).

The competitive advantages of Hyperloop over FSA are the total travel time, fares and frequency. The overall impact of Hyperloop over FSA is high (4/5).

Both leisure and business passengers, drawn by lower total travel times, lower fares and higher frequency will choose Hyperloop for transportation services.

4.1.4-2- IMPACT OF HYPERLOOP ON THE LONG-RANGE FREIGHT TRANSPORTATION INDUSTRY

AIR	LR	OSS	IA	IB	Overall impact
Cost	4	4	N/A	4	**4**
Average Delivery time	4	4	4	4	**4**
Reliability	4	4	4	4	**4**
Flexibility	2	2	2	2	**2**
Safety	4	4	N/A	N/A	**4**
Availability	2	N/A	N/A	N/A	**2**
Accessability	3	N/A	N/A	N/A	**3**
Past experience	2	N/A	2	N/A	**2**
Overall impact					**3,13**

Table 5- Impact of Hyperloop on air freight transportation

ROAD	LR	OSS	IA	IB	Overall impact
Cost	3	3	N/A	4	3,33
Average Delivery time	5	4	5	4	4,5
Reliability	4	3	3	2	3
Flexibility	1	1	1	1	1
Safety	3	N/A	3	N/A	3
Availability	1	N/A	1	2	1,33
Accessability	2	N/A	1	N/A	1,5
Past experience	1	N/A	1	N/A	1
Overall impact					**2,33**

Table 6- Impact of Hyperloop on road freight transportation

1-Current mode of transport is much better than Hyperloop

2-Current mode of transport is somewhat better than Hyperloop

3-Current mode of transport is similar to Hyperloop

4-Hyperloop is somewhat better than current mode of transport

5-Hyperloop is much better than current mode of transport

Large and heavy consignments usually travel by rail or maritime shipping. These modes benefit from consolidation of cargo and economies of scale over large distances, and the cargo transported is usually low value. Hence, the gains of speed proposed by Hyperloop are not required and there will be no impact of Hyperloop on rail and maritime freight transportation.

Hyperloop's competitive advantages over air transportation are the cost, average delivery time, reliability and safety. Its competitive disadvantages are availability, flexibility and past experience. The overall impact of Hyperloop in air freight transport is medium (3,13/5).

Road transport has competitive advantages in past experience, accessibility, availability and flexibility, whereas Hyperloop is faster. The overall impact of Hyperloop on road freight transportation is low (2,33/5).

4.2-SCENARIOS

4.2.1-STAKEHOLDER IDENTIFICATION AND CLASSIFICATION

The long-range passenger transportation industry is constituted by FSA, LCC and HSR that compete indirectly between themselves (Lijesen & Behrens 2016). Thus, these are the three stakeholders identified in the personal segment of long-range transportation.

FSA are companies competing through quality service, comfort and speed.

LCC are airlines focused on low-cost price and speed.

The HSR offers a combination of comfort and quality service with competitive fares.

The freight transportation industry consists of the air, rail, road and maritime sectors (Marketline Global Transportation Industry Summary 2017). However, DP World Cargospeed and Transpod (Interview C) mention time-sensitive cargo as Hyperloop's freight market, which is currently carried by air (Eurostat 2019, Savy M. 2009, Interview B) or road, depending on the distance of haulage (Interview B) and thus this are the two stakeholders identified in the freight segment.

Air transport usually carry high-value and time-sensitive cargo across long distances, offering fast delivery of goods.

Road transport is more transversal and carries medium and high-value cargo across short, medium and long continental distances. It offers a competitive price-delivery time trade-off.

The environment is a major influence in the adoption of the technology, via media attention or lobbying, and is affected by a shift from more polluting modes, as air, to Hyperloop. In addition, the UE has defined a clear goal of shifting mobility towards low-emission modes (UE Current Trends and Issues 2018). Hence, environmental impact of a possible adoption of the Hyperloop technology is estimated alongside the other stakeholders in the personal and freight segment.

4.2.2- OUTLOOK

Scenarios were developed considering the adoption of the technology and its infrastructure development. The first scenario assumes an optimistic view of the technology adoption and an infrastructure development connecting major cities over domestic and international routes across Europe in a vast network, similar to a subway network. Scenario two deals with a moderate adoption and infrastructure network, connecting fewer cities where there is a high-demand and higher congestions of airports and, thus, greater need for an alternative high-speed mode of transport. Scenario three is pessimistic and assumes few independent and unconnected lines and poor adoption of the Hyperloop technology.

Reactions from the different stakeholders are related and dependent of each other and of the rate of adoption of the technology, as each of the three scenarios are consolidated.

4.2.3- POTENTIAL SCENARIOS

PERSONAL SEGMENT	**CONSOLIDATED SCENARIO 1**	**CONSOLIDATED SCENARIO 2**	**CONSOLIDATED SCENARIO 3**
FSA	Mergers & Acquisitions will lead to higher concentration and increasing competition on operated routes; switch from continental hub and spoke networks to intercontinental routes and networks; first movers to intercontinental networks are likely to increase margins and profits whereas latecomers are likely to merge, be	Margins will fall because FSA won't be able to compete in Hyperloop served routes; Some airlines may choose to redirect fleet to different routes whereas others may expand intercontinental routes; It is unlikely that airlines will leave the market, rather struggling airlines may have to merger or be bought by stronger airlines to increase	Air transport will still be the dominant mode of fast transport in Europe, with Hyperloop being built on specific routes chosen to decongestion airports. The Hyperloop link will concentrate the demand on the operating routes, but will actually lead to airport decongestion and operational efficiency of airlines. Margins are likely to

	integrated into a larger airline or leave the market; Increasing resemblance of business models of LCC and FSA which will eventually become one single business model; Air transportation's core market will be intercontinental transport, although some less dense Hyperloopless routes may still be served by FSA if demand is profitable enough, but no dense enough for a Hyperloop route and where it may continue the current type of competition with the HSR.	operational efficiency; Business models of airlines will remain fundamentally different.	increase, and airlines with high elasticity of frequency for market share will thrive. Competition with LCC will increase and business models may trend to grow increasingly different.
LCC	Change of business model into long-haul intercontinental flights; Mergers and Acquisitions will be trendy as they allow for cost reduction and price advantages; some LCC will not successfully make the transition and will suffer from the downsizing of the market; Some LCC may rely on current hub-and-spoke European networks to offer low-cost connections between Hyperloopless routes and may encounter FSA competition, although the demand won't be able to	Business model would remain the same, but airlines will decide to relocate for less dense routes, for example seasonal holiday routes. LCC are unlikely to switch to international routes. The market will be smaller and could lead to M&A. Indirect competition with FSA and HSR would remain similar, with LCC not being able to compete in Hyperloop served routes.	LCC will not benefit as much from airport decongestion as they are usually located at secondary, less crowded airports. Margins are likely to remain similar, as the business model.

	accommodate different competitors and it will also have the competition of the HSR; consequently there will be M&A of airlines with different business models and a merger of LCC and FSA business models.		
HSR	The HSR will experience a demand shift to Hyperloop; It will still be useful for travelling between less dense city pairs as it makes intermediate stops at smaller cities and thus is going to serve less crowded routes; overall business model will be maintained; tracks will not be decommissioned but frequency of departure will decrease; further development of HSR infrastructure network will not take place.	The HSR will compete with the Hyperloop in most dense routes and will decrease frequency of departures as Hyperloop attracts most of the demand on these routes, while keeping the same business models on Hyperloopless routes. As Hyperloop network and connections are not extensive, the HSR will compete with FSA and/or LCC for the remaining routes. Further extension of the infrastructure network is unlikely to take place.	The HSR will not suffer any decommission and will still be used especially for domestic long-range transportation. Hyperloop served routes will also be served by the HSR, although frequency of departures will be reduced. As Hyperloop infrastructure network development is poor, the HSR infrastructure will continue to develop as demand for long-range transportation increases.

Table 7- Consolidated scenarios with passenger industry stakeholders

FREIGHT SEGMENT	CONSOLIDATED SCENARIO 1	CONSOLIDATED SCENARIO 2	CONSOLIDATED SCENARIO 3
AIR	Air freight carriers will be specialized in intercontinental air freight, which is the most important sector already; further creation of intercontinental hub-and-spoke networks across major airports in Germany, UK and	Hyperloop's routes extension will not accommodate all the demand, air freight carriers would complete and offer the service on Hyperloopless routes; intercontinental air freight transportation	Air freight carriers will dominate the market in the long-range freight transportation of high-density value products; Hyperloop may compete in operating routes, but the extension of the network is not

	France as air courier traffic increases and Hyperloop allows for inland fast delivering.	will be the core market.	enough to make a significant impact.
ROAD	Road transporters would focus on short and medium-range hauls on the domestic market; business model will depend on the last-miles and tendency is to improve that service and make it "tailor-made"; cooperation with Hyperloop mode to gain efficiency and provide the end costumer with a faster and better connected transport system.	Road transportation will lose some market share on Hyperloop links, connections and hub-and-spoke networks created from those stations, but will still be competitive on the long-range freight transportation as it has a more extensive network and more flexibility; main focus on the last mile and "tailor-made" services for the end customer.	Road transport will not lose market share, as Hyperloop links will not be able to compete with road's flexibility and availability.

Table 8- Consolidated scenarios with freight industry stakeholders

ENVIRONMENT	A minimum 20% reduction in aviation emissions, combined with less substantial reduction in road freight traffic. Reduction in number of flights and trucks in traffic has positive effect in noise pollution.	Demand shift to Hyperloop is not substantial enough to have an environmental impact.	Demand shift to Hyperloop is not substantial enough to have an environmental impact.

Table 9- Consolidated scenarios with environment as stakeholder/influencer

4.2.4-ASSENSSING THE LIKELIHOOD OF THE SCENARIOS

In order to assess the likelihood of each scenario, a probability of 1/3 if first assigned to each of them, and after a reflection of secondary research through academic papers or reports, and primary research through expert interviews, each probability was calibrated accordingly.

Scenario 1 assumes the optimistic scenario of adoption. Hyperloop is a cheaper, faster and frequent mode of transport, and is "hard to imagine a scenario where Hyperloop solution would make less sense [than other transport modes]" (Cristian Santibañez Interview D). Moreover, the environmental impact of a massive shift from air transport to Hyperloop would be considerable

and positive, whilst representing a relatively small investment when compared to the alternative modes. Although a fixed-guideway high-speed transportation is not ideal for freight, Hyperloop technology would also be used to transport cargo on low-demand hours to maximize utility. As a direct consequence, there would be a decongestion of airports and roads. For all these reasons, public authorities and the general public are more likely to adopt the Hyperloop technology since it presents considerable upgrades when compared to other transportation modes. This consolidated scenario has a likelihood of 50%.

In scenario 2 the technology is present in a limited number of high-traffic routes. There isn't a demand or necessity that drives private and public authorities to develop an extensive infrastructure network as alternative to more polluting and expensive means of transportation. Stations are likely to link major domestic and international routes in countries with higher passenger traffic like the United Kingdom, France, Germany, Italy and Spain. The market covered by Hyperloop routes would have an effect in aviation and HSR, on the personal side, and in air and road freight transportation, but the market where Hyperloop isn't available will continue to be served by the current competitors, FSA, LCC and/or the HSR, and air and/or road transport. It is not likely that once the Hyperloop technology is successfully operating in dense markets the network wouldn't be developed and extended to the entire EU region, maximizing utility and further decreasing gas emissions. Due to the above-mentioned facts, a scenario where the adoption of the technology involves a few selected routes and connections, not maximizing the advantages of network effects and further enhancing differences in countries' available technologies is not probable, hence the scenario was attributed a likelihood of 20%.

Scenario 3 deals with a pessimistic view of the adoption of the Hyperloop technology. Although is better than existing modes in several aspects, there are a vast number of reasons that could render the disruption to have a low adoption rate, among them the perception that there is no necessity for a vast infrastructure network of such a high-speed mode of transport, as the current alternatives can suppress the demand in most cases. In addition, companies present in the aviation and rail market are usually influencing companies with links to the state, as a shareholder or even full ownership, and thus public authorities may be unwilling to invest in alternatives, more competitive modes: "I think it's possible they [the aviation industry] try to prevent us from becoming a reality" (Cristian Santibañez, interview D). This scenario was attributed a likelihood of 30%.

4.2.5- DESCRIBING THE PROBABLE SCENARIO

The HSR would not be decommissioned, as it has the capacity of making intermediate stops and thus serves more city-pairs than the origin and destination locations, contrary to the Hyperloop or air transport. To respond to a demand shift to Hyperloop, HSR departures will become less frequent.

FSA will now focus on intercontinental routes, where Hyperloop will not be present. The market size of FSA will be substantially reduced, as short and medium-haul flights are now served by Hyperloop and the industry can not compete with it. International agreements regarding airports and air space rights for traffic will be of major importance, and airlines relying on strong agreements and hub-spoke systems will a competitive advantage. FSA will specialize in different markets: some airlines will focus on haulage from Europe to Northern America, others to Norther Africa, and others to different locations across the globe. Alliances will grow in importance, as they allow to decrease costs and for better negotiating power, and competition between them will be fiercer, as the demand decreases. In order to decrease costs or avoid bankruptcy, M&A will occur, and the market will become more concentrated than before as airlines tend to merge after an external shock leads to a demand decrease. Decongestion of airports will also promote higher margins for the surviving airlines throughout higher frequency of flights. The market will have fewer number of operating FSA but the size of each of these airlines will be bigger.

LCC will be more affected than FSA for several reasons. The first is that LCC usually rely on short and medium-haul flights, the Hyperloop core market. Secondly it is because LCC compete based on speed when compared to the HSR, and price when compared to the FSA. The Hyperloop render both these advantages obsolete. As many of LCC are subsidiaries of FSA created to respond to the then new airline business model, many of these airlines will leave the market. Other LCC will compete in the intercontinental market, and Ryanair has even planned to enter this market before the Hyperloop is constructed. However, it may be difficult for LCC to replicate the model for long-haul flights, as many of the costs possible to reduce during short flights, like high-density seating and no free meal offering, are forbidden or compulsory in long-haul flights. Hence, there may be an approximation of the business model of LCC and FSA, where operational efficiency to reduce fares will be the panacea to most. In this sense, M&A between LCC will happen, but it will also occur M&A between airlines with current different

business models, not meant to diversify the competing market of airlines but as a mean to increase market share in the new unified airline market.

European routes that are less dense and may not justify an Hyperloop route may continue to be served by LCC or FSA, especially if the route is located at a hub or spoke network of an airline. These routes will not be dense enough to be served by two competing airlines, and a price battle between airlines for control of the route is the probable scenario. Although some airline may specialize in this niche market that are less dense continental routes, currently usually served by LCC, most of the market will consist of intercontinental routes.

The Hyperloop freight transportation services focuses on goods currently travelling by air or road. This scenario assumes Hyperloop to have developed an extensive passenger line network, using it to transport cargo in low-demand hours.

Air freight transportation is likely to be affected by Hyperloop transportation. The network allows Hyperloop to substitute air freight transportation services within the continent, however the air transport would still be dominant in intercontinental transport services which represent the majority of air freight transport. Hence, there would be no major change in air carriers' business model, rather a reduction in the market size.

Road transport will also be affected, especially for larger distances and only for higher-value cargo that can now travel faster at a lower cost. As Hyperloop will link major cities at considerable distance, road transport allows for greater flexibility and a possibility of reach greater than Hyperloop transportation. However, for longer distances, the Hyperloop allows for a faster delivery at a similar cost and will affect in road transportation market share. Road will still be popular for international routes, and the break-even distance between road and Hyperloop transportation will mostly depend on the cost of switching modes, as the last mile will continue to be performed by road transport services. As Hyperloop becomes popular in the long-range cargo transport, road will focus its business model on the last mile, where challenges for the industry for the next years lie. Hyperloop solutions could also aid road transport with efficiency gains by decongesting roads and by working closely in an efficient intermodal system.

Environmental gains will be considerable. Although the effects on the freight side will not be as substantial as on the passenger side, substituting virtually all demand from continental flights to non-polluting modes will reduce aviation emissions by over 20%. A typical 1-hour flight

carrying 150 passengers releases 8500 thousand of kilos of CO2, 30 thousand kilos of nitrogen oxides, 2.5 kilos of Sulphur dioxide and 0.4 kilos of hydrocarbons (EU "European Aviation Environmental Report 2019). Therefore, a major shift from air transport to Hyperloop in domestic and continental routes, that together represent a 64% of all European flights, will have a massive positive environmental impact, especially when considered the decrease in noise pollution and the less substantial reductions in pollution caused by a shift from long-range road transport and continental air freight transportation to Hyperloop.

4.2.6- WHAT WILL THE LONG-RANGE PERSONAL AND FREIGHT INDUSTRY IN EUROPE LOOK LIKE ONCE THE TECHNOLOGY IS ADOPTED AND OPERATIONAL

The Hyperloop technology will disrupt the long-range European personal transportation industry, by attracting the current demand travelling through FSA, LCC and HSR, and will be the preferred transportation mode for travelling across the continent or within major domestic routes. Intra-EU flights represented 47% of the market, whereas domestic flights represented 17%. Hyperloop's impact in the market will range from the 64% of domestic and intra-EU flights to 40%, depending on the extension of the Hyperloop infrastructure network.

The HSR was not decommissioned, but the demand travelling from origin to destination shifted from HSR to Hyperloop transportation, leaving the HSR serving passengers in the intermediate stops. As a consequence of this demand shift, the frequency of HSR departures decreased. The availability of a faster mode of mass transportation, with cheaper infrastructures and operating costs, rendered the development of the HSR infrastructure network to stall, with no further lines and routes being built.

FSA will focus on intercontinental routes, where efficiency rates are higher and competition from other modes is non-existent. The market was reduced in 40% to 64% of flights corresponding to domestic and intra-EU flights, rendering many airlines to merge or leave the market. The latter is now dominated by a fewer number of airlines, thus is more concentrated than before. Airports deal mainly with intercontinental flights, and hence are decongestion and allow for greater efficiency and margins. Some airlines with strong hub-and-spoke system in less dense routes that are not served by Hyperloop will offer the service, although the margins in these routes would not be attractive as intercontinental routes and where it encounters competition from HSR and potentially from LCC.

LCC are the most affected stakeholder and fundamentally re-adapted its business model to intercontinental routes. FSA had an advantage in these routes as they possess a fleet capable on long-haul flights and do not require the investment, and many LCC had to merge to be able to compete, or leave the market. Some LCC relied on hub-and-spoke continental networks to keep operating less dense, and less profitable routes where they encounter the usual competition of HSR and possibly the competition of FSA, although LCC have an advantage in these medium-haul continental flights.

The effect of Hyperloop technology on the European long-range freight market is less substantial and disruptive. This market is fragmented, and Hyperloop competes with road and air transportation for time-sensitive and high-value merchandise.

Air transportation most important market is intercontinental freight transportation, where gains of delivery time are more considerable comparing to existing modes. Hyperloop affected intra-EU air freight transport and cause the demand to shift in mass, but the shifted demand is not substantial enough to have a significant impact in the overall European long-range freight industry.

Road transportation experienced a greater demand shift to Hyperloop transportation, as the latter is preferable in terms of speed, at similar cost. This mode is still the most popular mode of transportation but focuses now on the “last-mile” and shorter distances, benefitting from an intermodal operating system efficiency, although it is still popular over larger distances due to its superior flexibility and availability.

Environmental effects are considerable, with most being on the account of demand shift from air intracontinental passenger transportation to a clean mode like Hyperloop and resulting in around 20% reduction in harmful gas emissions, as well as noise pollution. Less substantial but positive effects from the demand shift in the freight segment, from road and air transport to Hyperloop, also contribute to a more positive environmental impact of Hyperloop in the transportation industry.

5. CONCLUSION

Hyperloop technology has distinct effects on the long-range personal transportation and on long-range freight transportation in Europe, as the effects on the first are greater than on the latter.

On the passenger side, LCC are the most impacted stakeholder. The current business model, based on short and medium-haul flights, low-cost fares and reduced total travel time are not competitive against Hyperloop, which is faster, cheaper and more frequent. FSA, on the other hand, operate intercontinental routes where air transportation is the only available mode. On medium and short-haul flights it is also not competitive against Hyperloop technology. The HSR has the advantage of location of the stations and possibility of using electronic devices. Hence, it is the least impacted stakeholder.

The impact of Hyperloop technology in the freight segment is considerably lower, as some cargo does not require high-speed transportation and thus is outside Hyperloop's core market. That is the case of the cargo travelling by rail and maritime shipping. Some time-sensitive cargo transported by road, and air cargo will be affected by Hyperloop technology. However, flexibility of not having a fixed guideway gives air and road transportation a competitive advantage.

As a faster, cheaper, more frequent, autonomous and clean mean of transportation, Hyperloop adoption and spread are likely to be high, leading to an extensive network of connected, domestic and continental routes.

The HSR reacts to the demand shift by decreasing the frequency of departures. FSA and LCC, which encounter Hyperloop competition in short and medium-haul flights, will leave those markets and focus on intercontinental routes, or less dense routes where Hyperloop transportation is not available. The downsizing of the market will lead to M&A between airlines with similar and distinct business models and cause a number of airlines to leave operations altogether, especially LCC which, focusing on continental routes, low prices and lower accessibility, will face the greater demand shift and have greater difficulty in shifting to a different business model based on intercontinental routes. Airports will mainly deal with intercontinental flights and experience decongestion, enhancing the operational efficiency of surviving airlines and increasing its margins.

Air freight transportation will experience a demand shift in continental routes but will focus on intercontinental flights which are the current core market. Road transportation will be affected by an extensive development of Hyperloop transportation infrastructure, but the cargo transported by Hyperloop represents a fraction of the cargo transported by road. In addition, road transportation will increasingly focus on the “last-mile” and may benefit from an efficient intermodal system with Hyperloop transportation.

The environmental impacts are mainly caused by a shift in medium and short-haul flights in continental routes to Hyperloop transportation. This market represents 64% of all flights in Europe, leading to a reduction of around 20% in aviation emissions.

5.1 LIMITATION AND POTENTIAL FOR FUTURE RESEARCH

This thesis was developed under several assumptions, previously outlined, as the technology is still developing and there is yet no deployment of the technology. Results depend on interpretation of the author of primary and secondary data gathered. With further time, funds, and expert interviews the present paper would be more complete and have more exhaustive conclusions.

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7. APPENDICES

7.1. INTERVIEW 1- JOSÉ COSTA FARIA (DHL)

1. **What are the most important characteristics when companies look for transportation?**

Talking about the transportation industry as something homogeneous is a fallacy. There is not an industry that aggregates every transportation mode, and client's necessities vary according to the mode: rail, road, air and maritime. There is no "one size fits all" rule. What logistics managers do is, for each moment of the transportation, opting for the most adequate mode. The various modes of transport should integrate themselves in the transport system whenever is possible to facilitate and improve the service. In most cases, there is little need for fast transportation. The first characteristic that clients value the most is accessibility, followed by regularity, consistency and reliability. New businesses like e-commerce prompted a lot of new challenges and innovations are appearing in the "last mile" of the transportation system, as this is the most likely segment to change over the upcoming years.

2. **Does competition in the freight transportation industry occur mainly within modes, or more between modes?**

Clearly within, although there are situations where there is overlap, for example between road and maritime transportation in international transportation, or rail and road transportation. But competition occurs fundamentally within each mode of transport.

3. **That poor performance of rail operators, with rail services being considered one of the poorest performing in the EU, is holding back rail freight transport industry and making intermodal transportation less competitive?**

Yes. At the end of the day, clients need to meet deadlines and supply chains to serve, and need efficiency and effectiveness in the transportation system, and unfortunately rail transportation in Europe, especially in Southern Europe lacks those characteristics. This is due to historical reasons, as rail operators were property of the State. When the market was liberalized things improved, but before each country had its own rail administration responsible for deployment and management of the lines. To use rail from Portugal to Germany, four different rail administrations need to be bypassed. Each of these administrations has different requisites and ultimately render rail transportation to be inefficient overall. To worsen the situation, there is a

trend towards lower inventory volumes, and the lower the inventory volume, the more reliable the transports need to be.

4. **There is a lot of public opinion pointing to intermodal transportation as a mean to decrease CO2 emissions, as road transportation, the principal mode, is more polluting than rail transportation. Are these concerns extended to law makers and transportation services consumers?**

I have been working in the industry for a long time and I never noticed some mode being preferred over another due to environmental issues. Things are changing and evolving, but we are yet far from the environmental awareness of the transport services consumers. The initiative to use intermodal solutions will arise from the private side, when firms understand they can provide solutions that satisfy the necessities of their clients. I do not believe in public initiative to change something, but the State will obviously take a part in that change.

5. **Is the industry evolving into the creation of a European Integrated Transport System that is currently fragmented?**

Yes, I believe in that. Intermodal transport solutions depend on that system, but it does not mean there is a need for an integrating law. The discussion surrounding a European integrated transport system is recurrent and is a point that is always in the agenda, the question is more about the time these issues stop being discussed and start being tackled in the real world.

6. **Do you believe a technology like Hyperloop will add value to the long-range transportation market?**

I do not believe in the technologies' potential for the freight industry. There is no high-speed freight transportation in Europe, except for some small packages travelling in HSR on small compartments. The question is: is there a need for high-speed in freight transportation? In addition, Hyperloop joins point A with point B, and does not serve other areas. My opinion is that the technology potential for freight is very low, especially when considered the freight flux needed to make one trip viable. Utility of the transport service will depend on the frequency of utilization of a line, and I do not believe the flux in Europe is dense enough to make Hyperloop freight transportation viable.

7.2. INTERVIEW 2- NELSON SOUSA (JSL; ANTRAN)

1. **What are the most important characteristics when companies look for transportation?**

Flexibility, cost and time.

2. **Are there a maximum distance for which road transportation is no longer competitive, when compared to other modes?**

No, although depending on the markets because road transport has own legislations, including rest time for drivers, infrastructure costs are also different from country to country.

3. **Are the main competitors for road transportation within the sector, or does it compete with other modes?**

Rail or maritime transport, which already exist and are being developed (example of maritime Nantes-Gijon corridor which was stopped for ceasing investments from Spanish and French governments that were crucial) are not reliable, because sometimes maritime is subject to weather conditions, far more exposed than road transport. Besides its flexibility, its reliability plays a big role (on-demand and on-time, whilst maritime and rail or air are not flexible, and maritime is not reliable). Maritime highways help us being more competitive but it's not reliable nor flexible. Rail services in Portugal lack infrastructure investments, and the Iberia is isolated from international rail corridors due to different width of rail tracks. Adding to that, nowadays, tunnels are sometimes too short for intermodal rail transport to be an alternative because the cargo is too big, and the tunnels create height constraints. Intermodal transport also adds transport time for changing vehicles, and operator's inefficiency often ends up making intermodal transport economically unviable.

4. **That poor performance of rail operators, with rail services being considered one of the poorest performing in the EU, is precisely due to that lack of sufficient investment on infrastructures, the differences in rail specifications that doesn't allow extensive international corridors, or is it due to inefficiency in operations themselves due to the industry's historical lack of competitiveness?**

There are several problems. First, infrastructure investment. Then, the inoperability regarding intermodality, which is key for rail freight transportation services as it works from point A to point B and not from the manufacturer to the client's desired destination. First and last mile are

road's market and conjugation between the two modes is easier as intermodality is facilitated. Intermodal boxes already exist, but the cost of the switching mode operation makes it unviable. It also needs volume. The time windows are large and rigid (fixed departure time and volatile arrival time). In addition, every city or town wants a station, but as the train stops at more stations it delays its delivery time and increase operational costs. But rail can indeed be the solution for a specific type of freight, but always combined with road transportation.

5. **There is a lot of public opinion pointing to intermodal transportation as a mean to decrease CO2 emissions, as road transportation, the principal mode, is more polluting than rail transportation. Are these concerns extended to law makers and transportation services consumers?**

There is an edge between law makers and the industry. There are utopic goals, set without verifying its feasibility. The government doesn't listen to the industry, that is opened to make efforts to reduce harmful emissions. It is the industry's wish to reduce emissions as much as possible as fast as possible, and solutions as the Eurocombi are being introduced and are already operation in the Nordic countries, where for example rail and maritime transportation is more developed than Portugal. However, this new configuration is yet not permitted in all European countries, and transporters using this configuration are prohibited of performing in the majority of the European countries, confined to markets where this technology is allowed. There are directives from the EU to allow these vehicles to transit when travelling between two countries where the technology is allowed but needs to pass through a third country where legislation forbids it. So the technology allows more fuel efficiency per tonne, a gain in capacity and reduces cost associated with infrastructure utilization and requires solely private investment, far smaller than that required for rail infrastructure. However, it was or is "on hold" in many countries due to political bureaucracy or lack of will. In Iberia is permitted both in Portugal and Spain, but only with special transit permits attributed only to trucks with national license. Basically, international transport with Eurocombi is forbidden, while its gains grow larger as road distance increases.

6. **Is the industry evolving into the creation of a European Integrated Transport System that is currently fragmented?**

The system exists or has potential to exist, but members are increasingly making independent decisions, disrupting sometimes the Common European Space. It frightens us. Eurocombi example again: we have our solution, Spain has theirs. Nordic countries have a more opened

model. And the system works independently. Even within Portugal, specific factories are granted licenses to increase height of their vehicles by 40 cm, doubling its transport capacity and competitiveness.

7. **Is there any current trend in the industry worth pointing out?**

Increasing flexibility, as the one allowed by Eurocombi. Before, businesses require full loadings and kept larger stocks. Nowadays, they require lighter stocks but increasing frequency of medium or small loads adjusted to their needs, keeping inventory needs as low as possible. Road transportation was able to adapt, but maritime and rail transportation don't have the capabilities to answer. Needs are different: increasingly "just-in-time", decreasing operations time and increasingly fractioned cargo. This idea seems contrary to the proposed Eurocombi just mention, although it is not. Eurocombi makes sense in the transport between warehouses. The first and last miles will continue to be done by a lighter fleet. We need to logistic tools for consolidation and deconsolidation of cargo, while the first and last mile are tailor-made.

8. **The HSR has often been regarded as a high-speed solution for cargo, but never realized. Is it proof that there isn't such a high demand for high-speed cargo transportation, other than the demand met by air transportation?**

Usually, high-value consignments travel by plane. Medium value travel by road, and only low-value cargo uses rail or maritime transportation. This happens because companies buy large quantities of low-value products at once and keep them in stock. High-value merchandise is usually not available in stock, thus the need to respond to this kind of demand. High-speed cargo transportation looses because it's costly and not flexible, and it's no viable solution.

9. **Do you believe a technology like Hyperloop will add value to the long-range transportation market?**

I believe in the technology's potential for passengers, but not for freight. Although it presents velocity gains, when compared to rail, the rest of the problems are identical: there is no flexibility for the cargo shipment's height, and its condition of being slot to a specific time doesn't meet the needs of most clients. Just-in-time is the trend and we need to adapt to the demand, and not the demand to transportation's characteristics. With passengers, it's annoying a delayed or cancelled flight. But factories could stop producing if transportation of materials is delayed. This shows the demand degree inherent to each transportation mode.

7.3. INTERVIEW 3- THIERRY BOTIER (TRANSPOD)

1. **What is Transpod? What is Transpod's mission and what problems is it trying to solve?**

TransPod is a company created in 2016 to develop an innovative and efficient solution for hyperloop transportation. Although the product we are developing is a hyperloop type of transportation, or vacuum tube transportation, our design makes our solution more affordable, and more comfortable for the passengers. A hyperloop system is a generic term for tube transportation. TransPod does not want to be another hyperloop company. Starting from a blank page, TransPod's technology has been drafted so it could offer a better proposal than the ones from our competitors.

Our mission is to gather experts and adopt a physics-first approach to solve mankind's biggest problems. We are working on tube transportation, and are already thinking of another project to go forward.

The current offer in terms of transportation is not efficient enough, and we are bringing a new mean of transportation that will solve our current issues.

2. **What is Transpod's vision for Hyperloop? Is an European integrated system a possibility or is Hyperloop going to be built on particular separated routes?**

Our vision for hyperloop is a global network in which automated pods can take you from origin to destination, without the need to transfer from one route to another route. The short-term vision consists of lines that will bring passengers from point A to point B, hopefully with a few stations along the road. Such routes should replace diesel trains, cars, short- and medium-haul flights. The long-term vision is a subway, but at the scale of a country.

A European integrated system is possible, however, the diversity of technical solutions to make the pods levitate and move makes a global integration impossible for now.

3. **For which distances do you believe Hyperloop technology is competitive?**

300km to 500km is the ideal distance for a first line. Below 300km, the vehicle would mainly accelerate, then decelerate, and the gain in terms of speed would not be significant enough. More than 500km is definitely possible, but the cost of the project would make it impossible to finance. Once the first lines will have been built, there is no limit. Stations should be at least 50km distant from each other, and a line can go from Paris to Shanghai.

4. **Is there a feasible current demand on the passenger side for such an infrastructure investment?**

The capacity of the TransPod system is about 1500 passengers per hour and per direction. Many couple of cities have this throughput of passengers already. The connection Toronto Montreal itself could host two hyperloop lines and be at full capacity on day one.

Note: hyperloop is not only for passenger, but also for cargo. Whenever the demand from passengers is not enough, cargo pods would travel in the tube, to maximize the use of the infrastructure.

5. **Is there demand on the freight side for such a high-speed transportation system? Or is it something for capacity utilization maximization on routes where passenger demand catalyzes the construction of Hyperloop?**

Following the answer of the previous question: hyperloop is for both passengers and cargo. We are considering time-sensitive freight: same day delivery (Amazon prime, DHL, UPS, FedEx, etc.), perishable products. Then, the use of the line depends on the demand. Some lines will be only for passengers, some line mainly for cargo, and for some it will be probably 50/50: passengers during rush-hours, cargo during low-peak hours.

6. **What role could the Hyperloop have on building smart cities and tackle cities overcrowding? Is it feasible to build a hyperloop that connects less populated areas to larger cities, to build new cheaper residential areas?**

A smart city is a group of infrastructures and smart solutions, at the scale of the city. Hyperloop won't help in that matter, as it connects cities together. It will definitely have an impact on overcrowding. One application for a hyperloop line is to offer the possibility to live further away from the workplaces to enjoy a more affordable, and more comfortable lifestyle, while keeping the same commute time. If the feasibility studies show the need for stations in the countryside, they will have to be carefully planned, as they will attract newcomers and will quickly become denser areas of population. However, a station has a fixed cost, and regional planning will have to be carefully studied before deciding the location of the stations.

Note: a pod does not necessarily stops at every station. Since the pods are small vehicles for 25 to 40 passengers, if no passenger needs to exit or board a pod at a dedicated station, then such station would be by-passed by the pod, which keeps travelling at full speed.

7. **What would be the response from stakeholders on passenger transportation industry such as full-service airlines, low-cost carriers and HSR? Would there be an almost total shift of mode on routes where Hyperloop transportation is available?**

A 45 minutes flight is in reality a 3 to 4 hours trip, if you consider the time to go to the airport, luggage checks, security checks, boarding, un-boarding, commute back to city center – without considering the usual delays associated with crowded airports, and without considering the risk of missing your flight if you're late. A 45 minutes trip by hyperloop is an hour overall trip, with the same considerations. It will be cheaper, more comfortable, and more secure. And there's no need to book a ticket in advance, as pods depart every 2-3 minutes. So no need to plan your journey, transportation is a service, and not a constraint. We expect a massive shift from short-haul and medium-haul flights toward hyperloop. Oh, and hyperloop is cheaper than air travel.

Same considerations apply for HSR, that is slow, departs at fixed times, stops at every station even for very few passengers. Moreover, HSR is not profitable and people don't choose to use HSR, but they use HSR if it's available. We don't expect a shift from HSR to hyperloop, since HSR tracks will not be decommissioned, and hyperloop lines will not be built in parallel to HSR tracks.

8. **Which would be Hyperloop cargo focus? Will Hyperloop compete only with air freight services or with other existing modes, such as road and rail, that carry a different kind of cargo?**

As I said before, hyperloop cargo will be fairly expensive. So, it can be compared to air cargo, but not train cargo. Trains carry heavy and not valuable freight (ore, rocks, raw materials, etc.). Air cargo is time-sensitive, and either has a very high ratio cost / weight, either customers are ready to pay a premium to have goods delivered by air. Same will apply to hyperloop cargo.

9. **What is your long-term vision of Hyperloop and the long-range transportation industry once the technology is implemented and operational?**

Once the technology is implemented and operational, the long-term vision is an extension of the initial network, and construction of more lines and networks on other continents. Short- and medium-haul flights will be replaced by hyperloop connections, and airports will mainly deal will larger planes for long-haul flights, which are more efficient and more profitable. Hyperloop will also allow people to travel very fast from a regional airport to another regional airport, and

airports should become terminals connected with an ultra-high-speed ground connection. The size of the warehouses should be reduced, as such a transportation system will allow same-day deliveries to the cities.

7.4. INTERVIEW 4- CRISTIAN SANTIBAÑEZ (HYPERLOOP TRANSPORTATION TECHNOLOGIES)

1. **What is HTT? What is HTT's mission and what problems is it trying to solve?**

HTT mission is to deliver the next breakthrough in mobility. We noticed that, if you look at the transportation industry as a whole, we haven't had a major breakthrough in the way we move people and goods around for the past 100 years or so. The combustion engine was a major hit but since then, especially if we talk about mass transportation, we haven't seen anything that has managed to crack the technological limits or efficiency limits of things like airlines, rail and so on. With that in mind, and thanks to Elon Musk white paper on Hyperloop Alpha, our founder decided to crack the Hyperloop system and bring it out of paper, and created a company with that vision of creating a transportation mode that is safer, clean, human-centric, faster, efficient and sustainable. It is also profitable, which is overlooked in the transportation industry. Rail and airlines in particular are not profitable systems- both are subsidized at some point, whether in the construction of planes or some other point. But no one has been able to crack a profitable self-sustaining mass transportation system

2. **What is HTT's vision for Hyperloop? Is an European integrated system a possibility or is Hyperloop going to be built on particular separated routes?**

That is something I cannot answer, actually, and is not necessarily part of our current scope of thought. As a company, we don't define ourselves as builders and operators, but as a technology company creating technology to allow other people to construct and operate Hyperloop systems. We are building the necessary technology and helping third party companies, but we will not be the ones using it. I'm saying this because places where lines will be built ultimately depend on the company building it, and secondly on the public authorities. Right now there is only one line we are going to build, which is our technological demonstrator. It's a commercial line in the UAE and connects Abu Dhabi to Al-Ain.

3. **Is there a predicted date for the first operational Hyperloop line?**

I cannot answer that question with precision. We have an internal roadmap that we don't communicate about, mostly because it concerns heavy engineer and heavy infrastructure projects, where miscalculations often mean setbacks of months and that is why we don't

communicate our timeline. What I can say is we are confident that we will see a fully operational system in our lifetimes, within the next 10 years or so.

As we speak, we are the only ones providing a solution that has been evaluated by third-party entities and was found to be viable, feasible and economically sustainable. This was recently published by the company and all the documents are public.

4. **For what distances do you believe the Hyperloop system would be competitive?**

There is no universal answer to that. It really depends on the ground conditions. To give an example, if a line was to cross the desert the cost equation would be different than if you want to make it underground, as you would have to dig and costs would mountain. We wouldn't be able to use solar power so again, the cost equation would be different. It's easy to imagine lines having regional, inter-regional and international applications. But again, it would always depend on the ground conditions and that is why feasibility studies are important to determine the applicability of Hyperloop, and if so under which conditions. In pretty much any scenario you can imagine is more interesting than existing modes because it's faster, safer, has similar passenger load and makes economic sense, on top of being sustainable. Hyperloop construction cost are about 20 times cheaper and operational costs are about 50 to 100 times cheaper depending on the parts of the track. It suggests it will be hard to find conditions where Hyperloop systems would make less sense.

5. **Is there demand on the passenger side for such an infrastructure investment?**

Because of my previous answers, I would say yes. The cost equation is very different from existing alternatives and particularly HSR. Because we have very low operating costs, we can very easily compete in transportation systems where generally speaking there is demand. Especially if the demand is elastic to price, because of our operating costs we can play with price a lot more.

6. **Is there a feasible demand on the freight side for such high-speed transportation? What kind of cargo would the pods transport?**

I think there is an opportunity on the freight side, and we are exploring a major opportunity in Hamburg.

It is still early to answer. What we are building is a tube in which you can put a vehicle, like pods, to transport people. In the future we are expecting to build different vehicles, through partnerships with private companies or R&D, that transport cargo. Right now we do not know what kind of cargo those vehicles are going to transport, so I cannot answer your question.

7. **Do you think Hyperloop could have an application in tackling overcrowded cities?**

If you look at different urban models and cities around the world, there are people already living far away from the place they work, but that is of course limited by the maximum speed and mobility options that citizens have available. We are building a mode that is faster than any current modes, especially over long distances, so if people want to live even further away from urban centers, our technology will enable that. If it will happen or not or if Hyperloop will have a role in that, or is constructed for that end, is difficult to say. Satellite cities have similar strategies and they don't work because they quickly become denser and with higher economic activity, turning into another urban center and creating segregations among the population. So probably public authorities wouldn't approve that, but it's not our decision or within our control.

8. **How will the transportation procedures of Hyperloop be like regarding security screening, luggage storage and other protocols, or location of stations?**

We haven't publicly made any decisions regarding those aspects although internally we are starting to think about the answers to that. Because of our company's open model, I can say that we can internally develop answers quickly based on the analysis of best practices used in other transportation modes as we have experts in those industries, so our standards will certainly not be under aviation or rail standards.

Regarding the stations, it is possible to build in city centers. If it will happen, it's a decision of the public authorities.

9. **What would be the response from stakeholders on passenger transportation industry such as full-service airlines, low-cost carriers and HSR? Would there be an almost total shift of mode on routes where Hyperloop transportation is available?**

I remember Airbus' or Boeing's CEO making a declaration a week ago, in which he said (I don't really remember the exact words) he would do everything to prevent Hyperloop from becoming a reality. My point is we threat that (aviation) industry in particular and that was a

recent development. As for consequences in particular yes I think it's possible they try to prevent us from existing because that's the industry's functioning, it's likely that happens.

10. What is your long-term vision of Hyperloop and the long-range transportation industry once the technology is implemented and operational?

That's a very open question so I can speak on my behalf, as I've been involved in urban mobility for the last seven years. The impact will be huge, from a social standpoint if you look at history of transportation and economic development, generally speaking, it's very deeply connected with the way you connect people and places together. If you can offer an alternative transportation to the ones already existent, in a better and more efficient manner, you talk about something that has a very positive impact because it connects people more on a very fundamental level, that is human being as political animals. When we are connected together technology improves, culture improves, bad things also deteriorate but we become aware that there are spaces that need to be regulated and we start regulating them to prevent the worst effects of that. Hyperloop solution, from that perspective, is the first mass transport alternative for a long time -the other one was rail and it's the only structuring system that exists by now. The extent to which the high-speed long-range transportation system can structure the territory, landscape and thus people's lives depends on the scenario. Most likely it will have that impact which is very positive. If you top that with two additional features, sustainability and profitability, I think we really are looking at something that can change the face of cities, regions, countries and more generally speaking, society. Sustainability because it produces more than it consumes and is the first mode of transport capable of that. The profitability part means taxes would no longer be used to subsidize transportation cost or investments and that's a change in mass transportation paradigm around the world. In addition, it combines many different technologies and allows to create something completely new, on every aspect, even on the way to manage flows. So as we speak, there's a tone of technological and organizational development happening as we develop the Hyperloop system that are full of potential for other industries as well.