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Finding eco-efficiency in domestic short-haul passenger transportation

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Abstract

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Airline scheduling is one of the most profound and complex tasks in airline management. The scheduling team of a hub-and-spoke airline must resolve the challenges of schedule attractiveness while maximizing aircraft utilization and connectivity. The ultra short-haul flight legs are vital part of the network structure as they feed passengers to connecting flights. But as flight time is so short, the energy-intensive phases of flight are not offset by cruise phase making them less eco-efficient than longer sectors.

Civil aviation globally accounts 2% of the man-made greenhouse gas emissions. In addition, Finland's domestic air traffic accounts 2% of emissions from whole domestic transportation. Finland has declared to halve CO2 emissions generated by domestic transportation by 2030 and have carbon-free transportation sector by 2045. Various regions have published their climate strategies supporting the goal.

This research was conducted as a qualitative case study to understand current level of eco-efficiency in the Finnish domestic transportation sector. Data was collected by interviewing subject matter expert's in various transportation related companies and regional organizations.

Results show that eco-efficiency actions are vital part of companies' strategies and visible throughout the company. Currently transportation companies would like to be even more eco-efficient, but their actions are not yet supported. Operators view that consumers are not yet prepared to alter their travelling or purchasing behavior even if it would mean more eco-efficient transportation and legislation should be more supportive towards their environmental initiatives. Company customers are more responsible as companies own eco targets guide their staff travels. For individuals it is currently challenging to compare transport methods eco-efficiency as there is no widely accepted ecolabel scheme available for transportation sector.

Carbon neutrality means a paradigm shift. The industry cannot wait for new technological developments for increased eco-efficiency, but they need to act themselves by finding new approaches. Replacing ultra-short haul flying with alternative transportation methods could be a viable solution if the challenges of infrastructure, service concept and schedule feasibility are resolved.

Asiasanat
Eco-efficiency; airline scheduling; multimodal transportation; greenhouse gas emissions

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1 Introduction

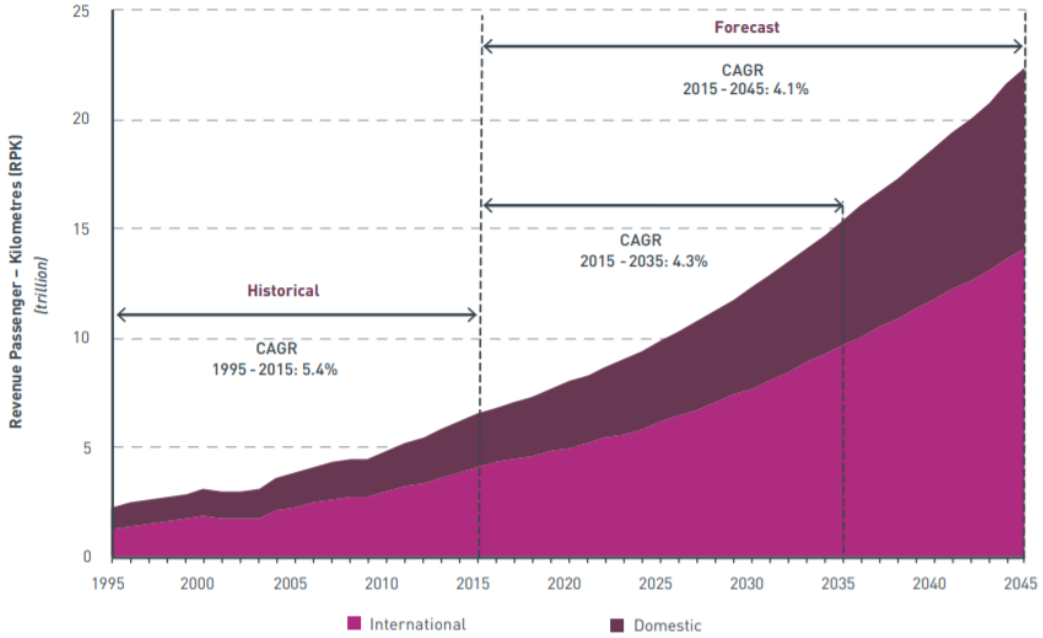
If Shakespeare would have been present nowadays, his famous play “Hamlet” could have included the debate of “to fly or not to fly”.

The idea for this thesis grew during 2019 which will be remembered of unforeseen global sustainability action. Aviation and its emissions competed in headlines with climate demonstrations and extreme weather conditions. Steps towards more sustainable future were taken when European Union introduced the Green Deal but inability to agree anything in UN Climate change conference resulted two steps backwards.

The aviation industry must act. For long-term solution airlines and airports are joining forces to research and accelerate the introduction of electric aviation. For example, the Nordic countries have established Nordic Network for Electric Aviation (NEA) with the goal of reducing carbon emissions from regional flying (Nordic innovation 2020). Moreover, aircraft manufactures have come up with ambitious plans to develop small electric aircraft for regional routes. The technological development is really needed if the goals set by governments are to be met. Norway has declared that it wants all domestic flights to be emissions-free by 2040 and Sweden intends to have all domestic and international flights fossil-free by 2045 (Fossil-free aviation 2020). Meanwhile in France and United Kingdom, legacy carriers Air France and British Airways have pledged to offset all the carbon dioxide emissions generated by domestic flights (Simpleflying 2019). This strive for sustainability has added a new dimension to the already fierce competitive landscape where airlines operate. Various statistics, different figures and subtle hints of green choice are given to the customers. As the industry is missing a credible ecolabelling system and some airlines are flexing their environmental credentials, it’s challenging for customers to know the real facts (WSJ 2020).

As the global aviation industry is growing (figure 1) so are the absolute emissions. The positive signal is that the carbon dioxide emissions per revenue ton kilometer are decreasing, for example Finnair has reduced them by 27% from 2005 levels. In the long-term Finnair’s ambition is to have carbon neutral operations. (Finnair 2019). An airline cannot change the world so to reach these goals the technological and political development needs to be accelerated. Moreover, the consumer needs to be prepared for the change. For example, if airlines decide to use next generation biofuels manufactured from hydrocarbon, it would challenge customers willingness to pay extra for the sake of flying green. The ultimate alternative is to fly less.

Figure 1. Total passenger traffic, history and forecast (ICAO 2019)



This research is supported by Finnish airline Finnair and is part of their constant strive to become more sustainable. Although Finnair's environmental program covers the entire company, this thesis does focus mostly on airline operation side. In addition, the thesis discusses sustainability from more eco-efficiency point of view leaving important topics as social aspects out of scope. Simultaneously it can be considered as a sequence to author's bachelor thesis reviewing the domestic long-distance transportation sector in 2012. The change in eco-awareness is clearly seen when comparing the two dissertations.

The main research questions revolve around four themes: Eco-efficiency actions, domestic transportation, domestic consumer behavior and lastly, multimodal travel chains. Each theme contained several questions and the results of are also organized according to these larger themes. Then key research questions are:

- What types of eco-efficiency actions your company/organization exercises in your daily operations?
- How to develop domestic public transportation towards carbon neutrality?
- How consumers can evaluate which mode of transport is most eco-efficient?
- What would be needed for Finland to have an effective multimodal transportation service?

The key concepts of this thesis include "airline scheduling" which according to Wensween (2015) is the art of designing systemwide flight patterns that provide optimum public service, in both quantity and quality. Moreover, the concepts of "multimodality" and "intramodality" are discussed largely. Multimodality is the combination of multiple means of transport under one contract whereas intramodality is combination without the need for

contract, like combination of train and bike. In addition, the concept of “eco-efficiency” is discussed throughout the thesis, taken as the value of product or service divided by its environmental influence. Lastly, the thesis presents a concept of “ultra short-haul” which in this research means flights less than 200km radius from Helsinki. Finnair serves two domestic airports and one foreign airport located less than 200km from Helsinki.

As a national carrier Finnair has established a comprehensive hub-and-spoke network operating in and out from its Helsinki hub to hundreds of destinations, or spokes, worldwide. Moreover, Finnair has the responsibility to operate to various domestic airports and offer passengers connection from regions to Helsinki and beyond. This responsibility also includes the need to operate as eco-friendly as possible, meaning burning less fuel and creating less CO2 emissions and noise. What makes this complex is reality. Finland has the size to go long-distance and is still one of the least densely populated countries in Europe. Most of Finnish inhabitants live by the coast, south and southwestern parts of the country, leaving the eastern and northern part extremely non-tightly populated. For a network airline which funnels all the traffic via its Helsinki hub, the home base of the airline, this poses challenges. The passenger loads are thin and somewhat seasonal (table 3). In addition, domestic schedules need to have connectivity to the network beyond Helsinki meaning that multiple daily connections need to be operated which consumes essential resources such as aircrafts and Helsinki airport prime landing and departure slots. In regions local businesses consider direct flight connections vital meanwhile local politicians oppose any cuts to network or frequency levels (Yle 2020). What is more, environmentally short-haul flying is debatable as energy-intensive departure and approach phases cannot be offset by cruising and alternative transportation methods such as trains and busses are available. The big question is how to serve domestic regions and keep their airports open in a manner which is both economically and environmentally viable? As the response requires governmental actions, this thesis aims not to solve this problem completely. It targets to provide an outlook to the current state of the matter and provide steps to get closer to solving this fundamental issue.

Thesis follows the principles of a qualitative study. It aims to describe phenomena such as airline schedule planning process and aviation’s impact on climate and link these to the domestic context. As the research topic is rather current, special focus was put into finding the most relevant, up-to-date and credible data sources. Thus, various online articles, publications, news and press releases were exploited. Governmental publications and company’s own databases and analyzers were used to gather statistics and to illustrate the current state of the matter. In addition, literature was used to create the framework for bigger entireties such as airline planning process and sustainability. Various interviews

were conducted to gain views from transportation sector and from regional perspective and these provided a quantity of insights and knowledge not written to any books nor articles. Lastly, the critical question of could ultra short-haul domestic flying be operated with other metal than aircraft sparked vivid discussions leading to a concept presented later in this thesis.

2 Aviation industry

What started as an airship operation in Germany early 1900-century has evolved into complex global business and a necessity for modern world. An airline transforming from simple postal flights to carry 200 million passenger per year has witnessed the fast-paced development of the industry (American Airlines 2020). Globally in 2018 airlines carried 4.3 billion passengers and flew 38 million scheduled commercial flights (ICAO 2019, 8). This chapter discusses the factors why aviation industry has grown to become as essential industry as it is currently.

2.1 The economic and social benefits of air transport

The benefits of having a flight route between cities can be divided into economic and social benefits. Although global aviation has an impact on the environment, it would create massive challenges if flying would stop.

Global air transportation industry generates around 65 million jobs of which roughly 10 million are direct jobs. In addition, as the industry is highly capital-intensive it contributes 3.6% to the global GDP. As a comparison the contribution of aviation to the global economy is roughly similar than the overall GDP of the United Kingdom. (ICAO 2019, 17.) The air transportation also facilitates world trade and is indispensable for tourism. Consumers can benefit from shorter delivery times and wider selection of goods. For business operations air transport enables companies to meet their clients and good connections influences where companies choose to invest. To some extent companies' sales are dependent on regular air service. (ATAG 2005.)

Air transportation plays a significant role in supporting and promoting international tourism. The tourism industry then generates economic growth for the region and provides opportunities for increased employment rates and better conservation of protected areas and the environment. In addition, air transport provides access to remote areas which can be difficult to reach with other transport modes and provides a mean of delivering essential supplies. (ATAG 2005.) Air transportation is also vital for international students as for many the access for higher quality education requires travelling abroad. Lastly, aviation can be regarded to help fostering awareness of other cultures and making it easier to visit distant friends and relatives. (ICAO 2019, 31.)

2.2 The economic impact of airports

Typically, there are two types of economic impact at airports. It brings employment, income, capital investment and tax revenues. Secondly the airports facilitate the development of tourism and supports the local businesses. The economic impacts can also be classified into four different groups; direct, indirect, induced and catalytic. Direct economic impact means employment and income generated by the airport, for example new hotels and car parks built to the airport's vicinity. Indirect impact is the income generated in the supply chain to the direct activities, for example fuel supplier. Induced impact is the employment and income generated by the employees, for example buying a house nearby the airport. Lastly, catalytic impact means the tendency of airport area to attract and sustain economic activity in the surrounding area. (Graham 2014, 264-265, 273.)

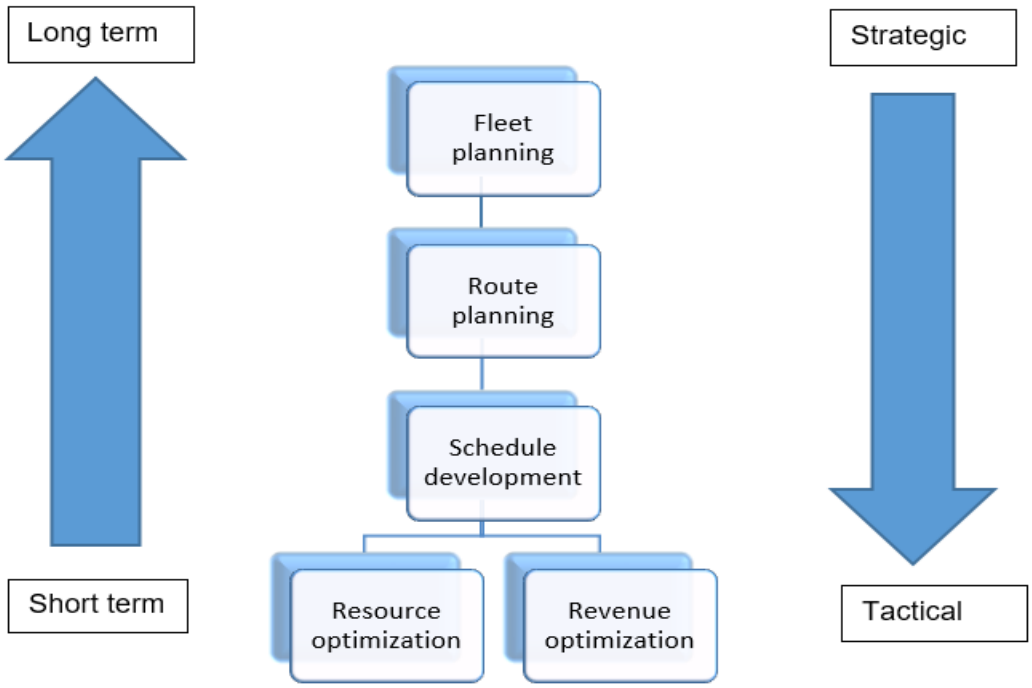
Picture 1. Cycle of aviation benefits (ICAO 2019)

Airport can play an important role in retaining current businesses or encourage them to expand. Moreover, the vicinity of airport may influence the decision where to locate the factory or head quarter. For regions it can be difficult to attract inward investments if there are no air services. Airports are often considered as the key component of regional development and competitive advantage over other regions without an airport. The expansion of low-cost carriers has benefitted many airports in relatively unknown regions as the airlines have transformed them into new tourism destinations and generated international traffic flows to and from the region. (Graham 2014, 273-275.) The Finnish regional airports of Tampere and Lappeenranta have both experienced the growth generated by low-cost carriers (Yle 2019). Picture 1 summarizes the benefit cycle that aviation can generate for airports and regions.

3 Airline planning process

This chapter discusses the airline planning process separating it into three different categories. The airline planning process begins with longer term decisions about fleet composition followed by hub and route evaluation and schedule development. After the plans are developed, other vital commercial decisions as pricing and revenue management strategies need to be made and airline must ensure it has enough crew to operate the flights and at the airport. Typically, these different sections are separate departments inside the organization but the co-operation between the departments need to be efficient for airline to be successful. As the thesis focuses more on the route planning and schedule development it is highlighted more than the other vital planning processes.

Figure 2. The airline planning process (Adapted Belobaba 2015, 160)



3.1 Fleet planning

The aircraft fleet that airline decides to acquire is very much a long-term strategic decision for the airline. Each aircraft type has its own characteristics e.g. range, payload, number of engines and noise level. Moreover, the fleet planning decision represents a significant capital investment that directly impacts on the airline's overall financial position. The aircraft should suit to the market needs allowing airline to operate the market in profitable manner and also support airline's marketing strategies. The ultimate challenge is that the

chosen aircraft type might have a lifecycle of 30 years during which the market conditions will change, and technology will develop significantly. Therefore, airline's fleet plan should reflect the chosen future strategy including the amount of aircraft needed by aircraft type, the delivery times, schedule for retiring of older fleet and importantly some contingency plans to allow flexibility in changing market conditions. (Belobaba 2015, 161; Wensween 2015, 418.)

The fleet planning process is traditionally dominated by economic/financial evaluations and the technical/performance characteristics of different aircraft types, then environmental criterion cannot be anymore be overlooked. In fact, the growing number of environmental regulations imposed by different governments adds complexity in the airline's fleet planning. One major topic has been noise performance of jet aircraft, newer models are quieter than the old models, and airports have created regulations to limit or prevent airlines operating with noise-heavy aircraft. In addition, the European Union imposed an "emissions trading scheme" ETS in 2012 to limit the carbon emissions of airlines departing or arriving in the European Union. The regulations incentives airlines to update their aging fleets, even earlier than previously planned. (Belobaba 2015, 165-166.) The financial evaluations include the cost of aircraft plus spare parts and its operating economics. In addition, revenue potential and direct operating costs must be examined. (Wensween 2015, 435.)

3.2 Route planning

The route planning process is driven by economic considerations and expected profitability. The process involves highly developed demand and revenue forecasts and careful consideration of available fleet. It's not unusual that the identification of economically viable route opportunity might require acquiring a new aircraft type. A part of network carriers characteristic is a hub, home base where the airline connects the passenger flows. (Belobaba 2015, 170.) Major airlines can have up to five hubs while it is more common to have 1-2 hubs located at the center of region they serve. Every hub has a set of cities that it serves, usually referred as spokes. (Bazargan 2010, 31.) This hub-and-spoke network structure can be critical for route profitability. Moreover, the network carriers operate very few flights that carry only local O-D, origin-destination, passengers, not using the wide range of connections. This hub-and-spoke network allows the airline to operate many O-D markets with fewer flight departures which then means less required aircraft resulting to lower operating costs than in complete point-to-point route network. The hub airline's advantage is the possibility to consolidate traffic from several O-D markets on each flight sector into and out of its hub which then allows the airline to

provide connecting service even to low demand O-D markets. It further allows the hub airline to provide more frequencies to connect the multiple banks at its hub airport. From passenger's perspective, multiple connecting departures per day via the hub may be more beneficial than single daily nonstop flight. (Belobaba 2015, 170-171; Holloway 2012, 386.)

The hub-and-spoke network structure has great impact on how the economics of new services are evaluated by the airline. In an established hub network, it becomes easier to justify new routes to smaller spoke cities. (Holloway 2012, 386.) Even if the local O-D market demand too small to operate the route profitably, the new connecting passengers can make a positive contribution to the airline's total network revenue and may even cover up the operating costs of the new service. But the logic is a two-edged sword; it makes more difficult to eliminate a service to an unprofitable destination that provides connecting traffic support to other flights. (Belobaba 2015, 174-175.) Also hub-and-spoke construction requires passengers to fly greater distances between origin and destination, adding more travel time, cost and emissions than point-to-point service. (Holloway 2012, 387-388.)

Figure 3. Finnair's hub-and-spoke model (Adapted Holloway 2012, 409)

Before route planning process is completed the airline needs to decide the vision of its operations, e.g. whether to focus on domestic or long-haul services. Moreover, the route selection decisions are both strategic and tactical. The outcome typically affects the types of products the airline offers to customers, e.g. business class product. In addition, it also impacts the airline's cost structure as longer routes will likely be flown with bigger aircraft to allow lower unit costs per seat and shorter low-demand routes with a small aircraft. As previously stated, the route planning can also be a short-term tactical process as markets might change unexpectedly. For example, the bankruptcy of another airline can lead to

new route opportunities than should be acted upon with months or even weeks. (Belobaba 2015, 175-176.)

3.3 Airline schedule development

It can be argued that airline's schedule is one of the most important indicators of its business strategy and competitive position. Wensween (2015) defines airline scheduling as "the art of designing systemwide flight patterns that provide optimum public service, in both quantity and quality". By choosing which markets to serve at which times, the airline determines how and where to operate and compete. However, these major decisions are limited by various previously discussed practical considerations, such as fleet composition, crew and maintenance availability, airport access and governmental allocations. (Belobaba 2015, 189.)

In principle the airline schedule development is a continuous process, starting more than year in advance of flight departure and it may continue close up until the actual departure time. There might be several unexpected operational constraints than can necessitate schedule and rotation changes and irregular operations planning until the flight departs. Moreover, the overall market volatility creates a challenge as demand might drop due security concerns or terrorist attacks. (Belobaba 2015, 180.) The schedule optimization objective is to identify profit-maximizing schedules that are aligned with airline's operational, marketing and strategic goals (Belobaba 2015, 189). The scheduler will face sometimes conflicting objectives to maximize passenger convenience and revenues while meeting the numerous operational constraints that impacts the convenience. (Belobaba 2015, 181.) Table 1 presents internal and external factors impacting the schedule development.

Table 1. Internal and External factors affecting scheduling (Adapted Wensween 2015, 389)

Internal factors	External factors
• Maintenance requirements • Flight operation requirements • Facility constraints • Marketing factors	• Airport authorities • Public service obligations • Local communities • Travel agents • Air freight shippers

Each aircraft needs a designated maintenance plan and schedule needs to support it. Flight crews need to be trained. Furthermore, the schedule impacts crew need as long-haul flights might require augmented crew or mountainous airports special training. Facilities as gate positions and baggage handling capabilities influence passenger minimum connection time which then determines how schedules are created. External factors as airport curfews, slots, gate availability can add scheduler's headache. The local communities and politicians may have their opinion regarding offered schedules. In leisure business the tour operators and hoteliers influence on the desired schedule. (Wensween 2015, 388-389.)

The convenience of air travel for passengers can be improved by increasing the frequencies on a route. In addition, the increased frequency can stimulate the demand and thus result with increased revenues and market share. More frequent departures reduce the passenger wait time between the flights, reducing the travel inconvenience for passengers. The most attractive departure times are early morning and late afternoon, suited for time-sensitive business traveler's needs. (Belobaba 2015, 181.) However, not all departures can be at these attractive hours as it requires a massive amount of aircraft. When establishing a schedule of flight departures, the scheduler meets the challenge of maximizing the aircraft utilization and schedule convenience for passengers. In practice, the timetable must sustain for example sufficient turnaround time to enplane and deplane passengers, refuel and clean the aircraft. That time varies between the aircraft types and characteristics of the flights involved. Moreover, the earliest feasible departure time for the following flight on the same aircraft might not be desirable in terms of schedule quality. Most airlines choose to maximize aircraft utilization and keep ground times to a minimum,

resulting in off-peak flights with relatively low load factors. The approach allows airline to position aircraft for peak flights to other cities but leaves little buffer for maintenance and weather delays. Moreover, the approach is a trade-off between maximizing expensive aircraft resources and reduced airline profitability caused by unprofitable off-peak flying. The hub-and-spoke network leaves little room the schedule departures from spokes to hub if the flights are expected to serve both local and connecting passengers. (Belobaba 2015, 182-183; Wensween 2015, 398.)

The complexity of airline's schedule development problem makes most schedule changes incremental. Moreover, only a single change in departure time can have major impacts to passenger connections, aircraft rotations and even to fleet planning. The problem is further constrained by limited airport slots and crew and maintenance constraints, requiring close coordination between all internal and external stakeholders. Every airline schedule can be viewed as separate product with its own market and even minor schedule change can have an impact on the market situation. Furthermore, as the airline schedule has high number of dependencies, like routes sharing an aircraft, a change to the morning rotation can trigger change requirements for evening rotations. (Belobaba 2015, 183; Wensween 2015, 405.)

4 Aviation impact on climate and eco-efficiency actions

This chapter looks the topic from climate's viewpoint and discusses the most important emissions and the mechanisms how these emissions affect the climate.

4.1 The environment impact of flying

When flying aircraft emit chemical species and produce physical effects that have an impact on climate. It is widely recognized that the greenhouse gas "Carbon dioxide" causes increase in global temperatures. These CO2 emissions may stay in the atmosphere for 500 years and affect the climate. In addition, contrails are formed when warm air in an aircraft's engine mixes with cold air in the atmosphere. Contrails can be considered as thin clouds and thus they have warming effect as they reduce the amount energy that is radiated from the earth into space. They can also contribute in formatting more dense clouds, cirrus clouds. However, the long-term effect of contrails is difficult to estimate as their lifetime is rather short. (Belobaba 2015, 449-450.)

The impact of a single flight can be summarized as follows. Locally the most visible short-term impact are contrails and aviation-induced cirrus effect. It is followed by warming impact of ozone changes. In a global level and over a timescale of years, the reduced methane has a cooling impact. From decades to centuries there is a warming effect as carbon dioxide remains in the atmosphere. It is still subject to scientific studies what is the net effect of all these impacts on the climate. (Belobaba 2015, 451.)

It is challenging to institute effective technological and operational controls for emissions as the scientists are uncertain regarding the impacts of aviation on climate. However, the aviation greenhouse gas emissions have continued to increase. The European Commission has established a greenhouse gas emissions trading scheme across many major industries, including aviation. This ETS scheme is designed so that it places an overall cap on emissions, under which airlines are able to trade emission allowances. If the quota is exceeded, the airline needs to buy additional allowances. (Belobaba 2015, 452-453.) In more global level, in late 2016 ICAO implemented a global market-base measure – Carbon Offset and Reduction Scheme for International Aviation (CORSIA). It aims to stabilize emissions at 2020 levels by mandating all air carriers to offset their emissions exceeding this level. This measure begins with a pilot phase in 2021 and is voluntary until 2026 and mandatory afterwards. Finland will join the scheme in 2021. (ICAO 2019a) As aviation is a long life-cycle industry it can be challenging to implement and diffuse new technologies. Moreover, it can take 10 years from drawing board to first

flight and then the model is manufactured for around 20 years with each aircraft having typical lifespan of 25-40 years. One of the retirement options for older passenger aircraft is to convert them into freight aircraft which then slows down the revolution of newer greener technologies. (McKinnon, Brown, Piecyk & Whitening 2015, 180.)

According to International Energy Agency, IEA, the transportation sector is globally the second largest producer of CO2 emissions. The sector's CO2 emissions has been growing by 68% from 1990 to 2015. The increase was led by emissions from road sector but the most significant growth in emission rates were capped by marine +77% and aviation +105%. (IEA 2017)

In 2017 civil aviation contributed total 859 million tonnes of CO2 and is account for 2% of global man-made greenhouse gas emissions (IATA 2019). In European Union the direct emissions from aviation accounts for 3% of EU's total CO2 emissions. Furthermore, in 2020 global aviation emissions are projected to be roughly 70% higher than the emissions in 2005 and ICAO has forecasted that by 2050 the greenhouse gas emissions could grow by further 300-700%. In comparison, if global aviation was a country, it would be in top 10 emitters. (EU 2019) Aviation sector is constantly developing tools and methods to reduce its emissions, but one solution presented is a modal shift to more sustainable transport modes (Europarl 2018).

4.2 The environment impact of airports

The most imminent environmental impact is the aircraft noise. Although the noise levels of aircraft have been declining due to new technology, the public tolerance to the noise has diminished as well. To overcome this issue local regions together with airport management have applied noise zoning methods. It is a noise buffer around the airport where the construction of new houses is not allowed. It presents a challenge how to efficiently use the land if noise-sensitive buildings are not allowed. (Graham 2014, 287-288.)

The emissions from aircraft impact the air quality and many airports monitor the air quality in the area. An increasing number of airports also monitor water quality as chemicals from de-icing fluids and ones used in maintenance can pollute the water. Moreover, the modern airports are also executing efficient waste recycling schemes and energy management. There is also a need to consider the local wildlife, heritage and landscape. (Graham 2014, 288-296.) For example, in New York JFK airport the operations are every year impacted by local tortoise community (CNN 2011).

4.3 Finding eco-efficiency and reducing emissions

The widespread concept of eco-efficiency aims at linking together economic performance with its environmental impact. Its purpose is to identify and implement activities that enable more economically efficient and cleaner productions. (Wursthorn, Poganietz & Schebek 2010, 488.) Eco-efficiency improvements can vary significantly. One fundamental of eco-efficiency actions is the adoption of better practices and technology. These are usually “win-win” initiatives as the company can reduce costs and impact on environment simultaneously. Other cornerstone of eco-efficiency action is the development of new practices and technology. Furthermore, by reacting to changing market conditions companies can increase their eco-efficiency. For example, increased competition could incentive finding more eco-efficient technology and practices. (OECD 2008, 17.)

There are various approaches that aviation has already taken and is currently studying to increase the eco-efficiency. Airlines focus on weight as any extra weight decreases the fuel efficiency. One solution was to replace heavy operating manuals with electronic flight bag generating simple fuel savings. More wilder idea is air-to-air refueling that would generate fuel savings of 30-50%. Eco-efficiency methods are used on airline operations daily as flight routes and cruise altitudes are optimized to be as fuel consumption favorable as possible. (Grewe & Linke 2017, 690-691.)

The length of the flight sector has an impact on the amount of emissions created and the overall environmental impact. Generally, airplanes emit the most during energy-intense departure and arrival phase while in cruise the engines run steadily and do not consume much fuel. The new generation Airbus 350 aircraft consumes 2.9 liters of fuel per passengers per 100 kilometers. The overall consumption per passengers is the lowest on a flight sector of 8000 kilometer. After 10 000 kilometers the consumption per passenger begins to rise and in ultra long-haul flights of 14 000 kilometer the consumption curve takes a sharp upward turn. The root cause for this behavior is the payload reduction as aircrafts cannot carry as much weight in longer sectors due to maximum take-off weight restrictions. The payload is reduced by placing less seats into the aircraft and thus the consumption per passenger is far greater. But also, short flights consume great amount of fuel per passenger since the needed amount of fuel correlates with the amount of reserves. Furthermore, short flights are operated with smaller airplanes with less seats making the consumption per passenger figure high. (YLE 2019a; Burzlaff 2017) The fuel consumption curves are shown in figures 4 and 5.

Figure 4. A320 fuel consumption (Burzlaff 2017)

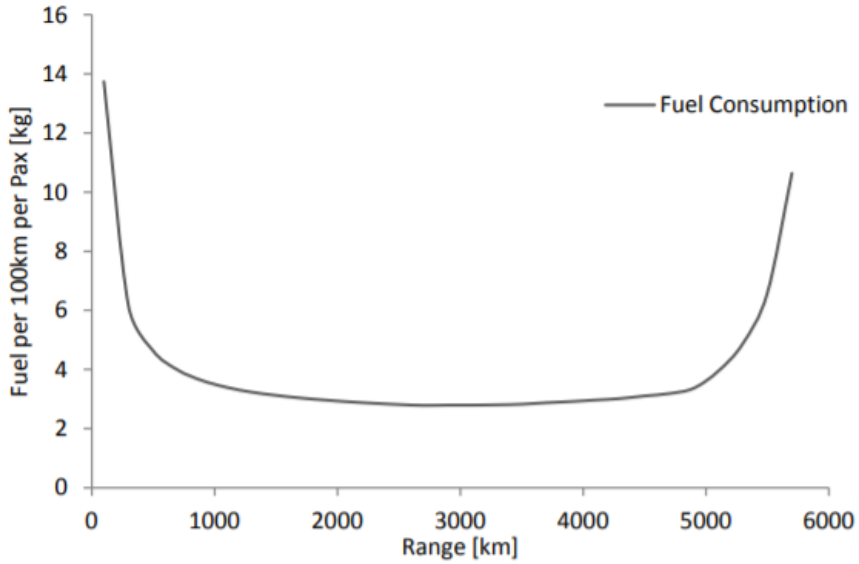
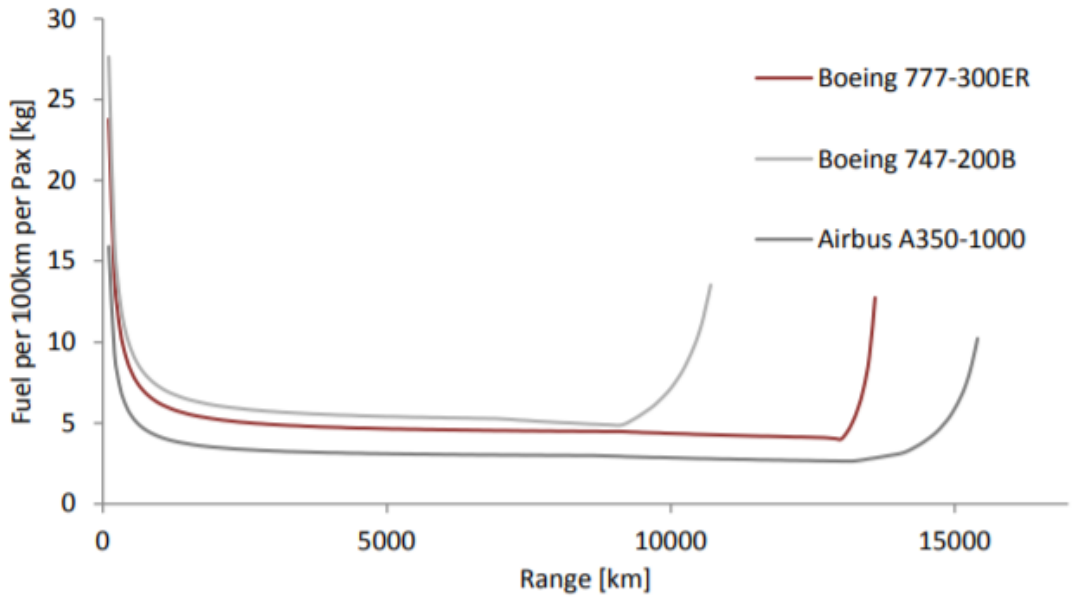


Figure 4. and 5. show that both narrowbody and widebody aircraft have the same behavior of having greater consumption per passenger in ultra-short and ultra-long sectors.

Figure 5. Fuel consumption between wide-body aircrafts (Burzlaff 2017)



According to Air Transport Action Group, the flights over 1500km produces 80% of all aviation CO2 emissions. For these sectors there are no practical alternative mode of transport. (ATAG 2019) Babikian, Lukachko & Waitz (2002) argues that usage of turboprop aircrafts instead of jets on shorter routes can result in significant emission

reduction due to turboprops' capability to operate more efficiently than jets. This notion is supported by comparison of turboprop and jet emissions in similar route in table 4.

The ultra long-haul market has grown in recent years mainly due to new developed aircraft capable of operating long routes economically. Not having to stop can save time, fuel and money but only with a correct aircraft type. Payload reduction will impact the revenues as there are less seats to sell. Direct ultra long-haul flights would also ease the congestion at hubs and reduce the total flight distance if the hub is not geographically well positioned. (Burzlaff 2017) Currently the longest non-stop flight is Singapore Airlines service from Singapore to Newark USA with almost 19 hours of scheduled flight time. The route is operated with Airbus 350-900 ultra long range – model with only 161 seats. Finnair's equivalent A350 can carry up to 336 passengers. Currently the aircraft manufacturers are working to provide an aircraft that could operate non-stop with full payload from Sydney to London. (BBC 2018)

As aircraft technology and operational environment improves, ICAO has suggested that the average fuel efficiency will increase by 0.57-1.50 per cent per annum up to 2050 (McKinnon et al. 2015, 180). McKinnon (2015) suggests that there are three main sources for fuel efficiency improvements; airframe efficiency, engine technology and air traffic management. The airframe of the aircraft determines the aerodynamic efficiency and the weight of the aircraft. In addition, newer aircraft have more composite materials and state-of-the-art aerodynamic design which immediately increase the fuel efficiency. Older aircraft have been retrofitted with winglets which reduces fuel consumption. Another important technological development is newer engine models as new generation engines are more fuel efficient than their predecessors. The initiatives to improve air traffic management target to have more direct flight routes, resulting in less accumulated nautical miles and thus less CO2 emissions. The challenge is that some optimal routes cross war zones or political tensions don't allow airline to cross certain airspaces and airlines are the forced to fly longer detours. (McKinnon et al. 2015, 181-182.)

To decarbonize aviation, one cannot use similar solutions than for land-based transportation modes. Using renewal or nuclear power is not feasible option for aviation. Moreover, the aviation power source needs to have very high ratio of energy to weight. The traditional kerosene is still holding its position as the energy density of batteries is not yet close to that. Several airlines have made trial flights using alternative fuels, some even completely powering engines with certified biofuel. However, the wider commercialization of biofuels is being constrained by high production costs, limited availability and lack of political support for aviation biofuels. There are also concerns regarding the net life-cycle

carbon savings of biofuels and wider environmental effects of switching to biofuels. (McKinnon et al. 2015, 182-183.)

4.4 Ecolabel for flights

For organization there are several different methods to document and report on their sustainability activities. One of the most visible examples is to obtain an ecolabel which could be defined as a sustainability certificate. UN (2020) defines ecolabels as “a means of measuring performance and also communicating and marketing the environmental credentials of a given product”. In addition, ecolabels could be seen as tool for performance management, as they require certain adherence to given measures and limits.

Baumeister & Onkila (2017) explored how an ecolabel could be developed for aviation industry to be a trigger for behavioral change. The purpose of ecolabels is to inform consumers about more sustainable consumption decisions and also act as a reminder to consider environmental issues. The first aircraft ecolabeling scheme was introduced by Flybe in 2007 which then created movement to develop a common ecolabel scheme for the aviation industry. However, despite the efforts no industry-wide standard currently exists. The findings of the study show a need for an ecolabel in the airline industry as consumers are currently unable to compare flights environmentally. Moreover, the findings underlined the challenge of finding the right actor to drive such scheme forward.

Baumaister & Onkila suggest five criteria for airline ecolabel development:

- Credibility: Ecolabel should be globally recognized and include all greenhouse gasses
- Comparability: Ecolabel should support consumer in decision making and be flight specific
- Clarity: Multiple ecolabel schemes should be avoided not to generate confusion and ignorance
- Transparency: Objectives should be transparently communicated
- Participation: Multiple stakeholder participation encouraged but finding a common industry approach might be difficult.

A very recent thesis (Kusiak 2020) was researching if Finnish travelers appreciate ecolabels. The results showed that ecolabels are regarded as beneficial by accommodation providers as they give directions towards more sustainable operation and guide decision making. However, the research also noted that Finnish travelers did value sustainability efforts and actions but ecolabels by themselves were not affecting their buying decisions.

German non-profit organization “atmosfair” publishes annually a report ranking the 200 largest airlines of the world by their carbon efficiency. The objective is to make climate efficiency a factor of competition among the airlines. Atmosfair has created a formula that uses the characteristics of the aircraft such as engines, winglets, seating capacity as well as both passenger and cargo load factors. The results show, as previously mentioned, that CO2 emissions per passenger and kilometer are always higher on short distance flights due to energy-intensive take-off and climb. Furthermore, atmosfair data shows that airlines can optimize their CO2-efficiency. The greatest effect is on optimizing the passenger occupancy followed by the type of aircraft used. (Atmosfair 2018) In reality it means increasing the load factor and avoiding empty seats as much as possible.

4.5 Multimodality studies

In transportation sector multimodal transport signify the use of different modes or means of transport on the same journey. Multimodality is driven by the trend of digitalization and applies to both passenger and freight traffic. The concept aims to take advantage of the strengths of the various modes to improve the efficiency of transportation for people and goods. This integrated transport system should deliver both eco-efficiencies and cost-efficiencies. (EC 2020.)

Recent studies in Europe argue that high-speed trains can compete with air transport but disagree on the range where it’s the most effective. Janic (1993), Rothengatter (2011) and Steer Davies Gleave (2004) all show evidence that the competition from high-speed trains is the strongest at distances of 400-800km. SDG also argues that high-speed trains offer little benefit for journeys less than 150-200km and longer than 800-1000km. Dalla Chiara et al. (2017) argues that if the route length is increased the energy efficiency of high-speed trains compared to air transport diminishes whereas the aircraft speed makes the real difference. Moreover, in longer routes more expensive track infrastructure is needed that air transport doesn’t need.

Behrens & Pels (2012) investigated multimodal competition in UK and found out that the main determinants of travelers’ choice are frequency, total travel time and distance to UK port. Furthermore, business and leisure travelers behave differently. Their analysis on the London-Paris market shows that longer travel times of high-speed trains compared to air transport can be offset by frequency and fares to attract both business and leisure travelers.

D’Alfonso et al. (2016) argue that it is not straightforward to say that new high-speed train is beneficial for the environment. Moreover, it depends on the environmental friendliness of the locomotive – electric trains produce less C02 emissions than diesel trains. Also different operation conditions, like number of stops and need for energy-intensive acceleration all play a role. The real difference in emissions between high-speed trains and aircraft depend on the scope of mitigation strategies available for both modes and on the policy measures for emission reduction. D’Alfonso concludes that introduction of high-speed train may be detrimental to the environment as it will not only substitute air traffic but generate new traffic demand and the greenness of high-speed trains depends heavily on the mix of energy sources used to generate the electricity. This notion is also supported by Preston (2013) who argues that 25% of the high-speed train demand is generated directly while the remaining is abstracted from rail transport, air transport and road transport.

Dalla Chiara et al. (2017) suggests that close integration between high-speed rail stations and airports would be profitable as the competition decreases the energy efficiency of long-distance travelling. Furthermore, it would enable a well performing and sustainable transportation chains.

5 Finland: the current and future state of main transportation modes

This chapter discusses the current state and future development plans of transportation sector in Finland. In table 2 the four different transportation modes are compared. Travelling by own car is the most popular method of transportation. Also notable is the relative low load factors in domestic long-distance coaches and trains. Especially trains are well supported by the government which could result domestic air transportation being the most efficient mode of transport.

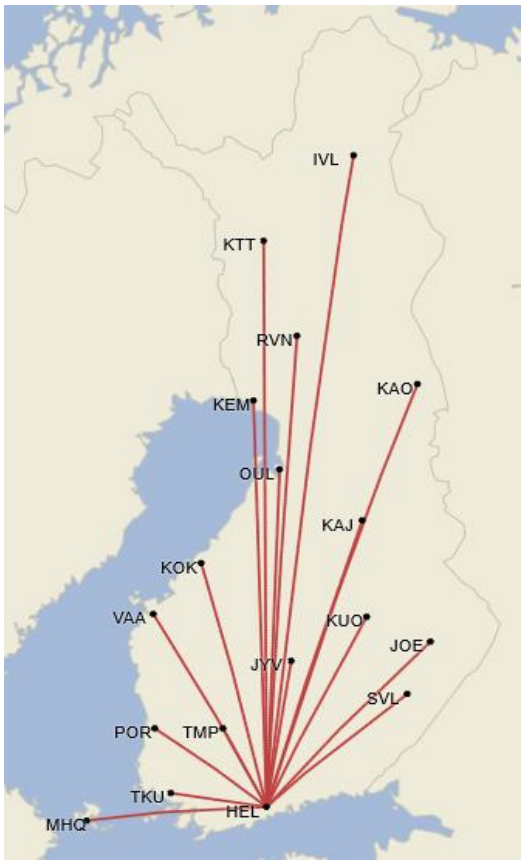
Table 2. Transportation modes (Väylä 2015)

	Car	Coach	Train	Air
Market share per passenger kilometer	84%	6.5%	5.7%	1.7%
Load factor		19%	33%	62%
Number of passengers in millions		6.8	13.6	2.4
Public funding, millions EUR		6.0	37.4	3.4
Public funding, cent per passenger kilometer		1.0	1.2	0.3

According to recent study the cities of Helsinki, Tampere and Turku are growing fast which will result in increased commuting between the cities. These three cities hold a powerful catchment area with 54 per cent of whole Finland's population. (Ramboll 2018.)

5.1 Domestic airport network

Finavia operates 21 civil airports in Finland with the biggest in passenger numbers being Helsinki Airport (Finavia 2018). The primary catchment area of Uusimaa region has 30% of all Finland's population (Stat 2018). As a major international hub Helsinki Airport has global connections as well as connections to 17 domestic airports.

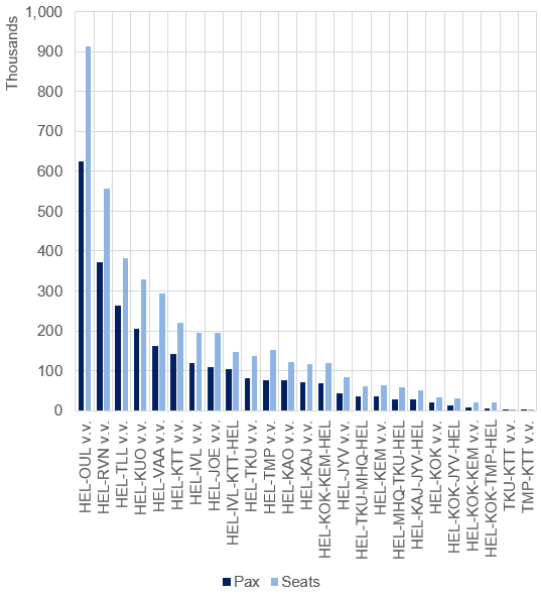


Picture 2. Helsinki-Domestic flight connections 2019 (Adapted from internal data)

The attention in this thesis is in the closest airports near Helsinki, meaning Tampere and Turku airports. The airports in Savonlinna and Pori are excluded as they are not served by Finnair. The next set of airports roughly 500km from Helsinki (Joensuu, Vaasa, Kokkola, Kuopio, Jyväskylä) have recently been impacted by the climate change discussion while they fight for their survival. Recent study showed that many companies have decreased their number of flight trips due to the climate change discussion. If this trend continues the local communities and airport managements will face pressure to keep their airport open and justify the need for air connection. (Yle 2020a.) The development of Tampere and Turku airport will have an impact on the rest of the airport network.

In 2018 (table 3) most passenger travelled between Helsinki and Oulu where also the most seats were offered. The second place goes to Helsinki and Rovaniemi and third to Helsinki and Kuopio -route. Every domestic route had more capacity than travelers meaning that the overall load factors are relatively low. Out of the top 3, both HEL-OUL and HEL-RVN are served by both Finnair and Norwegian.

Table 3. Passengers and capacity in 2018 (Adapted from internal data)

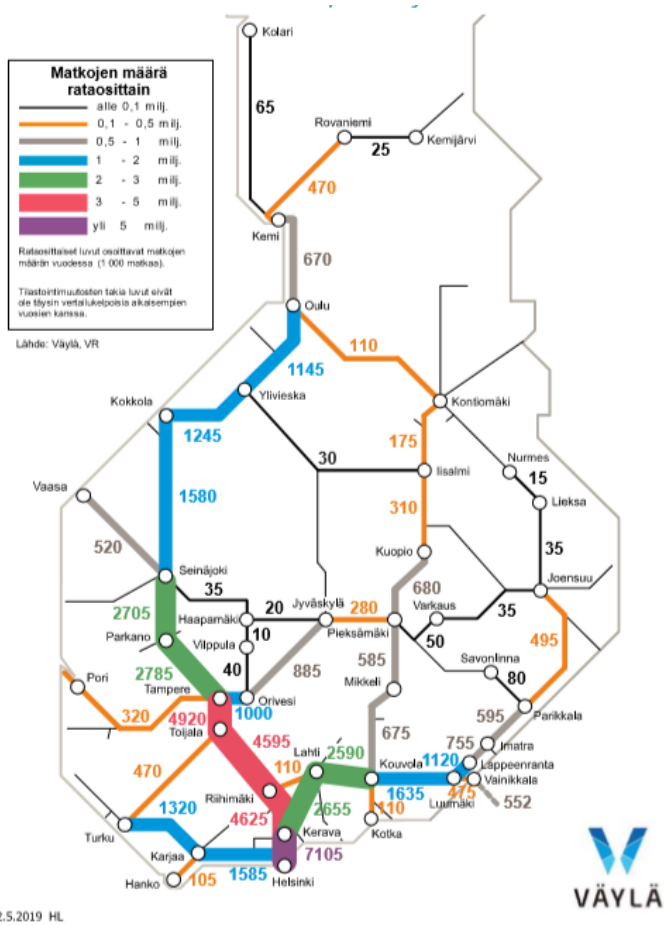


Both Turku and Tampere airport are served by several carriers. Moreover, TKU airport market leader is currently WizzAir operating to several destinations in Poland. Tampere Airport has a reputation of low-cost carrier airport but also network carriers as Air Baltic and SAS operate daily flights. The privately own airport of Lappeenranta has been able to increase the presence of low-cost carriers in short time.

Picture 3. Southern Finland airports flight connections to Europe in summer 2019 (Adapted from internal data)

5.2 Domestic rail network

The length of Finland's rail tracks is nearly 6000km. It is mostly single-corridor tracks, only few tracks in the South of Finland are twin-corridor tracks. The top speed on passenger trains are 220 km/h and the regular operating speed is around 140-160km/h as only few tracks can be operated with maximum speed. Out of 16 city pairs presented in picture 3, 12 are connected also with rail. Only Lapland cities Kuusamo, Ivalo and Kittilä and the capital of Åland, Mariehamn are not connected with Helsinki on rail tracks. The average travel time on routes that are also served by air transportation, example Helsinki-Kuopio is about four hours. This would be reduced by 30 minutes if the proposed track developments are completed. In comparison the average flight time on Helsinki-Kuopio route is less than one hour. The Helsinki Airport has currently no long-distance rail tracks, only regional train connection to Helsinki city center via the Ring line. In addition, the airport train stops in Tikkurila and Pasila which are connected to the long-distance rail tracks. (Väylä 2018.)



Picture 4. Map of Finland's rail track network (Väylä 2019)

The ministry of transportation expects that number of passengers are increasing and the most significant growth between Helsinki and Lappenranta. In 2018 long-distance

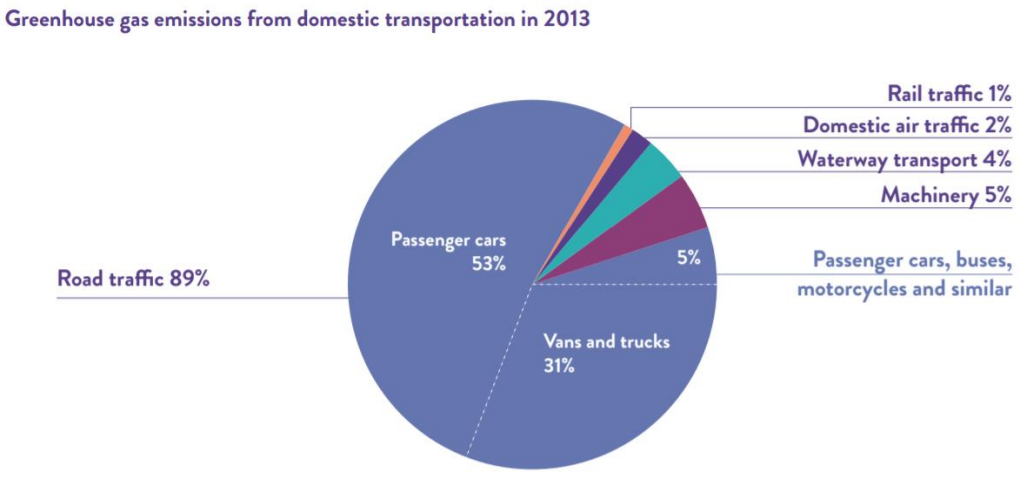
passenger train trips totaled to 13.5 million trips and the most served city pairs being Helsinki-Tampere, Helsinki-Turku and Helsinki-Jyväskylä. (Väylä 2019.)

The Finnish ministry of Transportation has identified three paths for rail network development. “One-hour train to Turku”, a high-speed rail link between Helsinki and Turku, estimated to be constructed in 10-years’ time. “Finland track”, high-speed rail link between Helsinki and Tampere cutting the travel time to 1 hour. In addition, the plan includes possibility to enable direct rail connection from provinces and from Russia to the Helsinki Airport. Third path is “East train”, a faster train connection from Helsinki to the cities near the eastern border. (LVM 2019.)

Another relevant future development plan is Rail Baltica project which aims to build electric train network through the Baltic countries. The cities of Helsinki and Tallinn and the Ministries of Transport of both countries are preparing an extension to Rail Baltica by building a tunnel connection Helsinki and Tallinn. The expected tunnel completion date is the year of 2024 and would then allow passengers to reach cities in 30 minutes. (Railbaltica 2017.)

5.3 Domestic transportation emissions

Domestic transportation accumulated 28% of all Finland’s CO2-emissions. The biggest emitter being road transportation with 10.7 Mt, trains 0,06Mt and air transport 0,2Mt. However, only 5% of total road transportation emissions is produced by coaches. Emissions generated by waterway transportation has increased where the biggest emitters are international traffic in Finnish waters. (Liikennefakta 2019.)



Picture 5. Greenhouse gas emissions 2013 (Ilmasto-opas 2015)

The Finnish Government has announced that the country will be carbon neutral by 2035. Moreover, Finland is committed to reduce greenhouse gas emissions by 50 per cent by the end of 2030 compared to the emissions level on year 2005. The aimed reduction is aligned with European Union commitment. (LVM 2019.)

As discussed previously, short-haul flying has greater emission impact as the energy-intensive departure cannot be divided by greater miles, like with long-haul flying. Furthermore, depending on the calculation method the level of emissions in domestic flying can twice as much as with long-haul flying (YLE 2018). Baumeister (2019) showed that long domestic flights from Lapland to Helsinki generate significantly more C02 emissions per passenger than flights between Southern Finland. Recent internal studies support this notion and show that for domestic air transportation the choice of aircraft type has clear impact on the emissions created. The turboprop aircraft is much eco-friendlier than the small jet aircraft on the same route.

Table 4. Comparison of CO2 emissions on HEL-JOE route (Adapted from internal data)

Leg	**DISTANCE**	**AC TYPE**	**CO2, kg per passenger**
HEL-JOE	360	ATR	46,7
HEL-JOE	360	E90	83,8
JOE-HEL	360	ATR	58,1
JOE-HEL	360	E90	99,0
Roundtrip		*ATR*	*104,8*
		E90	*182,8*
		diff	*174,4 %*

5.4 National strategy on transport development

The Finnish ministry of transportation is currently preparing a national transport system plan for the upcoming years 2021-2032. The plan will include measures and actions for the next 12 years for state and municipalities on how the transport network will be constructed and maintained, and what type of transport and mobility services will be purchased. Moreover, the National Transport System plan is aiding Finland reaching its goal of reducing transport emissions by 50 per cent by 2030. The draft plan will be completed during autumn 2020 and be approved by the Government spring 2021. In March 2020 the parliamentary steering group outlined three key targets which then acts as a base for the action programme. The targets include to improve opportunities to

choose more sustainable modes of mobility, ensuring accessibility of the whole of Finland and businesses needs are covered and thirdly to improve the socioeconomic efficiency of the transport system. (LVM 2019.)

Another project launched by the current Finnish government is to produce a road map for fossil-free transportation sector. The project's aim is to present the measures how the CO2 emissions generated by domestic traffic will be halved by 2030 and how transportation sector is transformed into fossil-free by 2045. The working group will evaluate how to minimize emissions, develop biofuel accessibility and generate metrics to support further decision-making. The actions targeted to reduce emissions will also include international traffic which takes place in Finland. (Valtioneuvosto 2019.)

The Finnish Ministry of Finance has established a working party to develop the taxation related to transportation sector. The aim is to evaluate how current taxation system supports climate goals and how to guide towards more sustainable decisions. (Valtionvarainministeriö 2019.)

Furthermore, in road transportation the number of electric busses are increasing as cities require bus companies to comply with new standards. For example, Helsinki region aims to have 400 electric bus by 2025. The busses run with power from renewable energy sources and have the range of 300km with single charge. (HSL 2019.)

5.5 Regional climate strategies

The region of Tampere has created a climate strategy for 2030 where it aims to reduce emissions per inhabitant by 40% in 2030 from 1990 levels. The strategy outlines targets for different sectors, including transportation sector where the focus should be creating more efficient public transport and support more emission-free moving such as bicycling and walking. (Tampereenseutu 2020.)

The region of Turku aims to be carbon neutral by 2029. The climate strategy was put in place in 2018 and also outlines targets for various sectors. For transportation sector the aim is to increase public transport and support pedestrian activities. City's inner public transportation shall be emission-free by 2025 and overall public transportation by 2029. (Turku 2020.)

The city of Vantaa is committed to become carbon neutral city by 2030. Moreover, the city has agreed to reduce CO2-emissions by 80% from 1990 level and compensate remaining

emissions. The strategy includes targets for different sectors with a great emphasis on new construction. For transportation sector the major steps are actions to reduce private motoring, increase the efficiency of public transportation and support pedestrian activities. The report states that aviation emissions are not calculated to the city total, but the emissions created by the airport are calculated. (Vantaa 2020.)

6 The research process

This chapter presents the chosen research method and argues the benefits of the chosen method. After designing the key research questions, it became evident that research will be qualitative. It allows more profound and holistic angle to the research than quantitative research method. In addition, interviews were chosen as key data collection method as the topic requires subject expertise.

6.1 Research method

The research was conducted as a case study. According to Woodside (2016) case study research is “an inquiry that focuses on describing, understanding, prediction and/or controlling the individual”. In a case study the subject of the research can be an organization or one department of an organization, a product, service or a process. The case study aims provide detailed and comprehensive information of a recent phenomenon in its own environment or field. A case study often tries to answer questions like “how?” or “why?”, and to provide new information that is a base to development. Moreover, when the objective is to fully understand an organization’s functions or a certain type of behavior among the employees, or to improve something, the case study is a suitable approach. (Ojasalo, Moilanen & Ritalahti 2014, 52-53.) This approach was chosen, because the aim of the project was to understand what the current level of eco-efficiency in the Finnish domestic transportation sector, especially relating to ultra short-haul flying, and how the phenomenon is perceived in both airlines and airports. In a case study approach, a phenomenon could be investigated in several organizations, for example, but it is essential that the subject of the research is understood as one case (Ojasalo et al. 2014, 53). In this research it can be viewed as although there are several organizations that have been interviewed for this research, they all present the same industry and phenomenon that the industry is experiencing.

Case study is typically considered as a qualitative research method, but it can contain elements from quantitative data collection methods, such as surveys. Combining both quantitative and qualitative data collection methods, like interviews, surveys, focus group interviews, observation or benchmarking, can provide a more comprehensive result and understanding of the case. (Ojasalo et al. 2014, 55.) However, in this research it was a conscious decision to solely exploit qualitative research methods, because it was evident that the information was needed from a limited sample. Typically, before starting the project and defining the research problem, the researcher has some previous knowledge or understanding about the case or phenomenon. Moreover, some orientation to the

subject is needed before being able to understand what to research and what kind of questions can be asked. (Ojasalo et al. 2014, 54.)

6.2 Data collection

The goal in qualitative research is to gain comprehensive understanding of a phenomenon (Ojasalo et al. 2014, 105). An interview is a suitable choice for a data collection method, when the topic of the research is relatively new or has not yet been thoroughly researched. An interview offers the possibility to repeat or clarify the question if needed, and to have a conversation about the topic with the interviewee (Tuomi & Sarajärvi 2009, 73). In this research, an interview was chosen for a data collection method, as there were limited number of organizations to collect data from. An interview was also considered more effective method than a survey, for example, because it was important that the topics could be discussed and explained in person in case of misunderstandings. The chosen method was half-structured interview, which means that the interview proceeds according to specified themes and theme-related questions. Interview themes and main questions were kept same for all participants, but some more specific questions were modified to suit better to the expertise of the interviewee. In semi structured interview, the aim is to seek answers to the list of topics, and also additional questions could be asked vice versa. (Saunders & Lewis 2018, 158-159.)

The interviews are recorded, when the participants allow it, and notes are written during the interview. The recordings are transcribed, meaning that a text version is written from the answers of the participants. As the event is better in the interviewer's memory directly after, it is best to transcribe as soon as possible. Therefore, the best practice is to transcribe the interviews directly after. (Saunders & Lewis 2018, 162, 182-183.)

During this research various online interviewing methods were used. Online interviewing is possible to organize as a face-to-face meeting with various online tools as Skype and Teams. It allows exchange of questions and answer directly. In addition, online interviews can be organized in an asynchronous form. This method allows researcher to send questions to the participants and they send their answers back after some time, often conducted via email. In online interviewing the researcher needs to carefully prepare the instruction in written form, and they need to be as detailed as possible so that the participant can easily follow. (Flick 2009, 266-267.) As interviews were conducted during the period of March-June 2020 when COVID-19 related restrictions were firmly in place, the author needed to use more online interviewing methods than originally expected.

Moreover, the related temporary layoffs throughout the industry and certain political aspects related to domestic network created challenges and delays to data gathering.

As the research topic is rather current, special focus was put into finding the most relevant, up-to-date and credible data sources. Thus, various online articles, publications, news and press releases were exploited. Governmental publications and company's own databases and analyzers were used to gather statistics and to illustrate the current state of the matter. In addition, literature was used to create the framework for bigger entireties such as airline planning process and sustainability. The chosen literature is written by university professors and recognized aviation professionals worldwide and is used in various air transport specific curriculums. The limitation of the literature is that it lacks recent development. As the topic of the study is current, the author's aim was to combine literature with newest scientific articles and statistics. Furthermore, as study focuses on domestic Finland there are little literature available but plenty of scientific articles and governmental publications. The number of scientific articles and other publications underline the importance and constantly developing nature of the research topic.

7 Analysis of the data and findings

The interviews were conducted during spring and summer 2020. The participants include aviation and transportation sector professionals, sustainability experts and members of local organizations. Furthermore, one participant is based in the Netherlands giving international view to the topic. The researcher contacted 15 possible interviewees and was able to gather 9 interviews.

The interviews were divided into three themes deriving from the four main research questions. Moreover, questions regarding domestic public transportation and consumer behavior were grouped together. The full set of questions is found in attachment 1. Each category included common questions to all participants and specific questions to better suit the expertise of the interviewee. The interviews were mostly conducted in Finnish, except one which was conducted in English. Moreover, the author has translated the responses into English and tried to maintain the message as original as possible.

The first set of questions was aimed to find out respective companies/organization's eco-efficiency actions and if those actions are part of their strategy and daily operations. In addition, the questions served as an introduction to the topic and allowed participants to discuss about their own actions and environmental milestones. The main research question is: "What types of eco-efficiency actions your company/organization exercises in your daily operation?".

The second set of questions were all relating to domestic transportation. In this research domestic means mostly the transportation inside Finland but as one interview was outside Finland, domestic transportation meant the transportation inside responders' home country. The questions were set to find out how the responders would improve the eco-efficiency of domestic transportation. Moreover, questions were applied with theory presented earlier in the research, seeking expert's opinion's how these theories work in practice. The main research questions were: "How to develop domestic public transportation towards carbon neutrality?" and "How consumers can evaluate which mode of transport is most eco-efficient?".

The third and last set of questions were related to multimodal travel chains. The questions were examining the possibilities of increasing travel chains in domestic Finland transportation and whether alternative transport modes could replace the traditional ones. The main research question was: "What would be needed for Finland to have an effective multimodal transportation service?".

The responses are coded to maintain full anonymity. The responders working in an airline are coded as A1, A2, A3, while others working in various companies/organizations are coded as B1, B2, B3, B4, B5 and B6. Table 5 summarizes the results by research question and by responder type and highlights the theory base of each research question.

Table 5. Result matrix.

Research question	Theory	A results	B results
Q1. What types of eco-efficiency actions your company/organization exercises in your daily operations?	Chapter 4	Essential part of strategy and actions are visible throughout the organization. Adding resources to be truly responsible not only obedient	Essential part of strategy and actions are visible throughout the organizations. Investments to fleet renewals and staff training
Q2. How to develop domestic public transportation towards carbon neutrality?	Chapters 3 and 4	Efficient operations with right-sized aircraft type. Changes in legislation and mind-set.	Enhancing co-operation, evaluate if multimodality options for ultra-short haul flights are more sustainable or not. The price of biofuels is too high, and consumers are not yet willing to pay extra to cover the difference.
Q3. How consumers can evaluate which mode of transport is most eco-efficient?	Chapters 4 and 5	No definite tool for comparison. Company clients and individual clients have different requirements; companies require a proof of carbon compensated air travel whereas individuals want to do the decision by themselves. Some companies have created their own eco-rankings to guide their staff travels.	Currently consumers need to rely on company's declaration. Ideally the most eco-efficient options should be the cheapest as well. An unbiased standard or certificate should be developed, and companies could then apply for it.
Q4. What would be needed for Finland to have an effective multimodal transportation service?	Chapters 4 and 5	Focus on bigger passenger flows. Current rail network is not matching the needs. Busses are good alternative, but the service should feel like being onboard aircraft and be as seamless as possible. Concerned that passengers take competitor's air service instead and fly via Stockholm, Riga etc.	Rail network should run via Helsinki airport. Multimodality includes questions of liability which need to be agreed. Revenue share between operators should be fair and encourage operators to find multimodal options.

The research has not full validity as the respondents were selected based on their subject matter expertise, some through the professional network of the researcher. The

responses are not representing whole Finland but only a limited sample of professionals working close to the topic. However, the limiting the sample for subject matter experts allows the researcher to measure the concepts that researcher attempts to measure and thus increases the validity of the research. The researcher believes that this limited sample group with pre-requisites also benefitted the reliability of the study. In addition, the interview questions were trialed beforehand to minimize the risk for misunderstanding or misleading of the concepts. However, the researcher cannot exclude the possibility of misunderstandings as some interviews were conducted via email. The researcher informed participants that he is available for any questions deriving from the interview questions. The research is considered reliable.

7.1 Eco-efficiency actions

All participants responded that conserving the environment is part of their strategy and integrated into their daily routines. Furthermore, all companies and organizations taking part to this study have published environment strategy which outlines the targets and actions, some short-term and some longer-term goals. During the interviews, especially on skype-interviews, the researcher was able to sense proudness from responders working closely with the company's or organizations environment strategy. Examples of eco-efficiency actions varied from coaching drivers to operate economically and maintaining stable cruising speeds, both on ground and at air, to changes to corporate by-laws to enable more leverage to eco-efforts. It is also notable that environment programs are mostly not separate programs running in parallel with other programs but well integrated into all processes and strategy outlines while covering significant entireties and complicated dependencies.

The responders had similar views on how their organization will reach the targets set in the environment program. It was stated to be crucial to be as eco-efficient as possible, meaning burning less fuel and generate fewer emissions as possible. Many responders mentioned biofuels and explained the pros and cons of biofuels compared to fossil fuels. Also energy efficiency throughout the company was highlighted. In addition, there was a consensus within the respondents that co-operation between stakeholders is essential.

One further commonality between responders was that all have been and will be investing money and resources to become more eco-efficient. For example, responders explained how they are partnering with biofuel producers, renewing their fleet to meet eco-standards and supporting renewable energy sources. In addition, different carbon offset programs are being evaluated to find the most suitable one. Employees have received training how to be more sustainable in their work and various metrics have been created to monitor the

development. In addition, an organization has set target to initiate monitoring of carbon footprint generated by their employees' business travel. More effort is needed to bring these to the customer's attention as it soon could be one of the major factors in the decision process.

> *At the moment customers are not ready to pay extra for using biofuels and there is an assumption that we should just buy many times more expensive biofuel. However, we see that change is taking place and company customers are increasingly valuing eco-factors, not just the price. Companies want to act responsibly, and we need to be able to offer that. (A3)*

A responder explained how their company has been in the forefront of changing their fleet to electric-powered and is determined to continue introducing more during this year. Moreover, the change has been throughout in the organization as also company cars have been changed to electric. The responder also highlighted that the company is committed to use renewable energy sources, not just carbon-free sources and is currently investing into wind power as their main energy source. The responder was very proud of their environment strategy and achievements so far.

As previously mentioned, the responders had clear opinions on using biofuels. All stated that the biggest challenges in using biofuels are the scarce availability and thus, high price. Furthermore, one responder stated that currently the market price for biofuel compared to fossil fuel is five times higher. The availability gap results from the lack of suitable raw material. A responder stated that their company would like to use more biofuels, but the price stability is a risk that it's difficult to manage. The pricing mechanism is complicated and for the company it's impossible to predict the price per liter next year. In aviation where the market should be competitive, currently there is only one supplier for bio-jet fuel in Europe. The same goes applies to renewable diesel fuel.

> *The challenge is finding suitable raw material as it cannot generate extra emissions or reduce overall carbon sink capacity. There are alternative raw materials available but cannot be exploited due to legislative difference in various countries. (A1)*

The operators are facing a critical dilemma. They should increasingly reduce emissions to meet Finnish Government 2035 targets of carbon neutrality but currently the use of biofuels will also significantly increase the operating costs. Furthermore, in a highly

competitive landscape, the companies might lose the business if they over-price themselves.

> *In our field the margins are thin so in current operations biofuels are too expensive for us. Besides, there is a price war between several operators, and we must keep our cost base as low as possible in order to keep us in the game. Unfortunately, the customers are not yet willing to pay extra for green operations. (B5)*

The usage of renewable energy sources has been easier to adapt and according to many responders it has been incorporated to environment programs and company's/regions' future strategy. Similarly, with biofuels, the renewable energy sources need still to overcome challenges and a complete change will take decades.

> *For Finland to be completely self-sufficient there needs to be changes in political landscape, meaning government support system and legislation changes. But as important is to get consumers, companies and the entire society to commit using renewable energy source in everyday life and production. (B3)*

The change to electric-powered vehicles requires upgrades to the bus depot infrastructure in order to be able to charge the vehicles properly. This could stress the city's electrical grid. The similar challenge also applies to electric flying where likely both airports on the route pair need to be able to provide charging station. The development of battery technology could solve some of the issues in the future.

7.2 Domestic Finland

The next section of questions was targeted to investigate the current eco-efficiency of domestic transport and expert's views on how to develop it. The more specific questions targeted for aviation sector examined how experts consider theories related to consumer behavior and eco-efficiency, presented in chapters 4.3 and 4.5. Lastly, the challenge of inadequate ecolabel scheme in transportation sector, explained in chapter 4.4, was discussed.

The aviation experts did not consider domestic flying as eco-inefficient. Some responders explained how airlines can flexibly change between different aircraft types in order to

maximize the load factor and minimize the emissions per passenger. Another responder was looking at the bigger picture:

> *The entirety is well managed. Airline, airport and various service providers all have effective environmental programs to cut emissions. (B1)*

A responder stated that domestic flights are necessary in Finland for big and small businesses. As the characteristic of Finland is long distances, flying offers a quick and eco-efficient method of transport between the capital and regions. According the one responder, the critical limit where flying dominant method is above 400km radius or 4-hour travel time from Helsinki.

A responder explained that short flight trips can generate more emissions than longer ones as the energy-intensives takeoff and landing cannot be offset by long cruise-phase. According to the responders the key to keep domestic flying as eco-efficient as possible is to maximize load factor. However, in practice this can be challenging. In Europe loss-making short flight trips have turned into more land-based transport after road and rail connections improved, enabling direct and effective journey:

> *Unfortunately, there are domestic routes where there aren't enough passengers even for the smallest available aircraft type. It means that on these routes the emissions per passenger are higher. (B1)*

All participants had ideas and concrete examples on how to develop domestic transportation towards the target of carbon neutrality. The key words were "technology, legislation and integration". Regarding technological development, the participants had examples of fleet and vehicle investments which are more eco-efficient than their previous models. Moreover, the next generation should be even more eco-efficient, generating less emissions and making the target reachable. Also, more powerful optimizers have helped finding the most efficient routes, be it on ground or in air, and this development is still ongoing. In aviation, moving to Single European Skies should increase efficient route planning, decrease flight times and reduce fuel consumption and emissions. Change to electric-powered transportation is already ongoing in land-based transportation and experts view that it will revolutionize flying in future. Currently in Finland the network of suitable charging stations is thin and according to a responder it should be rapidly increased to same levels as traditional petrol stations. Otherwise electric vehicle owners and operators need to carefully plan their itinerary and route offering.

> *Domestic flight operations can be made more sustainable by switching them to rail or bus, or electric flying, or at least flying on sustainable aviation fuel. Electric flying is still a long way off. Switching to rail or bus requires those modes of transport to be propelled in an environmentally friendly way, and the electricity they use must be generated in a sustainable manner. It also requires better integration between the modes of transport. (B2)*

A responder shared a view that in city traffic the companies who have electric busses are favored when applying for traffic rights as the operating costs are significantly lower than with diesel busses. In longer routes between cities the current range of approximately 300km doesn't allow efficient operation. The infrastructure is not ready, and a responder is calling for expansion of charging station network. A more political shift would be to encourage operators to use second-generation biodiesel with e.g. financial support.

The responders agreed that government cannot demand carbon neutrality without making changes to current legislation. Moreover, examples of legislation denying attempts to take environmental actions were provided. Also changes to taxation are needed to make biofuels more cost-efficient so that companies can invest to them.

> *We invested significant amount of money and resources to create a system for customers to offset their emissions generated by travelling. It was popular among customers and companies had also growing interest towards it. Unfortunately, we just had to close it as local legislation ruled it illegal. The legislation should be changed to support environmental initiatives. (A1)*

The responders are also calling for better integration of different modes of transport. It includes efforts to make transportation as seamless as possible and urging government to plan domestic transportation as one entirety. A common ground has already been established by finding the joint enemy; own car.

> *The decision-makers should consider that replacing flying by taking own car generates more road traffic congestions, road accidents and the need for road repairs. If the aircraft has reasonable load factor, the emissions per seat is lower than emissions of driving your own car. The difference can be increased by offsetting programs, using biofuels and eco-efficient airport management. Short domestic flights should not be accused but instead look at the bigger picture and overall emissions. (B3)*

7.3 Domestic consumer behavior

The next set of questions were targeted to find out expert's views on domestic passengers' behavior and mindset. Furthermore, the questions sought to infuse theories presented in chapters 2-5 with reality. The questions were:

- How conscious customers/companies can be sure of making environmental choice of transport mode?
- Are customers/companies willing to decrease their comfort and personal space in order to reduce emissions?
- Are customers/companies willing to increase travel time to reduce emissions?

As presented in chapter 4.4, transportation sector is missing comprehensive and coherent eco-labelling system. Several participants respond that it is possible that consumer doesn't know what the environmentally sound choice is and needs to trust that the company is telling the truth. Moreover, it's not due to consumers lack of basic knowledge but due to lack of tools to compare different options. A responder reminds that airlines own emissions calculator give at least an indication. Also following company on media, its participation to sustainability actions, sustainability publications and for example fleet renewals are also indicators for consumer of an eco-serious company. Another responder says a company had identified the issue and taken matter to their own hands.

> *A client company takes environmental aspects very seriously and wanted that its employees really travel as environmentally friendly as possible. As there was no good solution available, they created their own eco-ranking to guide employees to choose the best alternative. (A3)*

A responder continues that it would be beneficial to create a standard and certification from an unbiased organization that company could apply for and update on annual basis. The best time do it would be now when ministry of transport is working on its road map and finding ways to meet the carbon-neutrality goals.

According to responders there are differences on how environmental aspects are taken into considerations between different continents. Currently European consumers and companies are more aware and demand sustainable traveling than their counterparts in other regions. There is also difference on how consumer and company act.

> *The companies require a proof that its employees have travelled in a sustainable manner. But consumers want to have more active role and do the choice themselves. The feeling of "I did it" is rewarding. Science has*

shown that if individuals have active role, they are more happy compared to a passive role. (A1)

Lastly, a responder reminded that price is still big factor when doing decisions. Sustainable choices should be inexpensive for the company to acquire because only then the company could offer cheap and eco-efficient product for customers. Now it has to decide either or.

The next questions were targeted to investigate consumer behavior and willingness for change to increase eco-efficiency of chosen transportation. Multiple responders had similar views that fully loaded airplanes or vehicles are not favored by passengers, but some reminded that it can also be part of the business model and customer is aware of it. Furthermore, responders agreed that transportation company needs to do business and answer to demand fluctuations accordingly. Unprofitable company is not able to be eco-efficient as the focus goes to surviving rather than planning future eco-investments.

Although interviews were conducted when the full implications of COVID-19 pandemic weren't known, the responders had already a vision that full loads might be cumbersome in the future. Due to the situation additional personal space could be regarded more valuable than attempts to reduce emissions per seat.

The next question was relating to another attribute that consumer's value, travel time. As presented in table 4 where comparison between jet-aircraft and turboprop aircraft shows that the latter one generates far less emissions on same routing. The downside is that generally jets are faster and can be parked to gates instead of bussing to terminal which also adds travel time. The responders shared the notion that time is valued, even if it is only ten minutes. Some responders would like to see companies to advert more eco-efficient options as now majority of customers are not aware of the difference. Similarly, routes tagging multiple cities are not favored as travel time increase but if the emissions saved would be informed to the customers, they could change their opinion.

One main reason to fly domestic Finland is the speed. In case flights are operated with slower aircraft it can be a reason to change to an alternative transport method. But for example, a jet flies from Helsinki to Oulu in 1 hour, turboprop in 1,5hours and train takes up to 6 hours. The slow option is still much faster than train. I'm sure many would choose turboprop if they knew its eco-efficiency capabilities. (B1)

The responders argue that, in this case, airlines need to work more to overcome a perception issue. The turboprops are seen as less comfortable and in very harsh views those flights should be replaced by other means of transport. In addition, there are regions where the era of jet-flights is still remembered and longed after. An airline respondent explained how their team has been touring domestic cities and clients trying to promote the eco-efficiency of turboprops, and they are able to see the attitudes slowly changing. Another responder argues that in the future electric flying will change how public considers flying. Most likely the first electric aircrafts will be small, not being able to carry as many passengers than current variants and might not have the speed of regional jet aircraft. Then these “bad turboprop” attributes can become accepted and valued.

To summarize chapter 7.3, it is again valuable to link these topics to a bigger context. An approach that solely investigates certain routes or certain behavior is not favorable, like one responder states:

> *As ultra-short haul travelling is not so much local traffic but more transit traffic linking region to bigger network via capital airport, it is much more important for the region and to the nation and it should not be ceased just because of the ultra-short haul CO2-emissions. The topic needs to be examined as an entirety. We consider regional flying, even the ultra short-haul flights, are beneficial for the region and to whole nation and outweighs the harms of regional operations. (B3)*

7.4 Multimodal transportation

The next set of questions were related to multimodal transportation. The development has been most rapid in Central-Europe, where there are many examples of successful multimodal transportation chains. The questions were set to find out expert’s views if and how this development could happen in Finland. Generally, the responders considered it would be positive but also highlighted the issues what operators might face and would need to take action for.

The responders have seen development in our domestic multimodal transportation and are supportive of the initiatives. The principle idea of finding and buying the whole journey from one source is supported. As previously discussed, the length of the country, distance between cities and relatively small population are the major obstacles of efficient demand generation. Where there is demand, the infrastructure is not adequate which builds bottlenecks and then increases the travel time. Some responders gave example of rail

network bottleneck of Tampere-Helsinki, which would need to be fixed before fast train connection is reality. Moreover, effective multimodal travel chains need to be looked at without political pressure and located where the major traffic flows are. According to multiple responders' region to region traffic demand is thin, whereas from Helsinki it would be easier to find passengers and media coverage for any multimodal initiative. The experience of political pressure for air connection was included in several responses. Moreover, the politics hasn't been the driver for the development and initiatives have fallen into deaf ears.

> *The emotions are running high if the discussion includes any cuts to the frequencies. Their thinking is that city is not a city if it doesn't have an air connection. But if we cannot fly, maybe the solution could come from multimodality. We would just need to keep the passenger experience similar and hopefully retain the passengers (A1)*

The criticism towards multimodal travel chains from operators' point of view derives from economical and liability considerations. As the pricing of the package needs to be competitive it might require significant price reductions from all participants. According to IATA principles the revenues are shared by operated miles and if the same logic is applied, the operators of short-legs are left with nothing.

> *Let's take example of Utsjoki-Hanko route, a customer takes the bus from Utsjoki to Rovaniemi where he/she boards the aircraft and flies to Helsinki. Then at Helsinki Airport another bus takes the passenger to Hanko. Here the big majority of kilometers is travelled by airplane and the airline will take the lion share of the revenue. (B6)*

Moreover, the question of liability is already a concern. The operator might not be the one selling the ticket and thus not responsible for any delays. Current multimodal travel chains are built in a safeguard method where the travel time and transfers times are increased. The customer will make the connection but with the cost of efficiency and flexibility.

Several responders also highlighted the transparency of travel chains. The examples of using search engines to find a flight connection resulting into fake travel chain and buying two separate tickets, where making the connection is on passenger's own responsibility, were provided and these should be avoided.

The responders were well aware of the development in Europe where multimodal offering is vast. The examples of Lufthansa train from Frankfurt airport to neighboring cities were accompanied with more recent initiatives of using busses instead of aircraft in the US. A responder gave a thorough example of their home country initiative to run a bus service from the airport to cities nearby. The example also reveals the concern for the airline, does the bus service attract customers or will they rather start using competitor's air services.

> *This bus service is an initiative by (local airline). They offer these bus services free of charge, to their customers, as well as those flying on (partner airlines). It is important to remember that people originating in these cities, close to the borders with Germany and Belgium, have alternative big airports at their disposal, where they can board the airline service to the capital but there are also many other carriers offering air connections. (A2)*

The benefit for the local airline is that by offering a bus service it can keep the passengers under its umbrella, as otherwise customer could easily choose another carrier operating from the near airport and use the competitor's network. Moreover, as there is demand from the regions to the capitol, the local airline by its own bus service is much better positioned to capture these passengers to its own network. If customer uses other providers, they can also use another airline. The same notion is echoed by several responders and also applies for sales; customer must be able to purchase the entire trip from one channel. It would allow the airline to capture the customers even though for a part of the trip they are not using the airline's own metal. An opinion from an airline respondent suggests that it would be possible to have an "airline bus".

> *It is a matter of service design. If we could create a passenger experience that would feel the same than being onboard on our flights, it could be successful. It should not feel like local bus but have some of that luxury what many still see in air travelling. In addition, the concept would need to be simple and worked together with the airport operator. For example, the passengers should not be queueing in security as they have already started their journey (A1)*

The responders agreed that the domestic infrastructure is not fully compatible, and enhancements are needed. Many argued that the lack of high-speed rail network means that there is no real alternative for flying. Also, several respondents argued that Helsinki Airport would need a long-distance train station in order to have a feasible "Lufthansa

train" product. According to a respondent the building of the long-haul train station at the airport has a decision in principle but current estimate is that it will take at least 10 more years to be complete. In addition, a responder reflected electric flying and how it would change the need for alternative transport method, however it could take more than 10 years to be reality.

If train takes 10 years to arrive, will this generate possibility for bus companies to partner with airlines? According to respondents using busses on ultra short-haul flight routes could be competitive option. Two respondents praised the speed and flexibility what this transportation method can offer. In addition, busses could have one more advantage over other alternative transport methods. In theory, they could be driven to apron and be parked as an aircraft next to a gate. Furthermore, the benefits for passengers are evident. It would allow ultra-seamless connection and passengers don't need to re-collect and re-check-in their luggage. According to a responder, this is still on an idea level even in Europe and currently only more traditional bus arrival to airport is in use.

Deriving from the responses, the author wanted to pull all themes from chapters 7.1 to 7.4 together and added a question for airline, airport, region organization and bus company responders. Would it be possible to launch a "Finnair bus" for Helsinki – Tampere route? Airline representatives considered the idea as worth of further development. As previously mentioned, the product should match the quality of a normal flight product. Moreover, the benefits for customers, like ability to work and being part of sustainability efforts should be well promoted. The airline responders also viewed the possibility to have more dense frequencies and flexible schedules as the route would not be constrained by aircraft resources nor airport capabilities.

> *We are open for development and it's in our company values to support environment initiatives. If there is customer demand for this kind of product, we would be need to be there. Otherwise someone else will pick the demand. (A3)*

Airport responders were also interested about the idea. From their point of view, it would be better if the bus runs to Tampere city not to the airport. Then it would be a similar concept than its European counterparts, albeit bus instead of a train. As there are several bus connections between the two cities, where making the connection is at passenger's own risk, this service should be something different. It should be distributed via Finnair's sales channels and the airline should bear the risk of making the connection. An added value for customer would be the possibility to check-in already at Tampere city and

luggage would then automatically transfer to the onward flight. Furthermore, if Helsinki Airport would be ready to consider having the bus on the apron, making the travel as seamless as possible. It would then be the pioneer in its field and might hold strong marketing value.

Area representatives consider the flight from Tampere airport to Helsinki airport convenient and it's the fastest way to connect to the global network. The bus service should run from Helsinki airport to Tampere city center to have any advantages over the aircraft service. They expect people rather taking their own car and drive straight to Helsinki airport if they need to catch the bus at the relatively remote Tampere airport. In addition, area representatives mention that newly built bus terminal at Tampere city could provide the infrastructure for check-in and baggage drop. This city to airport -bus could be an appealing option for flying.

Responder's from bus companies consider Helsinki-Tampere as a good example of short-haul traffic where bus could have a lot of benefits. For example, as a shuttle service the travel time could be reduced from current bus travel times. In addition, bus representatives estimate that bus could be cheaper to operate, especially with gas or biodiesel than aircraft and also generate less greenhouse gasses. But here airline and bus companies need to co-operate. The shuttle service would be difficult for the bus company to make profitable so subcontracting the service could benefit both parties.
A responder from bus company reminds that co-operation between airlines and busses is not a new phenomenon.

> *We have partnered with airline for several decades operating a shuttle route from Helsinki airport to the city. Moreover, in the 90s we launched shuttle services from Turku and Tampere to Helsinki Airport and these services were popular and on peak days we operated them with only 30min intervals. With our long history and fleet of electric busses we would be ready to start co-operation rather quickly. (B6)*

8 Discussion

Based on the interview data it can be said that taking environmental factors into account and running eco-efficient and sustainably conscious operations are important in the transportation industry. In addition, a growing number of individual passengers or company clients either consider themselves environmentally conscious or are aiming towards it. Currently they might not practice the equal level of consciousness when choosing their transportation method. The comparison is complicated due to the lack of regulated ecolabels for operators. Table 6 summarizes the main findings by research themes.

Table 6. Key findings by theme

Theme	Eco-efficiency and consumer behavior	Domestic transportation	Multimodal travel chains
Key findings	Sustainability is key element of operations. Operators have various methods to reduce emissions but the support for initiatives is thin and competition is tough. Company customers are active and want to act responsibly. Individual customers have limited possibility to compare eco-efficiency.	Regional flights are important part of network but have suffered from low load factors increasing the emissions per passenger. Eco-efficient aircraft type considered as small and slow. Electric flying or rail track development takes decades, but electric road transportation is progressing rapidly. Better integration of modes and support from Government needed to meet the carbon neutrality targets.	Multimodality is promoted in Europe and it could work in Finland if the service level, schedule and booking experience are kept attractive. Successful multimodality needs infrastructure and general attitude to develop. Partners need to agree on revenue sharing and liability questions. Competition aspects need to be considered carefully

8.1 Flight and bus schedule comparison

This research partly investigated the idea of a “flying bus” where one of the ultra short-haul destinations in Finnair’s domestic network would be operated with alternative transport method, specifically by a bus. Although the idea was not included in main research questions, the author wanted to elaborate the theory and data to present an idea for Finnair, the supporter of the thesis.

Chapter 3.3 discussed the complexity of airline scheduling and stated it to be a continuous process. Most attractable departures are early morning and afternoon enabling effective business day for time-sensitive business travelers. The scheduler must balance between compelling timings and efficient aircraft usage. Moreover, in a hub-and-spoke network the schedules should support connectivity and for example Tampere-Helsinki schedule must meet the critical banks to maximize connectivity as the share of local origin-destination passenger is rather low. Furthermore, every schedule is a product and in highly competitive environment even minor changes can influence the market situation.

Table 7 presents and compares the current flights timetables and a proposed bus schedule. The flight schedule is optimized to connect to and from Helsinki hub main waves and also holds valuable slots in peak hours. The challenge with the schedule comes from the difference in speed. The flight has a block-time of 35min whereas the shuttle bus is estimated to take around 2hrs. Even in the ultra-short distance the turboprop has almost 90min advantage over the bus. It means that the bus schedule cannot be similar than flight schedule, otherwise it loses all connectivity and the product would perish its value.

Table 7. Flight and bus schedule comparison

Origin	Departure flight	Departure bus	Destination	Arrival flight	Arrival bus	Min. connection time in Helsinki
TMP	06:05	4:40	HEL	06:40	06:50	0:45
TMP	13:40	13:10	HEL	14:15	15:20	0:45
HEL	16:05	16:15	TMP	16:40	18:25	0:45
HEL	23:55	23:05	TMP	00:40	01:15	0:45

In case Finnair would continue researching this idea, the company would need to carefully consider the viability of the bus schedule, connectivity impact and competition aspects.

8.2 Conclusions

When this research started in autumn 2019 aviation together with the whole transportation industry was wrestling the challenges of growth and sustainability. The common question was how to decarbonize transport, while maintaining the projected traffic growth rates both domestically and globally. The growth was temporarily halted by the COVID-19 crisis,

but the underlying challenge still exists. Although transportation companies, especially in aviation sector, are deeply troubled by the short-term virus challenge, the long-term existential challenge is unresolved and will bounce back once traffic returns to pre-COVID-19 levels. The crisis has brought up new sustainability challenges: For a moment, airlines feared that the global offset-based scheme CORSIA becomes tighter constraint than expected as the agreed baseline was the average flying in 2019 and 2020. In July ICAO voted to only use 2019's emissions (Businesstraveller 2020). The alleviation is only short-term, and airlines need to keep in mind that the EU's green deal still calls to deliver climate neutrality by 2050.

The COVID-19 crisis has also expedited the development of multimodal travel chains. Due to the financial challenges' airlines have been receiving governmental bailouts from their home country's government. Some bailouts are linked with sustainability conditions. Recent news reports state that Austrian Airlines has agreed to halve its domestic CO2 emissions by 2050 and cut flights that could be done by rail in less than three hours. The 45min turboprop flight between Vienna and Salzburg is now operated by national rail operator with the travel time just under three hours. Moreover, the train even has first class coach for the business class passengers. Another example is Air France whose bailout included condition not to compete with train services where the journey by train is less than 2.5 hours. Interestingly Swiss banking group UBS has recently studied that public tolerance for longer travel times is rising and according to their data business travelers don't mind journeys of less than four hours and leisure travelers journeys up to six hours in train. (Simpleflying 2020) According to the respondents the domestic passengers haven't yet been keen to change their need for as short travel times as possible and regions are fighting to keep air connection alive. It remains to be seen whether the trend from Europe arrives to Finland as well. To be successful it needs support from all stakeholders and from the government. As in the Tampere example, the passenger would still be able to choose between flight to foreign hub and bus to Helsinki hub and there is a risk that environmental initiatives are made ineffectual by increased competition.

Not all eco-efficiency actions need to be massive fleet renewals, adaptation of new technology or changes to current legislation. The respondents highlighted the importance of training of staff. Examples of guidelines on how to recycle to driving classes for professional drivers were shared. In the end, how could your customers know your eco-efficiency if your staff doesn't know it? The abovementioned topics generate the major headlines, but it could be argued that true eco-efficiency is more than that. In Finnair's

case, the author recommends increasing the staff eco-efficiency knowledge by further virtual learning courses, some which could even be mandatory for all.

Several respondents considered sustainable energy sources and biofuels to be the key for carbon-neutral transportation sector. They also commonly named two major challenges; price and supply side. Operating with sustainable fuels increases the operating costs significantly and as according to respondents, the customers are not yet willing to pay extra. It seemingly puts the operators into difficult position. Either to take extra cost and save from somewhere else or choose to continue with traditional fuels. In transportation sector the competitive environment is fierce and, be it in bids for new routes or ticket price, the offered price still holds a significant value in decision-making process. Interestingly, in both aviation and bus transportation company clients and municipalities require sustainability efforts from the operators whereas individual customers are more concerned about the price and total travel time. The supply side holds two issues, lack of governmental support and the quantity of the sustainable alternatives. Some respondents were calling for changes to taxation or new support for operators and providers in order to make the change to sustainable alternatives. A policy change to reduce taxes for operators using sustainable fuels and increasing them for those not to would be a major change but the COVID-19 crisis has shown that once unthinkable policy measures could be swiftly agreed and implemented. But this only makes sense when there are enough sustainable alternatives in the market, otherwise it would only be an extra burden to the operators.

Electric flying is still far in the future and is not really an alternative for ultra short-haul flights anywhere soon. In bus sector, the revolution has started, and operators have introduced electric busses to their services, mostly for inner city bus routes. As currently the batteries are not yet powerful enough and the lack of nationwide charging station network the range of the electric busses is limited. One could see the similar challenges arising when electric flying really commences, the technology needs to work in heat and drizzle and airports together with alternative airports need to be equipped with charging equipment. The idea of merging bus transportation with ultra short-haul flight routes was supported by the respondents. In addition, it sparked the thinking process after which respondents argued how this could be done from their perspective. As this kind of initiative would be groundbreaking, the co-operation between all possible stakeholders is essential. For Finnair, this investigation to the idea of a flying bus gives the ground where the company could continue to work.

8.3 Implications for further research

The research process began in autumn 2019 when the world looked completely different than it is currently in late 2020. The COVID-19 crisis affected everyone and especially the professional's working in the tourism and transportation sector. The process wasn't the smoothest with various other external factors halting the research time to time. As the topic is very current, new developments and new ideas were reported, sometimes to author's benefit and sometimes not. Although the author has worked in aviation for several years, the research process taught a new point of view to the whole transportation sector.

This research contains multiple threads that could be further investigated. Moreover, the research is written from aviation point of view which doesn't allow as holistic approach as writing from transportation sector point of view. Further studies could focus on more bus and train multimodality initiatives as in this research train point-of-view is rather limited. Another study could be done by investigating the topic with qualitative methods to understand more the consumer behavior relating to sustainability choices. In addition, the topic of ecolabel needs further investigation and hopefully further studies could deliver an ecolabel model to the transportation sector. The ICAO's (2019) target of carbon neutral growth from 2020 onwards will require transformational ideas to be researched where universities and aviation companies could co-operate. For Finnair, the topic could be further researched from network strategy point-of-view and elaborated with customer data and vast market knowledge.

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Attachments

Attachment 1. Interview questions

Yrityksen X ympäristöohjelma

- Miten ympäristö näkyy päivittäisessä tekemisessänne?
- Miten saavutatte asettamanne ilmastotavoitteet?
- Ovatko biopolttoaineet/uusiutuvat energialähteet osa yrityksenne nykyhetkeä vai tulevaisuutta?
- Minkä näette biopolttoaineiden/uusiutuvien energialähteiden käytön suurimmaksi haasteeksi?

Kotimaan liikenne

- Miten näette lyhyiden kotimaan lentojen ekologisuuden?
- Kuinka kotimaan julkista liikennettä voisi kehittää kohti hiilineutraaliutta?
- Ilmailualalta puuttuu yhtenäinen ympäristöystävällisyysmittari? Miten ympäristötietoinen asiakas voi luottaa tehneensä ympäristöä vähemmän kuormittavan valinnan?
- Erään tutkimuksen mukaan lentoyhtiöt voisivat kehittää ympäristöystävällisyyttään maksimoimalla istuinten määrän ja myymällä koneen mahdollisimman täyteen, jolloin päästöt jakautuisivat mahdollisimman monen matkustajan kesken. Tällä voi kuitenkin olla vaikutusta asiakastyytyväisyyteen. Miten näette matkustajien halukkuuden tähän?
- Näettekö, että kotimaan matkustajat olisivat valmiita tekemään ympäristövalintoja kuten lentämään hitaammin potkurikoneella, joka on huomattavasti ympäristötehokkaampi kuin suihkukone lyhyillä reiteillä?

Matkaketjut

- Liikenneministeriössä valmistellaan liikennestrategiaa ja hiilineutraalin liikenteen tiekarttaa, miten nämä näkyvät yrityksessänne?
- Miten näette matkaketjujen tulevaisuuden?
- Keski-Euroopassa on “lentoyhteyksiä”, jotka operoidaan vaihtoehtoisella kulkuvälineillä. Voisiko samankaltainen olla mahdollista myös Suomessa ja mitä se vaatisi?