



Evaluating Route Suitability for Electric Regional Aviation in Finland

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AVIBBA

Bachelor's Thesis

2025

Abstract

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Degree Bachelor of Business Administration, Aviation Business
Report/Thesis Title Evaluating Route Suitability for Electric Regional Aviation in Finland
Number of pages and appendix pages 45 + 11
<p>This thesis examines how electric regional air mobility (eRAM) could be used in Finland to improve transportation between different regions. It looks at which routes are most suitable for connecting areas and reducing emissions. Considering Finland's dispersed landscape and existing travel challenges, the research discusses how electric aircraft can expand routes and better serve less connected regions. The study also explores the specific challenges and opportunities of introducing eRAM.</p> <p>This study uses a mix of research methods, combining both quantitative and qualitative approaches. It includes geographic and demographic analysis, a survey about preferences and awareness of the eRAM service, and interviews with two key stakeholders in electric aviation. The research aims to answer five key questions: current issues in transport networks, demand patterns, geographic factors affecting feasibility, user preferences and willingness to adopt, and expert opinions on the practicality of implementation. To support this study, three main theories are used: Innovation Diffusion Theory, Regional Innovation Systems Theory, and Transport Network Theory. These theories help to connect and understand the different parts of the research.</p> <p>The key findings highlight three main groups of routes for near-term and medium-term implementation. High-priority routes include Helsinki-Tampere and Helsinki-Oulu. Routes for medium-term development include the Helsinki-Kuopio and Helsinki-Jyväskylä routes. Opportunities for medium to long-term growth include creating a new route from Helsinki to Rovaniemi via a Helsinki-Oulu hub, as well as establishing regional cross-connections to reduce reliance on hub-and-spoke network structures.</p> <p>This thesis offers evidence on how to prioritise routes for eRAM. It combines technical details, economic factors, and user preferences, which can be applied to other regions as well. The study also confirms that working together with aircraft manufacturers, operators, local communities, and policymakers can create shared value. Overall, the findings suggest that eRAM is a feasible option for Finland's transportation future.</p>
Key words Electric regional air mobility, Route suitability, Regional connectivity, Sustainable transport

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1 Introduction

This chapter explains the background and reasons for the thesis. It describes the geographic and climate-related challenges that make electric regional air mobility (eRAM) important for Finland. The chapter also states the research questions, defines the study's scope and boundaries, and gives an overview of the thesis organisation.

1.1 Background, Motivation, and Importance

Finland's geographic landscape presents a unique transportation challenge. The country's scattered population, large territory, and limited east–west rail connections create accessibility problems in less-populated areas, despite good links to major cities. Solving these connectivity issues is important for regional growth and equal access to services, jobs, and opportunities.

New eRAM technologies offer a promising solution to both challenges. Recent improvements in battery-electric and hybrid-electric aircraft show that short-distance routes of 100–800 kilometres can be operated with very low emissions. However, moving from technological potential to real-world use requires strong evidence on which routes are most suitable, taking into account demand, user acceptance, and practicality.

This thesis aims to fill that evidence gap by evaluating routes in Finland to determine which are best suited for first-generation electric regional aircraft. It combines geographic and demographic analysis, demand studies, insights from users and aviation experts, and theories from innovation, regional systems, and network design. The study produces a list of prioritised routes and offers a practical framework for selecting routes. Ultimately, this work supports Finland's transition to sustainable regional aviation and helps improve transportation options in underserved areas.

1.2 Research Problem and Research Questions

While electric aircraft technology is quickly advancing, a critical gap remains. There is currently no systematic, evidence-based framework for identifying which routes in Finland are most suitable for implementing eRAM. This thesis addresses that gap through a mixed-methods approach integrating quantitative demand analysis with qualitative stakeholder insights.

The main research question this thesis wants to answer is:

Which routes are most suitable for implementing eRAM in Finland to enhance regional connectivity and promote sustainable transport?

To address this, the thesis will focus on the following problems presented as questions:

- What are the current challenges in transport networks in different regions of Finland, especially those that are underserved?
- How do demographic characteristics affect the demand for RAM routes?
- How geographical factors such as population density, route distance, climate, or existing infrastructure influence the feasibility and effectiveness of electric regional air routes in Finland?
- What could be the preferences and expectations of potential users of RAM services?
- How viable and practical is the implementation of eRAM from the perspective of regional transport planning and aviation experts?

1.3 Scope and Delimitations

This thesis focuses exclusively on evaluating the route suitability of routes for eRAM in Finland. It considers first-generation electric aircraft with ranges of about 200 to 800 kilometres and passenger capacities of 9 to 30 seats, such as the Eviation Alice and Heart Aerospace ES-30. The study does not perform a detailed cost analysis for specific business models or cover urban air mobility (UAM). The focus is on Finland's existing airports and transportation networks to identify routes serving underserved regions and current public service obligation routes.

1.4 Structure of the Thesis

This thesis is organised into seven chapters. Chapter 2 reviews current advancements in electric regional aviation technology and their environmental benefits. Chapter 3 discusses Finland's geographic features, transportation system, and policy environment, highlighting key connectivity challenges and climate commitments. Chapter 4 introduces the theoretical frameworks (innovation diffusion theory, regional innovation systems, and transport network design) that guide the analysis and interpretation of the results. Chapter 5 explains the research methods, including data sources and analytical techniques, used to answer the research questions. Chapter 6 presents the main findings from both quantitative and qualitative data, including route demand analysis, survey results on user preferences, and insights from interviews with experts. Chapter 7 summarises the key findings into a prioritised route framework, explores their implications for policy and practice, and suggests directions for future research.

2 Background and context of Regional Air Mobility and Electric Aircraft Technology

Modern transportation is developing quickly, and air travel is no exception. Traditional aircraft, which typically operate on fossil fuels, face significant environmental challenges due to their emissions and high operating costs. At the same time, many regions, particularly those with lower population densities or remote locations, struggle with connectivity and access to fast and reliable transportation (Baumeister et al., 2020).

Regional Air Mobility (RAM) offers a potential solution to address these challenges. Using smaller aircraft to link regional and local destinations helps make travel faster and more convenient. Recent advances in electric and hybrid aircraft technology have opened up new possibilities for RAM, offering cleaner, quieter, and potentially more affordable air travel options (Baumeister et al., 2020; EA Maven, 2024).

This chapter provides a quick overview of Regional Air Mobility, explores the latest advancements in electric aircraft, and discusses the potential benefits and challenges of using electric aircraft for regional travel.

2.1 Overview of Regional Air Mobility (RAM)

Regional Air Mobility (RAM) is a form of air transportation that links smaller cities, towns, and rural regions, typically covering distances of 100 to 800 kilometres. Unlike traditional commercial aviation, which operates between large airports over long distances, RAM focuses on routes with lower traffic volumes that are vital for local accessibility and economic development but often unprofitable for large aircraft. RAM uses smaller aircraft, usually seating 9-30 passengers, designed for more frequent, shorter flights from regional and smaller airports closer to passengers' starting points (EA Maven, 2024; Baumeister et al., 2020).

Key features of RAM include:

- **Smaller Aircraft:** Typically seating between 9 and 30 passengers, RAM aircraft are designed for shorter routes and more frequent service (Baumeister et al., 2020).
- **Point-to-Point Travel:** RAM reduces travel time by avoiding layovers and unnecessary deviations (EA Maven, 2024).
- **Improved Regional Connectivity:** RAM can connect underserved or remote areas, improving access to jobs, services, and markets (EA Maven, 2024).
- **Potential Integration with Other Transport Modes:** RAM services can link with ground transportation (cars, buses, trains) (EA Maven, 2024).

RAM is primarily developing due to technological advances in aircraft propulsion and navigation, as well as a growing awareness of the environmental impacts of conventional aviation. By using electric or hybrid aircraft, RAM promises lower emissions, reduced noise pollution, and potentially lower operating costs, which can make regional air services more sustainable and accessible (Baumeister et al., 2020). The distinctions between RAM and conventional aviation are summarised in Table 1.

Table 1. RAM and Normal Aviation Comparison Table

Feature	Regional Air Mobility (RAM)	Normal Commercial Aviation
Typical Route Distance	100 – 800 km	800+ km
Aircraft Size	Small (9 – 30 passengers)	Large (100+ passengers)
Airports	Small regional/local airports	Large airports
Service Frequency	More frequent, flexible, short routes	Scheduled, less frequent on small routes
Travel Type	Point-to-point (direct flights)	Hub-and-spoke (via major hubs)
Environmental Impact	Lower emissions (electric/hybrid propulsion)	Higher emissions (jet fuel)
Operational Costs	Potentially lower due to electric/hybrid tech	Higher operating costs
Accessibility Focus	Connects underserved/remote regions	Connects major cities and hubs

While this thesis emphasises RAM, it is important to understand how it relates to other emerging air mobility concepts, especially Urban Air Mobility (UAM) and the broader Advanced Air Mobility (AAM) ecosystem. The table below highlights the key differences between RAM, UAM, and AAM. To clarify RAM's positioning within the broader Advanced Air Mobility ecosystem, Table 2 compares RAM with Urban Air Mobility (UAM) and the wider Advanced Air Mobility (AAM) framework.

Table 2. Comparison Table: RAM vs UAM vs AAM

Feature	Regional Air Mobility (RAM)	Urban Air Mobility (UAM)	Advanced Air Mobility (AAM)
Primary Purpose	Connect regional cities, towns, and underserved areas	Short urban and suburban trips, as well as air taxi services	This term serves as an umbrella that covers both UAM and RAM
Typical Route Distance	100–800 km	10–100 km	Varies (10–800+ km)
Use Case	Regional connectivity, hub feeder routes	Intra-city transportation that avoids ground traffic congestion	Integrated air mobility ecosystem
Operations	Short takeoff and landing (STOL) on regional airports	Vertical takeoff and landing (VTOL) on vertiports	Mixed operations (STOL, VTOL, conventional)
Speed	150–480 km/h	100–300 km/h	Varies by aircraft type
Passenger Capacity	9–30 passengers	1–5 passengers	1–30+ passengers
Propulsion	Hybrid-electric or fully electric	Fully electric (battery)	Electric, hybrid, or sustainable fuels
Infrastructure Needs	Regional airports with charging facilities	Urban vertiports, rooftop landing pads	Airports, vertiports, multimodal hubs

2.2 Recent Developments in Electric Aircraft

Table 3. Future Electric Aircraft Comparison

Specification	Eviation Alice	Heart Aerospace ES-30	Electra EL9 Ultra Short
Passenger Capacity	9	30	9
Maximum Range	~ 460 km (250 mi)	~ 200 km (105 mi) all-electric 800km (430 mi) hybrid	~ 2035 km (1100 nm)
Cruise Speed	~ 480 km/h	~ 150 km/h	~ 324 km/h
Propulsion	Fully electric	Fully electric / hybrid	Hybrid-electric
Certification Target Year	Expected commercial use in 2026-2028	Certification expected around 2028	Production model expected around 2026-2028
Noise and Emissions	Zero operational emissions	Quieter than turboprops, zero operational emissions	Reduces fuel consumption by 40%



EVIATION ALICE



HEART AEROSPACE ES-30



ELECTRA EL9 ULTRA SHORT

Figure 1. Eviation Alice, Heart Aerospace ES-30, and Electra EL9 Ultra Short images

Table 3 provides an overview of three promising electric aircraft candidates currently in development, and Figure 1 illustrates these three aircraft types: the Eviation Alice, Heart Aerospace ES-30, and Electra EL9. The progress in electric propulsion benefits from several technological improvements, including more efficient electric motors, lightweight battery systems, and better energy management. However, challenges remain, primarily the limited energy density of batteries, which

restricts the payload capacity and range of electric aircraft compared to conventional aircraft fuelled by jet fuel (Epstein & O'Flarity, 2019).

The Nordic countries, including Finland, have emerged as global leaders in promoting electric aviation, leveraging their clean electricity grids, supportive regulatory frameworks, and active industry collaboration (Nordic NEA, 2023). The establishment of the Nordic Network on Electric Aviation (NEA) further accelerates the commercial adoption of electric aircraft through coordinated stakeholder efforts and policy support (Nordic NEA, 2025).

Even with an optimistic outlook, adoption can be limited by infrastructure requirements such as fast-charging facilities at regional airports, safety concerns related to battery technology, and the need for harmonised regulations to ensure seamless operations (Baumeister et al., 2020). Market readiness also depends on economic factors, including operating costs and demand for new air mobility services, which are influenced by aircraft performance and the accessibility of underserved regions.

In sum, recent developments in electric aircraft technology represent a transformative phase in regional air mobility and a promise of lower emissions, reduced noise, and lower operating costs. Achieving extensive adoption will need continuous technological advancements, regulatory alignment, and investment in infrastructure (Baumeister et al., 2020).

2.3 Potential benefits and challenges for Regional Aviation

Electric RAM has significant potential to enhance regional connectivity while promoting sustainable transportation, especially in Finland, where geography, climate, and population distribution present unique challenges. First-generation electric aircraft (FGEA), such as Eviation's Alice and Heart Aerospace's ES-19/ES-30, exemplify the emerging types of electric aircraft designed for short-haul routes. These aircraft offer a viable way to reduce the aviation sector's emissions, particularly on shorter flights, which are the least efficient per ton-kilometre.

One of the primary advantages of electric aviation is lower operating emissions compared to current turboprop and jet aircraft, with studies showing the potential for 20–60% reductions in CO₂-equivalent emissions on short routes (Baumeister et al., 2020). The emissions benefits of electric aircraft become more convincing when powered by renewable energy sources, such as Finland's predominantly hydropower-based electricity grid, which could drive emissions close to zero in the future (Baumeister et al., 2020). Electric aircraft also offer reduced noise pollution and lower maintenance and operating costs, thanks to simpler motor designs compared to combustion engines.

Compared with other modes of transportation, replacing car travel with electric aircraft is advisable on routes longer than approximately 170 km, where electric aircraft offer faster travel times with comparable or slightly higher emissions, offset by the reduced travel time and convenience (Baumeister et al., 2020). However, replacing train travel with electric aircraft is not recommended under the current energy setup because trains, which already run primarily on renewable electricity, have much lower emissions per passenger-kilometre. The development of high-speed rail (HSR) corridors between Helsinki, Turku, and Tampere may further increase rail competitiveness on routes up to 400 km (Baumeister et al., 2020).

Finland's dispersed population and extensive domestic flight network make it especially suitable for eRAM, which can serve smaller airports currently lacking commercial flights and improve accessibility to underserved and remote areas (Baumeister et al., 2020). This aligns with the Nordic region's ambition, supported by the Nordic Network for Electric Aviation (NEA), to achieve a fossil-free domestic flight sector by 2030–2040 (Nordic NEA, 2023).

Case studies such as the Iisalmi Airport development plan highlight the practical application of regional electric aviation. Iisalmi and the region have economic sectors such as technology, manufacturing, and tourism that can benefit from enhanced air connectivity. Despite infrastructural challenges such as runway length and limited facilities, multiple investments could facilitate commercial operations with light electric or hybrid aircraft, offering direct connections to hubs like Helsinki and Tampere, and improve transport efficiency (Destia, 2024).

In the UK, eRAM routes offer notable carbon savings, time efficiency, and economic benefits, driven by demand for sub-regional air connectivity. Electric RAM supports decentralising from major hubs to secondary airports, aiding aviation decarbonisation and expanding accessibility and local economic activity (EA Maven, 2024).

Overall, the deployment of eRAM presents a strategic opportunity to transform regional transport systems by offering environmentally sustainable and economically viable alternatives. While challenges such as battery technology limitations, regulatory issues, infrastructure adaptation, and market readiness persist, ongoing advancements and regional policy support will enable these new modes of transport to make a significant contribution to future sustainable mobility landscapes.

Electric aircraft also align well with future airline network designs that emphasise hub-and-spoke models, optimising frequency and load factors, which complement the smaller capacities and higher trip frequencies of electric aircraft. This model supports the establishment of new regional feeder networks serving smaller airports closer to population centres, thereby enhancing regional accessibility (Simon, 2021).

3 Literature Review

Electric regional air mobility (eRAM) offers a promising way to cut emissions on short-haul flights, and Finland's scattered population makes it an ideal place to test electric. This review assesses how these aircraft perform in terms of range, payload, and charging needs under Finland's current electricity mix, examines lifecycle and operational emissions (including the effects of replacing other transport modes), and explores public service obligation routes in Finland. Finally, it evaluates airport charging readiness, regulatory support, and incentive schemes to guide the integration of eRAM into Finland's existing transport network.

3.1 Introduction to Regional Air Mobility and Electric Aviation

Electric RAM is a new transportation mode that uses battery-electric propulsion systems, distinct from traditional aircraft, and that impacts route planning, network design, and flight operations. Initial electric aircraft will carry 9–30 passengers, with batteries weighing 35–50% of take-off weight, limiting range to about 200–350 km (Baumeister et al., 2020). These factors are vital given Finland's regional geography, which features mostly short-to-medium routes.

A CO₂ emissions assessment by Jenu et al. (2021) on Finland's current electricity mix revealed reductions of up to 70% in operational emissions compared to conventional regional aircraft, particularly on short routes under 300 km. However, Nordic climatic conditions present unique challenges, as battery capacity can drop by 10–20% at temperatures below 0 °C. This highlights the importance of implementing effective operational strategies during winter.

The Nordic NEA Innovation report (2023) identifies key challenges related to standardising high-power charging infrastructure at regional airports and adapting aircraft designs to suit Nordic climate conditions. Emphasising cross-border collaboration among Nordic countries, the report advocates aligning regulatory frameworks and advancing shared technological developments to develop resilient, scalable eRAM networks tailored to the unique geographic and environmental conditions of Northern Europe.

The FAIR report (2021) emphasises the potential of eRAM to improve mobility on low-passenger-density, short-distance routes. By better utilising Nordic airports and integrating them with other modes of transportation, travel efficiency can be improved. The document aims to demonstrate how to adopt flexible operational models and digital solutions to promote zero-emission flights powered by renewable energy, supporting both sustainability and competitiveness. The report reinforces the importance of coordinated development in technology, infrastructure, and innovative business models to improve the potential of electric aviation in regional contexts.

3.2 Environmental and Emissions Impacts

eRAM offers a significant opportunity to reduce aviation's environmental impact, particularly when powered by clean electricity grids. The environmental benefits of first-generation electric aircraft in the Nordic regions are particularly notable, given the region's high reliance on renewable energy sources.

Research by Stiebe (2025) on electric general aviation indicates that electric aircraft can achieve significant reductions in carbon emissions compared to conventional aircraft when powered by clean electricity. Under ideal conditions, using the Pipistrel Velis Electro, a full private pilot training syllabus can save up to 1.5 tCO₂e compared to completing a private pilot's license training on conventional aircraft. This finding highlights the potential role electric aircraft could play in reducing aviation carbon emissions, especially for training and regional operations.

However, these results depend strongly on the electricity grid's decarbonisation. In countries that rely on fossil fuels for power generation, the lifecycle emissions of electric aircraft may exceed those of efficient combustion alternatives. A study by CE Delft (2025) comparing the E9X electric aircraft with hydrogen and sustainable aviation fuel alternatives found that battery-electric aircraft have the lowest climate impact among all aviation options, requiring approximately 0.71 MJ of energy per passenger-kilometre, compared to 1.07 MJ for hydrogen-powered aircraft. However, emissions associated with battery production constitute a significant portion of the total lifecycle emissions and should be considered when assessing environmental benefits.

Jenu et al. (2021) found that while electric trains consistently show lower emissions than electric aircraft under Finland's current electricity mix, electric aircraft can reach emission levels comparable to those of regular buses, while offering significantly faster travel times. This indicates that electric aircraft could be a practical middle ground, combining the environmental benefits of rail transport with the speed benefits of traditional aviation.

The mix of electricity sources significantly affects the environmental impact of electric aircraft. Research indicates that the carbon intensity of electricity generation can significantly impact the total emissions of electric transport modes. Electric aircraft perform exceptionally well in countries with clean electricity grids, such as Sweden and Finland. However, in countries where grids are powered by fossil fuels, they may potentially have higher emissions than conventional alternatives.

3.3 Transport Accessibility in Finland

Finland's transport system relies on a multimodal network that integrates road, rail, air, and maritime transportation, shaped by its expansive geography and low population density. Road transport dominates domestic travel, accounting for approximately 90% of passenger volumes, while the extensive rail network serves over 82 million passengers annually (Fintraffic, 2023). Domestic air transport primarily operates through a hub-and-spoke system centred on Helsinki-Vantaa Airport, which handles over 80% of passenger traffic. Regional airports provide essential but limited connectivity to remote areas (Finavia, 2025).

Despite this infrastructure, regional connectivity challenges persist. Much of the network prioritises links between Helsinki and major cities, resulting in poor direct transport services between smaller towns and rural areas, especially in the north and east of Finland (Baumeister et al., 2020). This hub-centric model extends travel times and reduces efficiency for passengers in these underserved regions. Travellers in underserved regions often experience longer trips and higher costs due to fewer direct routes and irregular schedules. For example, routes that require travel through Helsinki or other major cities increase travel time, making some trips within the same region less efficient. These inefficiencies lead to increased operating costs for transport providers, which are reflected in ticket prices that may become unaffordable for frequent travellers. Low passenger volumes in low-density areas make profitability difficult, often resulting in the reduction or cancellation of routes (Simon, 2021).

As illustrated in Figure 2, Railway infrastructure is concentrated in southern Finland, with limited cross-regional east-west connections and single-track sections often constraining speed and capacity outside main corridors (Vayla, 2024). The lack of direct transportation options in many regions highlights the need for new mobility solutions that enhance regional accessibility and economic development.

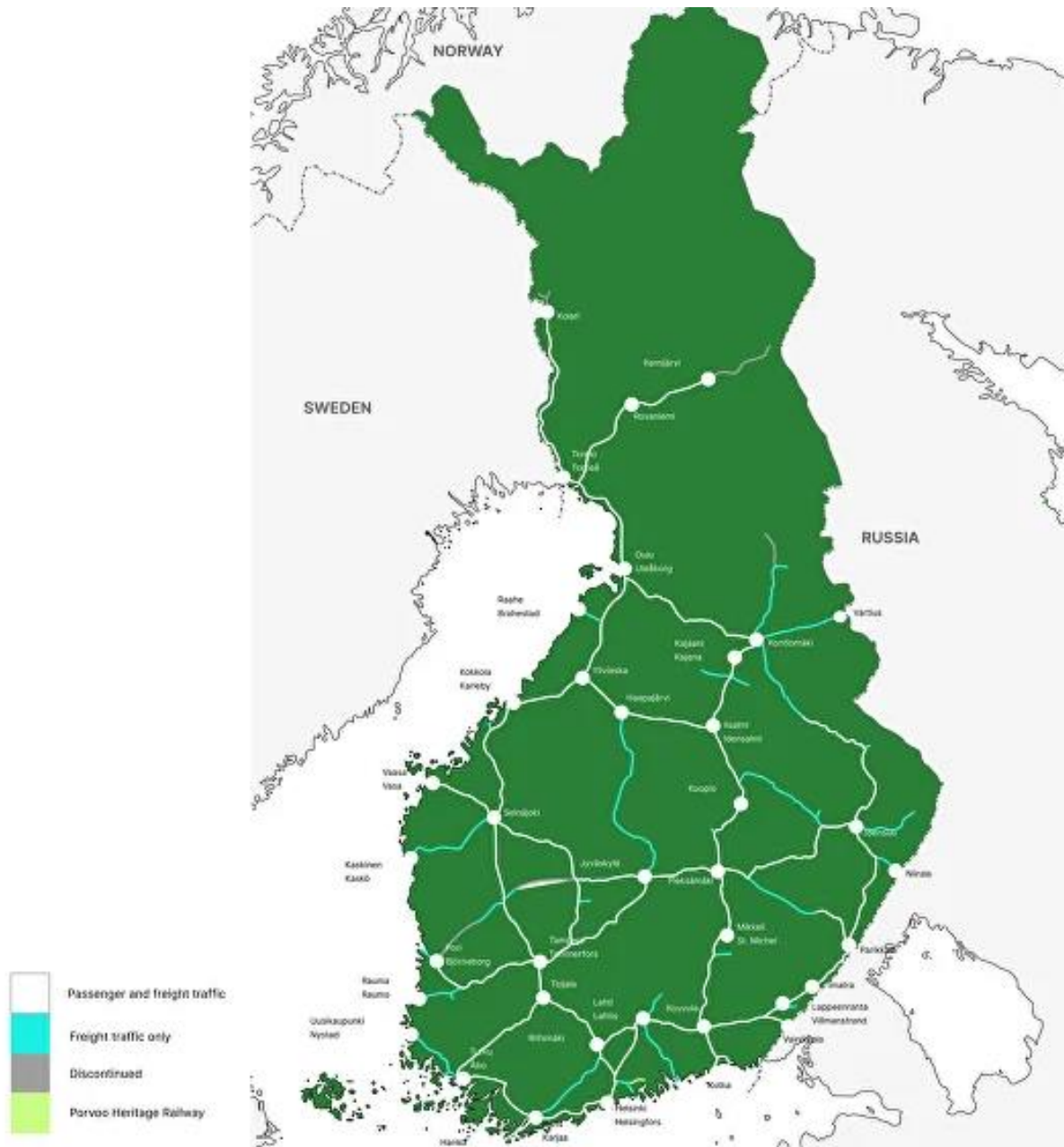


Figure 2. Finland Railway Map (Finland Trains, 2025)

eRAM is a new way to improve travel options and reach areas that are currently hard to access. According to the Nordic NEA (2023) and the FAIR report (2021), electric planes could help connect different regions, including remote towns, by flying short distances. This can help local economies grow. However, for eRAM to work well, several issues must be solved. Flights must be reliable year-round, even in bad weather, tickets should be affordable, and they should integrate smoothly with other modes of transportation.

3.4 Public Service Obligations (PSO) routes in Finland

Some regional air routes in Finland operate under Public Service Obligations (PSOs), where the state subsidises scheduled air services to maintain connectivity to remote or economically less viable regions. The Finnish Transport and Communications Agency, Traficom, has recently added several PSO routes between Helsinki and regional airports, including Joensuu, Jyväskylä, Kajaani, Kemi-Tornio, Kokkola-Pietarsaari, Savonlinna, and Pori.

The PSO routes from Helsinki to Joensuu, Jyväskylä, Kajaani, Kemi-Tornio, and Kokkola-Pietarsaari are operated by Norra (Nordic Regional Airlines) on behalf of Finnair under a contract valid from April 29, 2024, to March 28, 2026. New agreements have introduced direct connections to Kemi-Tornio and Kokkola-Pietarsaari, replacing previous triangular flight patterns and facilitating approximately 10 round-trip flights per week on these routes (Traficom, 2024). For the Savonlinna–Helsinki route, BAsE Airlines Ltd won the tender to operate state-subsidised flights until February 27, 2028, marking an important continuity in maintaining linkages for this eastern region. Similarly, BAsE Airlines has also secured the air services contract for the Pori–Helsinki route, ensuring continued connectivity for the western part of the country (Traficom, 2024).

These PSO-supported services are essential to regional development, economic activity, and social inclusion in Finland's spread-out population centres. They highlight how public funding helps maintain necessary air connectivity where commercial flights alone might not be sustainable. This is relevant to the research because emerging eRAM solutions could either complement or eventually replace traditional aircraft on these PSO routes. eRAM has the potential to operate more cheaply and produce fewer emissions, making it a promising alternative to the current subsidised flight network in Finland. Analysing PSO routes provides a baseline for assessing route suitability and funding strategies, helping understand how electric aircraft might fit into or change regional air transport in Finland.

3.5 Demographic and Socioeconomic Factors Influencing RAM Demand

Finland's demographic and socioeconomic factors lead to unique demand patterns for regional air mobility services, which differ significantly from those in more densely populated areas. Understanding these factors is important for assessing the feasibility and development of eRAM networks.

Finland's population of around 5.5 million inhabitants is characterised by significant geographic concentration and dispersal patterns that influence transport demand. The Helsinki metropolitan area serves as the main population hub, while secondary urban districts, such as Tampere, Turku, and Oulu, function as regional nodes (Statistics Finland, 2025). However, one-third of the Finnish

population lives in rural areas, with population density varying by geographical location and rural area type (SMARTA, 2019). This dispersed settlement pattern presents specific mobility challenges, particularly for residents in the distant northern and eastern areas, where transportation options are limited.

Finland's economy relies heavily on export industries, technology sectors, and tourism, which generate specific mobility needs that shape RAM demand patterns. Business travel requirements are particularly significant in regions with manufacturing centres, technology hubs, and resource-extraction industries that demand frequent links to national and international markets (FAIR, 2021). The Nordic region's focus on international business connectivity means that even smaller regional centres must maintain reliable transport links to remain economically competitive (Nordic NEA, 2023).

Tourism represents another significant demand driver, especially in northern Finland, where international winter tourism has experienced extensive growth. Lapland's tourism sector demonstrates particular potential for RAM services, as traditional transport modes often involve lengthy travel times that limit visitors' access to remote destinations (FAIR, 2021).

Finnish residents demonstrate high purchasing power and environmental awareness, both of which influence transport mode choices. Studies of passenger attitudes towards eRAM reveal a strong environmental motivation among potential users, even though practical considerations, such as travel time savings and schedule flexibility, are also vital for the future adoption of this type of aviation. However, price sensitivity remains a critical factor, especially for routes serving smaller communities where frequent travel may be economically limited (Brandt, 2021).

4 Theoretical Framework

The previous review of sustainable electric aviation research revealed valuable insights into infrastructure needs, environmental advantages, and operational challenges. However, it also identified gaps in integrating these findings within a unified explanatory framework. To fill this gap, this chapter introduces a theoretical framework based on technology adoption theory, systems of innovation, and transport network modelling. By examining key sources, this framework aims to unify the diverse themes in the literature and equip the subsequent empirical analysis with relevant analytical tools.

This theoretical framework provides the academic foundation for evaluating the suitability of eRAM routes in Finland. The chapter focuses on how regional connectivity and sustainable transport can benefit from innovative aviation solutions. Recent research and expert insights are combined to explain and link the primary theoretical ideas that support this study. By analysing established theories and connecting them to Finnish transport networks and demographic realities, this framework supports understanding and assessment of RAM implementation. It grounds the research in relevant literature and establishes new links among transport infrastructure, the Sustainable Development Goals, and user perspectives.

4.1 Conceptual Foundations

This section defines the core concepts used to evaluate electric regional air mobility in Finland (eRAM, regional connectivity, and Sustainable Transport). eRAM refers to short-distance air services (approx. 150–800 km) that use battery-electric or hybrid aircraft to connect regional airports and airfields, within the technical limitations of current aircraft and infrastructure. The focus is on routes with the goal of improving accessibility and reducing emissions compared to other modes of transportation. Aircraft range, infrastructure compatibility, regulations, and local travel demand determine route suitability.

Regional connectivity measures how well transportation links connect remote areas with urban centres, aiming to reduce travel times and support social and economic activity. Connectivity is evaluated by comparing RAM service time savings to those of existing modes, as well as the impact on service frequency in underserved regions.

Sustainable transport is evaluated by considering its overall environmental impact, cost-effectiveness, and social equity. This includes reducing CO₂ emissions and infrastructure costs, as well as providing equal access for rural residents. Finland's mostly renewable electricity makes electric

aircraft especially viable for reducing aviation emissions. Social equity is addressed by improving accessibility in places currently lacking viable travel options.

4.2 Innovation Diffusion Theory

Innovation Diffusion Theory, introduced by Everett Rogers in 1962, explains how new technologies and ideas spread among people and organisations (Halton, 2025). In eRAM, its key attributes (relative advantage, compatibility, complexity, trialability, and observability) help predict how quickly electric aircraft may be adopted (Sridharan, 2021). Relative advantage refers to how much electric aircraft are seen as superior to conventional fossil-fuel aircraft and other transport modes. Research indicates that electric aircraft offer significant environmental advantages, notably lower CO₂ emissions, particularly when powered by renewable energy sources (Baumeister et al., 2020). Compatibility assesses how well eRAM aligns with Finland's existing infrastructure, energy systems, regulations, and societal values. Finland's energy grid, which primarily relies on renewable sources such as hydropower, makes the country well-suited for electric aviation (Baumeister et al., 2020). Complexity and trialability highlight the importance of making electric aircraft easy to use and understand, while allowing for testing before widespread introduction. Observability, on the other hand, involves demonstrating the benefits of an innovation to potential adopters.

While IDT offers insights into technology adoption, it has limitations. Critics argue that it oversimplifies social processes by focusing on individual adopters and ignoring structural barriers, like regulations and infrastructure. Its 'pro-innovation bias' (the idea that all innovations are naturally beneficial and should spread) has been challenged, especially when innovations face real technical, economic, or environmental constraints (Crofton, 2024). For example, in electric aviation, battery limits and charging infrastructure are barriers that require coordinated policy and investment. Additionally, focusing on individual choices can overlook factors such as government policies and support systems, which are better explained by the Regional Innovation Systems theory. Finland's adoption of electric aviation depends on cooperation among manufacturers, airports, energy providers, and policymakers. It may not fully reflect how technology spreads in regional aviation, where location, population, and policies play significant roles. Despite these limitations, IDT remains a strong framework for analysing the adoption dynamics of eRAM in Finland, especially when combined with theories that consider other factors.

4.3 Regional Innovation Systems (RIS) Theory

Regional Innovation Systems (RIS) theory explains that the success of eRAM in Finland depends on regional collaboration among public authorities, industries, and research institutions rather than on technology alone. It highlights that innovation prospers when spatial proximity, institutional

backing, and common policies promote effective learning and knowledge sharing (Ónday, 2016). In Finland, RIS is evident in initiatives such as the Nordic Network for Electric Aviation (NEA), which brings together manufacturers, airlines, airports, and policymakers to develop electric flight technologies and business models together. Universities and research centres also contribute by advancing battery technology, optimising system integration, and conducting market analyses (Nordic NEA, 2023). This collaborative environment supports experimentation, learning, and the scaling of practical electric aviation solutions. Regional collaboration can provide these solutions more quickly and efficiently than isolated national efforts. The FAIR project, which focuses on Ostrobothnia, South Ostrobothnia, and Central Ostrobothnia, demonstrates how RIS can help stakeholders collaborate to identify demand, shape infrastructure development, and integrate electric aviation into existing transport systems to improve connectivity and avoid duplication of effort or infrastructure.

However, RIS has its limitations. Not all regions have the infrastructure, funding, or policy support to make RIS effective. In Finland, innovation resources are primarily concentrated in Helsinki and a few major cities, leaving the surrounding regions underdeveloped. RIS might also overlook obstacles from national regulations, aviation safety standards, or global supply chain issues that require coordination beyond regions. Despite these challenges, RIS remains a vital tool for understanding how regional networks can accelerate the electrification of air transport through cooperation, policy alignment, and the development of shared regional strategies. Regional Innovation Systems (RIS) theory provides a valuable perspective for understanding how the successful implementation of eRAM in Finland depends not only on technological innovations but also on a complex network of collaboration among public agencies, industry players, research institutions, and other organisations. Unlike purely national approaches, RIS highlights the importance of the regional dimension, where partnerships, knowledge sharing, and policy incentives foster innovation and adaptation (Ónday, 2016).

4.4 Airline Business Models and Transport Network Theory

Transport network theory explains how transportation routes can be planned to connect places more efficiently, making travel faster, and helping more people access transportation options across different areas. It examines how important points, such as airports and cities (nodes), and the routes between them (links), interact. This theory helps clarify why network design, particularly the choice between different airline business models, determines how effectively regional air mobility serves diverse communities and meets operational needs. (Rodrigue & Ducruet, 2024). In terms of transport network theory, hub-and-spoke and point-to-point models are typically the only ones mentioned. However, this chapter will discuss other models used in airlines.

The hub-and-spoke model has become the dominant structure in commercial aviation, especially since deregulation in the late 1970s. In this system, flights are routed through central hub airports, which act as main connection points for passengers (Zgodavová et al., 2018). Smaller electric aircraft, with typical capacities of 9–30 passengers, are optimised for hubs that aggregate and consolidate travel from multiple origins, making frequent operations more viable (Baumeister et al., 2020). This demand aggregation is crucial for achieving profitability, operational flexibility, and sustainability targets in Nordic aviation. Finland's urban centres, such as Helsinki, Tampere, Turku, and Oulu, serve as natural hubs, collecting passengers from surrounding regions (Traficom, 2022).

In contrast, the point-to-point model provides direct flights between city pairs with no intermediate stops through hubs, minimising journey times for passengers prioritising convenience. This model works best where demand for a specific route is high enough to support regular direct service, but it requires many more individual routes to achieve comparable coverage. Connecting 100 destinations would require 4 950 separate flights, versus 99 in a hub-and-spoke configuration for the same coverage (Zgodavová et al., 2018). Point-to-point enhances operational resilience, as failures or delays on one route do not disrupt the network as a whole.

The grid network model offers a hybrid approach, blending point-to-point connectivity with flexible hub connections to create numerous routing options. However, not all connections go through a hub, and some may not exist at all, adding network flexibility. This can be useful as technological improvements make electric aviation more capable and adaptable for changing patterns in passenger behaviour (Karsbergen, 2025; Klophaus et al., 2021).

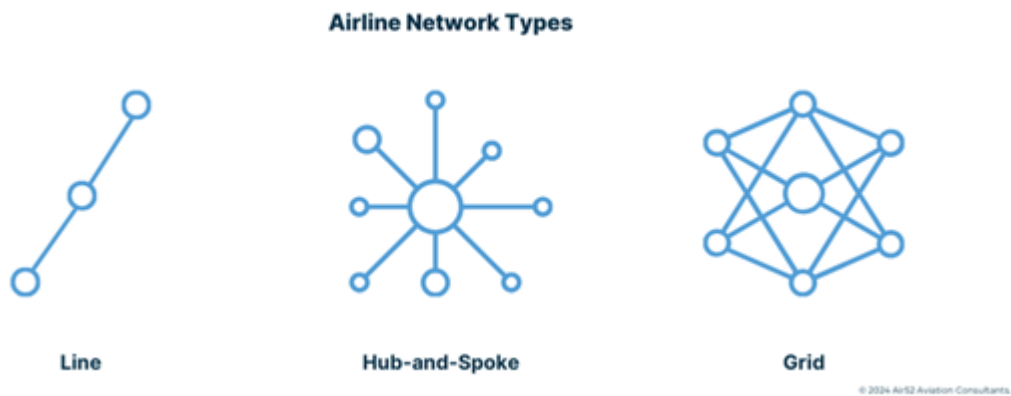


Figure 3. Airline Network Types (Karsbergen, 2025)

Finland's demographic and geographic factors further reinforce the suitability of the hub-and-spoke model for electric aviation. Urban population density, alignment with electric aircraft in terms of capacity and range, and the need for operational efficiency drive route selection towards this model (Simon, 2021; Traficom, 2022). Daily rotations between regional airports and hubs maximise aircraft utilisation and offer flexible departure times. Charging requirements also strongly favour hub-based operations, allowing flexibility for ground times (Nordic NEA, 2023).

The transport network theory has been criticised for prioritising efficiency and centralisation, leaving remote regions sometimes underserved unless policy interventions, such as Public Service Obligation (PSO) routes, are used to maintain service equity. Finland's PSO routes demonstrate how regulatory support addresses market gaps to promote fair access and connectivity across the country (Traficom, 2022). The technical advantages and lower costs of future electric aircraft may also encourage more direct point-to-point or hybrid network designs, meeting demand for faster, more flexible travel, or even introduce a new, innovative business model for the airline market that aligns with the needs of electric aircraft. (Rodrigue & Ducruet, 2024).

Recent studies also indicate that as demand and technology advance, the dominance of hub-and-spoke designs may weaken, making hybrid networks or new combinations increasingly suitable for Finland's evolving mobility needs (Rodrigue & Ducruet, 2024; Karsbergen, 2025). In summary, selecting the right model is crucial for successfully implementing eRAM, as it must balance operational needs with economic and social goals (Baumeister et al., 2020; Zgodavová et al., 2018).

4.5 Integrating the Theories

The three theoretical perspectives (Innovation Diffusion Theory (IDT), Regional Innovation Systems (RIS), and Transport Network Theory) focus on different but related aspects of implementing electric regional air mobility in Finland. While each provides valuable insights on its own, combining

them forms a complete analytical framework that reflects the complexity of introducing a transformative transport technology in a particular regional setting.

These theories examine different levels and aspects of the research questions, yet they also connect naturally. IDT (Innovation Diffusion Theory) focuses on individual and organisational decisions about adopting new technologies, as well as the factors that influence this process. RIS (Regional Innovation Systems) operates at the regional level, exploring how regional institutions, knowledge networks, and partnerships collaborate to create an environment that supports innovation and growth. Transport Network Theory operates at the big-picture level, providing principles for designing routes, enhancing connectivity, and improving transport efficiency. In the context of eRAM in Finland, the adoption of new aircraft technology (IDT) occurs within collaborative innovation ecosystems (RIS) that must be organised according to network efficiency principles (Transport Network Theory) to achieve efficient regional connectivity.

4.5.1 Points of Convergence

Several critical themes emerge from the intersection of the three theories and their support. Infrastructure compatibility is a primary concern across all frameworks. IDT emphasises the importance of infrastructure readiness for adoption, while RIS focuses on how regional infrastructure investments are driven by stakeholder collaboration. Transport Network Theory demonstrates how infrastructure configurations affect operational feasibility and service frequency.

Stakeholder coordination is another key convergence point. IDT recognises that in complex systems such as aviation, effective adoption relies on coordinating different stakeholders (airlines, airports, regulators, and passengers). RIS explicitly illustrates these interactions, showing how knowledge sharing and policy support evolve through regional networks that involve aircraft manufacturers, operators, airports, and government agencies. Transport Network Theory further emphasises that coordination needs to align with network optimisation principles to ensure efficient operations.

Demand aggregation and market viability are linked to all three theories in explaining route suitability. Transport Network Theory demonstrates that hub-and-spoke structures consolidate dispersed demand, creating viable routes for small-capacity aircraft. RIS describes how regional partnerships recognise and foster this demand via collaborative market development. IDT suggests that proving viability with successful pilot routes improves observability and accelerates adoption.

4.5.2 How Theoretical Gaps are addressed

The limitations of each theory are partly addressed by insights from other theories, thereby strengthening the analytical framework. IDT often overlooks structural barriers, such as regulatory frameworks, infrastructure issues, and other irregularities. However, RIS theory addresses this by demonstrating institutional environments and policy instruments. Similarly, IDT's focus on individual adopters is complemented by Transport Network Theory, which demonstrates how individual adoption decisions should align with broader network configurations to achieve sustainability goals.

Transport Network Theory traditionally focuses on making transportation as cost-effective as possible. However, this view is expanded by three ideas: IDT, which considers users' preferences and their willingness to try new services; and RIS, which examines how government policies can support transportation networks. IDT also explains how people's acceptance of new transport options affects whether these services can be socially sustained.

This framework combines three theories (Innovation Diffusion Theory, Regional Innovation Systems Theory, and Transport Network Theory) to evaluate the suitability of eRAM routes in Finland. These theories work together to examine different levels: individual adoption, organisational collaboration, and the overall network. By combining these perspectives, the analysis considers technology, institutions, location, and behaviour, providing a complete picture of the implementation of eRAM in Finland.

5 Methodology

Transportation is constantly changing, and aviation is no exception. Traditional aeroplanes rely mainly on fossil fuels, which contribute significantly to environmental problems and lead to high operational costs. Additionally, areas with low population or remote locations often struggle to maintain reliable connectivity and access to quick, reliable transportation.

Electric Regional Air Mobility (eRAM) is a new concept designed to address these challenges. It uses smaller aircraft to connect small cities, towns, and rural areas within regions, making travel quicker and more efficient. Recent developments in electric and hybrid aircraft technology have expanded RAM's potential by providing cleaner, quieter, and potentially more cost-effective air travel solutions.

This thesis focuses on evaluating the suitability of routes for electric regional aviation in Finland. Finland's geography and population distribution make it an interesting case for examining how electric regional air services can enhance regional connectivity and support sustainable transportation goals.

To answer the research questions presented in Chapter 1, this study will combine quantitative data analysis, including demographic and transport statistics, with qualitative methods such as expert interviews and potential user surveys. The results aim to provide valuable insights to guide the development and implementation of electric regional aviation routes in Finland and similar regions.

5.1 Quantitative Research

This chapter explains the quantitative methods used to assess the suitability of routes for electric regional aviation in Finland. Quantitative analysis is essential for understanding demographic trends, transport accessibility, and geographic elements that influence demand and the feasibility of electric air services.

5.1.1 Data Sources and Analysis Methods

The primary data sources include official statistics on population distribution, regional demographics, current transport networks, and air traffic volumes. Statistical analysis methods are applied to demographic and transportation data to identify underserved regions and potential demand hubs. Metrics such as travel time savings, service frequency, and route viability thresholds are calculated to evaluate route effectiveness and user benefits.

5.1.2 Route Evaluation Criteria

Suitability criteria for selecting routes include population density, node-to-node distances, current transportation service levels, and economic activity. Environmental considerations, such as potential reductions in emissions compared to traditional modes, are also quantitatively evaluated.

5.1.3 Economic Feasibility Analysis

Understanding economic feasibility is essential for evaluating new routes, as it helps determine whether eRAM routes are financially viable.

5.2 Qualitative Research Design

This chapter describes the qualitative research methods used to explore the feasibility and acceptance of eRAM in Finland. These methods complement quantitative data by collecting expert opinions and user preferences, which are vital for efficient route planning and service design.

5.2.1 Expert Interviews

Interviews will be conducted with key stakeholders. The purpose is to explore the challenges, opportunities, and factors that influence the implementation of eRAM routes. Interview questions focused on infrastructure requirements, regulatory frameworks, economic viability, and sustainability considerations.

5.2.2 User Preference Surveys

The user preference component involved a structured survey aimed at potential passengers interested in eRAM services. The survey will be conducted online to ensure a diverse sample from across Finland.

The survey was designed to collect valuable insights into how people feel about current regional transport options, their openness to electric aircraft, and their views on the benefits and challenges of electric aircraft. Participants are invited to share their views by ranking or rating key factors, including travel time, cost, convenience, environmental impact, and safety.

Key components of the survey included background demographics and travel habits, an evaluation of current transportation options, and openness to new electric air services. It also included preferences for route choices and the factors that might influence adoption. Additionally, there were open questions that allowed respondents to share any additional thoughts or concerns about eRAM.

5.3 Overlay Matrix

The matrix below shows how each research question is explored using specific theories, data sources, methods, and result chapters, ensuring clear and organised coverage throughout the thesis.

Table 4. Overlay Matrix

Investigative Question	Theoretical Framework (Chapter)	Methodology	Results (Chapter)	Survey Questions
What are the current challenges in transport networks in different regions of Finland, especially those that are underserved?	Transport Network Theory	Statistics Finland, Traficom, Finavia data	6.1	Q6–Q9
How do demographic characteristics affect the demand for RAM routes?	Innovation Diffusion Theory and Regional Innovation Systems	Census data, population projections, and survey analysis	6.1 and 6.2	Q1–Q5
How do geographical factors such as population density, route distance, climate, or existing infrastructure influence the feasibility and effectiveness of electric regional air routes in Finland?	Transport Network Theory and Regional Innovation Systems	Distance matrices and infrastructure mapping	6.1	Q16–Q21
What could be the preferences and expectations of potential users of RAM services?	Innovation Diffusion Theory	Descriptive and thematic analysis of the survey	6.2	Whole survey
How viable and practical is the implementation of eRAM from the perspective of regional transport planning and aviation experts?	All the theories	Semi-structured interviews with 2 experts	6.3 and 6.4	Interview questions (Appendices 2 and 3)

This structured approach ensures that all research questions are addressed with appropriate methods and that the results are grounded in both theoretical understanding and empirical data.

6 Research and Findings

This chapter presents the findings from the mixed-methods research evaluating the suitability of eRAM routes in Finland. By blending detailed analyses of demographics, transport networks, and distances with insights from user surveys and expert opinions, this study can address the research questions that guide it. These include understanding the challenges faced by transport networks in underserved areas, how demographic factors influence RAM demand, the geographic and infrastructural considerations for route feasibility, user preferences, and the practical aspects of implementation from an expert perspective. By combining quantitative and qualitative data, this chapter transforms the theoretical frameworks and methodological approaches established in previous chapters into evidence that directly helps form future route recommendations.

6.1 Geographic and Demographic Route Analysis

The process of identifying appropriate routes for eRAM requires understanding Finland's population distribution, the characteristics of its existing transportation network, and regional accessibility patterns. This section provides the necessary geographic and demographic background to assess potential eRAM corridors. It examines four main aspects: the location and characteristics of population centres; the strengths and weaknesses of the current transportation system; poorly connected regions; and the distances and connectivity constraints that affect route feasibility. By identifying areas with enough population to support services, regions with significant connectivity gaps, and routes that are technically feasible given current electric aircraft ranges, this section sets the foundation for future route evaluations, economic studies, and stakeholder input.

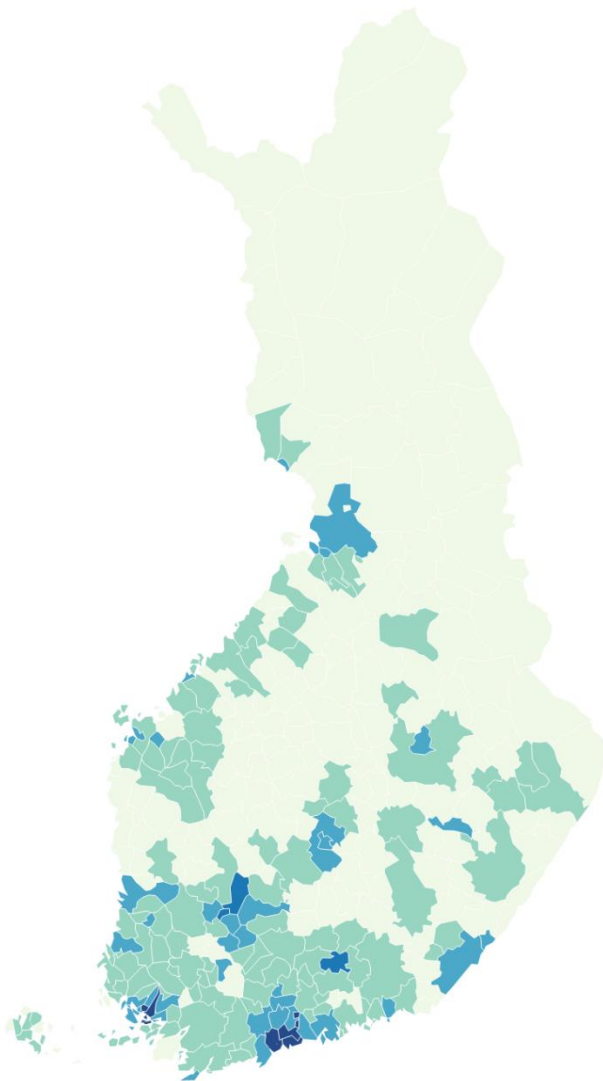
6.1.1 Population Distribution and Density Patterns

Finland's population is unevenly distributed across the country, with Helsinki being the largest population hub, with approximately 693 000 residents, followed by secondary urban centres such as Tampere (263 000) and Turku (209 000) (Statistics Finland, 2025). These urban centres serve as key endpoints for potential eRAM routes. Additionally, cities like Oulu (217 000), Jyväskylä (150 000), and Kuopio (126 000) serve as important regional nodes. (Statistics Finland, 2025). Population growth trends indicate dynamic shifts: metropolitan areas are generally increasing, while some rural areas are stagnating or declining (Statistics Finland, 2025). Employment sector distribution indicates strong clusters of technology and manufacturing industries in southern and western Finland, particularly around Helsinki and Tampere, potentially driving regular business travel demand (Statistics Finland, 2025).

As shown in Figure 4, Finland's population density varies significantly across regions. Urban areas like Uusimaa have about 195 people per square kilometre (Helsinki with 3 187), while rural areas such as North Karelia have only 9 people per square kilometre (Statistics Finland, 2024). This difference means that service models for eRAM need to be adapted. In densely populated areas, more frequent, smaller-scale services are suitable, while in remote regions, larger, less frequent services may be required to ensure accessibility. Understanding these population patterns is important for choosing the best routes for eRAM. These routes should meet both operational needs and user demand, forming a basis for further analysis of route options and economic feasibility (Baumeister et al., 2020; Finavia, 2025).

Finland's Population Density Map (2024)

< 10 10-50 50-250 250-500 ≥ 500



Source: Statistics Finland (2024) • Map data: Maanmittauslaitos • Created with Datawrapper

Figure 4. Finland's Population Density Map (Statistics Finland, 2024)

6.1.2 Current Transport Network Gaps and Travel Times

Current transportation options vary significantly across routes, affecting how well eRAM can improve regional mobility. For example, the Helsinki-Tampere corridor offers good service with frequent, efficient rail and road transport, although electric flights could provide even more frequent and flexible options (Traficom, 2024). On the other hand, northern and eastern routes such as Helsinki-Kajaani and Helsinki-Joensuu have longer travel times and fewer connections by road, rail, or bus. Air travel in these areas is limited to high-cost, infrequent flights (Traficom, 2024). Travel time studies indicate that routes taking more than two hours by car or public transport, along with service gaps and seasonal disruptions, are ideal candidates for eRAM.

6.1.3 Identification of Underserved Regions

Underserved regions are defined here as areas with low populations, limited transportation options, longer travel times relative to distances, and economic challenges. Examples include parts of Lapland, which face additional difficulties due to harsh climate and poor infrastructure. These factors make these regions strong candidates for enhanced connectivity via eRAM. These areas often depend on subsidised Public Service Obligation routes, which show market failure but also present opportunities (Traficom, 2024). Economic indicators, such as declining populations and low incomes, suggest caution when estimating demand in these remote locations (Statistics Finland, 2025).

6.2 User Preference Survey Results

This section presents findings from the survey conducted to understand potential users' travel patterns, awareness of electric aviation, willingness to adopt eRAM, and preferences regarding service features. The survey collected 45 responses from residents of Finland between September and October 2025.

6.2.1 Demographic Profile of Respondents

The survey respondents were predominantly young adults, with 64.4% aged 18-24 years and 24.4% aged 25-34 years, together representing 88.8% of the sample. This age distribution reflects a population segment likely to be early adopters of innovative transport solutions. The geographic distribution showed a strong concentration in the Helsinki metropolitan area, with Helsinki (48.9%), Vantaa (17.8%), and Espoo (8.9%) accounting for 75.6% of respondents' primary residences. Additional answers came from other cities, including Porvoo (15.6%) and Rovaniemi (4.4%), as well as smaller municipalities such as Kokkola, Kouvola, and Lovisa, providing perspectives from both urban centres and more remote regions.

The data shows that 68% of respondents were either students or unemployed, while 32% were employed. Although the group was mainly composed of students, it represents an important future market for regional air mobility services. Most respondents were from the Helsinki area, which aligns with Finland's overall population distribution.

6.2.2 Current Transport Experience and Challenges

The analysis of travel frequency showed that 44.4% of respondents travel more than 100 km between Finnish cities or regions a few times per year. Additionally, 26.7% travel monthly, and 13.3% travel weekly. This indicates a high need for travel between regions. When asked about preferred transportation methods, most respondents chose train (71.1%) and car (66.7%), followed by bus or coach (42.2%) and airplane (24.4%). These results suggest that only a small part of travellers use current regional flight services. The main reasons for travel were mainly tourism and leisure (55.6%), family or personal reasons (55.6%), and work or business (35.6%). This shows that eRAM services could fulfil various travel needs.

Frequent routes are mostly centred on Helsinki, with the most common connections being Helsinki-Tampere (42.2%), Helsinki-Turku (37.8%), and Helsinki-Oulu (13.3%). Other regional routes include Helsinki-Jyväskylä, Helsinki-Kuopio, and Helsinki-Vaasa. Respondents reported several challenges with current transportation options. These issues include high ticket prices due to limited competition on some routes, infrequent service, delays when changing trains, and

transportation barriers to areas outside major cities such as Espoo, Vantaa, and Helsinki. For example, routes requiring train transfers are often problematic due to frequent delays. These issues highlight the potential for eRAM to fill a significant gap by providing more frequent, direct regional travel options.

6.2.3 Willingness to Adopt eRAM

Awareness of electric aviation was evenly divided among respondents. Specifically, 53.3% were unaware that electric aircraft could soon be used for regional flights, highlighting the need to inform the public about this technology. Despite limited initial awareness, many respondents expressed a strong willingness to consider using electric aircraft for domestic travel, with an average score of 7.5 out of 10. Notably, 37.8% of respondents rated their likelihood of using electric aircraft at 10, indicating a highly enthusiastic early-adopter segment.

The preferences for trip length suggest that electric aircraft are best suited to medium-distance journeys. Specifically, 53.3% of respondents preferred trips between 300 and 500 kilometres. Smaller proportions favoured routes over 500 km (13.3%), 100-300 km (15.6%), and under 100 km (13.3%). Only 4.5% of respondents would not consider switching to electric flights, indicating a generally positive attitude towards this technology. These preferences correspond with the current capabilities of electric aircraft, especially hybrid-electric models that can travel nearly 800 km on a single charge. Regarding travel purpose, electric flights would be more popular for tourism or leisure (66.7%), followed by family or personal reasons (53.3%) and business needs (24.4%), reflecting common travel motivations.

6.2.4 Preferred Routes and Service Expectations

The preferred routes for eRAM show a high demand for long-distance connections to northern and central Finland. The most popular routes are Helsinki-Rovaniemi, Helsinki-Oulu, and Helsinki-Turku. There is also notable demand for routes such as Helsinki-Kuopio, Helsinki-Tampere, and Helsinki-Vaasa, as well as regional connections such as Turku-Tampere and Tampere-Jyväskylä. These preferences highlight the need to connect Helsinki with northern and eastern areas of Finland, where current transportation options are currently limited or expensive.

The service preferences expressed by respondents offer clear guidance for the design of eRAM services. The most important feature identified was low ticket prices and affordability, chosen by 86.7% of respondents. Other important features included frequent and flexible flight schedules (64.4%), safe and reliable operations (64.4%), easy access to airports and shuttle connections (60%), and quick booking, check-in, and boarding processes (48.9%). Additional valued features were comfortable seating (42.2%), eco-friendliness and carbon neutrality (42.2%), quiet and

smooth flights (31.1%), and good in-flight services (31.1%). These findings indicate that while environmental benefits are valued, key factors such as cost, convenience, and safety remain the most influential for the adoption of eRAM services.

6.2.5 Price Sensitivity and Value Perceptions

Price sensitivity analysis shows that many potential users are quite cost-conscious. About 40% are not willing to pay more for electric flights compared to traditional flights on the same route, but 28.9% are willing to pay up to 10% extra. A smaller group, 20%, are willing to pay between 10-25% more, while only 4.4% would pay over 25% extra. Additionally, 6.7% are unsure. This suggests that while some users are drawn to sustainability, eRAM services need to match or closely match the costs of current options to attract a larger audience.

Factors most likely to encourage people to try electric flights include lower ticket prices (44.4%), positive media coverage and safety reports (20%), and direct routes to desired destinations (24.4%). Additionally, environmental certifications, recommendations from others, and the novelty of electric flights were also noted as appealing. Participants mentioned that "electric plane tickets should be equally or less expensive than traditional jet/turboprop tickets" and expressed a desire to "make it cheaper than train". The main barriers to adopting electric aviation were concerns over ticket prices (75.6%) and safety/technical reliability (51.1%), followed by limited destinations/routes (51.1%) and worries about charging time/turnaround (17.8%). Some concerns, such as environmental scepticism and lack of direct connecting flights, were also mentioned.

Additional respondent comments shared a mix of enthusiasm and practical concerns: "Very excited about them!" and "Personally, I am looking forward to this future." Meanwhile, others had worries about economic viability, such as "whether the airports that these aircraft would operate from could turn a profit without needing to be kept afloat with many subsidies", and technical readiness, like "I do not think that it would be happening any time soon. Batteries are too heavy." These insights remind us of the importance of open and honest communication about the technology, operational costs, and realistic timelines for eRAM implementation to help set proper expectations and trust among users.

6.3 Expert Interview Findings

Expert interviews were conducted with two key stakeholders in the electric aviation ecosystem: Roope Kekäläinen, Founder of Lygg (a regional air mobility company), and Christina Suomi, Helsinki U-Space 2024-2026 Project Director. These interviews gathered insights on operational feasibility, infrastructure requirements, regulatory challenges, and route selection criteria for implementing eRAM in Finland.

6.3.1 Infrastructure and Regulatory Perspectives

The infrastructure requirements for widespread eRAM use in Finland are actually less demanding than many might think. Experts suggest that hybrid or fully electric aircraft do not always need dedicated charging stations. Instead, what is important is having a flexible system for buying and distributing electricity so that it can be bought in one place and used in another. Fully electric aircraft, however, will need charging stations, and new options, such as Tesla-compatible charging ports, are already being installed. The market for electric aircraft is expected to launch in about five years, giving plenty of time to plan and set up the necessary infrastructure. (Kekäläinen, 2025)

However, regulatory changes are extensive and will take time to implement. From Christina Suomi's perspective, changes in national defence coordination, airspace management, ground infrastructure standards (such as charging, electrical grids, and emergency services), and aircraft certification and operational requirements are necessary. Currently, the structure of the airspace control zone (CTR) and terminal manoeuvring area (TMA) presents some challenges to implementing more flexible routes, especially when it comes to flight approaches and departures. To address these challenges, solutions should include adding local airspace flexibility measures, such as separate operating zones and closer integration with U-Space (Unmanned Aircraft System airspace management), as well as developing clearer coordination procedures with air traffic control. A phased deployment strategy is recommended, starting with trials and demonstrations in key areas where impacts are more manageable. This approach allows the parallel development of regulatory frameworks and infrastructure, helping shorten the overall timeline. It is also important to consider training for air traffic control staff, aircraft maintenance technicians, and airport emergency teams, since their current expertise may not directly apply to the new aircraft operations (Suomi, 2025).

6.3.2 Operational Feasibility and Challenges

The success of eRAM depends on ensuring each aircraft is used enough to cover the high fixed costs. Aircraft need to fly consistently to justify the heavy purchase price, which can then be reduced to only electricity costs during operation. With this in mind, it is suggested that eRAM services begin with busy corporate routes that can generate the necessary passenger volumes and frequency. (Kekäläinen, 2025)

Successful route identification requires focus on travel time savings as the primary competitive advantage. As Roope Kekäläinen (2025) emphasises, everything starts with time-saving (“Time is not buyable”). Companies are willing to pay, and eRAM should have routes that really save time. Routes should be selected where electric flights provide at least a 30% reduction in travel time compared to existing transport modes (Suomi, 2025), making medium- to long-distance corridors (200-600 km) particularly attractive. For Finnish markets, it was recommended to initially focus on routes from Helsinki to Turku, Tampere, Jyväskylä, and Kuopio (all within 1.5 hours of flight time) (Kekäläinen, 2025).

Roope Kekäläinen's experience with the Helsinki-Örebro-Linköping route demonstrated that despite market analysis suggesting substantial demand, actual passenger volumes fell far short of expectations (30 passengers instead of the projected 300), indicating that the flight time of 1.5 hours may exceed acceptable trip lengths for regional markets (Kekäläinen, 2025). However, in other European markets, routes with 400-500 km distance were more successful, suggesting an optimal distance range for eRAM viability (Kekäläinen, 2025).

6.3.3 Market Readiness and Adoption Barriers

Business travellers are a key group for the first eRAM services, as they are more willing to pay extra for convenience, time savings, and eco-friendly benefits (Kekäläinen, 2025; Suomi, 2025). Notably, customers in Europe are open to paying premium prices for sustainable travel options, unlike in North America, where sustainability does not influence pricing as much (Kekäläinen, 2025). This difference in how sustainability is valued across regions highlights an excellent opportunity for eRAM in Finland, especially for corporate travel segments.

Key barriers to market adoption include price comparisons with alternatives, regulatory uncertainties, and stakeholder engagement. For example, a return ticket for a 9-seater aircraft could cost about €700 during initial runs. However, once fixed costs are covered, electric or hybrid aircraft could cut operational costs by about 25%. Many customers, especially those interested in leisure travel, are pretty sensitive to price changes, which makes expanding the market beyond business travel challenging. (Kekäläinen, 2025)

Stakeholder engagement is a key challenge, as airports in Finland seem to show limited proactive interest in developing eRAM infrastructure. Roope Kekäläinen highlights that the biggest companies and local communities should commit to supporting the rise of eRAM, underscoring the importance of coordinated efforts and shared investment from multiple stakeholders. Similarly, Christina Suomi observes that stakeholder cooperation is "often a decisive factor in the feasibility and acceptability of routes," showing how involving local actors helps ensure land use, safety, noise control, and economic factors are addressed.

6.3.4 Policy Recommendations and Support Mechanisms

Public Service Obligations (PSO) subsidies are a valuable way to help cover aircraft's fixed costs during the early stages of market growth (Kekäläinen, 2025). Experts have highlighted certain geographic opportunities that deserve focus. Christina Suomi points out three particularly promising areas: the inner-city Pasila-Ilmala zone for urban air services, medium-distance regions like Lahti, Hämeenlinna, and Porvoo-Loviisa (covering 100-200 km), and long-distance routes spanning 200-600 km, including Jyväskylä, Savonlinna, Joensuu, and international flights to Tallinn. It is especially important to note that routes with fast rail options should be given lower priority, as strong rail competition on well-established corridors reduces the chances of eRAM's success (Kekäläinen, 2025).

Cross-stakeholder cooperation mechanisms are essential for effective route implementation. Suomi (2025) identifies six priority route selection criteria ranked by importance: travel time reduction, multimodal connectivity, demand and profitability, environmental impacts, feasibility for rapid pilot deployment, and international strategic value. This prioritisation framework guides structured route evaluation.

The Helsinki U-Space project offers valuable lessons for adopting a more comprehensive approach to airspace management and integrating it into urban environments. It highlights the importance of treating urban airspace as a connected whole, with coordinated planning that includes both manned and unmanned aircraft. Using digital tools like 3D city models and other simulation tools can help simulate scenarios and assess impacts effectively. Collaboration across stakeholders, bringing together experts in aviation safety, law, zoning, and data management, is crucial. Additionally, setting up innovation platforms, such as Helsinki's Forum Virium accelerator, allows for quick pilot testing and learning opportunities before new regulations are finalised (Suomi, 2025). These insights remind us that successful integration of eRAM depends not just on technical solutions but also on strong stakeholder cooperation.

6.4 Route Suitability and Economic Viability Assessment

Following the geographic and demographic analysis, combined with insights from user preferences and expert stakeholder perspectives, this section evaluates candidate routes for implementing eRAM using integrated criteria encompassing technical feasibility, economic viability, and market demand. This section applies a structured evaluation framework to candidate routes, synthesising quantitative data on population, distances, and financial parameters with qualitative insights from users and experts to identify priority routes for near-term implementation.

6.4.1 Route Selection Criteria

Route suitability assessment applies six prioritised criteria, as recommended by Christina Suomi: (1) travel time reduction of at least 30% compared to existing transport modes, (2) multimodal connectivity enabling integration with ground transportation, (3) demand and profitability estimates based on population catchment and demonstrated willingness to use RAM services, (4) environmental benefits and emissions reductions, (5) feasibility for rapid pilot deployment within existing infrastructure constraints, and (6) international strategic value for cross-border connectivity.

The Feasibility Assessment evaluates routes against current electric aircraft capabilities. The Eviation Alice, with a maximum range of approximately 460 km, and the Heart Aerospace ES-30 hybrid configuration, with extended range to approximately 800 km, define the operational envelope for near-term eRAM services. Routes are categorized as follows: (1) Short-range routes (<250 km) are fully feasible with current technology and offer optimal aircraft performance, (2) Medium-range routes (250-500 km) are feasible with performance margins, particularly with hybrid configurations, and (3) Extended-range routes (500-800 km) require hybrid-electric aircraft and a good weight/payload management (Baumeister et al., 2020; Kekäläinen, 2025).

Economic Viability Assessment incorporates three components: (1) aircraft acquisition and fixed costs, (2) operational costs including electricity, maintenance, and personnel, and (3) revenue potential based on realistic passenger volumes. Research indicates that aircraft for 9-30 passenger eRAM operations cost millions of euros in acquisition and require high utilisation to achieve profitability (Kekäläinen, 2025). Public Service Obligation subsidies are identified as a relevant mechanism to support initial route profitability and aircraft cost recovery (Kekäläinen, 2025).

6.4.2 Route Evaluation

Helsinki-Tampere (170 km) represents the highest-priority route based on integrated assessment criteria. The 170 km distance falls within the optimal range for a fully electric aircraft. The catchment population exceeds 1.2 million residents across the corridor. The user survey showed that 42.2% prefer this route, driven by existing high travel volumes and business connectivity between technology hubs. Current transport options include an efficient train service and a frequent bus service, limiting the competitiveness of eRAM for schedule-focused users. However, frequency and flexibility advantages could drive adoption among business travellers, particularly those seeking same-day round-trip capability. Experts recommended this as a strong corporate business route for early-stage operations, given demand aggregation and operational feasibility (Kekäläinen, 2025).

Helsinki-Oulu (620 km, Hybrid-Electric Required) represents an extended-range capability that requires hybrid-electric aircraft such as Heart Aerospace's ES-30. However, this route scores exceptionally high on demand criteria, with 62.2% survey user preference, strong business demand (manufacturing and technology sectors in the Oulu region). Current alternatives include a 9+ hour train journey or a 6+ hour car drive, indicating substantial potential to reduce travel time (>30% of the requirement met) (Kekäläinen, 2025; Suomi, 2025).

Helsinki-Kuopio (290 km) and Helsinki-Jyväskylä (280 km) represent medium-distance routes within the optimal range of Eviation Alice. Survey data shows demand for these routes (31.1% interested in Helsinki-Kuopio service and 24.4% for Jyväskylä). Both routes serve as PSO-subsidised services, indicating recognised connectivity gaps and government support infrastructure. Current multimodal alternatives require 4-5 hours (train or bus), offering a substantial time-saving opportunity (about 2 hours for Helsinki-Kuopio and 40 minutes for Helsinki-Jyväskylä).

Helsinki-Kajaani (400 km) is considered a medium-range route suitable for hybrid-electric services. Survey respondents shared concerns about connectivity issues in Northern Finland. The Kainuu region has a population of about 72 000 and a large manufacturing sector, creating specific business opportunities (Statistics Finland, 2025). At present, the area is only served by public service obligation (PSO) routes, and train journeys to Helsinki can take over 10 hours. Kajaani might be a promising area where eRAM could improve access, but it is important to estimate demand on this route carefully.

Helsinki-Rovaniemi (830 km) currently exceeds the range of electric aircraft and is more suited to future multi-leg routes or next-generation planes. That said, the survey revealed a strong desire among users, with 68.9% preferring this route, mainly due to tourism, high ticket prices, and accessibility issues. A practical approach could be to use Helsinki-Oulu (which is doable with the ES-30 hybrid) as an intermediate hub, then connect Oulu to Rovaniemi with future aircraft or operational techniques like intermediate charging stops. This plan would meet high user demand while considering the current limitations of aircraft technology.

Regional cross-connections like Turku-Tampere, Tampere-Jyväskylä, and Kajaani-Tampere are exciting new opportunities to lessen dependence on Helsinki's hub-and-spoke system. While current demand is potentially low and existing transport options are competitive, there is interest (4.4% for Turku-Tampere based on survey responses). Experts believe these routes could become more viable as fleet utilisation improves and operational costs decrease, especially when electric aircraft operating costs drop by about 25% after amortisation.

6.4.3 Economic Viability Analysis

Implementing eRAM routes involves an upfront investment in aircraft, usually ranging from €2-5 million per plane for 9-30 passenger electric or hybrid models (Kekäläinen, 2025). These initial costs are the biggest challenge to starting the service and highlight the importance of maximising aircraft usage. Experts point out that "you need to find a solution to kill the price of the plane. After it is paid, you only pay for electricity" (Kekäläinen, 2025), showing that the most challenging part for profitability is often during the debt repayment period. However, it gets easier once the capital costs are covered.

Operational costs include electricity, which is the main variable expense for electric aircraft, as well as maintenance, personnel, airport fees, and insurance. Maintenance costs for electric motors and batteries are significantly lower than those for combustion engines, although there is limited operational experience with these systems so far. Staff requirements are fixed costs, and to be cost-effective on smaller aircraft, multiple daily rotations are typically necessary.

Survey analysis shows that many potential users are highly price sensitive. About 42.2% are not willing to pay extra for electric flights, while 28.9% are open to paying up to 10% more. This means that pricing plays a significant role in the revenue we generate per passenger, and staying competitive with current options is essential. Experts recommend focusing first on corporate travellers, who tend to value time savings highly and are more willing to pay a premium (Kekäläinen, 2025; Suomi, 2025).

7 Conclusions and Recommendations

7.1 Synthesis of Key Findings

This section highlights the key discoveries from the research, bringing together detailed geographic and demographic analysis, insightful feedback from survey respondents, two expert interviews, and theoretical ideas from Innovation Diffusion Theory, Regional Innovation Systems, and Transport Network Theory. The discoveries centre on three key themes: three main route groups for eRAM, the strong connection between evidence and theoretical expectations, and the crucial success factors for making the eRAM successful and sustainable. The following synthesis consolidates these findings into an actionable implementation roadmap.

Table 5 shows a prioritisation matrix that ranks routes from those suitable for immediate deployment to longer-term options. Each row represents a different stage of implementation, considering both technological readiness and market demand. The Demand Level shows survey responses, Technical Feasibility indicates whether aircraft capabilities meet current or upcoming needs, and the Rationale column provides the reasoning behind each category.

Table 5. Route Implementation Prioritisation Matrix

Route Category	Routes	Demand Level (Survey)	Technical Feasibility	Rationale
High Priority	Helsinki-Tampere	42.2%	✓✓ Fully electric feasible	Experts say this is a strong corporate business route for early-stage operations
High Priority	Helsinki-Oulu	62.2%	✓ Feasible with Hybrid	Strong interest from the manufacturing and technology sectors in the area. Current transportation options include a 9-hour train ride or a 6-hour car drive
Medium Priority	Helsinki-Kuopio, Jyväskylä	31.1%, 24.4%	✓✓ Fully electric feasible	PSO support is available, which lowers the financial risk for early-stage eRAM operators
Medium to Long Term	Helsinki-Rovaniemi (via Oulu hub)	68.9%	✗✓ Feasible with one stop	High demand but technological limits. However, establishing Helsinki-Oulu as an intermediate hub, then connecting Oulu-Rovaniemi, could address high user demand while respecting current technological constraints.

Three main patterns are identified: first, high-priority routes that balance technical feasibility with demand and economic viability; second, medium-term routes requiring infrastructure investments or hybrid aircraft; and third, future opportunities that meet the highest demand but require hubs or technological advancements to overcome range limitations.

Regional cross-connections (Turku-Tampere, Tampere-Jyväskylä, Kajaani-Tampere) also offer exciting opportunities to reduce dependency on Helsinki's hub-and-spoke dominance. These routes will become increasingly viable as fleet utilisation improves, and operational costs reduce after aircraft amortisation.

7.1.1 Theoretical Framework Integration

The integration of three theoretical lenses (Innovation Diffusion Theory (IDT), Regional Innovation Systems (RIS), and Transport Network Theory) successfully predicted patterns observed in the research:

This study confirms predictions from the Innovation Diffusion Theory (IDT). The theory states that specific characteristics of new technologies impact how quickly people adopt them. One key characteristic is observability, which refers to how visible or noticeable the technology is to potential users. The survey found that 53.3% of respondents did not initially know that electric aircraft could soon be used for regional flights. However, once they learned about it, they showed a high willingness to use such services, with an average rating of 7.5 out of 10. This supports IDT's prediction that when a technology is not yet well known, people may hesitate to adopt it, even if they are interested. Another important factor was the perceived advantage of the technology. Respondents mainly valued the potential for saving travel time, especially for trips between 300 and 500 km.

Regional Innovation Systems (RIS) theory suggests that successful innovation relies on collaboration among diverse stakeholders rather than on technical factors alone. Interviews with experts support this idea, highlighting that engaging stakeholders is crucial for the success of innovation projects. Christina Suomi pointed out that cooperation among local actors often matters more than technical feasibility, because they address important issues such as land use, safety, noise control, and economic concerns. The Nordic Network for Electric Aviation (NEA) is a good example of RIS in action, showing how manufacturers, airports, regulators, and policymakers working together can help promote electric aviation.

The study confirmed that the hub-and-spoke model is suitable for implementing eRAM in Finland, considering the country's population distribution and geography. Most demand, 83.9%, comes from routes connecting Helsinki to Tampere, Oulu, Kuopio, and Jyväskylä, while only 4.4% of demand is for direct regional flights. This focus on central routes is important because smaller aircraft

(carrying 9-30 passengers) need high passenger numbers to be profitable. The research also suggests that, as technology improves, network models similar to grid networks could emerge. However, experts recommend establishing initial hub routes first to ensure stability before expanding to other regional connections.

7.1.2 Other Key Findings

The research identified that Finland's existing Public Service Obligation (PSO) framework substantially reduces implementation risk for early-stage eRAM services:

Current PSO routes, such as Helsinki-Joensuu, Helsinki-Jyväskylä, Helsinki-Kajaani, Helsinki-Kemi-Tornio, Helsinki-Kokkola-Pietarsaari, Helsinki-Savonlinna, and Helsinki-Pori, are supported through government subsidy mechanisms with transparent processes and funding schedules. Experts suggest that it is a good idea to use PSO subsidies strategically to help cover aircraft fixed costs during the early stages of deployment.

Research also consistently emphasised that environmental advantage depends on a clean electricity supply. Under Finland's predominantly renewable electricity mix (hydropower-based), electric aircraft achieve up to 70% operational emissions reduction compared to conventional regional turboprops on short routes under 300 km. Battery production constitutes a significant portion of lifecycle emissions, requiring assessment beyond operational emissions alone.

Research shows that electric planes are better for the environment than cars for trips longer than about 170 km. However, they are less environmentally friendly compared to trains, which already use renewable energy and produce fewer emissions per passenger. This means electric planes have a clear environmental benefit in Finland, but this advantage depends on which transportation modes are compared. Building high-speed trains (like the Helsinki-Tampere-Turku route) could reduce the environmental benefits of electric planes on specific routes. Therefore, marketing should focus on benefits such as improved access, especially to routes where trains are impractical, rather than claiming that electric planes are always the most environmentally friendly option.

Early interest in electric aircraft is high: 37.8% of survey participants rated their likelihood of using them as 10 out of 10, showing strong initial support. However, awareness is still limited, with 53.3% unaware of upcoming electric aircraft capabilities. The main obstacles to adoption are price concerns (75.6%), safety and reliability worries (51.1%), limited flight routes (51.1%), and charging logistics concerns (17.8%). For leisure travellers, ticket prices need to be much lower than for business travellers, which initially restricts the market to business segments.

7.1.3 West–east connectivity considerations

Finland's transportation system, as described in Chapter 3.3, shows a consistent east–west connectivity gap outside the main corridors. The survey data mainly support north–south routes centred around Helsinki, with 83.9% indicating this preference. However, this may be biased, since 75.6% of participants were from Helsinki, and regions in the east and centre of the country were less represented. Expert interviews revealed potential for improvement in cross-regional routes such as Turku–Tampere and Tampere–Jyväskylä, suggesting hidden demand for east–west connections. In the short term, the deployment of eRAM should focus on high-demand routes in Helsinki and in the longer term, a strategic approach could include pilot projects for east–west routes, developed in partnership with regional stakeholders. This would help address Finland's longstanding connectivity issues in its peripheral areas and support regional collaboration, in line with the principles of the Regional Innovation Systems theory.

7.2 Research Limitations

As mentioned in Chapter 1.3, the scope and boundaries of this study were established at the beginning. This section examines limitations resulting from the data sources, sample sizes, and methodological choices used in the research.

7.2.1 Survey Sample Limitations

The user preference survey demonstrates significant geographic concentration, limiting the representativeness of its findings across Finland's regional diversity. Survey respondents showed geographic concentration: Helsinki (48.9%), Vantaa (17.8%), and Espoo (8.9%) together account for 75.6% of all responses. This overrepresentation of the Helsinki metropolitan area, while reflecting Finland's overall population concentration, substantially limits the research's ability to capture preferences and constraints specific to other Finnish regions.

The survey respondent demographic profile is also heavily biased toward early-career professionals and students: 64.4% aged 18–24 years and 24.4% aged 25–34 years, together comprising 88.8% of all respondents. This age concentration creates substantial validity concerns for any claim about "user preferences" broadly across Finland's population.

Employment status also skews the sample: 68% of respondents were students or unemployed, while 32% were employed. This employment profile suggests income constraints and travel patterns (vacation travel, visiting family) that differ substantially from those of full-time employed professionals who generate business travel demand. The research acknowledges that this group

"represents an important future market," but the present sample does not reliably predict actual demand from employed business travellers or established workers.

7.2.2 Expert Interview Limitations

The research involved conducting two expert interviews, as clearly stated in the thesis, with Christina Suomi and Roope Kekäläinen. These experts offer valuable experience and viewpoints, but their small number limits the scope of what can be concluded. Having only two experts means the study cannot fully capture the opinions of all relevant stakeholders involved in the project. Specifically, the sample lacks direct input from Finnish airports (Finavia), airlines, battery and propulsion manufacturers, grid operators, civil aviation regulators, and other participants in the Regional Innovation System. As a result, the expert opinions mainly reflect the perspectives of these two individuals and their networks, rather than representing the wider stakeholder community.

7.3 Future Research

This thesis offers fundamental insights into the potential for eRAM routes in Finland. However, further research is necessary. Long-term studies of how users adopt eRAM over time are important for understanding how preferences change as people learn more about the technology and more services become available. Additionally, increasing the number of survey participants from different regions across Finland, not just Helsinki, will help make the findings more accurate and applicable to the entire country.

A detailed technical evaluation of airport infrastructure, electrical grid capacity, and regulatory airspace integration is essential for practical implementation. At the same time, analyses comparing different transportation modes should consider how new high-speed rail networks and other alternatives affect the appeal of eRAM and shifts between transportation modes.

Finally, international comparative studies can place Finland's findings into a broader context of regional and global electric aviation development. This can help identify effective strategies that apply everywhere, as well as considerations specific to local areas. These future research directions will support the careful and evidence-based expansion of eRAM technologies beyond initial projects.

7.4 Thesis journey and limitations

This thesis has been a rewarding yet challenging experience. It revealed the complexities involved in researching new technologies in changing infrastructure and policy landscapes. I was particularly interested in electric regional aviation because of its potential to improve transportation and

reduce environmental impact. However, while reviewing the literature, I noticed that many sources repeated similar ideas and data. This made it challenging to develop an original theoretical background that would effectively support my practical research.

Writing the theoretical section challenged my motivation and engagement. While the conceptual frameworks were important for understanding the findings, they initially seemed abstract and disconnected from the actual data. Thanks to my advisors' guidance, I was able to overcome these difficulties and better understand how these theories help explain barriers to adoption, stakeholder relationships, and network effects. This process showed me how perseverance and good mentorship are essential in academic research.

The data collection process faced several challenges. It was difficult to gather survey responses from individuals outside the student group, resulting in a sample that was mainly younger people from Helsinki. Although the data provided valuable insights, including a more diverse group (such as older people, individuals from different jobs, and people from various locations) would have made the results more representative. Additionally, the number of expert interviews was limited due to participants' availability. This limitation affects how broadly we can apply the findings to other contexts related to operational feasibility and policy decisions.

This thesis helped me better understand both the topic and how research works. It showed me the importance of being flexible, thinking carefully about my work, and recognising that a study cannot cover everything in a fast-changing, complex field. In the future, these lessons will guide my research and help me value the collaborative, ongoing process of gaining knowledge in dynamic areas.

7.5 Final thoughts

This research shows that eRAM is a practical and important option for improving transportation in Finland while supporting sustainability goals. Using a mix of methods, including geographic data, surveys, and interviews with experts, the study highlights some routes as key, with strong potential for success. These routes are chosen because they have strong demand, are within the range of future initial electric aircraft, and offer significant time savings compared to existing transport options. Challenges such as travellers' price sensitivity, low public awareness, regulatory changes, and infrastructure needs can arise. However, Finland's use of renewable electricity, existing policies, and collaborative efforts position it well for eRAM development. The findings offer practical guidance on which routes to prioritise, balancing technical, economic, and other factors.

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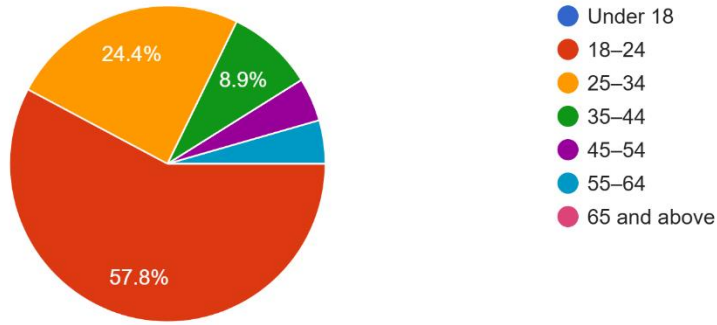
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Appendices

Appendix 1. Perceptions Survey results

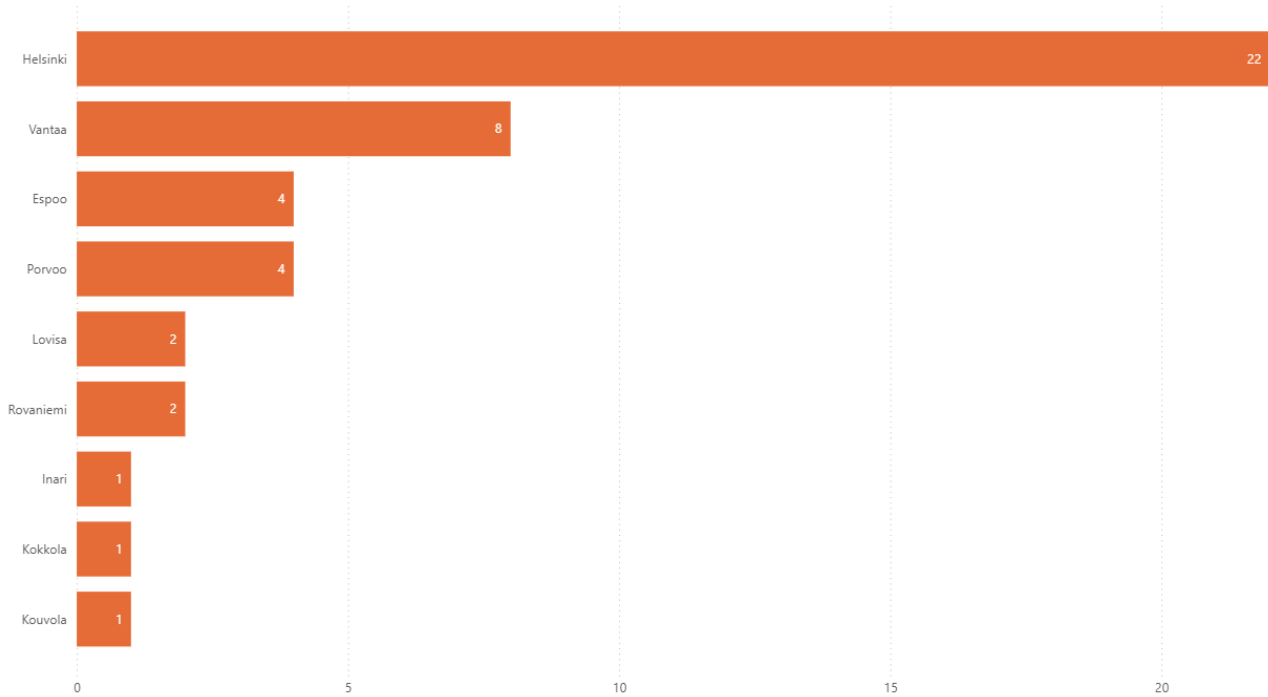
1. Which age group do you belong to?

45 responses



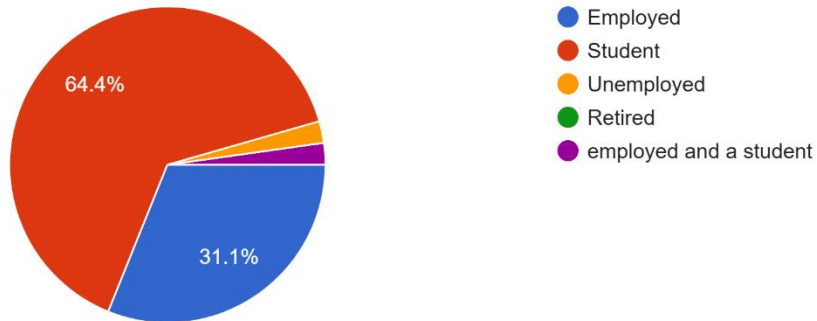
Where is your primary residence located? (City)

45 responses



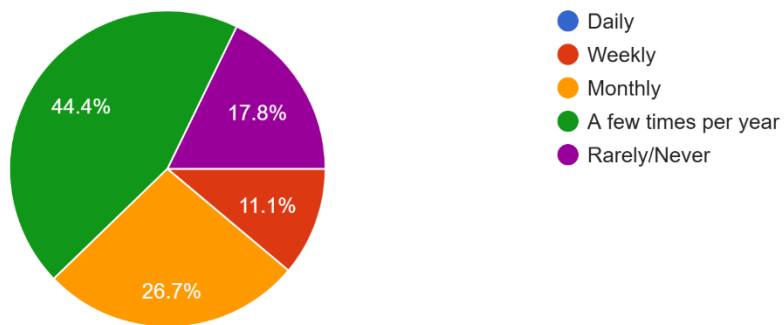
3. What is your current employment status?

45 responses



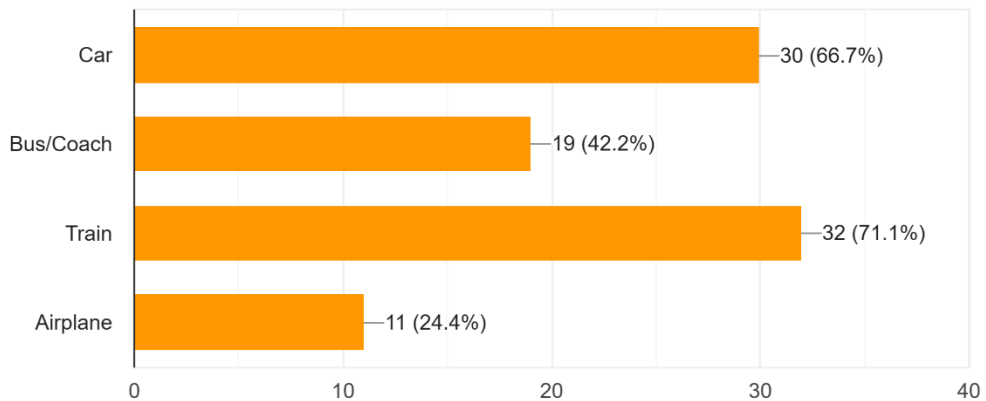
4. How often do you travel a distance of more than 100 km between cities or regions in Finland?

45 responses



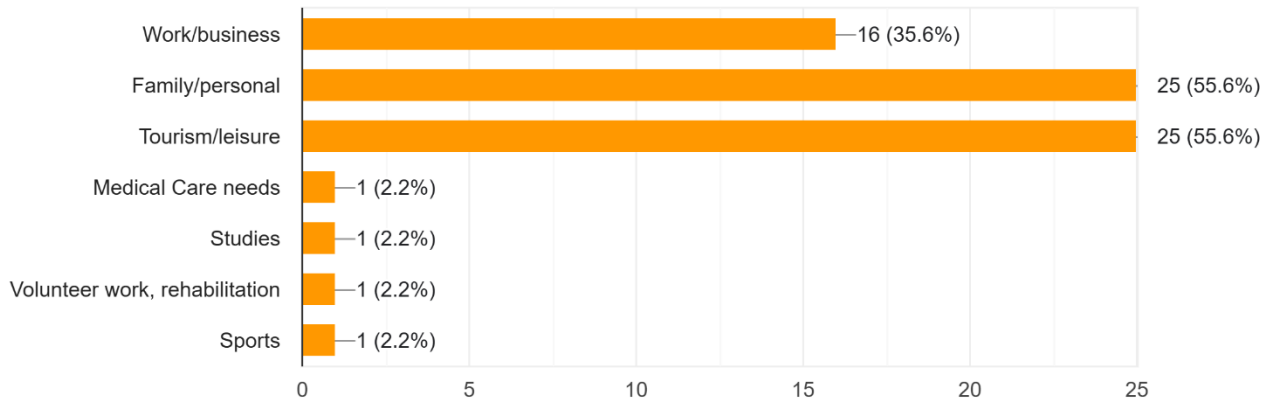
5. What modes of transport do you typically use for intercity/regional trips? (Select all that apply)

45 responses

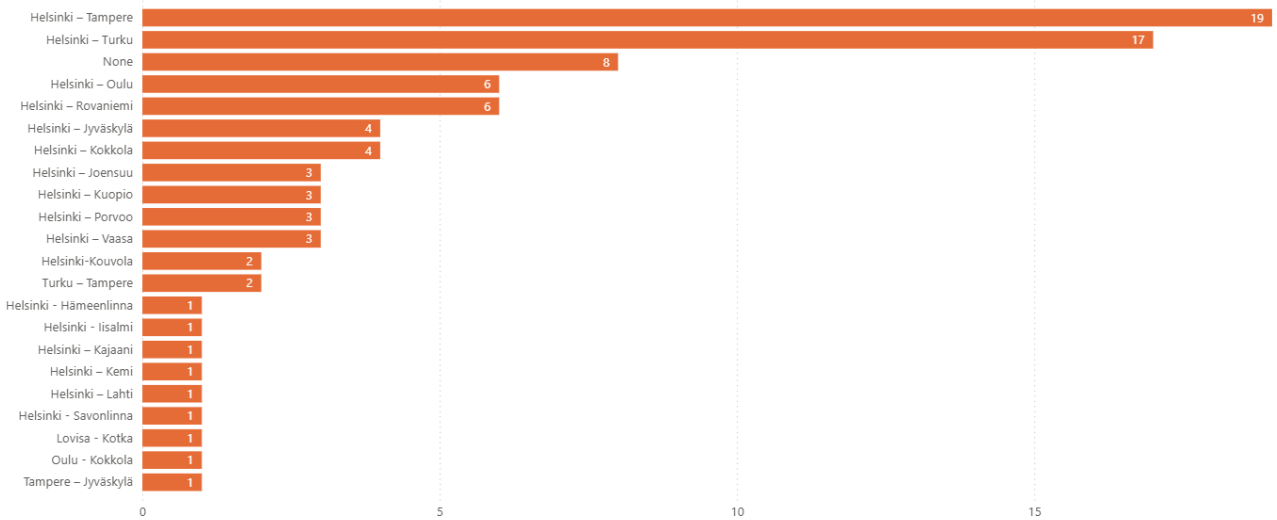


6. What are the main reasons for your intercity/regional travel? (Select all that apply)

45 responses

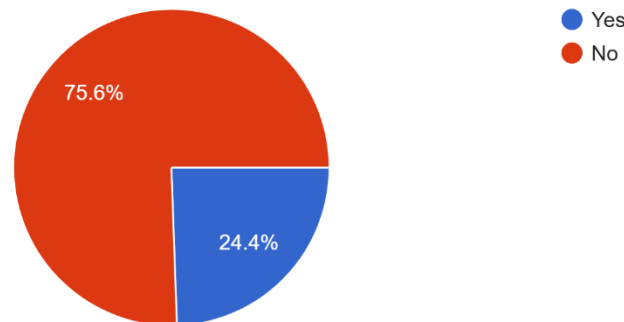


7. Which regional routes or city pairs in Finland do you currently travel most frequently? Please select all that apply or specify others.



8. Have you experienced challenges accessing regional destinations in Finland with current transport options? In which route?

45 responses



9. If yes, please describe the route and respective challenges.

"Helsinki-Kouvola occasional train delays, even cancellations"

"Helsinki-Oulu: after COVID lack of competition and Finnair monopoly flight tickets for this route can be very expensive."

"The argument for not keeping small airports in Finland, due to the economics, is understandable. Now when there are routes available, the timetables are sometimes difficult to puzzle together."

"Cost, schedules, delays"

"Any route where you need to change trains is difficult, because trains are often late and the changing times short."

"Helsinki-Kittilä, planes are crazy expensive, buses are uncomfortable and take forever. Trains only go up to Rvn/Kolari, so you still have to figure out some way of getting to the destination in addition to the train trip"

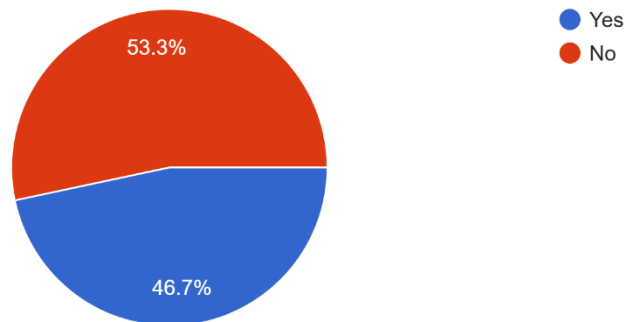
"Helsinki Porvoo. Only one bus service dominates, and ticket price is high"

"Many, places outside Espoo, Vantaa and Helsinki, become increasingly harder and expensive to get to, the further you go out and the options that are available are quite expensive as a student, granted if you book beforehand, they are cheaper, but not every can or would."

"Helsinki - Turku train tracks are tricky on the weekends"

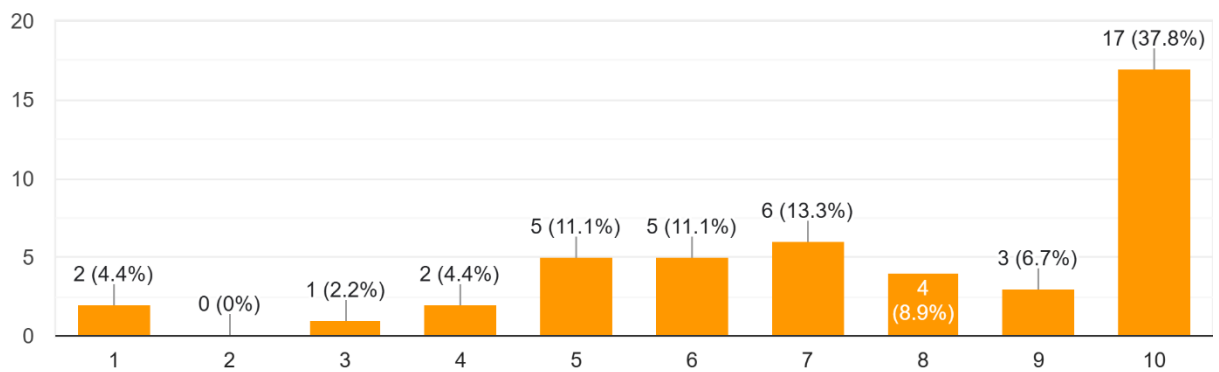
10. Before this survey, were you aware that electric airplanes might soon be used for regional flights?

45 responses

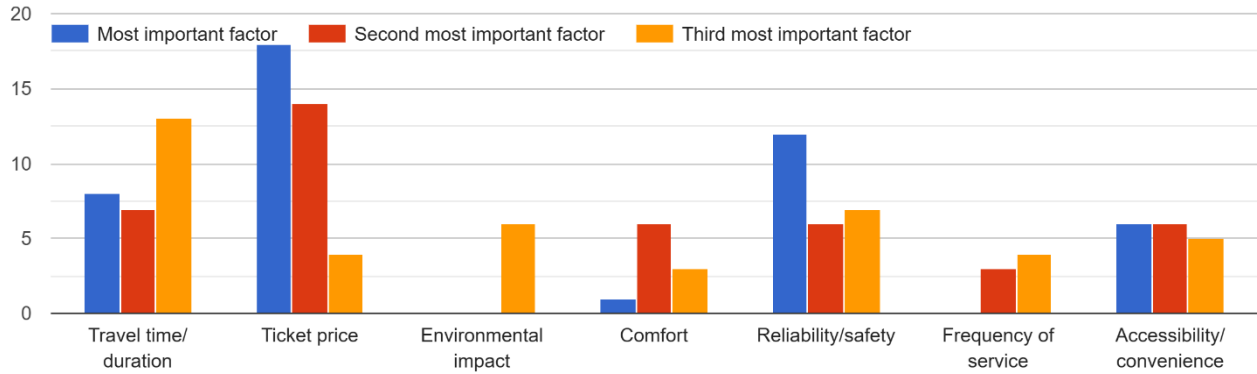


11. How likely would you be to consider using an electric airplane for a domestic flight in Finland?

45 responses

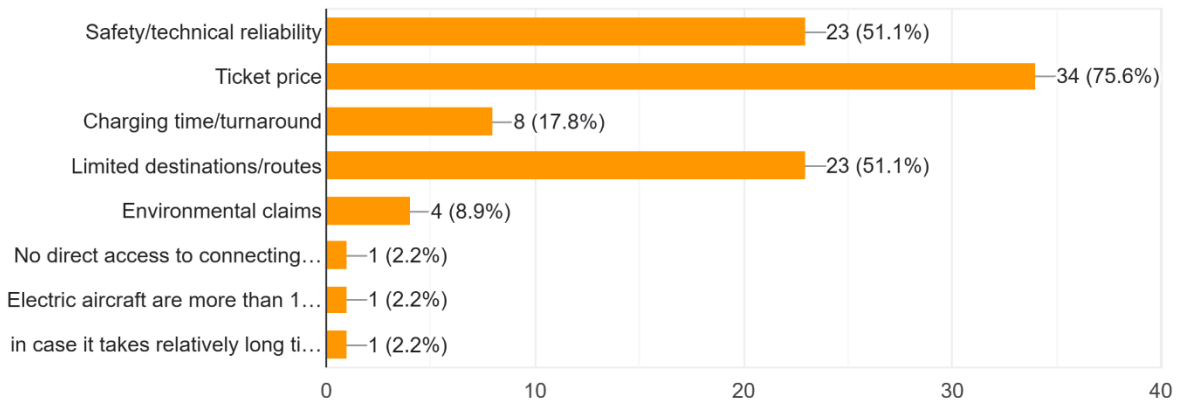


12. Out of the following factors, please choose the three most important for you when selecting an intercity/regional travel mode, and rank them from most important to third most important.



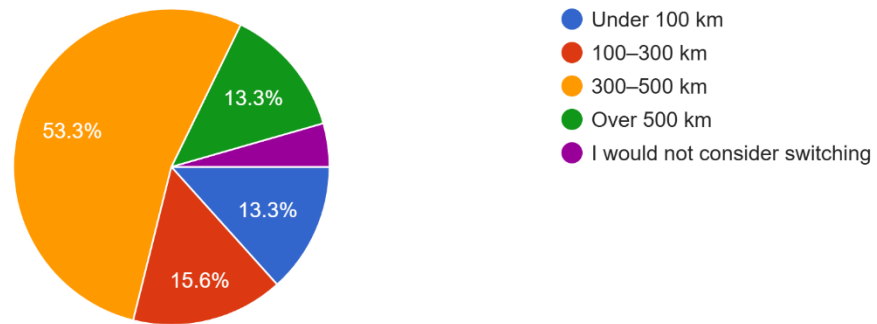
13. What could prevent you from choosing electric aviation? (Select all that apply)

45 responses



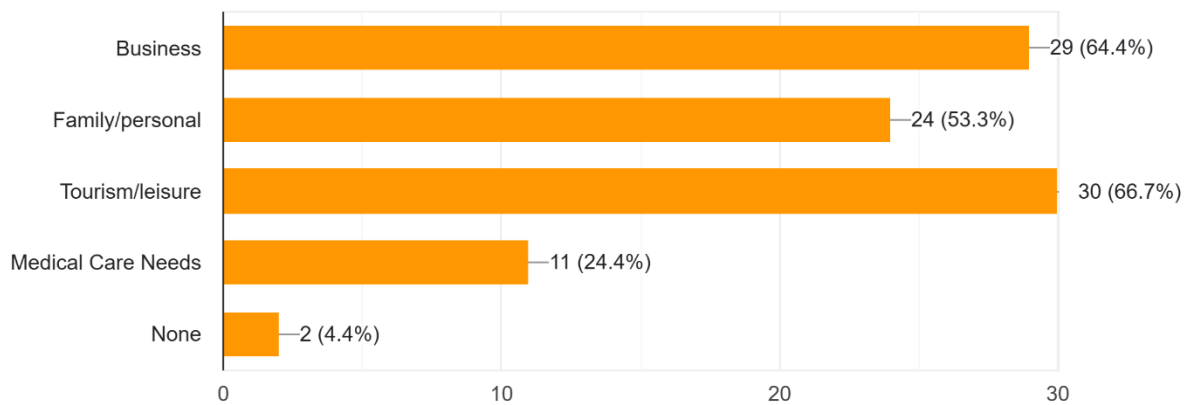
14. On what trip length would you consider switching to electric flights rather than other type of transport?

45 responses

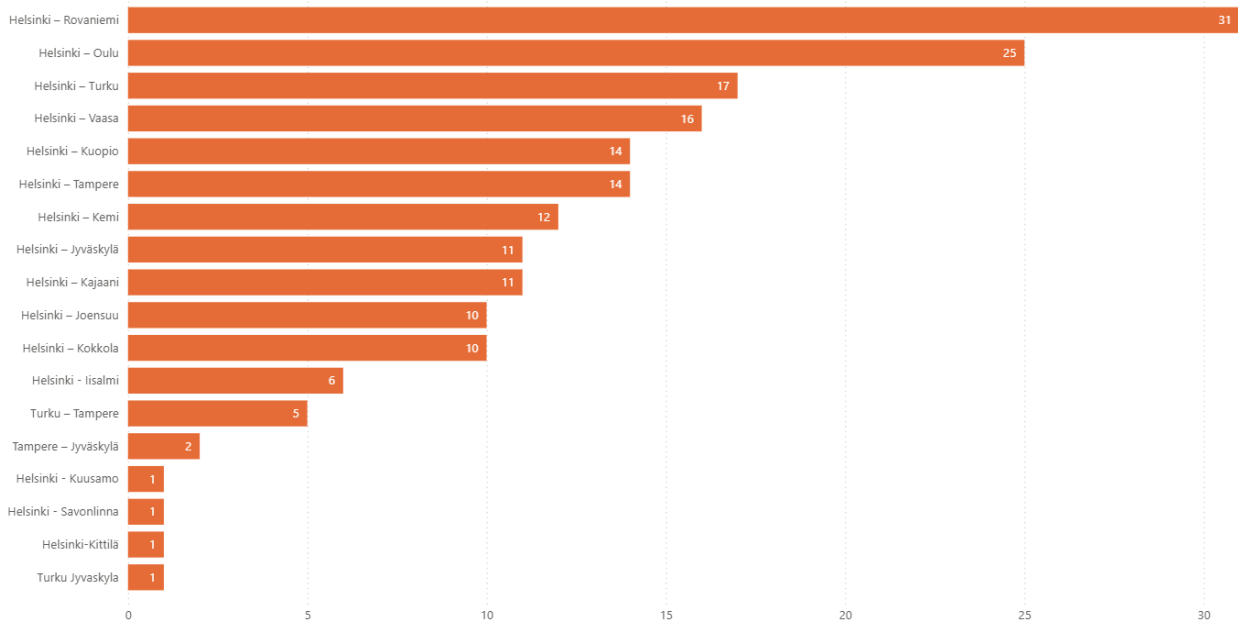


15. For which travel purposes would you consider electric regional flights? (Select all that apply)

45 responses

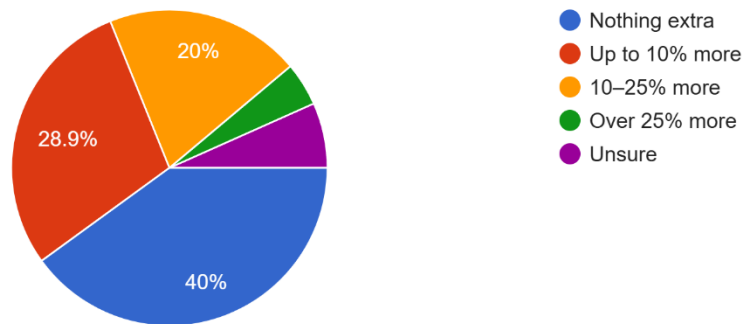


16. Which regional routes in Finland would you consider using electric Regional Air Mobility (RAM) services for? Please select all that apply or specify others.



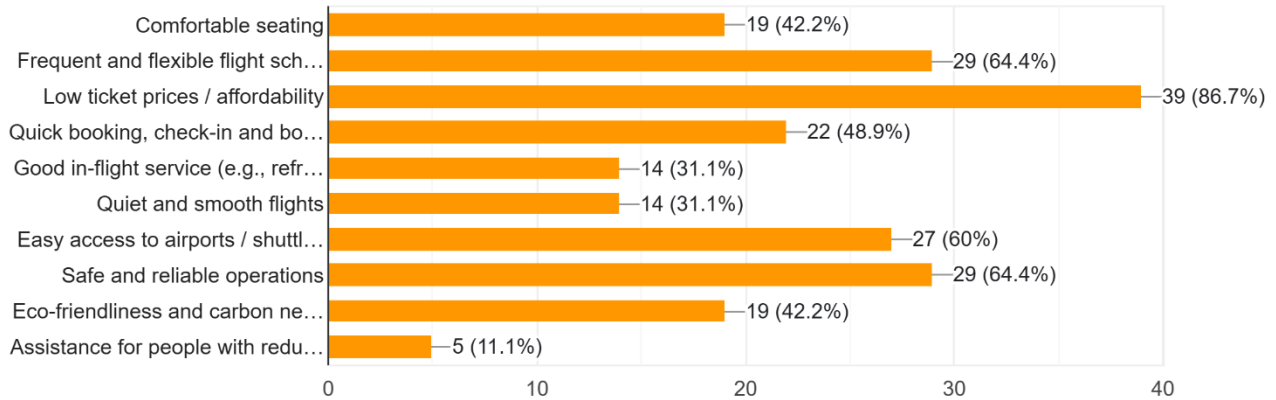
17. How much extra would you be willing to pay for a sustainable, all-electric flight compared to a normal flight on the same route?

45 responses



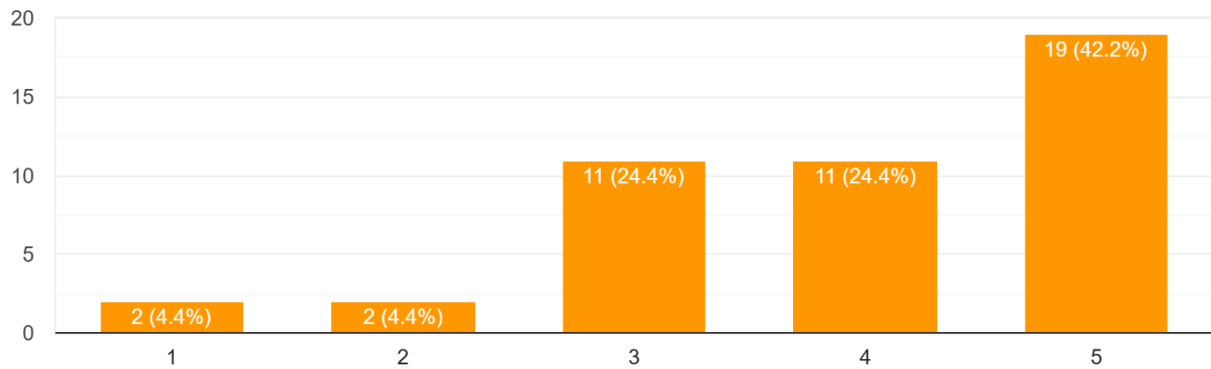
18. What service or comfort features would make regional electric aviation particularly attractive to you? (Select all that apply)

45 responses



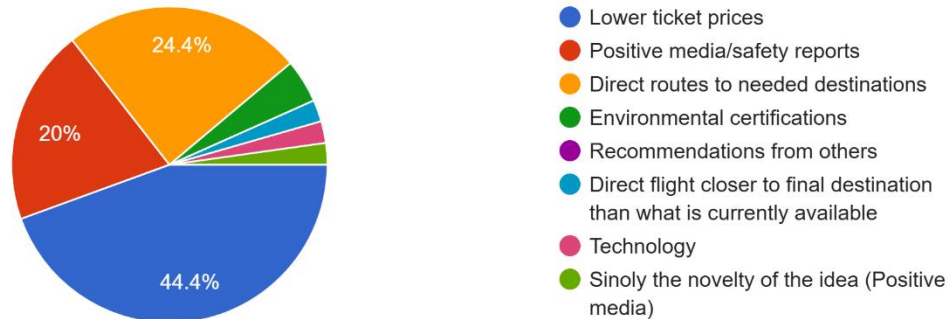
20. How comfortable would you feel travelling in a new electric aircraft on a short domestic flight?

45 responses



21. What would encourage you the most to try an electric flight?

45 responses



22. Do you have any additional thoughts or concerns regarding electric regional aviation in Finland?

"In a time where regional routes are being cut and/or replaced with lengthy train/bus connections due to environmental reasons I feel like electric aviation is a fresh breeze of new innovation. As an aviation professional myself I value Finnish aviation culture and choose plane for routes 300-500km due to convenience and travel times. However, for basic joes out there the ticket cost is the most important factor so electric plane tickets should be equally- or less expensive than traditional jet/turboprop tickets."

"I doubt if demand will grow only due to flights being electric, when there is no demand now with current aircraft"

"save Malmi airport"

"Personally, I'm looking forward to this future, but I suspect that the first couple of years might experience some headwind in public opinion."

"Cross boarder flights between Finland and Sweden are more needed"

"Whether the airports that these aircraft would operate from could turn a profit without needing to be kept afloat with many subsidies."

"It's crucial to fight the suit sport. If the distance is far, and I can get faster with plane, I would take it but for an affordable price, because I could also take the train/car but will be a bit longer time. So, finding the right locations/prices is definitely a need. Now the check in/security is also something crucial, meaning If it takes too long at the airport is a very tiring process that you do not have to

have by train or car. So, find a fast track for such condition flights would be good. There could be some creative question about luggage in this questionnaire, weights etc. What are the conditions for no passenger flights but let's say post or goods? could it be more profitable in this sense?"

"Make it cheaper than train"

"I don't think that it would be happening any time soon. Batteries are too heavy. Maybe hybrid at the best where you would carry final reserve and alternate fuel as low weighted JET and the trip "fuel" as electricity. But as a downside you would have then two technologies in one aircraft and thus doubling the maintenance costs."

"Safety reasons might stop people from choosing electric planes, ticket price also matters."

"Very excited about them!"

Appendix 2. Interview questions for Roope Kekäläinen

- Which routes in Finland do you believe have the highest potential for electric RAM implementation?
- What were the main challenges you've encountered when establishing routes like Helsinki-Örebro-Linköping? And what has changed with the North Sea route?
- What are the key factors to focus on when marketing electric aircraft flights?
- How important is collaboration with local municipalities, regional airports, and transport authorities in determining suitable electric RAM routes?
- What kind of infrastructure investments would companies or the government need to make at Finnish regional airports to support widespread use of eRAM?
- What kind of infrastructure investments would companies or the government need to make at Finnish regional airports to support widespread use of eRAM?
- What do you think is the most relevant customer segment for electric RAM services in Finland in the future?
- If you were to interview someone, whose opinion would you like to have?
- Do you think electric aircraft would face bigger challenges in winter conditions?

Appendix 3. Interview questions for Christina Suomi

- Which areas around Helsinki are most promising for the implementation of eRAM?
- Is eRAM easy to implement in Finland soon, or will changing the infrastructure and regulations take a lot of time?
- CTR restrictions - could the current airspace structure and regulation prevent the implementation of eRAM?

- How important is the cooperation of many stakeholders (municipalities, airports, authorities, OEMs) in route selection?
- What main transport challenges in Finland could eRAM realistically help solve?
- What factors should be prioritised when choosing routes?
- What are the most important regulatory or operational barriers before the large-scale deployment of eRAM in Finland?
- What lessons from the Helsinki U-Space project should be used for eRAM integration?