Opportunities for regions with zero-emission aircraft technology

AFCS

28 May 2021

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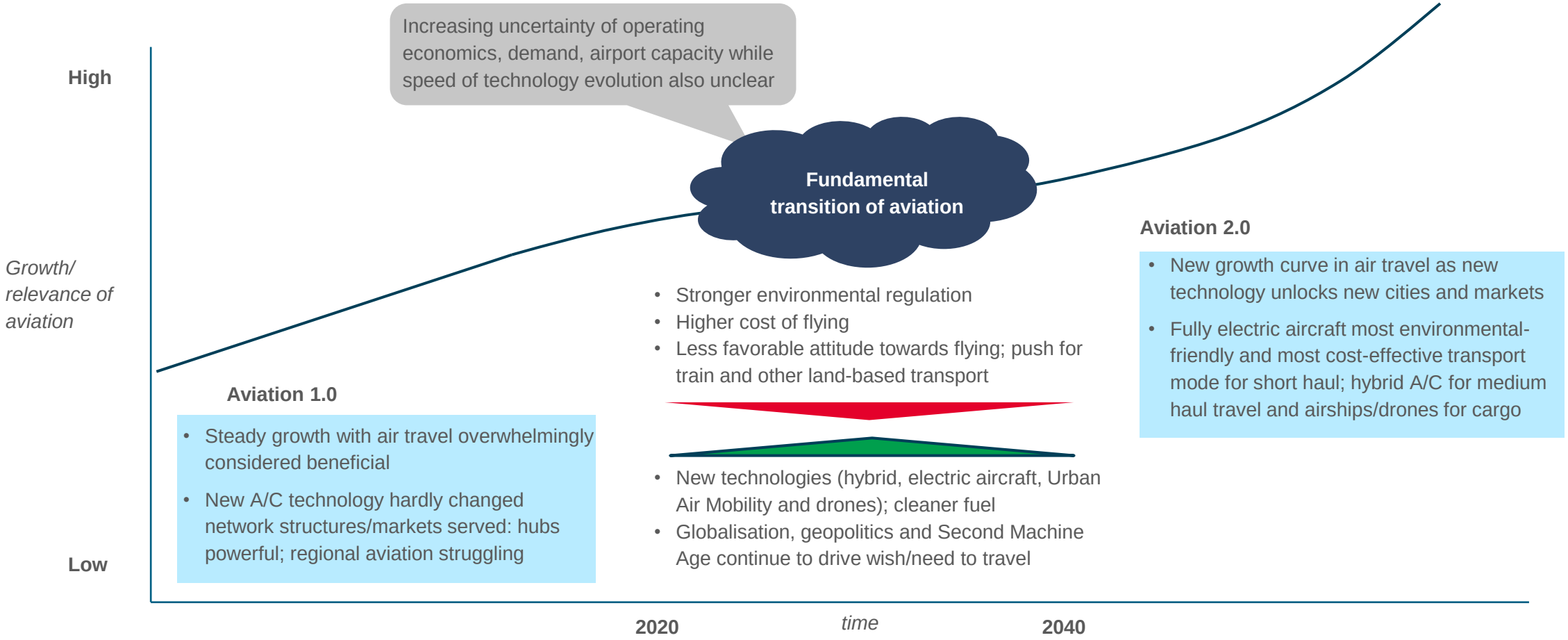
Aviation 1.0 is under increasing pressure with more uncertainty for stakeholders but with a bright prospect of Aviation 2.0 after a fundamental transition



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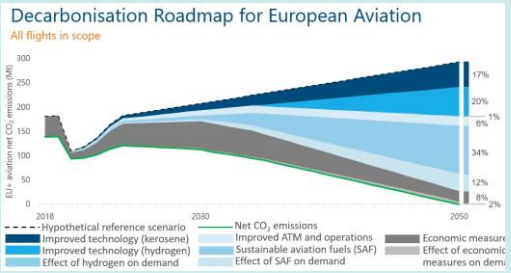
Sustainable aviation efforts traditionally focuses on making air travel more sustainable.....

Sustainable Aviation

Aspect	Key developments	Relevance to society	Industry initiatives (example)
Making air travel more sustainable	• Sustainable Aviation Fuel • Electrification of airport operations • New large aircraft • Pricing/fiscal measures	• Essential to drive down aviation emissions • No improvement in network • Higher cost (with likely reduced growth) • Gradually lower emissions per flight • Same stakeholders as today	

The sustainability measures for making current air travel more sustainable also bear the risk of reduced connectivity, mainly for regional aviation

An increasing environmental pressure is put on aviation…

Increasing operating constraints

- Calls for capping growth/annual volume
- Opening new runway/ airport capacity blocked

Rapidly deteriorating support for aviation

- Negative stance towards
- Inability of aviation sector to formulate compelling narrative

Increasing cost and changing aircraft economics

- Ticket taxes, CO2 costs, VAT on tickets, excise duties on jet fuel and noise/emission-based airport charges

Fundamentals of hubs likely to be challenged

- Airline pricing based on willingness to pay does not match with environmental optimisation
- Discounts given by airports for transfer passengers hard to justify (especially when capacity constrained)

…which will reduce environmental footprint but at a cost

Direct effects

- Reduced (growth) in CO2
- Locally improved air quality
- Reduced noise (as older aircraft are being replaced with newer, less noisy aircraft)
- More airlines to face financial difficulties,
- More airports (***especially regional airports***) face financial difficulty

Indirect effects

- Reduced airline profitability will make investments in cleaner technology more difficult
- Reduced benefit of connecting people and businesses. Countries highly dependent on aviation and inbound tourism affected the most
- ***Risk of losing infrastructure*** that will be needed again once new aircraft technology is maturing

Sustainable aviation also entails breakthrough technologies that will greatly enhance regional air mobility

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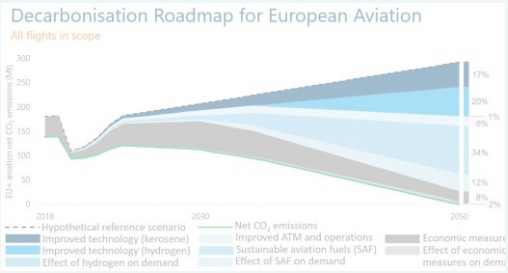
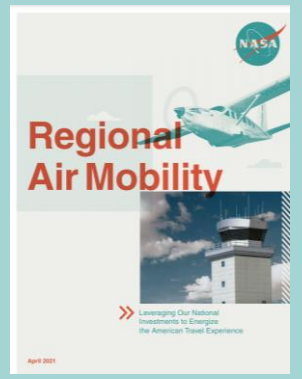
Making air travel more sustainable	• Sustainable Aviation Fuel • Electrification of airport operations • New large aircraft • Pricing/fiscal measures	• Essential to drive down aviation emissions • No improvement in network • Higher cost (with likely reduced growth) • Gradually lower emissions per flight • Same stakeholders as today	
Leveraging new sustainable aircraft technology to improve regional connectivity	• New propulsion technologies • New small scale aircraft (with some retrofitting) • New energy providers (storage/fueling) • Policy and regulatory context not yet adapted with potential bottlenecks in certification	• Massive expansion of regional networks • Much reduced cost for like-for-like A/C size • Much reduced travel times between regions • Reduction of car emissions and potentially avoidance of land-based infra investment • Much lower noise footprint • Positive commercial business case • Opportunities for new aerospace businesses	

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There are three relevant new aerospace technologies being introduced in the next 5 – 10 years

Battery-/hydrogen-electric aircraft

- Battery-electric electric planes initially with 9-19 seats (2025-2030) at ranges up to 500-750 km; after 2030 also up to 1000 km and possibly more seats
- Hydrogen-electric aircraft may have as early as 50 seats 500-750 km between 2025-2030
- Hybrid aircraft possible with 70 seats from 2028

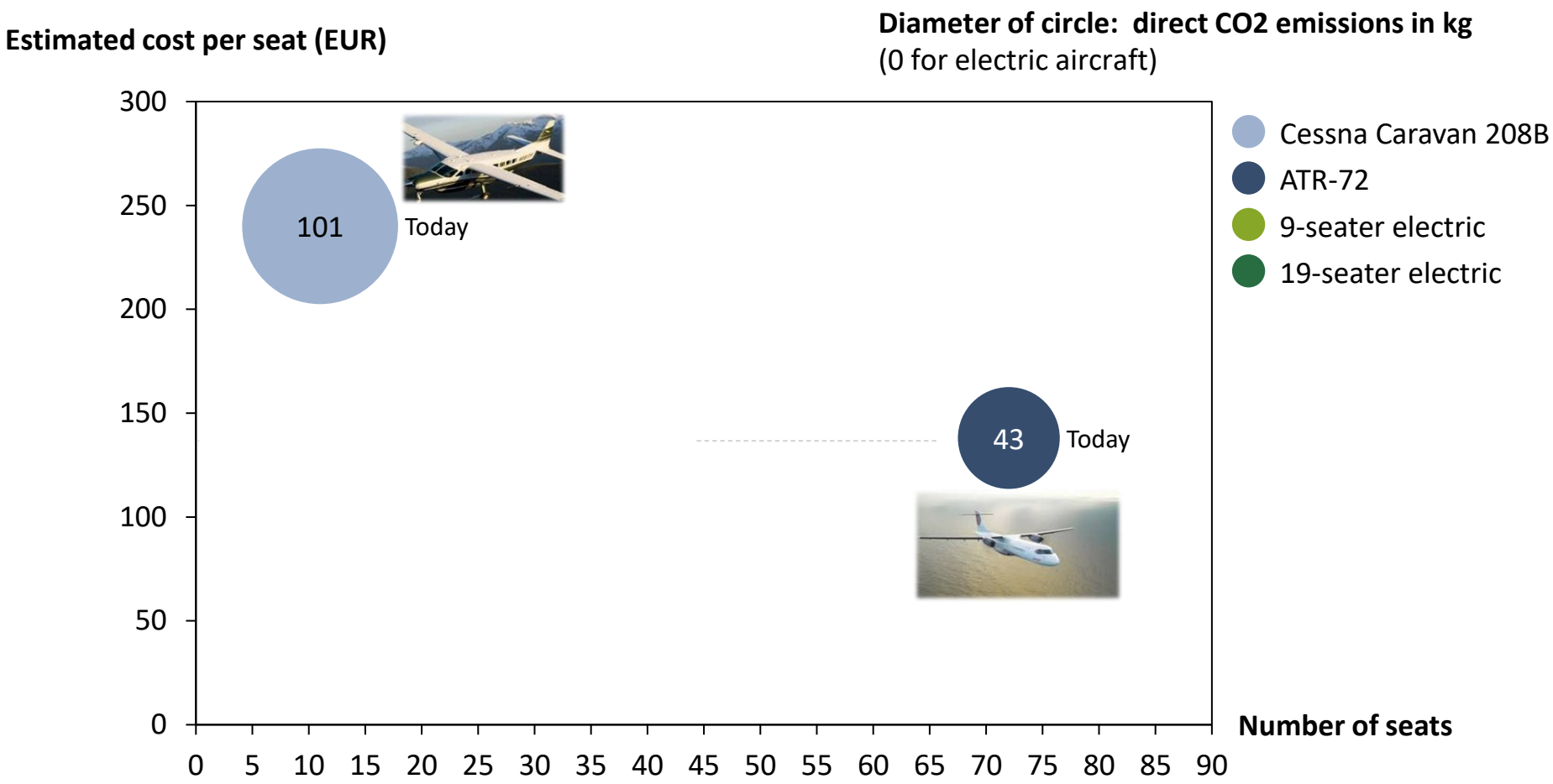
Urban Air Mobility (eVTOL)

- "Air taxis" (Urban Air Mobility) with electric drive and "Vertical Take-Off and Landing" (VTOL) with 2 - 7 passengers at distances of 25 - 200 km
- Initially with pilot; but unmanned is already being tested in China

Cargo drones/air ships

- Urban package services initially mainly for medicines / medical transport; but also already committed to packages
- Medium-distance air cargo drones (2500 kg over 1800 km in 2022/2023); also initiatives for Boeing 747 freighter-comparable capacity without pilot (halving air freight costs)
- Airships with potential remote area deployment for heavy loads (60 tons by 2024)

Battery-electric aircraft will allow operating thin routes more viably and more sustainably



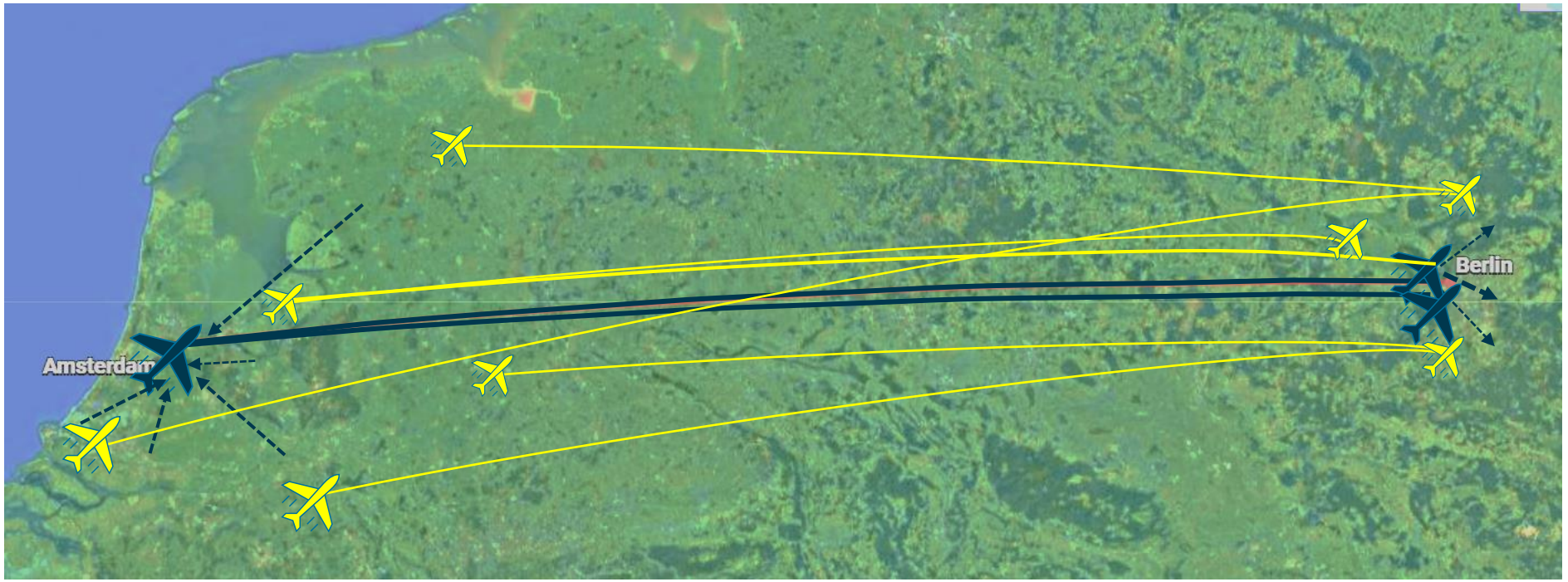
Bron: M3 analysis based on extensive bottom-up modelling of cost, travel time, energy consumption and emissions

Small-scale zero-emission technology will not replace current routes but serve regional flows that are not viable with Aviation 1.0 technology

Aviation 1.0 connections

Current landside feeders

Potential Aviation 2.0 connections



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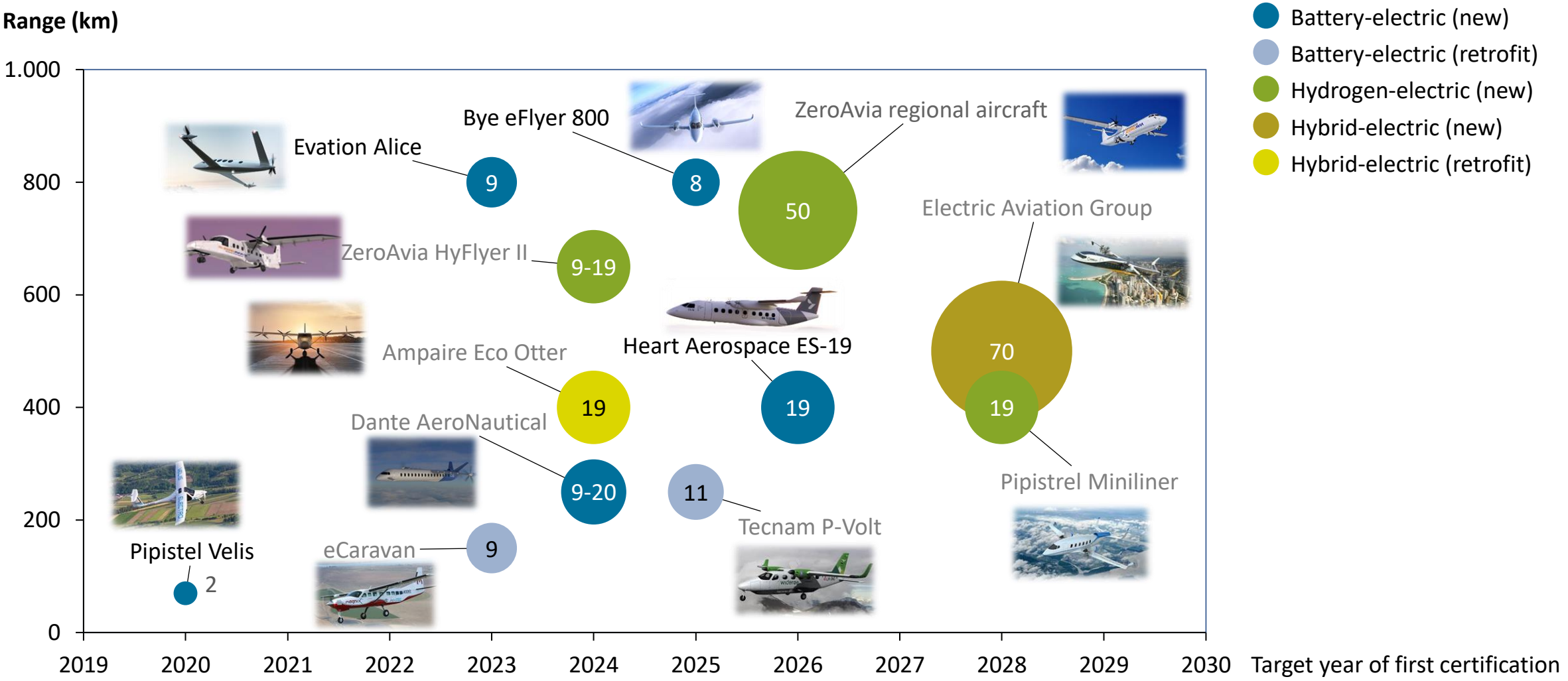
In the next 5 – 7 years the first zero-emission aircraft will enter the market

Selection van announcement of zero-emission and hybrid aircraft by year of target certification

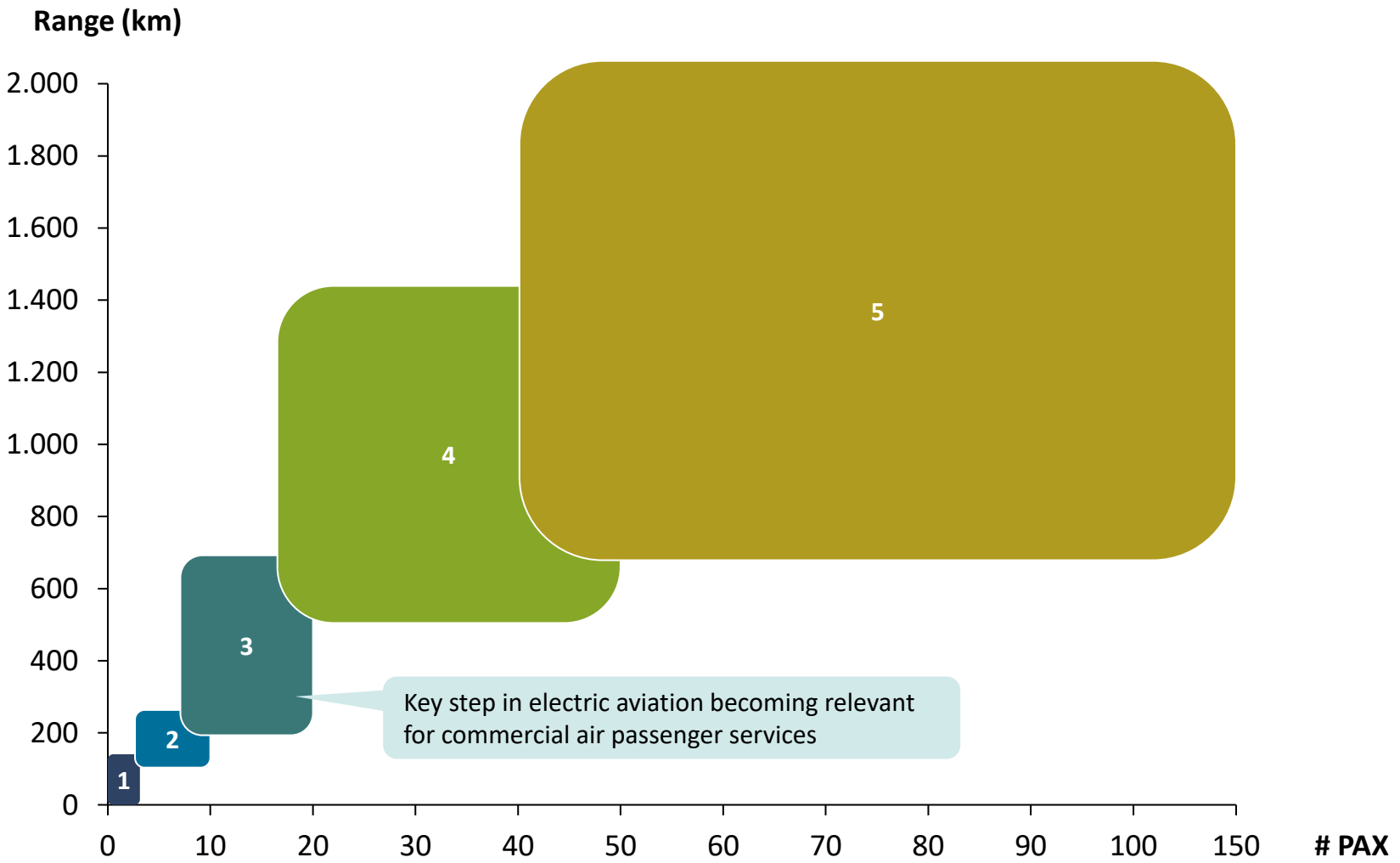


Note: the range has not been announced for all aircraft types and estimated based on technology. In practice, performance may turn out to be less than currently announced

Source: M3 desk research

We expect zero-emission aircraft to reach maturity beyond 2035, in 5 distinct stages

Development of range and size of zero-emission aircraft

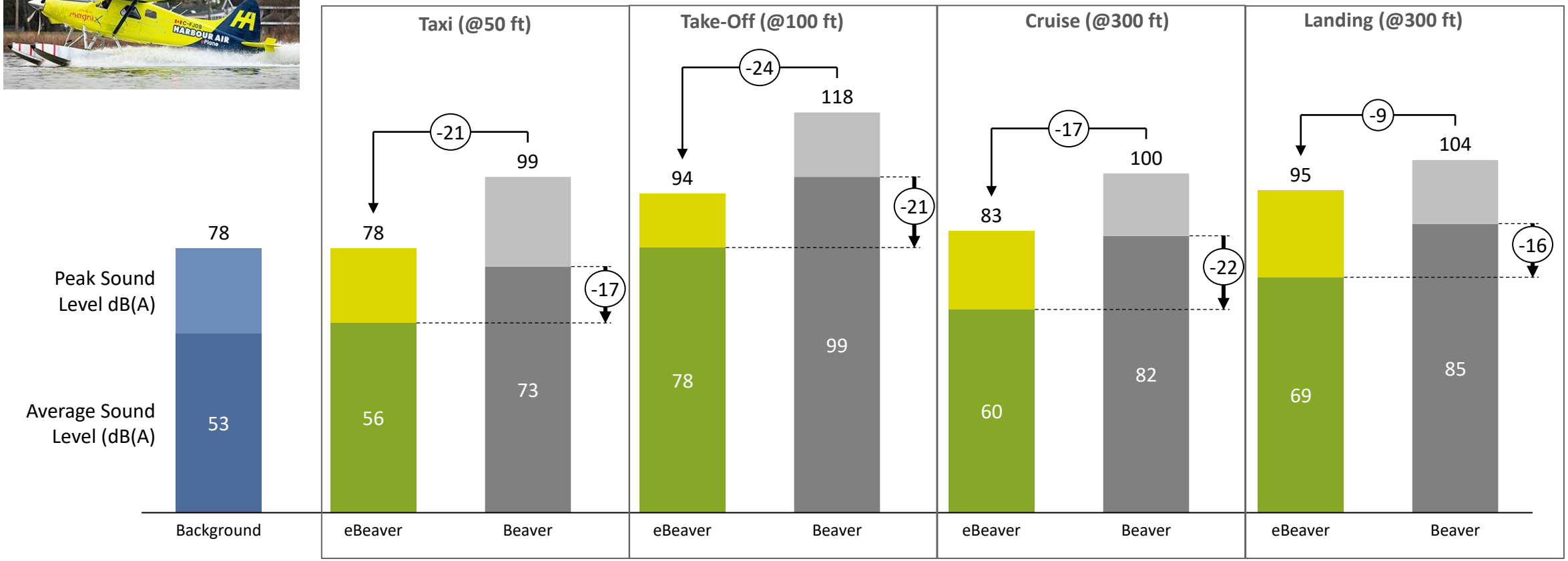


1. Current status: several battery-electric and hydrogen-electric test flights, and 2-seater aircraft certified
2. 2024-2026: battery-electric STC'd aircraft come to market (eCaravan, P-Volt)
3. 2026-2030: new design battery-electric aircraft come to market (e.g. Alice, Heart)
4. 2030-2035: 2nd generation battery-electric and hydrogen aircraft (Alice successor, Miniliner, H_2-propelled Dash 8)
5. 2035-2040: hydrogen/hybrid aircraft for medium range and 50+ pax (Airbus)

Source: M3 Consultancy/PEN EM

Recent test shows 16-22 dB(A) average sound level reduction across various flight segments when using an electric engine compared to a convention engine using a Harbour Air / MagniX DHC-2 Beaver

20 dB(A) reduction is equivalent to 100 times lower noise energy and 4 times quieter perceived sound level by humans

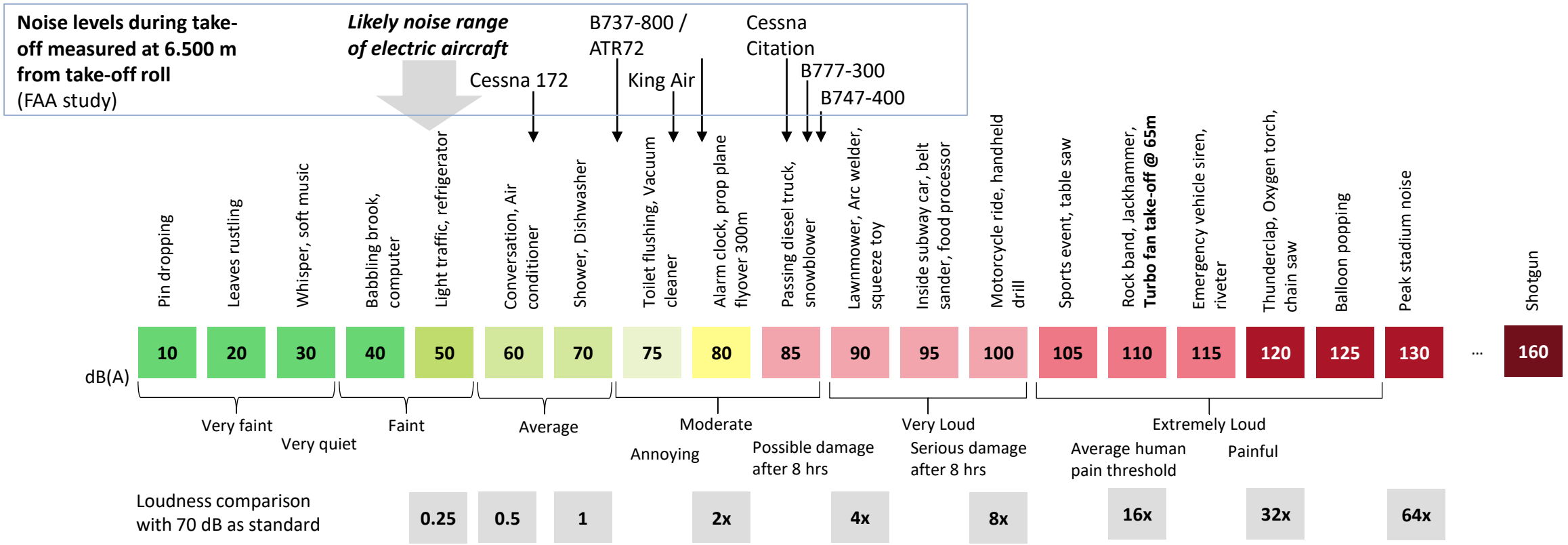


Taxi and cruise sound levels for the eBeaver are similar to normal background noise levels

Source: https://transportup.com/headlines-breaking-news/vehicles-manufactures/truth-in-data-magnix-testing-shows-considerable-noise-reduction-in-electric-aircraft/

The noise level of electric aircraft will likely be well below current aircraft noise levels and at or below background noise levels outside of the airport perimeter

dB(A) = Decibels, A weighted



Source: https://soundproofingguide.com/decibels-level-comparison-chart/ ; https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_36-3H_with_chg_1.pdf

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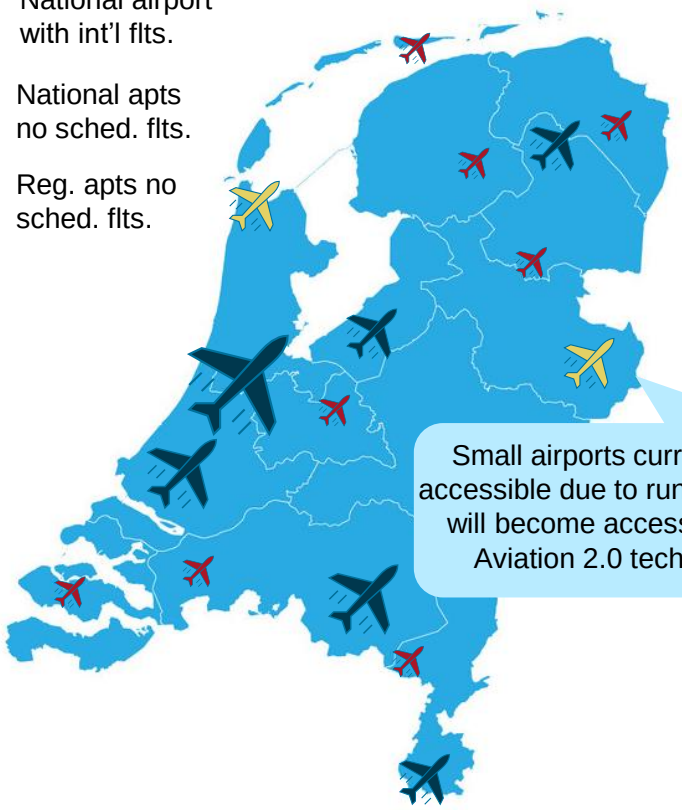
New aircraft technologies will profoundly change aviation networks

Many new small airports will become accessible for passenger/cargo air transport

National airport with int'l flts.

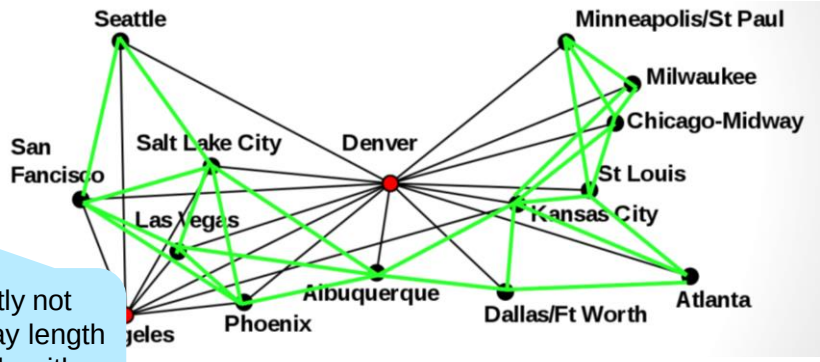
National apts no sched. flts.

Reg. apts no sched. flts.



Small airports currently not accessible due to runway length will become accessible with Aviation 2.0 technology

Thinner routes will become viable resulting in much expanded networks (reduced need for PSO)



More on demand services due to much lower cost per seat for small A/C

City airports will get a new lease of life due to reduced noise footprint

Example: Paris Le Bourget airport

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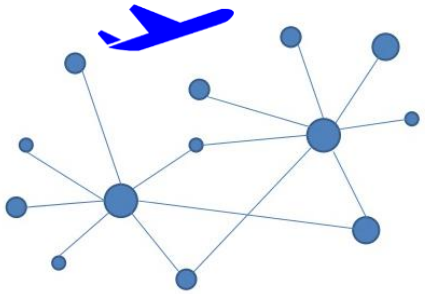
Improved air accessibility from regional airports can have a positive impact on regional economic growth especially in the Services/IT sector

Air accessibility



Economic growth

Impact of air accessibility on economic growth

- Causality largest for large airports
- However, causal relation of ***air accessibility driving economic growth can also be found for regional airports*** in particular when:
  - The regional airport is important in the region's overall air accessibility
  - The Services/IT sector constitute a high share of the economy
- A network of 10 – 15 additional destinations for a region of 500k – 1 million inhabitants enabled by zero-emission technology will likely have a significant economic impact

Impact of economic growth on air accessibility

- Strong causality for all airports: economic growth drives air accessibility
- However, for regions with low density and low economic activity economic growth may not directly lead to better air accessibility due to the minimum efficient scale of operations required for an air network
- Zero-emission aviation will reduce this minimum scale and therefore result in a better air accessibility

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Source: Faculty of Spatial Sciences, University of Groningen (draft paper:Regional airports: runways to regional economic growth? (Pot; Koster)

Branded as Power Up the Proof-of-Concept initiative was officially announced in April targeting a launch of services between Dutch regional airports in 2026

Dedicated website to share updates

Scope
- The testing of commercial zero-emission passenger air services on a limited set of domestic routes in the Netherlands

Planning
- Launch of first commercial flights in 2026

Role of airports
- Provide a package of conditions related to airport cost and airport operations at the participating airports for the operation of zero-emission flights between those airports
- Contribute alongside other Regional Air Mobility stakeholders to securing a favorable operating context

Approach
- Airports prepare a “package” e.g, airport readiness, efficient (special) pax process, discounted charges, slot access, etc.
- Launch tender-like process to secure operator
- Conduct thorough market consultation ahead of the tender process to ensure package is attractive and planning is realistic

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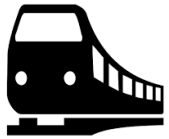
Aviation 2.0 will have significant implications for spatial development and other means of transport and will boost regional development

Spatial development

- Noise footprint of airports will shrink enabling housing/commercial property development in typically highly valuable locations near airports
- Need to identify locations for new VTOL ports or short runway airports



Other modes of transport

- Aviation becomes most sustainable operation (as infra already in place mostly with no impact on land)
- Business cases for ferries, new long distance rail links and hyperloop will be affected as Aviation 2.0 will offer lower cost of air travel and much denser network and/or higher frequency

Regional development

- Better connectivity of regional cities will be a powerful counterforce against the trend of concentration of people and economic activities in centrally-located big cities
- Where we live and where we work will profoundly chance in the long term

Impact on air travel

- Short term: Increase due to gain in modal share
- Medium/long term: Increase due to growing overall mobility

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Regional Air Mobility is a new ecosystem of stakeholders with common interests that will benefit from a joint vision, roadmap and a supportive policy context

- Inspires and guides the ecosystem
- Identifies and respresents common interests
- Coordinates efforts at national/ international level

Regional Air Mobility ecosytem

Industry participants

- Zero-emission regional aircraft OEMs and their main suppliers
- Regional airlines and air mobility service providers
- Regional airports, vertiports and air navigation/UAM service providers
- New energy providers

Beneficiaries

- Regional governments
- Regional business community, knowledge institutes and
- Travellers

Facilitates/enables/accelerates

Policy makers and authorities

- European authorities (EASA)
- European policy makers
- National policies including also economic affairs (it's not just a transport topic!)
- National authority (CAA)

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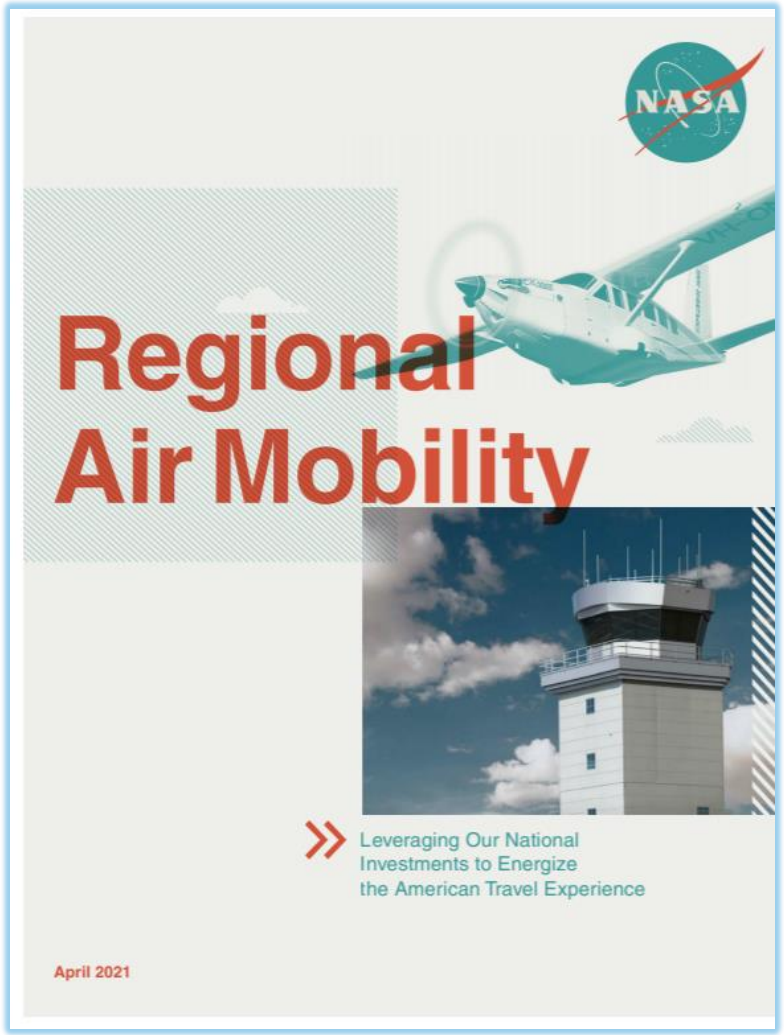
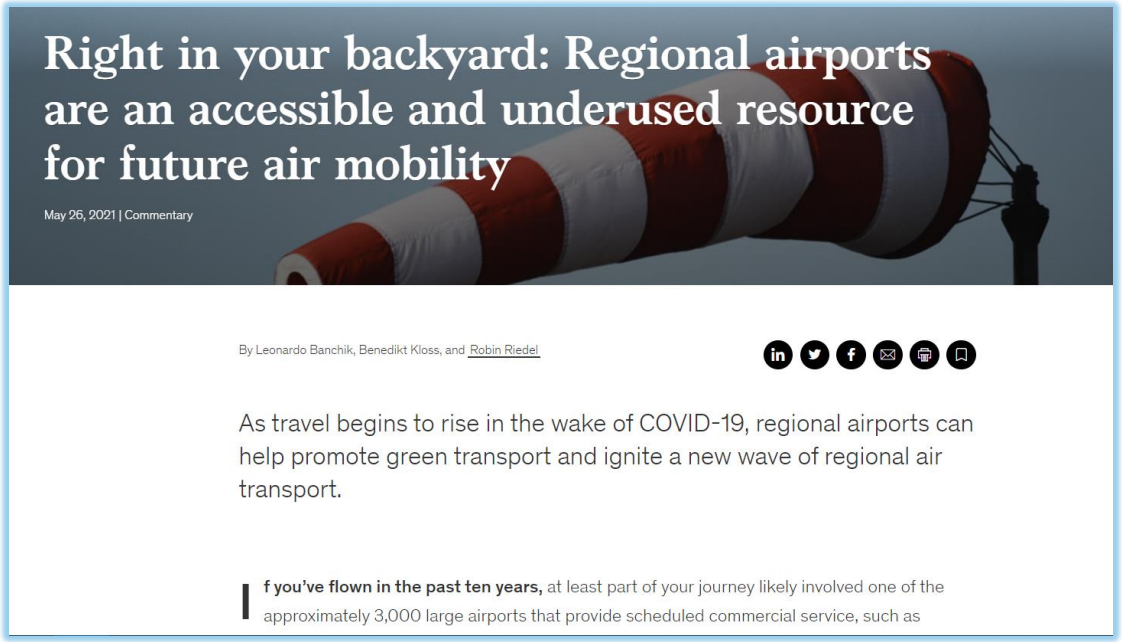
Recommended reading!





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