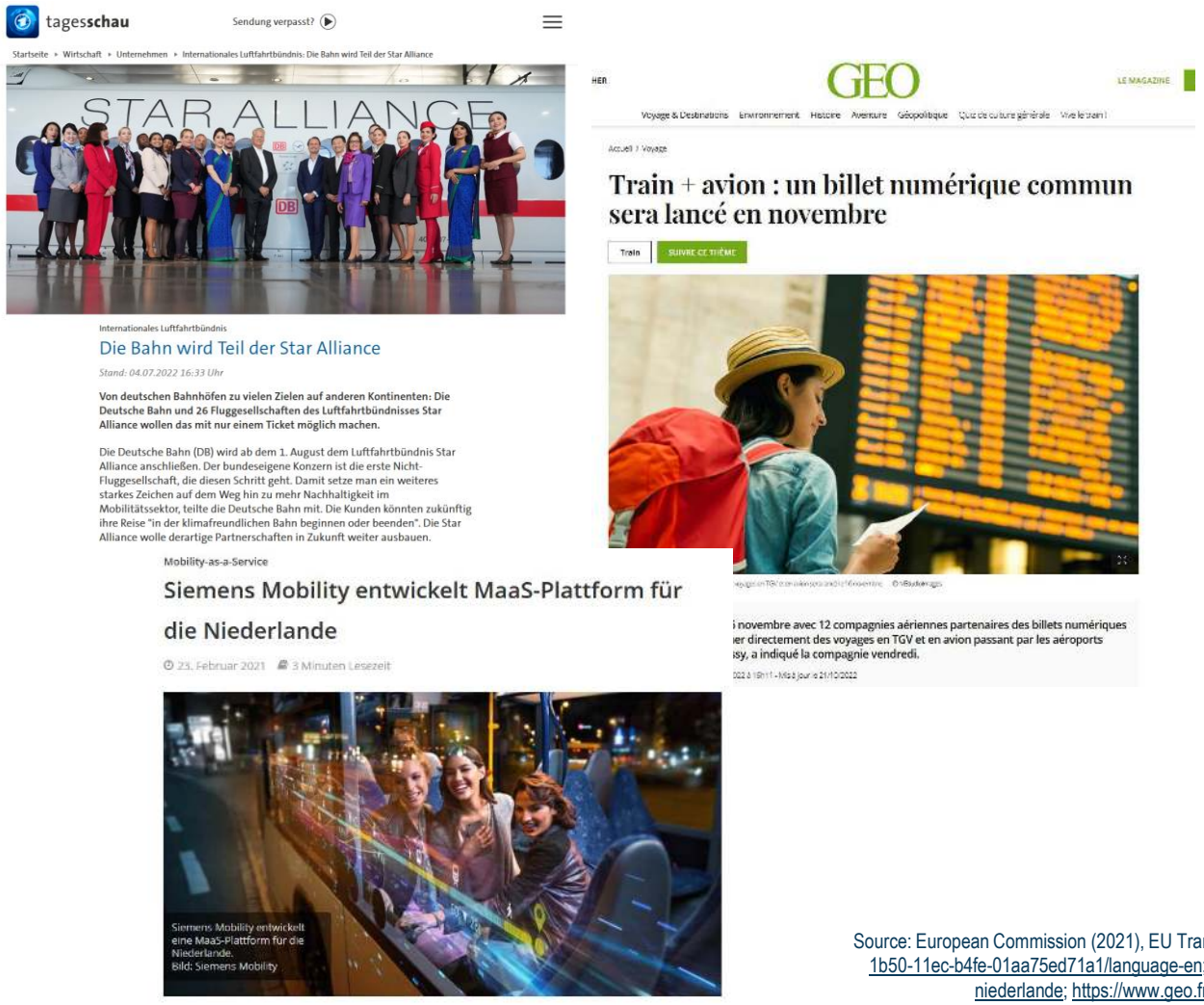
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# Vernetzung der Verkehrssysteme

Dr. Annika Paul, Bauhaus Luftfahrt

Symposium Nachhaltige Luftfahrt
Hamburg, 03.11.2022

# The Future of Mobility – Complex Challenges and Opportunities




**Passenger transport volume (billion km) and growth**

| Transport mode | 1995 | 2019 | Growth |
|---|---|---|---|
| Sea | 26.3 | 21.1 | -19.7% |
| **Air** | **237.2** | **582.9** | **145.7%** |
| Tram&Metro | 63.8 | 87.0 | 36.3% |
| Railway | 312.7 | 421.4 | 34.8% |
| Bus&Coach | 468.0 | 486.7 | 4.0% |
| P2W | 108.2 | 114.2 | 5.6% |
| Passenger cars | 3238.8 | 4325.0 | 31.7% |

Source: European Commission (2021), EU Transport in Figures; https://op.europa.eu/en/publication-detail/-/publication/14d7e768-1b50-11ec-b4fe-01aa75ed71a1/language-en; https://industrie.de/mobilitaet/siemens-mobility-entwickelt-maas-plattform-fuer-die-niederlande; https://www.geo.fr/voyage/train-avion-un-billet-numerique-commun-sera-lance-en-novembre-212261; https://www.tagesschau.de/wirtschaft/unternehmen/deutsche-bahn-star-alliance-101.html



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# Moving Towards a Multimodal European Transport System

**Enabling a seamless passenger journey and single ticketing.**

**90% reduction in transport sector's emissions by 2050.**

**Fair and efficient pricing across all transport (e.g., carbon pricing).**

**Multimodal framework, door-to-door oriented passenger rights.**

**Rethinking the use of current infrastructure and future challenges.**

**Identifying and developing new business models that enable multimodal transport.**

Source: Adapted from Schmalz et al. (2021); European Commission (2020), Sustainable and Smart Mobility Strategy; European Commission (2022), "Fly the Green Deal, Europe's Vision for Sustainable Aviation.



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# Future Global Mobility Demand

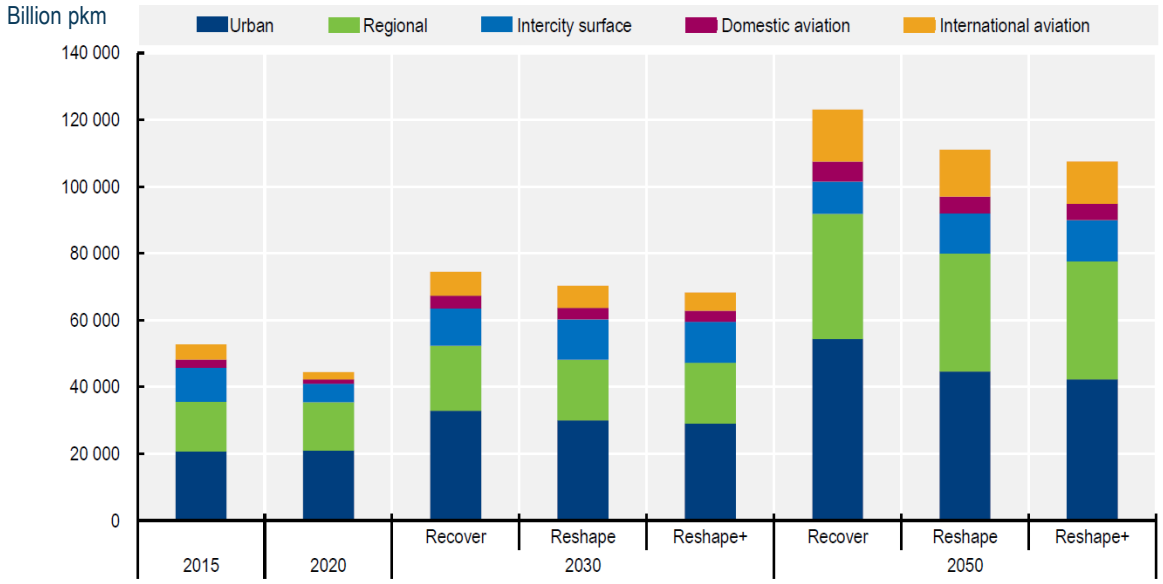
## Potential development pathways

- Recover: **Economic recovery** (reinforcing established economic activities).
- Reshape+: **Transformational transport decarbonisation policies** (increased investments; more political ambition in regard to existing policies and technologies)

## Transport decarbonisation by

- Avoiding unnecessary travel
- Shifting necessary travel to sustainable modes
- Improve vehicle and energy technologies

**Global demand passenger transport by sub-sector to 2050 (OECD ITF scenarios)**




Note: Figure depicts ITF modelled estimates. Recover, Reshape and Reshape+ refer to the three scenarios modelled, which represent increasingly ambitious post-pandemic policies to decarbonise transport. Regional refers to daily local transport activity that happens outside of urban areas (peri-urban, rural); intercity surface refers to transport movements by private road vehicles (two- and three-wheelers, cars), buses, and rail between urban areas

Source: ITF (2021), ITF Transport Outlook 2021, OECD Publishing, Paris, https://doi.org/10.1787/16826a30-en.

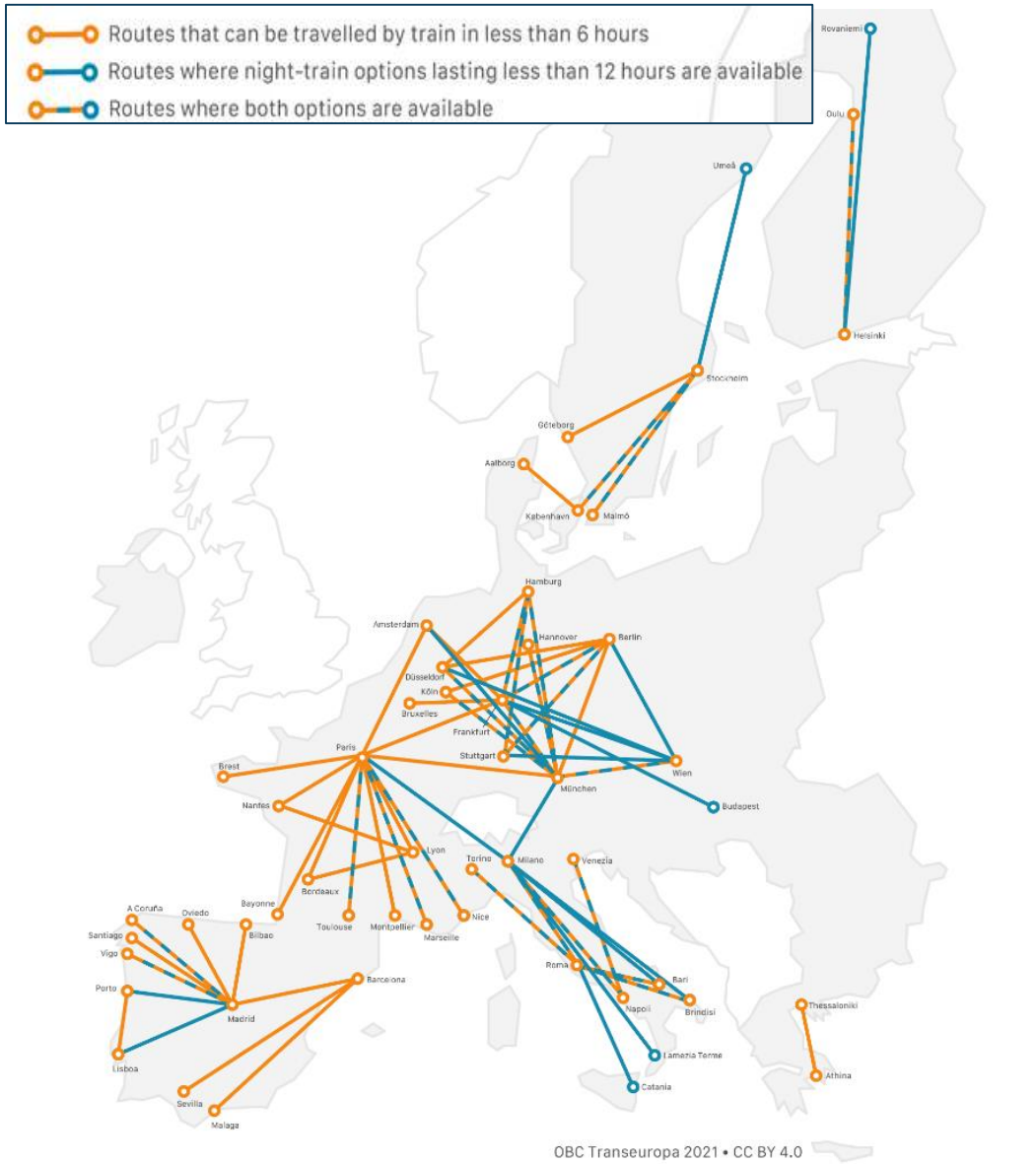


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# Joint Air-Rail Mobility in Europe

- **Substitution and/ or complementarity between air and rail**
  - Restrictions and replacement of short-haul flights (via bans/ incentives)
  - High-speed rail as feeder mode for airports, enlargement of catchment areas
  - Multimodal cooperation to facilitate synergies (*e.g.*, Deutsche Bahn as Star Alliance Member)
  - Rescheduling in case of disruptions or delays
- **Consideration of door-to-door travel chain and passenger expectations**

European short-haul flight and rail network[1]




Source: https://www.balcanicaucaso.org/eng/All-the-news/More-trains-fewer-emissions-213551; [1] only routes corresponding to the 150 busiest short-haul flight routes in the EU are shown.

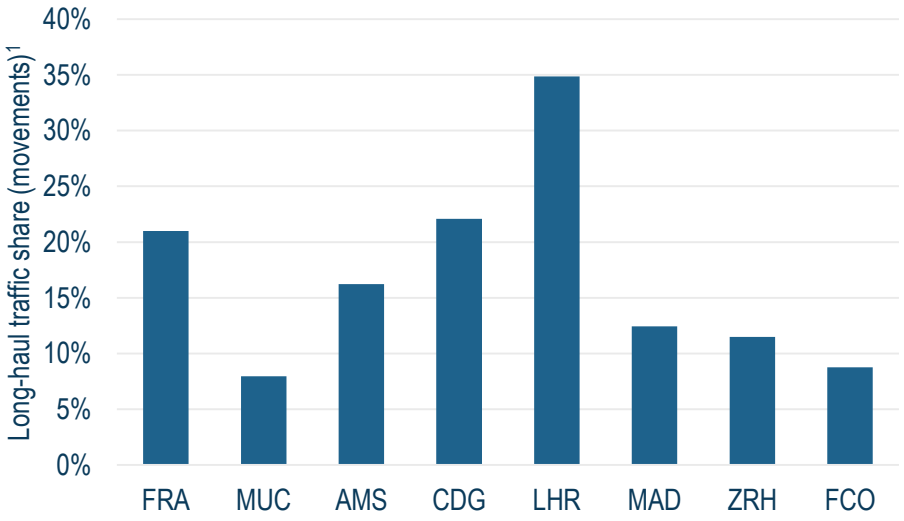


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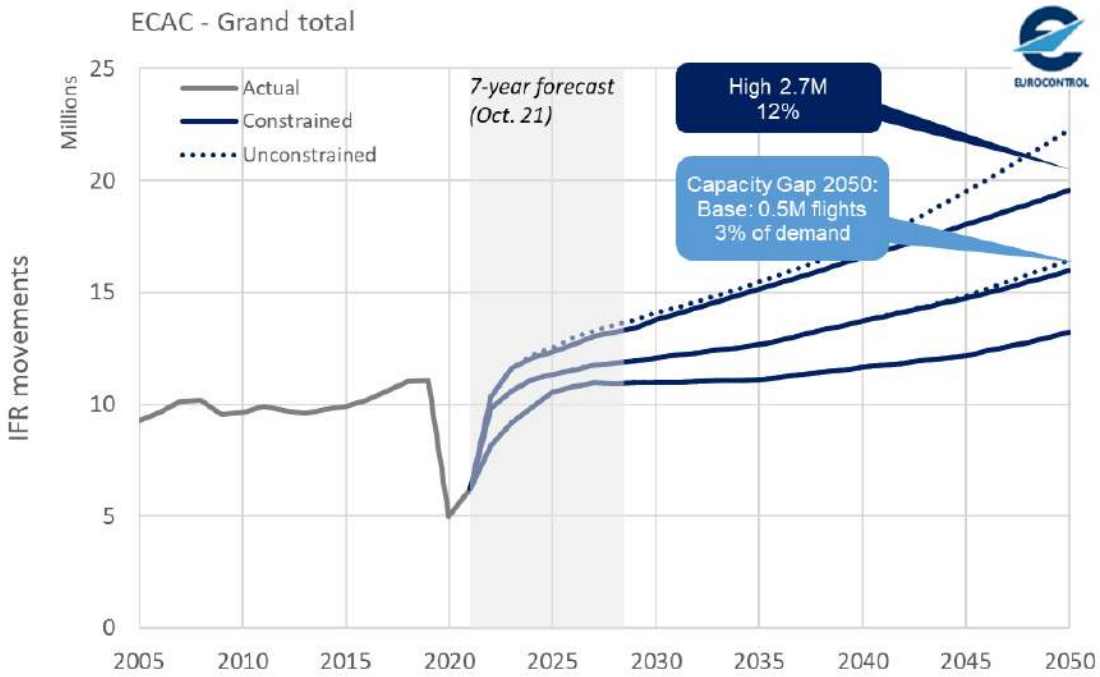
# Airline Networks and Airport Capacities

## Airlines‘ hub-and-spoke networks

- Traffic and fleet mix at hub airports and respective feeder traffic share
- Economies of scale and density of traffic bundling




## Mitigating airport capacity constraints




Source: 1 OAG 2016; all movements >400 km; Michelmann, J., Gruber, B., Stroh, F. and M. Hornung (2022), Evolutionary Fleet Development Considering Airport Capacity Limitations and their Mitigation, in: Aviation 2022; https://www.eurocontrol.int/publication/eurocontrol-forecast-update-2022-2024.



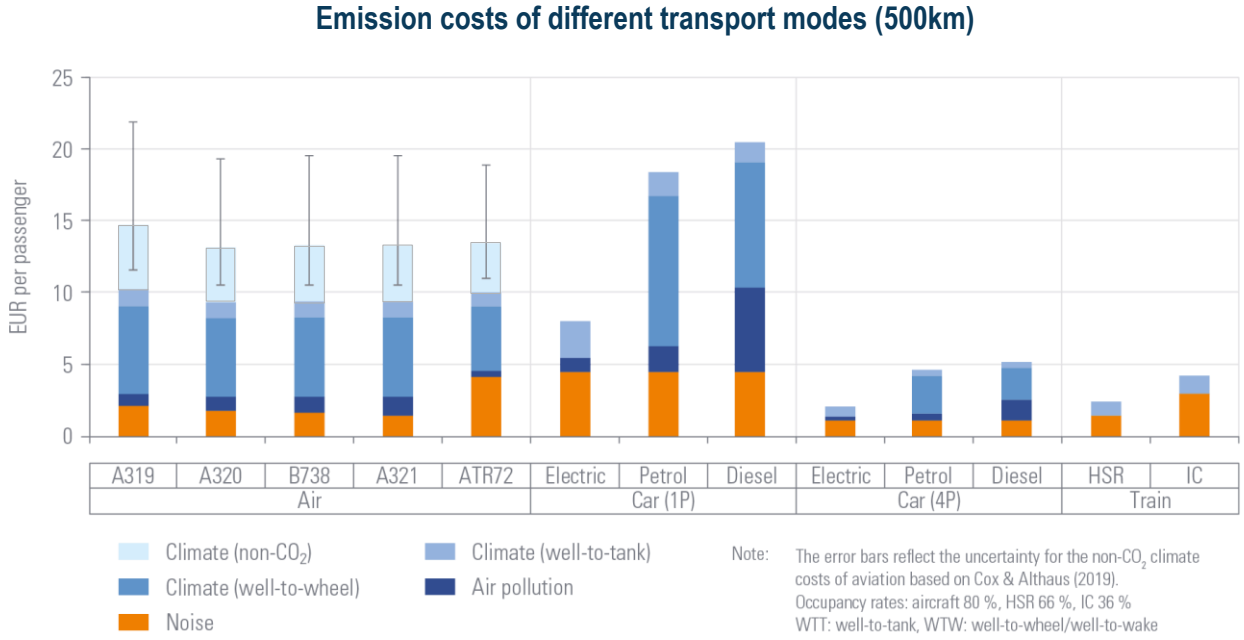
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# Transport Emission Costs and Impact Assessment

## Holistic assessment of climate impact of different modes, considering:

- Up- and downstream impacts (*e.g.*, life cycle costs of vehicles and infrastructure)
- Net impact of new investment projects (*e.g.*, land development, habitat impact)
- Regional- and route-specific conditions to ensure connectivity and integration of remote regions

## Comprehensive overview of environmental and social costs required




Source: European Environment Agency (2020), Transport and Environment Report, Train or Plane?



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# Multimodal Decision-Making

## Various factors drive passenger decisions

- Travel costs
- Value of time and travel time reliability
- Frequency of services
- Convenience, comfort, quality of service, safety
- Environmental awareness and willingness to pay

**Future aviation pathways and challenges**

| Passenger Travel | | Aviation System | |
|---|---|---|---|
|  | Awareness for more sustainable travel |  | Seamless & integrated D2D air travel chains |
|  | New generation of passengers |  | Personalised offers & a menu of travel options |
|  | Differentiated journeys and new forms of tourism |  | Social acceptance as essential part of technology strategies |
|  | Value-adding use of travel time |  | Digitalisation, leveraging personal data, & privacy protection |

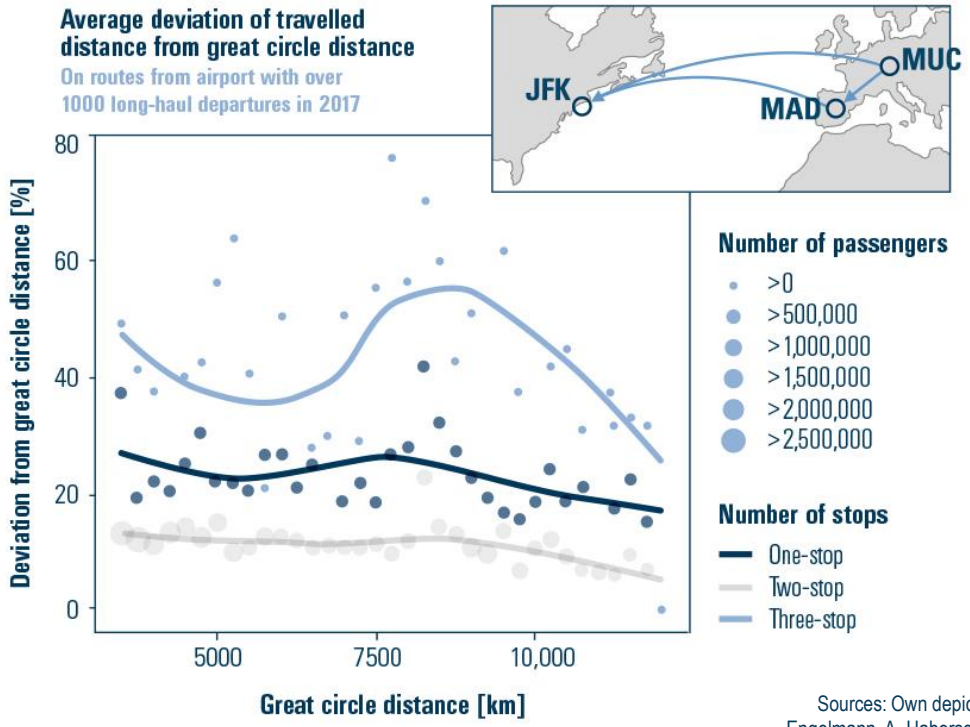
Sources: P. Arich, T. Bolic, I. Laplace, N. Lenoir, S. Parenty, A. Paul, C. Roucolle (2022) Substitution path between air and rail in Europe: a measure of demand drivers in: ATRS, Antwerp, online, August 2022; Schmalz, U. (2022), Future Technologies & Trends – Assessing Drivers of Change, ILA Berlin 2022



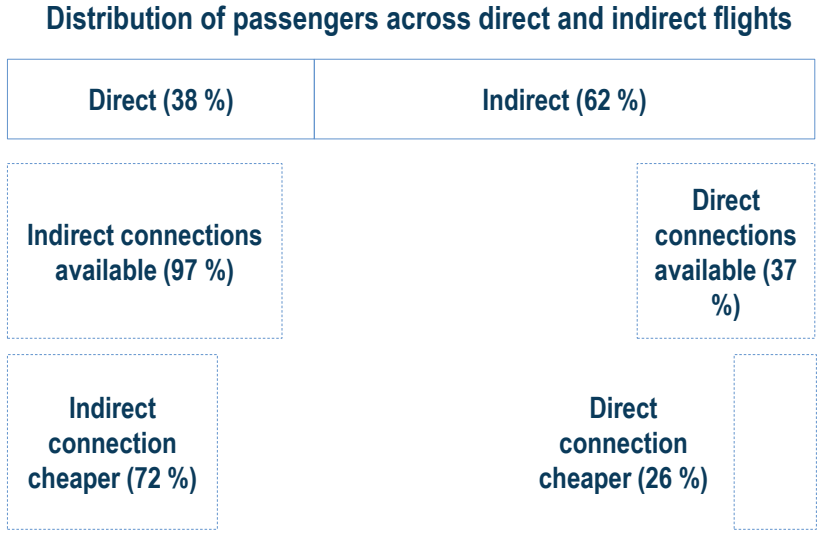
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# Operational Inefficiencies in the Long-Range Market

## On average, ~8 % deviation from optimal route on long-haul flights




## Majority of long-haul passengers travels on indirect connections




Sources: Own depictions, based on Sabre (2016), Sabre Data & Analytics Market Intelligence; D. Steinweg, K.-D. Büchter, M. Engelmann, A. Habersetzer, U. Schmalz, A. Paul, " A business model enabling a passenger-distance-improved long-haul network to decrease transport inefficiencies", Aviation, Vol. 25, No. 3, pp. 187 - 201, DOI: 10.3846/aviation.2021.15678, 2021.

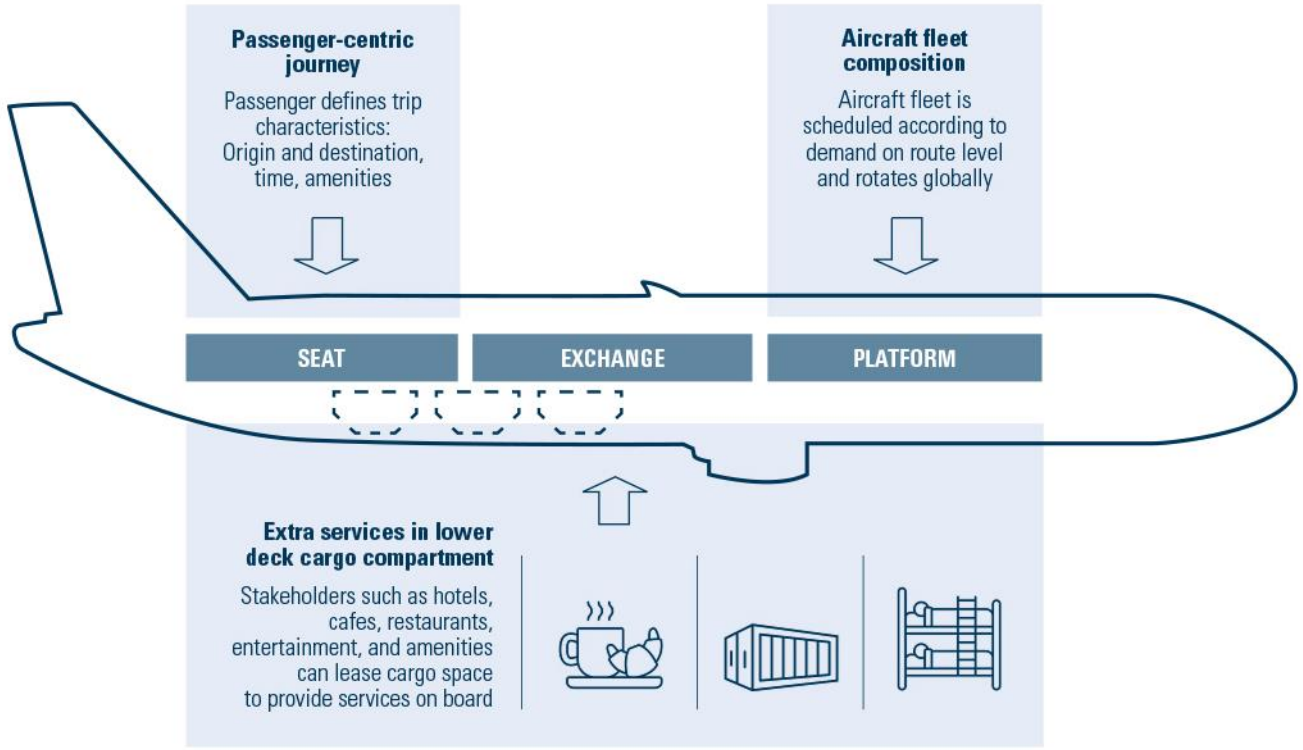


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# Seat and Aircraft Sharing to Increase Long-Range Efficiency

## Implementation of seat exchange platform to increase efficiency:

- **Direct flights and higher load factor**: Passenger pooling to bundle demand and offer more direct flights
- **Optimised aircraft planning**: Aircraft sharing to align demand and aircraft size
- **Integrated travel**: Focus on seamless passenger journey from door-to-door
- **Business model innovation**: New actors can participate in exchange platform






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# Multimodal Opportunities and Challenges

## Future fleet and network composition

- **Aircraft types**: Most efficient in terms of fuel consumption (per passenger)
- **Routes and stage length**: Least $CO_2$ emissions options

## Passengers' door-to-door journey

- **Travel times**: Improving reliability and predictability
- **Single ticketing**: Common framework, liabilities and booking options (cross-border/-mode)

## Airport infrastructure and operations

- **Access mode choice**: Pooling options, public transport
- **Capacities**: Depending on fleet composition and at specific airports

## Market structure and competition

- **Structure of transfer traffic**: Carbon leakage and competition effects
- **Multimodal system**: Holistic assessment of investment in modal alternatives; common regulatory framework



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