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Frequency Regulation: Approaches and Potentials

Felix Presto (Speaker), Volker Gollnick, Klaus Lütjens - AGIFORS 2021

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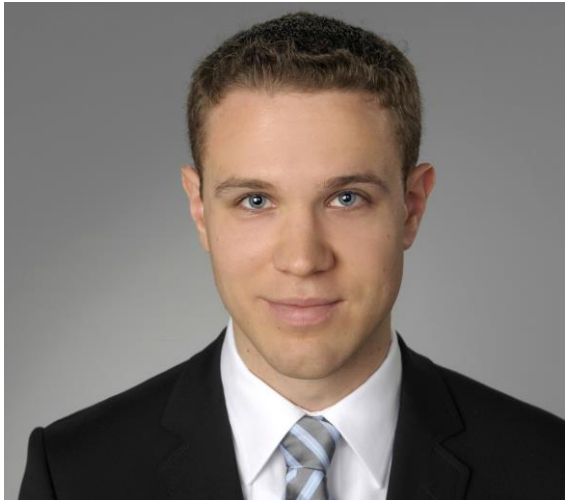
Speaker Biography



Felix Presto

Since 2018	Ph.D. Student at Institute of Air Transportation Systems, TUHH, Hamburg ➢ Airline Operations ➢ Fleet and Network Planning
2015-2018	MRO Network Development, Lufthansa Technik AG, Hamburg
2013-2015	M.Sc. Industrial Engineering with focus on Aerospace Technology and Management (with Hons.), TU Braunschweig
2009-2013	B. Eng. Aerospace Systems Engineering and Mgmt., University of Applied Sciences Bremen

Agenda

1. Motivation and research question
2. Model
3. Results
4. Conclusion

Research question and motivation are driven by increasing emissions and delay

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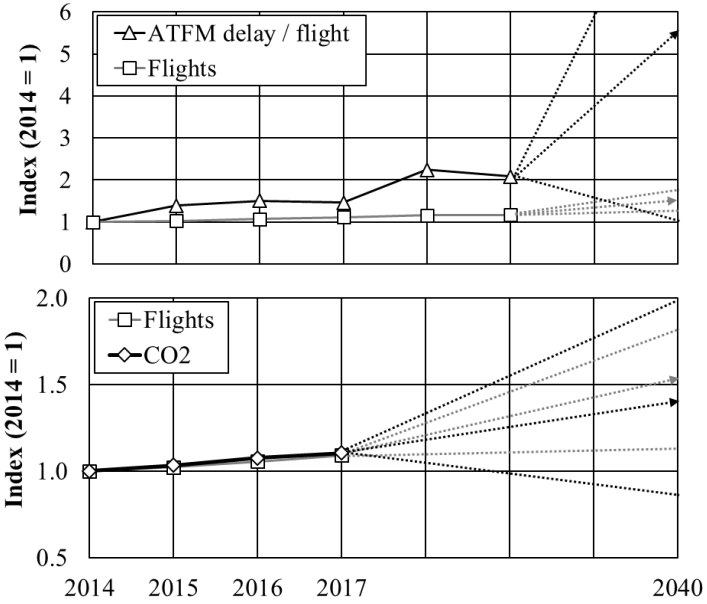
Research question

- To what extent is the regulation of flight frequency an appropriate capacity management approach to reduce delays and to realize economies of scale by deploying larger aircraft?



Adapted from: EUROCONTROL (2018), EEA (2020)

Motivation

- Projected increase of (CO_2-) emissions and ATFM delay in aviation (EUROCONTROL 2018, EEA 2020)
- Evidently low to negative utility of too many frequencies in terms of flights per day (Flores-Fillol 2010, Givoni & Rietveld 2009, Hansen 2002)
- Overarching (research) trends:
  - „A little less can be more“ (Fan & Odoni 2002, Vaze & Barnhart 2012)
  - Adjustment of regulatory misincentives in terms of airport slot allocation mechanisms that foster frequency competition (Givoni & Rietveld 2009)
  - Historic natural aircraft size growth (Airbus 2018, Morrell 2009)
  - Integration of airport and airspace capacity management (ACI Europe 2020)

2-step approach to reflect realistic conditions

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Input

ATFM delay
Flight plans
Aircraft sizes
Frequencies
Passengers

FRED – Frequency REDuction Model

Frequency Regulation

→ *Output*

Target frequencies
Target aircraft sizes

Input →

Fleet Assignment

Output

Fleet adjustments
Fuel consumption
DOC/COC
Travel times
(Δ Input values)

➢ (1) Regulator limitation: How could frequency be regulated?

Desintegration

➢ (2) Airline reaction: How does the fleet mix change on frequency-reduced routes if daily seat capacity is held constant?

Frequency regulation approach (selection)	Mechanism
Capped frequency	Setting of a maximum allowed frequency (e.g. max. 15 flights per day)*
Positive marginal temporal utility (MTUF)	Reducing all frequencies where the increase in ATFM delay exceeds the decrease in schedule delay* („temporal cost-benefit tradeoff“)

**Adapted from Hansen et al. (2001) and Hansen (2002)*

Complexity

Motivation
Model
Results
Conclusion

Scope of study: the top routes by frequency in the EUROCONTROL area until 2040

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Investigation area

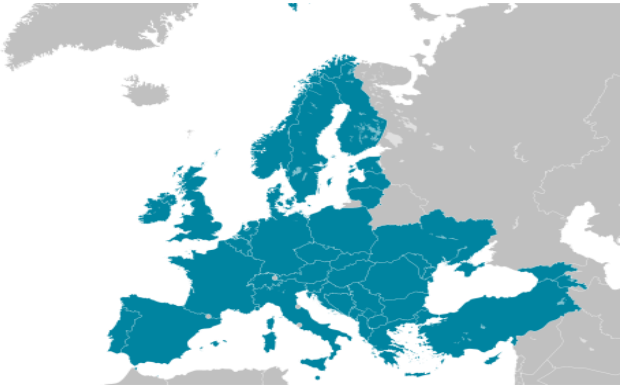
- Application of FRED to the 798 top routes by frequency from EU top 26 airports (avg. route length 1.010 km, 2.3 million flights in 2019)
- Projection of flights and delay until 2040 performed (adapted from *EUROCONTROL (2018))*

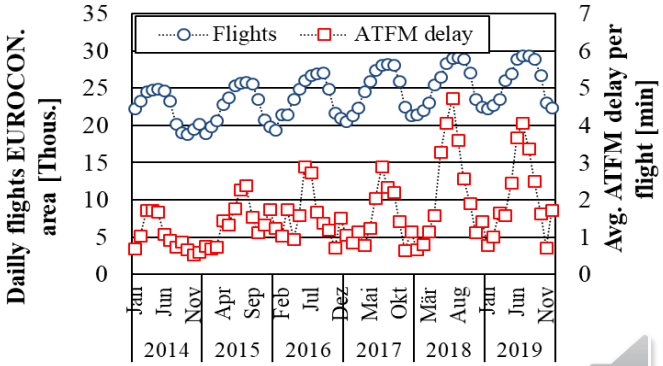
A few assumptions

- Frequency regulation needs to be introduced on a transnational level for all competing airlines and airports („level playing field“)
- Demand remains constant as all alternative travel options are affected, hence seat capacity on each route remains constant as well

Delimitation

- No assessment of legal feasibility, focus is on quantitative potential (temporal, ecologic, economic)



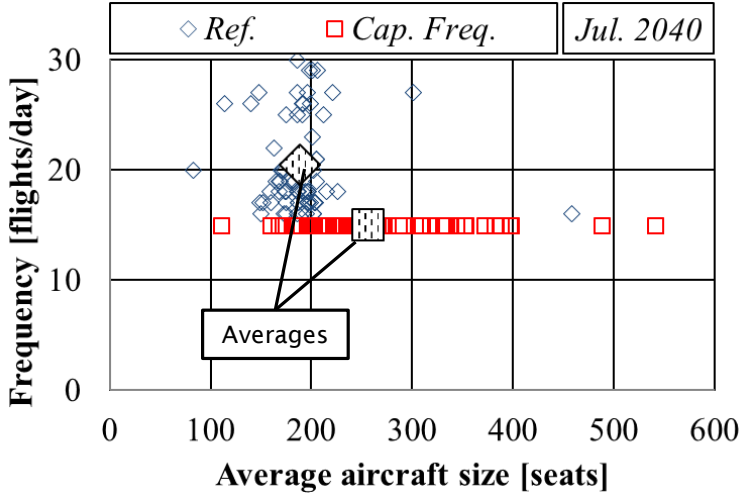


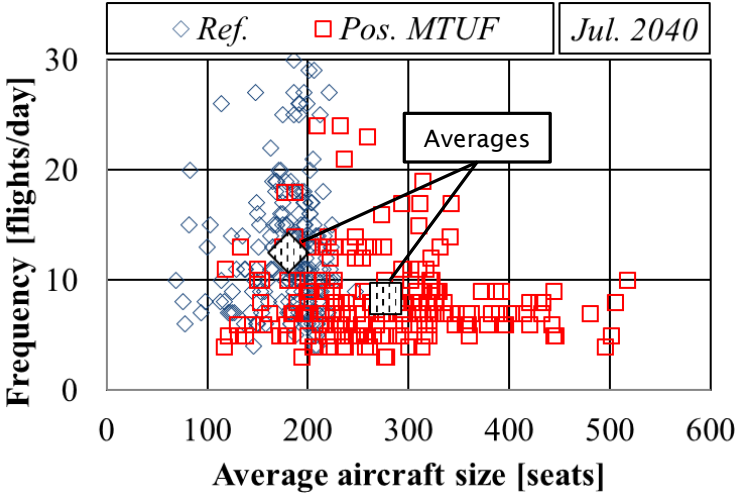
ATFM delay: capacity-induced fraction of total departure delay

Chart adapted from EUROCONTROL (2019)

Motivation
Model
Results
Conclusion

Regulation approaches show a broad range of target frequencies and aircraft sizes on frequncy-reduced routes

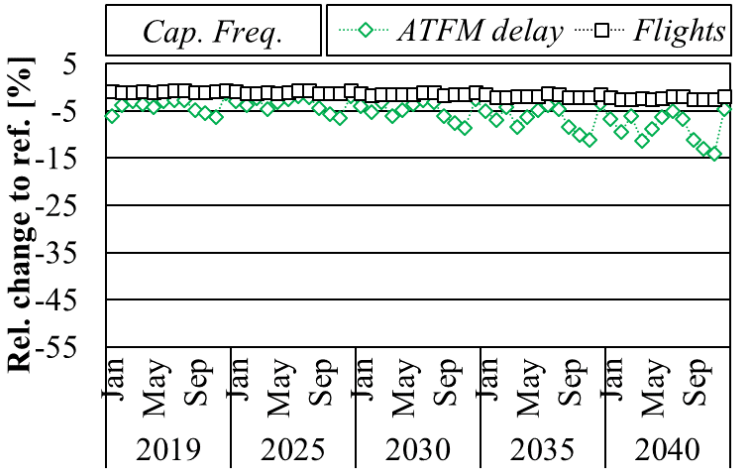


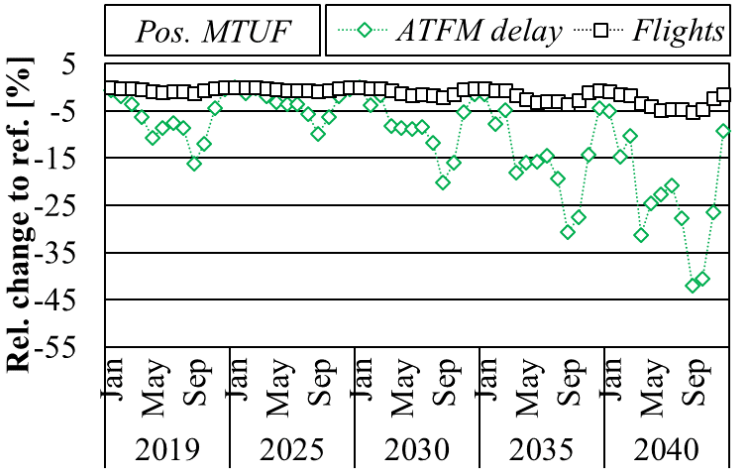


Interpretation

- Approach *Capped Frequency (left):* the max. allowed frequency of 15 is clearly visible
- Approach *Positive MTUF (right):* Target frequencies and aircraft sizes are more scattered, more routes are affected
- Both approaches require the extensive deployment of twin-aisle aircraft on short ranges compared to prior almost exclusive single-aisle operation

Reduction of the *right* frequencies yields a disproportionally higher decrease in system-wide ATFM delay

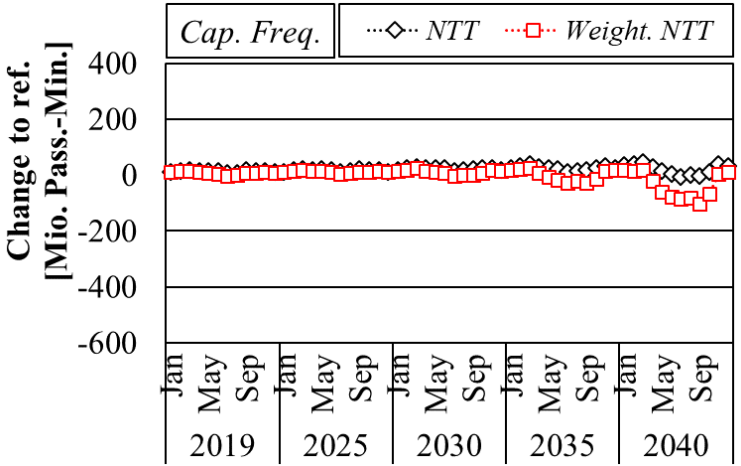


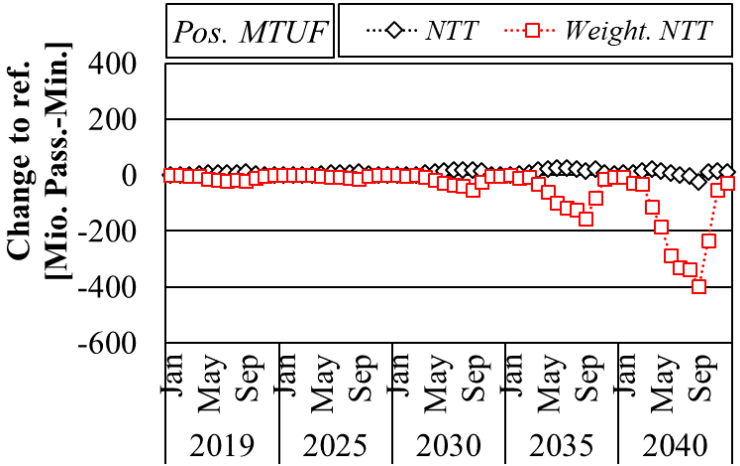


Interpretation

- A relatively small reduction of frequencies yields to a disproportionally higher decrease in system-wide average ATFM delay for both approaches (resulting from the nonlinear character of delay over capacity in queuing theory)
- Positive MTUF yields a notably stronger decrease due to the inherent focus on particularly congested routes
- Assuming ATFM delay-related airline cost of 100€ / min (Cook & Tanner 2015) savings of EUR 0.8B and (*Capped Frequency*) and EUR 2.2B (*positive MTUF*) can be generated in 2040

Net travel time benefits for passengers (Δ Σschedule delay – Δ ΣATFM delay)





NTT: net travel time (Δ Σschedule delay – Δ ΣATFM delay)

Interpretation

- The accumulated decrease in passenger ATFM delay almost offsets the accumulated increase in schedule delay (black diamonds)
- Accounting for the higher temporal disutility of ATFM delay (unplannable) relative to schedule delay (plannable) with a conservative factor of 2, generates subjective temporal benefits for passengers in all years (red squares)

Only if seasonality and available aircraft technology are considered, eco-efficiency gains are feasible (1/2)

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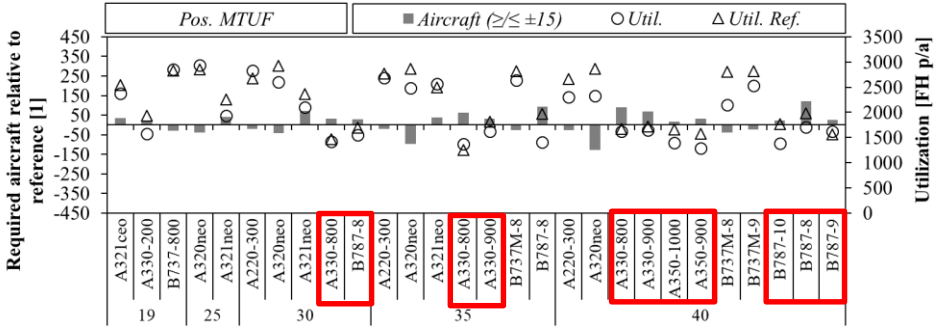

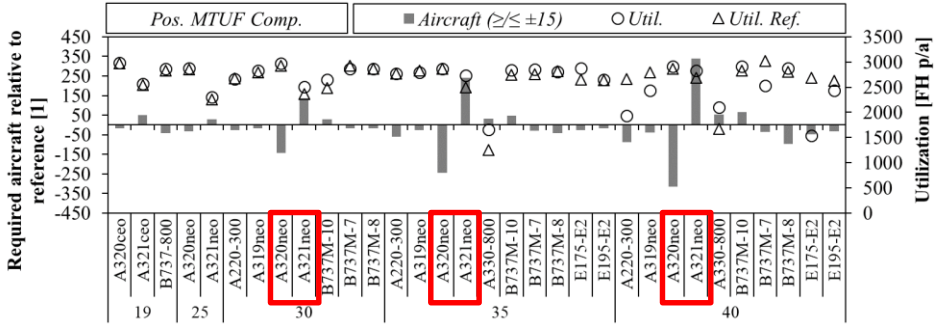

Positive MTUF

- Twin-aisle operation on short ranges (COC↗, FC↗)
- Additional aircraft required (OC_{Kap} ↗) to perform flight schedule

Positive MTUF + aircraft size limit (compensation) + year-round aircraft size alignment

- Mainly A321neo required instead of A320neo
- Fewer aircraft required to perform flight schedule
- Higher regulatory effort and intervention character

Only if seasonality and available aircraft technology are considered, eco-efficiency gains are feasible (2/2)

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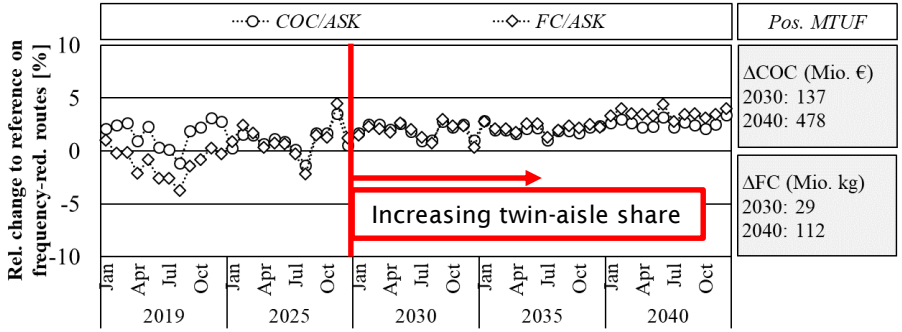

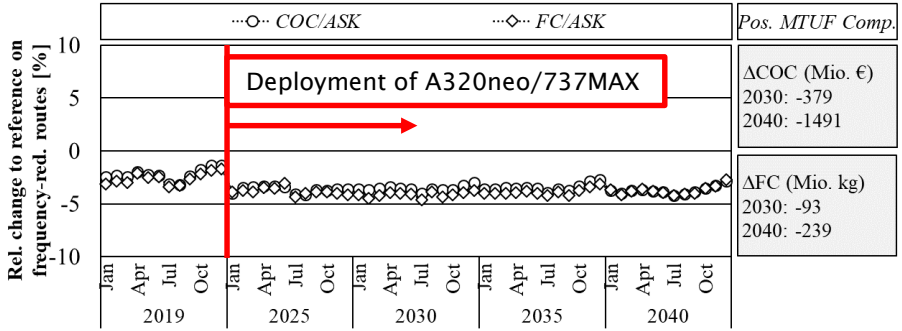

COC/ASK: cash operating cost per ASK

FC/ASK: fuel consumption per ASK

Positive MTUF

- From 2030 the increasing share of twin-aisle aircraft leads to increasing COC/ASK and FC/ASK
- Increase in FC/ASK is higher than COC/ASK

Positive MTUF + aircraft size limit (compensation) + year-round aircraft size alignment

- Increasing fleet penetration of A321neo instead of A320neo yields COC/ASK and FC/ASK efficiency gains of approx. 2%-4%
- Overall efficiency gains are between low and moderate when distributed among all airlines and compared to typical airline operating cost numbers

Frequency regulation needs to be looked at from all perspectives due multidimensional implications

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Chances / Pros	Risks / Cons
A reduction of average ATFM delay is achieved with both approaches yielding a notable ATFM delay cost reduction (here: EUR 0.8B – EUR 2.2B in 2040)	Frequency regulation has a relatively strong intervention character
Already if ATFM delay is conservatively weighted against schedule delay, frequency reduction yields subjective travel time benefits	Eco-efficiency gains are only feasible with approaches with additional regulatory complexity
Eco-efficiency gains (COC, FC) are feasible if seasonality of demand and available aircraft technology are considered within the regulation scheme (here: 2% - 4%)	COC savings for an individual airline are between low and moderate when compared to total cost positions
A hypothetical new large SR/MR aircraft type („NMA“) could increase eco-potential to 7%-9%	

Frequency regulation needs to be looked at from all perspectives due multidimensional implications

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Some concluding thoughts

- COVID-19 temporarily reduces pressure for delay reduction measures, short-/mid-term need remains, particularly for ecological efficiency gains
- Further research questions:
  - How could frequencies be allocated to individual airlines in alignment with airport slot allocation mechanisms and maintaining fair competition?
  - What could „lighter“ regulation approaches look like to accelerate the natural up-gauging process? E.g. airport slots are not given to competitors when unutilized due to voluntary frequency reduction

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Thank you for your attention!

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