A realistic view on the future of aviation

Don’t expect too much

Joris Melkert
Faculty of Aerospace Engineering

TU Delft

Content

- Snowball effect in aviation
- Developments so far
- Supersonic aircraft
- Electric aircraft
- Alternative fuels
- An airport in the North Sea
- New configurations
- Conclusion

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Snowball effect in aviation

1 kg more mass
-> 1 kg more lift required
lift is not for free - > more aerodynamic drag
more drag -> more thrust
more thrust -> bigger engines
-> more fuel
} -> more mass

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Snowball effect in aviation

Quick estimate numerical value snowball factor Airbus A380:

$$\frac{\text{Maximum take-off weight}}{\text{Payload}} = \frac{548{,}000\ \text{kg}}{83{,}000\ \text{kg}} = 6.60$$

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Developments so far - spot the differences

1967

1987

2017

Sources: airliners.net, @zhangmx969, Shimin Gu

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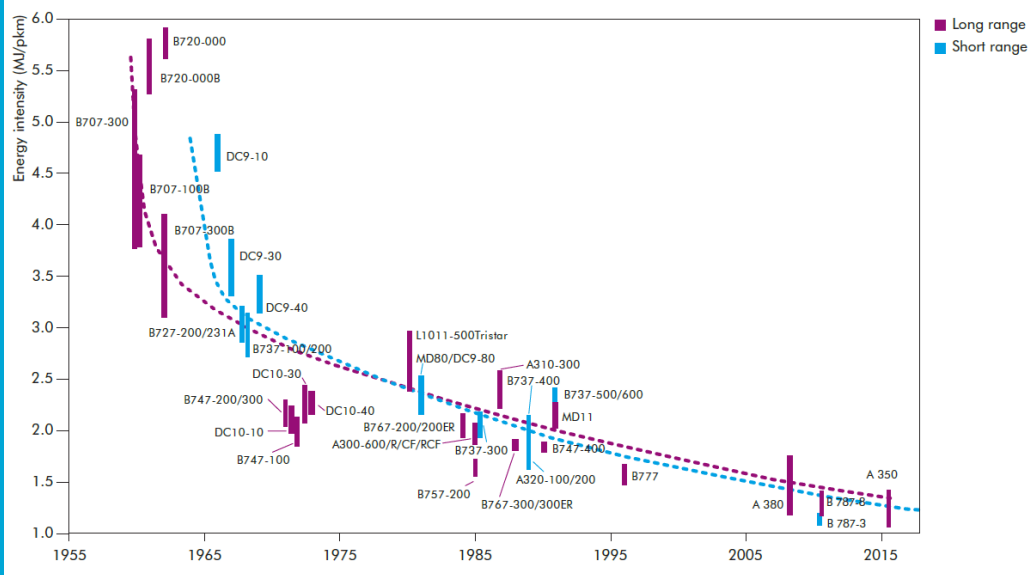
Developments so far – fuel consumption



Note: The range of points for each aircraft reflects varying configurations; connected dots show estimated trends for short-and long-range aircrafts.

Sources: Lee, *et al.*, 2001 IEA updates.

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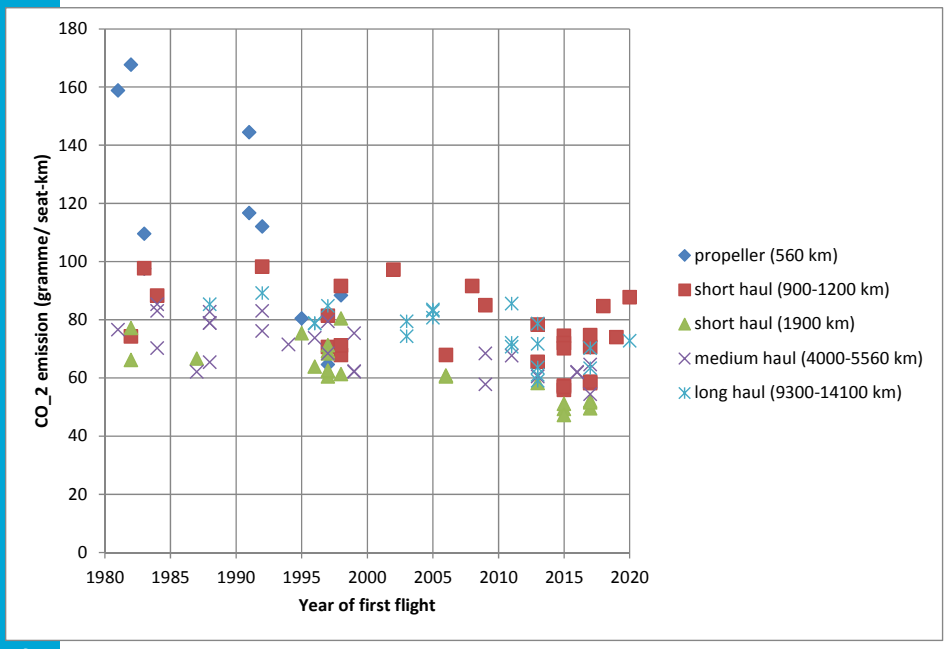
Source: Lee, IEA

Developments so far – fuel consumption



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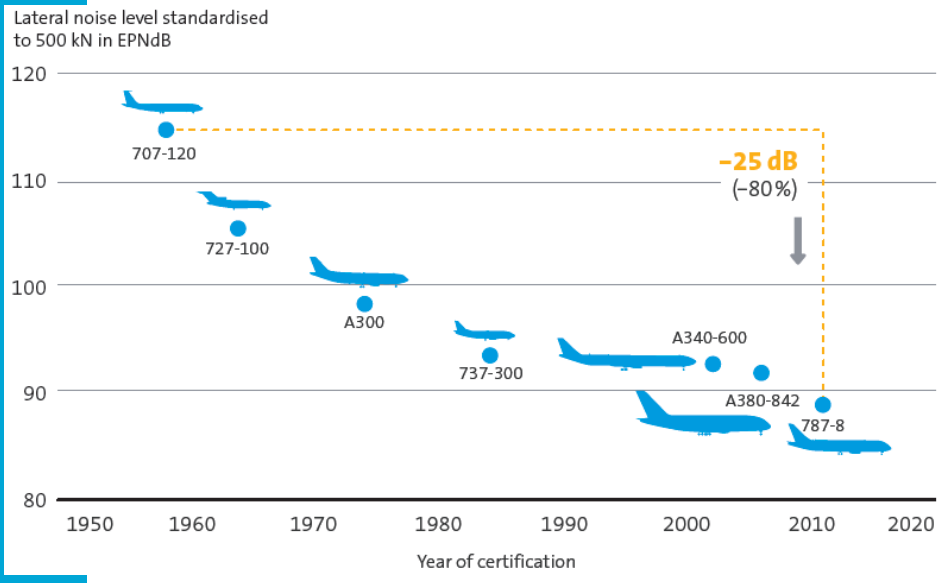
Developments so far - noise



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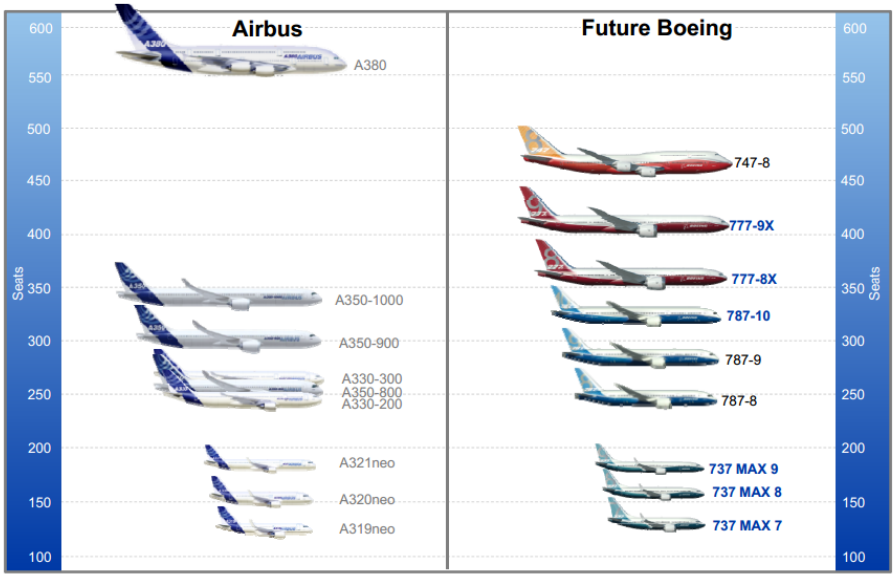
Developments so far - manufacturers

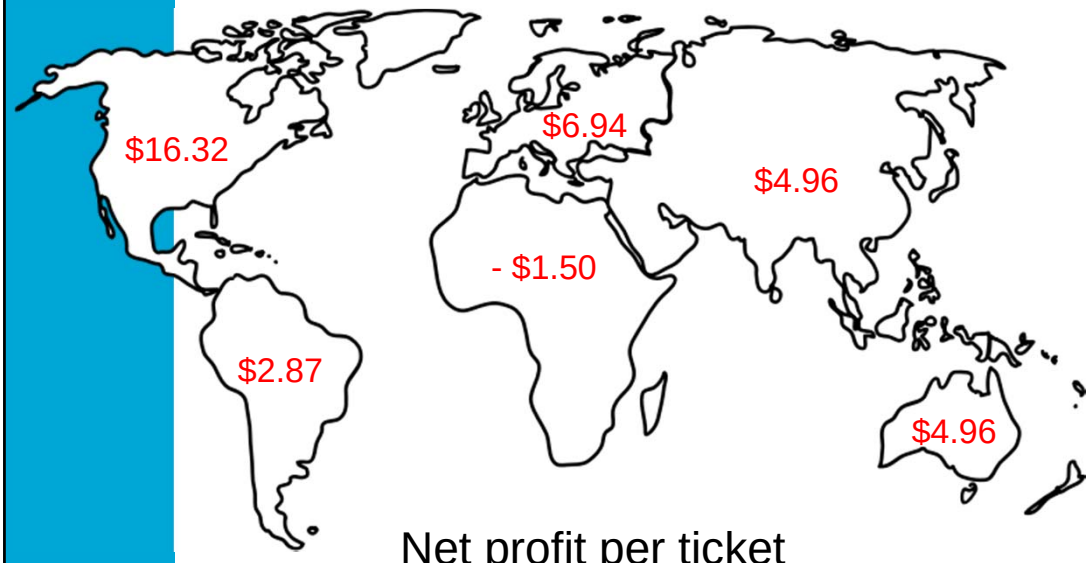
Developments so far - manufacturers

Boeing product line-up vs. the competition

Superior value, efficient market coverage



Developments so far - airlines



Net profit per ticket

Source: IATA

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Supersonic flight

Mach number : $M = \frac{flight\ speed}{speed\ of\ sound}$

M < 0.8	**subsonic aircraft**
0.8 < M < 1.2	**transsonic aircraft**
1.2 < M < 4	**supersonic aircraft**
M > 4	**hypersonic "vehicles"**

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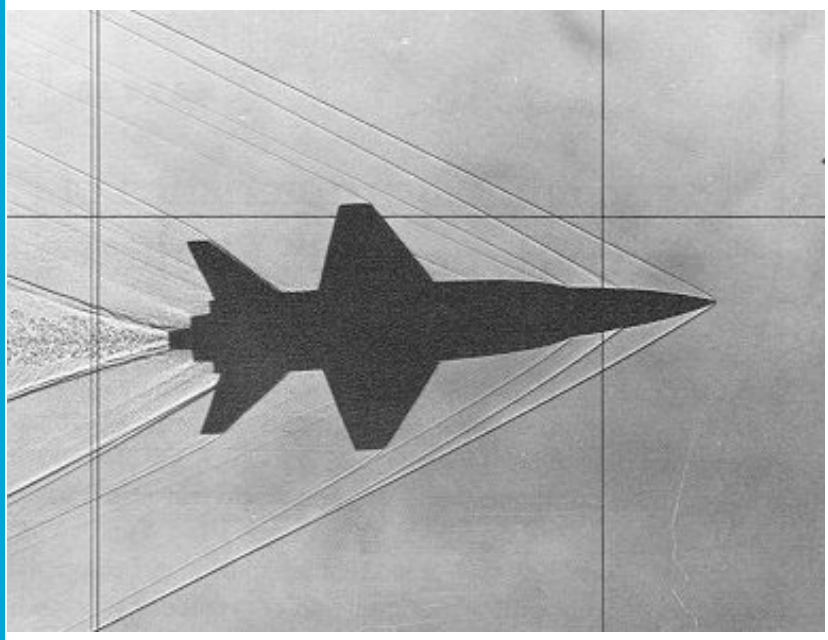
Supersonic flight



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Supersonic flight

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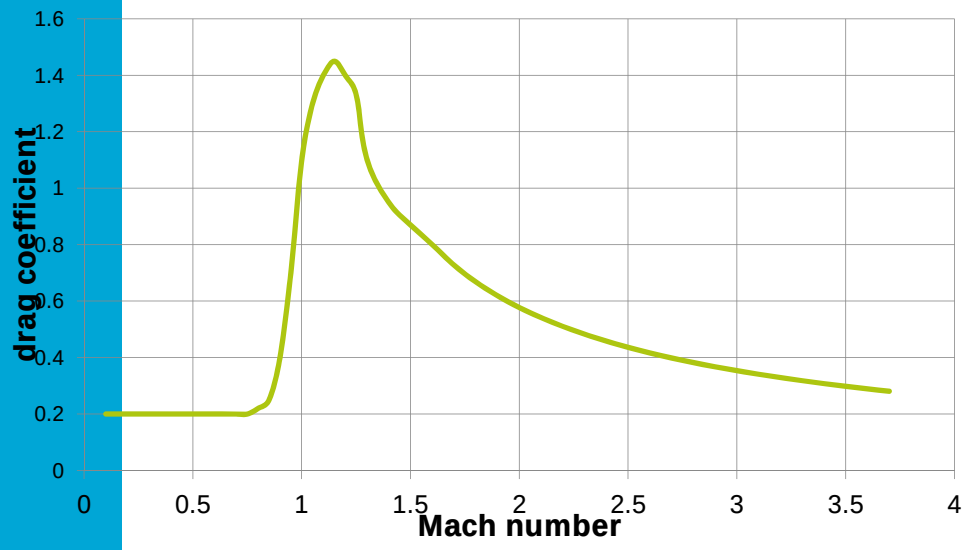
Supersonic flight



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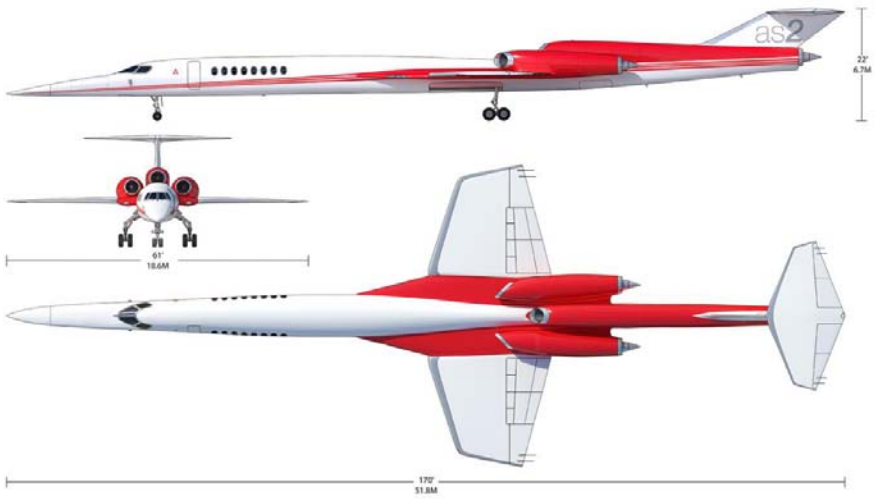
Supersonic flight



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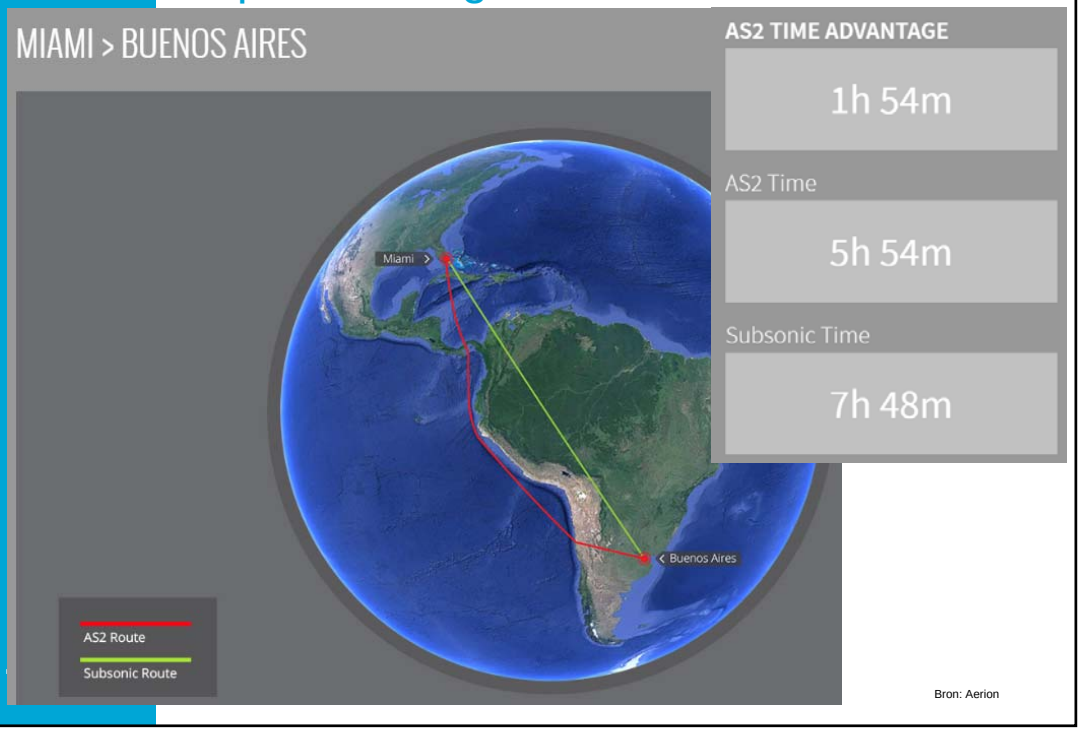
Bron: Aerion

Supersonic flight

Bron: Aerion

Supersonic flight

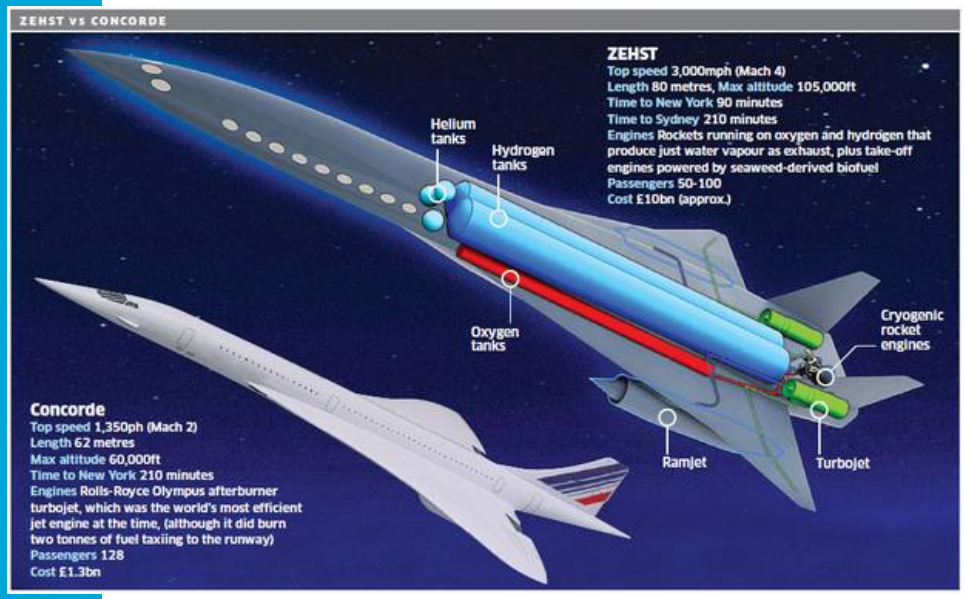


Bron: Aerion

Supersonic flight

Source: Medium

Supersonic flight



Source: EADS

Supersonic flight

Source: Lockheed Martin

Supersonic flight

Source: Avherald

Supersonic flight

Source: TU Delft

Electric Aircraft

Source: Pipistrel, Airbus

Electric Aircraft

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Source: Pipistrel, Airbus

Electric Aircraft

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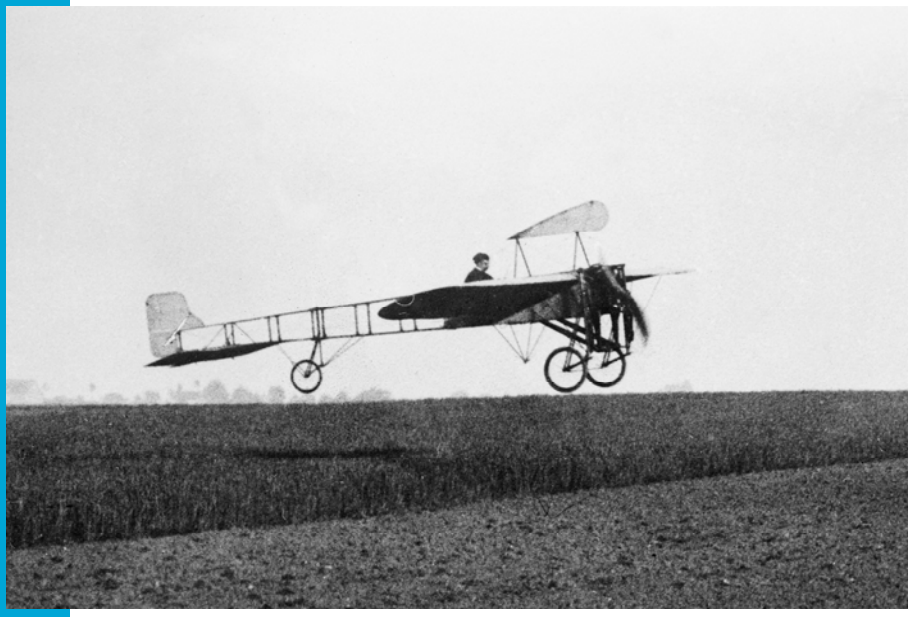
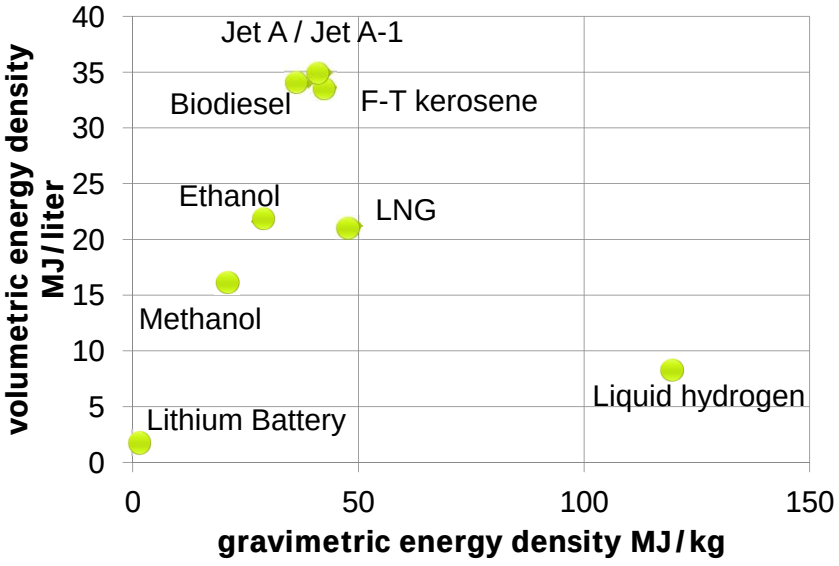
Source: Pipistrel, Airbus

Electric Aircraft



Source: Hartzellprop.com

Electric Aircraft



Electric Aircraft

Electric flight will be there!

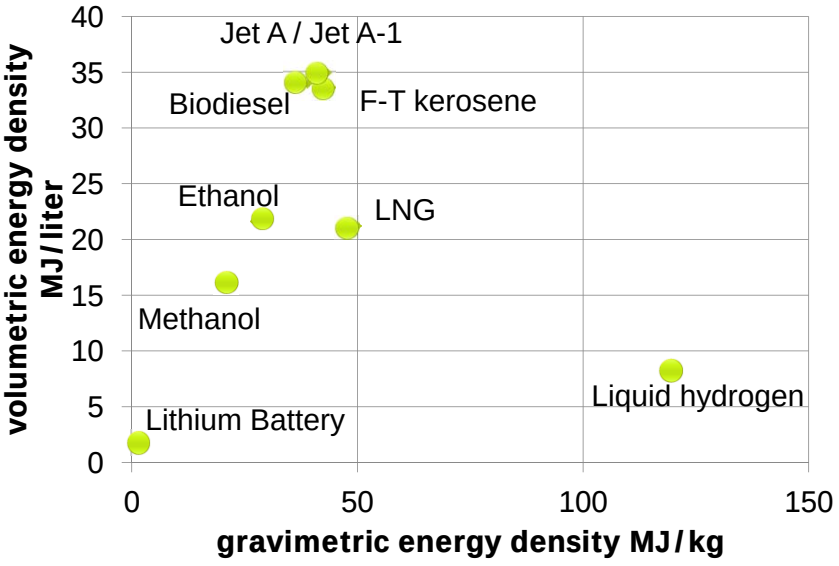
However:
- It will not be the next generation commercial aircraft
- It will come via two routes
  1. General aviation
  2. Hybrid passenger aircraft

Source: Hartzellprop.com

Alternative fuels

Source: KLM

Electric Aircraft



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Alternative fuels

Area-averaged probe

Measurement of ICAO LTO emissions by DLR

Direct particle size and number

- Cessna Citation II - P&W JT15Ds
- GTL 0-50% in two base fuels for ground testing
- GTL 0-90% in flight testing

Alternative fuels

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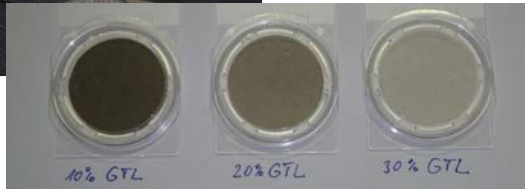

Soot filters in undiluted sampling line

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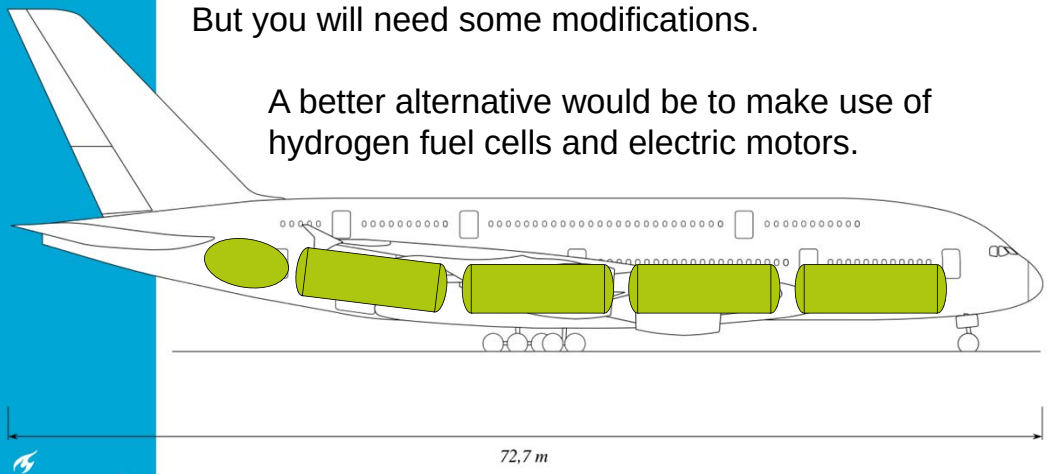
Alternative fuels

Is hydrogen an option?

Yes, you can use hydrogen in jet engines.
But you will need some modifications.

A better alternative would be to make use of hydrogen fuel cells and electric motors.



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Source: Olivier Cleynen

An airport in the North Sea

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Source: tix.nl, By Wylkie Chan - Wylkie Chan, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=11251117

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An airport in the North Sea

Source: Vlucht naar Voren

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An airport in the North Sea

Source: kwaliteitsatlas.nl

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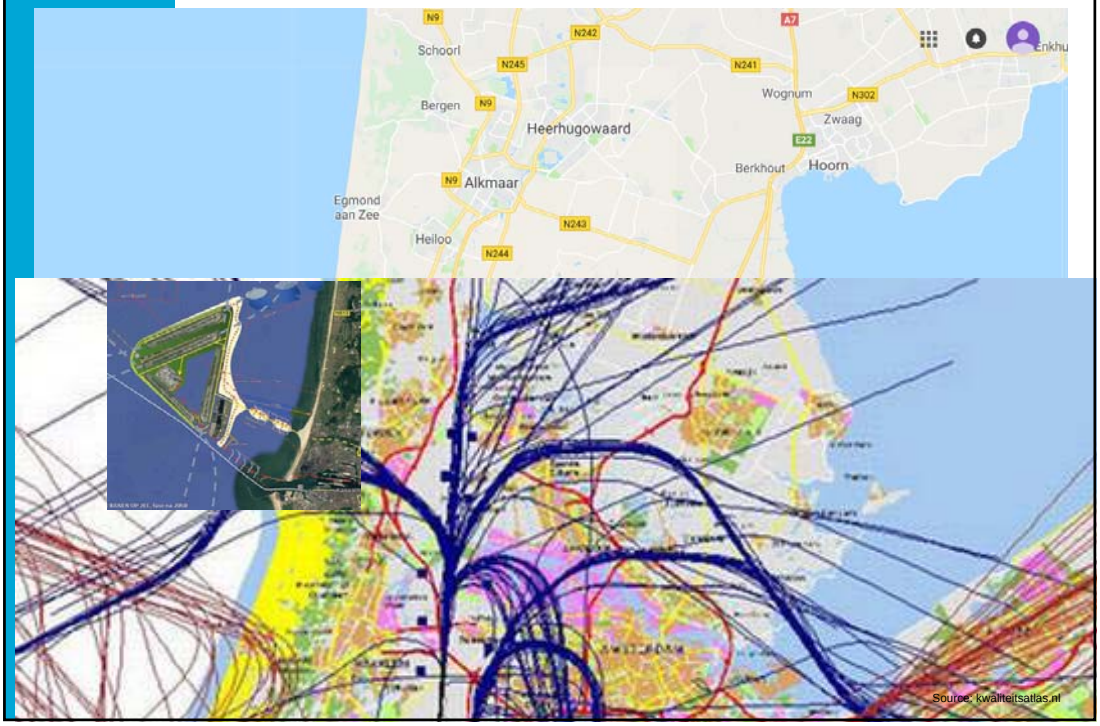
An airport in the North Sea



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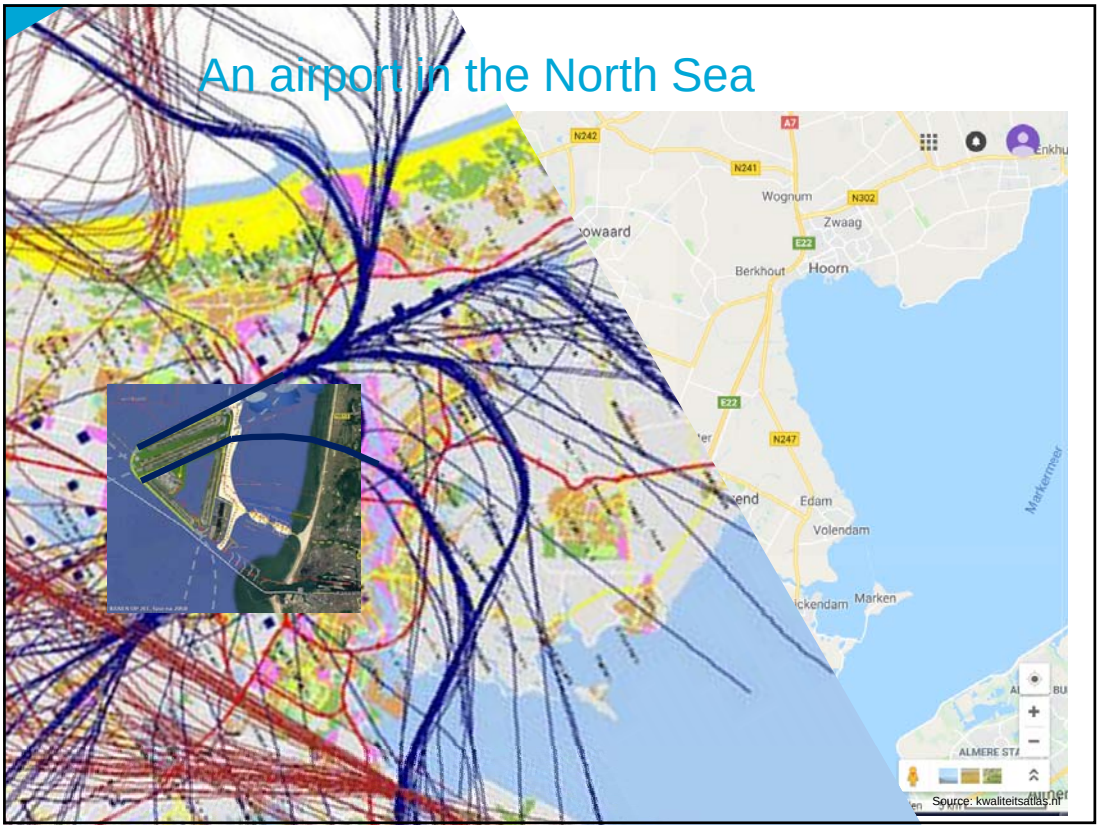

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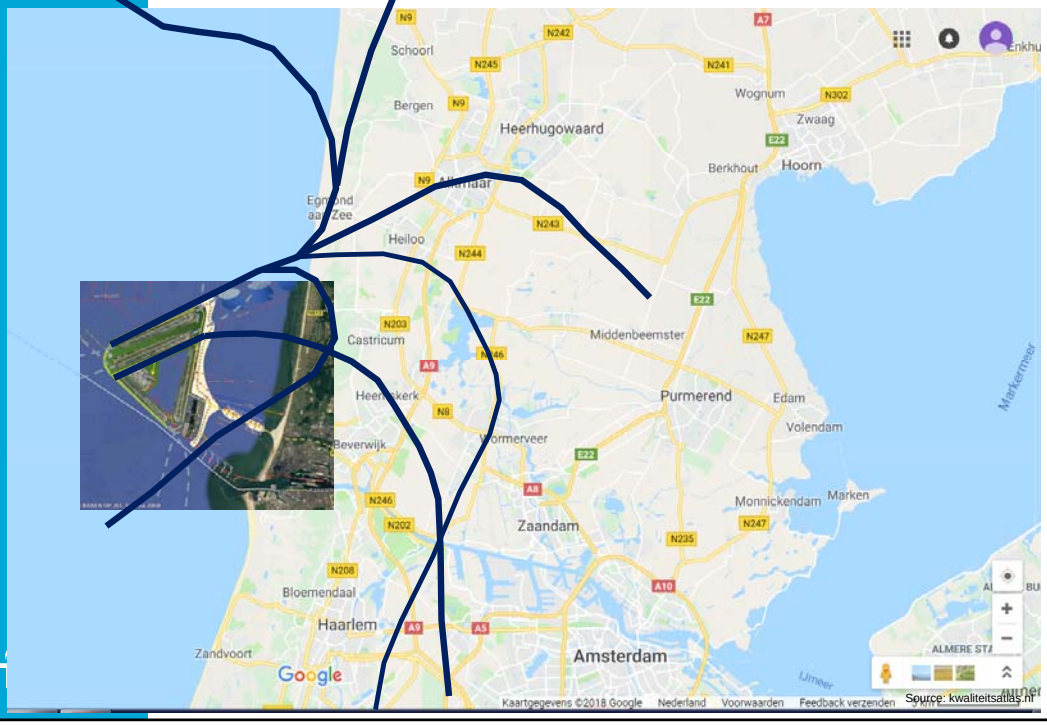

Future developments on airports

Ultra–green

Highly customer oriented

Highly time efficient

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Future developments on airports

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New configurations

Source: orbitalvector.com

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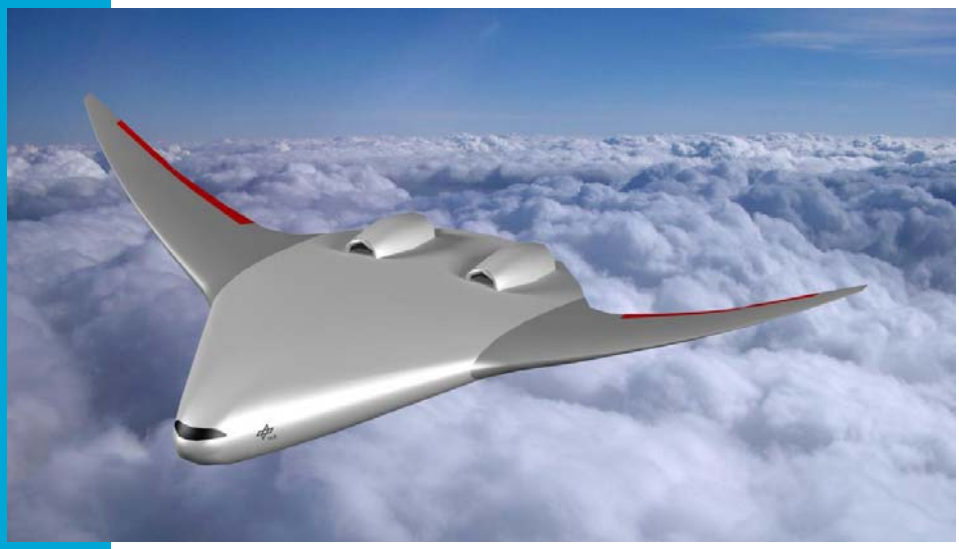
New configurations



Source: DLR

New configurations

Source: NASA

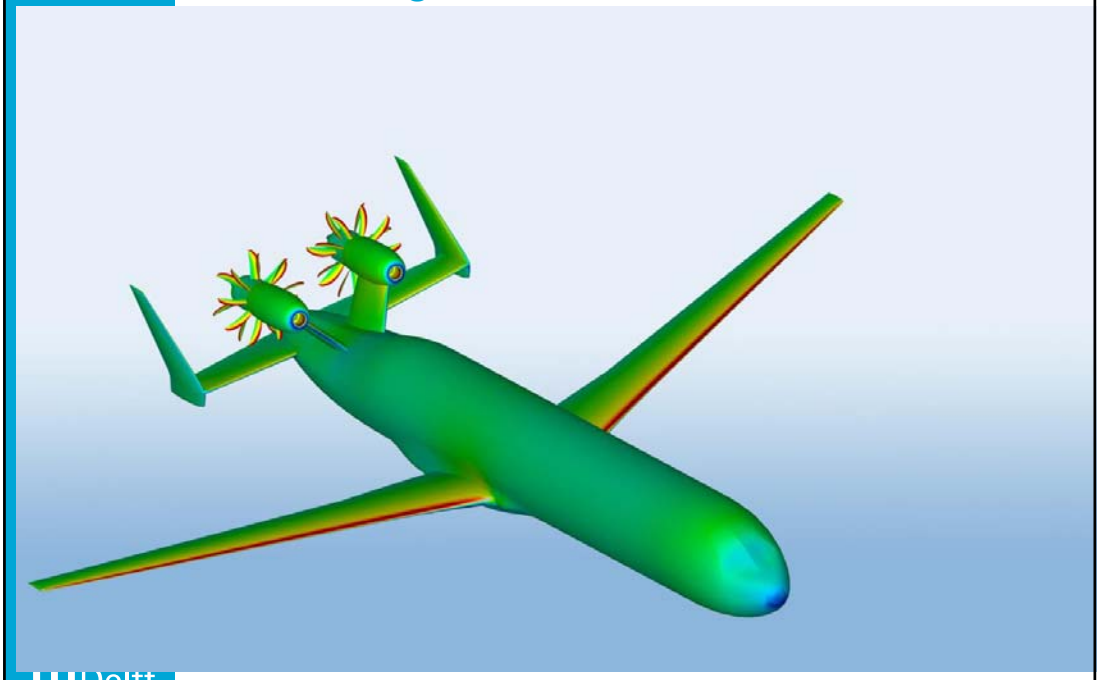
New configurations

Source: theverge.com

New configurations

Source: Airbus

New configurations



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Sources: GE, NASA, aerobuzz.fr,Entrevoisins, NLR

New configurations

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Sources: NASA

New configurations – quick change

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New configurations – quick change

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New configurations – quick change

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New configurations – quick change

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New configurations – quick change

Source: Mets747, CNN, Airbus

New configurations – quick change

Source: blogs.wsj.com

Conclusions

There are no major quick changes to be expected

We need more research and development

We need to look into alternative “drop-in” fuels

We need better procedures (Single European Sky)

For more rapid changes we need stronger incentives (legislation + societal pressure)

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