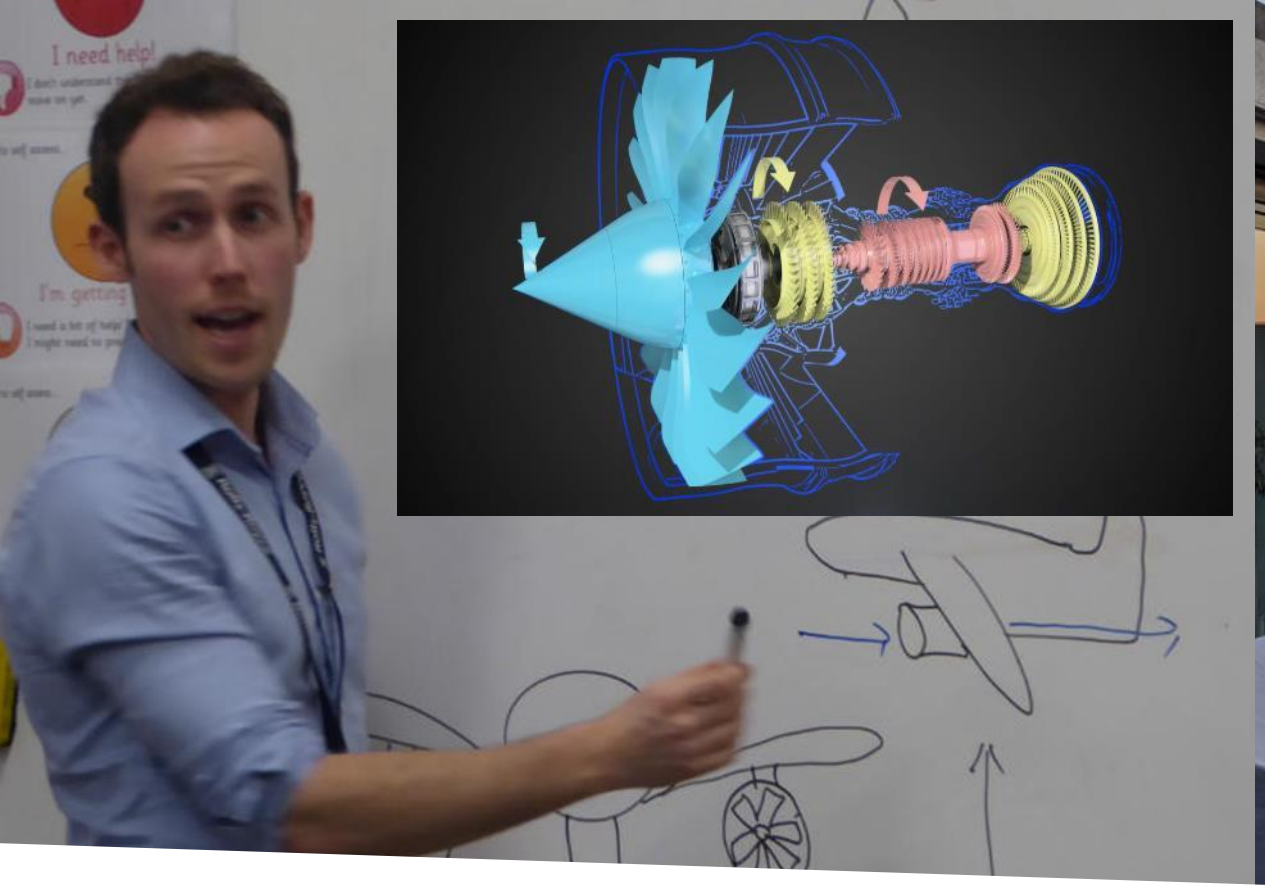
Aircraft Engine Design

Fuel efficiency vs. Noise

uecna
European Union Against Aircraft Nuisances

Safe
Landing



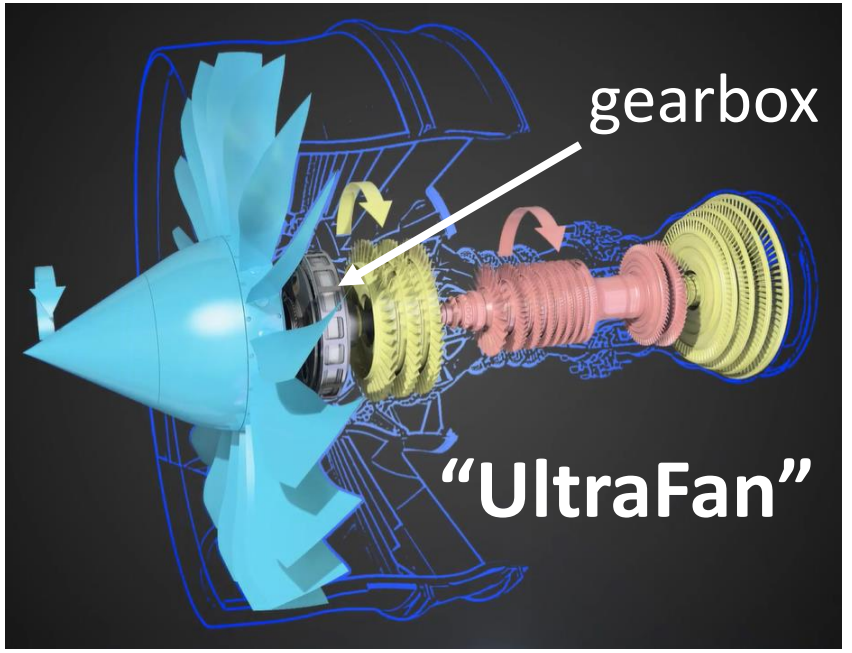
Finlay Asher

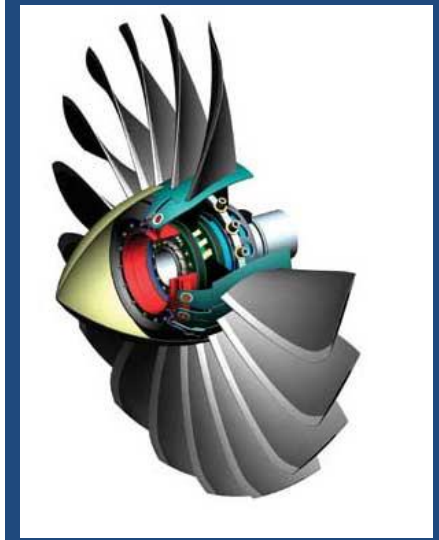
- Mechanical / Aerospace Engineer
- Safe Landing & Green Sky Thinking
- 7 Years @ Rolls-Royce: Future Aircraft Engine Design

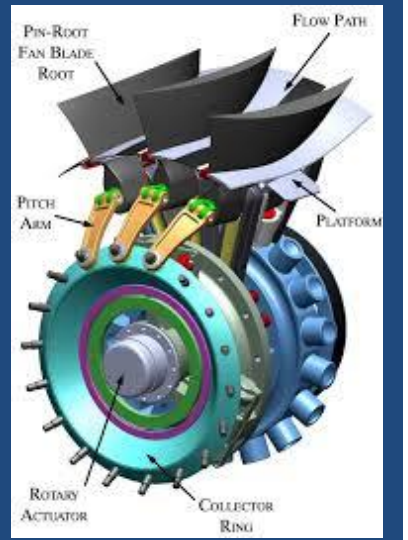
Safe Landing

My Background: Future Concepts

"Future Programmes" = 2030-2040







"Variable Pitch Fan"


Employee Sustainability Group

Safe Landing

AVIATION WORKERS
FOR A SUSTAINABLE FUTURE

"A group of aviation workers, looking to navigate a sustainable future for the industry"

The goals of Flightpath 2050

In 2050 technologies and procedures available allow a:

- 75% reduction in CO2 emissions per passenger kilometre
- 90% reduction in NOx emissions.
- 65% reduction in perceived noise emissions

Relative to the capabilities of typical new aircraft in year 2000.

Source:
ACARE

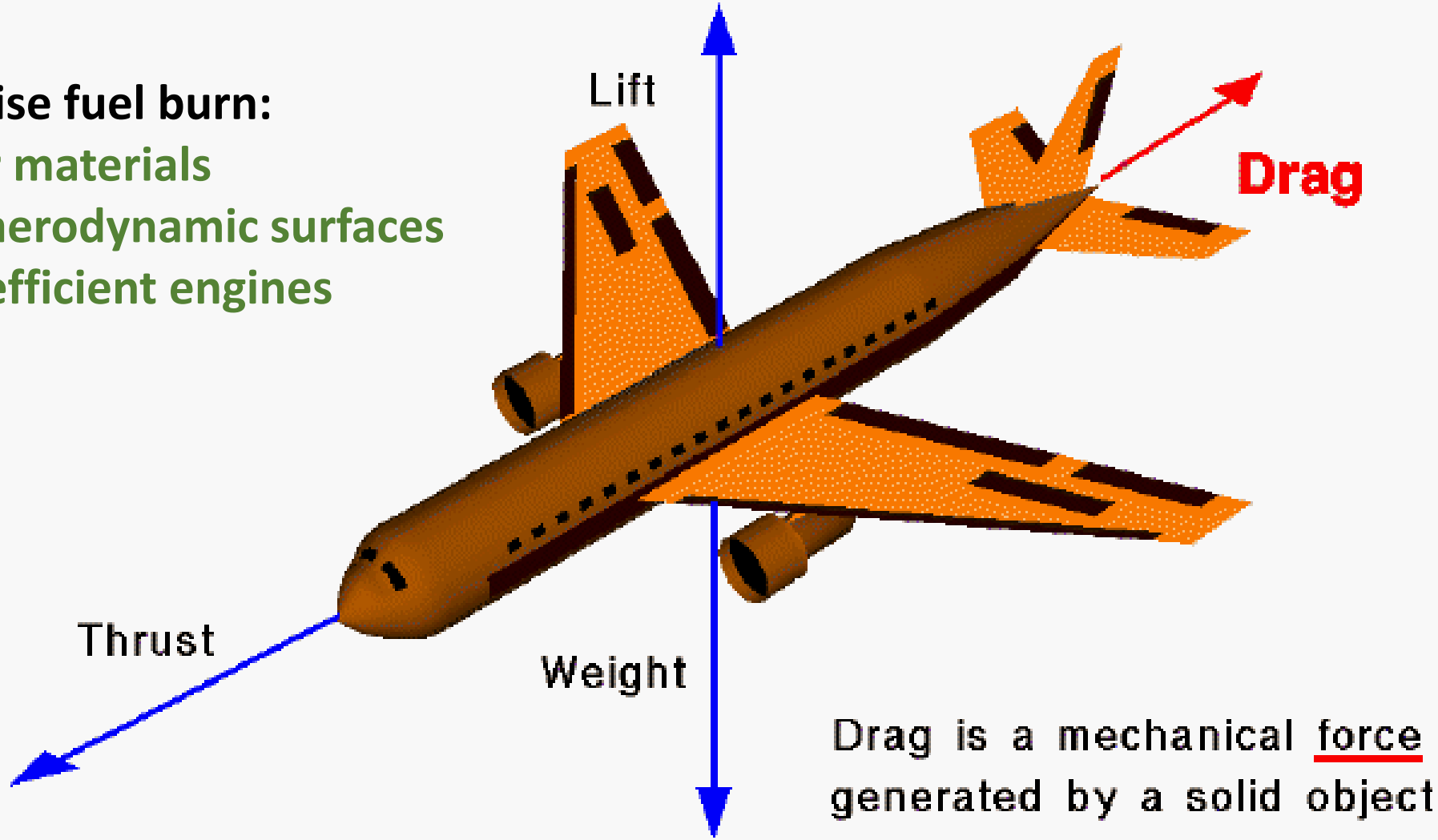
Aircraft Efficiency

What is Drag?

Glenn Research Center

To minimise fuel burn:

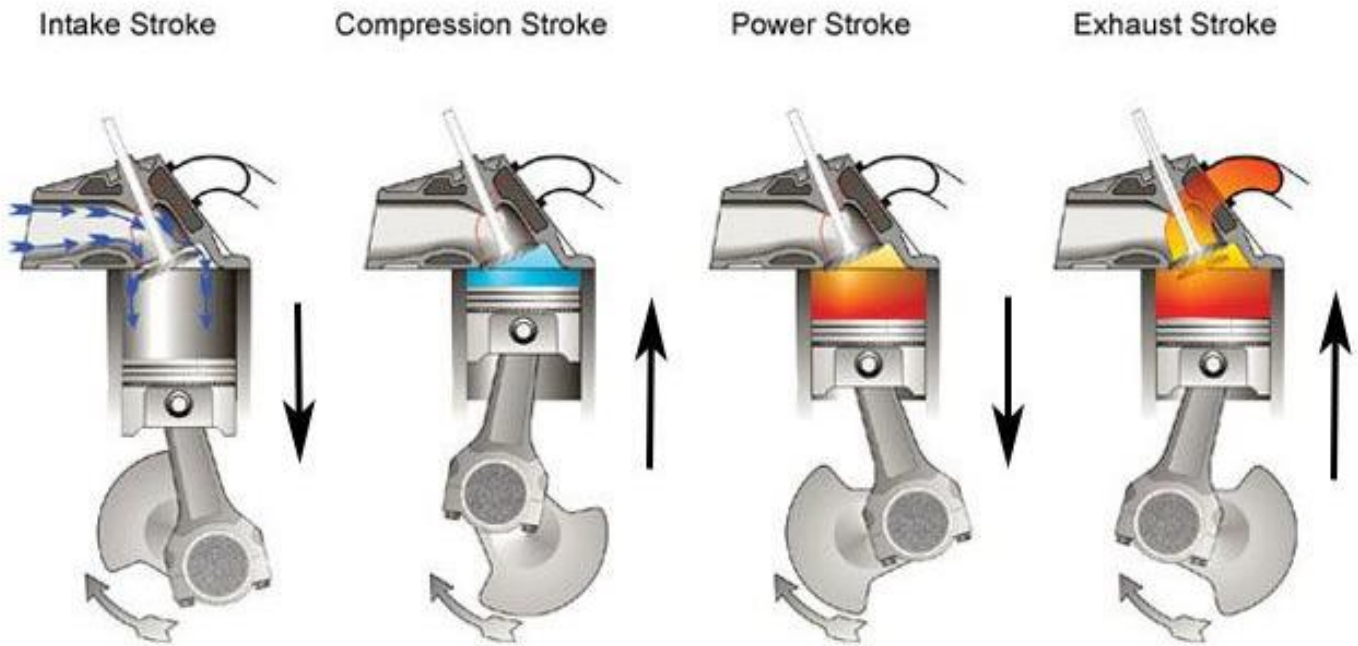
- ✓ Lighter materials
- ✓ More aerodynamic surfaces
- ✓ More efficient engines



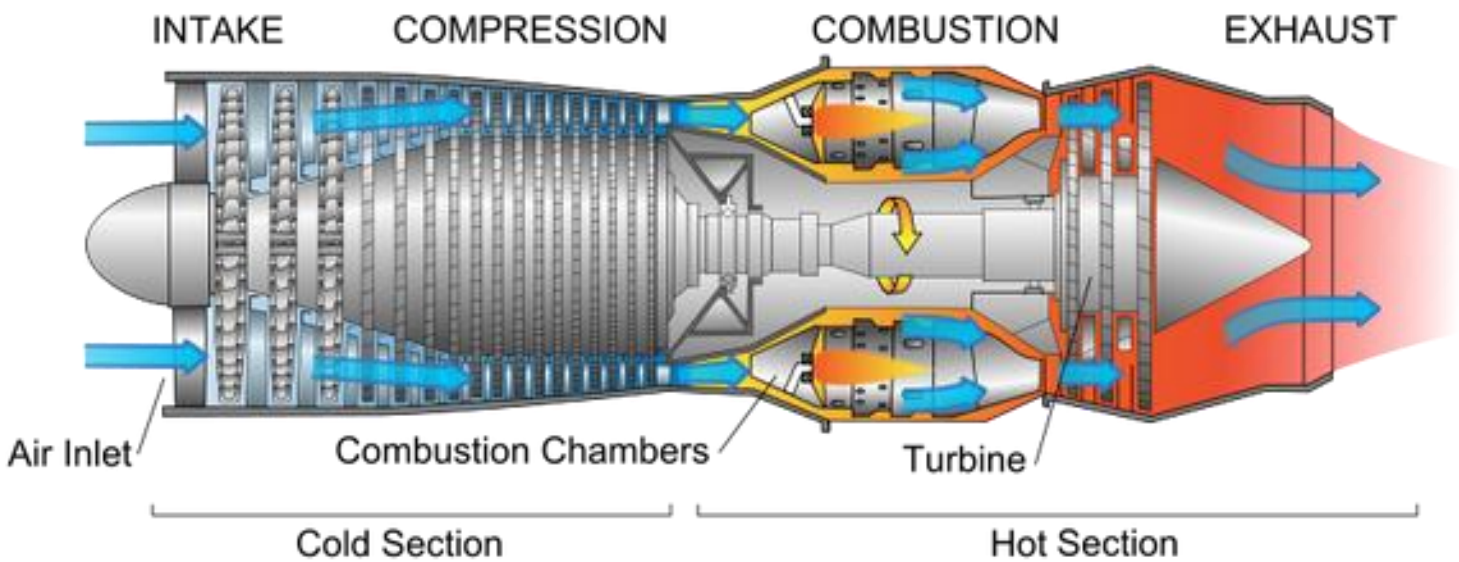
Drag is a mechanical force generated by a solid object moving through a fluid.

Force = Mass x Acceleration

Piston Engine



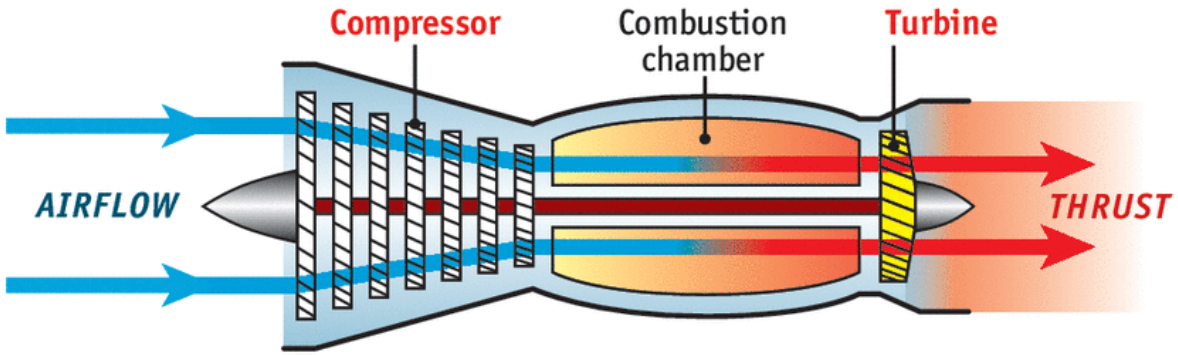
Jet Engine



Three jet ages

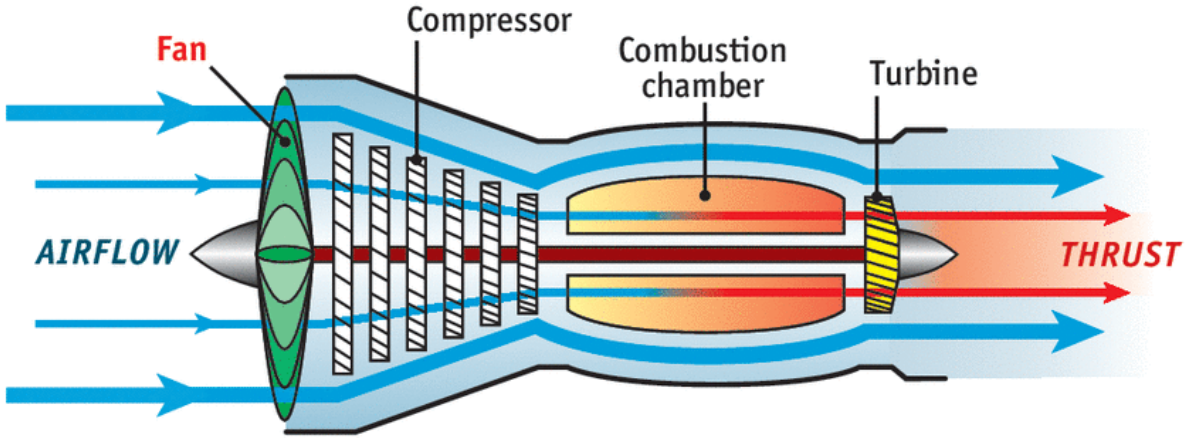
TURBOJET

In early jets incoming air was directed to the compressor and ignited with fuel to create thrust and drive a turbine



TURBOFAN

A fan is used to drive a proportion of the air more slowly around the core of the engine, to provide thrust more efficiently



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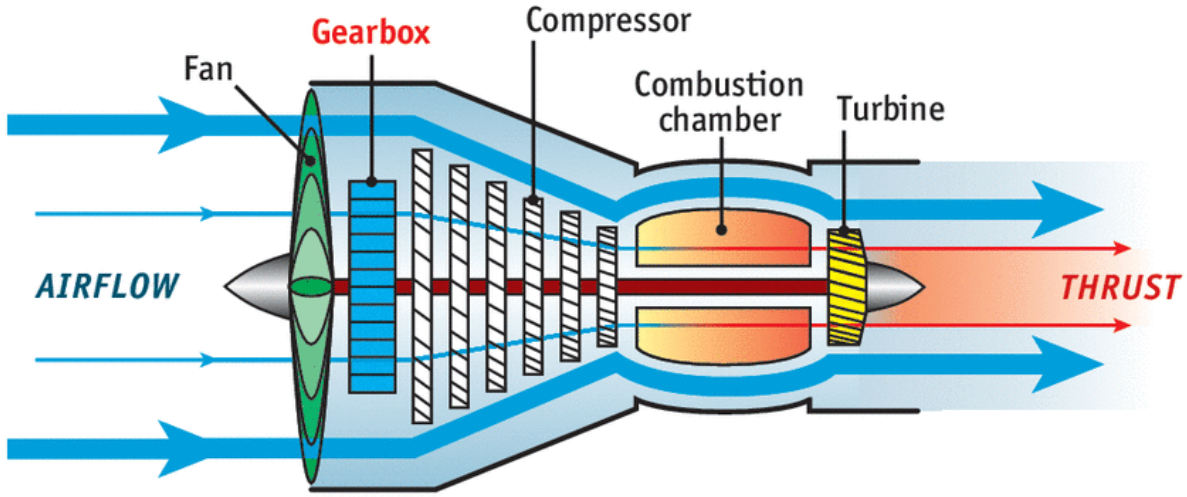
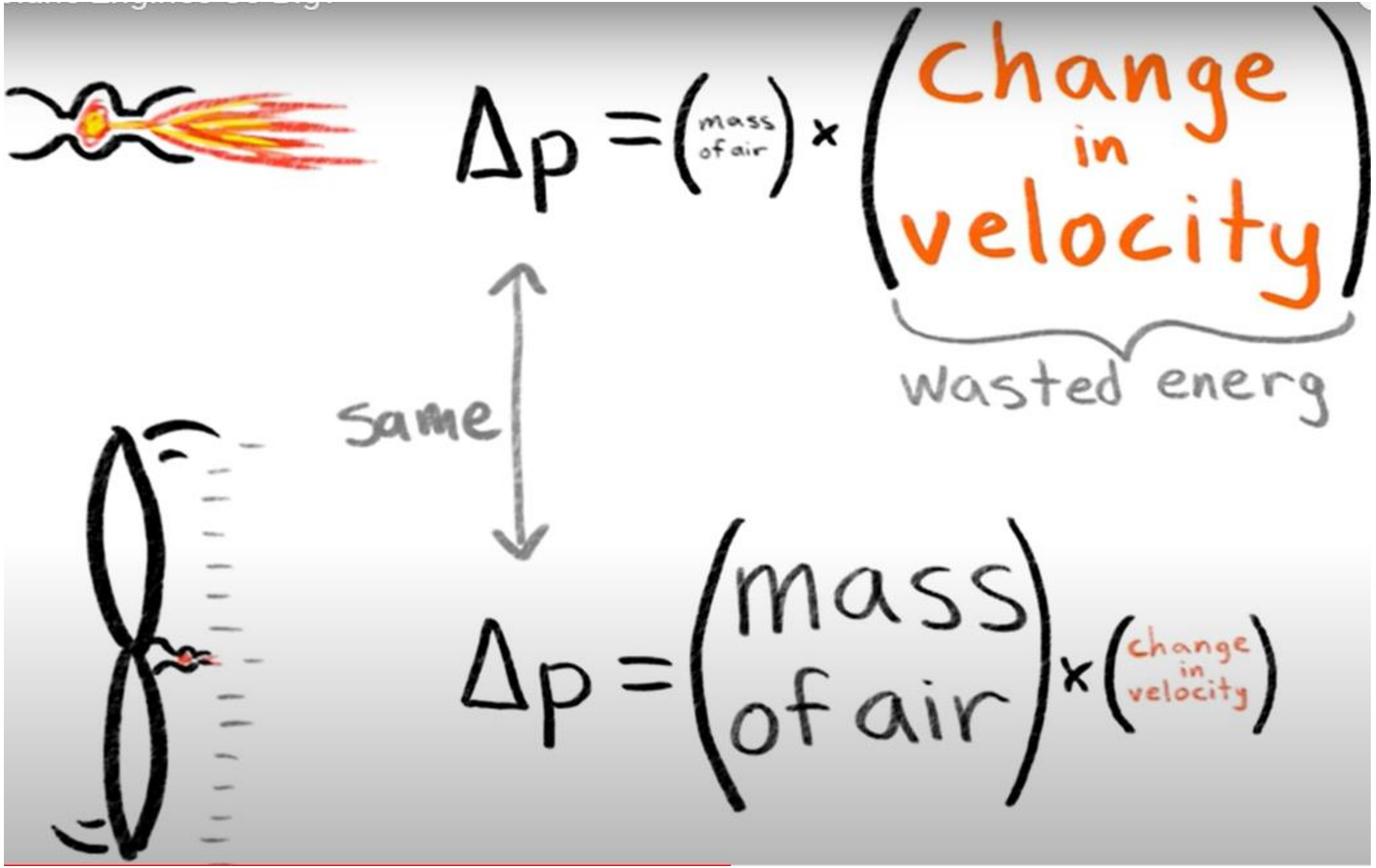


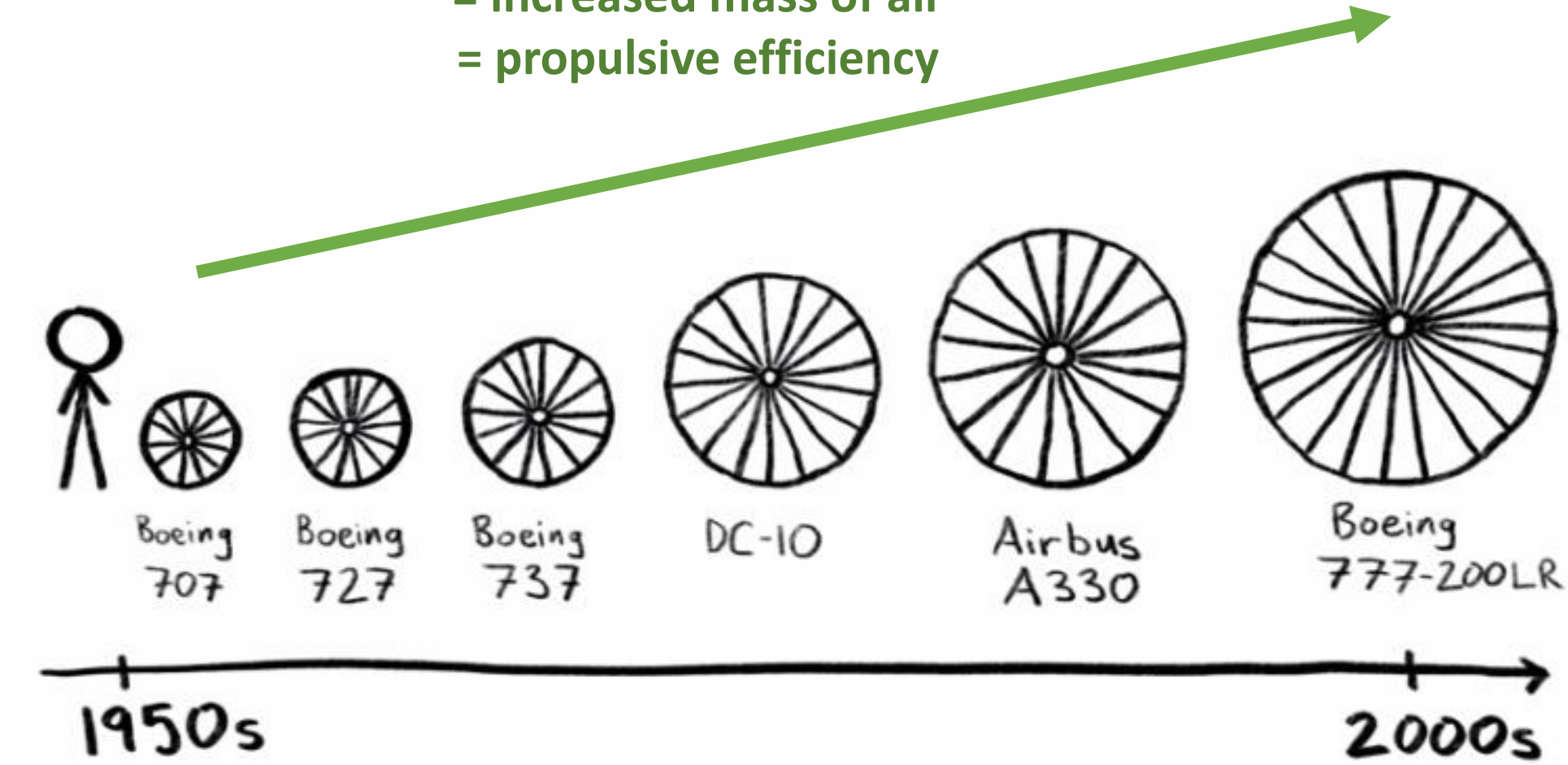
Economist.com

Source:
The Economist



Source:
[MinutePhysics]

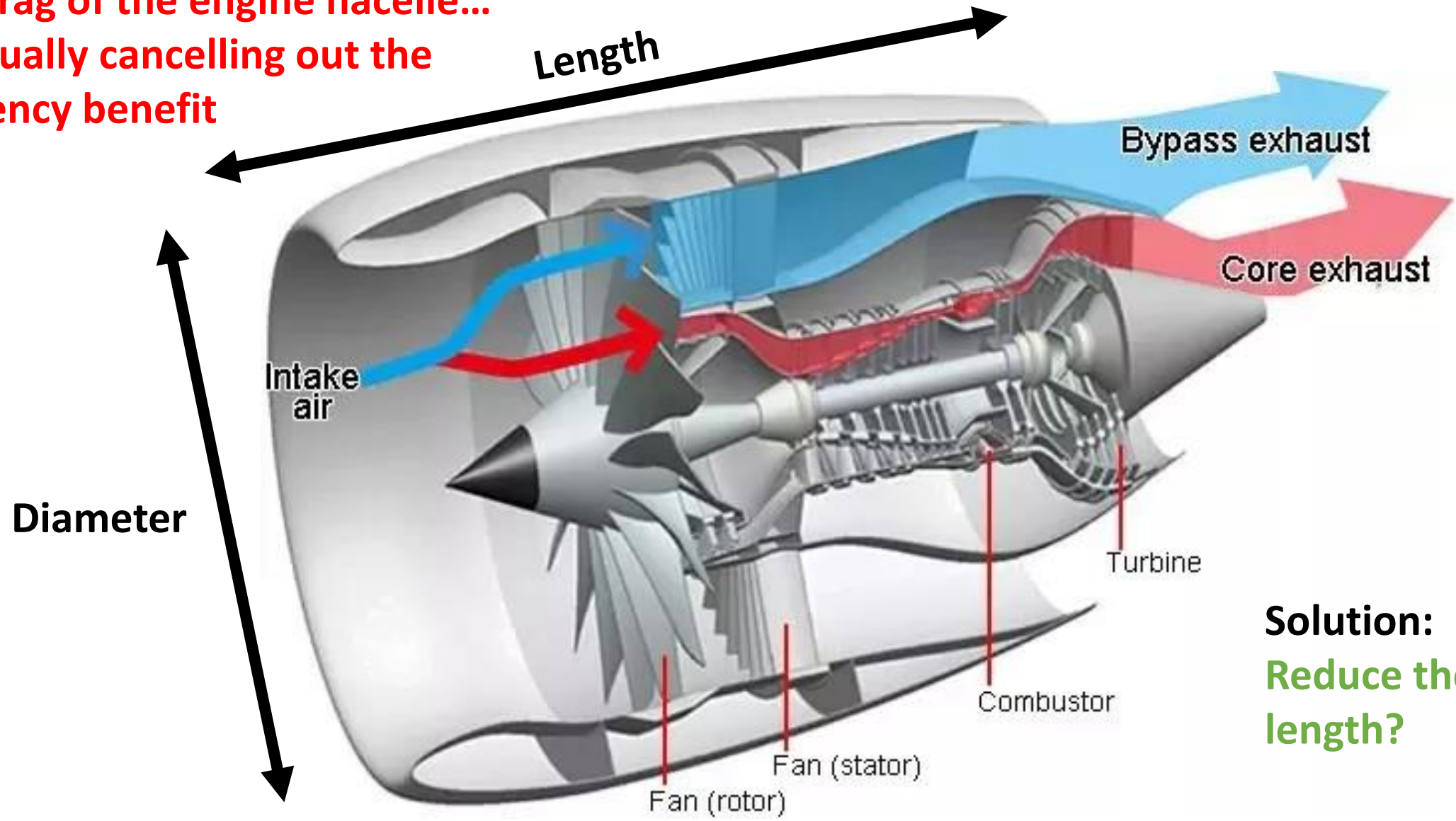
Increasing Engine Diameter
= increased mass of air
= propulsive efficiency



Source:
MinutePhysics

Design Issue:

Increasing the diameter of the engine also increases the weight and drag of the engine nacelle… eventually cancelling out the efficiency benefit



Solution:

Reduce the engine length?

BOEING

Commercial Defense Space Services Safety Innovation

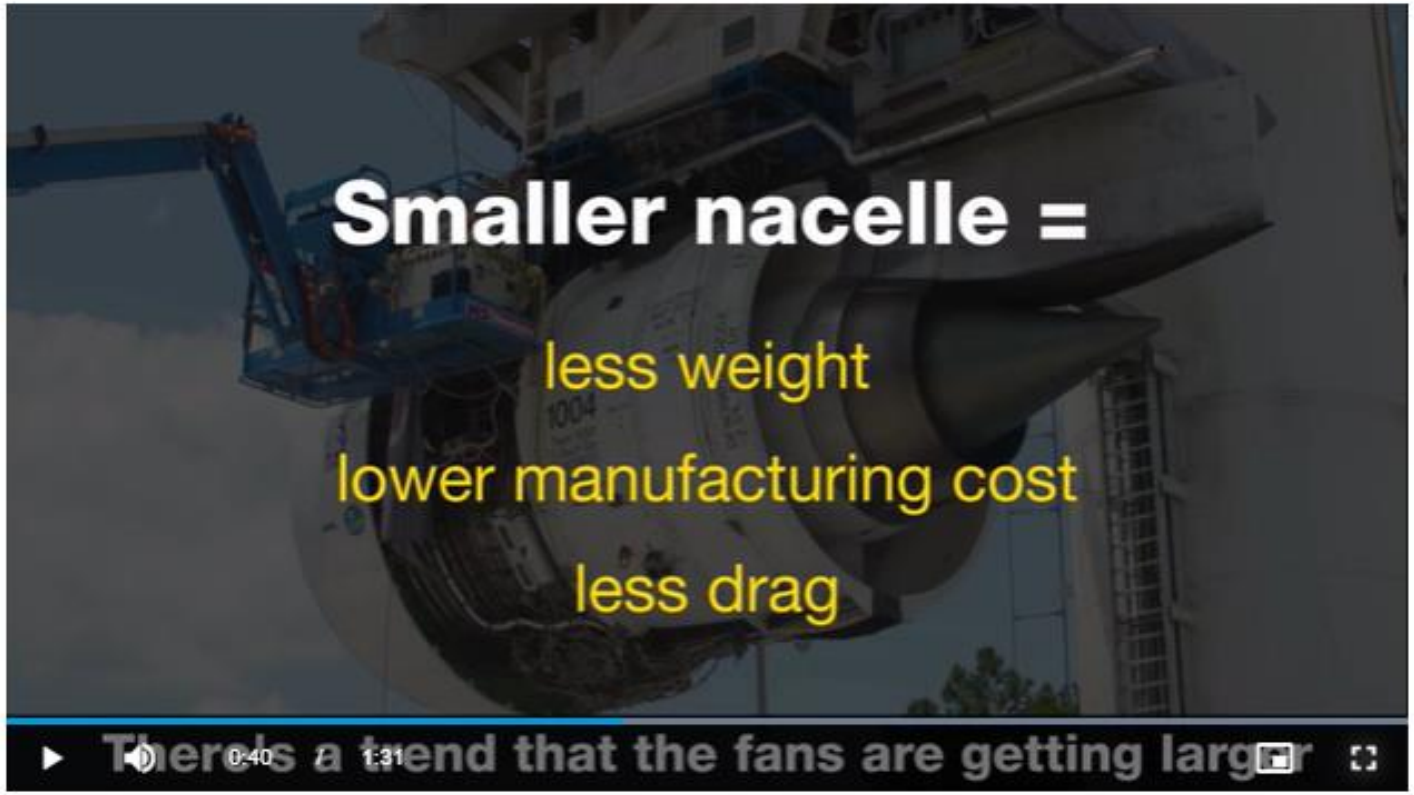
BOEING > FEATURES & MULTIMEDIA > TECHNOLOGY > BIG ENGINE QUESTION COULD HAVE 'SHORT' ANSWER

Big engine question could have 'short' answer

February 23, 2018 in Technology, Commercial

Boeing

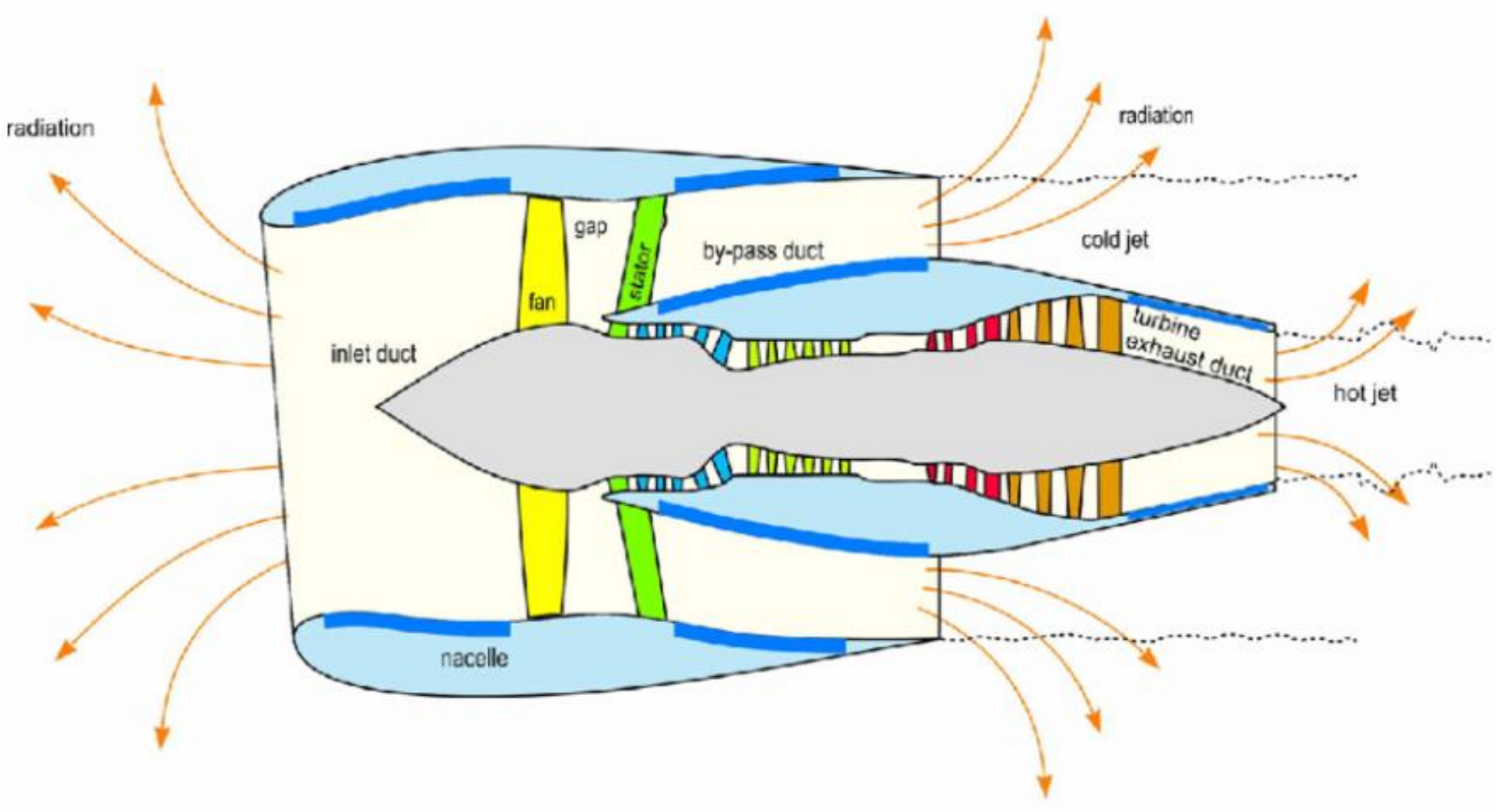
“Short Inlet”



Source:
Boeing

Design Issue:

Shortening the engine nacelle = shorter engine inlet and bypass duct, will decrease the space available for acoustic liners (noise damper panels) within the nacelle.



Location of acoustic liners in an aircraft engine.

Source:
Tamer Elnady, ResearchGate

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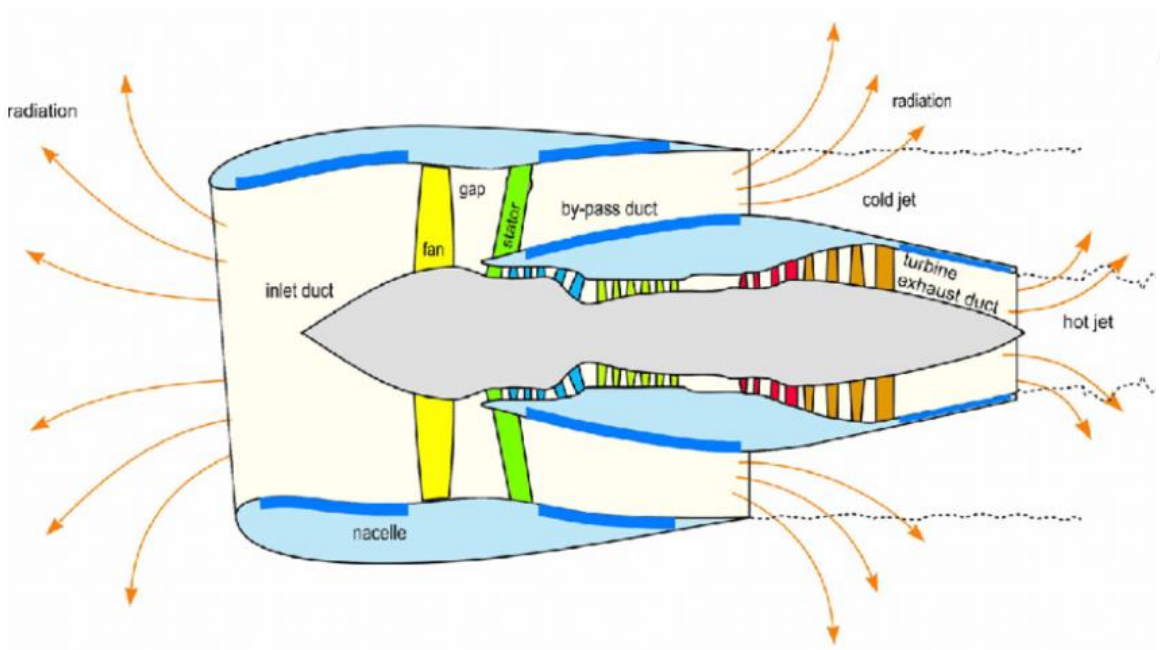
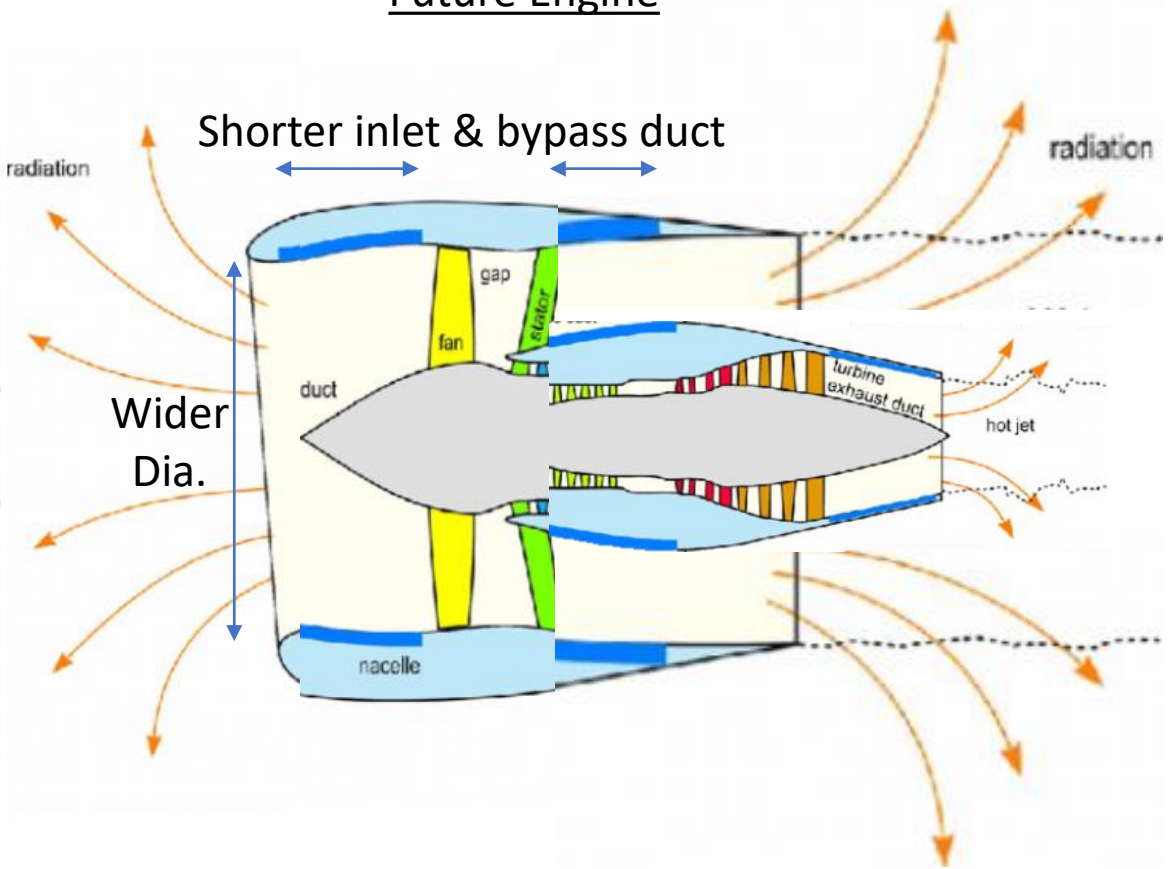
Current Engine



Location of acoustic liners in an aircraft engine.

Future Engine



Source:
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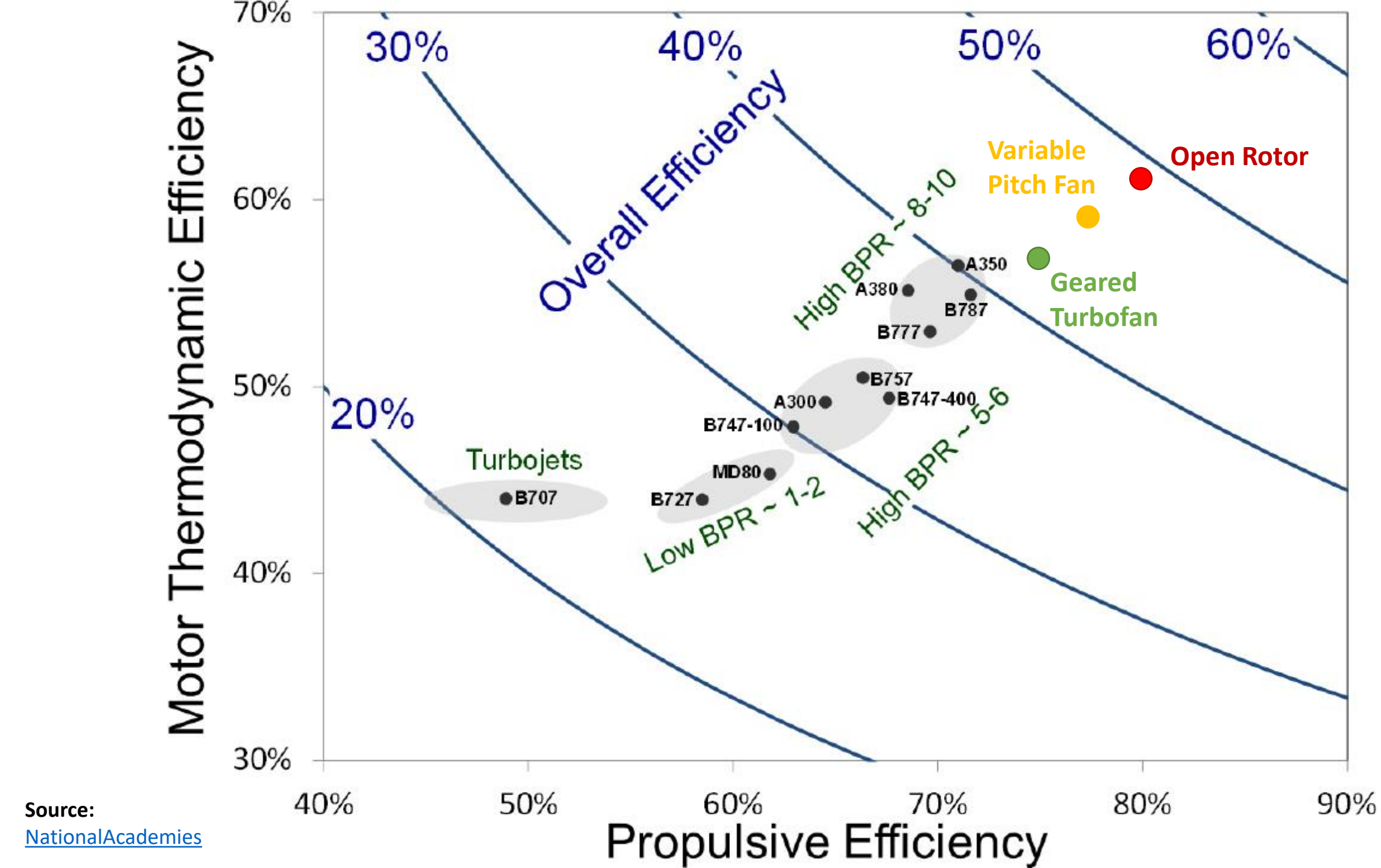

Source:
NationalAcademies

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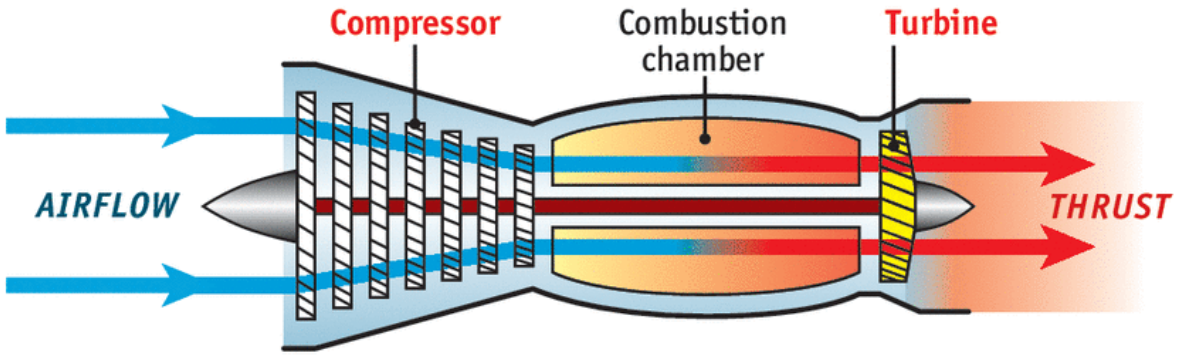

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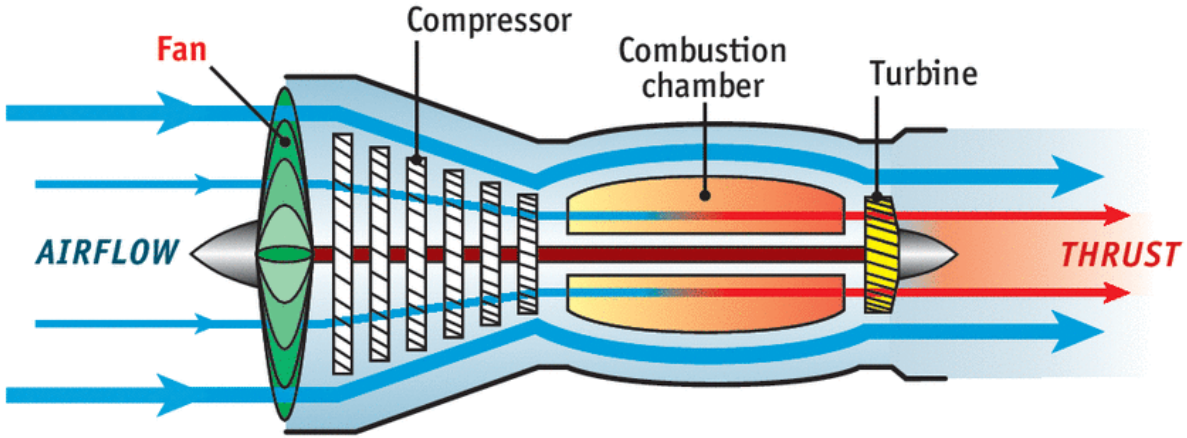

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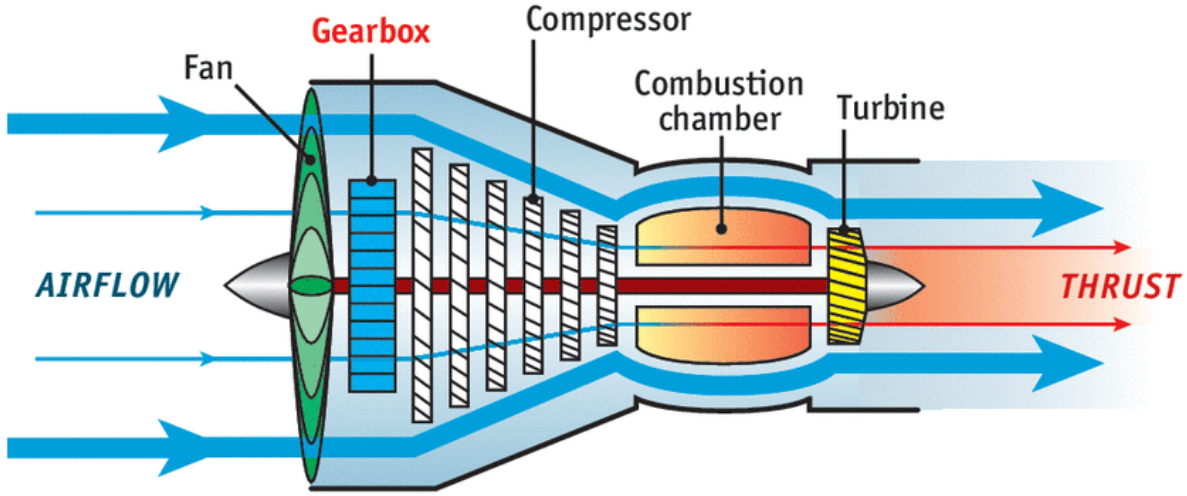
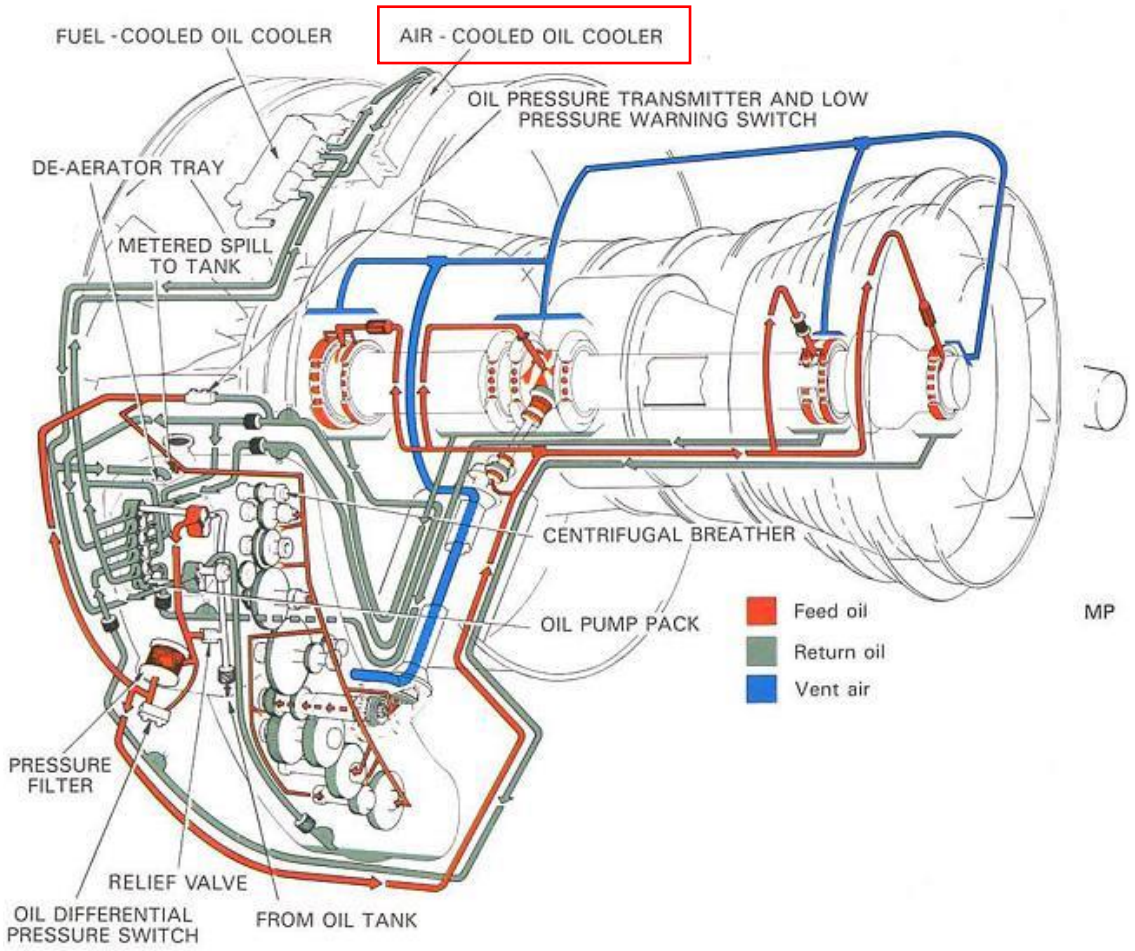


Economist.com

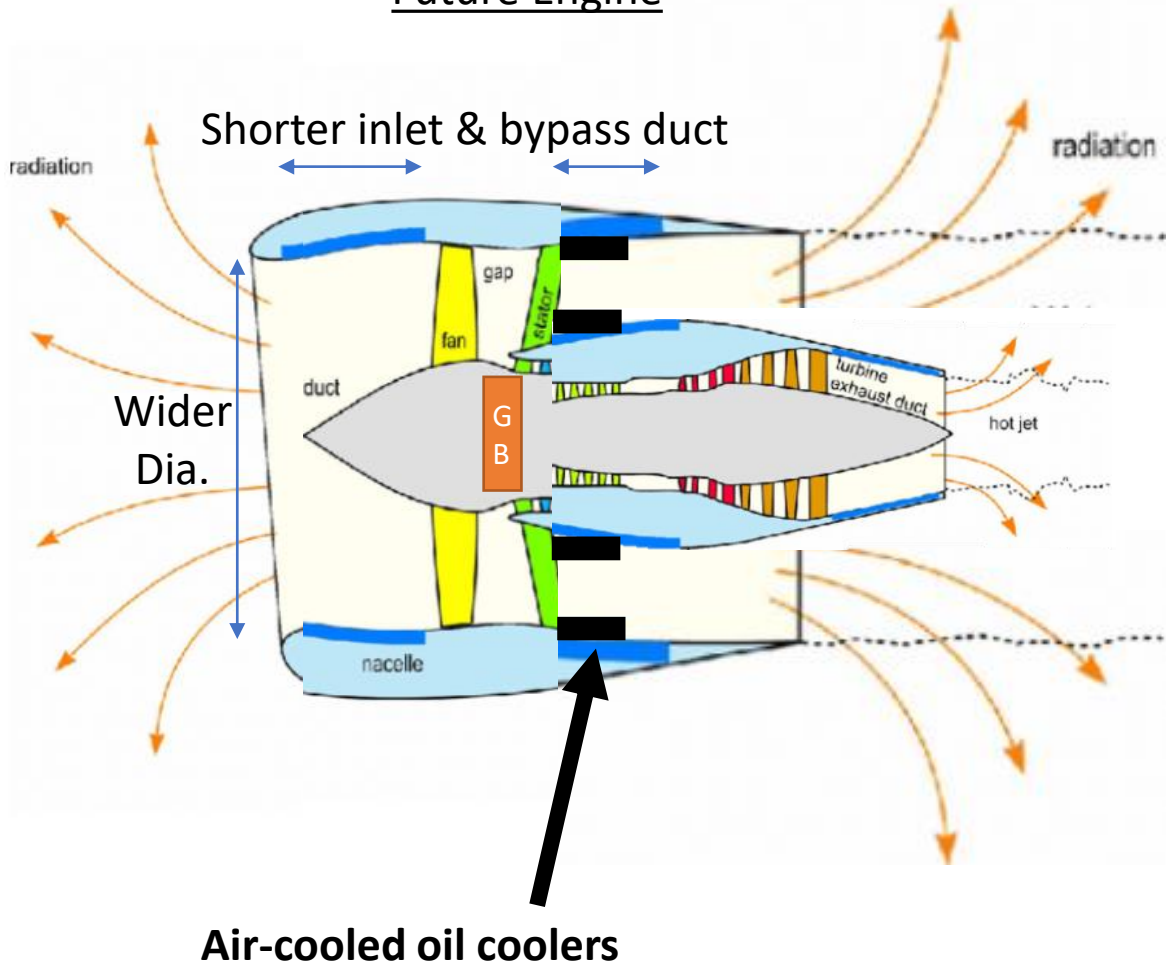
Source:
The Economist

Design Issue (Geared Turbofan):

Extra gearbox creates significant extra oil heat which requires extra oil coolers in the bypass duct = less space for acoustic liners



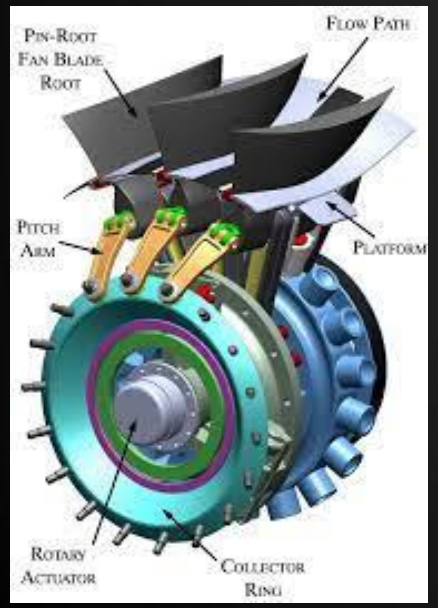
Future Engine

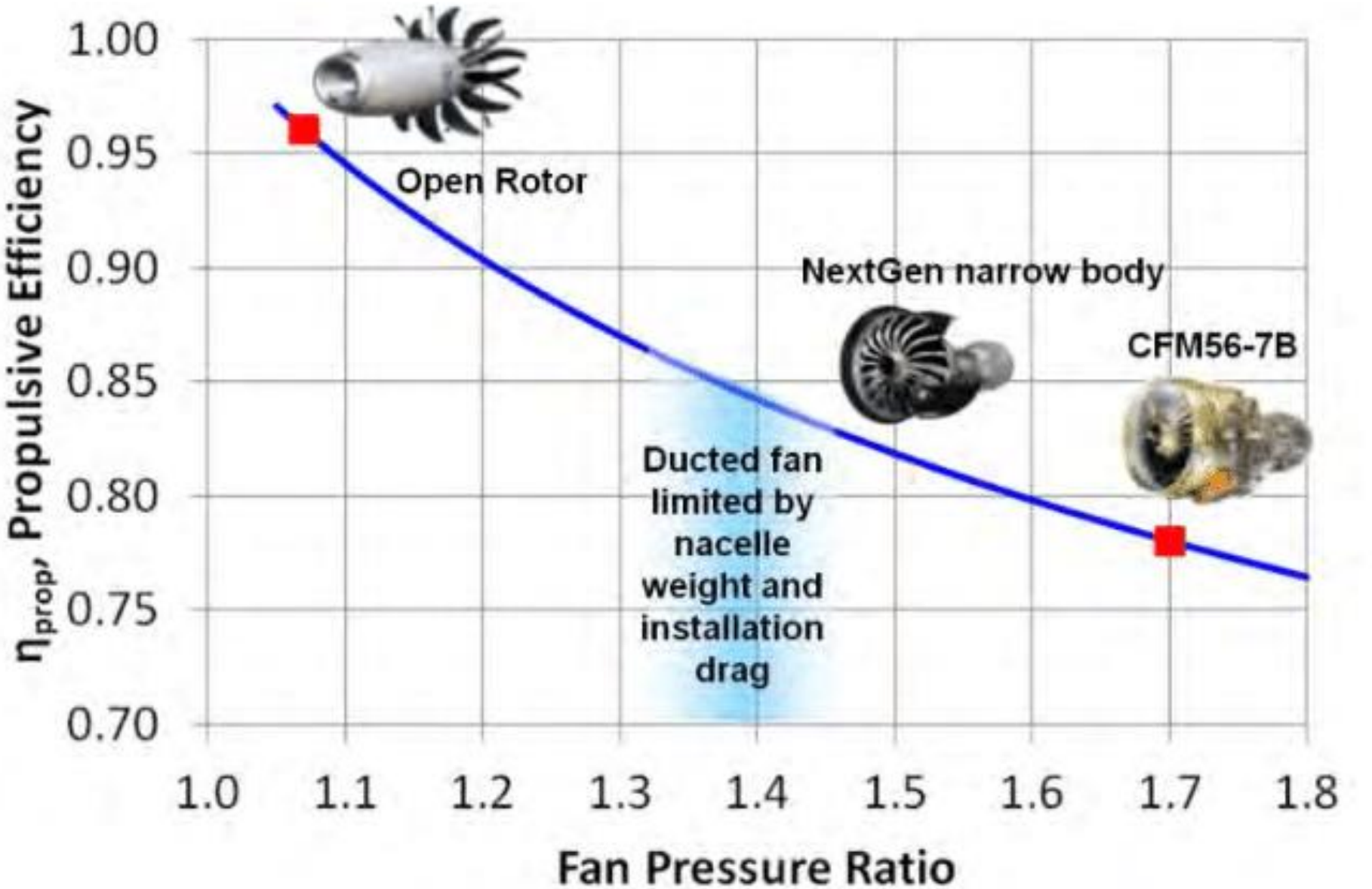


Variable Pitch Fan

Variable Area Nozzle

Issue: both add weight/cost/complexity but also add noise sources

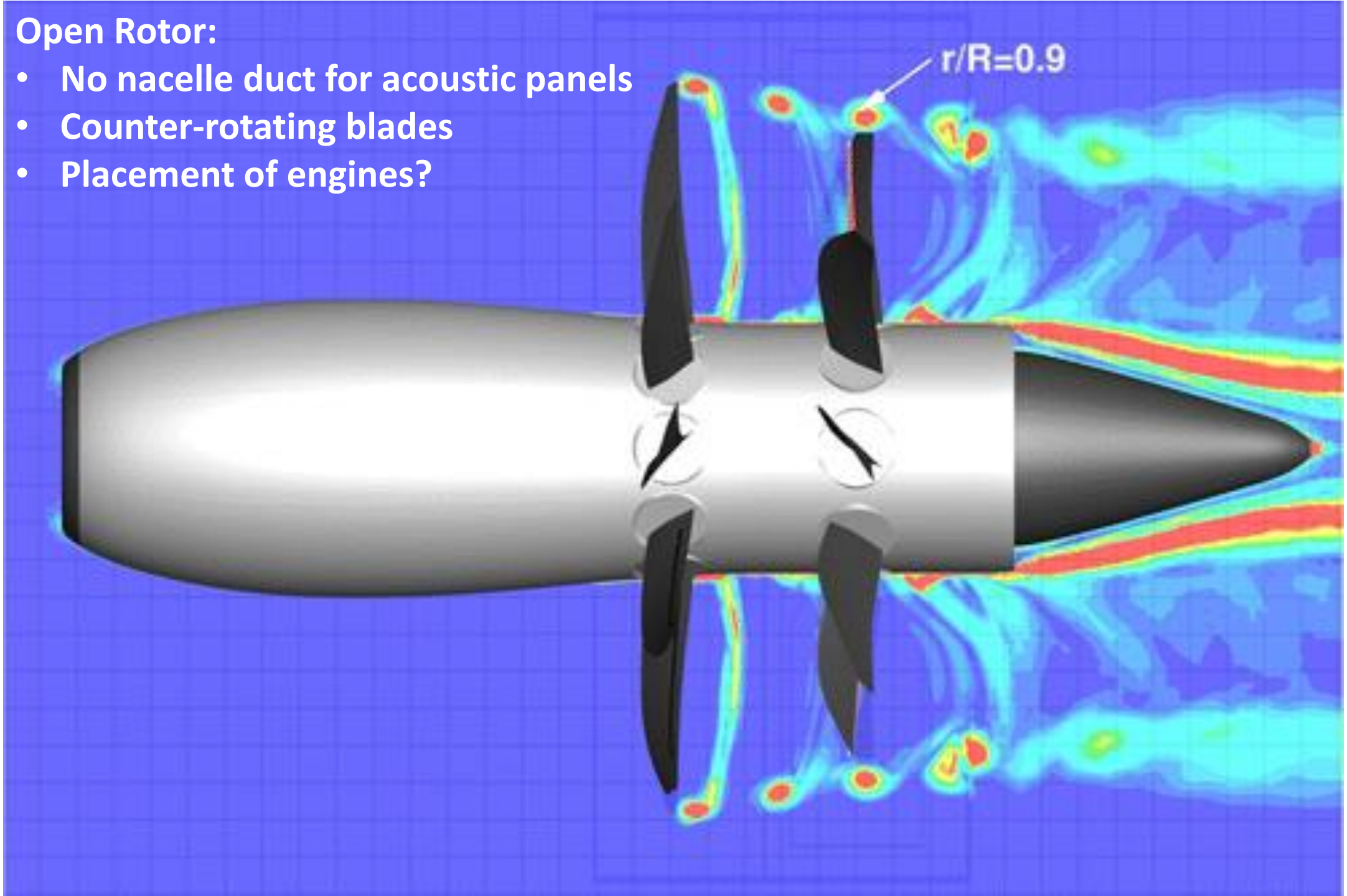




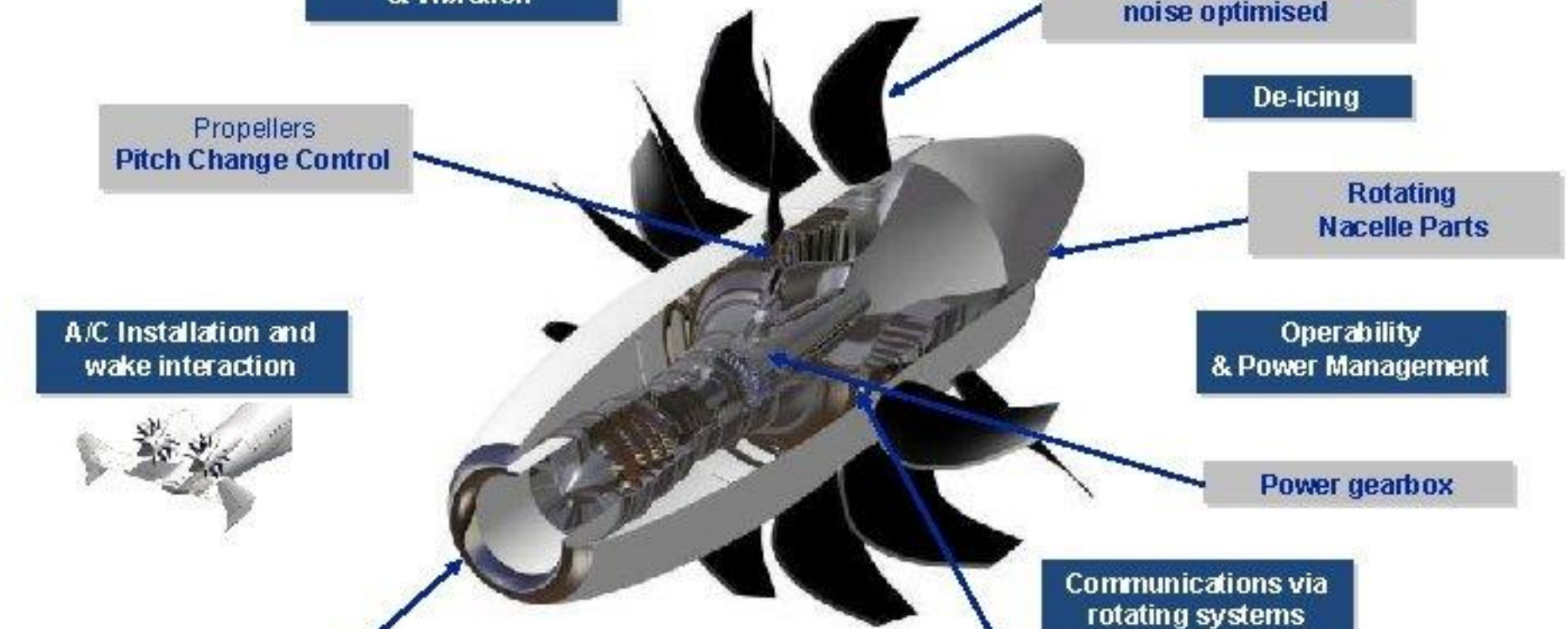
Source:
Andrew Dorsey, ResearchGate

Open Rotor:

- **No nacelle duct for acoustic panels**
- **Counter-rotating blades**
- **Placement of engines?**

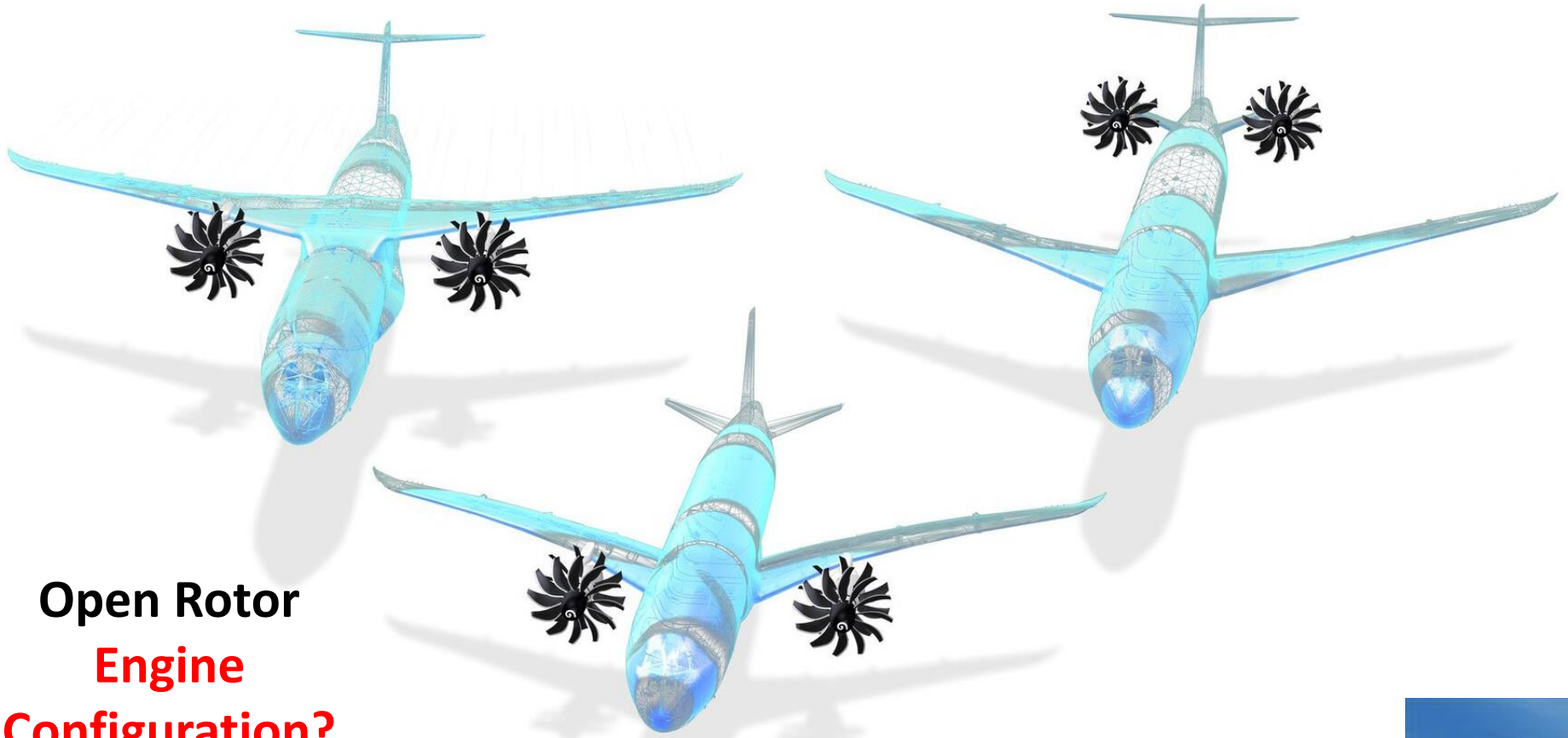


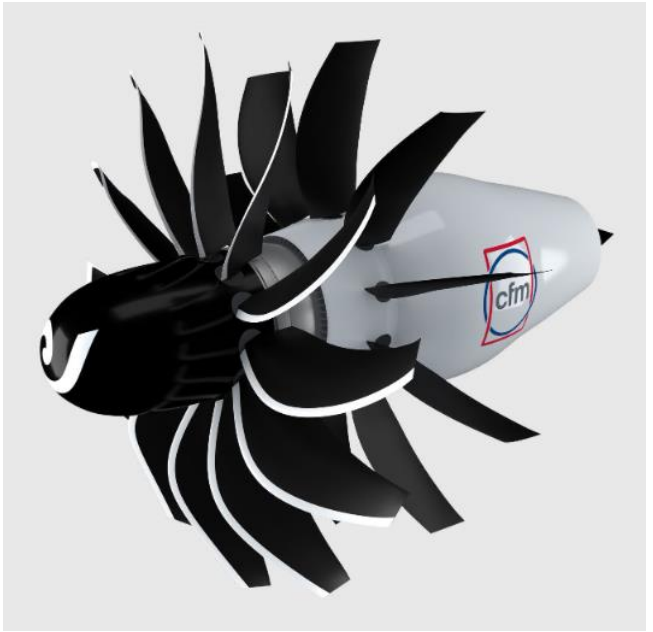
Contra-Rotating Open Rotor – Concept Challenges



First ground test before end 2015

Clean Sky





Open Rotor

Engine Configuration?

SUMMARY

Summary

- The engine is major source of aircraft efficiency gains
- Current turbofans increase propulsive efficiency by increasing engine diameter but marginal gains due to increased engine weight and drag.
- Shortening the nacelle to compensate reduces area for acoustic liners which is an unresolved challenge.
- Geared turbofans have an additional challenge due to heat exchanger requirements.
- Variable pitch fan / variable area nozzles could be additional noise sources – these will be required below a certain fan pressure ratio.
- Open rotor provides further fuel efficiency but nacelle lost completely, and unclear how to reduce noise and where to place engines.

Other thoughts:

- Tendency towards ‘stretched’ aircraft with higher passenger capacities and higher load factors = greater take-off weight = greater take-off thrust required = increased take-off and climb noise?

- Tendency towards longer-range flights = more fuel on board at take-off = greater take-off weight = greater take-off thrust required = increased take-off and climb noise?

- Higher day temperatures (due to global warming) = lower air density at ground level = higher engine speed for same engine thrust = increased take-off, climb, descent noise?

safe landing

www.safe-landing.org info@safe-landing.org