Aircraft Concepts and Technologies for Sustainable Aviation

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Outline

- Perspectives on Transportation
  - Aircraft fuel efficiency
  - Aviation and the global environment
- Future Aircraft Concepts
  - Near-term opportunities
  - Longer-term options
- Reflections on this Meeting

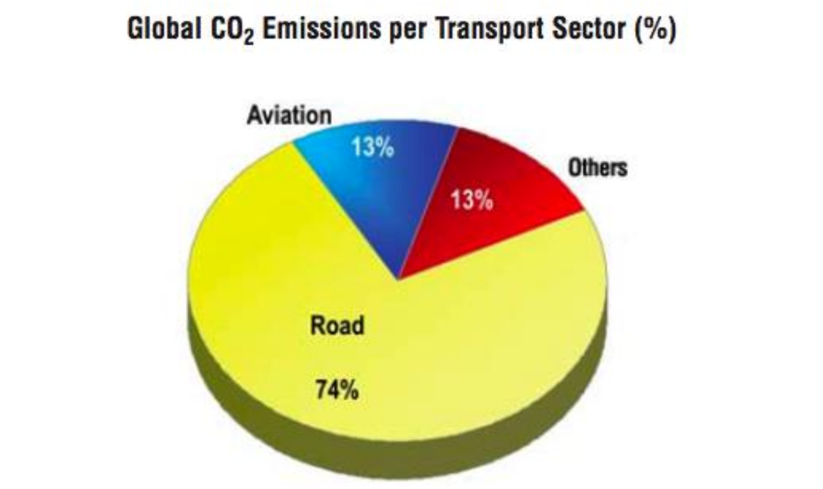
Modern Aircraft Fuel Efficiency

For a flight from Seattle to Washington D.C., each passenger needs about 29 gallons of fuel

2,325 mi, 3,709 gal, 162 pax, 80% load factor

Aviation Contribution to GHG

- Transport responsible for about 13%-20% of all GHG emissions.
- Aviation contributes about 13% of transportation CO2 emissions.
- That seems like 2%-3% of CO2, but net effect is perhaps 2-4 times this (4%-12%), and is increasing.



Total aviation accounts for about 13% of CO_2 emissions from transport sources compared to 74% of total transport CO_2 emissions from road transport.
Source: IPCC Special Report on Aviation and the Global Atmosphere (1999)

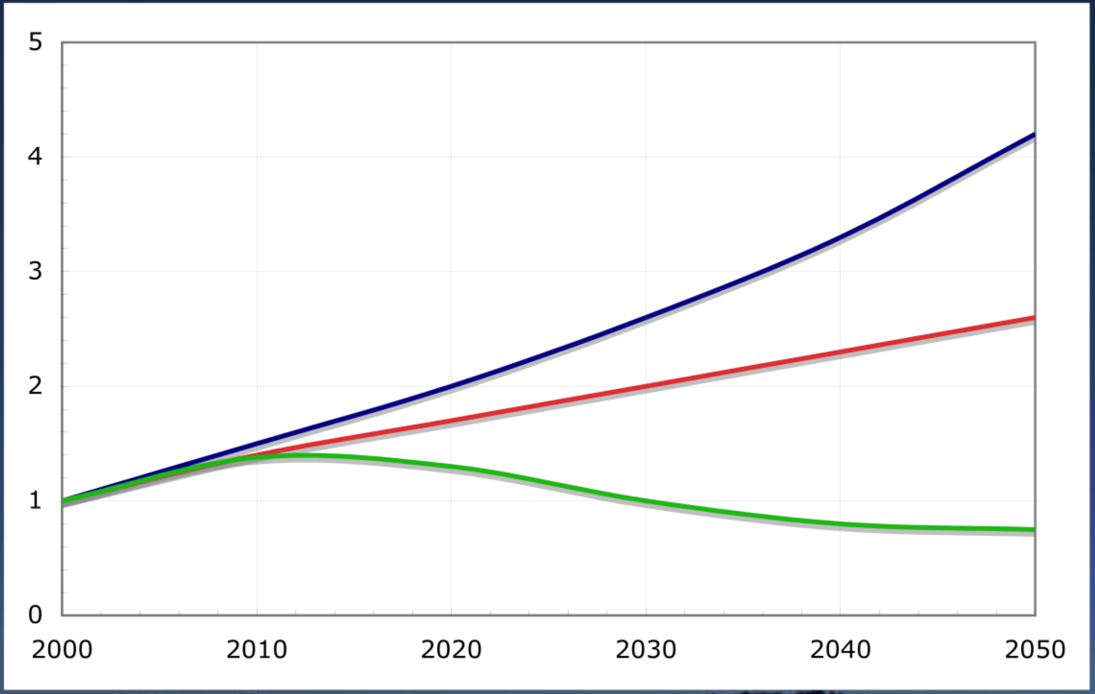
Sustainable Aviation – The Problem

With the expected increase in global air travel over the next 20-30 years, the reliability and environmental impact of aviation are becoming critical issues for the future of flight.

Issues:
Safety
Efficiency
Noise
NO_x
CO_2
H_2O

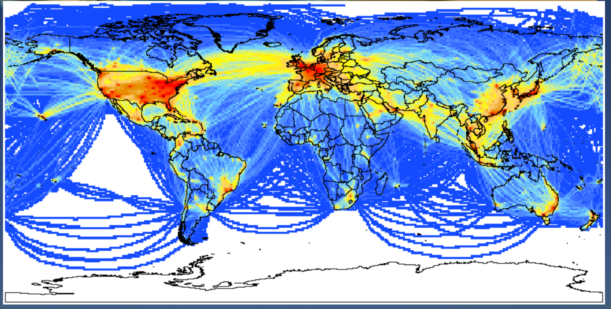
Sustainable Aviation

Goal: Develop technologies that will allow increased capacity with a **reduction** in environmental impact.



Approaches to Sustainable Aviation

- Aerospace system design for the environment
- Safely increase the capacity of the airspace system
- Active monitoring and managing air transportation's environmental footprint



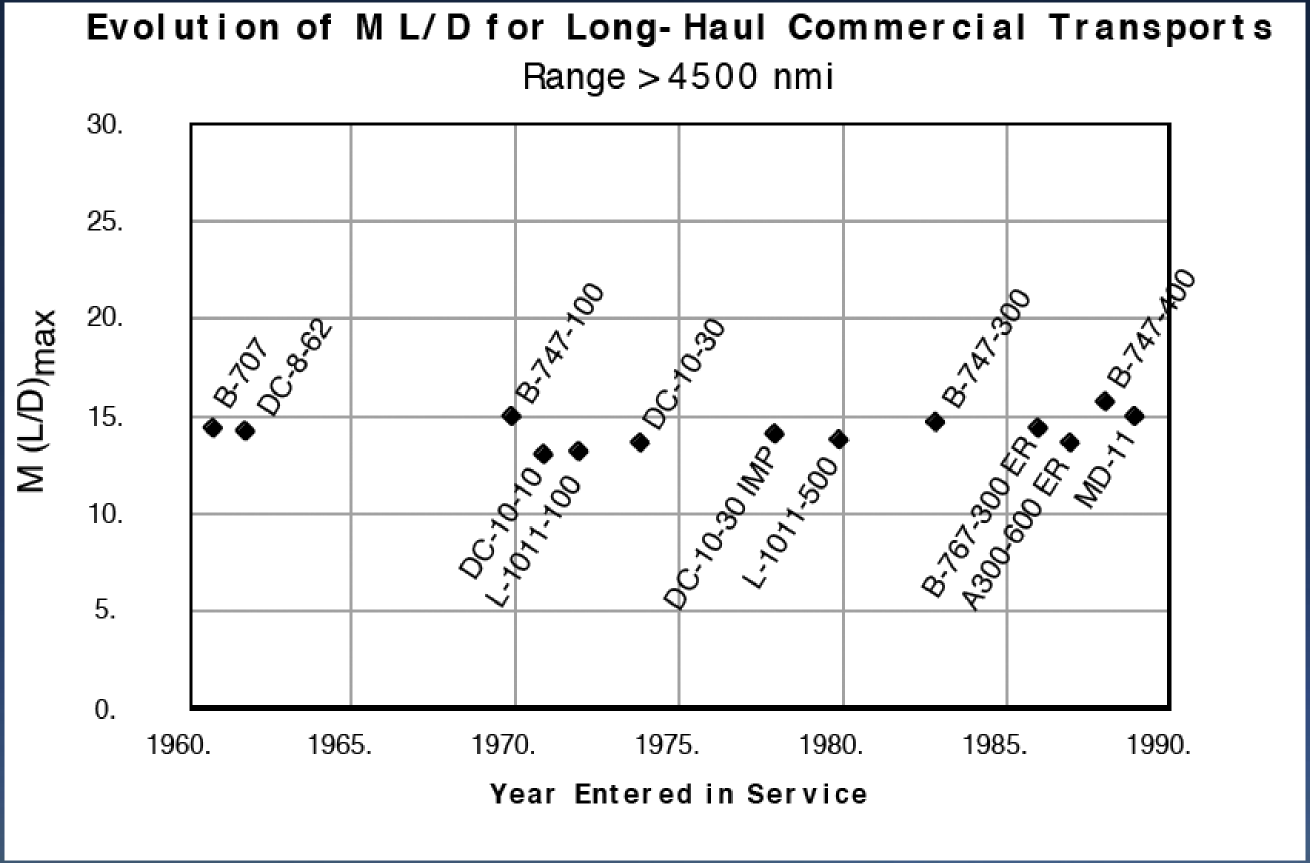
Increasing Aircraft Efficiency

- Engine efficiency, η, is about 40% (twice that of automobiles), and further gains are increasingly difficult.

- Transportation is basically 0% efficient. Why do we need energy?

- Energy / distance = Drag / η = Weight / η L/D

Aircraft L/D



Evolution of M L/D for Long-Haul Commercial Transports
Range >4500 nmi
M (L/D)max
30.
25.
20.
15.
10.
5.
0.
1960.
1965.
1970.
1975.
1980.
1985.
1990.
Year Entered in Service
B-707
DC-8-62
B-747-100
DC-10-10
L-1011-100
DC-10-30
DC-10-30 IMP
L-1011-500
B-747-300
B-767-300 ER
A300-600 ER
B-747-400
MD-11

Lift-to-Drag Ratio of Other Transport Modes

Passenger car:

L/D = 100 at V≈0

L/D = 40 at V = 60 mph

L/D = 16at V = 120 mph

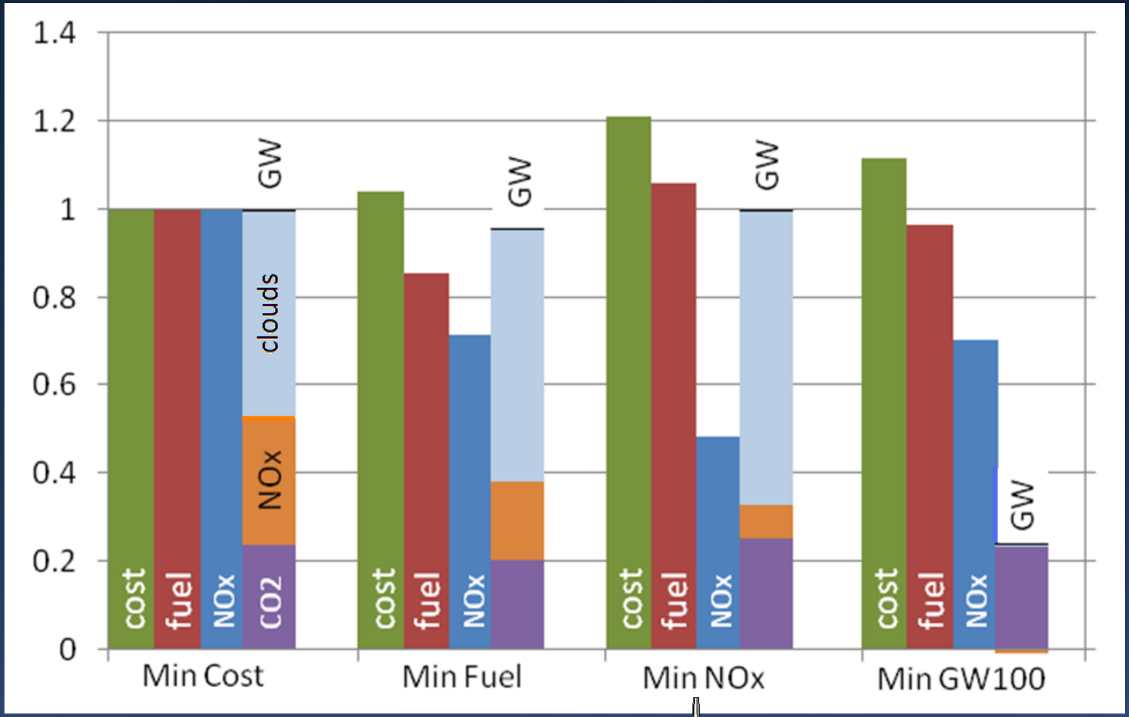
Rail car: L/D = 1000+ at V≈0

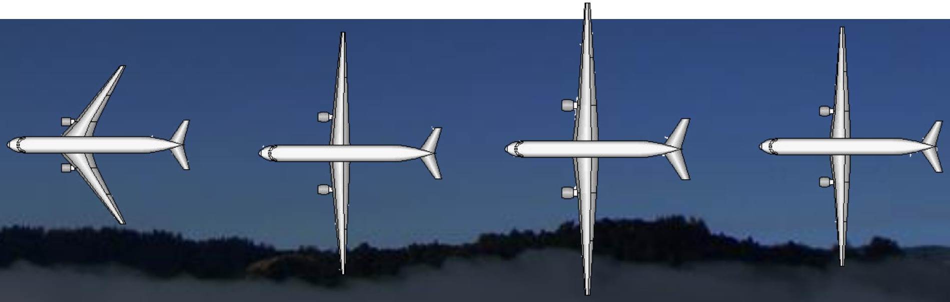
Ships: 550 ft destroyer at 35 kts: L/D ≈ 18

L/D is not fundamentally limited to ~20

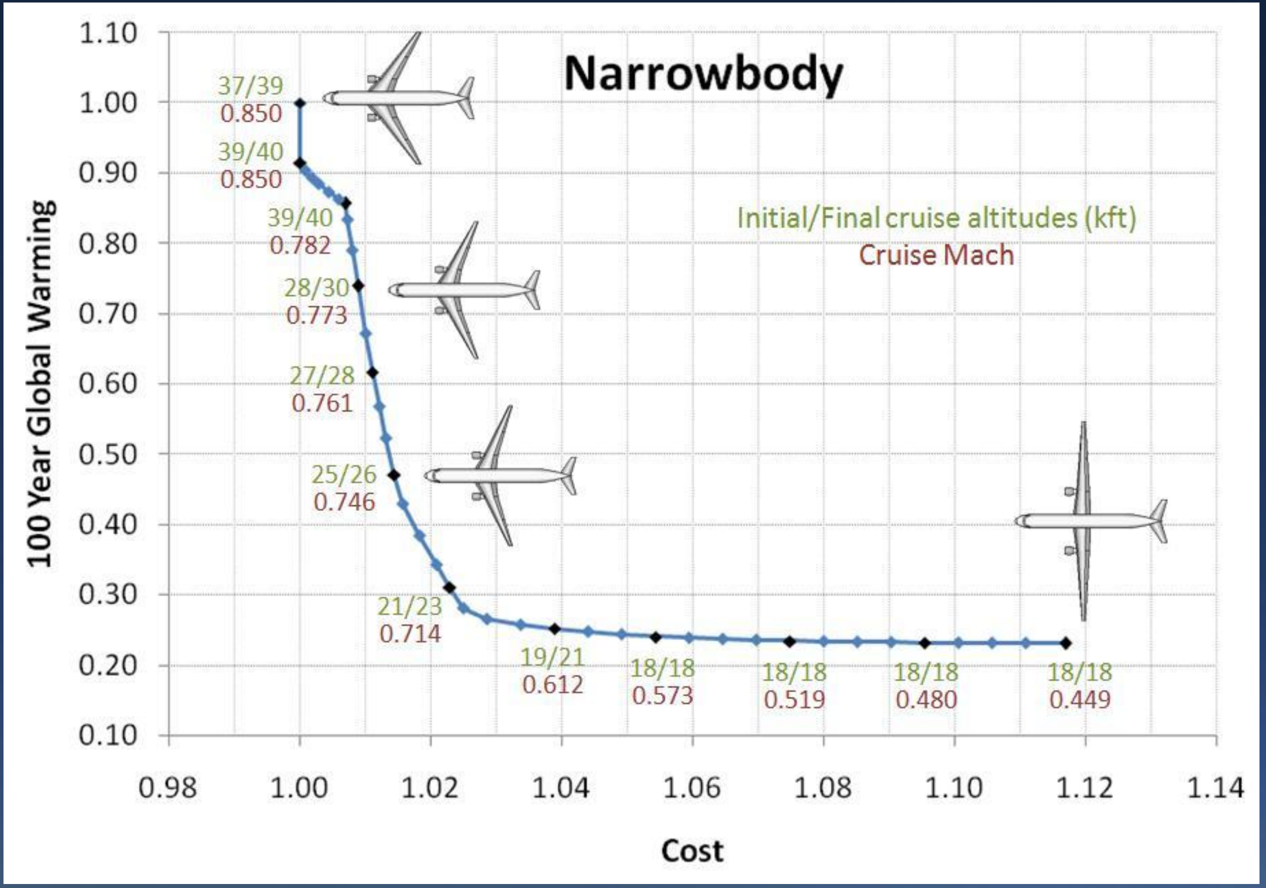
Current transport fuel consumption is partly due to turbulent tube + wing configuration, but also due to optimization metrics (cost).

Optimization for Cost, Fuel, NOx, Climate





Trading Cost and Climate Impact

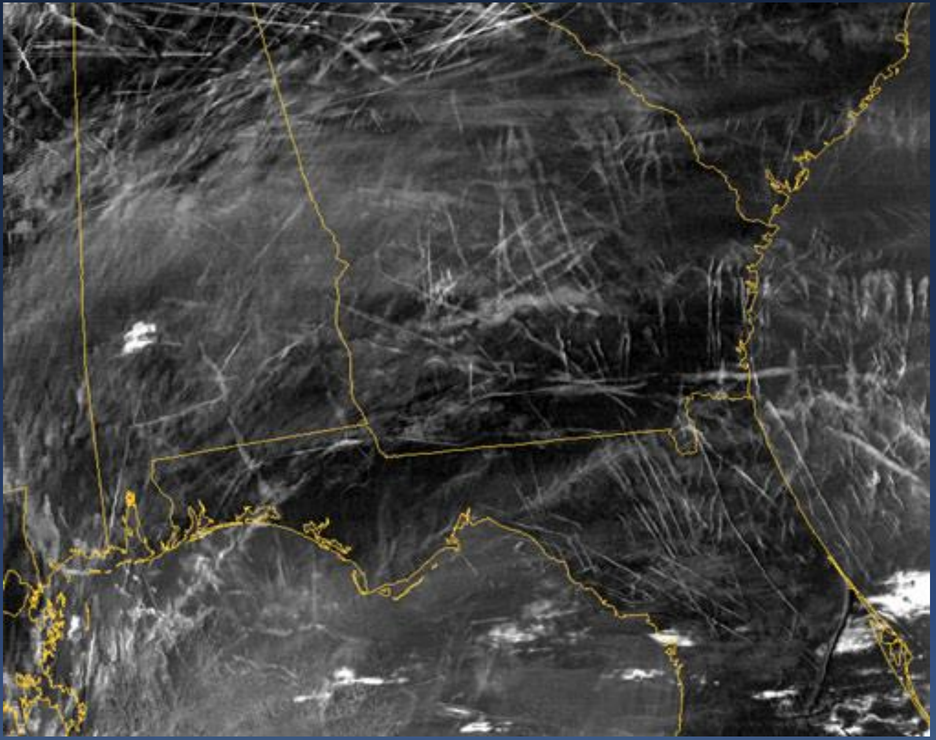


Contrails and Aviation-Induced Cloudiness

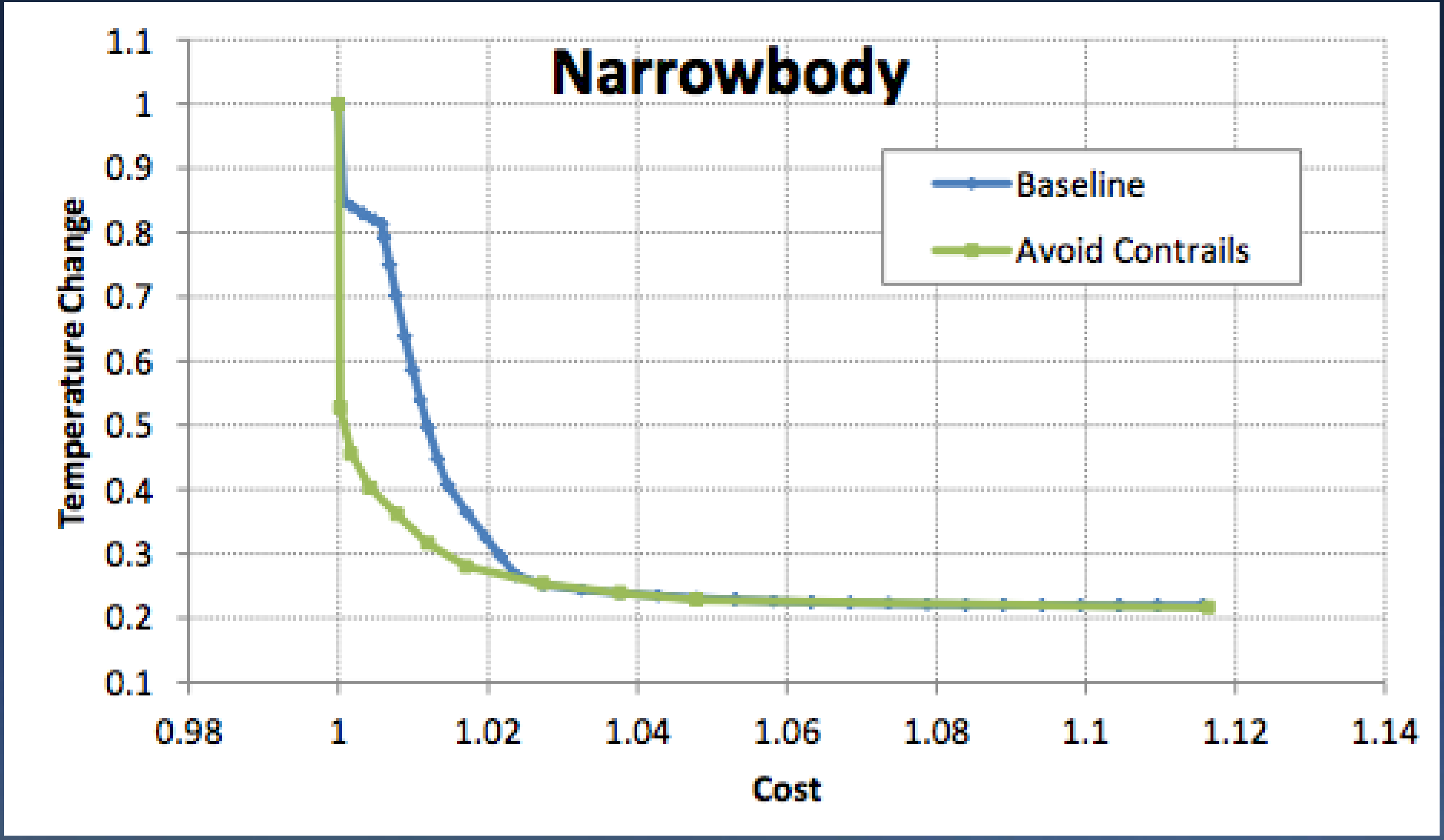
Persistent contrails formed in super-saturated and cold air.

Contrails and Aviation-Induced Cloudiness

Effect on climate has high uncertainty and might be mitigated with active rerouting.



Climate Cost Trade with Contrail Avoidance



“New” Technologies

New technologies and configuration concepts shift the trade-space

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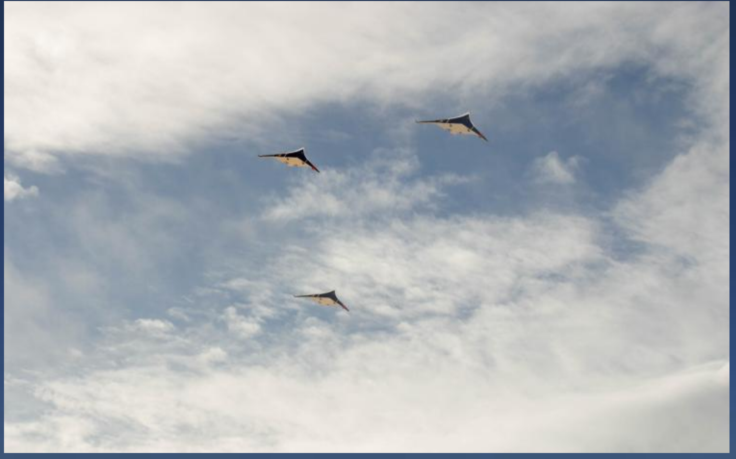

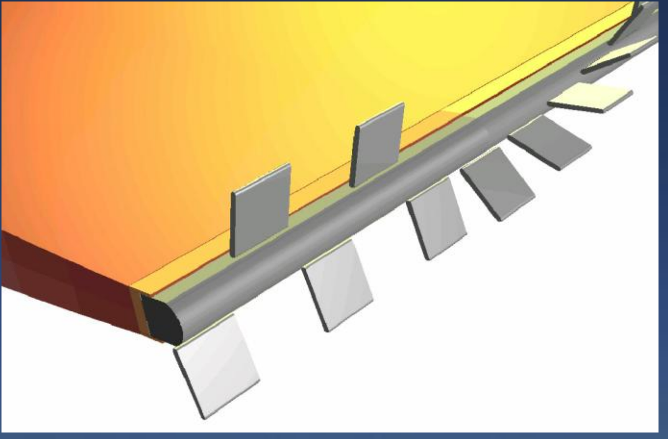

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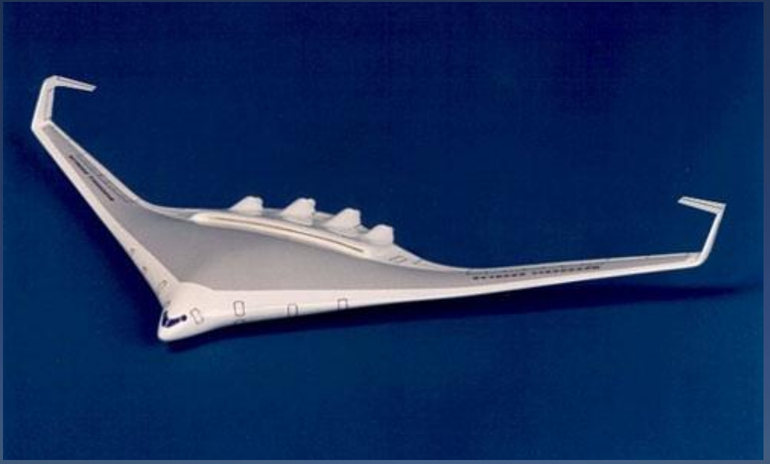


Near-Term Natural Laminar Flow Transport

- 150 pax
- 3000 n mi turbulent range
- Mach 0.75
- TOFL 7500 ft
- -6% to -8% fuel burn compared with turbulent wing design

Boeing High L/D Electric Transport Concept

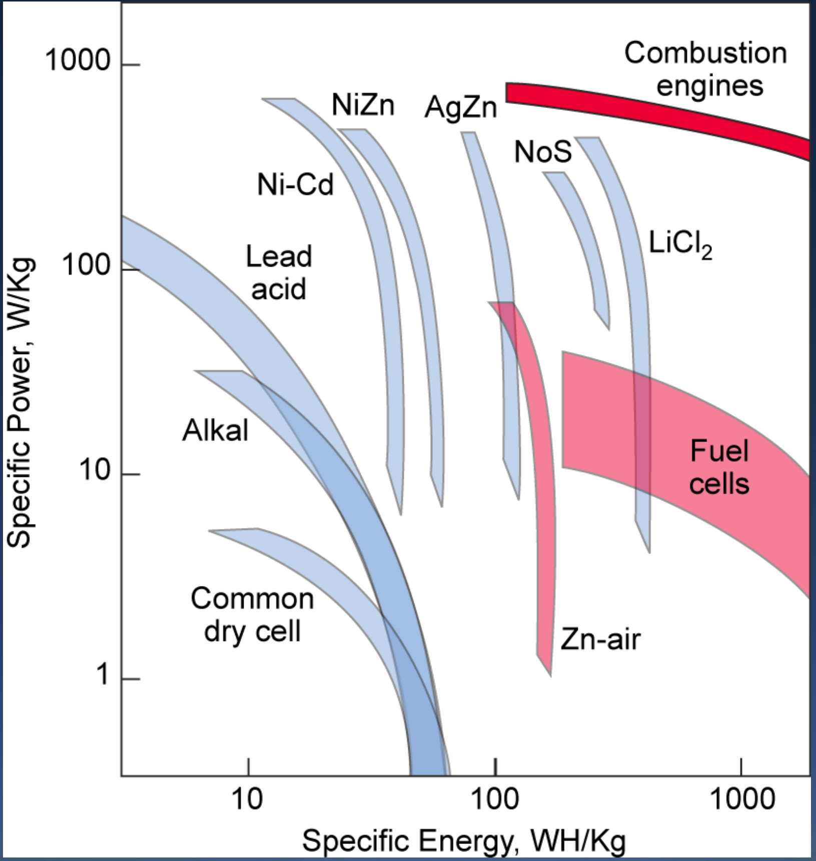
- N+3 Design Study
- Electric propulsion with batteries/fuel cells/hybrid considered
- 70% fuel burn reduction for 900 mi range, 750 wh/kg batteries
- Mach 0.7 to 0.78

Specific Energy of Power Systems

Electric power systems intriguing but very challenging.

Near term possibilities for smaller aircraft.

Most electric storage tech development focused on cost, volume.



Reflections

NASA focus on green aviation:

- Provides a framework for integrating research across ARMD and with related organizations
- Encourages more direct interaction with industry
- Defines a clearly relevant field of study for students and university researchers
- Addresses the most important problem in aeronautics

Back-up Slides