Making an Extraordinary Machine Better

An Extraordinary Machine: The Passenger Jet

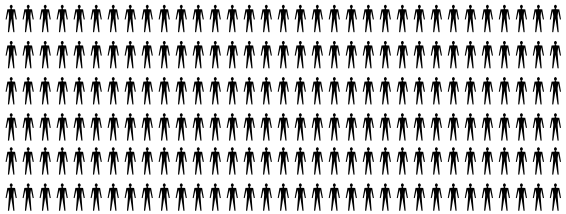
Compared to an automobile, a modern jet is ...

- 10× faster (560 mph)
- 100× safer per passenger-mile
- comparable in fuel burn per passenger-mile

www.boeing787.net

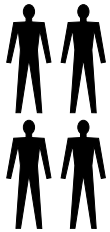
Typical Passenger-Miles Per Gallon

www.boeing787.net



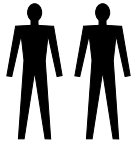
200 P
$\times$ 0.6 mpg
120 P-mpg

images.autobytel.com



4 P
$\times$ 25 mpg
100 P-mpg

image.automobilemag.com



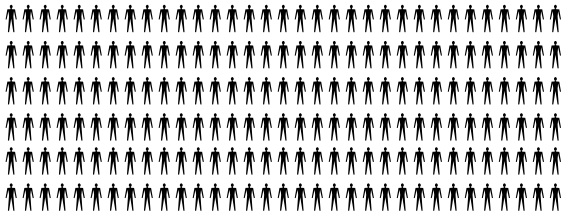
2 P
$\times$ 50 mpg
100 P-mpg

image.automobilemag.com

1 P
$\times$ 50 mpg
50 P-mpg

Subsonic vs. Supersonic

www.boeing787.net



200 P
× 0.6 mpg
120 P-mpg

www.randyasplund.com

120 P
× 0.17 mpg
20 P-mpg

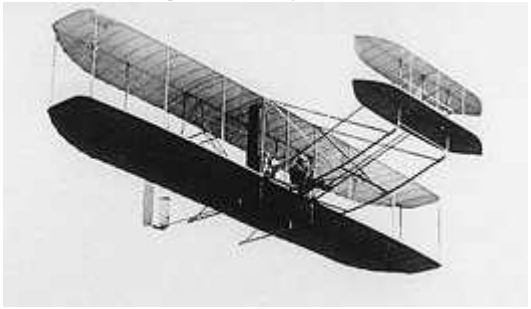
www.strutmasters.com

1 P
× 15 mpg
15 P-mpg

. . . some things are just *fundamentally* more energy-intensive

Progress

Wright Flyer



1903

. . . 55 years . . .

Boeing 707

1958

45 P-mpg

. . . 55 years . . .

Boeing 787

2013

120 P-mpg

$$\text{P-mpg} \sim \underline{\text{(Payload weight / Total weight)}} \times \underline{\text{(Lift/Drag)}} \times \underline{\underline{\text{Engine efficiency}}}$$

What Else Can We Do? — Unducted Fan

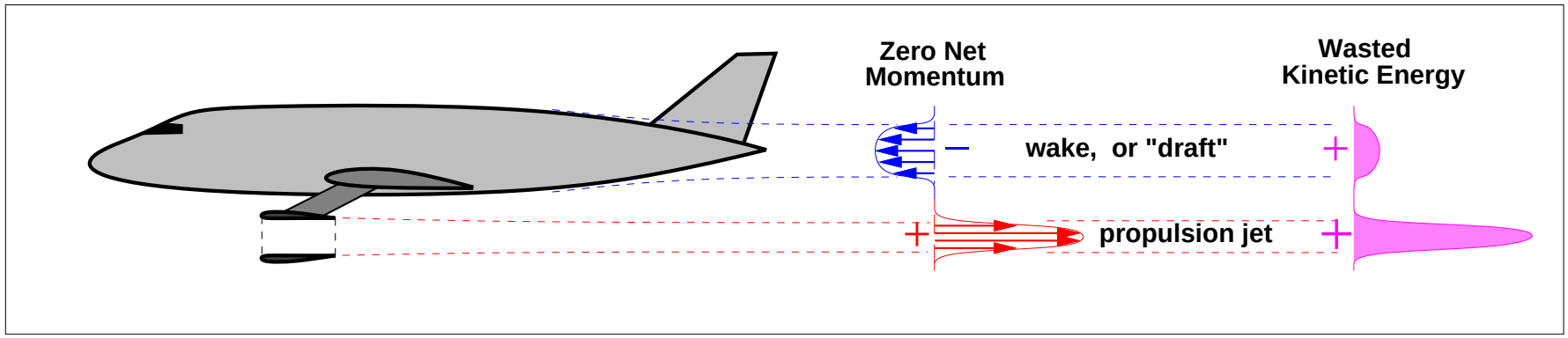
McDonnell-Douglas MD-UHB Demo (1987)

www.md80.it

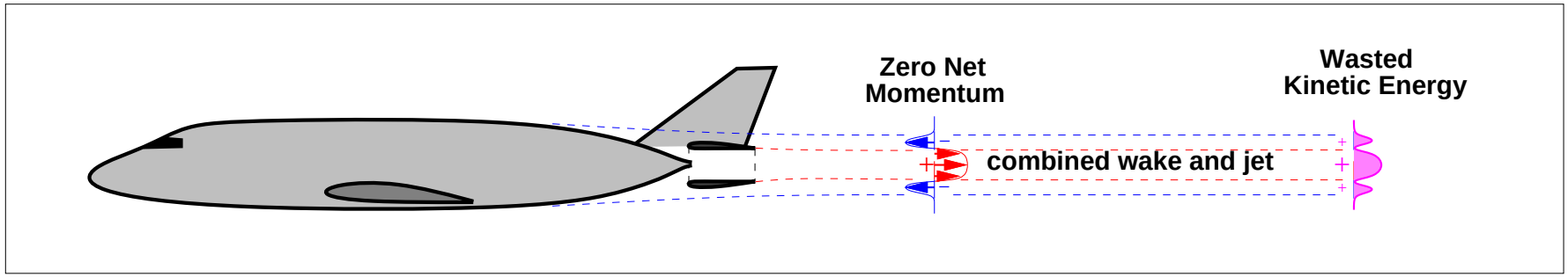
10-15% better in P-mpg, but noisy

What Else Can We Do? — Engine/Airframe Integration

Conventional Propulsion



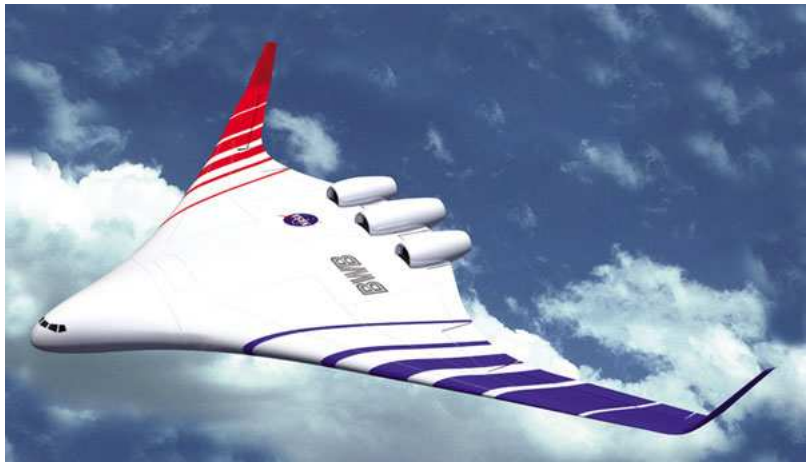
Boundary Layer−Ingesting (BLI) Propulsion



BLI is 5-10% better in P-mpg , and quiet

What Else Can We Do? — Unconventional Configurations

Blended Wing-Body



www.nasa.gov

Truss-Braced Wing

www.eweek.com

Likely better, but risky (many uncertainties)

A Recent Concept: The D8 "Double-Bubble" Aircraft

Estimated 140–165 P-mpg ,
via synergy between configuration and integrated engines

Configuration Comparison

B737−800

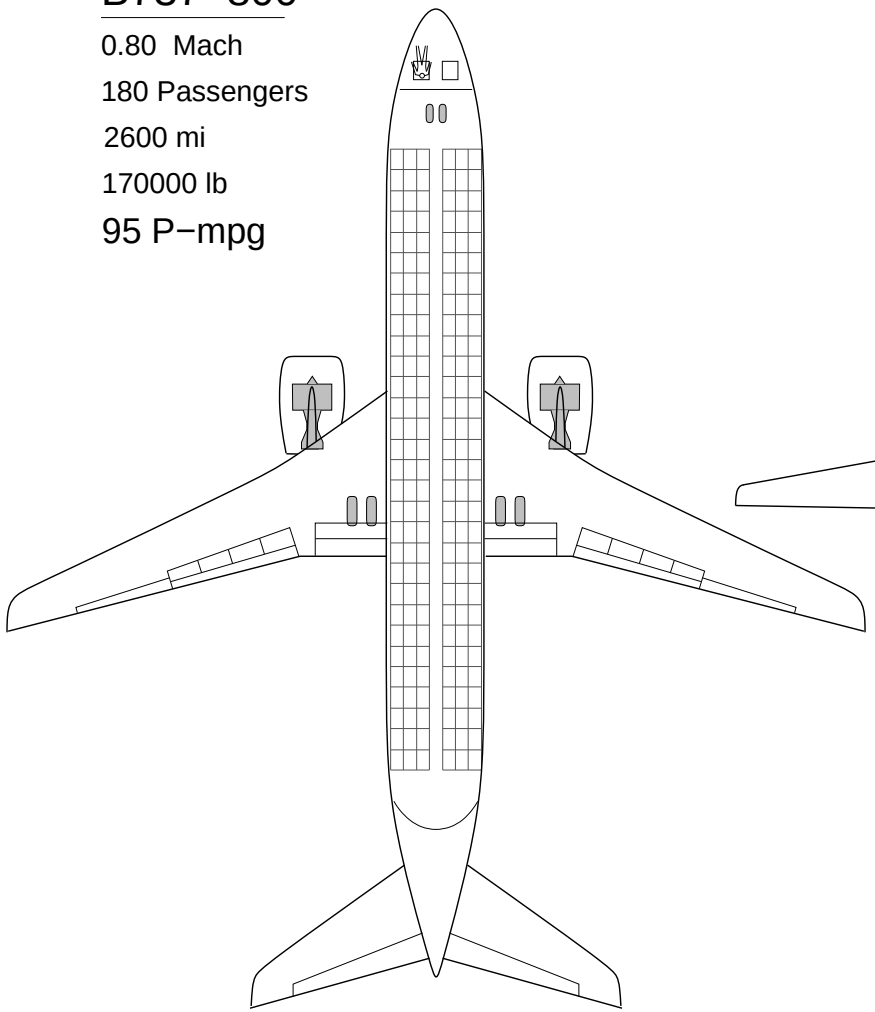
0.80 Mach

180 Passengers

2600 mi

170000 lb

95 P−mpg



D8.2

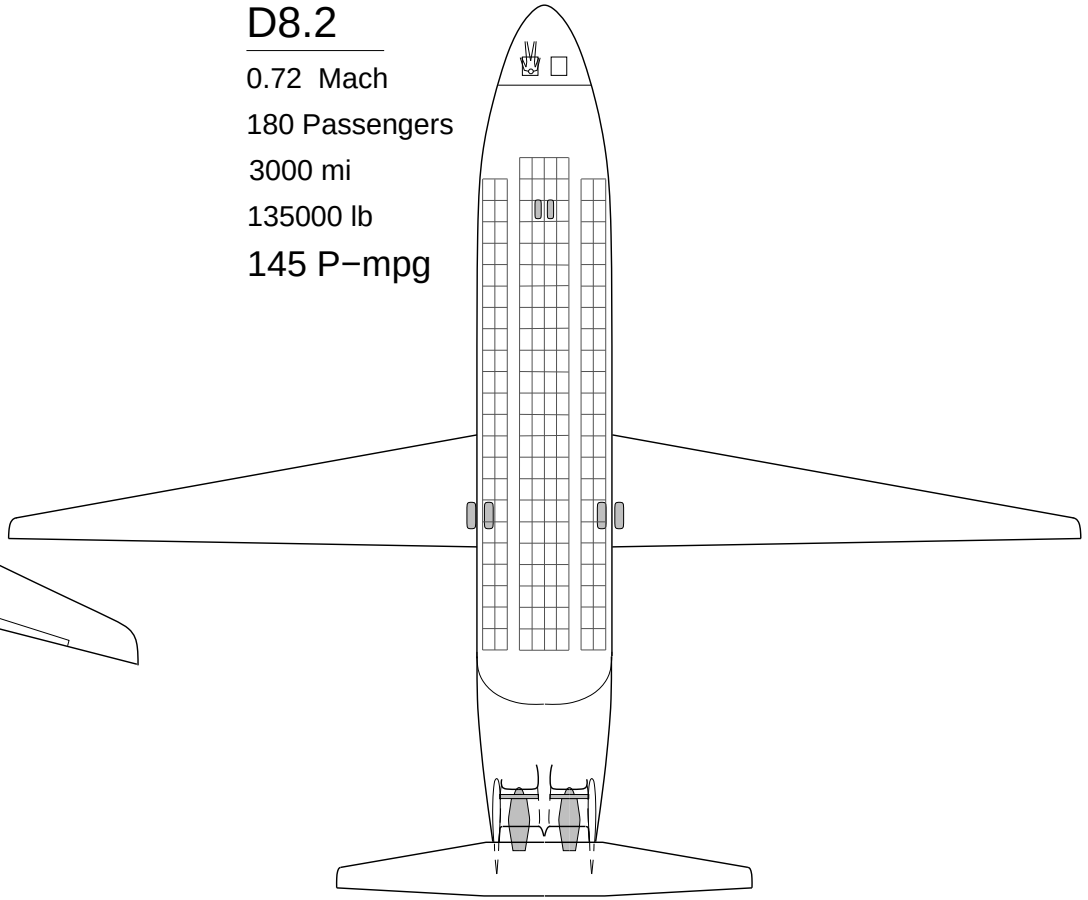
0.72 Mach

180 Passengers

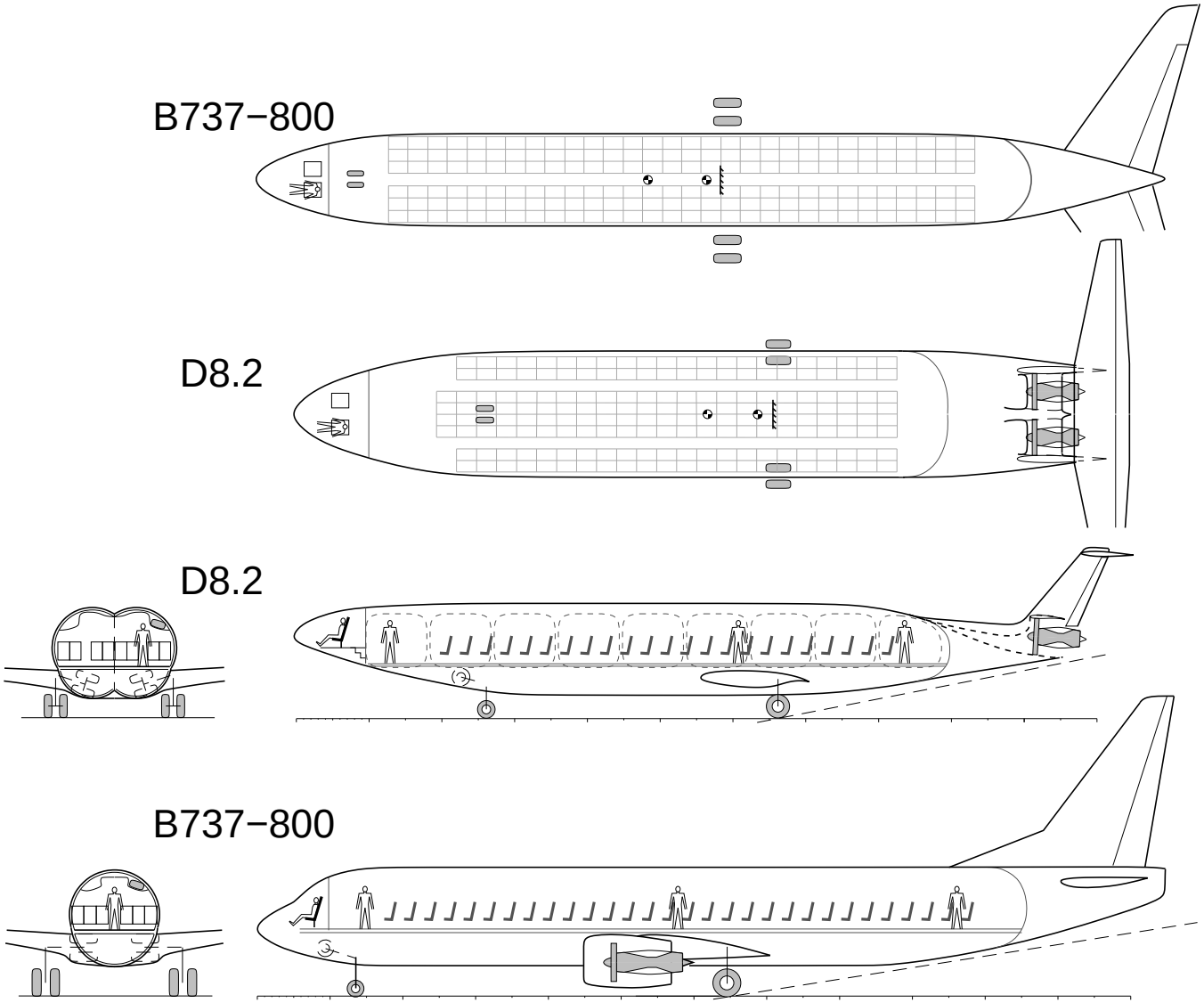
3000 mi

135000 lb

145 P−mpg

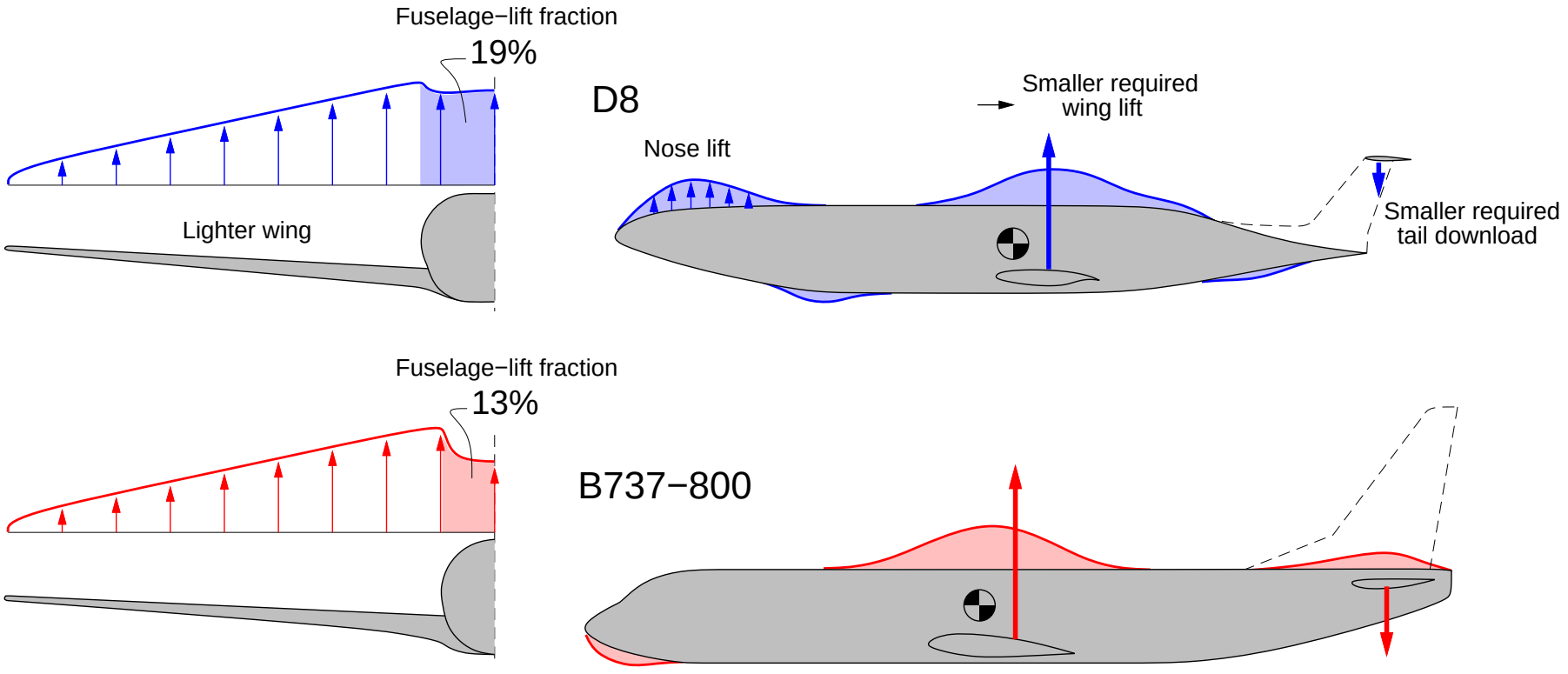


Fuselage Comparison



D8 Fuselage – Primary Benefits

- More fuselage lift $\rightarrow$ shrinks exposed wing
- Localized nose lift $\rightarrow$ shrinks tail, tail download, wing

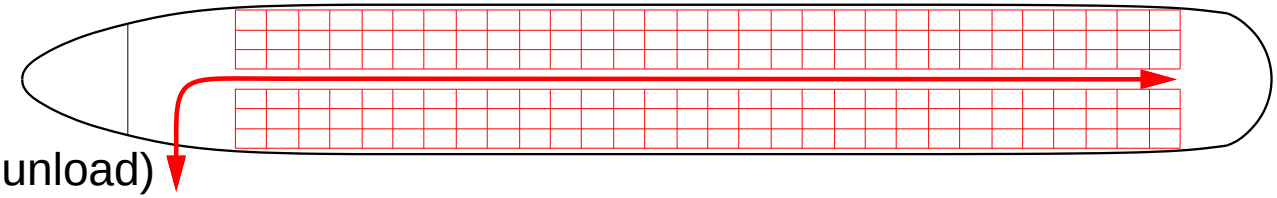


Load/Unload Time Comparison

B737−800

30 x 6 per aisle

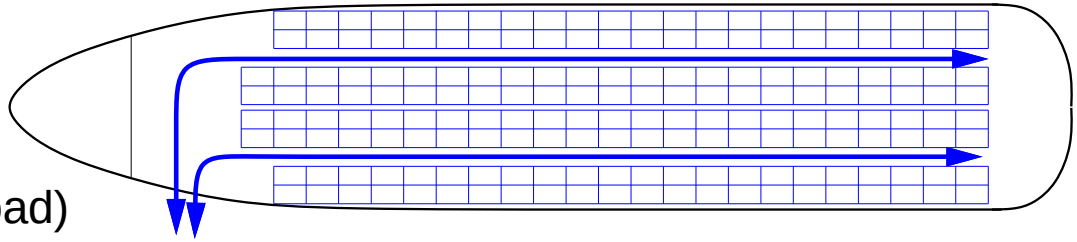
(30 minutes load,unload)



D8

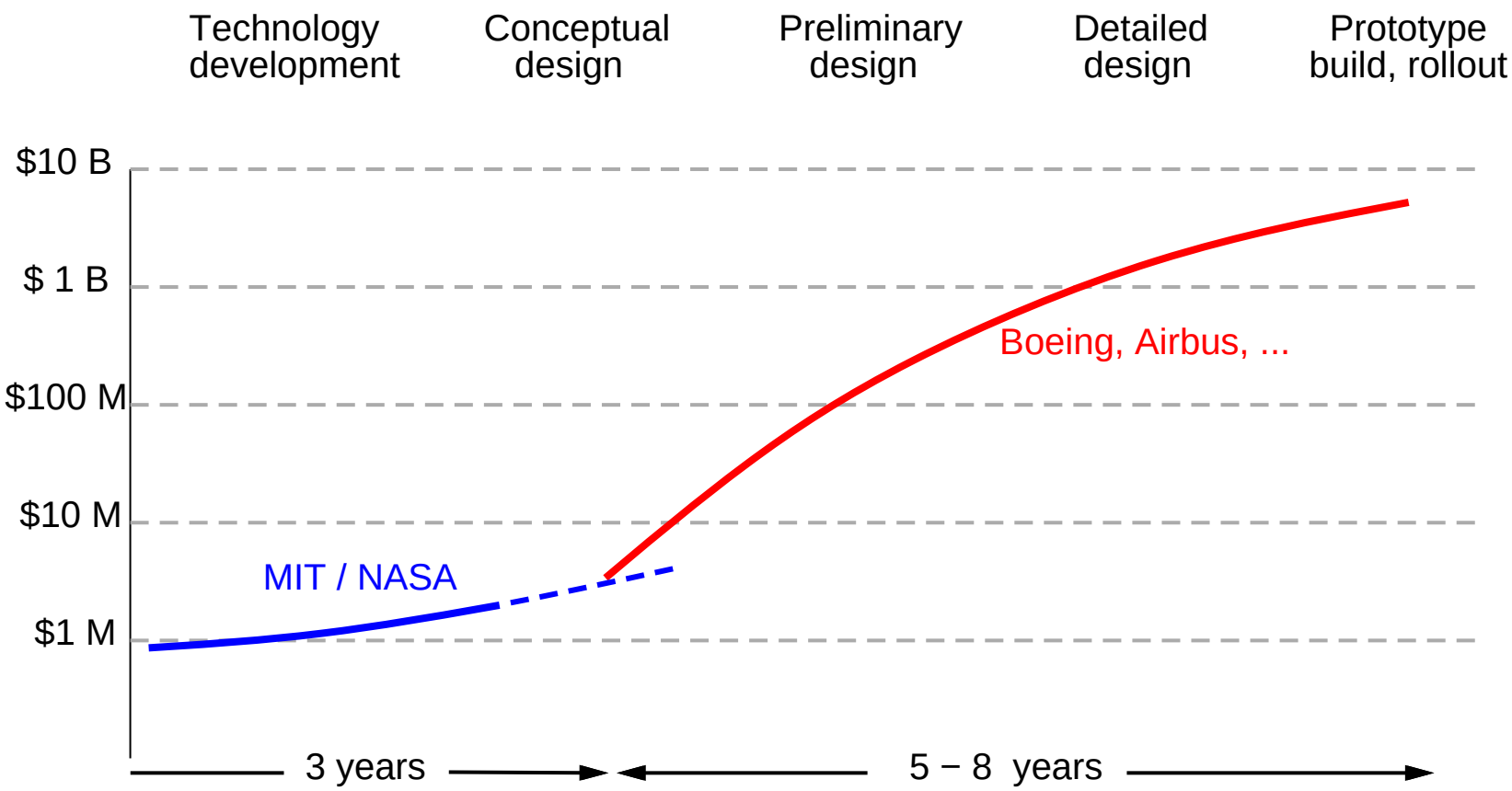
23 x 4 per aisle

(15 minutes load,unload)



NYC-LAX gate-to-gate time is similar, despite D8's slower cruise

The Development Path Forward

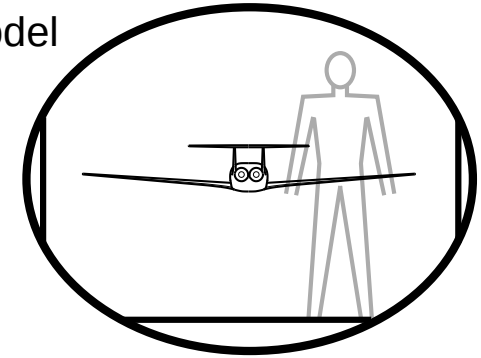


Technology Development

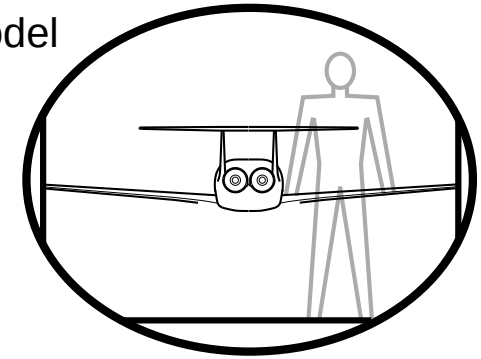
Current and future wind tunnel tests

MIT 10x7 Tunnel

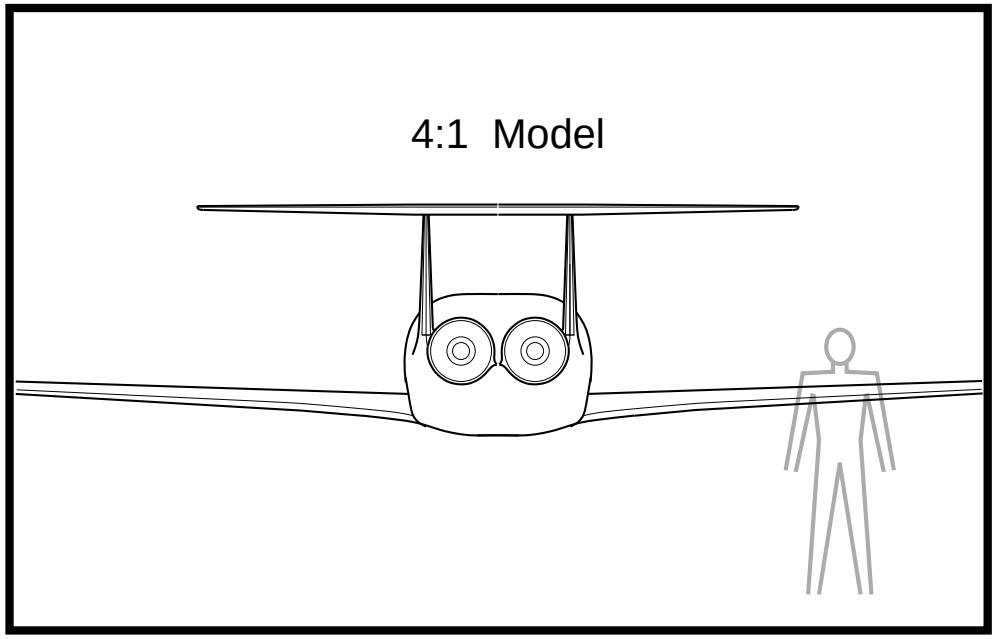
20:1 Model



11:1 Model

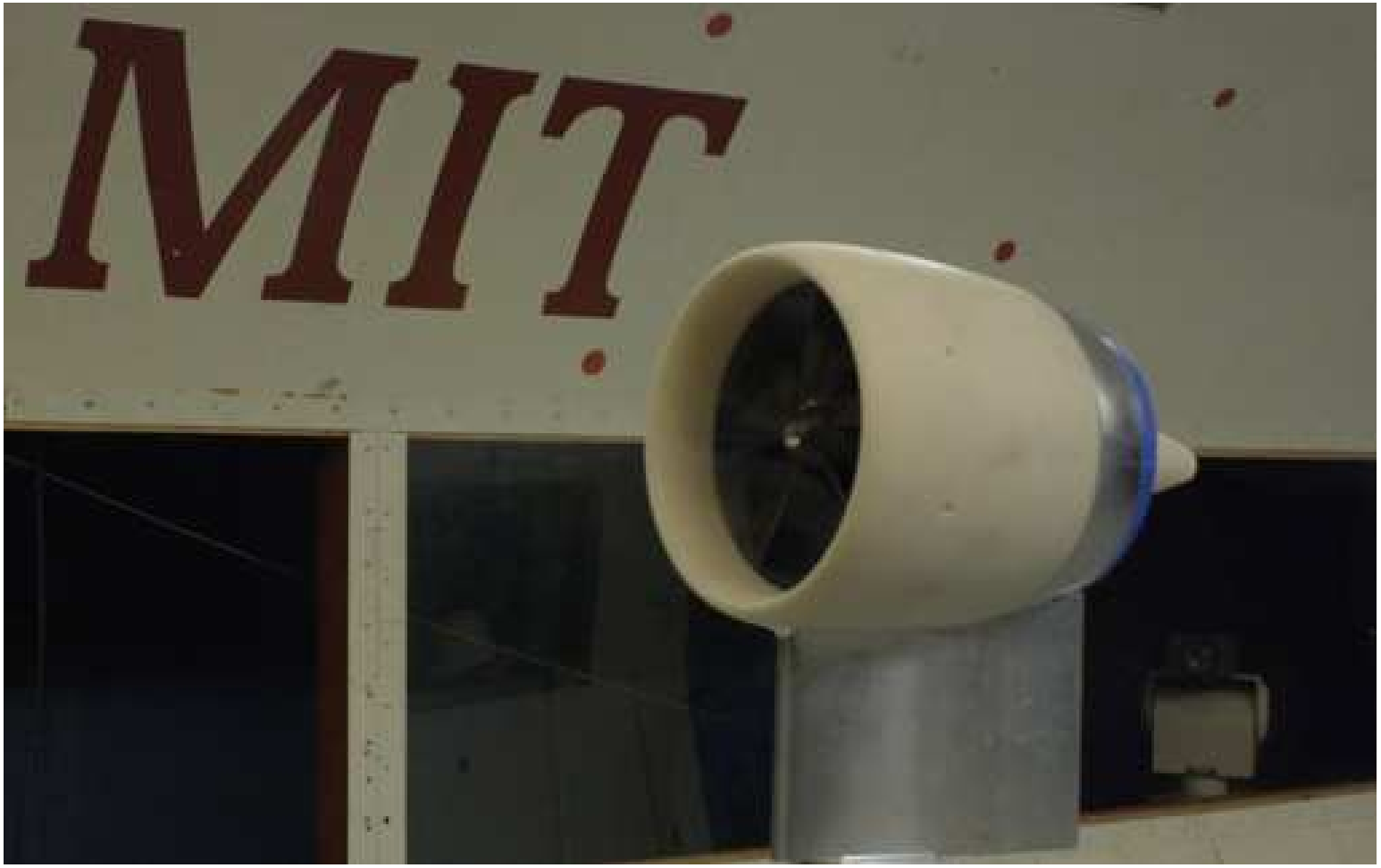


NASA Langley 22 x 14 Tunnel



Technology Development

BLI Propulsor Testing



Technology Development

20:1 D8 wind tunnel model

The D8 aircraft . . .

. . . changing the look of commercial aviation