The New Textbook ”Advanced Aircraft Design – Conceptual Design, Technology and Optimization of Subsonic Civil Airplanes“

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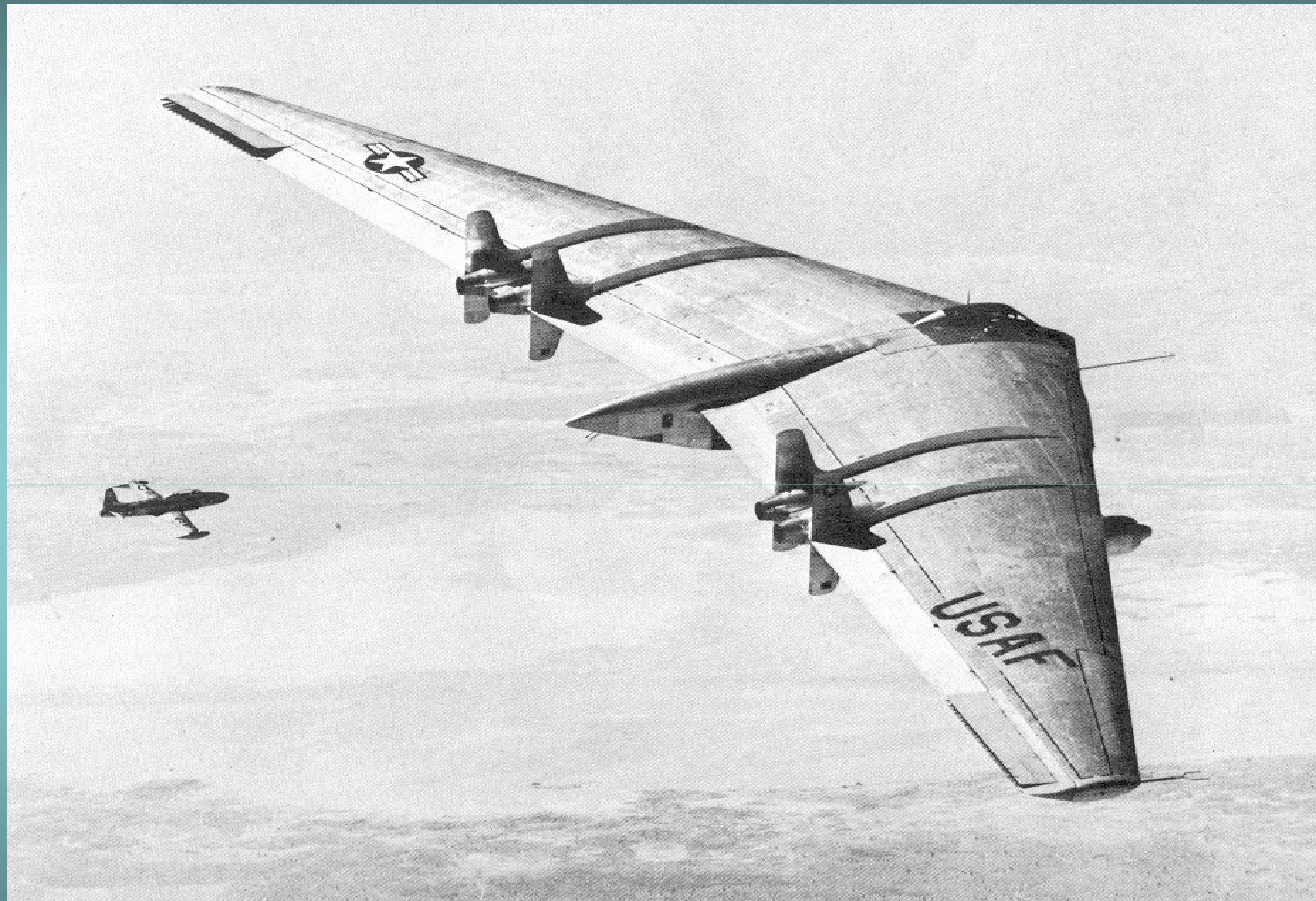
ADVANCED AIRCRAFT DESIGN

Conceptual Design, Analysis and Optimization of Subsonic Civil Airplanes

1. Design of the Well-Tempered Aircraft
2. Early Conceptual Design
3. Propulsion and Engine Technology
4. Aerodynamic Drag and its Reduction
5. From Tube and Wing to Flying Wing
6. Clean Sheet Design
7. Aircraft Design Optimizations
8. Theory of Optimum Weight
9. Matching Engines and Airframe
10. Elements of Aerodynamic Wing Design
11. The Wing Structure and its Weight
12. Unified Cruise Performance

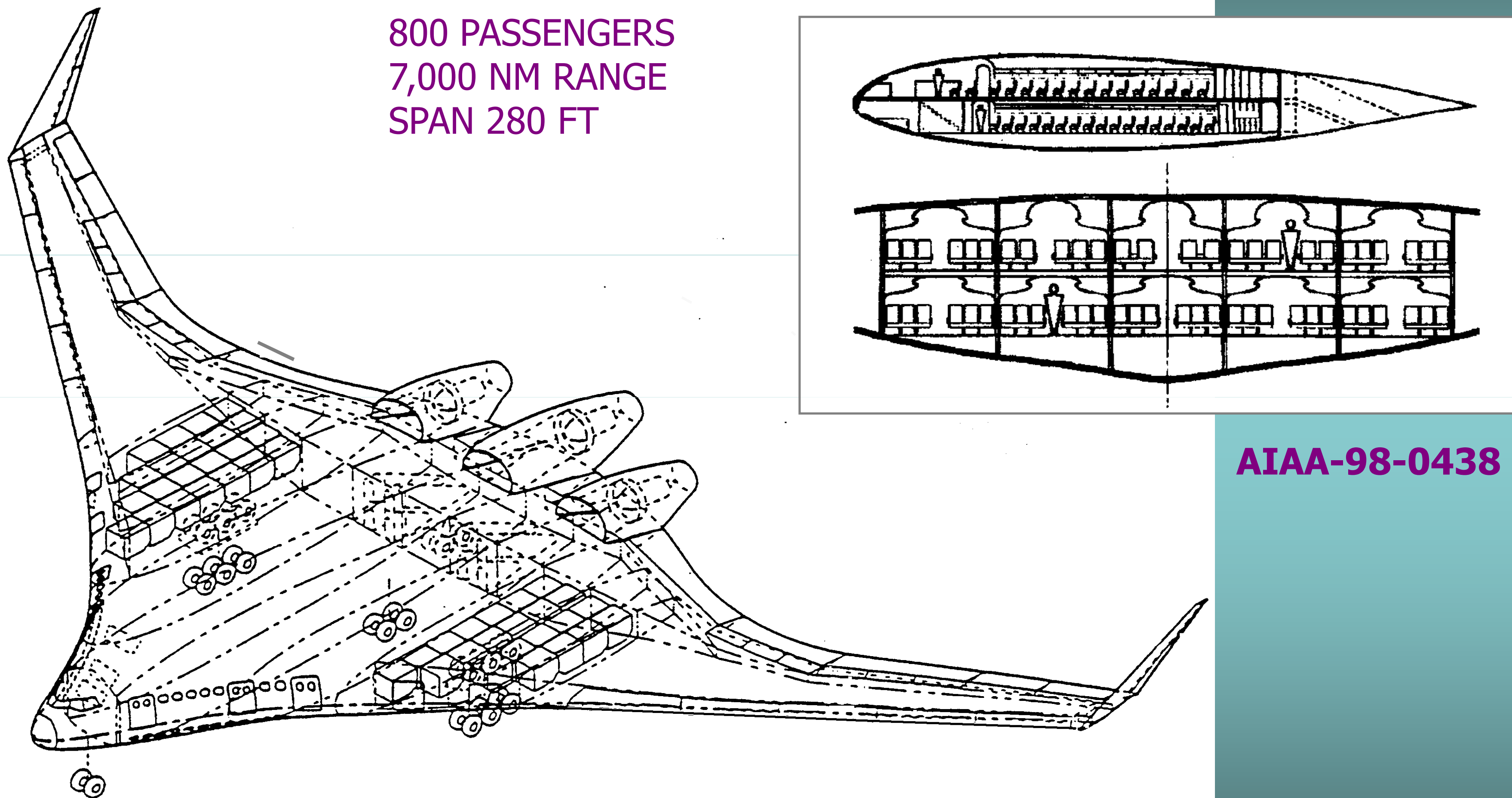
NORTHROP YRB - 49A (1950)



It has long been recognized that the flying wing, when jet propelled, is a poor choice for an aircraft configuration intended to achieve long range (J.V.Foa 1984)

EARLY MDD BWB DESIGN

800 PASSENGERS
7,000 NM RANGE
SPAN 280 FT



AIAA-98-0438

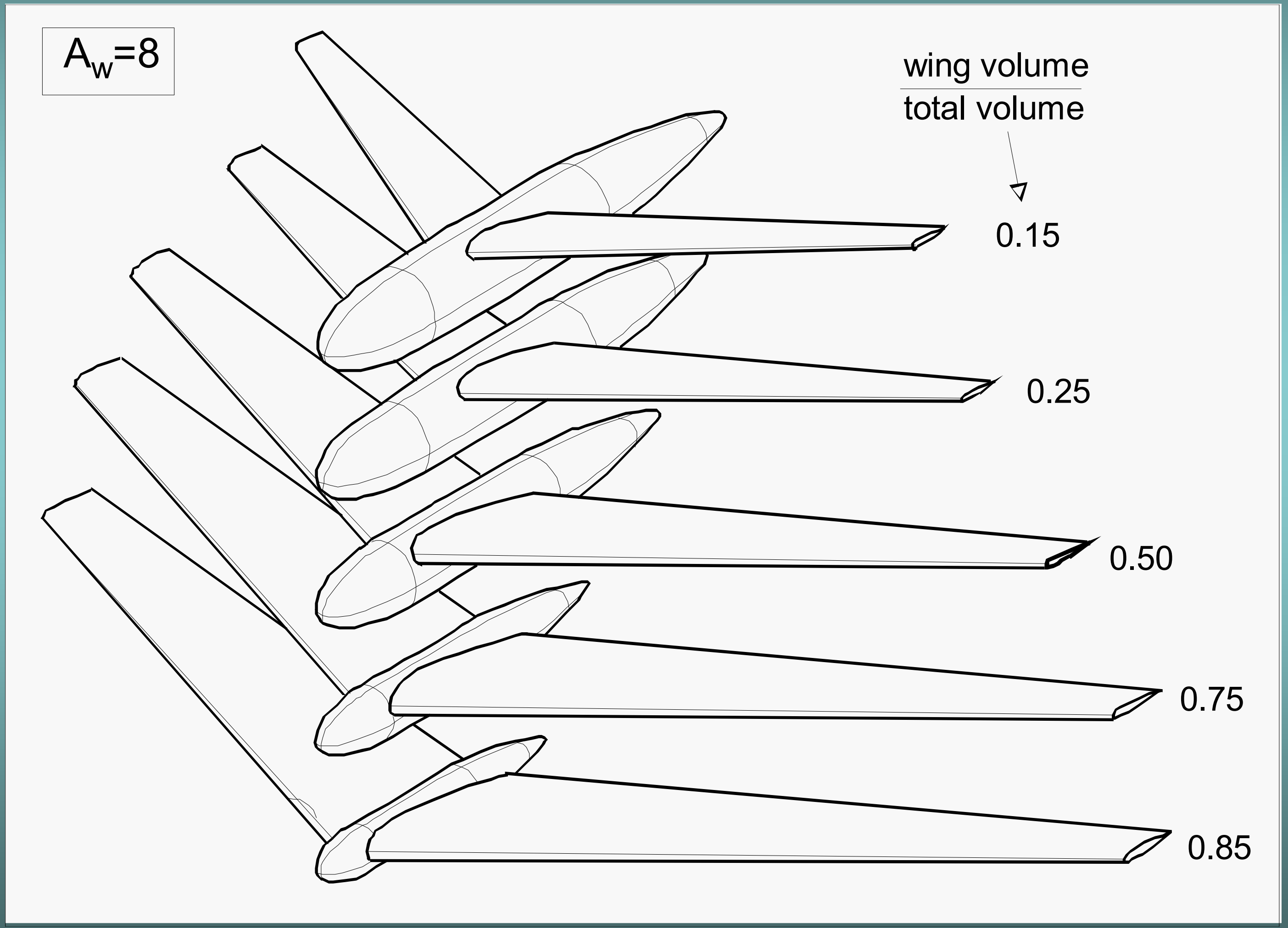
BOEING BWB-450 DESIGN HAS PASSENGER SEATS ON UPPER DECK, BAGGAGE ON LOWER DECK

SYNERGY OF BASIC DISCIPLINES IN BWB

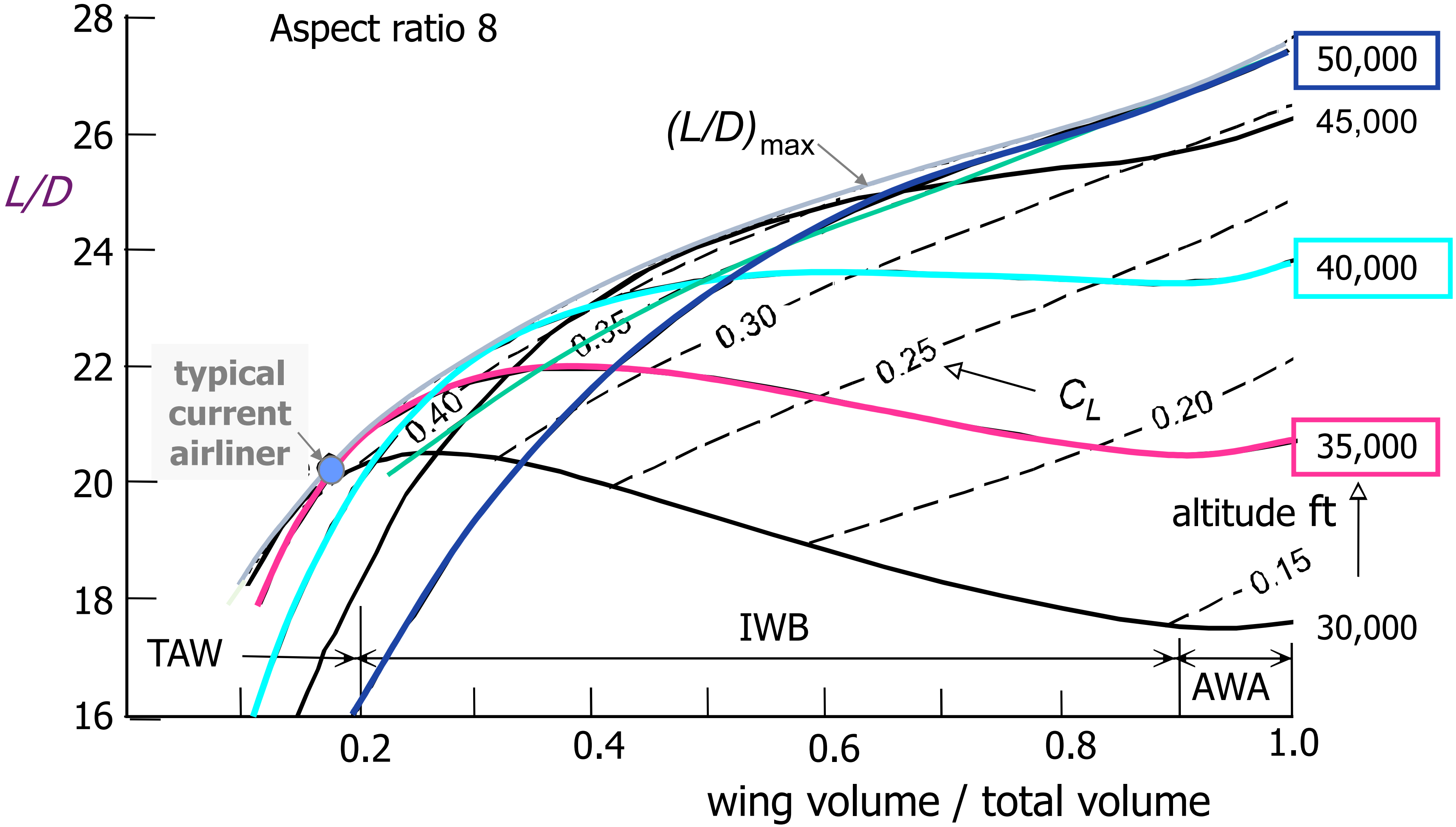
- VERTICALS PROVIDE DIRECTIONAL STABILITY AND ACT AS WINGLETS
- THE FUSELAGE IS ALSO A WING, AN ENGINE INLET AND A PITCH CONTROL SURFACE
- TOTAL WETTED AREA IS REDUCED BY 33% RELATIVE TO CONVENTIONAL LAYOUT

- INTERACTION OF THE BASIC DISCIPLINES IS UNUSUALLY STRONG; CONVENTIONAL DESIGN INTUITION AND APPROACH ARE CHALLENGED
- A SMALL CHANGE IN PLANFORM LEADS TO RECONFIGURATION OF THE ENTIRE VEHICLE

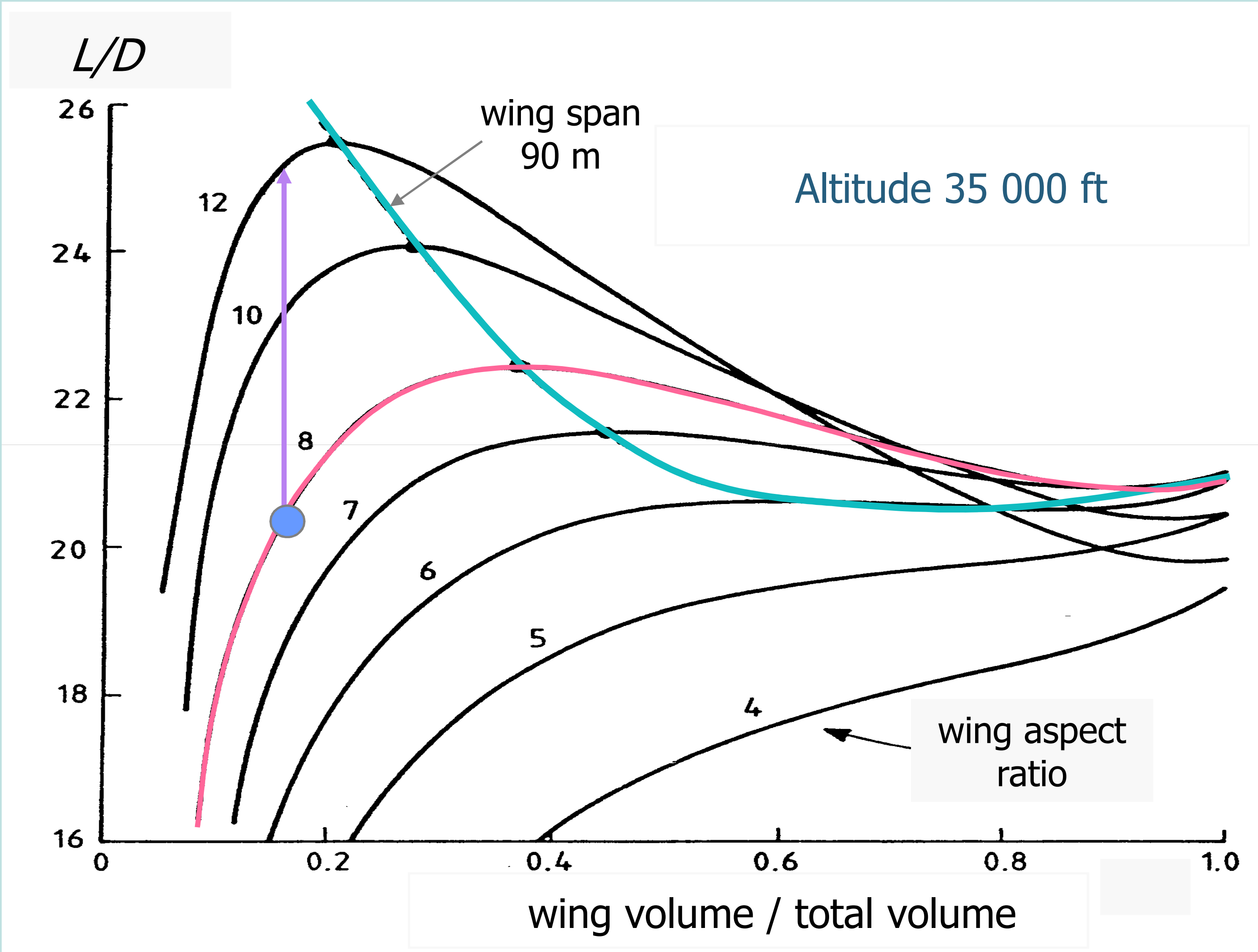
WING / BODY CONFIGURATIONS
WITH EQUAL TOTAL VOLUME



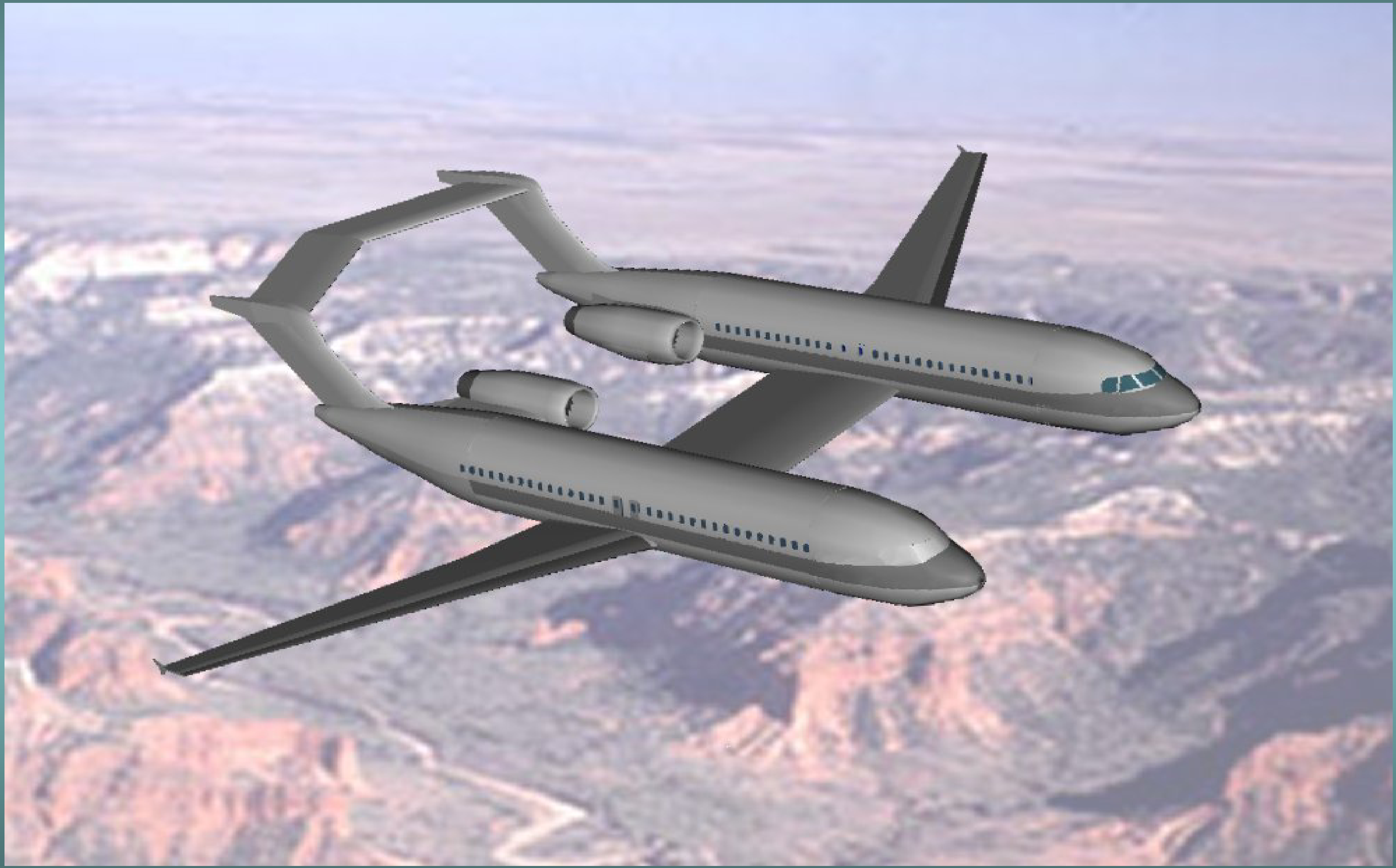
AERO. EFFICIENCY AFFECTED BY ALTITUDE



AERO. EFFICIENCY AFFECTED BY ASPECT RATIO



AIRBUS 300/310 SUCCESSOR ?



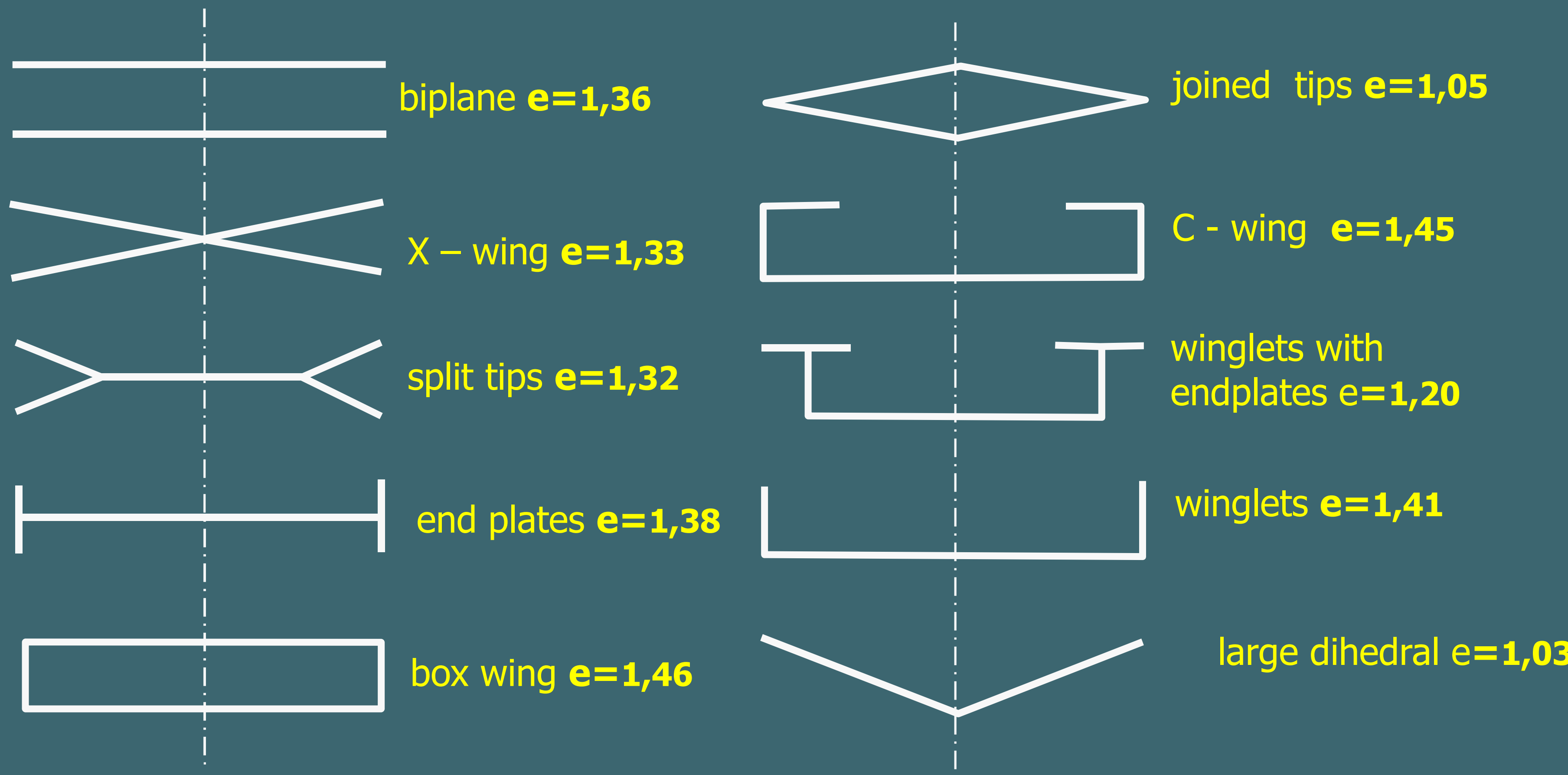
E. JESSE / E. TORENBEEK (2002)

TWIN FUSELAGE WEIGHT ADVANTAGES

Design mass, kg	conventional	twin fuselage	Δ %
MTOW	155,000	134,000	-13.5
MLW	128,000	113,000	-11.7
MZFW	120,000	106,000	-11.7
OEW	84,000	70,000	-16.7
Payload (structural limit)	36,000	36,000	0
Block fuel for 8,000 km	40,715	34,245	-15.9

WING SHAPE AND SPAN EFFICIENCY FACTOR

span efficiency factor for vortex -induced drag

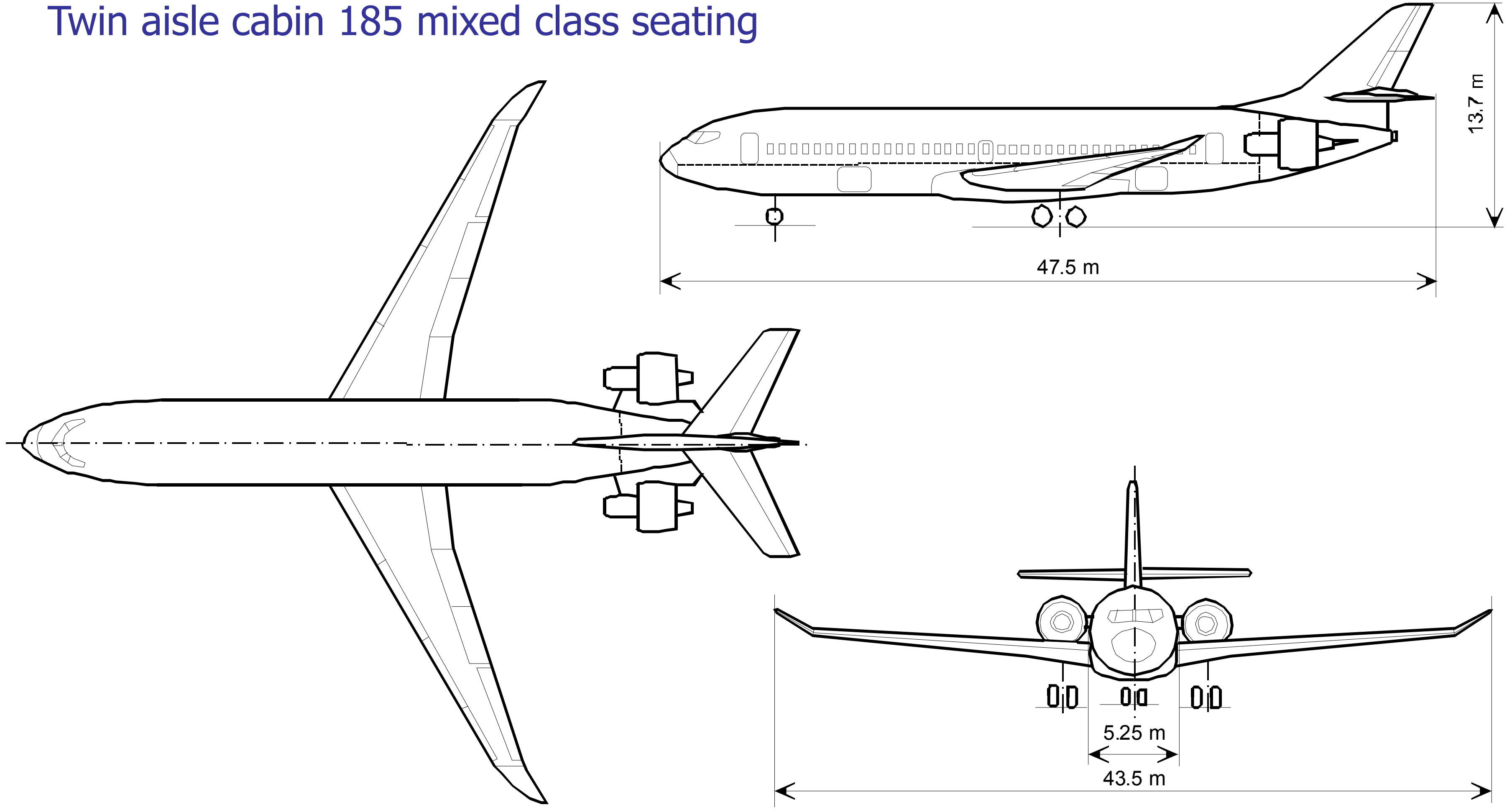


PROBLEMETIC ISSUES OF RADICAL CONCEPTS

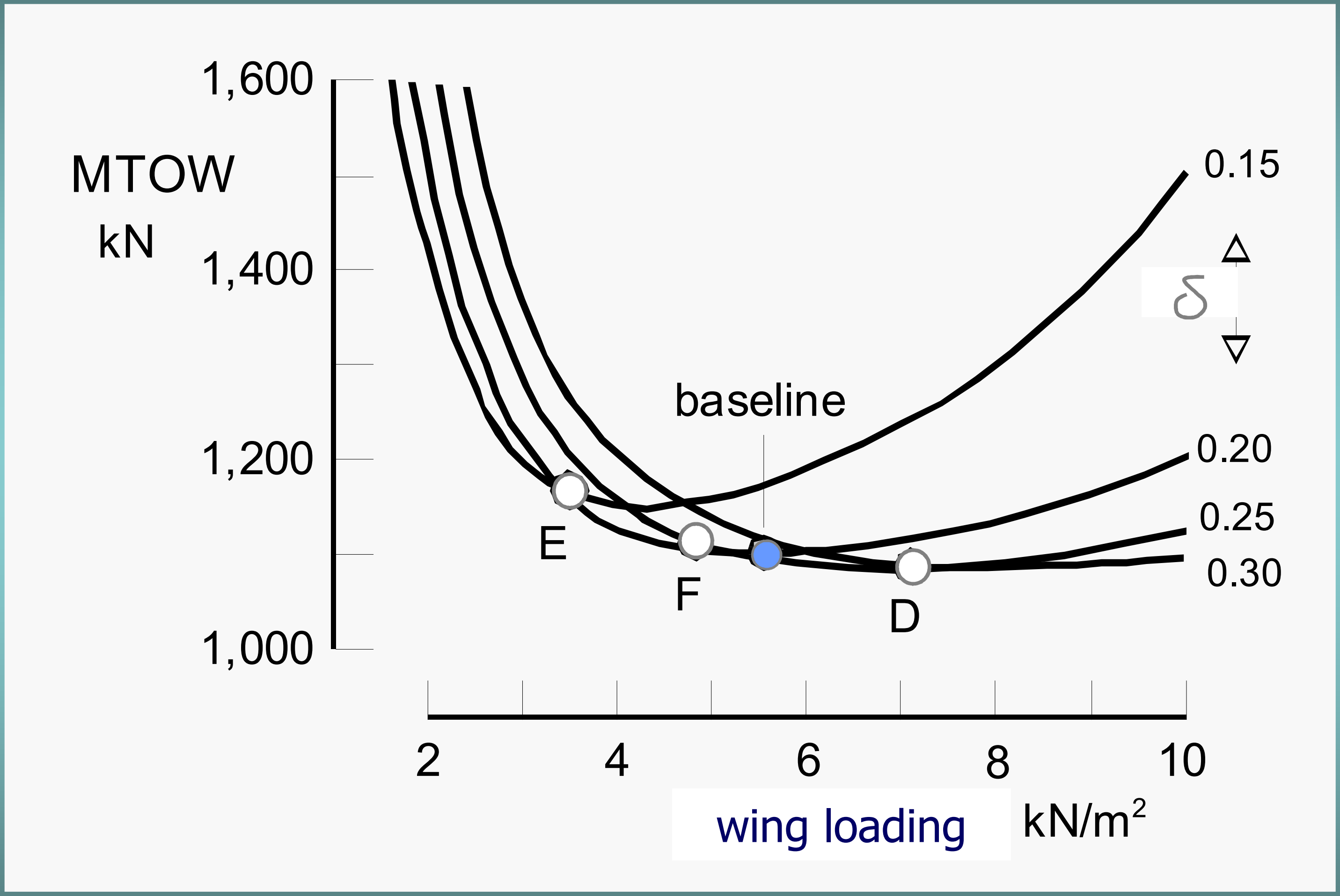
- IT IS DIFFICULT TO PREDICT THE SENSITIVITY OF ECONOMIC PERFORMANCE TO VARIATION OF UNUSUAL DESIGN CHARACTERISTICS
- RADICAL DESIGNS MAY HAVE OBJECTIONABLE INHERENT AEROELASTIC BEHAVIOR
- SOME DEGREE OF PASSENGER DISCOMFORT MAY BE DIFFICULT TO AVOID

BASELINE DESIGN OF A MEDIUM RANGE AIRLINER

Twin aisle cabin 185 mixed class seating



DESIGN SENSITIVITY OF MTOW



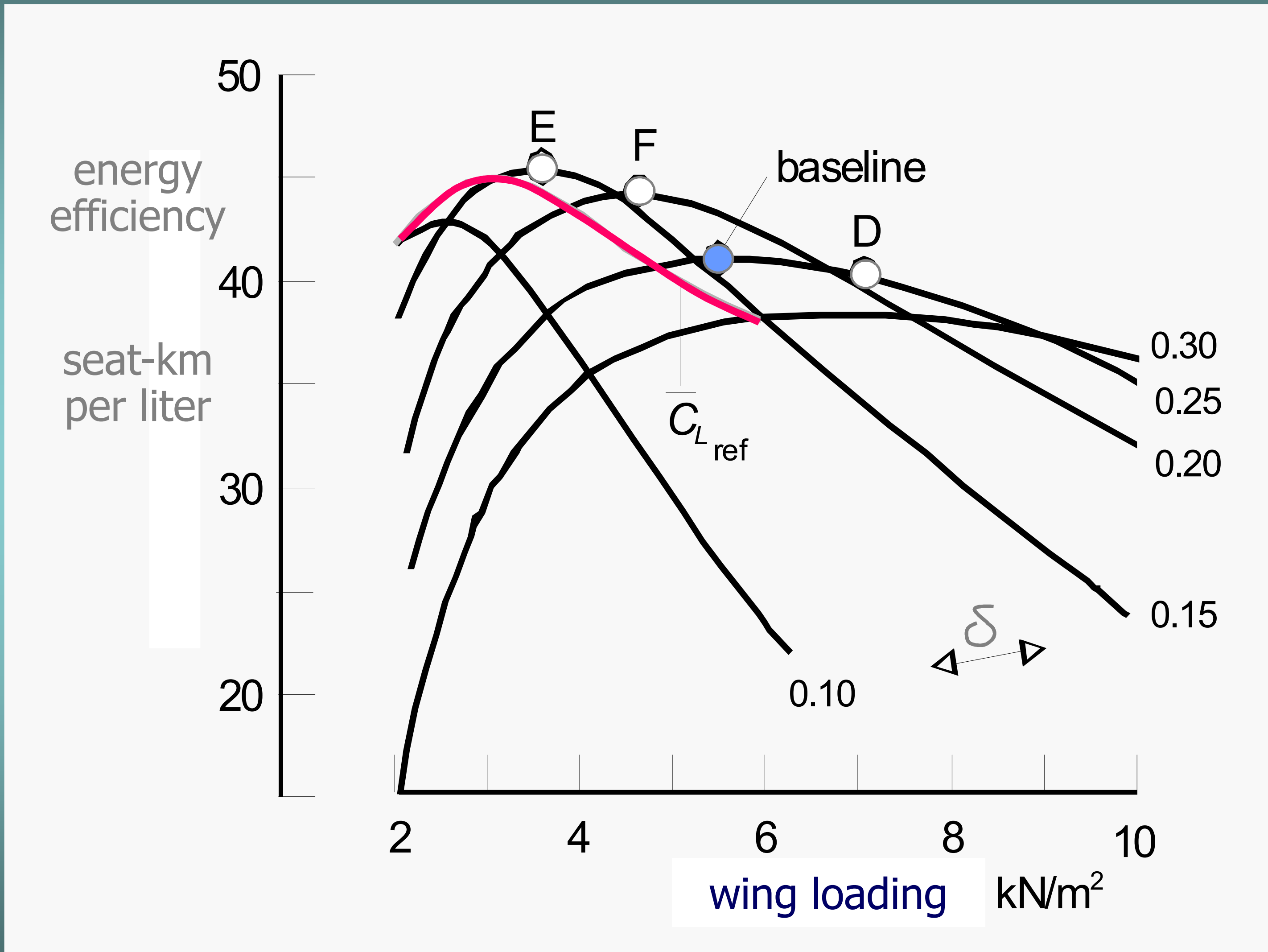
OPTIMUM DESIGNS

D: minimum MTOW

E: maximum fuel efficiency

F: minimum fuel + engine weight

DESIGN SENSITIVITY OF ENERGY EFFIFIENCY



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D: minimum MTOW

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OPTIMIZATION: OBSERVATIONS AND PROBLEMS

- OPTIMIZATION BY MEANS OF CFD IS A POPULAR SUBJECT OF CFD SPECIALISTS. HOWEVER, OFF-DESIGN PROPERTIES SUCH AS BUFFETING AND STALL PROPERTIES ARE OFTEN NEGLECTED
- THE EARLIER THE DESIGN STAGE, THE MORE VARIABLES ARE SUBJECT TO OPTIMIZATION. THIS LEADS TO A MULTI – FIDELITY APPROACH
- SENSITIVITY OF EMPTY WEIGHT TO PRIMARY SELECTION VARIABLES IS HARD TO OBTAIN. THE TERM ***VALUE OF A POUND*** IS ALMOST FORGOTTEN.
- AND NOBODY KNOWS THE ***VALUE OF A COUNT***.
- LET US RELY ON THE FOLLOWING EARLY DEFINITION OF A GOOD PRODUCT:

PRIZE THAT WHICH IS BEST IN THE UNIVERSE;

AND THIS IS THAT WHICH

USETH EVERYTHING AND ORDERETH EVERYTHING

Marcus Aurelius (AD 121-180) Meditations, v. 21.

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