737 Wingspan Optimization

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INTRODUCTION

The Boeing 737 is the most produced commercial jetliner in history, so even small efficiency gains matter at fleet scale. Cruise efficiency is dominated by *induced drag*, which falls as wingspan grows, but longer wings also carry a heavier structural penalty.

This project asks: what wingspan minimizes the combined cost of drag and structure for a 737-class aircraft?

Baseline:

Plane + payload (no fuel) = 138,300 lb. Wing surface area = 1,344 ft² (~30 parking spaces). Wings are swept back 25°, taper to 24% of root width, are 15% thick at the body, and the structure is built to survive 3.75 g.

RESEARCH METHODOLOGIES

From 118-158 feet of span, in two foot increments:

- Used Torenbeek's formula to predict how heavy the wing structure has to be, given its size, sweep, and load.
- Induced drag is the unavoidable cost of generating lift. Calculated using AVL (a wing-analysis program). Added to a fixed parasite drag of 200 counts to get total drag.
- Then used Breguet equation which says how much extra fuel each pound of drag burns. For a design 737 mission, every drag count costs about 129 lb of fuel.
- Used summation curve to find total effective weight in a range.

DATA AND FINIDNGS

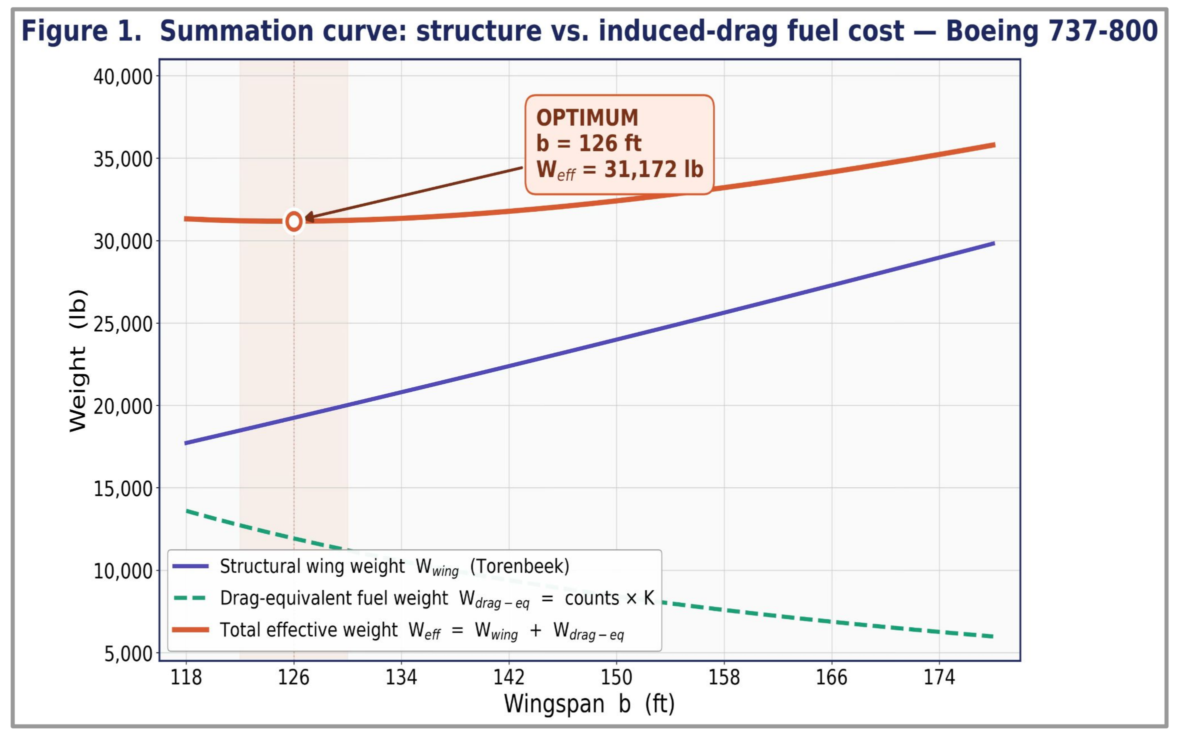
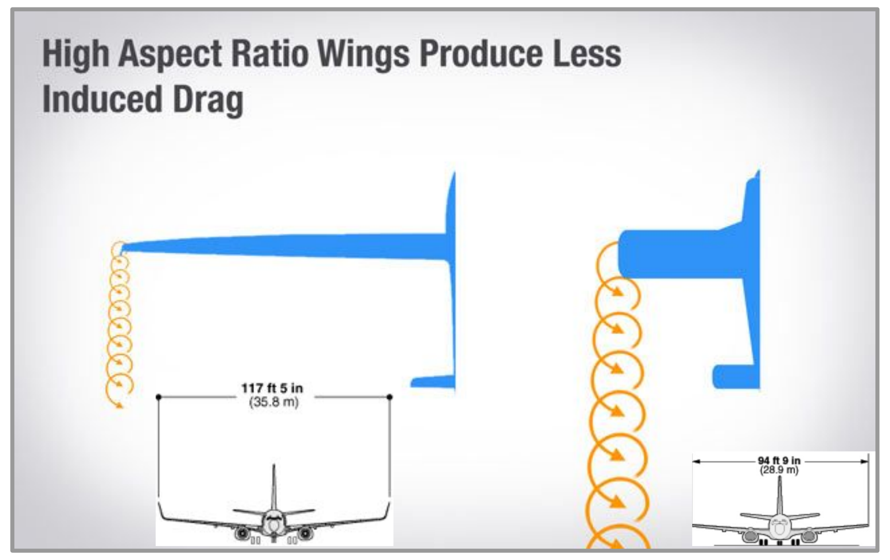


Figure 1. Wing weight (purple) climbs with span; drag-equivalent fuel weight (green) falls; their sum (orange) bottoms out at b = 126 ft.

b (ft)	AR	W_wing (lb)	CDi (counts)	W_drag-eq (lb)	W_eff (lb)
118	10.36	17,717	105.78	13,601	31,318
122	11.07	18,477	98.95	12,723	31,200
126	**11.81**	**19,244**	**92.77**	**11,928**	**31,172 ◀ min**
130	12.57	20,018	87.15	11,206	31,224
150	16.74	23,991	65.46	8,417	32,408
178	23.57	29,818	46.49	5,977	35,795



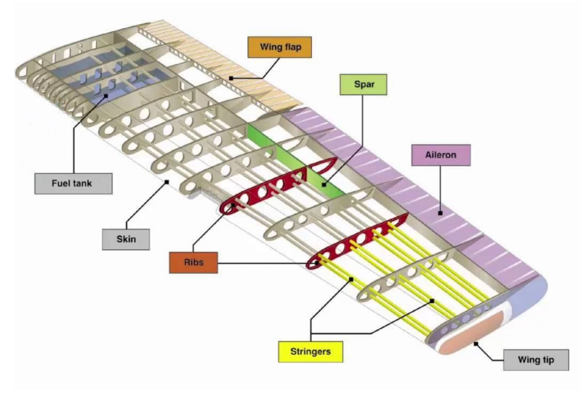


Figure 2. 737-800 vs. -200

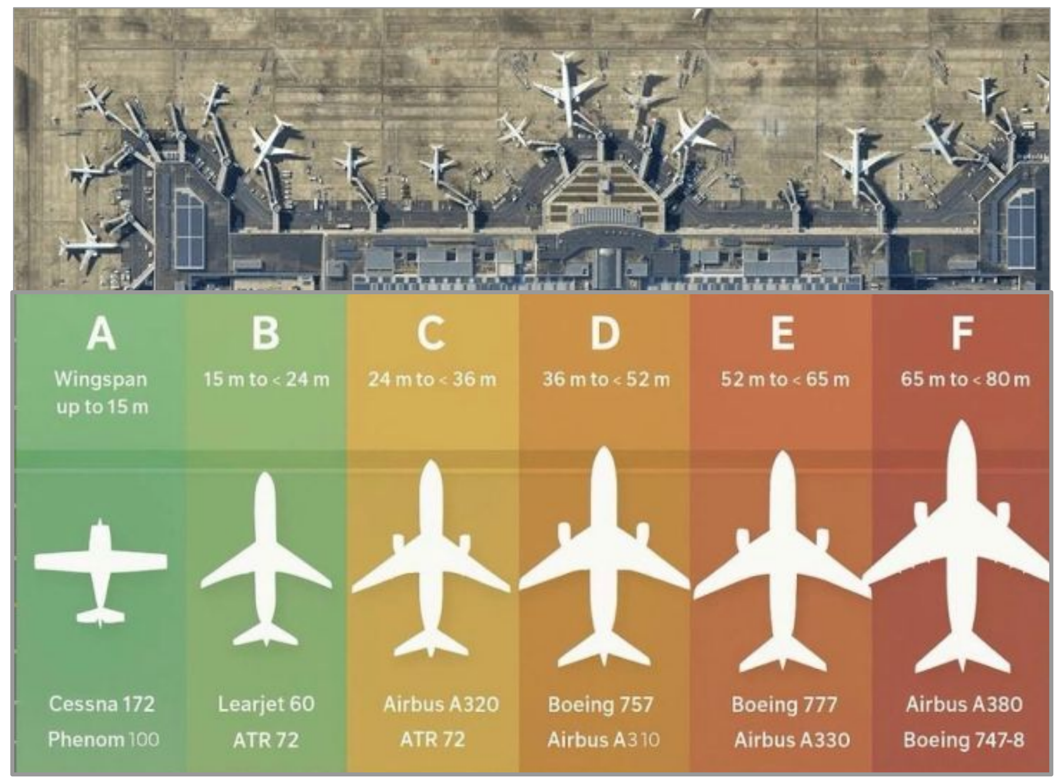


Figure 3. Aircraft ICAO Gate Code Letters

DISCUSSION, ANALYSIS, AND EVALUATION

- Below the optimum, adding span removes more drag weight than it adds structural weight. (figure 2) Above the optimum, structural weight wins: Torenbeek scales ~ b² while drag savings shrink as 1/b².
- Current 737 span of 118-ft. sits short of the 126-ft. optimum, but doesn't have meaningful room to grow due to limitations of Gate Code C (figure 3)
- At optimum, Lift to Drag ratio is 18.5 vs 17.7 at baseline, meaning for every pound of weight it lifts it produces 4.5% less drag. This is where fuel savings come from, and CL/CD is inversely proportional to Breguet's fuel burn.

Please note my study the aircraft type I modeled my data from is the -800, which is a common variant, but isn't as accurate as the newer max series/-900.

CONCLUSIONS, IMPLICATIONS, AND NEXT STEPS

- At the optimum, structure costs 19,244 lb and drag costs 11,928 lb of fuel → saves 146 lbs of takeoff weight.
- Our calculation matches the real 737-800's wing weight to within 4%, so it makes the model reasonable.
- Final Results have comparable spans to 757 and P-8 Poseidon aircraft.

Future Considerations:

- How do lighter materials such as advanced composites affect wingspan?
- Is it reasonable to add folding wingtips las seen on the new 777-X to the 737 family?
- If Boeing designs a clean-sheet aircraft, how will its design differ from these findings?

ACKNOWLEDGEMENTS / REFERENCES

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References

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Drela, M. & Youngren, H. *AVL 3.40 User Primer*.