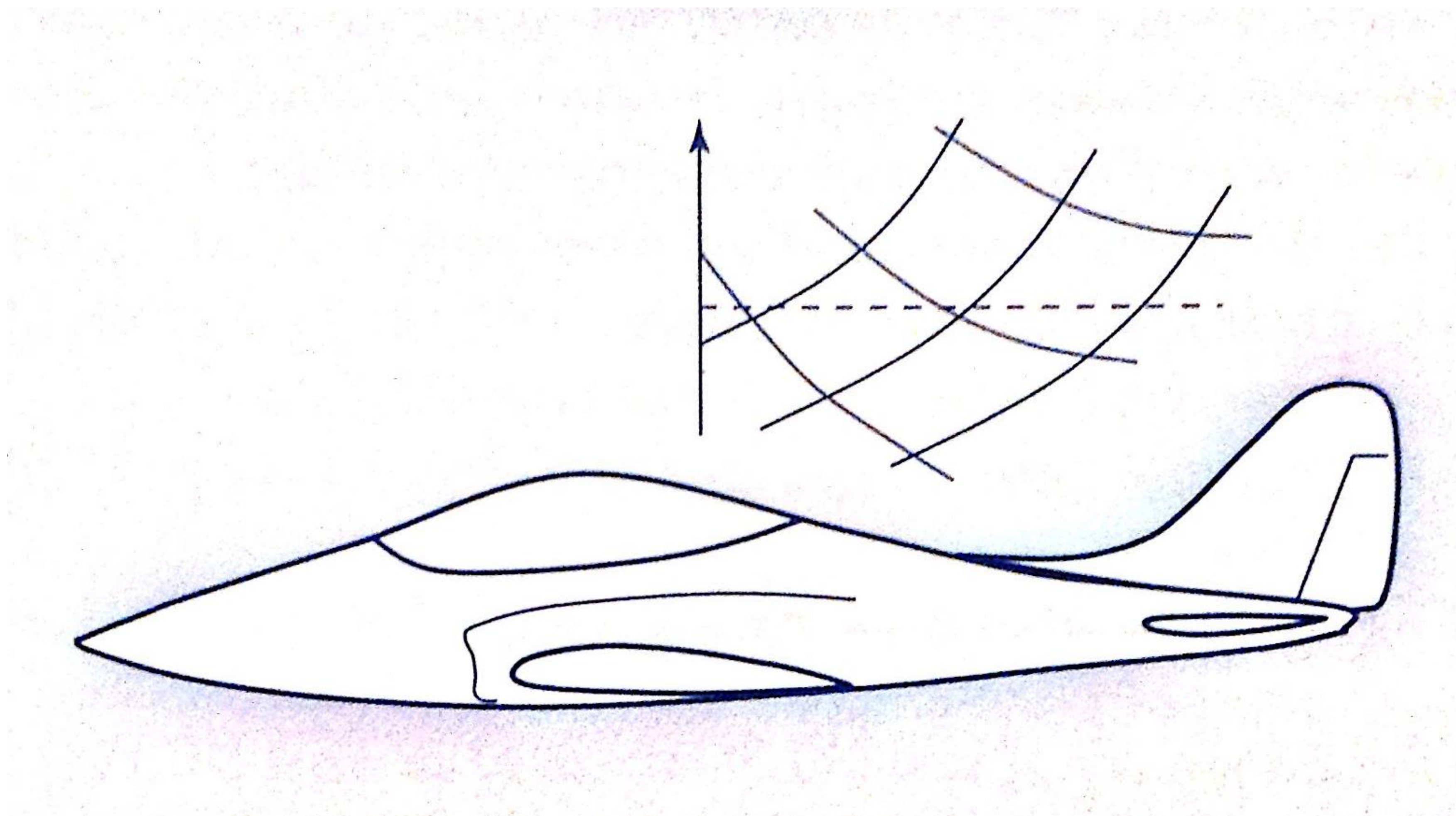
ME4932 Aircraft Performance & Design

Sizing &Trade Studies (Chapter 19)



Source: Aircraft Design by Daniel P. Raymer

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Sizing &Trade Studies (Chapter 19)

- After doing detailed analysis of our Dash-One we know where we are performance-wise.

- Parametric studies will define the Dash-2 that will better satisfy requirements.

- Sizing computer programs iterate to size the design to meet range, compute point performance for variations of Sref, Engine Scale Factor, Aspect Ratio, Wing Sweep, Taper Ratio, Wing Thickness, etc.

- Optimization, the systematic search of the design space for the best design is mostly done graphically with the intervention of the sizing/performance engineer and/or using an automated optimization algorithm (MDO).

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- With the better weight methods, we calculated a revised empty weight. The new W_e may not allow for enough fuel for our mission. So, we can adjust W_e to account for this!

$$W_e = W_{e_{\text{as drawn}}} \left[\frac{W_0}{W_{0_{\text{as drawn}}}} \right]^{1+c}$$

- Could also find your own design's "c" by increasing W_0 arbitrarily 10% and recalculating W_e and solving for "c" .

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Sizing &Trade Studies (Chapter 19)

- Photo-Scaling Problems
- When scaling down severely, say that Wo goes down 50%, this could dictate a fuselage size that just doesn't have enough volume for all the fixed items.
- The downsized aircraft should really have a higher We/Wo than originally thought !
- Sophisticated sizing programs take this into account. Just be careful,
- This also affects aerodynamic coefficients. You may reduce S_{ref} 50% (due to the Wo reduction), but because you keep a relatively large fuselage C_{D0} goes up!

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	$W/S = 50(\text{lb/ft}^2)$	$W/S = 60$	$W/S = 70$
$T/W = 1.1$	1 $W_0 = 56{,}000$ lb $P_s = 700$ fps ($M0.9$, 30k ft, 5g's) $S_{to} = 340$ ft $a = 46$ s	2 $W_0 = 49{,}000$ lb $P_s = 330$ fps $S_{to} = 430$ ft $a = 42$ s	3 $W_0 = 46{,}000$ lb $P_s = 30$ fps $S_{to} = 660$ ft $a = 39$ s
$T/W = 1.0$	4 $W_0 = 48{,}500$ lb $P_s = 430$ fps $S_{to} = 450$ ft $a = 50.5$ s	5 Resized baseline $W_0 = 43{,}700$ lb $P_s = 30$ fps $S_{to} = 595$ ft $a = 47$ s	6 $W_0 = 42{,}000$ lb $P_s = -190$ fps $S_{to} = 800$ ft $a = 45$ s
$T/W = 0.9$	7 $W_0 = 44{,}000$ lb $P_s = 140$ fps $S_{to} = 670$ ft $a = 56$ s	8 $W_0 = 39{,}000$ lb $P_s = -230$ fps $S_{to} = 810$ ft $a = 53$ s	9 $W_0 = 36{,}000$ lb $P_s = -320$ fps $S_{to} = 1070$ ft $a = 51$ s

Require: $P_s \geq 0$ at $M0.9$, 30k ft {9144 m}, 5g's
$S_{to} \leq 500$ ft {152 m}
a 50 s from $M0.9$ to $M1.5$

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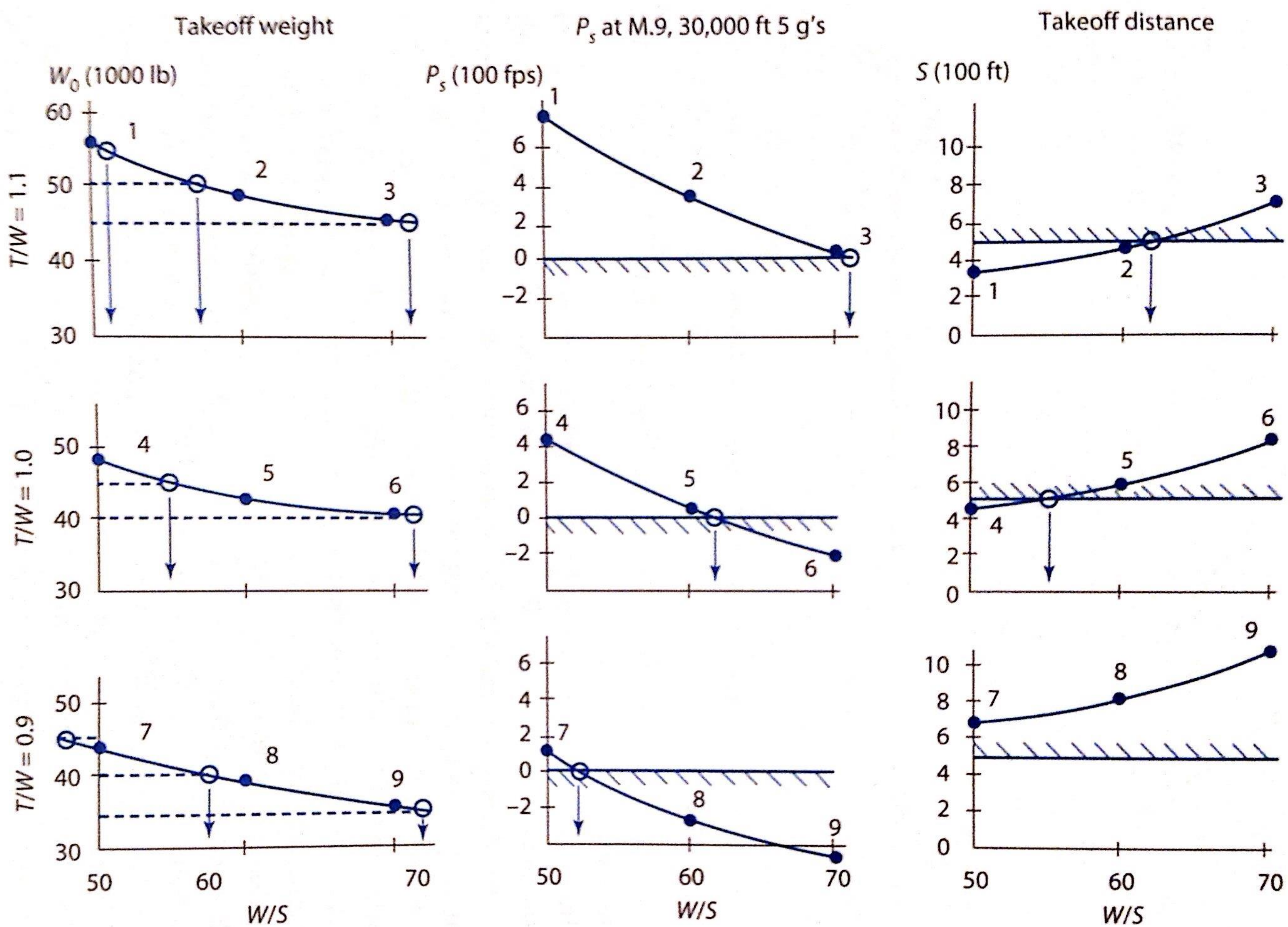

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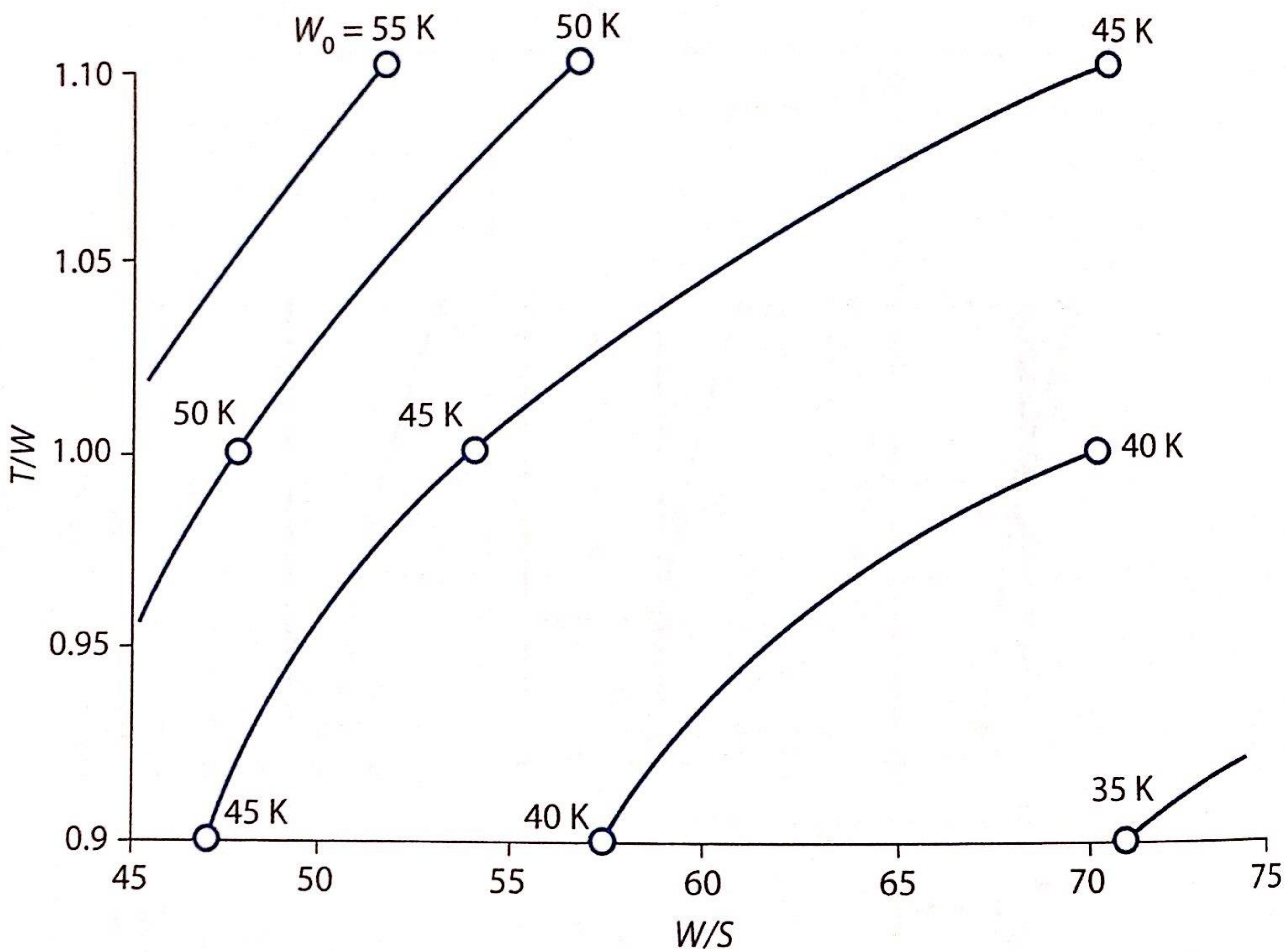

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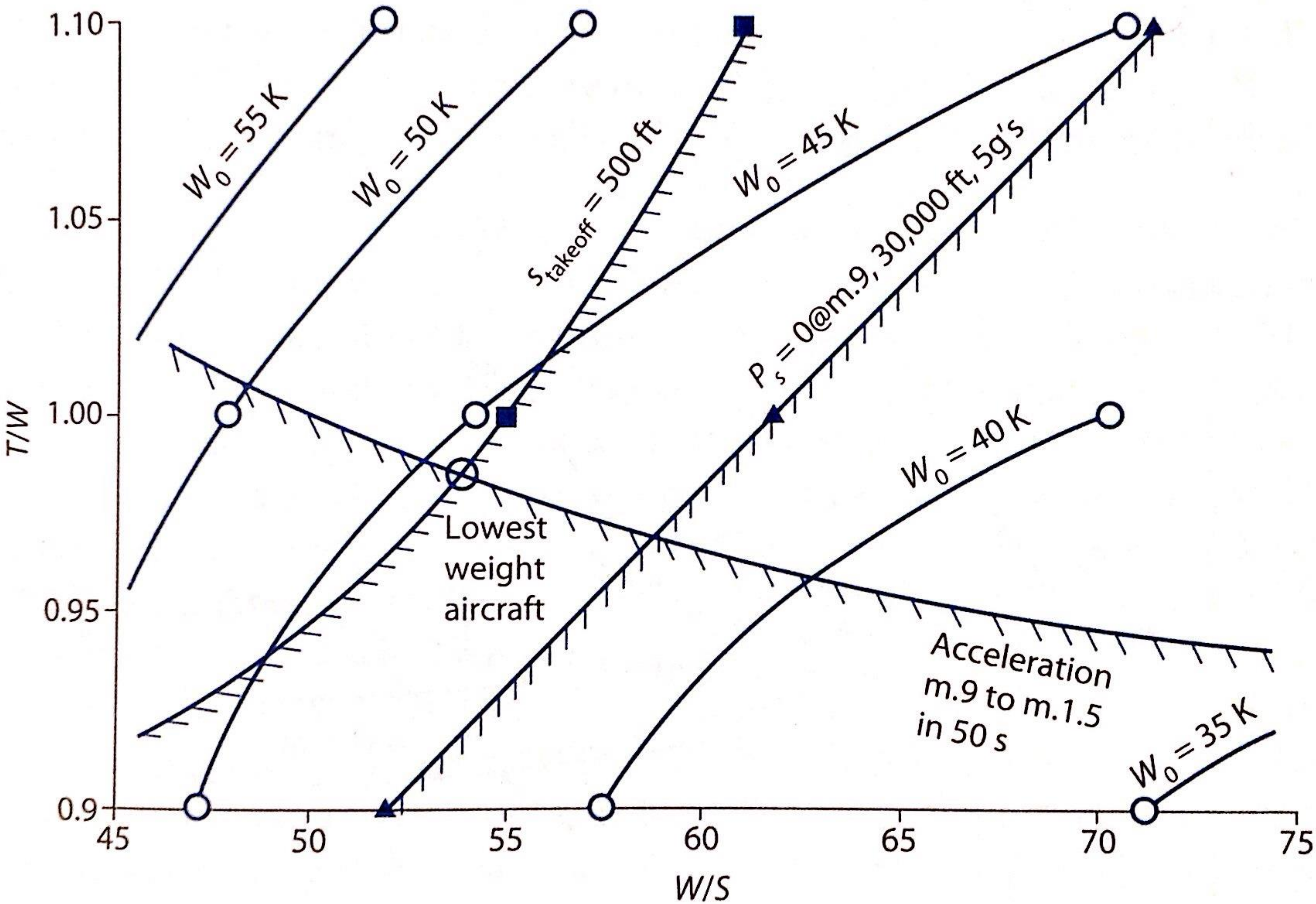

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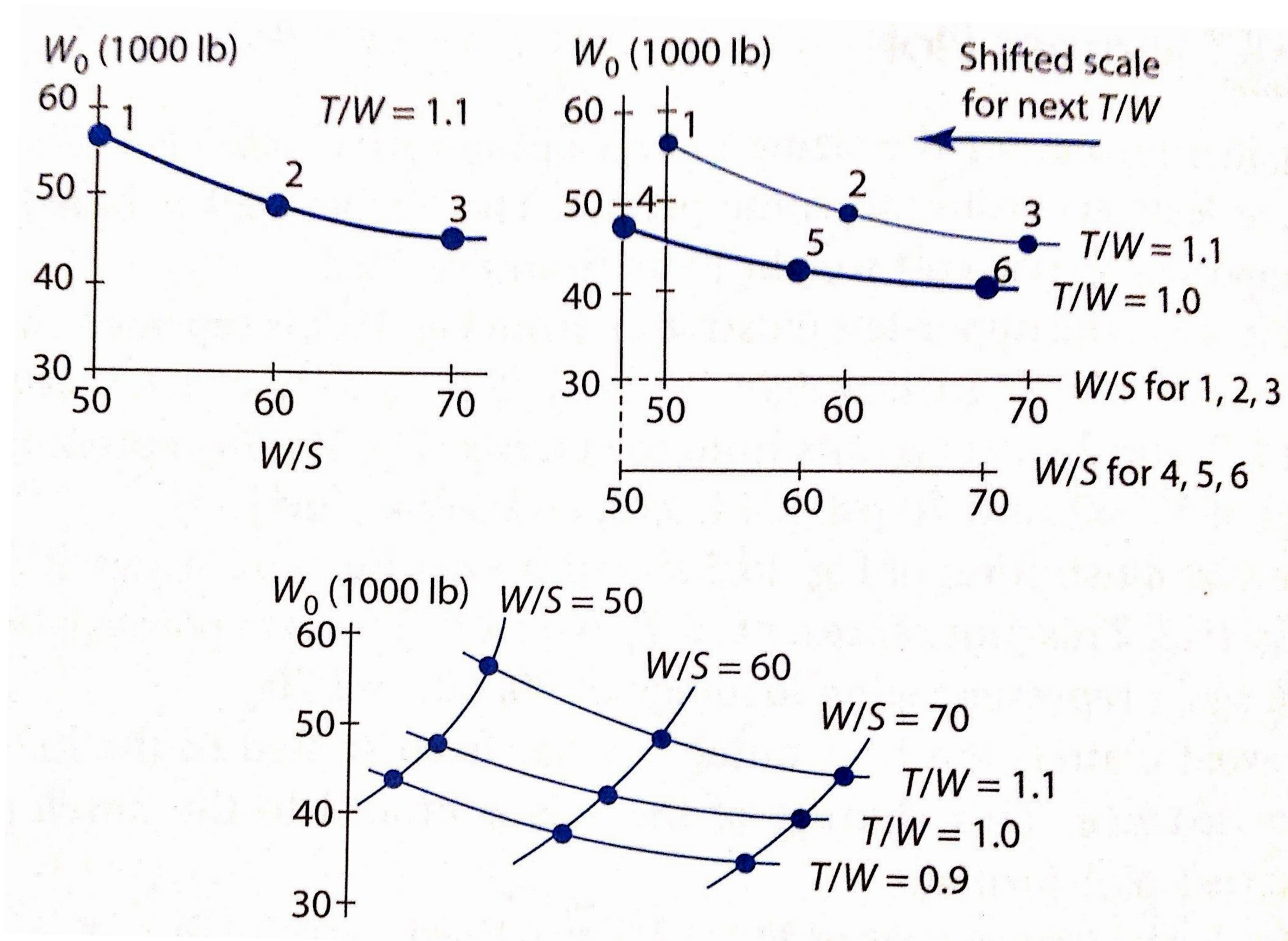

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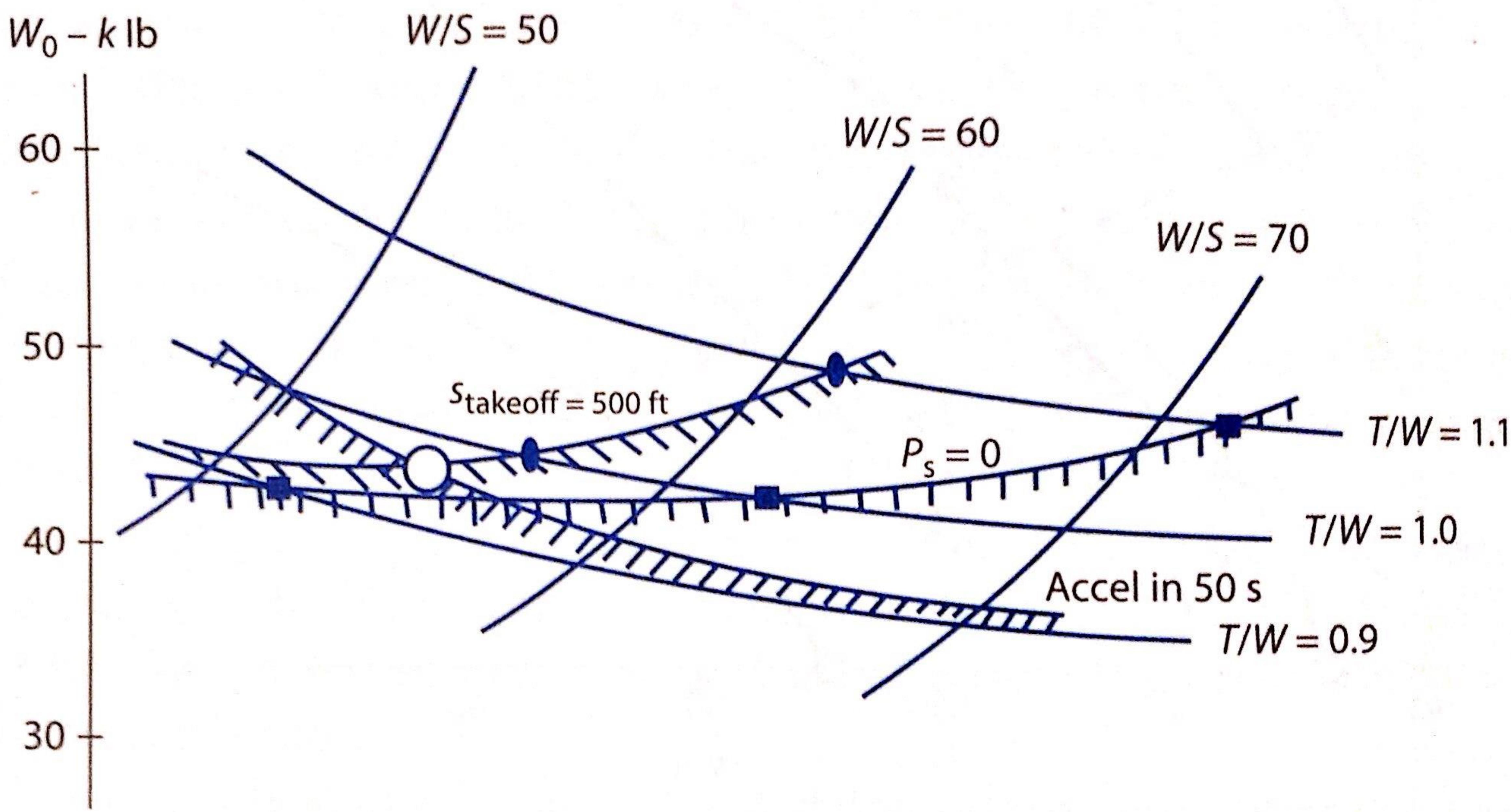

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Sizing &Trade Studies (Chapter 19)

- Study trade-offs of other parameters (HLD, Airfoil, Engine parameters, etc.)
- Alternate configurations (Tail vs. Canard, # engines, etc.)
- Requirement trades (what if we got a huge Wo reduction just by relaxing a bit a requirement?)
- Growth sensitivity studies (weight, CD, etc)

Source: Aircraft Design by Daniel P. Raymer

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Sizing &Trade Studies (Chapter 19)

- Other design trades:

Design trades	Requirements trades	Growth sensitivities
T/W and W/S	Range/payload/passengers	Dead weight*
A, Λ	Loiter time	C_{D_0} and K, $C_{D\text{wave}}$
P_s, $n_{\max}$ t/c, λ	Speed	$C_{D_{\max}}$
Airfoil shape and camber	Turn-rate, P_s, $n_{\max}$	Installed thrust and SFC
High-lift devices	Runway length	
Fuselage fineness ratio	Time-to-climb	Fuel price
BPR, OPR, TIT, etc.	Signature level	
Propeller diameter	Design-to-cost	
Materials		
Configuration Tail type Variable sweep Number and type of engines Maintainability features Observables Passenger arrangement		
Advanced technologies		

Source: Aircraft Design by Daniel P. Raymer