Aircraft Design
Tail Design

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Aircraft Design Process

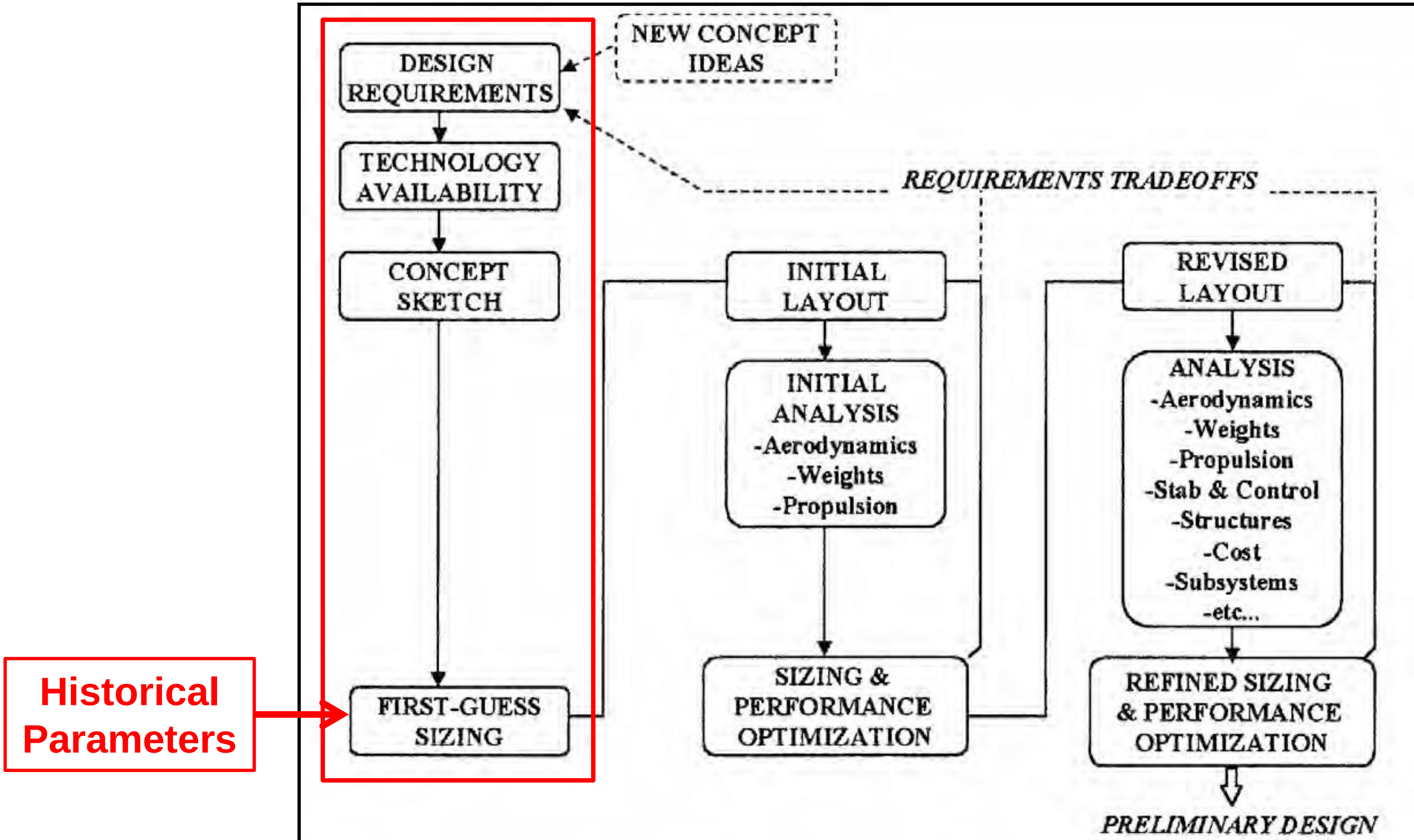

Fig. 2.4 **Aircraft conceptual design process.**

"Aircraft Design: A Conceptual Approach" by Daniel P. Raymer, page 9

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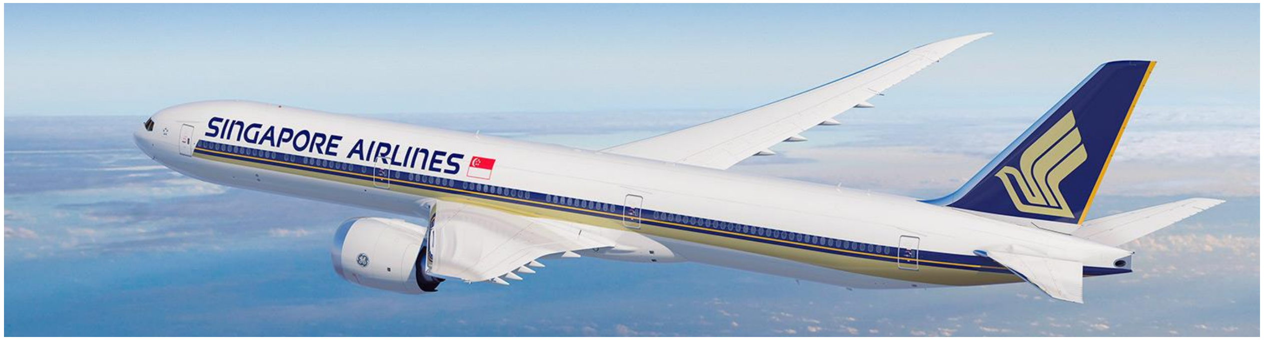
Tail Configurations



Conventional

V-Tail

T-Tail

Tail Configurations

Twin Tail

H-Tail

Canard

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Tail Design

Vertical Tail Sizing

$$C_{VT} = \frac{l_{VT}\, S_{VT}}{b_W\, S_W}$$

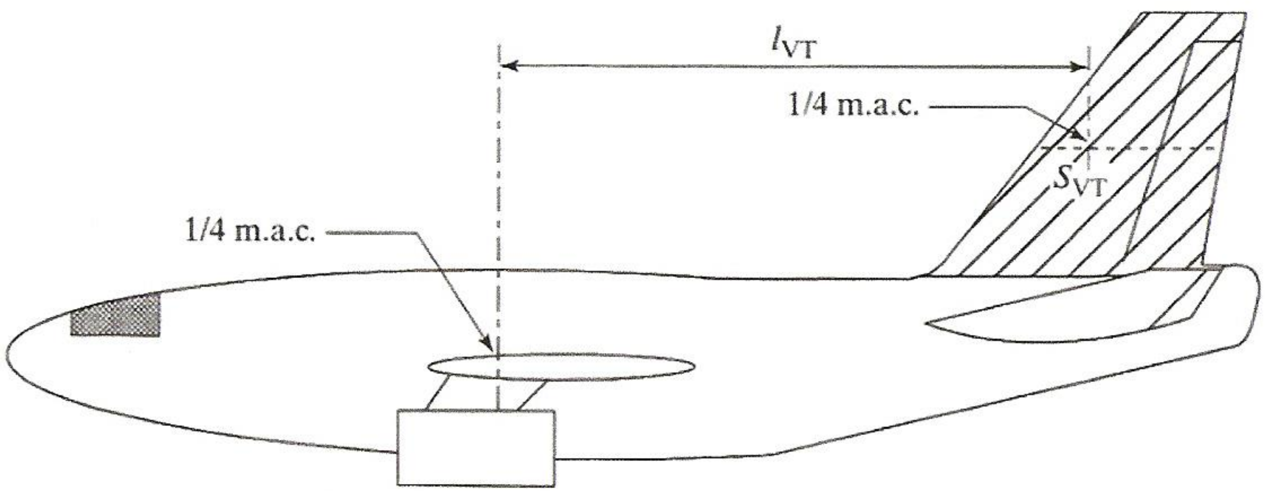
= 0.10 – 0.20 for commercial jet transports

l_{VT} – distance between MAC quarter-chord locations of the wing and vertical tail

S_{VT} – area of the vertical tail

b_W – span of the wing

S_W – area of the wing

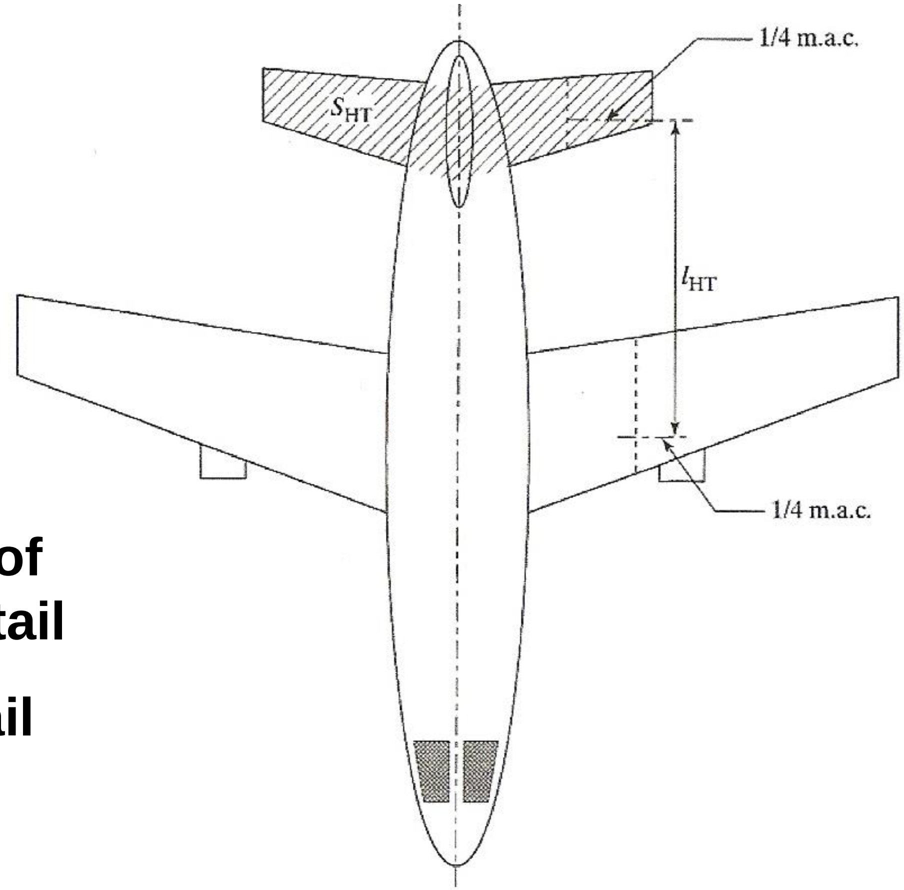


Tail Design

Horizontal Tail Sizing

$$C_{HT} = \frac{l_{HT}\, S_{HT}}{c_W\, S_W}$$

= 1.0 – 2.0 for commercial
jet transports



l_{HT} – distance between MAC quarter-chord locations of the wing and horizontal tail

S_{HT} – area of the horizontal tail

c_W – MAC of the wing

S_W – area of the wing

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Tail Design

Initial "Rule of Thumb" Values for Airliners

$$c_{HT} = \frac{l_{HT}\, S_{HT}}{c_W\, S_W} \cong 1.00 \text{ to } 2.00 \qquad c_{VT} = \frac{l_{VT}\, S_{VT}}{b_W\, S_W} \cong 0.10 \text{ to } 0.20$$

$$\Lambda_{HT} = \Lambda_W + x^\circ$$
$$\Lambda_{VT} = \Lambda_W + y^\circ$$

x = 2 to 6 for leading edge sweep
y = 6 to 12

$l_{tail}/l_{fuselage} = 40\%$ to 50% for fuselage-mounted engines

$l_{tail}/l_{fuselage} = 45\%$ to 55% for wing-mounted engines

$\lambda_{HT} \cong 0.25$ to 0.60 $\qquad$ $\lambda_{VT} \cong 0.30$ to 0.60

$AR_{HT} \cong 3$ to 5 $\qquad$ $AR_{VT} \cong 1.3$ to 2.5

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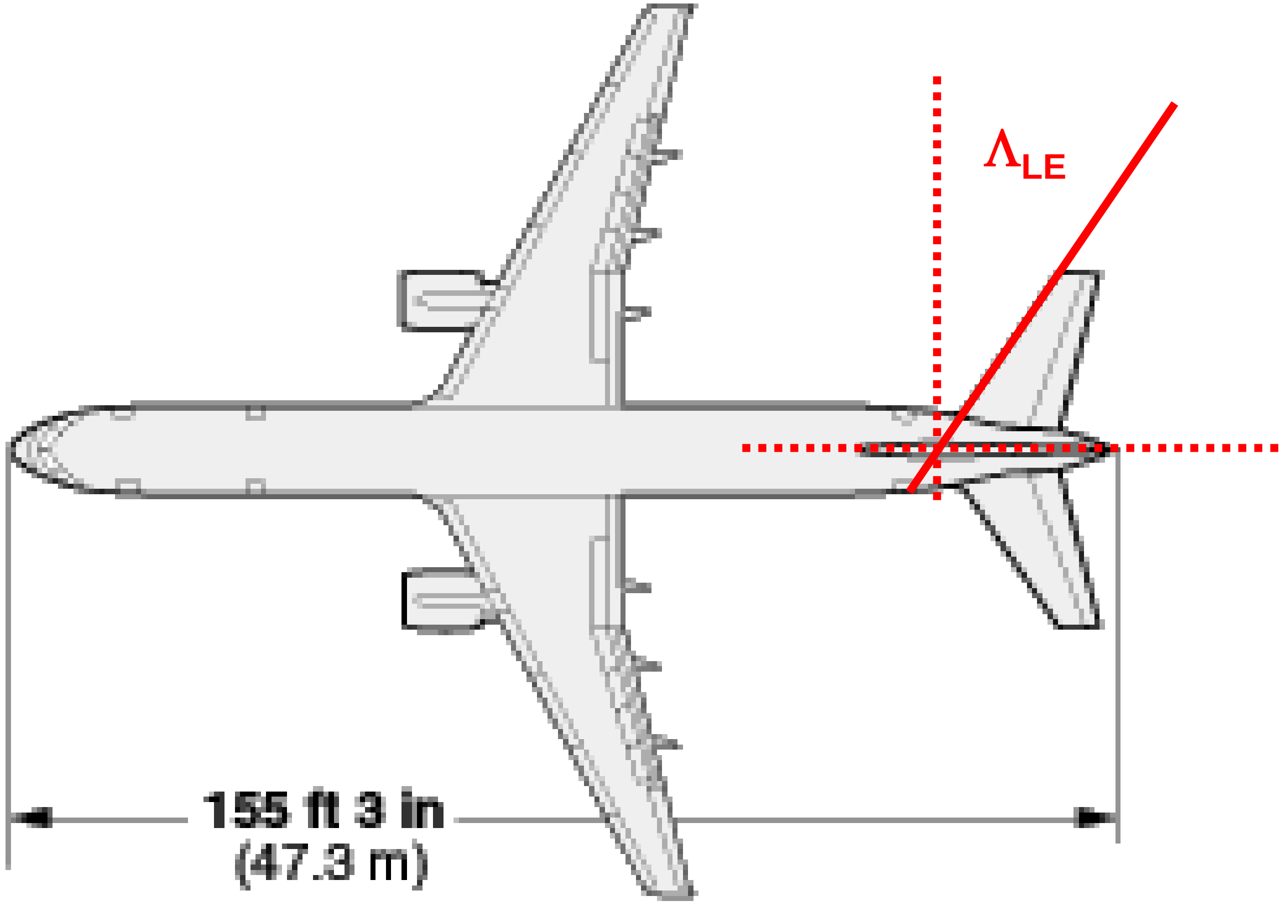
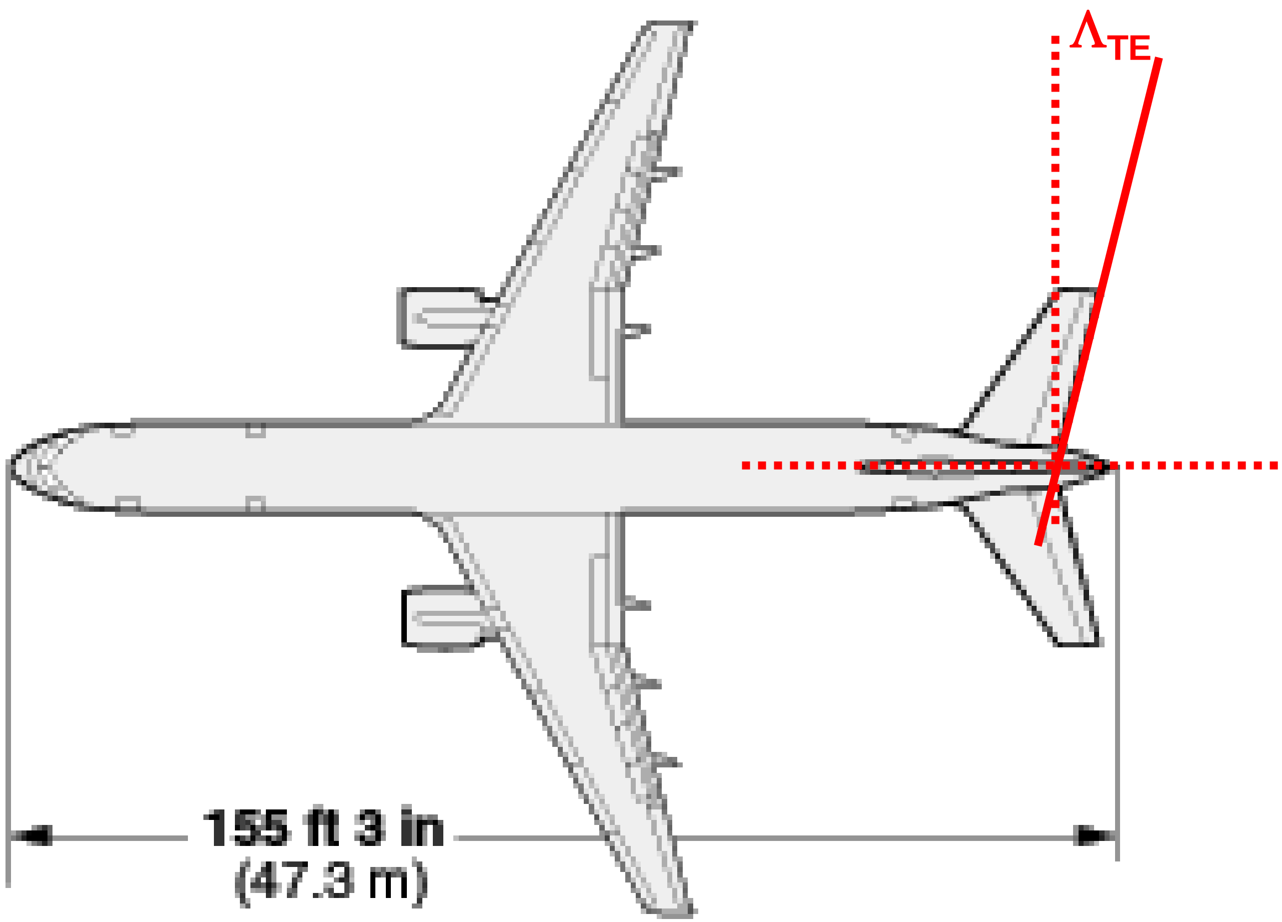
Horizontal Tail Measurements



Horizontal Tail Measurements

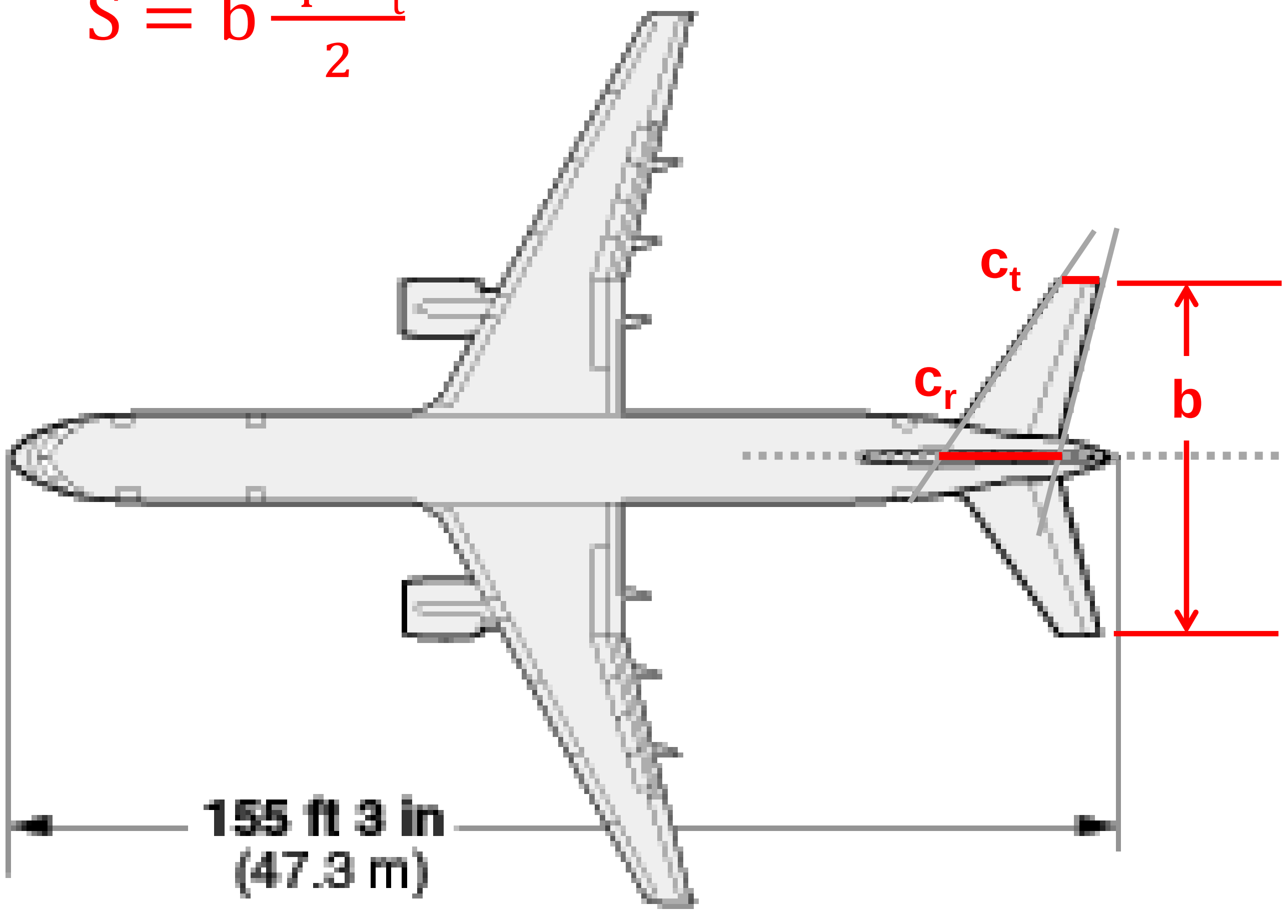


Horizontal Tail Measurements

$$\lambda = \frac{c_t}{c_r}$$

$$S = b\,\frac{c_r + c_t}{2}$$

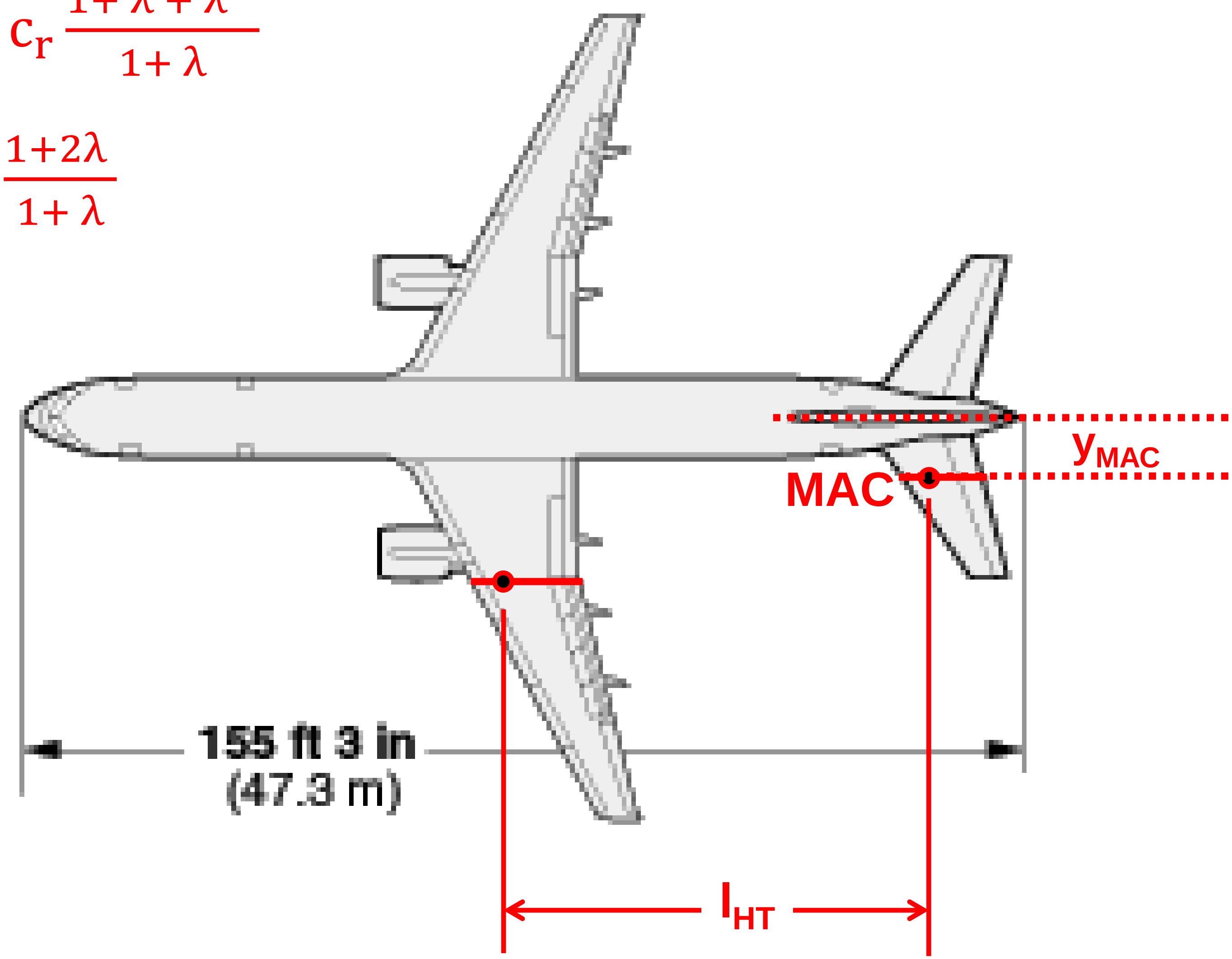
$$AR = \frac{b^2}{S}$$



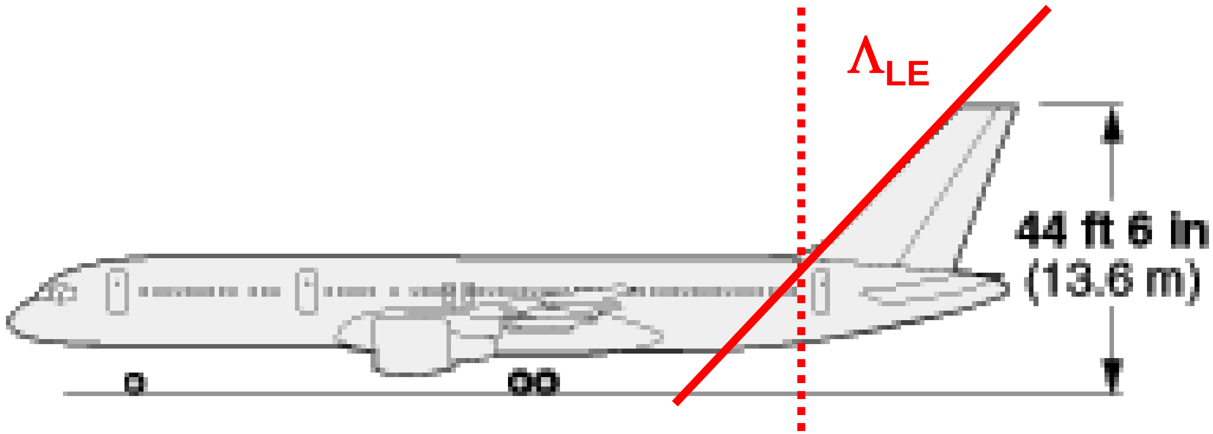
Horizontal Tail Measurements

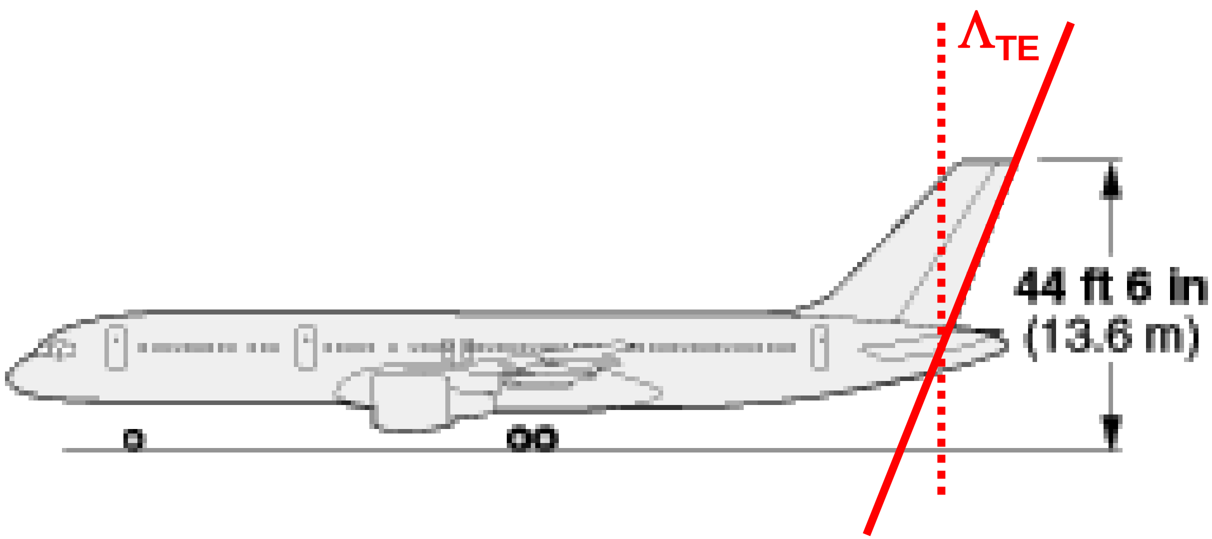
$$\mathrm{MAC} = \frac{2}{3}\, c_r \frac{1+\lambda+\lambda^2}{1+\lambda}$$

$$y_{MAC} = \frac{b}{6}\, \frac{1+2\lambda}{1+\lambda}$$



Vertical Tail Measurements





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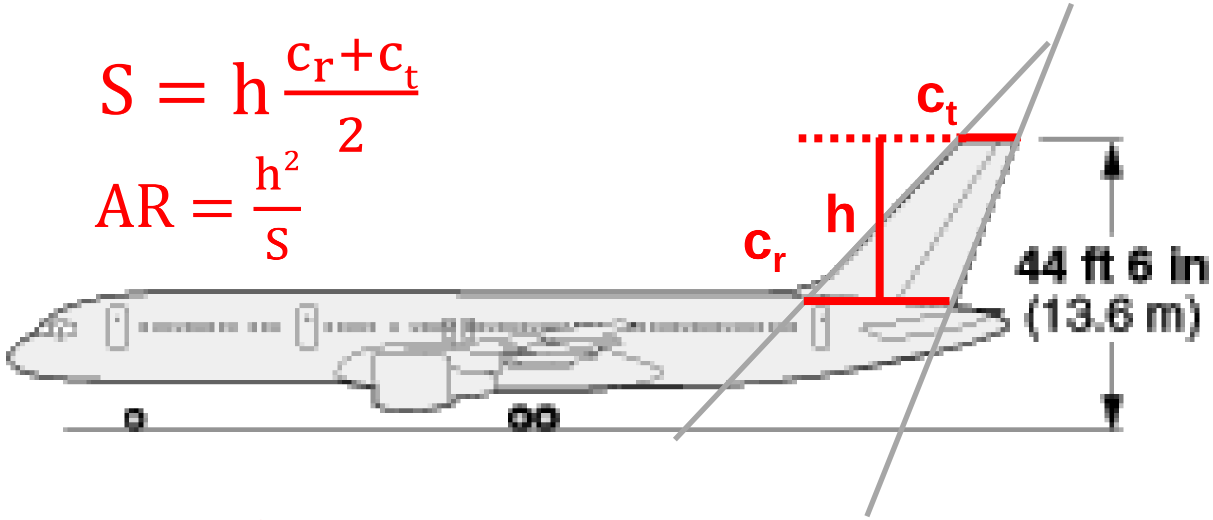
Vertical Tail Measurements

$$\lambda = \frac{c_t}{c_r}$$

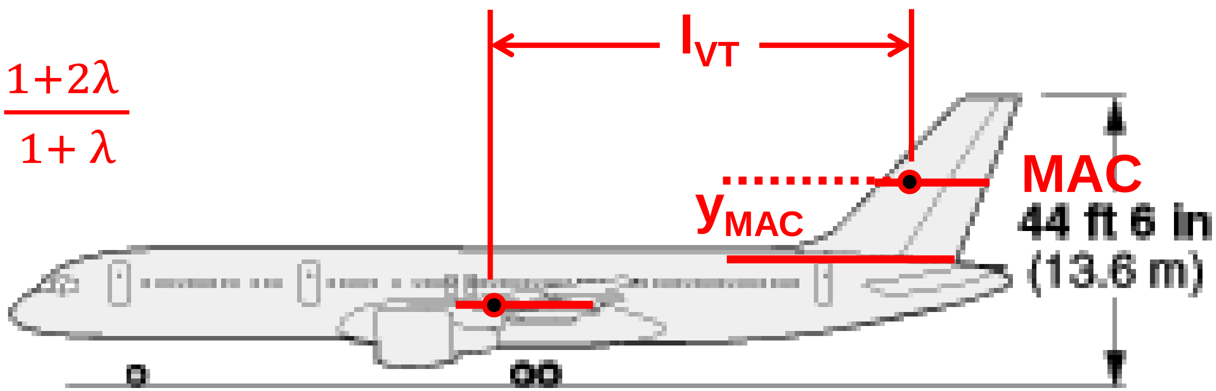
$$S = h\,\frac{c_r + c_t}{2}$$

$$AR = \frac{h^2}{S}$$



$$\text{MAC} = \frac{2}{3}\,c_r\,\frac{1+\lambda+\lambda^2}{1+\lambda}$$

$$y_{MAC} = \frac{h}{3}\,\frac{1+2\lambda}{1+\lambda}$$



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HW #24 – Tail Design

TAIL.XLS

“Design of Aircraft” - Thomas C. Corke

Main Wing Reference

b	32.2	ft
m.a.c.	21.5	ft
S	519	ft^2
Cruise M	2.10	
Λ_{LE}	62.00	deg
t/c	0.04	
λ	0.333	
Length	102.00	ft

Air Properties

Cruise Alt.	36,000	ft
V	2,061.36	f/s
ρ	0.023052	lbm/f^3
q	1521.026	lbf/f^2
μ	1.07E-05	lbm/(f-s)
ν (cruise)	0.000464	f^2/s

Vertical Tail

Design Parameters

C_{VT}	0.100	
l_{VT}	40.00	ft
Λ_{LE}	63	deg
t/c	0.04	
λ–vt	0.300	
AR-vt	1.10	

Airfoil Data

Name	NACA 64-004	
Cl_{max}	0.8	
Cl_{α}	0.111	1/deg
a.c.	0.258	c
α_{0L}	0	deg
Cd	0.004	

Calculations

S_{VT}	41.8	ft^2
h_{VT}	6.78	ft
c_r	9.48	ft
c_t	2.84	ft
MAC-vt	6.76	ft
β	1.85	
$C_{L\alpha}$	**0.022**	1/deg
Total Drag	**530.534**	lbf

Sweep Angles

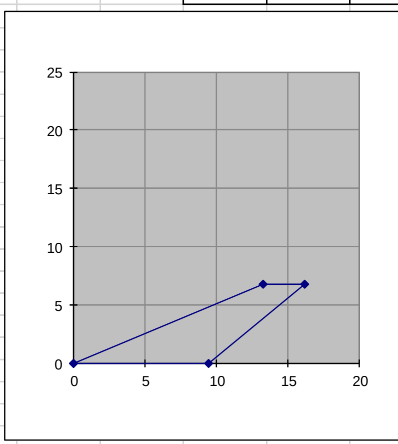
	x/c	$\Lambda_{x/c}$ (deg)
LE	0.00	63.0
1/4 chord	0.25	59.8
(t/c)max	0.35	58.3
TE	1.00	44.5

Viscous Drag

V_eff	935.8379	f/s
q_eff	313.4946	lbf/f^2
M_eff	0.95338	
Re_mac	13626478	
sqrt(Re)	3691.406	
Cf	2.64E-03	
S_wet	83.68434	ft^2
F	1.503537	
Q	1.05	
C_{D0}	**0.008349**	

Spanwise View

x (ft)	y (ft)
0.00	0.00
9.48	0.00
16.15	6.78
13.30	6.78
0.00	0.00



Horizontal Tail

Design Parameters

C_{HT}	0.11	
l_{HT}	50.0	ft
Λ_{LE}	63.0	deg
t/c	0.04	
λ–vt	0.350	
AR-ht	2.00	

Airfoil Data

Name	NACA 64-004	
Cl_{max}	0.8	
Cl_{α}	0.111	1/deg
a.c.	0.258	c
α_{0L}	0	deg
Cd	0.004	

Calculations

S_{HT}	24.5	ft^2
b_{HT}	7.01	ft
c_r	5.19	ft
c_t	1.82	ft
MAC-ht	3.77	ft
β	1.85	
$C_{L\alpha}$	**0.030**	1/deg
Total Drag	**341.927**	lbf

Sweep Angles

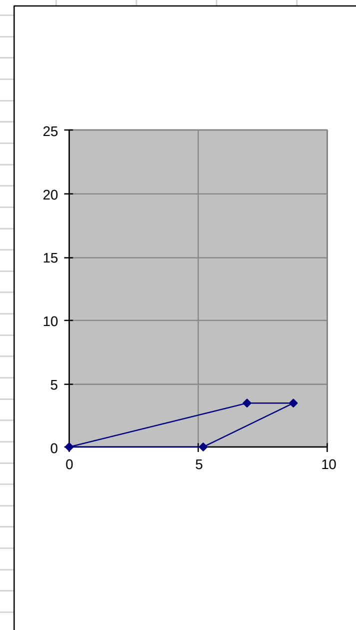
	x/c	$\Lambda_{x/c}$ (deg)
LE	0.00	63.0
1/4 chord	0.25	59.9
(t/c)max	0.35	58.4
TE	1.00	45.0

Viscous Drag

V_eff	935.8379	f/s
q_eff	313.4946	lbf/f^2
M_eff	0.95338	
Re_mac	7609520	
sqrt(Re)	2758.536	
Cf	2.90E-03	
S_wet	49.17105	ft^2
F	1.50248	
Q	1.05	
C_{D0}	**0.009157**	

Spanwise View

x (ft)	y (ft)
0.00	0.00
5.19	0.00
8.69	3.50
6.88	3.50
0.00	0.00



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HW #24 – Vertical Tail Design

Main Wing Reference		
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S	519	ft^2
Cruise M	2.10	
Λ_{LE}	62.00	deg
t/c	0.04	
λ	0.333	
Length	102.00	ft

Air Properties		
Cruise Alt.	36,000	ft
V	2,061.36	f/s
ρ	0.023052	lbm/f^3
q	1521.026	lbf/f^2
μ	1.07E-05	lbm/(f-s)
ν (cruise)	0.000464	f^2/s

Input data from fact sheet and previous spreadsheets

Vertical Tail

Design Parameters		
C_{VT}	0.100	
l_{VT}	40.00	ft
Λ_{LE}	63	deg
t/c	0.04	
λ–vt	0.300	
AR-vt	1.10	

Airfoil Data		
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Cl_{max}	0.8	
Cl_{α}	0.111	1/deg
a.c.	0.258	c
α_{0L}	0	deg
Cd	0.004	

Input data from three-view drawing and calculations

Calculations		
S_{VT}	41.8	ft^2
h_{VT}	6.78	ft
c_r	9.48	ft
c_t	2.84	ft
MAC-vt	6.76	ft
β	1.85	
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Cf	2.64E-03	
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F	1.503537	
Q	1.05	
C_{D0}	**0.008349**	

Use these values later!!

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HW #24 – Horizontal Tail Design

Input data from three-view drawing and calculations

Horizontal Tail

Design Parameters

C_{HT}	0.11	
l_{HT}	50.0	ft
Λ_{LE}	63.0	deg
t/c	0.04	
λ–ht	0.350	
AR-ht	2.00	

Airfoil Data

Name	NACA 64-004	
Cl_{max}	0.8	
Cl_{α}	0.111	1/deg
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S_{HT}	24.5	ft^2
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Use these values later!!

Homework Assignment

HW #24 – Tail Design
(due by 11:59 pm ET on Monday)

<u>HW Help Session</u>
Monday 4:00 – 5:00 pm ET

Posted to Canvas:
HW #24 assignment with instructions, tips, and checklists
Excel file TAIL.XLS

Questions?