Aircraft Design
Fuselage Design

Aircraft Design Process

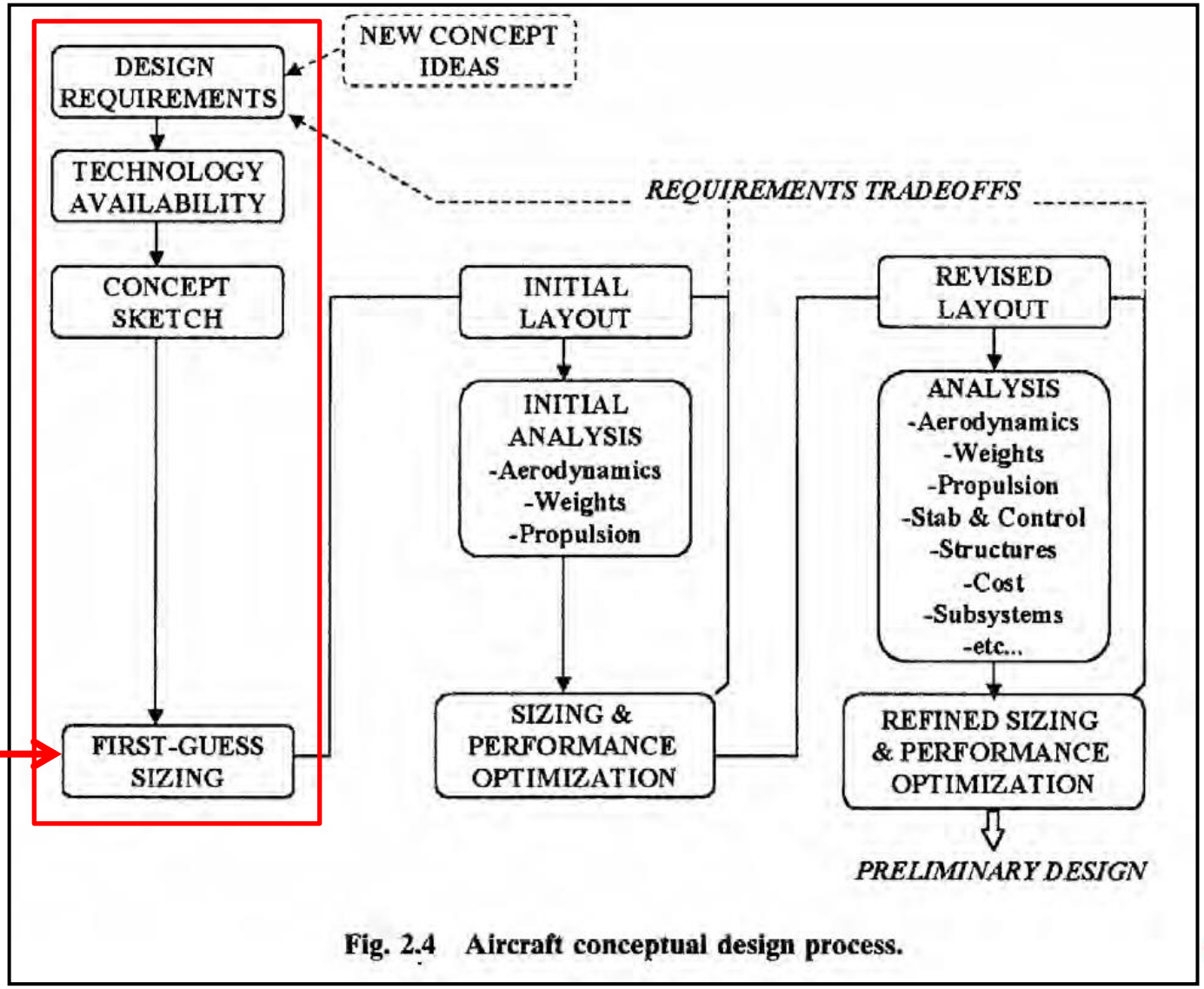

Fig. 2.4 Aircraft conceptual design process.

Historical Parameters

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

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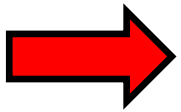
Fuselage Design

Airliner Fuselage Design Drivers

Number of Passengers
Seating Arrangements (Class, Seat Pitch)
Cargo Requirements

Long-Range vs Short-Range
Number of Lavatories (1/20 vs 1/50)
Number of Aisles (2 vs 1)
Baggage Storage (60 lb vs 40 lb)
- **25 vs 15 ft^3 checked baggage**
- **3 ft^3 overhead storage**



Fuselage Diameter and Length

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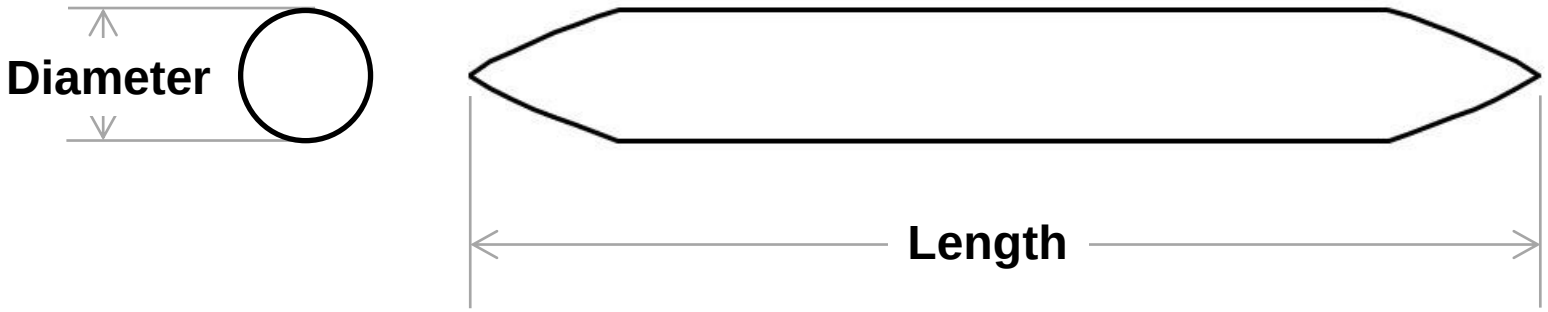
Fuselage Design

Fineness Ratio $(L/D)_{fuse}$

Aircraft Length (L_{fuse}) / Fuselage Diameter (D_{fuse})
Higher values = more streamlined body
Airliners: $7 < (L/D)_{fuse} < 14$



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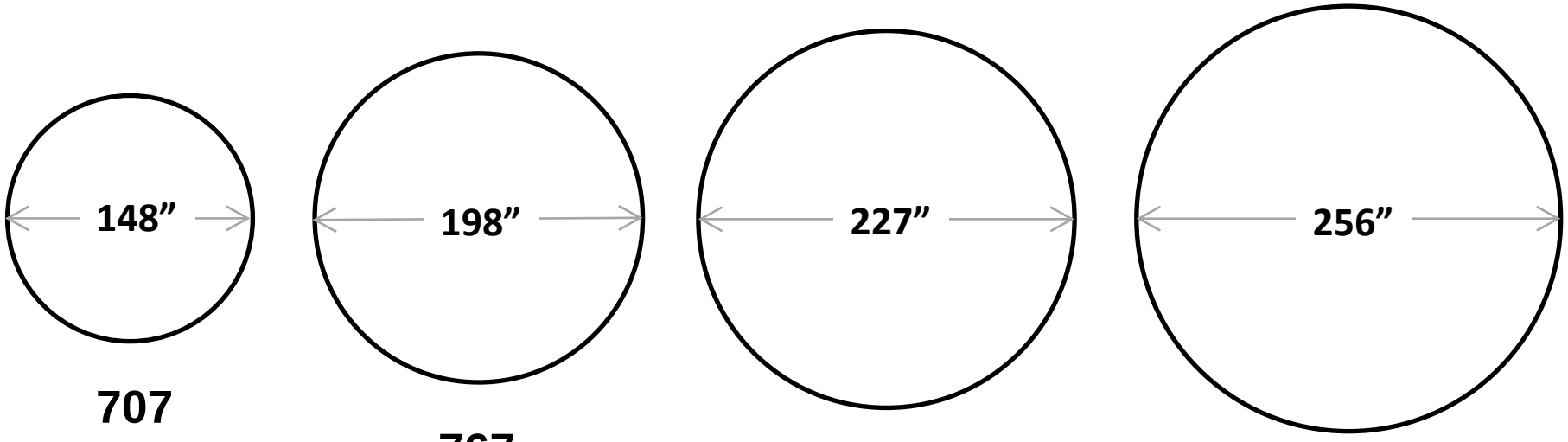
Fuselage Design

Fuselage Diameter

Boeing series of airliners



707
727
737
757

767

787

747

777 has a 244” diameter

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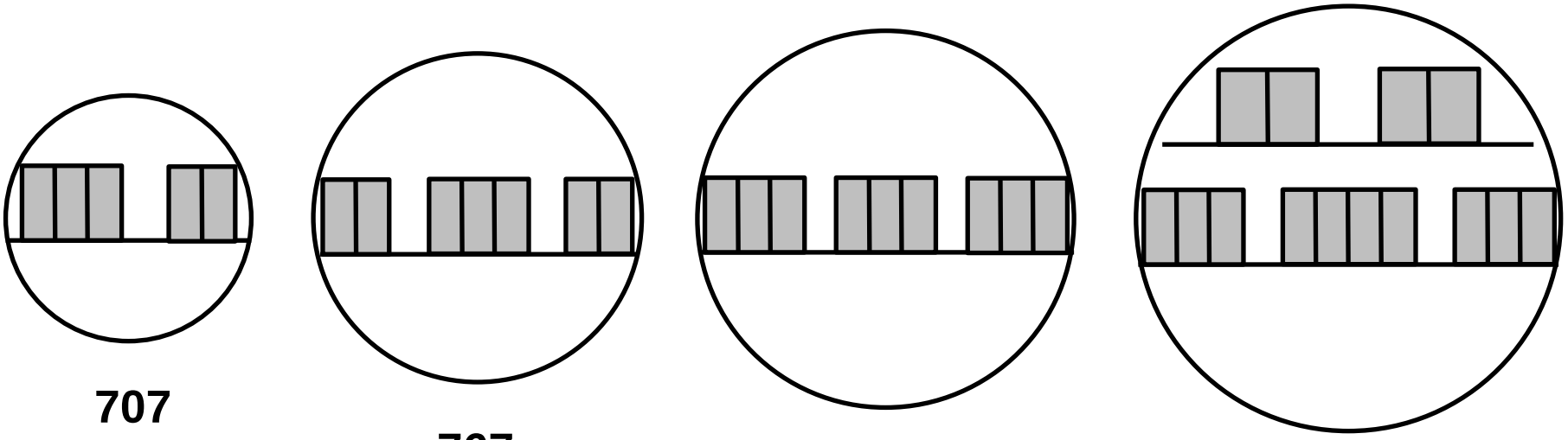
Fuselage Design

Fuselage Diameter

Boeing series of airliners



707
727
737
757

767

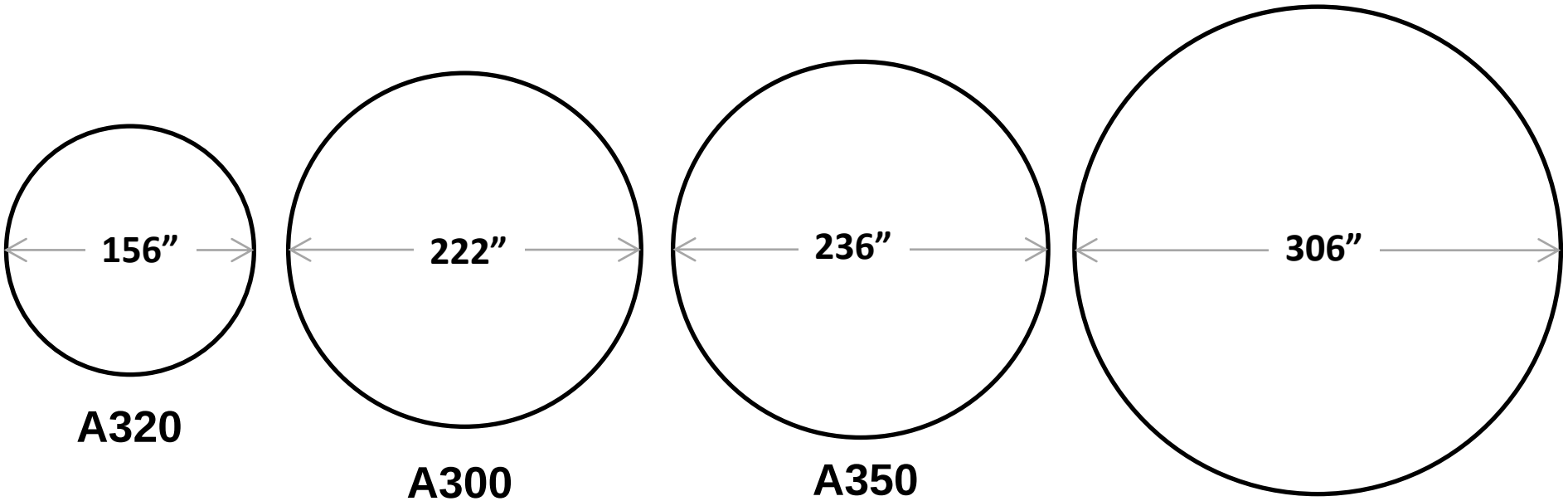
787

747

Fuselage Design

Fuselage Diameter

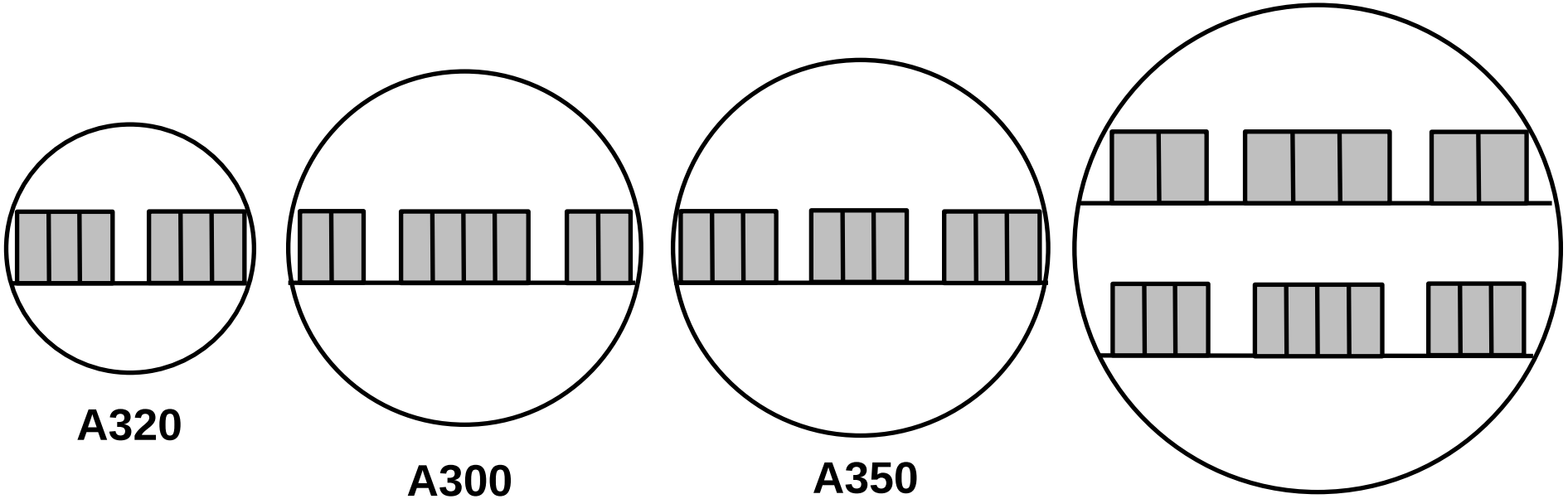
Airbus series of airliners



Fuselage Design

Fuselage Diameter

Airbus series of airliners



A320

A300
A310
A330
A340

A350

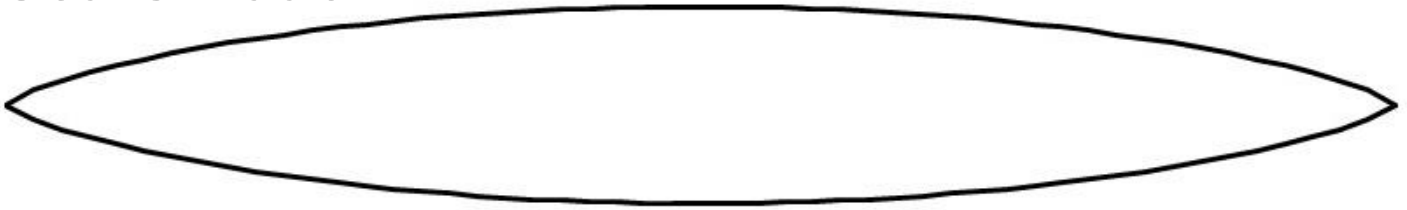
A380

Fuselage Design

Fuselage Shapes

Ogive

Sears-Haack



Power Series Cylinder

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Fuselage Design

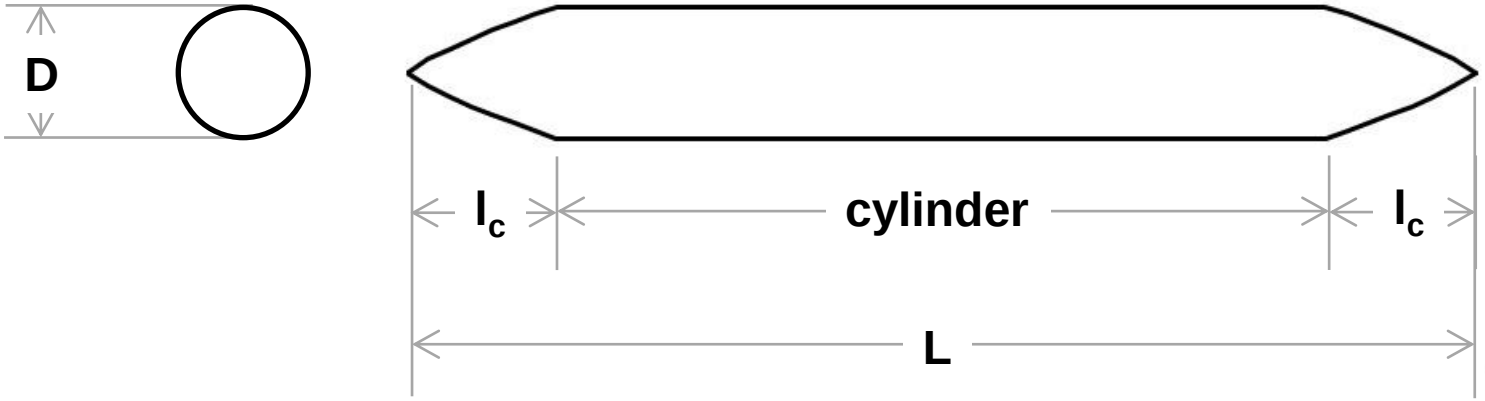
Power Series Cylinder

Constant diameter cylinder mid-section

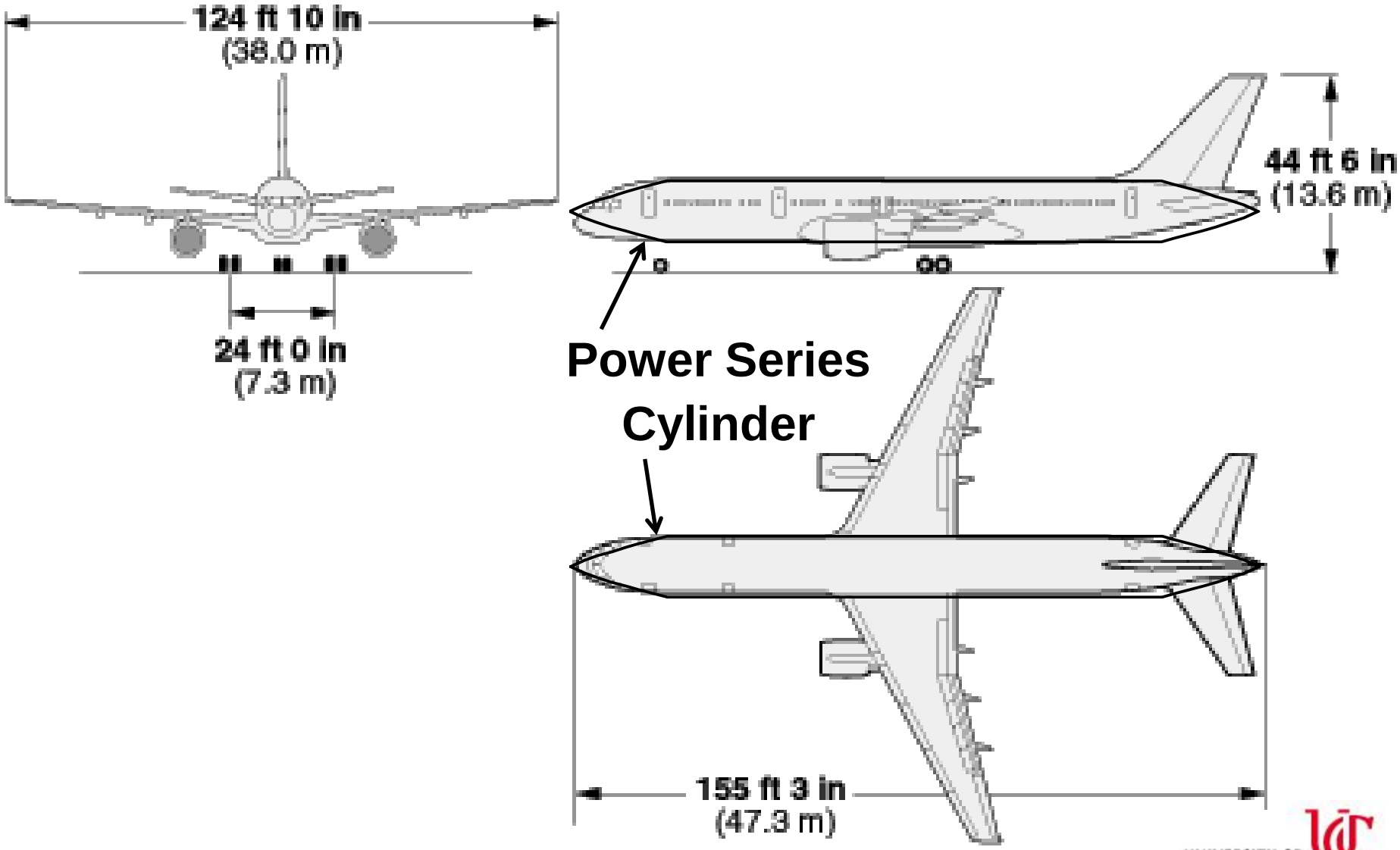
Nose and tail sections defined by:

$$d(\text{nose}) = D\left(\frac{x}{l_c}\right)^n$$ where n = 0.80 and l_c = 0.14 L

$$d(\text{tail}) = D\left(\frac{L-x}{l_c}\right)^n \qquad S_{wet} = \int_0^L \pi\, d\, dx$$



Fuselage Shaping



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HW #23 – Fuselage Design

			Fuselage Design		
Flight Regime Data:					
Cruise Mach	0.74				
Cruise Alt. (ft)	36,000				
V (f/s)	726.38				
ρ (lbm/f^3)	0.023052				
q (lbf/f^2)	188.8693				
μ (lbm/(f-s))	1.07E-05				
ν (cruise) (f^2/s)	0.000464				
Dimension Data:			**Form Factors:**		
D-max (ft)	12.33		*F*	1.090184	
L/D	9.69		*Q*	1	
L (ft)	119.50		*F*Q*	1.090184	
S (f^2)	1135.0				
lc - nose / L	0.14				
lc - tail / L	0.14				
n	0.80				

typical for airliners

FUSELAGE.XLS

"Design of Aircraft"
- Thomas C. Corke

Input data from fact sheet and previous spreadsheets

Input data for fuselage diameter shaping

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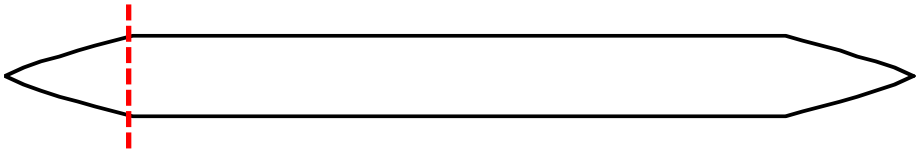
HW #23 – Fuselage Design

Viscous Drag Calculations:			*Power Series Cylinder*							
x/L	x (ft)	x-L/2 (ft)	D (ft)	P (ft)	Sw(ft^2)	Re_x	C_F	Drag (lbf)	+y (ft)	-y (ft)
0.00	0.00	-50.10	0.0000	0.0					0.0000	0.0000
0.02	2.00	-48.10	2.6002	8.2	16.4	3.1E+06	3.47E-03	12	1.3001	-1.3001
0.04	4.01	-46.09	4.5272	14.2	28.5	6.3E+06	3.08E-03	19	2.2636	-2.2636
0.06	6.01	-44.09	6.2618	19.7	39.4	9.4E+06	2.89E-03	24	3.1309	-3.1309
0.08	8.02	-42.08	7.8822	24.8	49.6	1.3E+07	2.76E-03	29	3.9411	-3.9411
0.10	10.02	-40.08	9.4228	29.6	59.3	1.6E+07	2.66E-03	34	4.7114	-4.7114
0.12	12.02	-38.08	10.9024	34.3	68.6	1.9E+07	2.59E-03	38	5.4512	-5.4512
0.14	14.03	-36.07	12.3333	38.7	77.6	2.2E+07	2.53E-03	42	6.1667	-6.1667
0.16	16.03	-34.07	12.3333	38.7	77.6	2.5E+07	2.48E-03	41	6.1667	-6.1667
0.18	18.04	-32.06	12.3333	38.7	77.6	2.8E+07	2.43E-03	40	6.1667	-6.1667
0.20	20.04	-30.06	12.3333	38.7	77.6	3.1E+07	2.40E-03	40	6.1667	-6.1667
0.22	22.04	-28.06	12.3333	38.7	77.6	3.4E+07	2.36E-03	39	6.1667	-6.1667
0.24	24.05	-26.05	12.3333	38.7	77.6	3.8E+07	2.33E-03	39	6.1667	-6.1667
0.26	26.05	-24.05	12.3333	38.7	77.6	4.1E+07	2.30E-03	38	6.1667	-6.1667
0.28	28.06	-22.04	12.3333	38.7	77.6	4.4E+07	2.28E-03	38	6.1667	-6.1667
0.30	30.06	-20.04	12.3333	38.7	77.6	4.7E+07	2.26E-03	37	6.1667	-6.1667
0.32	32.06	-18.04	12.3333	38.7	77.6	5.0E+07	2.24E-03	37	6.1667	-6.1667
0.34	34.07	-16.03	12.3333	38.7	77.6	5.3E+07	2.22E-03	37	6.1667	-6.1667
0.36	36.07	-14.03	12.3333	38.7	77.6	5.6E+07	2.20E-03	36	6.1667	-6.1667
0.38	38.08	-12.02	12.3333	38.7	77.6	6.0E+07	2.18E-03	36	6.1667	-6.1667
0.40	40.08	-10.02	12.3333	38.7	77.6	6.3E+07	2.16E-03	36	6.1667	-6.1667
0.42	42.08	-8.02	12.3333	38.7	77.6	6.6E+07	2.15E-03	36	6.1667	-6.1667

$l_c = 0.14\ L$



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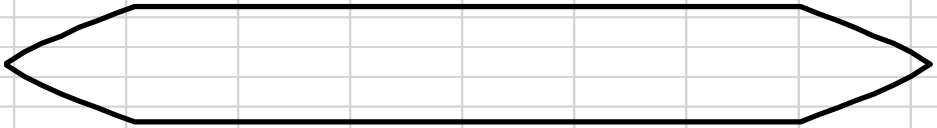
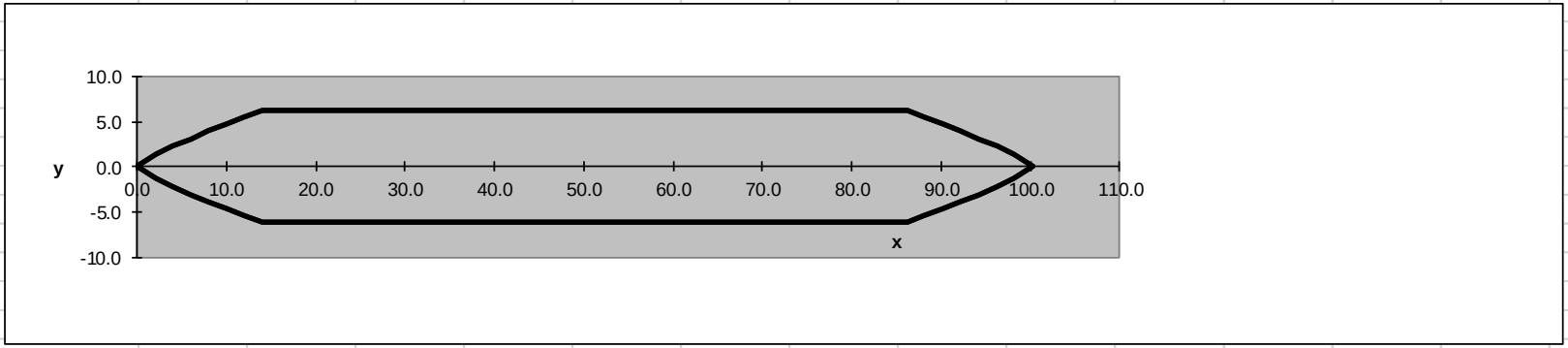
HW #23 – Fuselage Design

Totals:		**3396.7**	**1578**
		Swet	**Drag (lb)**

Wave Drag Calculations:	
A_max	119.4678
CDW	0.060602
Drag (lbf)	**1367.407**

Total Drag: (lbf)	**2945**
Equiv. CD	**0.0142**





Use these values later!!

Homework Assignments

HW #22 – Wing Design
HW #23 – Fuselage 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 #22/23 assignments with instructions, tips, and checklists
Excel files WING.XLS, FUSELAGE.XLS

Questions?