Introduction to the Aircraft Design Process

"Airplane design is both an art and a science"

Fuselage Group

Controls Group

Hydraulics Group

Electrical Group

Power Plant Group

Loft Group

Production Engineering Group

Equipment Group

Aerodynamics Group

Stress Group
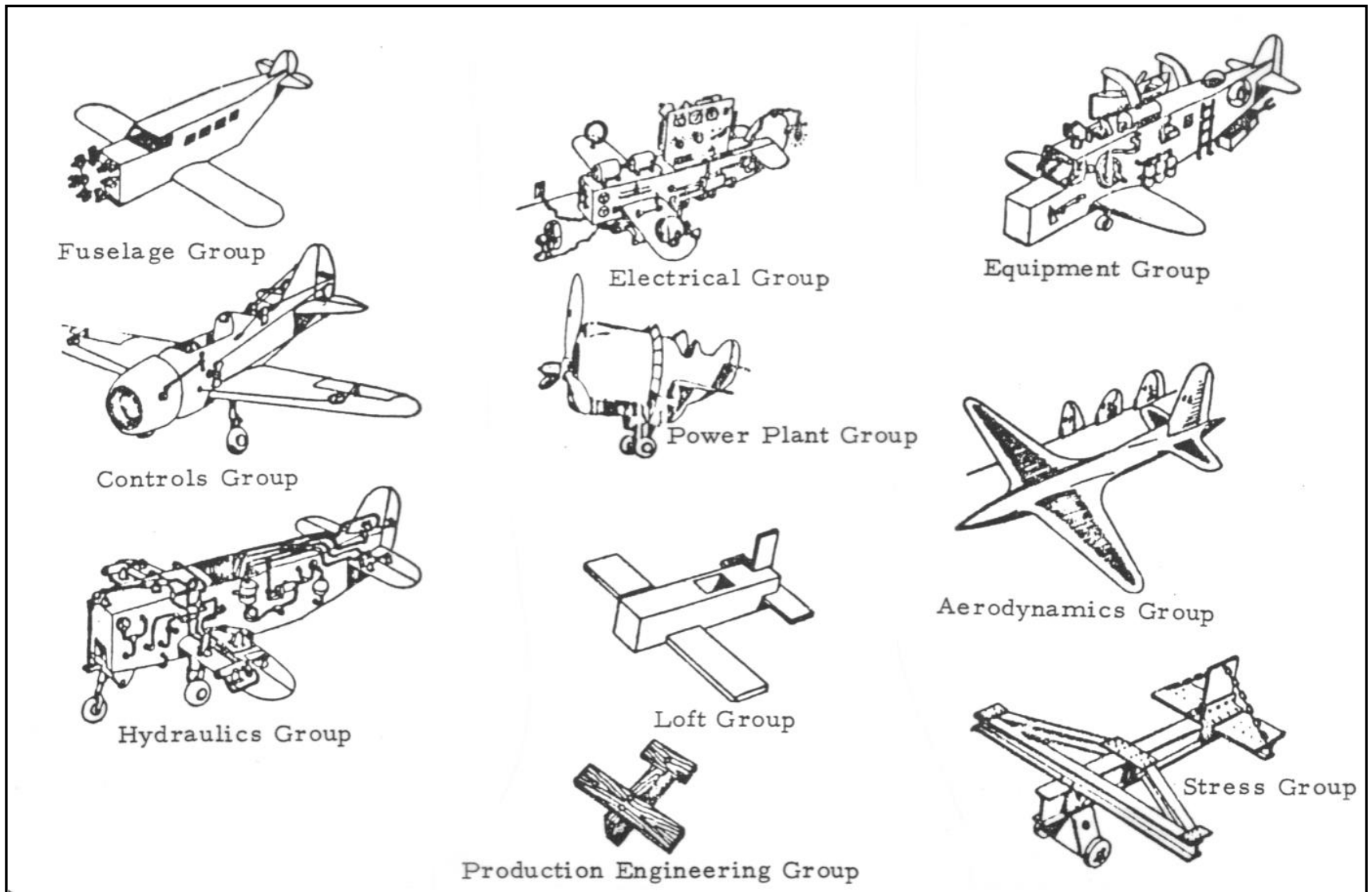
"Dream Airplanes" by C.W. Miller, as shown in *"Fundamentals of Aircraft Design"* by L.M. Nicolai

Aircraft design is a compromise

Aircraft Design Process

What kinds of airplanes are there?

What purposes are there for aircraft?

What missions do they perform?

Who uses all of these airplanes?

Why would we design a new aircraft?

Why can't we use an aircraft that's already built?

Aircraft Design Process

Year	Phase 0	Phase I	Phase II	Phase III	Phase IV
Today	Material Solution Analysis	Technology Development	Engineering & Manufacturing Development	Production & Deployment	Operations & Support
Cost	**1%**	**3%**	**6%**	**20%**	**70%**

Concept Exploration **Preliminary Design** **Detailed Design** **High Rate Production** **Operational Deployment**

Prototype & Demonstrator Aircraft

Developmental Aircraft

Production Aircraft

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Aircraft Design Process

Conceptual Design Phase

- competing concepts evaluated
- performance goals established
- preferred concept selected

Design drivers set
Does it meet req'ts?
Initial shaping

Preliminary Design Phase

- refined sizing of preferred concept
- concept analyzed
- some changes are allowed

Tradeoff studies
Wind tunnel tests

Detailed Design Phase

- final detail design
- drawings released
- only "tweaking" allowed

Certification
**Component tests**
Design flight control system

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Aircraft Design Process

The "12 Aircraft Design Activities":

1 - Customer Focus
2 - Design Synthesis
3 - Geometry Modeling
4 - Aerodynamic Analysis
5 - Propulsion Analysis
6 - Constraint Analysis
7 - Mission Analysis
8 - Weight Analysis
9 - Sizing
10 - Cost Analysis
11 - Optimization
12 - Performance Reporting

"Introduction to Aeronautics: A Design Perspective" by Brandt et al, chapter 9

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Aircraft Design Process

Fig. 2.4   Aircraft conceptual design process.

1 - Customer Focus

2 – Design Synthesis

3 – Geometry Modeling

4 – Aerodynamic Analysis
5 – Propulsion Analysis
6 – Constraint Analysis
7 – Mission Analysis
8 – Weight Analysis

9 – Sizing
10 – Cost Analysis
11 – Optimization
12 – Perf Reporting

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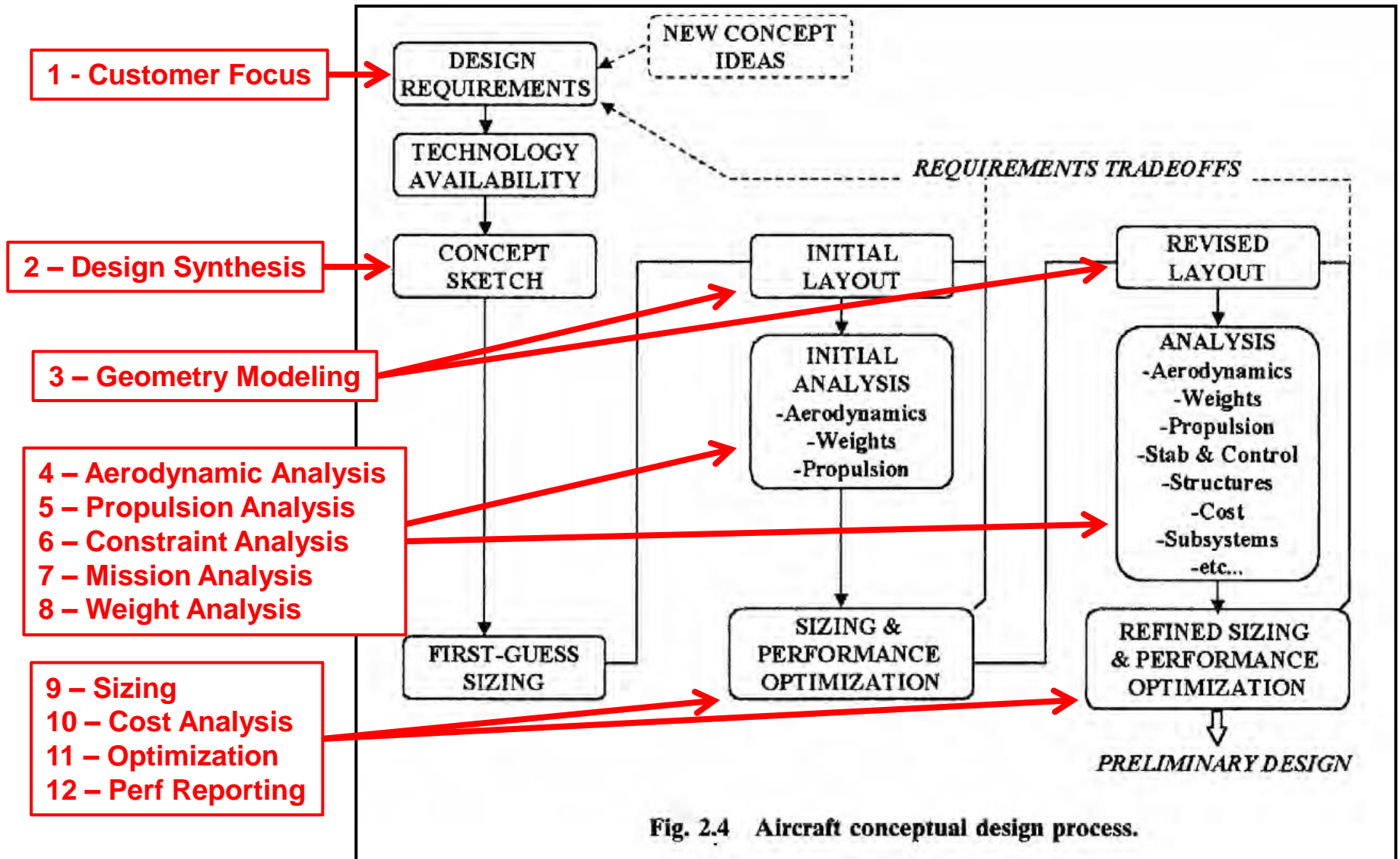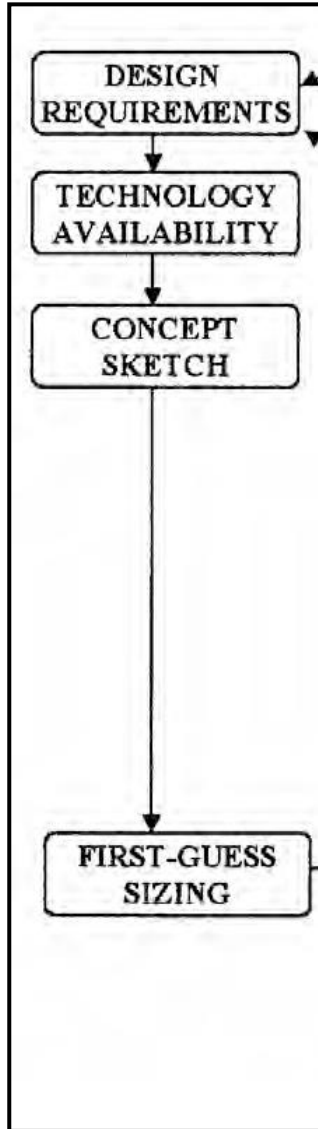
Airliner Design

What could the requirements for a new airliner be?

What would a design mission look like for this airliner?
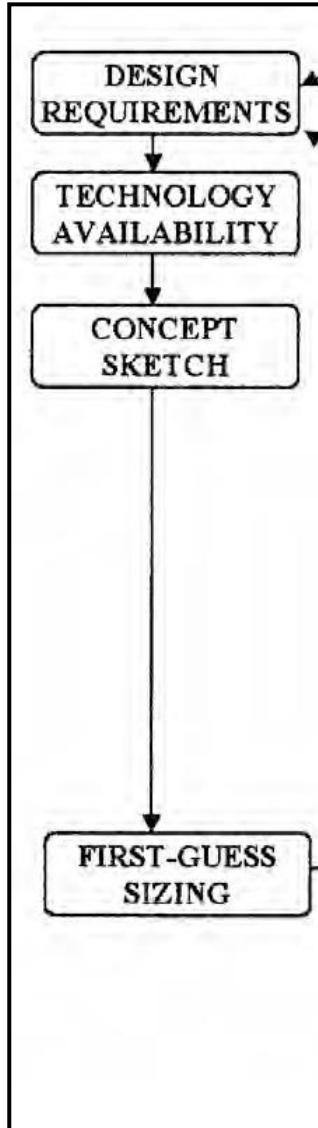
What kind of constraints are there for this airliner?

What are the design drivers for this airliner?

What new technology is available for this airliner?

Is there a substantial airliner historical database?

Airliner Design

Boeing aircraft (42)
-	**707**	**(4)**
-	**717**	**(2)**
-	**727**	**(3)**
-	**737 Original (-100 thru -200)**	**(3)**
-	**737 Classic (-300 thru -500)**	**(3)**
-	**737 Next Gen (-600 thru -900)**	**(4)**
-	**737 MAX**	**(4)**
-	**747 (-100 thru -300)**	**(3)**
-	**747 (-400, -400ER, -8I)**	**(3)**
-	**757**	**(2)**
-	**767**	**(5)**
-	**777**	**(5)**
-	**787**	**(3)**

Airbus aircraft (25)
-	**A220**	**(2)**
-	**A300**	**(2)**
-	**A310**	**(2)**
-	**A320**	**(5)**
-	**A320 NEO**	**(4)**
-	**A330 (2) & A380 (1)**	**(3)**
-	**A340**	**(4)**
-	**A350**	**(3)**

Bombardier aircraft (3)
Embraer aircraft (4)

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HW #16 & #17 – Airliner Research

#16: Use the historical airliner information provided to prepare a short synopsis paper that includes:

> Manufacturer
> Photo of the aircraft and three-view drawing
> First flight date
> Approximate # aircraft built to date and number of
> backlogged/ordered aircraft
> Approximate cost of each aircraft in the series
> Competitive aircraft
> Military variants, if any
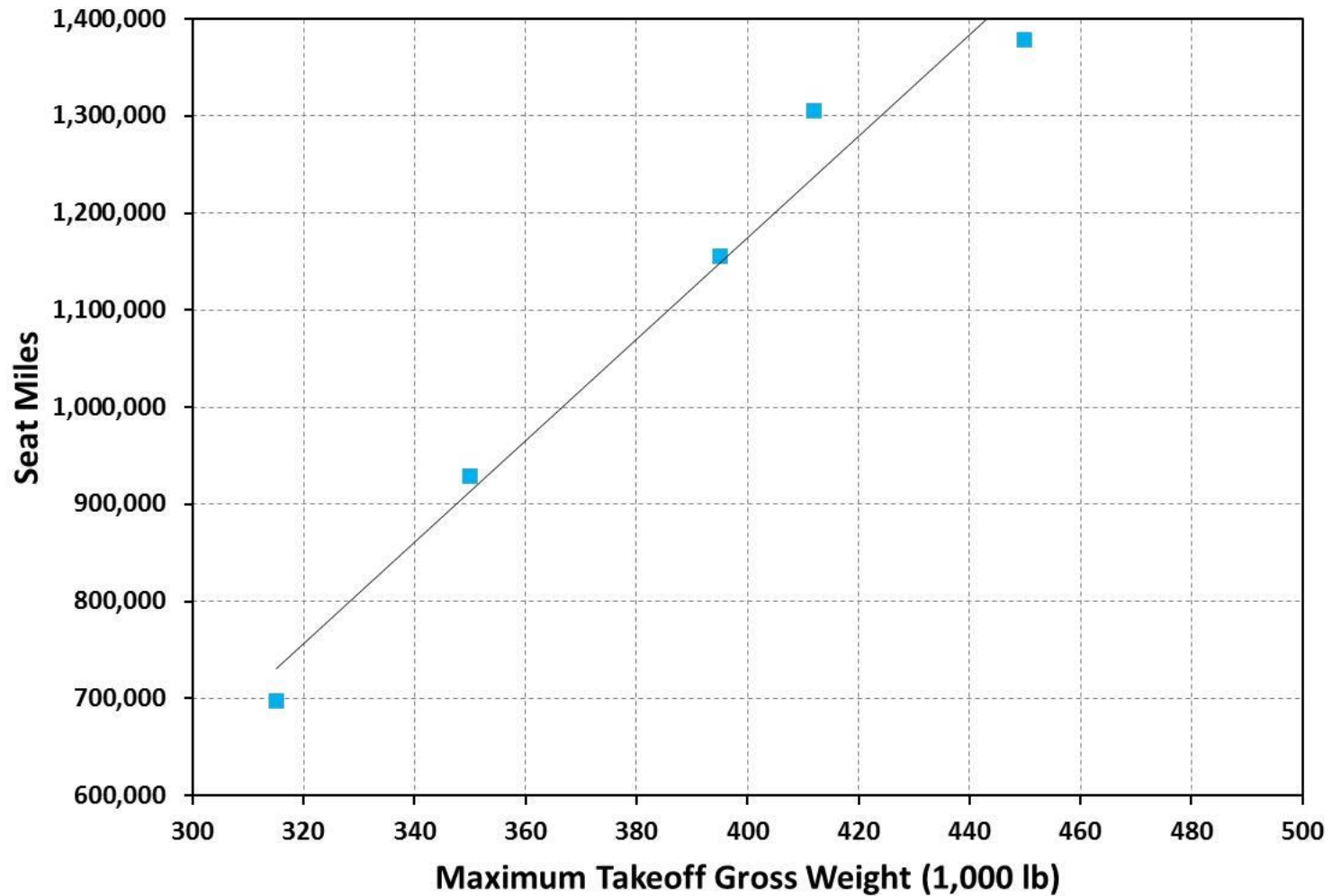> Other interesting facts or tidbits
> References

#17: Use the historical airliner information provided to prepare a three trend charts:

> Maximum Range vs Maximum Takeoff Gross Weight plot
> Typical payload vs Maximum Takeoff Gross Weight plot
> Seat Miles vs Maximum Takeoff Gross Weight plot

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Airliner Design

HW #18 – Airliner Research

#18: Use the airliner three-view drawing to measure and calculate the following parameters:

Wing Characteristics
Leading Edge Sweep Angle
Trailing Edge Sweep Angle
Quarter-Chord Sweep Angle
Tip Chord
Root Chord
Average Chord
Span
Taper Ratio
Surface Area
Aspect Ratio
MAC length
MAC location
Dihedral Angle

Aircraft Characteristics
Aircraft Height
Aircraft Length
Tail Bump Angle
Distance from nose LG to main LG

HW #18 – Airliner Research

WING CHARACTERISTICS		Units	Given Value	Measured Value	Calculated Value
Leading Edge Sweep Angle	Λ_{LE}	degrees			
Trailing Edge Sweep Angle	Λ_{TE}	degrees			
Quarter-Chord Sweep Angle	$\Lambda_{c/4}$	degrees			
Tip Chord	c_t	ft			
Root Chord	c_r	ft			
Average Chord	c	ft			
Span	b	ft			
Taper Ratio	λ	--			
Surface Area	S	ft²			
Aspect Ratio	AR	--			
MAC length	MAC	ft			
MAC location	y_{MAC}	ft			
Dihedral Angle	Γ	degrees			
AIRCRAFT CHARACTERISTICS			Given Value	Measured Value	Calculated Value
Aircraft Height		ft			
Aircraft Length	l_{fuse}	ft			
Tail Bump Angle		deg			
Distance from nose landing gear to main landing gear		ft			

Homework Assignments

HW #16, #17, & #18 – Airliner Research
(due by 11:59 pm ET on Monday)
Reading – Chapter 7

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

E-mailed to student teams:
HW #16/17/18 assignments with instructions, tips, and checklists; airliner data; airliner 3-view

Posted on Canvas:
HW #18 Template for data table in Excel
WING.XLS (to check your measurements)

Questions?