EML4551-2

Design Review 4

Team 507 - SAE Aero Design – Aero and Propulsion Team

Team Introductions

Sasindu Pinto:
Project /Aeronautics/Propulsion Engineer

Noah Wright:
Aerodynamics Engineer

Michenell Louis-Charles:
Thermal Fluids Engineer/Financial Chair

Cameron Riley:
Materials/Hardware Engineer

Adrian Moya:
Systems/Hardware Engineer

Sponsor and Advisors

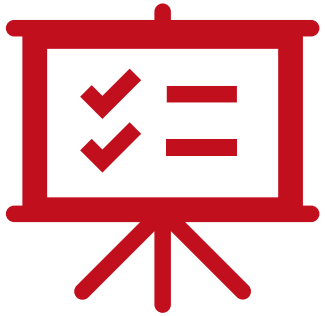
Florida Space Grant Consortium:
Funding Sponsor

Seminole RC Club:
Equipment/Personnel Sponsor

Dr. Chiang Shih:
Professor & AME Center Director Advisor

Presenter: AM

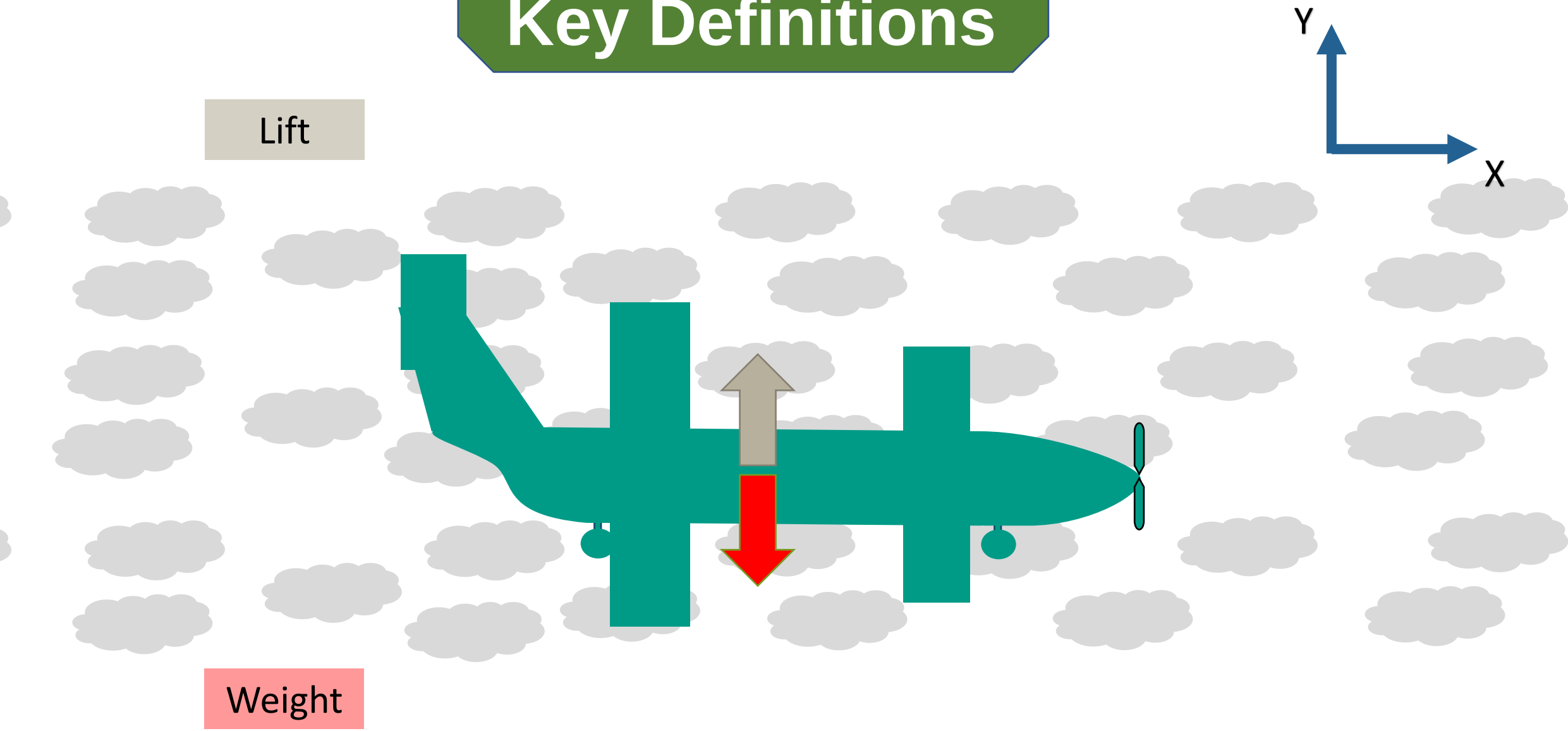
Team Objective



The objective of the aero-propulsion team is to ensure that the plane takes off and lands while carrying a payload while completing the flight path.

Presenter: AM

Key Definitions



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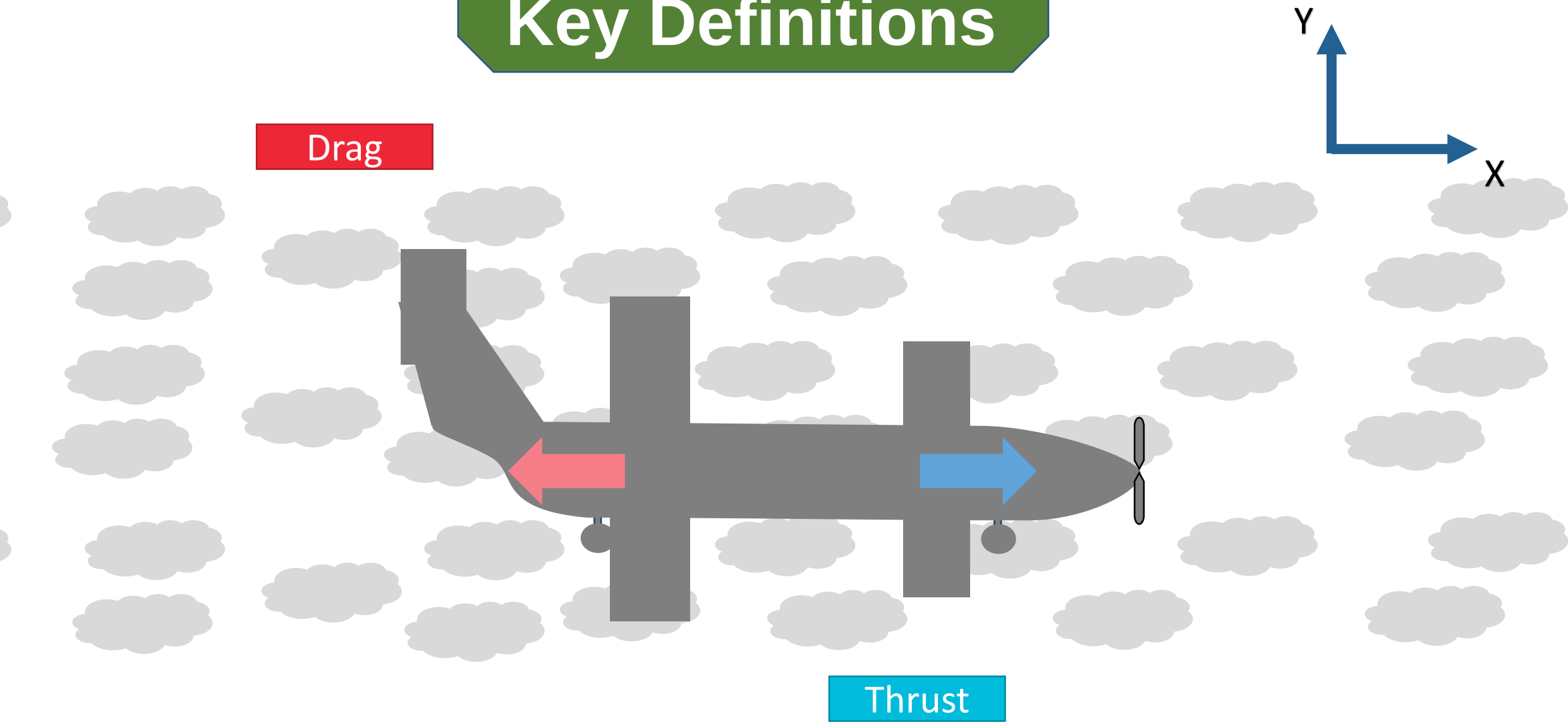
Key Definitions



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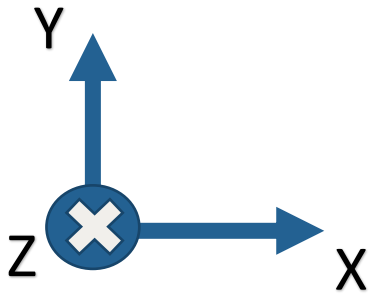
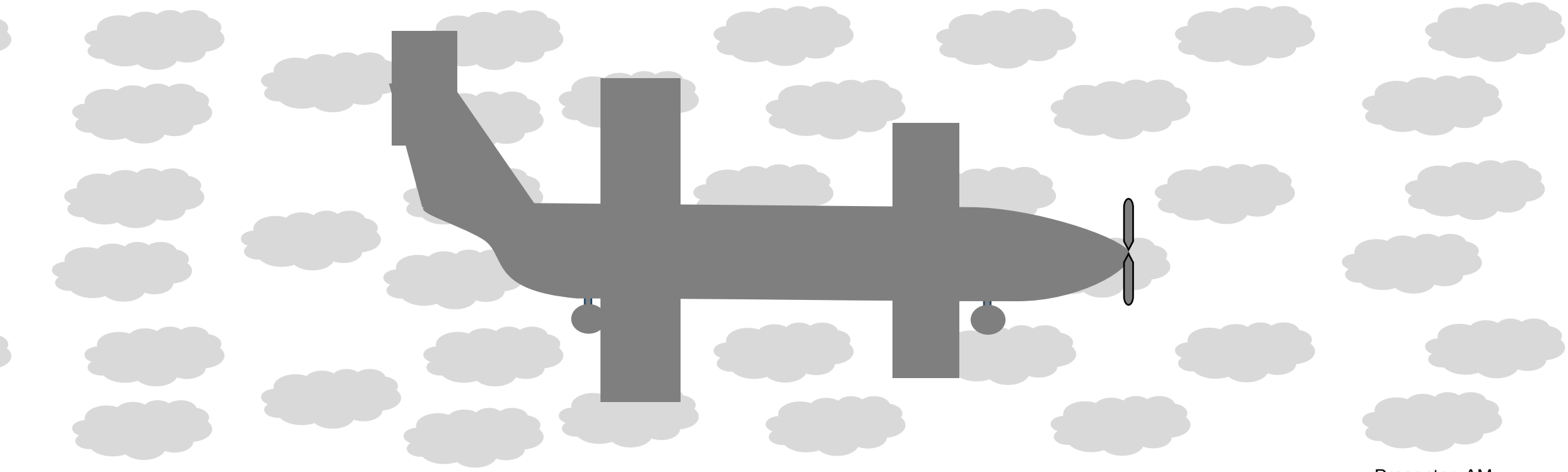
Key Definitions



Pitch



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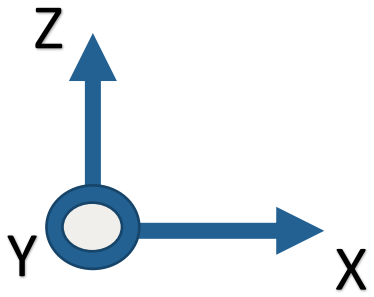
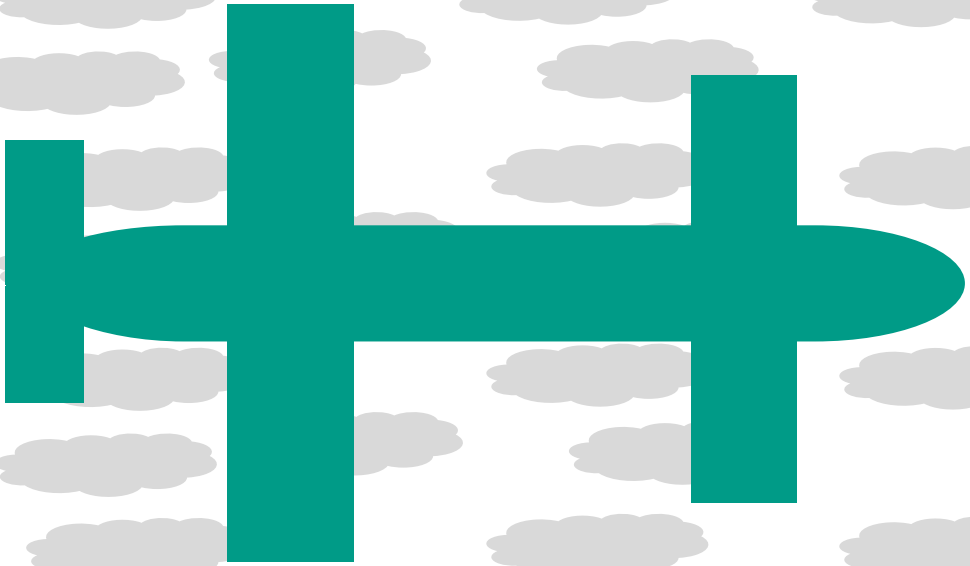
Key Definitions

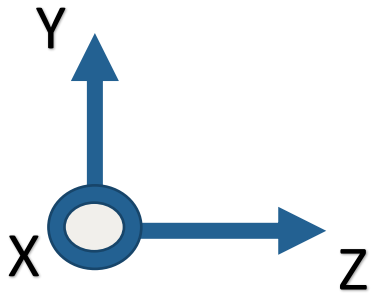


Yaw

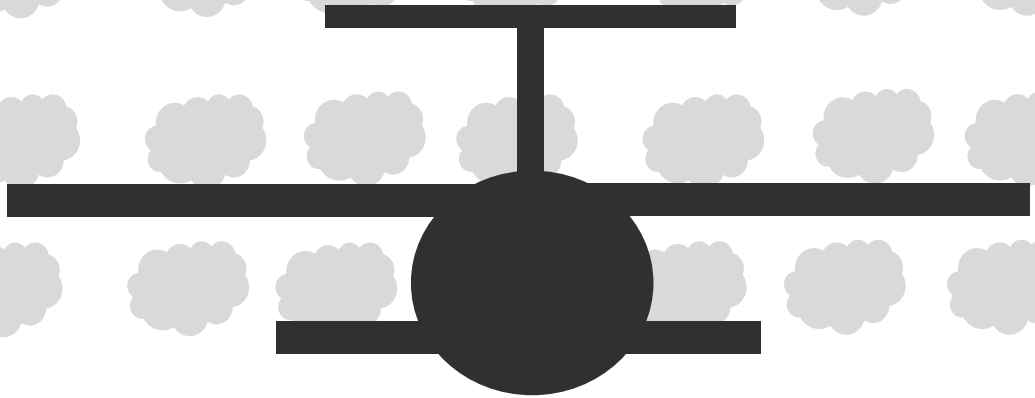


Presenter: AM

Key Definitions



Roll



Presenter: AM

Fall Semester Review

Presenter – Adrian Moya

Project Background

- Plane designed to be entered in SAE Aero Design Competition East
  - Only participating in the Design Knowledge Part due to financial constraints and heath risks
- Certain elements from last year's design will be used

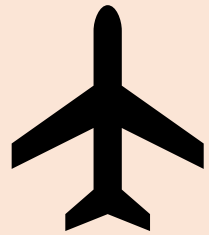
Presenter: AM

Key Goals

- The plane takeoff, cruise, and land while carrying a cargo load
- The plane carries a minimum of one soccer ball as the cargo load

Assumptions

- Will be flown in atmospheric conditions at sea level
- Motors and electronics will be store bought and not custom-made



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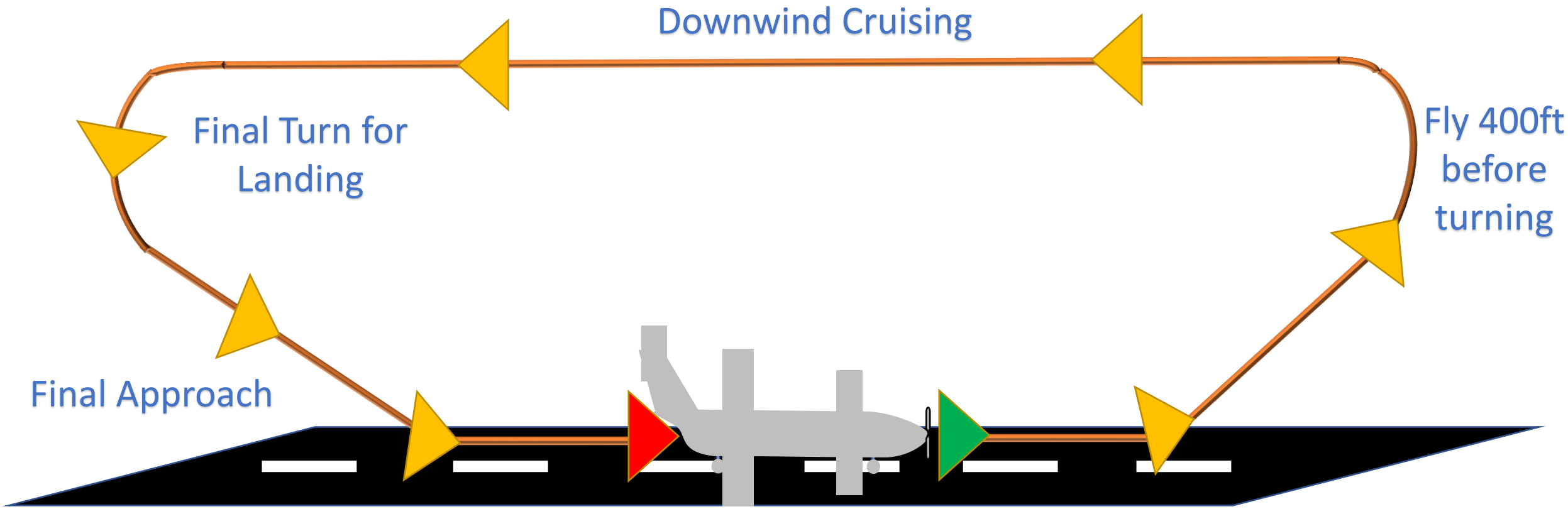
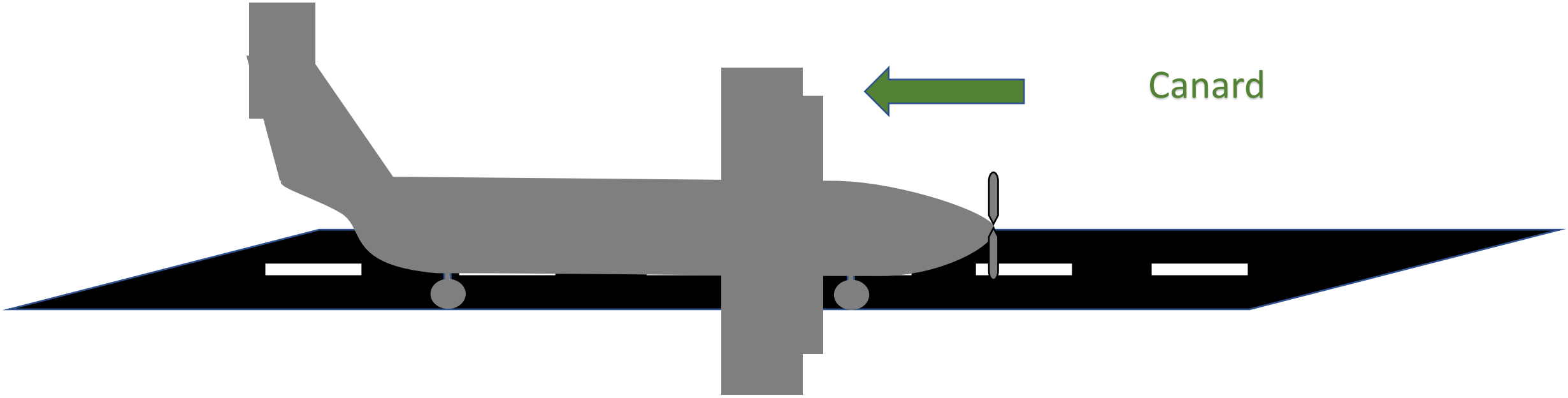
Customer Needs



Presenter: AM

Customer Needs

A signature
Innovation



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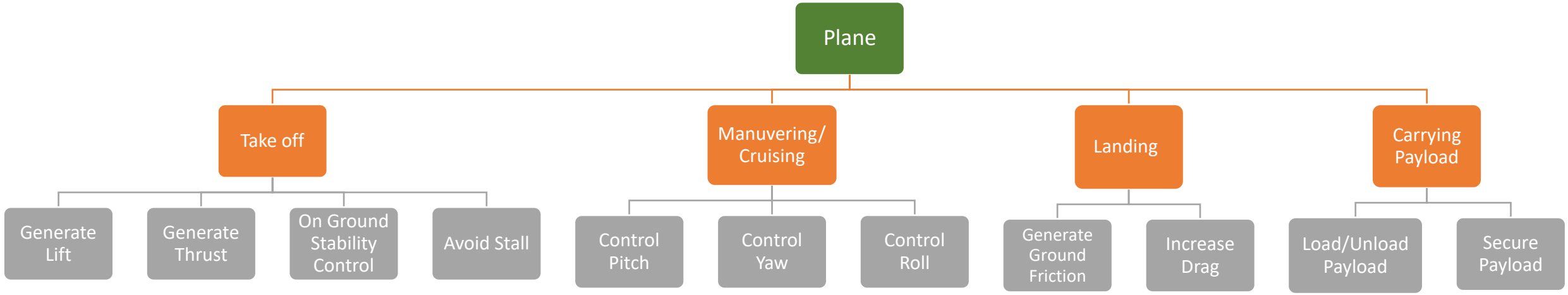
Functional Decomposition



Presenter: AM

Targets and Metrics

- Generate Lift
  - Coefficient of Lift ~ Greater than 1
- Max Angle of Attack (AoA)
  - For a canard design, AoA< angle between Mean Aerodynamic Centers of the wing
- Weight
  - Less than 55 lbs

Presenter: AM

Concept Generation

- Methods used
  - Morphological Analysis
  - Biomimicry
  - Competitive Benchmarking
  - Crapshoot

Presenter: AM

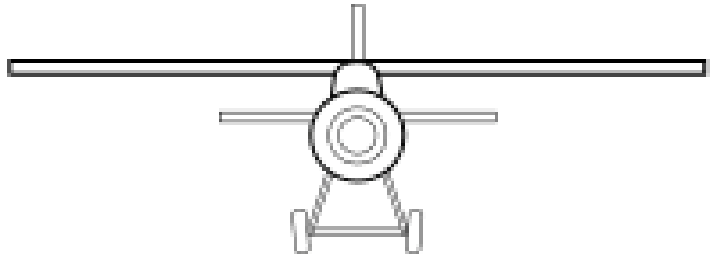
Design concepts

Rectangular

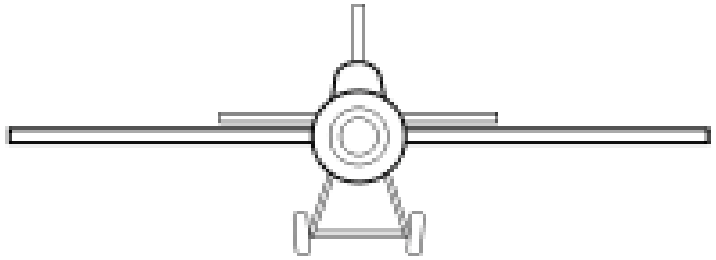
Rectangular Tapered

Rectangular
Elliptical

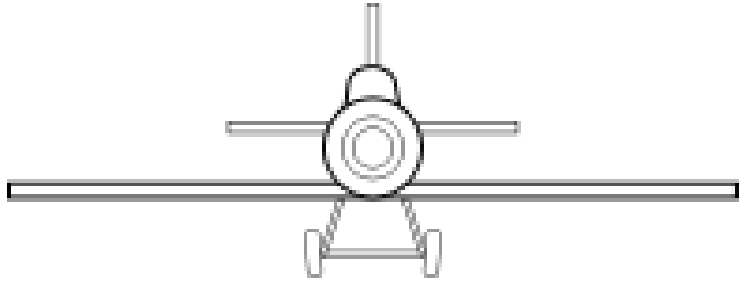
Elliptical



High-Wing



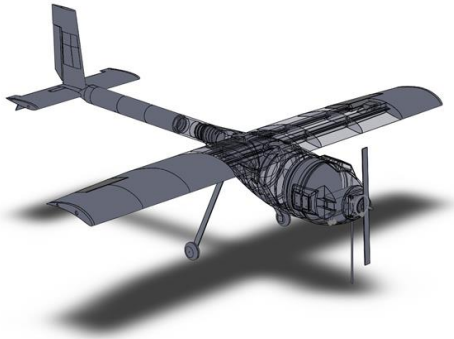
Mid-Wing



Low-Wing

Medium and High Fidelity Concepts

1. Boomtown



2. Rutan Long EZ

3. Rutan Quickie Q2

4. Boeing 747 Dreamlifter

5. Cessna 208 Grand Caravan

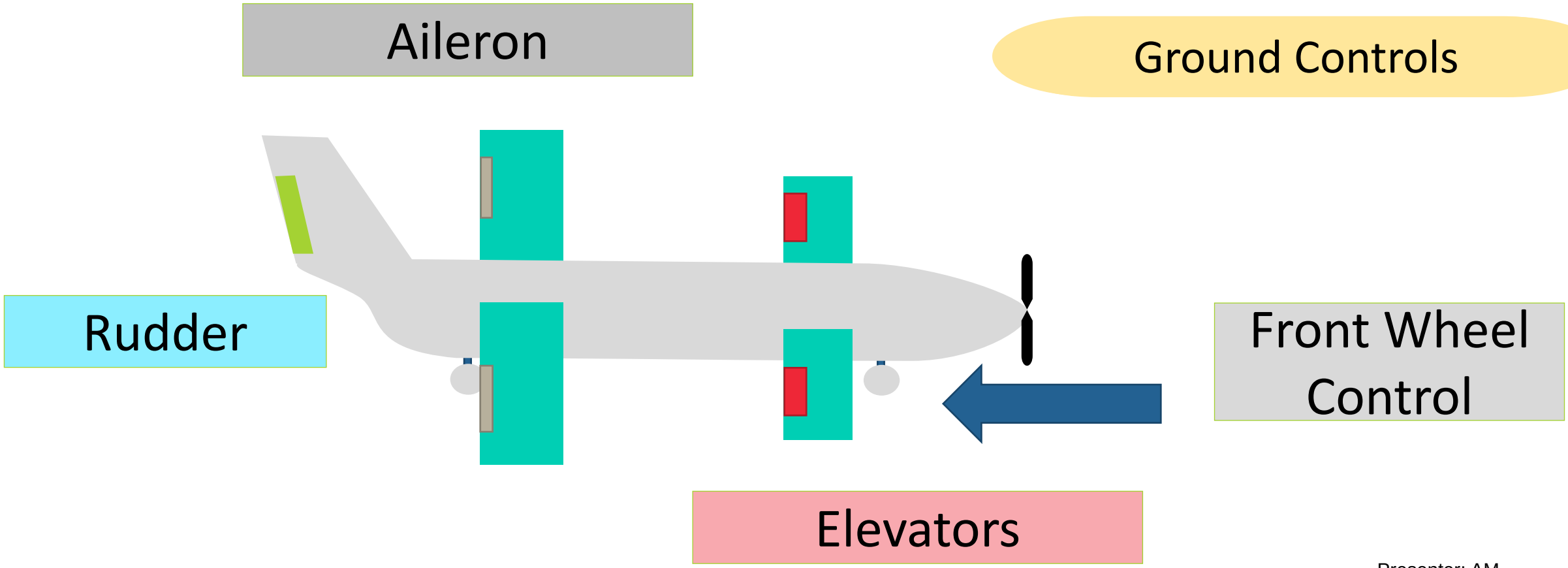
6. OMAC Laser 300

7. Aero Spacelines Super Guppy

8. Kawasaki C-2

Presenter: AM

Customer Needs Considered



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Engineering Characteristics

- Lift
- Drag
- Thrust
- Max Angle of Attack
- Stall Speed
- Acceleration
- Control Surface Movement
- Deceleration
- Weight
- Loading/Unloading Time
- Joint Strength
- Material Strength

Presenter: AM

Concept Selection - House of Quality

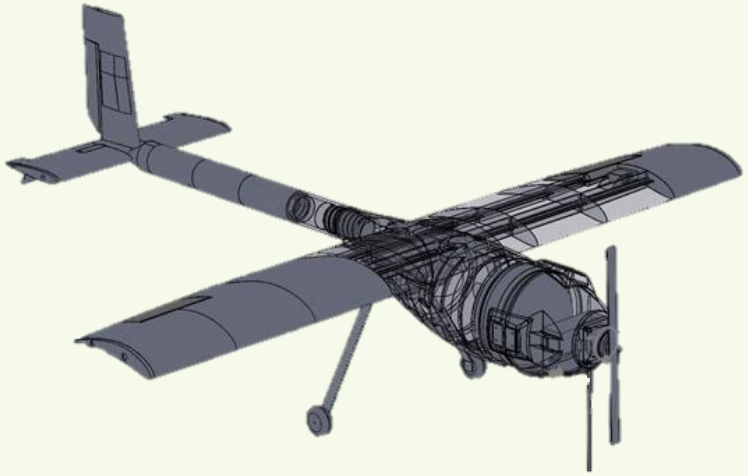
House of Quality													
		Engineering Characteristics (***From Main Targets***)											
Improvement Direction		↑	↓	↑	↑	↑	↑	↑	↓	↓	↑	↑	=
Units		lbf	lbf	lbf	degrees	ft/s	ft/s^2	degrees	seconds	lbs	ft/s^2	psi	psi
Customer Requirements	Importance Weight Factor	Lift	Drag	Thrust	Max Angle of Attack	Stall Speed	Acceleration	Control Surface Movement	Loading/ Unloading Time	Weight	Deceleration	Joint Strength	Material Strength
1. Material	1		1							9		9	9
2. Stability	6	9	3	3				9					
3. CG in front of CP	10	9	3	9	9	9		9		3			
4. Meet takeoff/landing requirements	7	9	3	9			9				9		
5. Wingspan meets restrictions	7	9	3		3	3		1				3	3
6. Sufficient Power	5	1	1	3			3	3		1	1		
7. Maneuverability	4				3	3		9		3		3	1
8. Light Weight	6	3		3			3			9	3		
9. Touch-down Impact	2							3		3	9	9	9
10. Ground Controls	7							1					
11. Carry the Minimum Cargo Load Required	8	9		3			3		9	9	3	9	9
12. Easy to Load/Unload	1								9	3		3	
Raw Score		365	96	228	123	123	120	215	81	191	128	135	124
Relative Weight %		18.92	4.98	11.82	6.38	6.38	6.22	11.15	4.20	9.90	6.64	7.00	6.43
Rank Order		1	11	2	6	6	10	3	12	4	8	5	9

Presenter: AM

Pugh Chart 2

Pugh Chart 2		Concepts		
		High		Medium
Selection Criteria	Concept 2	1	3	6
Lift	Datum	-	+	-
Thrust		S	S	S
Control Surface Movement		+	+	+
Weight		-	-	-
Joint Strength		S	S	S
# of pluses		1	2	1
# of S's		2	2	2
# of Minuses		2	1	2

Presenter: AM



1. Boomtown

Concepts Considered for AHP

3. Rutan Quickie Q2

6. OMAC Laser 300

Presenter: AM

Criteria Comparison Matrix - AHP

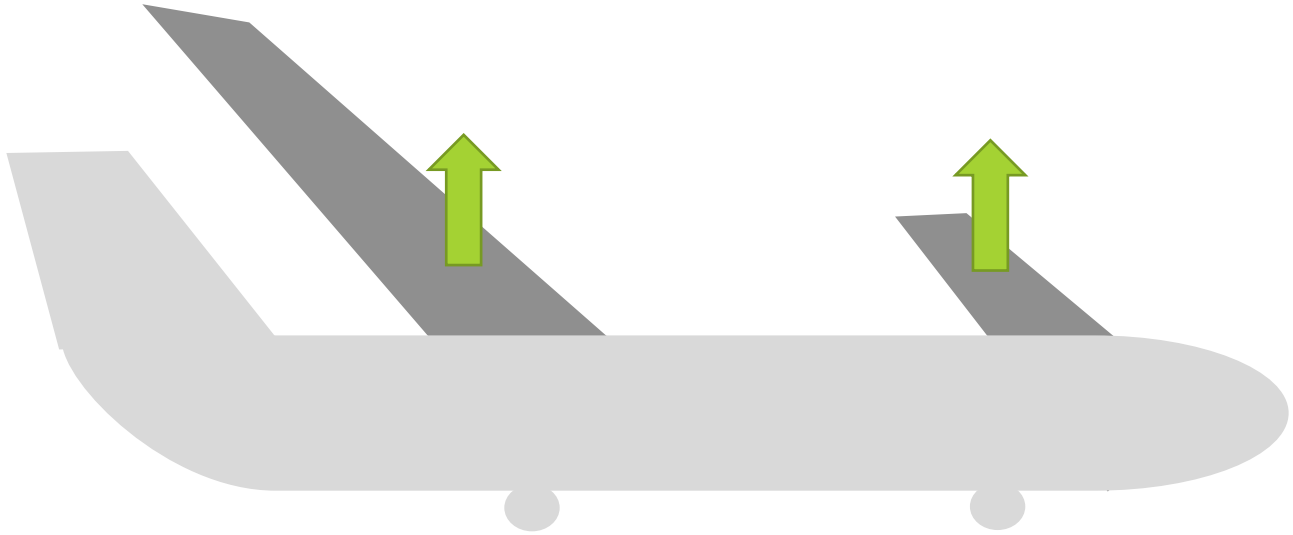
Development of a Candidate set of Criteria Weights {W}					
Criteria Comparison Matrix					
	Lift	Thrust	Control Surface Movement	Weight	Joint Strength
Lift	1.00	0.33	3.00	9.00	9.00
Thrust	3.00	1.00	3.00	9.00	9.00
Control Surface Movement	0.33	0.33	1.00	5.00	3.00
Weight	0.11	0.11	0.20	1.00	0.11
Joint Strength	0.11	0.11	0.33	9.00	1.00
Sum	4.56	1.89	7.53	33.00	22.11

λ Average Consistency	CI Consistency Index	CR Consistency Ratio
6.053	0.027	0.051

CR<0.1

Presenter: AM

Lift Comparison for Concepts - AHP



Canard + Main Wing

Lift

Concept 3 > Concept 6 > Concept 1

Concept 3: Rutan Quickie Q2

Concept 6: OMAC 300 Laser Plane

Concept 1: Boomtown

Presenter: AM

Final Rating & Alternative Values - AHP

Final Rating Matrix			
Selection Criteria	Concept 1	Concept 2	Concept 6
Lift	0.243	0.669	0.088
Thrust	0.333	0.333	0.333
Control Surface Movement	0.236	0.110	0.654
Weight	0.260	0.633	0.106
Joint Strength	0.333	0.333	0.333

Concept	Alternative Value
Concept 1	0.292
Concept 3	0.411
Concept 6	0.297

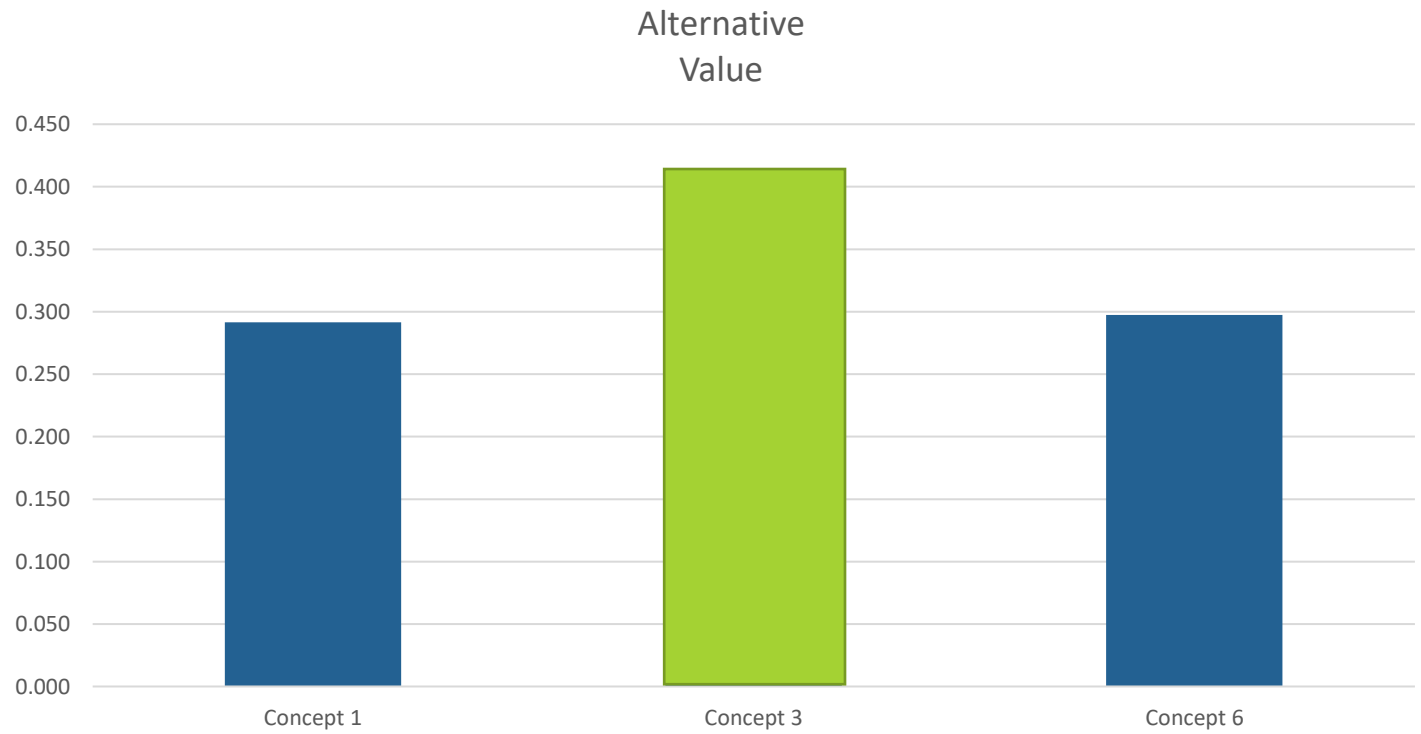
1

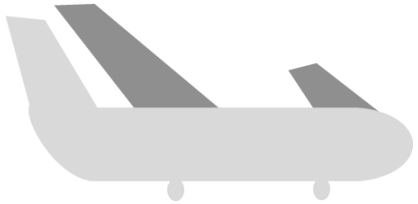
3

6

Presenter: AM

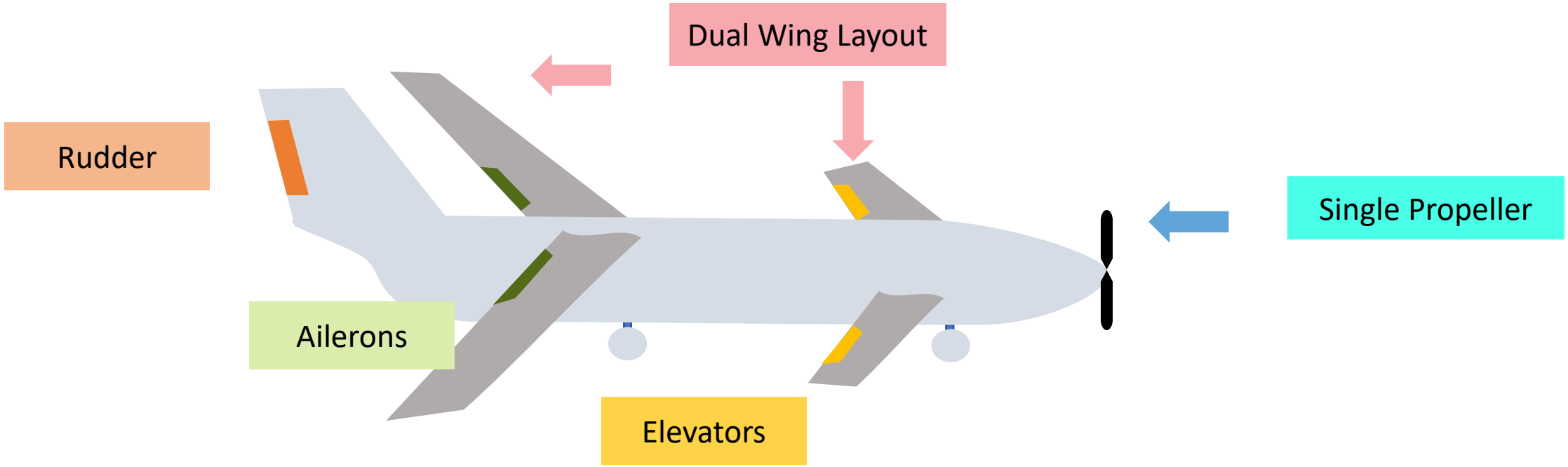
Concept Comparison- AHP





Presenter: AM

Chosen Design



Concept 3: Rutan Quickie Q2

Presenter: AM

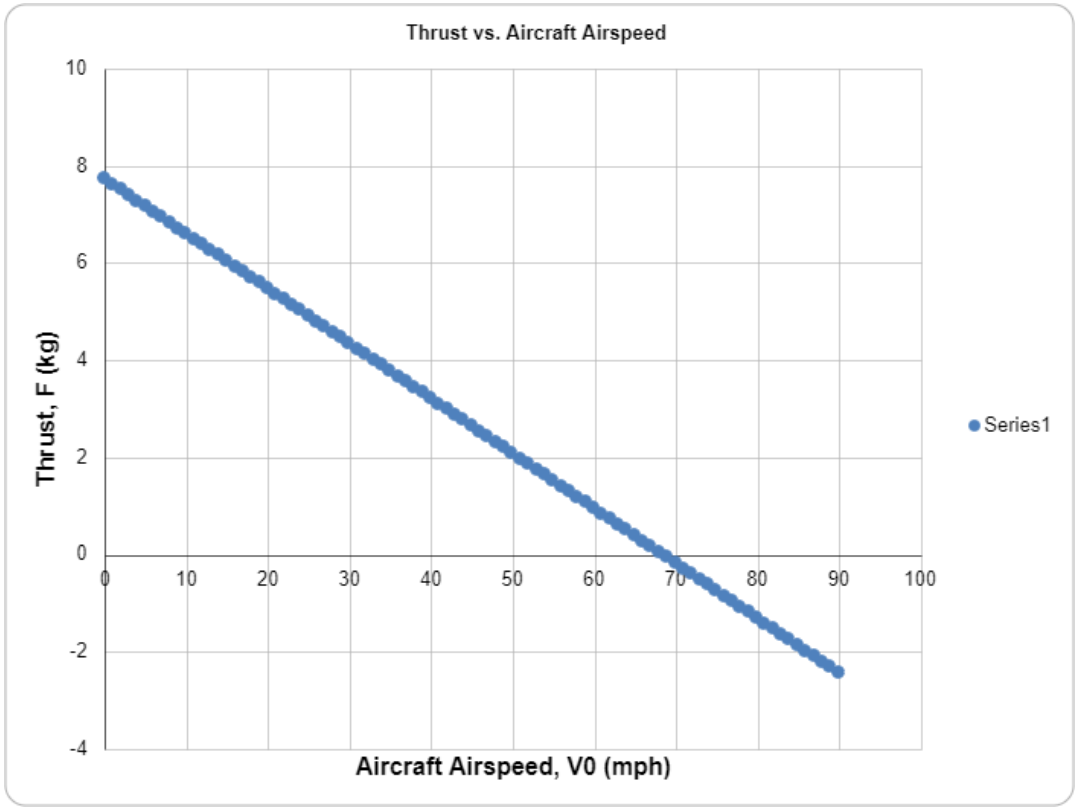
Thrust Test and Landing Gear Configuration

Sasindu Pinto

Thrust – Calculations

Calculations

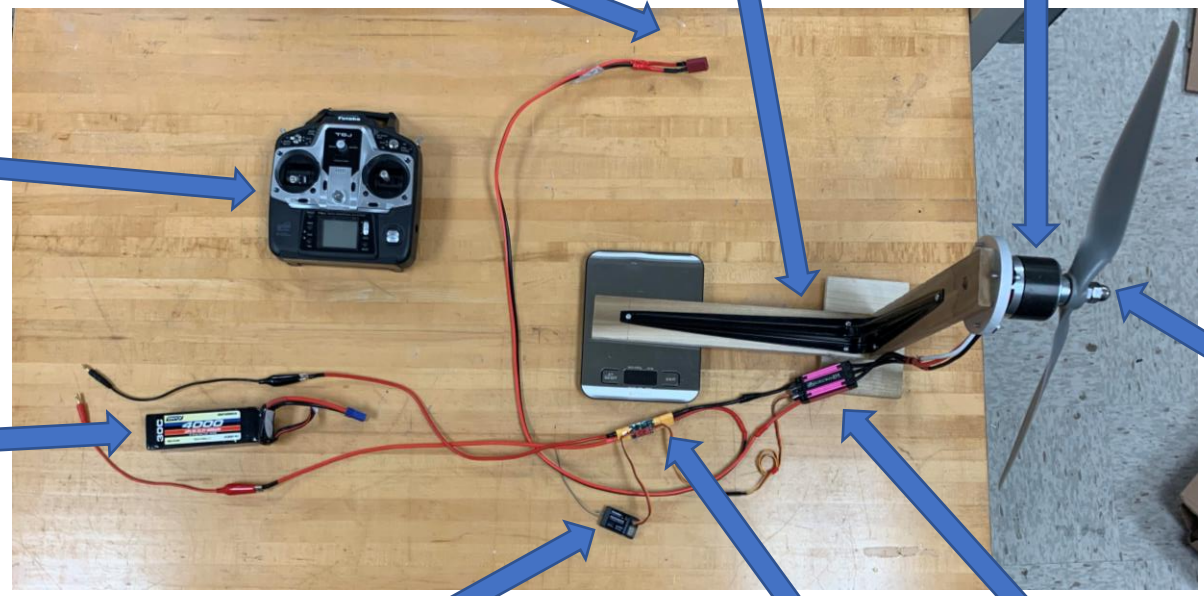
- Static Thrust Calculated ~ 167 lbf
  - Calculated thrust usually 15-30% less than actual static thrust
- Calculated dynamic thrust shown in the graph to the right



Presenter: SP

Thrust – Experimental Test

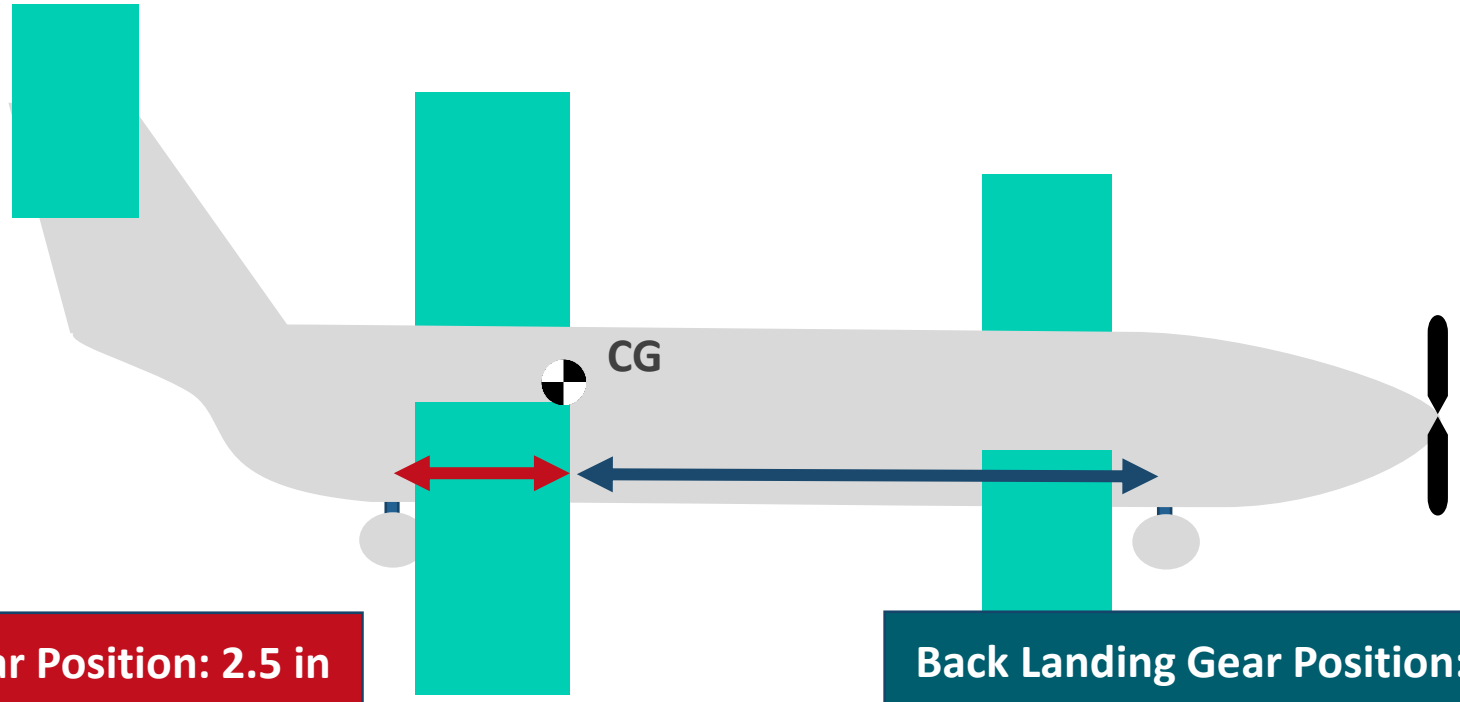
Thrust Test Setup



Experimental Thrust ~ 222 lbf

Presenter: SP

Landing Gear Positioning

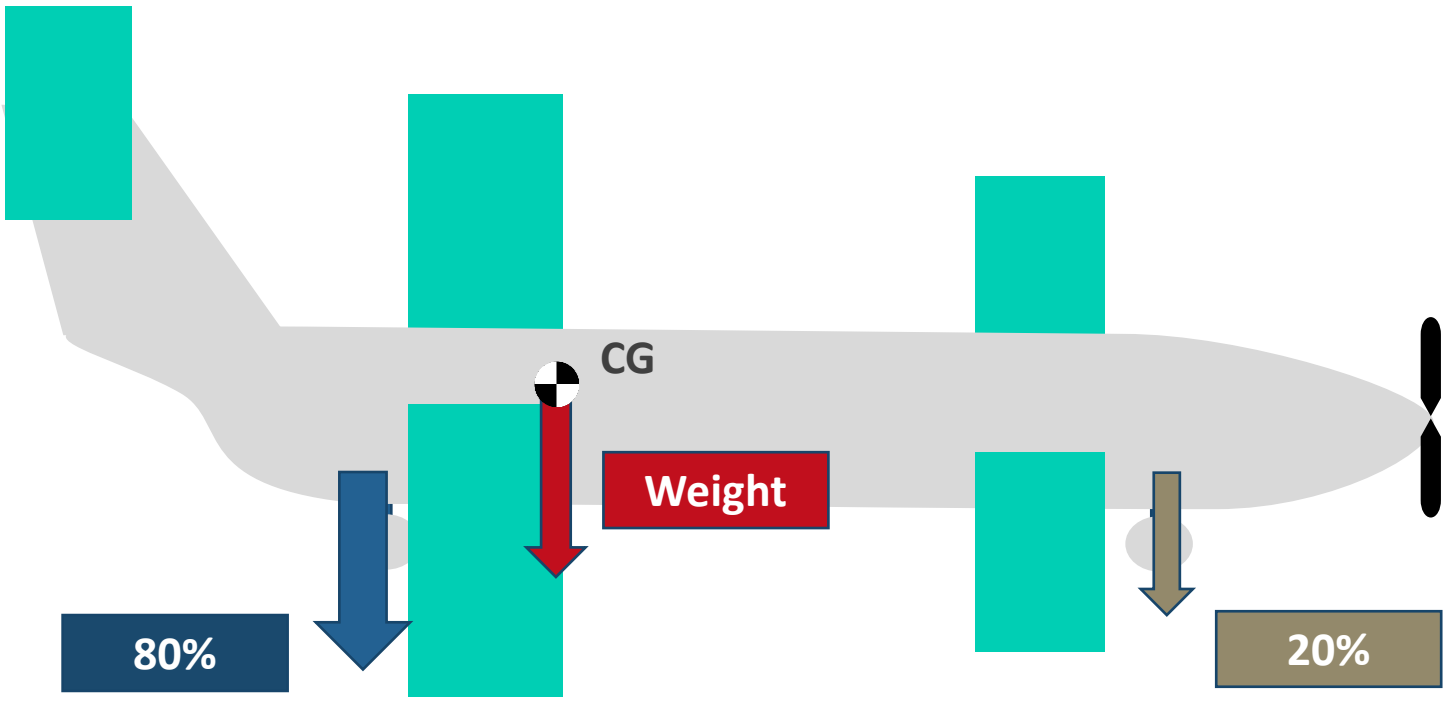


Back Landing Gear Position: 2.5 in

Back Landing Gear Position: 2.5 in

Presenter: SP

Weight Distribution

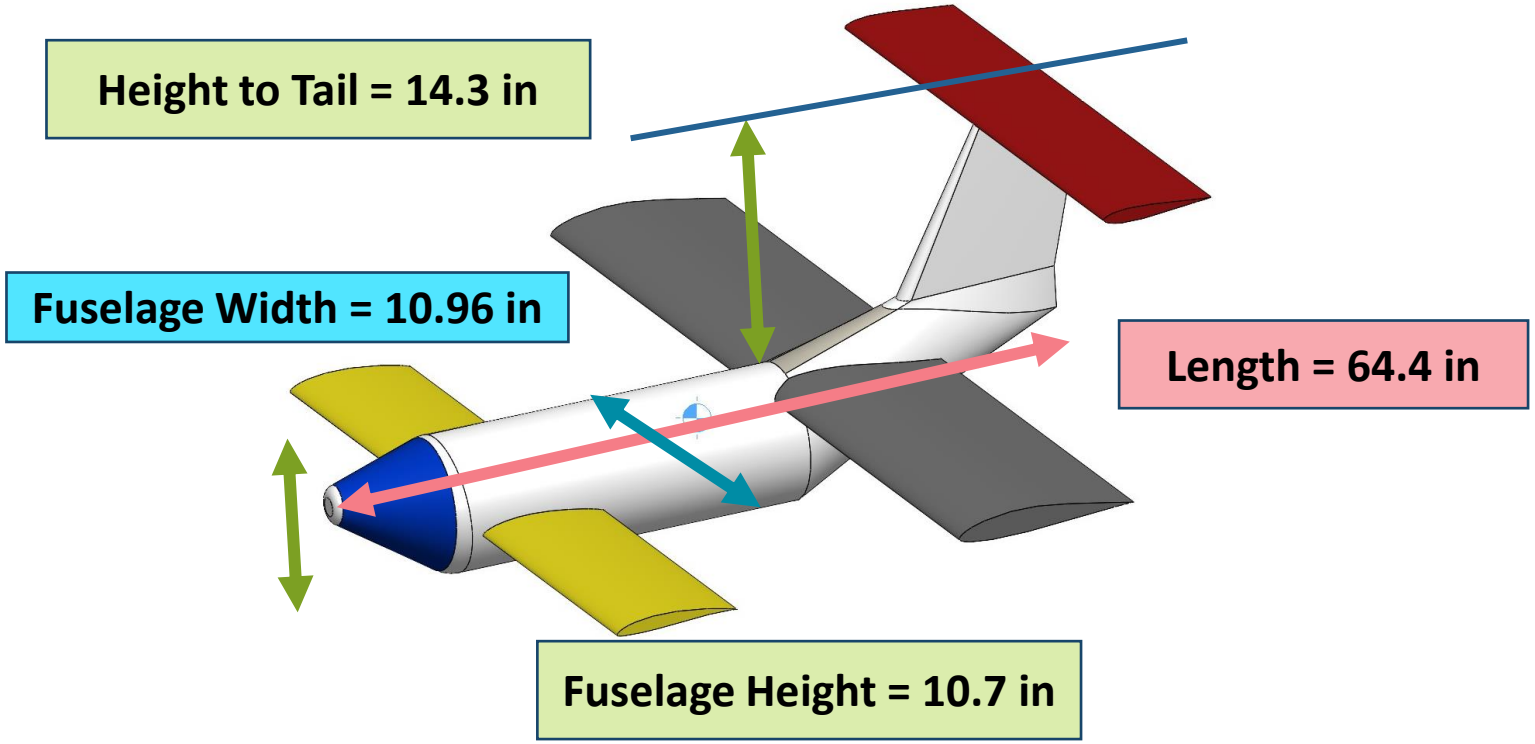


Presenter: SP

Dimensions, Initial CAD Design & CFD

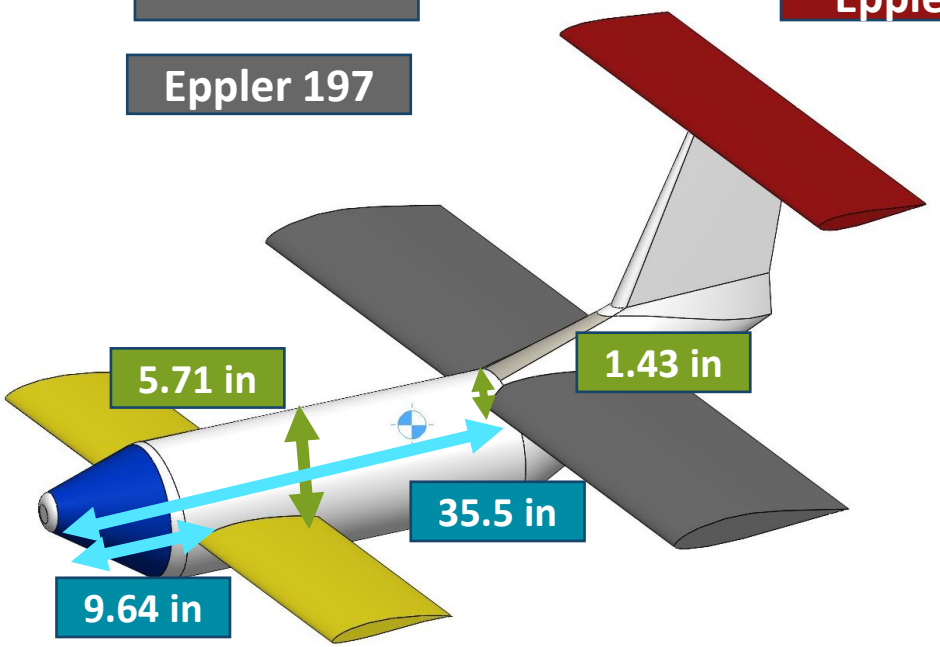
Presenter – Adrian Moya

Dimensions – Plane



Presenter: AM

Dimensions – Wing Placement

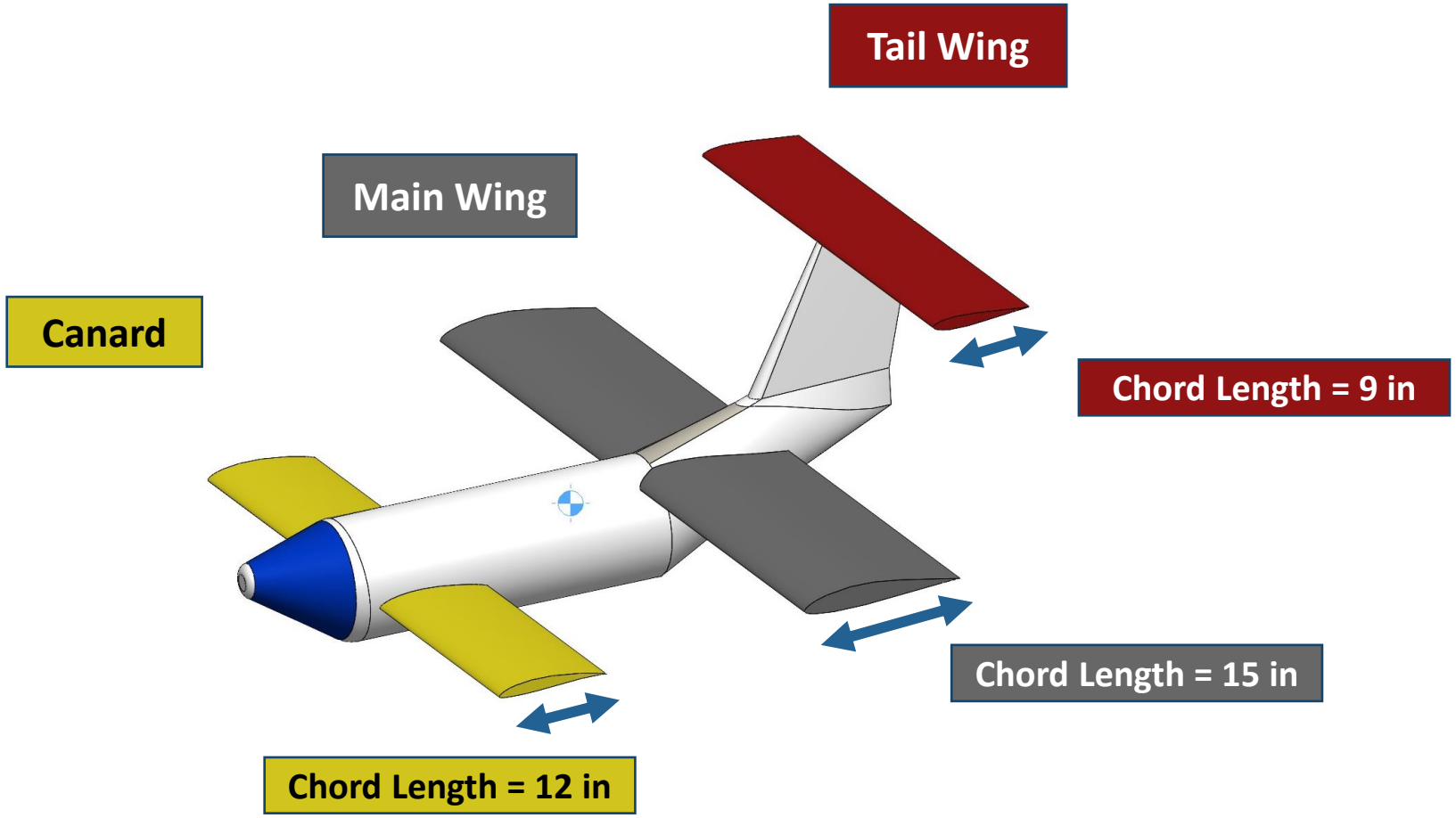


Distance from the Leading Edge of the Plane to Leading Edge of the Wing

Distance from the Top of the Fuselage to chord line

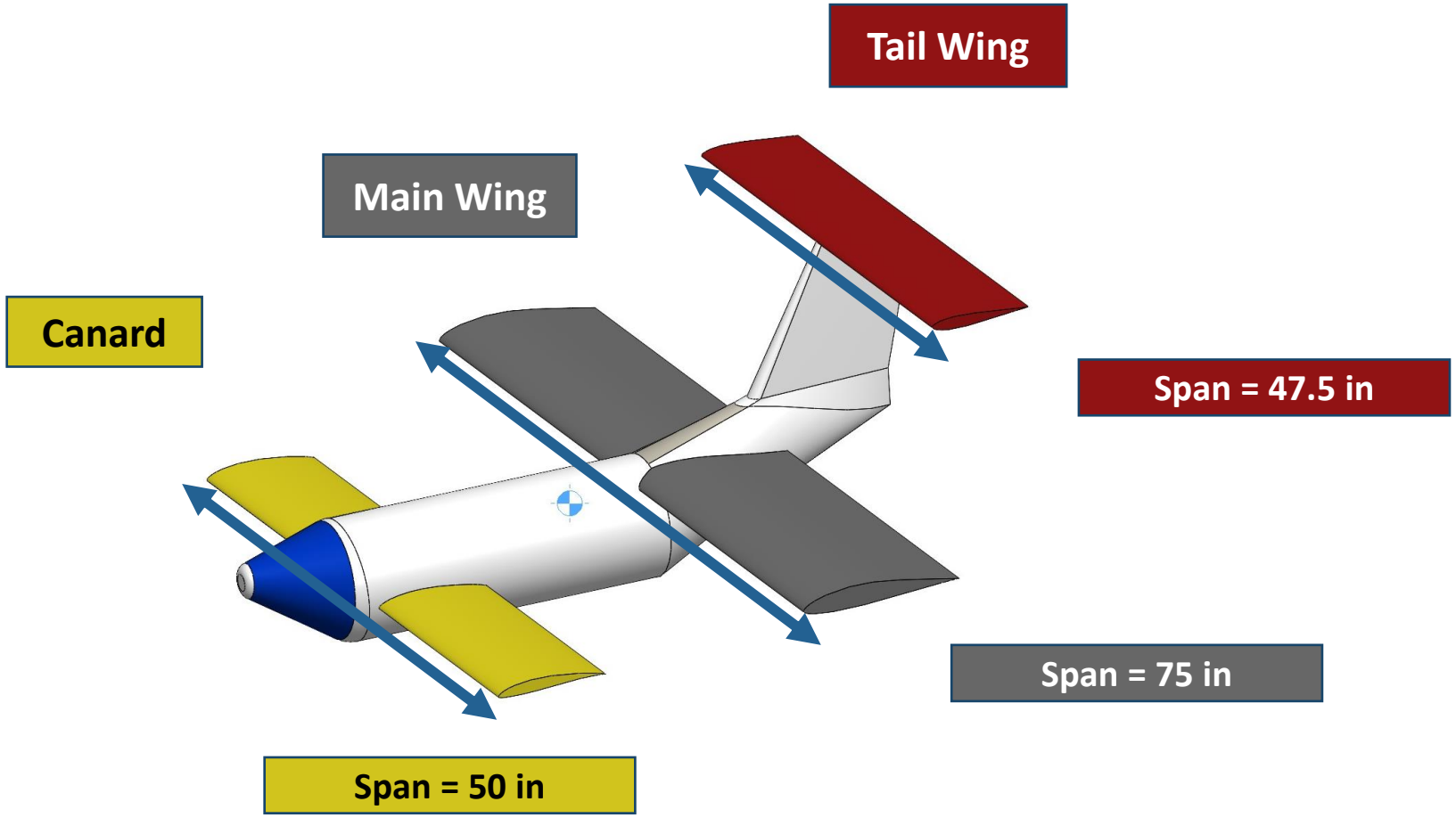
Presenter: AM

Dimensions – Wings



Presenter: AM

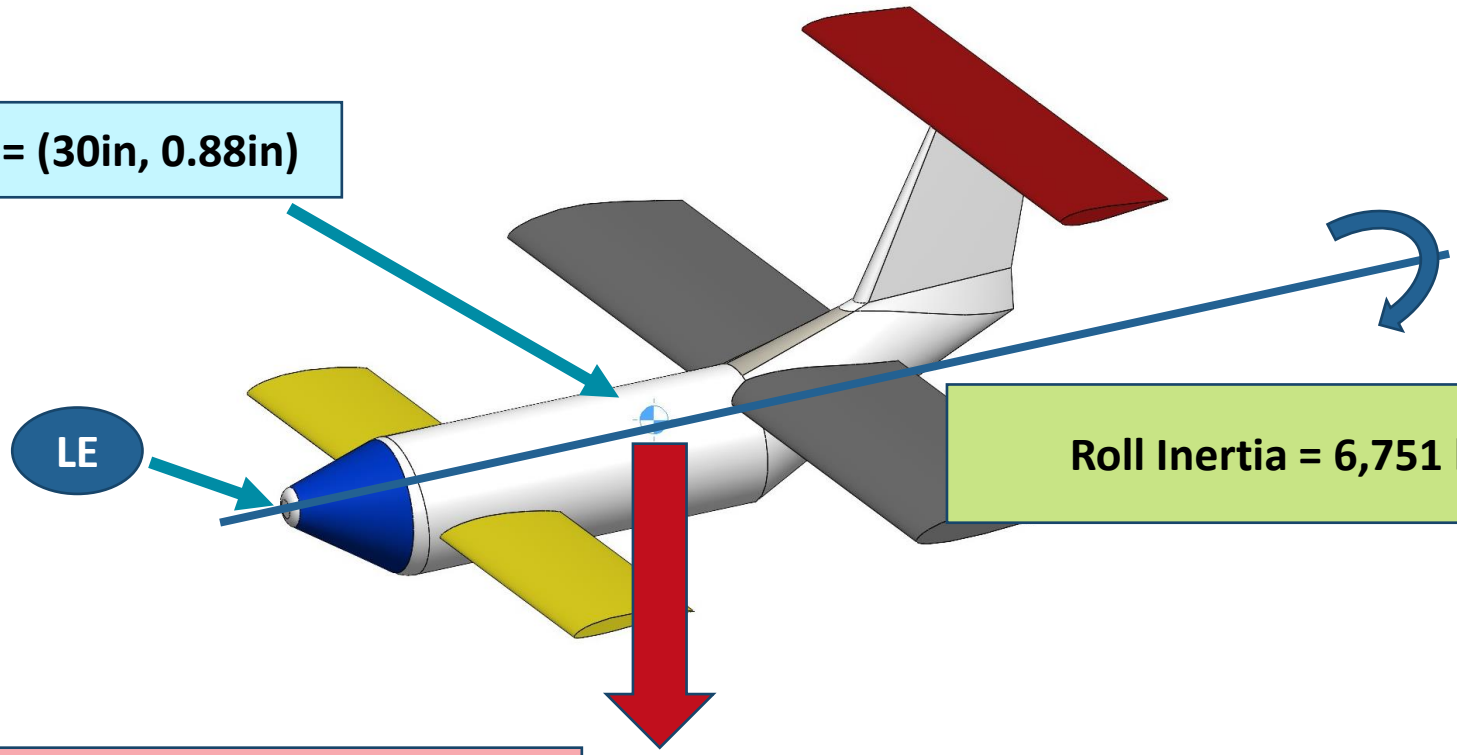
Dimensions – Wings



Presenter: AM

Initial CFD – Shell Properties

CG from Leading Edge (LE) (x,y) = (30in, 0.88in)

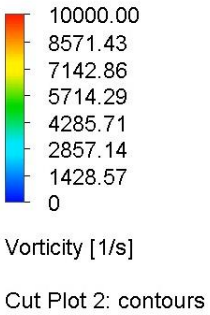


Roll Inertia = 6,751 lbm*in^2

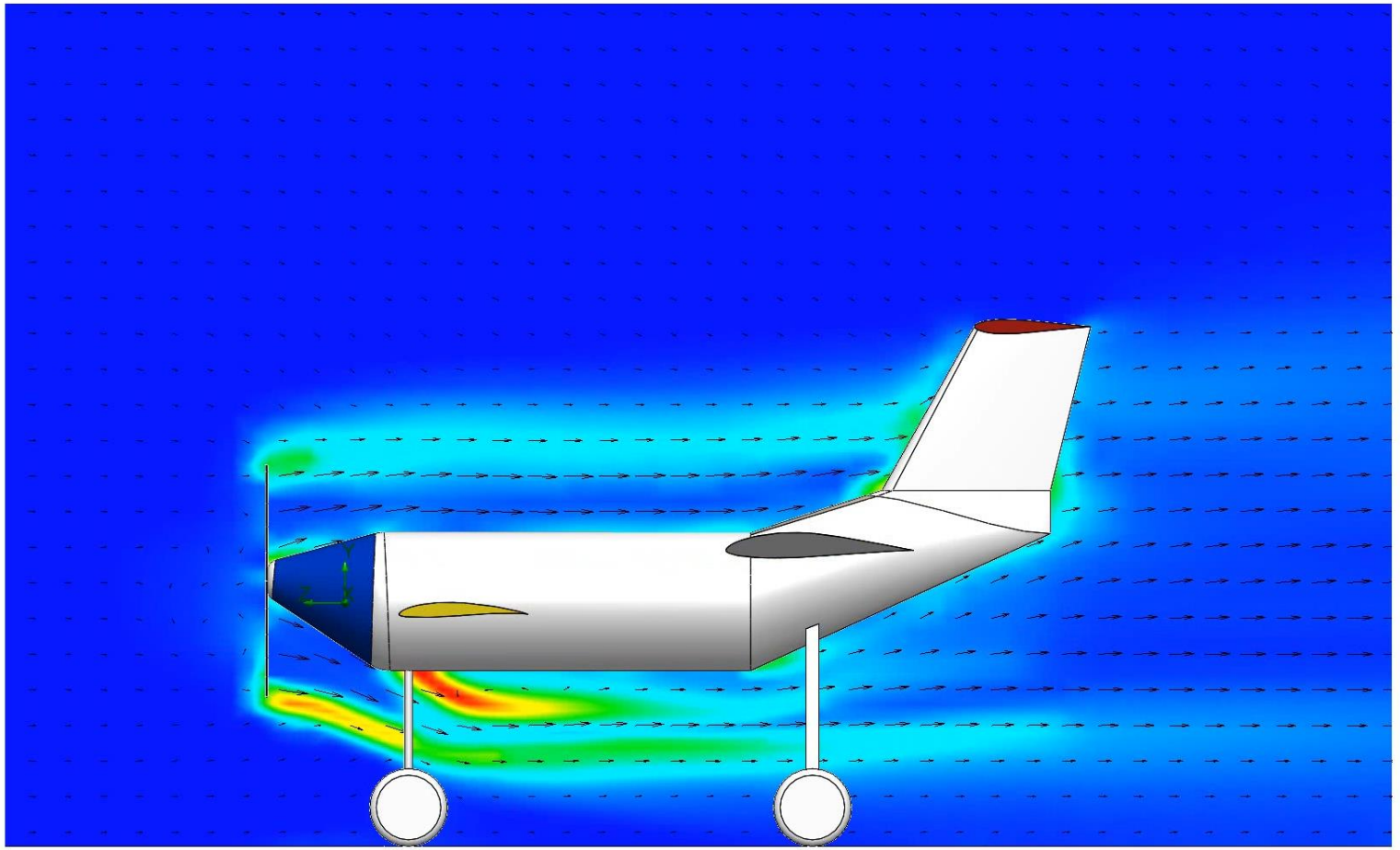
Mass = 18.14 lbm

Presenter: AM

Initial CFD – With Propeller & Landing Gear

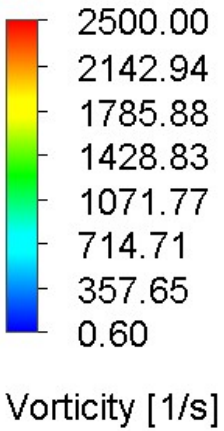


Vorticies below the fuselage

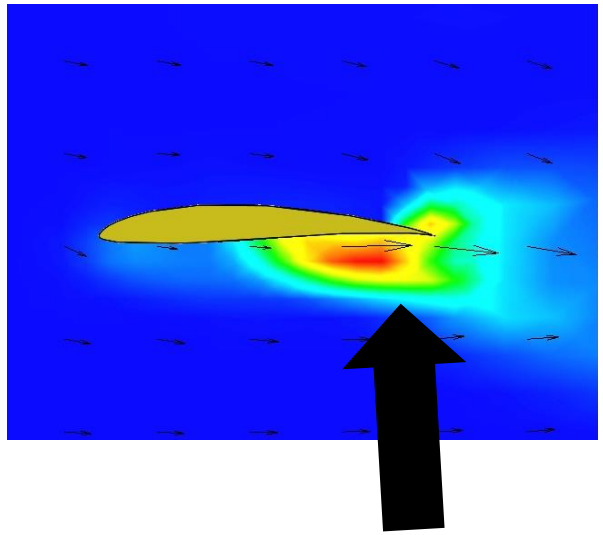


Presenter: AM

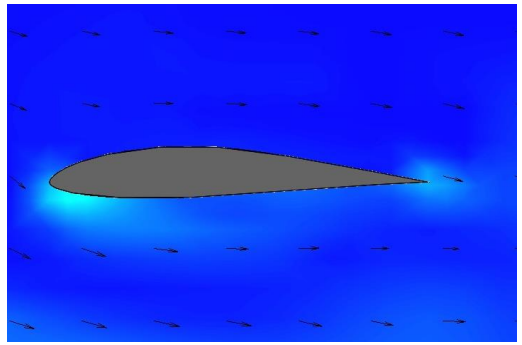
CFD – Wing Vorticity



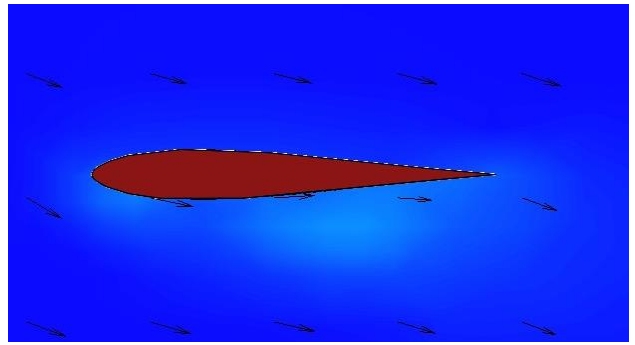
Canard



Main Wing



Tail Wing

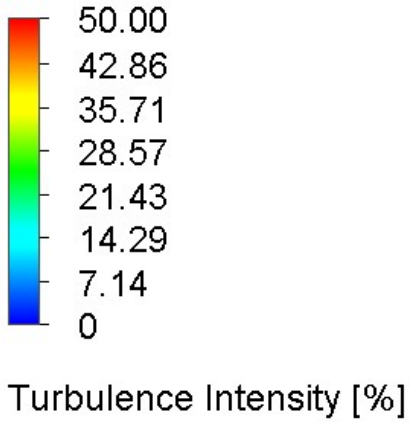


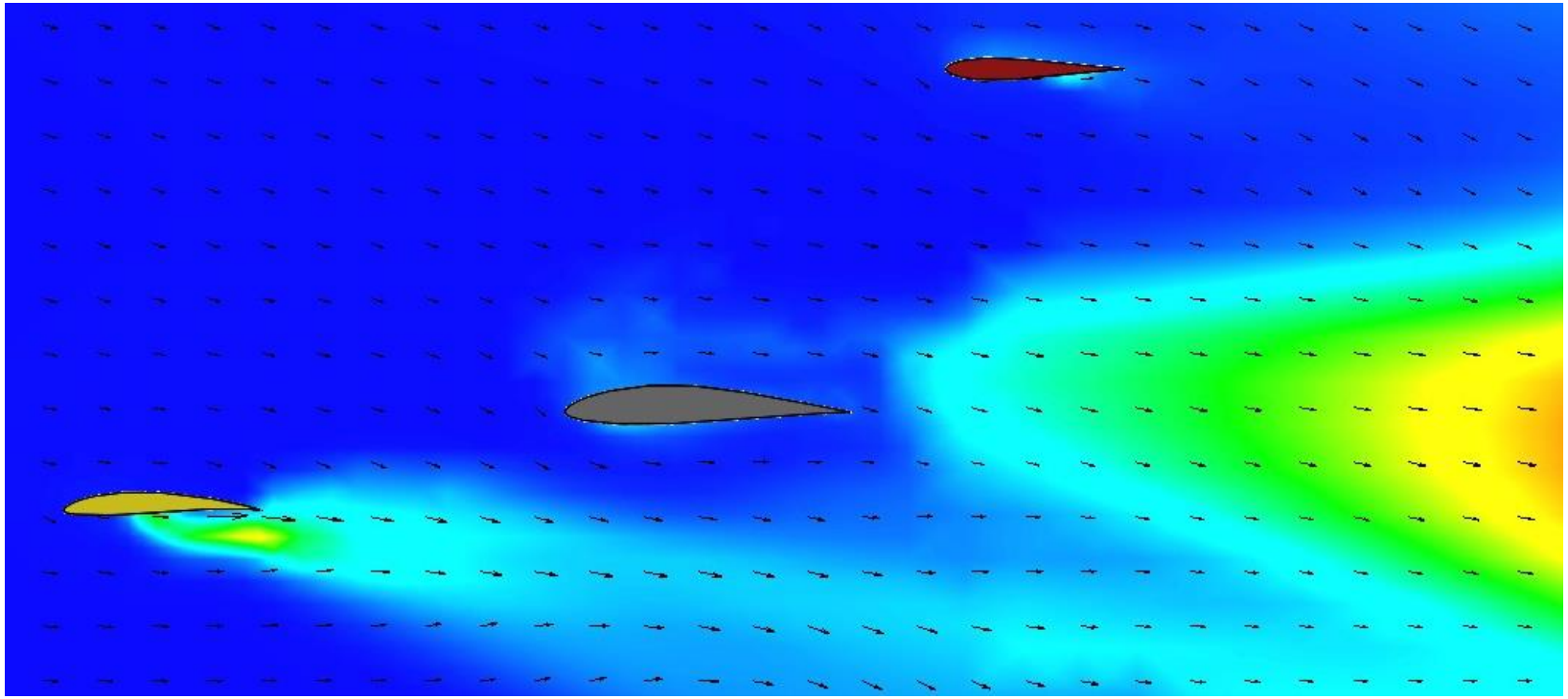
More vorticity due to concave shape on the bottom

Relatively less vorticity as the shapes are more symmetric

Presenter: AM

CFD – Wing Turbulence

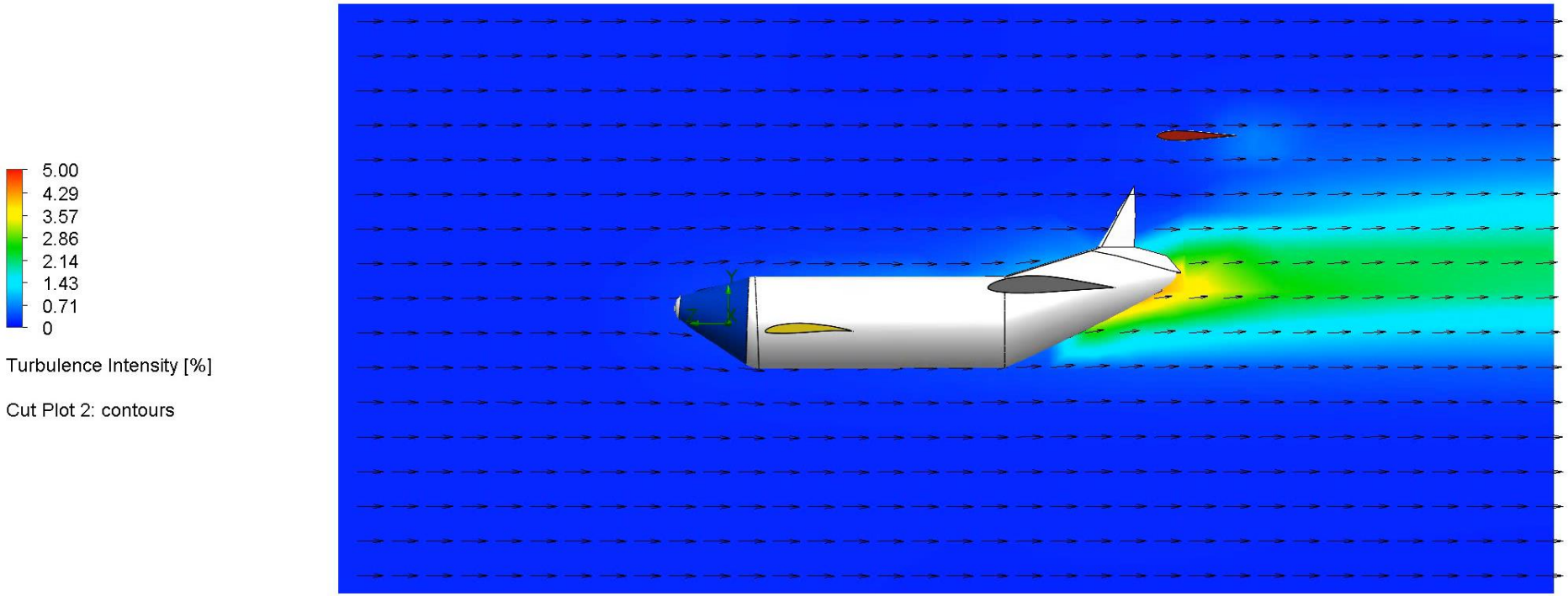




Negligible wake effects between wings

Presenter: AM

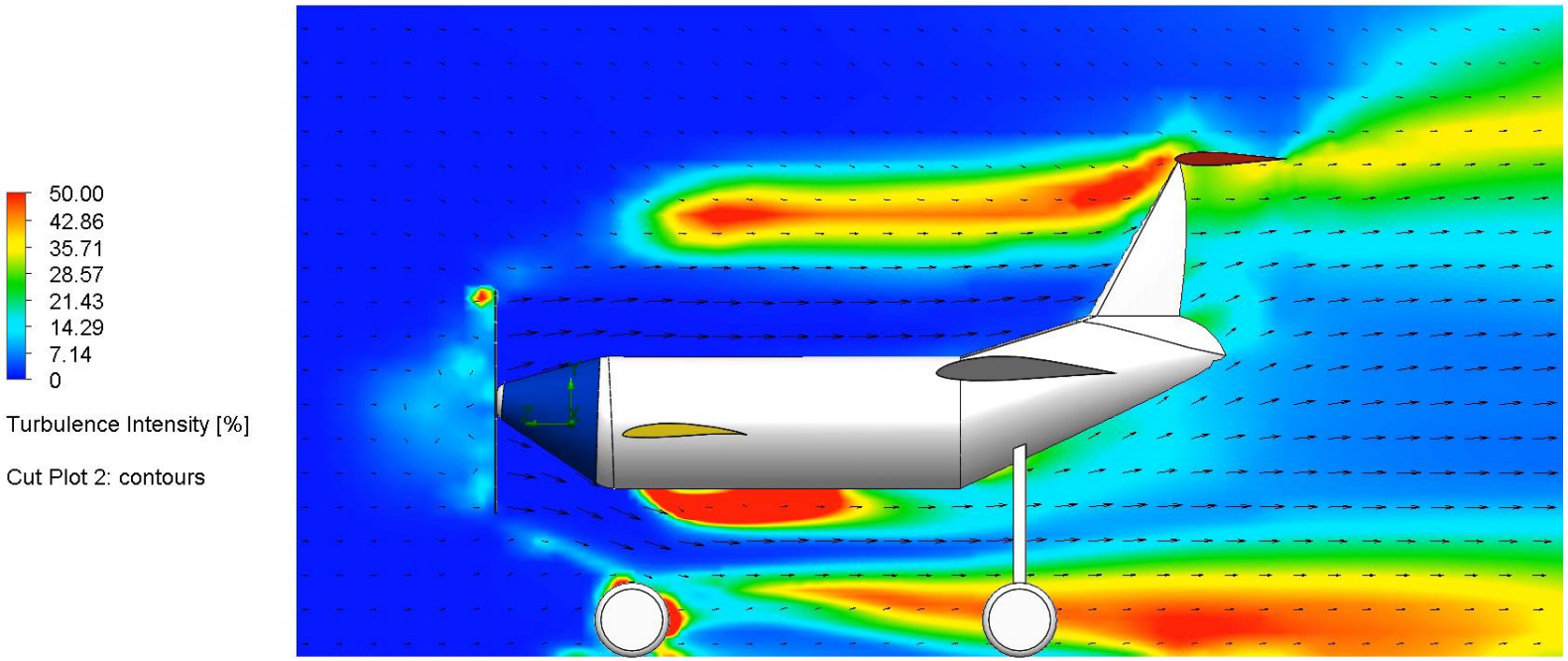
CFD – Fuselage Turbulence



Turbulence Effects Negligible

Presenter: AM

CFD – Turbulence With the Propeller



Tail Wing Turbulence Near the Centerline

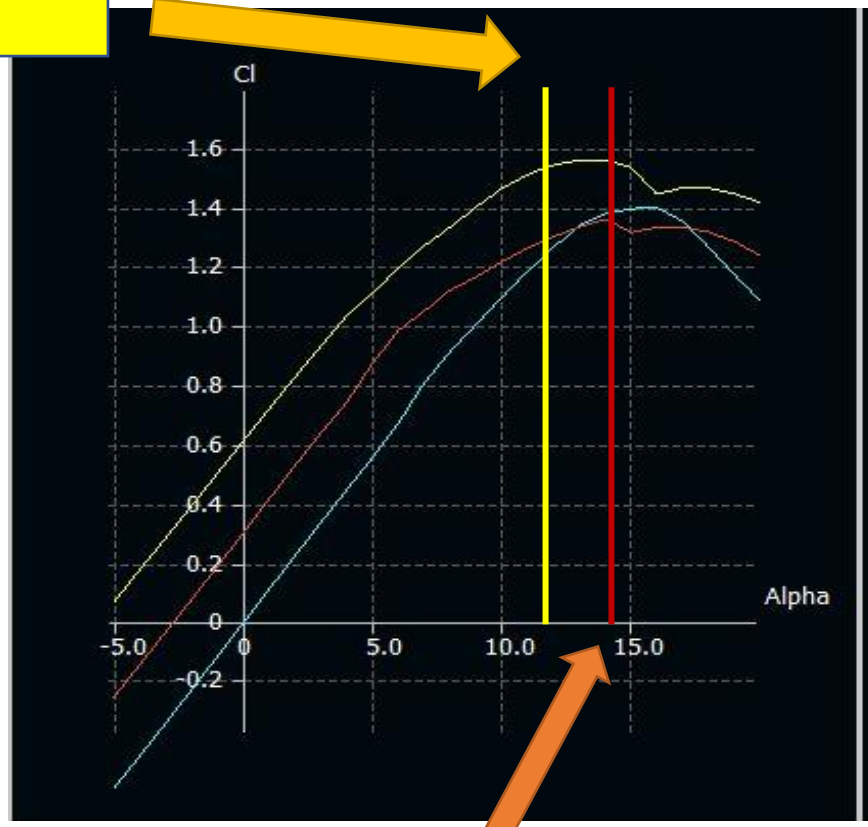
Ground Effects

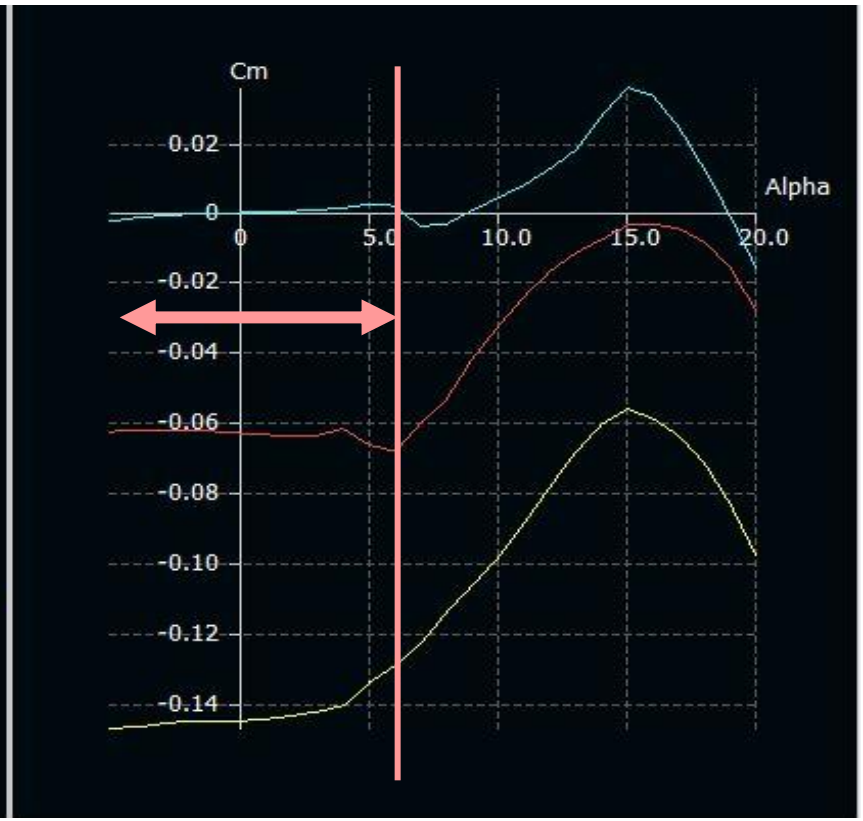
Presenter: AM

Xfoil Analysis

Canard Stall

Tail
E168 (12.45%)
T1_Re2.000_M0.03_N9.0
Main
E197 (13.49%)
T1_Re2.000_M0.03_N9.0
Canard
E214 (11.1%)
T1_Re2.000_M0.03_N9.0





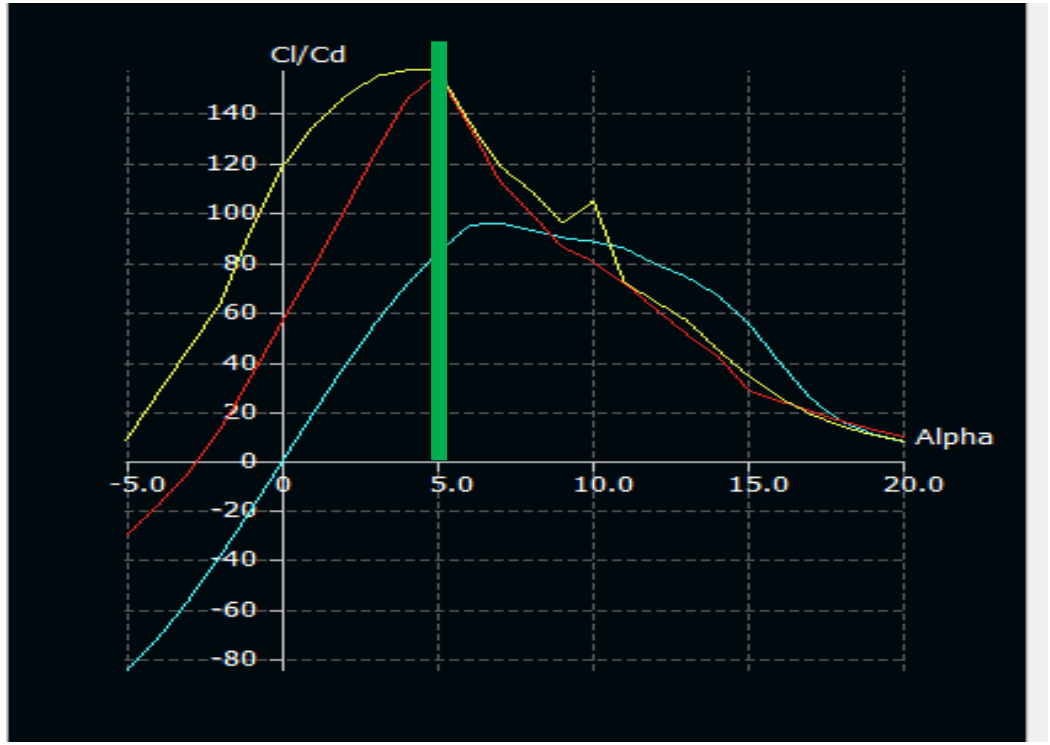
Main Wing Stall

Constant Moment Region

Presenter: AM

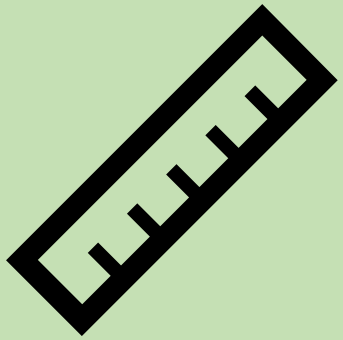
Xfoil Analysis

Tail
E168 (12.45%)
T1_Re2.000_M0.03_N9.0
Main
E197 (13.49%)
T1_Re2.000_M0.03_N9.0
Canard
E214 (11.1%)
T1_Re2.000_M0.03_N9.0



Optimum Performance Angle: 5 deg

Presenter: AM

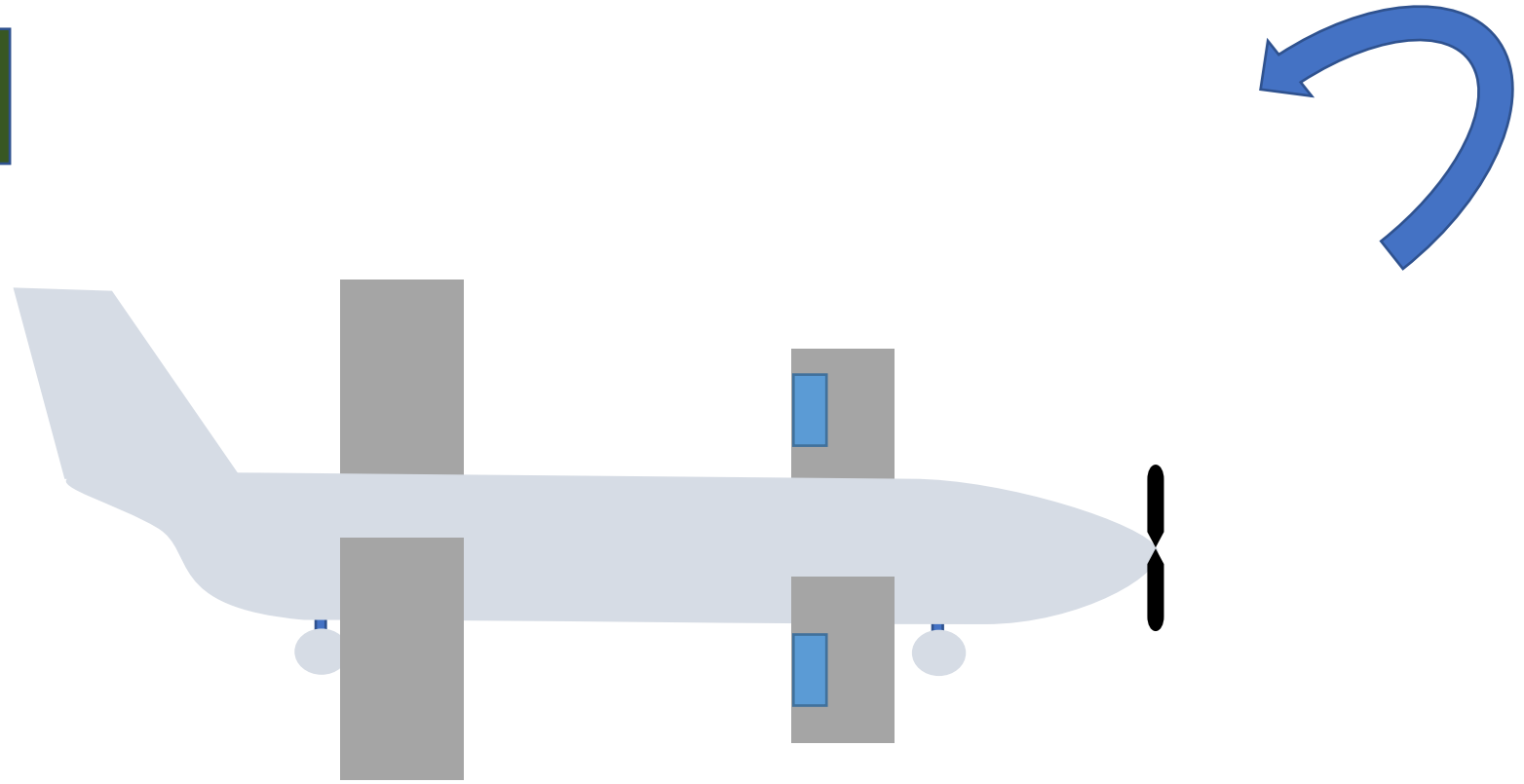


Stability Calculations

Presenter – Sasindu Pinto

Pitch Stability – Design Considerations

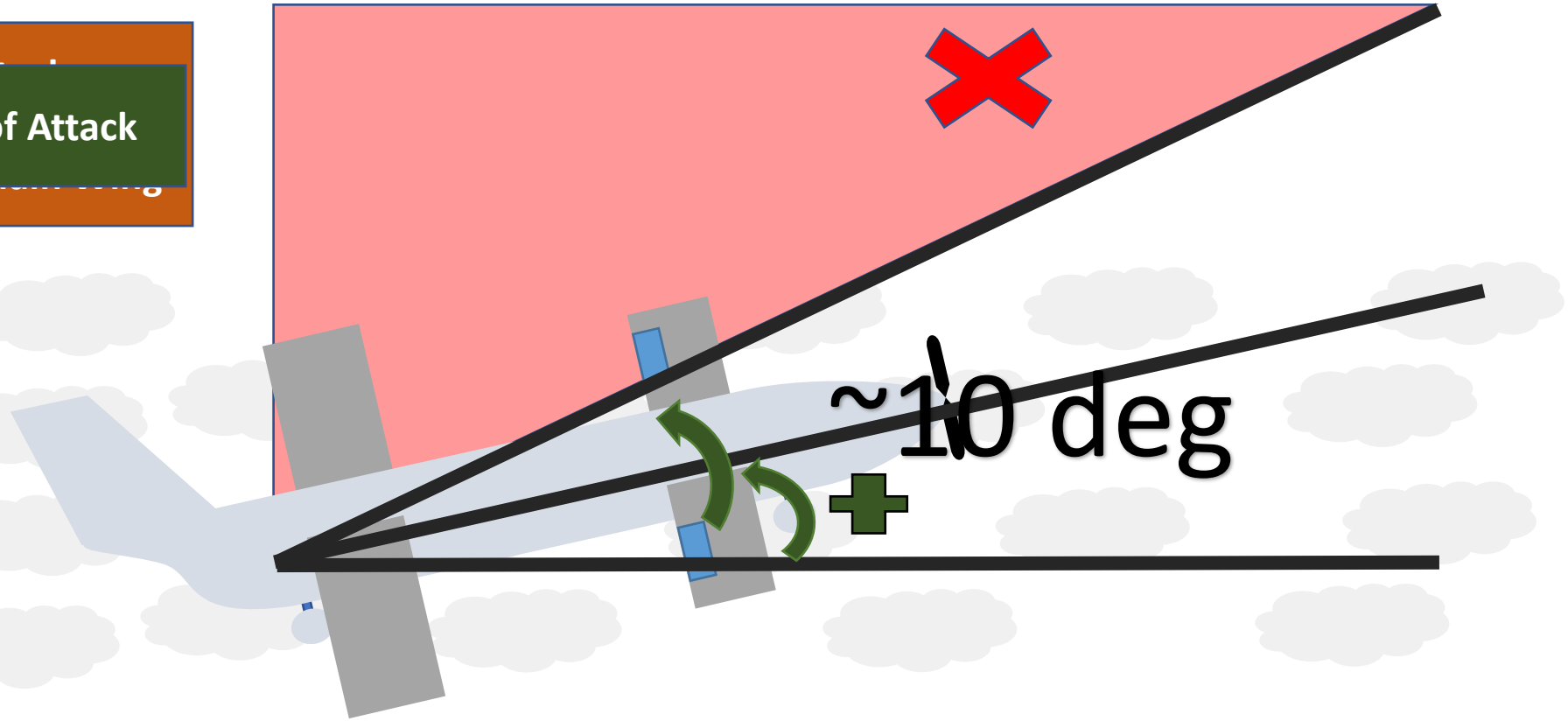
Positive Trim at 0 deg Angle of Attack



Presenter: SP

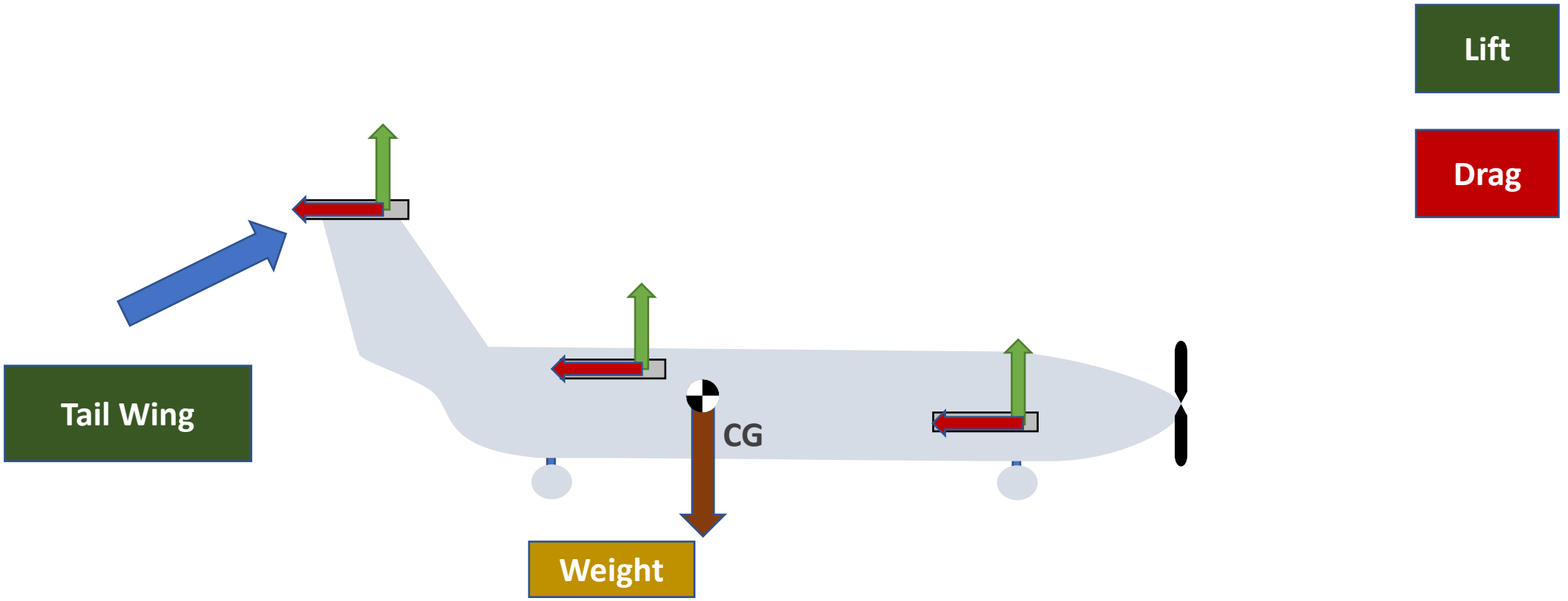
Pitch Stability – Design Considerations

Positive Equilibrium Angle of Attack



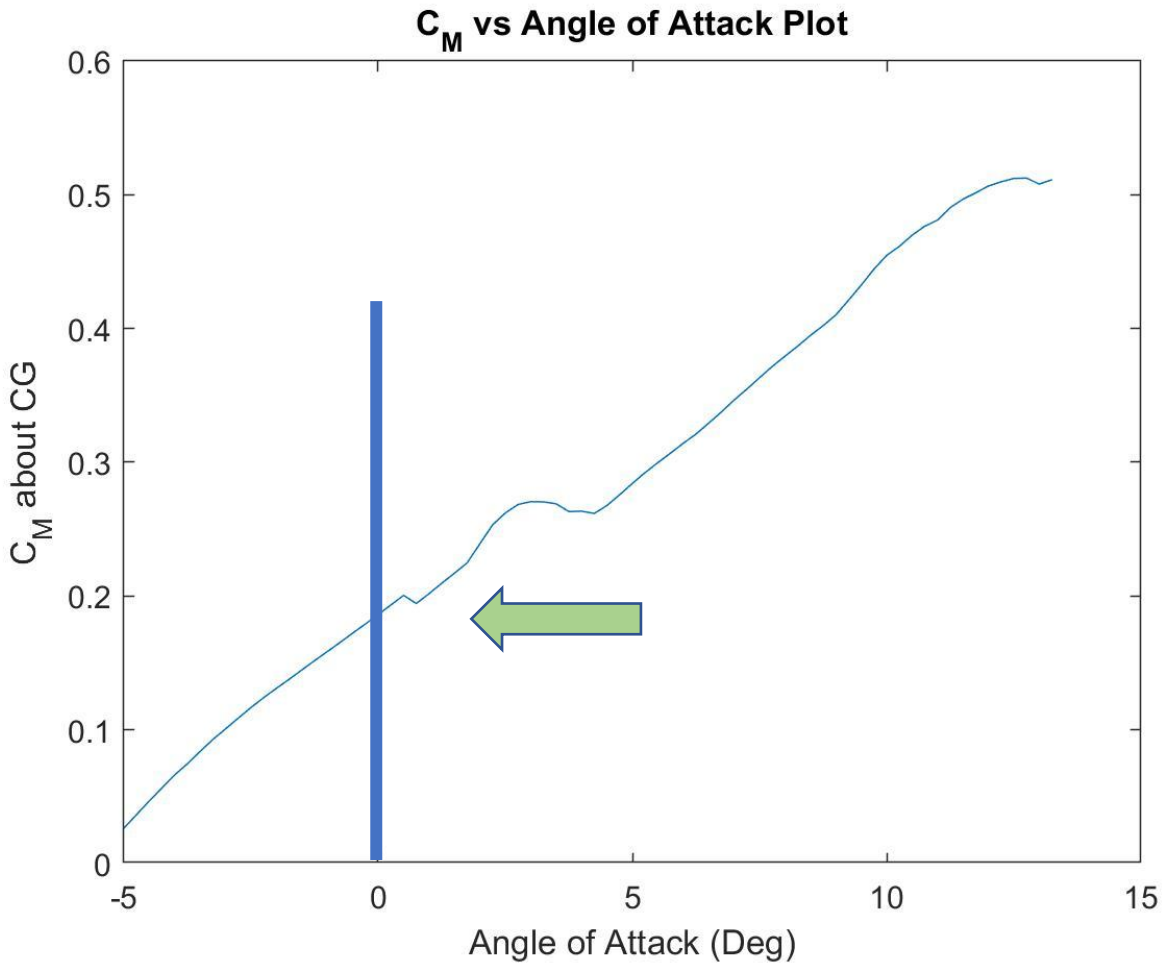
Presenter: SP

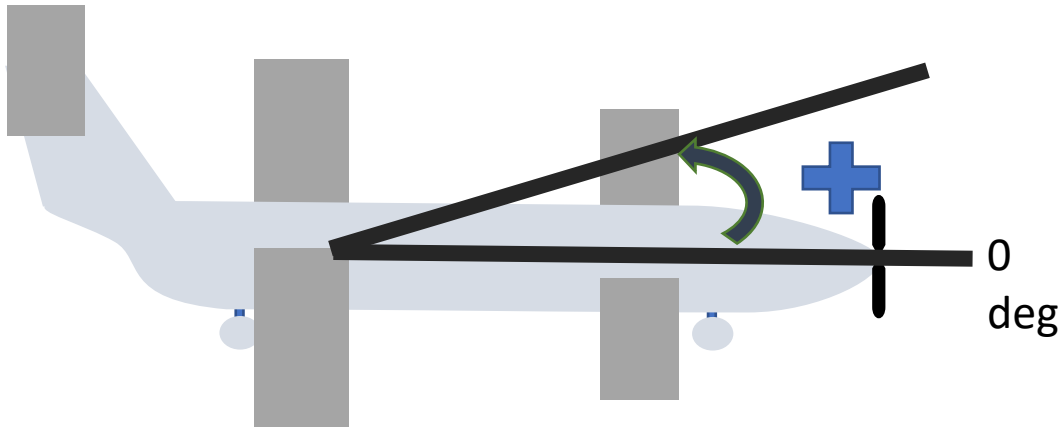
Pitch Stability – Free Body Diagram



Presenter: SP

Pitch Stability – Initial Stability Plot

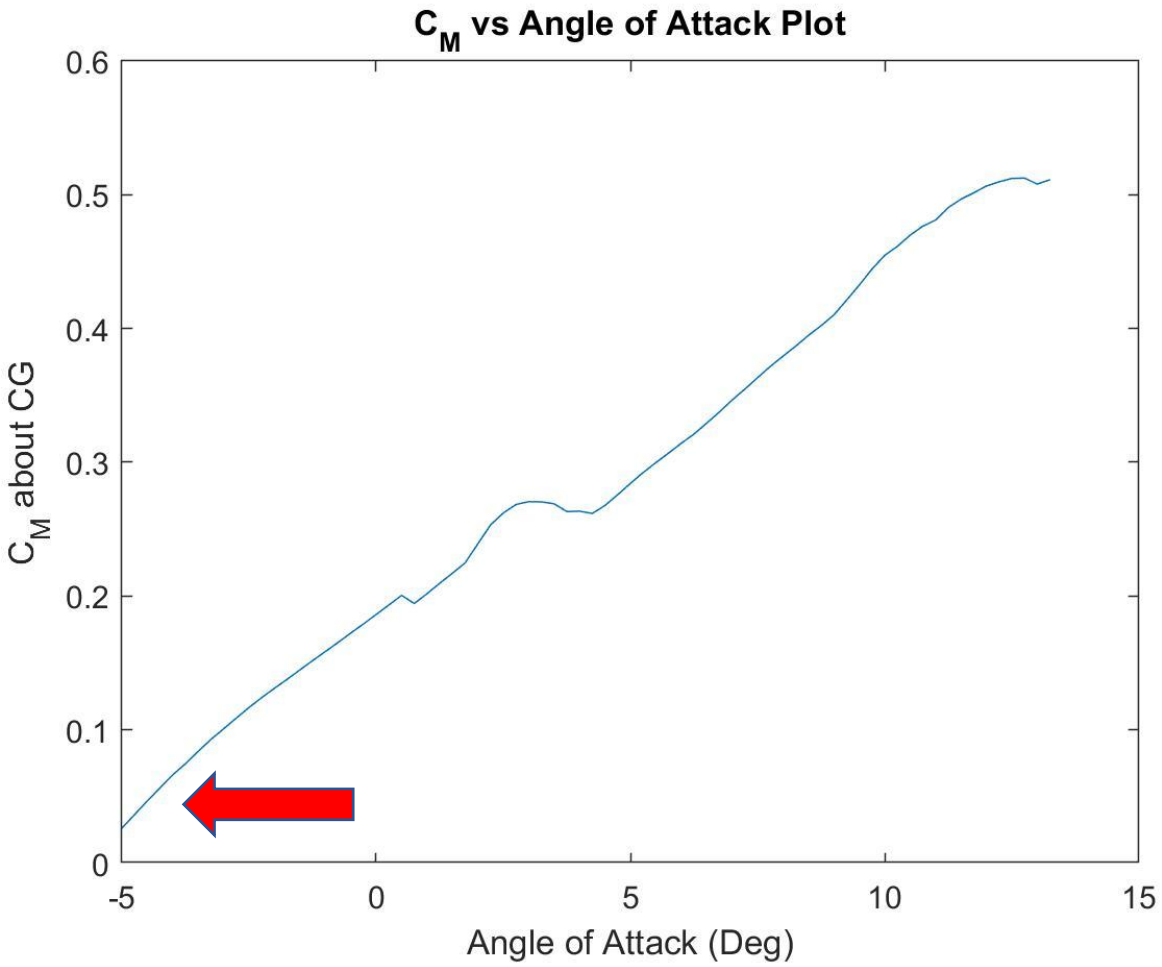


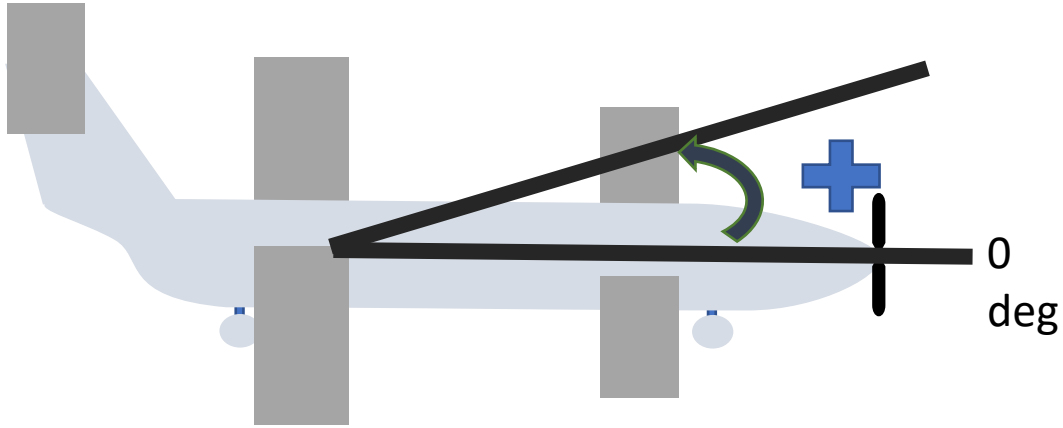


Positive Trim

Presenter: SP

Pitch Stability – Initial Stability Plot

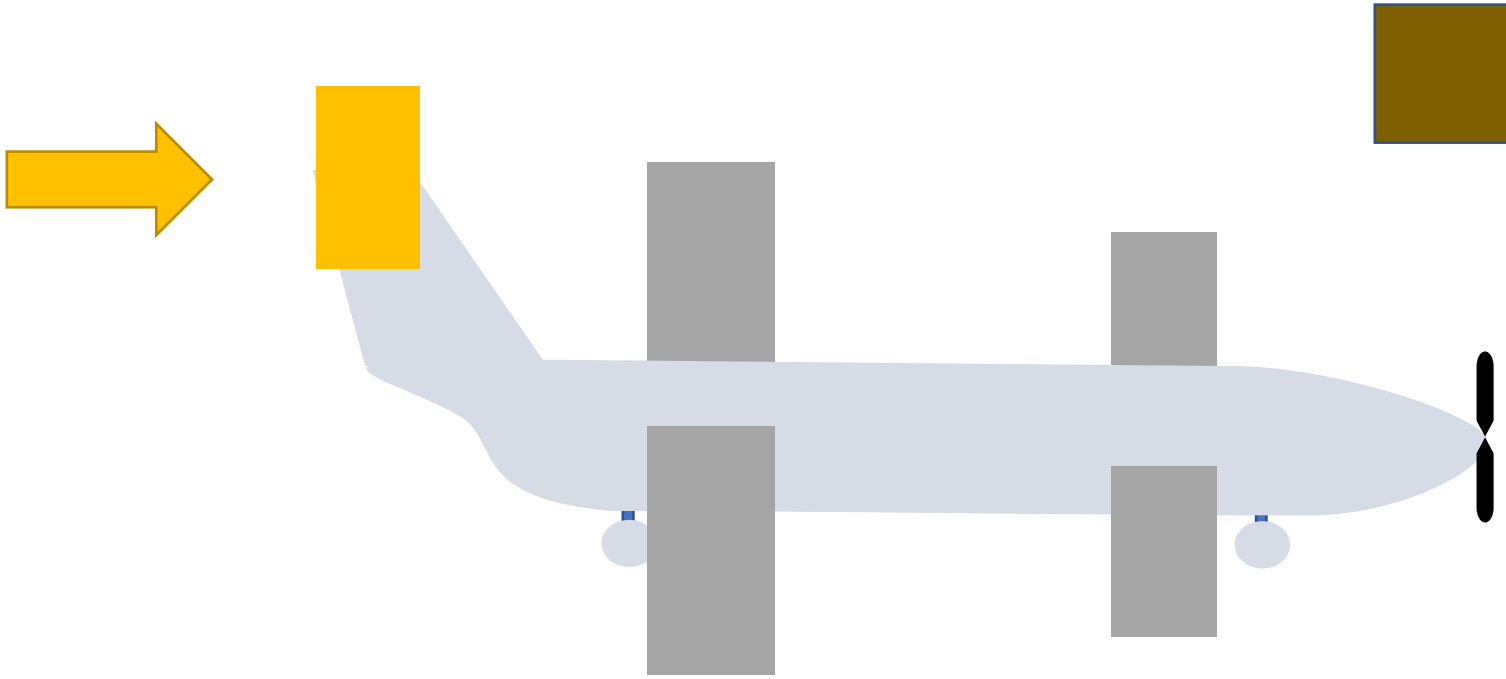




Negative Equilibrium Angle of Attack

Presenter: SP

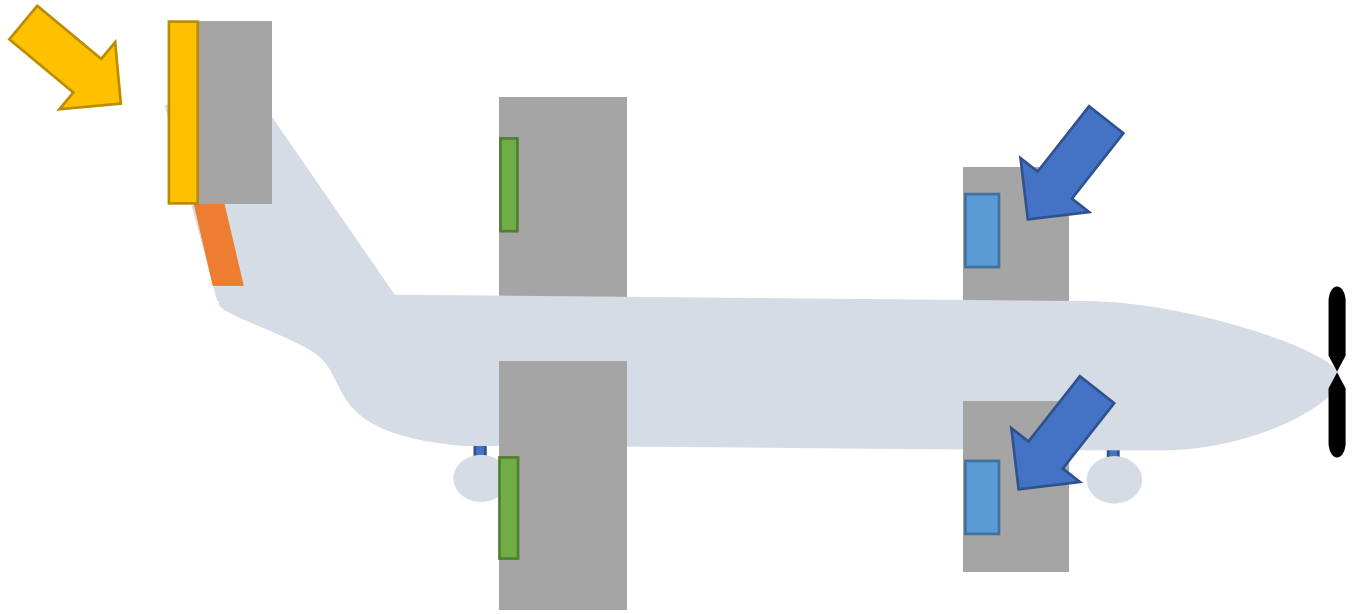
Pitch Stability – Design Adjustments



Addition of a Tail Wing

Presenter: SP

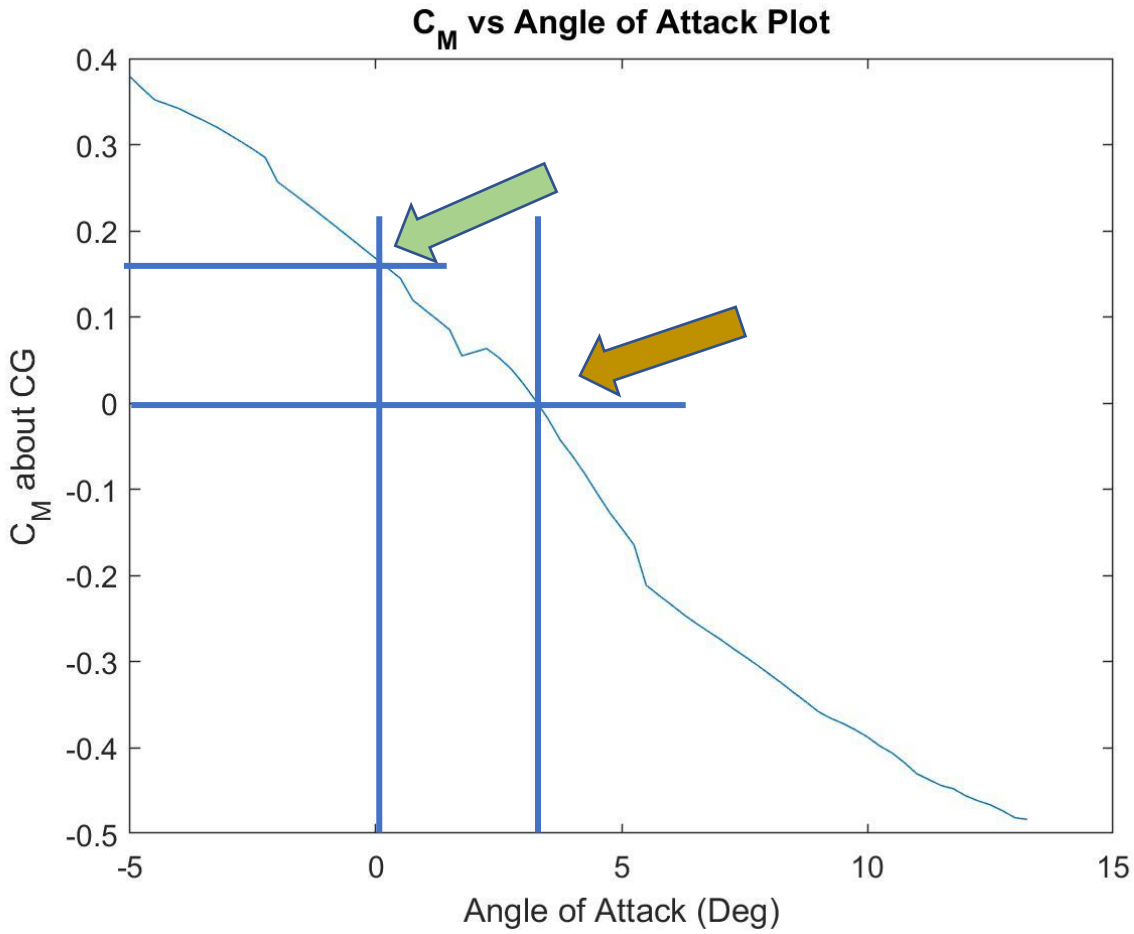
Pitch Stability – Design Adjustments

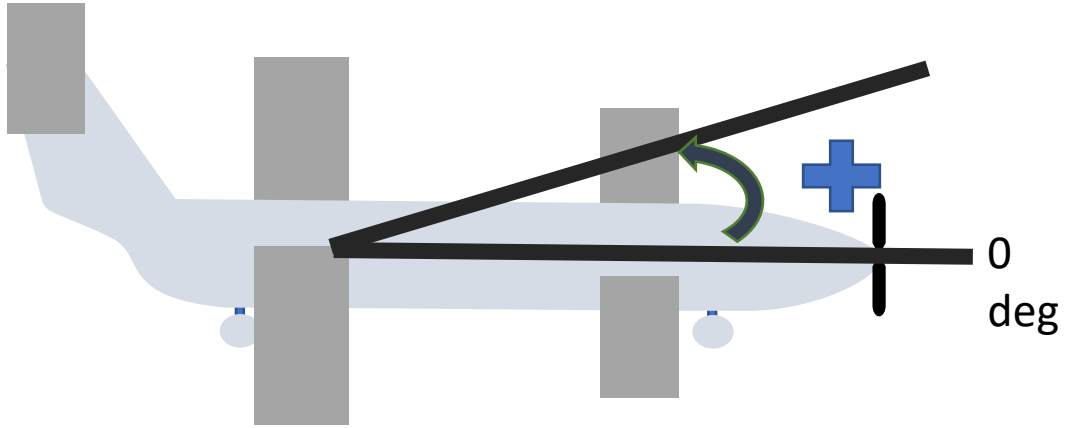


Elevator Repositioning

Presenter: SP

Pitch Stability – Final Stability Plot





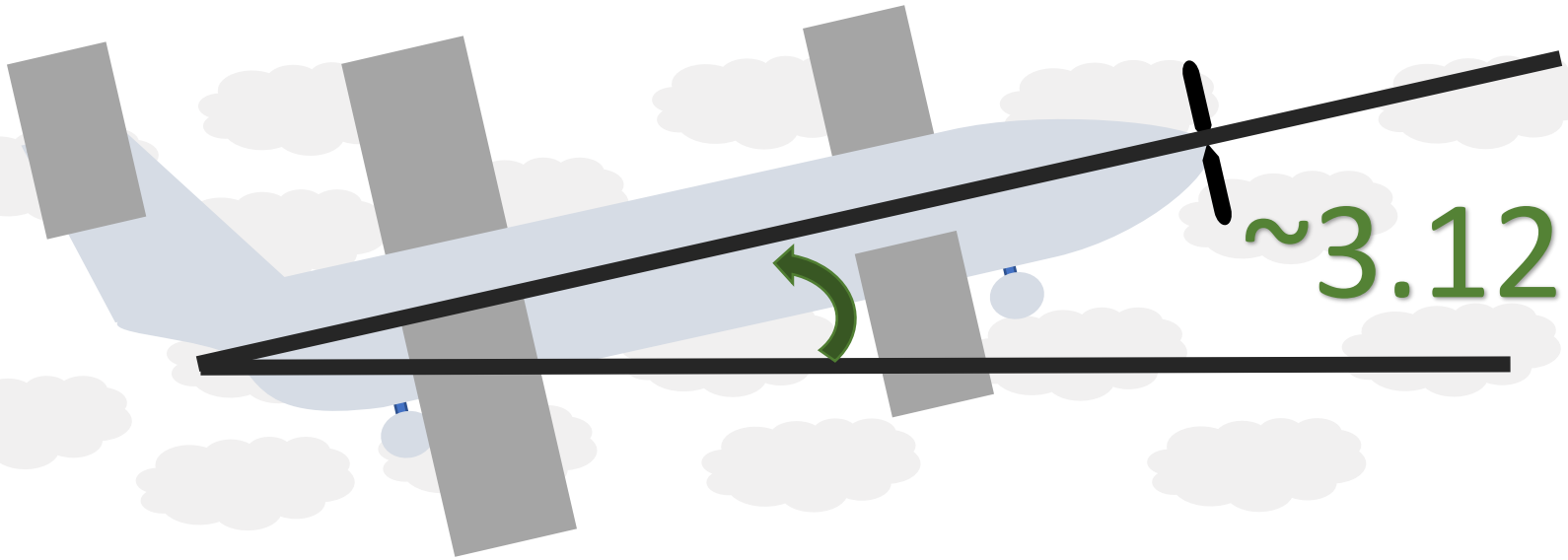
Positive Trim

Positive Equilibrium Angle of Attack

Presenter: SP

Pitch Stability – Outcomes

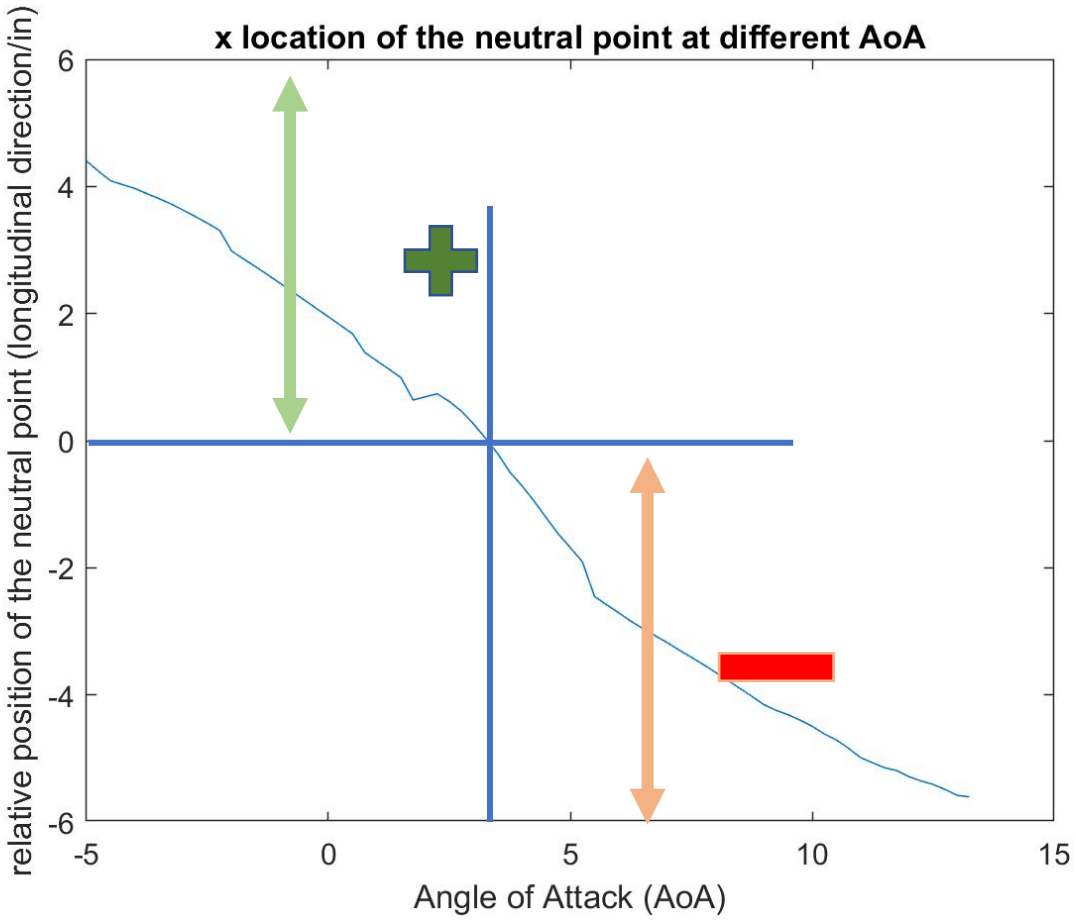
Equilibrium Angle of Attack

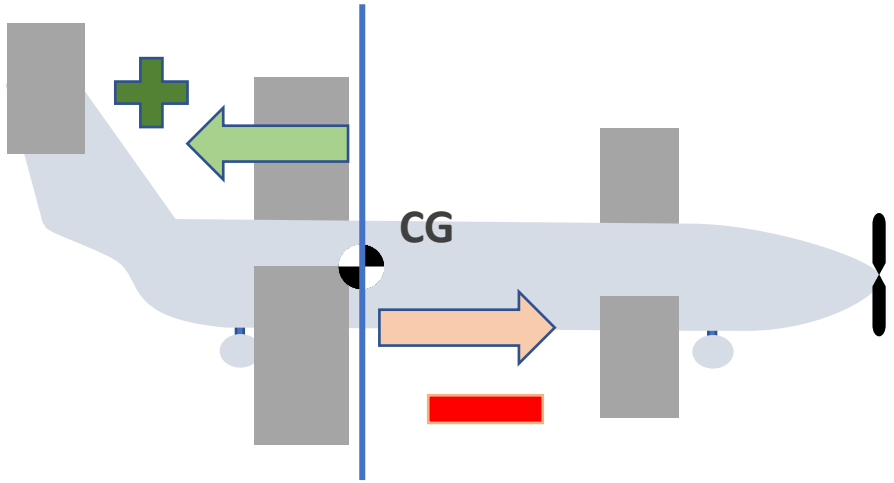


Presenter: SP

Pitch Stability – Neutral Point

Neutral Point (NP) – Point about which Cm is Zero



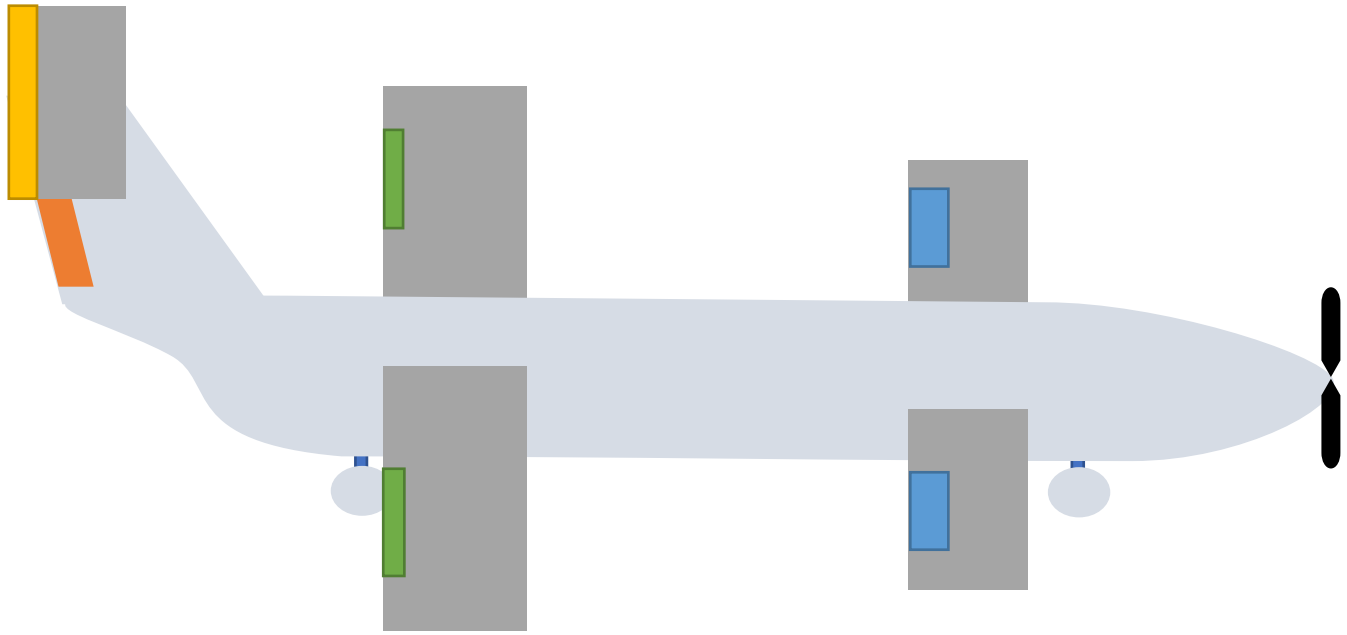


NP is behind CG before equilibrium AoA

NP is ahead of CG after equilibrium AoA

Presenter: SP

Pitch Stability – Outcomes - Elevator

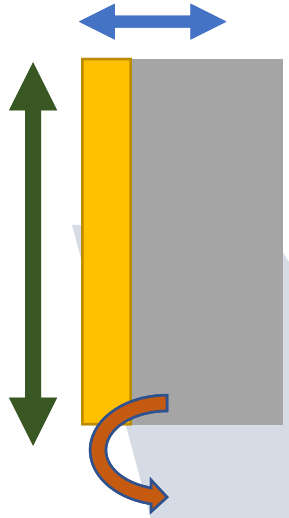


Presenter: SP

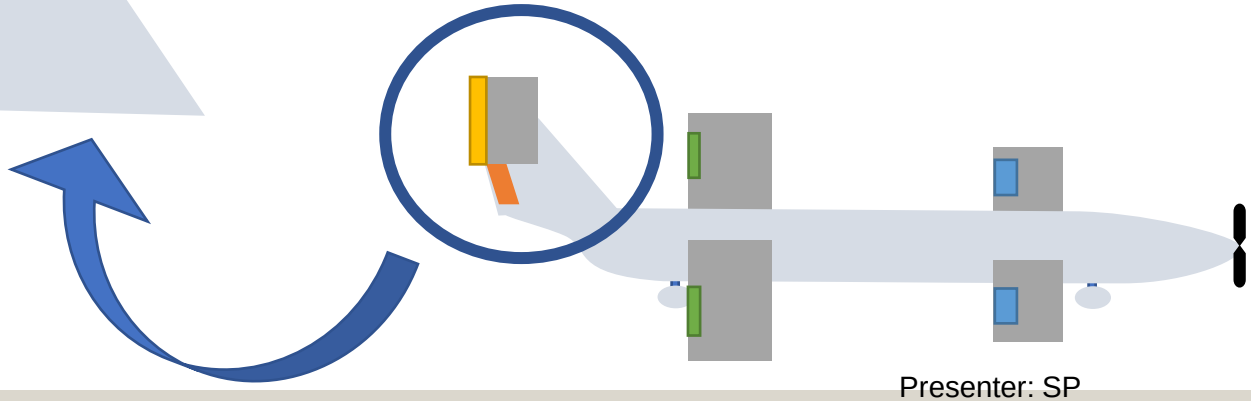
Pitch Stability – Outcomes - Elevator

Elevator Chord Length – 3.6 in

Elevator Span – 47.5 in

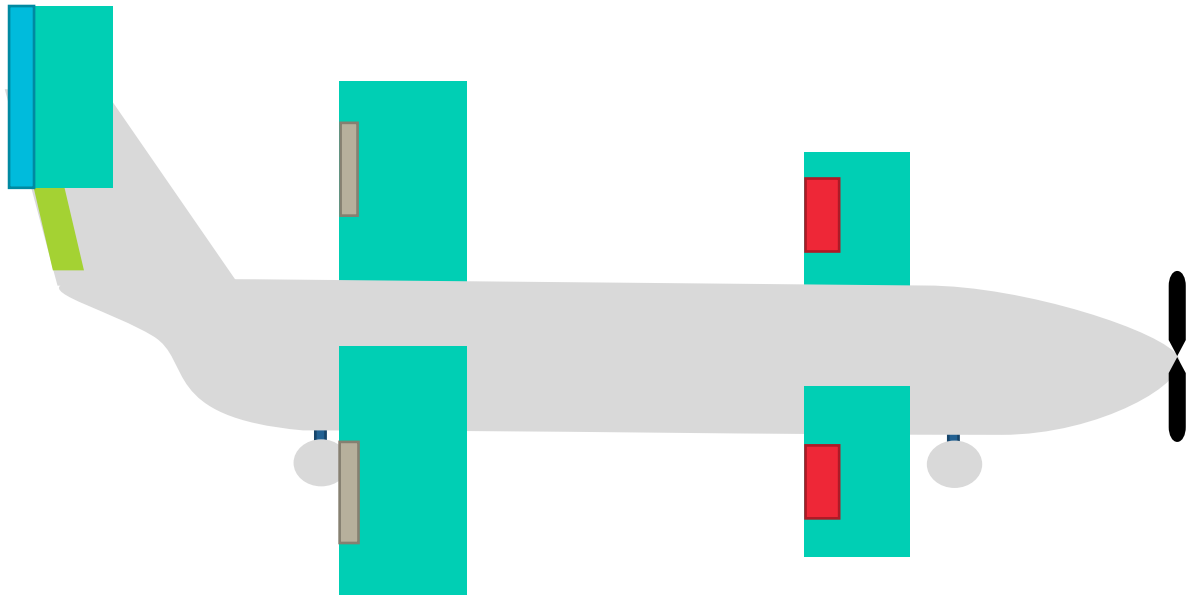


Deflection angle – 30 deg



Presenter: SP

Aileron Dimensions and Deflection



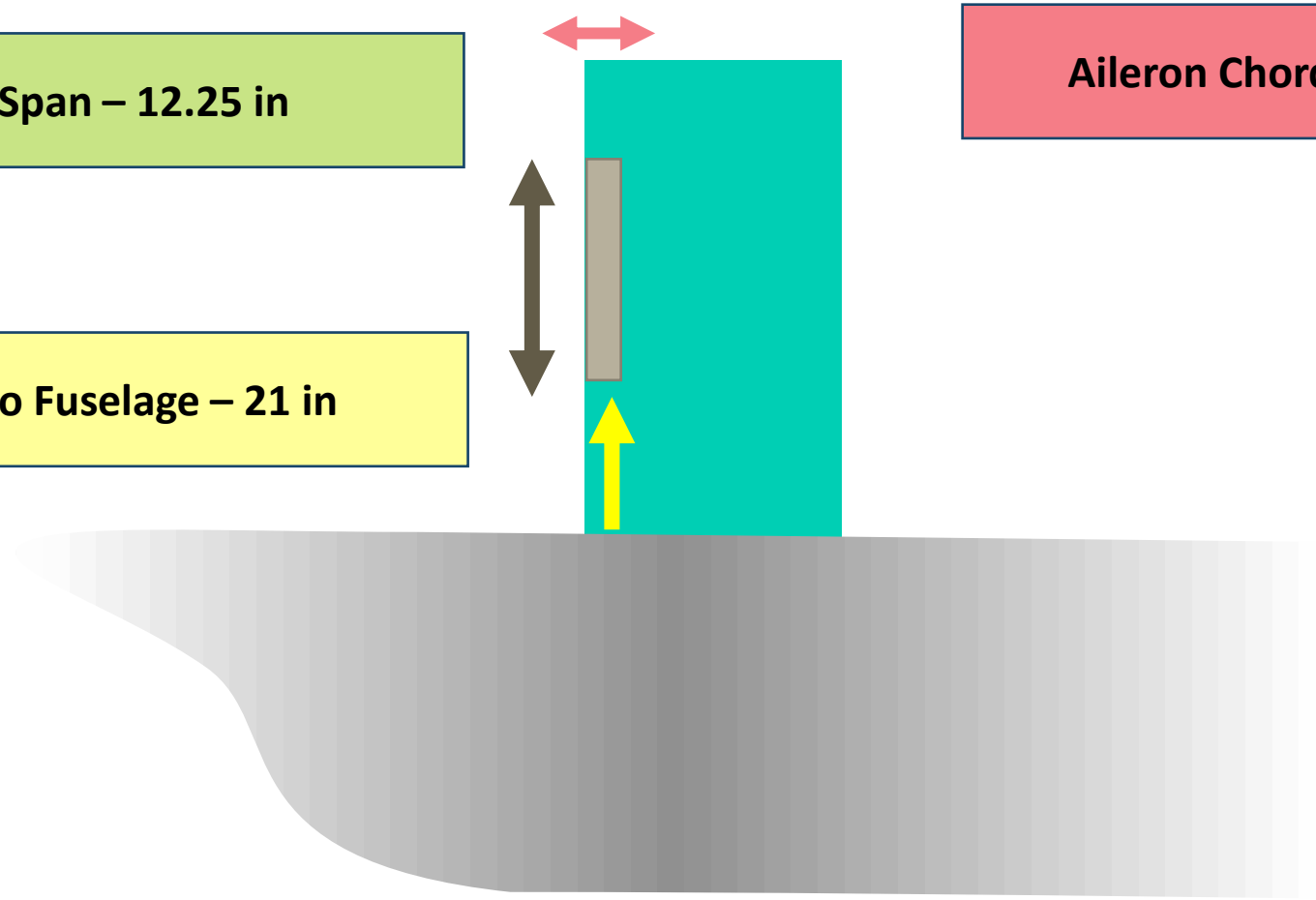
Presenter: SP

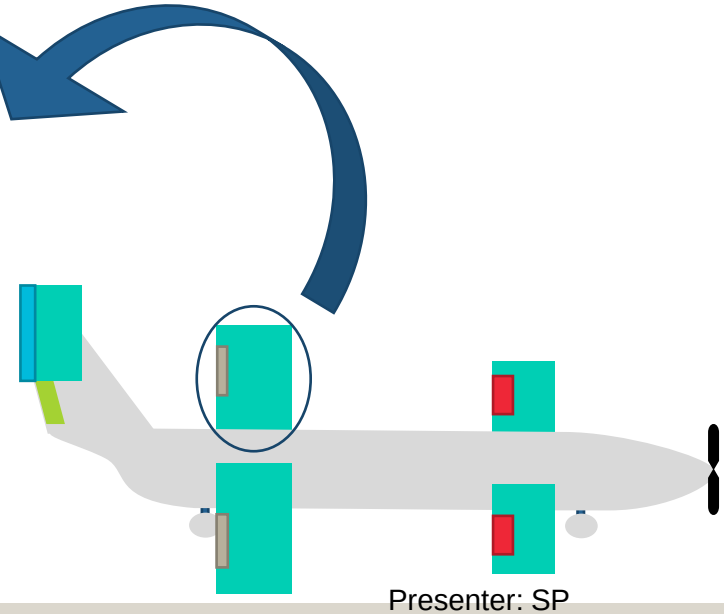
Aileron Dimensions

Aileron Span – 12.25 in

Distance to Fuselage – 21 in

Aileron Chord Length – 3.75 in



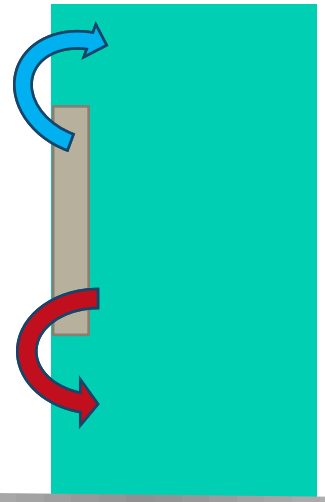


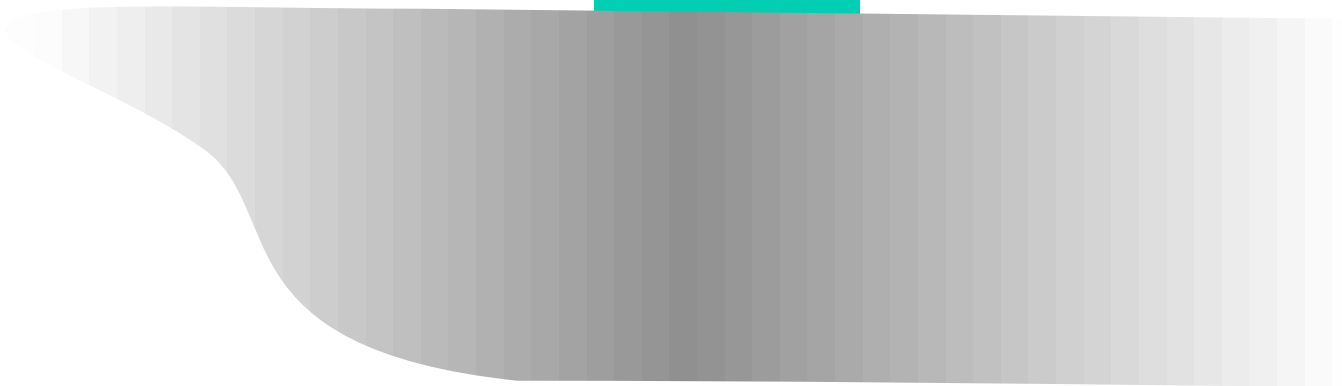
Presenter: SP

Aileron Deflection

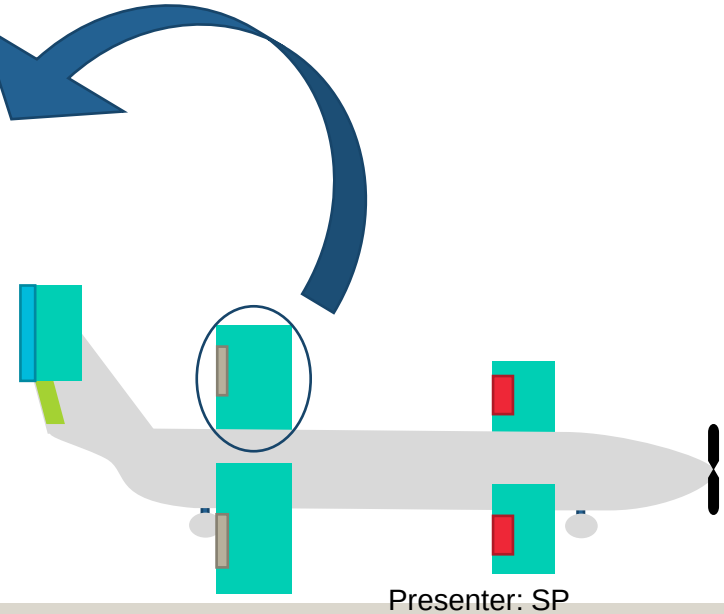
Upward Deflection Angle – 20 deg

Downward Deflection Angle – 8 deg



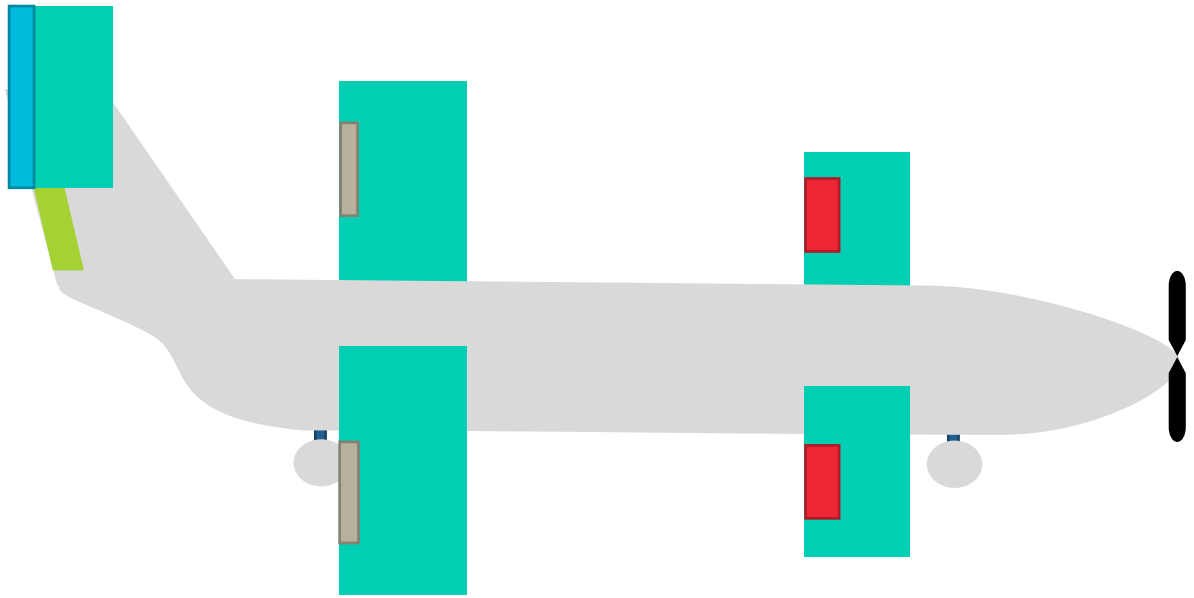


Differential Setting : 2.5:1



Presenter: SP

Rudder Dimensions and Deflection



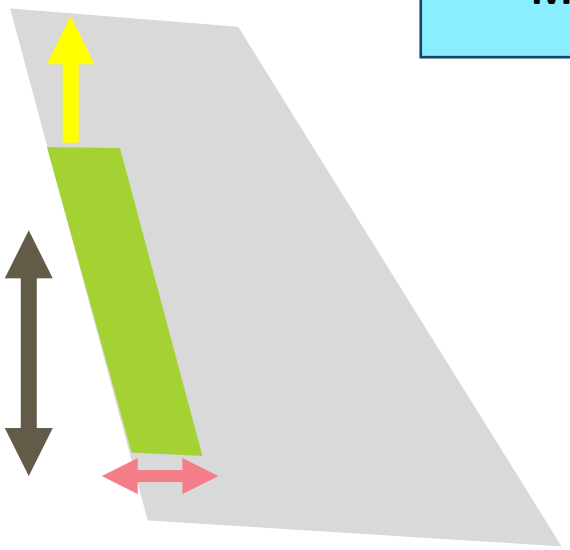
Presenter: SP

Rudder Dimensions

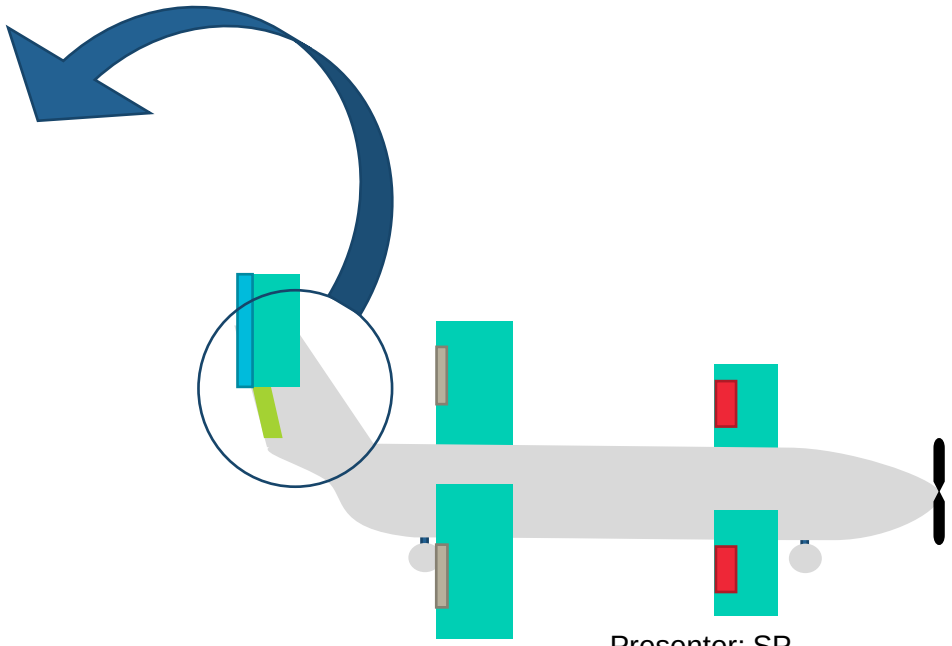
Distance to the top of the tail – 5 in

Rudder Span – 9 in

Rudder Chord Length – 2.7 in

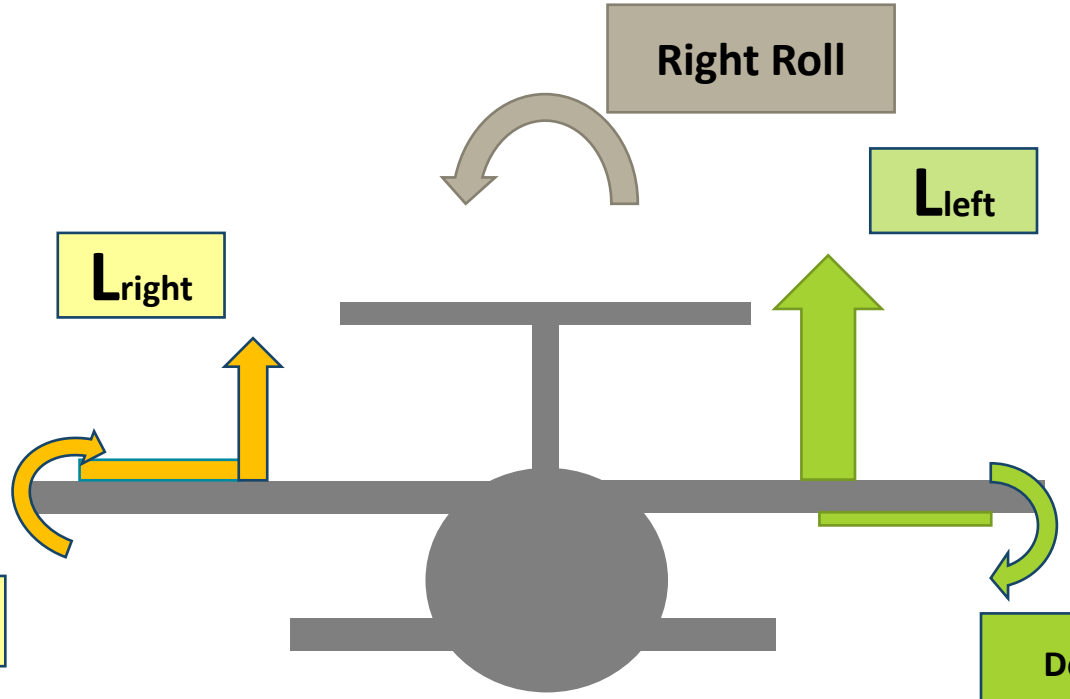


Maximum Deflection – 25 deg



Presenter: SP

Roll Stability – Design Considerations



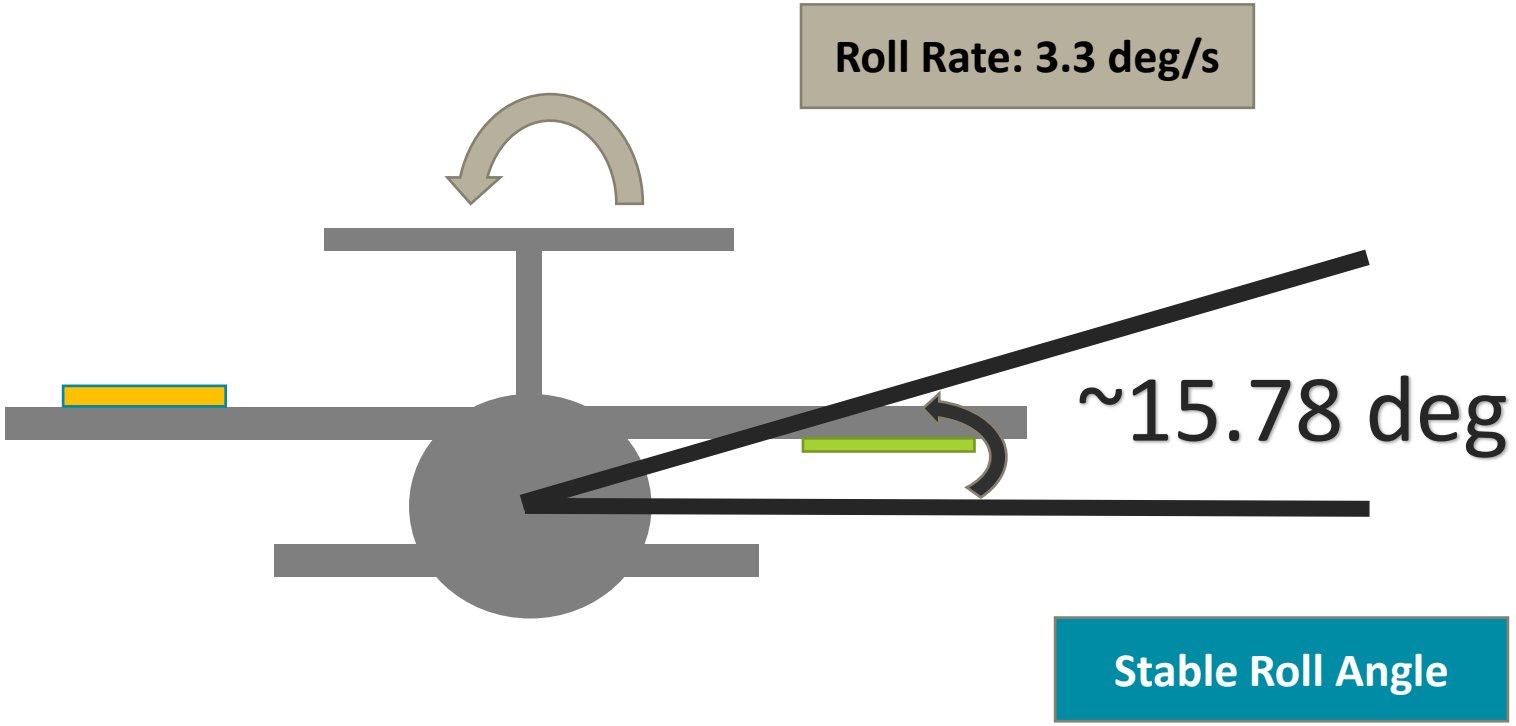
Upward Deflection Angle – 20 deg

Downward Deflection Angle – 8 deg

$L_{right} << L_{left}$

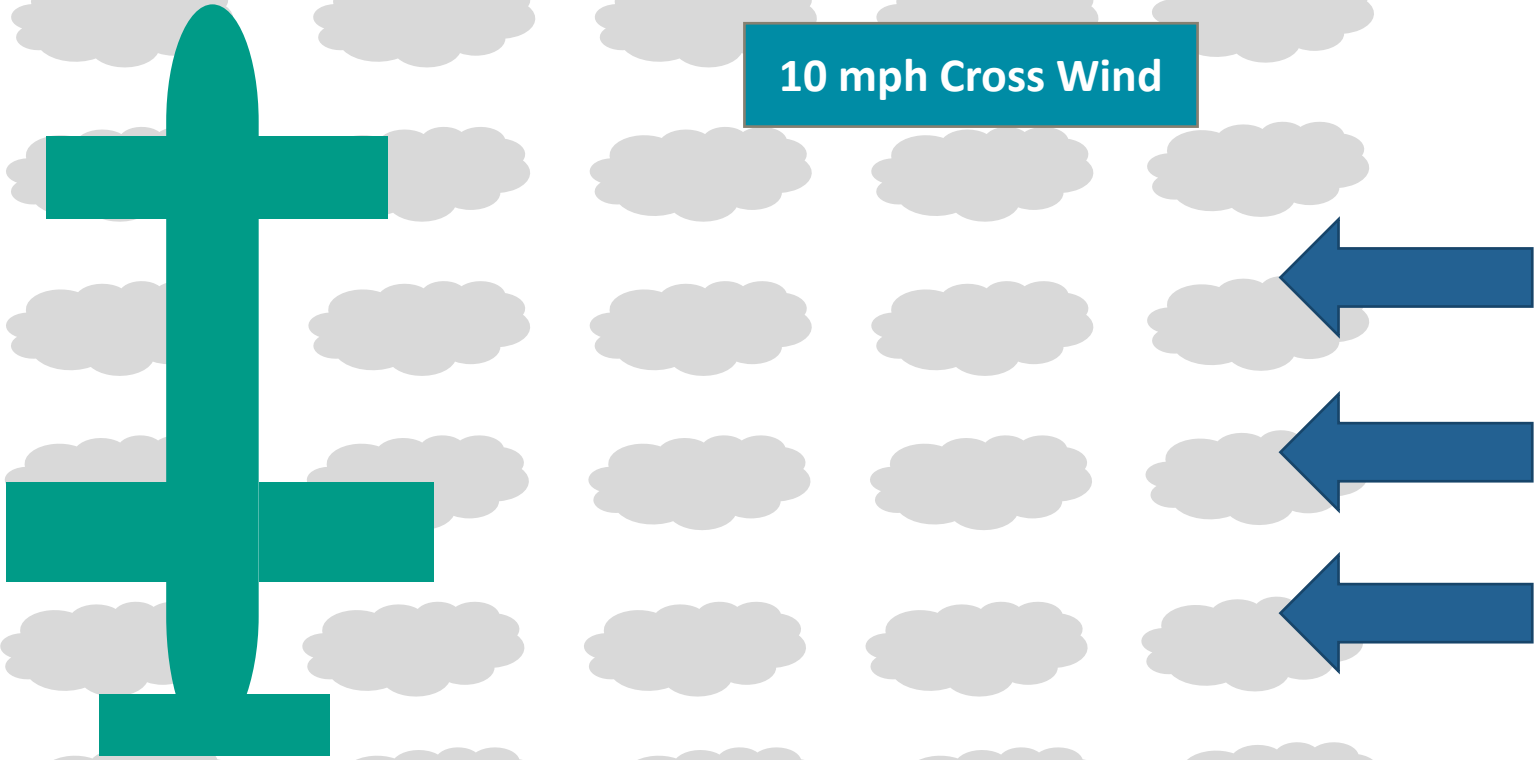
Presenter: SP

Roll Stability – Operation



Presenter: SP

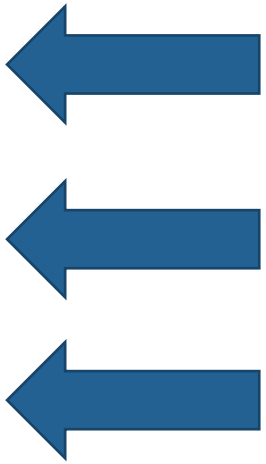
Yaw Stability – Design Considerations



Presenter: SP

Yaw Stability – Operation

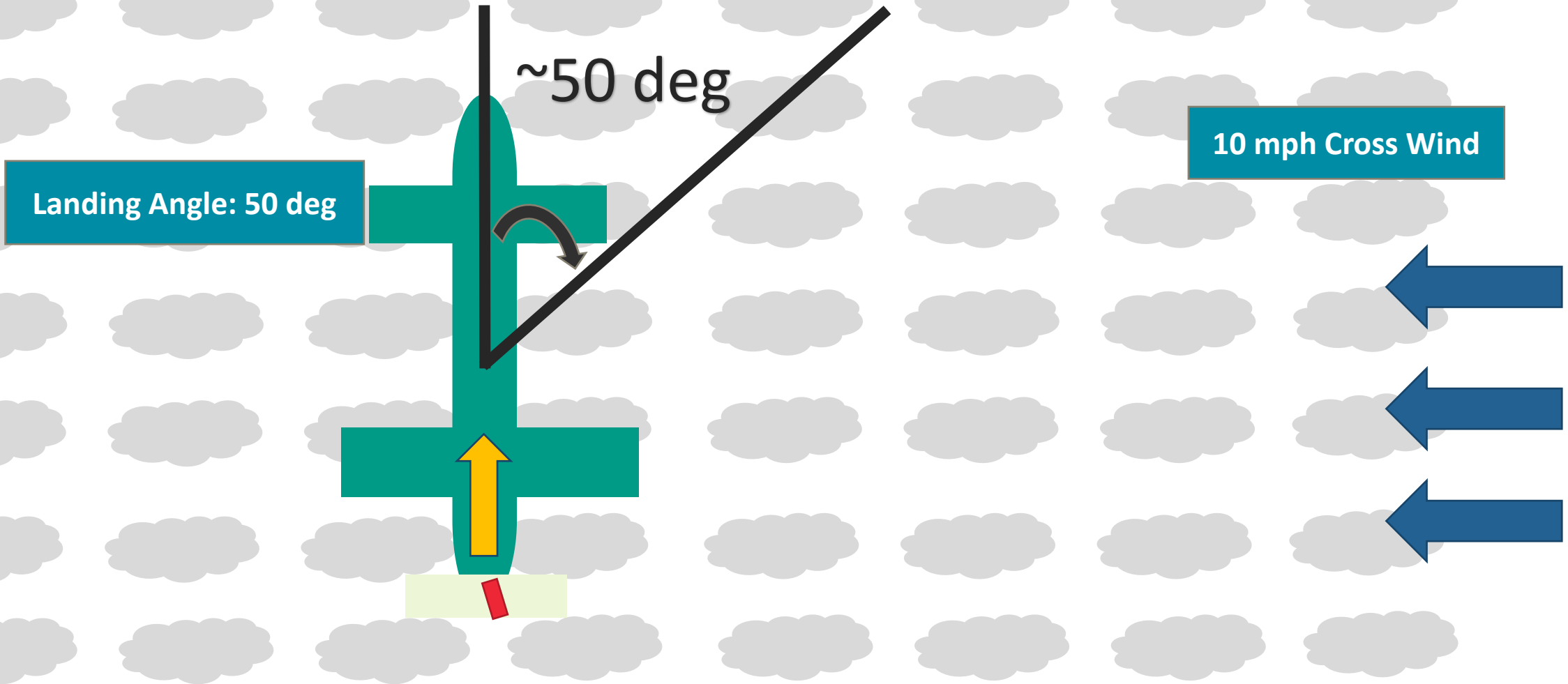
10 deg rudder rotation



10 mph Cross Wind

Presenter: SP

Yaw Stability – Operation



Presenter: SP

Control Surface Servos

- A contact at the RC club strongly recommended not using the servo brand currently owned by the COE and suggested more reliable options

Hitech HS-485HB

Old Vs. New

Weight (oz.)

1.59 | 1.0

Operating Voltage

4.8V- 6V | 6V to 8.4V

Max Torque (oz-in)

83 | 149

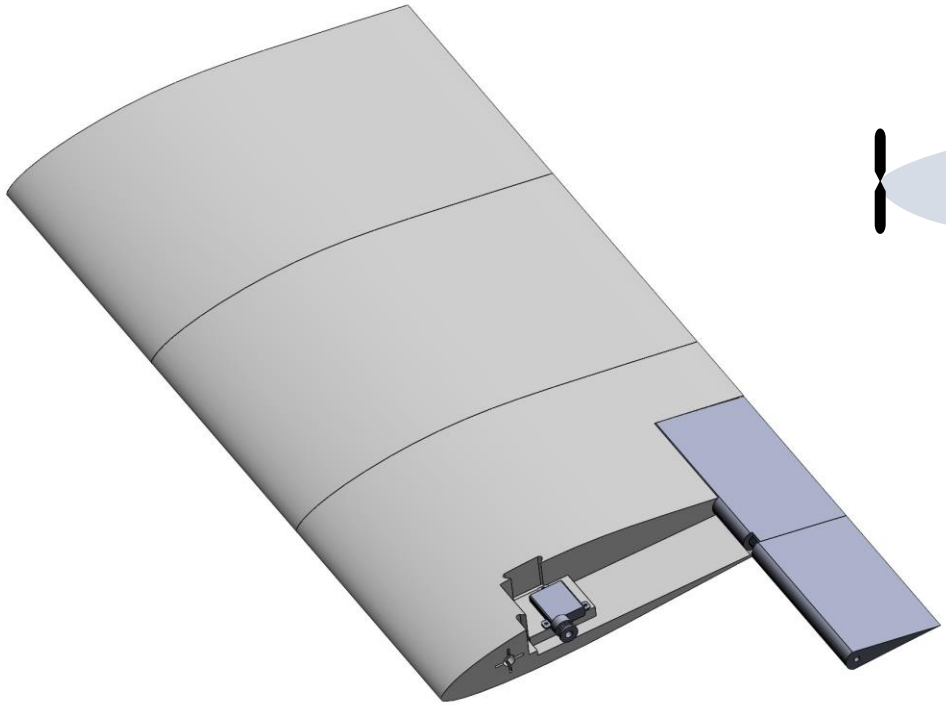
Price

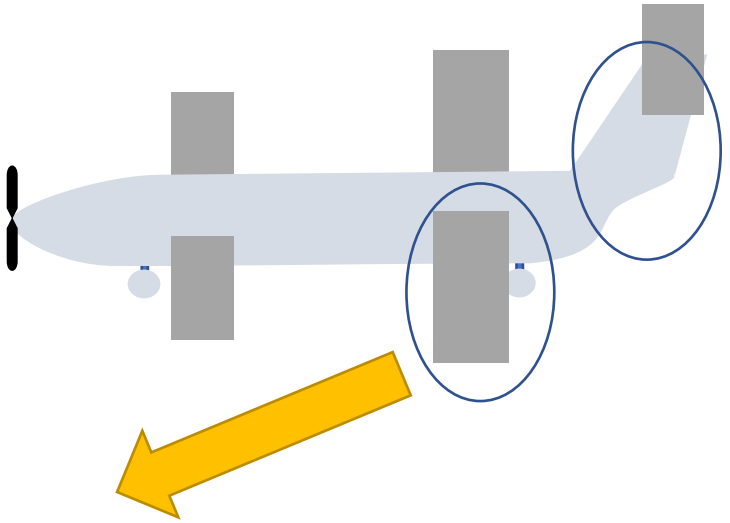
$20 | $45

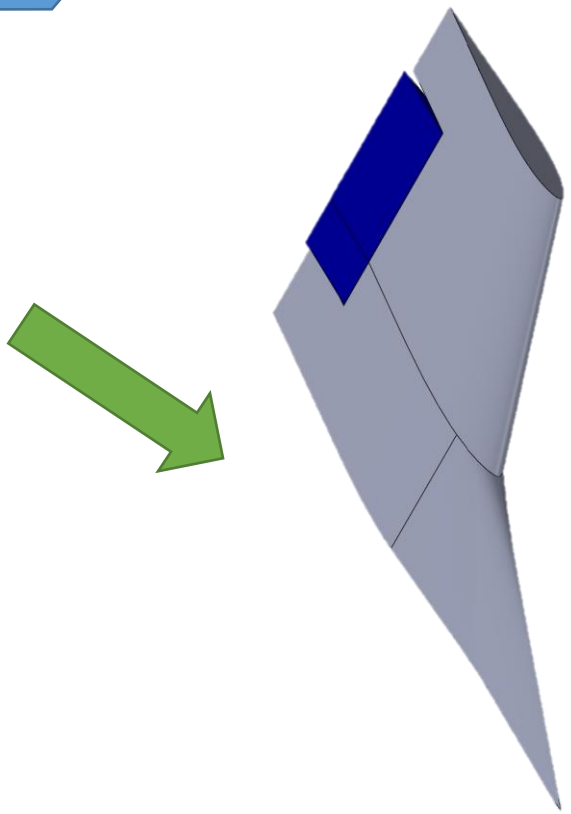
KST X10 Wing Servo

Presenter: SP

Current Work – CAD Assistance







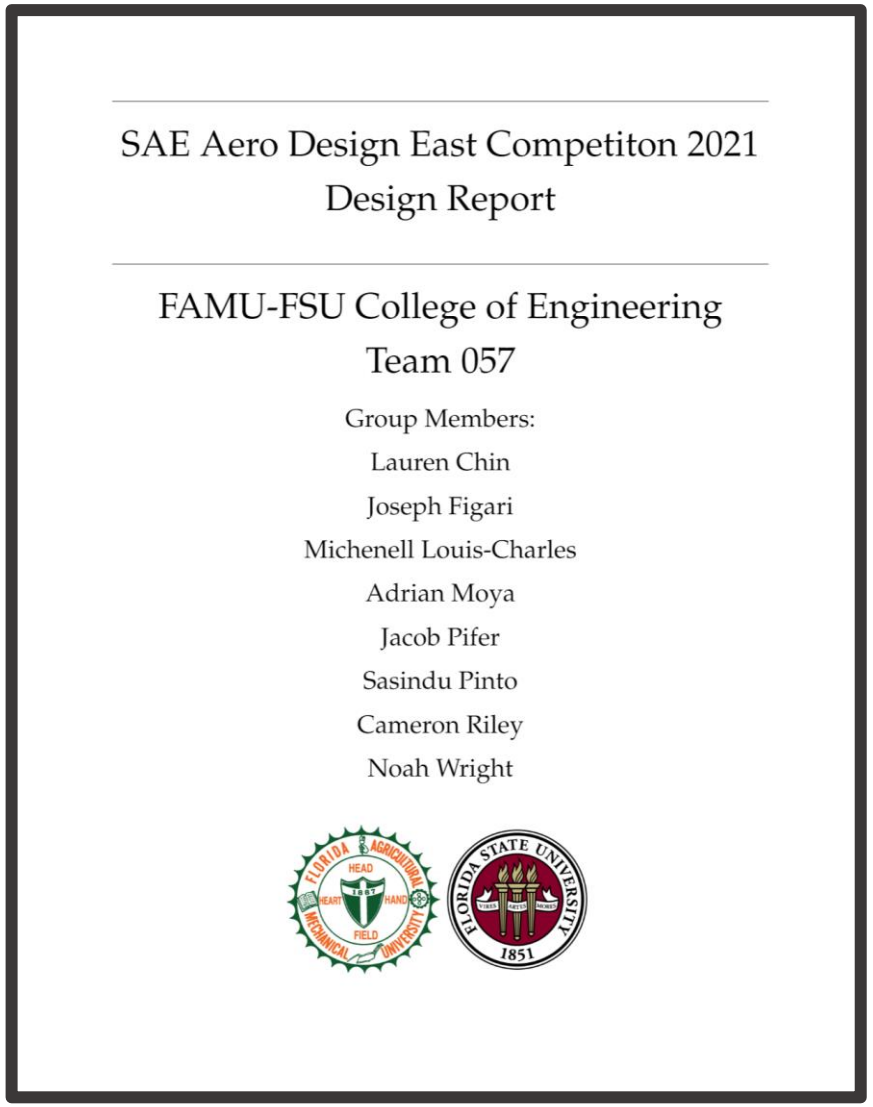
Main Wing

Tail Wing – Vertical Section

Presenter: SP

Current Work – Design Report

- Required for the design knowledge event
  - Minimum page amount – 30 pages
- Includes the complete design process and the manufacturing event
- Was submitted on 01/18/2021



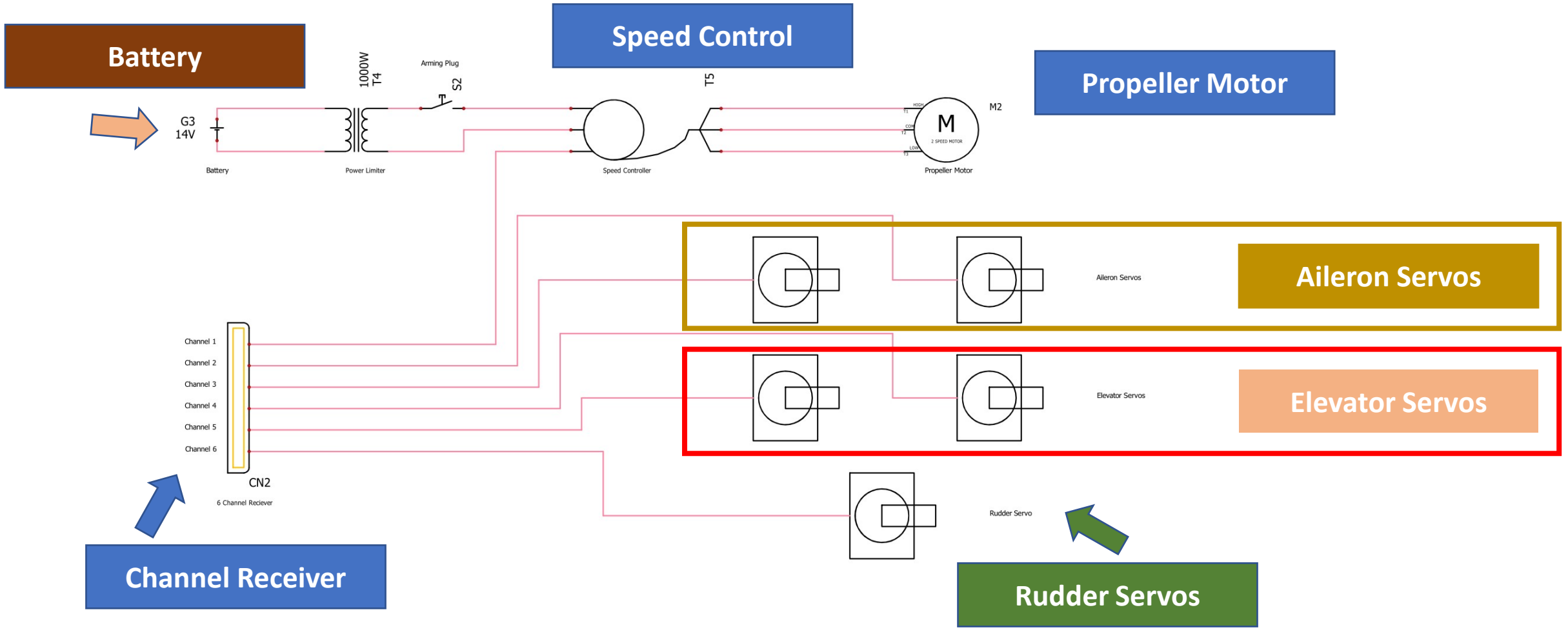
SAE Aero Design East Competiton 2021
Design Report

FAMU-FSU College of Engineering
Team 057

Group Members:
Lauren Chin
Joseph Figari
Michenell Louis-Charles
Adrian Moya
Jacob Pifer
Sasindu Pinto
Cameron Riley
Noah Wright

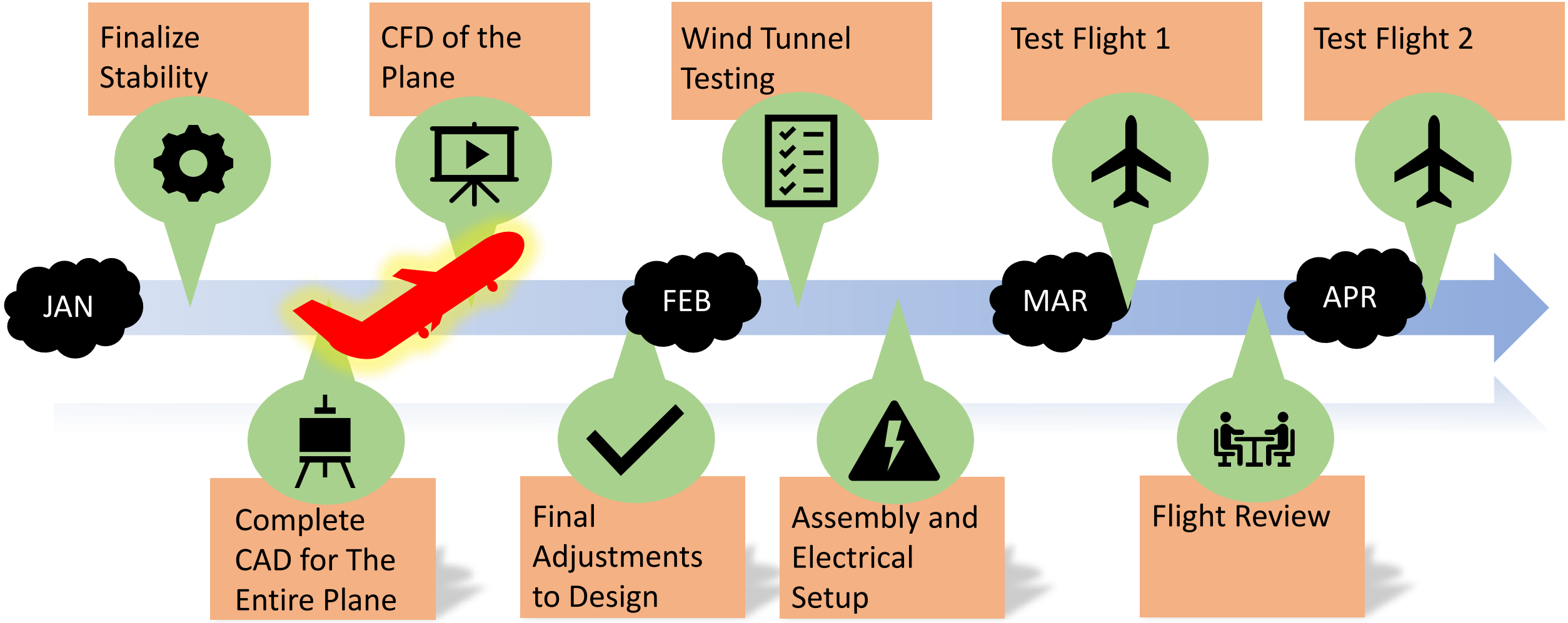
Presenter: SP

Future Work – Wiring and Electronics



Presenter: SP

Project Timeline – Spring



Presenter: SP

References

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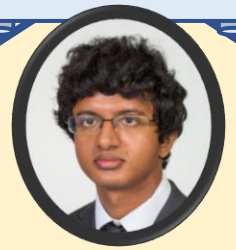
SAE Aero Design Competition 2021 Rule Book. Available on: https://public.3.basecamp.com/p/38Lpy4uyTLpNkwTZbtwjgtBZ

Tail Types. What-When-How. N.d. http://what-when-how.com/flight/tail-designs/

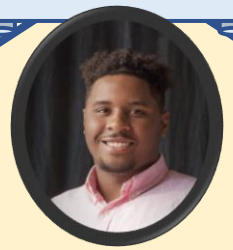
Presenter: AM

LinkedIn Information

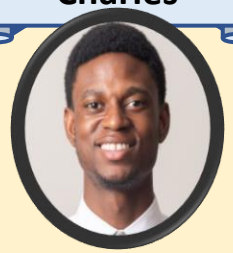
Sasindu Pinto



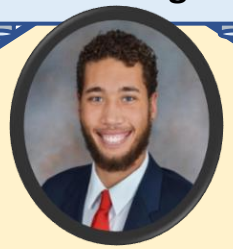
Cameron Riley



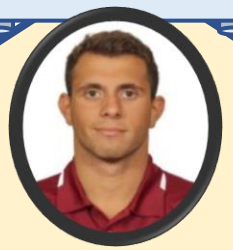
Michenell Louis-Charles



Noah Wright



Adrian Moya



Trust and LG | CAD and CFD | Stability | Backup Slides – Part 2

Backup Slides

Markets and Stakeholders

Markets

- Primary
  - SAE Aero Design Competition
  - Advisors
  - Sponsors
- Secondary
  - Professionals in the Aviation field
  - Aviation Companies
  - RC Hobbyists
  - Scholars that reference this project

Stakeholders

- Dr. McConomy and Dr. Shih
- FAMU-FSU College of Engineering
- SAE Design Competition
- RC Pilots

Presenter: CR

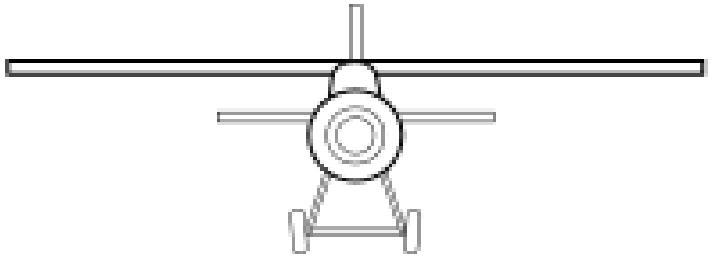
Design concepts

Rectangular

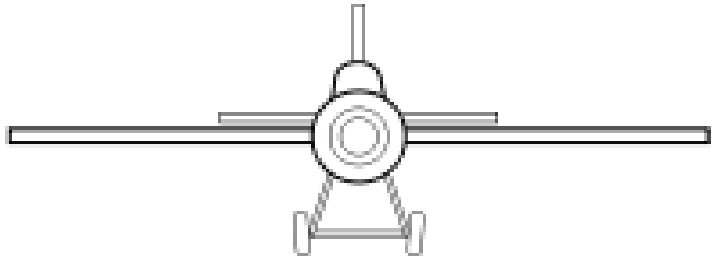
Rectangular Tapered

Rectangular
Elliptical

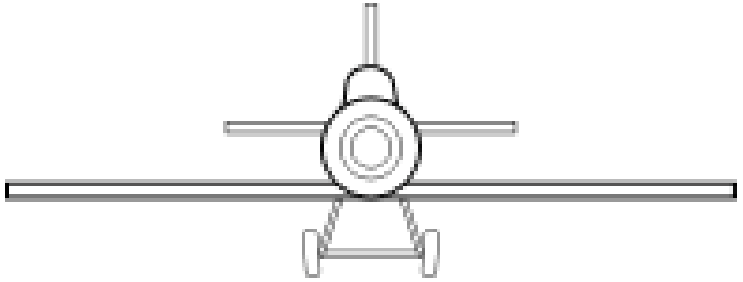
Elliptical



High-Wing



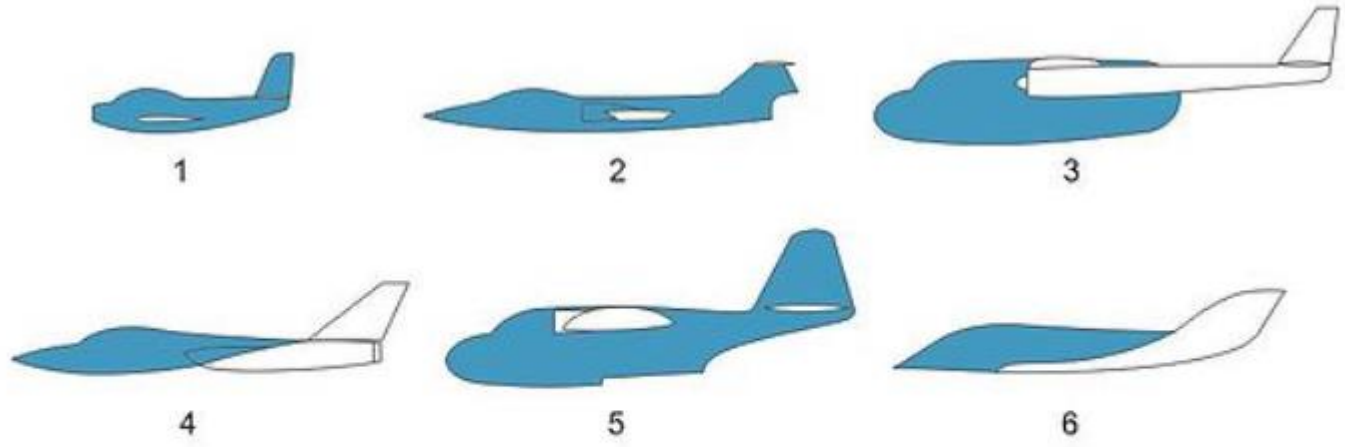
Mid-Wing



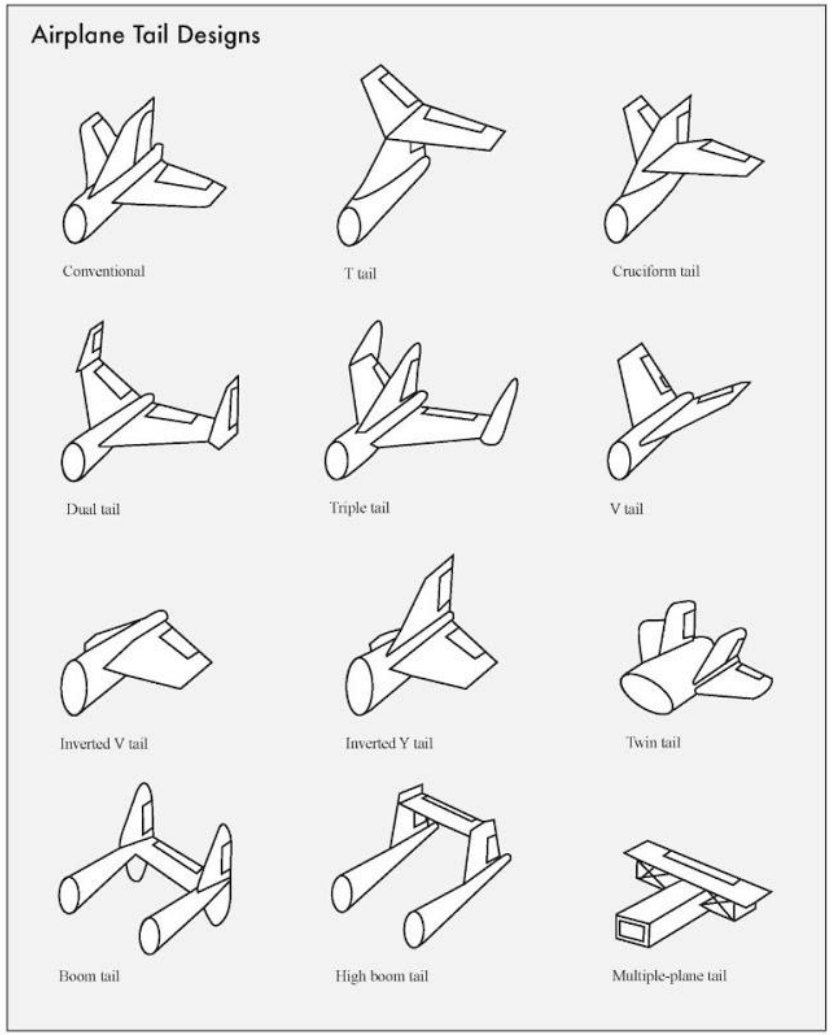
Low-Wing

Design Concepts

Fuselage Layouts



- 1: Subsonic
- 2: High-speed / supersonic
- 3: High-capacity subsonic
- 4: High-maneuverability supersonic
- 5: Flying boat
- 6: Hypersonic



Morphological Analysis

Morphological Analysis					
Wing Layout	Wing Type	Wing Position	Control Surfaces	Fuselage	Tail
Main-Tail	Main - Forward Swept Tail- Symmetric (x-29)	High Wing	Aileron	Bullet	Boom-Mounted Inverted V
Trapezoidal	Delta Wing	Mid Wing	Flaps	Flying Boat	H-Tail
Canard-Main	Main - Elliptical Tail - Symmetric	Low Wing	Elevators	Double Boom	Twin-Tail
	Main - Trapezoidal Tail - Symmetric				Tapered
					Triple-Tail
					Y-Tail

Competitive Benchmarking

Rutan Long E-Z:
Small composite plane with canards & tip sails

Cessna 208 Grand Caravan:
Typical bush plane with extra cargo space

Kawasaki C-2:
Japanese military cargo plane

Binary Pairwise Comparison

Binary Pairwise Comparison													
	1	2	3	4	5	6	7	8	9	10	11	12	Total
1. Material	-	0	0	0	0	0	0	1	0	0	0	0	1
2. Stability	1	-	0	0	0	1	1	1	1	0	0	1	6
3. CG in front of CP	1	1	-	1	1	1	1	1	1	1	1	1	10
4. Meet takeoff/landing requirements	1	1	0	-	1	1	1	0	1	0	0	1	7
5. Wingspan meets restrictions	1	1	0	0	-	1	1	1	1	0	0	1	7
6. Sufficient Power	1	0	0	0	0	-	0	0	1	1	1	1	5
7. Maneuverability	1	0	0	0	0	1	-	0	1	0	0	1	4
8. Light Weight	0	0	0	1	0	1	1	-	1	1	0	1	6
9. Touch-down Impact	1	0	0	0	0	0	0	0	-	0	0	1	2
10. Ground Controls	1	1	0	1	1	0	1	0	1	-	1	1	7
11. Carry the Minimum Cargo Load Required	1	1	0	1	1	0	1	1	1	0	-	1	8
12. Easy to Load/Unload	1	0	0	0	0	0	0	0	0	0	0	-	1
Total	10	5	0	4	4	6	7	5	9	4	3	10	-

Presenter: AM

Binary Pairwise Comparison

Binary Pairwise Comparison													
	1	2	3	4	5	6	7	8	9	10	11	12	Total
1. Material	-	0	0	0	0	0	0	1	0	0	0	0	1
2. Stability	1	-	0	0	0	1	1	1	1	0	0	1	6
3. CG in front of CP	1	1	-	1	1	1	1	1	1	1	1	1	10
4. Meet takeoff/landing requirements	1	1	0	-	1	1	1	0	1	0	0	1	7
5. Wingspan meets restrictions	1	1	0	0	-	1	1	1	1	0	0	1	7
6. Sufficient Power	1	0	0	0	0	-	0	0	1	1	1	1	5
7. Maneuverability	1	0	0	0	0	1	-	0	1	0	0	1	4
8. Light Weight	0	0	0	1	0	1	1	-	1	1	0	1	6
9. Touch-down Impact	1	0	0	0	0	0	0	0	-	0	0	1	2
10. Ground Controls	1	1	0	1	1	0	1	0	1	-	1	1	7
11. Carry the Minimum Cargo Load Required	1	1	0	1	1	0	1	1	1	0	-	1	8
12. Easy to Load/Unload	1	0	0	0	0	0	0	0	0	0	0	-	1
Total	10	5	0	4	4	6	7	5	9	4	3	10	-

Presenter: AM

HOQ

House of Quality

House of Quality														
		Engineering Characteristics (***From Main Targets***)												
Improvement Direction		↑	↓	↑	↑	↑	↑	↑	↓	↓	↑	↑	=	
Units		lbf	lbf	lbf	degrees	ft/s	ft/s^2	degrees	seconds	lbs	ft/s^2	psi	psi	
Customer Requirements	Importance Weight Factor	Lift	Drag	Thrust	Max Angle of Attack	Stall Speed	Acceleration	Control Surface Movement	Loading/ Unloading Time	Weight	Deceleration	Joint Strength	Material Strength	
1. Material	1		1							9		9	9	
2. Stability	6	9	3	3				9						
3. CG in front of CP	10	9	3	9	9	9		9		3				
4. Meet takeoff/landing requirements	7	9	3	9			9				9			
5. Wingspan meets restrictions	7	9	3		3	3		1				3	3	
6. Sufficient Power	5	1	1	3			3	3		1	1			
7. Maneuverability	4				3	3		9		3		3	1	
8. Light Weight	6	3		3			3			9	3			
9. Touch-down Impact	2							3		3	9	9	9	
10. Ground Controls	7							1						
11. Carry the Minimum Cargo Load Required	8	9		3			3		9	9	3	9	9	
12. Easy to Load/Unload	1								9	3		3		
Raw Score		365	96	228	123	123	120	215	81	191	128	135	124	
Relative Weight %		18.92	4.98	11.82	6.38	6.38	6.22	11.15	4.20	9.90	6.64	7.00	6.43	
Rank Order		1	11	2	6	6	10	3	12	4	8	5	9	

Presenter: SP

House of Quality

House of Quality														
		Engineering Characteristics (***From Main Targets***)												
Improvement Direction		↑	↓	↑	↑	↑	↑	↑	↓	↓	↑	↑	=	
Units		lbf	lbf	lbf	degrees	ft/s	ft/s^2	degrees	seconds	lbs	ft/s^2	psi	psi	
Customer Requirements	Importance Weight Factor	Lift	Drag	Thrust	Max Angle of Attack	Stall Speed	Acceleration	Control Surface Movement	Loading/ Unloading Time	Weight	Deceleration	Joint Strength	Material Strength	
1. Material	1		1							9		9	9	
2. Stability	6	9	3	3				9						
3. CG in front of CP	10	9	3	9	9	9		9		3				
4. Meet takeoff/landing requirements	7	9	3	9			9				9			
5. Wingspan meets restrictions	7	9	3		3	3		1				3	3	
6. Sufficient Power	5	1	1	3			3	3		1	1			
7. Maneuverability	4				3	3		9		3		3	1	
8. Light Weight	6	3		3			3			9	3			
9. Touch-down Impact	2							3		3	9	9	9	
10. Ground Controls	7							1						
11. Carry the Minimum Cargo Load Required	8	9		3			3		9	9	3	9	9	
12. Easy to Load/Unload	1								9	3		3		
Raw Score		365	96	228	123	123	120	215	81	191	128	135	124	
Relative Weight %		18.92	4.98	11.82	6.38	6.38	6.22	11.15	4.20	9.90	6.64	7.00	6.43	
Rank Order		1	11	2	6	6	10	3	12	4	8	5	9	

Presenter: SP

House of Quality

House of Quality													
		Engineering Characteristics (***From Main Targets***)											
Improvement Direction		↑	↓	↑	↑	↑	↑	↑	↓	↓	↑	↑	=
Units		lbf	lbf	lbf	degrees	ft/s	ft/s^2	degrees	seconds	lbs	ft/s^2	psi	psi
Customer Requirements	Importance Weight Factor	Lift	Drag	Thrust	Max Angle of Attack	Stall Speed	Acceleration	Control Surface Movement	Loading/ Unloading Time	Weight	Deceleration	Joint Strength	Material Strength
1. Material	1		1							9		9	9
2. Stability	6	9	3	3				9					
3. CG in front of CP	10	9	3	9	9	9		9		3			
4. Meet takeoff/landing requirements	7	9	3	9			9				9		
5. Wingspan meets restrictions	7	9	3		3	3		1				3	3
6. Sufficient Power	5	1	1	3			3	3		1	1		
7. Maneuverability	4				3	3		9		3		3	1
8. Light Weight	6	3		3			3			9	3		
9. Touch-down Impact	2							3		3	9	9	9
10. Ground Controls	7							1					
11. Carry the Minimum Cargo Load Required	8	9		3			3		9	9	3	9	9
12. Easy to Load/Unload	1								9	3		3	
Raw Score		365	96	228	123	123	120	215	81	191	128	135	124
Relative Weight %		18.92	4.98	11.82	6.38	6.38	6.22	11.15	4.20	9.90	6.64	7.00	6.43
Rank Order		1	11	2	6	6	10	3	12	4	8	5	9

Presenter: SP

House of Quality

House of Quality													
		Engineering Characteristics (***From Main Targets***)											
Improvement Direction		↑	↓	↑	↑	↑	↑	↑	↓	↓	↑	↑	=
Units		lbf	lbf	lbf	degrees	ft/s	ft/s^2	degrees	seconds	lbs	ft/s^2	psi	psi
Customer Requirements	Importance Weight Factor	Lift	Drag	Thrust	Max Angle of Attack	Stall Speed	Acceleration	Control Surface Movement	Loading/ Unloading Time	Weight	Deceleration	Joint Strength	Material Strength
1. Material	1		1							9		9	9
2. Stability	6	9	3	3				9					
3. CG in front of CP	10	9	3	9	9	9		9		3			
4. Meet takeoff/landing requirements	7	9	3	9			9				9		
5. Wingspan meets restrictions	7	9	3		3	3		1				3	3
6. Sufficient Power	5	1	1	3			3	3		1	1		
7. Maneuverability	4				3	3		9		3		3	1
8. Light Weight	6	3		3			3			9	3		
9. Touch-down Impact	2							3		3	9	9	9
10. Ground Controls	7							1					
11. Carry the Minimum Cargo Load Required	8	9		3			3		9	9	3	9	9
12. Easy to Load/Unload	1								9	3		3	
Raw Score		365	96	228	123	123	120	215	81	191	128	135	124
Relative Weight %		18.92	4.98	11.82	6.38	6.38	6.22	11.15	4.20	9.90	6.64	7.00	6.43
Rank Order		1	11	2	6	6	10	3	12	4	8	5	9

Presenter: SP

House of Quality

House of Quality														
		Engineering Characteristics (***From Main Targets***)												
Improvement Direction		↑	↓	↑	↑	↑	↑	↑	↓	↓	↑	↑	=	
Units		lbf	lbf	lbf	degrees	ft/s	ft/s^2	degrees	seconds	lbs	ft/s^2	psi	psi	
Customer Requirements	Importance Weight Factor	Lift	Drag	Thrust	Max Angle of Attack	Stall Speed	Acceleration	Control Surface Movement	Loading/ Unloading Time	Weight	Deceleration	Joint Strength	Material Strength	
1. Material	1		1							9		9	9	
2. Stability	6	9	3	3				9						
3. CG in front of CP	10	9	3	9	9	9		9		3				
4. Meet takeoff/landing requirements	7	9	3	9			9				9			
5. Wingspan meets restrictions	7	9	3		3	3		1				3	3	
6. Sufficient Power	5	1	1	3			3	3		1	1			
7. Maneuverability	4				3	3		9		3		3	1	
8. Light Weight	6	3		3			3			9	3			
9. Touch-down Impact	2							3		3	9	9	9	
10. Ground Controls	7							1						
11. Carry the Minimum Cargo Load Required	8	9		3			3		9	9	3	9	9	
12. Easy to Load/Unload	1								9	3		3		
Raw Score		365	96	228	123	123	120	215	81	191	128	135	124	
Relative Weight %		18.92	4.98	11.82	6.38	6.38	6.22	11.15	4.20	9.90	6.64	7.00	6.43	
Rank Order		1	11	2	6	6	10	3	12	4	8	5	9	

Presenter: SP

House of Quality

House of Quality														
		Engineering Characteristics (***From Main Targets***)												
Improvement Direction		↑	↓	↑	↑	↑	↑	↑	↓	↓	↑	↑	=	
Units		lbf	lbf	lbf	degrees	ft/s	ft/s^2	degrees	seconds	lbs	ft/s^2	psi	psi	
Customer Requirements	Importance Weight Factor	Lift	Drag	Thrust	Max Angle of Attack	Stall Speed	Acceleration	Control Surface Movement	Loading/ Unloading Time	Weight	Deceleration	Joint Strength	Material Strength	
1. Material	1		1							9		9	9	
2. Stability	6	9	3	3				9						
3. CG in front of CP	10	9	3	9	9	9		9		3				
4. Meet takeoff/landing requirements	7	9	3	9			9				9			
5. Wingspan meets restrictions	7	9	3		3	3		1				3	3	
6. Sufficient Power	5	1	1	3			3	3		1	1			
7. Maneuverability	4				3	3		9		3		3	1	
8. Light Weight	6	3		3			3			9	3			
9. Touch-down Impact	2							3		3	9	9	9	
10. Ground Controls	7							1						
11. Carry the Minimum Cargo Load Required	8	9		3			3		9	9	3	9	9	
12. Easy to Load/Unload	1								9	3		3		
Raw Score		365	96	228	123	123	[illegible]	215	81	191	128	135	124	
Relative Weight %		18.92	4.98	11.82	6.38	6.38	6.22	11.15	4.20	9.90	6.64	7.00	6.43	
Rank Order		1	11	2	6	[illegible]	[illegible]	3	12	4	8	5	9	

6.75

Presenter: SP

Pugh Charts

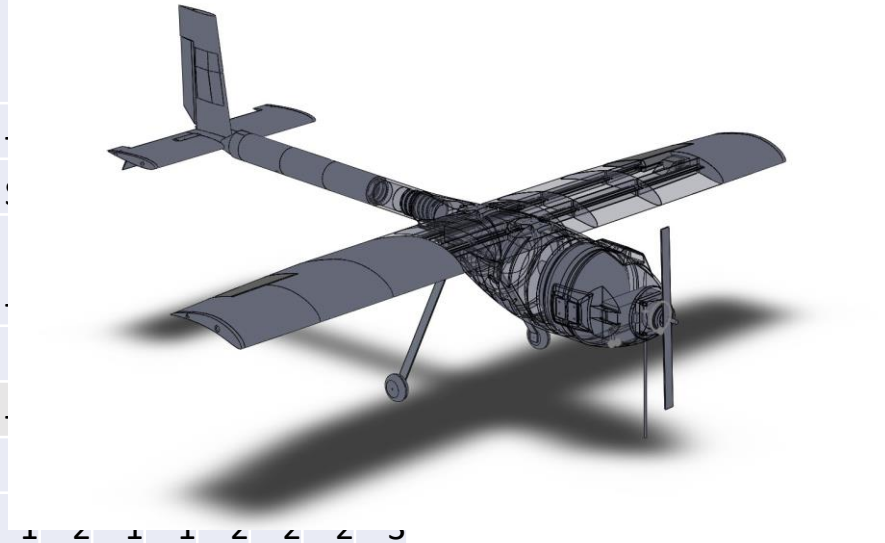
Pugh Chart 1

Pugh Chart 1		Concepts							
		High			Medium				
Selection Criteria	2020 Competition Entry	1	2	3	4	5	6	7	8
Lift	DATUM	+	+	+	-	-	+	-	-
Thrust		S	S	S	S	S	S	S	S
Control Surface Movement		+	+	+	+	S	+	S	S
Weight		-	S	-	-	-	S	-	S
Joint Strength		+	+	+	+	+	+	+	+
# of pluses		3	3	3	2	1	3	1	1
# of S's		1	2	1	1	2	2	2	3
# of Minuses		1	0	1	2	2	0	1	1

Presenter: SP

Pugh Chart 1

Pugh Chart 1		Concepts							
		High			Medium				
Selection Criteria	2020 Competition Entry								
Lift	DATUM								
Thrust									
Control Surface Movement									
Weight									
Joint Strength									
# of pluses									
# of S's		1	2	1	1	2	2	2	3
# of Minuses		1	0	1	2	2	0	1	1



Presenter: SP

Pugh Chart 1

Pugh Chart 1		Concepts							
		High			Medium				
Selection Criteria	2020 Competition Entry	1	2	3	4	5	6	7	8
Lift	DATUM	+	+	+	-	-	+	-	-
Thrust		S	S	S	S	S	S	S	S
Control Surface Movement		+	+	+	+	S	+	S	S
Weight		-	S	-	-	-	S	-	S
Joint Strength		+	+	+	+	+	+	+	+
# of pluses		3	3	3	2	1	3	1	1
# of S's		1	2	1	1	2	2	2	3
# of Minuses		1	0	1	2	2	0	1	1

Presenter: SP

Pugh Chart 2

Pugh Chart 2		Concepts		
		High		Medium
Selection Criteria	Concept 2	1	3	6
Lift	Datum	-	+	-
Thrust		S	S	S
Control Surface Movement		+	+	+
Weight		-	-	-
Joint Strength		S	S	S
# of pluses		1	2	1
# of S's		2	2	2
# of Minuses		2	1	2

Presenter: SP

Pugh Chart 2

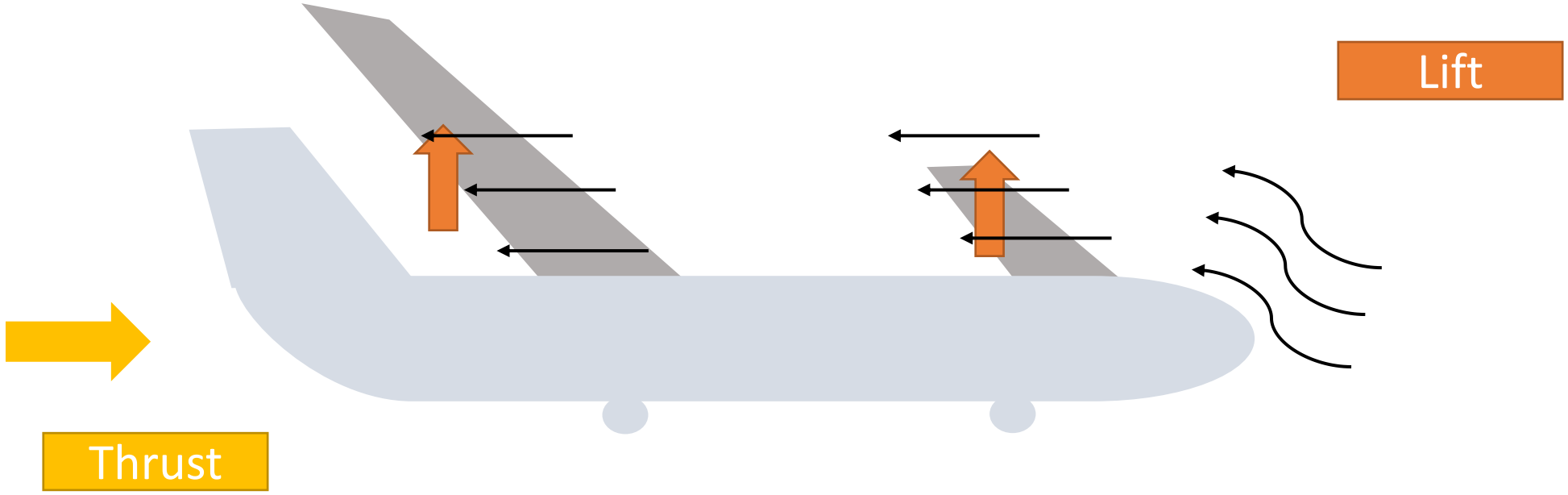
Pugh Chart 2		Concepts		
		High		Medium
Selection Criteria	Concept 2	1	3	6
Lift	Datum	-	+	-
Thrust		S	S	S
Control Surface Movement		+	+	+
Weight		-	-	-
Joint Strength		S	S	S
# of pluses		1	2	1
# of S's		2	2	2
# of Minuses		2	1	2

Presenter: SP

AHP Criteria Comparison

Criteria Comparison - AHP

Lift vs Thrust

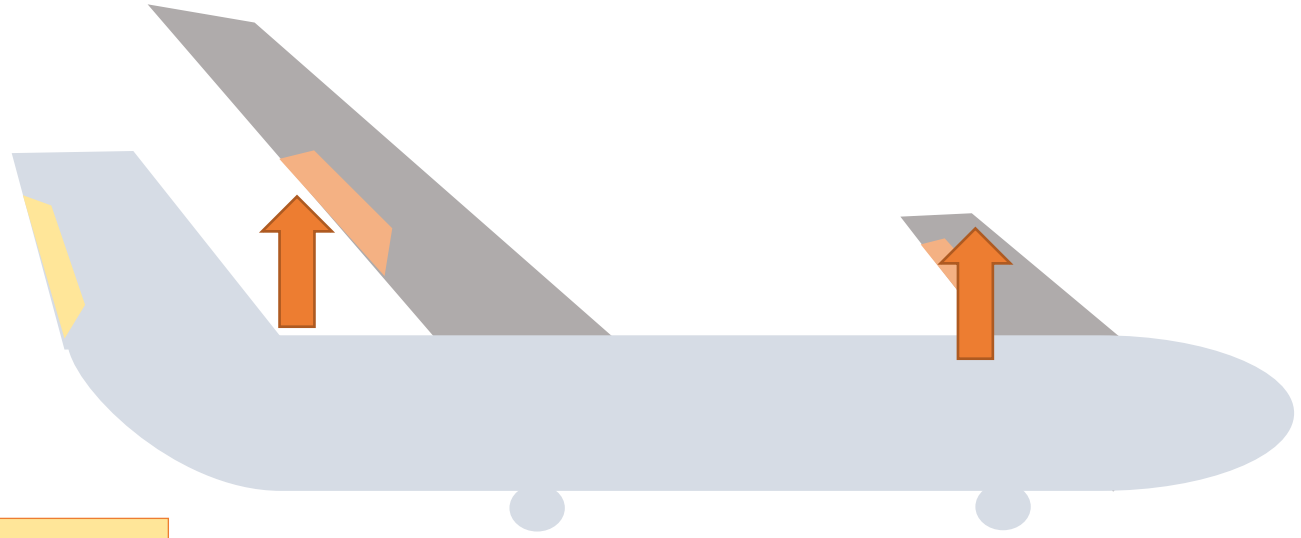


Thrust > Lift

Presenter: SP

Criteria Comparison - AHP

Lift vs Control Surface



Lift

Rudder

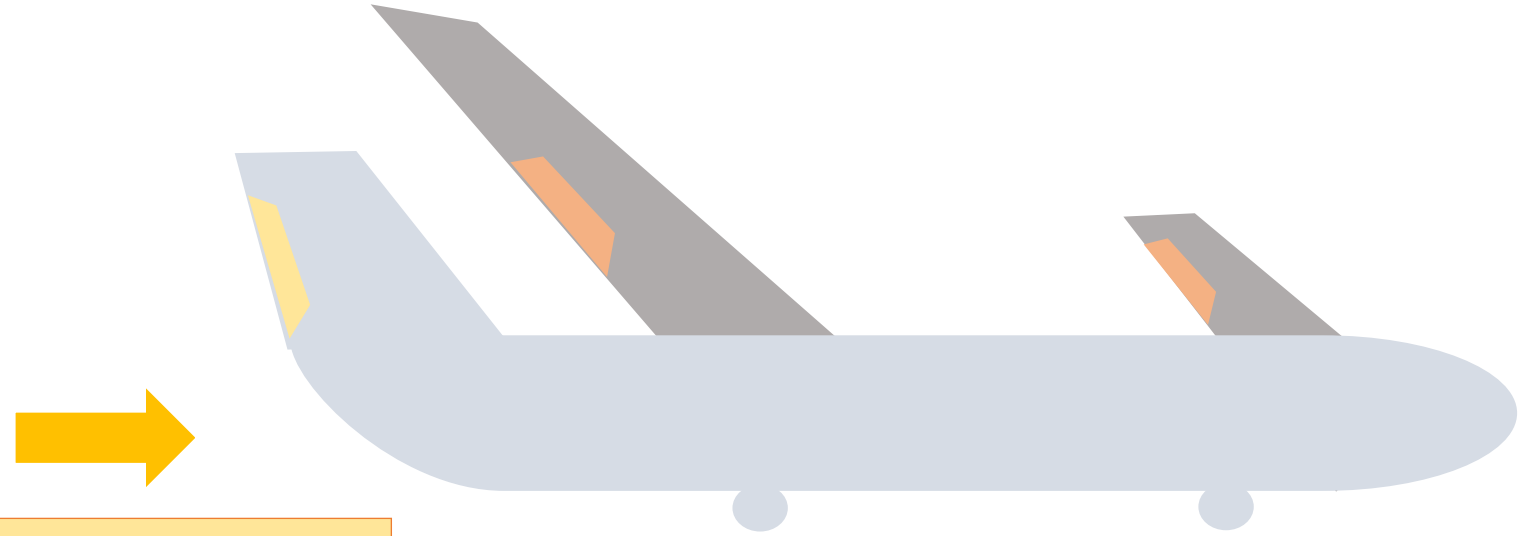
Elevators/Ailerons

Lift > Control Surface

Presenter: SP

Criteria Comparison - AHP

Thrust vs Control Surface

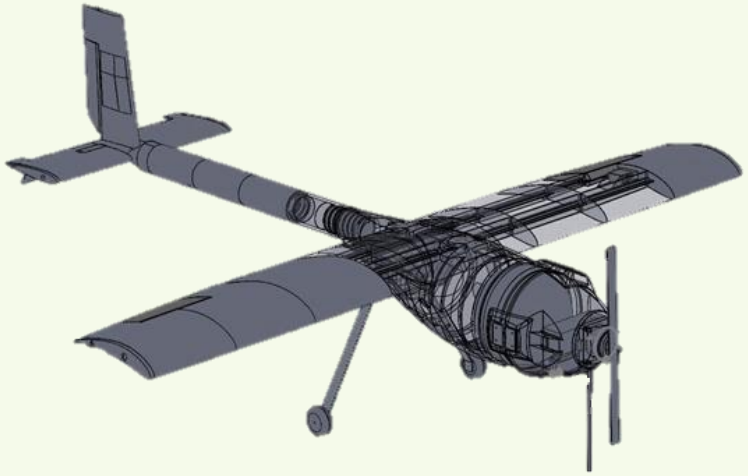


R Thrust

Elevators/Ailerons

Thrust > Control Surface

Presenter: SP



1. Boomtown

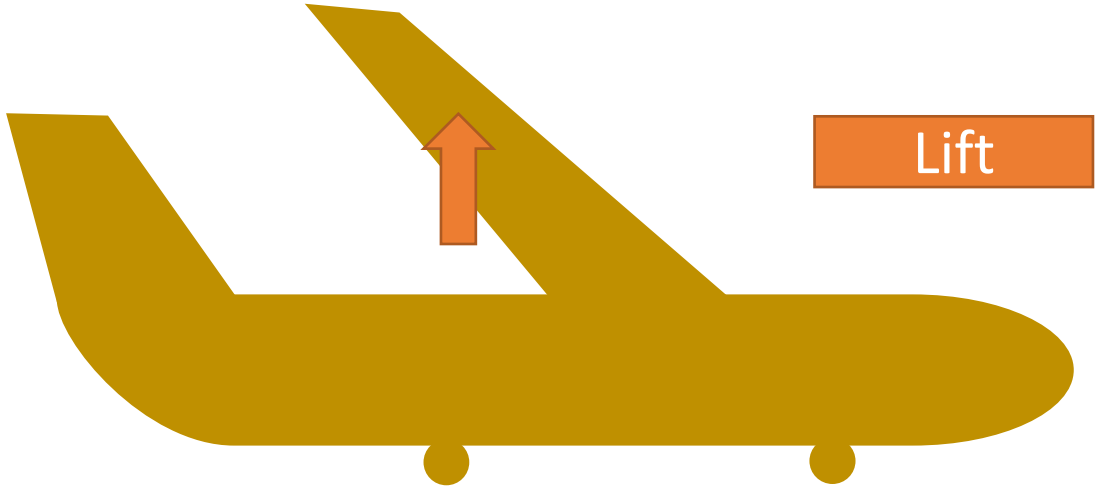
Concepts Considered for AHP

3. Rutan Quickie Q2

6. OMAC Laser 300

Presenter: SP

Lift Comparison for Concepts - AHP

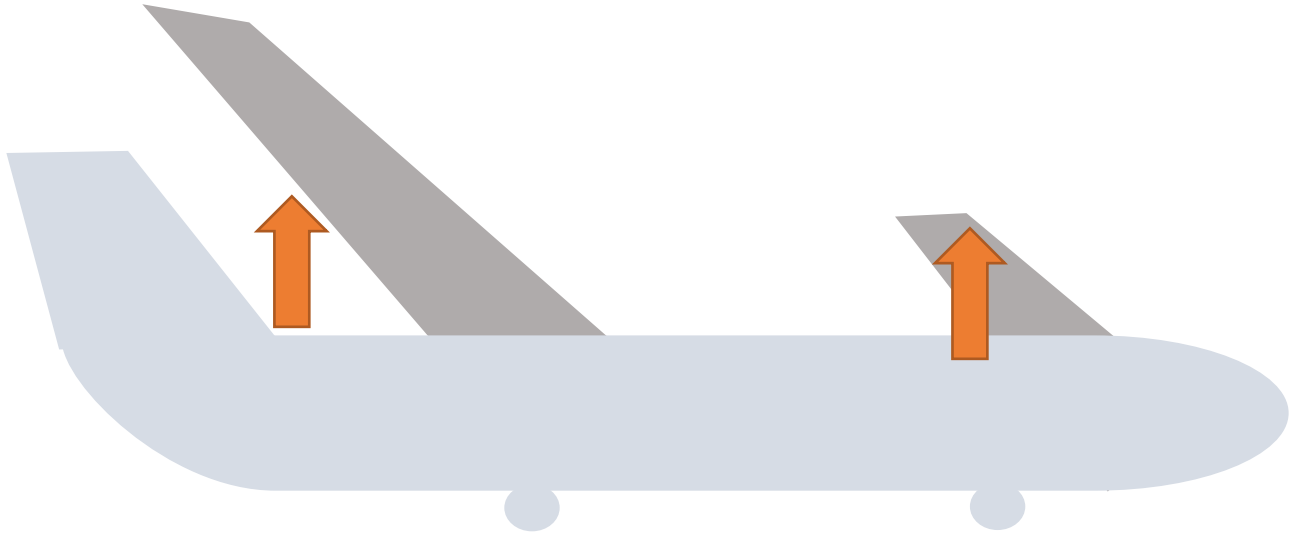


Just the main wing

Concept 1: Boomtown

Presenter: SP

Lift Comparison for Concepts - AHP



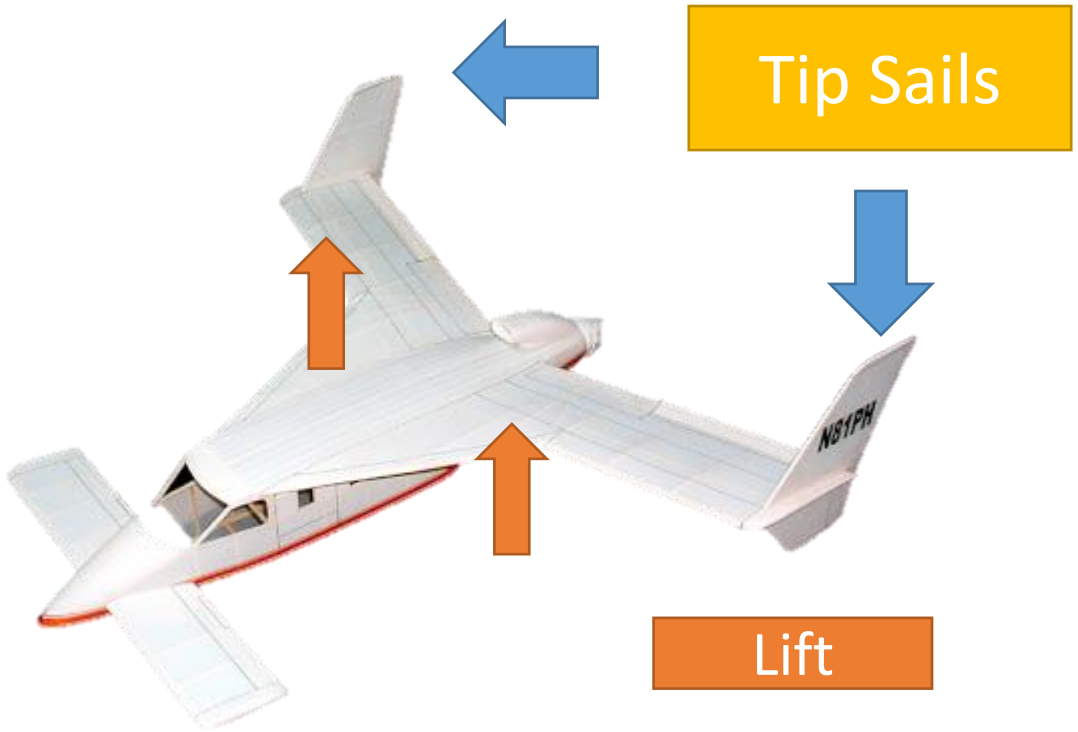
Lift

Canard + Main Wing

Concept 3: Rutan Quickie Q2

Presenter: SP

Lift Comparison for Concepts - AHP



Concept 6: OMAC 300 Laser Plane

Lower Wingspan +
Delta Restriction

Presenter: SP

Lift Comparison Matrix - AHP

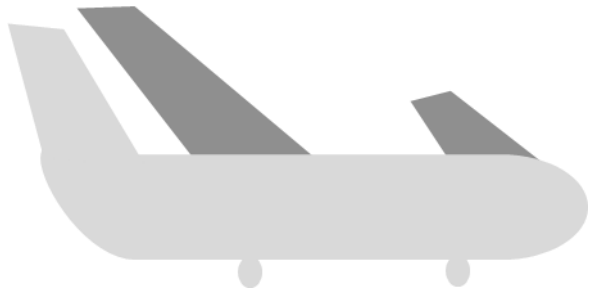
Comparison for All Criteria			
Thrust	CSM	Weight	Joint Strength

Lift Comparison			
	Concept 1	Concept 3	Concept 6
Concept 1	1.00	0.33	3.00
Concept 3	3.00	1.00	7.00
Concept 6	0.33	0.14	1.00
Sum	4.33	1.48	11.00

λ Average Consistency	CI Consistency Index	CR Consistency Ratio
3.00703	0.00352	0.00676

CR<0.1

1

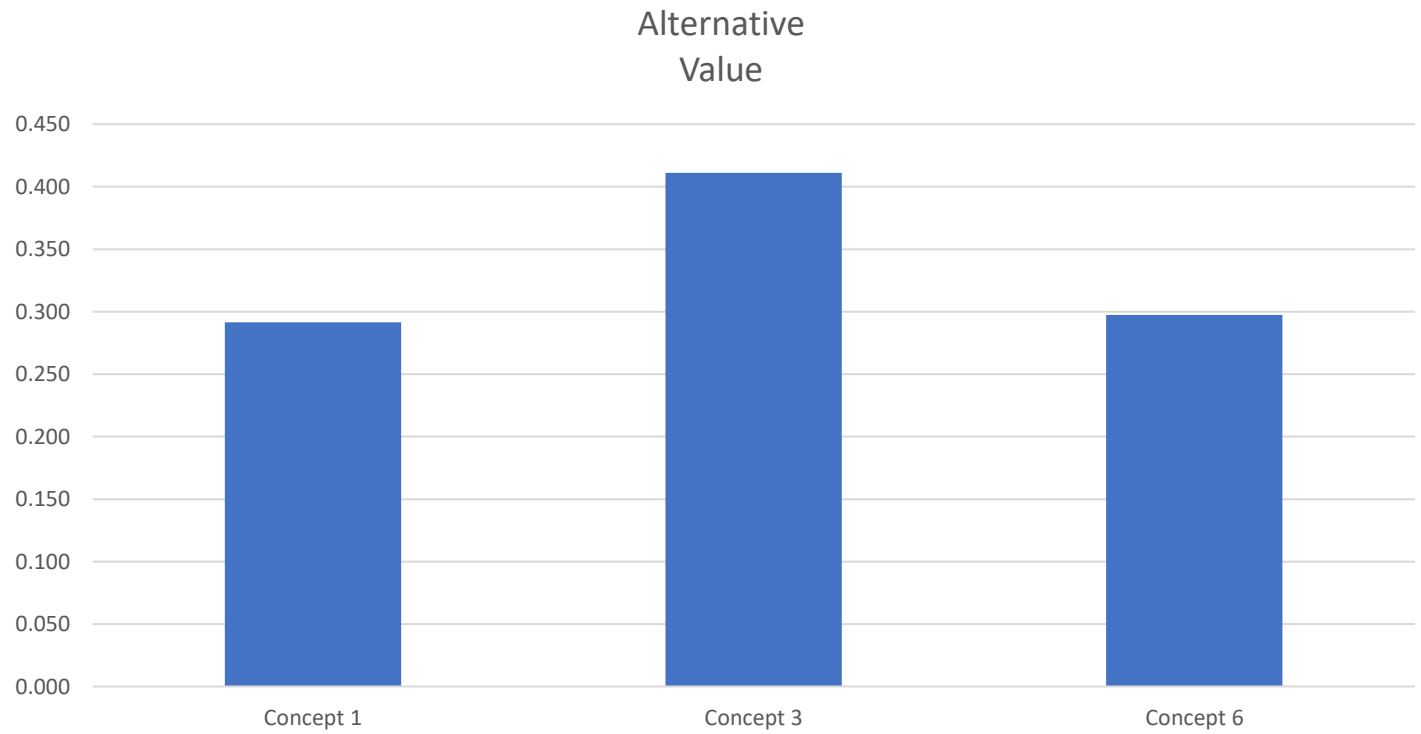


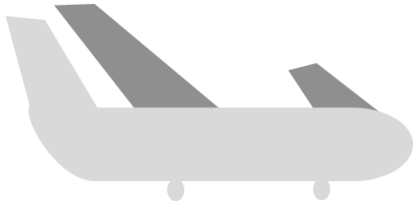
3

6

Presenter: SP

Concept Comparison- AHP





Presenter: SP

Criteria Comparison Matrix

Development of a Candidate set of Criteria Weights {W}					
Criteria Comparison Matrix					
	Lift	Thrust	Control Surface Movement	Weight	Joint Strength
Lift	1.00	0.33	3.00	9.00	9.00
Thrust	3.00	1.00	3.00	9.00	9.00
Control Surface Movement	0.33	0.33	1.00	5.00	3.00
Weight	0.11	0.11	0.20	1.00	0.11
Joint Strength	0.11	0.11	0.33	9.00	1.00
Sum	4.56	1.89	7.53	33.00	22.11

Normalized Comparison Matrix

Normalized Criteria Comparison Matrix [NormC]						
Criteria Comparison Matrix						
	Lift	Thrust	Control Surface Movement	Weight	Joint Strength	Criteria Weight
Lift	0.22	0.18	0.40	0.27	0.41	0.295
Thrust	0.66	0.53	0.40	0.27	0.41	0.453
Control Surface Movement	0.07	0.18	0.13	0.15	0.14	0.134
Weight	0.02	0.06	0.03	0.03	0.01	0.029
Joint Strength	0.02	0.06	0.04	0.27	0.05	0.089
Sum	1.00	1.00	1.00	1.00	1.00	1.000

Criteria Comparison Consistency Check

Consistency Check		
{Ws}=[C]{W} Weighted Sum Vector	{W} Criteria Weights	Con={Ws}./{W} Consistency Vector
1.911	0.490	3.899
2.802	0.230	12.184
0.796	0.140	5.683
0.149	0.040	3.720
0.478	0.100	4.780

λ Average Consistency	CI Consistency Index	CR Consistency Ratio
6.053	0.027	0.051

AHP – Lift Tables

Lift Comparison Matrix

Lift Comparison			
	Concept 1	Concept 3	Concept 6
Concept 1	1.00	0.33	3.00
Concept 3	3.00	1.00	7.00
Concept 6	0.33	0.14	1.00
Sum	4.33	1.48	11.00

Normalized Lift Comparison Matrix

Normalized Criteria Comparison Matrix [NormC]				
	Concept 1	Concept 2	Concept 6	Criteria Weight
Concept 1	0.231	0.226	0.273	0.243
Concept 2	0.692	0.677	0.636	0.669
Concept 6	0.077	0.097	0.091	0.088
Sum	1.000	1.000	1.000	1.000

Lift Consistency Check

Consistency Check 1		
{Ws}=[C]{W} Weighted Sum Vector	{W} Criteria Weights	Con={Ws}./{W} Consistency Vector
0.731	0.243	3.005
2.015	0.669	3.014
0.265	0.088	3.002

λ Average Consistency	CI Consistency Index	CR Consistency Ratio
3.00703	0.00352	0.00676

AHP – Thrust Tables

Thrust Comparison

Thrust Comparison			
	Concept 1	Concept 3	Concept 6
Concept 1	1.00	1.00	1.00
Concept 3	1.00	1.00	1.00
Concept 6	1.00	1.00	1.00
Sum	3.00	3.00	3.00

Normalized Thrust Comparison Matrix

Normalized Criteria Comparison Matrix [NormC]				
	Concept 1	Concept 2	Concept 6	Criteria Weight
Concept 1	0.333	0.333	0.333	0.333
Concept 2	0.333	0.333	0.333	0.333
Concept 6	0.333	0.333	0.333	0.333
Sum	1.000	1.000	1.000	1.000

Thrust Consistency Check

Consistency Check 2		
{Ws}=[C]{W} Weighted Sum Vector	{W} Criteria Weights	Con={Ws}./{W} Consistency Vector
1.000	0.333	3.000
1.000	0.333	3.000
1.000	0.333	3.000

λ Average Consistency	CI Consistency Index	CR Consistency Ratio
3.00000	0.00000	0.00000

AHP – Control Surface Movement Tables

Control Surface Comparison Matrix

Control Surface Movement Comparison			
	Concept 1	Concept 3	Concept 6
Concept 1	1.00	3.00	0.20
Concept 3	0.33	1.00	0.20
Concept 6	3.00	5.00	1.00
Sum	4.33	9.00	1.40

Normalized Control Surface Comparison Matrix

Normalized Criteria Comparison Matrix [NormC]				
	Concept 1	Concept 2	Concept 6	Criteria Weight
Concept 1	0.231	0.333	0.143	0.236
Concept 2	0.077	0.111	0.143	0.110
Concept 6	0.692	0.556	0.714	0.654
Sum	1.000	1.000	1.000	1.000

Control Surface Consistency Check

Consistency Check 3		
{Ws}=[C]{W} Weighted Sum Vector	{W} Criteria Weights	Con={Ws}./{W} Consistency Vector
0.697	0.236	2.959
0.320	0.110	2.898
1.912	0.654	2.924

λ Average Consistency	CI Consistency Index	CR Consistency Ratio
2.92716	-0.03642	-0.07004

AHP – Weight Tables

Weight Comparison Matrix

Weight Comparison			
	Concept 1	Concept 3	Concept 6
Concept 1	1.00	0.33	3.00
Concept 3	3.00	1.00	5.00
Concept 6	0.33	0.20	1.00
Sum	4.33	1.53	9.00

Normalized Weight Comparison Matrix

Normalized Criteria Comparison Matrix [NormC]				
	Concept 1	Concept 2	Concept 6	Criteria Weight
Concept 1	0.231	0.217	0.333	0.260
Concept 2	0.692	0.652	0.556	0.633
Concept 6	0.077	0.130	0.111	0.106
Sum	1.000	1.000	1.000	1.000

Weight Consistency Check

Consistency Check 4		
{Ws}=[C]{W} Weighted Sum Vector	{W} Criteria Weights	Con={Ws}./{W} Consistency Vector
0.790	0.260	3.033
1.946	0.633	3.072
0.320	0.106	3.011

λ Average Consistency	CI Consistency Index	CR Consistency Ratio
3.03871	0.01936	0.03723

AHP – Joint Strength Tables

From Team 508

Joint Strength Comparison Matrix (508)

Joint Strength Comparison			
	Concept 1	Concept 3	Concept 6
Concept 1	1.00	1.00	1.00
Concept 3	1.00	1.00	1.00
Concept 6	1.00	1.00	1.00
Sum	3.00	3.00	3.00

Normalized Joint Comparison Matrix (508)

Normalized Criteria Comparison Matrix [NormC]				
	Concept 1	Concept 2	Concept 6	Criteria Weight
Concept 1	0.333	0.333	0.333	0.333
Concept 2	0.333	0.333	0.333	0.333
Concept 6	0.333	0.333	0.333	0.333
Sum	1.000	1.000	1.000	1.000

Joint Strength Consistency Check(508)

Consistency Check 5		
{Ws}=[C]{W} Weighted Sum Vector	{W} Criteria Weights	Con={Ws}./{W} Consistency Vector
1.000	0.333	3.000
1.000	0.333	3.000
1.000	0.333	3.000

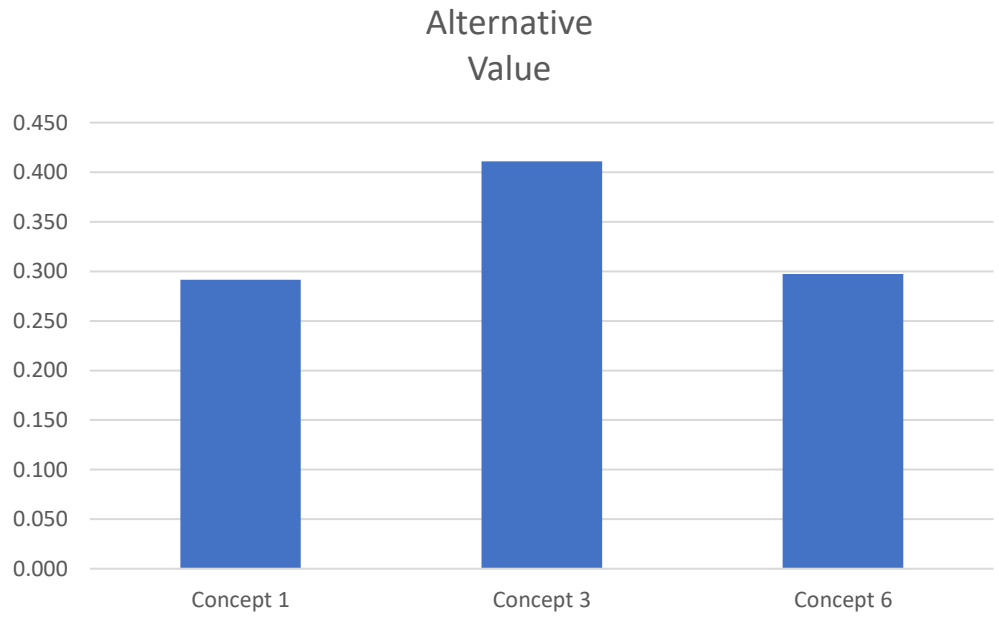
λ Average Consistency	CI Consistency Index	CR Consistency Ratio
3.00000	0.00000	0.00000

Final Rating

Final Rating Matrix

Final Rating Matrix			
Selection Criteria	Concept 1	Concept 2	Concept 6
Lift	0.243	0.669	0.088
Thrust	0.333	0.333	0.333
Control Surface Movement	0.236	0.110	0.654
Weight	0.260	0.633	0.106
Joint Strength	0.333	0.333	0.333

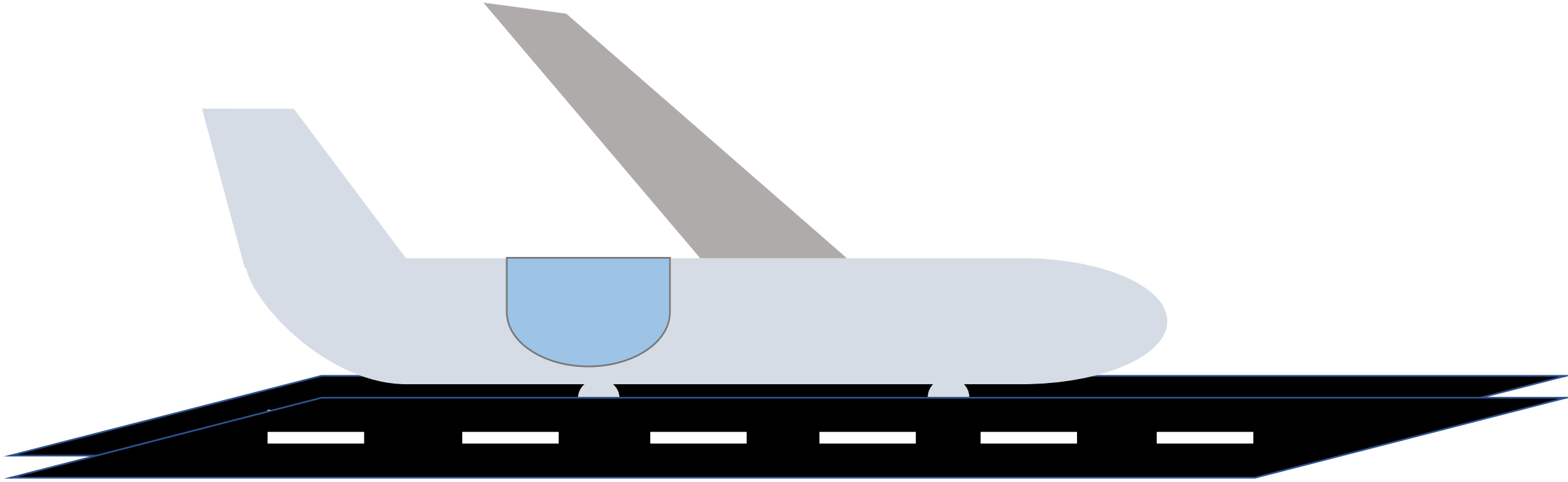
Concept	Alternative Value
Concept 1	0.292
Concept 3	0.411
Concept 6	0.297



Backup Slides – Winter Break

Customer Needs

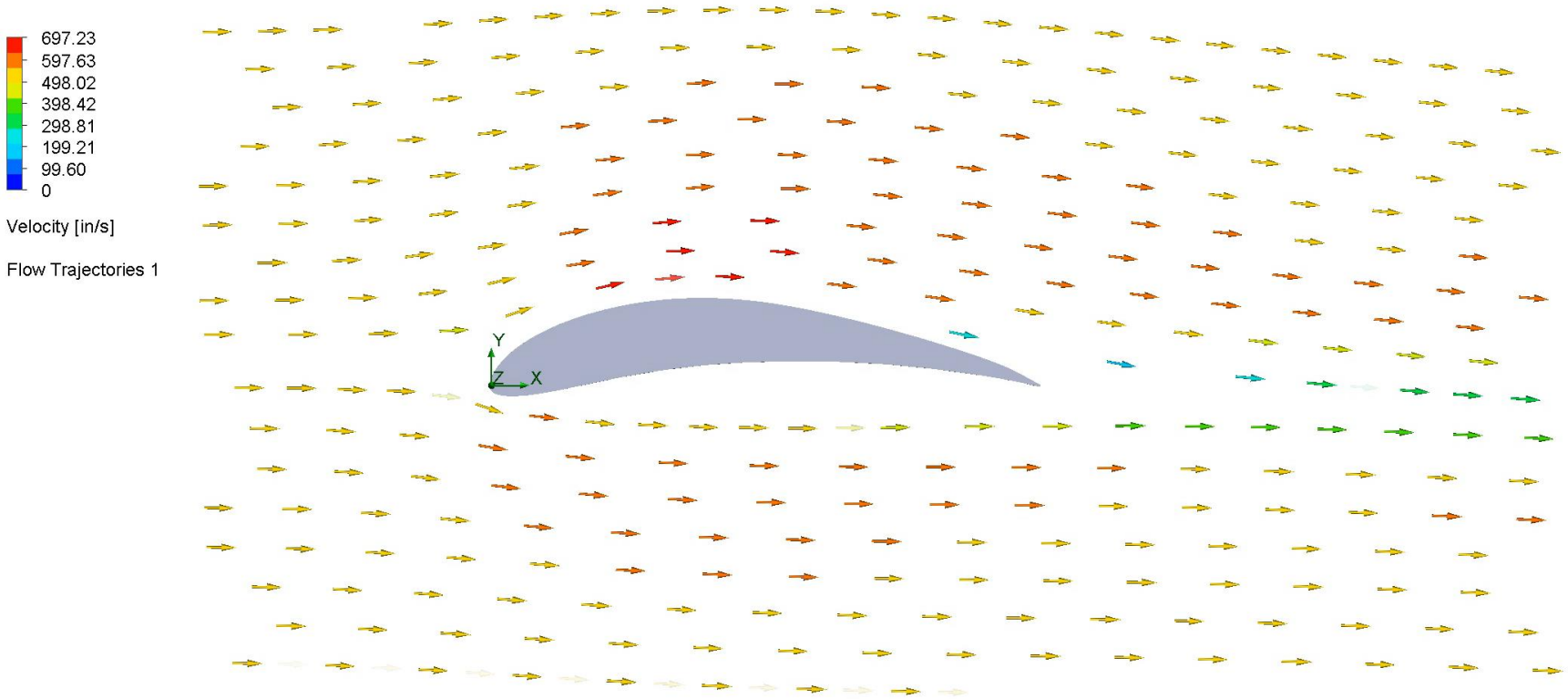
Loading/Unloading time – 1 min



Presenter: CR

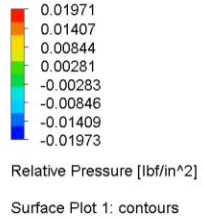
Current Work – Fluid Analysis

Eppler 423 Airfoil



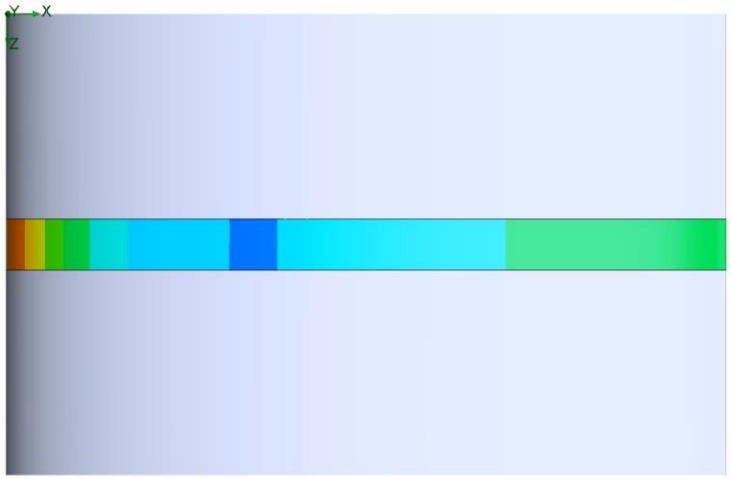
Presenter: AM

Current Work – Fluid Analysis



Drag Force	
X-component of Normal Force	0.017 lbf

Lift Force	
Y-component of Normal Force	0.036 lbf

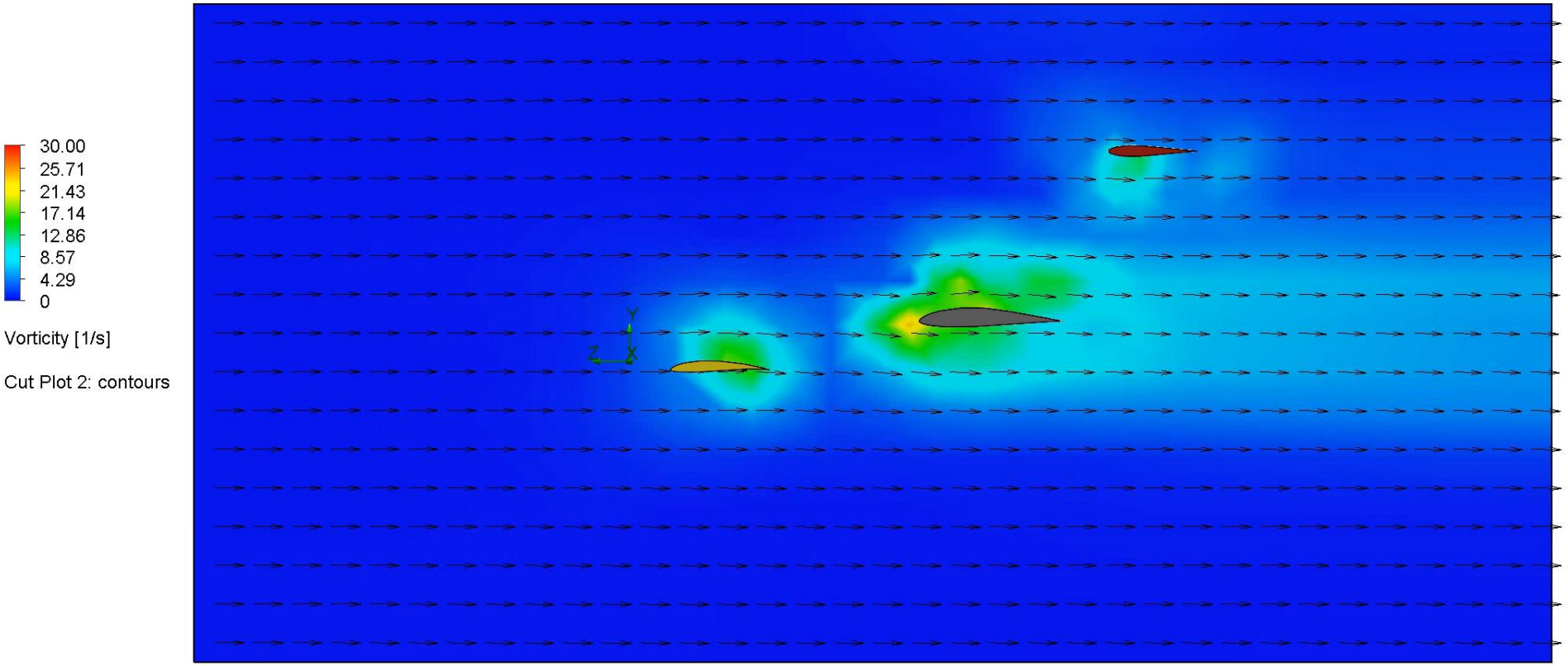


Top Surface

Bottom Surface

Presenter: AM

Initial CFD – Shell Properties



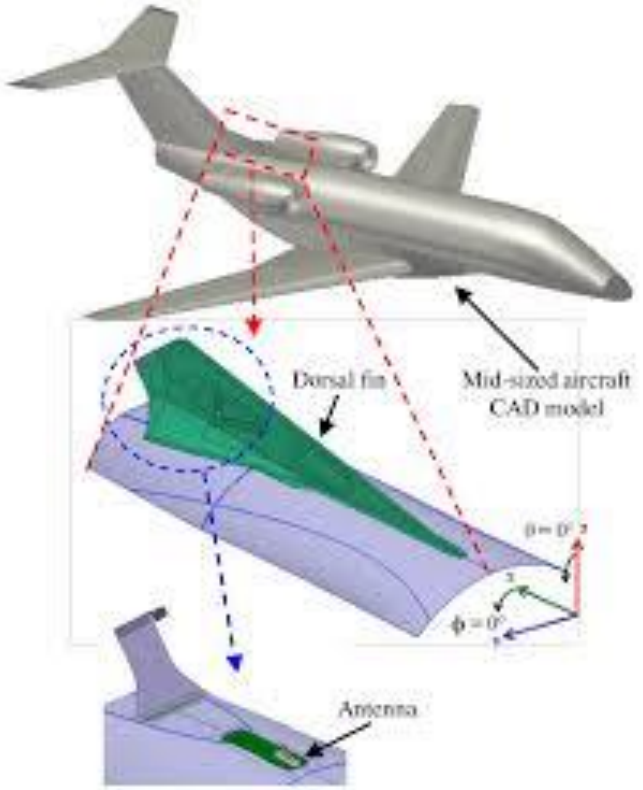
Presenter: AM

Fuselage Based on Lockheed X

Presenter: AM

Dorsal Fin

Dolphin Dorsal Fin



Biomimicry in Aircrafts

Presenter: AM