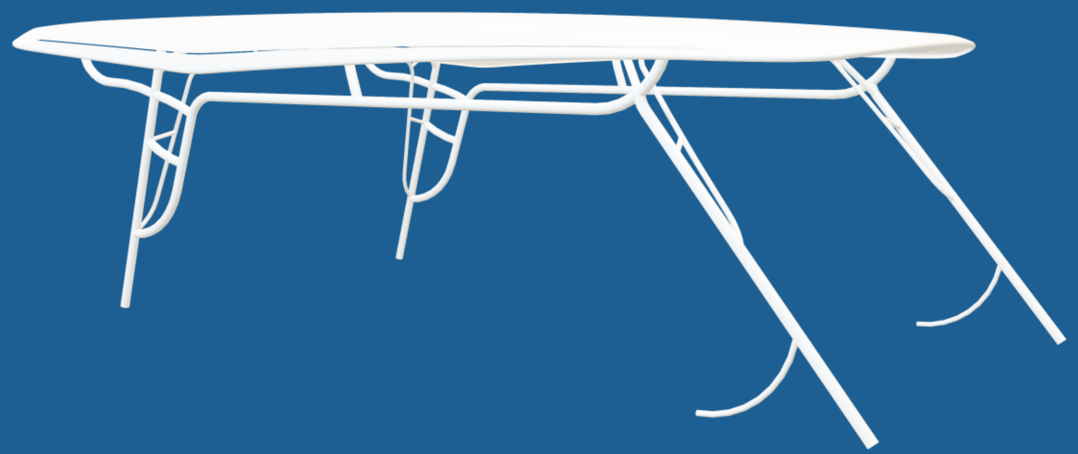
Team 511: Intrepid Hardtop



Juan Tapia   John Karamitsanis   Cory Stanley   Erika Craft

Intrepid - Redesigned Hardtop
Team 511

Materials Engineer
Juan Tapia

Lead Engineer
John Karamitsanis

Mechanical Design Engineer
Cory Stanley

Marine Design Engineer
Erika Craft

Erika Craft

Sponsors, Advisor, & Coordinator

President
Ken Clinton

V.P. of Engineering
Richard Ahl

Academic Advisor
Dr. William Oates

Senior Design Coordinator
Dr. Shayne McConomy

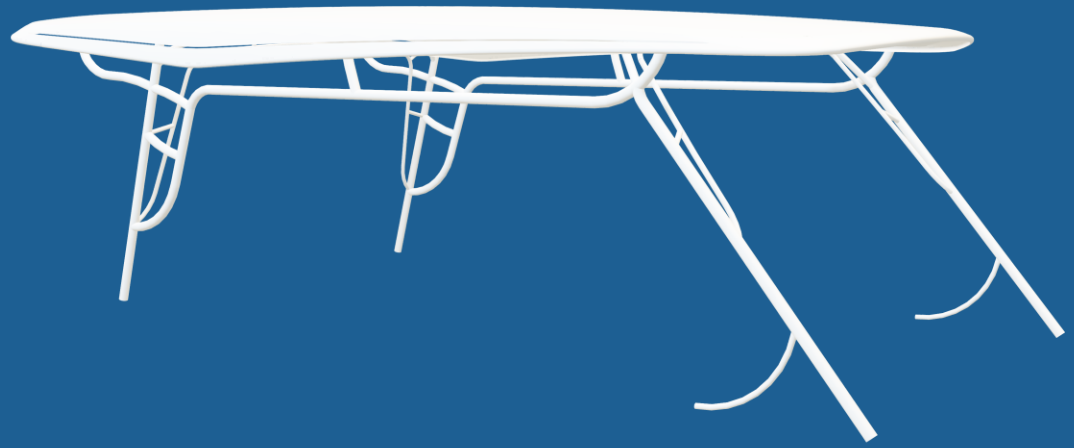
Erika Craft

Objective

To improve the on-water performance of the Intrepid 409 Valor by manipulating hardtop parameters.

Erika Craft

Description



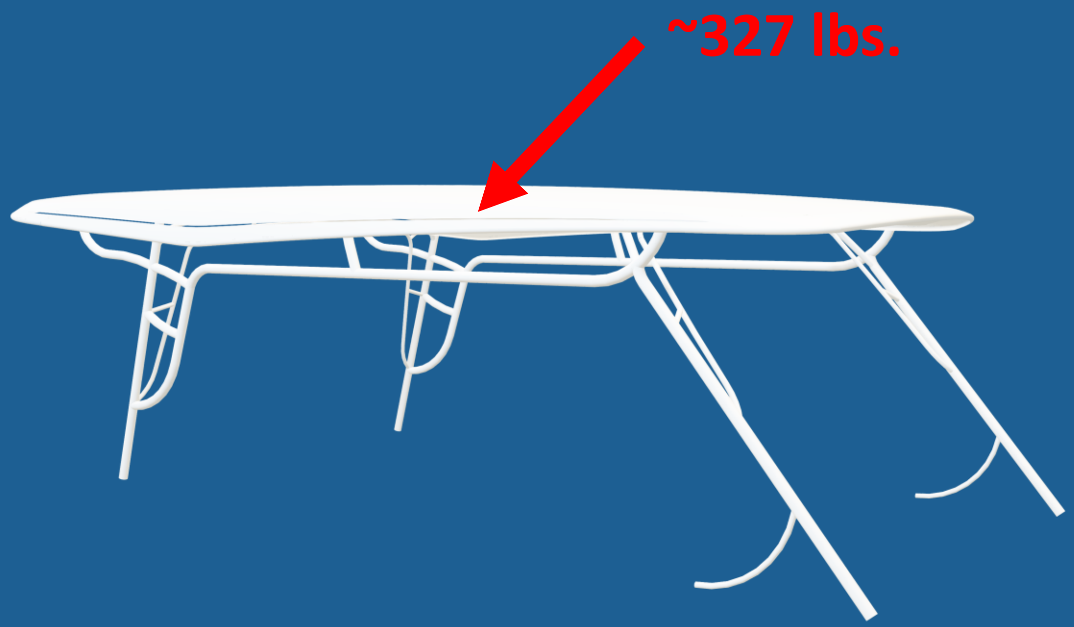
Intrepid wants to improve vessel performance

The current hardtop is heavier than desired

Improving the hardtop can solve Intrepid's problem of improving performance

Erika Craft

Description



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Erika Craft

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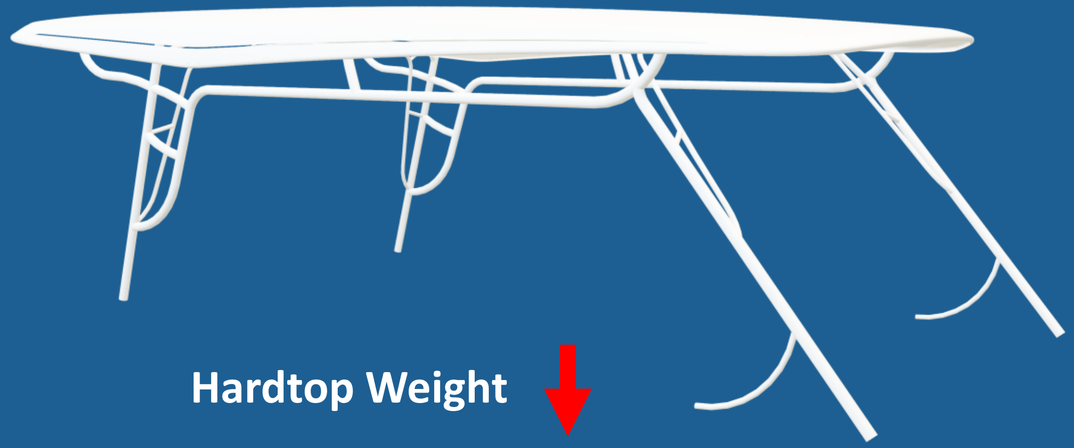


Hardtop Weight ↓

Lift ↑

Drag ↓

Erika Craft

Key Goals

Improve boat on water performance

Improve fuel efficiency

Analyze and enhance aerodynamics

Keep the design manufacturable

Erika Craft

Key Goals

Weight

25% Weight Reduction

50% Weight Reduction

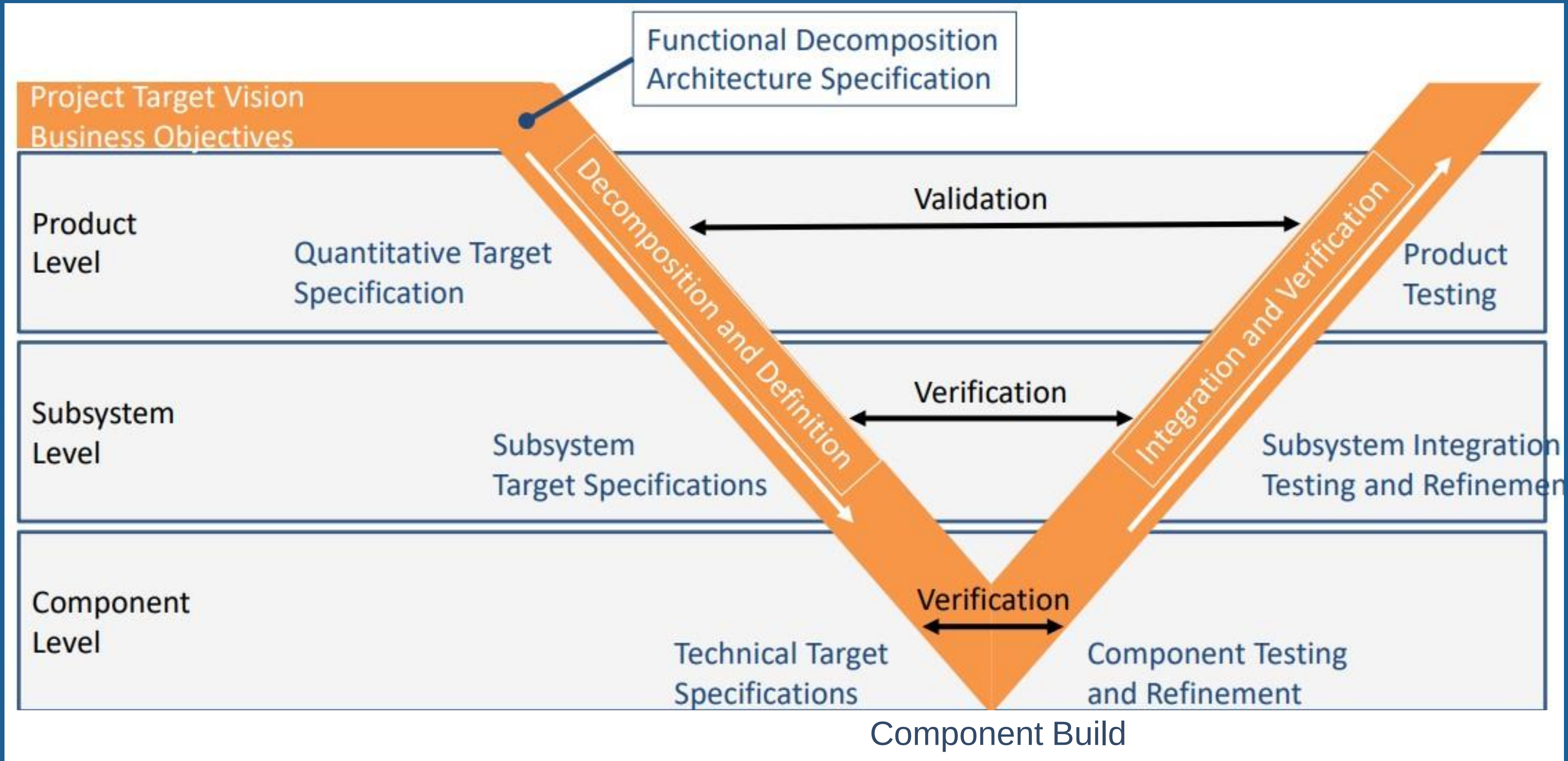
Cost

5% Cost Increase

25% Cost Increase

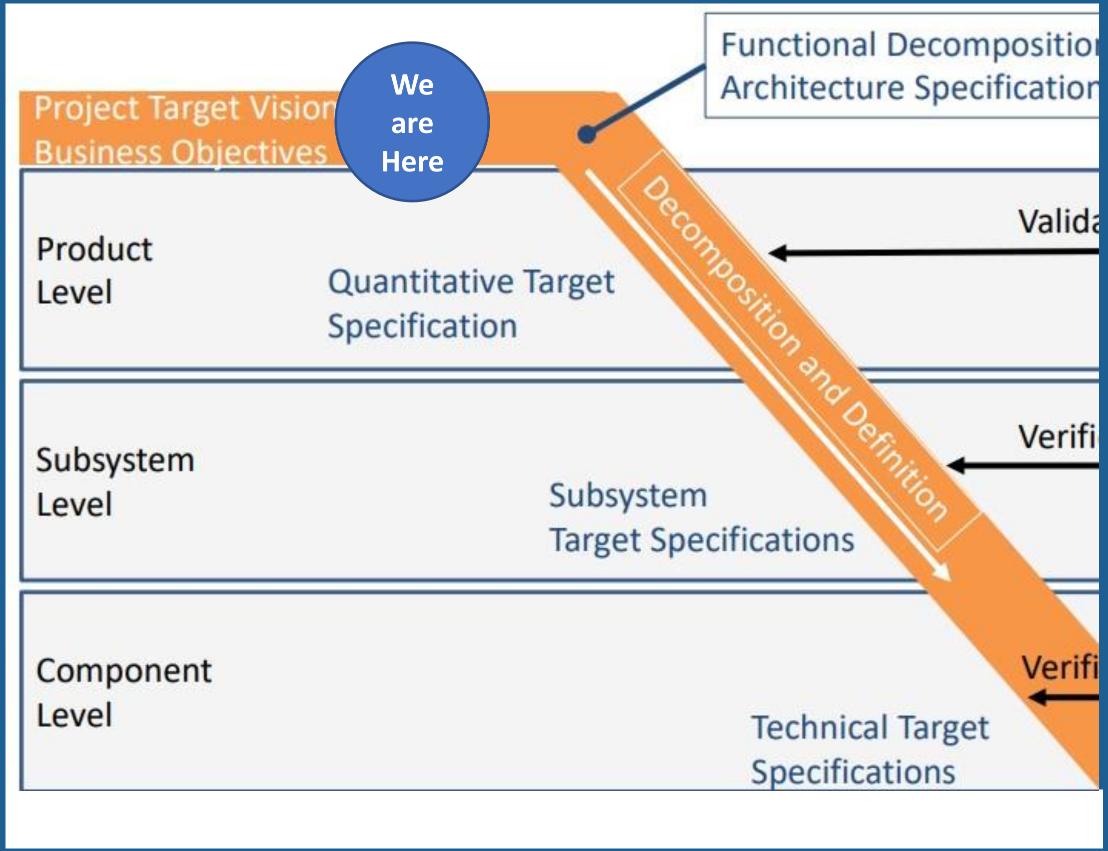
Erika Craft

Project Breakdown



Erika Craft

Project Breakdown



Customer Needs:

Similar materials

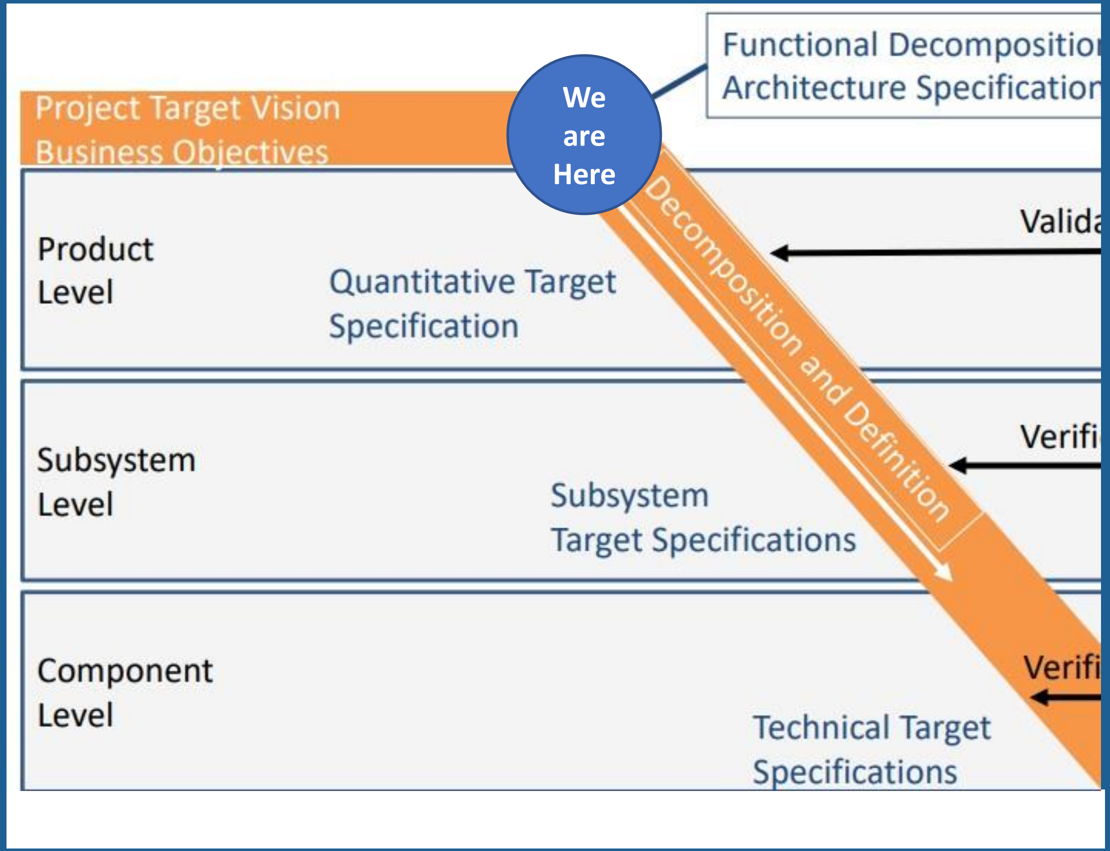
Same wire exit points

Retain manufacturability

Withstand all loads and conditions

Erika Craft

Project Breakdown



Function Decomposition:

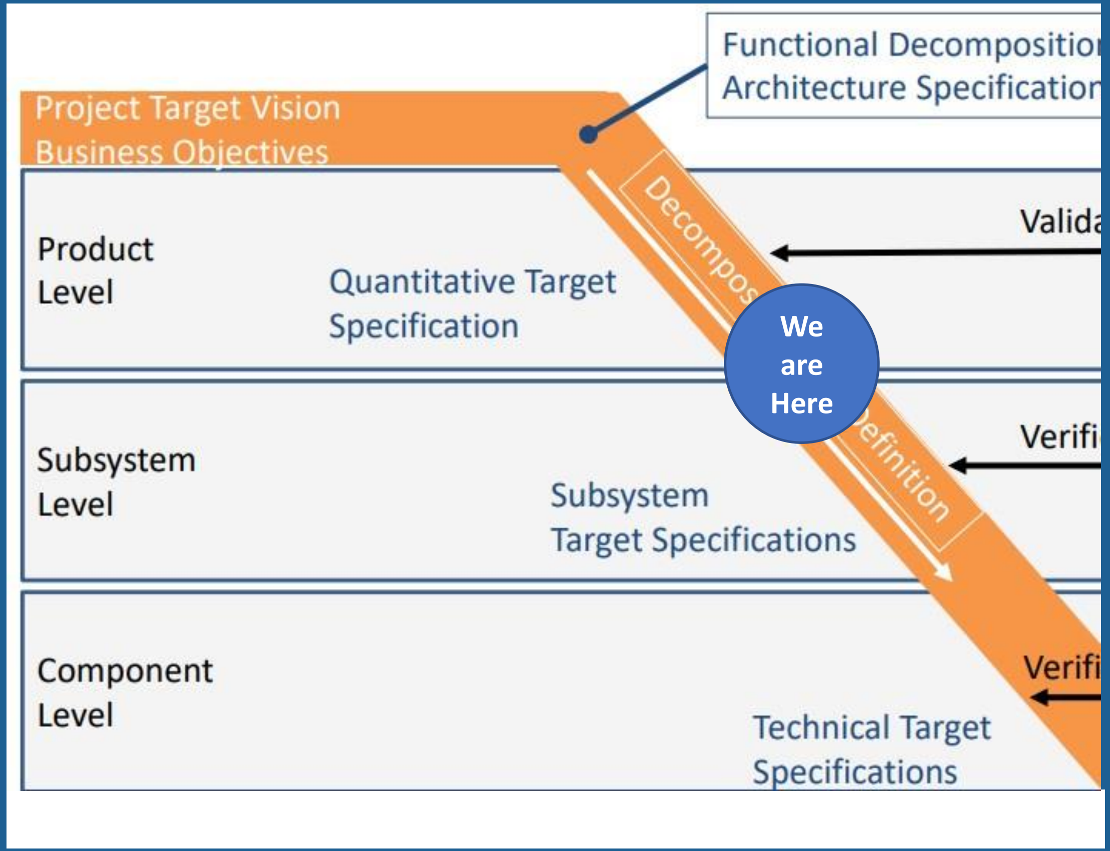
Aerodynamics:
Control Airflow
Combat Aerodynamic Load

Materials:
Resist Plastic Deformation
Regulate Deflection

Support:
Combat Aerodynamic Loads
Support Needed Weight
Resist Plastic Deformation
Regulate Deflection

Erika Craft

Project Breakdown



Targets:

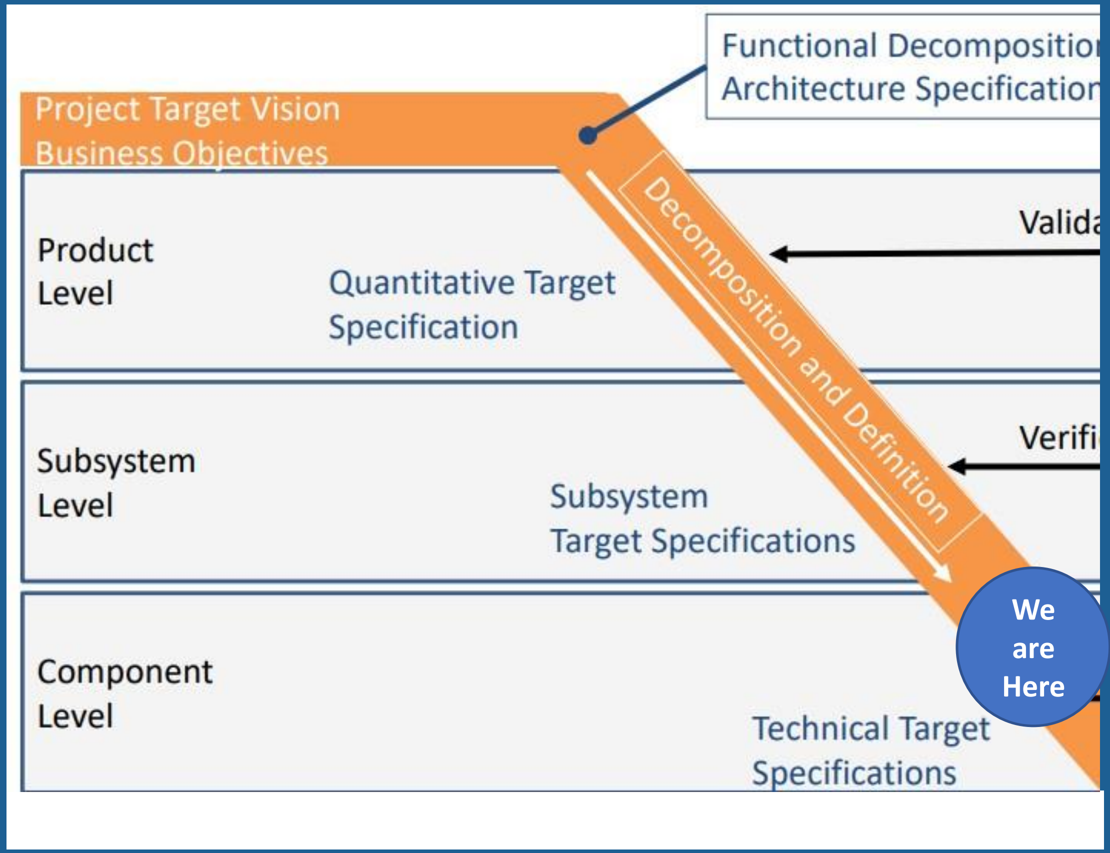
Withstand Loads

Control Airflow

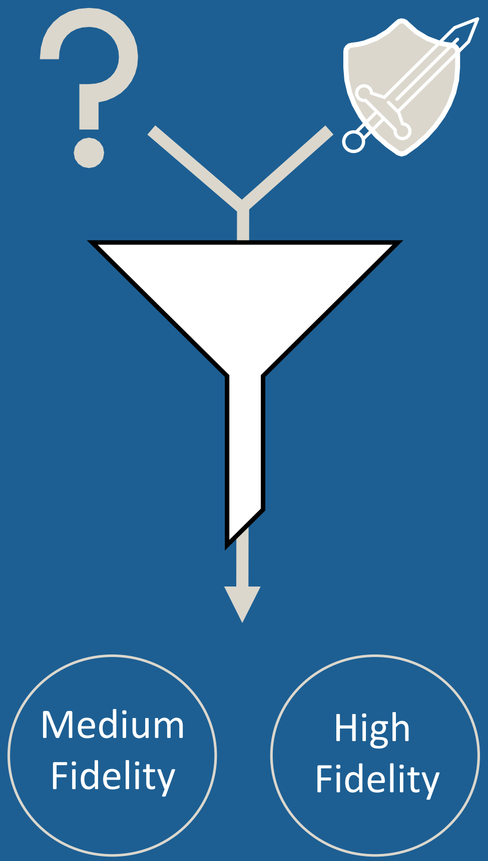
Support Weight

Erika Craft

Project Breakdown

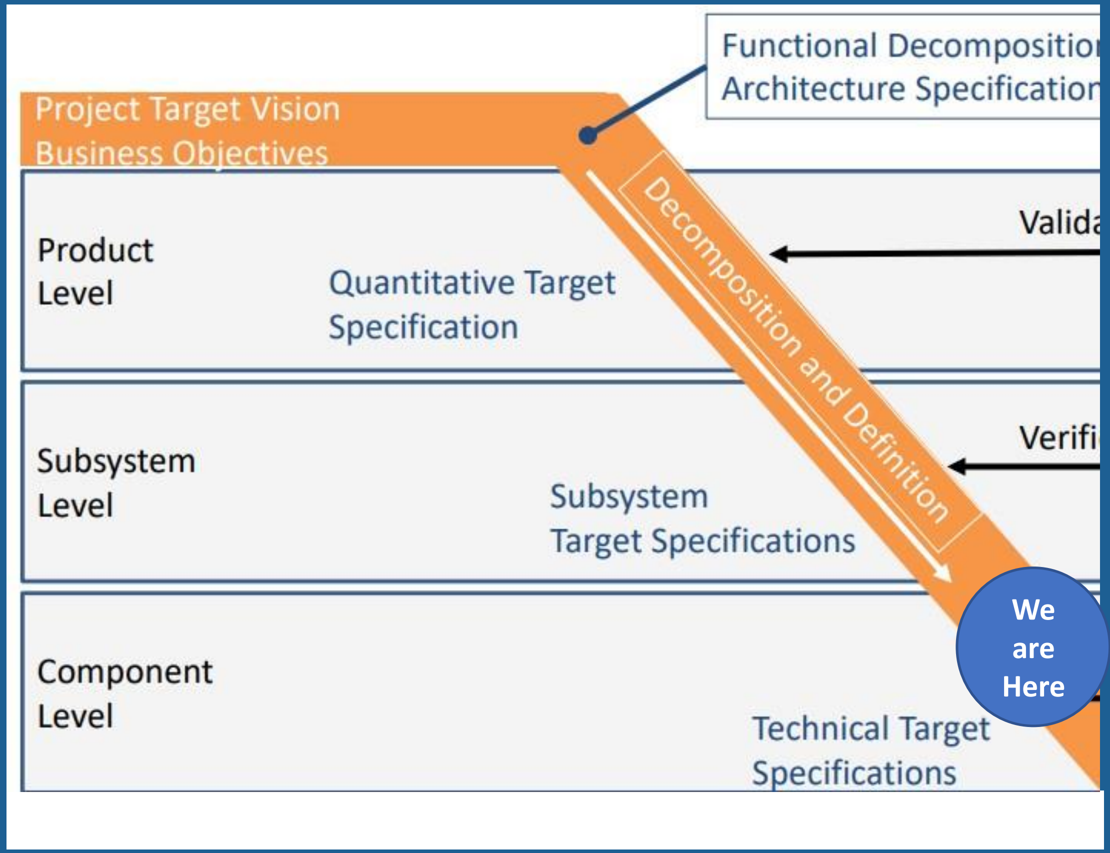


Concept Generation



Erika Craft

Project Breakdown



Concept Selection

Erika Craft

MATERIALS

Juan Tapia

Current Lamination Schedule

Changes can be made to the current lamination schedule for light-weighting

Current Lamination Schedule

Gelcoat

1 oz CSM

1208

¾” core

1” core

1208

1 oz CSM

Juan Tapia

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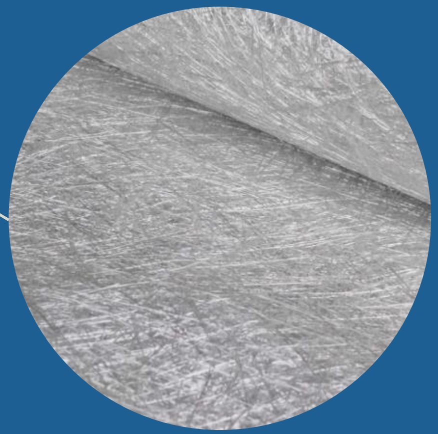

Juan Tapia

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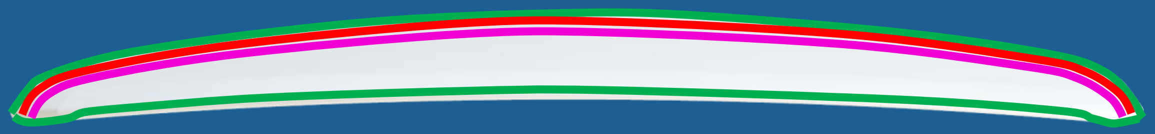

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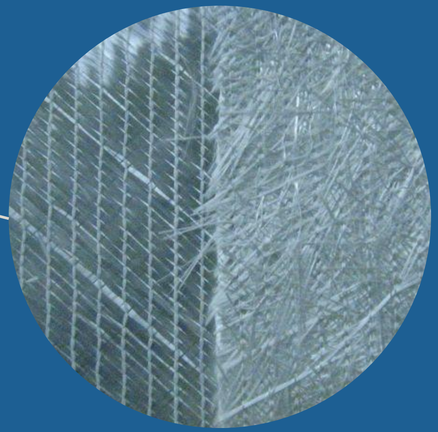

Juan Tapia

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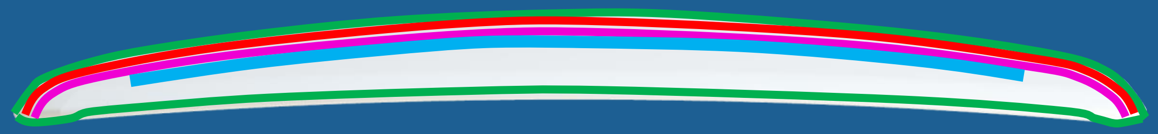

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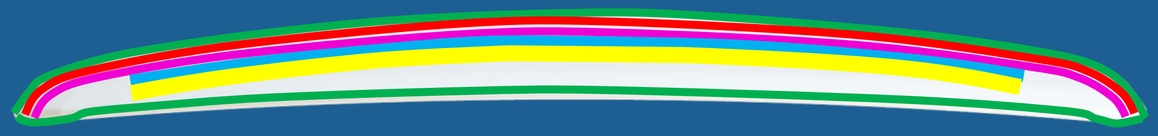

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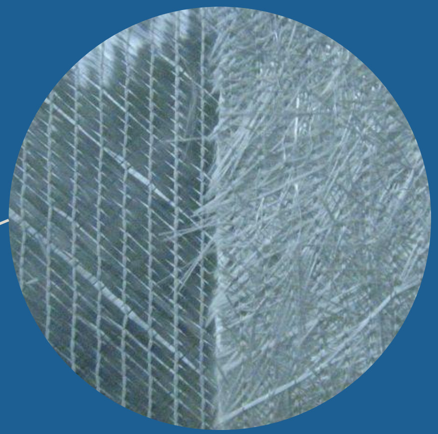

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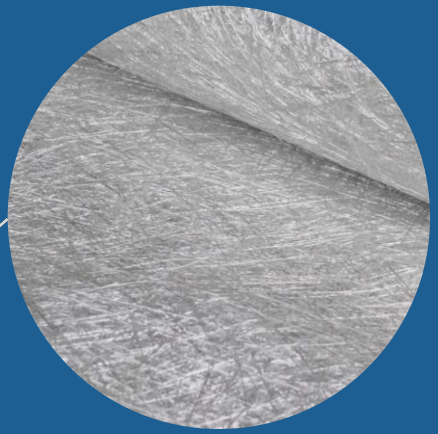

Juan Tapia

Lamination Schedule Changes

Lamination Schedule

Material	Mat. Weight (lbs)
Gelcoat	16.36
1 oz Chopped Strand Mat	46.30
1208 Fiberglass	81.53
¾" Core	78.51
1" Core	104.68

Juan Tapia

Lamination Schedule Changes

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Material	Mat. Weight (lbs)
Gelcoat	16.36
1 oz Chopped Strand Mat	46.30
1208 Fiberglass	81.53
¾" Core	78.51
1" Core	104.68

Important for:
- Surface Finish
- Waterproofing
- Mold Security

Also, least weight contribution

Juan Tapia

Lamination Schedule Changes

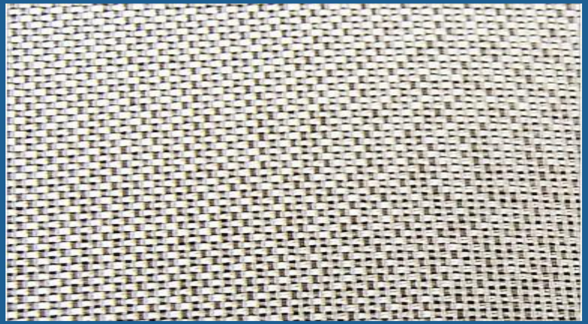
Lamination Schedule

Material	Mat. Weight (lbs)
1208 Fiberglass	81.53
¾" Core	78.51
1" Core	104.68

Juan Tapia

Fiberglass Change

S-2 Fiberglass



- Low Density
- Low Resin Absorption
- Very Thin Fiberglass Sheets
- Excellent Strength to Weight Ratio
- Great Engineering Characteristics
- Water, chemical, corrosion, and environmental resistance

1208 Fiberglass → S-2 Fiberglass

Juan Tapia

Fiberglass Engineering Characteristics

1208 Fiberglass

Tensile Strength(ksi)-> 270

Compressive Strength(ksi)--> 33.2

Shear Stress(ksi)--> 18.4

Flex. Ult. Strength(ksi)--> 35.6

S-2 Fiberglass

Tensile Strength(ksi)-> 681.7

Compressive Strength(ksi)-> 580.2

Shear Stress(ksi)-> 507.0

Flex. Ult. Strength(ksi)-> 94.1

Juan Tapia

Fiberglass Change

1208 Fiberglass → S-2 Fiberglass

Density -> 160.7 $\frac{lbs}{ft^3}$

Density -> **153.8** $\frac{lbs}{ft^3}$

Juan Tapia

Fiberglass Change

1208 Fiberglass → S-2 Fiberglass

1208 Fiberglass	S-2 Fiberglass
Density -> 160.7 $\frac{lbs}{ft^3}$	**Density -> 153.8 $\frac{lbs}{ft^3}$**
Thickness -> 0.04 in.	**Thickness -> 0.008 in.**

Juan Tapia

Fiberglass Change

1208 Fiberglass → S-2 Fiberglass

Density -> 160.7 $\frac{lbs}{ft^3}$

Thickness -> 0.04 in.

Total Weight -> 81.5 lbs.

Density -> 153.8 $\frac{lbs}{ft^3}$

Thickness -> 0.008 in.

Total Weight -> 21.6 lbs.

Juan Tapia

Fiberglass Change

1208 Fiberglass → S-2 Fiberglass

1208 Fiberglass

Density -> 160.7 $\frac{lbs}{ft^3}$

Thickness -> 0.04 in.

Total Weight -> 81.5 lbs.

Total Cost -> $221

S-2 Fiberglass

Density -> 153.8 $\frac{lbs}{ft^3}$

Thickness -> 0.008 in.

Total Weight -> 21.6 lbs.

Total Cost -> $393

Juan Tapia

Fiberglass Change

1208 Fiberglass → S-2 Fiberglass

18.3% Weight Reduction

3.85% Cost Increase

59.9 lbs. saved

Juan Tapia

Fiberglass Change

John Karamitsanis

Working with S-2 Glass

Safety Hazards

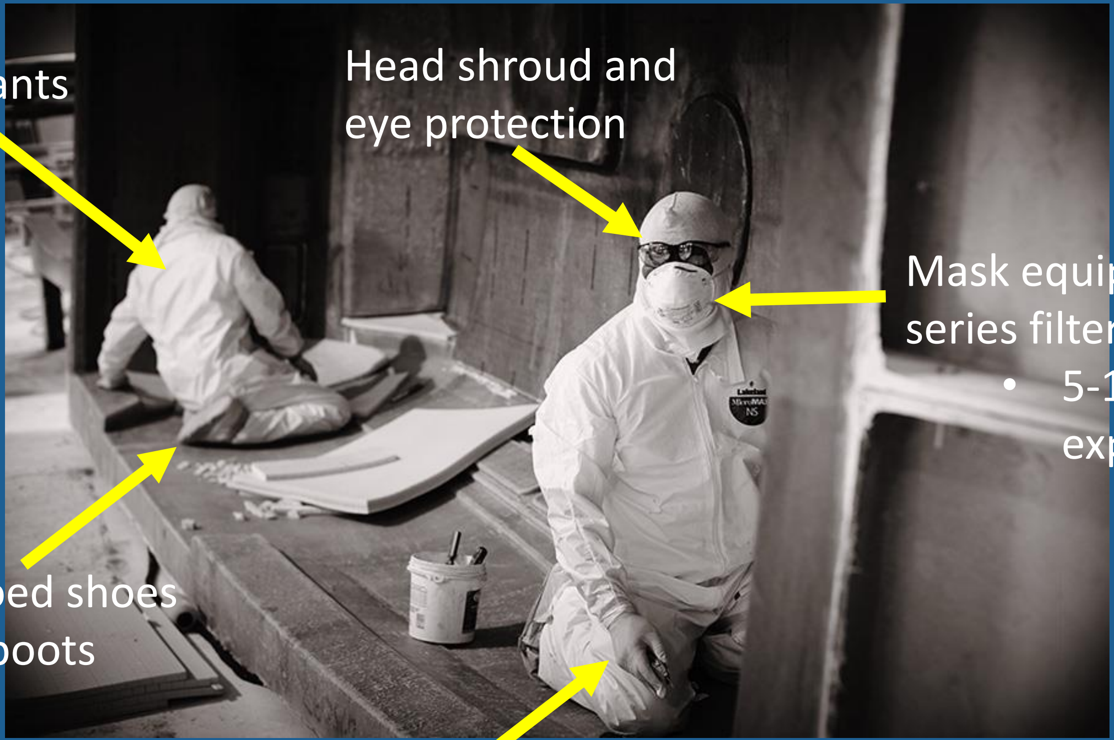
Exposure

Symptoms & Health Risks

John Karamitsanis

Working with S-2 Glass

PPE Required:



Long sleeves/pants and coverings

Head shroud and eye protection

Mask equipped with P-series filter

- 5-10X REL fiberglass exposure

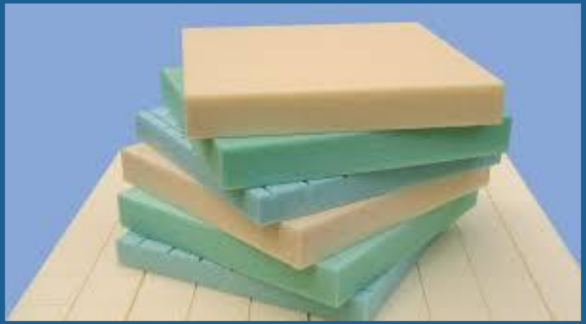
Closed toed shoes or work boots

Gloves

John Karamitsanis

Foam Core Change

Divinycell H-45



- Low Density
- High Stiffness to Weight Ratio
- Low Water Absorption
- Low Resin Absorption
- Excellent Strength to Weight Ratio
- Used for Marine Applications

Juan Tapia

Core Engineering Characteristics

Aircell T-100 Core

Tensile Strength(ksi)-> 1017

Compressive Strength(ksi)--> 1017

Shear Stress(ksi)--> 968.8

Flex. Ult. Strength(ksi)--> 966.2

Divinycell H-45

Tensile Strength(ksi)-> 1017

Compressive Strength(ksi)-> 1017

Shear Stress(ksi)-> 600

Flex. Ult. Strength(ksi)-> 966.2

Juan Tapia

Foam Core Change

Aircell T-100 → Divinycell H-45

Density -> 9.98 $\frac{lbs}{ft^3}$

Density -> 2.40 $\frac{lbs}{ft^3}$

Juan Tapia

Foam Core Change

Aircell T-100 → Divinycell H-45

Aircell T-100

Density -> 9.98 $\frac{lbs}{ft^3}$

Total Weight -> 183 lbs.

Divinycell H-45

Density -> 2.40 $\frac{lbs}{ft^3}$

Total Weight -> 45.2 lbs.

Juan Tapia

Foam Core Change

Aircell T-100 → Divinycell H-45

Aircell T-100

Density -> 9.98 $\frac{lbs}{ft^3}$

Total Weight -> 183 lbs.

Total Cost -> $1154.96

Divinycell H-45

Density -> 2.40 $\frac{lbs}{ft^3}$

Total Weight -> 45.2 lbs.

Total Cost -> $825.64

Juan Tapia

Foam Core Change

Aircell T-100 → Divinycell H-45

42.7% Weight Reduction

7.70% Cost Decrease

140 lbs. saved

Juan Tapia

Total Weight Reduction

327 lbs. → **<u>127 lbs.</u>**

61% Weight Reduction

3.7% Cost Decrease

200 lbs. saved

1% decrease in overall vessel weight

Juan Tapia

GEOMETRY CHANGES

John Karamitsanis

Aerodynamic Calculations

$$L = \frac{1}{2} C_L \rho V^2 A$$

Increase

$$D = \frac{1}{2} C_D \rho V^2 A$$

Decrease

$$\frac{L}{D}\ Ratio$$

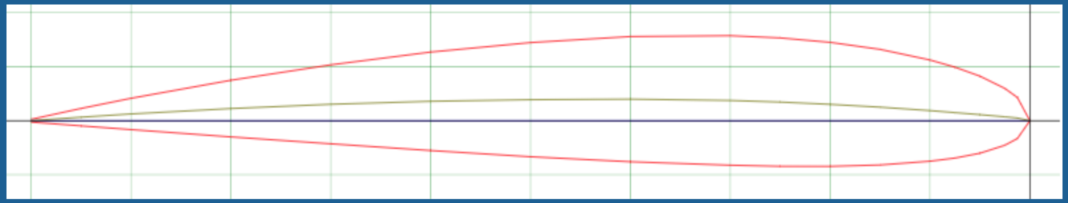
Maximize

John Karamitsanis

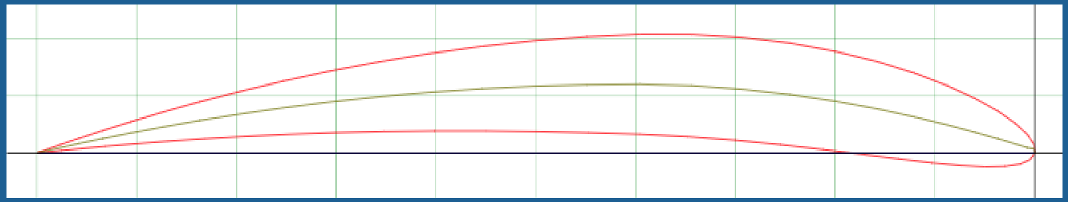
Aerodynamic Calculations

Current hardtop cross-section

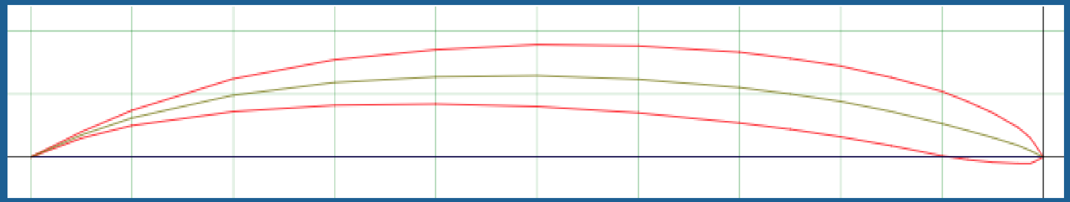
100% Thickness Airfoils



NACA 2412



NACA 6409



EPPLER 58

John Karamitsanis

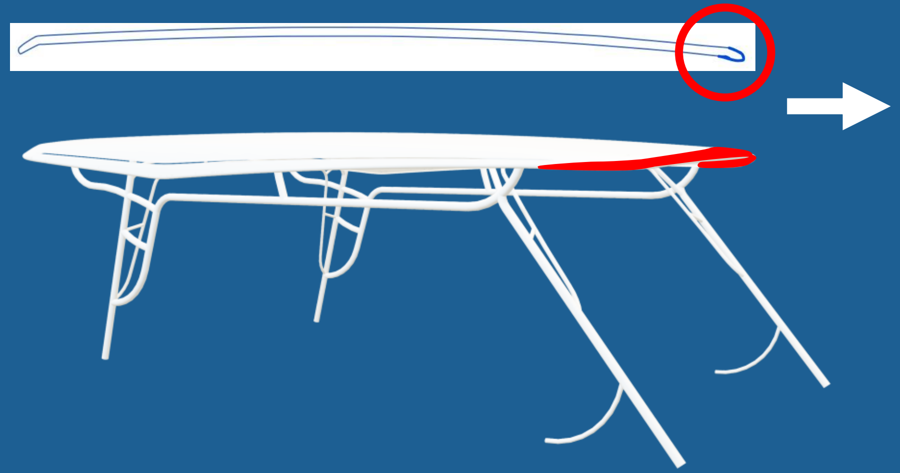
Aerodynamic Calculations

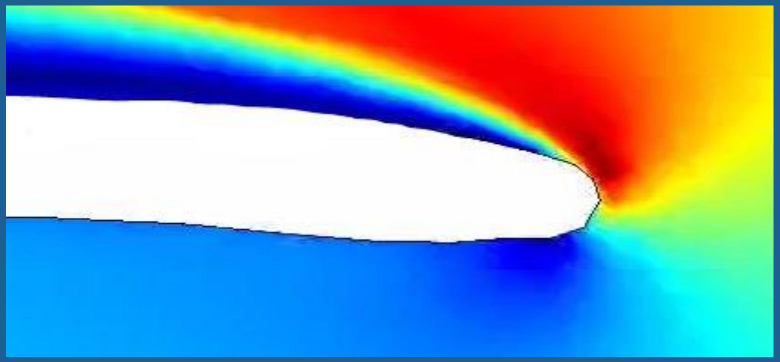
Current 409 Valor Hardtop Cross-section			
Cross-section tested at 70 mph (31.2928 m/s) in COMSOL at three different angles of attack.			
Angle of Attack, α (degrees)	0°	2.5°	5°
Lift (N/m)	1131.9	2237.8	3241.5
Drag (N/m)	32.498	49.169	142.84

NACA 6409 Airfoil, 25% thickness cross-section			
Cross-section tested at 70 mph (31.2928 m/s) in COMSOL at three different angles of attack.			
Angle of Attack, α (degrees)	0°	2.5°	5°
Lift (N/m)	646.66	1893.9	3129.3
Drag (N/m)	12.826	51.620	194.58

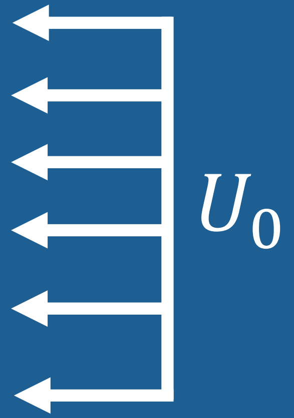
John Karamitsanis

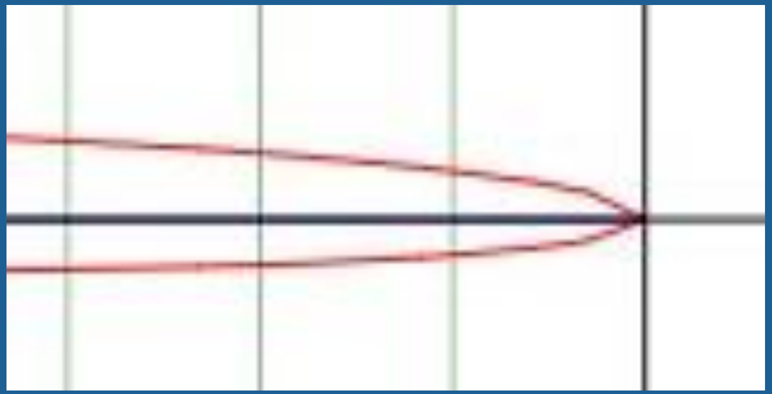
Edge Geometry Changes





Current Hardtop





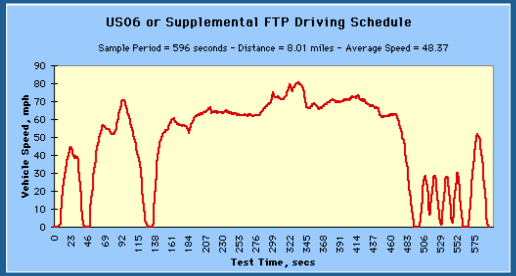
NACA 2412; 25% Thickness

Cory Stanley

SIMULATION

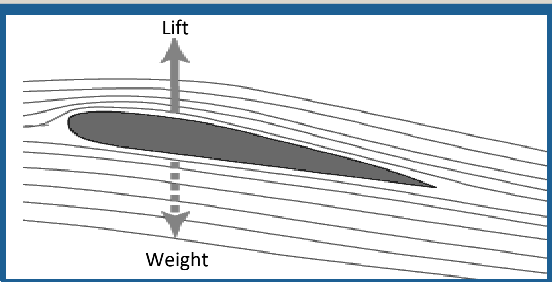
Cory Stanley

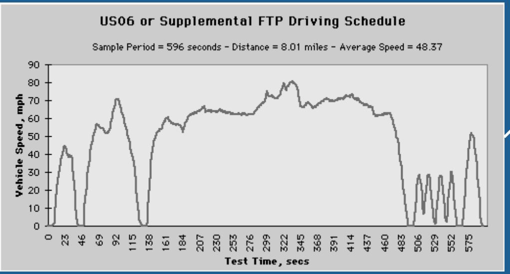
System Modeling



Cory Stanley

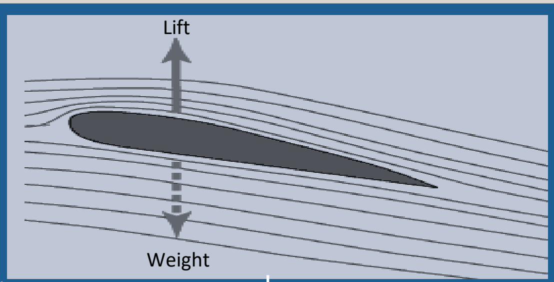
System Modeling

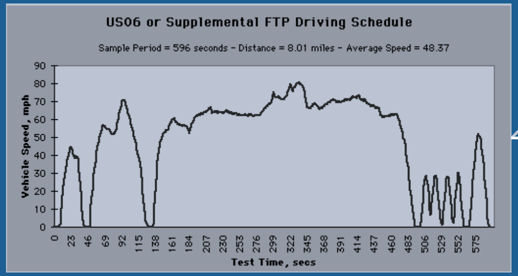


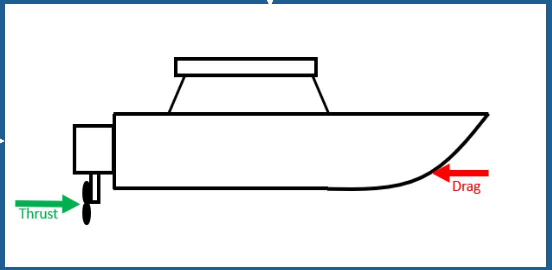


Cory Stanley

System Modeling







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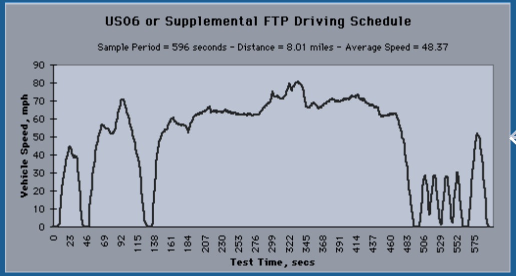
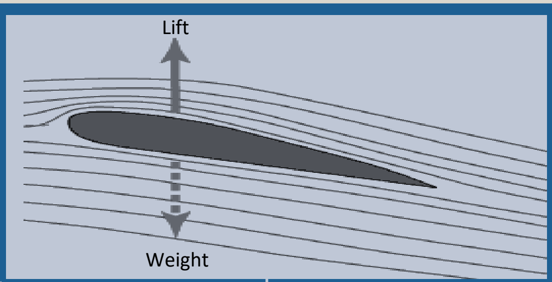
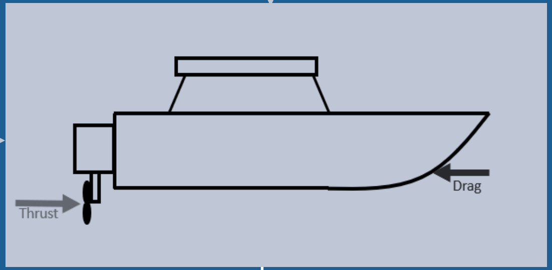


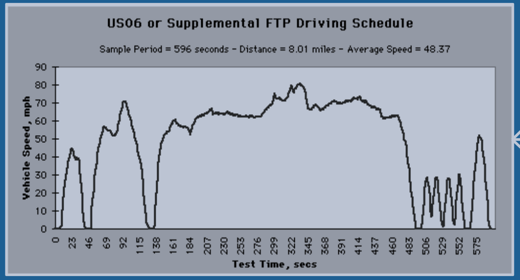


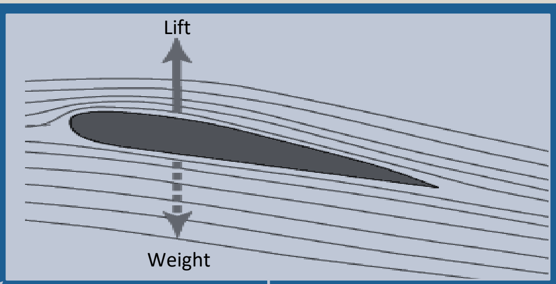


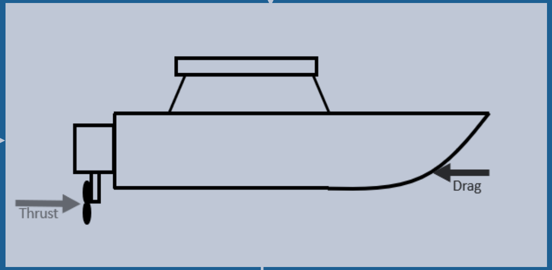
$$P = Fv$$

Cory Stanley

System Modeling







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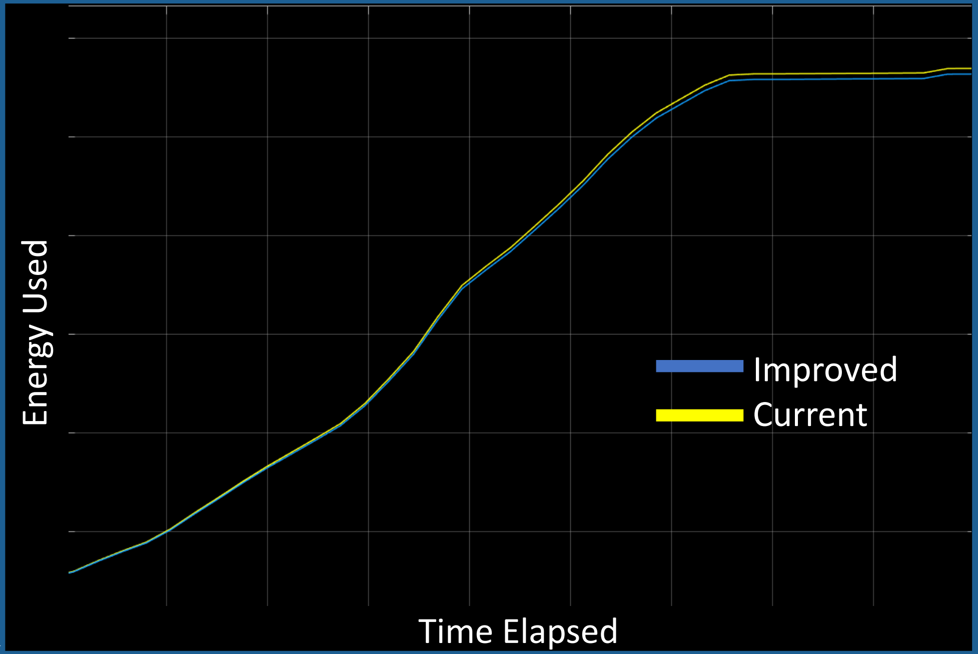
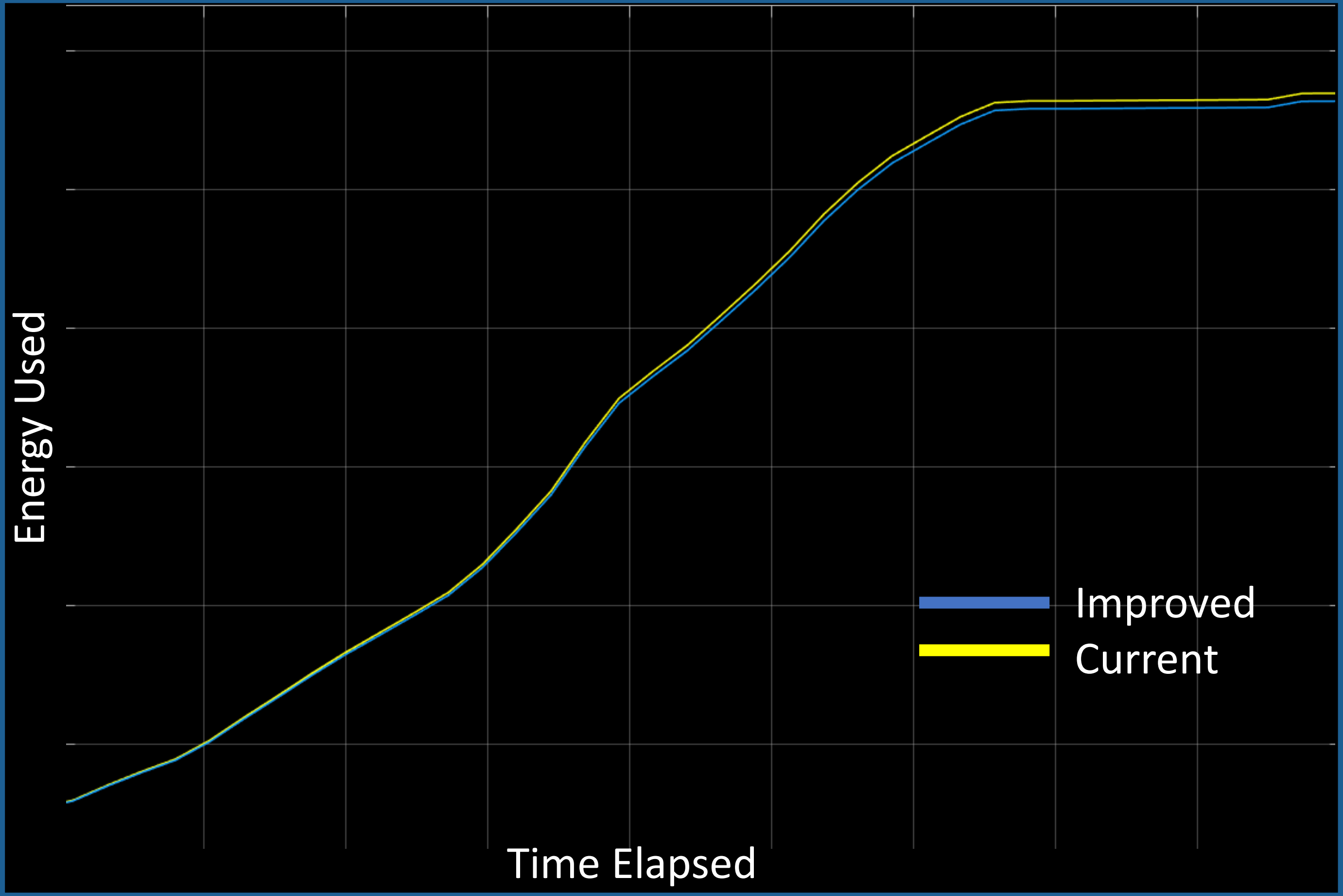


Cory Stanley

System Modeling



Cory Stanley

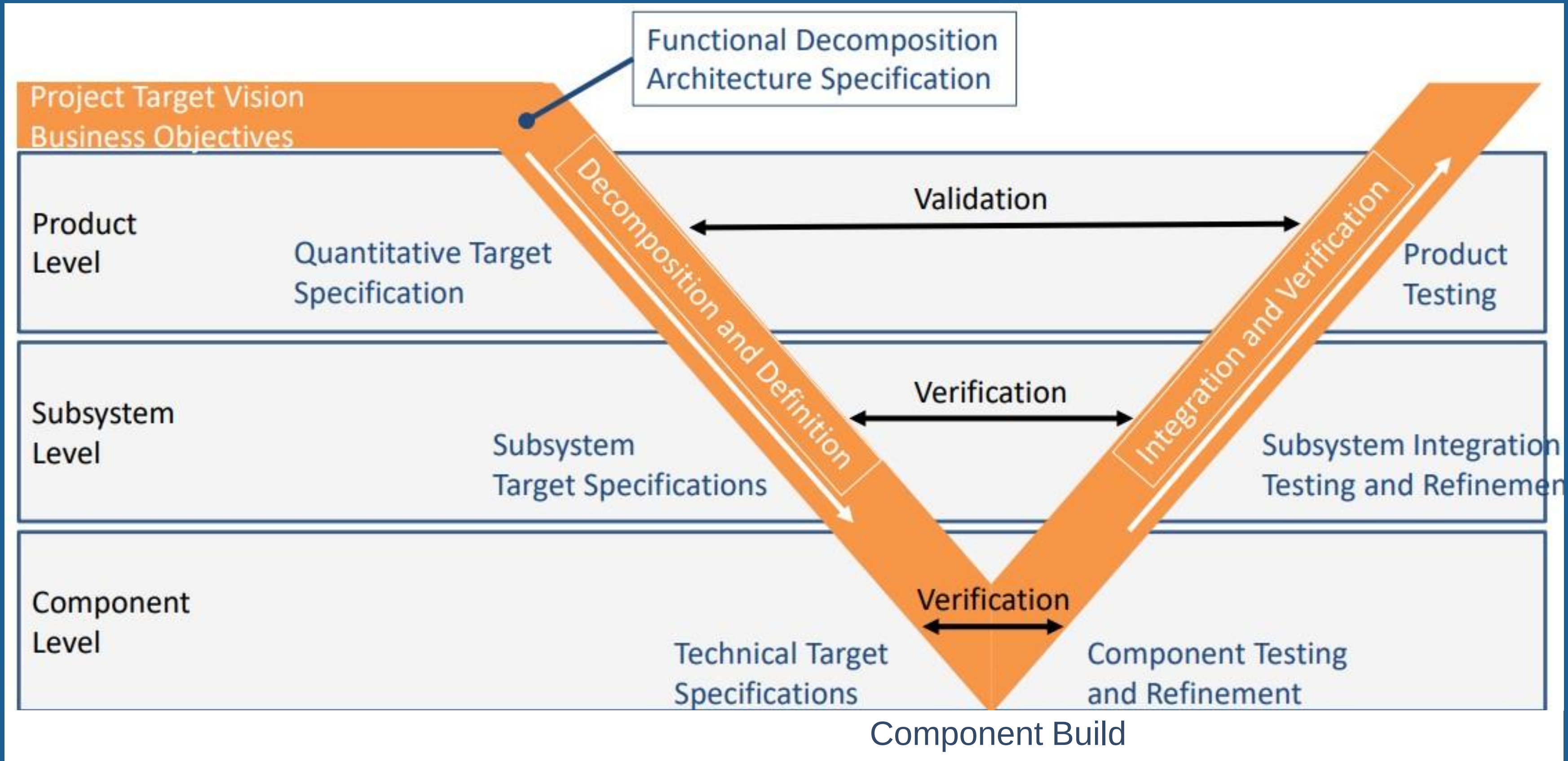
System Modeling

At full throttle:

Fuel savings = ~.9 G/h

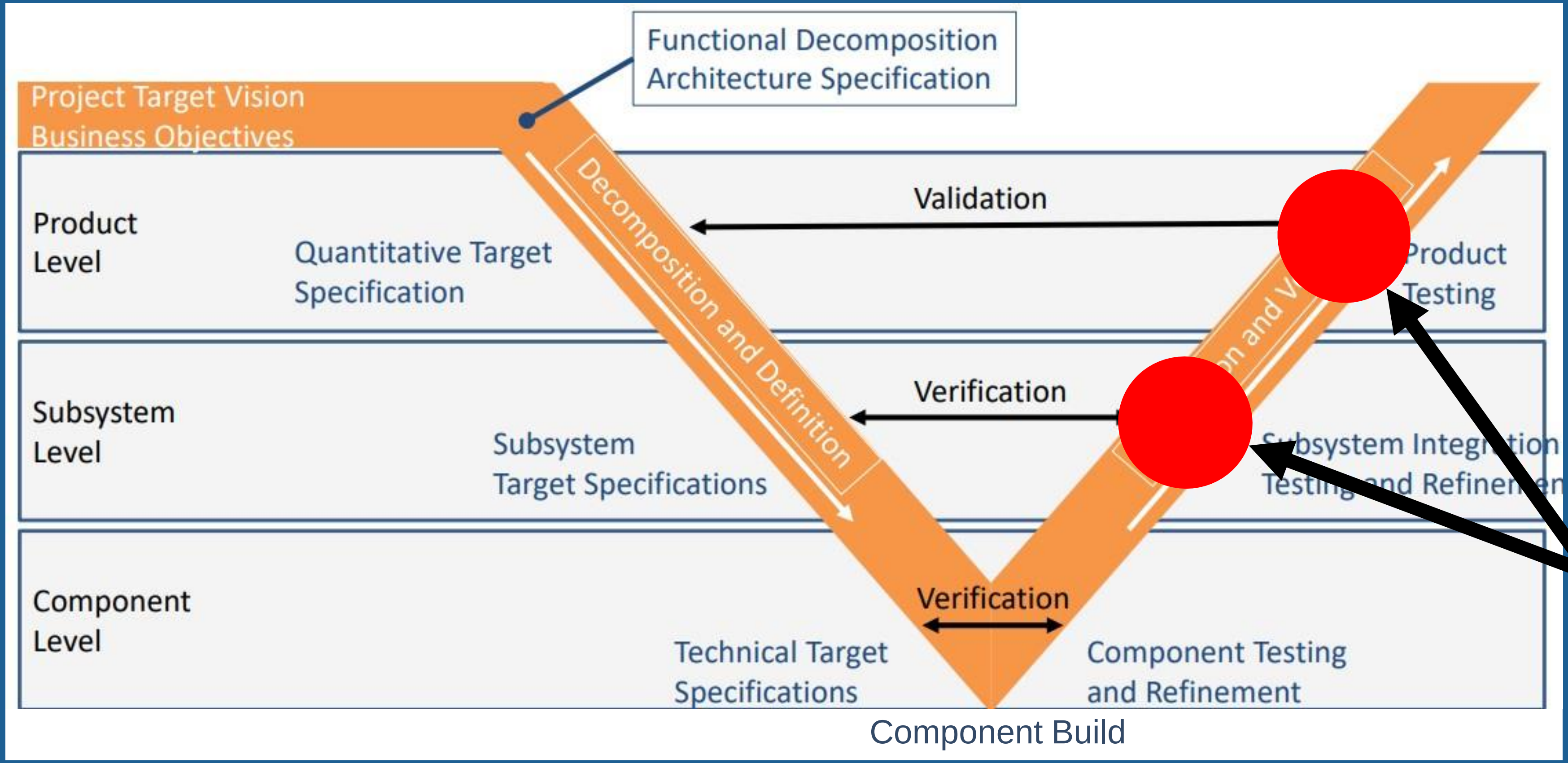
Cory Stanley

Design Thinking



Cory Stanley

Design Thinking

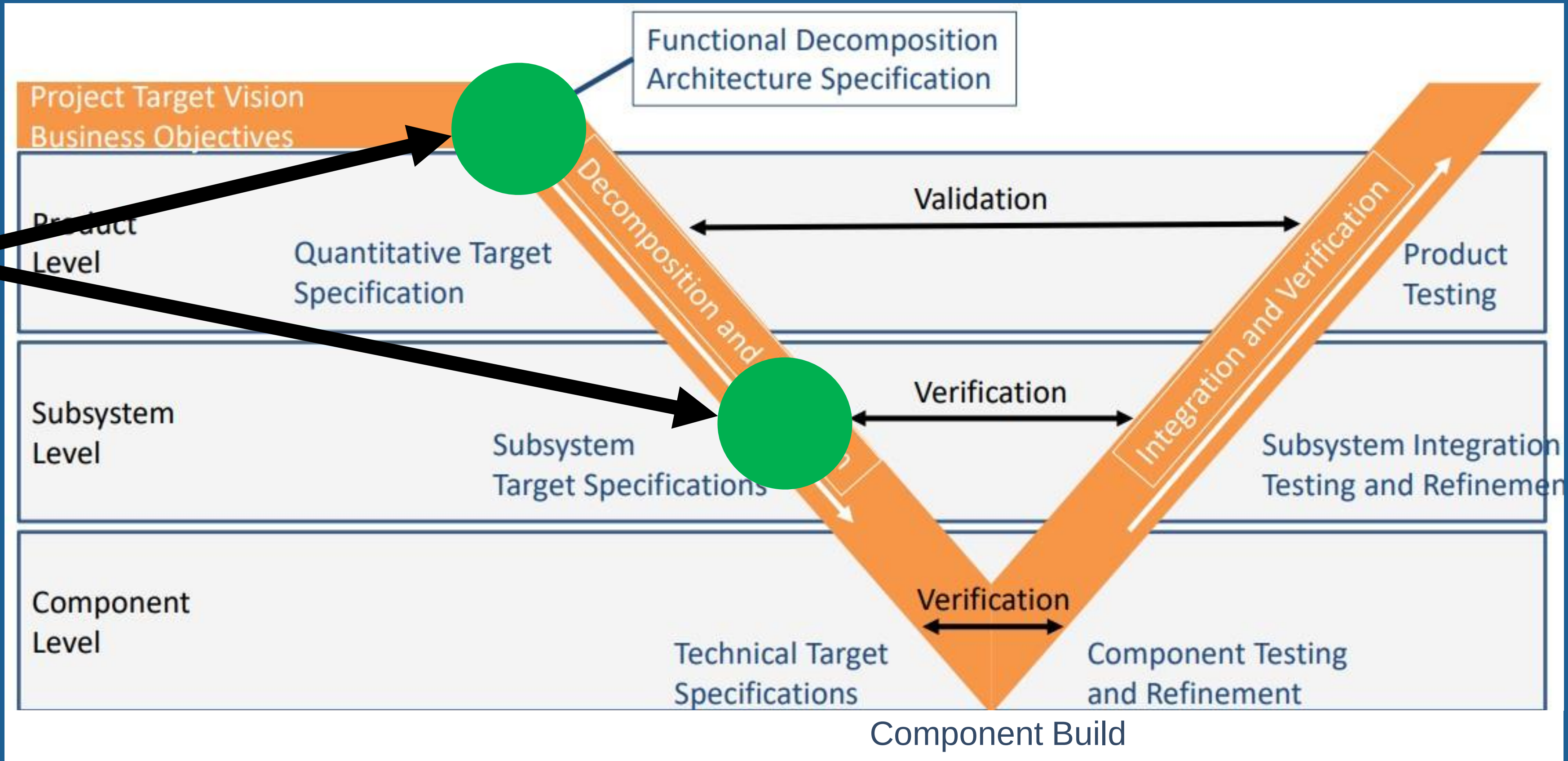


CURRENTLY HERE!

Cory Stanley

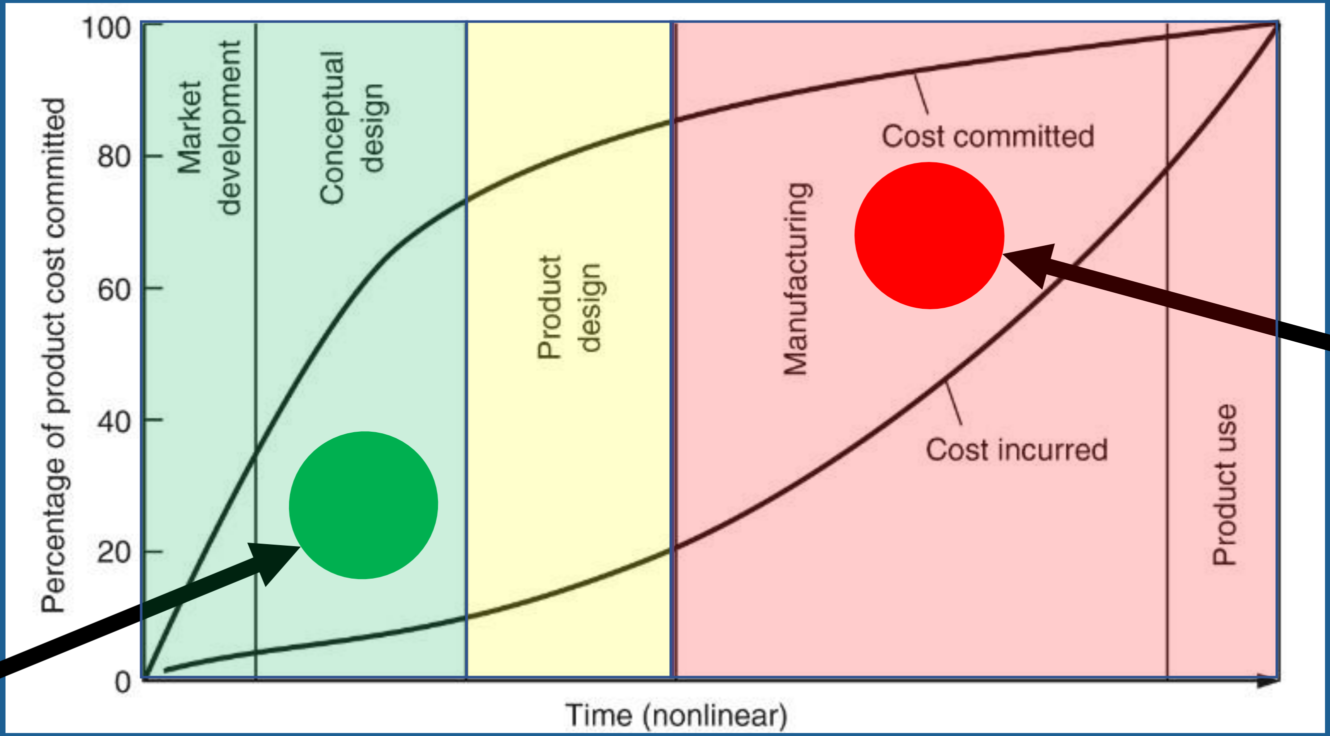
Design Thinking

MAKE CHANGES HERE!



Cory Stanley

Design Thinking



Changes = money

Changes become design considerations

Cory Stanley

Lessons Learned

- Follow the design process and design thinking
  - Cost-benefit analysis showed changes are more valuable early in the design process
  - While changes can be made to the current model to improve it, cost discourages one from making changes this late in the design process
- Reasonable assumptions OK, but try to do without
  - Starting weight reported as ~300 lbs., assumed core material allowed for starting weight of 327 lbs.
- Validation is important
  - The weight reduction achieved is large, materials must be validated
- Check calculations
  - Initial values for material engineering characteristics, densities, and costs incorrect, so checking against all group members allowed us to avoid reporting incorrect values

Cory Stanley

Summary

Objective: To improve the performance of the Intrepid 409 Valor by manipulating hardtop parameters

Switched fiberglass and core materials to achieve a 200 pound weight savings (60% overall hardtop weight)

Current hardtop geometry is desirable and can function to the boat's benefit

Analyzed current hardtop geometry and found overall geometry change is not beneficial; leading and trailing edge changes may reduce drag

Design and manufacturing cost can be reduced if changes are implemented when new model is made
(i.e., cost to make changes now outweighs benefits)

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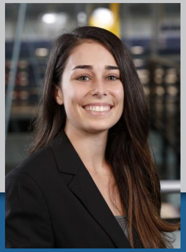

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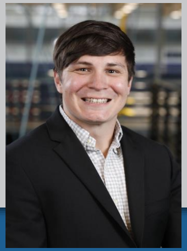

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Backup Slides

References

409 Valor. (n.d.). Retrieved October 15, 2020, from https://www.intrepidpowerboats.com/boats/409-valor/

McConomy, S. (2020, October 6). Retrieved October 15, 2020, from https://famu-fsu-eng.instructure.com/courses/4476/discussion_topics/18526

Tweedie, Dingo (2021, January 15). Retrieved from Savitsky Power Prediction | Page 6 | Boat Design Net

Knit, 1208 Biax (fiberglassflorida.com)

Chopped Strand Mat (fibreglast.com)

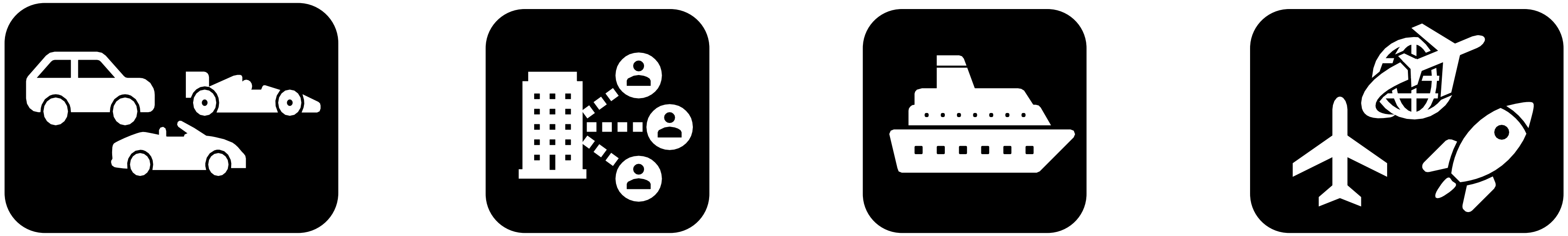
Gelcoat Product – Grainger Industrial Supply (grainger.com)

Foam Core Board, Uline Board (uline.com)

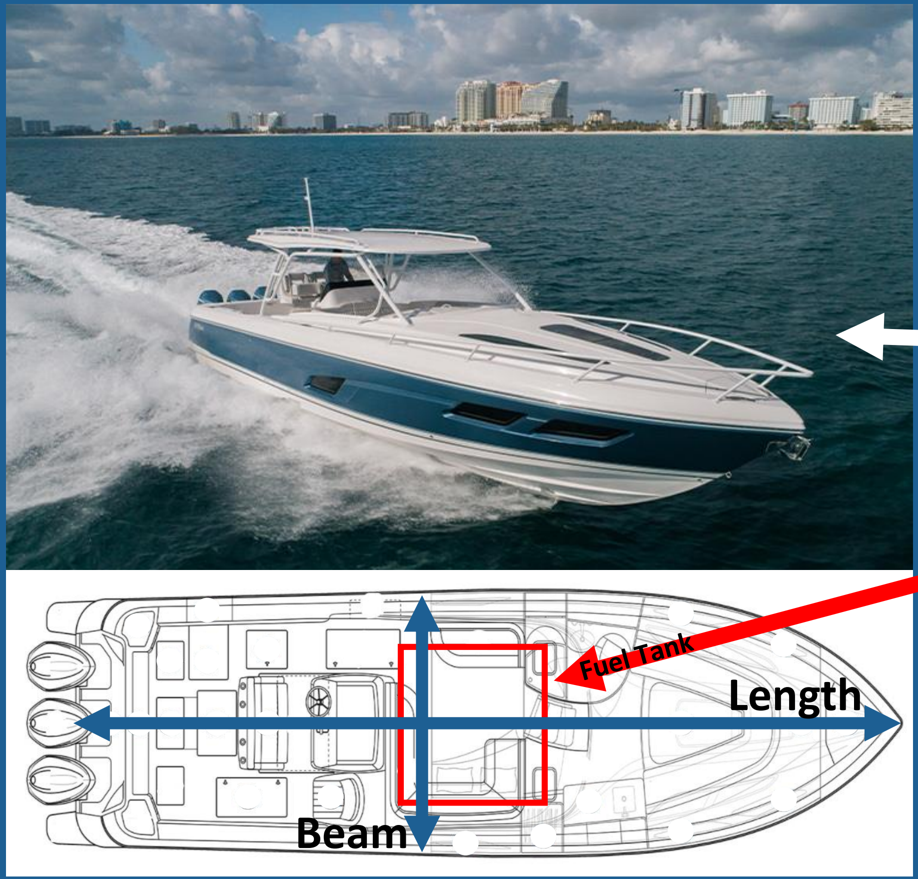
Project Scope Assumptions

- The changes to the hardtop will still use current mounting points.
- Our changes will only be applied to the hardtop and no other parts of the vessel.
- We are assuming we will not be physically producing the hardtop

Project Scope Markets



Objective



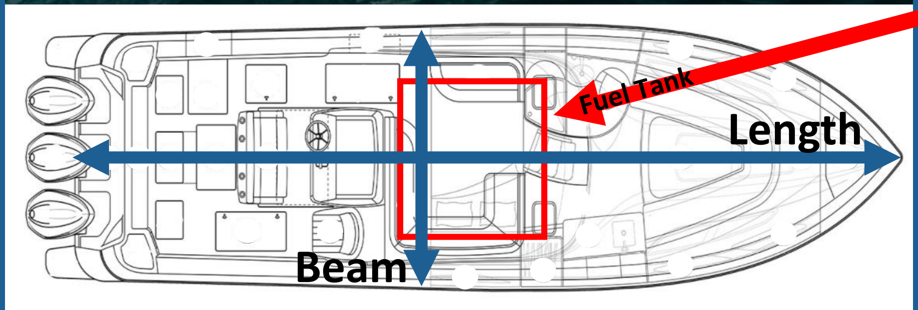
To improve the on-water performance of the Intrepid 409 Valor by manipulating hardtop parameters

Intrepid 409 Valor

Length:	40' 0"
Beam:	11' 1"
Fuel Capacity:	438 Gallons
Top Speed:	70+ mph
Range:	

Erika Craft

Objective



To improve the on-water performance of the Intrepid 409 Valor by manipulating hardtop parameters

<u>Intrepid 409 Valor</u>

Length:	40’ 0”
Beam:	11’ 1”
Fuel Capacity:	438 Gallons
Top Speed:	70+ mph
Range:	

Increase in Lift
Reduction of Drag
Reduction of Weight

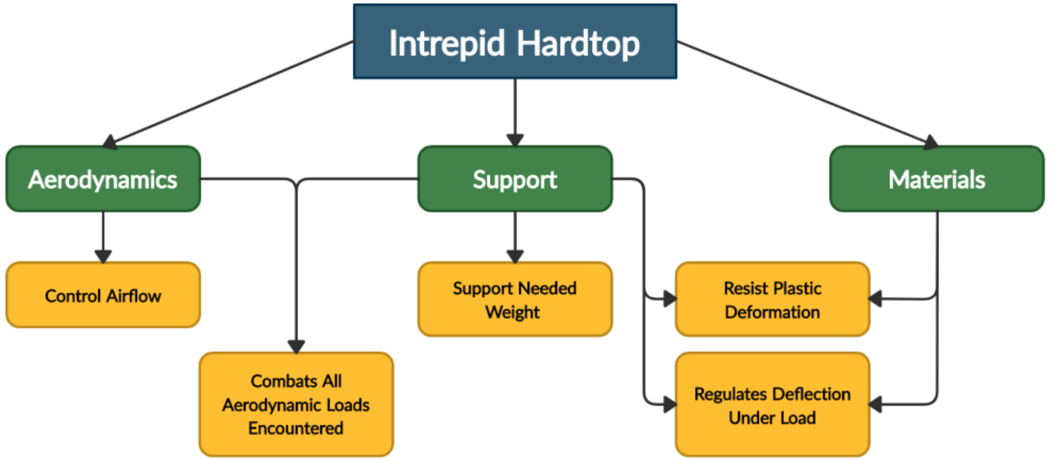
Erika Craft

Customer Needs

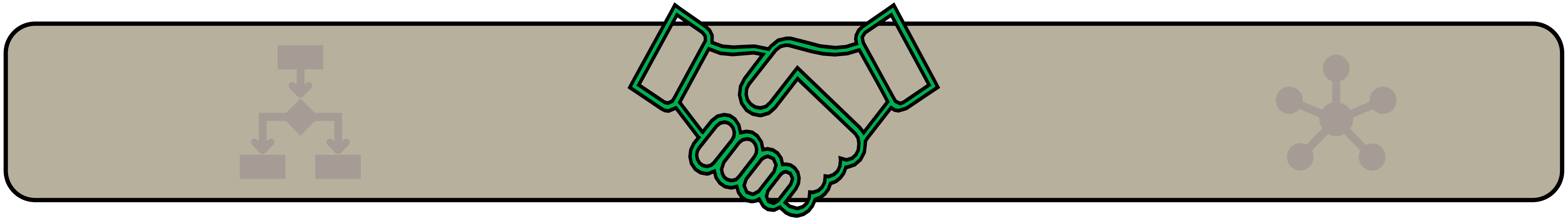
Question		Interpreted Need
What materials need to be considered?	→	Incorporate materials used within Intrepid
Parameters of the current hardtop?	→	Similar dimensions retained
Can we alter wire/chase tube layout?	→	Exit points must stay the same
Is there a certain weight the hardtop needs to withstand?	→	Design withstands all nominal loads and running conditions

Functional Decomposition

Flow Chart



Functional Decomposition



Smart Integration

Support — Materials

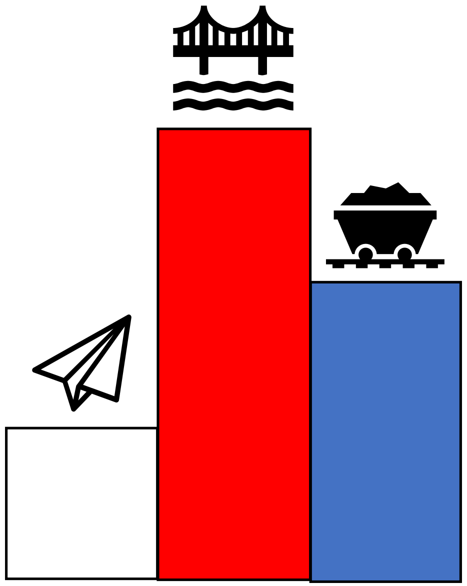
- Resists Plastic Deformation
- Regulates Deflection Under Load

Support — Aerodynamics

- Combats All Aerodynamic Loads

Functional Decomposition

Connection to Systems

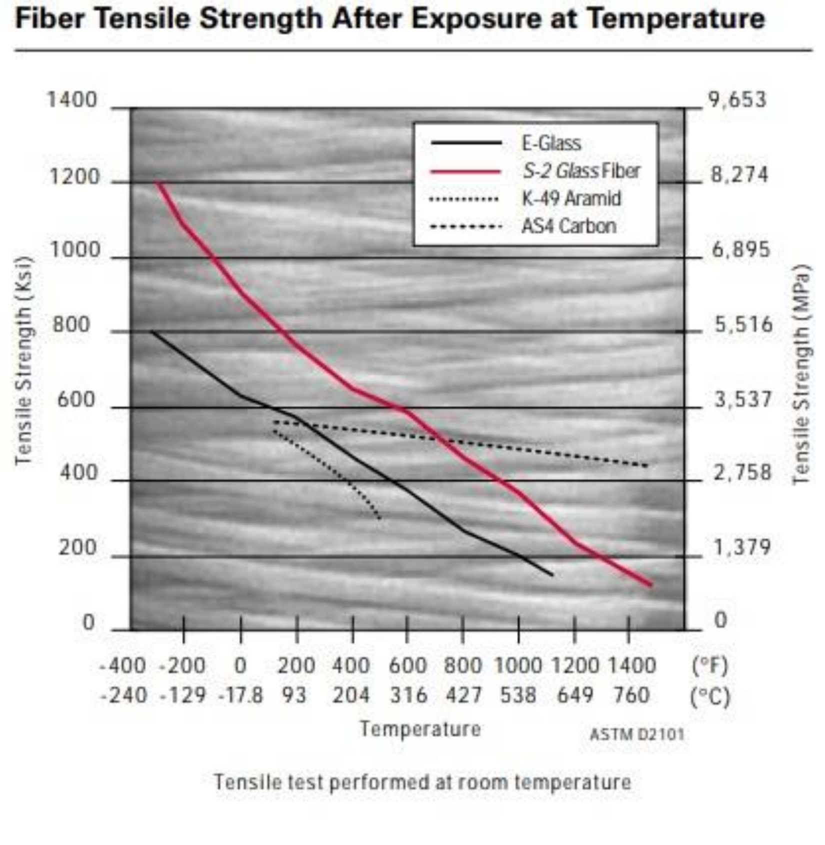


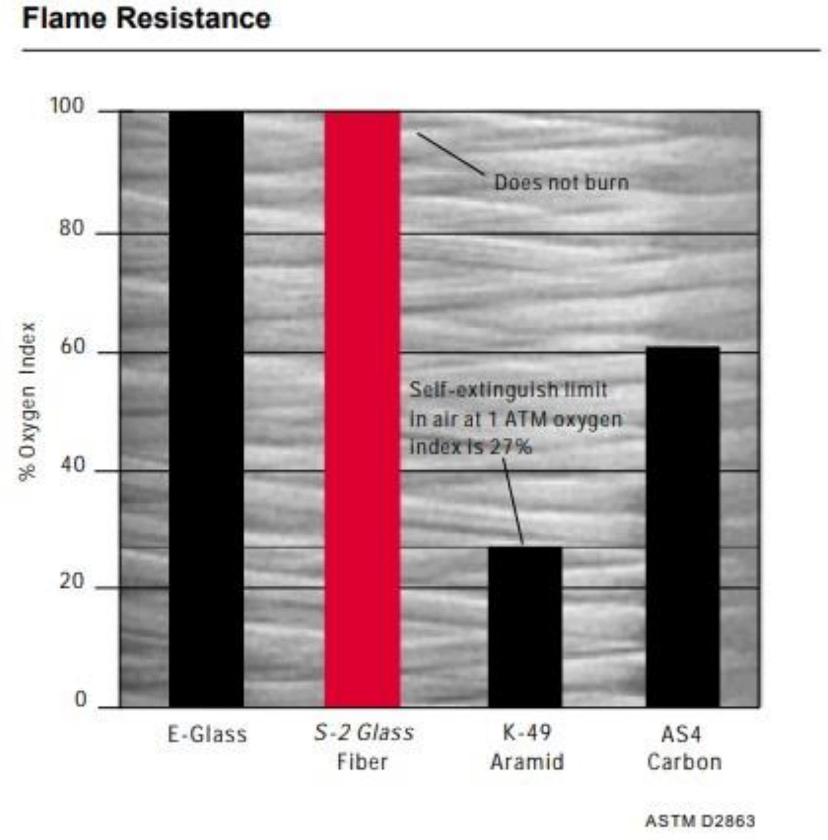
Highest number of functions
Highest number of cross system functions

Most shared functions with support system

Least shared functions across systems

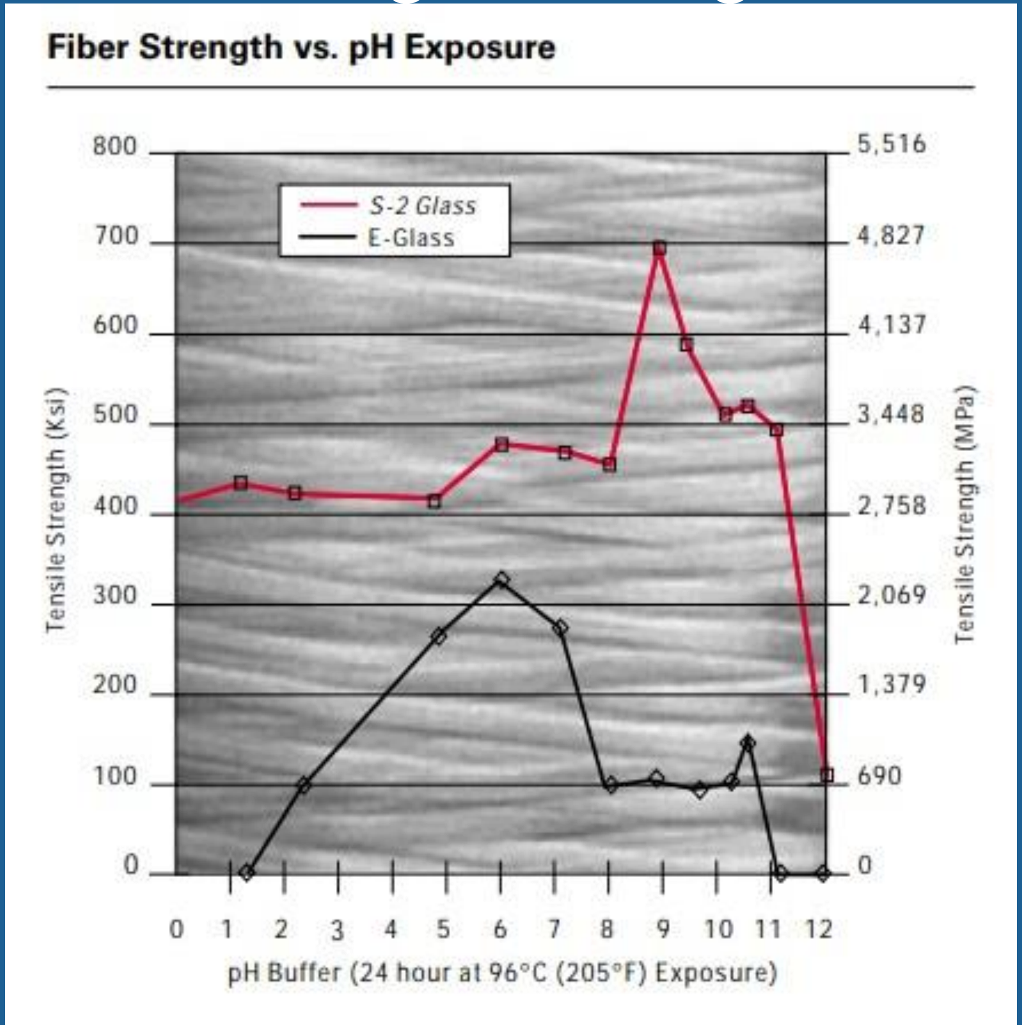
Fiberglass Change – S-2 Glass Temperature Resistance





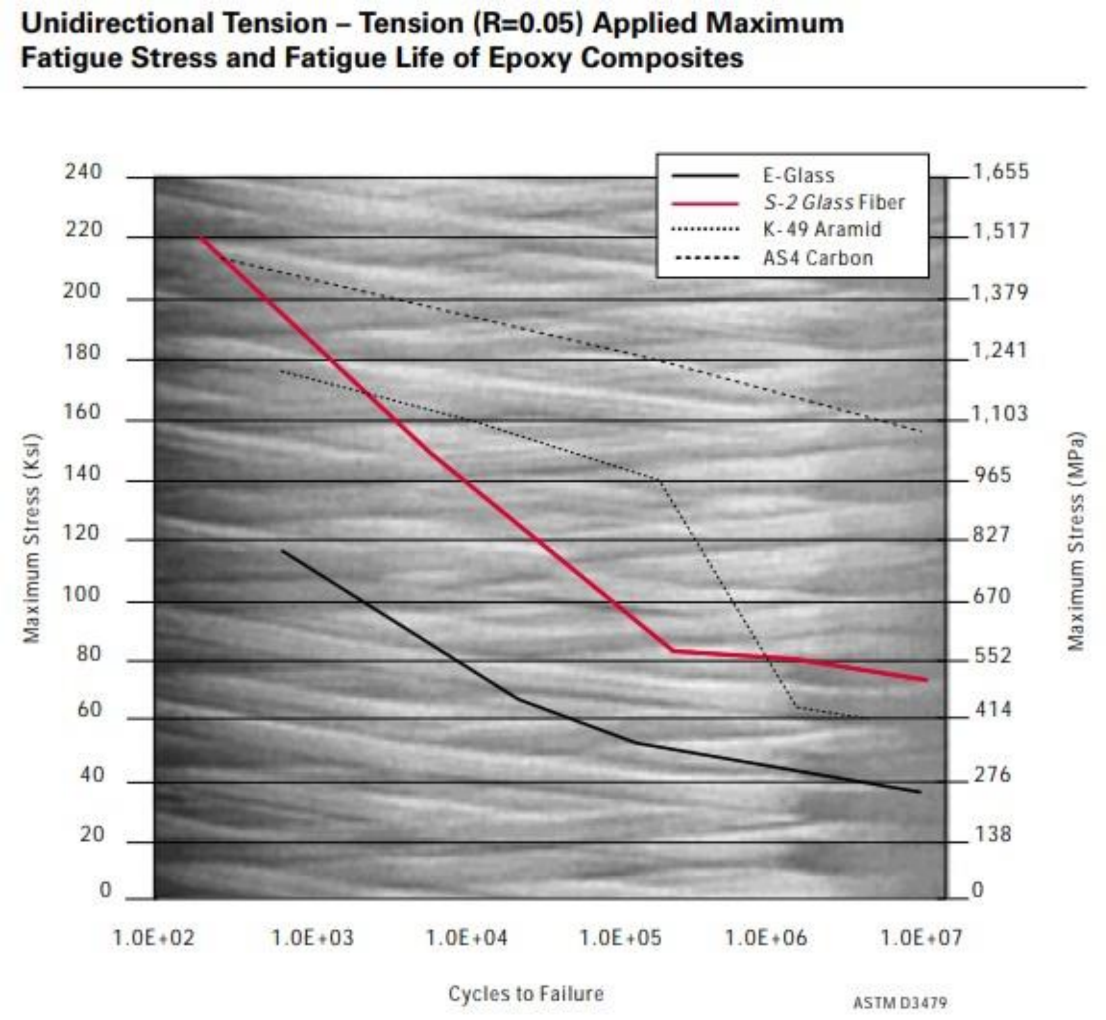
Juan Tapia

Fiberglass Change



John Karamitsanis

Fiberglass Change



John Karamitsanis

1208 Properties

ID	Lay-up, Top to Bottom Product	Fiber Content %	vol / wt	Top Up/Dn u/d/m/h	Rotation deg.	Fiber Wt. oz/sq.yd	Layer Thickness	Fiber lb/sq.ft	Resin lb/sq.ft	Total lb/sq.ft	Fiber $/lb	Fiber $/sq.ft	Resin $/sq.ft	Total $/sq.ft	Layer #
1. Ve	E-BXM 1208	44 %	Wt	Hom.	0	20.64	0.040	0.14	0.18	0.324	$ -	$ -	$ -	$ -	1
2.		-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
3.		-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
4.		-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
5.		-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
6.		-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
7.		-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
8.		-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
9.		-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
10.		-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
11.		-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
12.		-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
13.		-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
14.		-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
15.		-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
16.		-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
17.		-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
18.		-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
19.		-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
20.		-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
					Laminate :	20.6	0.040	0.143	0.18	0.32	Lam :	$ -	$ -	$ -	1
					Core / Solids :	-	-	-			Core:	$ -	$/lb :	$ -	
					Total :	20.6	0.040	0.143							

Layers / Adjustment

in this table by clicking on an existing name and selecting a property from the list that pops up.

Laminate Comparison Table — Table Units: US

Laminate # ->	1	
Laminate	Current Laminate	
Thickness	0.040	in.
Mf	44.27 %	by Wt.
Density	97.7	lb/cu.ft
Fiber Wt.	0.14	lb/sq.ft
Resin Wt.	0.18	lb/sq.ft
Laminate Wt.	0.32	lb/sq.ft
Vf	27.29 %	by Vol.
0º Modulus, Ex	1.45	MSI
90º Modulus, Ey	1.45	MSI
Poisson Ratio, PRxy	0.37	
Shear Modulus, Gxy	0.81	MSI
0º Ten. Ult. Stress	23.8	KSI
0º Comp. Ult. Stress	33.2	KSI
90º Ten. Ult. Stress	23.8	KSI
90º Comp. Ult Stress	33.2	KSI
Shear Ult. Stress	18.4	KSI
0º Flex. Ult. Stress	35.6	KSI
90º Flex. Ult. Stress	35.6	KSI

AIRCELL T-100 1”

	Lay-up, Top to Bottom ID	Product	Fiber Content %	vol / wt	Top Up/Dn u/d/m/h	Rotation deg.	Fiber Wt. oz/sq.yd	Layer Thickness	Fiber lb/sq.ft	Resin lb/sq.ft	Total lb/sq.ft	Fiber $/lb	Fiber $/sq.ft	Resin $/sq.ft	Total $/sq.ft	Layer #
1.	Pol	Aircell T-100 - 1"	100 %	Wt	Hom.	0	119.84	1.000	0.83	-	0.832	$ -	$ -	$ -	$ -	1
2.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
3.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
4.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
5.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
6.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
7.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
8.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
9.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
10.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
11.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
12.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
13.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
14.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
15.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
16.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
17.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
18.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
19.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
20.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
						Laminate :	0.0	-	-	-	0.83	Lam :	$ -	$ -	$ -	1
						Core / Solids :	119.8	1.000	0.832			Core:	$ -	$/lb :	$ -	
						Total :	119.8	1.000	0.832							

Layers
Adjustment

in this table by clicking on an existing name and selecting a property from the list that pops up.

Laminate Comparison Table Table Units: US

Laminate # ->	1	
Laminate	Current Laminate	
Thickness	1.000	in.
Mf	0.00 %	by Wt.
Density	10.0	lb/cu.ft
Fiber Wt.	0.00	lb/sq.ft
Resin Wt.	0.00	lb/sq.ft
Laminate Wt.	0.83	lb/sq.ft
Vf	0.00 %	by Vol.
0º Modulus, Ex	0.01	MSI
90º Modulus, Ey	0.01	MSI
Poisson Ratio, PRxy	0.27	
Shear Modulus, Gxy	0.00	MSI
0º Ten. Ult. Stress	1017.0	KSI
0º Comp. Ult. Stress	1017.0	KSI
90º Ten. Ult. Stress	1017.0	KSI
90º Comp. Ult Stress	1017.0	KSI
Shear Ult. Stress	968.8	KSI
0º Flex. Ult. Stress	966.2	KSI
90º Flex. Ult. Stress	966.2	KSI

DIVINYCELL H-45 1”

	Lay-up, Top to Bottom		Fiber Content		Top Up/Dn	Rotation	Fiber Wt.	Layer	Fiber	Resin	Total	Fiber	Fiber	Resin	Total	Layer
	ID	Product	%	vol / wt	u/d/m/h	deg.	oz/sq.yd	Thickness	lb/sq.ft	lb/sq.ft	lb/sq.ft	$/lb	$/sq.ft	$/sq.ft	$/sq.ft	#
1.	DIA	Divinycell H35 - 1"	100 %	Wt	Hom.	0	28.46	1.000	0.20	-	0.198	$ -	$ -	$ -	$ -	1
2.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
3.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
4.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
5.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
6.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
7.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
8.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
9.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
10.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
11.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
12.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
13.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
14.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
15.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
16.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
17.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
18.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
19.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	
20.			-	Wt	Hom.	0	-	-	-	-	-	$ -	$ -	$ -	$ -	

	Fiber Wt.	Layer Thickness	Fiber lb/sq.ft	Resin lb/sq.ft	Total lb/sq.ft		Fiber $/sq.ft	Resin $/sq.ft	Total $/sq.ft	Layer #	
Laminate :	0.0	-	-	-	0.20	Lam :	$ -	$ -	$ -	1	# Layers
Core / Solids :	28.5	1.000	0.198			Core:	$ -	$/lb :	$ -		Adjustment
Total :	28.5	1.000	0.198								

in this table by clicking on an existing name and selecting a property from the list that pops up.

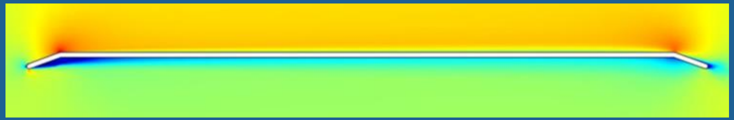
Laminate Comparison Table — Table Units: US

Laminate # ->	1	
Laminate	Current Laminate	
Thickness	1.000	in.
Mf	0.00 %	by Wt.
Density	2.4	lb/cu.ft
Fiber Wt.	0.00	lb/sq.ft
Resin Wt.	0.00	lb/sq.ft
Laminate Wt.	0.20	lb/sq.ft
Vf	0.00 %	by Vol.
0º Modulus, Ex	0.01	MSI
90º Modulus, Ey	0.01	MSI
Poisson Ratio, PRxy	0.27	
Shear Modulus, Gxy	0.00	MSI
0º Ten. Ult. Stress	1017.0	KSI
0º Comp. Ult. Stress	1017.0	KSI
90º Ten. Ult. Stress	1017.0	KSI
90º Comp. Ult Stress	1017.0	KSI
Shear Ult. Stress	600.0	KSI
0º Flex. Ult. Stress	966.2	KSI
90º Flex. Ult. Stress	966.2	KSI

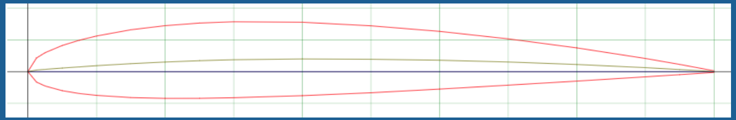
Aerodynamic Calculations

	A	B	C	D	E	F	G	H	I	J	K	L
1										cL	@ 0 deg	@ 5 deg
2	LIFT		Flat Plate	2412	NACA 6409	EPPLER 58				Flat Plate	0	0.7
3	0 deg	35	0	408 N	1135 N	1536 N				NACA 2412	0.2442	0.8089
4	0 deg	70	0	1632 N	4540 N	6146 N				NACA 6409	0.679	1.1928
5	5 deg	35	1170 N	1352 N	1994 N	2239 N				EPPLER 58	0.9192	1.3395
6	5 deg	70	4680 N	5409 N	7975 N	8956 N						
7												
8	DRAG		Flat Plate	2412	NACA 6409	EPPLER 58						
9	0 deg	35	0	9.5 N	12 N	10 N						
10	0 deg	70	0	38 N	47 N	40 N		A = 11.148 m^2		cD	@ 0 deg	@ 5 deg
11	5 deg	35	84 N	13 N	13 N	24 N		V = 15.6464 m/s		Flat Plate	~0	0.05
12	5 deg	70	334 N	54 N	54 N	96 N		V = 31.2928 m/s		NACA 2412	0.00568	0.00804
13								rho = 1.225 kg/m^3		NACA 6409	0.007	0.0079
14	We are using L = (1/2)*(cL)*rho * V * V * A							rho is STP		EPPLER 58	0.0059	0.01428
15	We are using D = (1/2)*(cD)*rho * V * V * A											

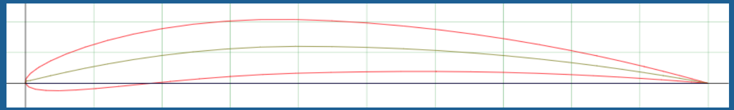
Aerodynamic Calculations



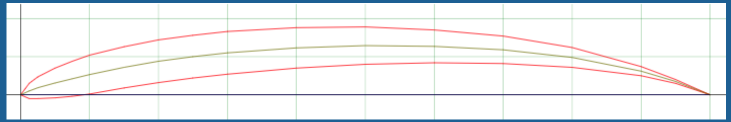
Current Hardtop



NACA 2412



NACA 6409

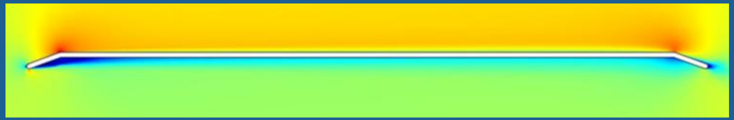
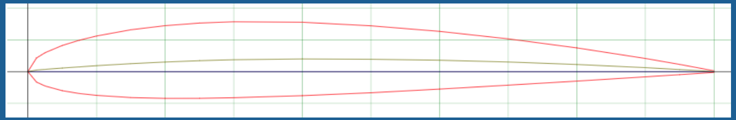
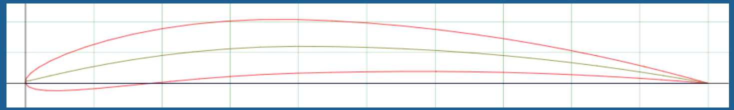
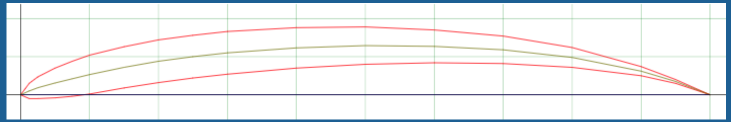


Eppler 58

Lift	Drag	Max. Thickness	Total Weight (lbs)
Least	Highest	1.5”	127
Medium	Low	21.75”	1000+
Medium	Low	~20”	1000+
Highest	Lowest	~17”	1000+

John Karamitsanis

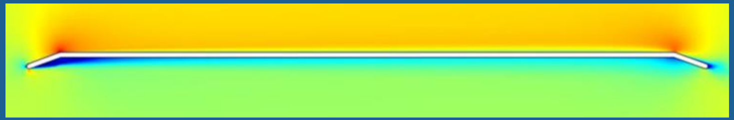
Aerodynamic Calculations

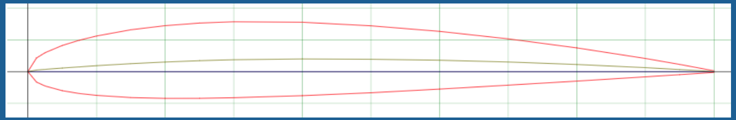
	Lift	Drag	Max. Thickness	Total Weight (lbs)
 Current Hardtop	Least	Highest	1.5”	127
 NACA 2412	Medium	Low	21.75”	1000+
 NACA 6409	Medium	Low	~20”	1000+
 Eppler 58	Highest	Lowest	~17”	1000+

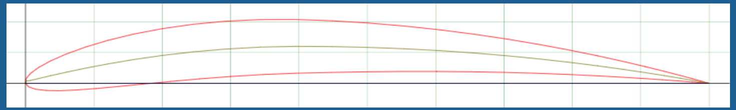
Thicknesses significantly higher

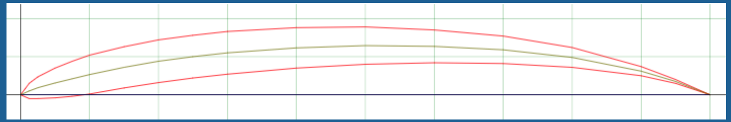
John Karamitsanis

Aerodynamic Calculations


Current Hardtop


NACA 2412


NACA 6409

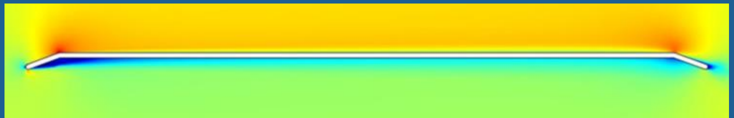

Eppler 58

Lift	Drag	Max. Thickness	Total Weight (lbs)
Least	Highest	1.5”	127
Medium	Low	21.75”	1000+
Medium	Low	~20”	1000+
Highest	Lowest	~17”	1000+

Weights significantly higher

John Karamitsanis

Aerodynamic Calculations



Current Hardtop

NACA 2412; 25% Thickness

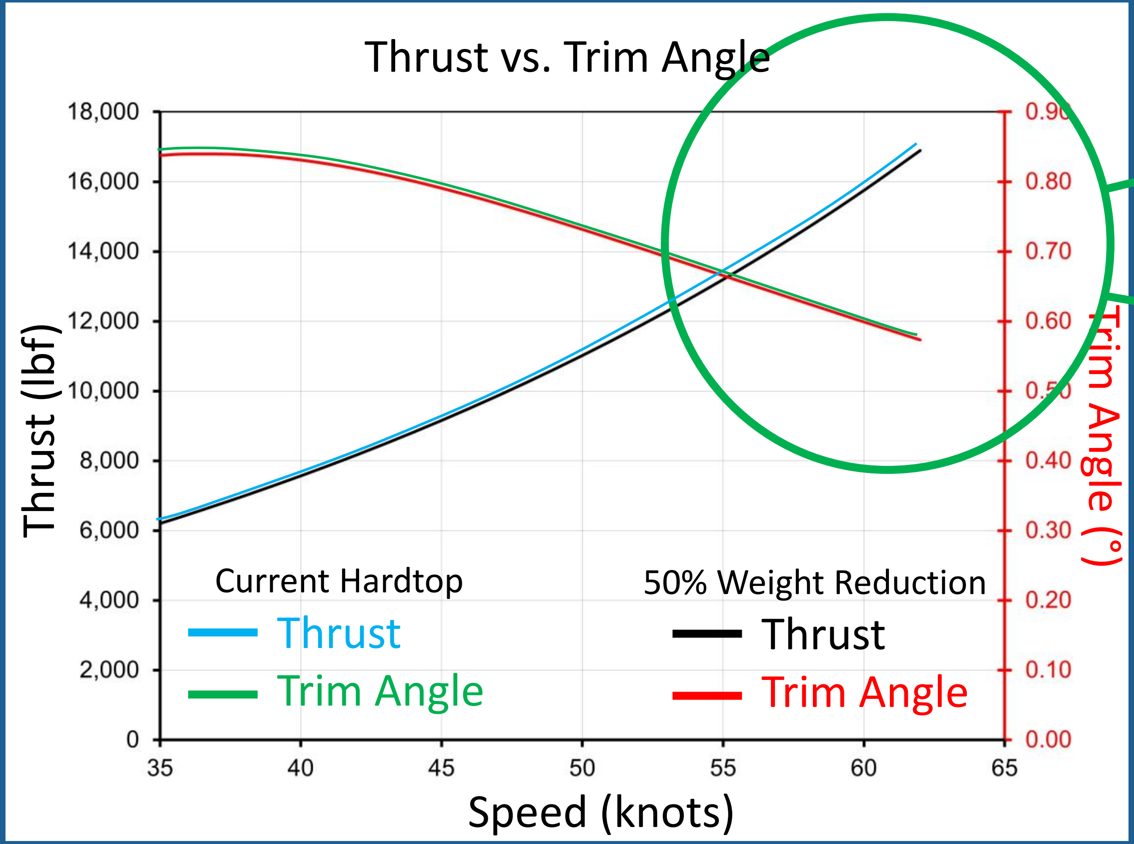
NACA 6409; 25% Thickness

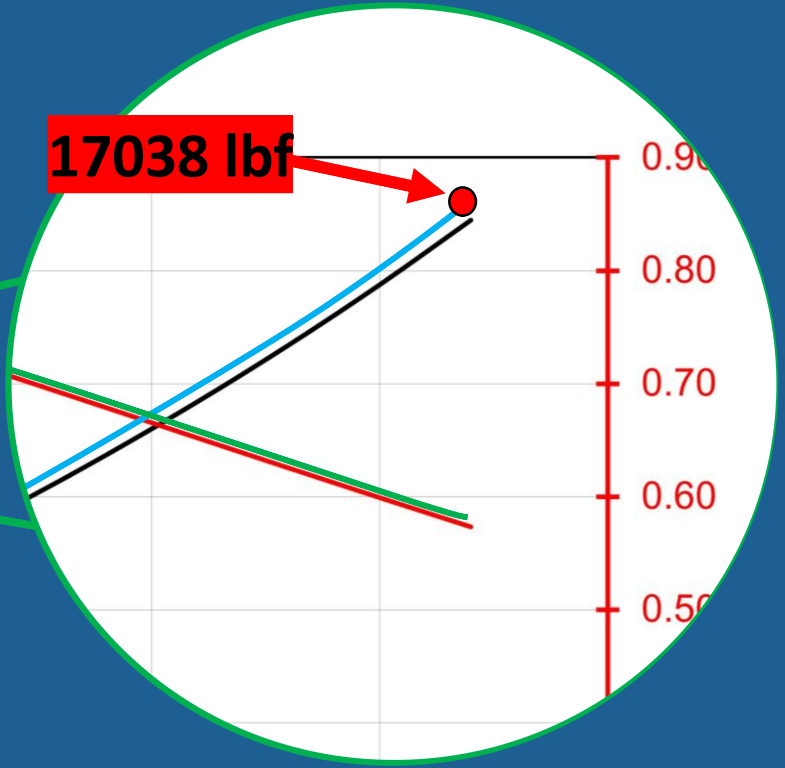
	Lift	Drag	Max. Thickness	Total Weight (lbs)
Current Hardtop	Low	Highest	1.5”	127
NACA 2412; 25% Thickness	Lowest	Low	5.4”	341
NACA 6409; 25% Thickness	Lower	Low	4.1”	336

John Karamitsanis

Improve fuel efficiency

Key Goals



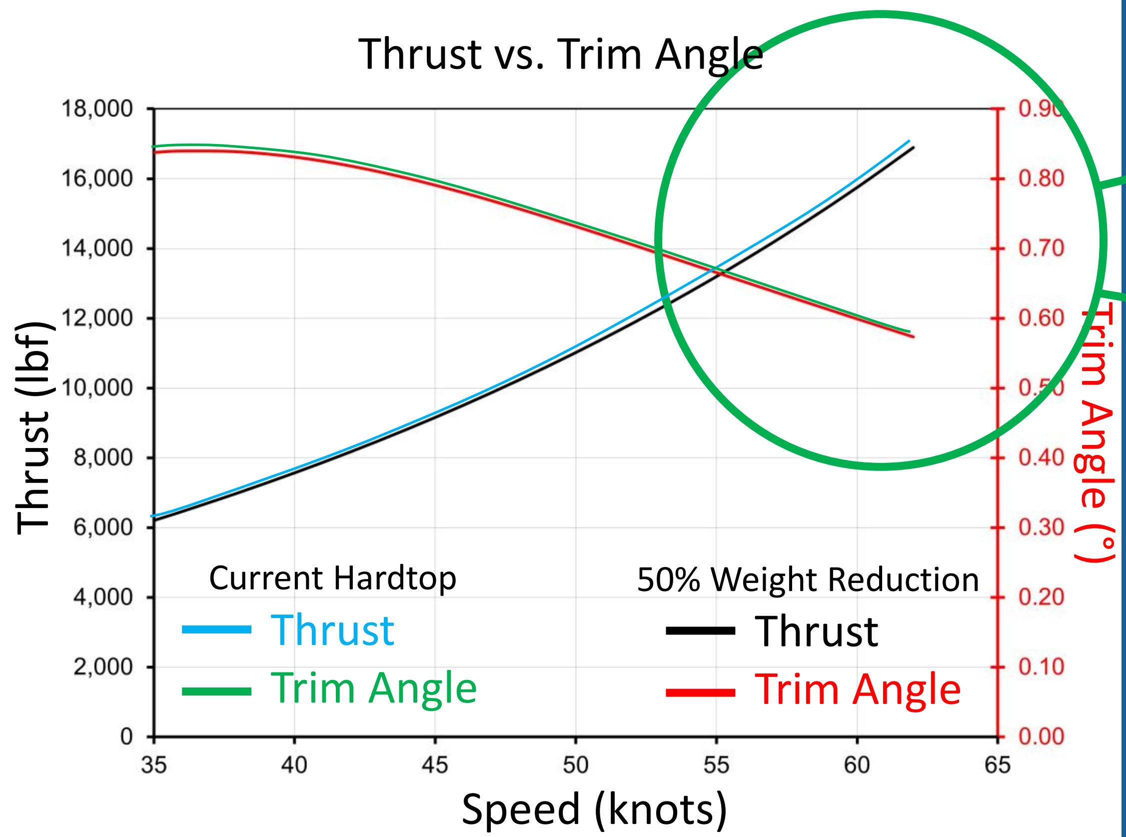


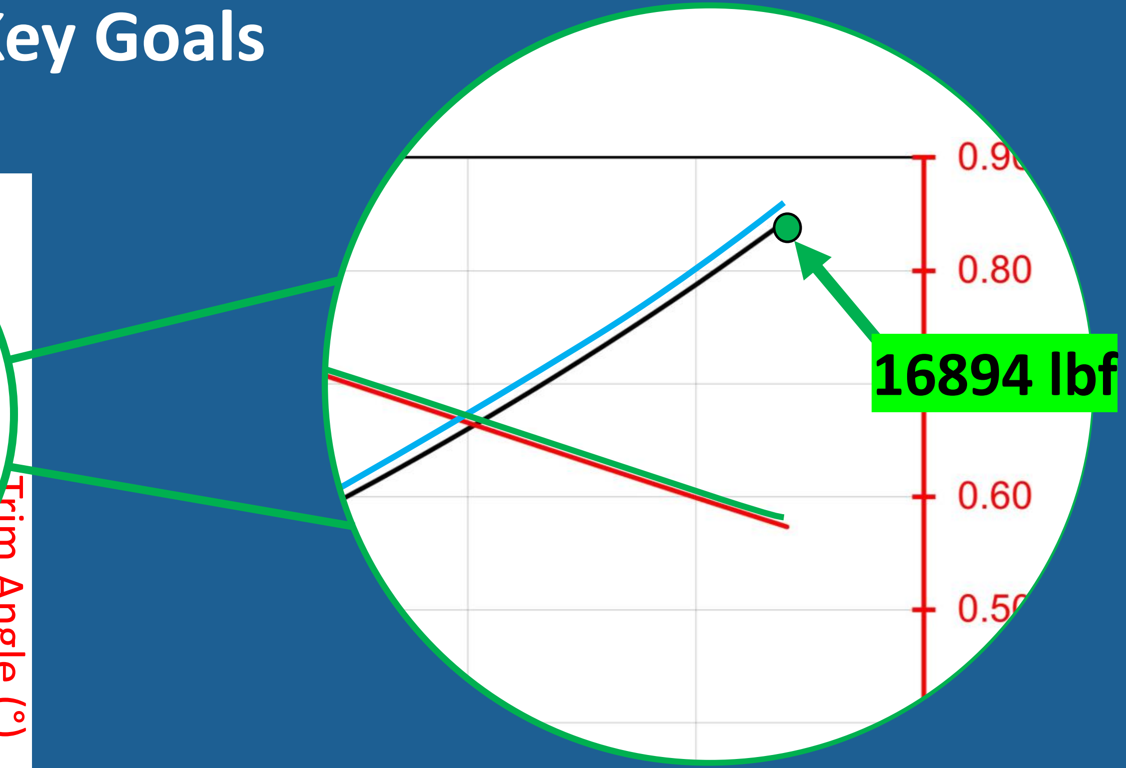
Thrust required is higher throughout powerband with current hardtop

John Karamitsanis

Improve fuel efficiency

Key Goals





Thrust required is lower throughout powerband with lighter hardtop i.e. Fuel is saved

John Karamitsanis

Thrust Calculations – 4 ft CoG

INPUT

This spreadsheet was written by Dingo Tweedie, October 2004.
Dit rekenblad werd deur Dingo Tweedie, oktober 2004, geschreven.
Versie 1.2.1

Hull	Length of Waterline	L_{WL}	40.00	feet	=	12.192	metres	
	Beam	B	11.08	feet	=	3.378	metres	
	VCG	VCG	4.00	feet	=	1.219	metres	
	Displacement	Δ	20,000	lbf	=	9,072	kg	
	Deadrise @ Transom	β_T	10.00	°				
	Deadrise @ Amidships	β)0(	10.00	°				
	Distance to Amidships	L)0(	20.000	feet	=	6.096	metres	
		θ	0.000	°				
	Angle of Thrust Line	ε	0.00	°				
		f	0.00	feet	=	0.000	metres	
	Minimum Speed	V_{min}	6.7	kn	=	11.3	feet/s	This is the minimum speed valid for this analysis
	Maximum Speed	V_{max}	145.4	kn	=	245.5	feet/s	This is the maximum speed valid for this analysis
S/Str.	Length Overall	LOA	40.00	feet	=	12.192	metres	
	Maximum Beam	B_{max}	11.08	feet	=	3.378	metres	
	Moulded Depth of Hull	Z	11.67	feet	=	3.556	metres	
	Height of House	H_{SS}	0.00	feet	=	0.000	metres	
	Breadth of House	B_{SS}	0.00	feet	=	0.000	metres	
	Frontal Area of House	A_{SS}	0.00	$feet^2$	=	0.000	m^2	
Number	Number of Propellers	N	3					
Trim Tab	Chord	c_F	1	feet	=	0.305	metres	
	Span Ratio	σ	0.333	(<= 1)				
	Deflection Angle	δ	2	°				
Rudder	Chord	c_{rudder}	0.00	feet	=	0.000	metres	
	Thickness	t	0.00	feet	=	0.000	metres	
	Area	A_{rudder}	0.00	$feet^2$	=	0.000	m^2	
	Centrepoint	x_c	0.00	feet from transom	=	0.000	metres	(+ve fwd)
		y_c	0.00	feet from baseline	=	0.000	metres	(+ve up)
Shaft	Diameter of Shaft	Φ_{shaft}	0.00	feet	=	0.000	metres	
	Length of Shaft & Hub	l	0.00	feet	=	0.000	metres	
	Centrepoint	x_c	0.00	feet from transom	=	0.000	metres	(+ve fwd)
		y_c	0.00	feet from baseline	=	0.000	metres	(+ve up)

Strut	Chord	c_{strut}	0.00	feet	=	0.000	metres		
	Thickness	t	0.00	feet	=	0.000	metres		
	Area	A_{strut}	0.00	$feet^2$	=	0.000	m^2		****
	Centrepoint	x_c	0.00	feet from transom	=	0.000	metres	(+ve fwd)	
		y_c	0.00	feet from baseline	=	0.000	metres	(+ve up)	

OUTPUT

Go

V	LCG		τ	D		T		$P_{effective}$		h		τ_{cr}		Comments	λ
[kn]	[ft]	[metres]	[°]	[lbf]	[kN]	[lbf]	[kN]	[ehp]	[ekW]	[ft]	[metres]	Lew.[°]	Angeli [°]		
35	29	8.839	0.84	6,201	27.6	6,202	27.6	666	497	1.19	0.363	3.23	2.12	Note: not planing	5.6630
36	29	8.839	0.84	6,459	28.7	6,459	28.7	714	533	1.19	0.363	3.08	2.04	Note: not planing	5.5945
38	29	8.839	0.84	6,996	31.1	6,997	31.1	816	609	1.16	0.354	2.83	1.90	Note: not planing	5.4736
40	29	8.839	0.83	7,566	33.7	7,567	33.7	929	693	1.14	0.347	2.60	1.77	Note: not planing	5.3743
42	29	8.839	0.82	8,172	36.4	8,173	36.4	1,053	786	1.12	0.341	2.41	1.66	Note: not planing	5.2951
44	29	8.839	0.80	8,818	39.2	8,818	39.2	1,191	889	1.09	0.332	2.24	1.56	Note: not planing	5.2351
46	29	8.839	0.78	9,505	42.3	9,506	42.3	1,342	1,001	1.06	0.323	2.09	1.47	Note: not planing	5.1925
48	29	8.839	0.76	10,237	45.6	10,238	45.6	1,508	1,125	1.03	0.314	1.95	1.39	Note: not planing	5.1658
50	29	8.839	0.73	11,017	49.0	11,017	49.0	1,691	1,262	1.01	0.308	1.83	1.32	Note: not planing	5.1537
52	29	8.839	0.71	11,847	52.7	11,848	52.7	1,891	1,411	0.98	0.299	1.72	1.25	Note: not planing	5.1552
54	29	8.839	0.68	12,732	56.7	12,733	56.7	2,110	1,575	0.96	0.293	1.62	1.19	Note: not planing	5.1689
56	29	8.839	0.65	13,675	60.9	13,676	60.9	2,350	1,754	0.93	0.283	1.53	1.14	Note: not planing	5.1946
58	29	8.839	0.63	14,679	65.3	14,680	65.3	2,613	1,950	0.91	0.277	1.45	1.09	Note: not planing	5.2312
60	29	8.839	0.60	15,750	70.1	15,750	70.1	2,900	2,164	0.89	0.271	1.38	1.04	Note: not planing	5.2792
62	29	8.839	0.57	16,894	75.2	16,895	75.2	3,215	2,399	0.87	0.265	1.31	1.00	Note: not planing	5.3390

Thrust Calculations – 4.25 ft CoG

INPUT

This spreadsheet was written by Dingo Tweedie, October 2004.
Dit rekenblad werd deur Dingo Tweedie, oktober 2004, geschreven.
Versie 1.2.1

Hull	Length of Waterline	L_{WL}	40.00	feet	=	12.192	metres		
	Beam	B	11.08	feet	=	3.378	metres		
	VCG	VCG	4.25	feet	=	1.295	metres		
	Displacement	Δ	20,000	lbf	=	9,072	kg		
	Deadrise @ Transom	β_T	10.00	°					
	Deadrise @ Amidships	β)0(	10.00	°					
	Distance to Amidships	L)0(	20.000	feet	=	6.096	metres		
		θ	0.000	°					
	Angle of Thrust Line	ε	0.00	°					
		f	0.00	feet	=	0.000	metres		
	Minimum Speed	V_{min}	6.7	kn	=	11.3	feet/s	This is the minimum speed valid for this analysis	
	Maximum Speed	V_{max}	145.4	kn	=	245.5	feet/s	This is the maximum speed valid for this analysis	
S/Str.	Length Overall	LOA	40.00	feet	=	12.192	metres		
	Maximum Beam	B_{max}	11.08	feet	=	3.378	metres		
	Moulded Depth of Hull	Z	11.67	feet	=	3.556	metres		
	Height of House	H_{SS}	0.00	feet	=	0.000	metres		
	Breadth of House	B_{SS}	0.00	feet	=	0.000	metres		
	Frontal Area of House	A_{SS}	0.00	$feet^2$	=	0.000	m^2		
Number	Number of Propellers	N	3						
Trim Tab	Chord	c_F	1	feet	=	0.305	metres		
	Span Ratio	σ	0.333	(<= 1)					
	Deflection Angle	δ	2	°					
Rudder	Chord	c_{rudder}	0.00	feet	=	0.000	metres		
	Thickness	t	0.00	feet	=	0.000	metres		
	Area	A_{rudder}	0.00	$feet^2$	=	0.000	m^2		
	Centrepoint	x_c	0.00	feet from transom	=	0.000	metres	(+ve fwd)	
		y_c	0.00	feet from baseline	=	0.000	metres	(+ve up)	
Shaft	Diameter of Shaft	Φ_{shaft}	0.00	feet	=	0.000	metres		
	Length of Shaft & Hub	*l*	0.00	feet	=	0.000	metres		
	Centrepoint	x_c	0.00	feet from transom	=	0.000	metres	(+ve fwd)	
		y_c	0.00	feet from baseline	=	0.000	metres	(+ve up)	

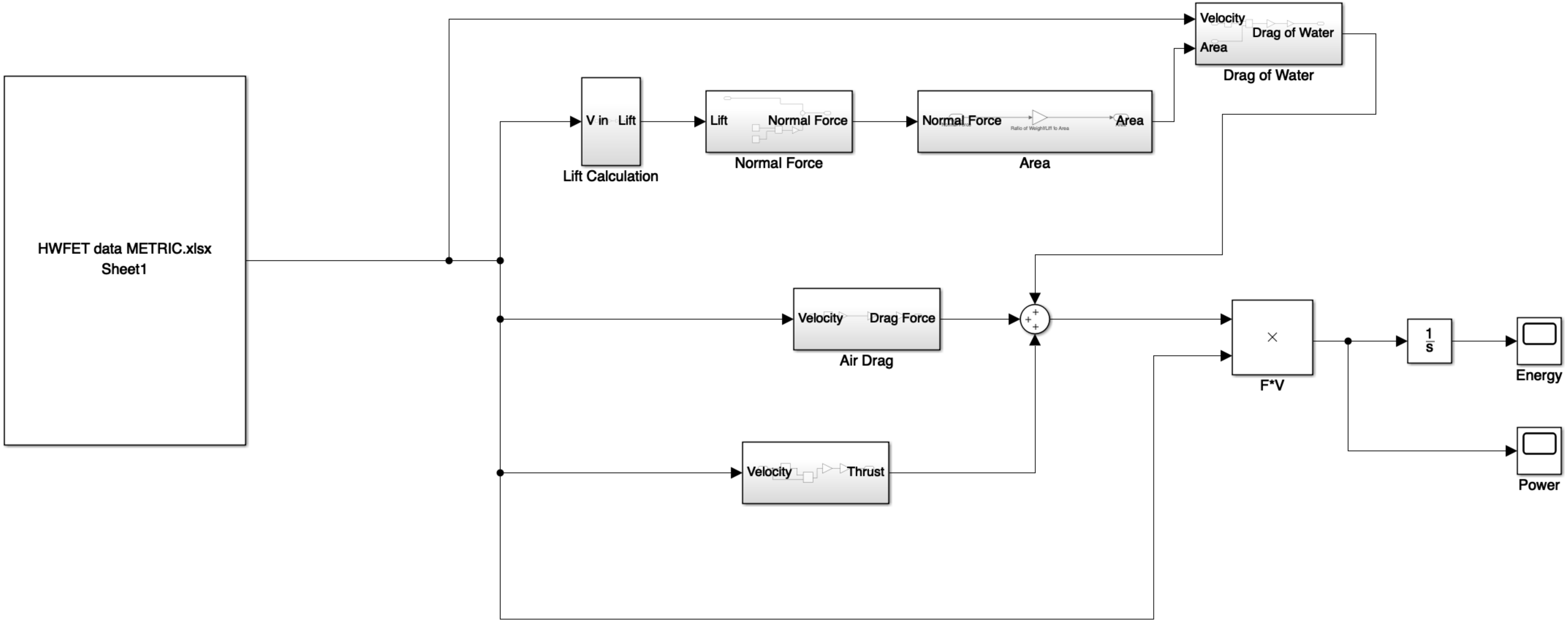
Strut	Chord	c_{strut}	0.00	feet	=	0.000	metres		
	Thickness	t	0.00	feet	=	0.000	metres		
	Area	A_{strut}	0.00	$feet^2$	=	0.000	m^2	****	
	Centrepoint	x_c	0.00	feet from transom	=	0.000	metres	(+ve fwd)	
		y_c	0.00	feet from baseline	=	0.000	metres	(+ve up)	

OUTPUT

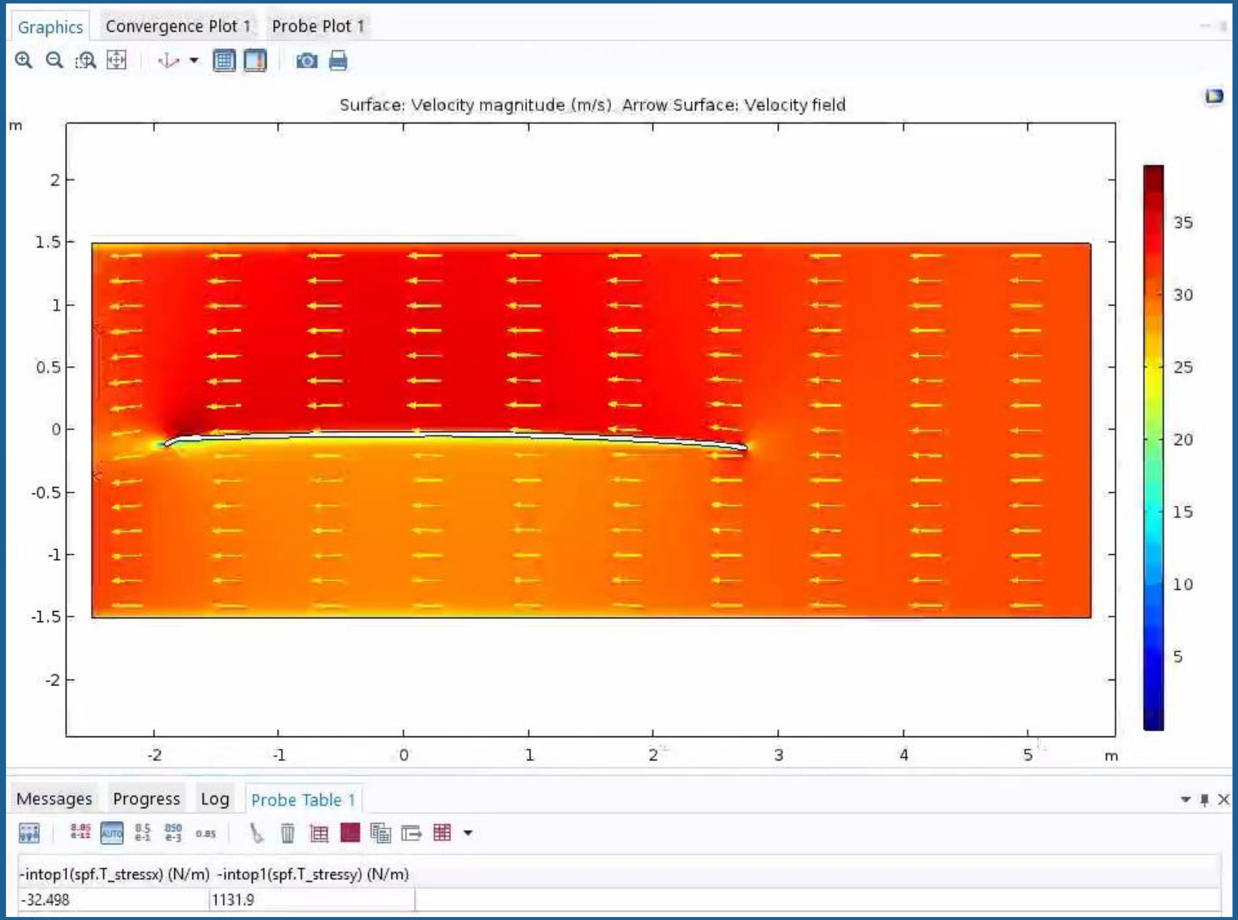
Go

V	LCG		τ	D		T		$P_{effective}$		h		τ_{cr}		Comments	λ
[kn]	[ft]	[metres]	[°]	[lbf]	[kN]	[lbf]	[kN]	[ehp]	[ekW]	[ft]	[metres]	Lew.[°]	Angeli [°]		
35	29	8.839	0.83	6,221	27.7	6,221	27.7	668	499	1.19	0.363	3.23	2.12	Note: not planing	5.6885
36	29	8.839	0.83	6,480	28.8	6,480	28.8	716	534	1.18	0.360	3.08	2.04	Note: not planing	5.6207
38	29	8.839	0.83	7,021	31.2	7,022	31.2	819	611	1.16	0.354	2.83	1.90	Note: not planing	5.5018
40	29	8.839	0.82	7,596	33.8	7,597	33.8	932	696	1.14	0.347	2.60	1.77	Note: not planing	5.4039
42	29	8.839	0.81	8,207	36.5	8,208	36.5	1,058	789	1.11	0.338	2.41	1.66	Note: not planing	5.3265
44	29	8.839	0.79	8,858	39.4	8,859	39.4	1,196	893	1.09	0.332	2.24	1.56	Note: not planing	5.2683
46	29	8.839	0.77	9,552	42.5	9,553	42.5	1,348	1,006	1.06	0.323	2.09	1.47	Note: not planing	5.2276
48	29	8.839	0.75	10,291	45.8	10,292	45.8	1,516	1,131	1.03	0.314	1.95	1.39	Note: not planing	5.2031
50	29	8.839	0.73	11,079	49.3	11,080	49.3	1,700	1,269	1.01	0.308	1.83	1.32	Note: not planing	5.1933
52	29	8.839	0.70	11,919	53.0	11,920	53.0	1,902	1,420	0.98	0.299	1.72	1.25	Note: not planing	5.1969
54	29	8.839	0.67	12,815	57.0	12,816	57.0	2,124	1,585	0.96	0.293	1.62	1.19	Note: not planing	5.2135
56	29	8.839	0.65	13,769	61.3	13,769	61.3	2,366	1,766	0.93	0.283	1.53	1.14	Note: not planing	5.2417
58	29	8.839	0.62	14,788	65.8	14,789	65.8	2,632	1,964	0.91	0.277	1.45	1.09	Note: not planing	5.2826
60	29	8.839	0.59	15,875	70.6	15,876	70.6	2,923	2,182	0.89	0.271	1.38	1.04	Note: not planing	5.3343
62	29	8.839	0.57	17,038	75.8	17,038	75.8	3,242	2,419	0.87	0.265	1.31	1.00	Note: not planing	5.3983

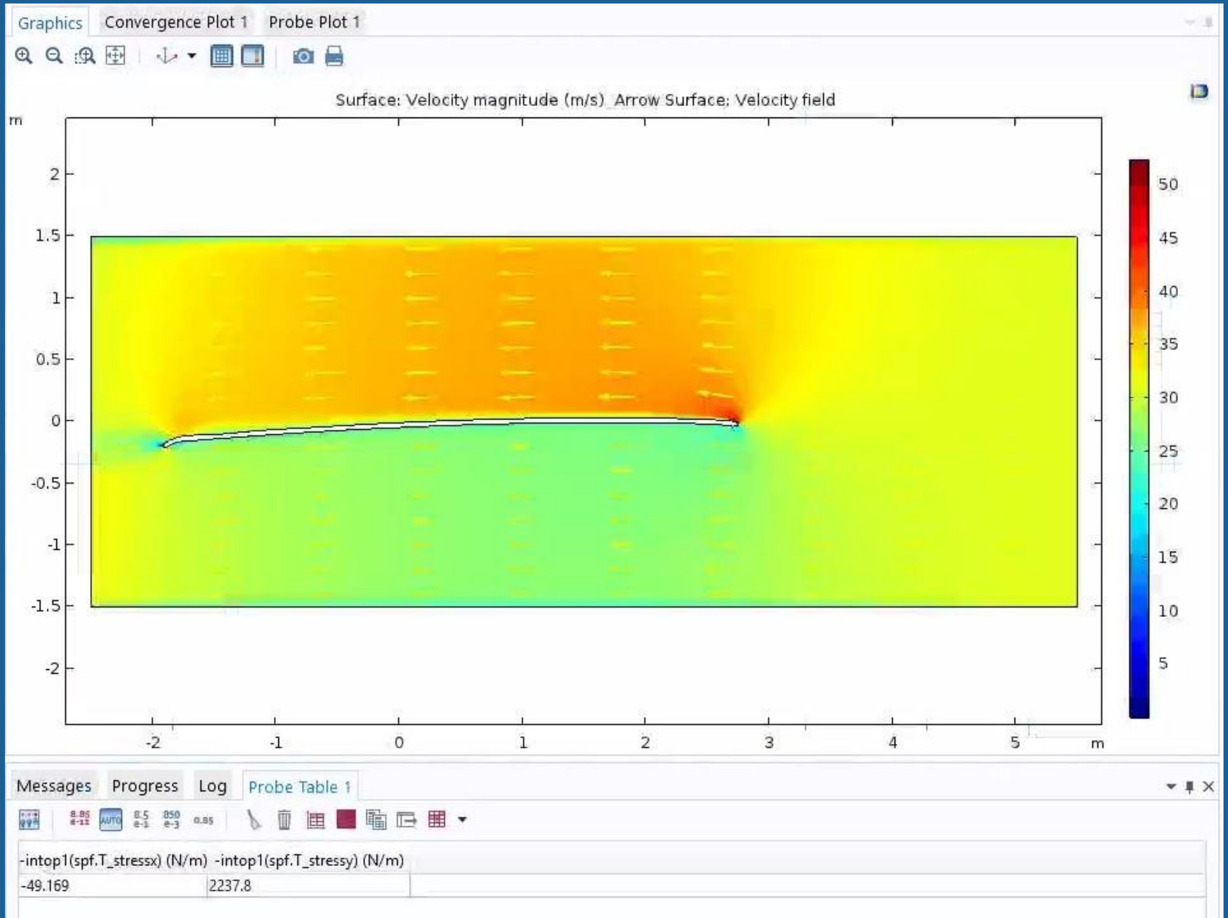
Simulink Model



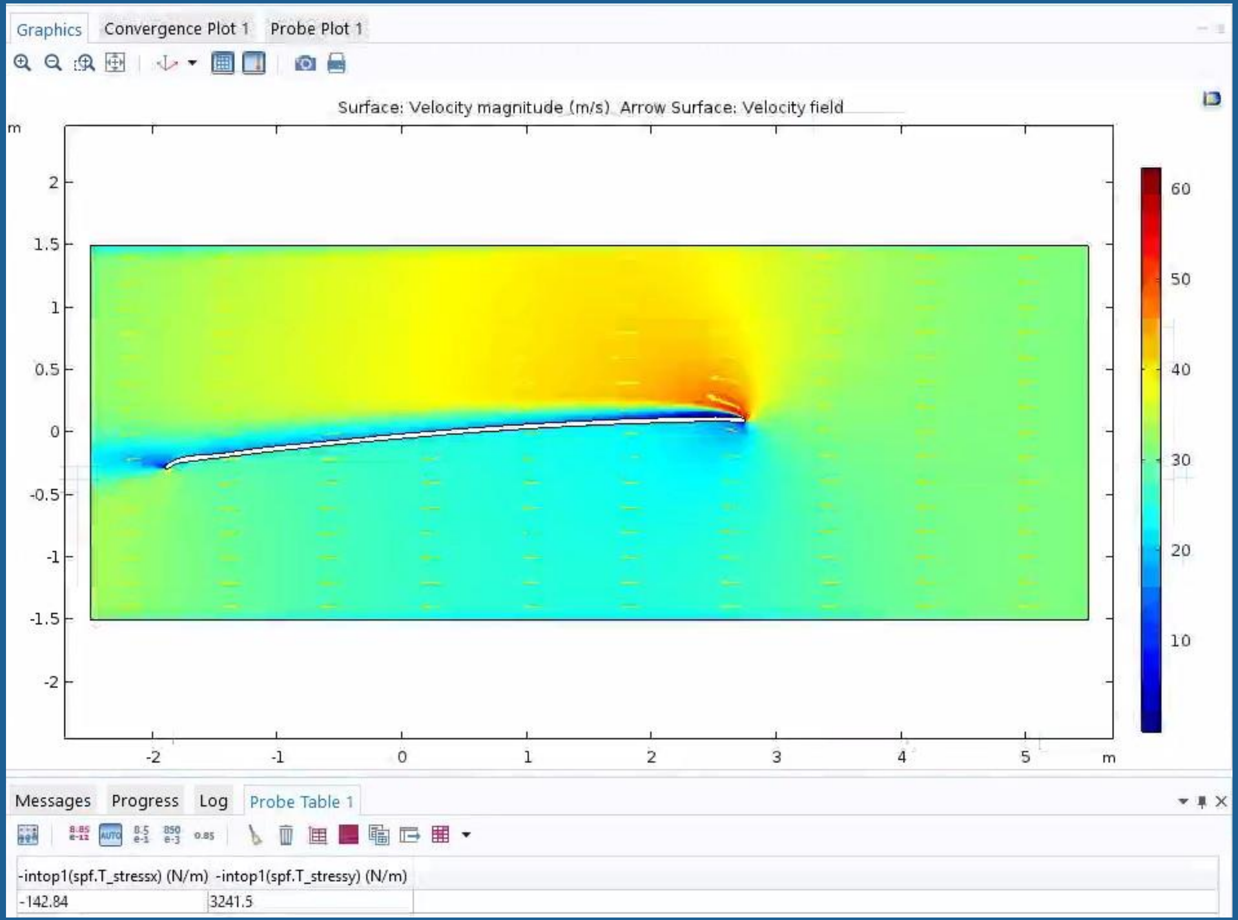
Current Hardtop Cross-Section @ α = 0°



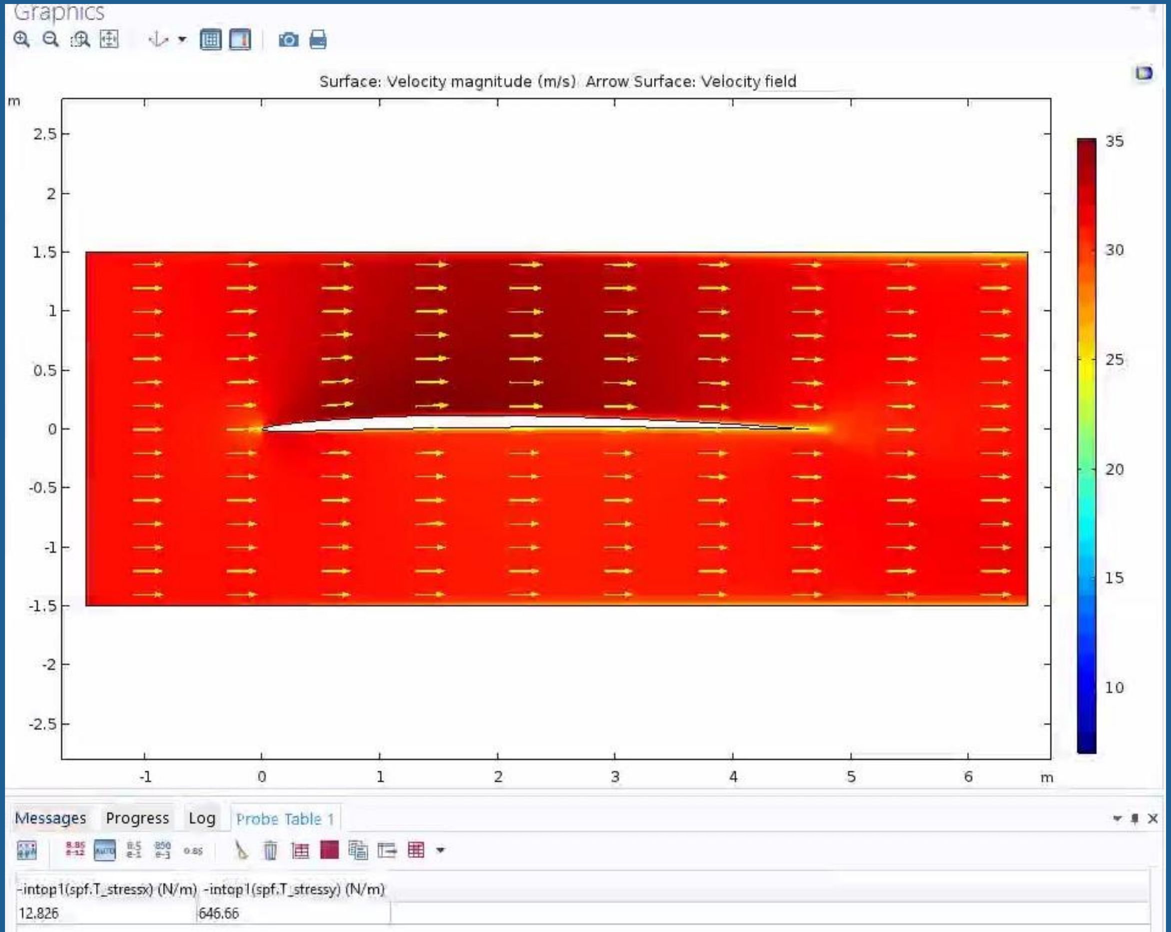
Current Hardtop Cross-Section @ α = 2.5°



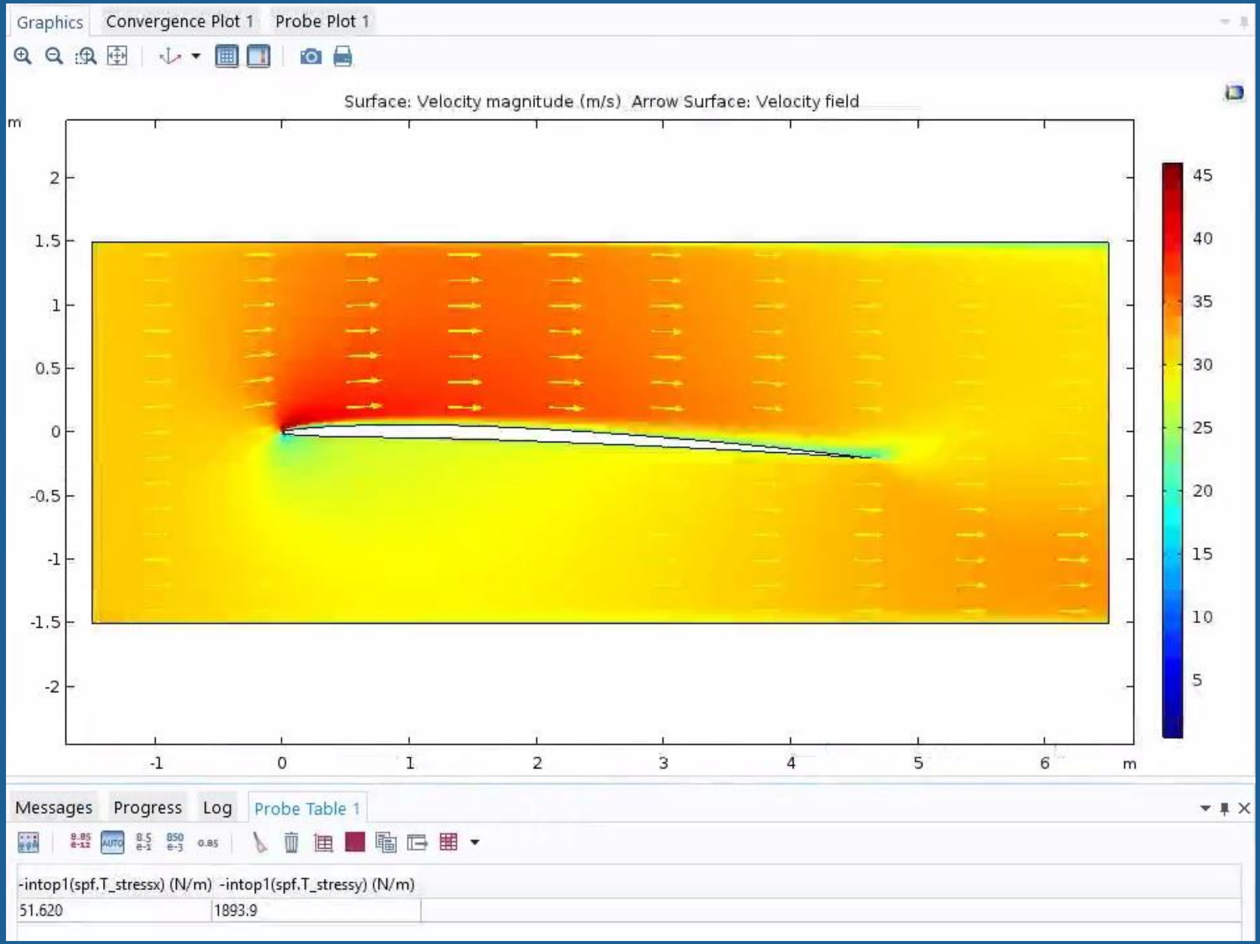
Current Hardtop Cross-Section @ α = 5°



NACA 6409 25% Thickness C.S. @ α = 0°



NACA 6409 25% Thickness C.S. @ α = 2.5°



NACA 6409 25% Thickness C.S. @ α = 5°