



Announcing HyperXpert™ Design Insights for Generating Lightweight Manufacturable Designs,

Collier UAM eVTOL FEM

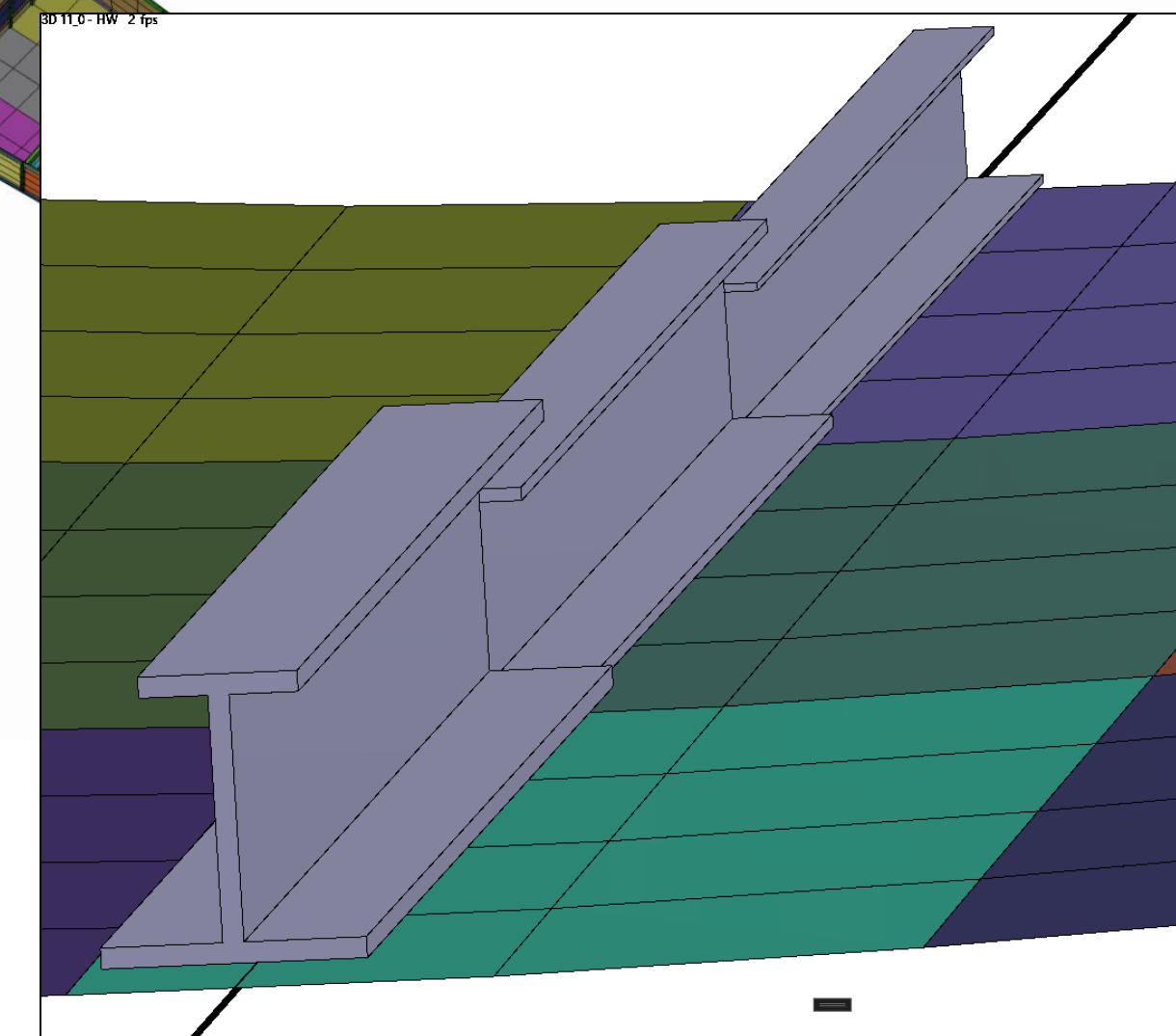
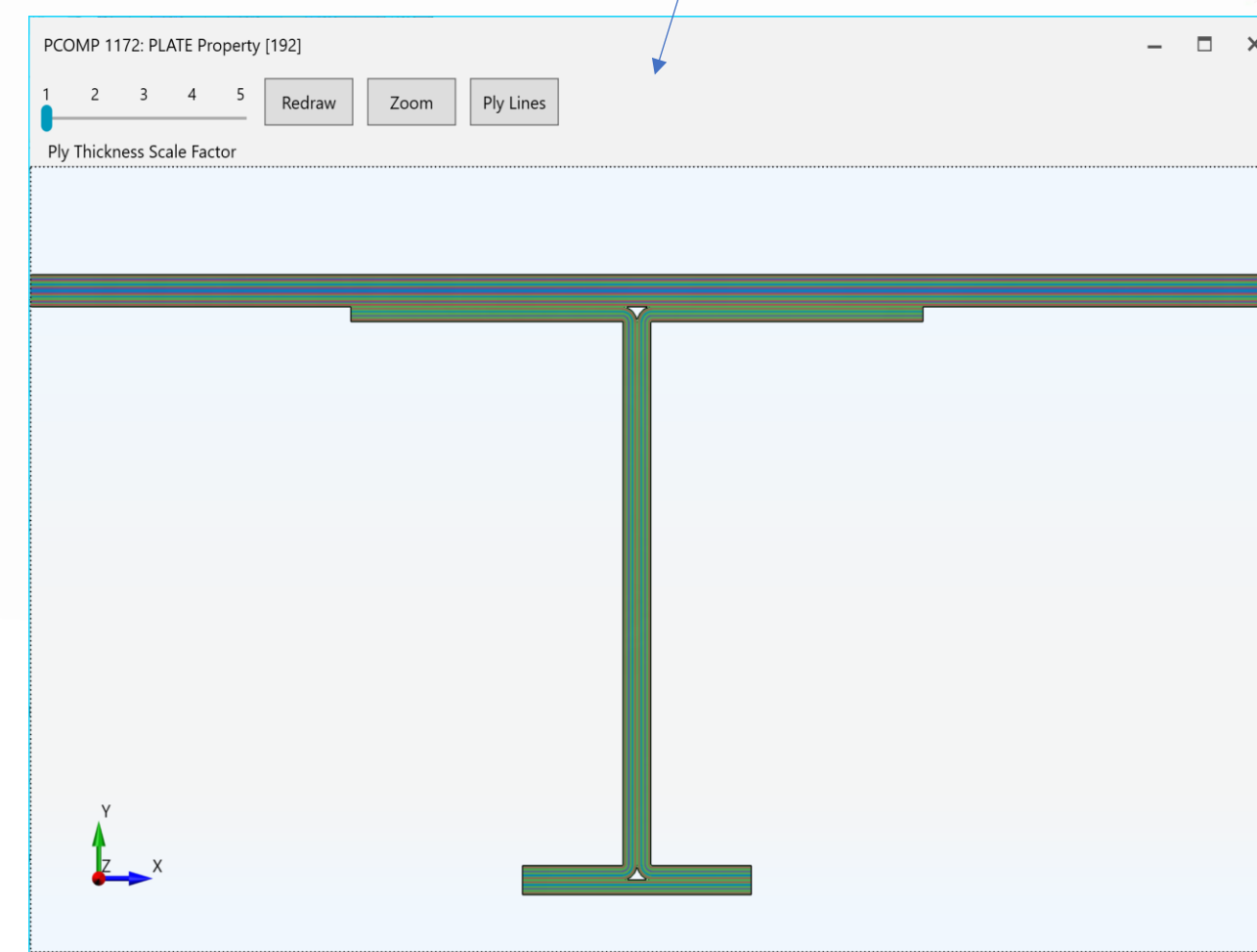
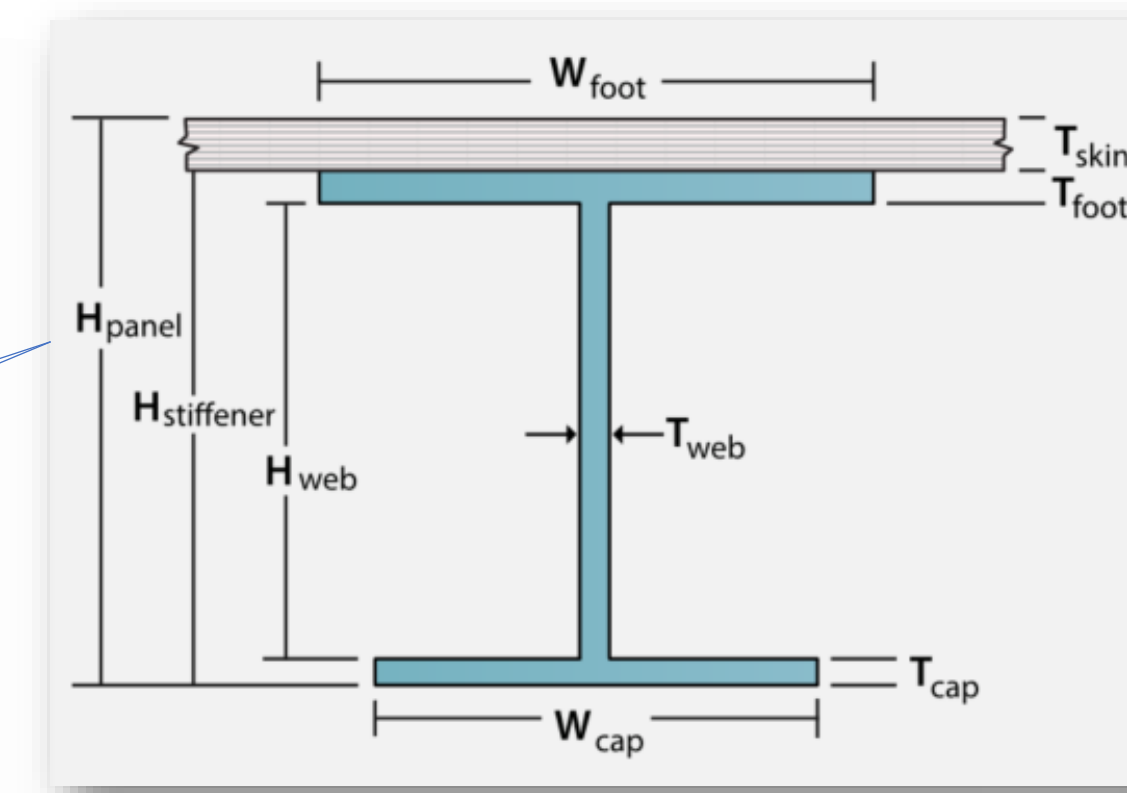
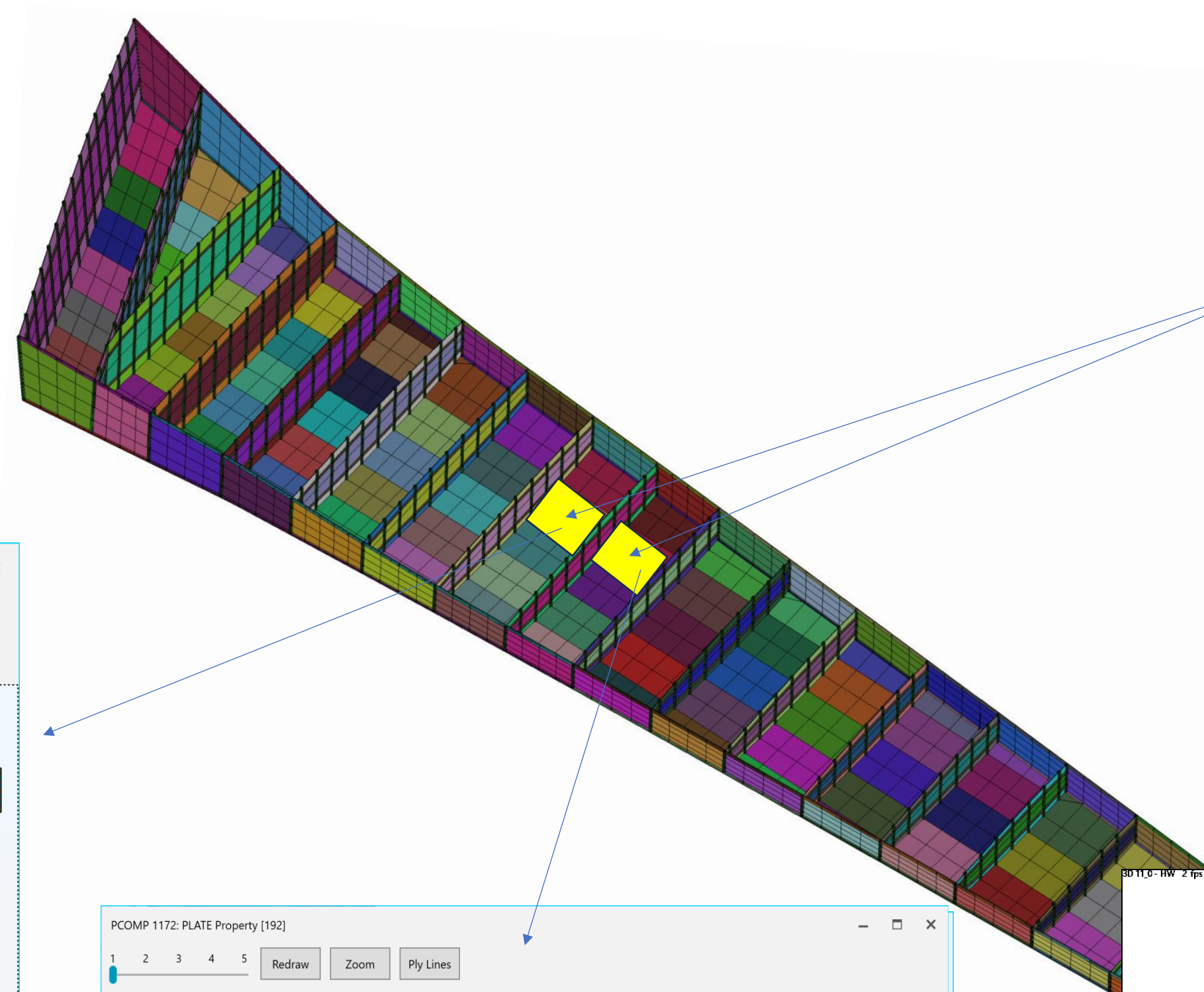
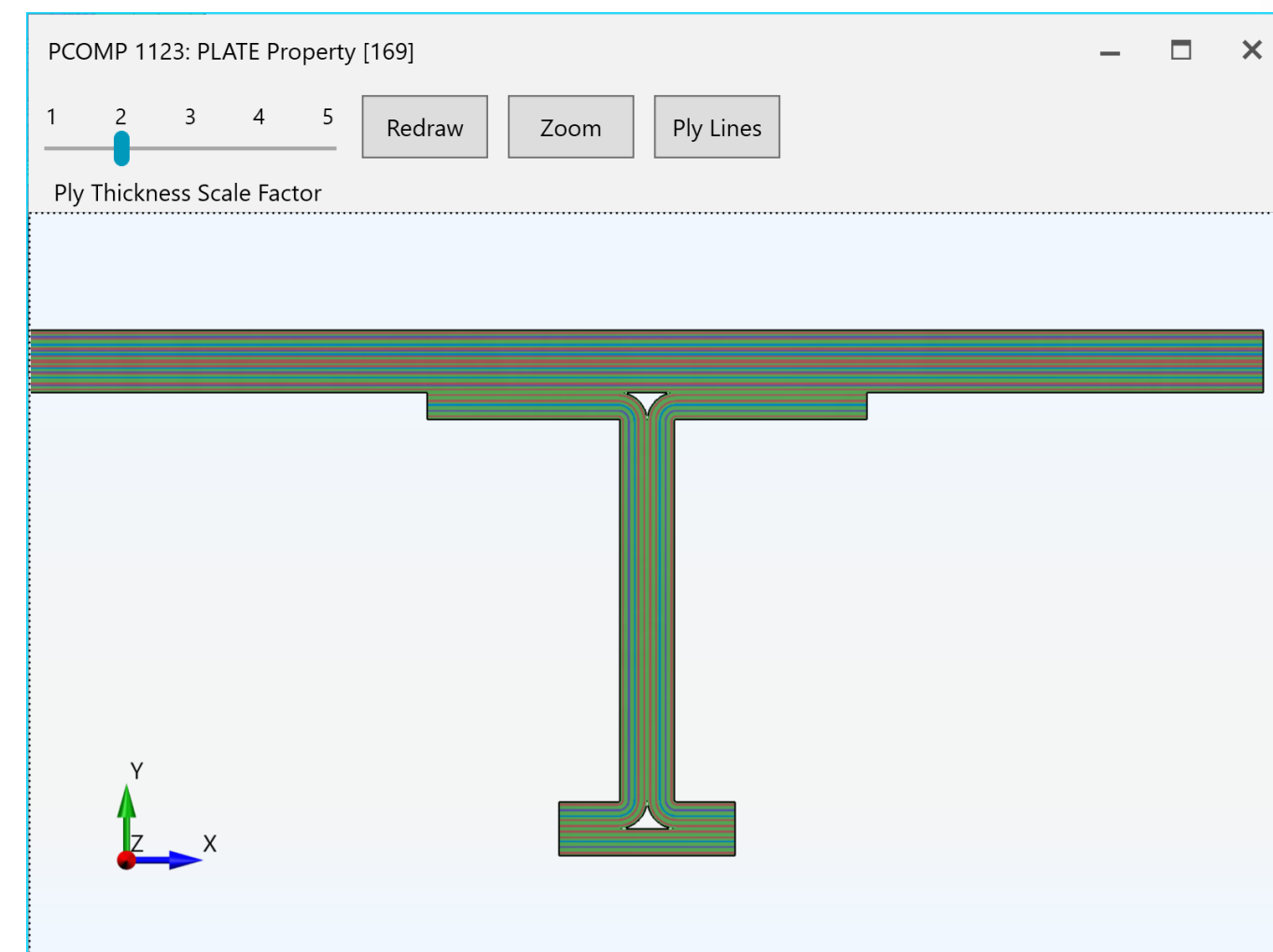
HyperXpert DOE 2025-06-17.pptx



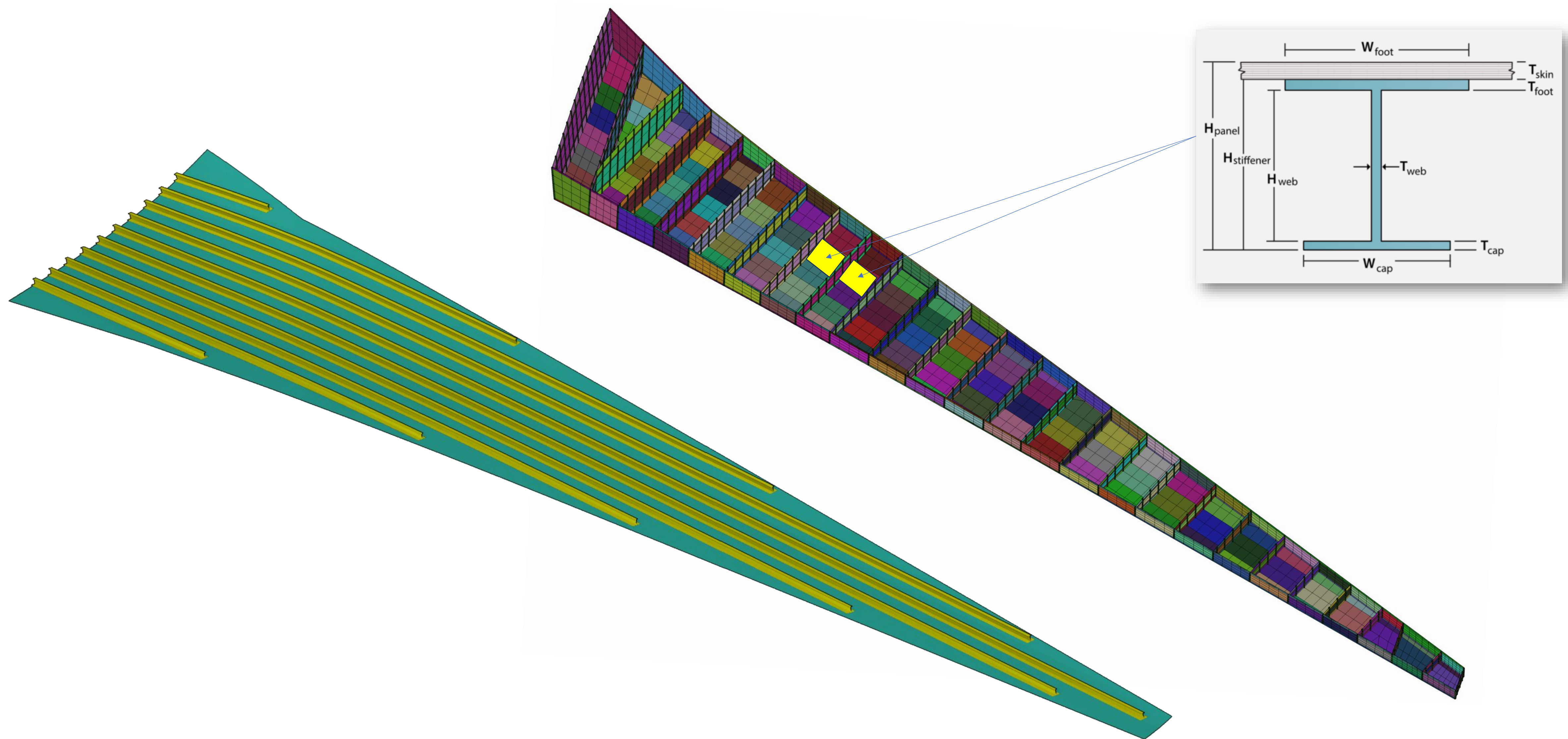
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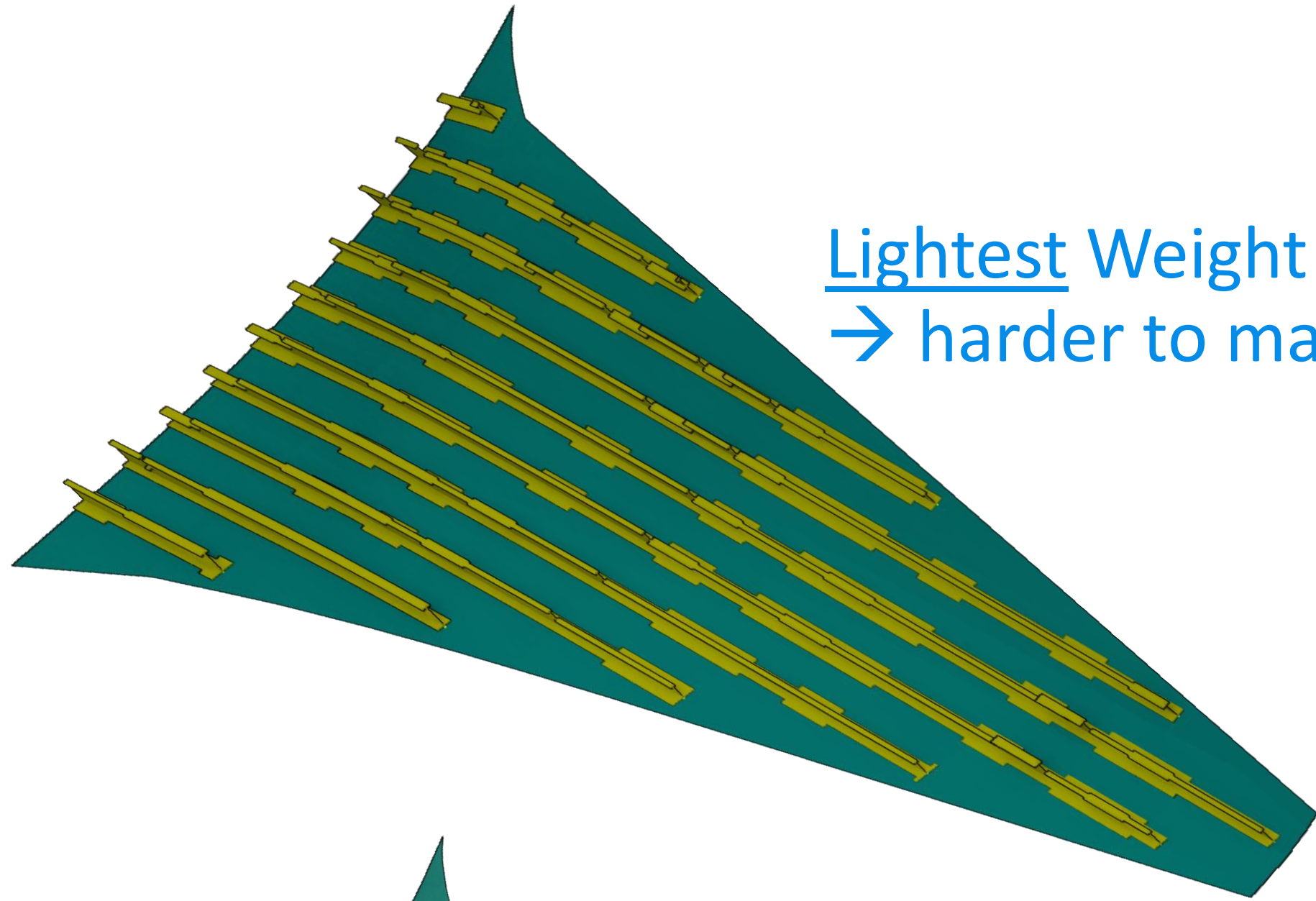
Commercial 737-like Composite Upper Skin Stiffened Panel



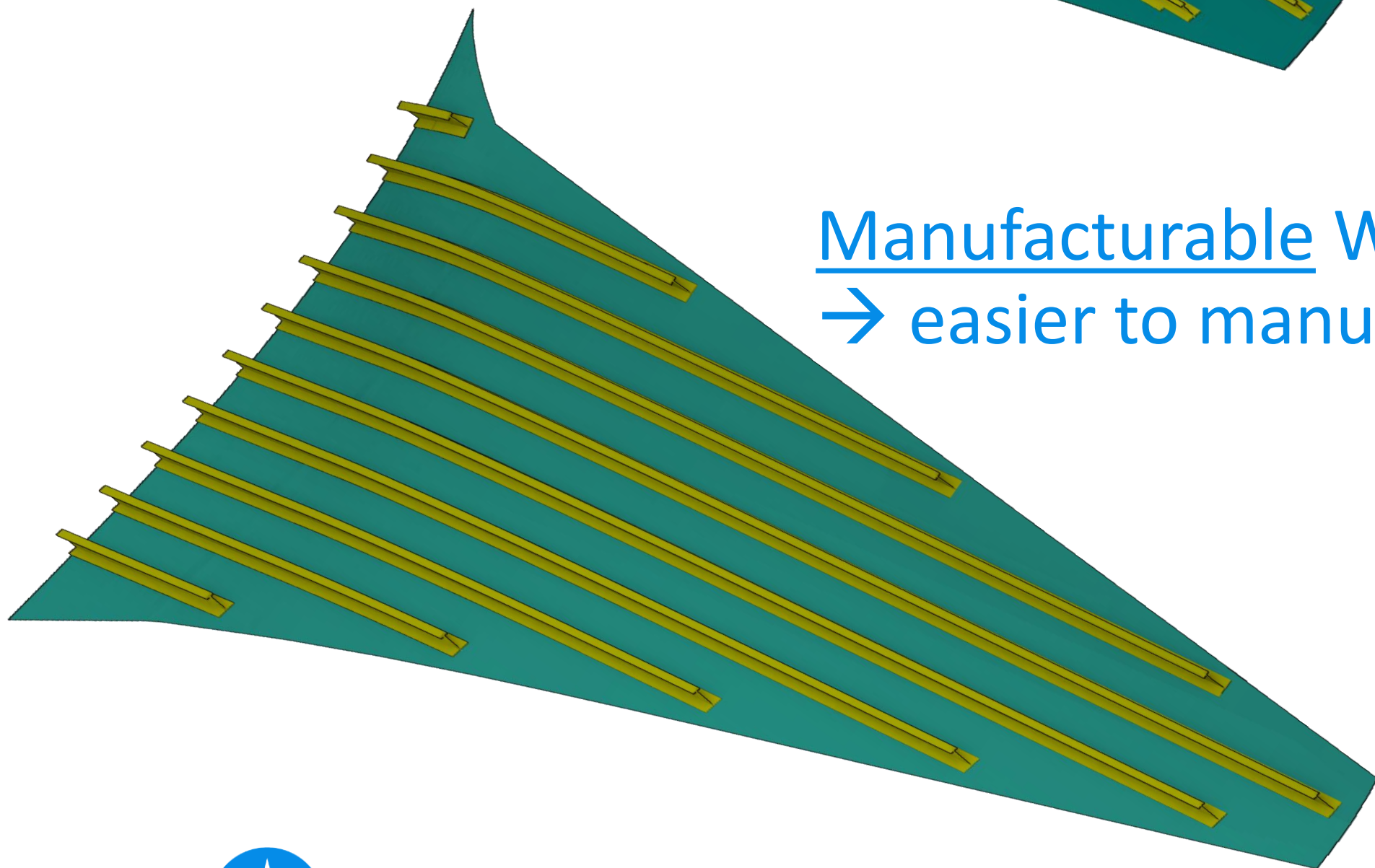
3 | Commercial 737-like Composite Upper Skin Stiffened Panel



4 | Lightest Weight vs Manufacturable Weight Design

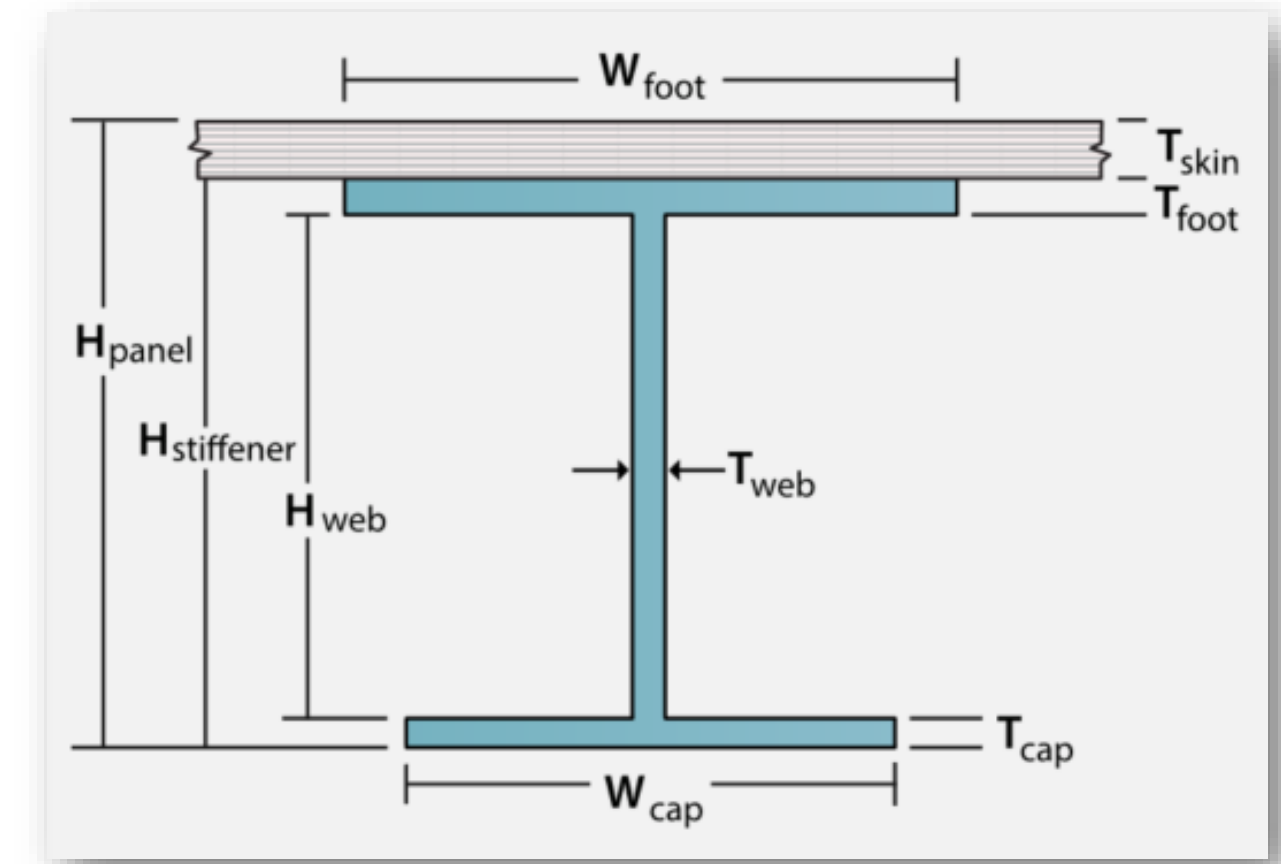


Lightest Weight = a lot of Variance in design
→ harder to manufacture



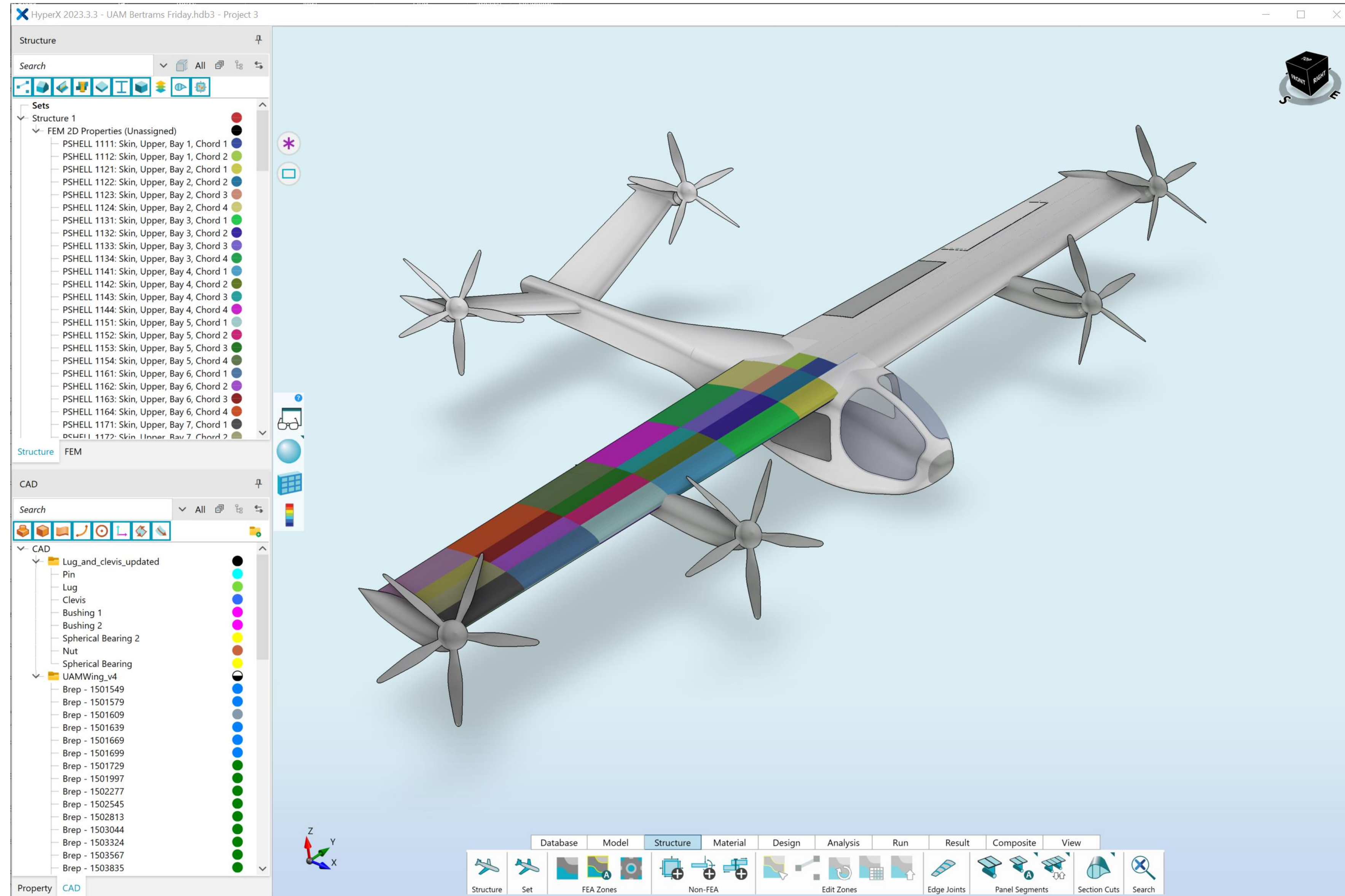
Manufacturable Weight = less Variance in design
→ easier to manufacture

A role of HyperXpert, help user find these design options that are also lightweight

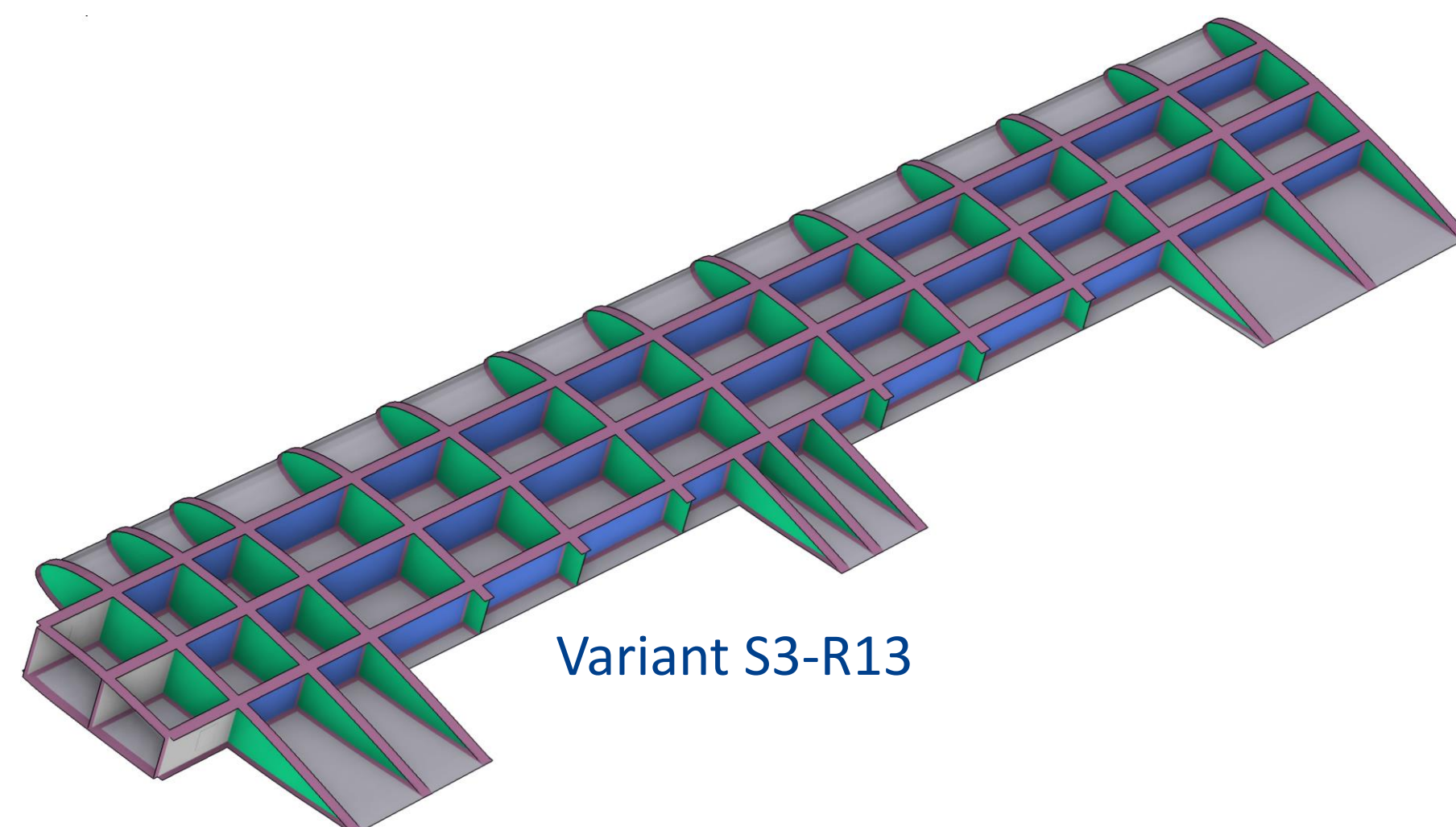
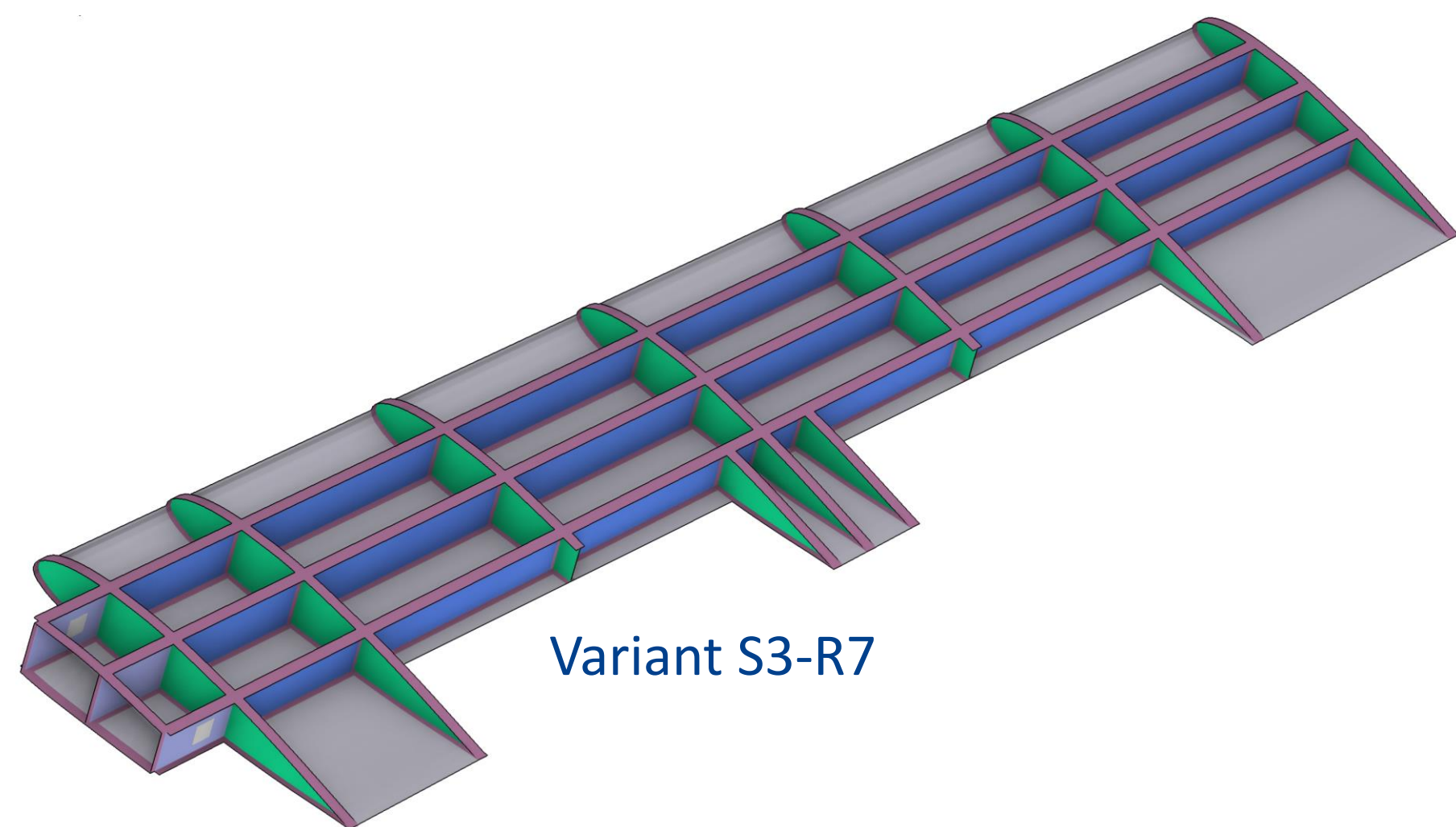
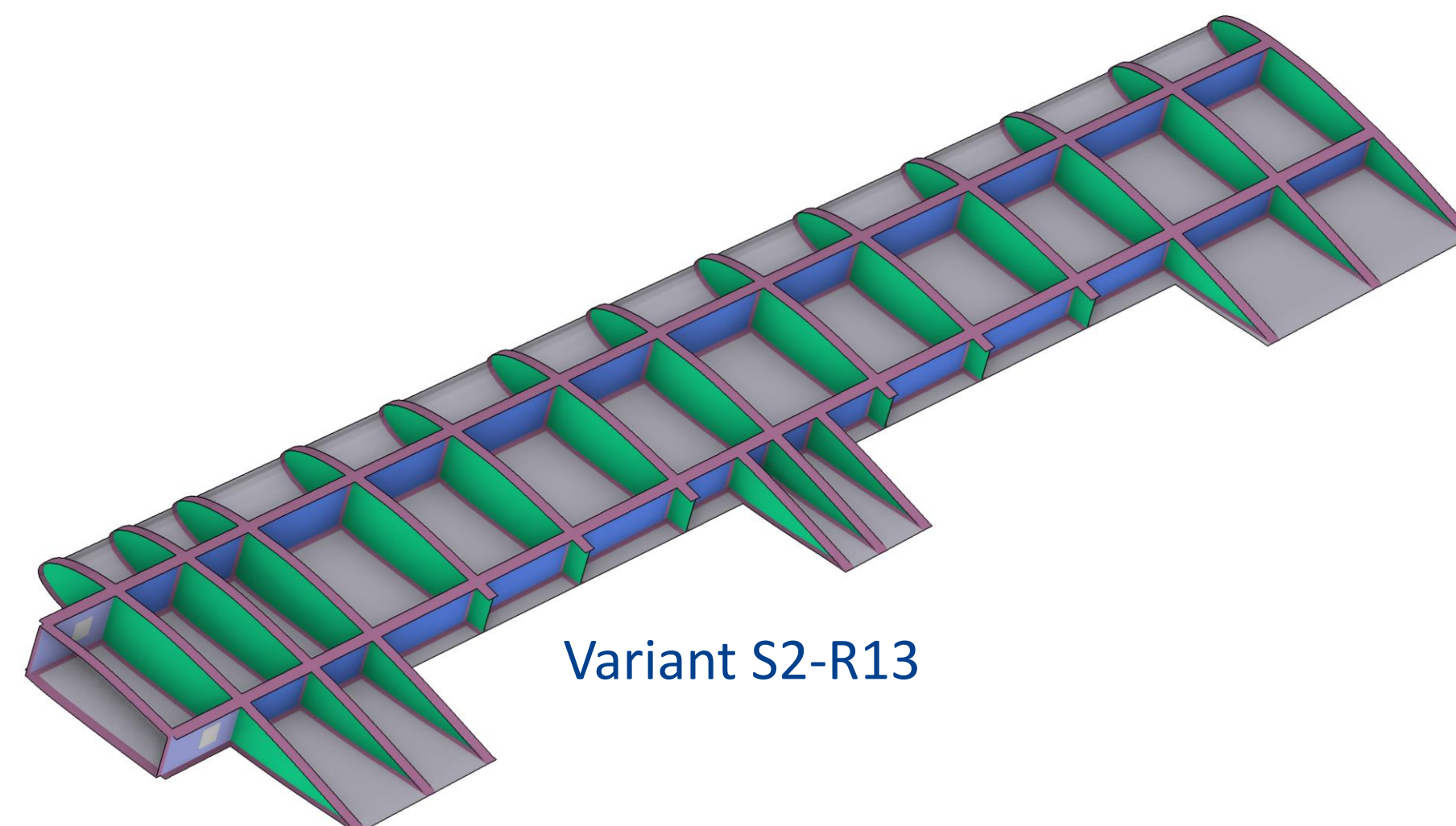
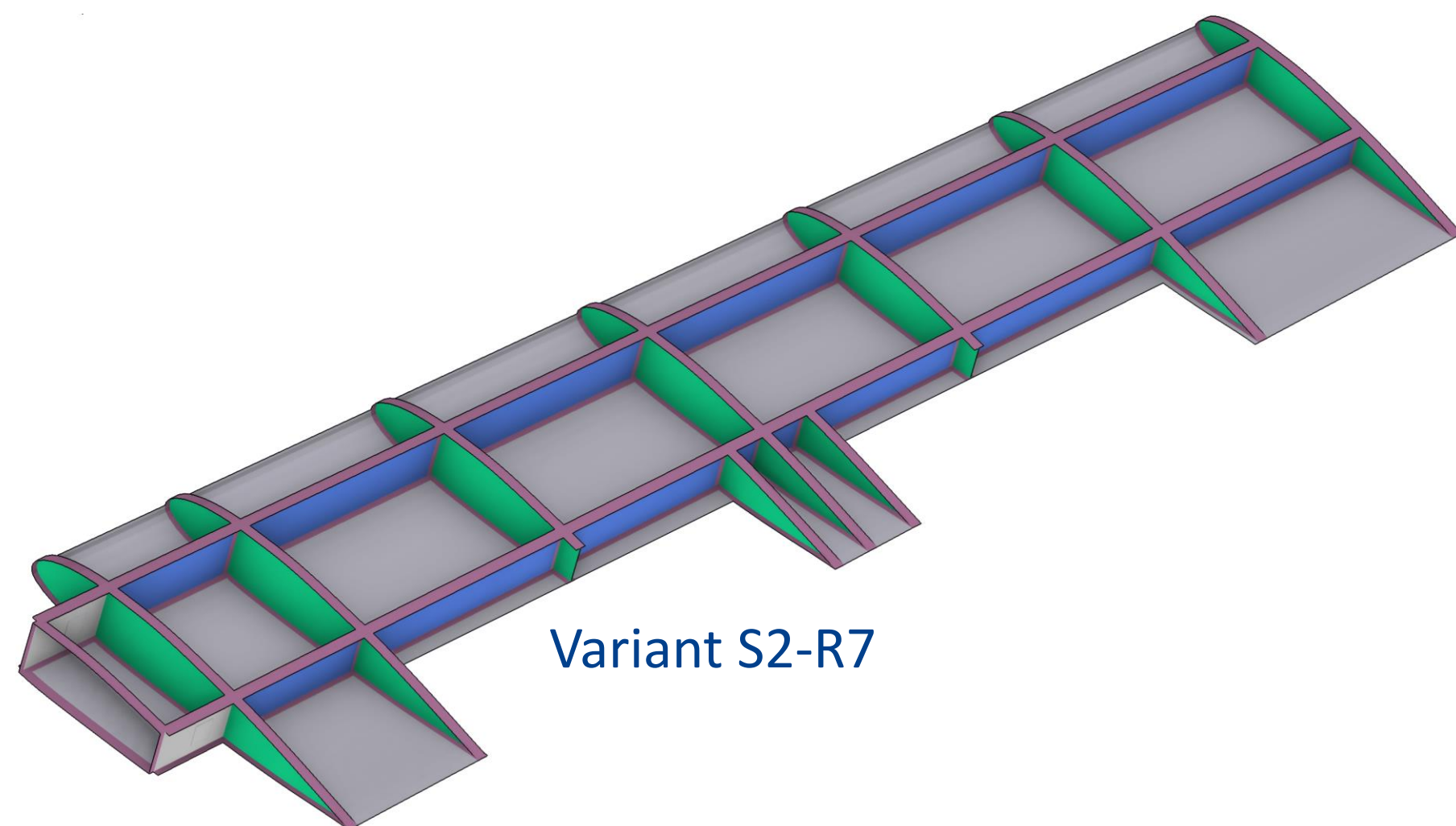


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Notes

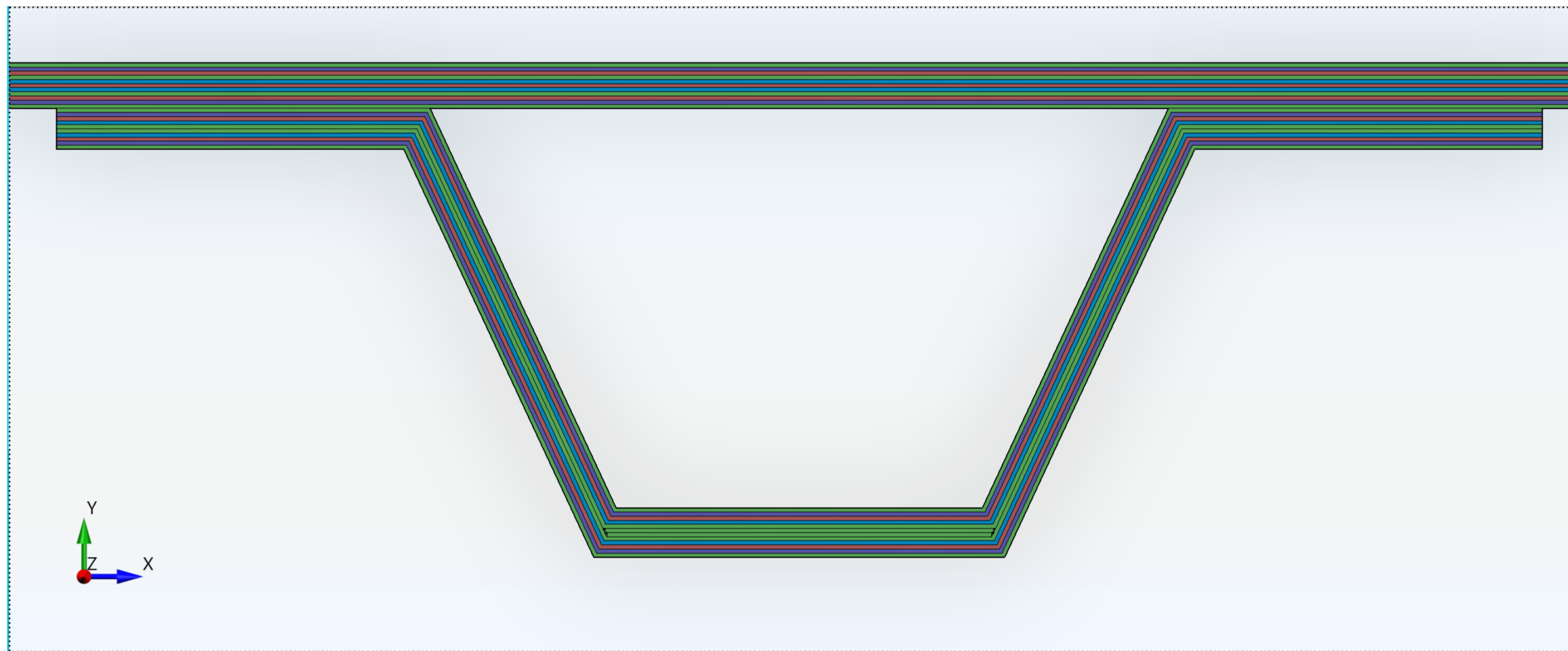


HyperXpert: Architectural Layout FEM Variants



Architectural Rib/Spar counts and placement

7 | HyperXpert: Panel Concepts/Materials/Laminates



Hat Stiffened Panel



Sandwich Panel

Architectural Rib/Spar counts and placement

8 | Sandwich Design Property Variables

Panel Design Property

UAM250 DOE Sandwich Fabric

Zones Assigned:

101012:101013,101021:101024,101041:101044,1

Unassign

Zones Selected:

Select items from viewport or tree

Assign

Sizing

Analysis

☐ Metal

☒ Composite

Zone

Detailed Sizing

Set Variables

Dimension	Use Analysis	Min	Max	Steps	Step Size	Material
T _{top face} (in)	☐	0.0165	0.1733	16		LF251 DOE SB Fabric 16 plies (16)
T _{core} (in)	☐	0.25	1	4	0.25	(2 honeycombs selected)
T _{bottom face} (in)	☐	0.0165	0.1733	16		LF251 DOE SB Fabric 16 plies (16)
Height (in)		(Dependent variable)				

Overrides

Req. Designs 1 # Candidates 2048

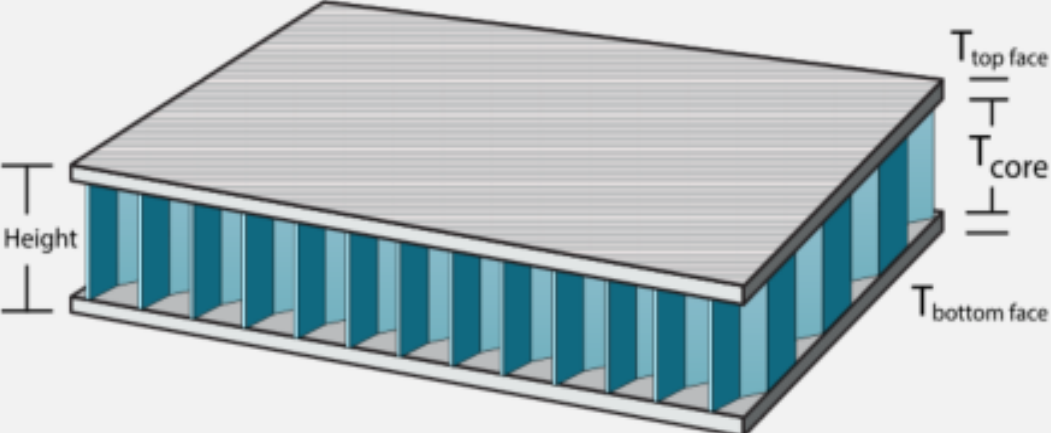
Advanced

This design is used in other projects

Apply

Close

2024-11-09 08:20:39



multiple Laminates
multiple Laminate Families

Hat Design Property Variables

Panel Design Property

UAM451 DOE Hat

Modeling Technique

Smeared

Diagram of a hat section with dimensions: $\frac{1}{2}W_{\text{foot}}$, H_{panel} , $H_{\text{stiffener}}$, H_{web} , W_{crown} , T_{skin} , T_{foot} , T_{web} , T_{crown} , and Angle.

Advanced

2024-03-17 03:29:25

Zones Assigned:

Zones Selected:

Unassign

Assign

Sizing

Analysis

☐ Metal

☒ Composite

Zone

Detailed Sizing

Set Variables

Dimension	Use Analysis	Min	Max	Steps	Step Size	Material
T_{skin} (in)	☐	0.0275	0.132	17		LF450 DOE Hat Skin 01 (17)
T_{web} (in)	☐	0.022	0.11	12		LF450 DOE Hat Stiffener 02 (21)
T_{foot} (in)	☐	0.022	0.11	16		(Determined by the web variable's material)
T_{crown} (in)	☐	0.0275	0.1265	16		(Determined by the web variable's material)
$H_{\text{stiffener}}$ (in)	☐	0.4	0.8	3	0.2	
Spacing (in)	☐	3.25	4.33	2	1.08	
Angle (°)	☐	65	75	2	10	
W_{foot} (in)	☐	1	1.375	2	0.375	
W_{crown} (in)	☐	0.3	0.8	3	0.25	
H_{panel} (in)		(Dependent variable)				
H_{web} (in)		(Dependent variable)				
W_{open} (in)		(Dependent variable)				

Overrides

Req. Designs 1

Candidates 5035

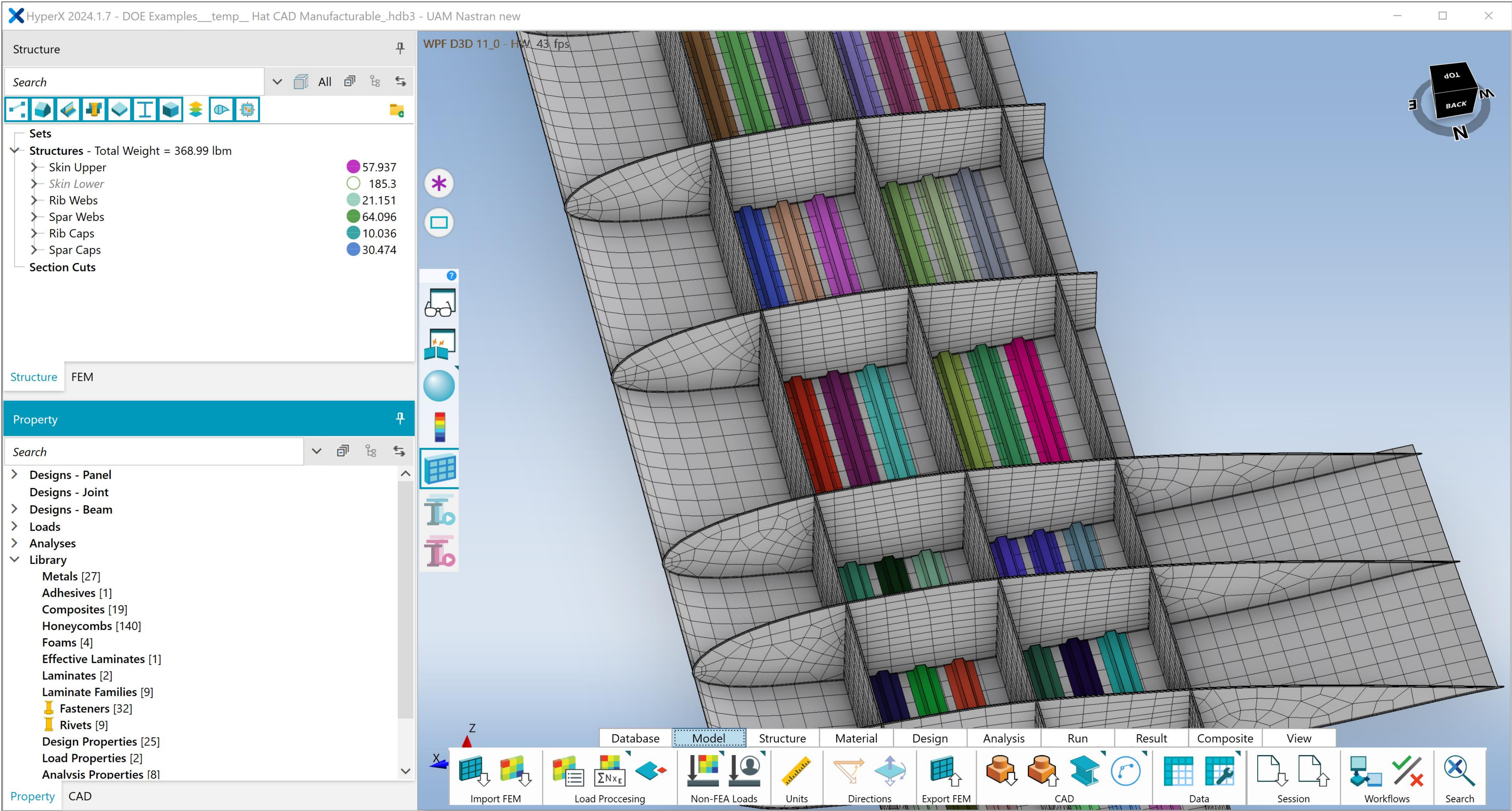
This design is used in other projects

Apply

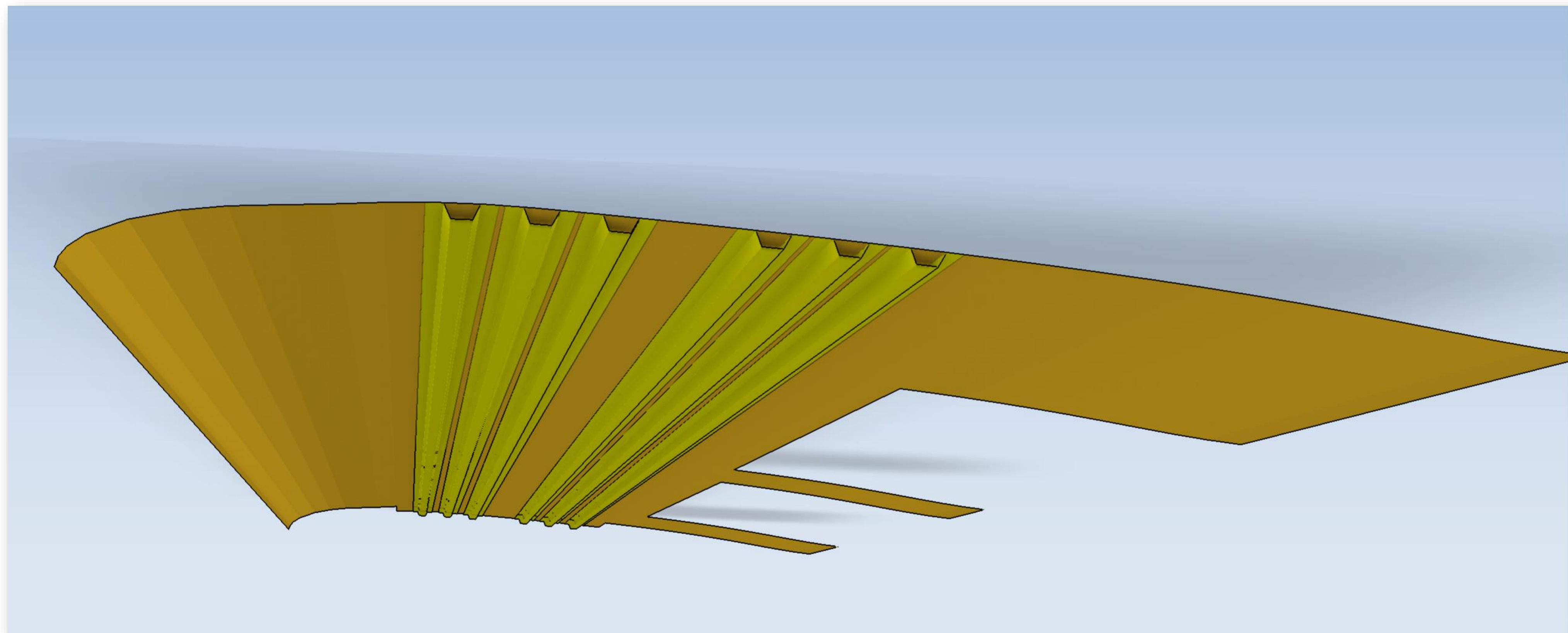
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multiple Laminates
multiple Laminate Families

HyperXpert Result Shown on the FEM

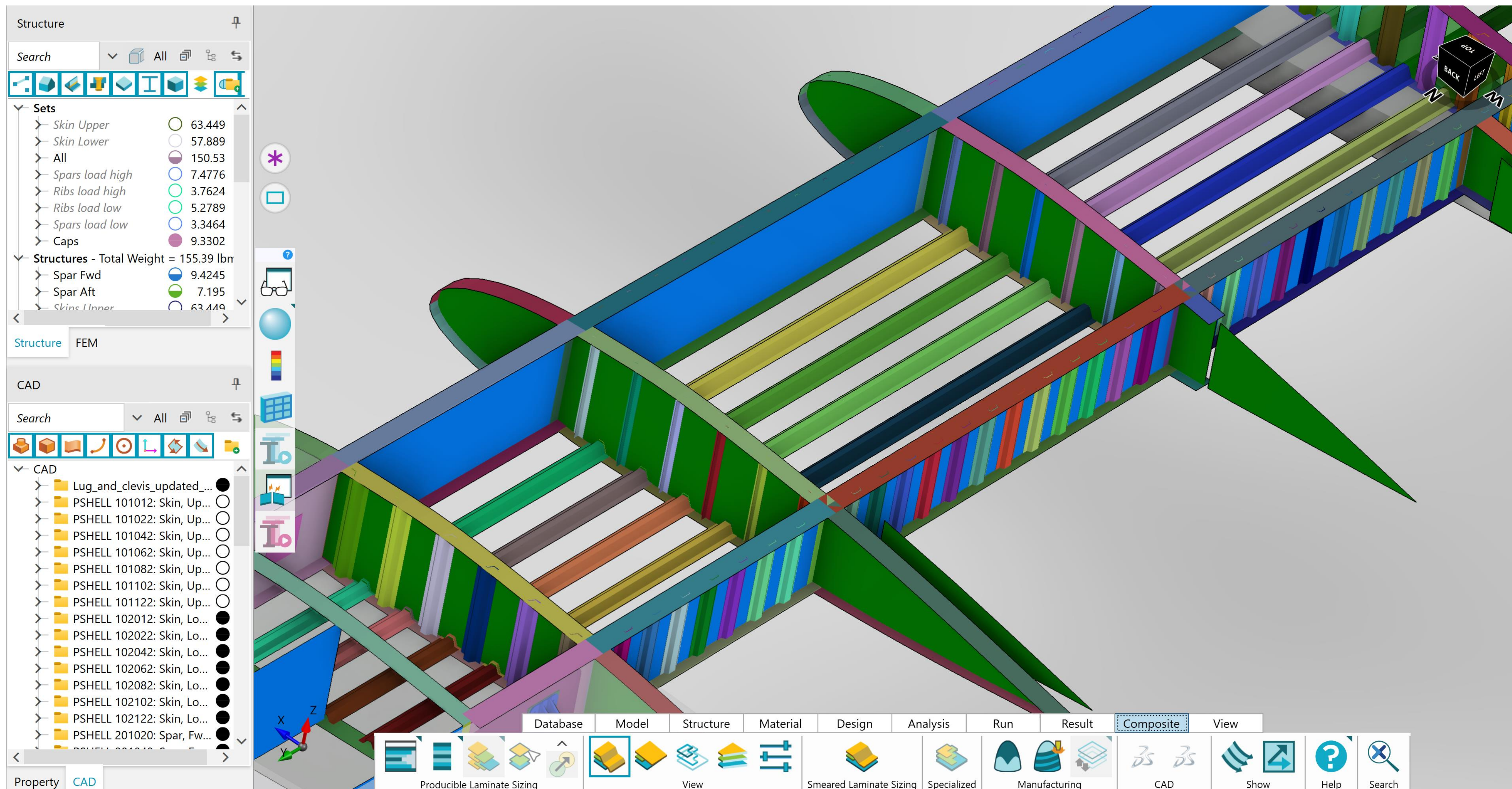


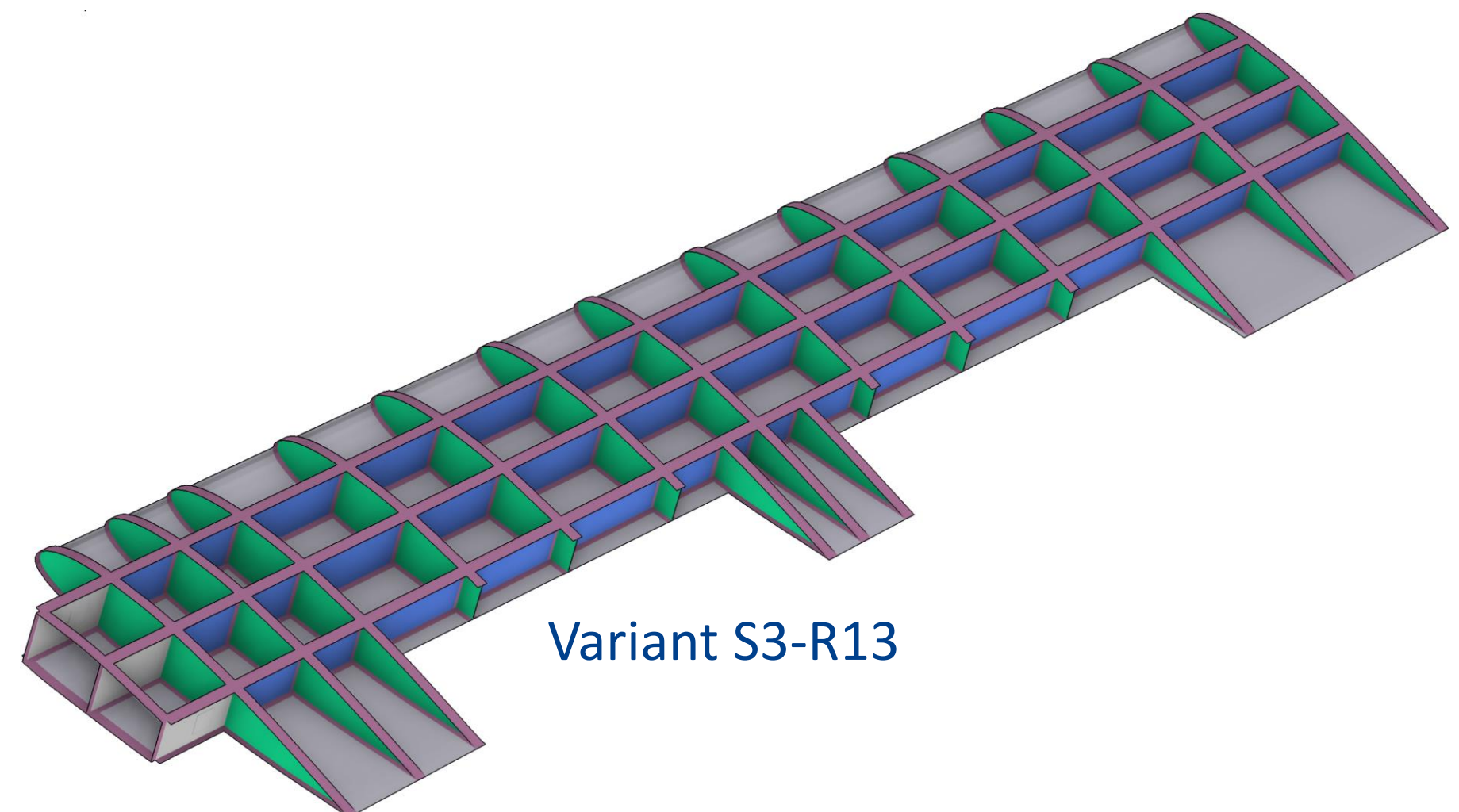
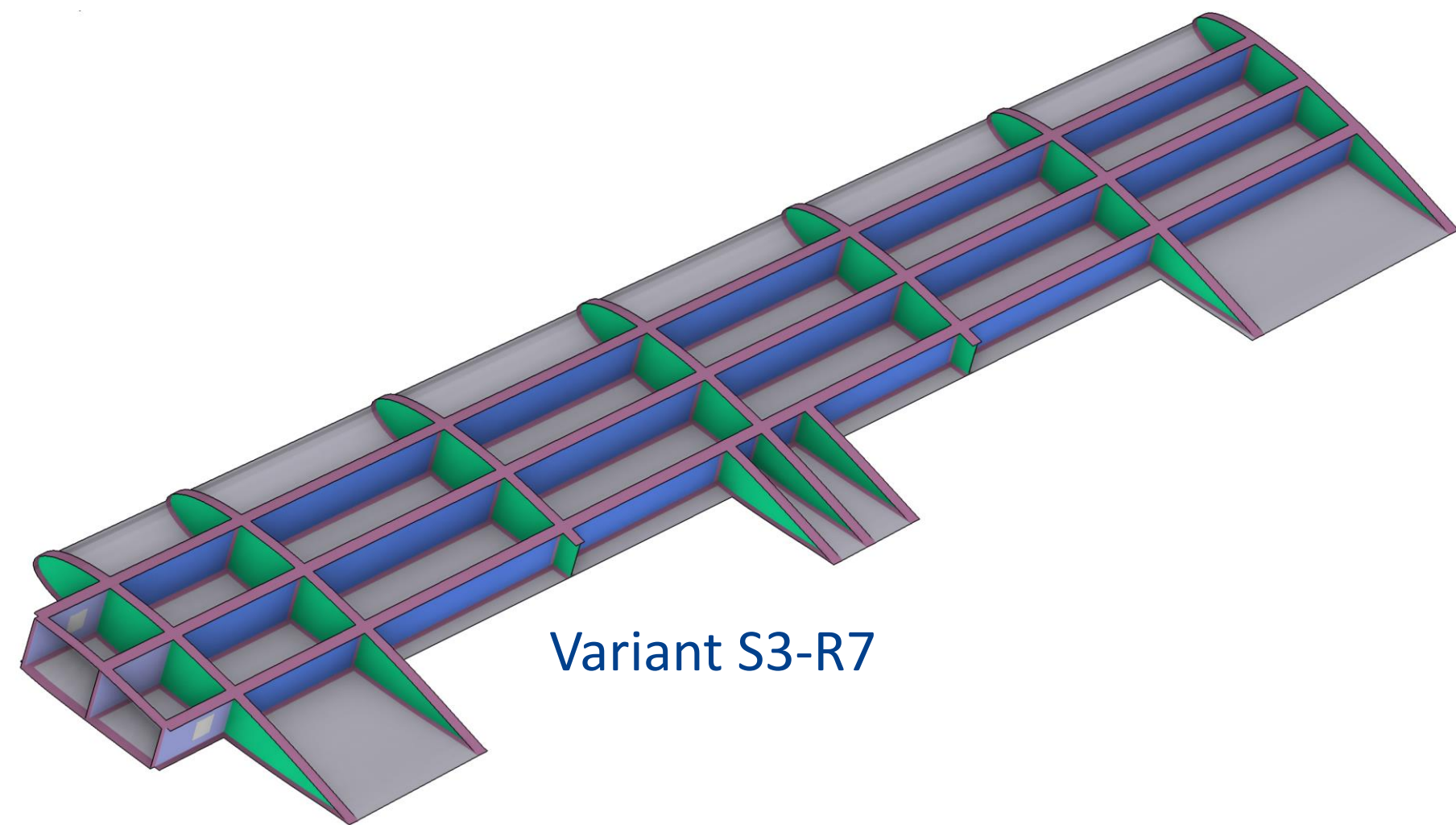
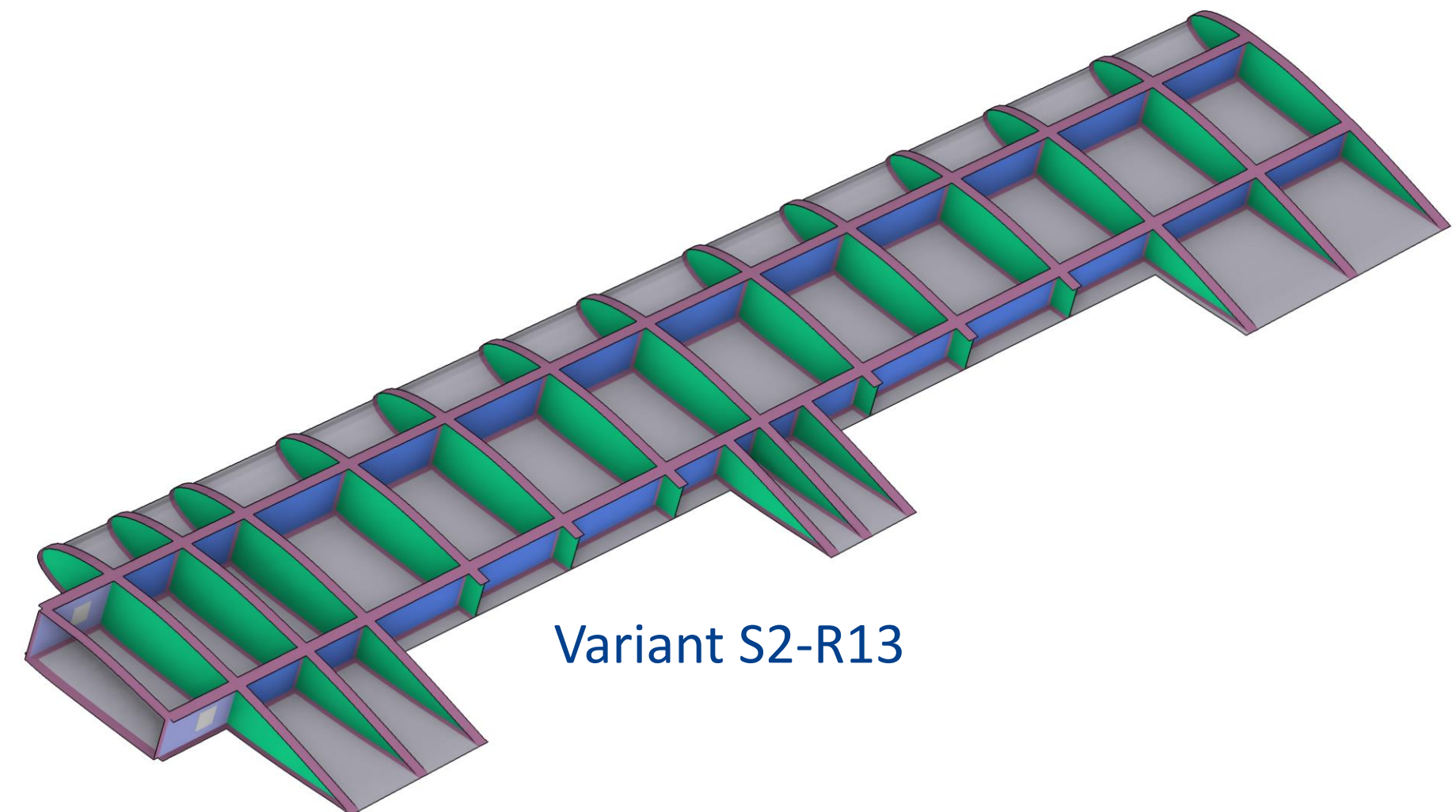
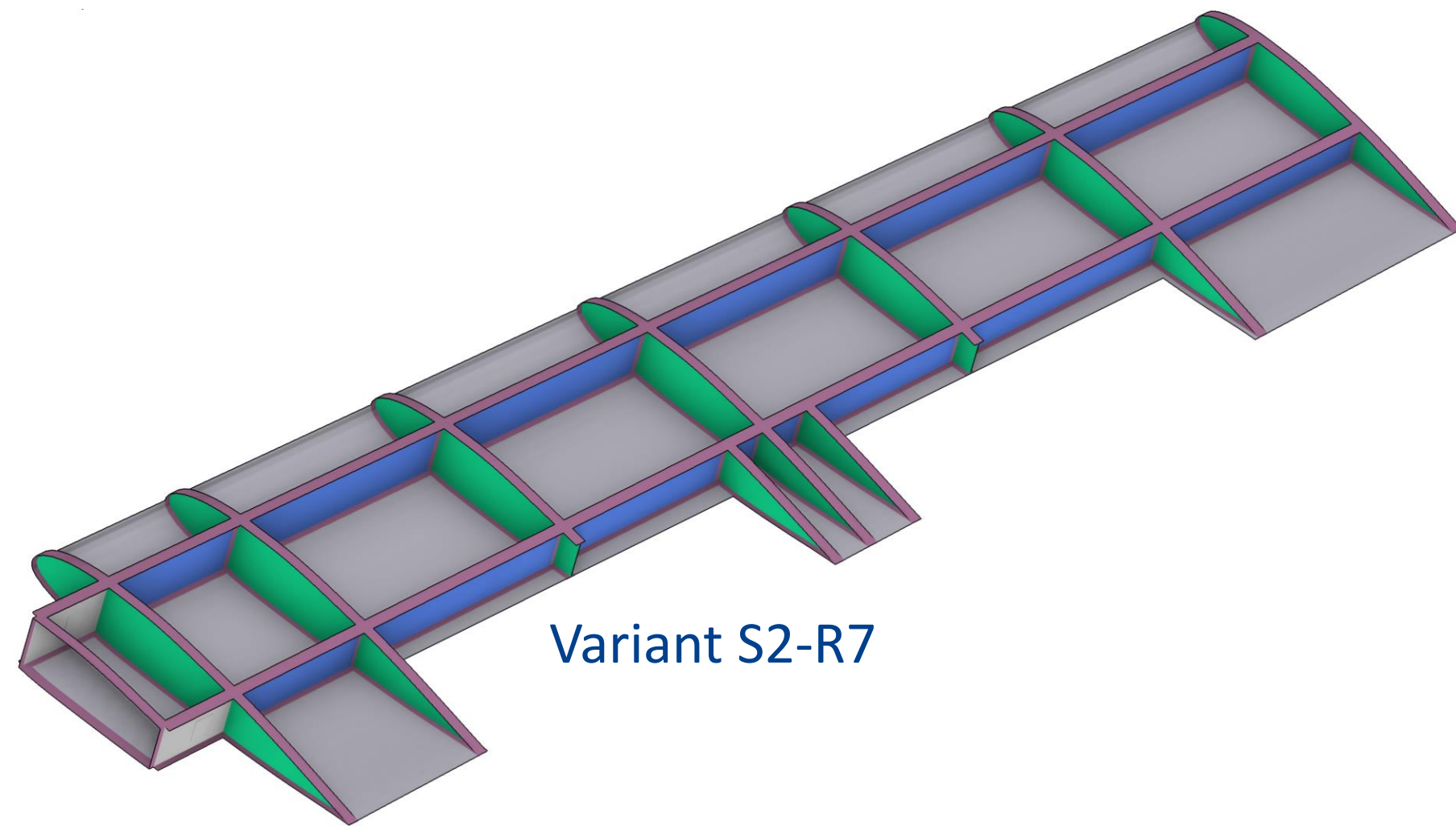
HyperXpert Result Shown on the CAD



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HyperXpert Result Shown on the CAD

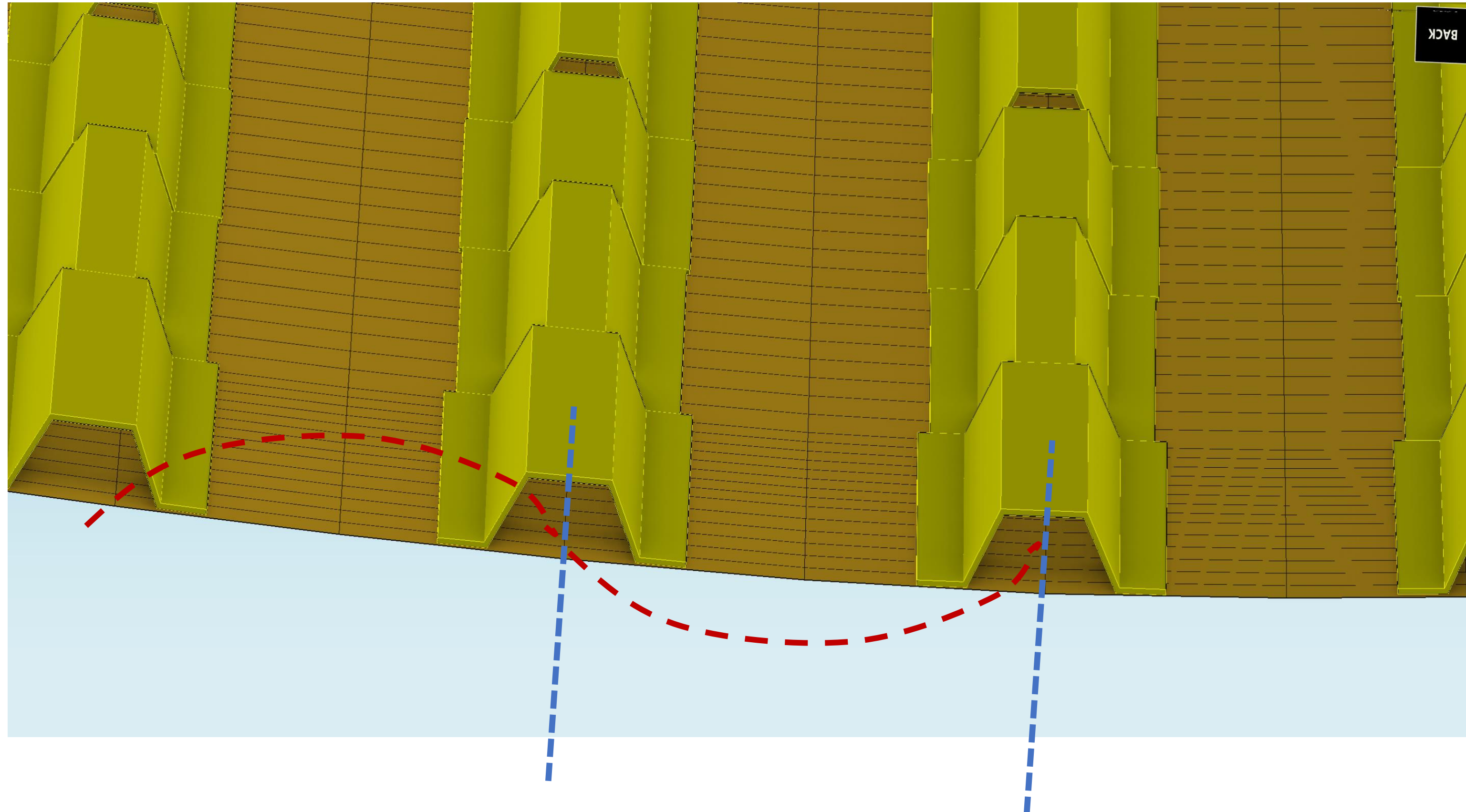




Architectural Rib/Spar counts and placement

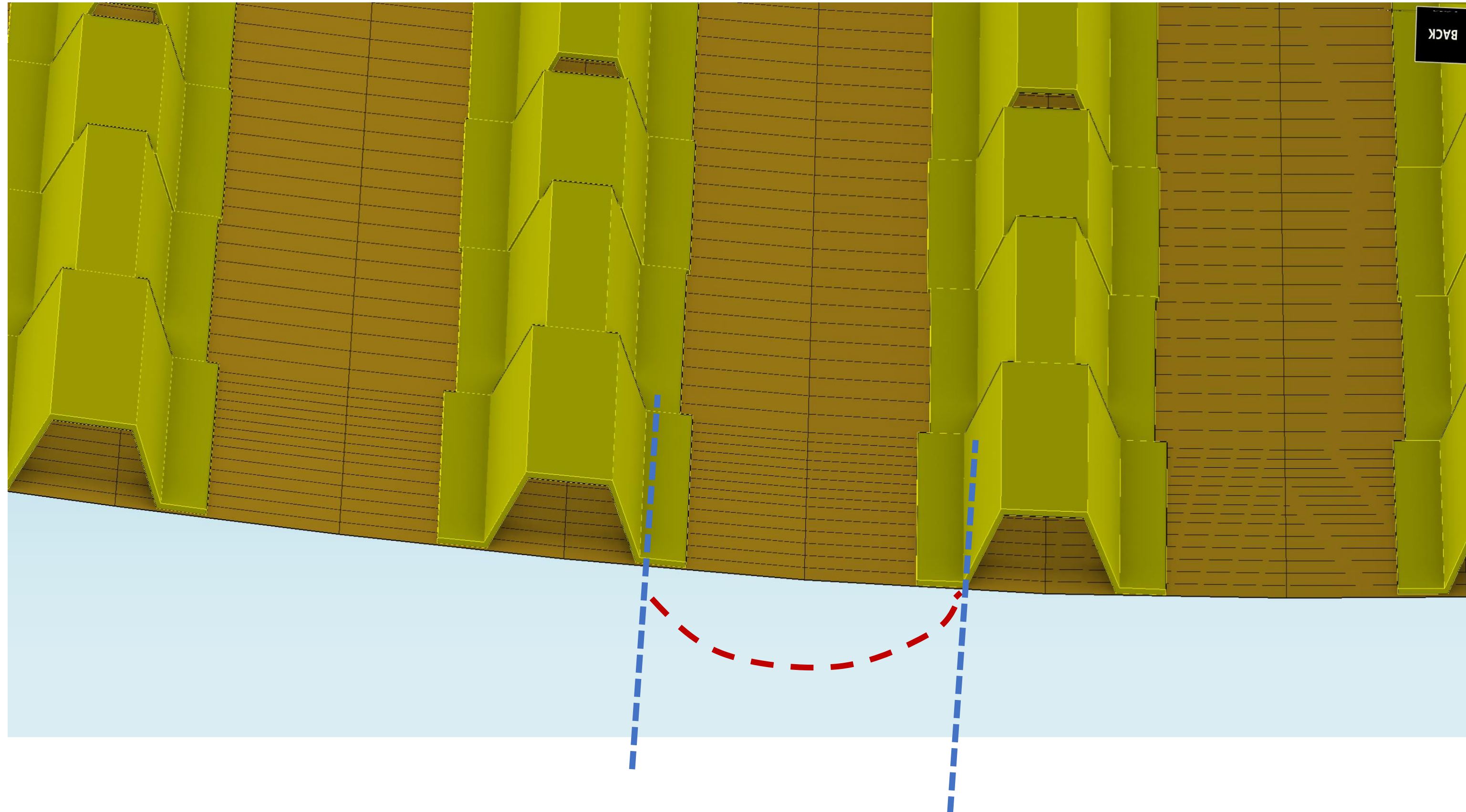
Live Demo 1

HyperXpert Analysis & Sizing for skin local buckling



Spacing Span – skin buckling

HyperXpert Analysis & Sizing for skin local buckling

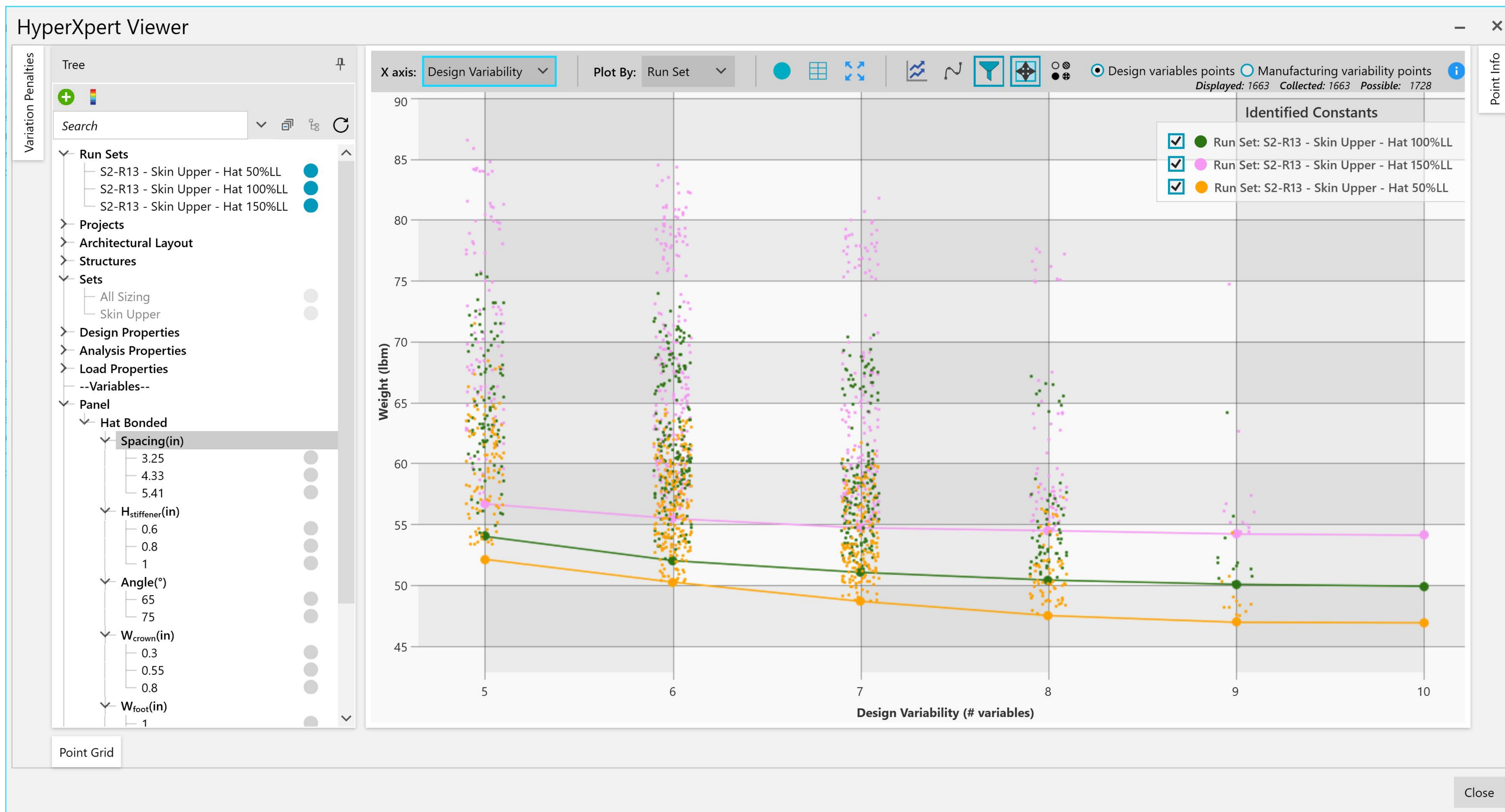


Spacing Span – skin buckling

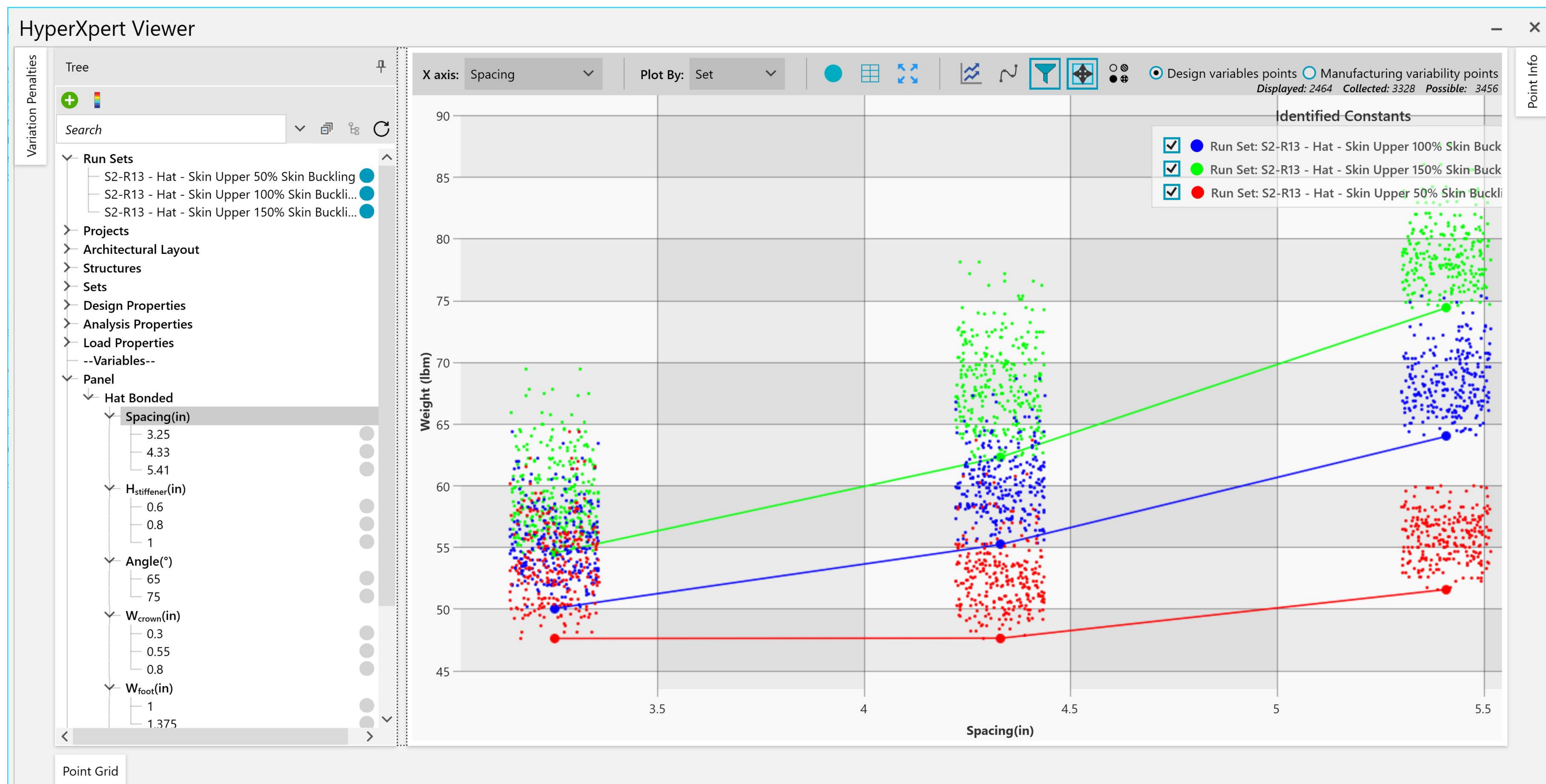


Live Demo 2

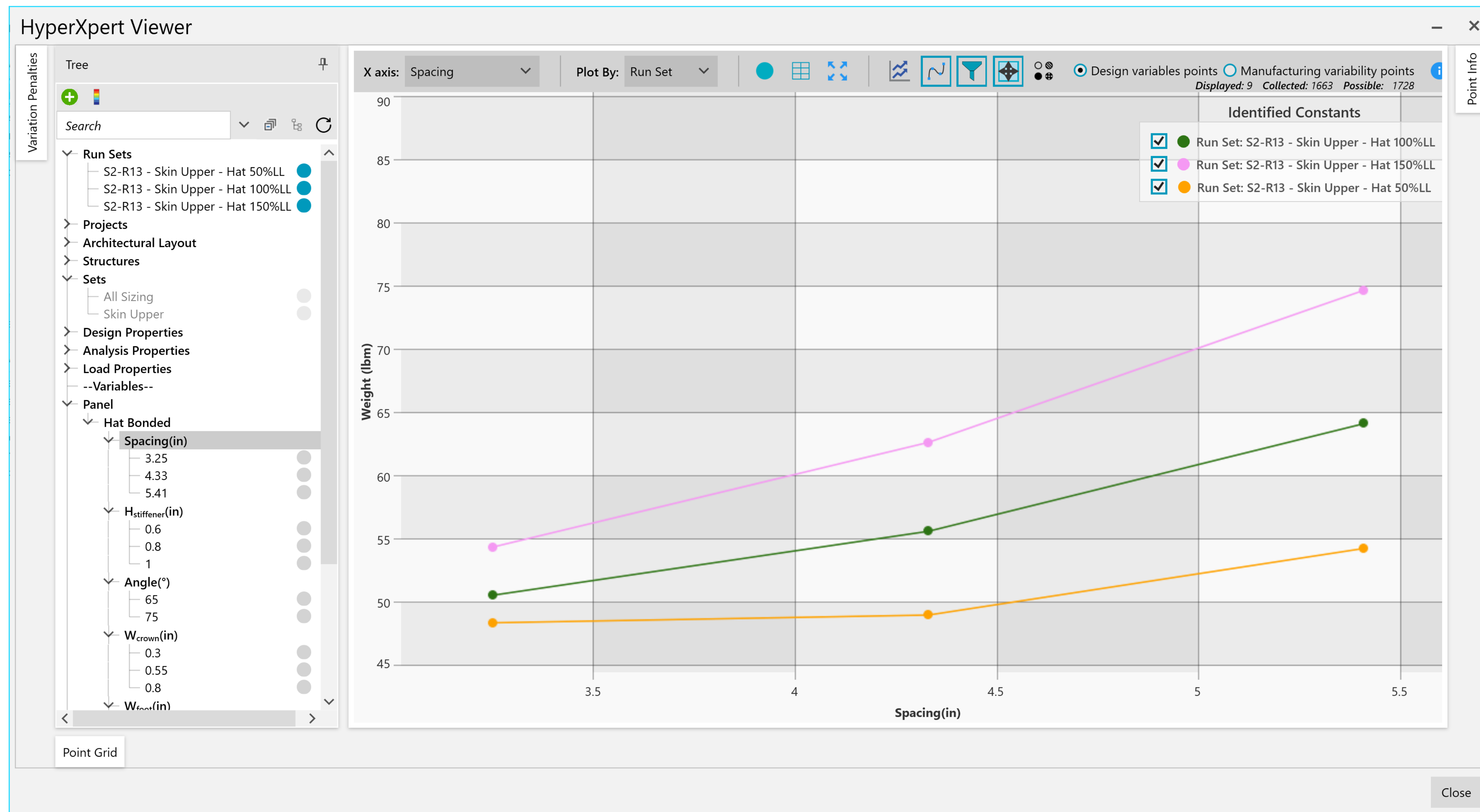
HyperXpert: Weight per % Skin Buckling Criteria



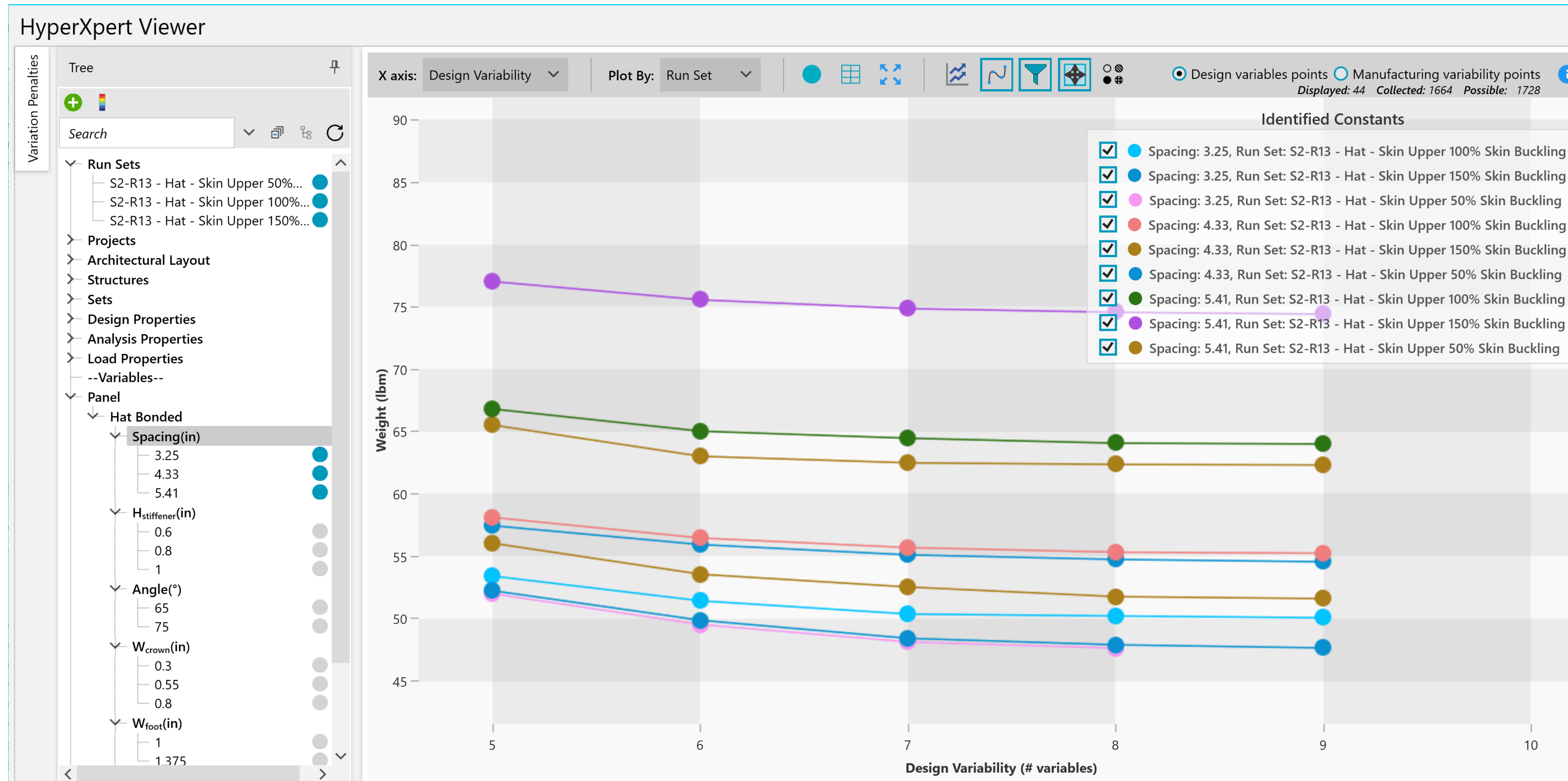
HyperXpert: Weight per % Skin Buckling Criteria



HyperXpert: Weight per % Skin Buckling Criteria



HyperXpert: Weight per % Skin Buckling Criteria



Produce sizing study trendlines to provide design insights to make smarter decisions

By Leveraging HyperX's unique structural sizing optimization approach

For the purpose of Instantaneous, on-the-fly linking of any variable(s) without having to rerun optimization

- No need to decide in advance what to link
- Once the HyperXpert data set is generated, then at anytime in the future, without having to rerun HyperX, can decide to link this variables value with that variables value, to get a result

HyperXpert is a way and a place to:

1 Collect HyperX runs

- To compare anything against anything
 - Example: different architectural layouts of wing ribs and spars (FEM variants)
- One place to display and save FEM variant results for a given set of input:
 - Design Properties (sizing bounds and laminates)
 - Analysis Properties (selected failure criteria)
 - Load Properties (selected FEA load extraction technique as well as included load cases/factors)

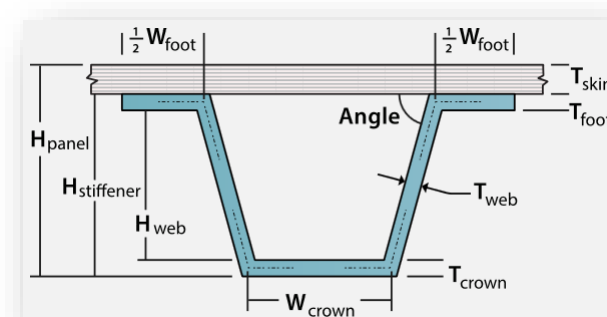
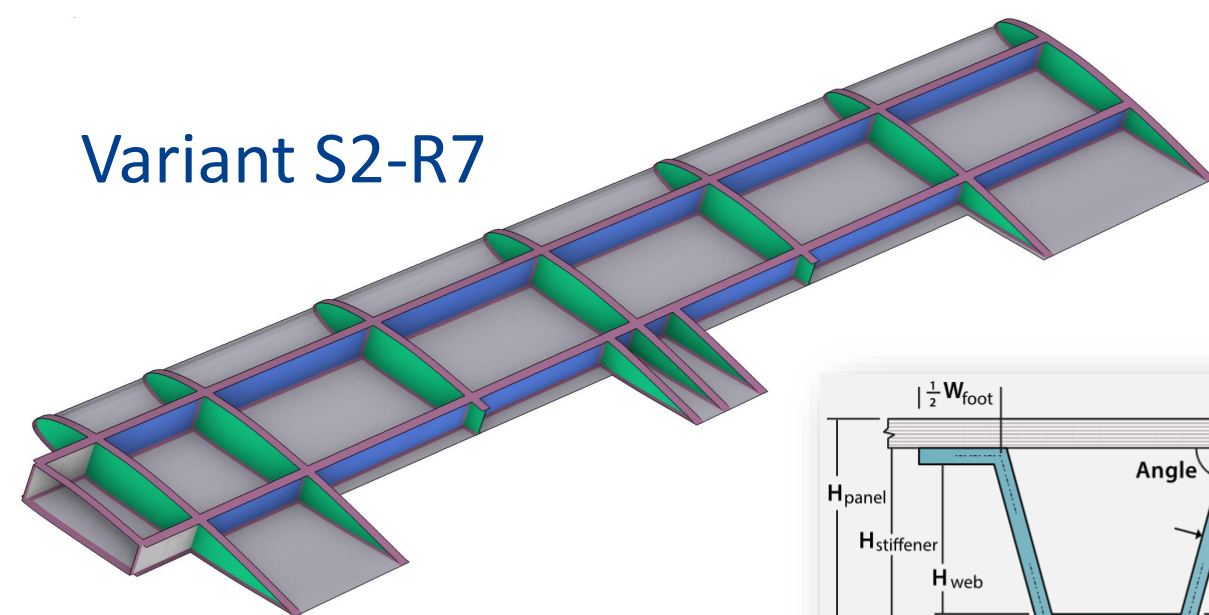
2 Produce trendlines for identifying the lightest weight design with least manufacturing variability in

- Dimensions
- Thicknesses
- Materials
- Laminate families
- Laminates

Backup

FEM and HyperX Data per Variant

Variant S2-R7

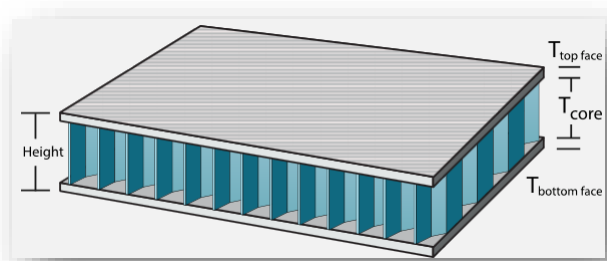


S2-R7 Hat.dat
S2-R7 Hat.op2

HyperX Project S2-R7 Hat

S2-R7 Sandwich.dat
S2-R7 Sandwich.op2

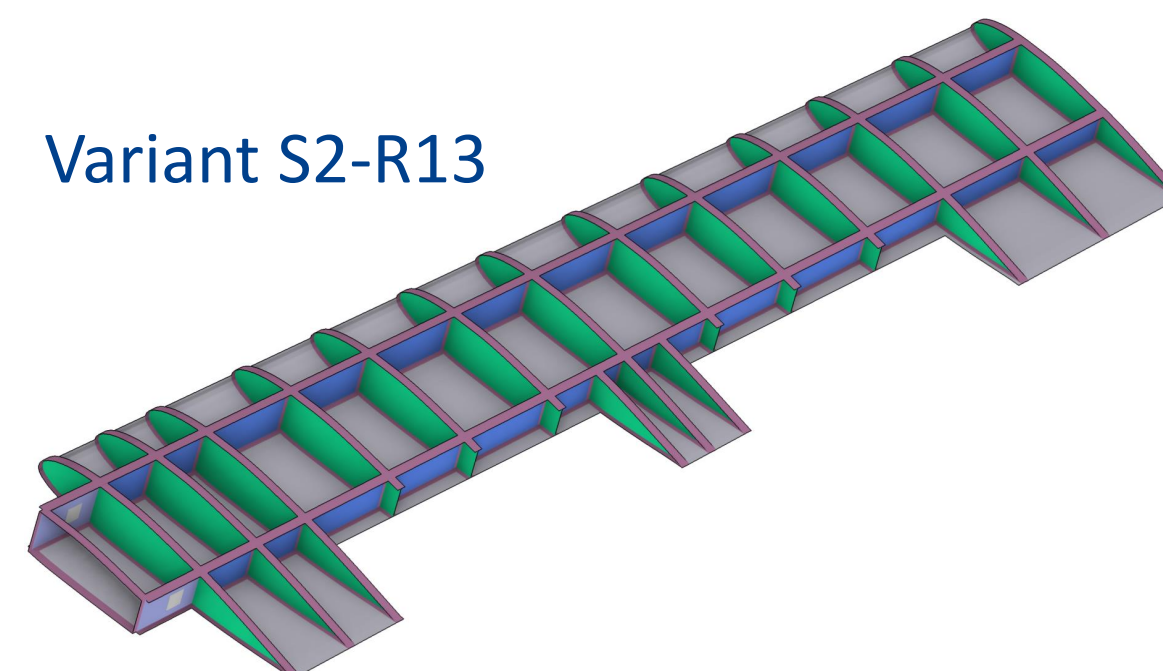
HyperX Project S2-R7 Sandwich



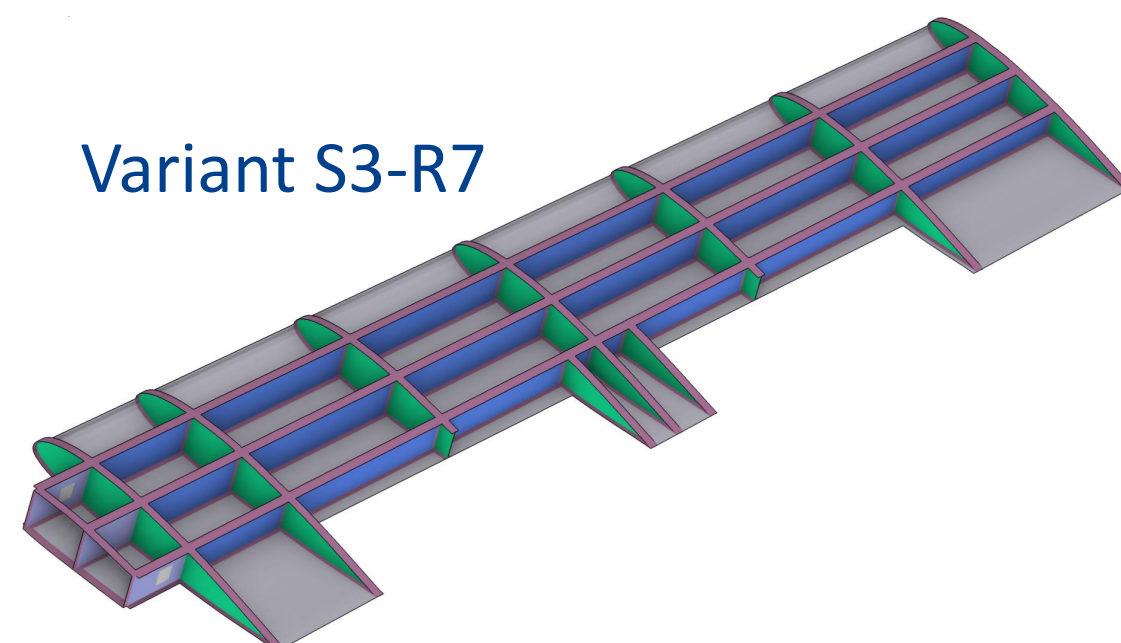
- 8 Projects
- 1 HyperX Database

*Same materials,
laminates, analysis
properties, design
properties, etc*

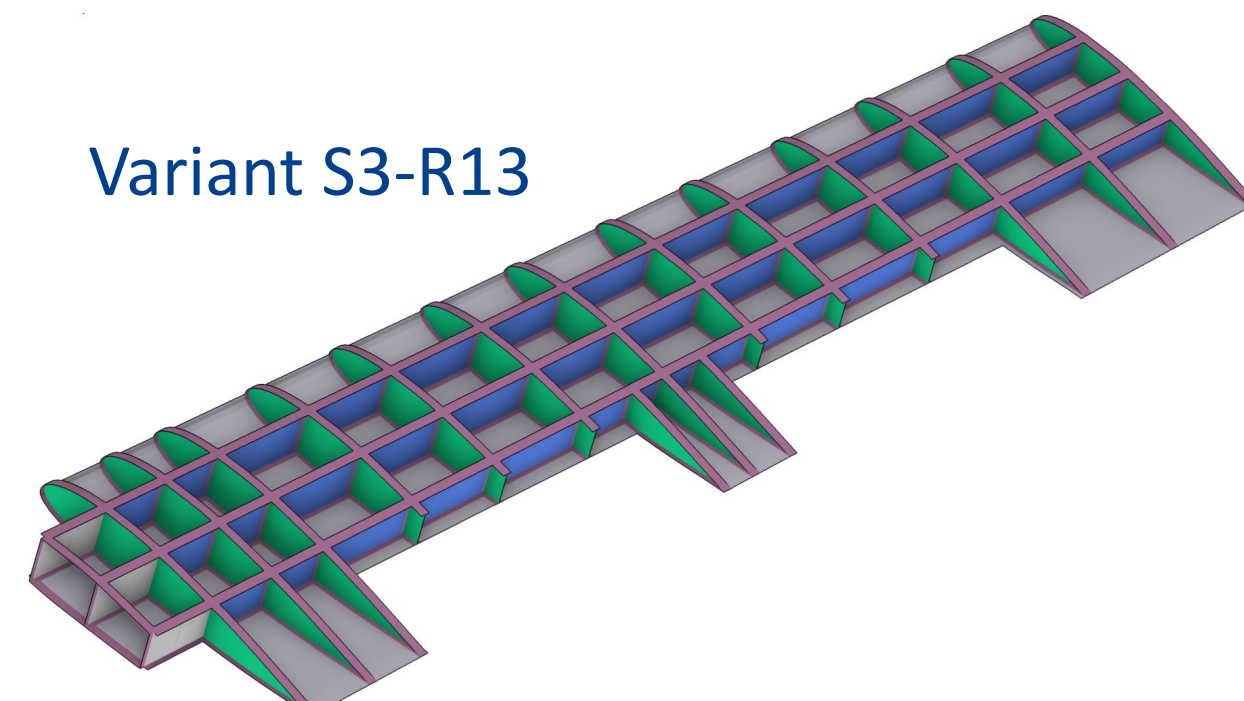
Variant S2-R13

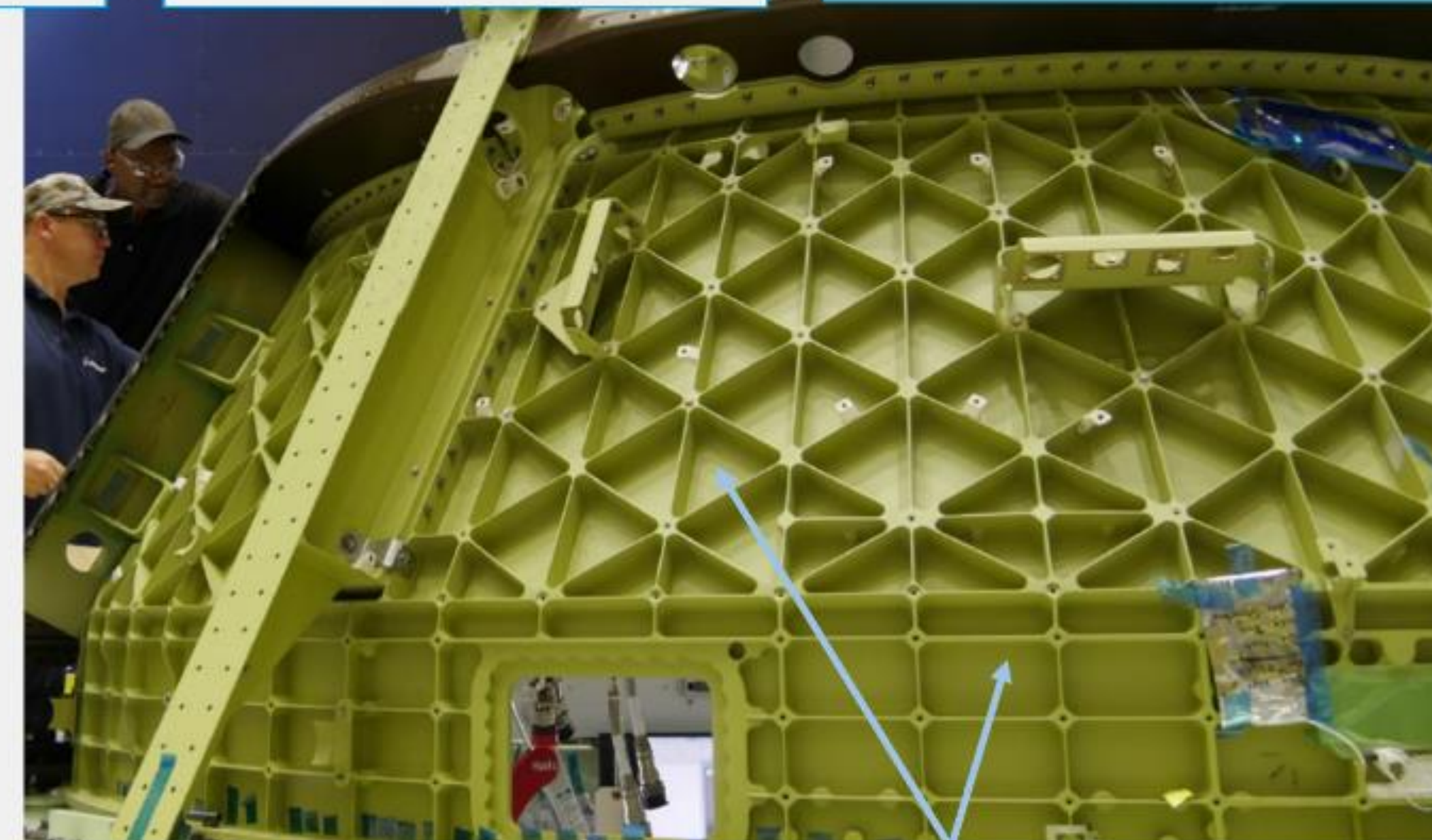
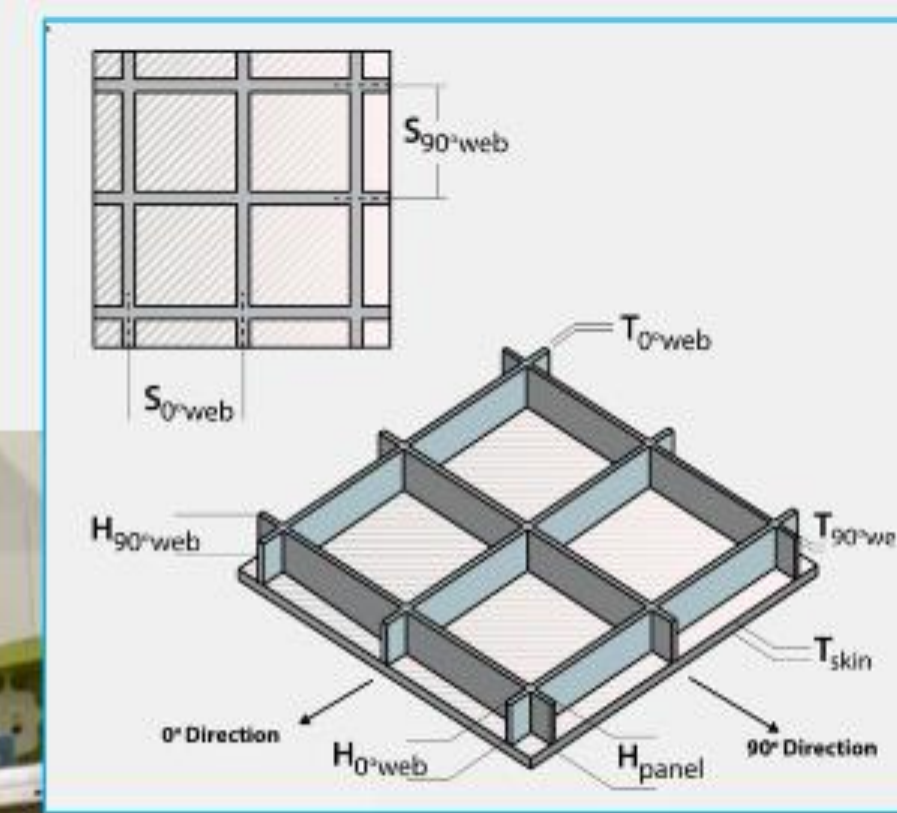
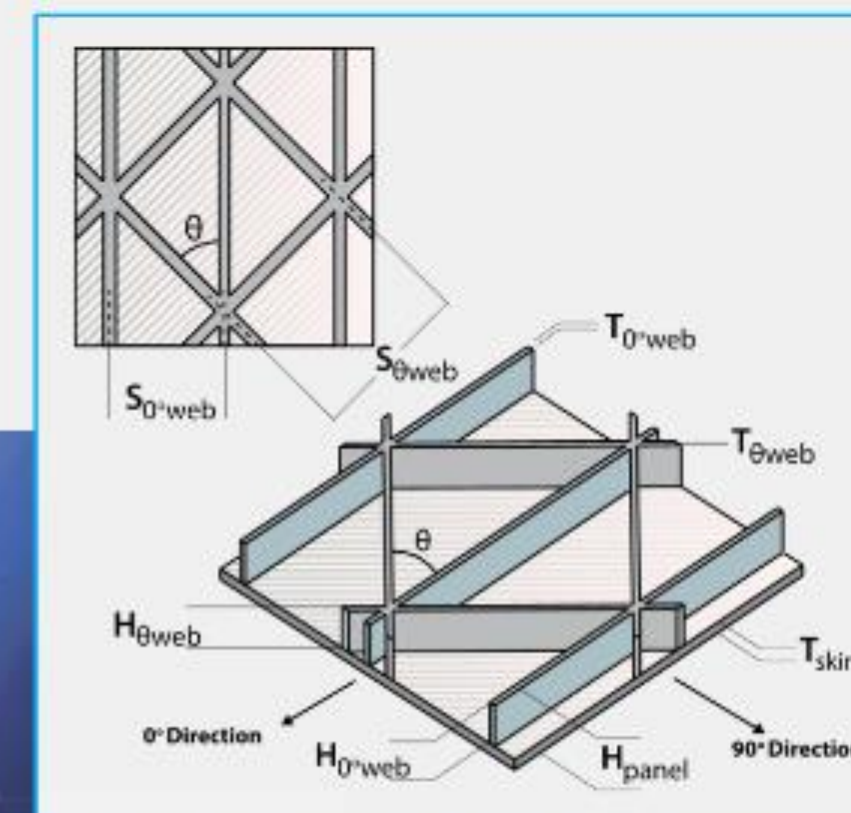
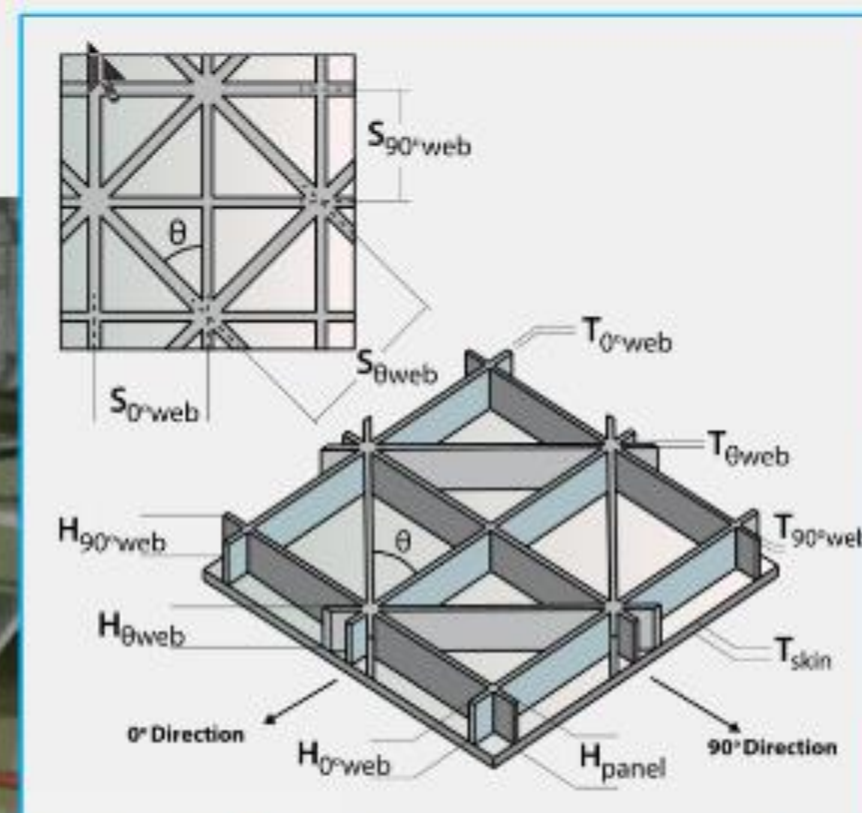
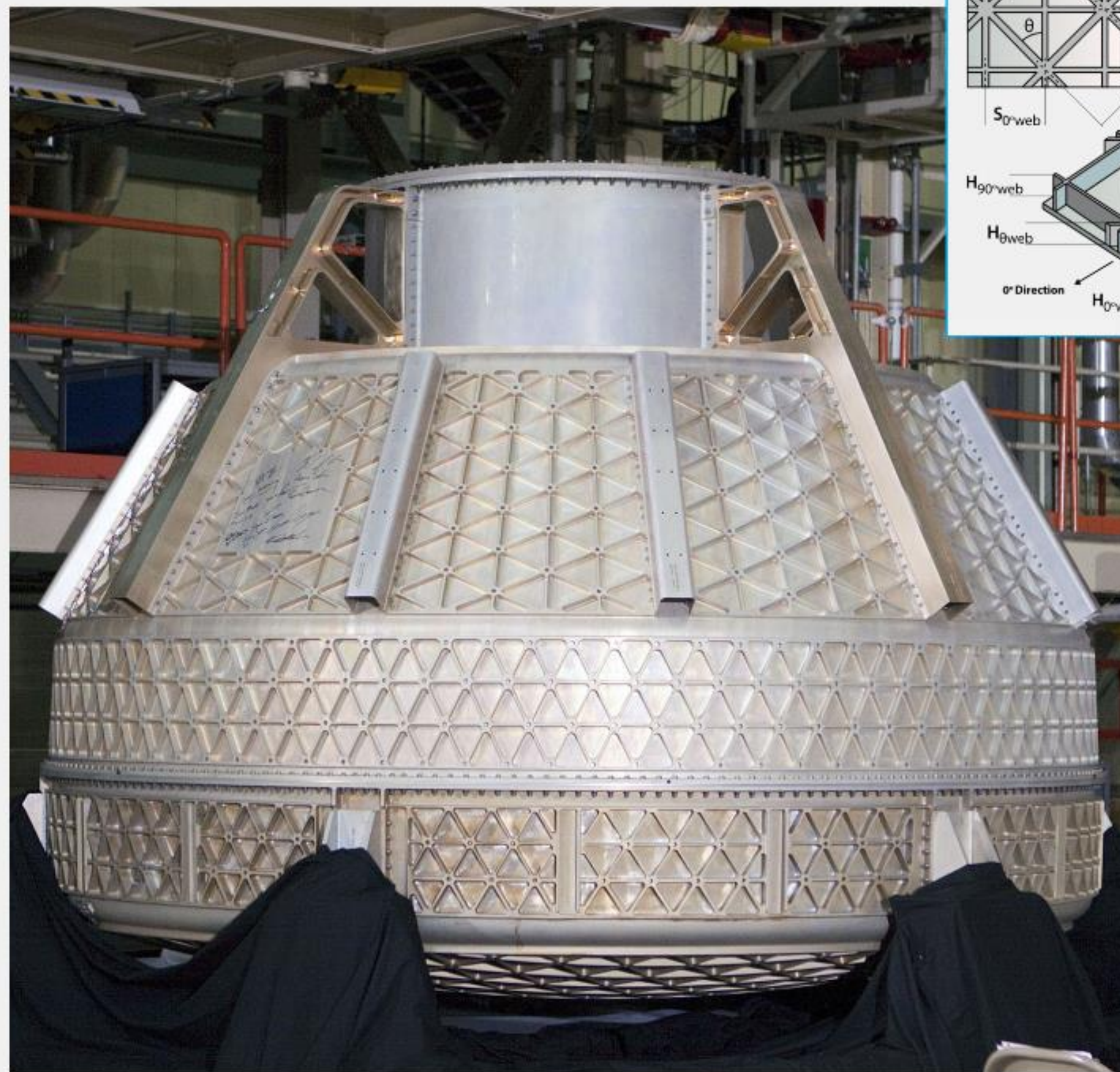


Variant S3-R7



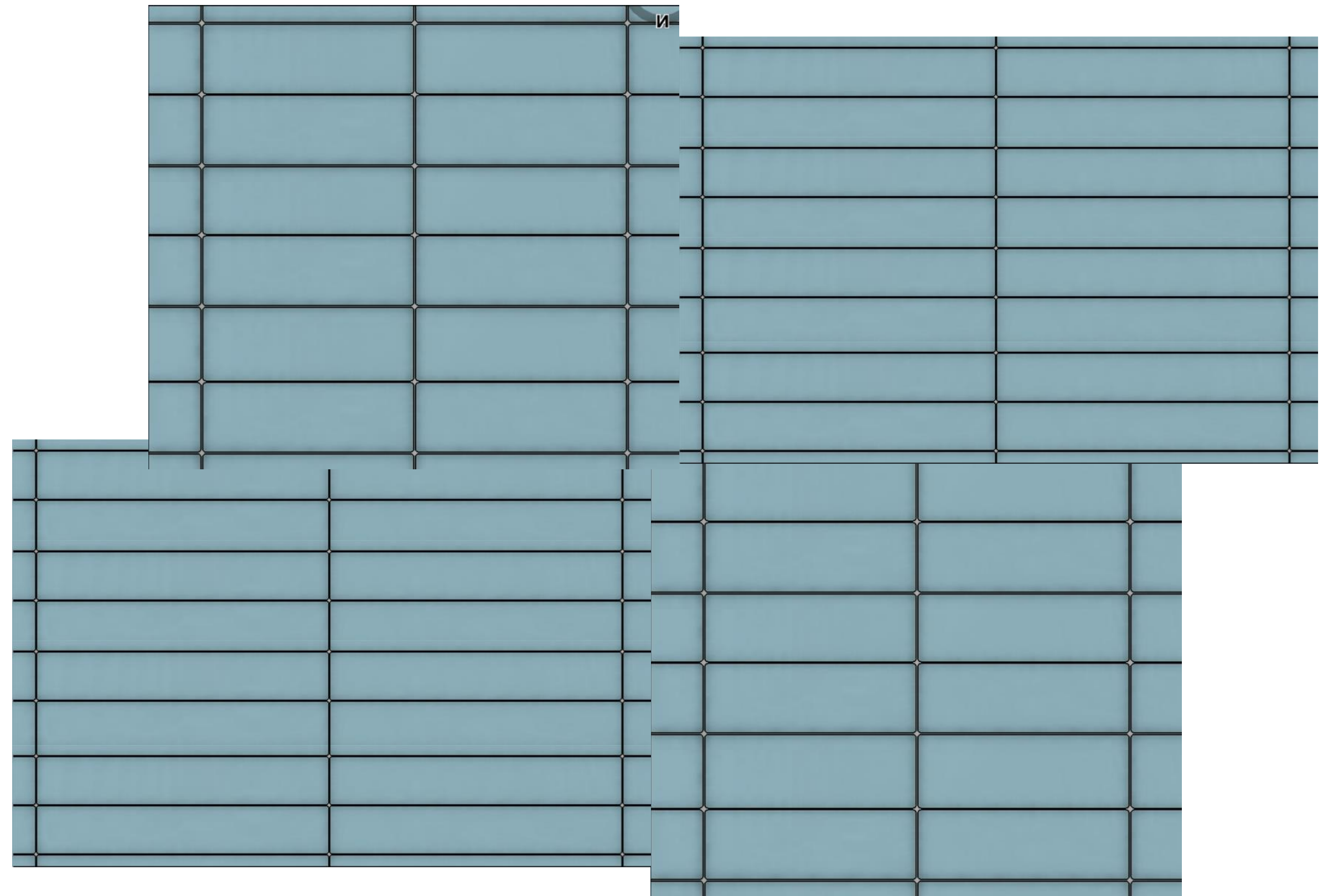
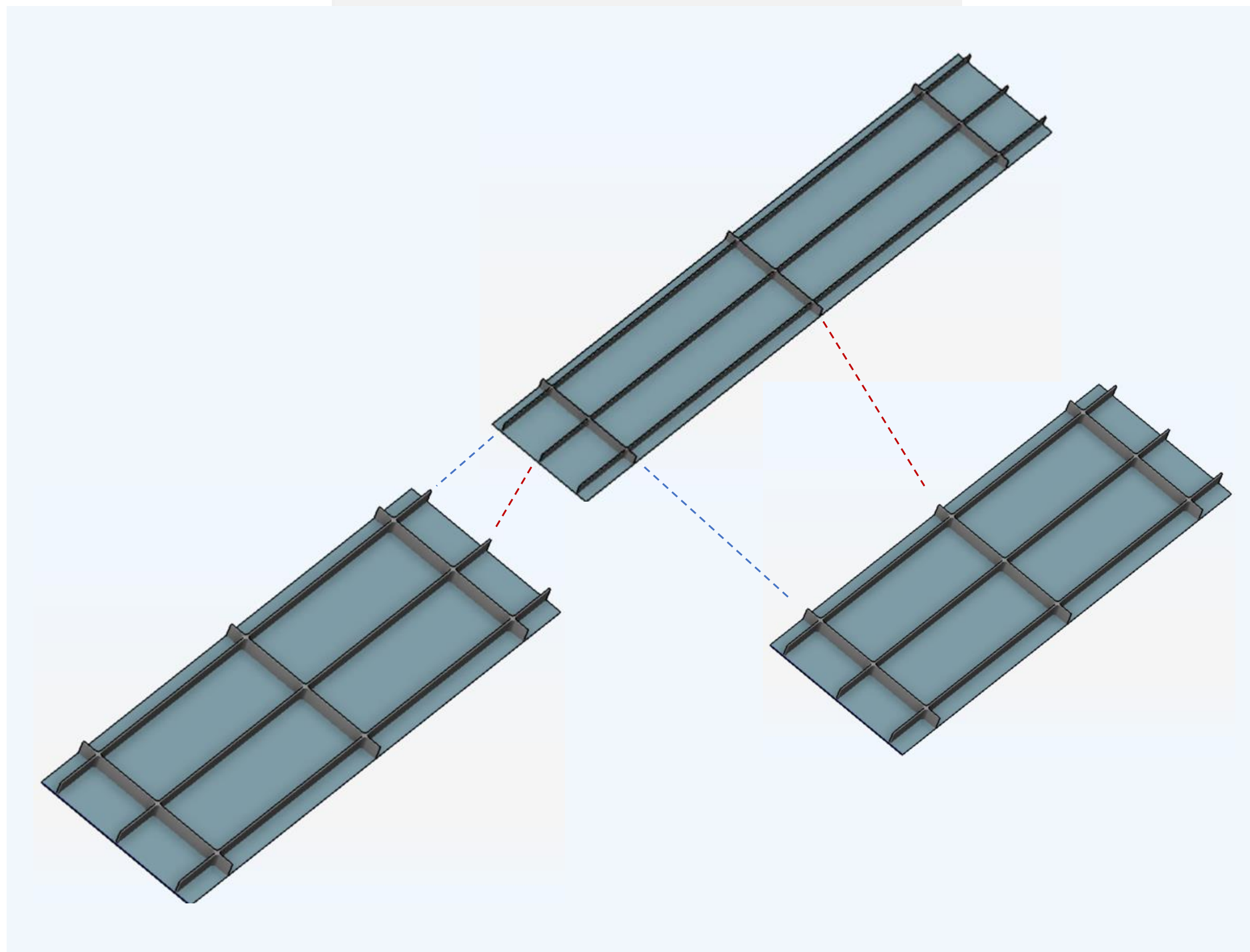
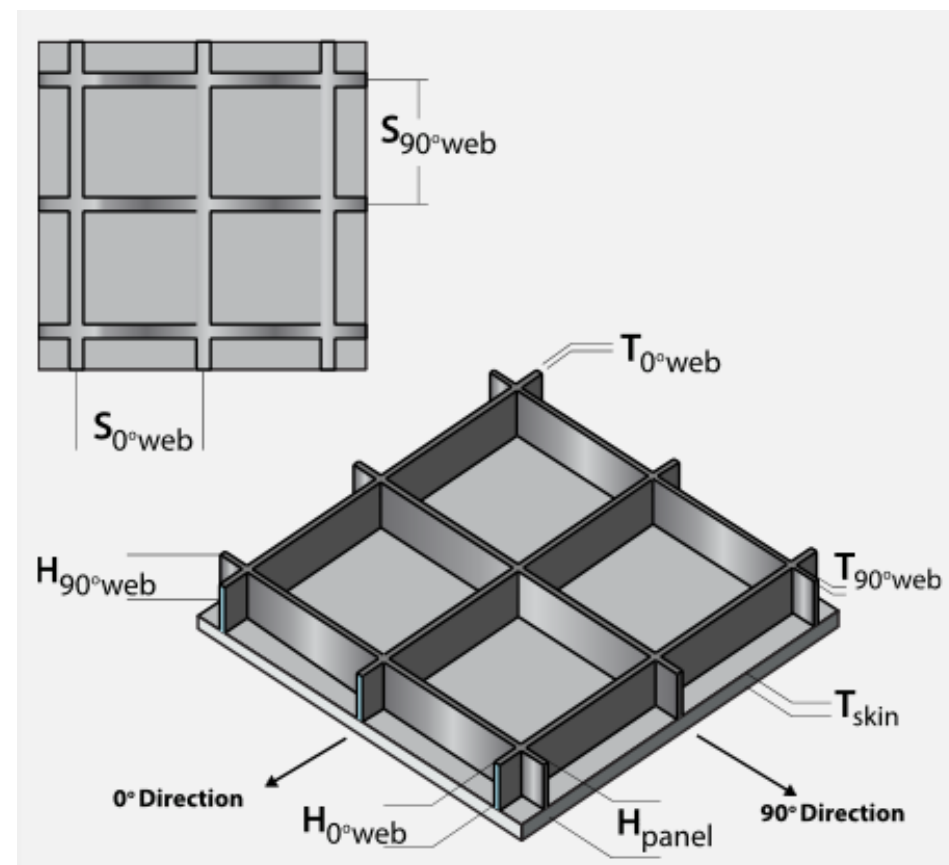
Variant S3-R13





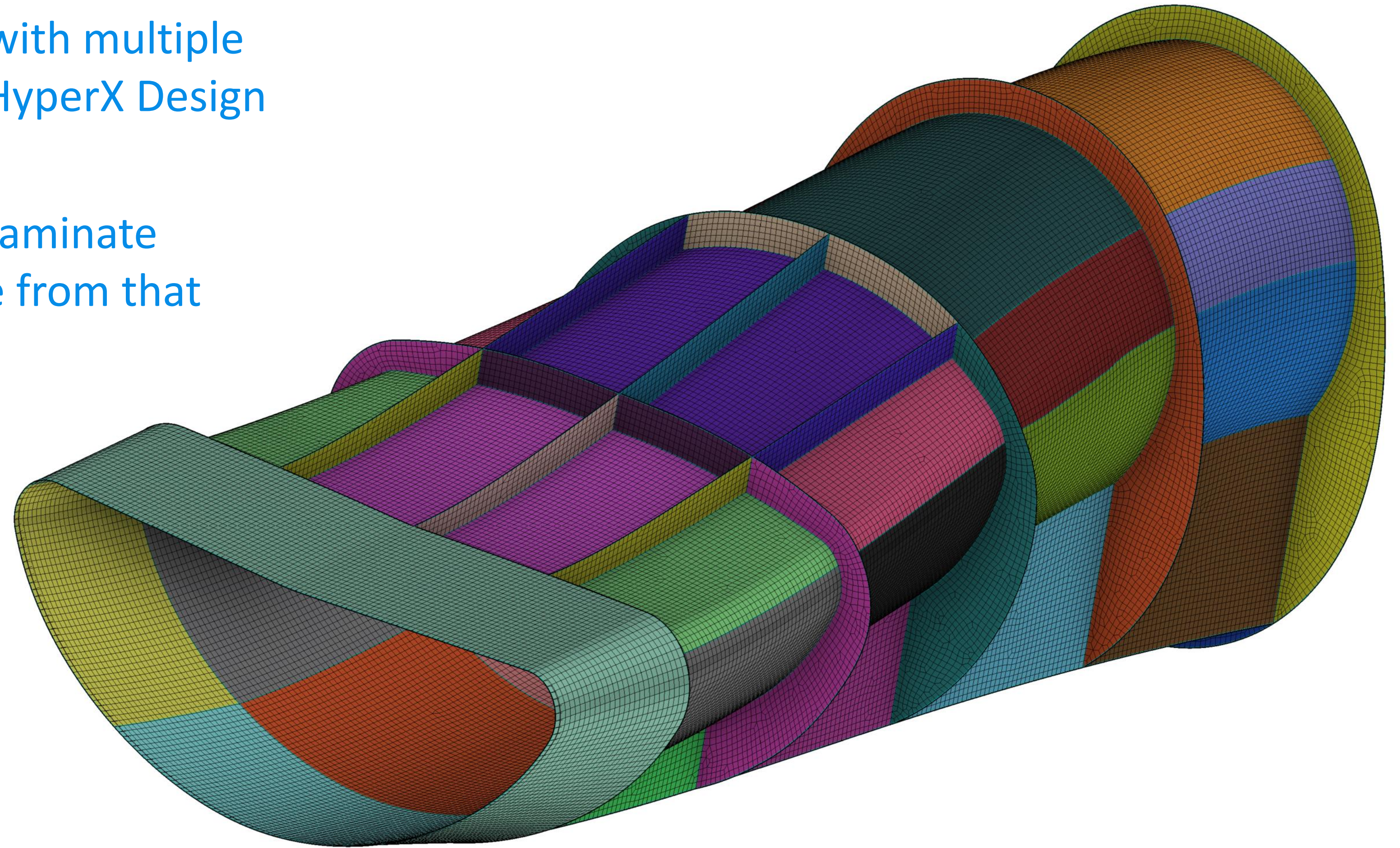
Trade concepts: Orthogrid vs. Isogrid

HyperXpert: Machined Orthogrid Panel Sizing



HyperSizer & HyperXpert Design of Fighter Engine Inlet

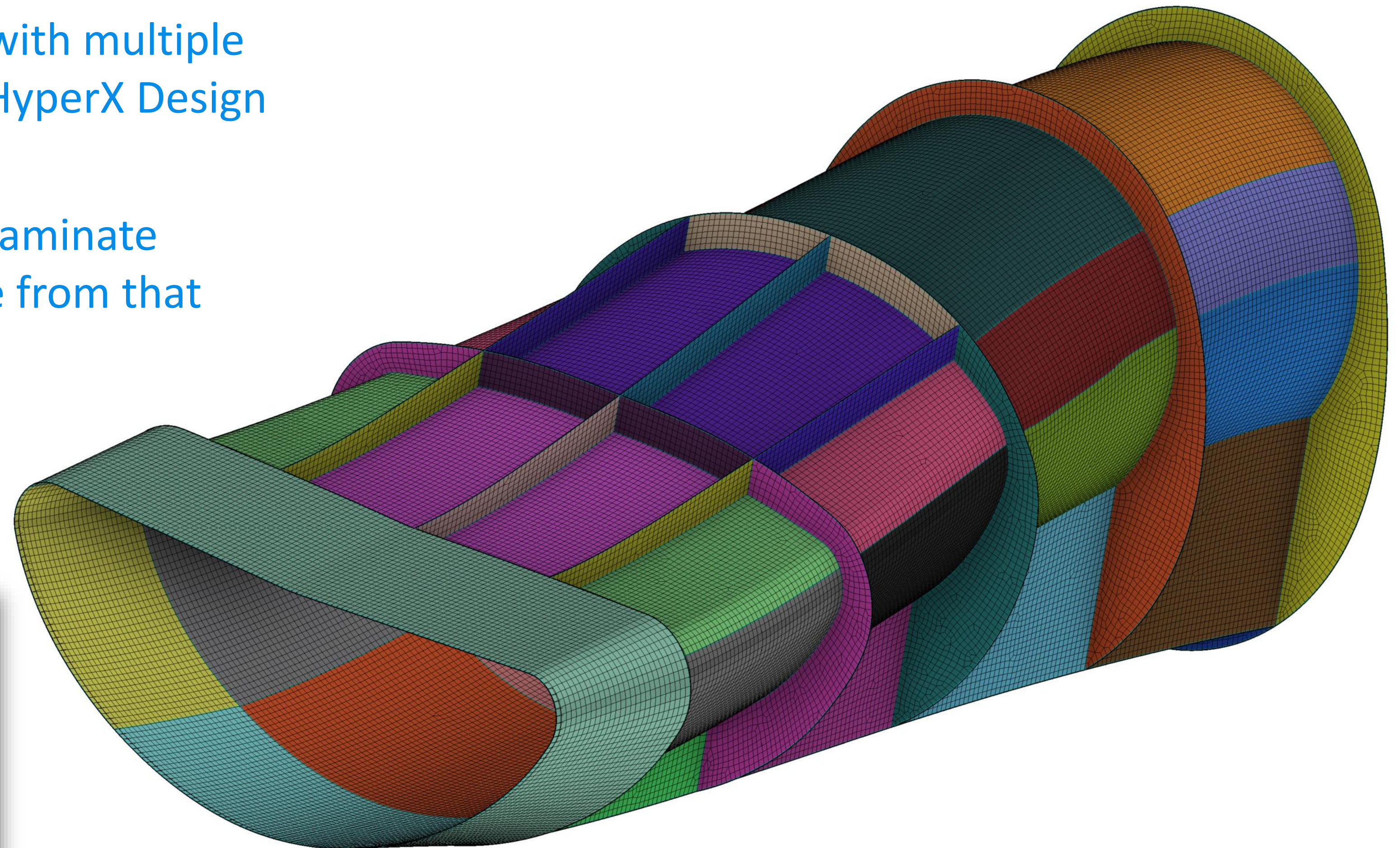
- Multiple laminate families, each with multiple laminates were provided on the HyperX Design Property
- Each zone can size to its optimal laminate family and to its optimal laminate from that laminate family.



- Traditional 0/45/90 laminates
- Non-traditional laminates like Professor Stephen Tsai's Double-Double $[\pm \Phi / \pm \Psi]$

HyperSizer & HyperXpert Design of Fighter Engine Inlet

- Multiple laminate families, each with multiple laminates were provided on the HyperX Design Property
- Each zone can size to its optimal laminate family and to its optimal laminate from that laminate family.



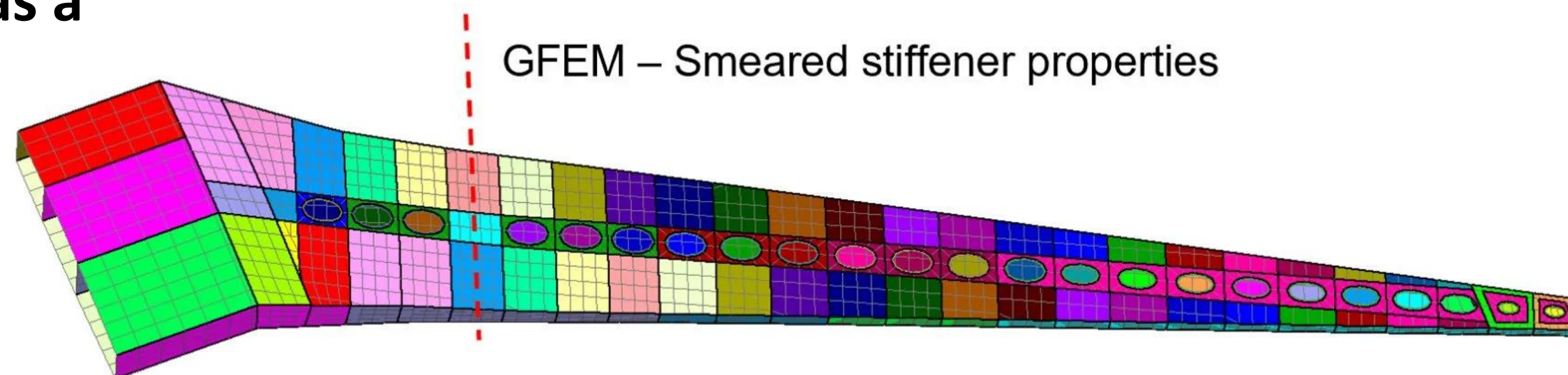
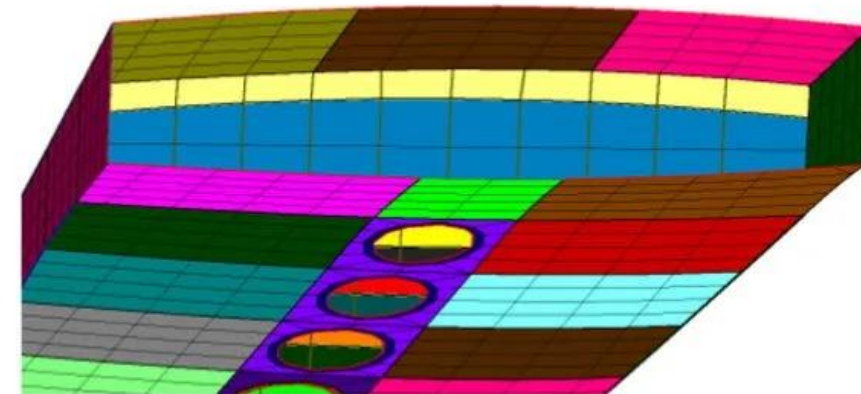
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1	0.0055	Simple Tape	FALSE	45	45	45	45	45	45	45	45	45	45
2	0.0055	Simple Tape	FALSE	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45
3	0.0055	Simple Tape	FALSE	0	0	0	0	0	0	0	0	0	0
4	0.0055	Simple Tape	FALSE	90	90	90	90	90	90	90	90	90	90
5	0.0055	Simple Tape	FALSE	0	0	0	0	0	0	0	0	0	0
6	0.0055	Simple Tape	FALSE	0	0	0	0	0	0	0	0	0	0
7	0.0055	Simple Tape	FALSE	45	45	45	45	45	45	45	45	45	45

Sequence	Thickness (in)	Material	Full Structure	Angle	1	2	3	4	5	6	7	8	9
1	0.0055	Simple Tape	FALSE	45	45	45	45	45	45	45	45	45	45
2	0.0055	Simple Tape	FALSE	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45
3	0.0055	Simple Tape	FALSE	0	0	0	0	0	0	0	0	0	0
4	0.0055	Simple Tape	FALSE	90	90	90	90	90	90	90	90	90	90
5	0.0055	Simple Tape	FALSE	0	0	0	0	0	0	0	0	0	0
6	0.0055	Simple Tape	FALSE	0	0	0	0	0	0	0	0	0	0
7	0.0055	Simple Tape	FALSE	45	45	45	45	45	45	45	45	45	45
8	0.0055	Simple Tape	FALSE	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45
9	0.0055	Simple Tape	FALSE	0	0	0	0	0	0	0	0	0	0
10	0.0055	Simple Tape	FALSE	90	90	90	90	90	90	90	90	90	90
11	0.0055	Simple Tape	FALSE	0	0	0	0	0	0	0	0	0	0
12	0.0055	Simple Tape	FALSE	0	0	0	0	0	0	0	0	0	0
13	0.0055	Simple Tape	FALSE	90	90	90	90	90	90	90	90	90	90
14	0.0055	Simple Tape	FALSE	0	0	0	0	0	0	0	0	0	0
15	0.0055	Simple Tape	FALSE	0	0	0	0	0	0	0	0	0	0
16	0.0055	Simple Tape	FALSE	90	90	90	90	90	90	90	90	90	90
17	0.0055	Simple Tape	FALSE	0	0	0	0	0	0	0	0	0	0
18	0.0055	Simple Tape	FALSE	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45
19	0.0055	Simple Tape	FALSE	45	45	45	45	45	45	45	45	45	45
20	0.0055	Simple Tape	FALSE	0	0	0	0	0	0	0	0	0	0
21	0.0055	Simple Tape	FALSE	0	0	0	0	0	0	0	0	0	0
22	0.0055	Simple Tape	FALSE	90	90	90	90	90	90	90	90	90	90
23	0.0055	Simple Tape	FALSE	0	0	0	0	0	0	0	0	0	0
24	0.0055	Simple Tape	FALSE	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45
25	0.0055	Simple Tape	FALSE	45	45	45	45	45	45	45	45	45	45

- Traditional 0/45/90 laminates
- Non-traditional laminates like Professor Stephen Tsai's Double Double $[\pm \Phi / \pm \Psi]$

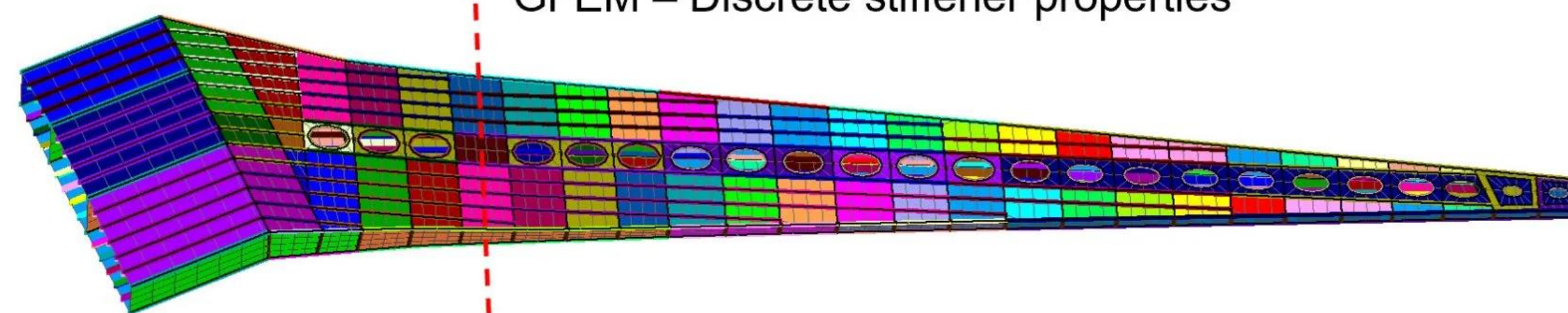
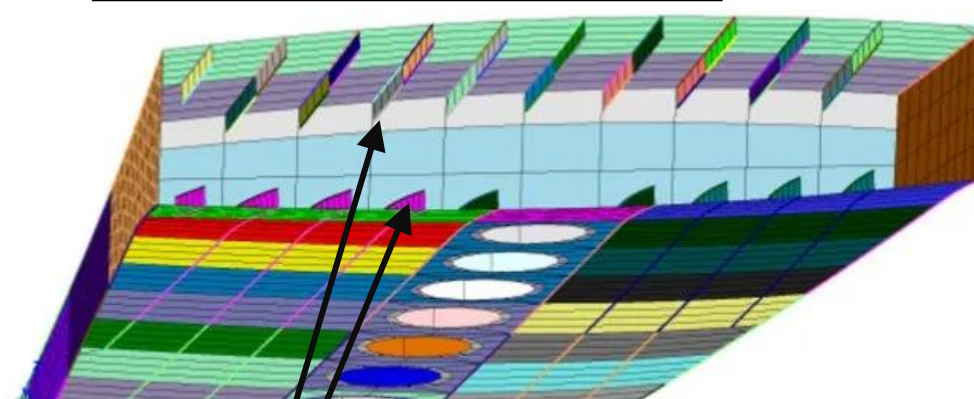
This example uses the smeared mesh

A FEM with Stiffeners as a Smeared Mesh

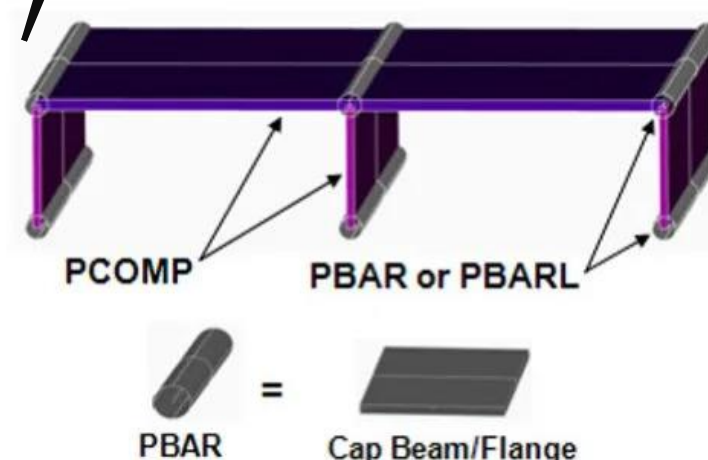


GFEM – Smeared stiffener properties

A FEM with Stiffeners as a Discrete Mesh



GFEM – Discrete stiffener properties



Both FEMs are “I” stiffened panels

END

Workflow

Panel Design Property

UAM451 DOE Hat

Modeling Technique

Smeared

Diagram of a hat section with dimensions: $\frac{1}{2}W_{foot}$, H_{panel} , $H_{stiffener}$, H_{web} , W_{crown} , T_{skin} , T_{foot} , T_{web} , T_{crown} , and Angle.

Advanced

2024-03-17 03:29:25

Zones Assigned:

Zones Selected:

Unassign

Assign

Sizing

Analysis

☐ Metal

☒ Composite

Zone

Detailed Sizing

Set Variables

Dimension	Use Analysis	Min	Max	Steps	Step Size	Material
T_{skin} (in)	☐	0.0275	0.132	17		LF450 DOE Hat Skin 01 (17)
T_{web} (in)	☐	0.022	0.11	12		LF450 DOE Hat Stiffener 02 (21)
T_{foot} (in)	☐	0.022	0.11	16		(Determined by the web variable's material)
T_{crown} (in)	☐	0.0275	0.1265	16		(Determined by the web variable's material)
$H_{stiffener}$ (in)	☐	0.4	0.8	3	0.2	
Spacing (in)	☐	3.25	4.33	2	1.08	
Angle (°)	☐	65	75	2	10	
W_{foot} (in)	☐	1	1.375	2	0.375	
W_{crown} (in)	☐	0.3	0.8	3	0.25	
H_{panel} (in)		(Dependent variable)				
H_{web} (in)		(Dependent variable)				
W_{open} (in)		(Dependent variable)				

Overrides

Req. Designs 1

Candidates 5035

This design is used in other projects

Apply

Close

multiple Laminates
multiple Laminate Families

Design Property Laminate Families

	A	C	D	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
1	Layer	Thickness (in)	Material	Angle	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
14	13	0.0055	Simple Tape	-45	-45	-45	-45	-45	-45	-45	-45	45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45
15	14	0.0055	Simple Tape	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
16	15	0.0055	Simple Tape	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	16	0.0055	Simple Tape	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
18	17	0.0055	Simple Tape	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
19	18	0.0055	Simple Tape	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	19	0.0055	Simple Tape	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45
21	20	0.0055	Simple Tape	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
22	21	0.0055	Simple Tape	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
23	22	0.0055	Simple Tape	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24																															
25																															
26																															
27																															
28																															
29																															
30	29	0.0055	Simple Tape	90	90	90	90	90	90	90	90	90																			
31	30	0.0055	Simple Tape	0	0	0	0	0	0	0	0	0																			
32	31	0.0055	Simple Tape	90	90	90	90	90	90																						
33	32	0.0055	Simple Tape	0	0	0	0	0																							
34	33	0.0055	Simple Tape	0	0	0	0	0																							
35	34	0.0055	Simple Tape	-45	-45	-45																									
36	35	0.0055	Simple Tape	45	45																										
37	36	0.0055	Simple Tape	-45	-45																										
38	37	0.0055	Simple Tape	-45	-45																										
39	38	0.0055	Simple Tape	45	45																										
40	39	0.0055	Simple Tape	-45	-45	-45																									
41	40	0.0055	Simple Tape	0	0	0	0																								
42	41	0.0055	Simple Tape	0	0	0	0	0																							
43	42	0.0055	Simple Tape	90	90	90	90	90	90																						
44	43	0.0055	Simple Tape	0	0	0	0	0	0	0																					
45	44	0.0055	Simple Tape	90	90	90	90	90	90	90	90																				
46	45	0.0055	Simple Tape	0	0	0	0	0	0	0	0	0																			
47	46	0.0055	Simple Tape	45	45	45																									
48	47	0.0055	Simple Tape	-45	-45	-45	-45	-45	-45	-45	-45	-45	45	-45																	
49	48	0.0055	Simple Tape	90	90	90	90	90	90	90	90	90	90	90	90																
50	49	0.0055	Simple Tape	90	90	90	90	90	90	90	90	90	90	90	90	90	90														
51	50	0.0055	Simple Tape	0	0	0	0	0	0	0	0	0	0	0	0	0															
52	51	0.0055	Simple Tape	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0													
53	52	0.0055	Simple Tape	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45													
54	53	0.0055	Simple Tape	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90												
55	54	0.0055	Simple Tape	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45												
56	55	0.0055	Simple Tape	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
57	56	0.0055	Simple Tape	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90											
58	57	0.0055	Simple Tape	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45											
59	58	0.0055	Simple Tape	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	59	0.0055	Simple Tape	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
61	60	0.0055	Simple Tape	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45
62	61	0.0055	Simple Tape	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63	62	0.0055	Simple Tape	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
64	63	0.0055	Simple Tape	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
65	64	0.0055	Simple Tape	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

- Multiple Skin Laminates in a Laminate Family
- Multiple Skin Laminate Families

I-Stiffened Panel					☒ Allowed		☒ Allowed		☒ Allowed		☒ Allowed								
Zones: 7:9.14:36					Min Ratio	Max Ratio	Min Ratio	Max Ratio	Min Ratio	Max Ratio	Min Ratio	Max Ratio							
Designs: Laminate - Design Study					0.2	0.7	0.2	0.7	0.2	0.7	0.2	0.7							
					Foot Plank		Foot Charge		Web Charge		Cap Charge								
					Plank			Foot			Base		Web		Cap				
Sublaminate	Sequence	Thickness (in)	Material	Angle	Full Structure	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Plank	1	0.0055	Simple Tape	0.0	FALSE	0.0	0.0	0.0											
	2	0.0055	Simple Tape	0.0	FALSE	0.0	0.0												
	3	0.0055	Simple Tape	0.0	FALSE	0.0													
Charge (foot)																			
Base	8	0.0055	Simple Tape	45.0	FALSE							45.0	45.0						
	9	0.0055	Simple Tape	-45.0	FALSE							-45.0	-45.0						
	10	0.0055	Simple Tape	90.0	FALSE							90.0	90.0						
	11	0.0055	Simple Tape	0.0	FALSE							0.0							
Charge (web)	12	0.0055	Simple Tape	0.0	FALSE									0.0	0.0	0.0			
	13	0.0055	Simple Tape	0.0	FALSE									0.0	0.0				
	14	0.0055	Simple Tape	0.0	FALSE									0.0					
Charge (cap)	15	0.0055	Simple Tape	0.0	FALSE												0.0	0.0	0.0
	16	0.0055	Simple Tape	0.0	FALSE												0.0	0.0	
	17	0.0055	Simple Tape	0.0	FALSE												0.0		

- Multiple Stiffener Laminates in a Laminate Family
- Multiple Stiffener Laminate Families

HyperXpert Workflow

Dimension	Use Analysis	Min	Max	Steps	Step Size
T _{skin} (in)	☐	0.0275	0.132	17	
T _{web} (in)	☐	0.022	0.11	12	
T _{foot} (in)	☐	0.022	0.11	16	
T _{crown} (in)	☐	0.0275	0.1265	16	
H _{stiffener} (in)	☐	0.4	0.8	3	0.2
Spacing (in)	☐	3.25	4.33	2	1.08
Angle (°)	☐	65	75	2	10
W _{foot} (in)	☐	1	1.375	2	0.375
W _{crown} (in)	☐	0.3	0.8	3	0.25

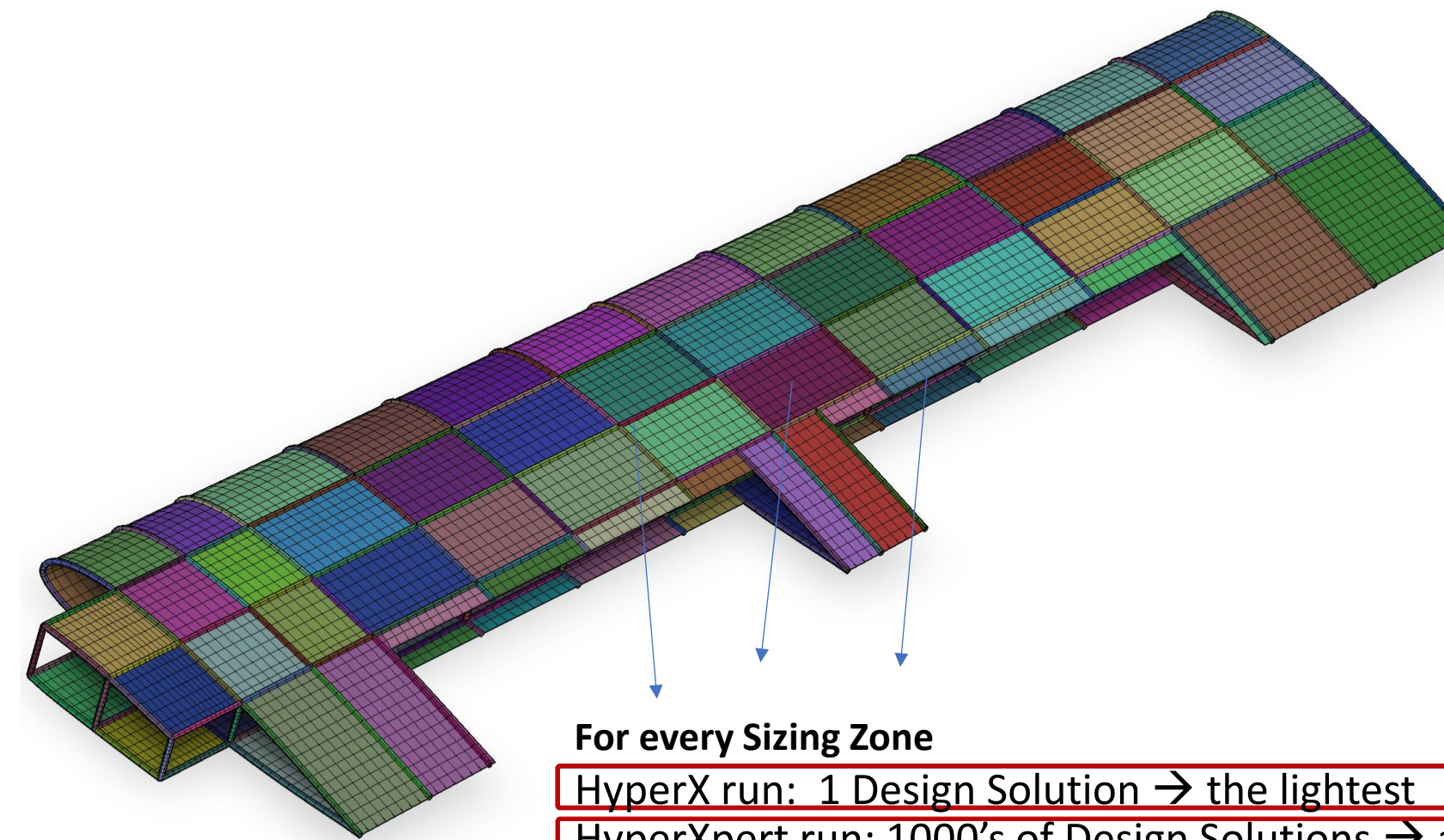
7 Variables

Weight = 131.5 lb

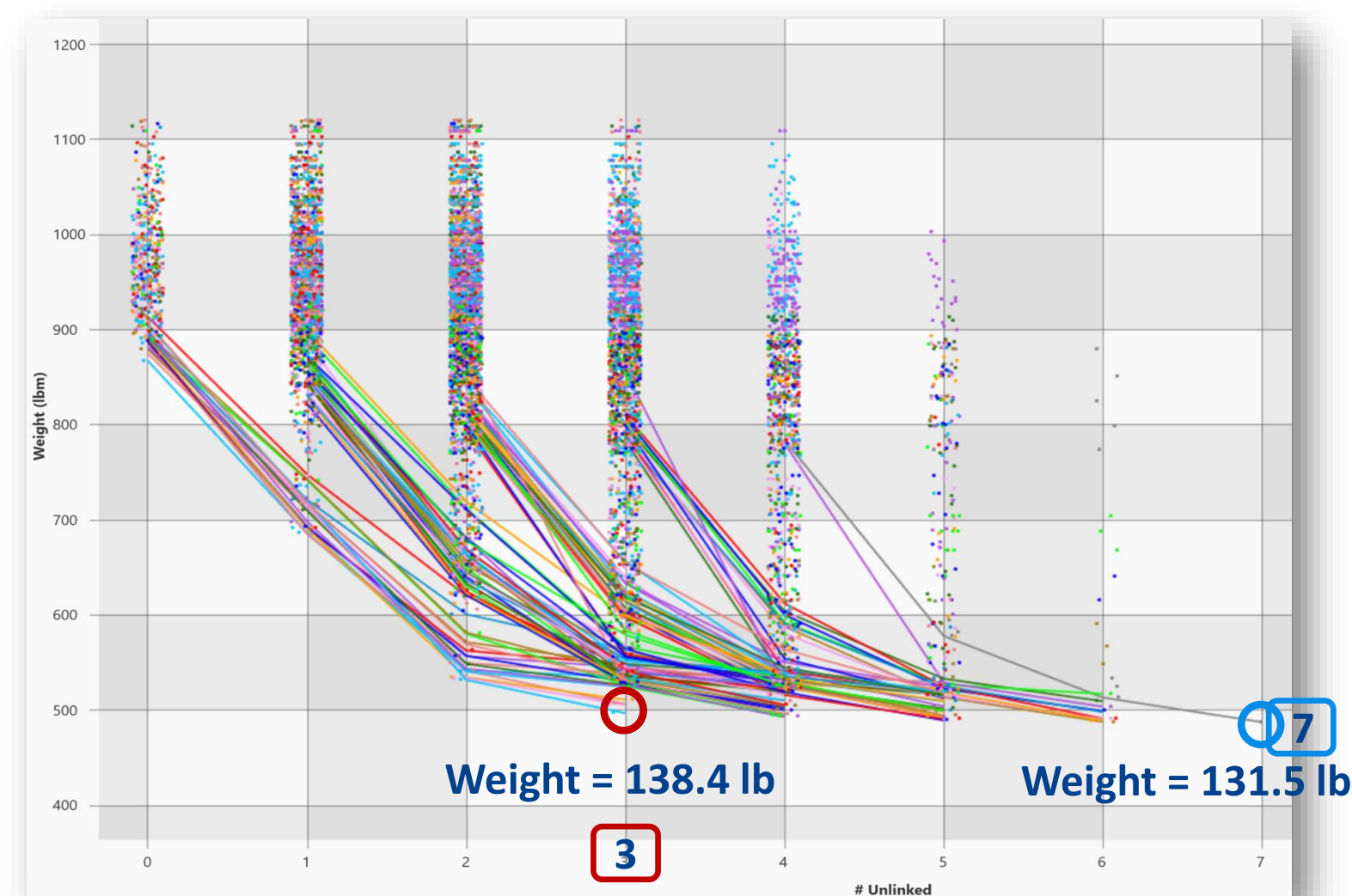
Dimension	Use Analysis	Min	Max	Steps	Step Size
T _{skin} (in)	☐	0.0275	0.132	17	
T _{web} (in)	☐	0.022	0.11	12	
T _{foot} (in)	☐	0.022	0.11	16	
T _{crown} (in)	☐	0.0275	0.1265	16	
H _{stiffener} (in)	☐	0.6		1	
Spacing (in)	☐	3.25		1	
Angle (°)	☐	65		1	
W _{foot} (in)	☐	1		1	
W _{crown} (in)	☐	0.3	0.8	3	0.25

3 Variables

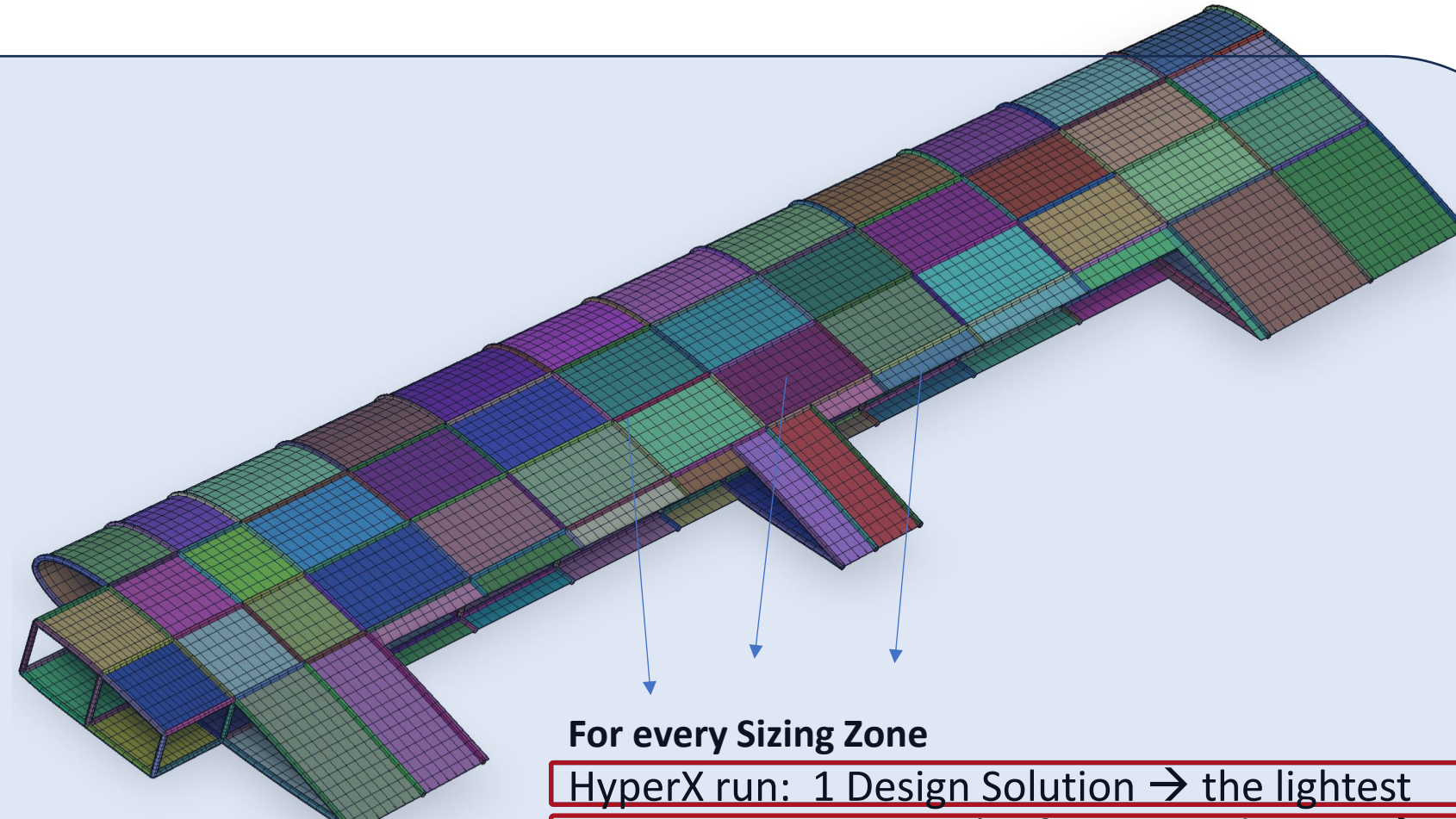
Weight = 138.4 lb



Data for selected zones is called a
HyperXpert Run Set



Dimension	Use Analysis	Min	Max	Steps	Step Size
T _{skin} (in)	☐	0.0275	0.132	17	
T _{web} (in)	☐	0.022	0.11	12	
T _{foot} (in)	☐	0.022	0.11	16	
T _{crown} (in)	☐	0.0275	0.1265	16	
H _{stiffener} (in)	☐	0.4	0.8	3	0.2
Spacing (in)	☐	3.25	4.33	2	1.08
Angle (°)	☐	65	75	2	10
W _{foot} (in)	☐	1	1.375	2	0.375
W _{crown} (in)	☐	0.3	0.8	3	0.25



For every Sizing Zone

HyperX run: 1 Design Solution → the lightest

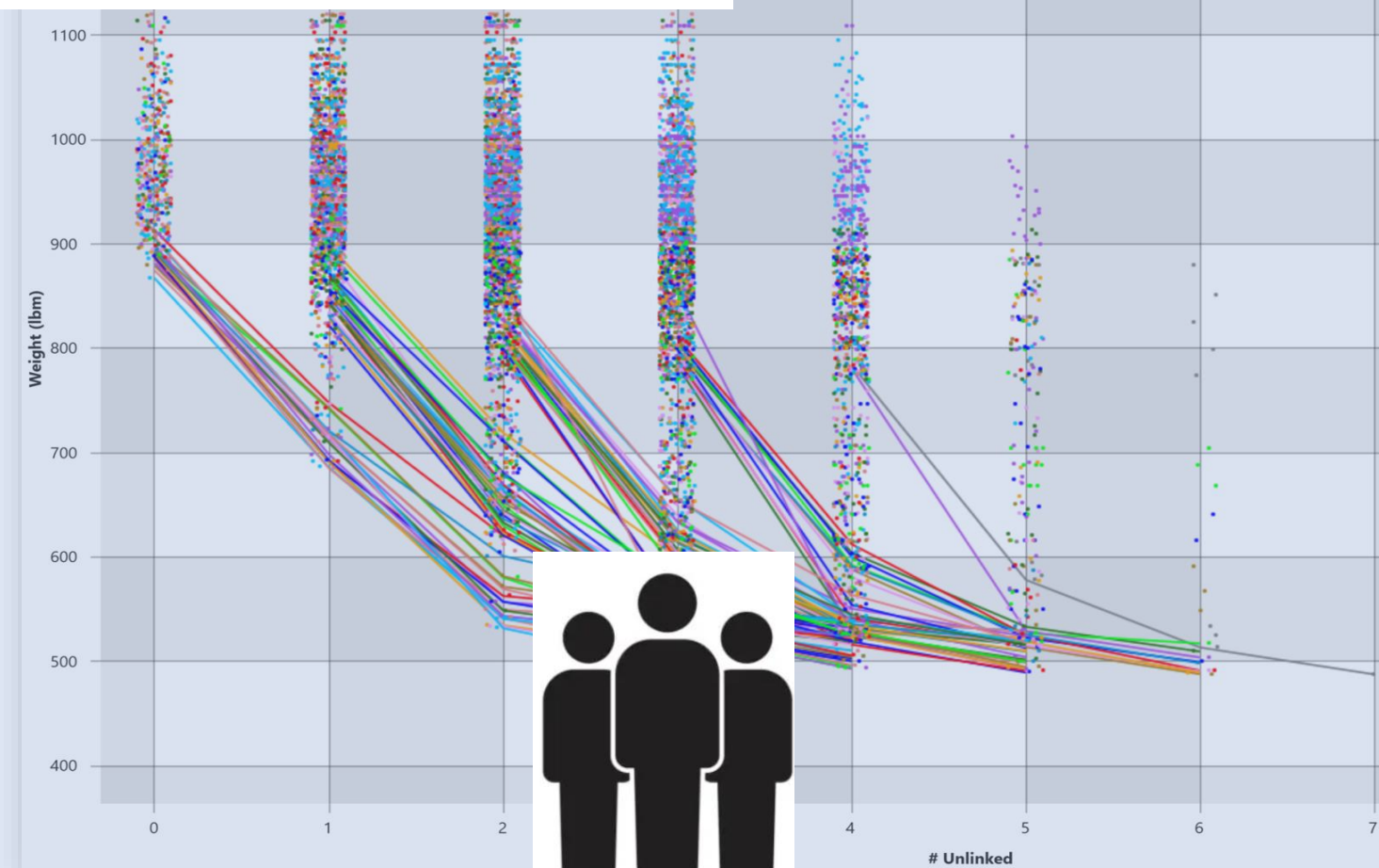
ert run: 1000's of Design Solutions → all with +margins

7 Unlinked Variables

HyperX Database on
your laptop

Dimension	Use Analysis	Min	Max
T _{skin} (in)	☐	0.0275	0.132
T _{web} (in)	☐	0.022	0.11
T _{foot} (in)	☐	0.022	0.11
T _{crown} (in)	☐	0.0275	0.1265
H _{stiffener} (in)	☐	0.6	1
Spacing (in)	☐	3.25	1
Angle (°)	☐	65	1
W _{foot} (in)	☐	1	1
W _{crown} (in)	☐	0.3	0.8

3 Unlinked Variables



HyperXpert