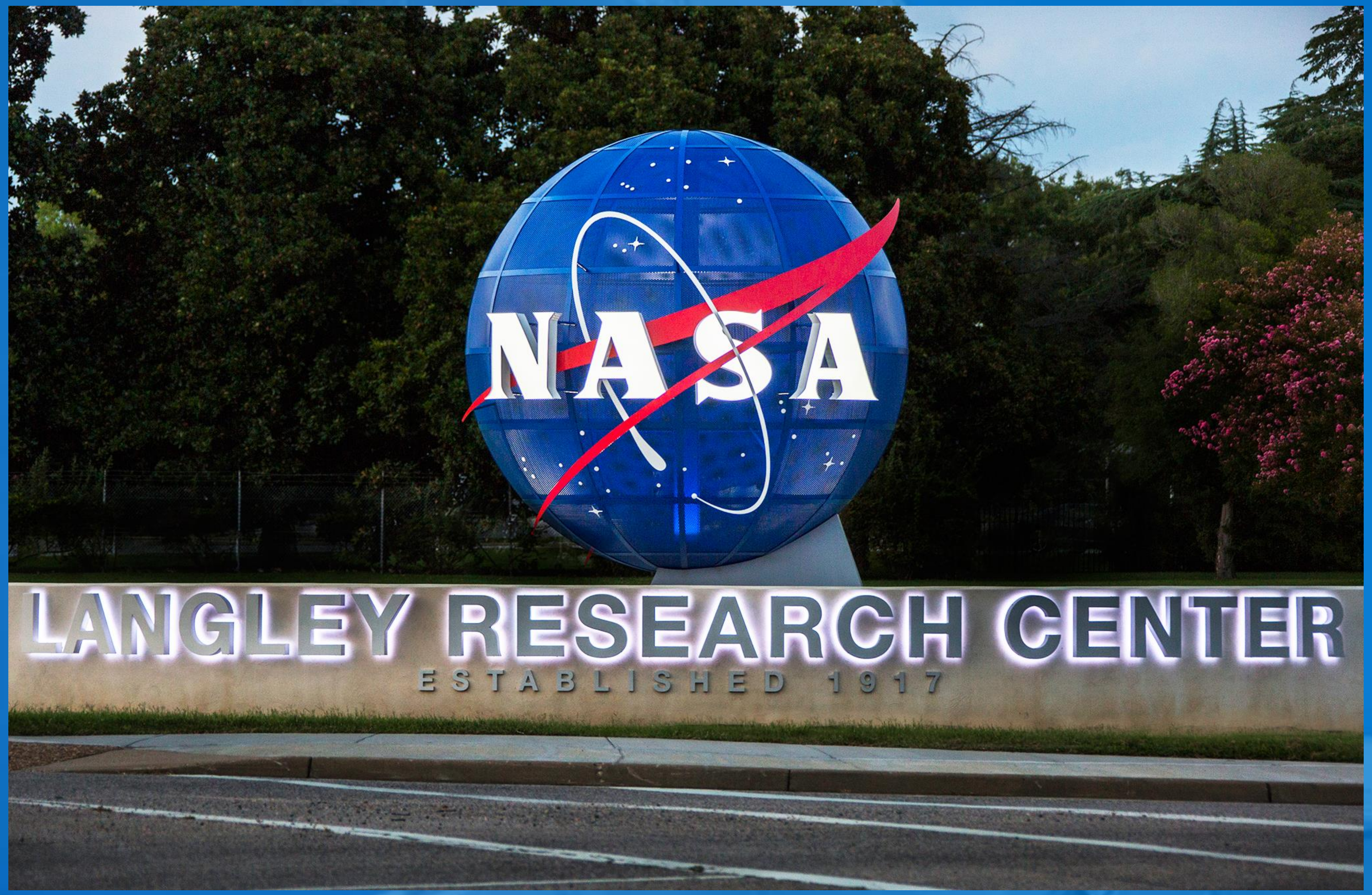
COLLIER AEROSPACE

AGENDA
HyperX Users Conference 2023

June 14-15, 2023

Pearl Young Theatre

NASA Langley Research Center



HyperX Users Conference

- **Why Attend?**
  - **Listen to HyperX users** present how they are using the software on their aerospace aircraft and launch vehicle structures
  - **Learn our Road Map of HyperX development** and plans for future HyperX features
  - **Learn from Collier engineers and developers** HyperX best practices
  - **Learn how to tailor a HyperX workflow** to meet your engineering team's needs with analysis Plugins, API customization, and the Enterprise Use Case
  - **Impact future HyperX development** with an opportunity to suggest features you would like to see
- **Why present?**
  - **Opportunity to showcase your project** and HyperX best practices to an engaging and interested audience
  - **Single track of presentations** insures well attended audience
  - **Get feedback** on your work from other aerospace engineers
  - **Recognition of peers**
  - **Broaden your professional network**

Day 1 - Agenda - HyperX Users Conference

Wednesday Morning, June 14, 2023

- 8:00 Transportation vans pick up at Marriott City Center Newport News
- 8:20 Arrive at NASA Langley Badge and Pass Office
- 8:40 Drive to NASA Langley Pearl Young Theatre for Coffee & Registration
- 9:00 → **Brief history of HyperSizer and NASA's use over 30 years**

  In honor of Jeff Cerro, the author of EZDESIT, 1985-1990, the trailblazer of HyperX
- 9:30 → **HyperX's Role in Certifying Flight Hardware for Human-Rated Spaceflight**

  Keynote Speaker: Michael T. Kirsch - Deputy Director, NASA Engineering & Safety Center
- 10:00 Coffee Break & Conversations
- 10:15 → Road Map of HyperX development plans for future capabilities

  High Performance Computing in the Cloud or on a Linux Cluster, Stephen Jones

  Digital Thread to CAD, August Noevere

  The Section Cut, Professional Stress Tool, Charli Cahill

  Enterprise Use Case for when your Engineering Department Adopts James Ainsworth
- 12:00 Lunch at NASA

Day 1 - Agenda - HyperX Users Conference

Wednesday Afternoon, June 14, 2023

Engineering Applications

- 1:00 → **Designing High Performance Composite Bike Frames with HyperX**
  Ryan McLoughlin, Trek Bicycle Corporation
- 1:30 → **Large Airframes and Launch Vehicles– Stiffened Panels – 35 Years of Specialized Capability**
  Craig Collier, Collier Aerospace
- 2:00 Break & Conversations
- 2:15 → **Space Launch Vehicles, High Performance Computing in AWS, and Engineering Services**
  James Ainsworth, Collier Aerospace
- 2:45 → **UAM eVTOLs from Conceptual to Preliminary to Detail Design with Associated FEM Modeling**
  Mischa Pollack, Collier Aerospace
- 3:15 → **The SP80 World Record Composite Sailboat**
  Mischa Pollack, Collier Aerospace
- 4:00 Transportation vans from NASA to James River Country Club for Networking Event, Included Dinner, and Sunset on the Dock over the Historic James River
- 8:00 Transportation back to the Marriott Hotel

Day 2 - Agenda - HyperX Users Conference

Thursday June 15, 2023

- 8:00 Transportation vans pick up at Marriott City Center Newport News
- 8:20 Arrive at NASA Langley Pearl Young Theatre for Coffee & Registration
- 9:00 → **How Spirit AeroSystems uses HyperX,** Theresa Williams, Spirit AeroSystems
- 9:30 → **Two Decades of Aerospace Conceptual Vehicle Analysis and Design with HyperSizer & HyperX,** Lloyd Eldred, NASA Langley
- 10:00 Coffee Break & Conversations
- 10:15 → **HyperX's Role in the NASA Advanced Composite Program (ACP) and the High Speed Composite Manufacturing (HiCAM) Projects,** Guest Speaker, NASA Langley
- 10:40 → **Design Optimization to Fabrication with HyperX Laminate Families for Traditional Quad 0/45/90 and Double-Double [± Φ / ± Ψ] Layups,** Brett Bednarcyk, NASA Glenn
- 11:15 → **Rolling out New Customer Support Tools – How to get Help,** Charli Cahill, Collier Aerospace
- 11:45 Lunch at NASA

Afternoon Session - Technical Interchange Discussions

- 12:30 → **Fastened Joints,** led by James Ainsworth
- 1:15 → **Bonded Joints,** led by Stephen Jones
- 2:00 Break & Conversations
- 2:15 → **Customer Customization: Bottom-Up with Plugins,** led by Noah Prezant
- 3:00 → **Customer Customization: Top-Down with the API,** led by KellyAnn Smith
- 3:45 Transportation vans from NASA back to Marriott City Center

Day 1 – Keynote Speech

HyperX's Role in Certifying Flight Hardware for Human-Rated Spaceflight

Michael T. Kirsch - Deputy Director, NASA Engineering & Safety Center

While assigned to the NASA Engineering & Safety Center (NESC), Mike has led several independent technical assessments that included developing an independent Crew Exploration Vehicle (CEV) design, evaluating the use of carbon fiber composites on Orion's crew module primary structure, a study of permeability through carbon graphite composites, fabricating a full-scale composite crew module (CCM), and contributing to an alternate design of the Orion heatshield carrier structure.

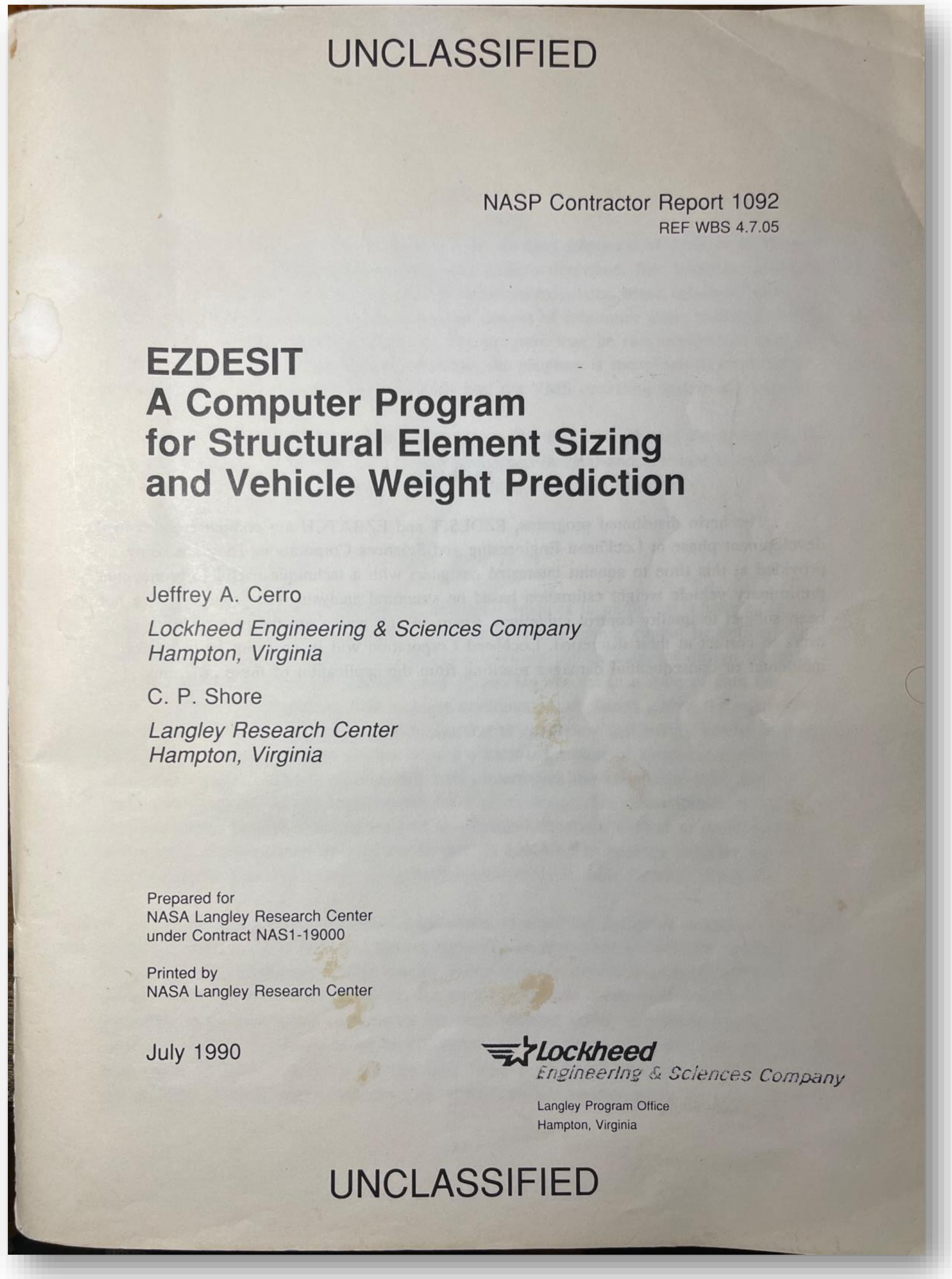
The NESC conducts independent technical assessments for NASA's highest risk Programs. **This keynote will describe how the NESC relies heavily on computational analysis to establish the safety of structure, and in particular HyperSizer's role on the composite crew module (CCM), and to the alternate design of the Orion heatshield carrier structure.**

Michael T. Kirsch - Deputy Director, NASA Engineering & Safety Center

Day 1: Brief history of HyperSizer and NASA's use over 30 years

Jeff Cerro – NASA Langley
Vehicle Design / Structures Engineer

In honor of Jeff Cerro, the author of EZDESIT, 1985-1990, the trailblazer of HyperX



UNCLASSIFIED

NASP Contractor Report 1092
REF WBS 4.7.05

EZDESIT
A Computer Program for Structural Element Sizing and Vehicle Weight Prediction

Jeffrey A. Cerro
Lockheed Engineering & Sciences Company
Hampton, Virginia

C. P. Shore
Langley Research Center
Hampton, Virginia

Prepared for
NASA Langley Research Center
under Contract NAS1-19000

Printed by
NASA Langley Research Center

July 1990

Lockheed
Engineering & Sciences Company
Langley Program Office
Hampton, Virginia

UNCLASSIFIED

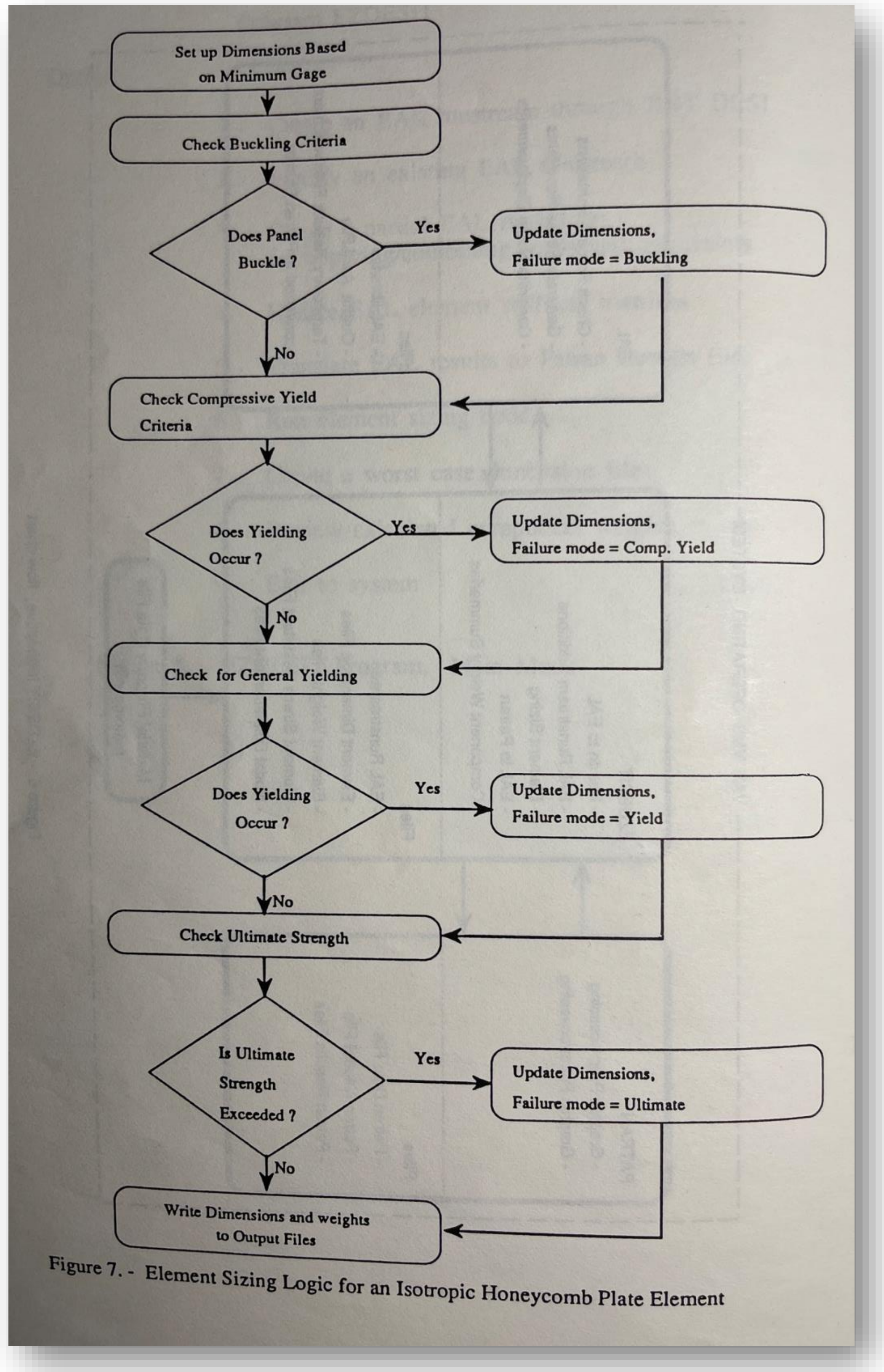


Figure 7. - Element Sizing Logic for an Isotropic Honeycomb Plate Element

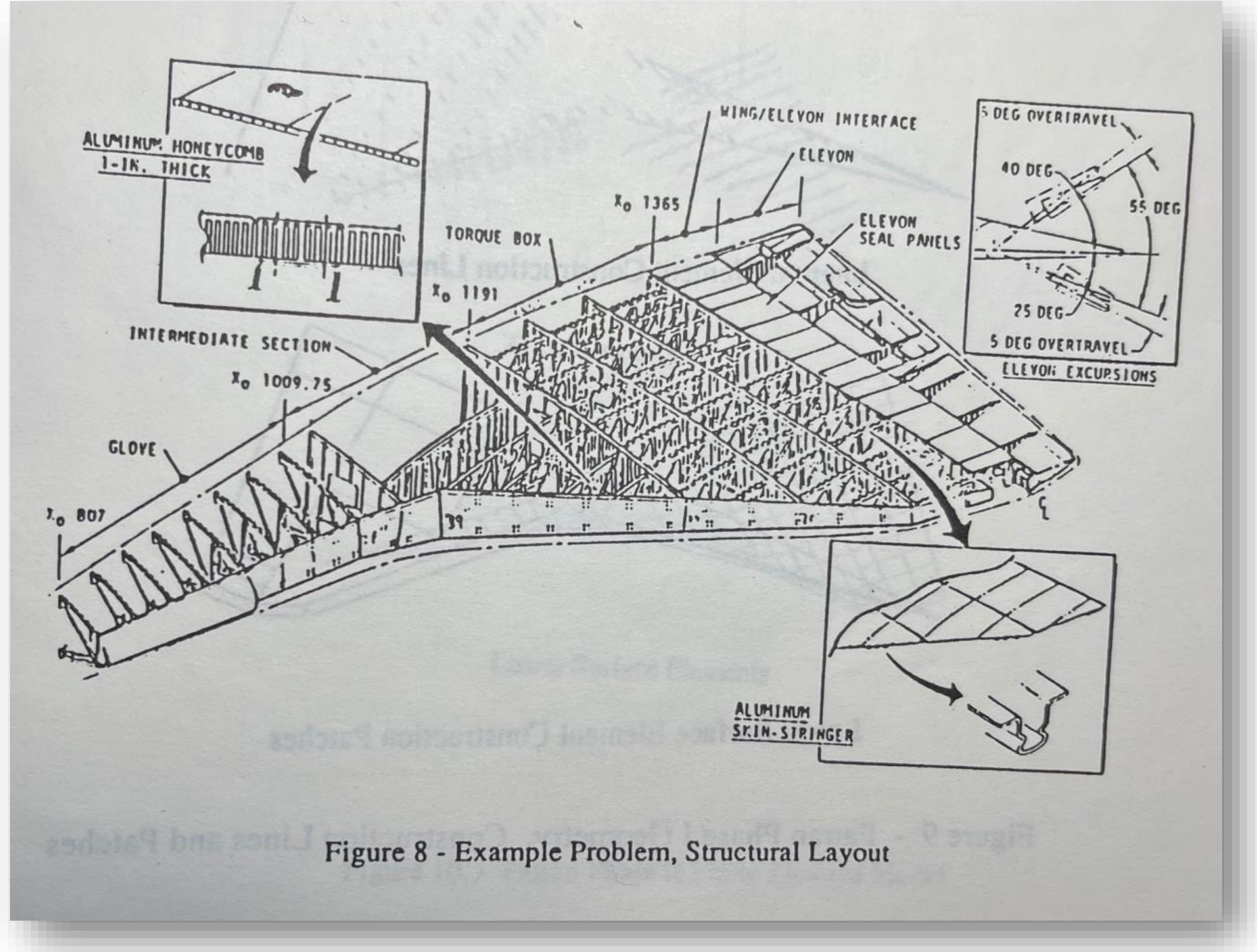


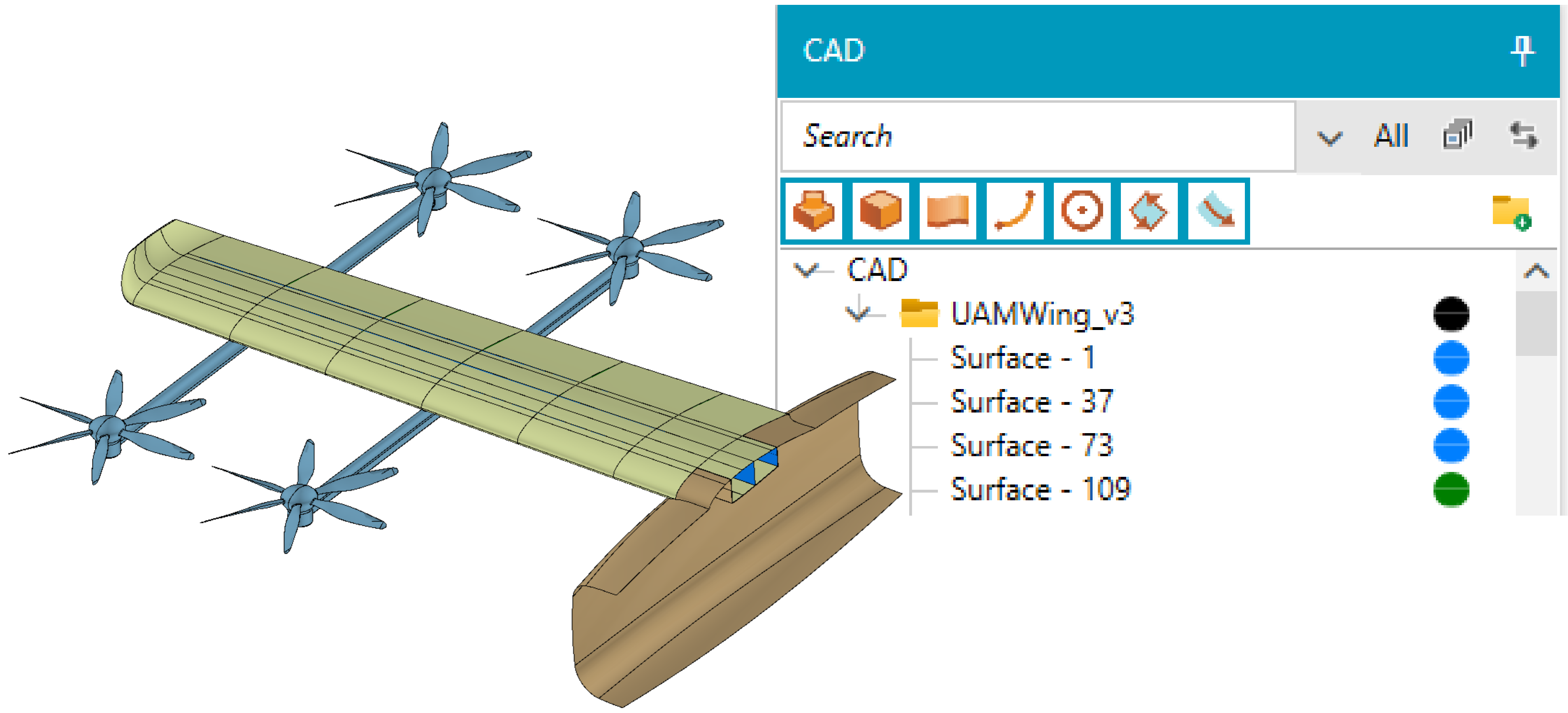
Figure 8 - Example Problem, Structural Layout

Day 1: CAD and the Digital Thread

August Noevere – Collier Aerospace
Director of Research & Senior Aerospace Structural Engineer

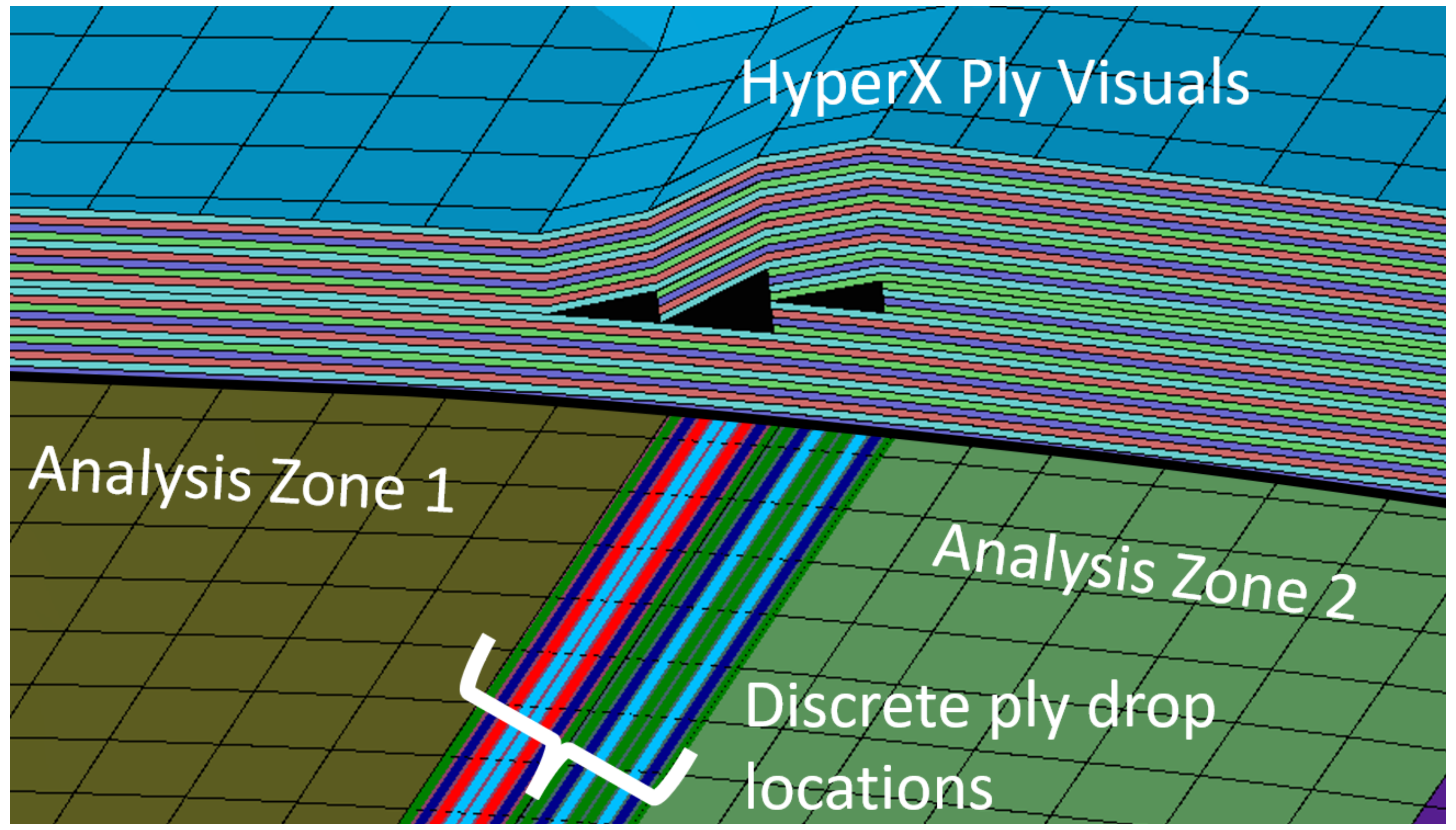
Management of CAD data

- Import CAD geometry from STEP and IGES files
- CAD entities can be managed (tree organization, visibility, etc) and overlaid on FEM in HyperX



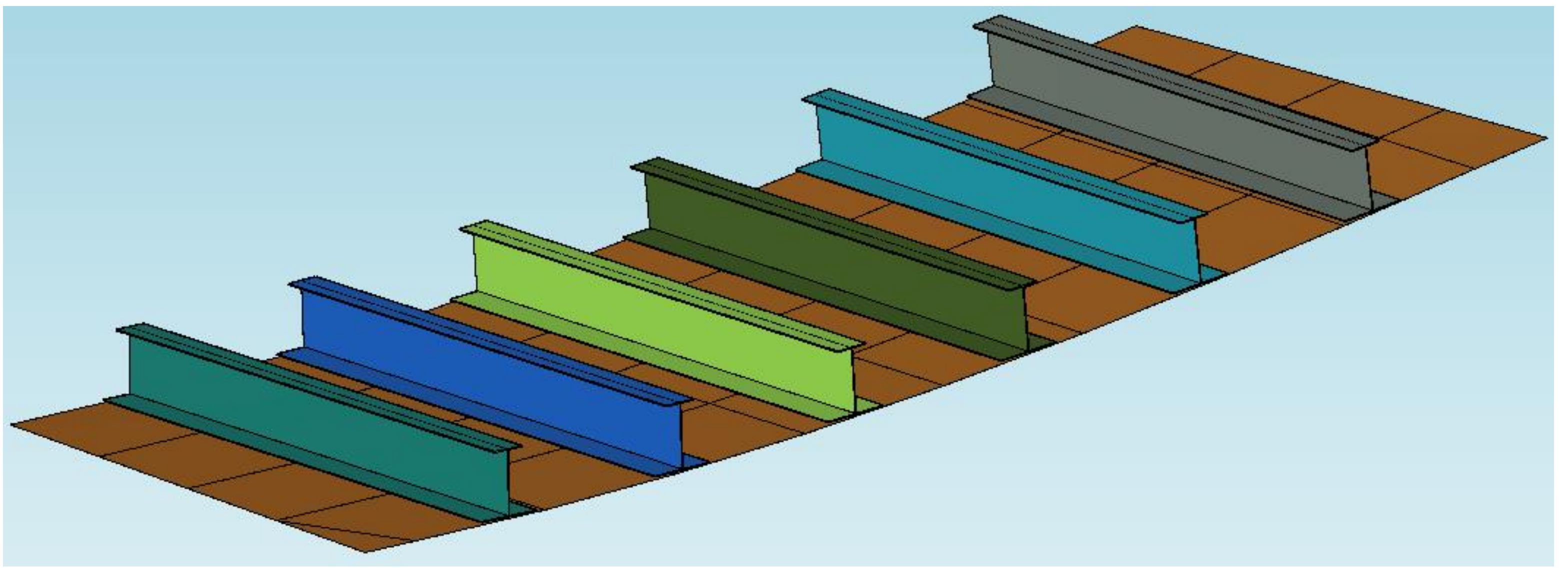
Bi-directional communication with composite data

- Auto-generate CAD curves on FEM ply boundaries
- Export ply boundaries and ply information to CATIA and other design tools
- Import ply boundaries from CATIA or other tools and automatically create plies on HyperX model



Generation of CAD stiffener geometry

- Auto-generate CAD stiffener geometry for smeared or discrete stiffened panels in HyperX
- Enables rapid communication of stiffener placement and geometry with design engineers in multiple CAD formats



Day 1: The Section Cut, Professional Stress Tool

Charli Cahill – Collier Aerospace
Manager of Customer Development

HyperX section cut analysis and sizing tool for aerospace engineering

Using Section Stiffnesses

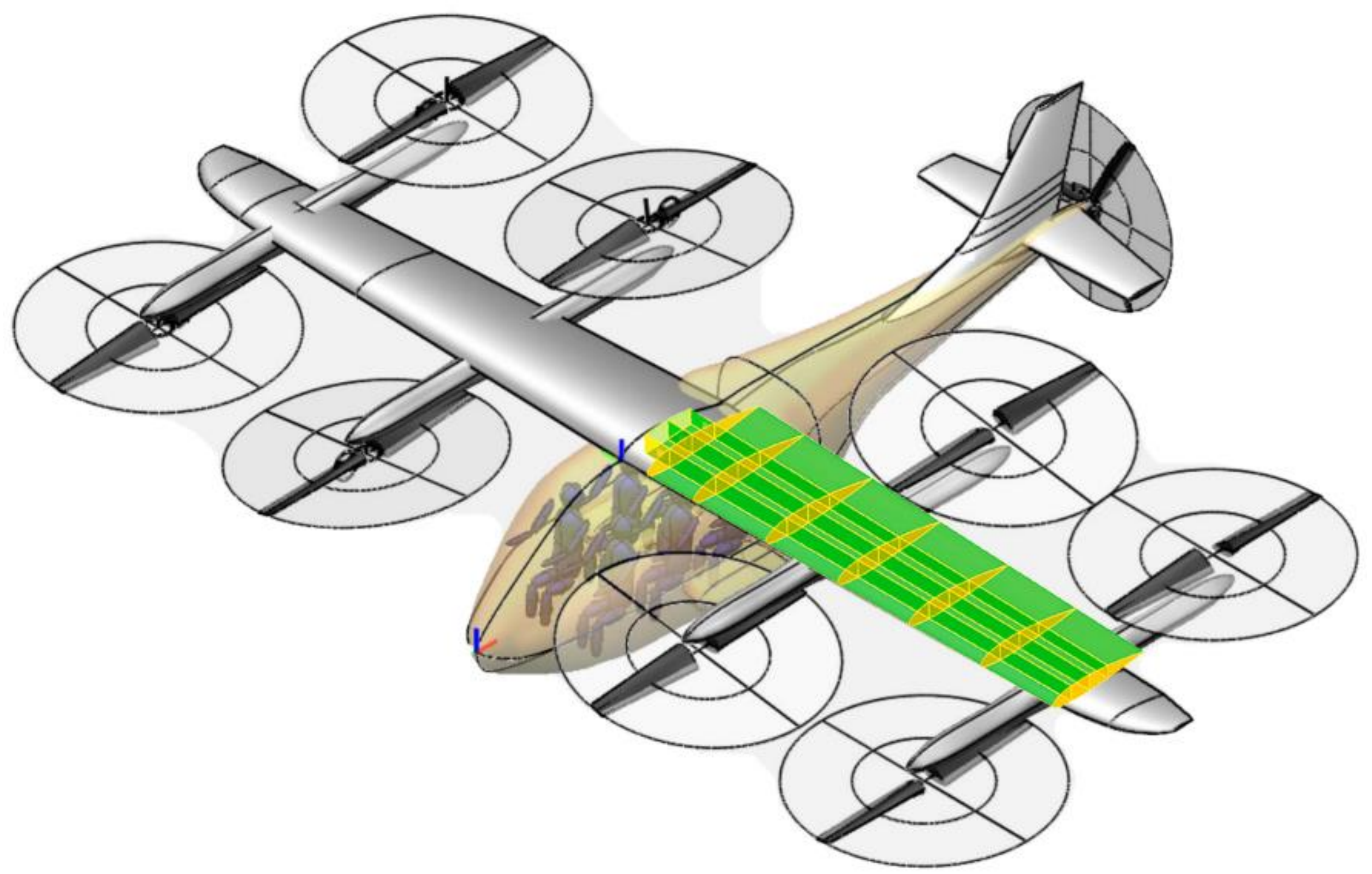
- Calculate section-level properties (EI, GJ, centroid locations, etc.)
- Size length-wise wing stations to optimally meet stiffness targets or centroid locations

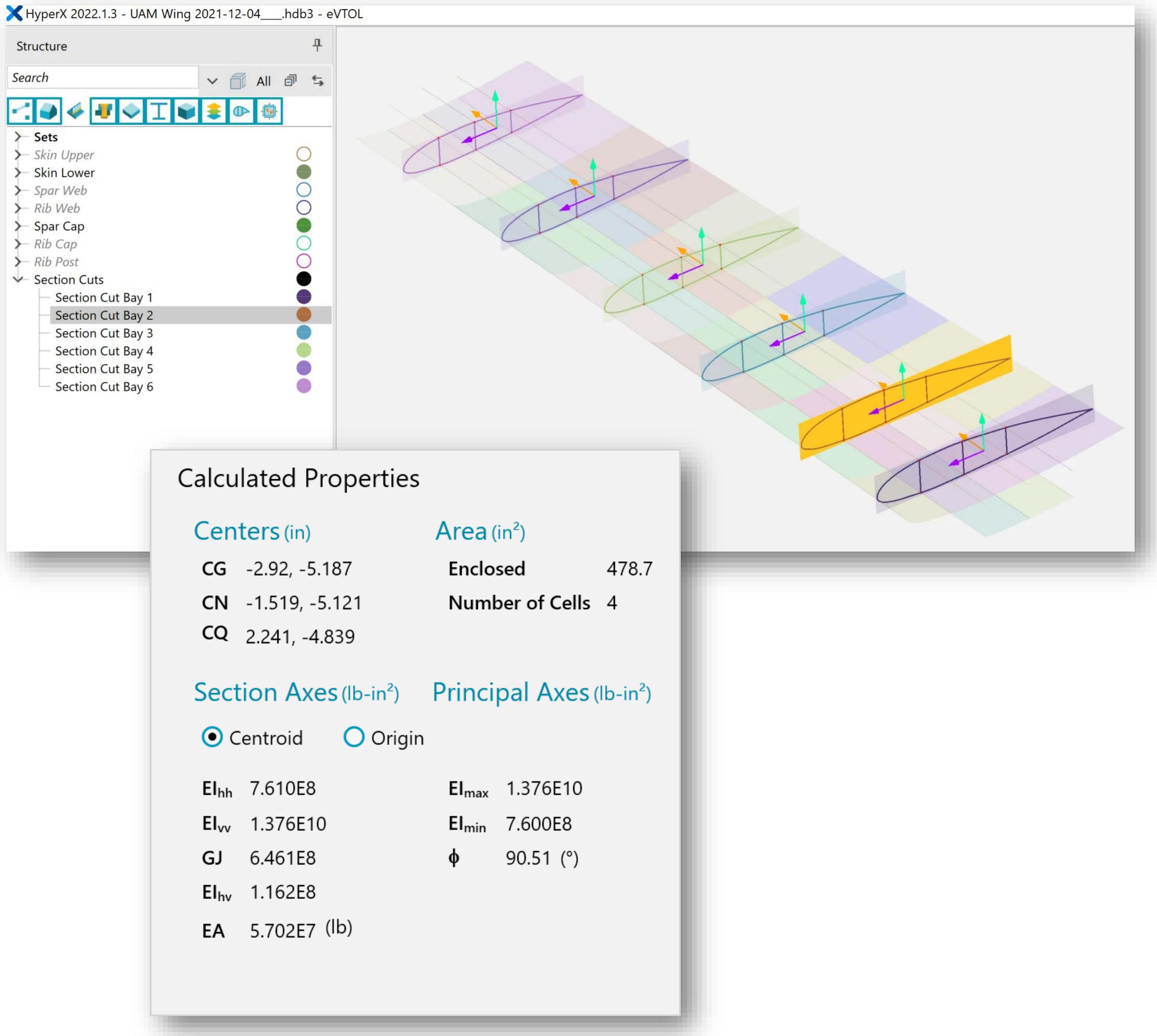
Using Section Loads

- Use Section FBD Loads calculated at incremental intervals along the length of a wing to generate shear/moment diagrams for each load case
- Automatically apply the section loads to a Non-FEA beam for section-based sizing and analysis

Real-World Examples

- Spar analysis tool using section cut FBD loads
- Use target shear and moments from section cut tool to derive load cell forces for fatigue test





Day 1: Enterprise Use Case for when your Engineering Department Adopts

James Ainsworth – Collier Aerospace
Managing Director of Engineering

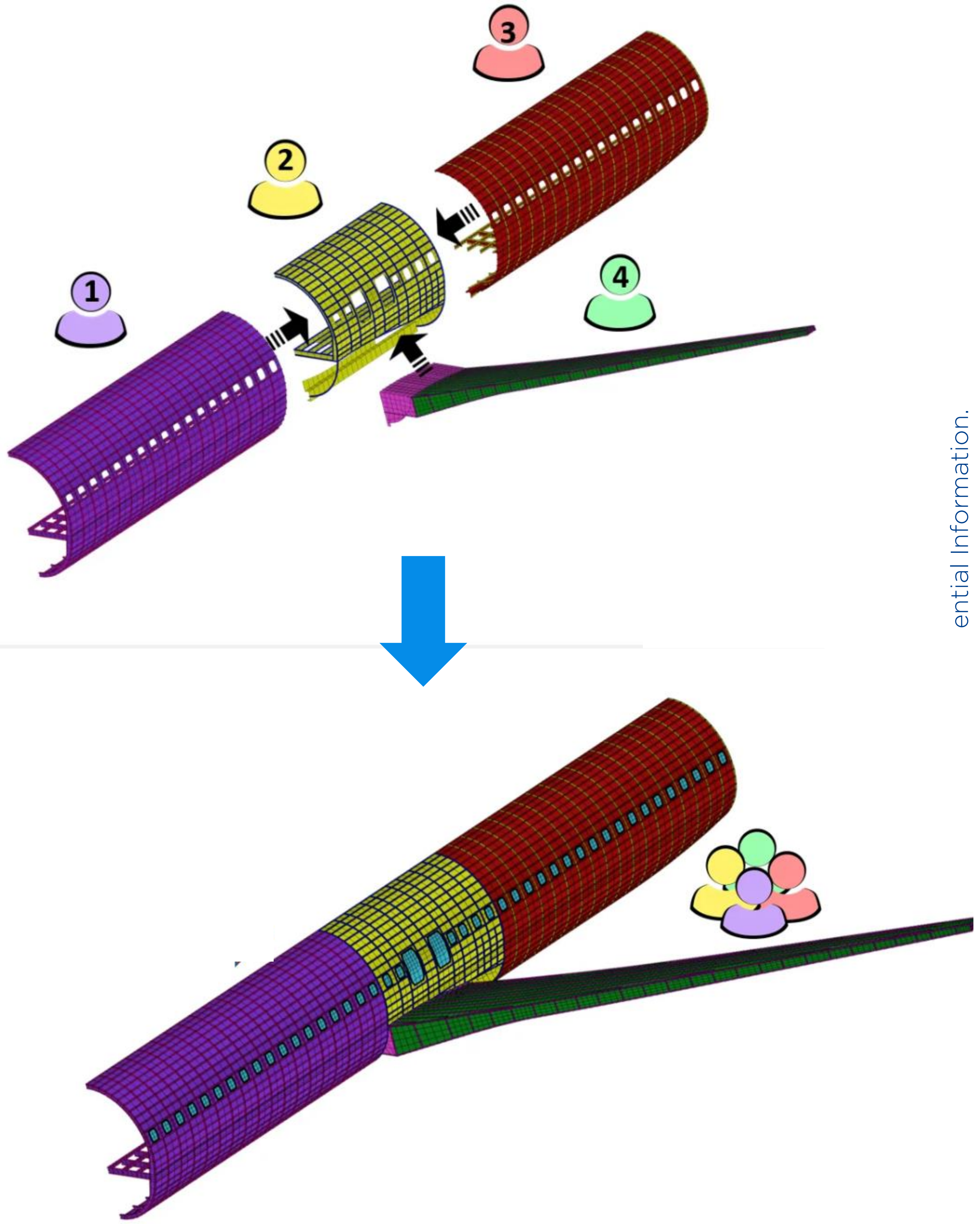
James can you speak on behalf one of our customers that use the dashboard. VG? Others?

The Enterprise Workflow

- Starts with a company database – with specifically defined defaults, materials, and analysis methods – and splits by aircraft section into individual engineering group databases for sizing, that get rolled up back to the group database.
- Starting with a HyperX Company Database template a Project database is made. The project database inherits the company materials, fasteners, laminate families, selected analysis methods, and company analysis plugins.
- From the Project database, the Project Group Lead imports the GFEM and specifies FEA static and fatigue loads and load factors. Within this database, the Enterprise tool is then used to separate it into individual engineer databases.

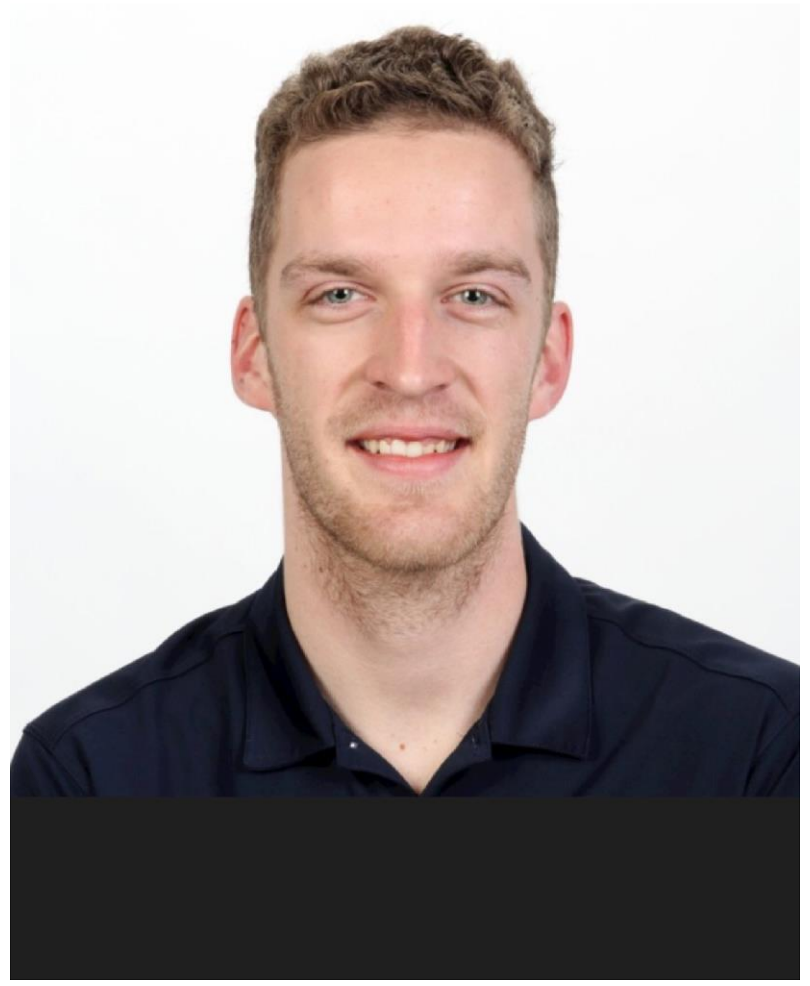
HyperX Enterprise utility

- Options to split the GFEM into individual databases
- Specify data permissions
- Place certain locks on data
- Authorize engineers to edit with changed-data tracking
- Identify data which has been potentially improperly modified



Automatically separate-out individual part databases from a single internal loads GFEM. Size all parts independently, maintaining consistent assumptions, then recombine into one full-structure database.

Day 1 – Designing High Performance Composite Bike Frames with HyperX



Ryan McLoughlin

Trek Bicycle Corporation

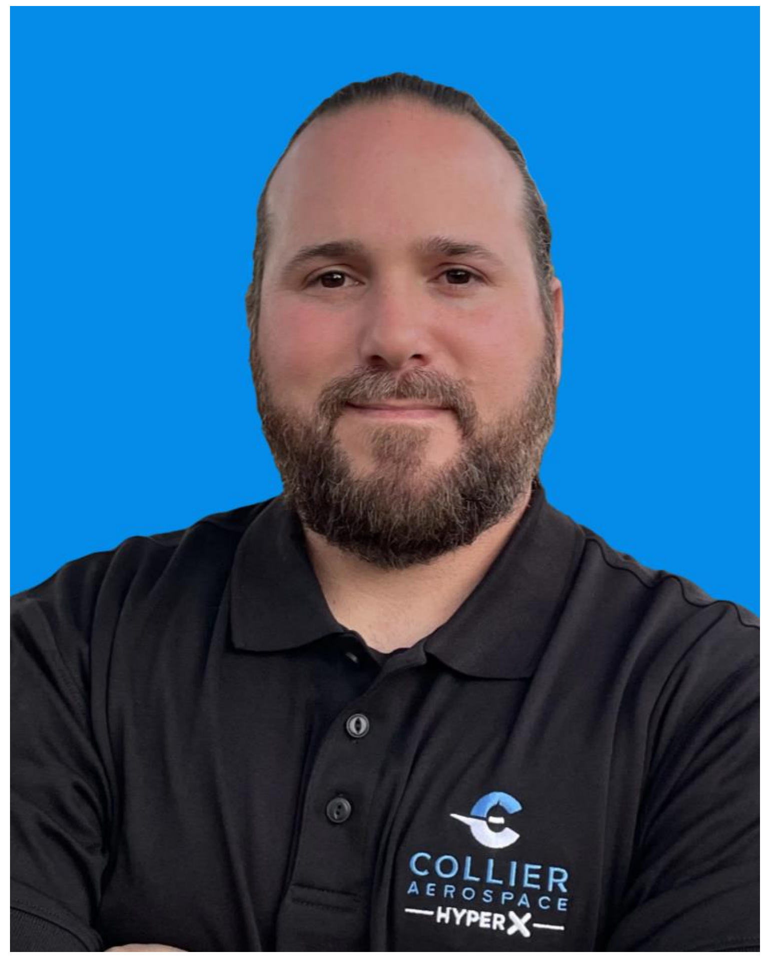
Good weight savings and great reduction in layup development time

- Ply and zone based laminate optimization workflow for production parts
- Multi stiffness and strength composite optimization
- Ply boundary generation and communication to CATIA
- **Projects:**
    - One production part (mountain bike handlebar)
    - Two halo projects (race handlebar and frame front lug)
    - Extending into full frame with VERY complicated geometry (Isoflow tube junction of **Madone**)
- **Future:**
    - Incorporate plybook feedback loop from vendor (Catia ply changes back to analysis/HyperX: using the XML workflow)
    - Incorporate draping (CAD curves for true fiber direction TFD)

The Trek Madone is the ultimate race bike, expertly crafted with unprecedented road bike aerodynamics, exceptional ride quality, and an **ultra-lightweight composite design.**

Think > $10,000 performance!

Day 1 – UAM eVTOLs from Conceptual to Preliminary to Detail Design with Associated FEM Modeling

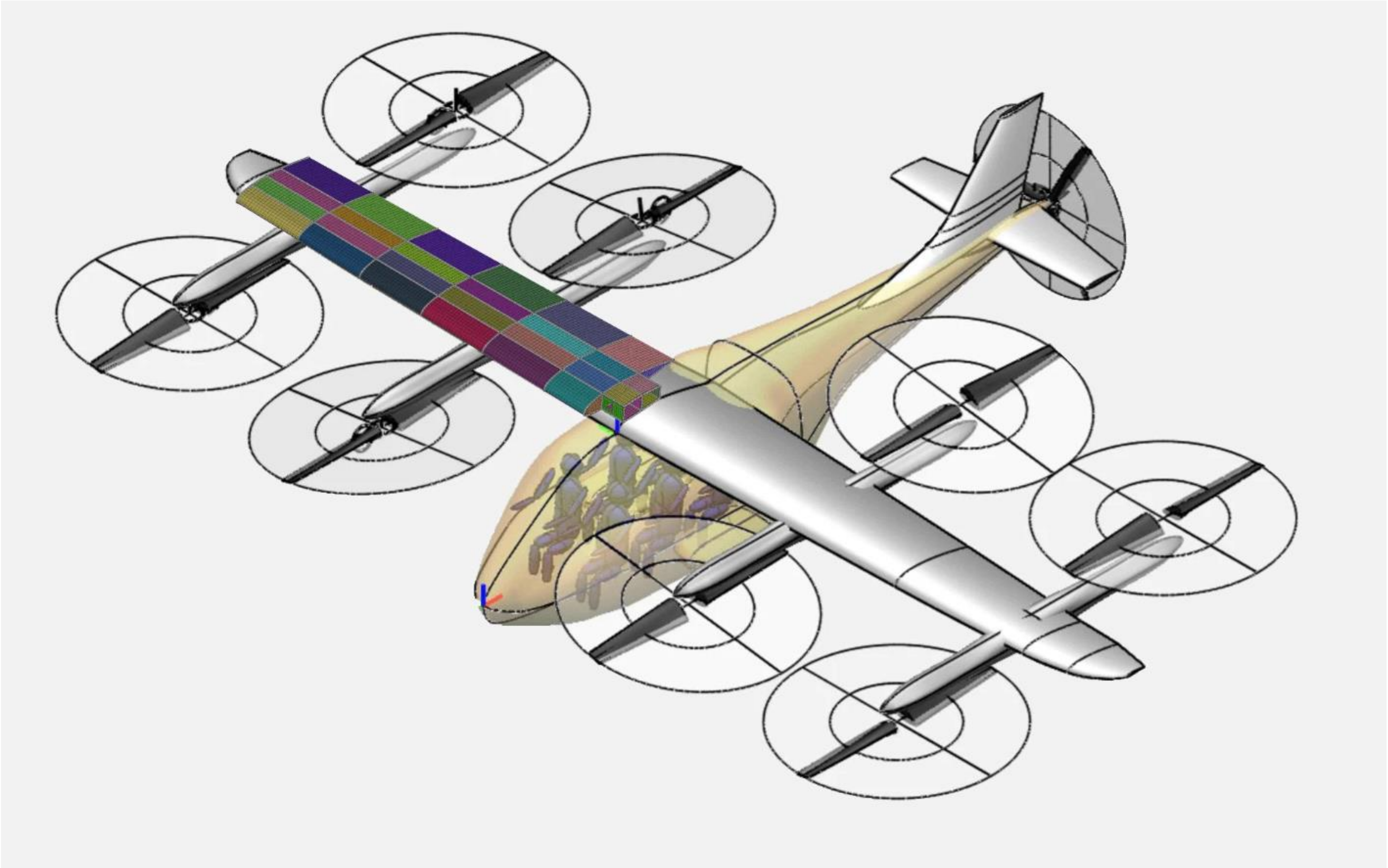


Mischa Pollack – Collier Aerospace
Director of Innovation & Senior Aerospace Engineer

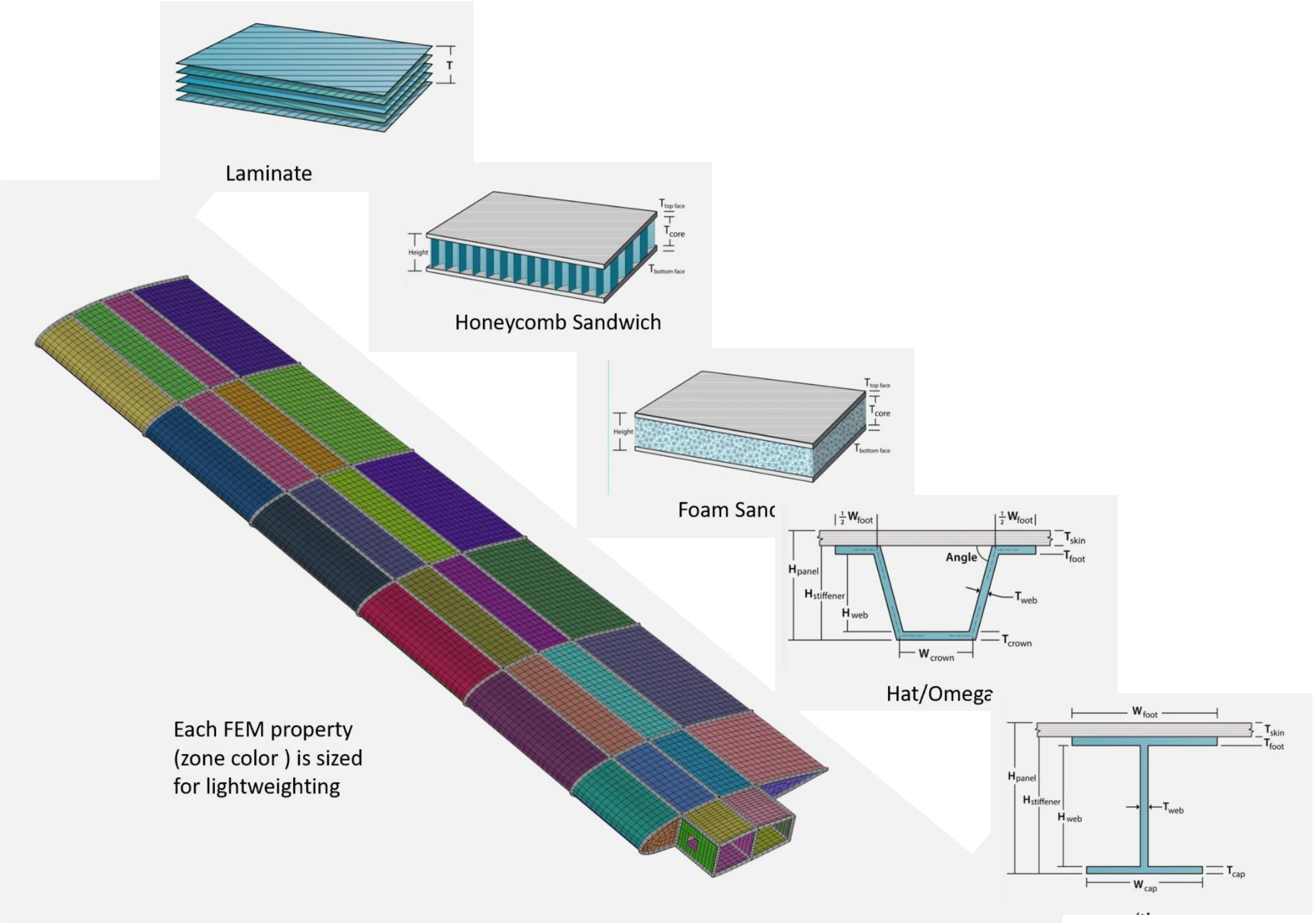
In 2011 I helped initiate the UAM market while working at Zee.Aero (now Wisk) and from 2019 to 2021 I was the Vehicle Structural Design Lead for Uber Elevate – supporting eVTOL projects with Joby, Hyundai (now Supernal), Bell, and others.

These are exciting times as hundreds of startup companies are designing vehicles to be the next Ford or Chevy.

A tool like HyperX is needed to be the one of the first startups to get a design flying and certified with its comprehensive suite of analyses methods. But before getting there the design has to be right for weight and right for high volume producibility. Meaning your engineering team needs to explore the design space completely and rapidly to find the right materials, and the right panel and joint structural architecture. HyperX is being used by other companies to achieve this and to go from Conceptual to Preliminary to Detail Design with Associated FEM Modeling.

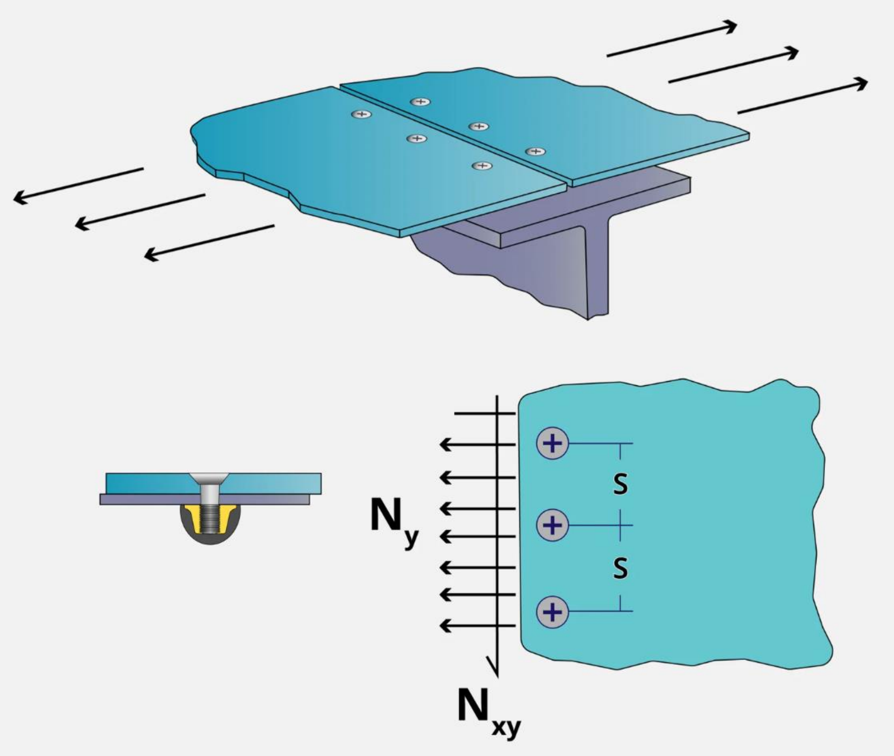


UAM wing.

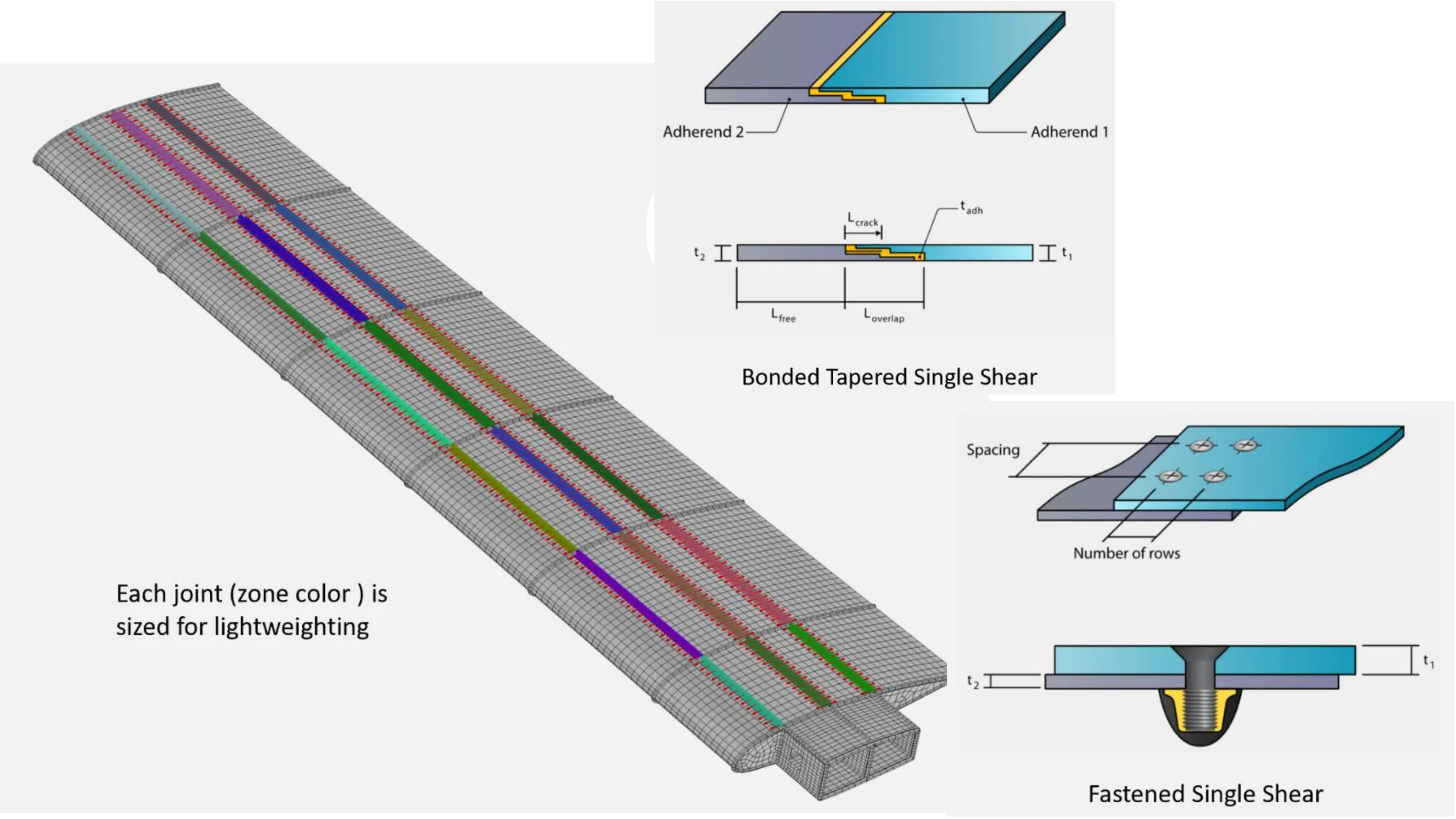


Different panel concepts evaluated for wing skin.

Discontinuous Skin

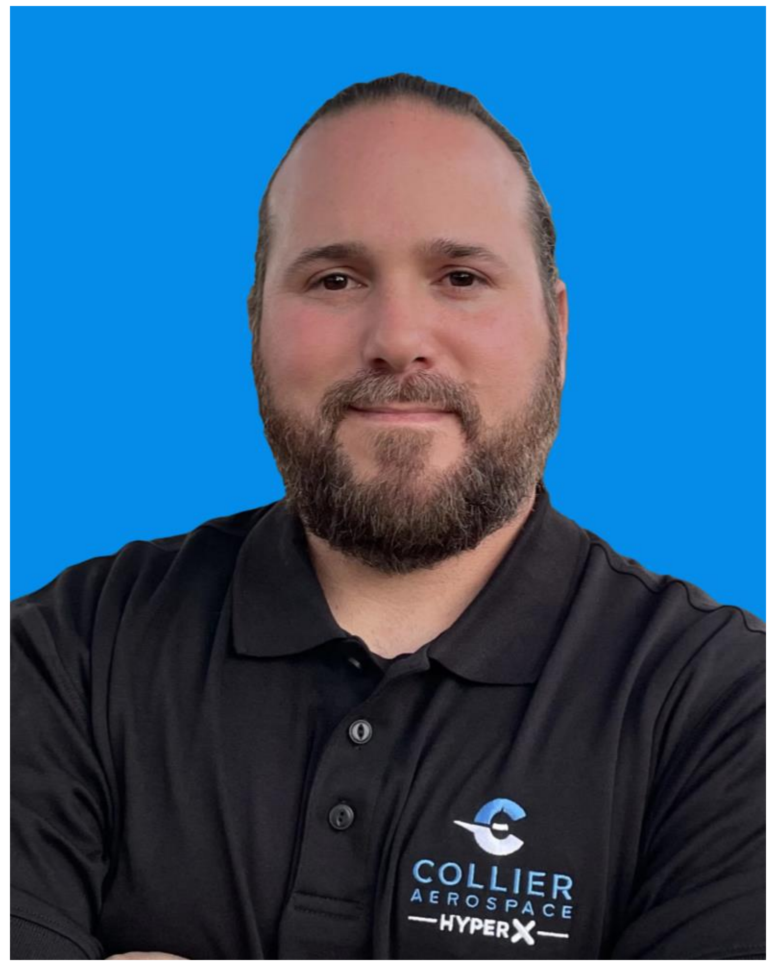


$$f_{bearing} = \frac{1}{Dt}\sqrt{(N_{xy}S)^2 + (N_yS)^2} \qquad f_{bypass} = \frac{1}{t}N_x$$



Different fastened, riveted, and bonded joint concepts evaluated for spar to wing skin.

Day 1 – The SP80 World Record Composite Sailboat



Mischa Pollack – Collier Aerospace
Director of Innovation & Senior Aerospace Engineer

HyperX was used to:

- Perform trade studies using numerous sandwich core materials
- Optimize the all-composite structure for minimum weight
- Produce/Export an “optimized for producibility” fabrication ply sequence using unique thin-ply carbon fiber tape manufacturing requirements

Challenges

- Determine inadequate structural design concepts, guide the necessary changes, and quickly size/optimize the newly generated structures
- Studies were performed in parallel to parts being fabricated
- 3DX re-meshing, property renaming (re-import issues), and unit inconsistencies

Pull content from our website page

Day 2 – Two Decades of Aerospace Conceptual Vehicle Analysis and Design with HyperSizer and HyperX

Lloyd Eldred

NASA Langley Research Center

Vehicle Analysis Branch
Structures Team Lead

Multidisciplinary preliminary analysis of aerospace vehicles at NASA Langley's Vehicle Analysis Branch

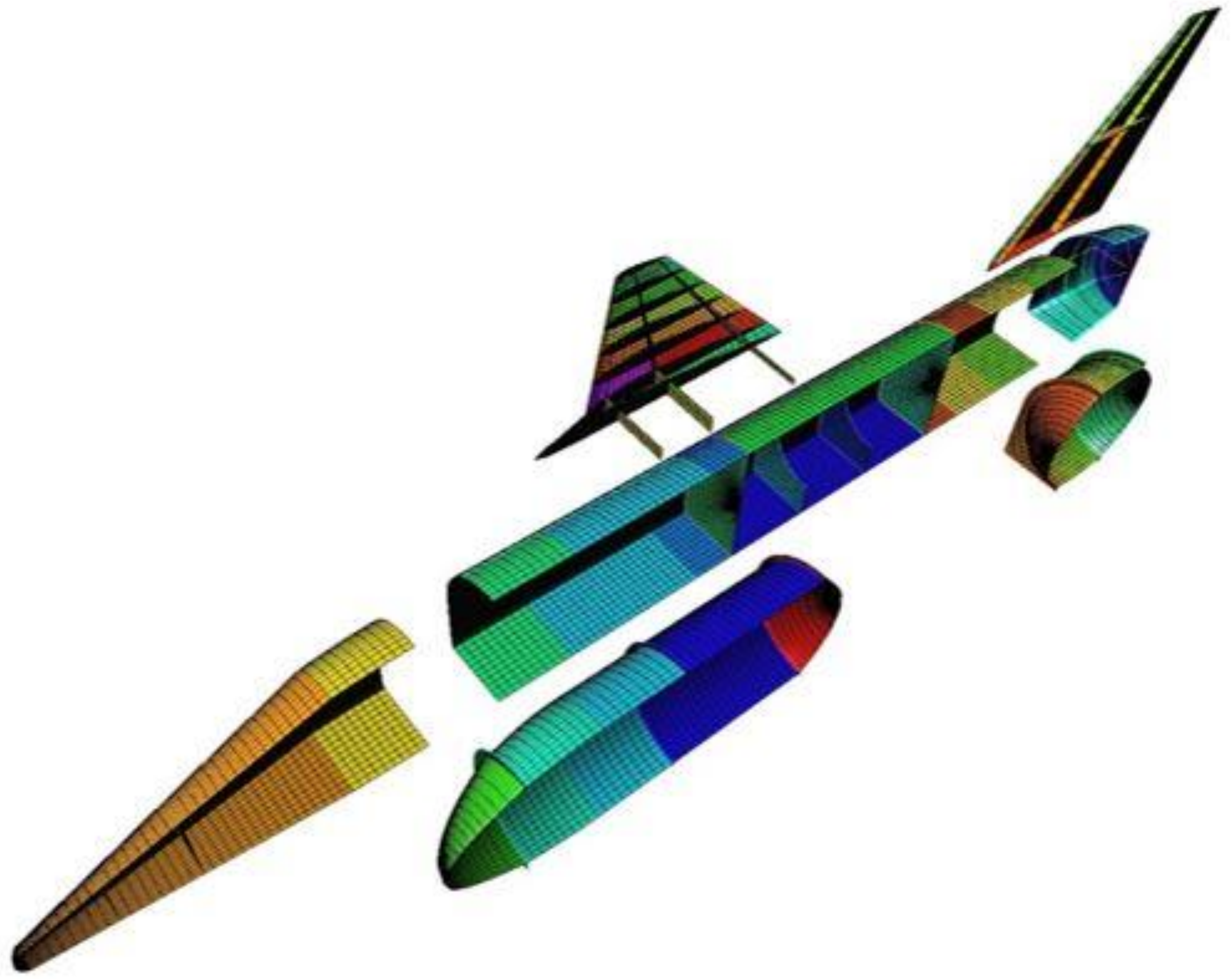
- Create meshes and load sets
- Solve in NASTRAN
- Size in HyperSizer
- Perform trades to reduce mass

Twenty+ years of design

- Wingbox calibration
- Next Generation Launch Technology wing optimization
- Lunar Lander concepts
- Two and single stage to orbit hypersonic concepts
- Launch vehicle fairings
- Low boom supersonic aircraft

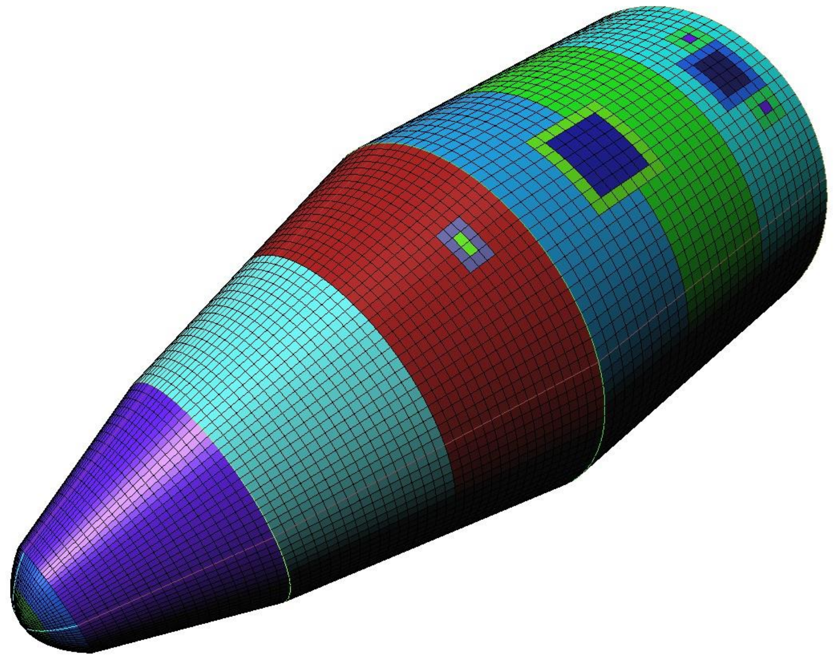
Automating HyperSizer

- HSLoad and HXLoad API driving codes
- Loft meshing for HyperSizer models
- Batch integration for rapid design space exploration and trade studies



TSTO Hypersonic orbiter concept

NASA Langley imagines the impossible. Hundreds of conceptual vehicle designs are explored and evaluated in great detail.

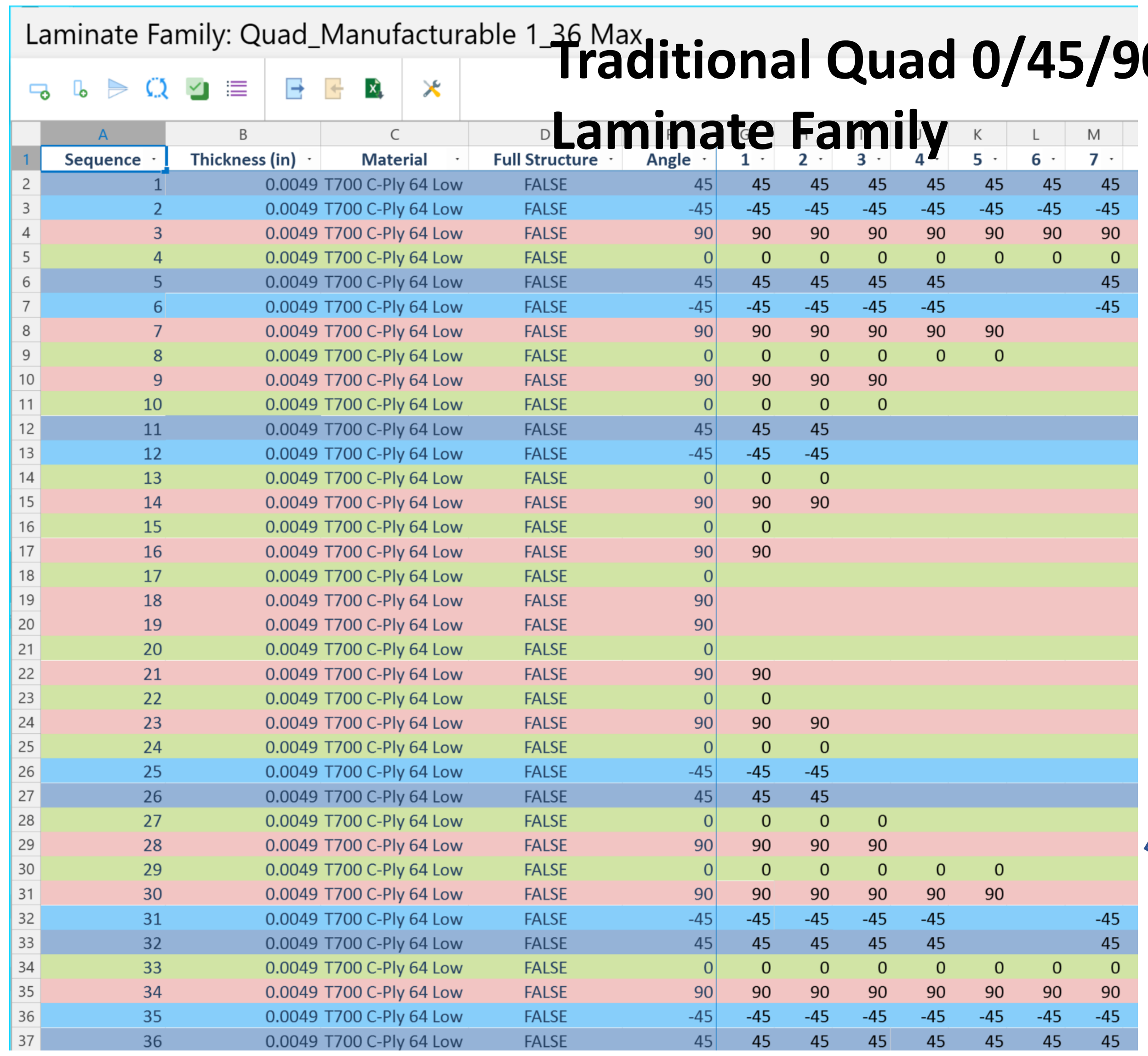


Ares V Payload Fairing concept

Day 2 – Design Optimization to Fabrication with HyperX Laminate Families for Traditional Quad 0/45/90 and Double-Double [± Φ / ± Ψ] Layups

Brett Bednarcyk

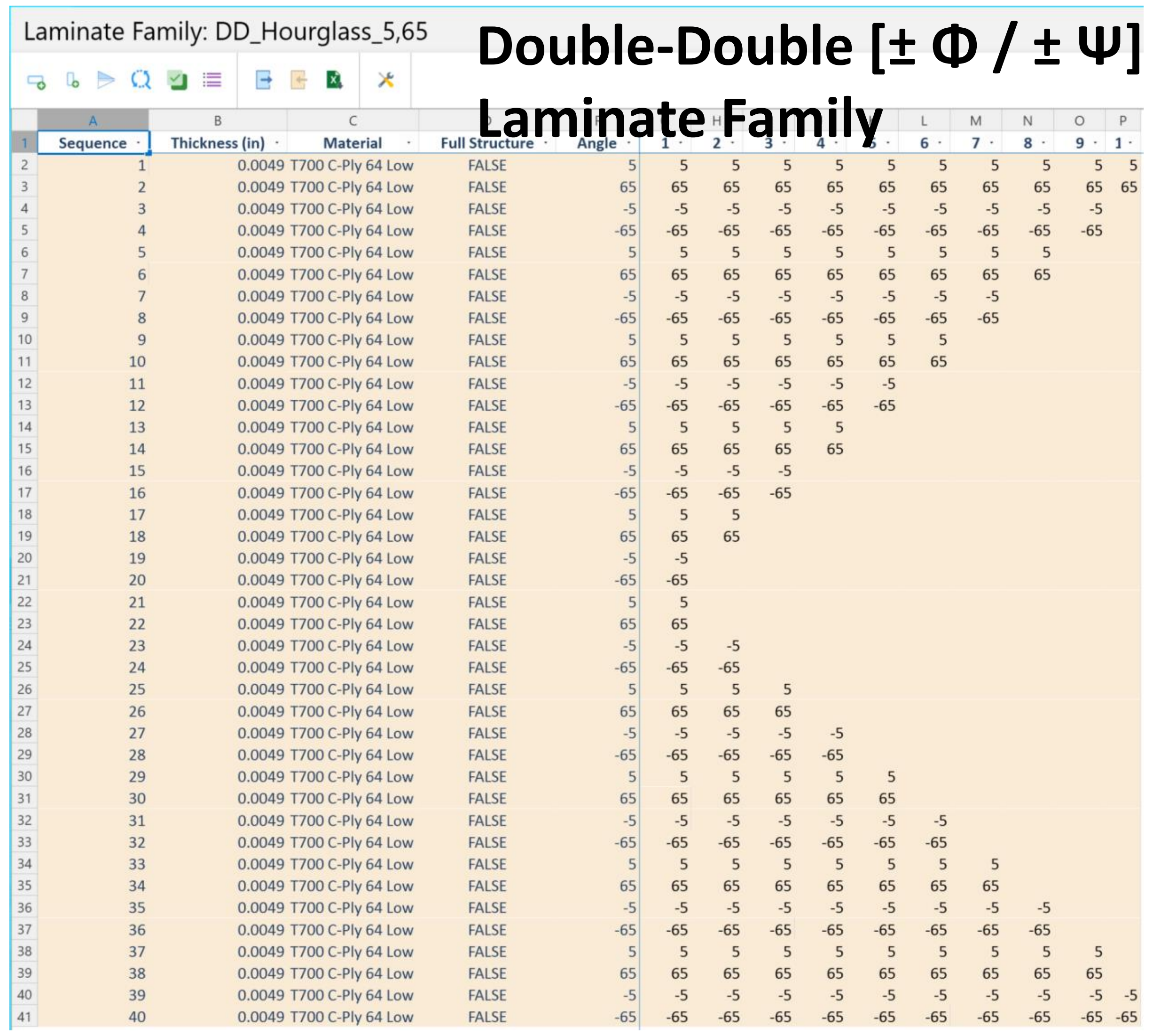
NASA Glenn Research Center



Traditional Quad 0/45/90 Laminate Family

Laminate Family: Quad_Manufacturable 1_36 Max

	Sequence	Thickness (in)	Material	Full Structure	Angle	1	2	3	4	5	6	7
2	1	0.0049	T700 C-Ply 64 Low	FALSE	45	45	45	45	45	45	45	45
3	2	0.0049	T700 C-Ply 64 Low	FALSE	-45	-45	-45	-45	-45	-45	-45	-45
4	3	0.0049	T700 C-Ply 64 Low	FALSE	90	90	90	90	90	90	90	90
5	4	0.0049	T700 C-Ply 64 Low	FALSE	0	0	0	0	0	0	0	0
6	5	0.0049	T700 C-Ply 64 Low	FALSE	45	45	45	45	45			45
7	6	0.0049	T700 C-Ply 64 Low	FALSE	-45	-45	-45	-45	-45			-45
8	7	0.0049	T700 C-Ply 64 Low	FALSE	90	90	90	90	90	90		
9	8	0.0049	T700 C-Ply 64 Low	FALSE	0	0	0	0	0	0		
10	9	0.0049	T700 C-Ply 64 Low	FALSE	90	90	90	90				
11	10	0.0049	T700 C-Ply 64 Low	FALSE	0	0	0	0				
12	11	0.0049	T700 C-Ply 64 Low	FALSE	45	45	45					
13	12	0.0049	T700 C-Ply 64 Low	FALSE	-45	-45	-45					
14	13	0.0049	T700 C-Ply 64 Low	FALSE	0	0	0					
15	14	0.0049	T700 C-Ply 64 Low	FALSE	90	90	90					
16	15	0.0049	T700 C-Ply 64 Low	FALSE	0	0						
17	16	0.0049	T700 C-Ply 64 Low	FALSE	90	90						
18	17	0.0049	T700 C-Ply 64 Low	FALSE	0							
19	18	0.0049	T700 C-Ply 64 Low	FALSE	90							
20	19	0.0049	T700 C-Ply 64 Low	FALSE	90							
21	20	0.0049	T700 C-Ply 64 Low	FALSE	0							
22	21	0.0049	T700 C-Ply 64 Low	FALSE	90	90						
23	22	0.0049	T700 C-Ply 64 Low	FALSE	0	0						
24	23	0.0049	T700 C-Ply 64 Low	FALSE	90	90	90					
25	24	0.0049	T700 C-Ply 64 Low	FALSE	0	0	0					
26	25	0.0049	T700 C-Ply 64 Low	FALSE	-45	-45	-45					
27	26	0.0049	T700 C-Ply 64 Low	FALSE	45	45	45					
28	27	0.0049	T700 C-Ply 64 Low	FALSE	0	0	0	0				
29	28	0.0049	T700 C-Ply 64 Low	FALSE	90	90	90	90				
30	29	0.0049	T700 C-Ply 64 Low	FALSE	0	0	0	0	0	0		
31	30	0.0049	T700 C-Ply 64 Low	FALSE	90	90	90	90	90	90		
32	31	0.0049	T700 C-Ply 64 Low	FALSE	-45	-45	-45	-45	-45			-45
33	32	0.0049	T700 C-Ply 64 Low	FALSE	45	45	45	45	45			45
34	33	0.0049	T700 C-Ply 64 Low	FALSE	0	0	0	0	0	0	0	0
35	34	0.0049	T700 C-Ply 64 Low	FALSE	90	90	90	90	90	90	90	90
36	35	0.0049	T700 C-Ply 64 Low	FALSE	-45	-45	-45	-45	-45	-45	-45	-45
37	36	0.0049	T700 C-Ply 64 Low	FALSE	45	45	45	45	45	45	45	45



Double-Double [± Φ / ± Ψ] Laminate Family

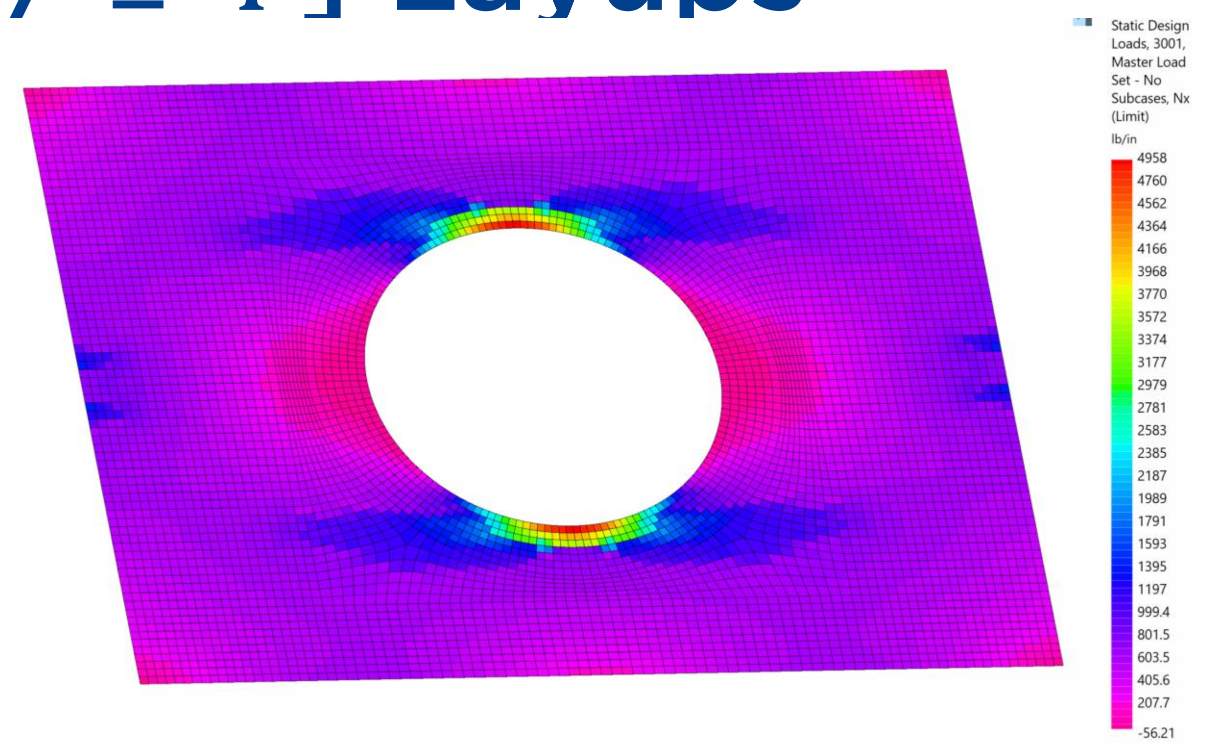
Laminate Family: DD_Hourglass_5,65

	Sequence	Thickness (in)	Material	Full Structure	Angle	1	2	3	4	5	6	7	8	9	1
2	1	0.0049	T700 C-Ply 64 Low	FALSE	5	5	5	5	5	5	5	5	5	5	5
3	2	0.0049	T700 C-Ply 64 Low	FALSE	65	65	65	65	65	65	65	65	65	65	65
4	3	0.0049	T700 C-Ply 64 Low	FALSE	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	
5	4	0.0049	T700 C-Ply 64 Low	FALSE	-65	-65	-65	-65	-65	-65	-65	-65	-65	-65	
6	5	0.0049	T700 C-Ply 64 Low	FALSE	5	5	5	5	5	5	5	5	5		
7	6	0.0049	T700 C-Ply 64 Low	FALSE	65	65	65	65	65	65	65	65	65		
8	7	0.0049	T700 C-Ply 64 Low	FALSE	-5	-5	-5	-5	-5	-5	-5	-5			
9	8	0.0049	T700 C-Ply 64 Low	FALSE	-65	-65	-65	-65	-65	-65	-65	-65			
10	9	0.0049	T700 C-Ply 64 Low	FALSE	5	5	5	5	5	5	5				
11	10	0.0049	T700 C-Ply 64 Low	FALSE	65	65	65	65	65	65	65				
12	11	0.0049	T700 C-Ply 64 Low	FALSE	-5	-5	-5	-5	-5	-5					
13	12	0.0049	T700 C-Ply 64 Low	FALSE	-65	-65	-65	-65	-65	-65					
14	13	0.0049	T700 C-Ply 64 Low	FALSE	5	5	5	5	5						
15	14	0.0049	T700 C-Ply 64 Low	FALSE	65	65	65	65	65						
16	15	0.0049	T700 C-Ply 64 Low	FALSE	-5	-5	-5	-5							
17	16	0.0049	T700 C-Ply 64 Low	FALSE	-65	-65	-65	-65							
18	17	0.0049	T700 C-Ply 64 Low	FALSE	5	5	5								
19	18	0.0049	T700 C-Ply 64 Low	FALSE	65	65	65								
20	19	0.0049	T700 C-Ply 64 Low	FALSE	-5	-5									
21	20	0.0049	T700 C-Ply 64 Low	FALSE	-65	-65									
22	21	0.0049	T700 C-Ply 64 Low	FALSE	5	5									
23	22	0.0049	T700 C-Ply 64 Low	FALSE	65	65									
24	23	0.0049	T700 C-Ply 64 Low	FALSE	-5	-5	-5								
25	24	0.0049	T700 C-Ply 64 Low	FALSE	-65	-65	-65								
26	25	0.0049	T700 C-Ply 64 Low	FALSE	5	5	5	5							
27	26	0.0049	T700 C-Ply 64 Low	FALSE	65	65	65	65							
28	27	0.0049	T700 C-Ply 64 Low	FALSE	-5	-5	-5	-5	-5						
29	28	0.0049	T700 C-Ply 64 Low	FALSE	-65	-65	-65	-65	-65						
30	29	0.0049	T700 C-Ply 64 Low	FALSE	5	5	5	5	5	5					
31	30	0.0049	T700 C-Ply 64 Low	FALSE	65	65	65	65	65	65					
32	31	0.0049	T700 C-Ply 64 Low	FALSE	-5	-5	-5	-5	-5	-5	-5				
33	32	0.0049	T700 C-Ply 64 Low	FALSE	-65	-65	-65	-65	-65	-65	-65				
34	33	0.0049	T700 C-Ply 64 Low	FALSE	5	5	5	5	5	5	5	5			
35	34	0.0049	T700 C-Ply 64 Low	FALSE	65	65	65	65	65	65	65	65			
36	35	0.0049	T700 C-Ply 64 Low	FALSE	-5	-5	-5	-5	-5	-5	-5	-5	-5		
37	36	0.0049	T700 C-Ply 64 Low	FALSE	-65	-65	-65	-65	-65	-65	-65	-65	-65		
38	37	0.0049	T700 C-Ply 64 Low	FALSE	5	5	5	5	5	5	5	5	5	5	
39	38	0.0049	T700 C-Ply 64 Low	FALSE	65	65	65	65	65	65	65	65	65	65	
40	39	0.0049	T700 C-Ply 64 Low	FALSE	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5
41	40	0.0049	T700 C-Ply 64 Low	FALSE	-65	-65	-65	-65	-65	-65	-65	-65	-65	-65	-65

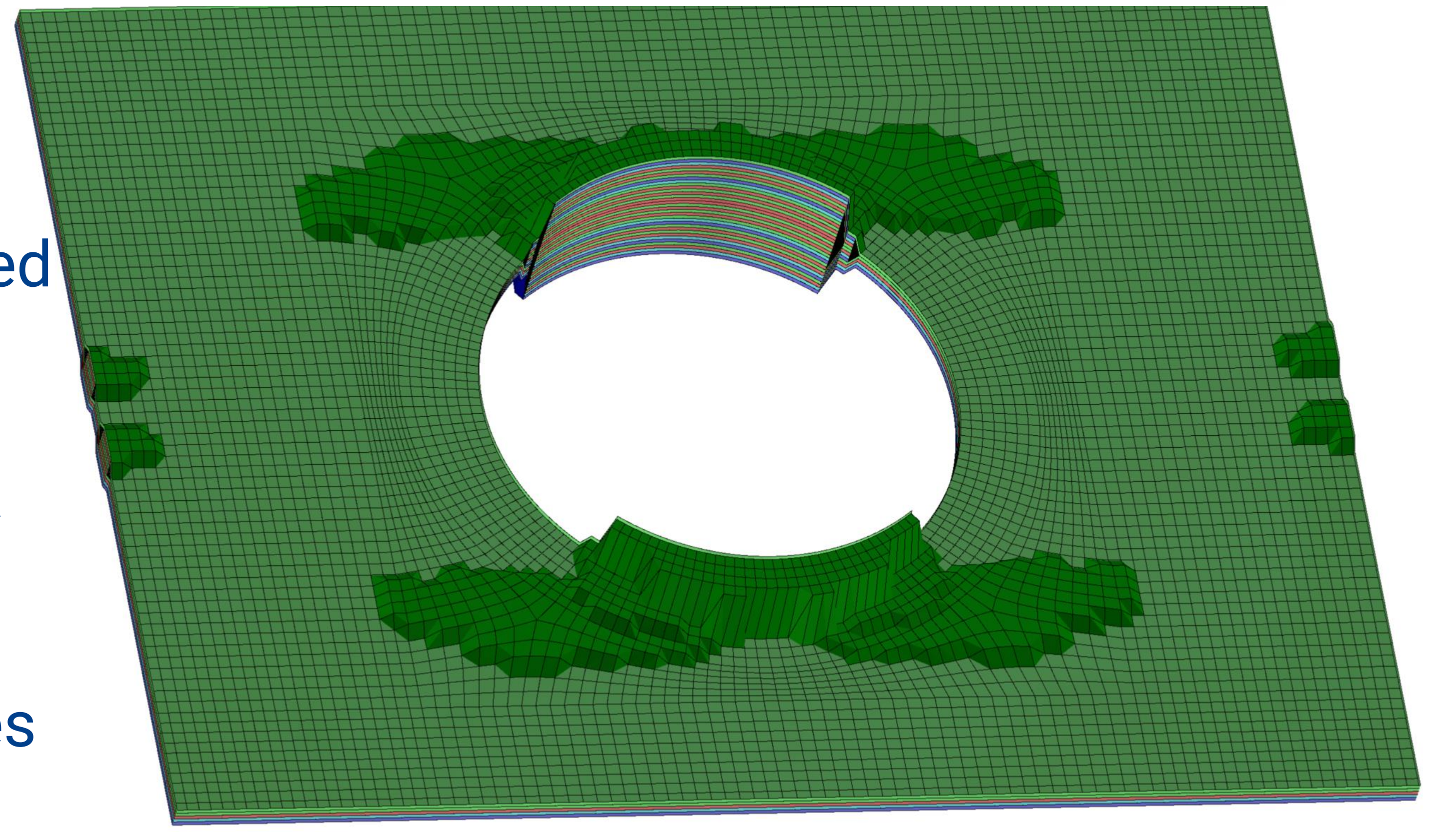
Summary Weight and Producibility Comparisons

Structure	Quad Laminate (weight)	Double Double Laminate (weight)	Quad Laminate (producibility Score)	Double Double Laminate (producibility Score)
737 like wing skin				
eVTOL UAM wing skin				
Plate Hole				

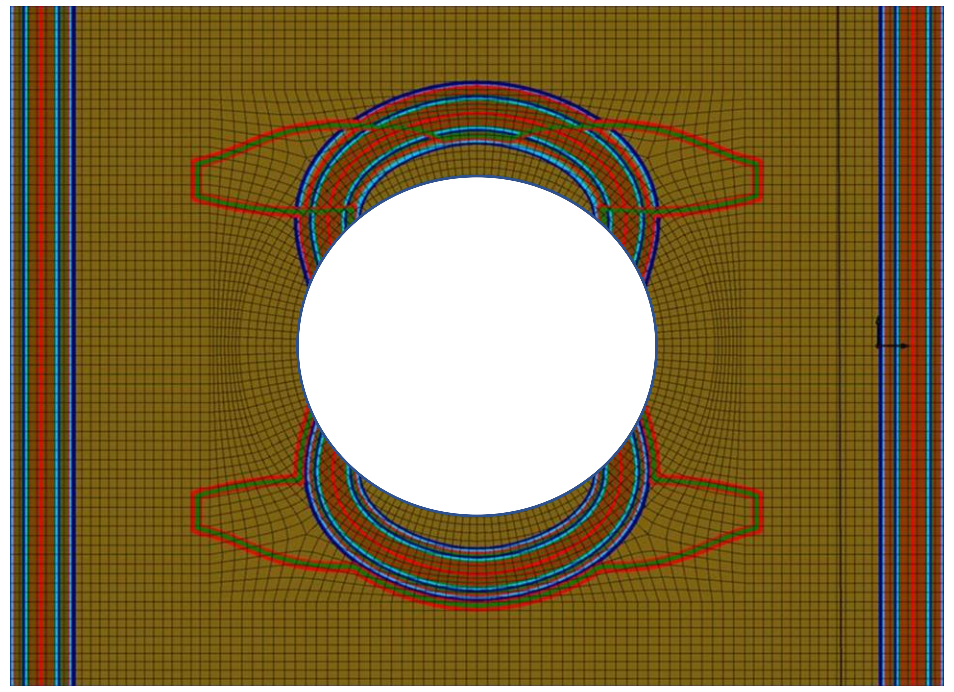
FEA Loads



HyperX optimized layup stacking, ply shapes and boundaries on a faceted FEM mesh with both laminate families



Actual ply shapes as defined with ply drop ramp limits on CAD surface as curves for part fabrication



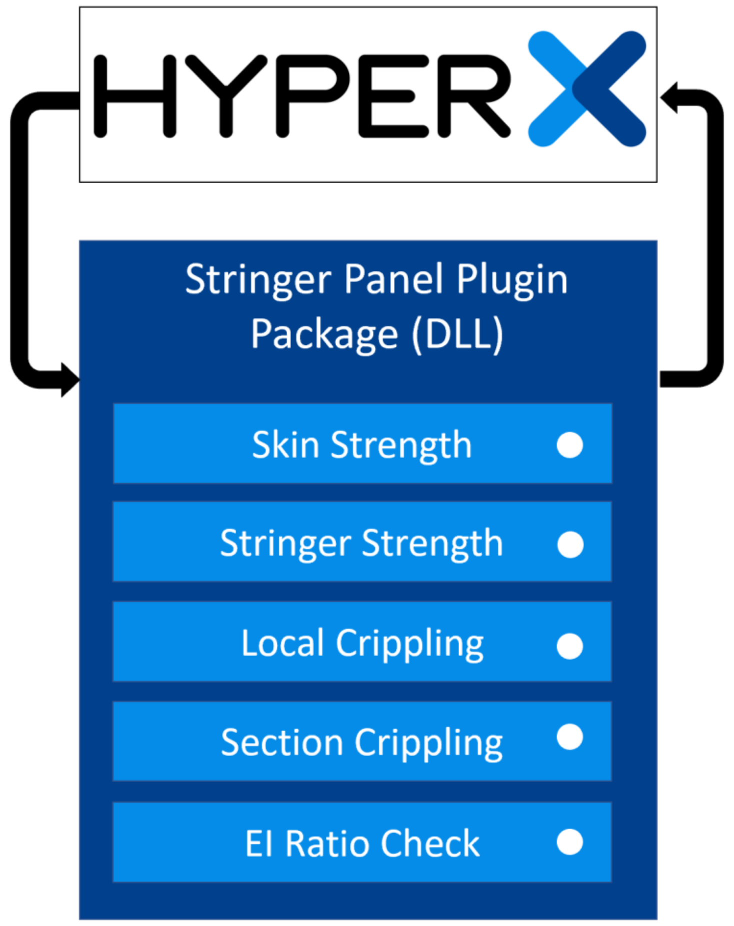
Day 2: Customer Customization: Bottom-Up with Plugins

Technical Interchange Discussions

Noah Prezant – Collier Aerospace
Lead Plugin Developer &
Aerospace Structural Engineer

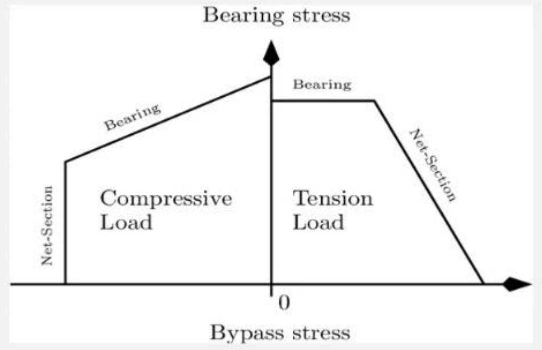
Plugins

- **Are <u>internal</u> to sizing loop**; API scripts are external
- Compute Margins of Safety based on your analysis method
- Can wrap existing stress libraries, allowing re-use of trusted and tested customer legacy code

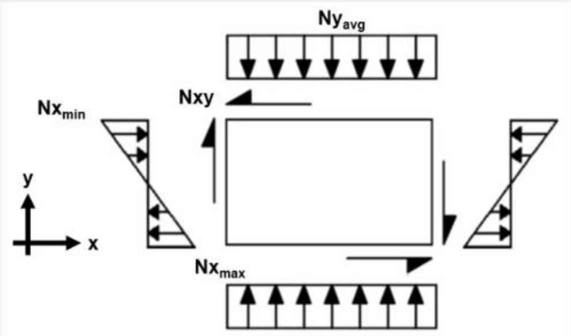


Customer plugins are treated just like Native HyperX analysis methods

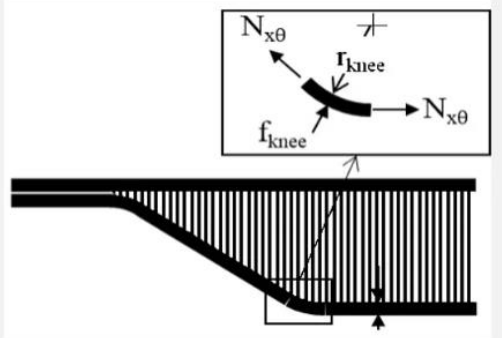
- Drive sizing
- Compute final margins
- Generate automated stress reports
- Displayed in the watch window
- Plotted directly on the model



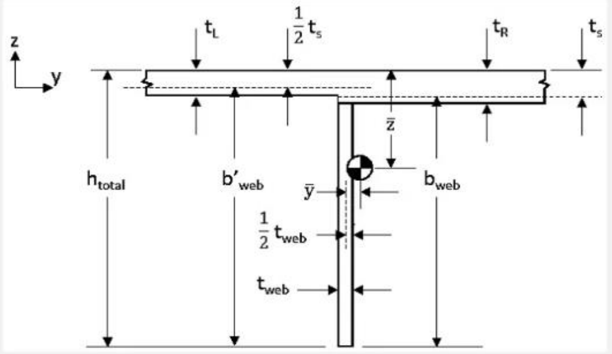
Bearing Bypass



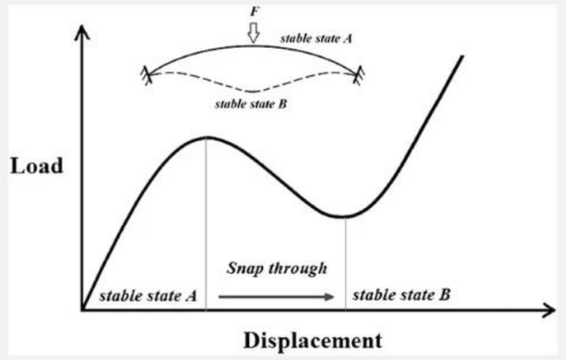
In-plane Bending Buckling



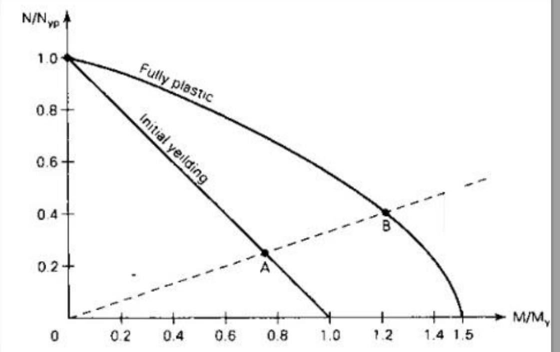
Core Ramp



Grid Stiffened



Snap-Though



Plastic Bending

Example non-proprietary plugins available with a HyperX license.

Day 2: Customer Customization: Top-Down with the API

Technical Interchange Discussions

Kelly Ann Smith– Collier Aerospace
Aerospace Structural Engineer

API

- **Plugins are internal to sizing loop; API Scripts are <u>external</u>**
- **API scripts enable user to replicate interface interactions**
  - model setup
  - custom reporting
  - trade studies
  - Integration with a larger customer tool set
- **HyperSizer API was built on COM**
  - Compatibility with VBA
- **HyperX API is built on .NET Framework**
  - Compatibility with common programming languages
  - But no direct VBA support

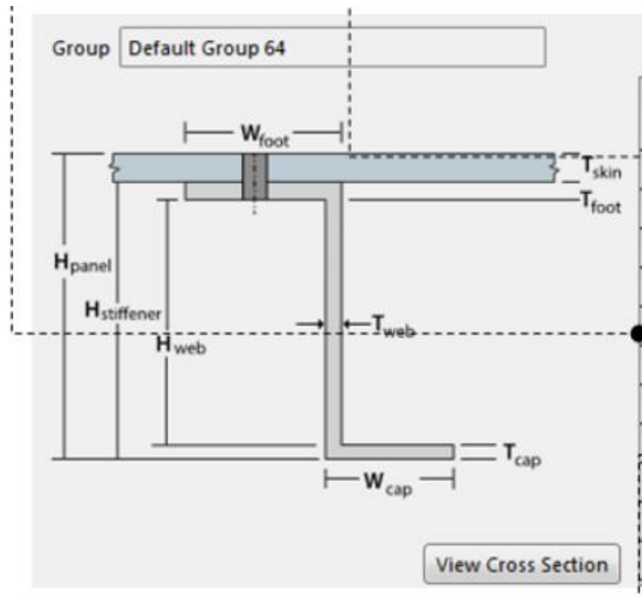
Example Customer Gulfstream

Brenden A. Autry
Verification and Refinement of an Aircraft Structural Design and Optimization Tool, ATLASS

Figure 11. Global Structural Finite Element Model

```python
def Run(database):
    # Select current active project
    project = database.ActiveProject
    print(f'Current active project: {project.Name}')

    # Size all the zones withihn the project
    project.SizeZones()
    print(f'Finished sizing all zones! Exiting script.')
```



Req. Designs 1 | # Candidates 28812 | All Designs

Dimension	Min	Max	Steps	Step Size	Link	Freeze	Result	Material
T_{skin} (in)	0.08	0.25	7	0.02833			0.13667	Metal: Al 7075-T6
T_{web} (in)	0.05	0.25	7	0.03333			0.083333	Metal: Al 7075-T6
T_{foot} (in)	0.077	0.22	7	0.0238			0.077	Metal: Al 7075-T6
T_{cap} (in)	0.05	0.22	7	0.02833			0.078333	Metal: Al 7075-T6
$H_{stiffener}$ (in)	2	3	3	0.5			2	
Spacing (in)	4	7	4	1	✓		4	
W_{foot} (in)	1	1	1	0			1	
W_{cap} (in)	0.75	0.75	1	0			0.75	
W_{open} (in)	(Dependent variable)						3	
H_{panel} (in)	(Dependent variable)						2.1367	
H_{web} (in)	(Dependent variable)						1.8447	

Manufacturable thickness increments vs # of candidates

Constant stringer spacing

Metal Zee Fastened Panels

HyperX Users Conference
Previous Slide Versions Follow – Ignore These

June 14-15, 2023