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
- **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 June 14, 2023 : HyperX for Production Structure!

- 8:00 Transportation vans pick up at Marriott City Center Newport News
- 8:20 Arrive at NASA Langley Badge and Pass Office, then vans drive you to NASA Langley Pearl Young Theatre for Coffee & Registration
- 9:00 → **Where we are now, and how we got here**

  Craig Collier (Collier Aerospace) In honor of Jeff Cerro, the author of EZDESIT, 1985-1990, the trailblazer of HyperX
- 9:35 → **HyperX's Role in Certifying Flight Hardware for Human-Rated Spaceflight**

  Keynote Speaker: Michael T. Kirsch (Deputy Director, NASA Engineering & Safety Center)
- 10:00 → **Session #1: Space Launch**

  Application: *Space Launch Vehicle HyperX & FEA Cloud Computing in (AWS) and Engineering Services*

  James Ainsworth and Brian Alonso (Collier Aerospace)

  10:30 Coffee Break & Conversations

  Development Roadmap: *High Performance Computing in the Cloud or on your Company's Linux Cluster with our Next-Generation Solver;* Stephen Jones (Collier Aerospace)
- 11:15 → **Session #2: Aircraft**

  Application part 1: *The NASA Advanced Composite Program (ACP) and the NASA High Speed Composite Manufacturing (HiCAM) Program for Commercial Airframes;* Rick Young (NASA Project Manager)

  Application part 2: *HyperX's Role in the NASA Advanced Composite Program (ACP) and the NASA High Speed Composite Manufacturing (HiCAM) Program for Commercial Airframes;* Craig Collier (Collier Aerospace)

  Development Roadmap: *Airframe Stiffened Panel Laminate Family Trade Studies Displayed in a Web Browser Dashboard and Related Digital Thread to CAD;* Craig Collier (Collier Aerospace)

Day 1 - Agenda - HyperX Users Conference

Wednesday June 14, 2023 : HyperX for Production Structure!

- 12:15 → Lunch at NASA
- 1:00 → **Session #3: Urban Air Mobility**

  Application: *UAM eVTOLs from Conceptual to Preliminary to Detail Design*

  Mischa Pollack (Collier Aerospace)

  Development Roadmap: *The Section Cut, Professional Stress Tool*

  Charli Cahill (Collier Aerospace)
- 2:15 → **Session #4: High Performance Composites**

  Application (a): *Designing High Performance Composite Bike Frames with HyperX*

  Ryan McLoughlin (Trek Bicycle Corporation)

  2:45 Break & Conversations

  Development Roadmap: *Design for Manufacturing and Digital Thread to CAD → Demos: 1)Ply Shapes and Boundaries 2) Stiffened Panel Profile Dimensions, 3) Metal Orthogrid Plate Thicknesses*

  August Noevere (Collier Aerospace)

  Application (b): *Designing the SP80 World Record Composite Sailboat*

  Mischa Pollack (Collier Aerospace)
- 4:45 Transportation vans from NASA to James River Country Club for Networking Event, Included Dinner, and Sunset on the Dock over the Historic James River
- 8:45 Transportation back to the Marriott Hotel

Day 2 - Agenda - HyperX Users Conference

Thursday June 15, 2023: Technical Interchange and Audience Participation

- 8:00 Transportation vans pick up at Marriott City Center Newport News
- 8:20 Arrive at NASA Langley Pearl Young Theatre for Coffee & Registration

Morning Session: Hear from HyperX Users

- 8:30 → **How Spirit AeroSystems uses HyperX,** Theresa Williams (Spirit AeroSystems)
- 9:00 → **Two Decades of Aerospace Conceptual Vehicle Analysis and Design with HyperSizer & HyperX,** Lloyd Eldred (NASA Langley)
- 9:30 → **Design Optimization to Fabrication with HyperX Laminate Families for Traditional Quad 0/45/90 and Double-Double [± Φ / ± Ψ] Layups,** Brett Bednarcyk (NASA Glenn) and Craig Collier (Collier Aerospace)
- 10:30 Coffee Break & Conversations
- 10:45 → **Bonded Joints,** Evan Pineda (NASA Glenn) and Stephen Jones (Collier Aerospace)
- 11:30 → **Fastened Joints,** James Ainsworth (Collier Aerospace)
- 12:00 Lunch at NASA

Afternoon Session: How to Make HyperX Work for You

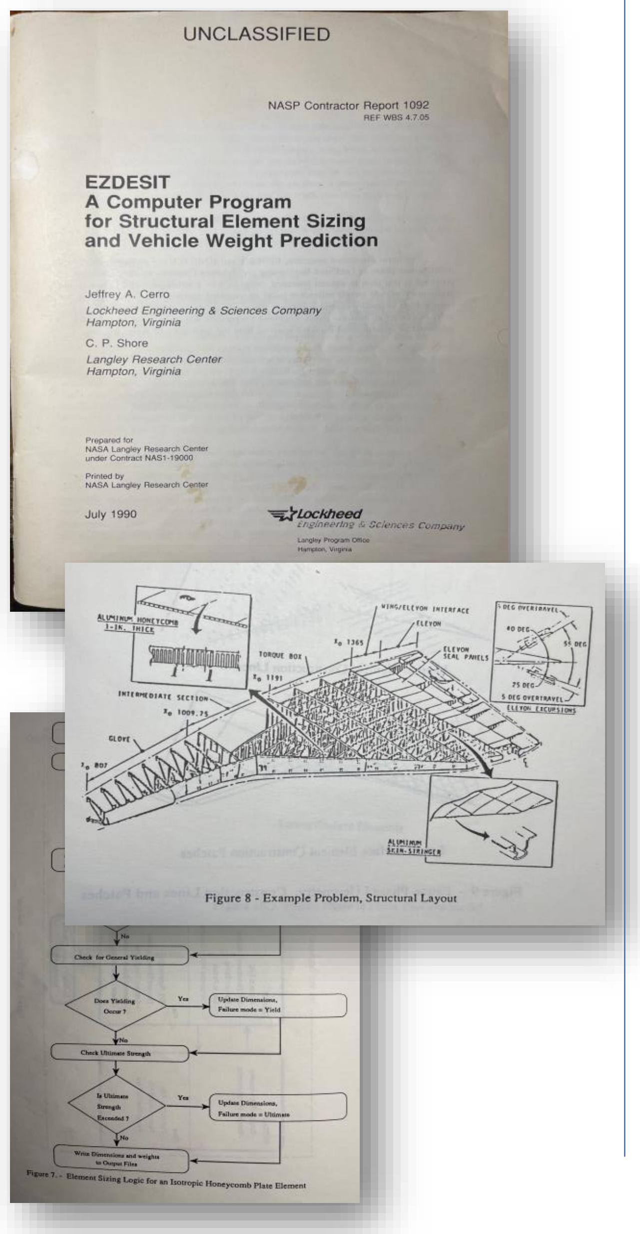
- 12:50 → **Rolling out New Customer Support Tools – How to get Help,** Charli Cahill (Collier Aerospace)
- 1:15 → **Enterprise Use Case for when your Engineering Department Adopts,** James Ainsworth (Collier Aerospace)
- 1:45 Break & Conversations
- 2:00 → **Customer Customization: Bottom-Up with Plugins,** Noah Prezant (Collier Aerospace)
- 2:30 → **Customer Customization: Top-Down with the API,** KellyAnn Smith (Collier Aerospace)
- 3:00 → **Open Forum – Questions, Feedback, Feature Requests, etc.**
- 3:45 Transportation vans from NASA back to Marriott City Center

Where we are, and how we got here

EZDESIT - 1985 → ST-SIZE - 1988 → HyperSizer - 1995 → HyperX - 2022

Craig Collier – Collier Aerospace
CEO and Founder

In honor of Jeff Cerro, the author of EZDESIT, the trailblazer of HyperX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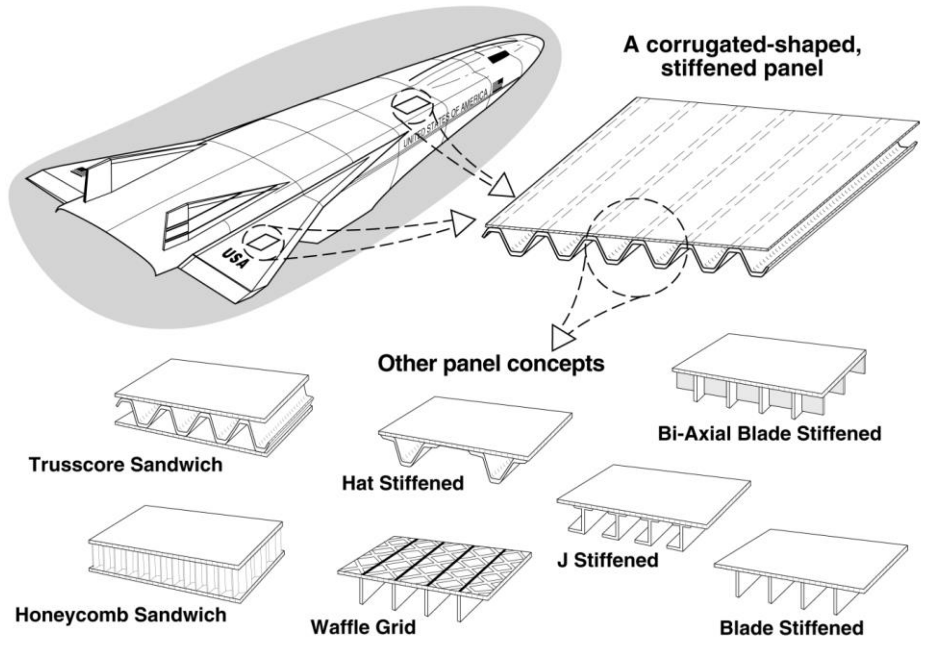
NASP Contractor Report 1092

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

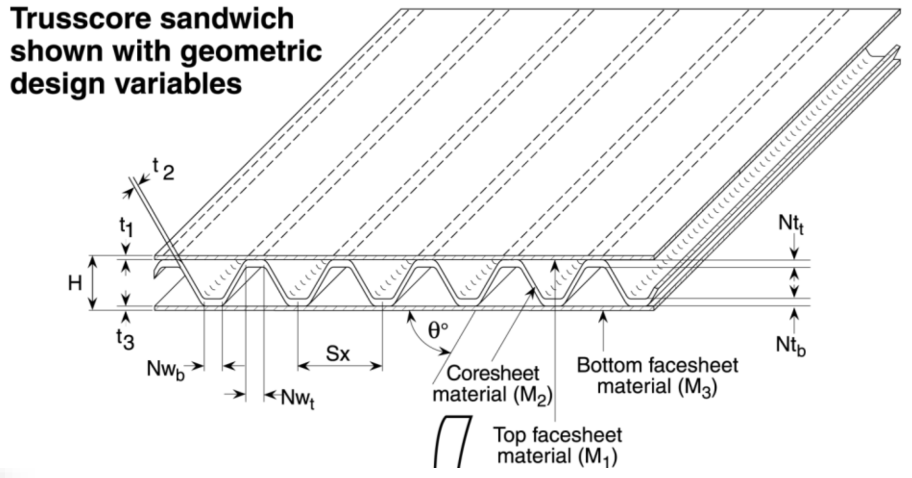
Jeffrey A. Cerro
Lockheed Engineering & Sciences Company
Hampton, Virginia

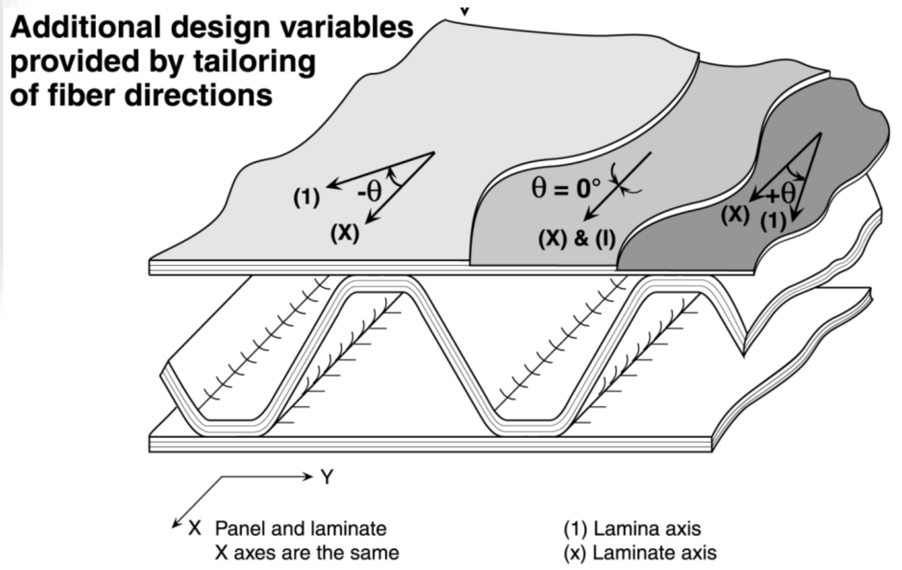
C. P. Shore
Langley Research Center
Hampton, Virginia

July 1990



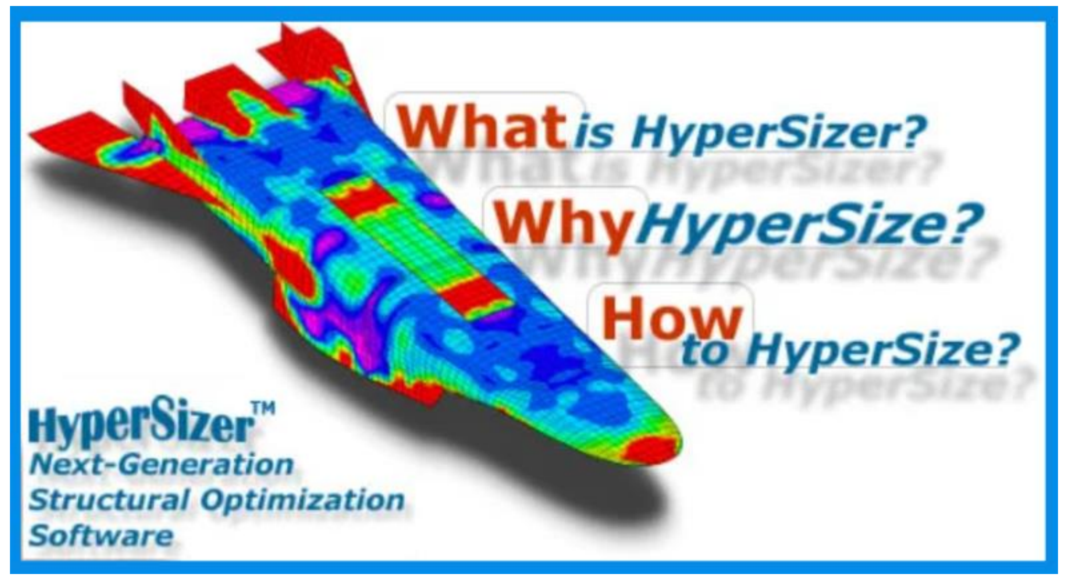
Developed at NASA Langley for hypersonic vehicles





HyperSizer®

COLLIER RESEARCH CORPORATION



HYPERX® SOFTWARE

COLLIER AEROSPACE

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: Space Launch Vehicles, High Performance Computing in AWS Cloud, and Engineering Services

James Ainsworth – Collier Aerospace
Managing Director of Engineering

Commercial Space Launch Customers use HyperX on every piece of structure

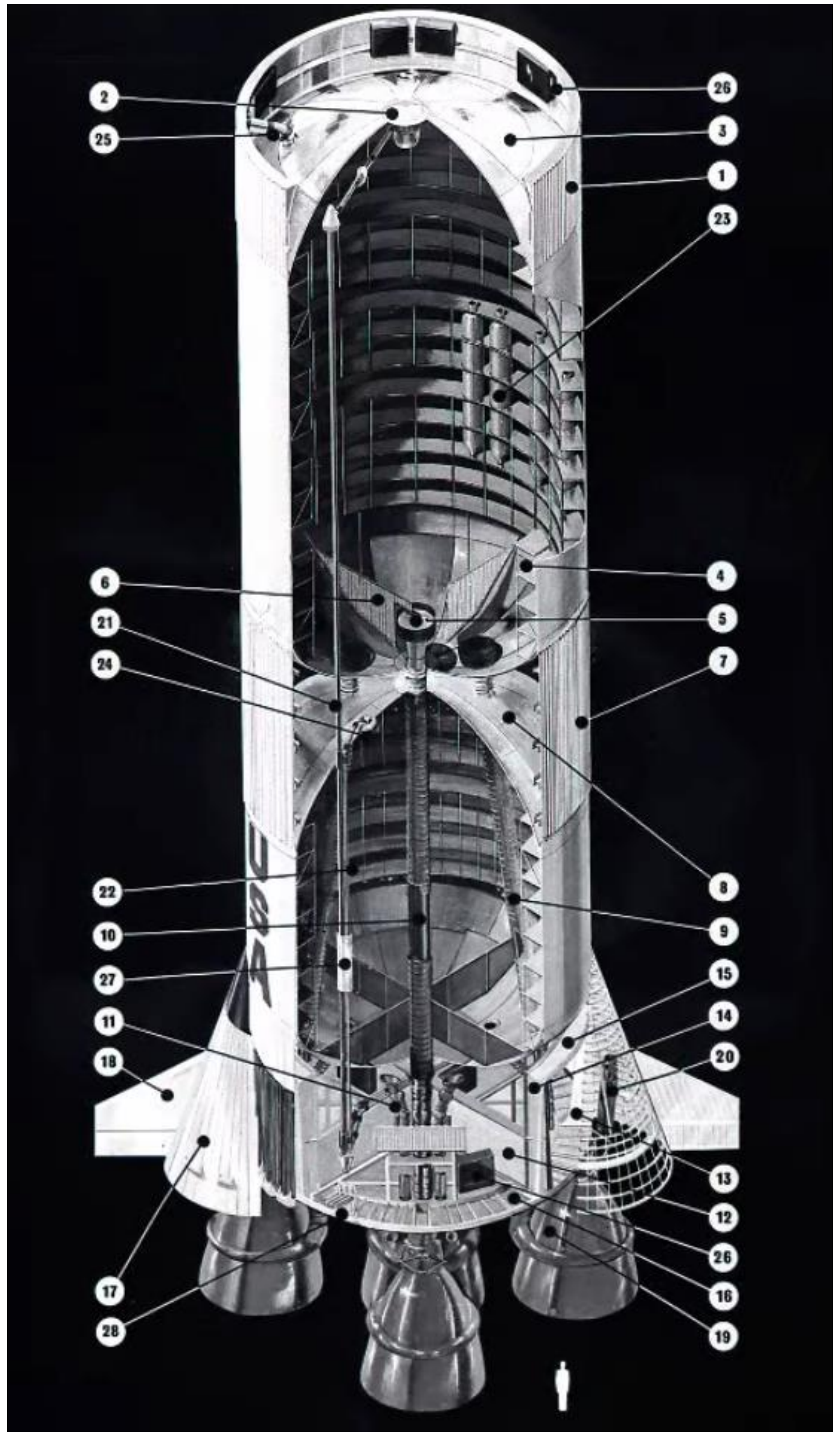
- Fuel tanks, interstage, fins, strakes, dry structure, thrust structure, instrument panel, fairing, etc.
- Metal and composite
- Weight reduction sizing, PDR to CDR to final analysis stress reports, all the way to part release sign off

Extremely large FEMs

- Referred to as mega FEMs with millions of elements per structure, and hundreds of thermomechanical external loadings
- Eigenvalue buckling and nonlinear FEA

Terabytes of Data

- So much data required going to the cloud
- We implemented a process to perform FEA and HyperX using Amazon Web Services (AWS)
- Automation scripts were developed to run jobs 24/7 that took sizing and analyses days to run

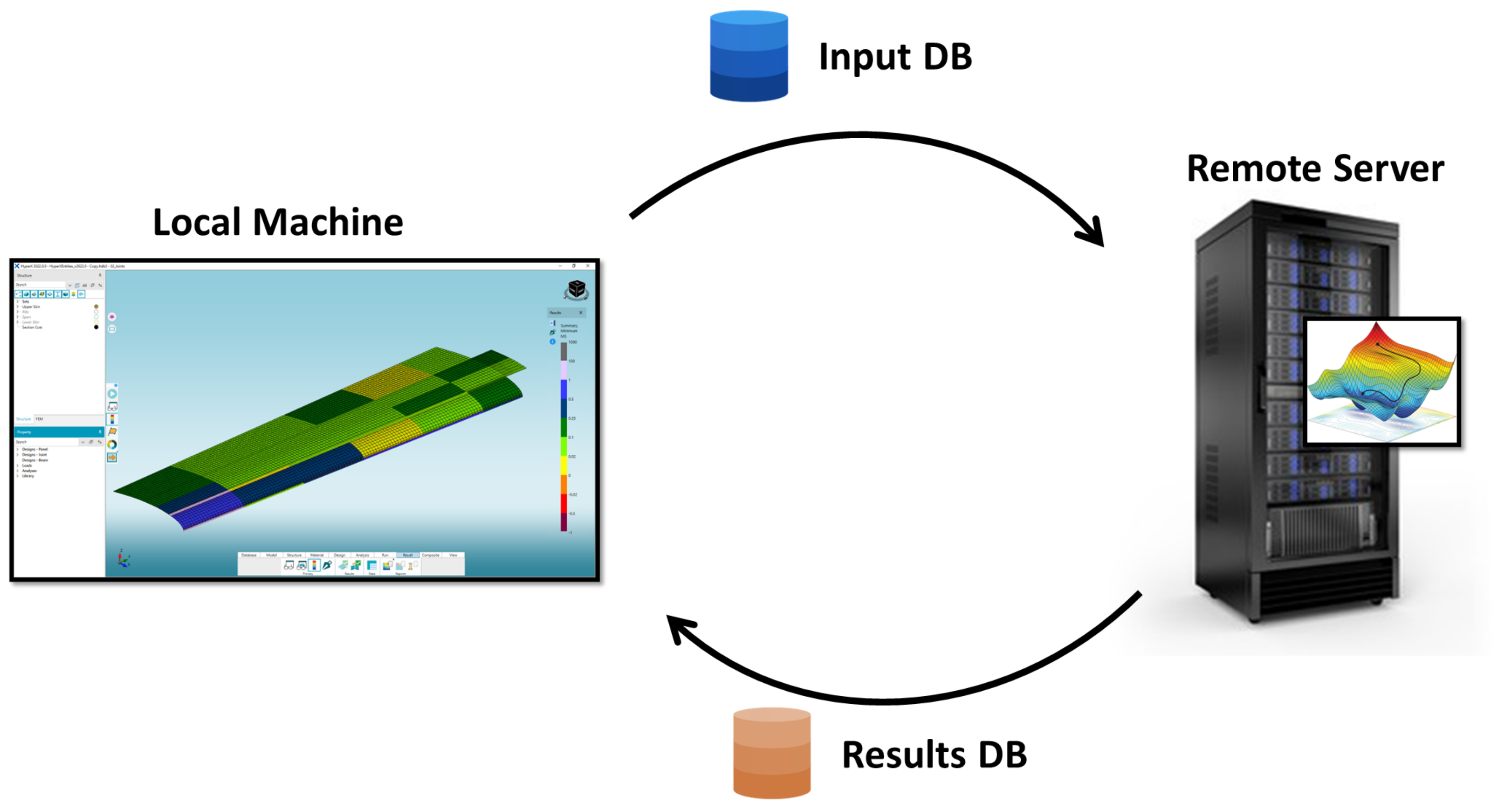


Day 1: High Performance Computing in the Cloud or on your Company's Linux Cluster with our Next-Generation Solver

Stephen Jones – Collier Aerospace
Manager Software Development

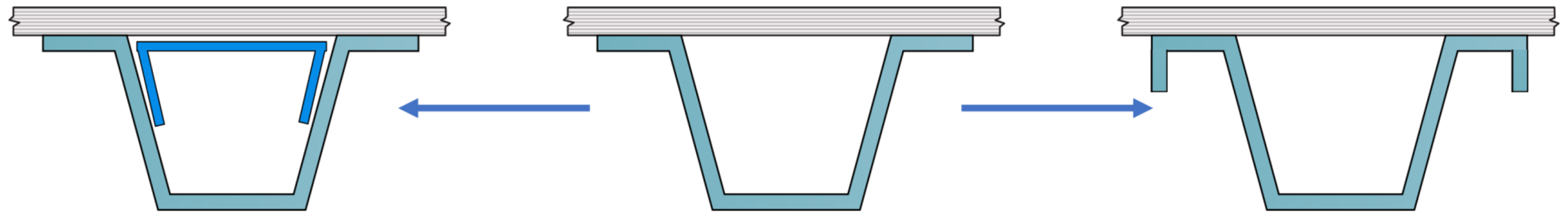
Modern High-Performance Architecture

- Multithreading and multiprocessing
- Cross-platform support for remote solving (e.g. HPC Linux cluster)



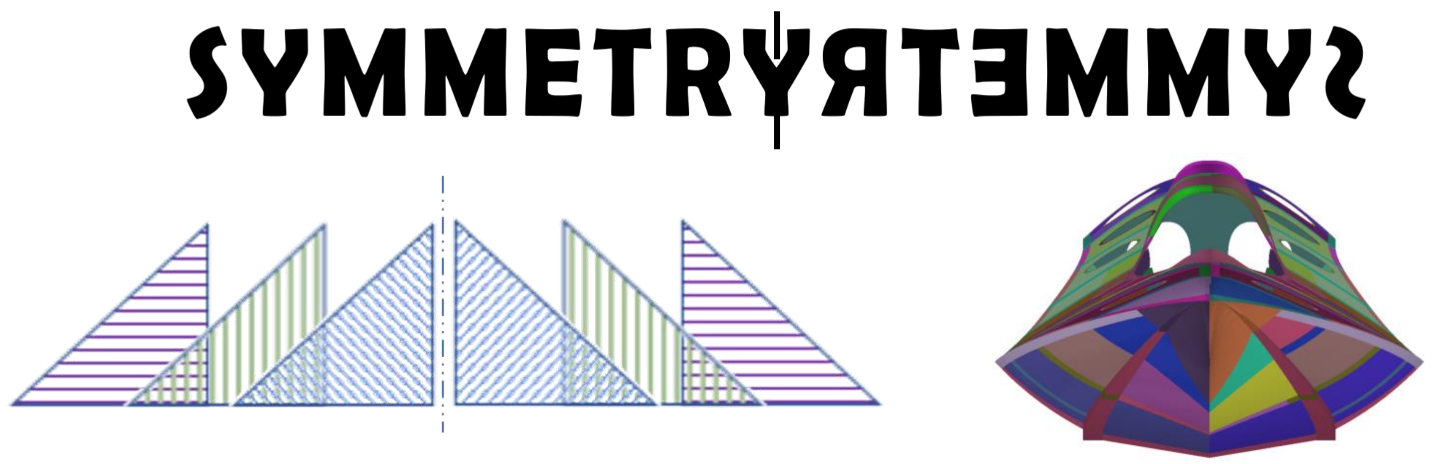
Responsive Development

- Modern tools expand Collier developer engagement
- Shorter response time to add or modify features to address customer needs
- A robust and modular framework that will support expansion for many years to come



Enhanced Features and Customization

- Enhanced optimization methods including multi-objective
- Innate handling of symmetry and linking
- Additional "hooks" to customize load processing, analysis, and optimization methods



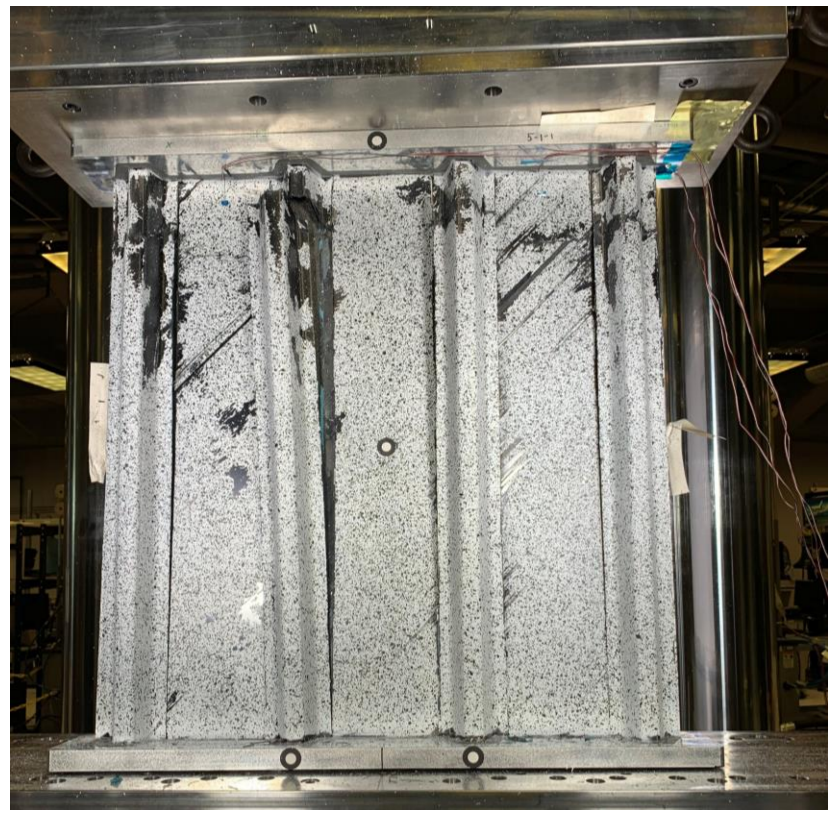
Day 1: The NASA Advanced Composites Project (ACP) and the NASA Hi-Rate Composite Aircraft Manufacturing (HiCAM) Project

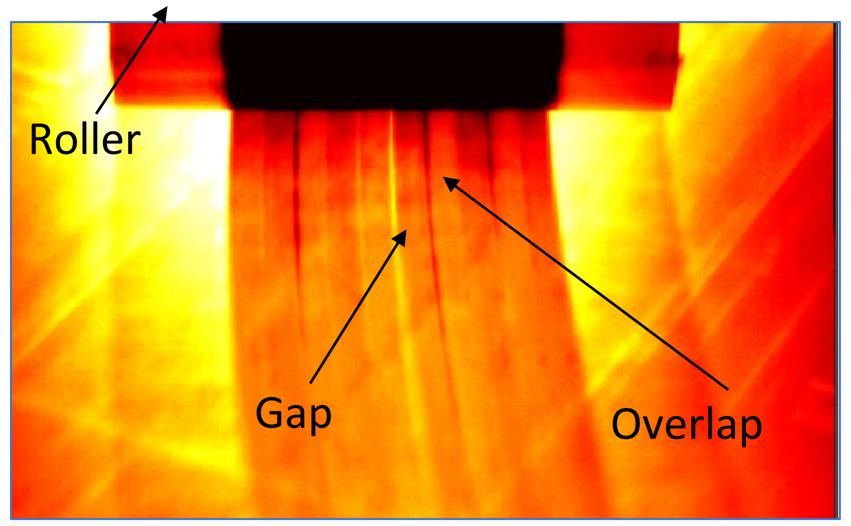
Rick Young – NASA Langley
ACP and HiCAM Project Manager

NASA Advanced Composites Project (ACP) (2015-2019)

Purpose: Reduce time to develop and certify composite structures

- 13 partners: NASA, FAA, OEMs, and engineering software
- Accomplishments
  - Accurate prediction of the strength and life of composite structures
  - Rapid inspection of composites
  - Efficient development of manufacturing processes
- NASA's investment = $138M, partner match = $35M; Total = $173M

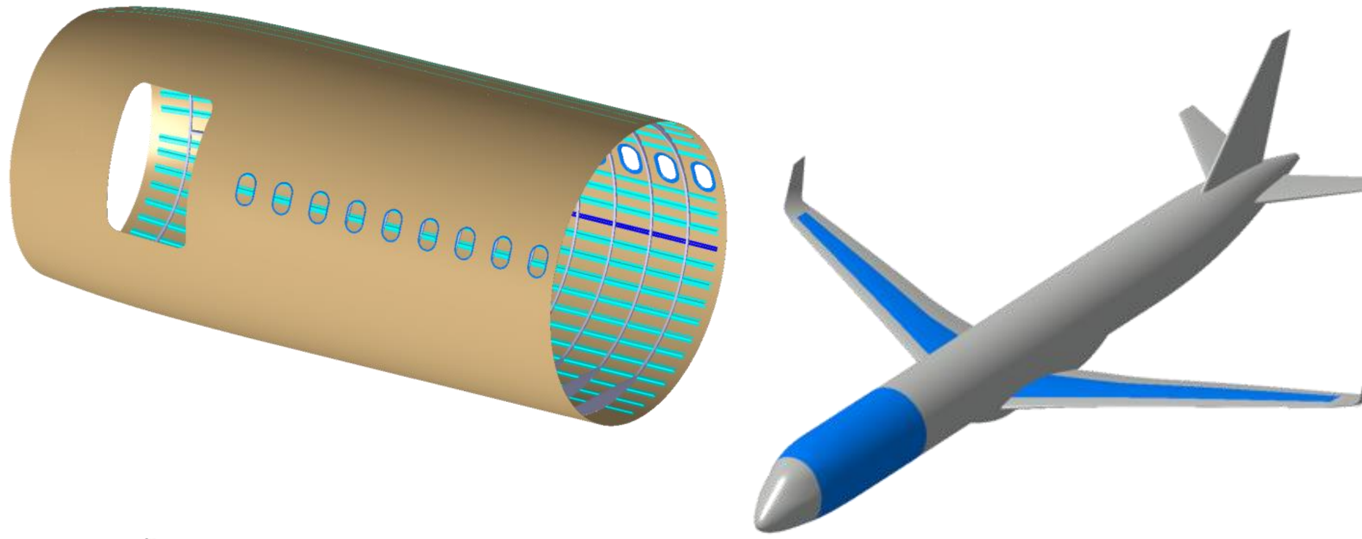


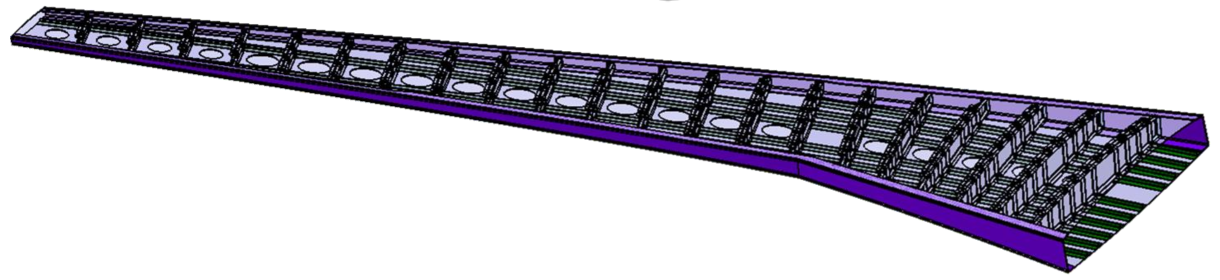


NASA Hi-Rate Composite Aircraft Manufacturing (HiCAM) Project (2021-2028)

Purpose: Enable high-rate production (up to 80 aircraft per month)

- Pursue manufacturing approaches for high-rate production that reduce labor, equipment, and tooling costs without compromising strength and safety. Considering three material systems:
  - Next generation thermosets
  - Thermoplastic
  - Resin Infusion
- 20 partners: NASA, FAA, OEMs, material suppliers, manufacturing equip, and engineering software
- NASA's investment = $184M, partner match = $136M; Total = $320 million





Day 1: HyperX's Role in the NASA Advanced Composite Program (ACP) and the NASA High Speed Composite Manufacturing (HiCAM) Program for Commercial Airframes

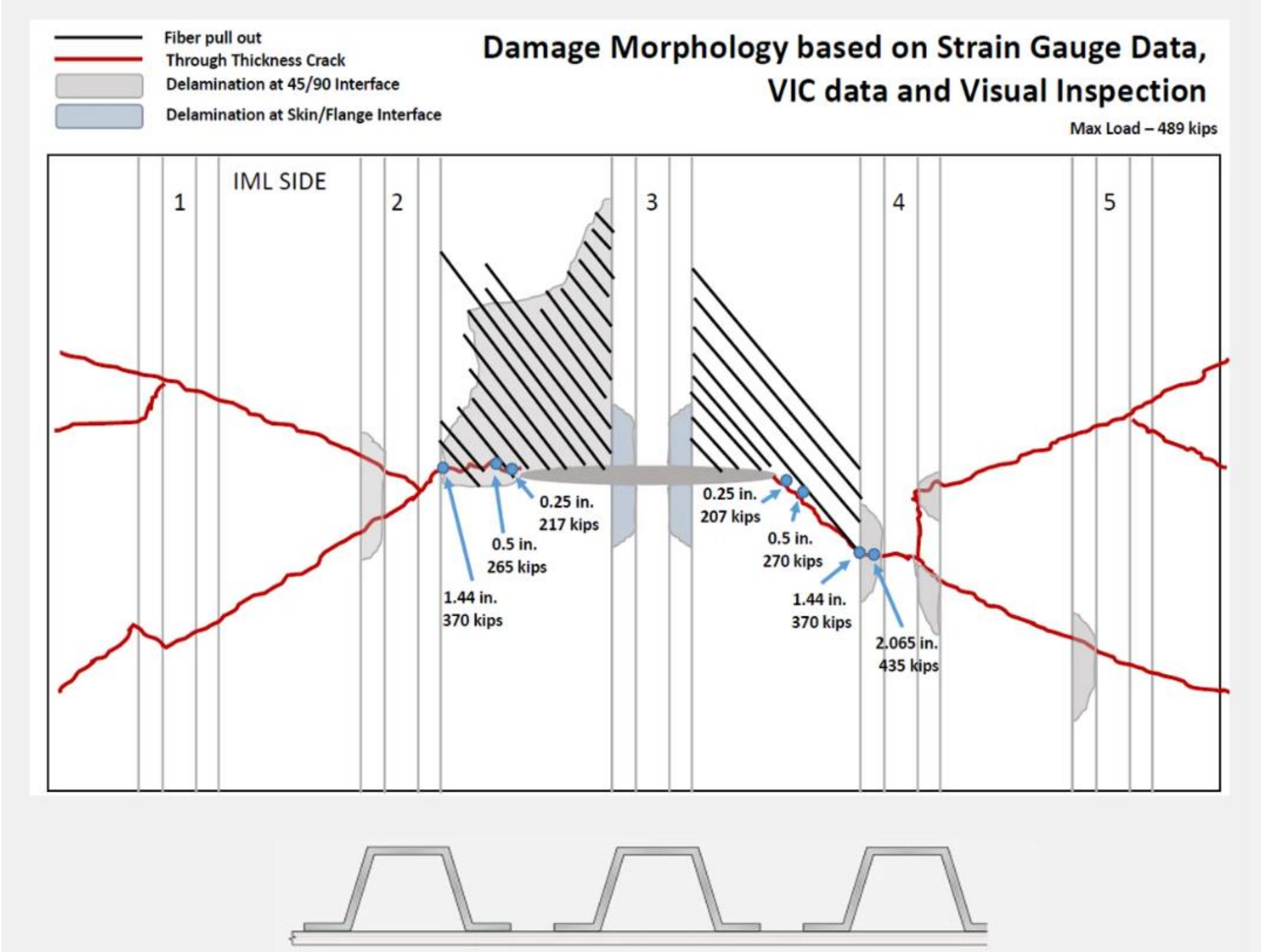
Craig Collier – Collier Aerospace
CEO and Founder

NASA Advanced Composite Program (ACP)
(2015-2019)
Purpose: Improve Certification by Analysis

- Rapid sizing analysis methods
- Plug in OEM customer tools into the HyperX Stress Framework
- Design for Manufacturing (DFM) with Automated Fiber Placement (AFP)

NASA High Speed Composite Manufacturing (HiCAM) Project (2021-2028)
Purpose: Design for High Speed Manufacturing

- Three material systems: next gen thermoset, thermoplastic, and resin Infusion
- Develop Weight Key Performance parameters (KPPs) with the HyperX structural sizing process
- AFP, fiber paths, avoiding laps and gaps
- Analysis methods development for new materials



HyperX Plugin for Boeing/NASA/Spirit AeroSystems - Two Bay Crack, Large Damage Residual Strength Analysis - for fly home loads

Day 1: Airframe Stiffened Panel Laminate Family Trade Studies, Displayed in a Web Browser Dashboard and Related Digital Thread to CAD

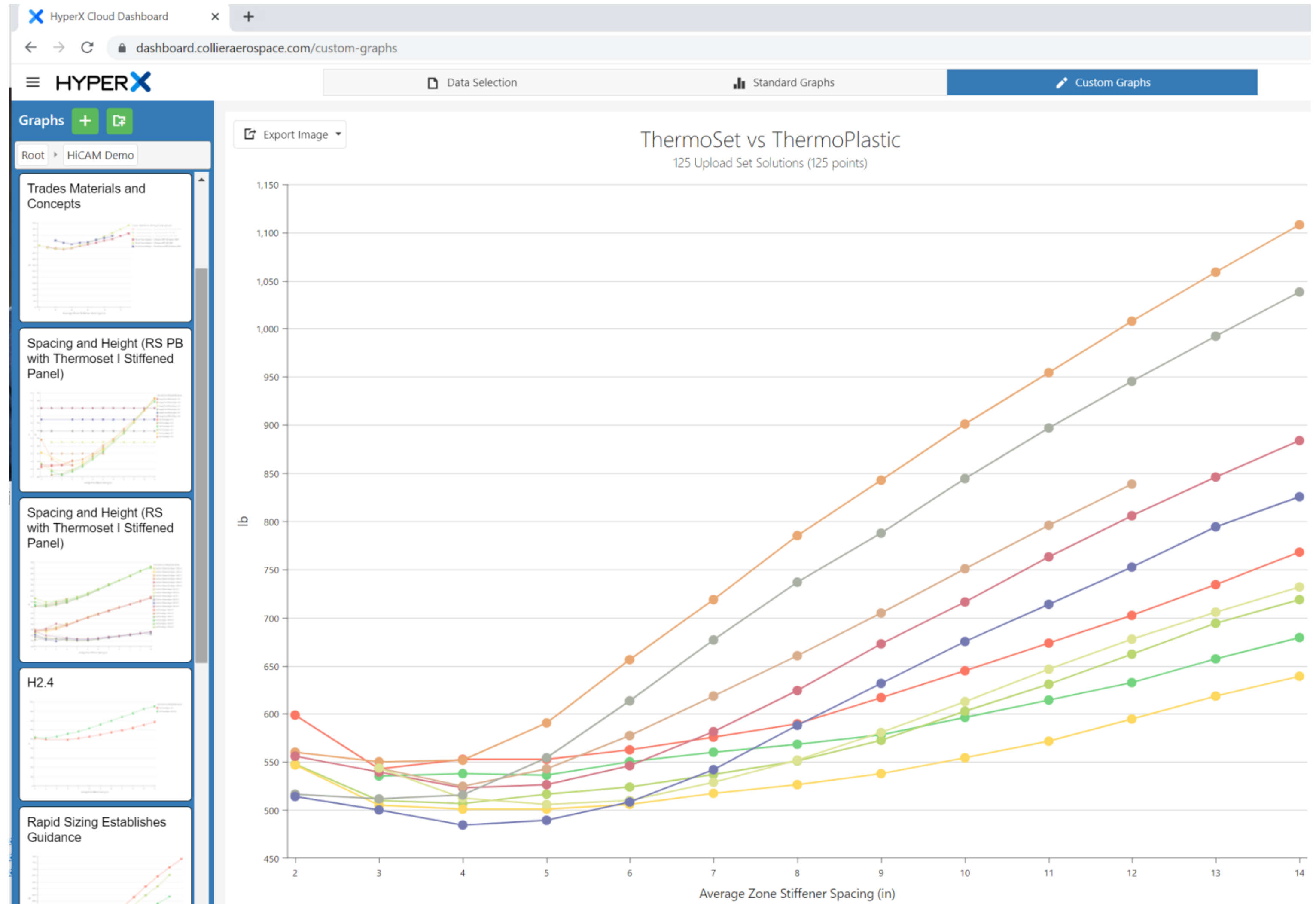
Craig Collier – Collier Aerospace
CEO and Founder

Users need:

- More than a single sizing optimization – users need to report and store sizing results for many HyperX optimizations
- More than updating FEM with HyperX sizing results – users need to update CAD as well
- More than rapid or effective laminate sizing – users need to use laminate families that provide more realism, insight, and control to design producible parts

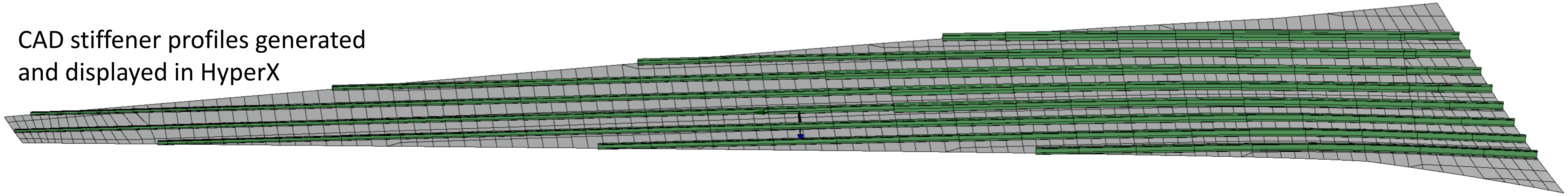
Roadmap Solutions – being delivered to users now

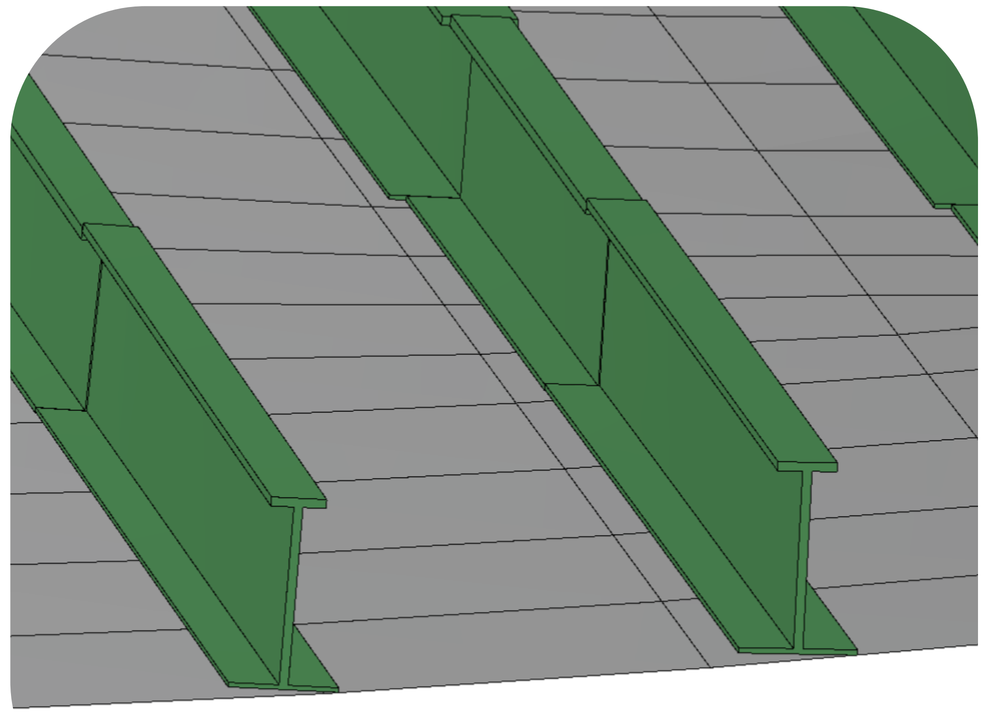
- A capability to upload sizing results to a **dashboard** for displaying as trend lines
- A capability to share this data as graphs with others for team decisions
- A capability for HyperX to generate IGES and STEP CAD data and display natively stiffener profiles and their placement on the FEM or CAD.
- A bidirectional export/import capability of stiffener profile dimensions between HyperX and CATIA
- More intuitive and editable stringer laminate families



Each point is a single sizing result stored in a cloud, server, or laptop dashboard and displayed in web browses as trend lines

CAD stiffener profiles generated and displayed in HyperX





Lunch

June 14-15, 2023

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 working at Zee.Aero (now Wisk) and from 2019 to 2021.

From there I was the Vehicle Structural Design Lead for Uber Elevate – supporting eVTOL projects with Joby, Hyundai (now Supernal), Bell, and others.

A tool like HyperX is needed

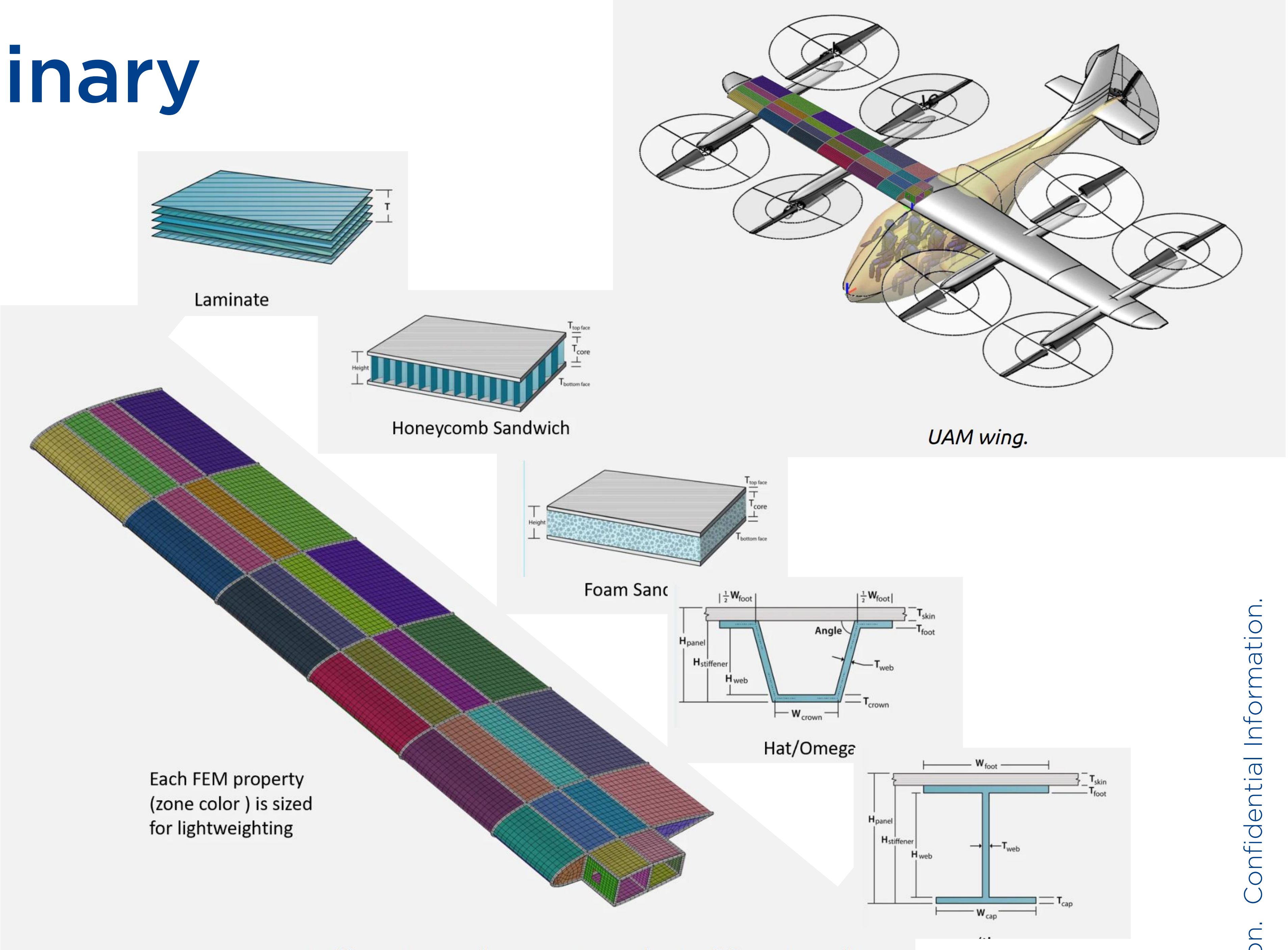
- To get a design flying and certified with its comprehensive suite of analyses methods
- Size length-wise wing stations to optimally meet stiffness targets or centroid locations

But before getting there

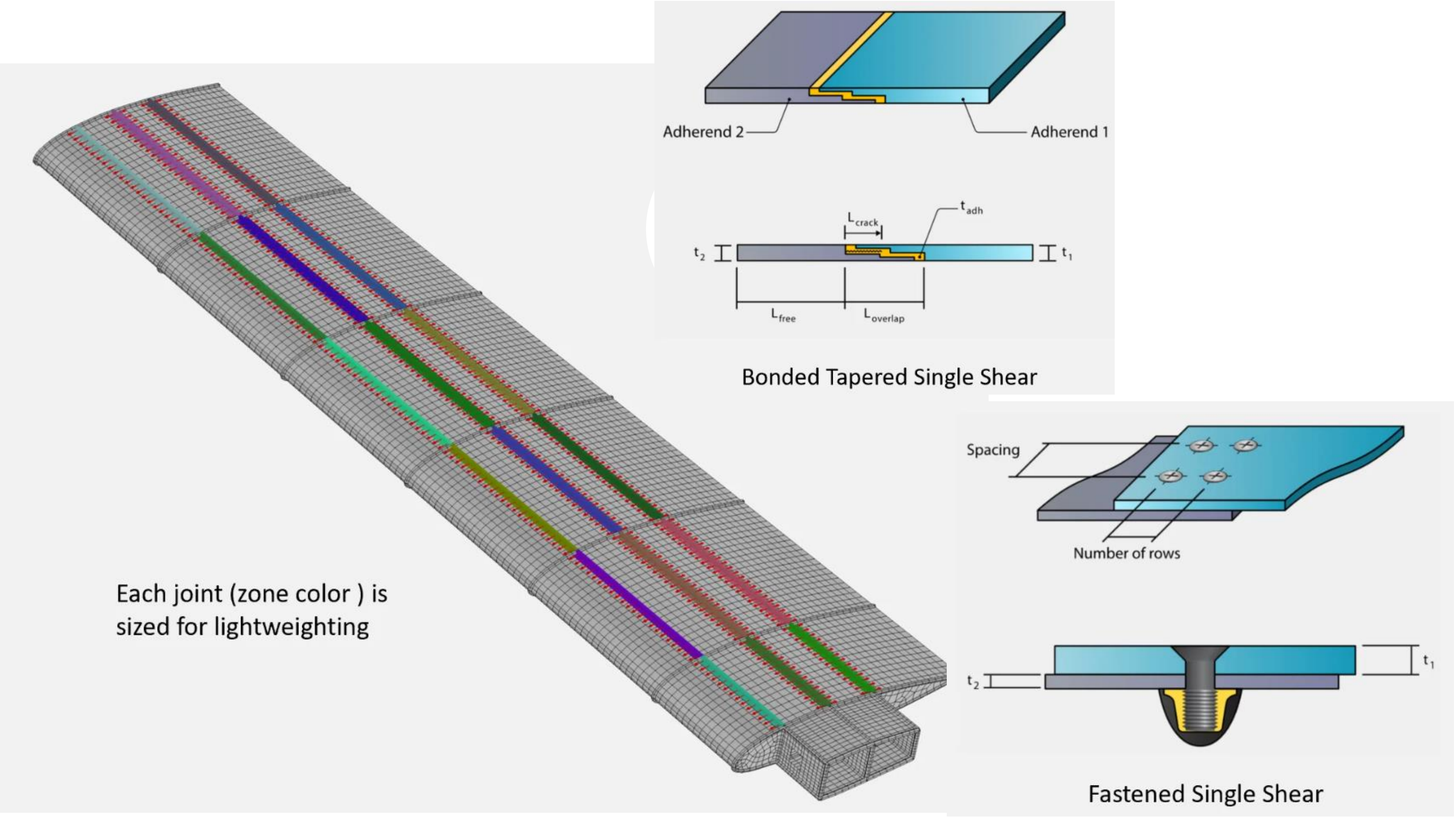
- The design has to be right for weight and right for high volume producibility
- Engineering teams need to explore the design space completely and rapidly

HyperX is being used by this Industry

- To achieve this and to go from Conceptual to Preliminary to Detail Design with Associated FEM Modeling



Different panel concepts evaluated for wing skin.



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

Day 1: The Section Cut, Professional Stress Tool

Charli Cahill – Collier Aerospace
Manager of Customer Development

Model Interrogation

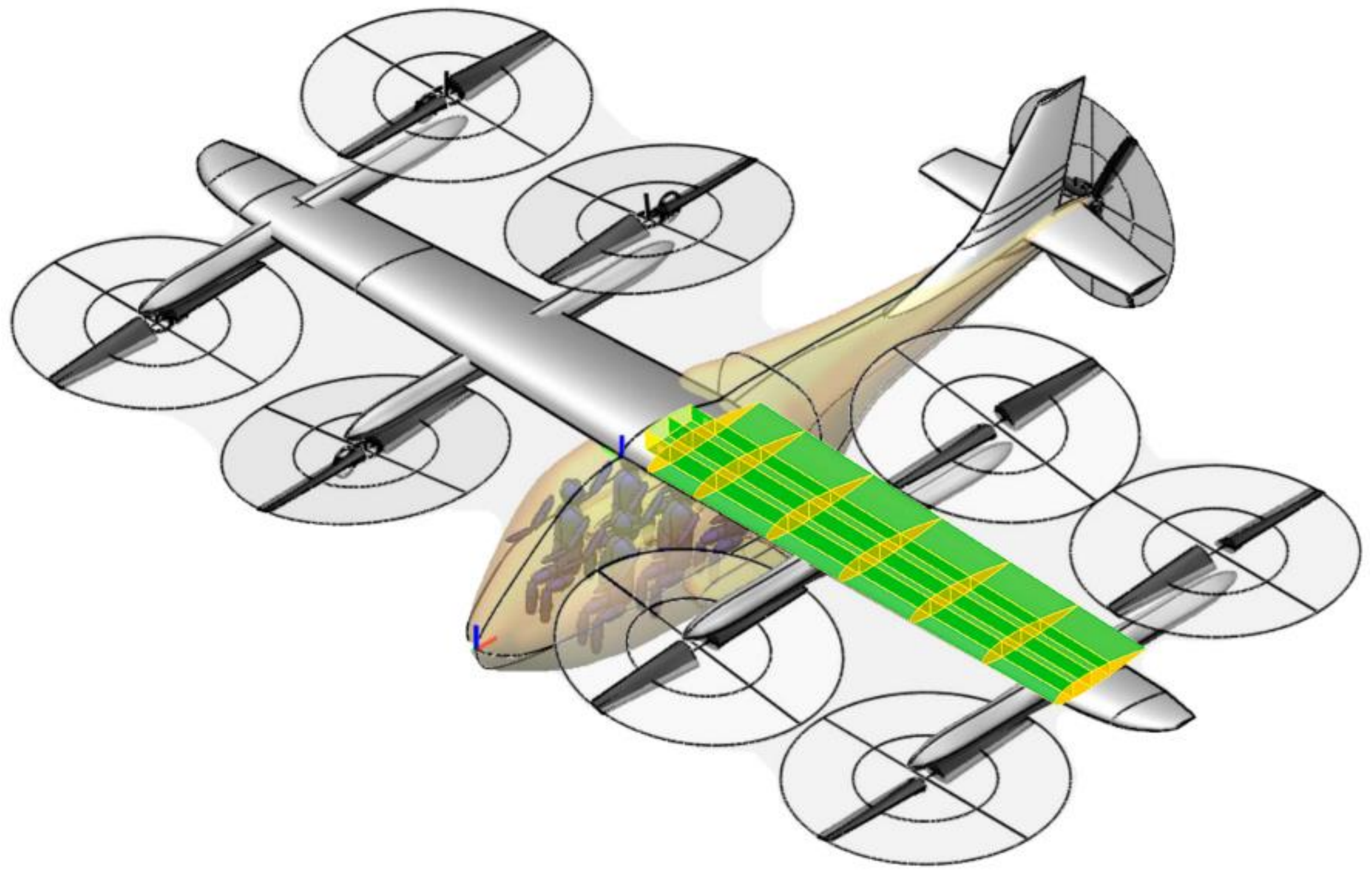
- Use Section FBD Loads calculated at incremental intervals along the length of a wing to generate shear/moment diagrams for each load case
- Calculate Section Stiffnesses in each bay

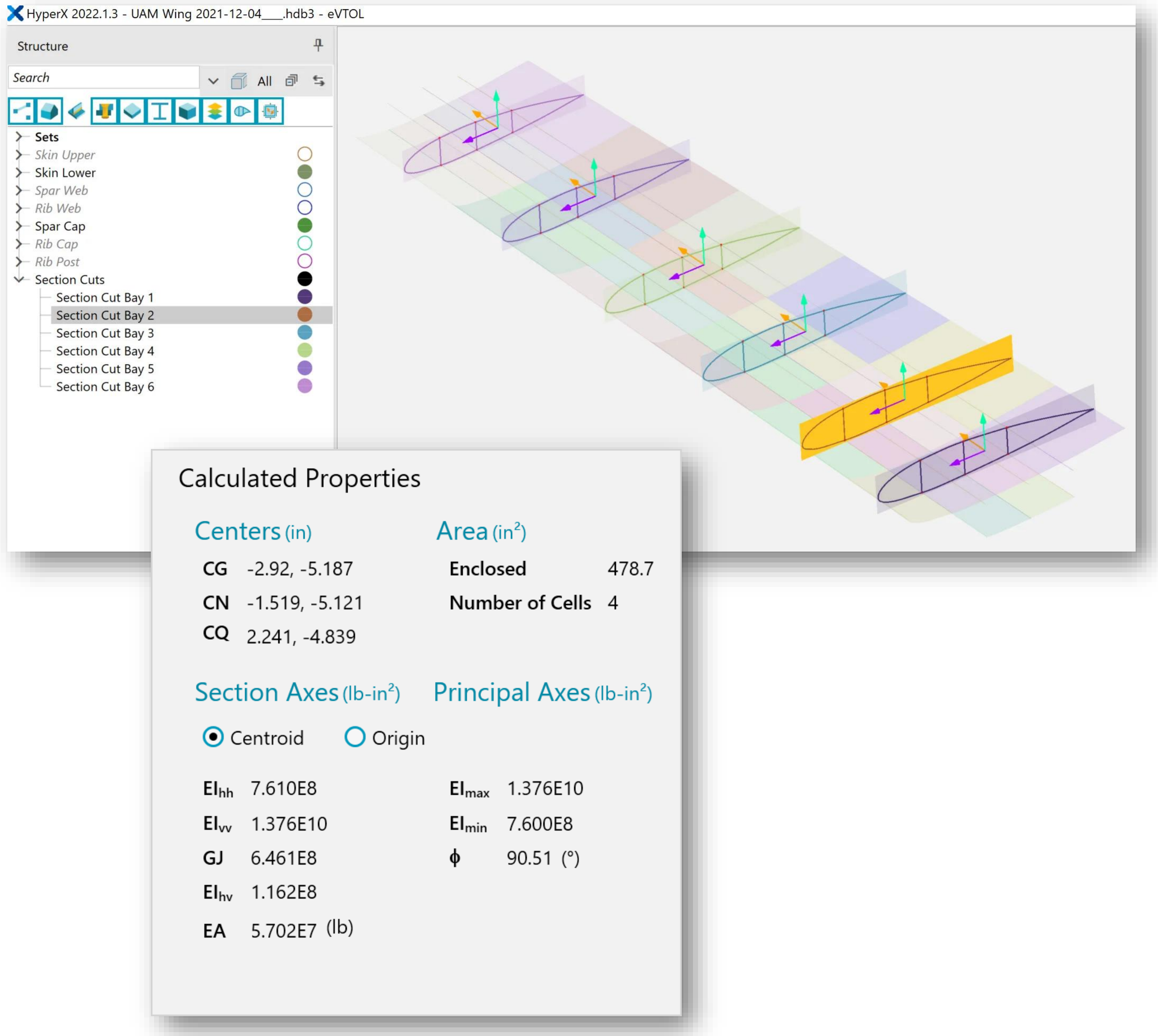
Sizing and Analysis

- Size length-wise wing stations to optimally meet EA, EI, GJ stiffness targets
- Automatically apply the section loads to a Non-FEA beam for section-based sizing and analysis

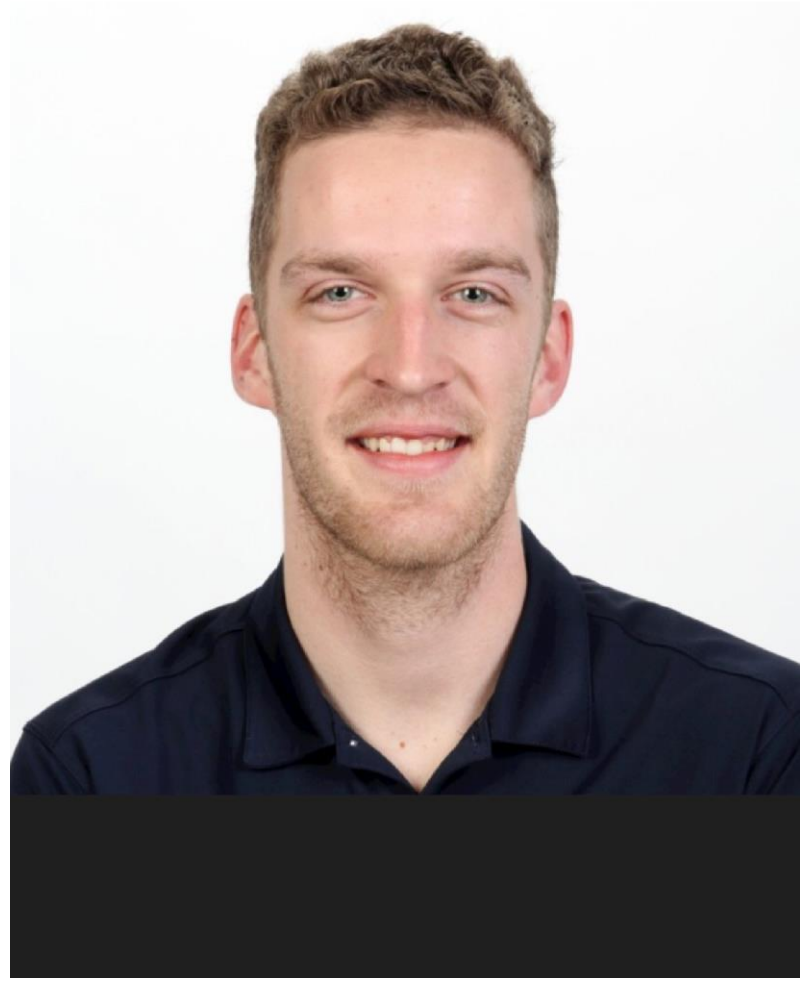
What's coming next?

- Spar analysis and sizing tool using section cut FBD loads





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)

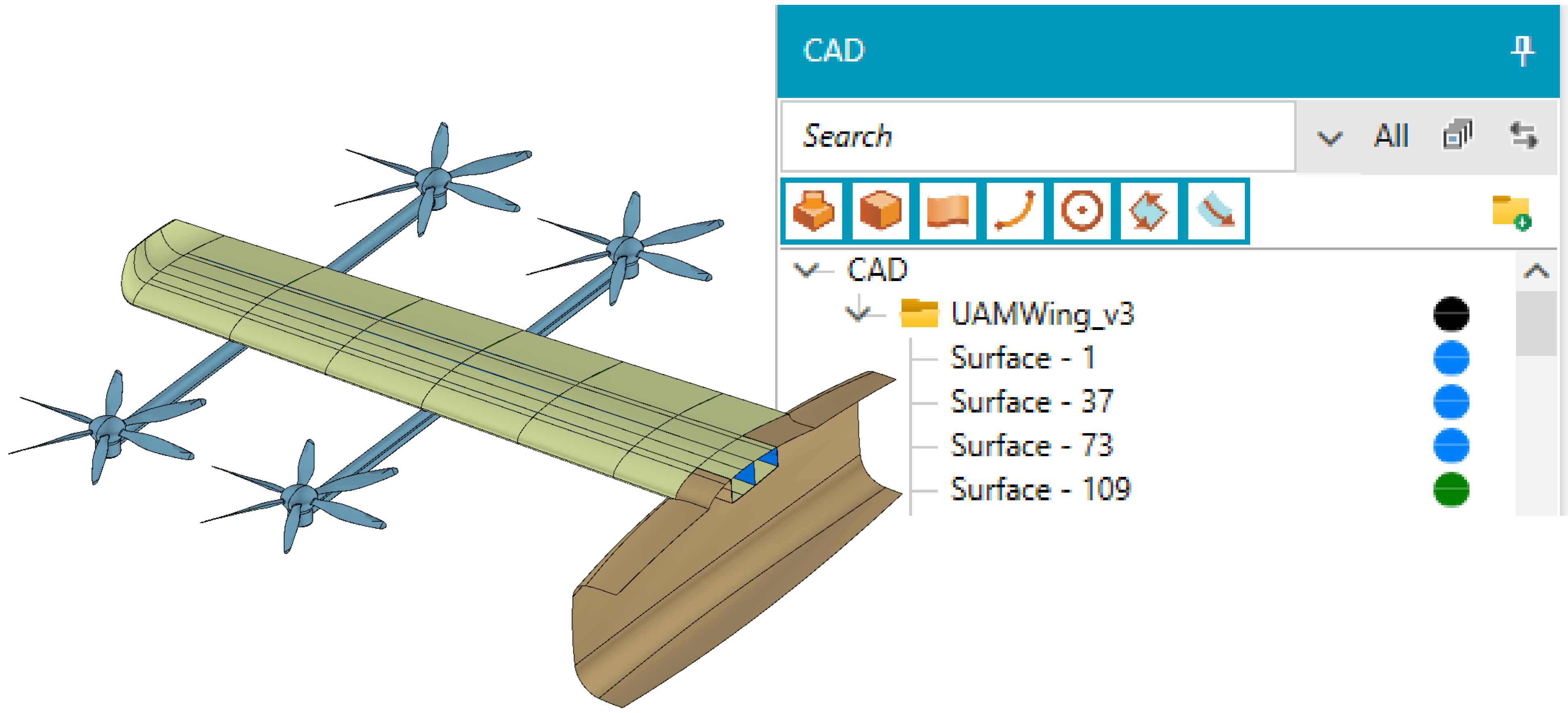
The Trek Madone is the ultimate race bike, expertly crafted with unprecedented road bike aerodynamics, exceptional ride quality, and an **ultra-lightweight composite design.** (Think > $10,000)

Day 1: CAD and the Digital Thread

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

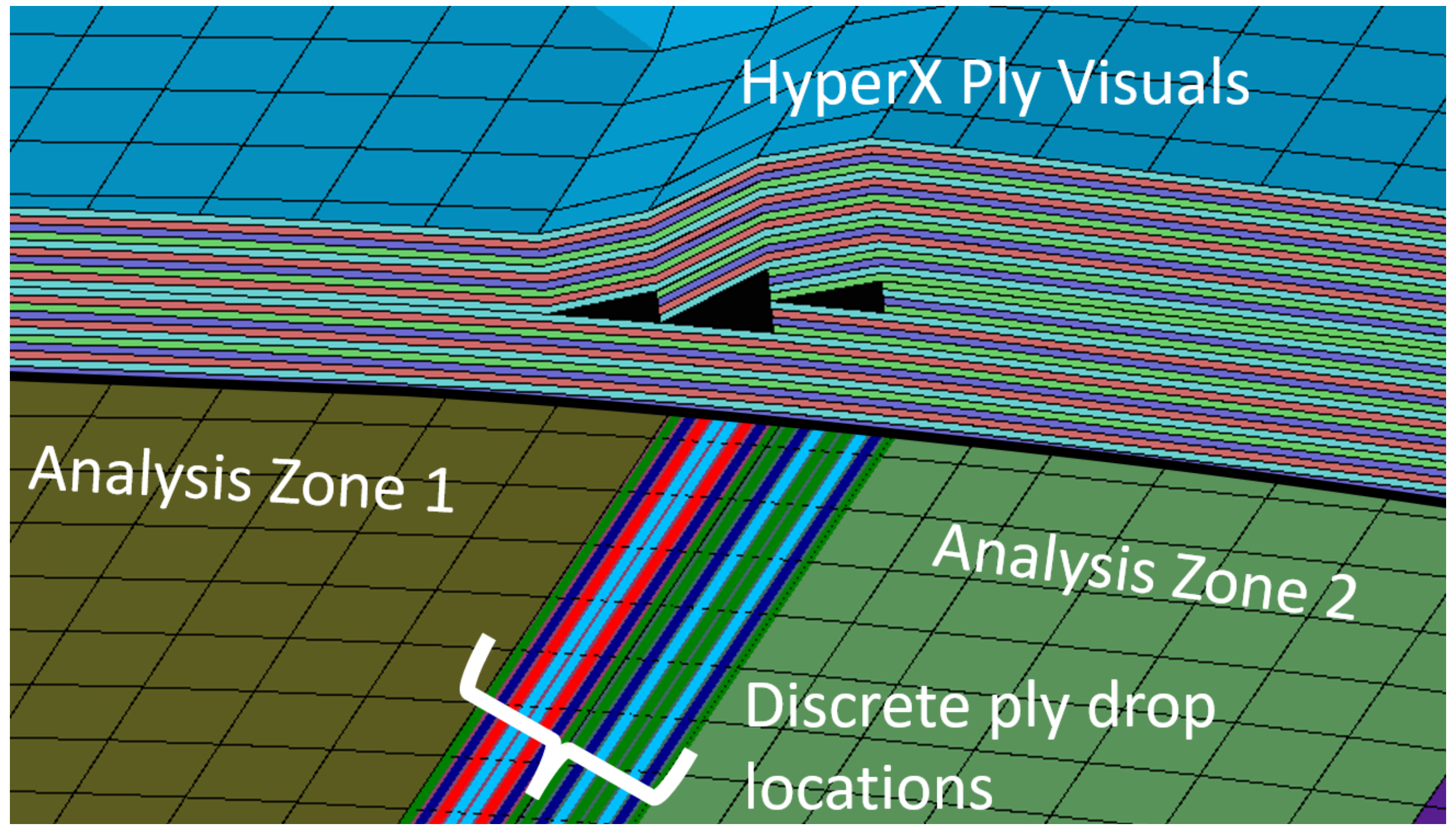
Management of CAD data

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



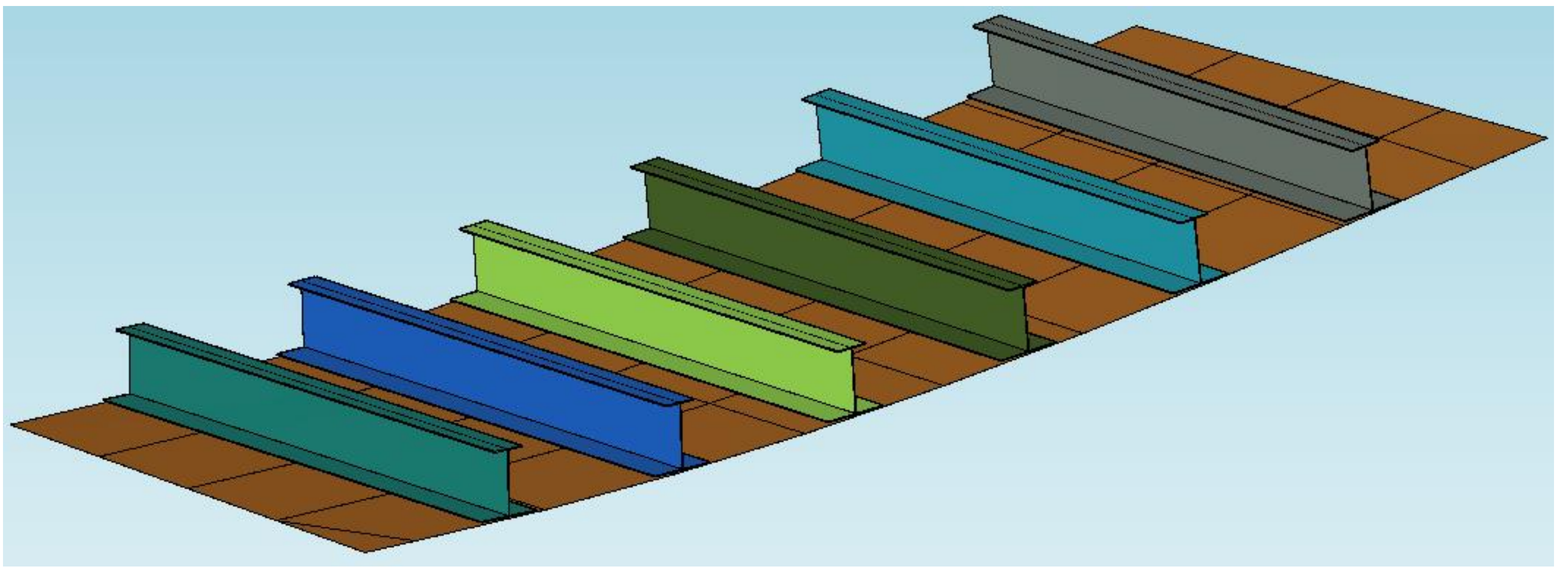
Bi-directional communication with composite data

- 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 SP80 World Record Composite Sailboat

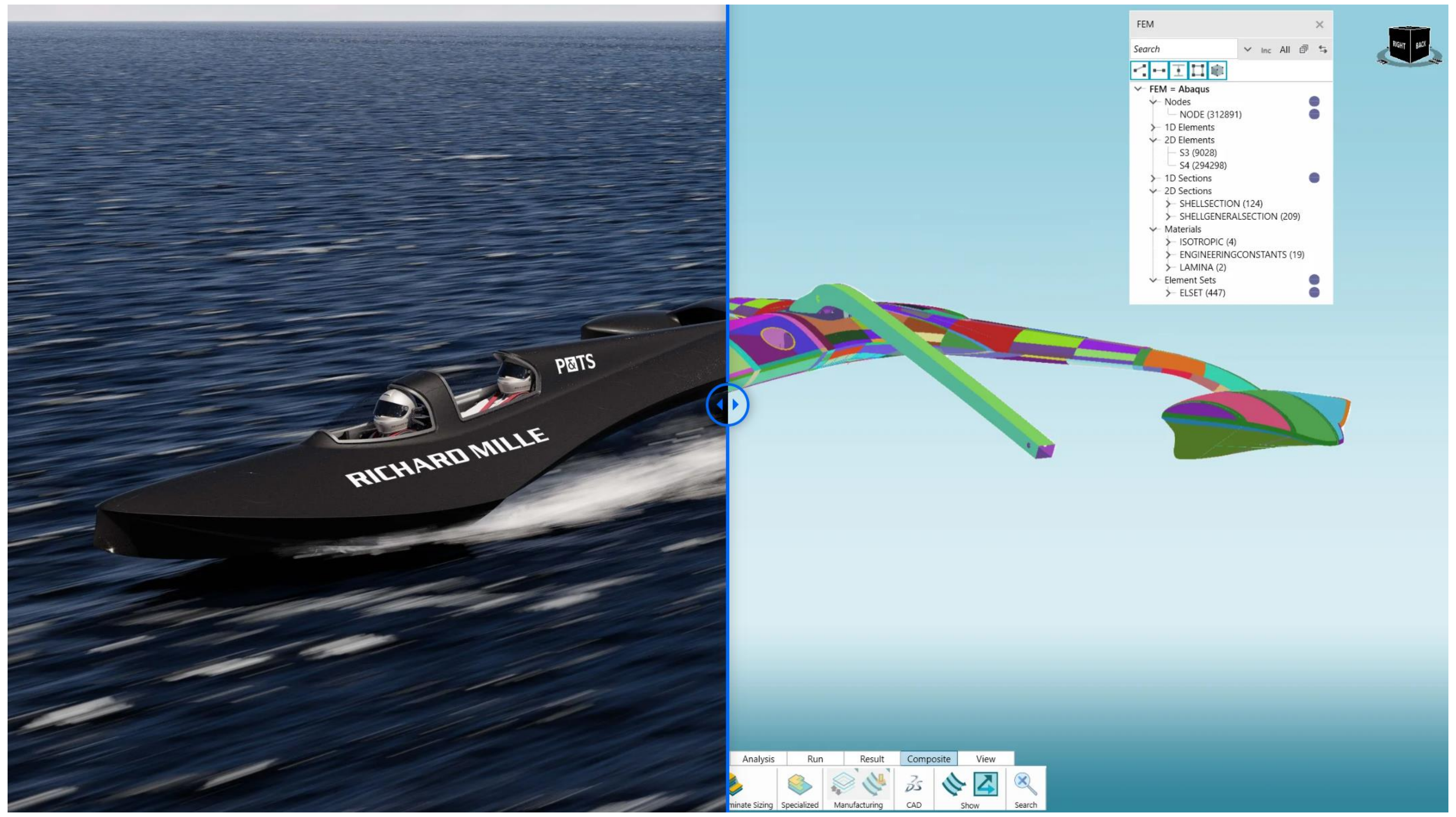
Mischa Pollack – Collier Aerospace
Director of Innovation & Senior Aerospace Engineer

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



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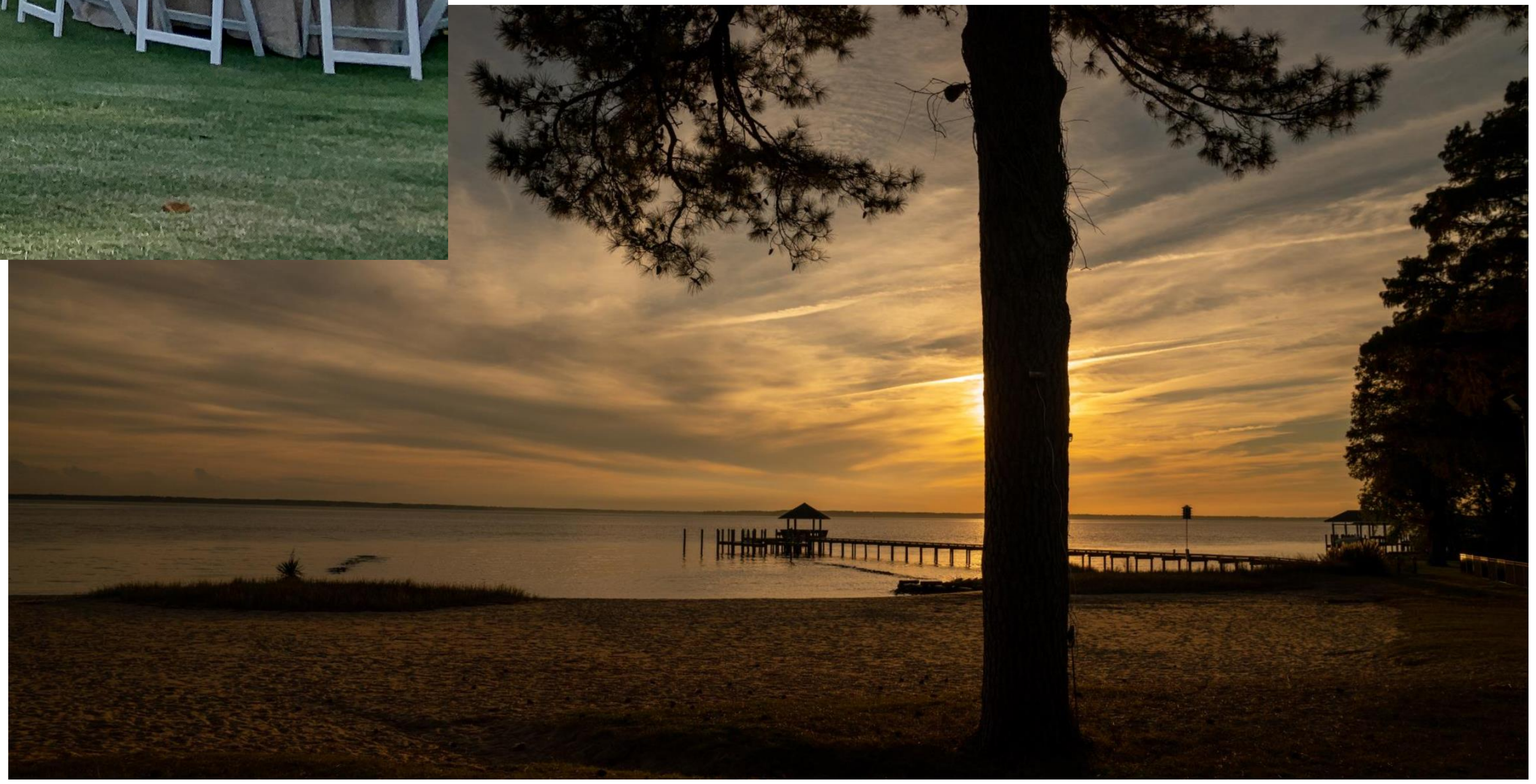
Dinner and Social

June 14-15, 2023

Wednesday evening: James River Country Club for evening of fun and networking over lawn games, an included outdoor coastal dinner, and sunset at the dock on the historic James River

Dinner and Travel is provided free to attendees. We will have vans going from NASA Langley Research Center to the James River Country Club and then to the Marriott hotel.



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

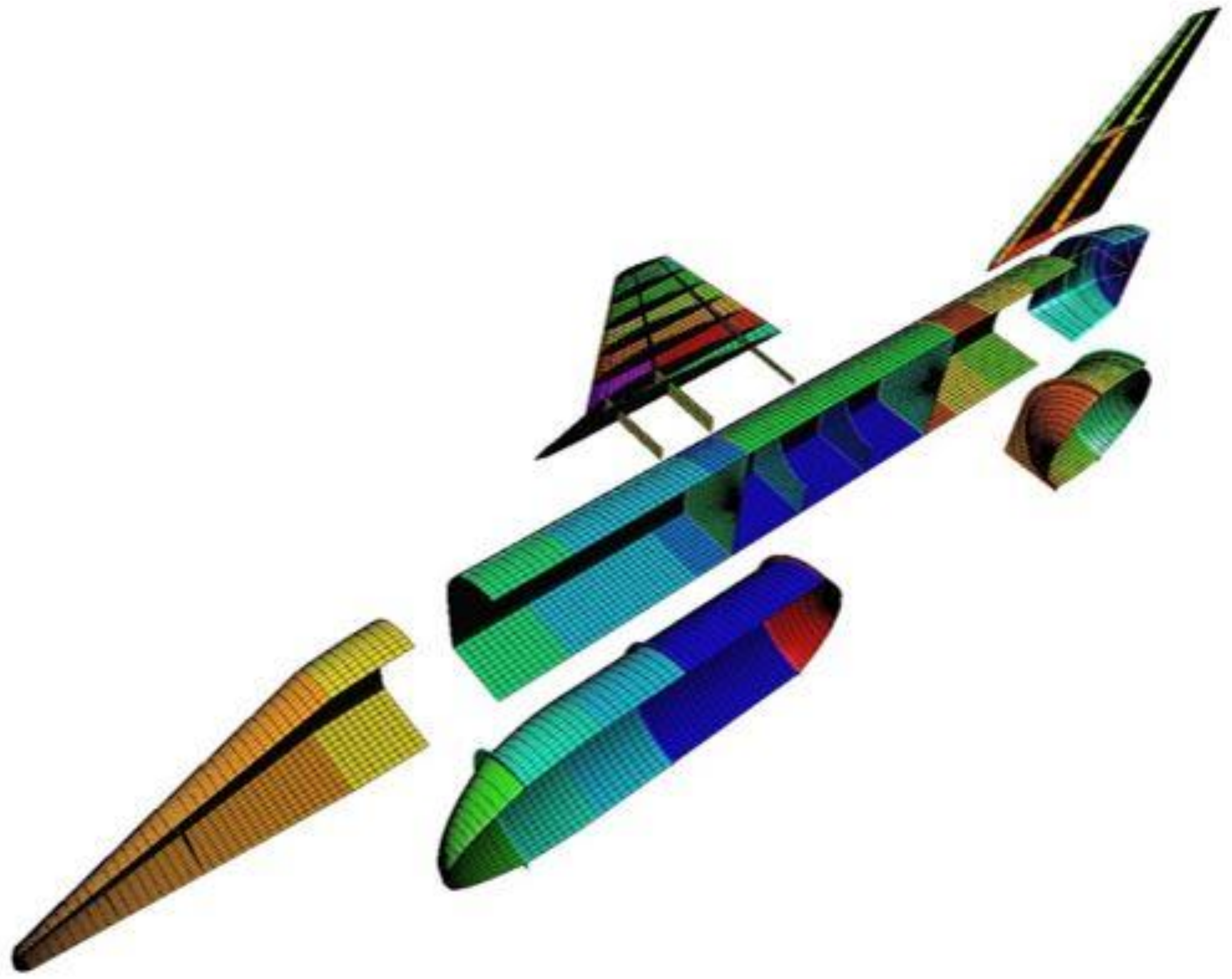
- Create meshes and load sets
- Solve in NASTRAN
- Size in HyperSizer
- Perform trades to reduce mass

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

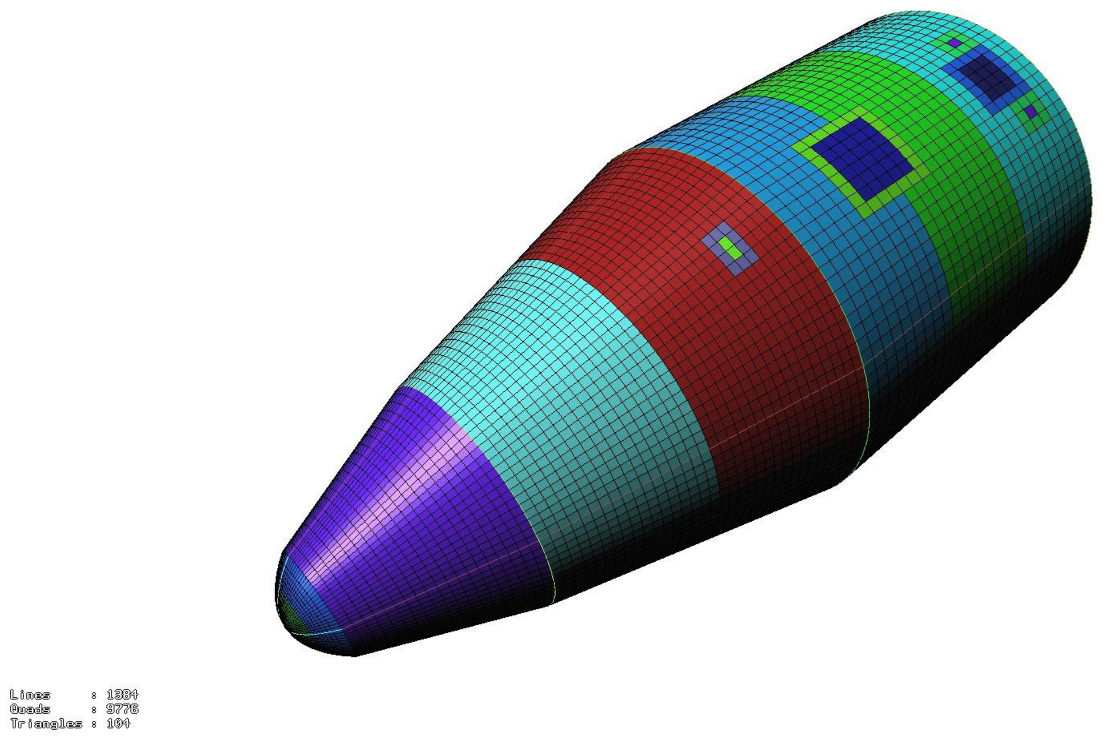
Automating HyperSizer

- 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: How Spirit AeroSystems uses HyperX

Theresa Williams – Spirit AeroSystems
HiCAM Stress Engineering

History with HyperSizer

- Use Hypersizer to find optimum solutions on numerous aerospace products

HyperX

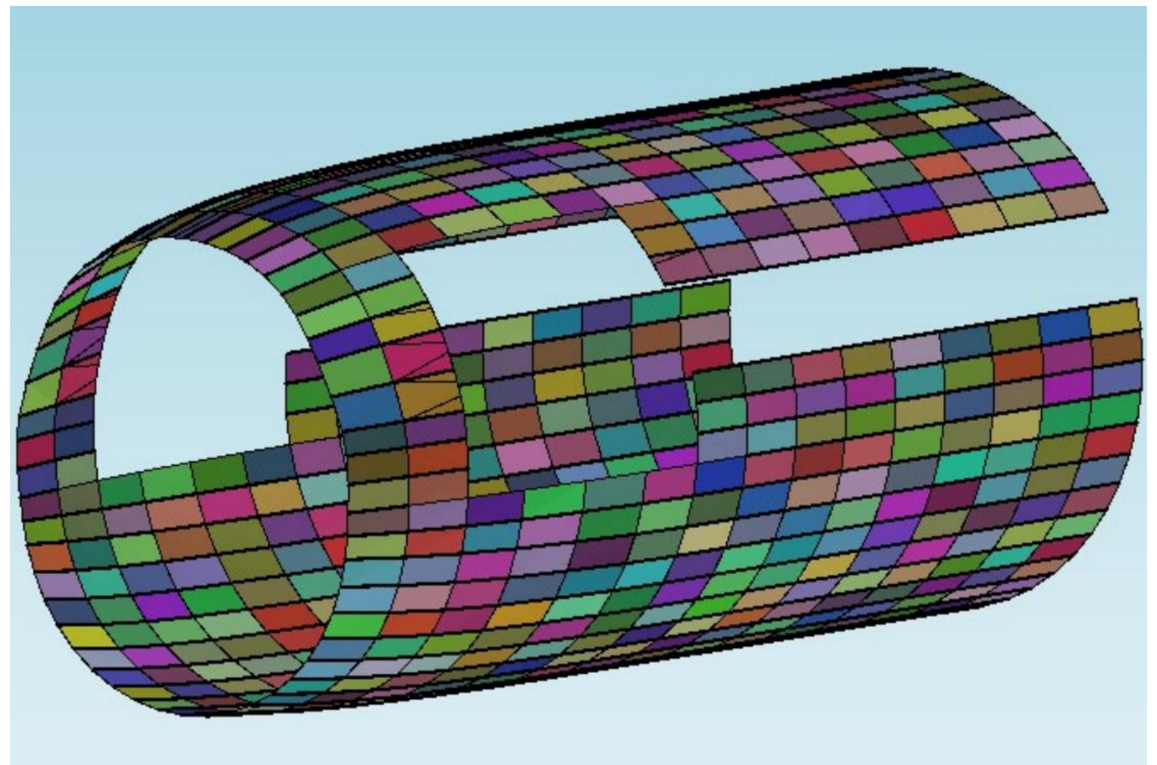
- Began usage in 2022
- Improves concept trade activity efficiency

Lessons Learned

- Things to look out for when converting Hypersizer Model
- Ways of working in HyperX

Optimum solutions on numerous aerospace products

Spirit AeroSystem's use of HyperSizer® on the Bell V-280 Valor Tiltrotor fuselage



Spirit AeroSystems as participant in Hi-Rate Composite Aircraft Manufacturing (HiCAM) project

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

	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

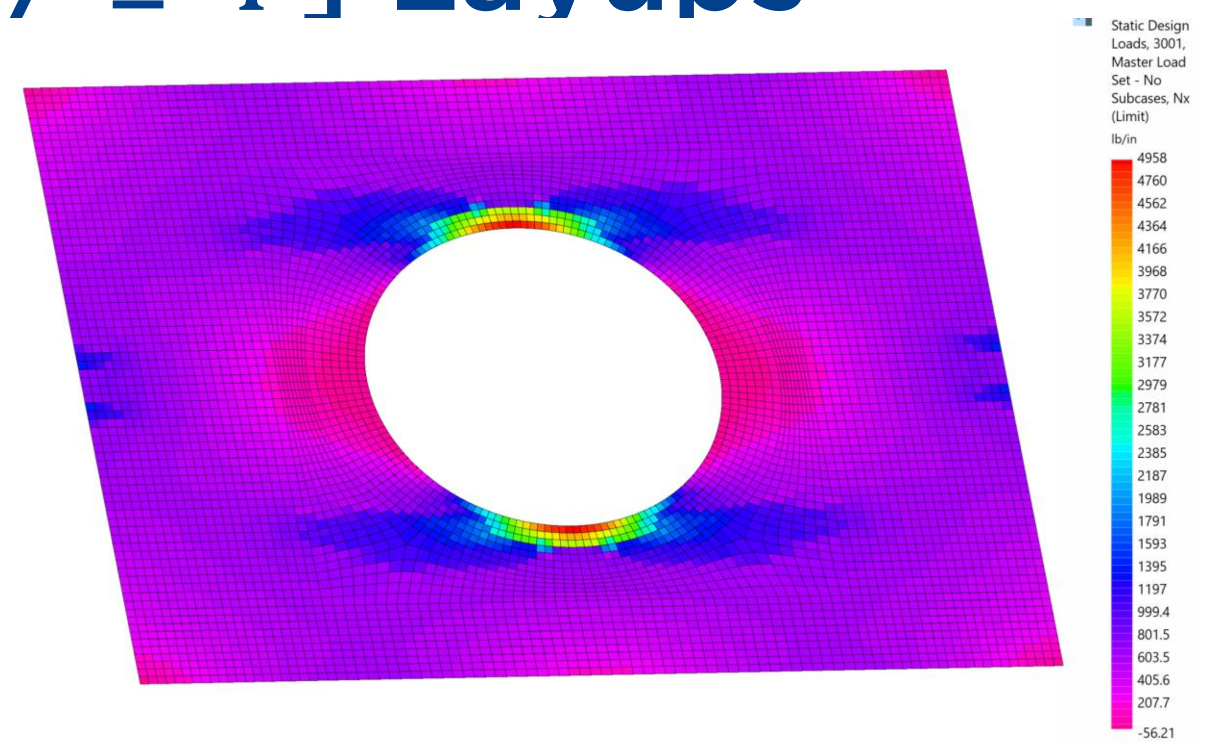
Double-Double [± Φ / ± Ψ] Laminate Family

	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

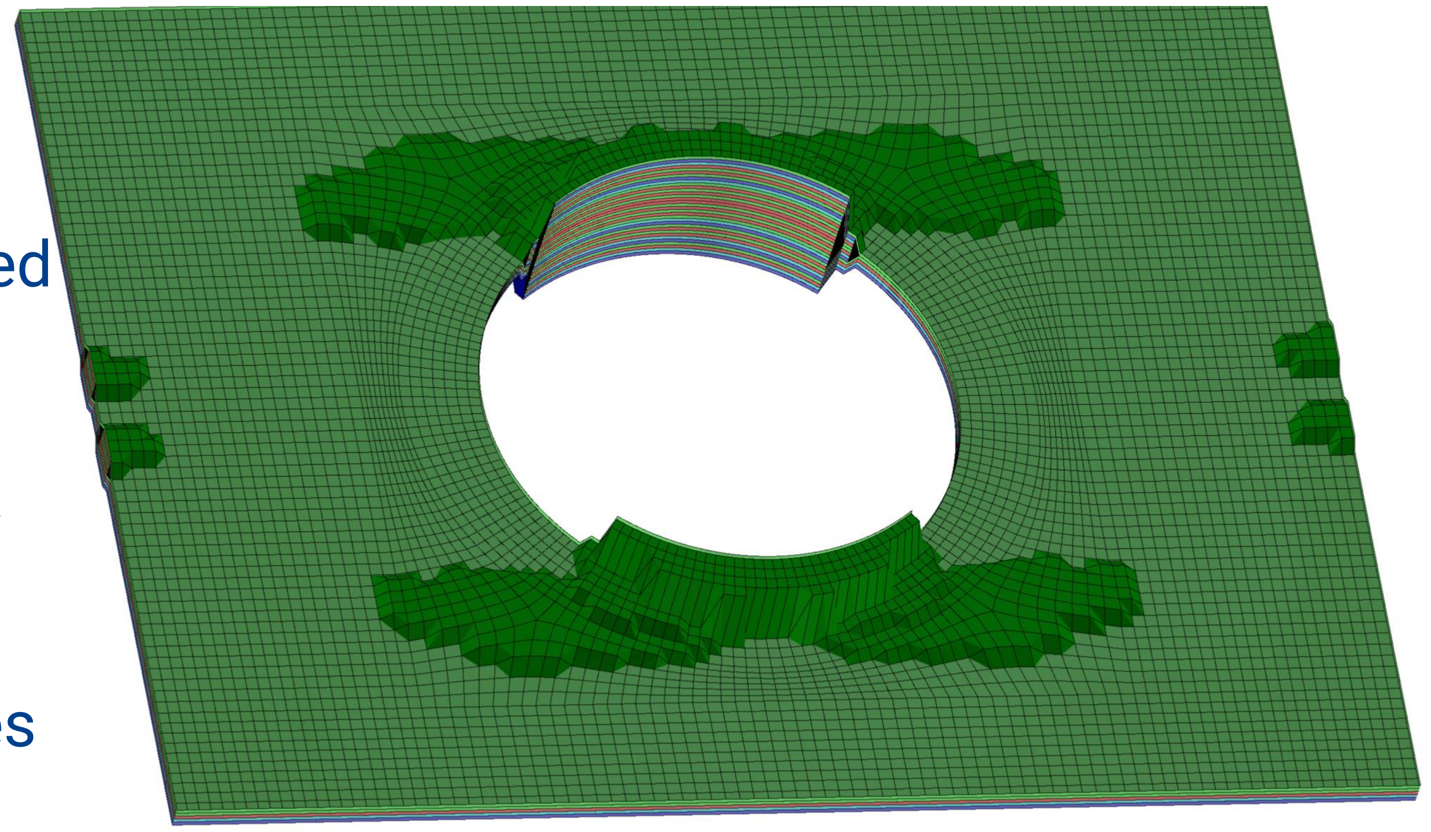
Summary Weight and Producibility Comparisons

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				

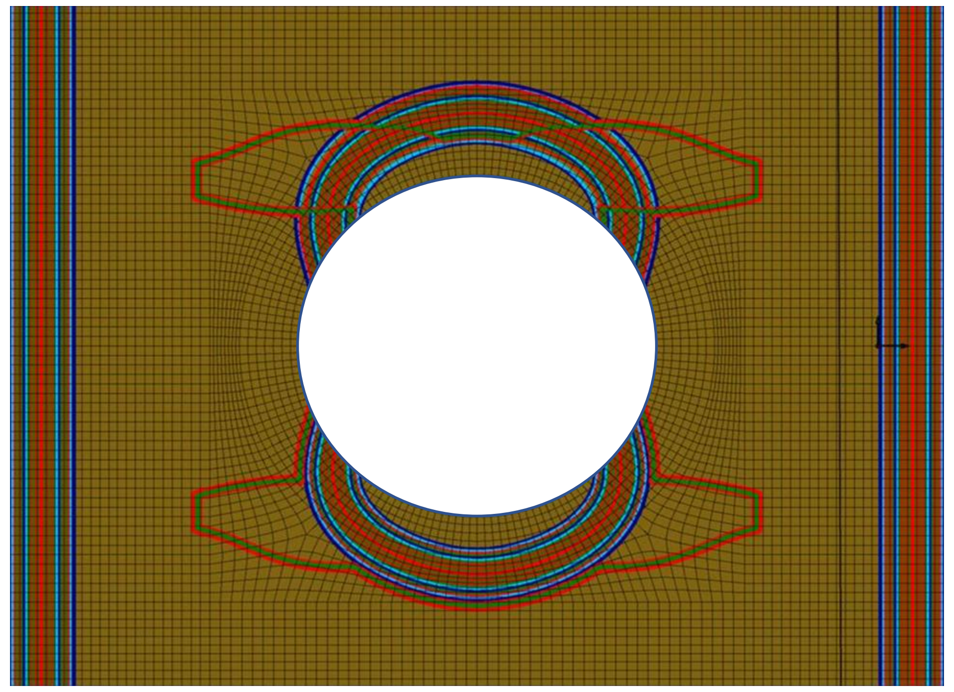
FEA Loads



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

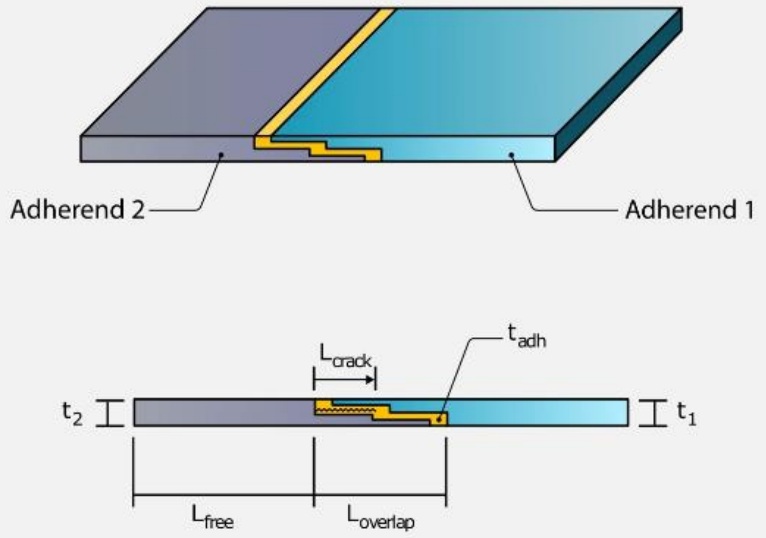


Actual ply shapes as defined with ply drop ramp limits on CAD surface as curves for part fabrication

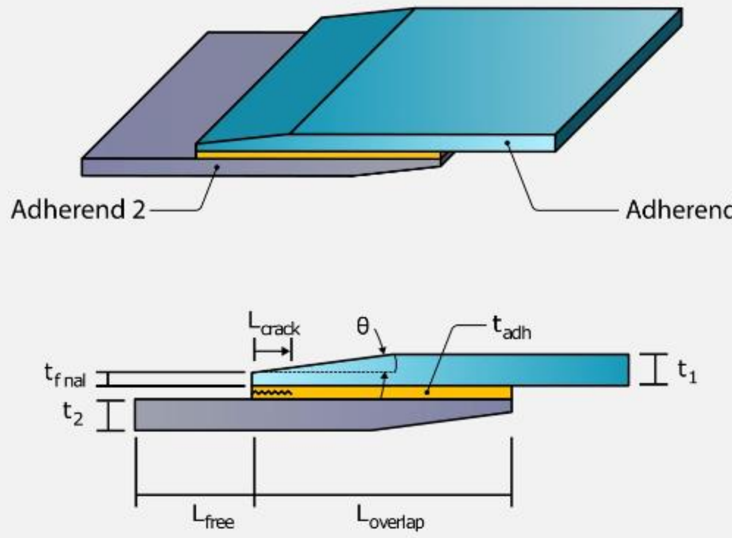


Day 2: Bonded Joints

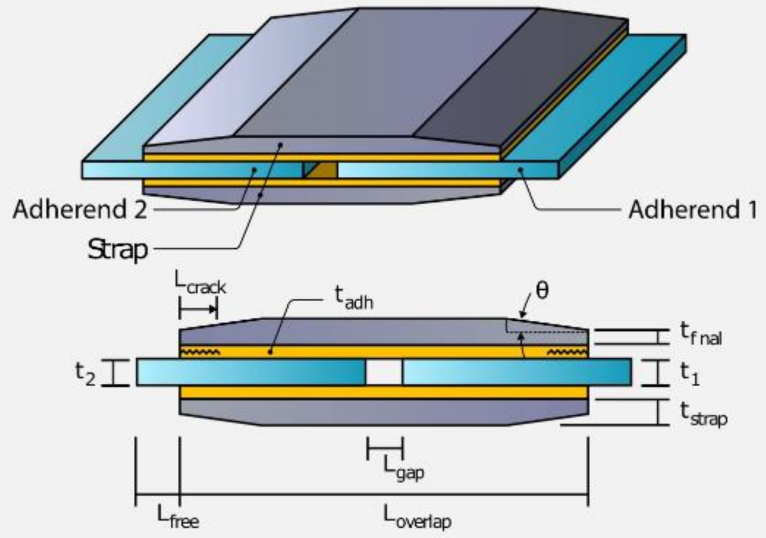
Stephen Jones – Collier Aerospace
Manager Software Development



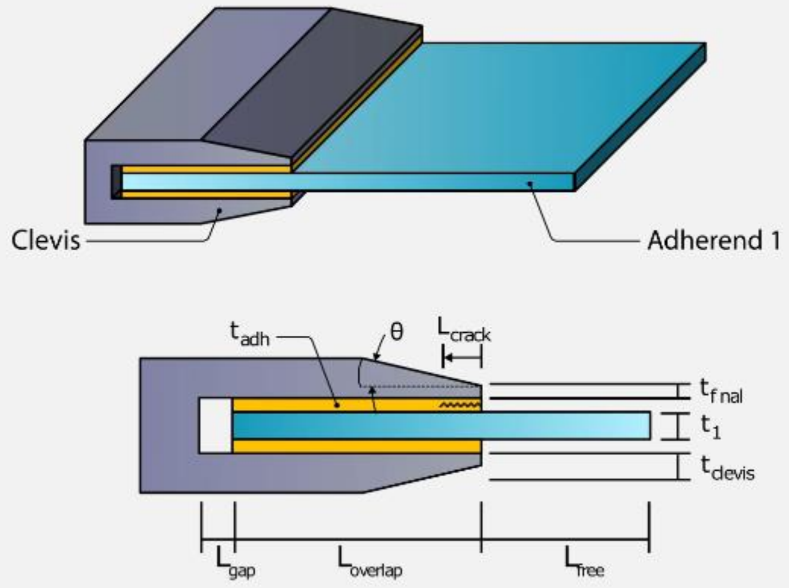
Single lap stepped



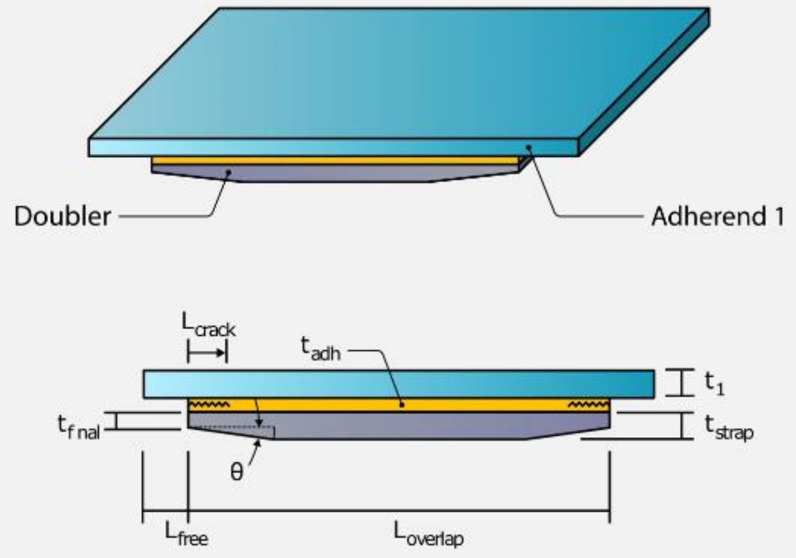
Single lap tapered



Double lap tapered



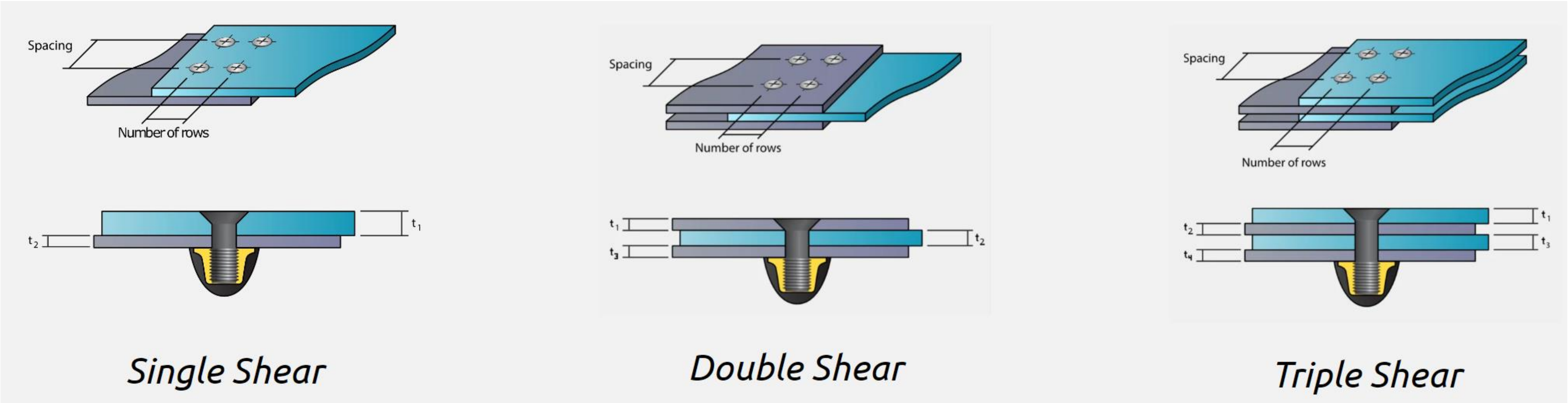
Clevis



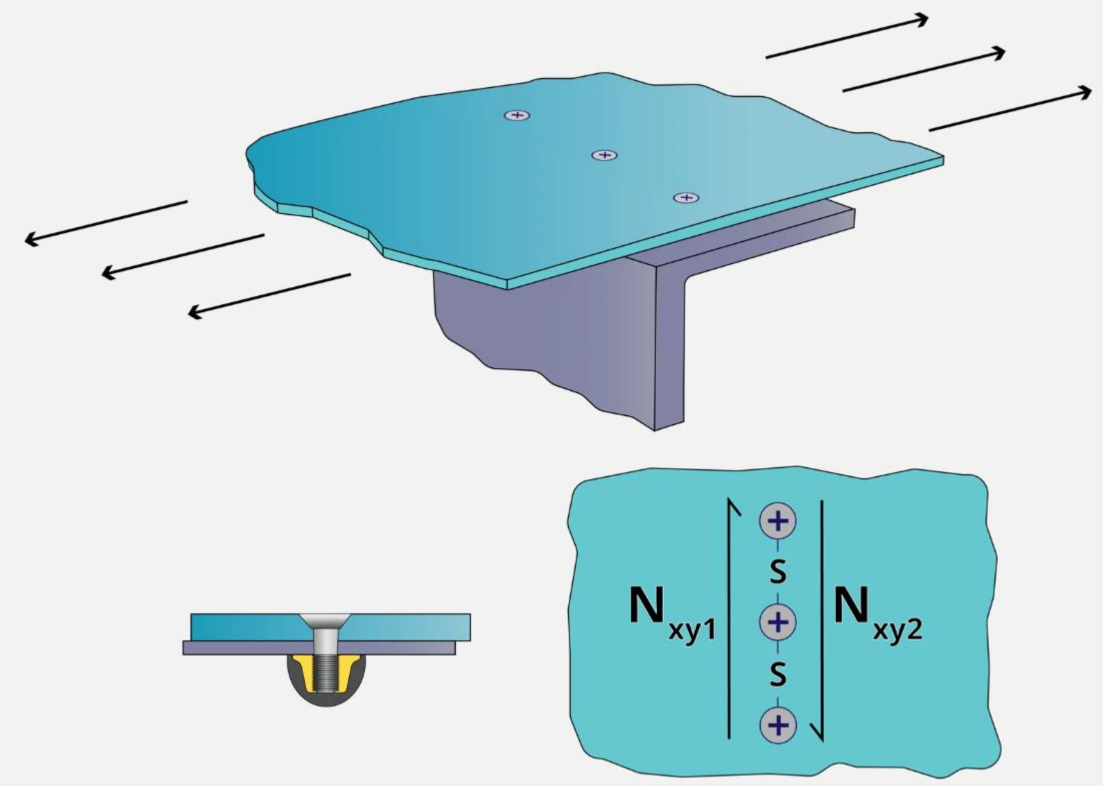
Double tapered

Day 2: Fastened Joints

James Ainsworth – Collier Aerospace
Managing Director of Engineering

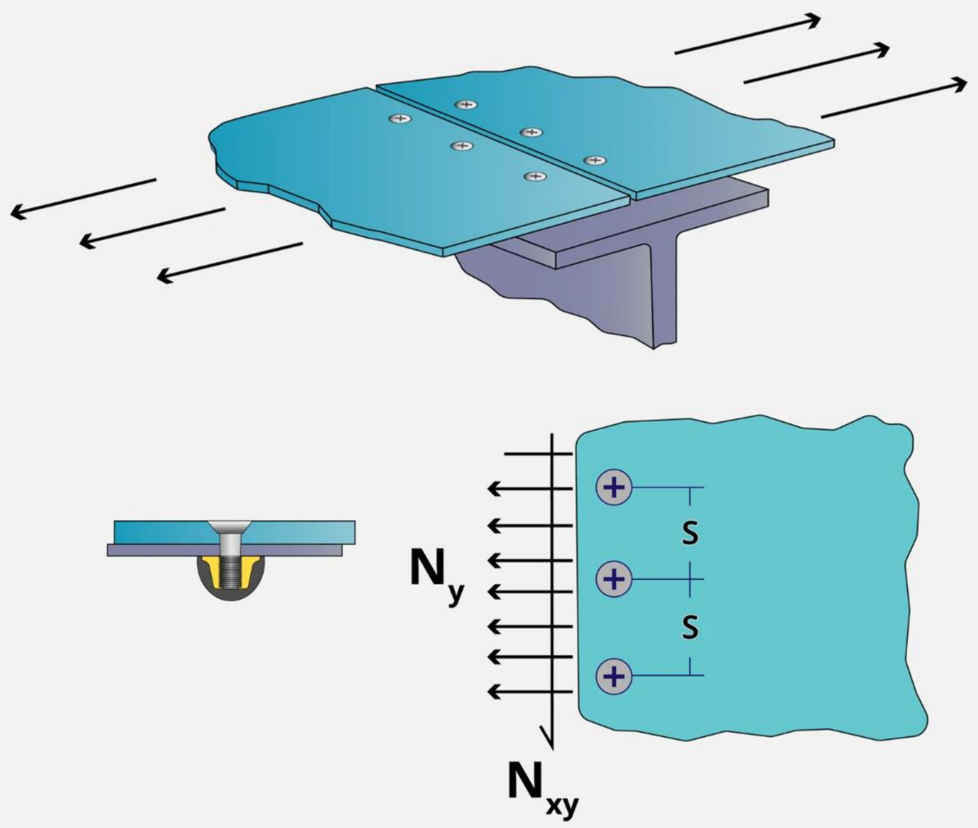


Continuous Skin



$$f_{bearing} = \frac{1}{Dt}\left|N_{xy1} - N_{xy2}\right| S \qquad f_{bypass} = \frac{1}{t}\sqrt{N_x{}^2 + N_y{}^2}$$

Discontinuous Skin



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

Lunch

June 14-15, 2023

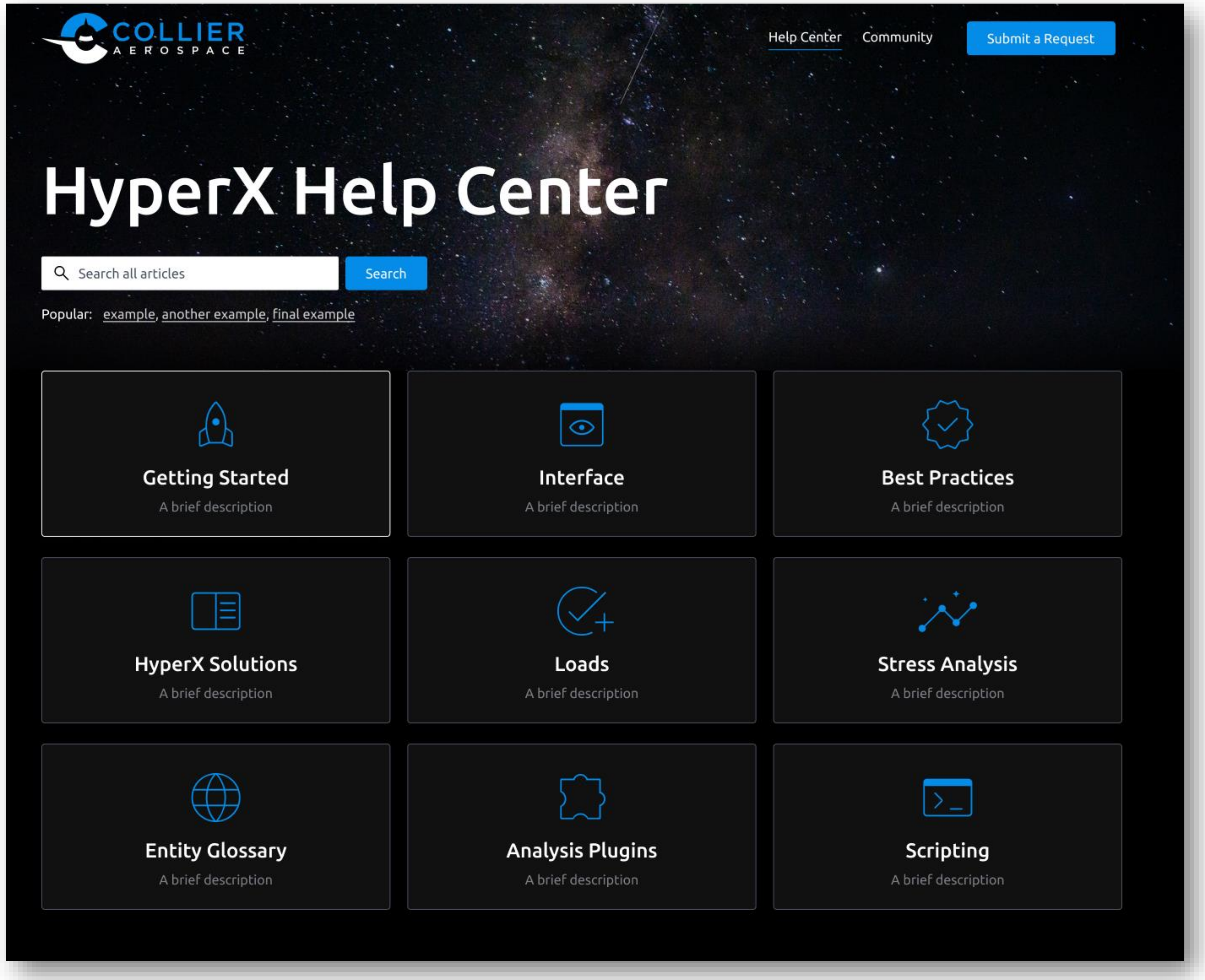
Day 2: Rolling out New Customer Support Tools – How to get Help

Charli Cahill – Collier Aerospace
Manager of Customer Development

HyperX Help Center
- Use a single login to have the full power of our support team at your fingertips

Documentation:
- Help System Pages
- Methods and Verification Training Videos

Interaction with us and other users:
- Ticket System
- User Forum



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

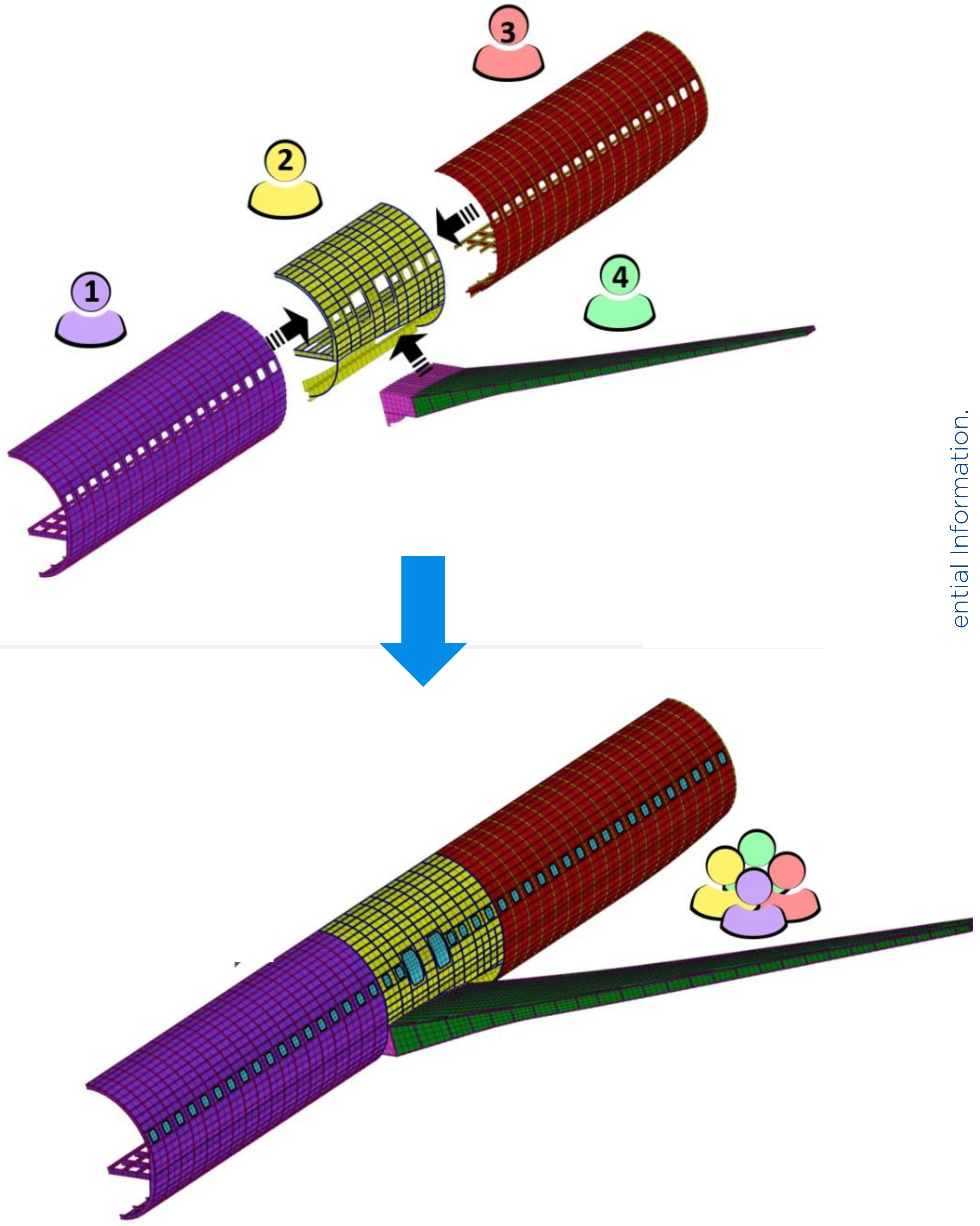
James Ainsworth – Collier Aerospace
Managing Director of Engineering

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



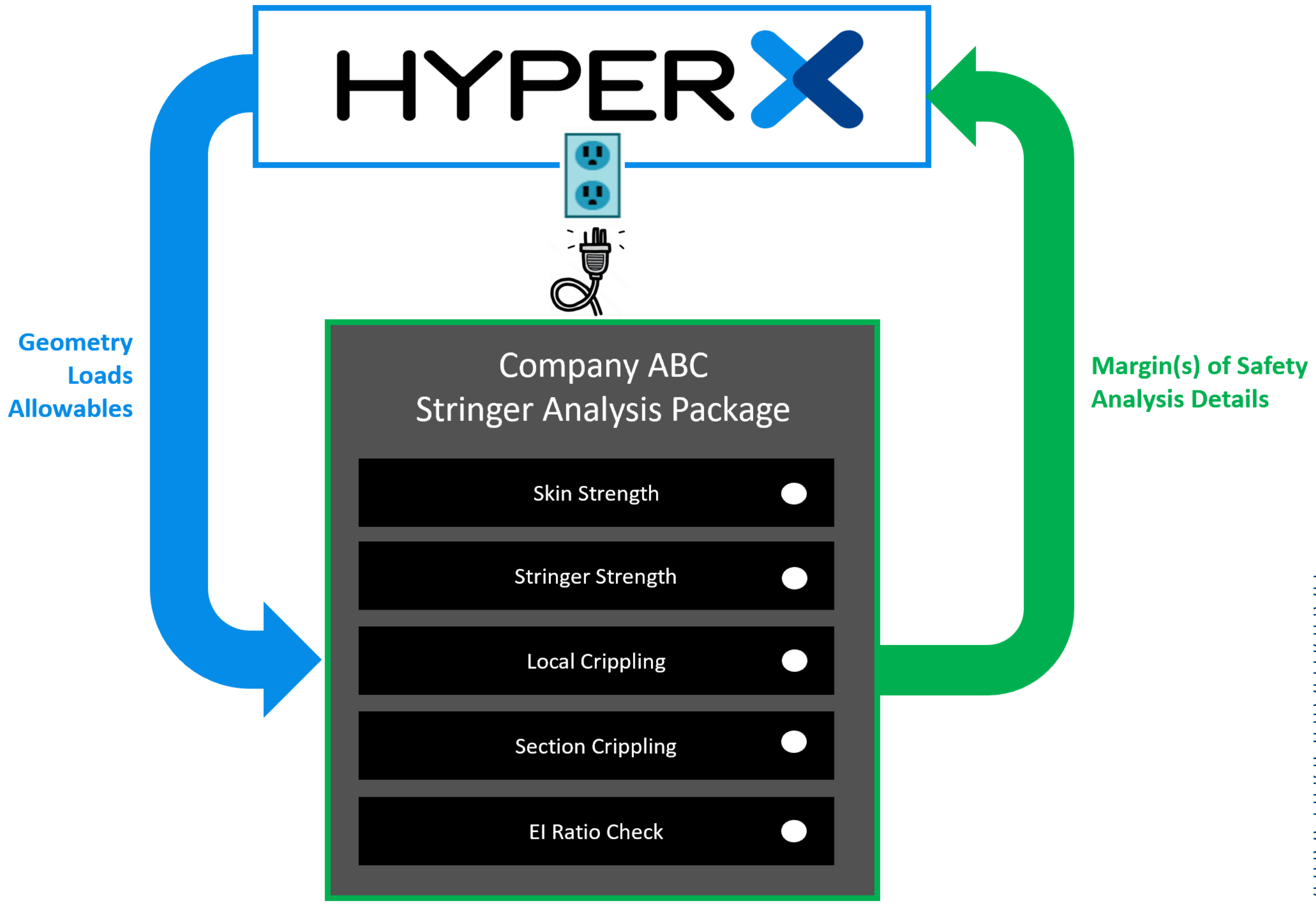
Automatically separate-out individual part databases from a single internal loads GFEM. Size all parts independently, maintaining consistent assumptions, then recombine into one full-structure database.

Day 2: Customer Customization: Bottom-Up with Plugins

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

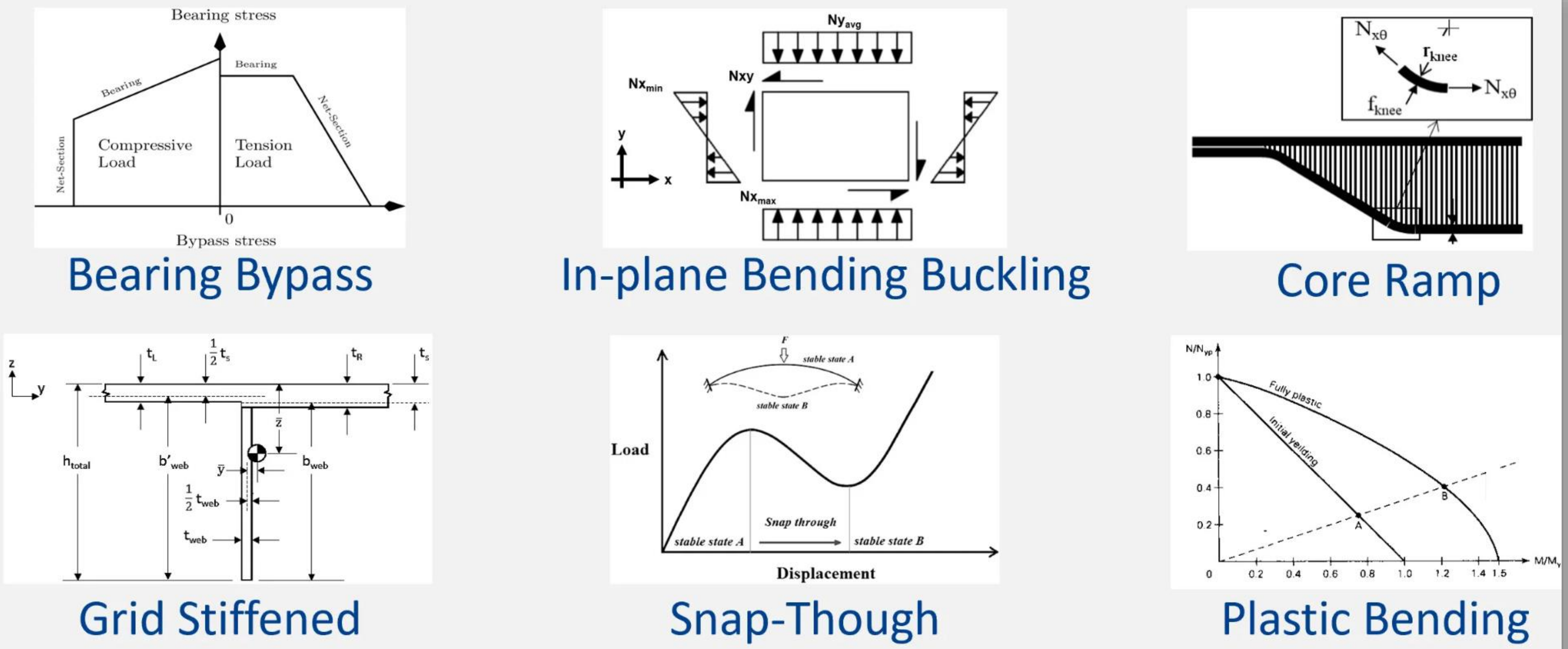
Plugins

- **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



Example non-proprietary plugins available with a HyperX license.

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

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 Business Jet OEM Customer

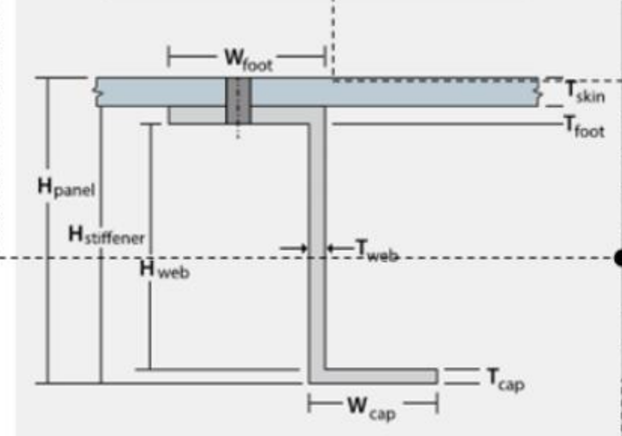
Brenden A. Autry
Verification and Refinement of an Aircraft Structural Design and Optimization Tool, ATLASS

Figure 11. Global Structural Finite Element Model

```
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.')
```

Group: Default Group 64 | 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

June 14-15, 2023