Deploying HyperX at Scale

Conceptual Design through Part Release

Background and Program HyperX Impact

Carey Cross – Engineering Sr. Manager

Mission and Vision

Delta Spaceship

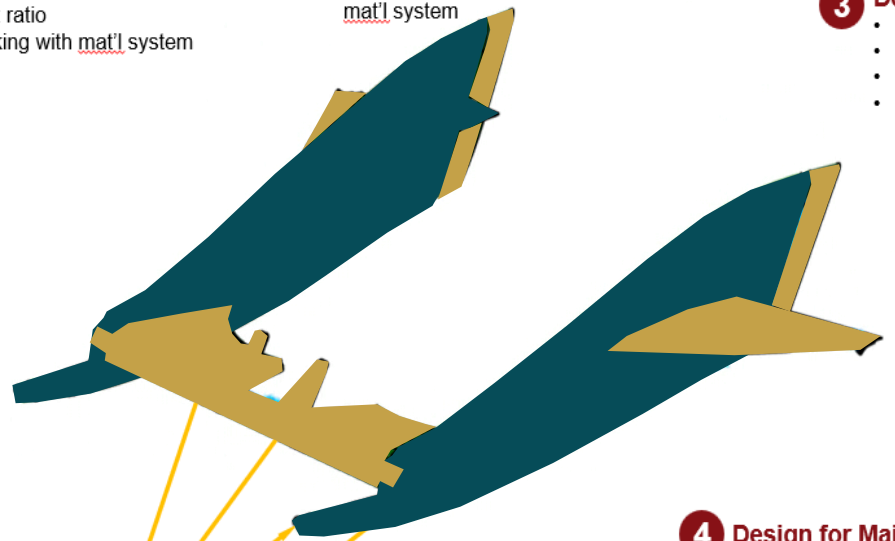
Feather System Overview

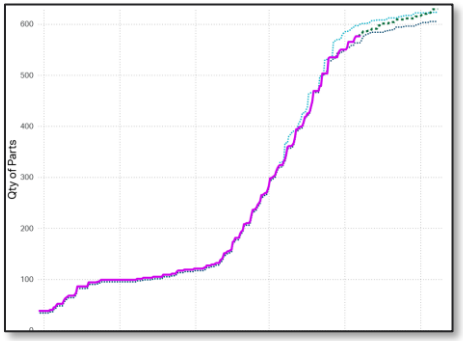
1 BMI Skins
- High temperature performance enables reduction of baseline TPS
- Good stiffness to weight ratio
- Bell is experienced working with mat'l system

2 Metallic and BMI Substructure
- Al 7050 for complex loaded joints
- BMI for weight reduction and single composite mat'l system

3 Design for Manufacturability
- Incorporation of Bell best practices
- Core pan-downs
- Eliminate tool trap
- Design to minimize assy. spans

7 Systems Integration
- Production systems
- Health monitoring
- Flight test instrumentation





Feather Part Release Curve

5 Major Interfaces
- Wing hinge fittings (4 pl)
- Feather actuators (2 pl)
- Tusk lock fittings (2 pl)
- Flight control actuators (6 pl)

4 Design for Maintainability and Producibility
- Change from bonded to bolted joints
- Tailor accessibility to bolted joint configuration while minimizing weight impact

Feather and Flight Control Surfaces Team

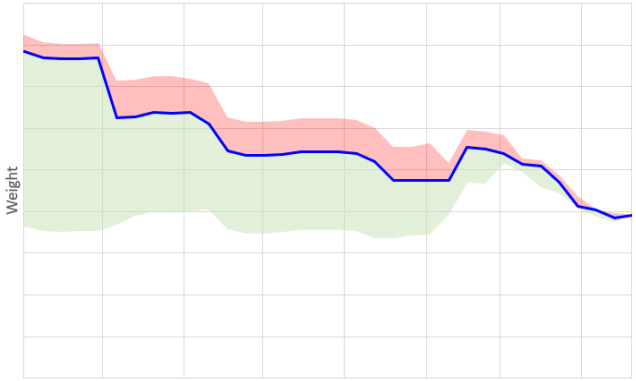
Virgin Galactic

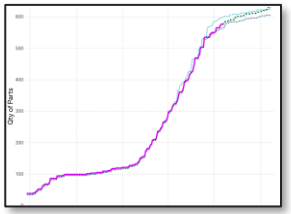
Design authority
Ship level mass properties
Flight sciences, mech sys, etc.

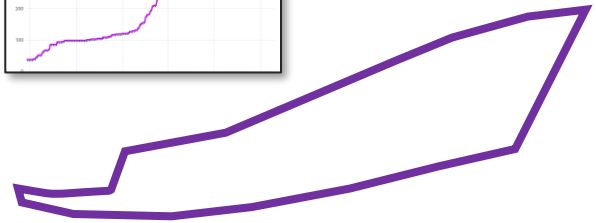
Engineering design
Structural analysis
Subsystem mass properties
BFEM creation / maintenance

Structural analysis
Plugin creation and support
Resource bench strength

Program Phases





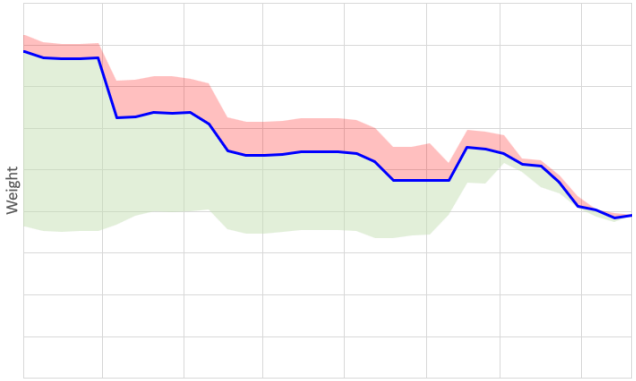


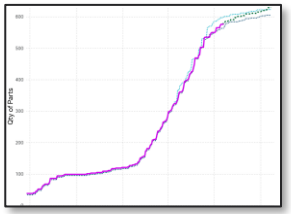
Preliminary Design

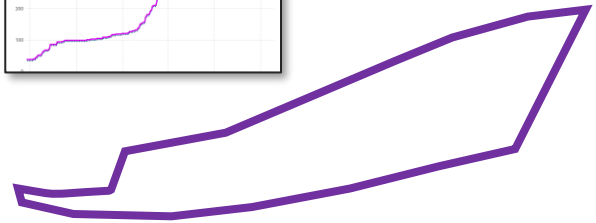
Weight Out Challenge

Detail Design

Program Phases

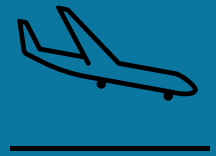






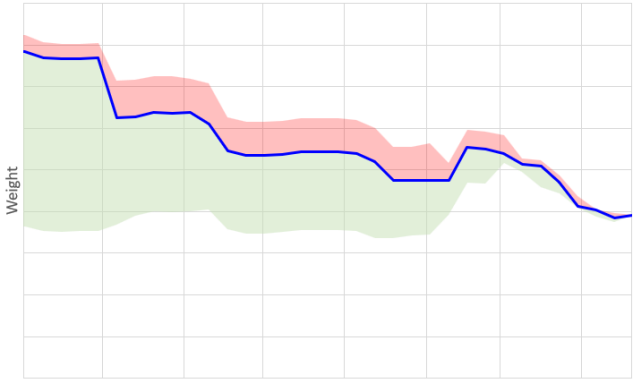
Preliminary Design

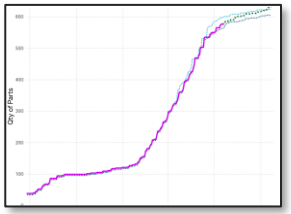
Weight Out Challenge

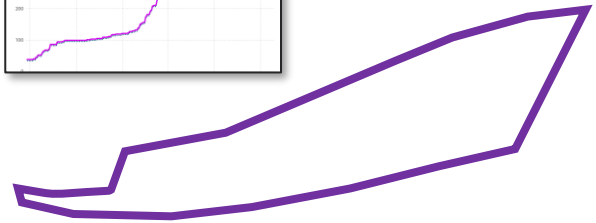


Detail Design

Program Phases







Preliminary Design

Weight Out Challenge

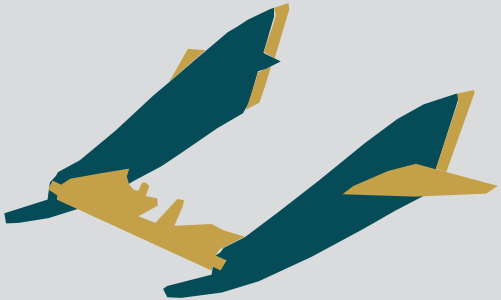
Detail Design

Integrated Product Team Perspective

Jorge DeLeon – IPT Manager, Boom and Strake

Analysis Process Planning | Tools

Prelim Design



Nastran

Patran

SLIM/
Vision

COLLIER AEROSPACE HYPERX

Hyperworks

Ansys

Excel

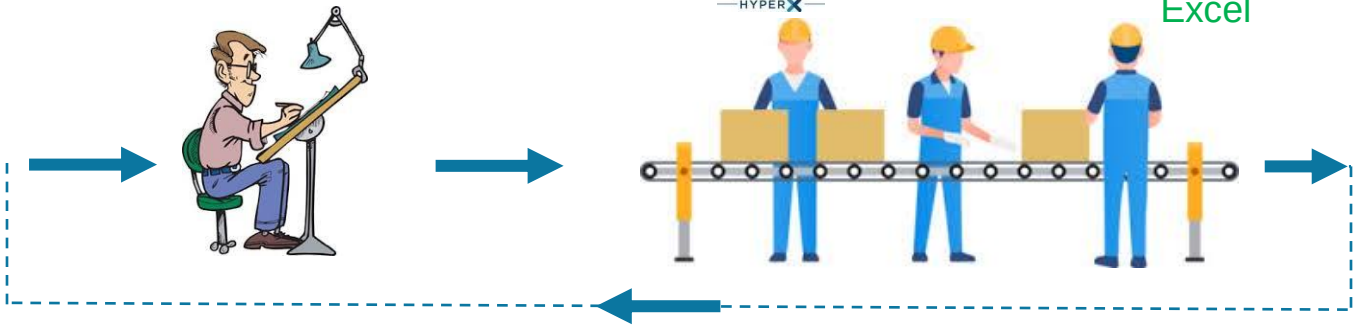
Python

Weight-Out

Detail Design

Design Engineering

Stress Engineering

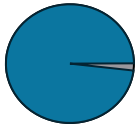


Analysis Process Planning | Workflow

Prelim Design

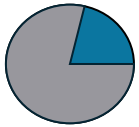
Weight-Out

Detail Design



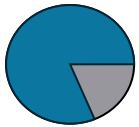
98%

Initial Acreage Sizing



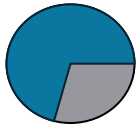
20%

Stability Analysis



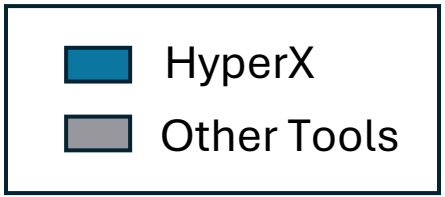
80 %

Initial Joint Sizing



70 %

Final Sizing Review & Stress Notes



Return of the Weight Targets

Prelim Design

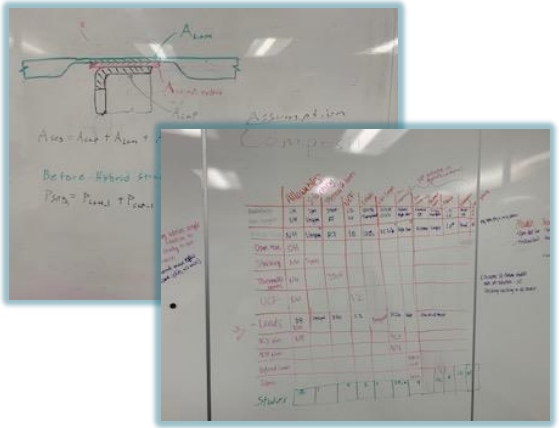
Weight-Out

Detail Design

Initial projections tracked feather to be heavier than desired

People / Tools / Process / Workflow / Methods

$$\text{AC Weight} = \frac{1}{C * Schedule}$$

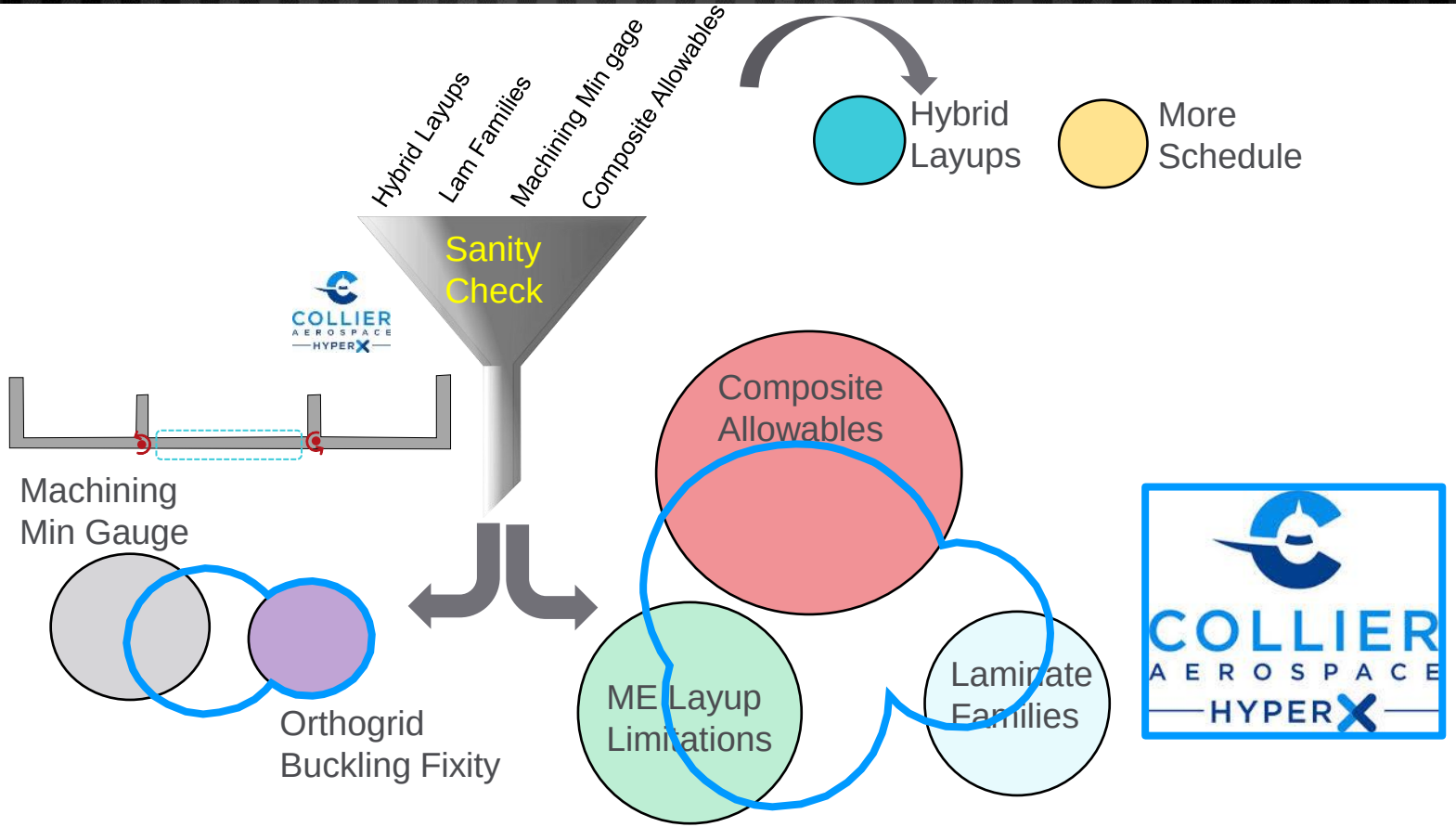


Stress Strikes Back

Prelim Design

Weight-Out

Detail Design



A New Sizing Hope

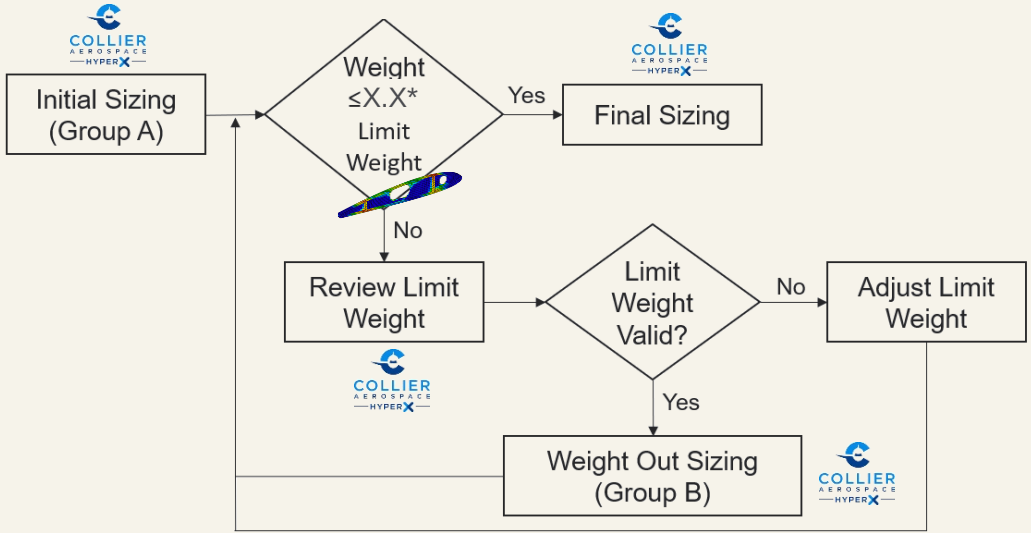
Prelim Design

Weight-Out

Detail Design

Implementing New Stress Analysis Process

Sizing Decision Workflow

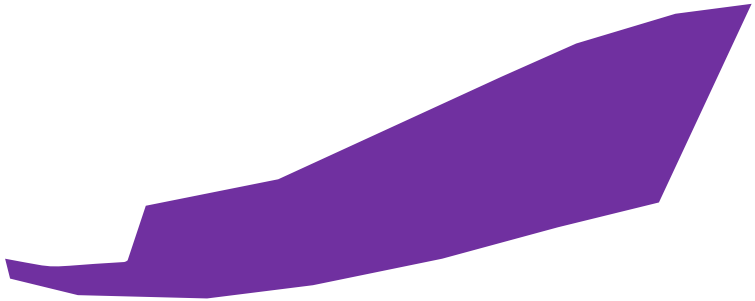


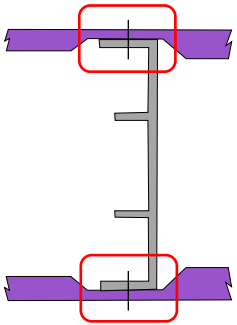
Prelim Design

Weight-Out

Detail Design

Road to Lands Locked





Bell Engineers

Collier Engineers

Closure of all weight studies

Sizing of all boom skins

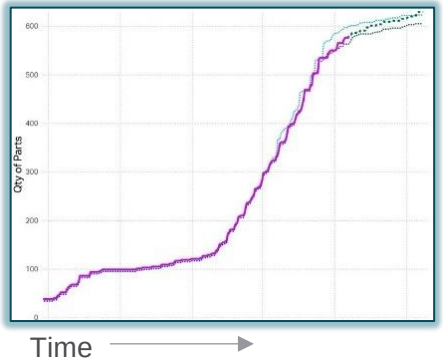
Sizing of all substructure caps

Prelim Design

Weight-Out

Detail Design

Part Release Grind



Collaborate (Disciplines & Companies)

Trust decisions

Follow established processes

Innovate and enjoy the challenge

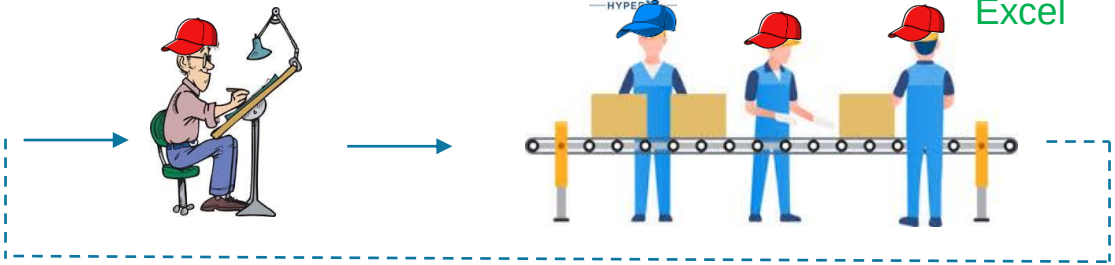
Design Engineering

Stress Engineering

Nastran

Patran

Excel



Leading a Stress Team of HyperX Users

Alessandro “Max” Silva – Stress Lead, Boom and Strake IPT

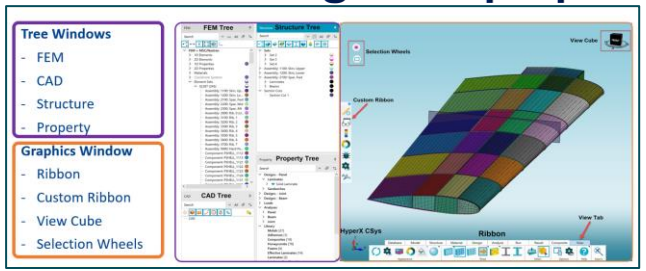
HyperX Knowledge Ramp Up

Prelim Design

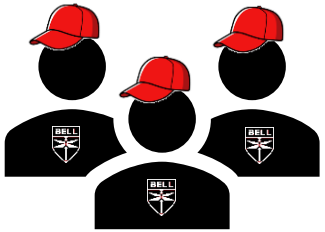
Weight-Out

Detail Design

HX Knowledge Ramp Up



Training Analysts



Sizing Parts

Preliminary Design

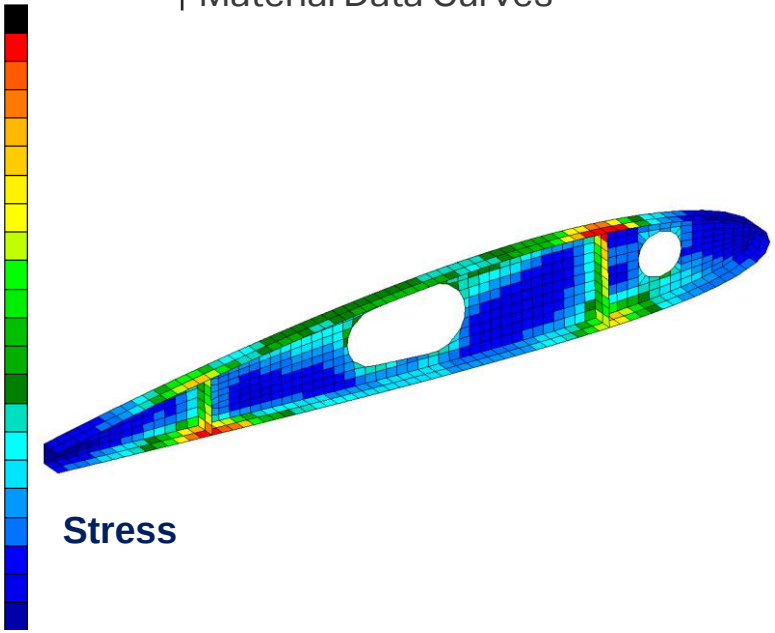
Prelim Design

Weight-Out

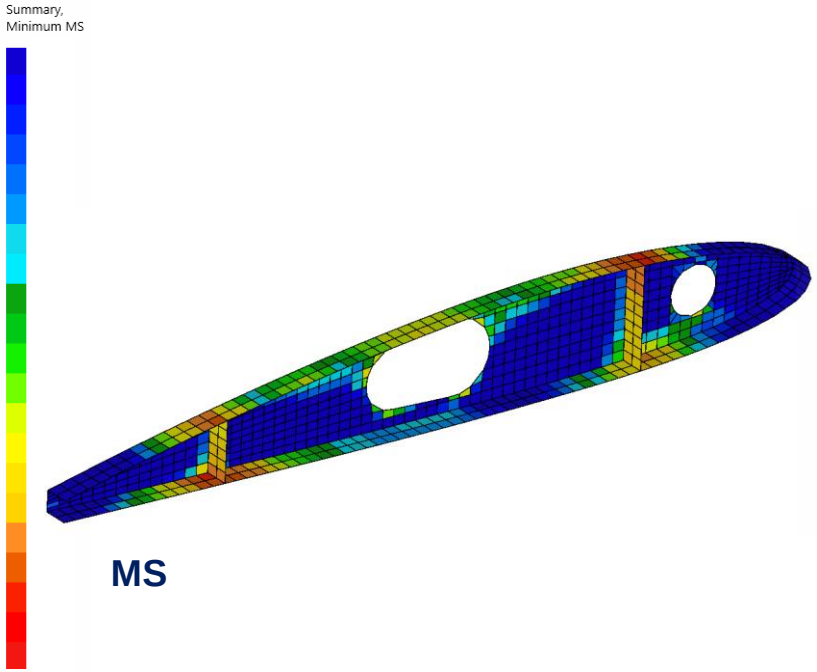
Detail Design

HyperX analysis deep dive

- Understand HX
- Start to build a HX Database
- Aligning HX to Bell's Structural Analysis Methods thru Plugins & Scripts
- Material Data Curves



Stress



MS

Preliminary Design - New FEM

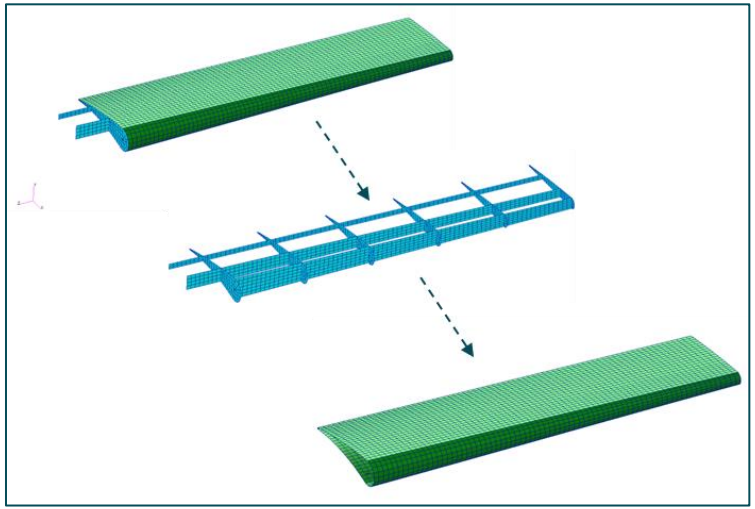
Prelim Design

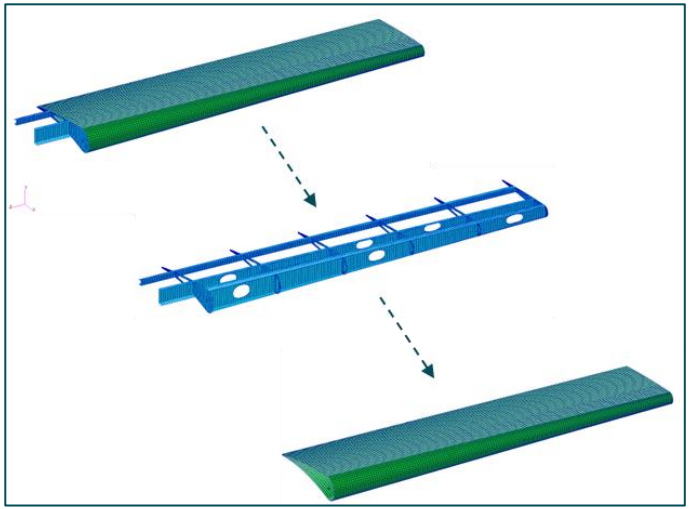
Weight-Out

Detail Design

Tailor the next FEM to maximize the usage of HX

- Refine the mesh to add more details
- Model Fasteners
- Transition from Effective Laminates to Laminate Families





Weight Optimization

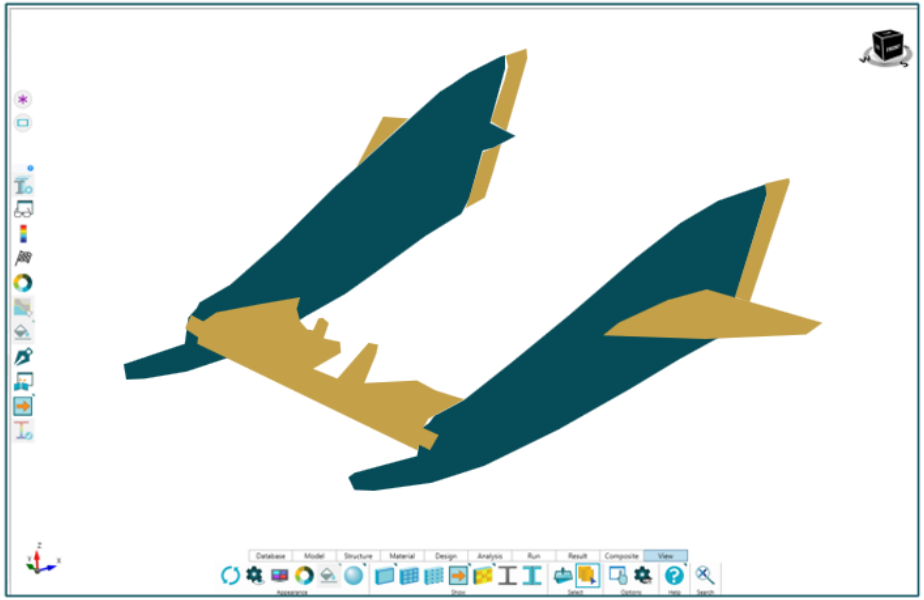
Prelim Design

Weight-Out

Detail Design

HX was extensively Used to do trade studies

- Material Change
- New composite Ply configurations – 100% Fabric vs Hybrid
- New Design Configuration (to improve load path)
- Use HX to combine ideas to reduce weight

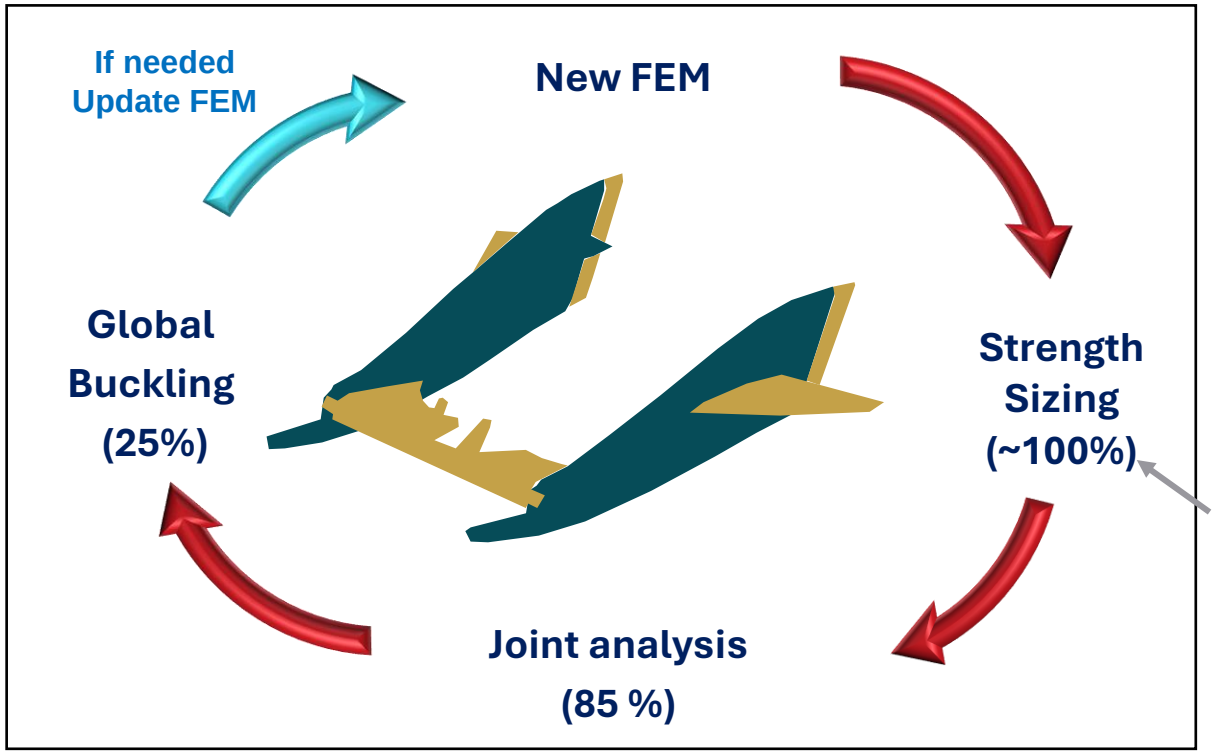


Detail Design – Final Sizing

Prelim Design

Weight-Out

Detail Design



Working-Level Perspective

Justin May – Stress Analyst, Boom and Strake IPT

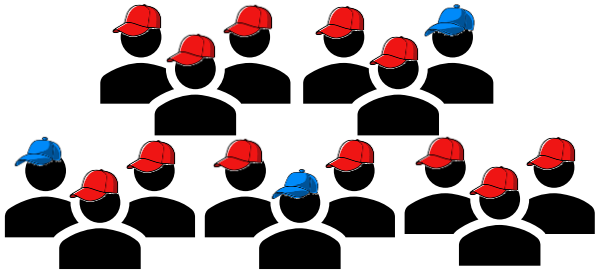
Engineering Services

- Dedicated HyperX technical expertise
- Comprehensive HyperX training
- Custom plugin development and integration
- Tailored workflow automation and optimization
- Resource bench strength
- Structural Analysis

Prelim Design

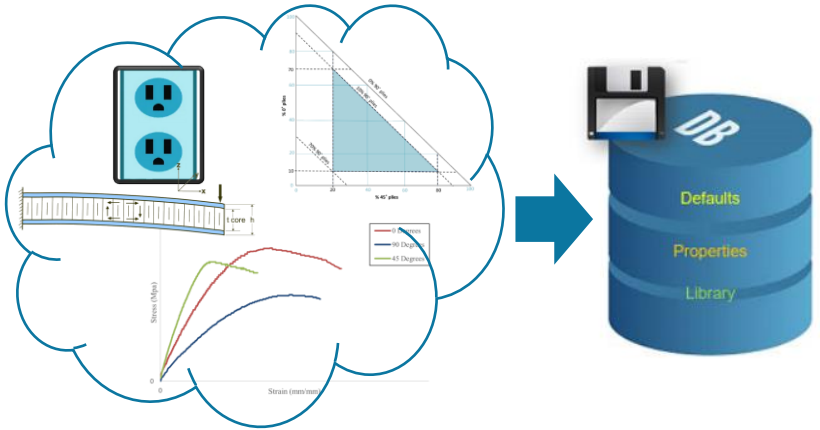
Weight-Out

Detail Design



Bell Engineers
Collier Engineers

Training

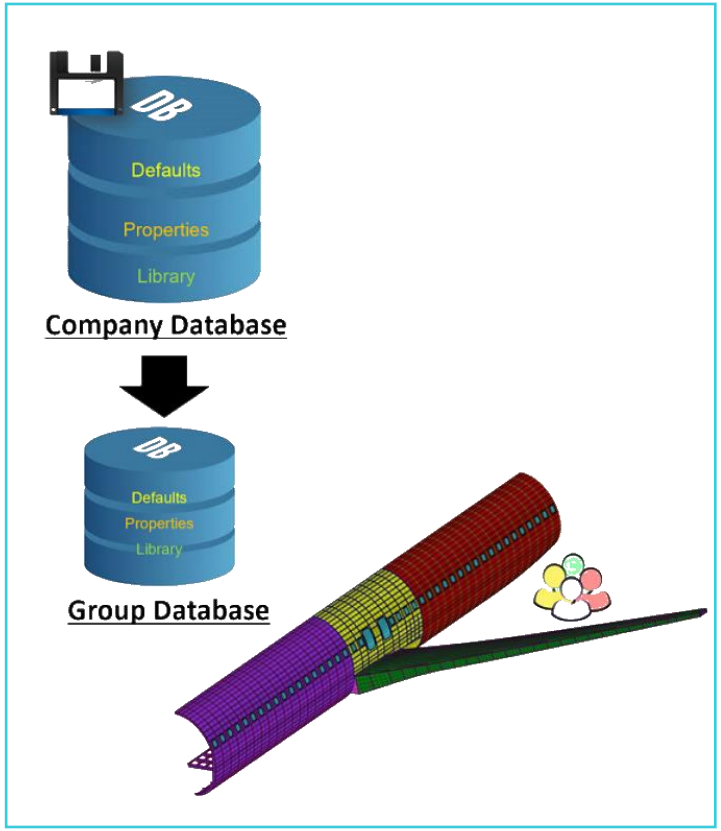


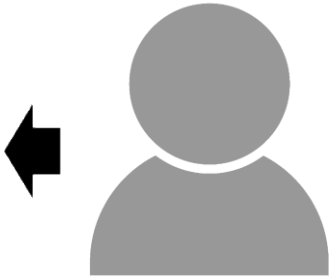
Preliminary Design - Enterprise

Prelim Design

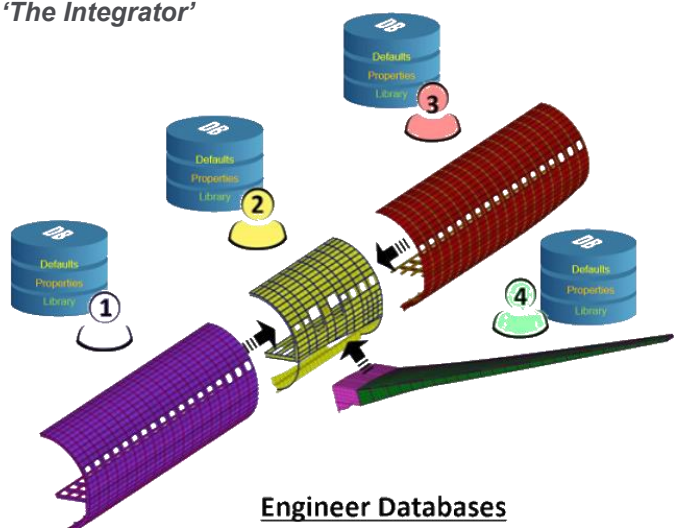
Weight-Out

Detail Design





'The Integrator'



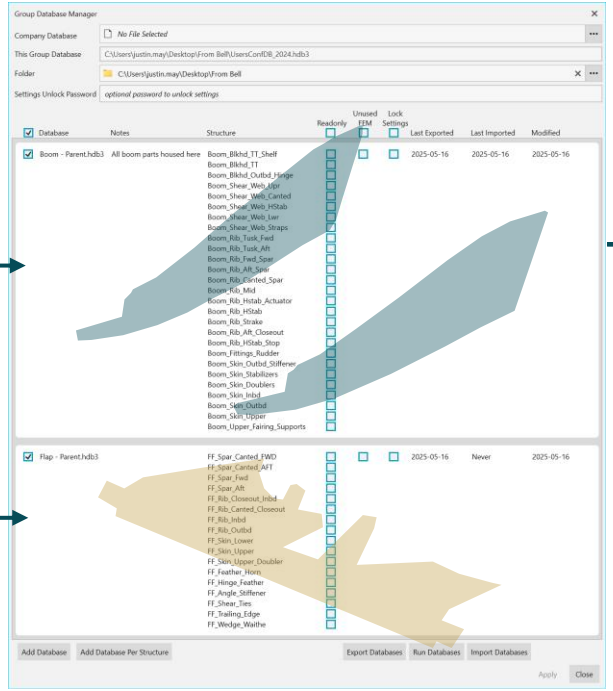
Preliminary Design - Enterprise

Prelim Design

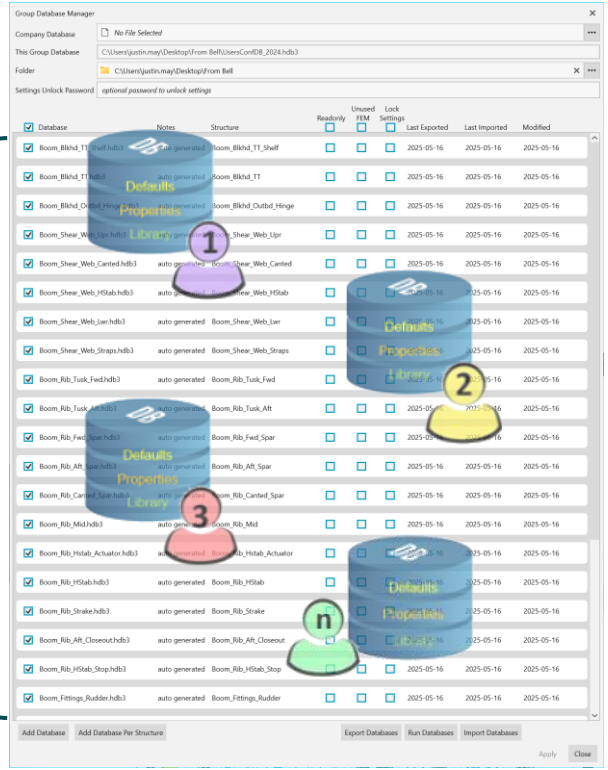
Weight-Out

Detail Design

Group Database



Level 1 Enterprise



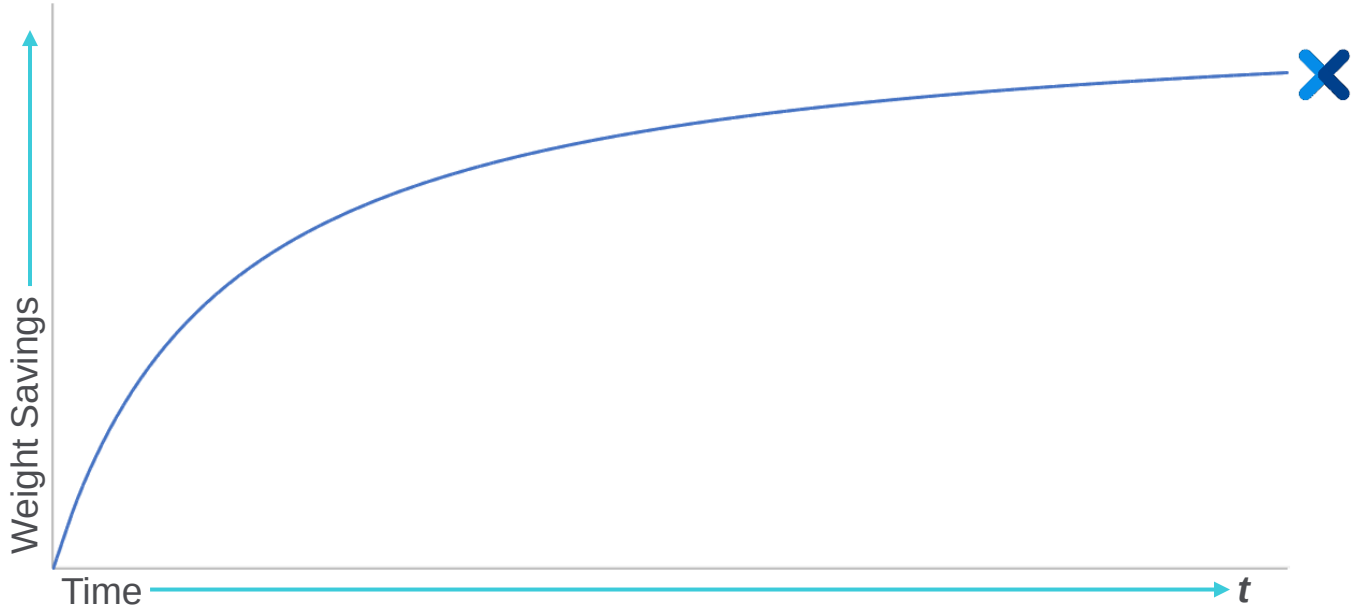
Level 2 Enterprise

Weight Out Challenge

Prelim Design

Weight-Out

Detail Design

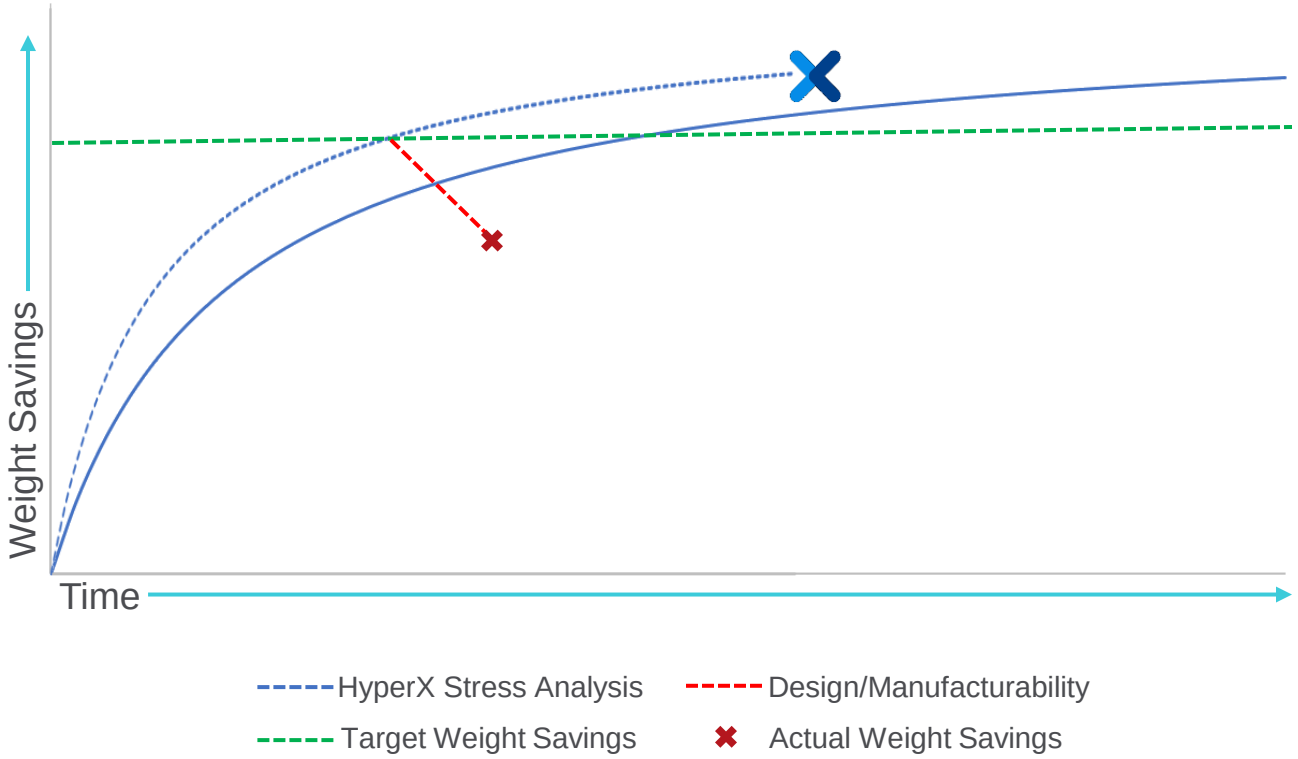


Weight Out Challenge

Prelim Design

Weight-Out

Detail Design



Weight Out Challenge - Stress 🤝 Design

Prelim Design

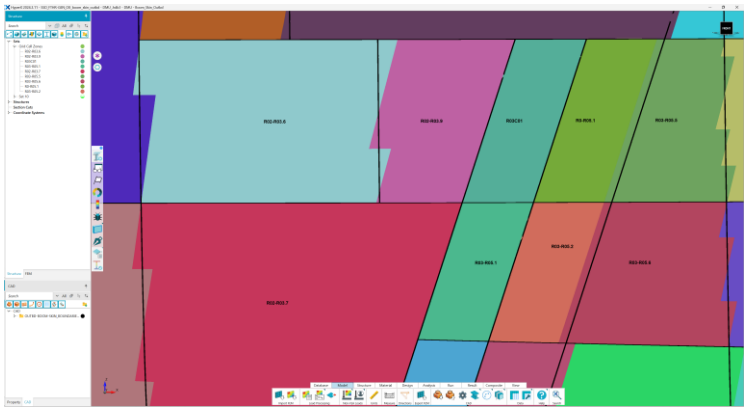
Weight-Out

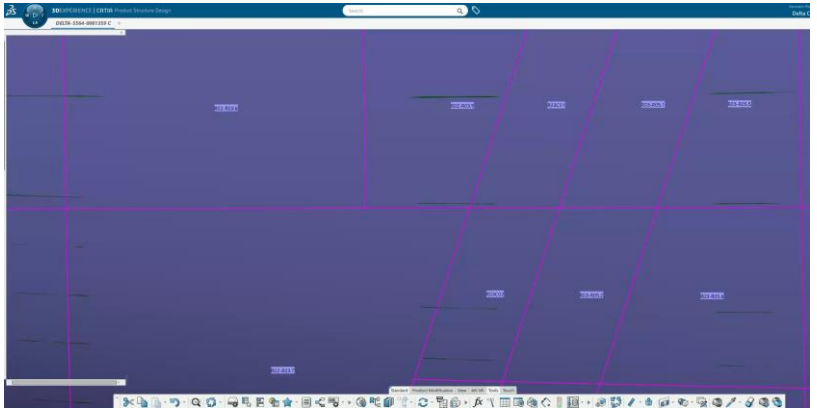
Detail Design

Zone Boundaries (.stp)

Grid Cell Boundaries (.xml)

3DEXPERIENCE®



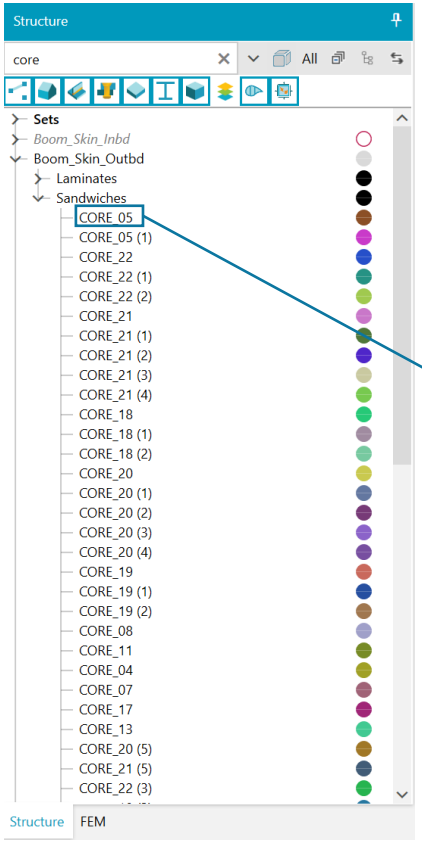


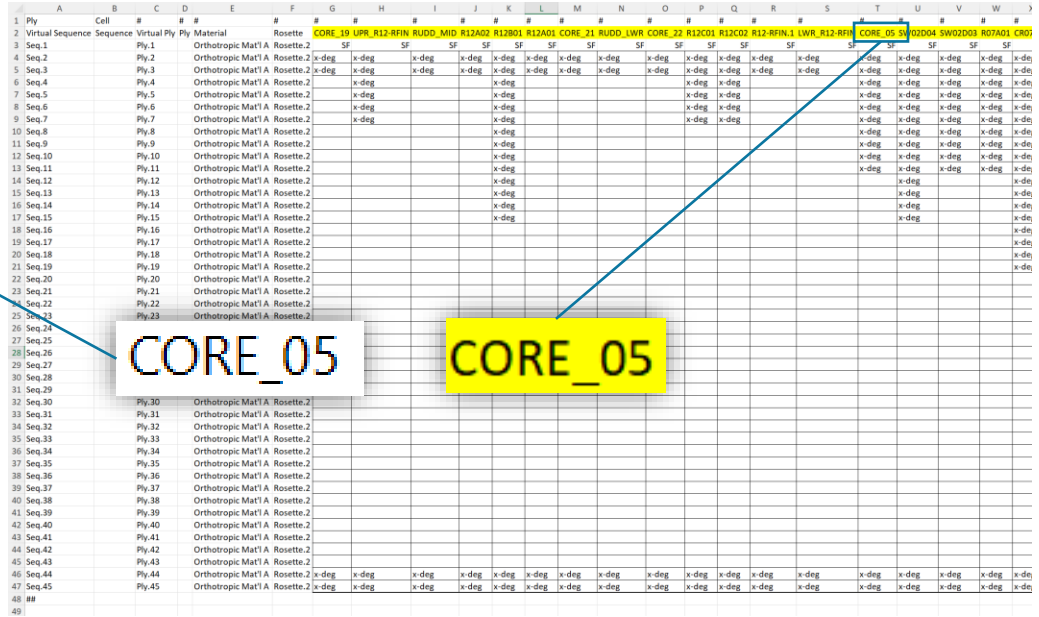
Weight Out Challenge - Stress 🤝 Design

Prelim Design

Weight-Out

Detail Design





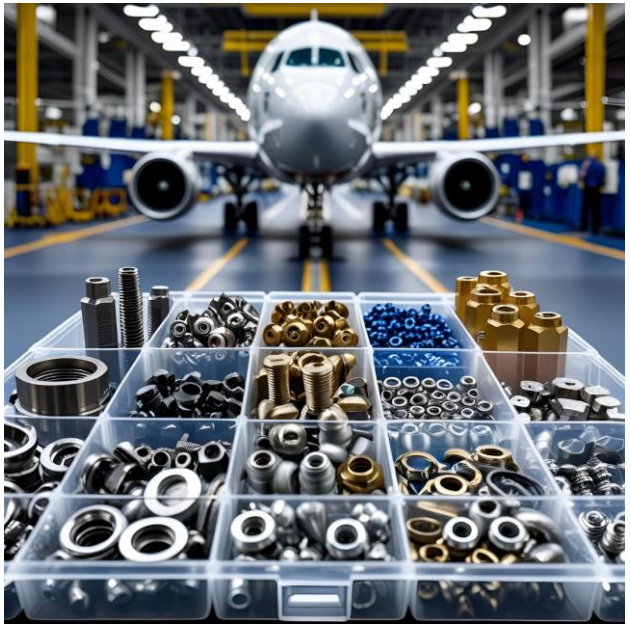
Detail Design

Prelim Design

Weight-Out

Detail Design

Final Strength and Joint Analysis



Part and Assembly Releases

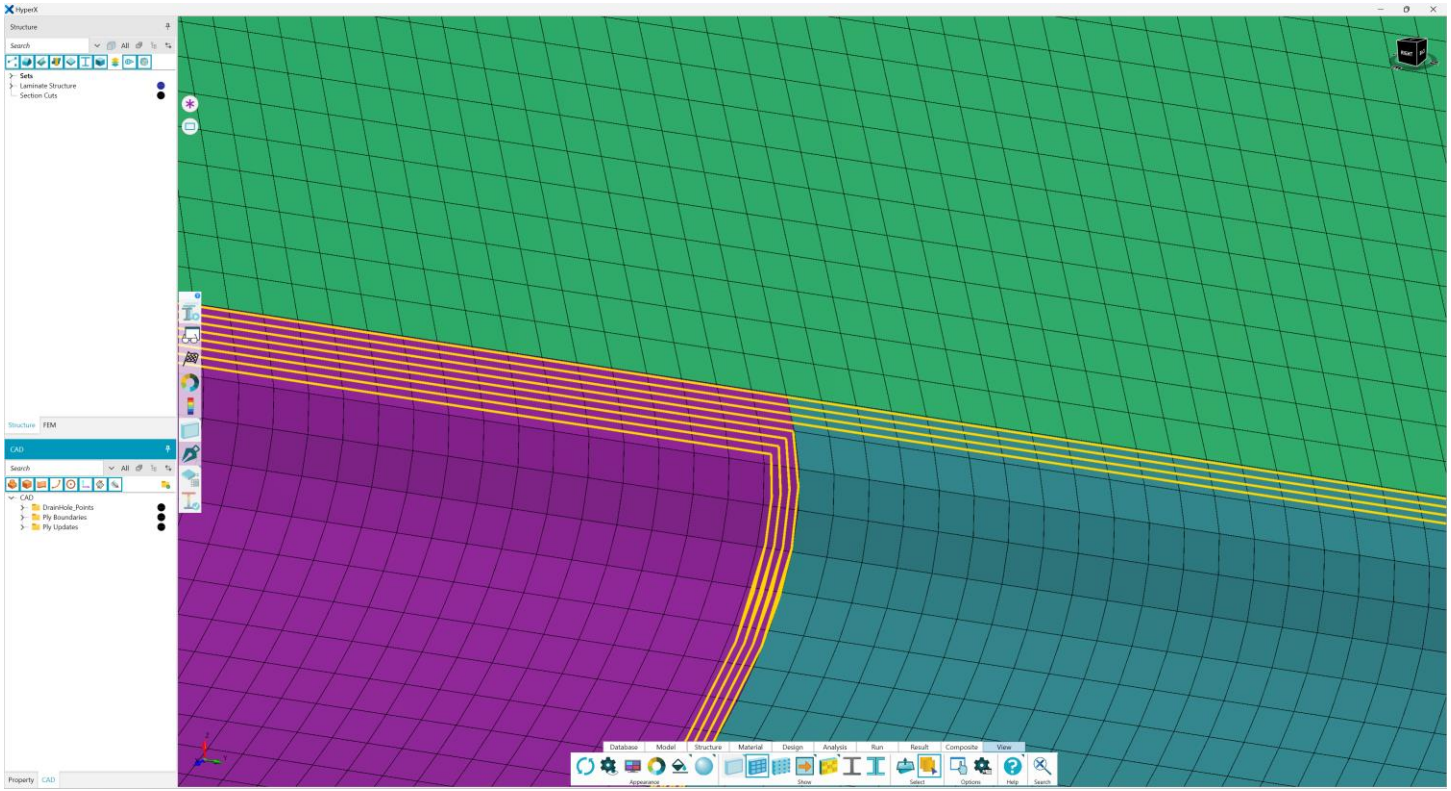
Detail Design – Layup Alignment

Prelim Design

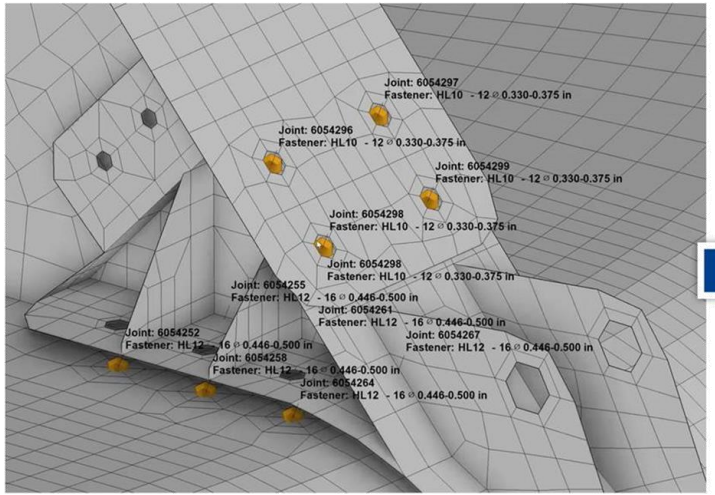
Weight-Out

Detail Design

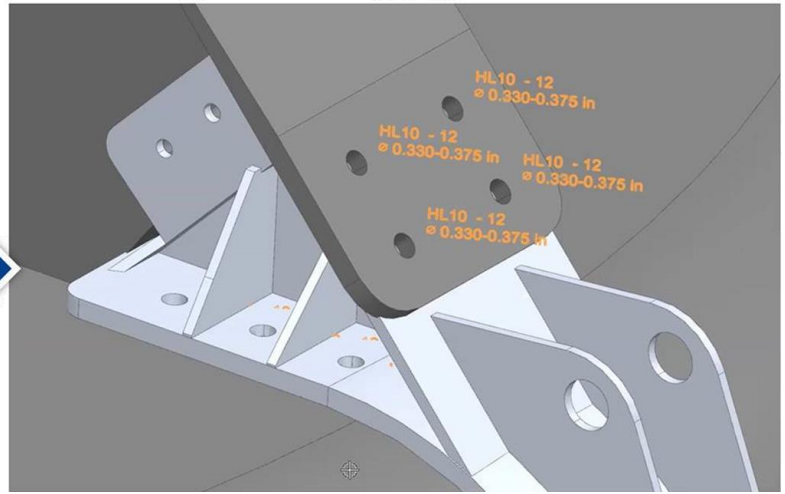
- **Imported Ply Boundaries**



- **Export CAD w/metadata for fastener labeling**



CAD
Software



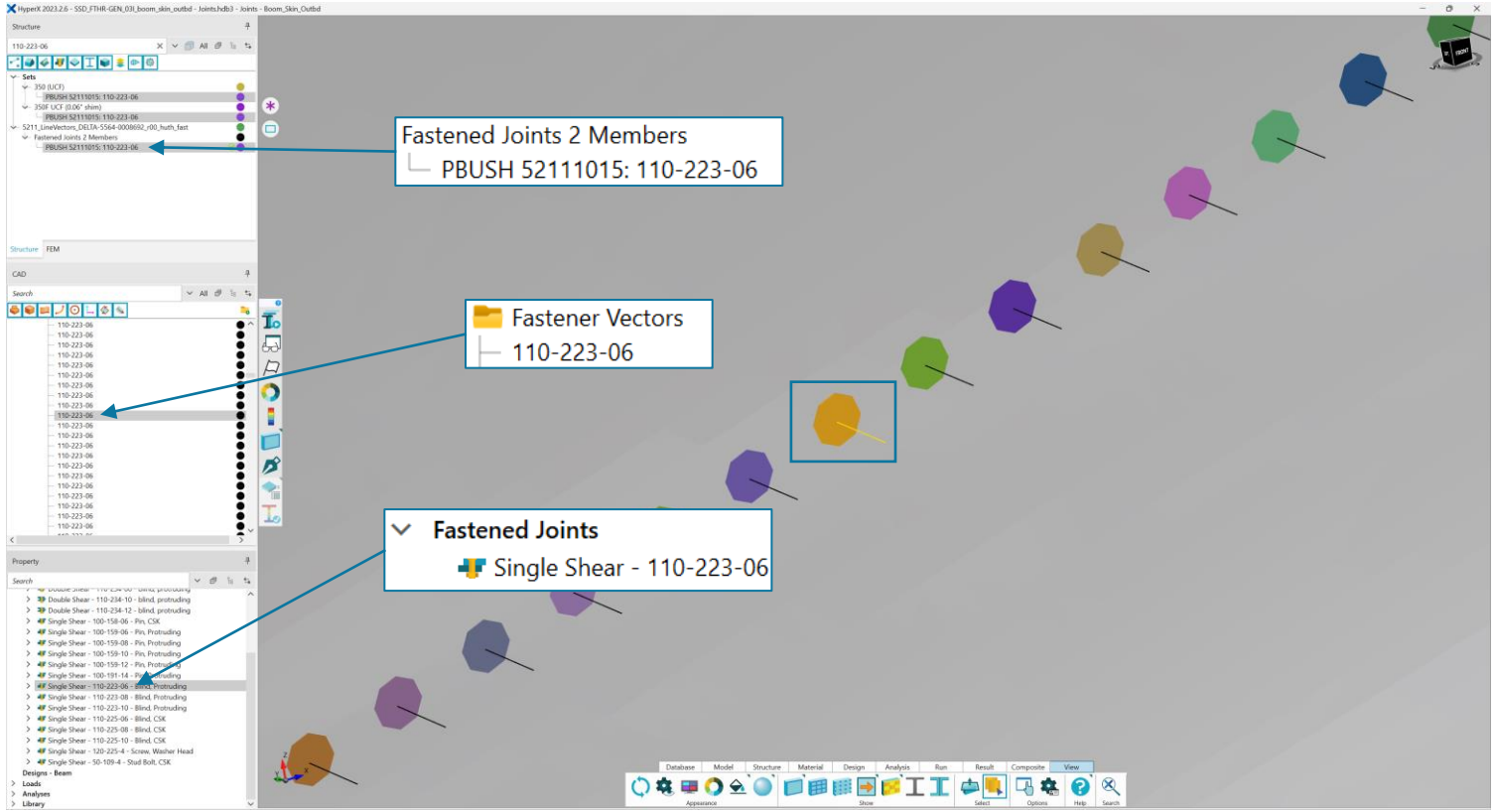
Detail Design – Joint Alignment

Prelim Design

Weight-Out

Detail Design

- Syncing HX fastener name, design property, and CAD geometry



Collier Support

HyperX Integration and Engineering Services Overview

- HyperX Deployment, Training, & Technical Expertise
- Custom Tool & Plugin Development
- Workflow Standardization & Optimization
- Design-to-Analysis Integration
- Advanced Structural Analysis Support
- Deadline-Driven Execution

Thank You.