

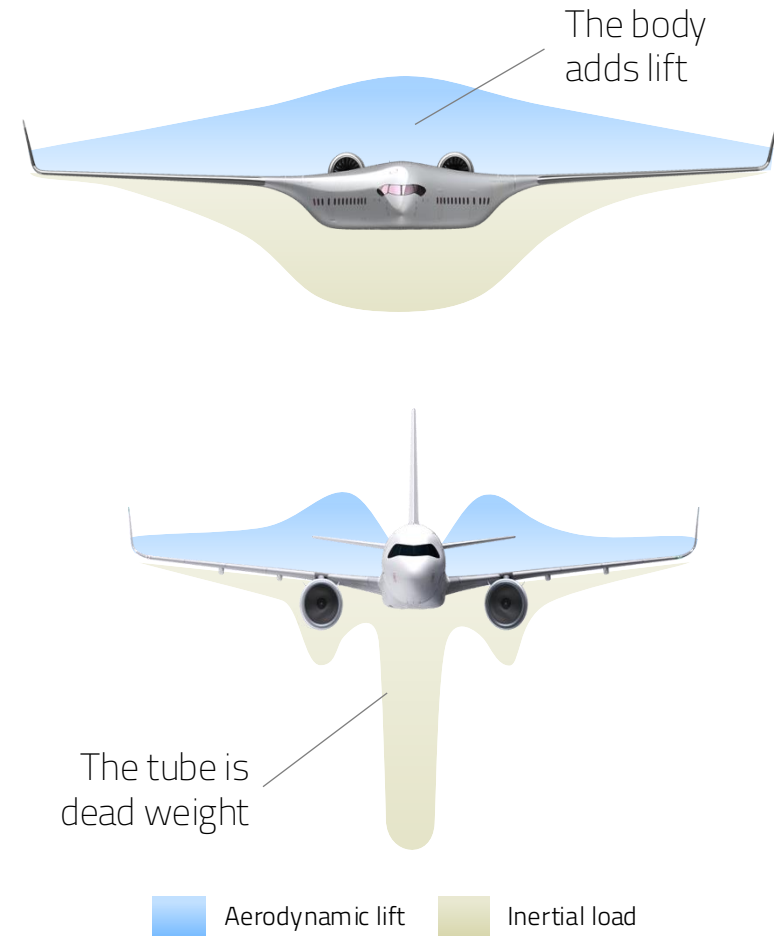


Aeroelastic Flutter Sizing with HyperX and NASTRAN SOL200 on BWB Aircraft

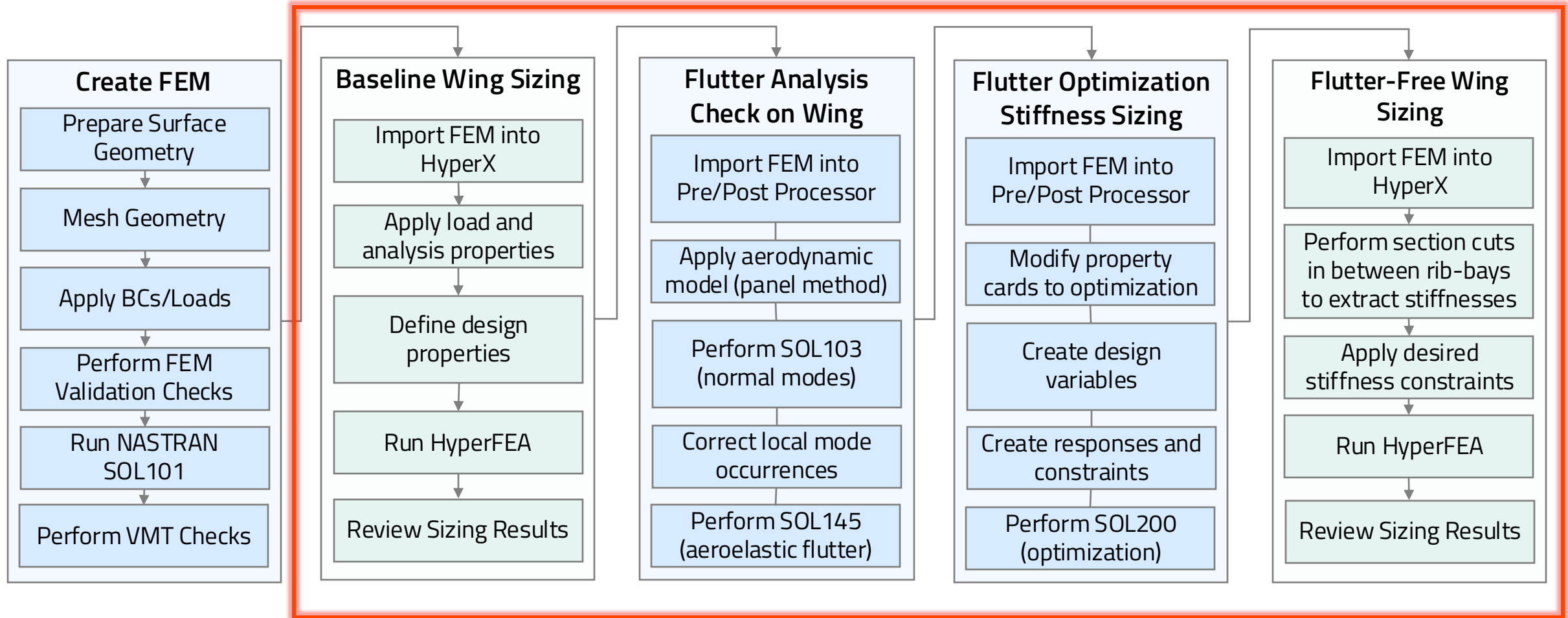
Napsia Buddhamatya

Importance of Aeroelastic Flutter on BWBs

- BWB generates lift across the entire body
→ *less reliance on traditional wing area*
 - Enables more slender, integrated wing structures → **thinner and less stiff structural components** compared to conventional designs
 - Nontraditional planform geometry alters aeroelastic behavior
- To reduce weight, composite materials are the obvious choice
→ *lower stiffness*
 - Reduced bending and torsional stiffness increases flutter susceptibility
- Flutter analysis is essential to ensure structural integrity and flight safety



Wing Flutter Sizing Workflow



Step 1



Step 2



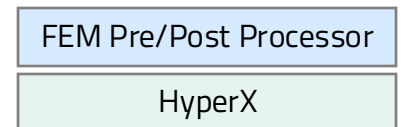
Step 3



Step 4



Step 5



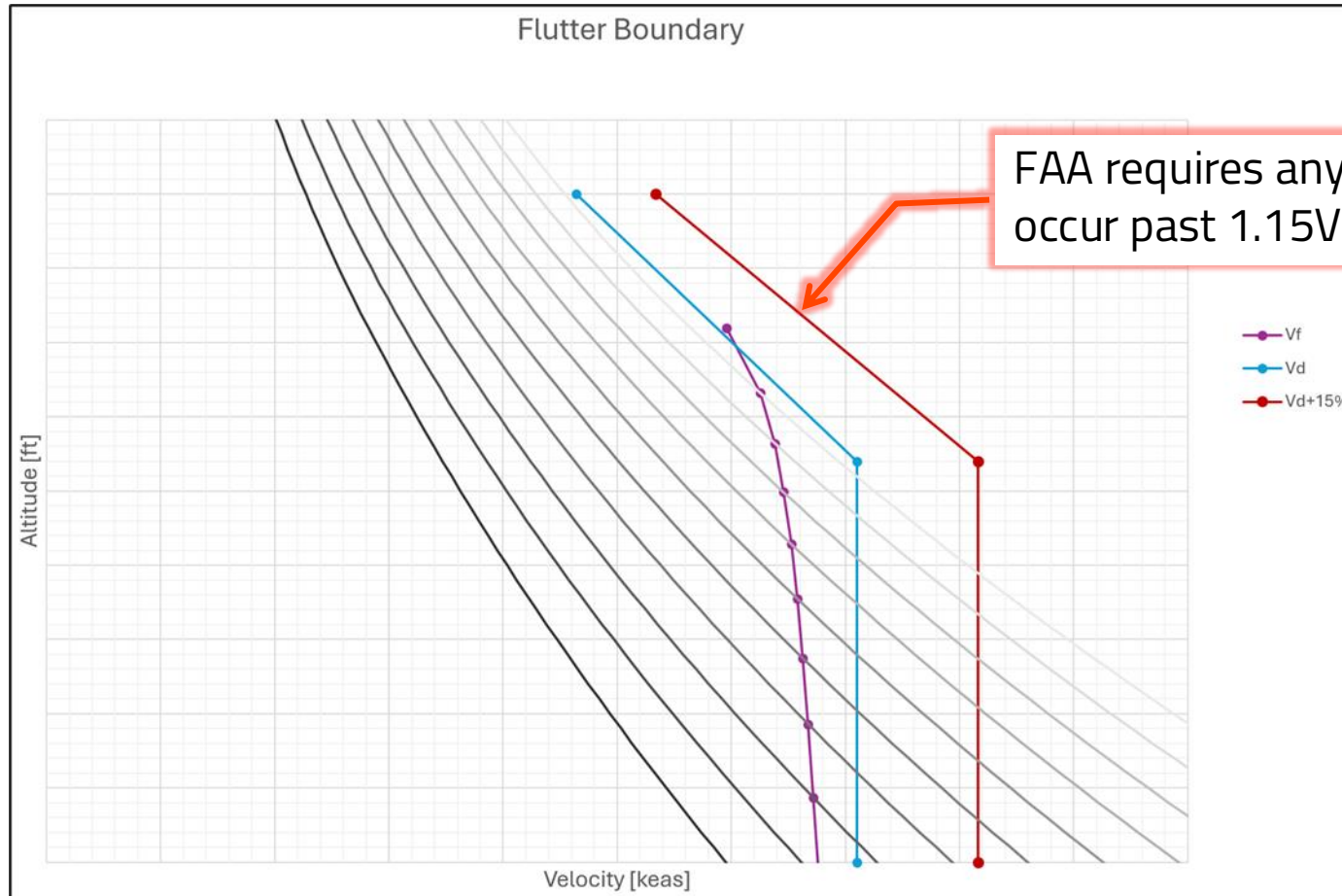
Wing Structural Layout Trade Study – Baseline Wing Sizing

- Objective
 - Determine weight optimized layout of major wing sub-structures (i.e., spars, ribs, and skins)
 - Partnered with Collier Aerospace to perform trade study structural analysis using HyperX software
- Study Areas
 1. Center Body Spar
 2. Inboard Rib Spacing
 3. Outboard Rib Spacing
 4. Inboard Mid-Spar
 5. Outboard Mid-Spar
 6. Forward Spar Chord Location
- Outcomes
 - Understanding of major wing sub-structure's sensitivity to spacing, chord location, etc.
 - Selection of baseline wing structural layout to be used in further studies



JetZero BWB Aircraft

Initial Sizing Results



FAA requires any aeroelastic flutter to occur past $1.15V_d$ (14 CFR § 25.629)

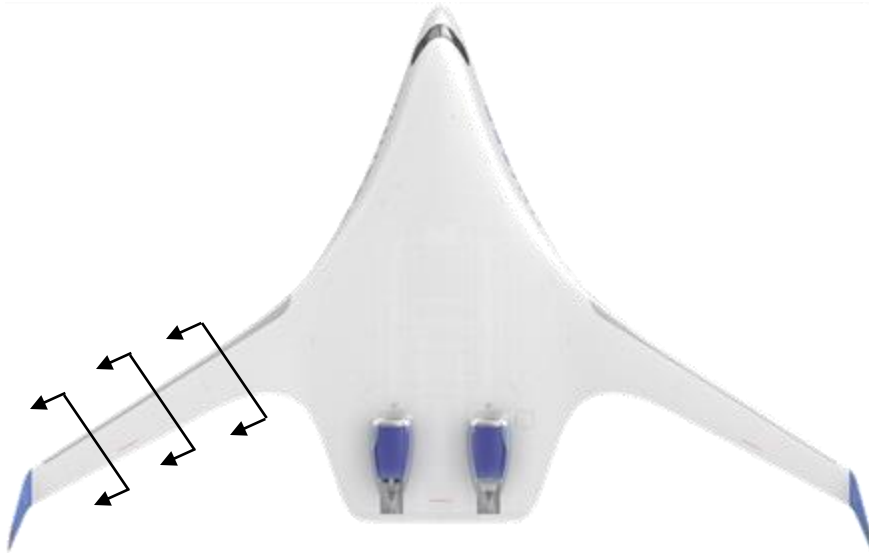
Initial Sizing Does Not Pass Flutter Requirement

HyperX Fluttering Sizing via Stiffness Constraints

- Trial 1
 - Increasing bending and torsional stiffness along the span to match “flutter-free” sized wing
- Trial 2
 - Increasing GJ/EI stiffness ratio along the span to match “flutter-free” sized wing
- Trial 3
 - Coupling SOL200 with HyperX to obtain optimized bending and torsional stiffness along the span
 - Modified properties for HyperX import

HyperX Section Cut Stiffness Properties

- Wing Stiffness
 - Extracted from HyperX by taking section cuts spanwise, in the middle of every bay
 - Section properties are calculated using common industry analytical methods



Section Cut Definition

Wing Section Cut

Draw Cut Select Members (120)

Constraints

Properties

FBD Loads

Cut Definition

Global X Y Z

Origin (in)

ΔX ΔY ΔZ

Normal

Horizontal

Vertical

Move

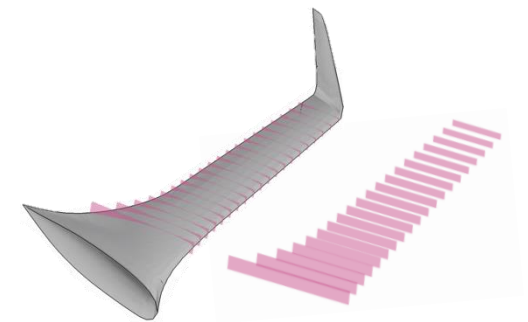
Section Cut Display

Apply Close

Calculated Properties

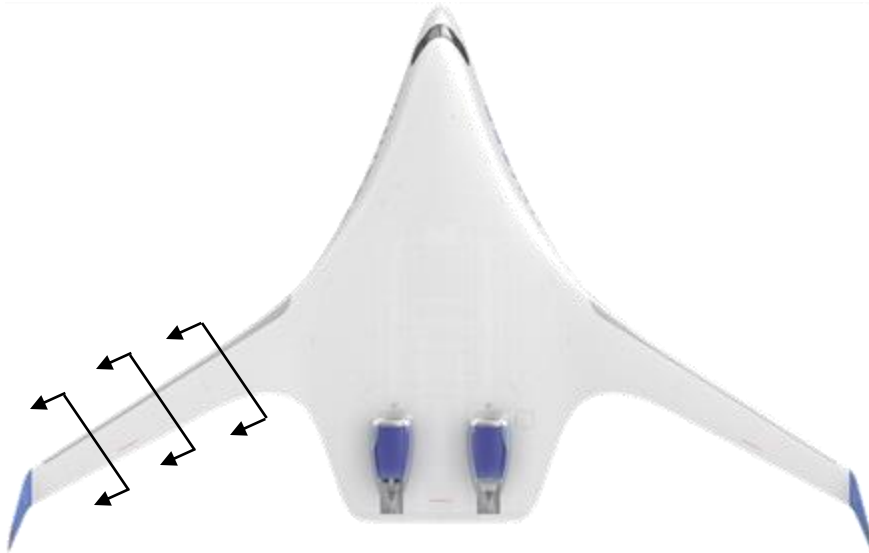
Centers (in)	Area (in ²)
CG	Enclosed
CN	Number of Cells
CQ	

Section Axes (lb-in ²)	Principal Axes (lb-in ²)
<input checked="" type="radio"/> Centroid <input type="radio"/> Origin	
E_{I_{hh}}	E _{I_{max}}
E _{I_{yy}}	E _{I_{min}}
GJ	ϕ
E _{I_{tv}}	
EA	



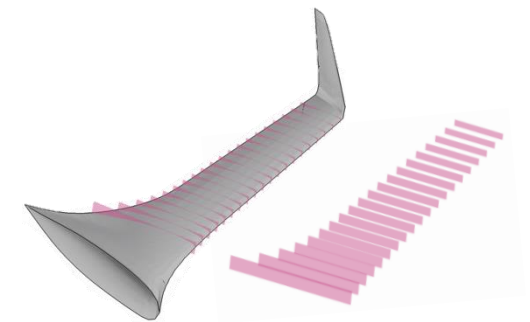
HyperX Section Cut Stiffness Constraints

- Wing Stiffness
 - Applied in HyperX by applying EI and GJ minimums for each rib-bay section

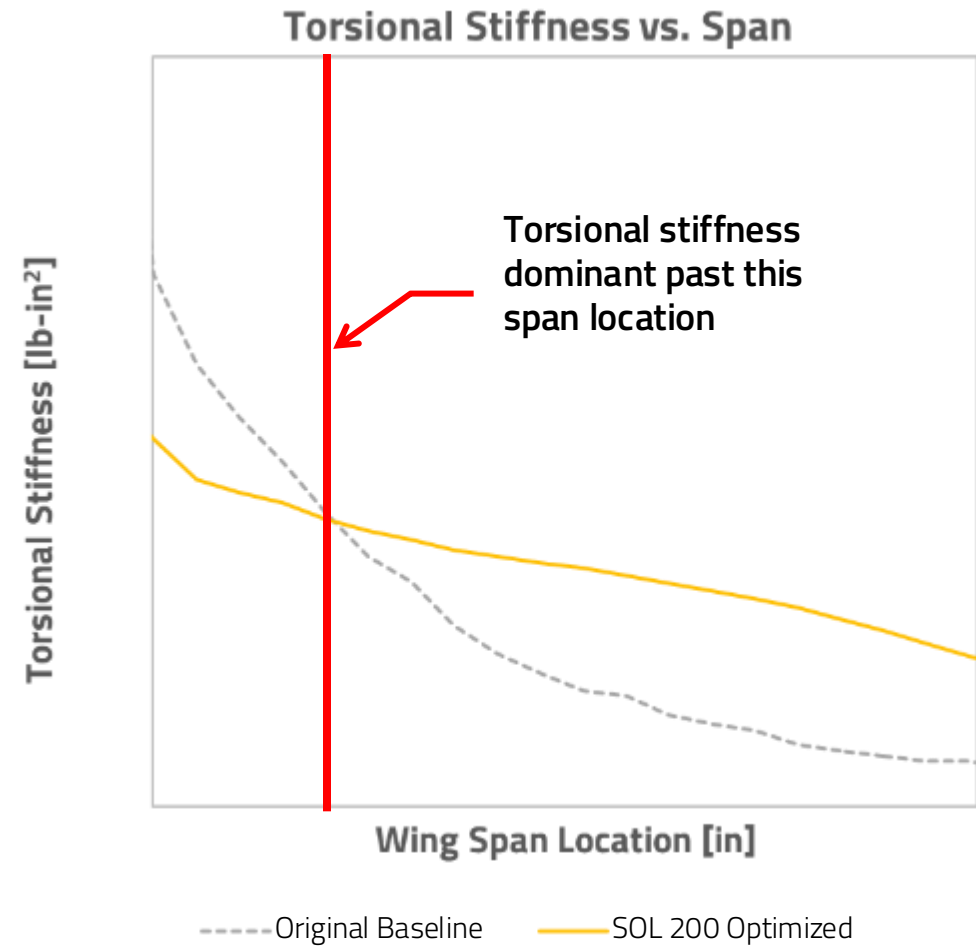
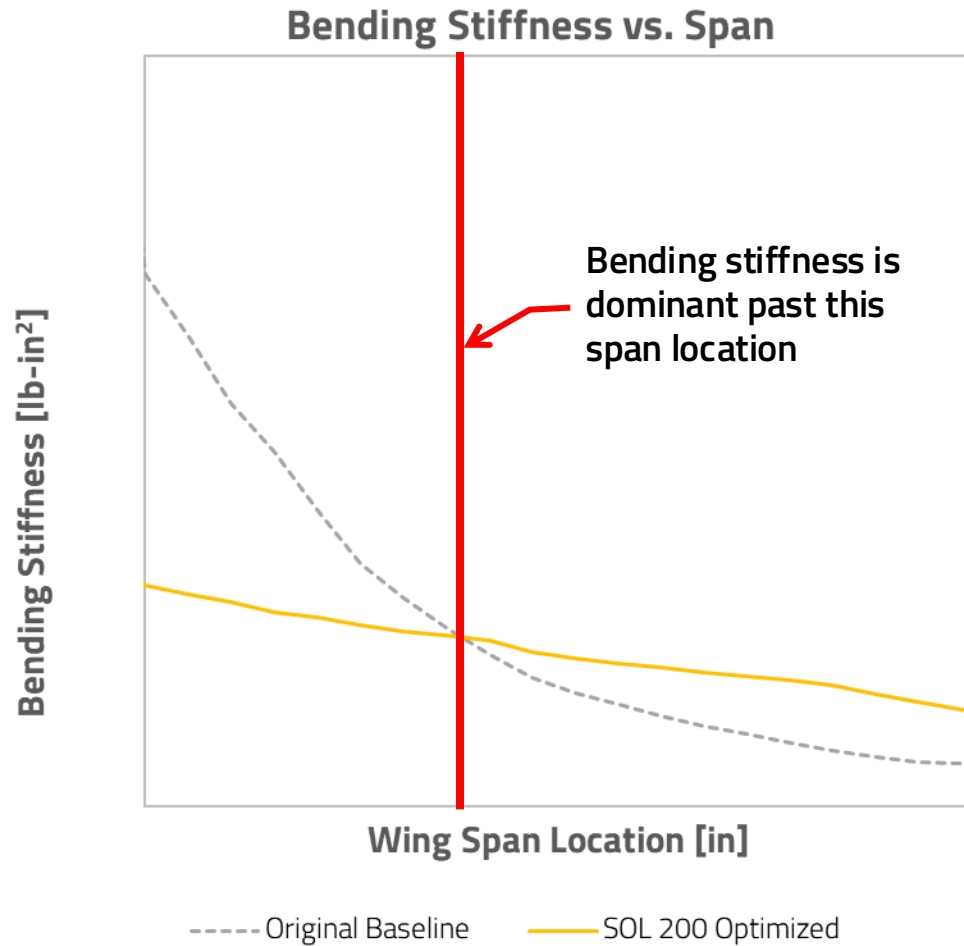


The screenshot shows the HyperX software interface. The 'Section Cut Definition' dialog box is open, showing the 'Wing Section Cut' configuration. The 'Constraints' tab is selected, and the 'Min Stiffness (lb-in²)' section is highlighted with a red box. The 'EI_y' and 'EI_w' fields are also highlighted with red boxes and arrows. The 'GJ' field is highlighted with a red box. The 'Zone Stiffness Distribution' section shows a slider between 'More Even' and 'More Targeted'. The 'Principal Angle Bounds (°)' section shows 'Min' and 'Max' fields. The 'Location Bounds (in)' section shows a table with columns for h_{min}, h_{max}, v_{min}, and v_{max}.

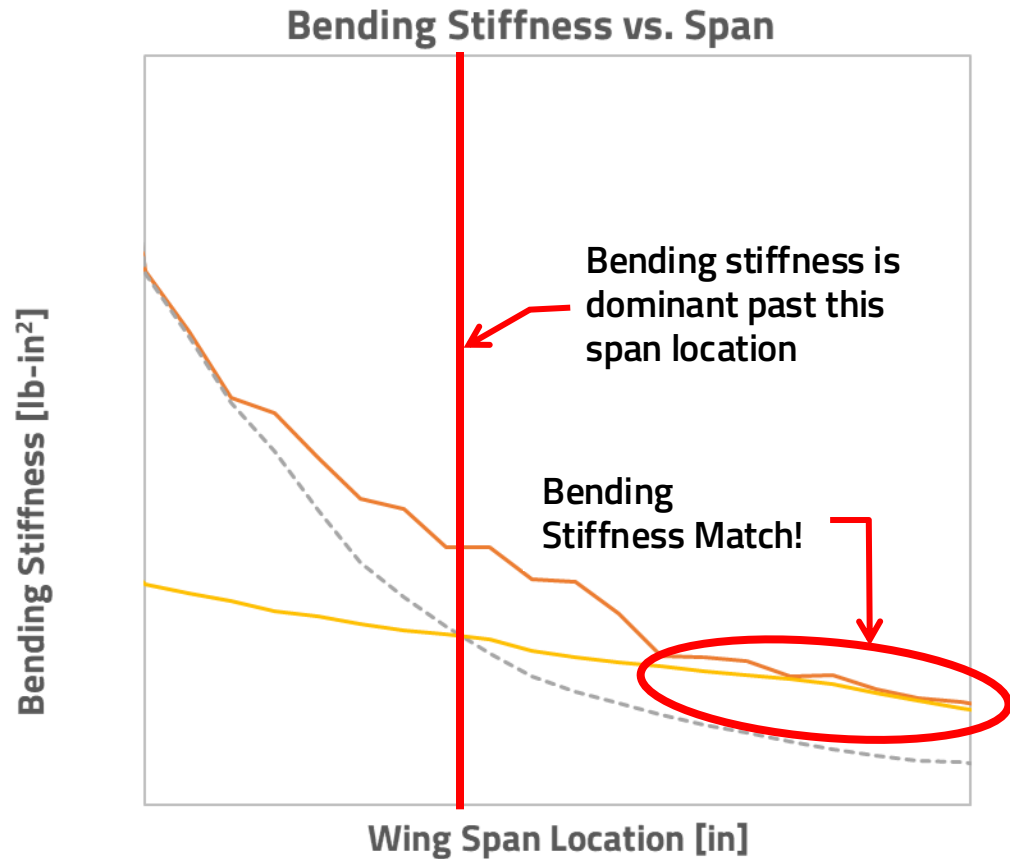
	h _{min}	h _{max}	v _{min}	v _{max}
CN	-∞	∞	-∞	∞
CQ	-∞	∞	-∞	∞



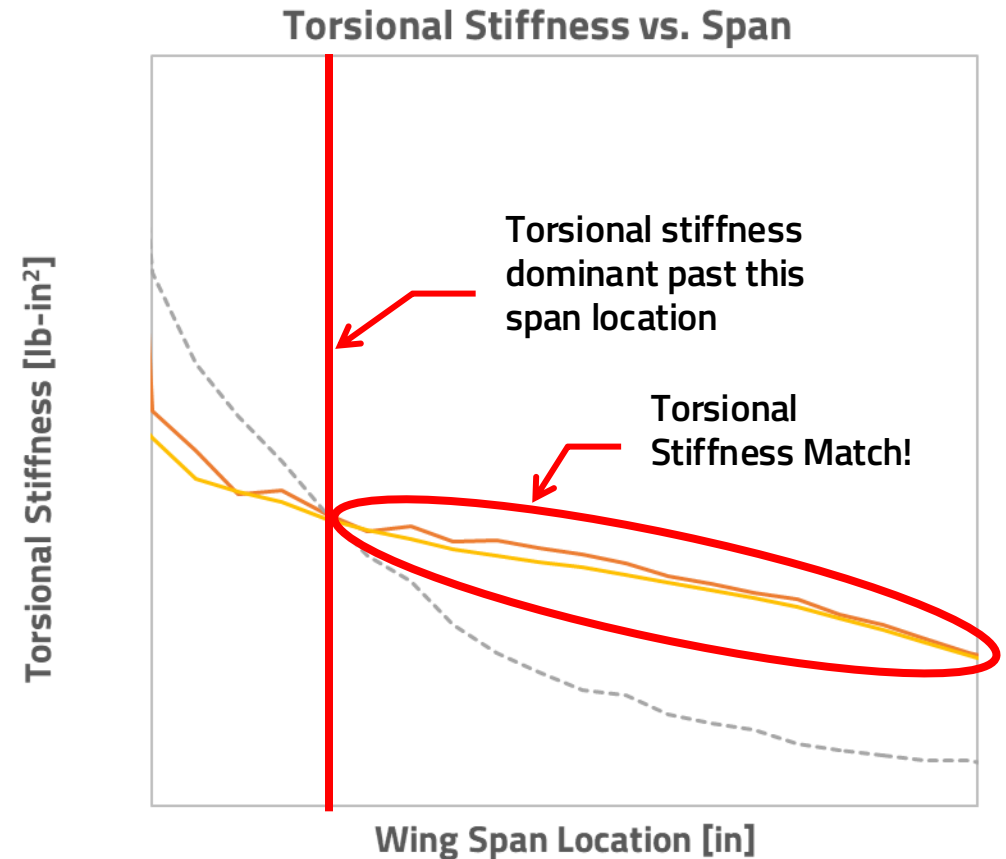
Stiffnesses Results From HyperX Cross-section Tool



Stiffnesses Results From HyperX Cross-section Tool

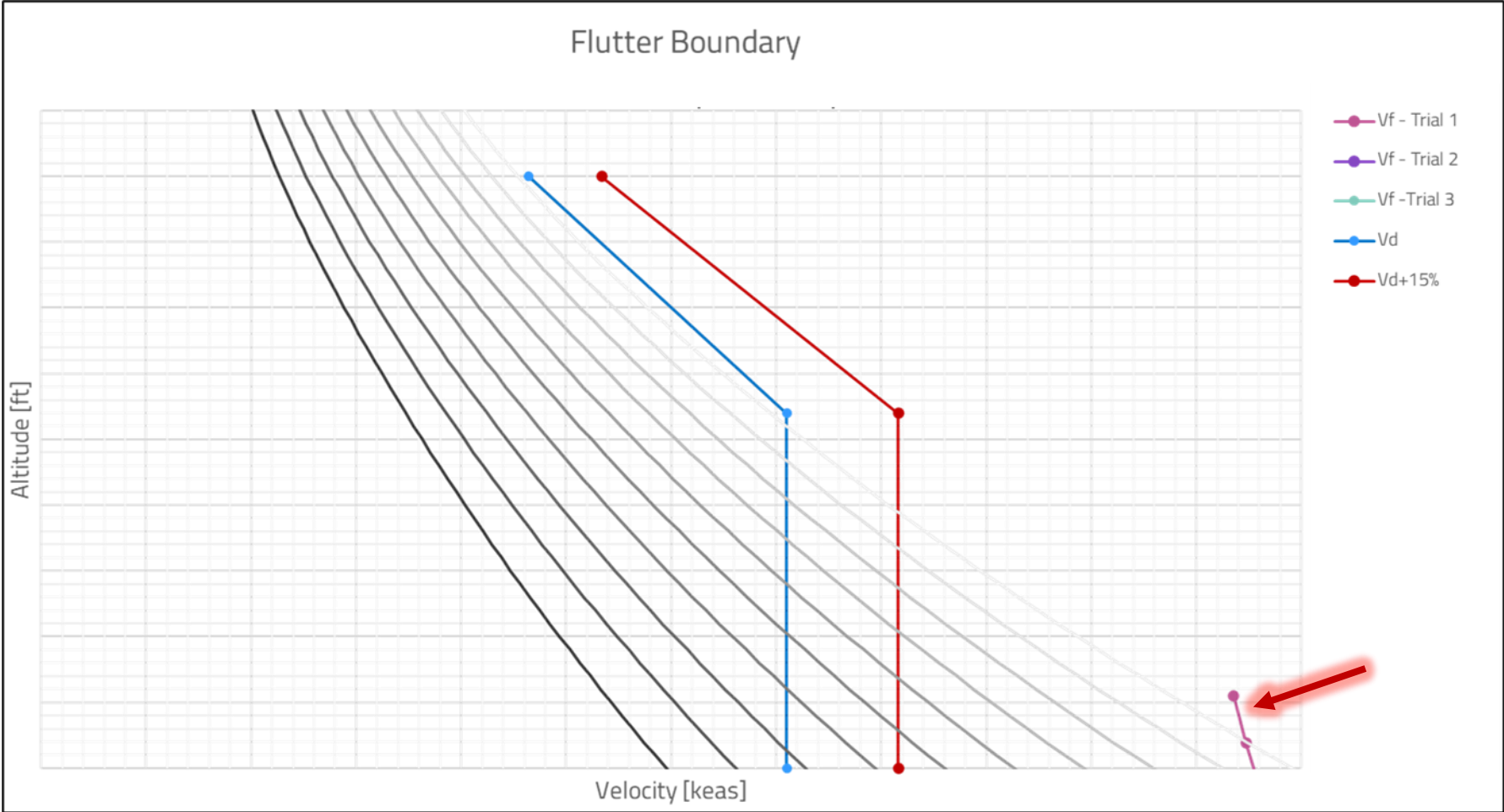


— Original Baseline - - - - Original Baseline - Adjusted — SOL 200 Optimized

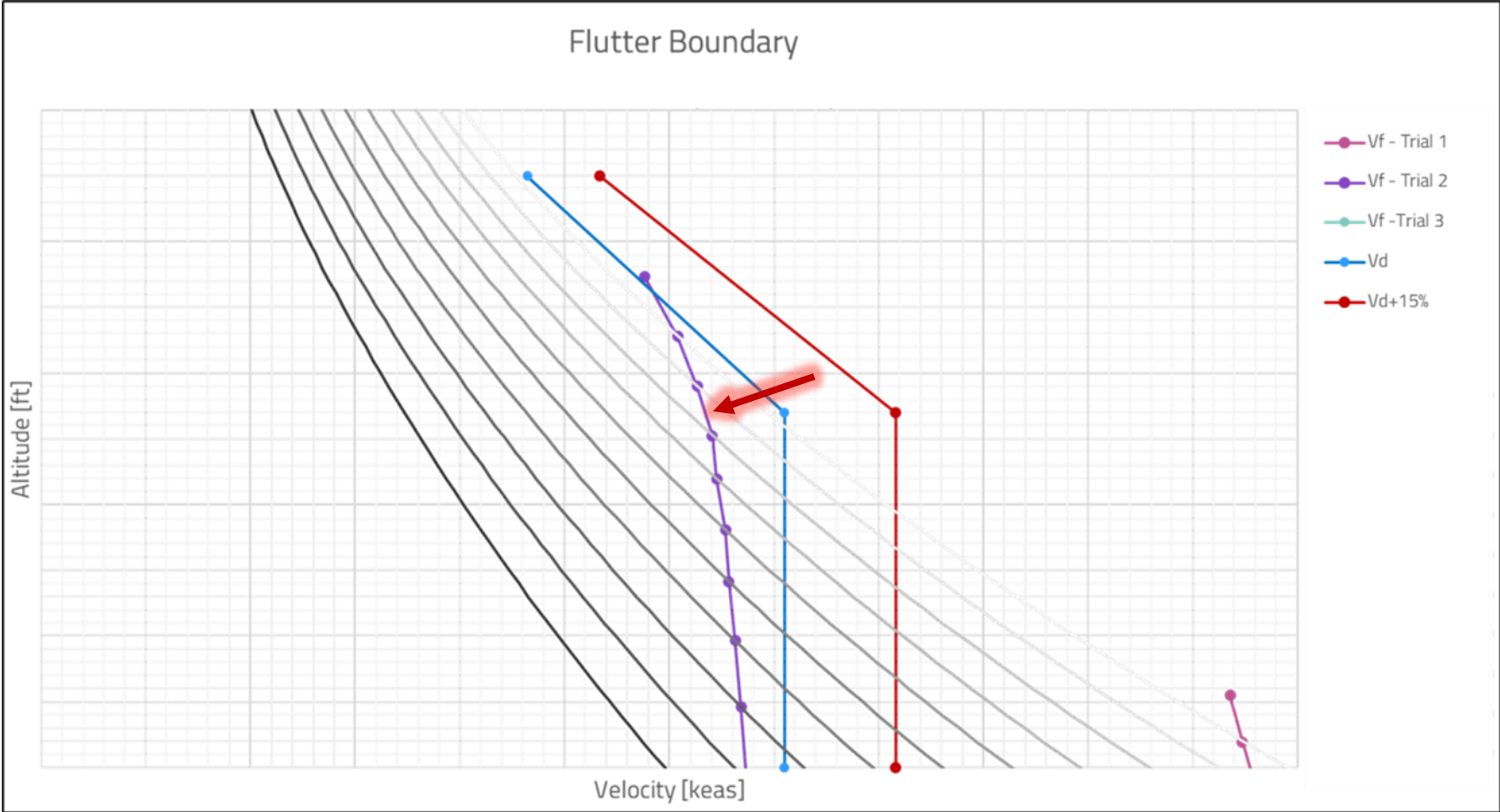


— Original Baseline - - - - Original Baseline - Adjusted — SOL 200 Optimized

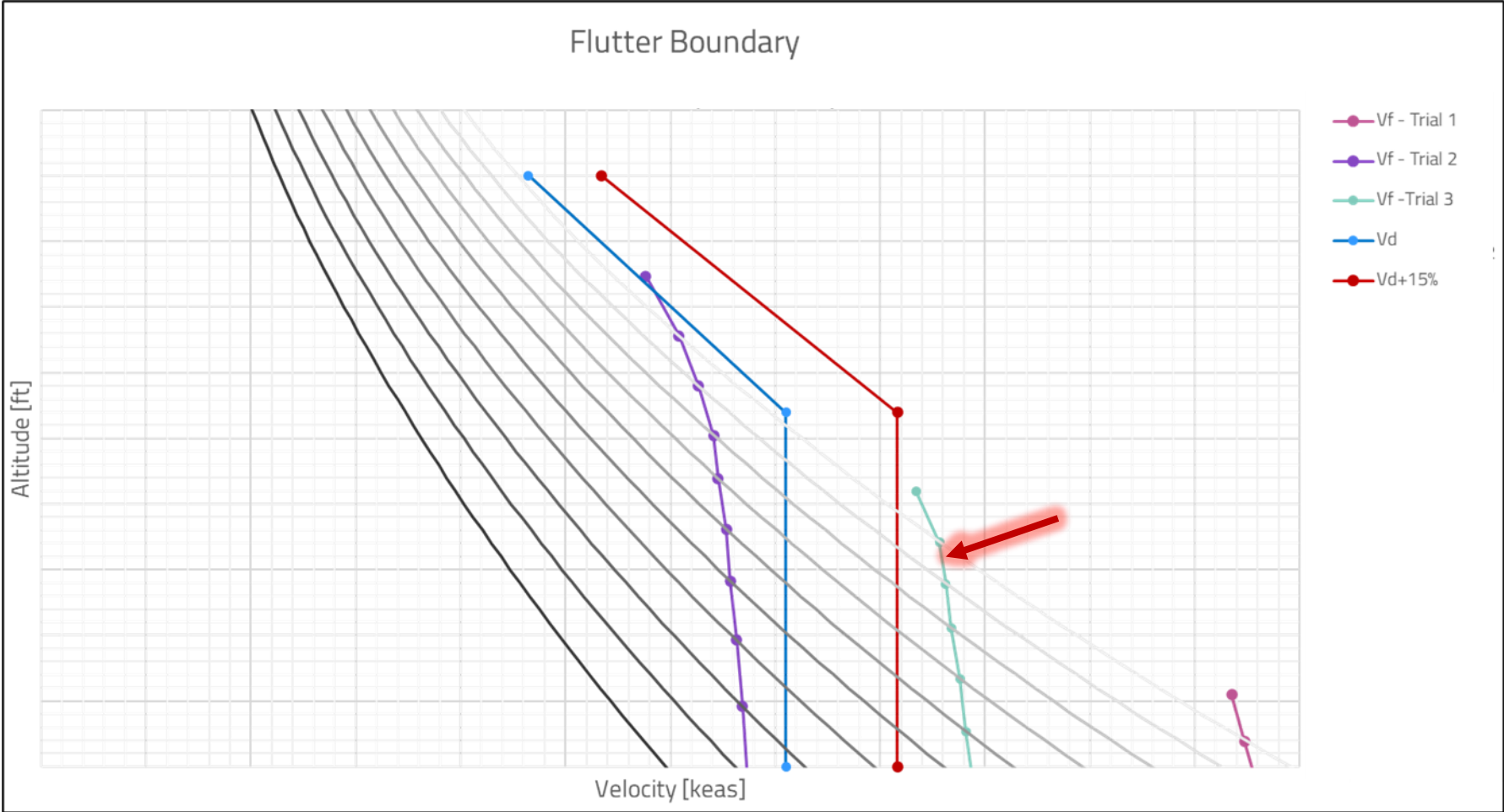
Flutter Boundary Results



Flutter Boundary Results

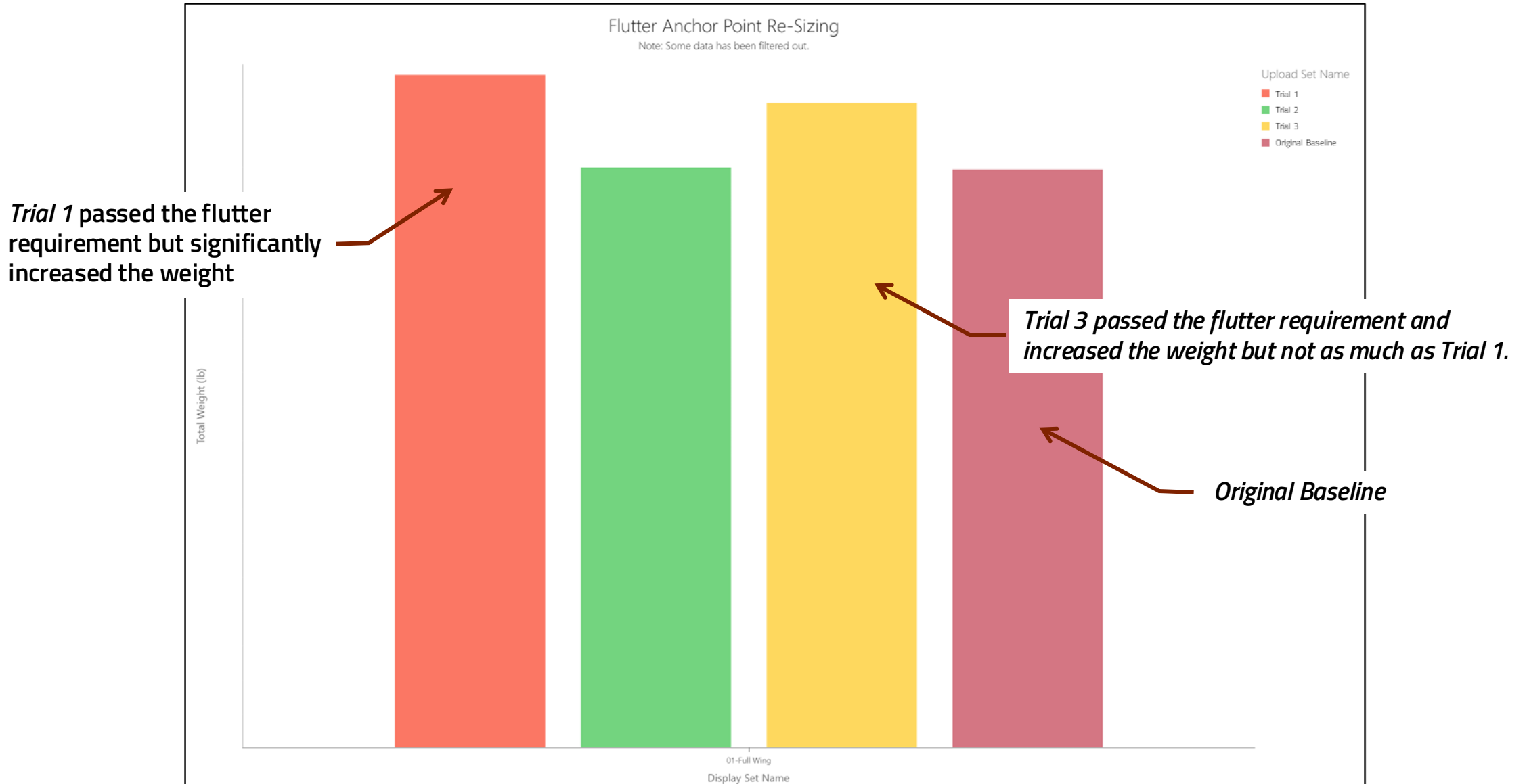


Flutter Boundary Results

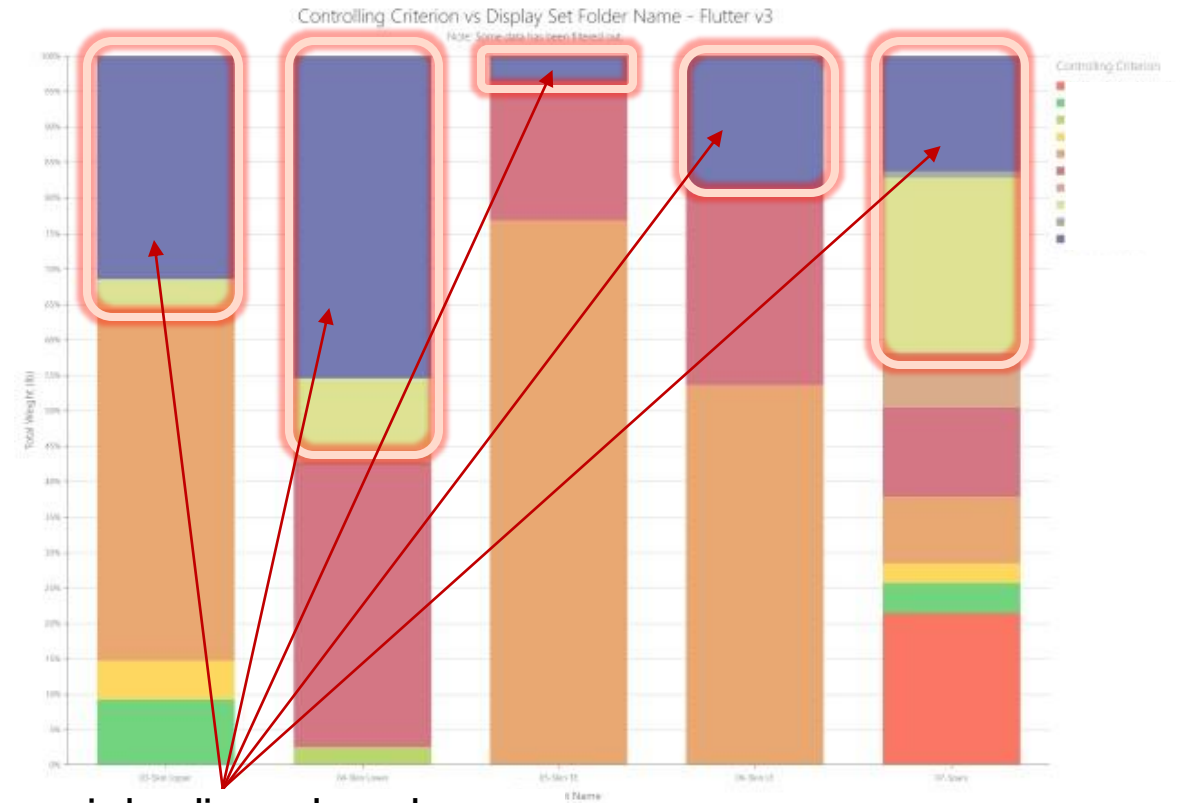
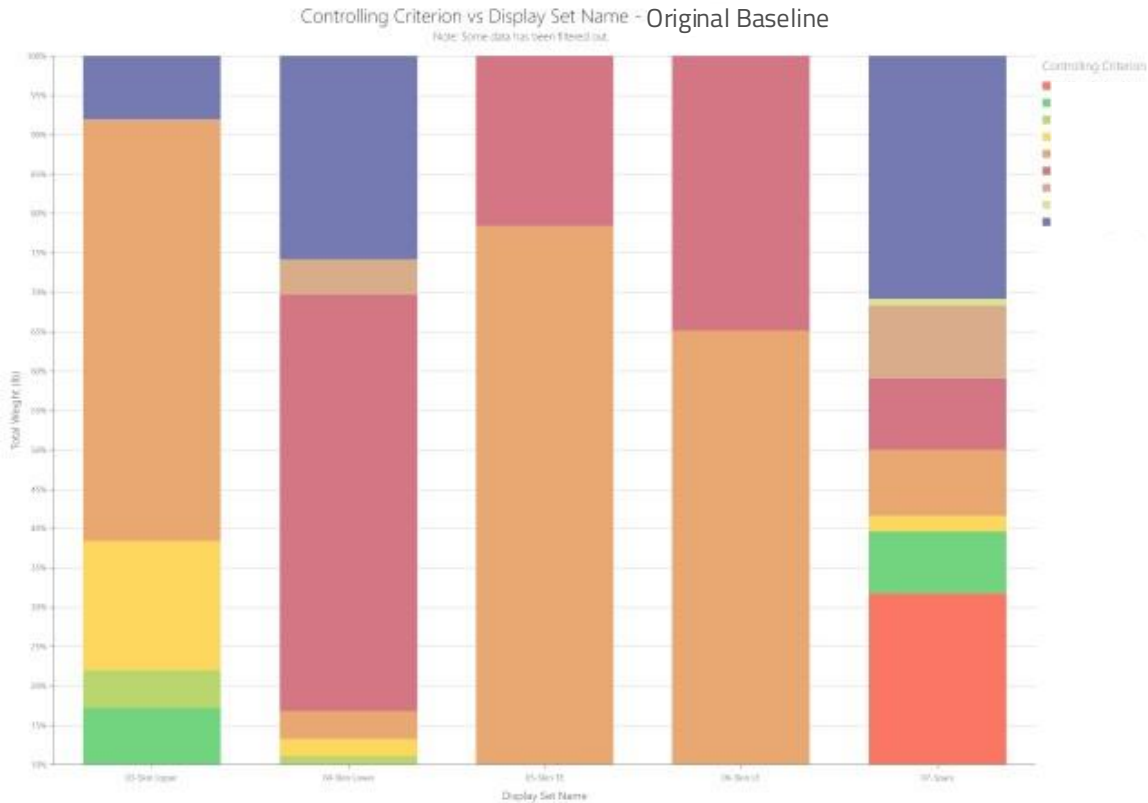


HyperX Flutter Sized Wing V_F within 7% of $V_D+15\%$

Comparing Sizing Results via Dashboard



Controlling Criterion Comparison via Dashboard



Increase in bending and membrane stiffness for a *flutter-free* wing

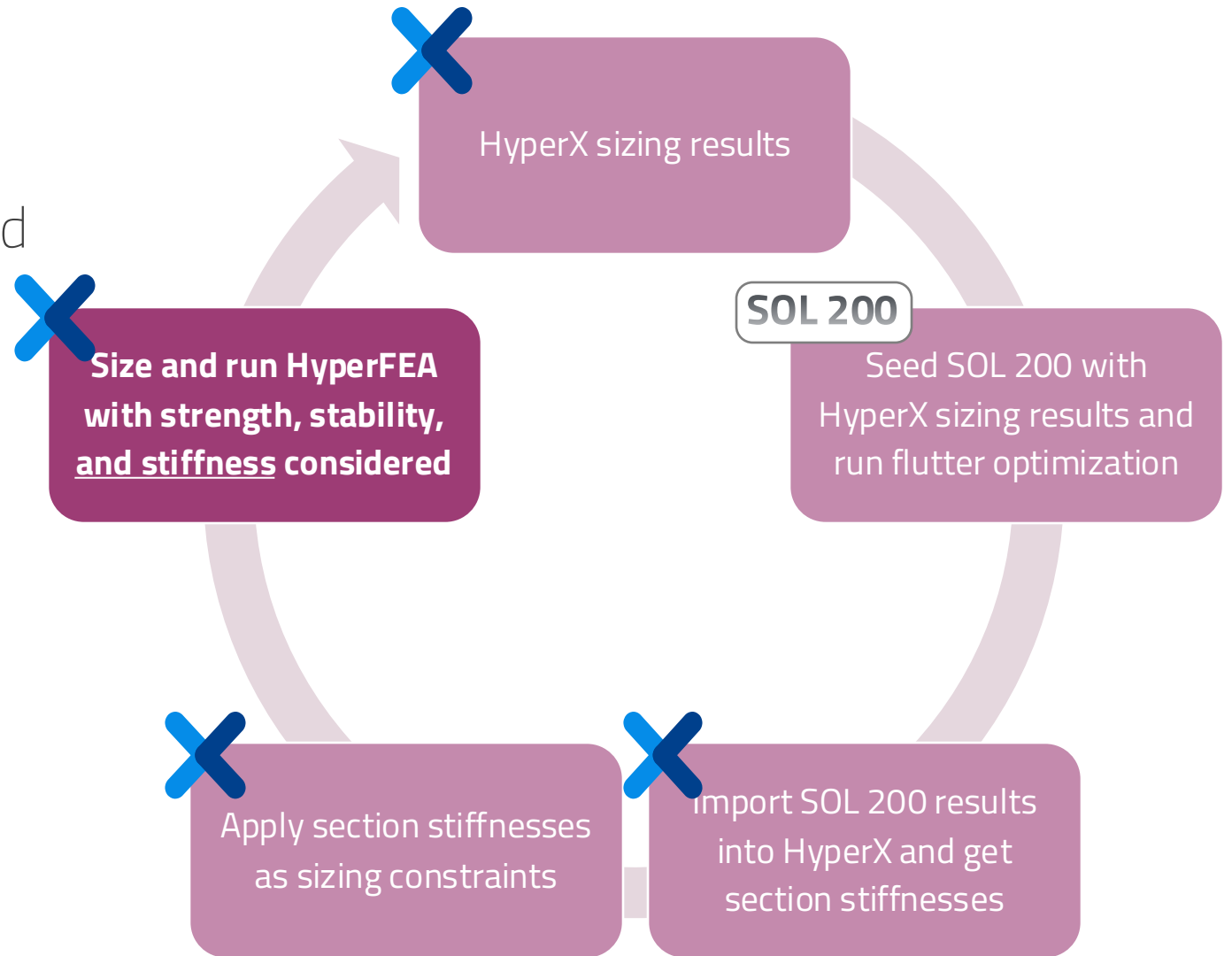
Key Takeaways

- Outcomes
 - HyperX may not have innate aeroelastic capabilities, but it is extremely powerful and has tools available for supporting an aeroelastic analysis workflow
 - HyperX allowed for rapid configuration re-sizing



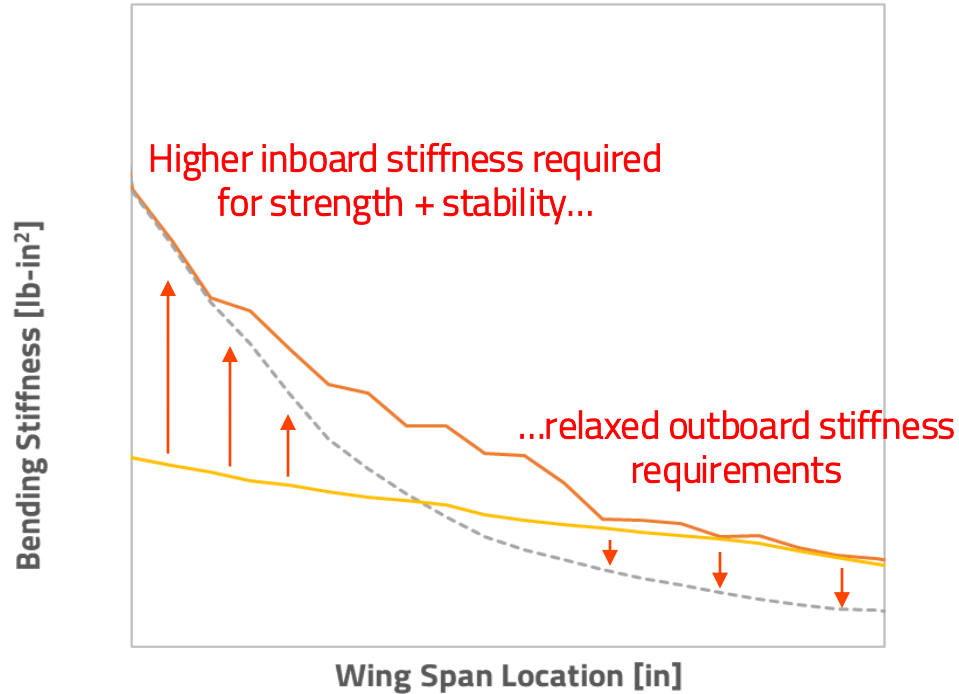
Continued Development

- After completing this work, an iterative HyperX-SOL 200 process has been demonstrated



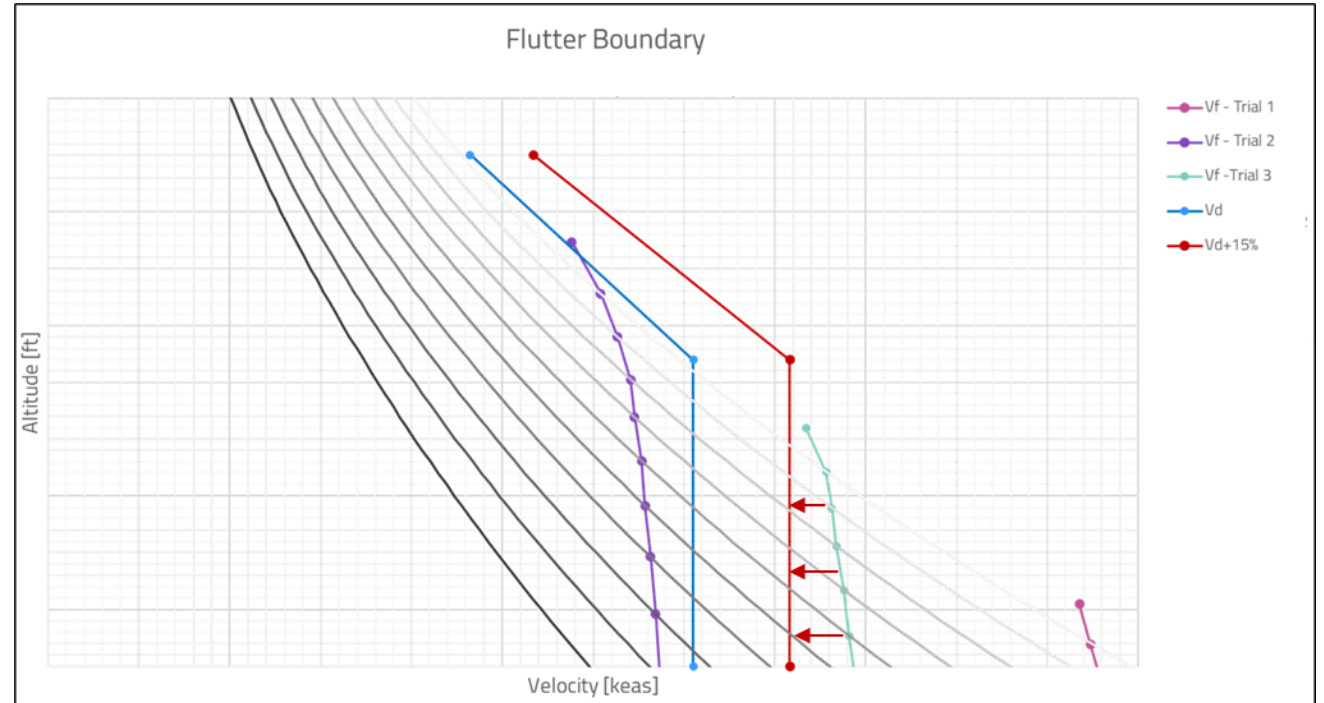
Benefit to Iterating HyperX w/ SOL 200

Bending Stiffness vs. Span



— Original Baseline - - - Original Baseline - Adjusted — SOL 200 Optimized

Flutter Boundary



Iterate to work towards closing the flutter boundary overshoot