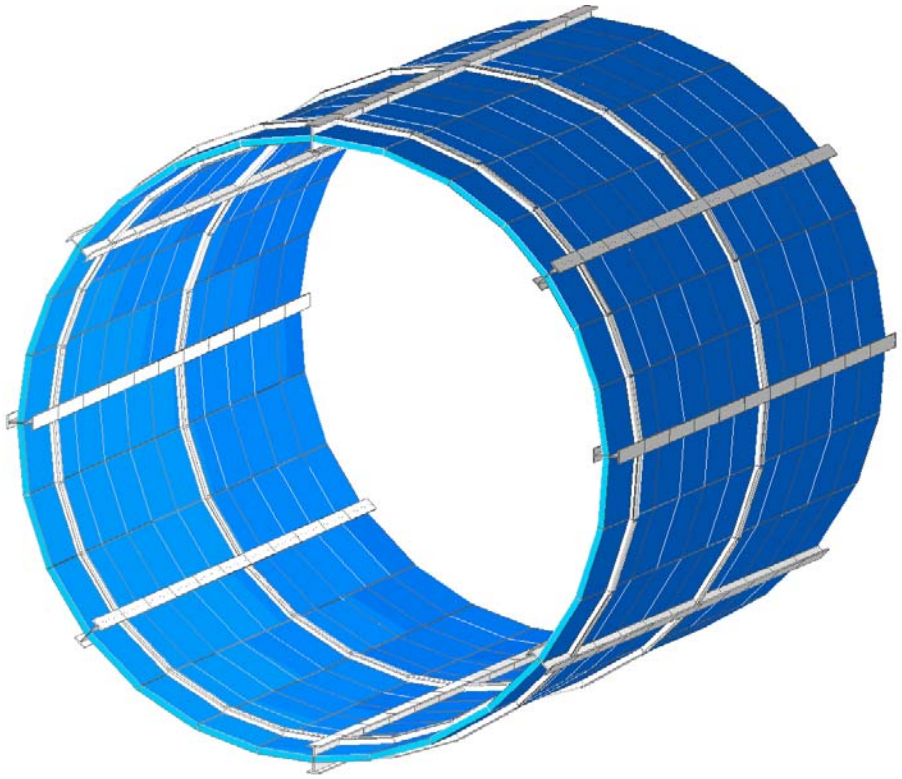
HyperSizer®

Coupling to FEA



Collier Research Corporation

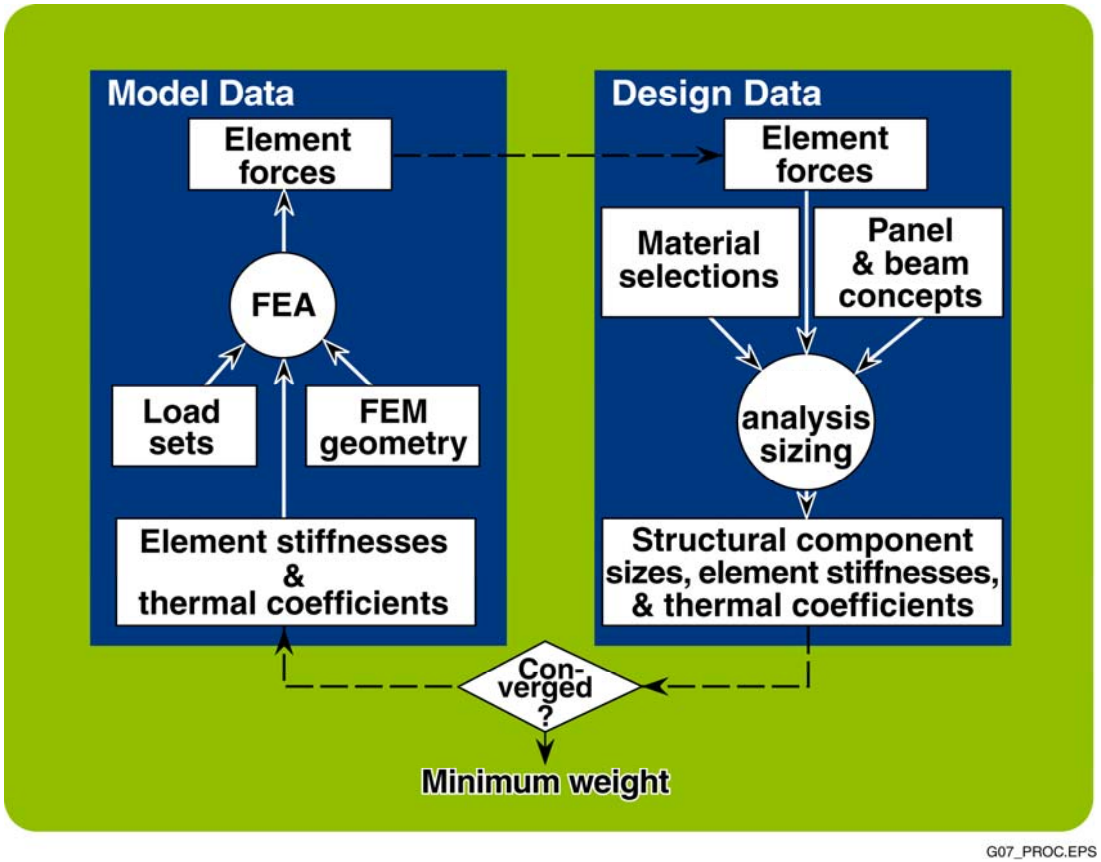
Coupling to FEA: Objective

- **Combine the capabilities of FEA and HyperSizer**
- **Develop an integrated capability where**
  - **FEA provides**
    - **global internal load paths**
    - **global stiffness optimization**
  - **HyperSizer provides**
    - **detailed design strength and stability analyses**
    - **local sizing optimization**
- **Support the industry leading FEA solvers and FEM modelers**

Coupling to FEA:
Technical Approach

1. **Accurately and consistently couple HyperSizer panel and beam thermoelastic stiffness formulations with FEM**
2. **Automate the process of data exchange between HyperSizer and finite element solvers and modelers**
   - **use NASTRAN bulk data file as a fundamental file format**
   - **integrate directly with commercial finite element modeling packages via their native databases or neutral files**
   - **display HyperSizer results in the native modeler's graphics**
   - **display FEA computed loads in HyperSizer's graphics**
3. **Use statistical methods to "pull-loads" from the FEA and to determine appropriate design-to loads**
4. **Perform loads calculations offline from FEA when applicable to reduce element count and fine meshes**

The Process of Coupling FEA with HyperSizer



HyperSizer is blue right side. HyperSizer sends to the FEM:

1. **Properties: PSHELL & PBAR**
2. **Materials:**

   Composite = MAT2

   Isotropic = MAT1

FEA is blue left side. FEA sends to HyperSizer:

1. **Internal loads**

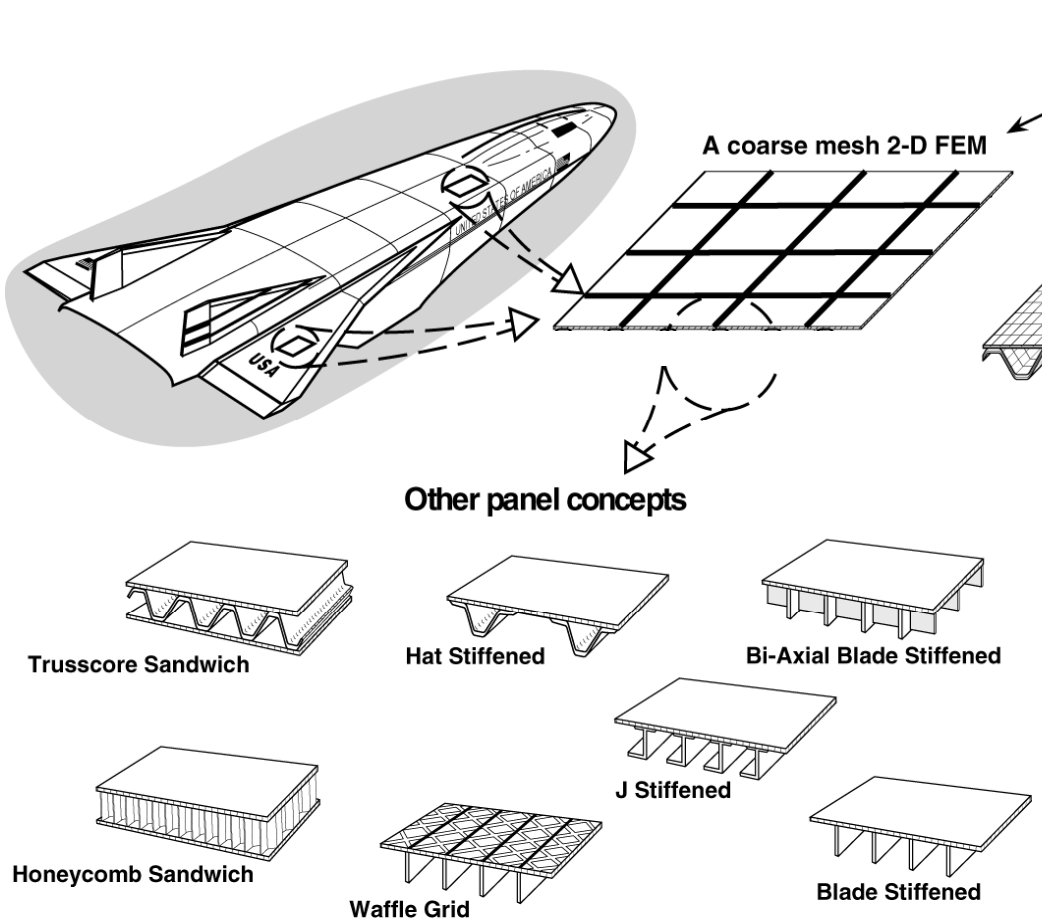
   Element forces = F06

The iterative process of exchanging element force and element stiffness data is repeated until the design sizes converge

FEA Commercial Solvers and Modelers Supported

- **Currently Supported**
  - **MSC/NASTRAN** solver -- bulk data file
  - **I-DEAS** solver and modeler -- universal file
  - **FEMAP** modeler-- neutral file
- **Planned to be Supported**
  - **PATRAN** modeler
  - **ANSYS** solver and modeler

HyperSizer's Panel Formulations Accurately Couple with Planar FEM Meshes



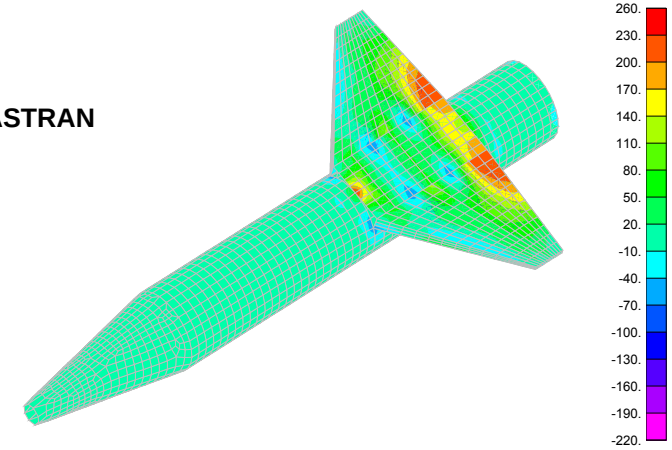
With a single plane of shell elements, HyperSizer is able to get accurate mechanical and thermal stress/strain fields throughout the panel depth for general FEM loading environments

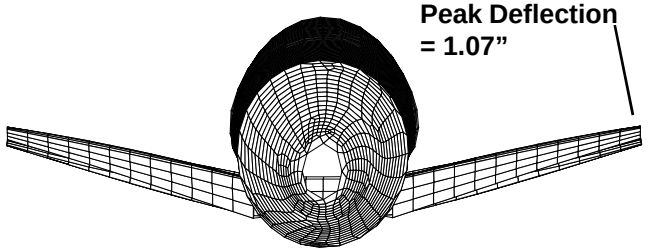
This permits quick evaluation of other panel concepts without the need of changing the FEM mesh

Comparison between MSC/NASTRAN and I-DEAS with HyperSizer Automatically Generated Model Data

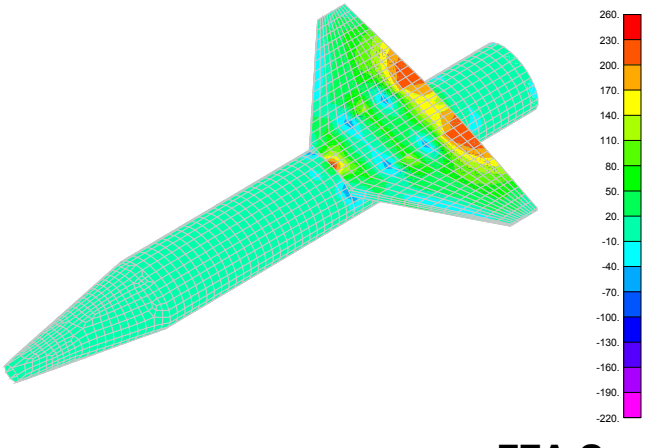
This is not meant to be a comparison of one product to another, but to provide verification that HyperSizer is completely coupled to each product. Though the model is simple, this test case was significant in that many of the challenging FEM data were included such as thermal loads, composite materials, unsymmetric and unbalanced panels; and beams with orientations, products of inertia, and offsets.

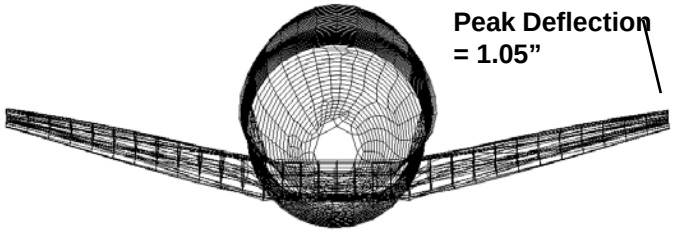
MSC/NASTRAN





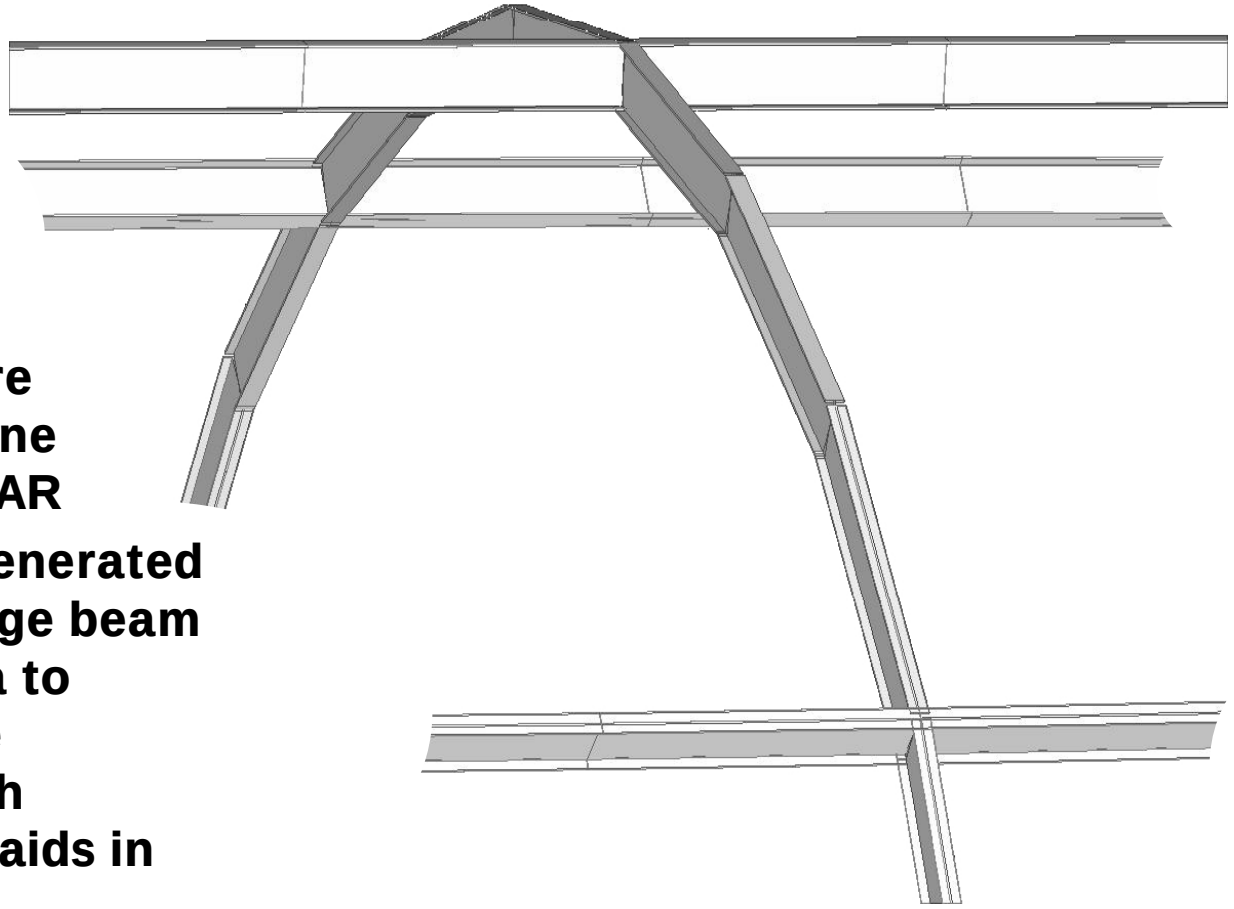
I-DEAS





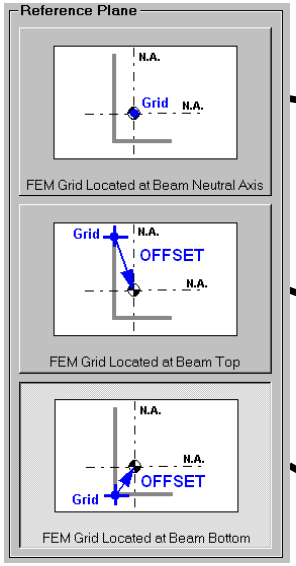
FEA Commercial Support

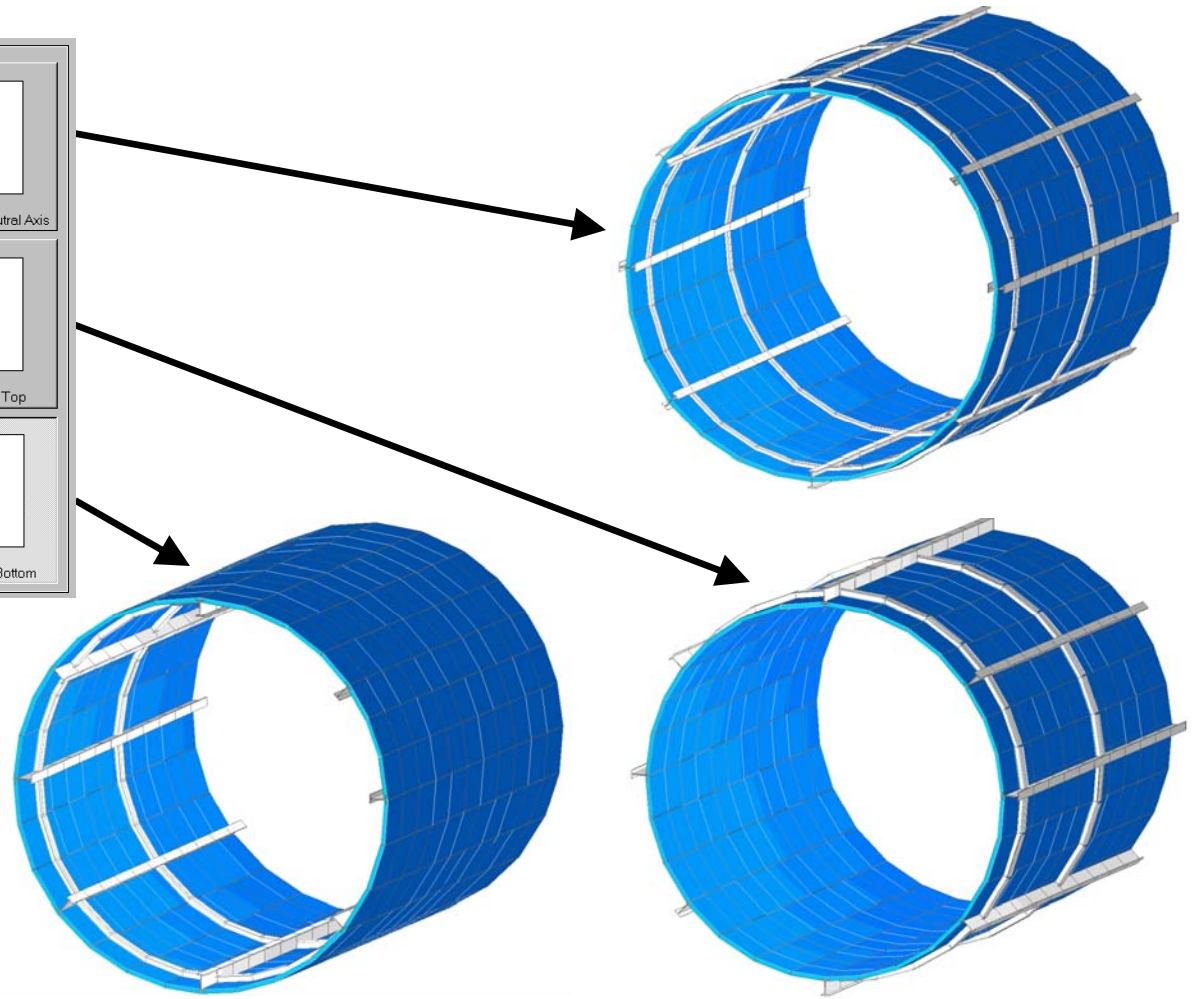
HyperSizer Automatic Beam Cross Section Visualization Data for FEM Modelers



- **The beams are modeled as line elements/CBAR**
- **HyperSizer generated the wide flange beam graphics data to display in the modeler. Such visualization aids in verification**

HyperSizer Automatic Beam Offset Vectors Defined for the FEM

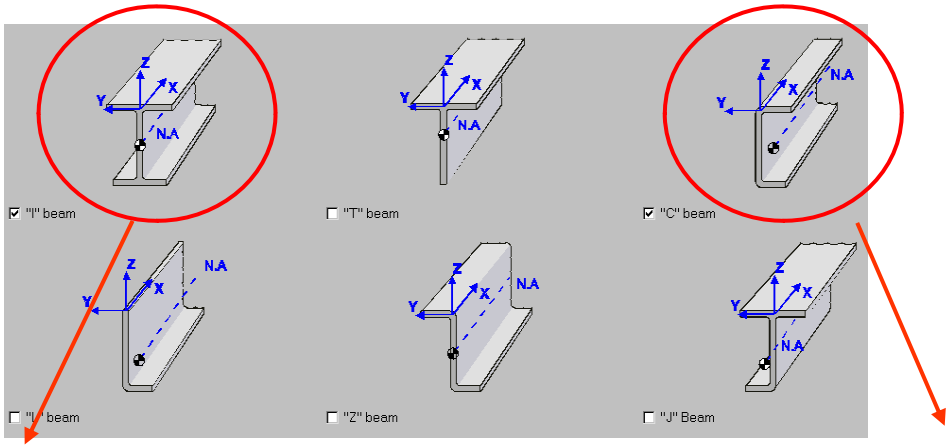


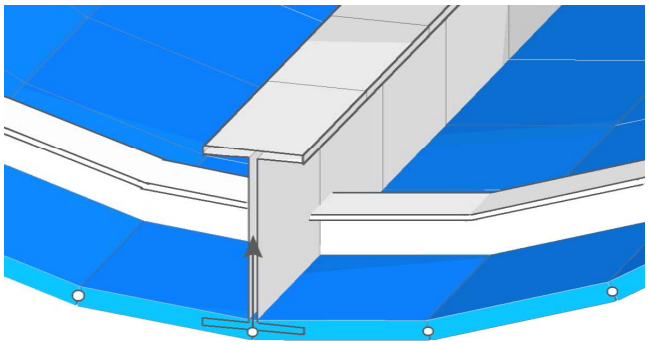


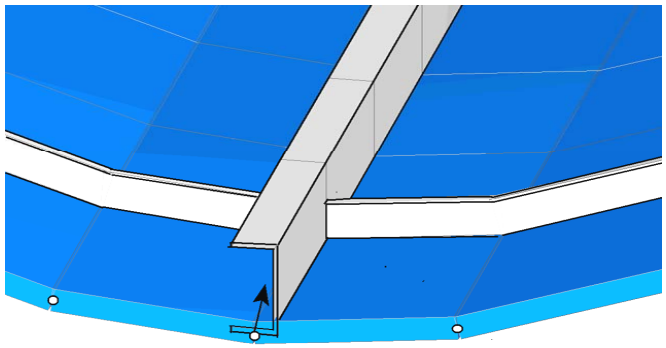
The user can select from these three options to cause the beams to be represented in the FEM at either their neutral axis, at the beam top flange, or at the beam bottom flange.

Beam Sizing Automatically Included in the FEM

Fuselage ringframes and longerons optimized with HyperSizer. Both I beam and C channel options turned on by user. HyperSizer determines optimum design and updates automatically the FEM beam stiffness, offset vector, and beam visualization data. Note these beams are line elements in the model, not shell segments. The white circles are the FEM grid points at the surface OML.

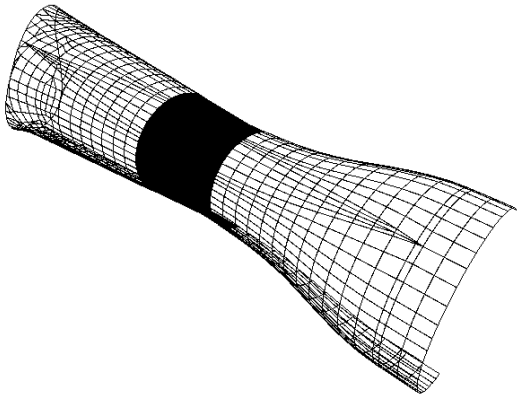


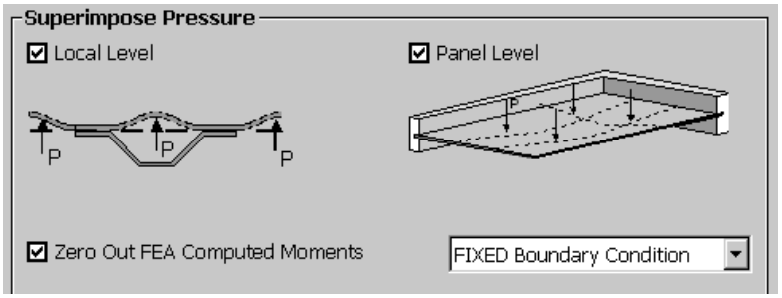


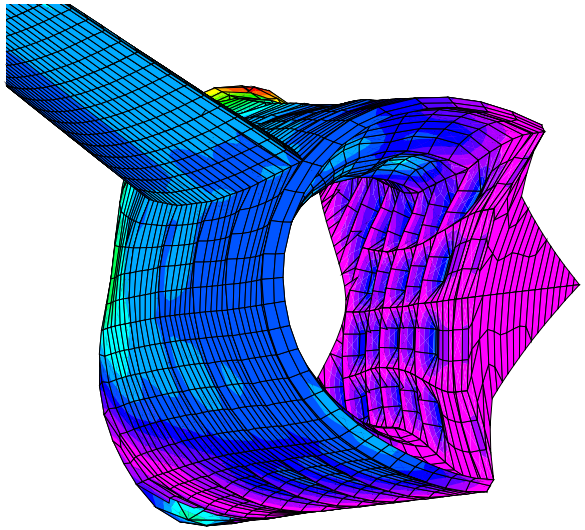


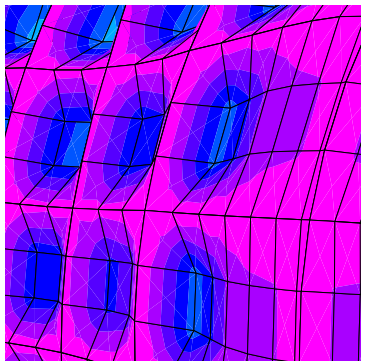
FEA Commercial Support

HyperSizer Corrects the Shortcoming of Coarse FEM Meshes for Pressures



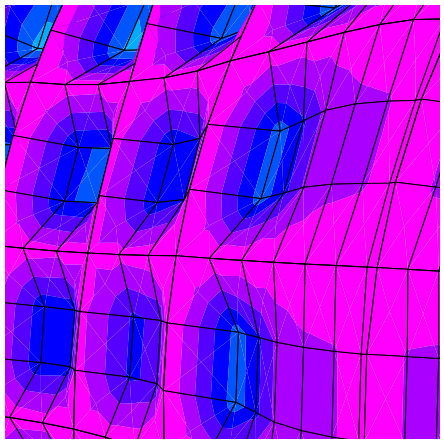






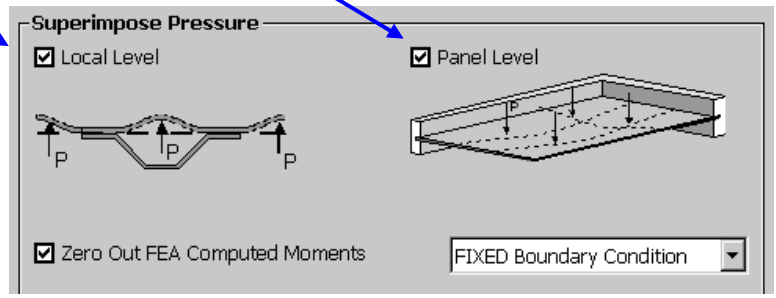
Compute Local Pressure Effects Offline of the FEA

- **In this example, the FEM mesh of nine elements per panel bay is not enough to capture pressure loading**



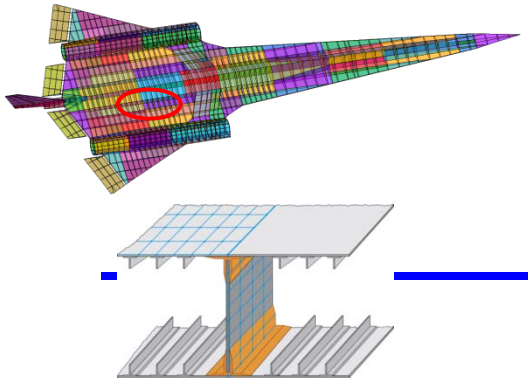
- **HyperSizer can calculate offline from the FEA, with closed form solutions, the bending moments, out-of-plane transverse shears, and midspan deflections for panels that are loaded in pressure**

- **Additionally, HyperSizer can calculate local level span pressure effects and superimpose those onto panel solutions. For example, the facesheet span between panel stiffeners**

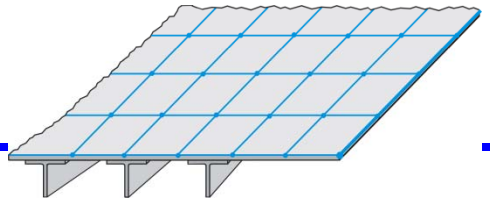


- **These HyperSizer calculated panel pressure loads can replace the panel pressure effects computed with FEA, while still using the FEA computed global load path distributions.**

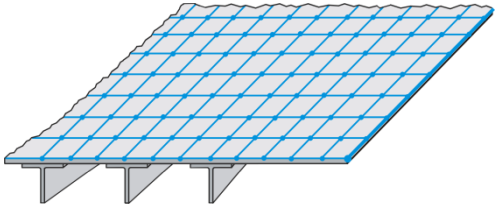
Modeling the Panel

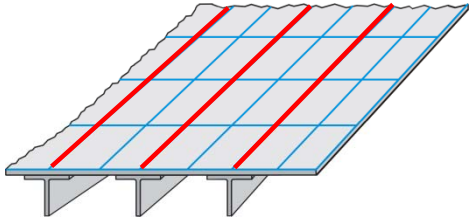


Global

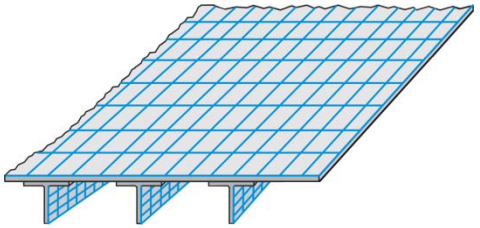


2) Planar 2D mesh with stiffeners smeared in shell elements

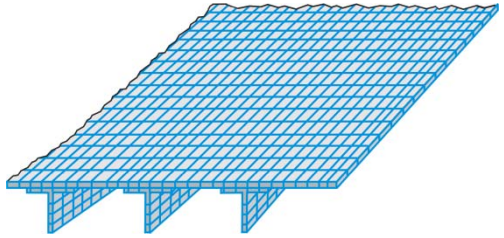




3) Planar 2D mesh with stiffeners modeled with beam elements



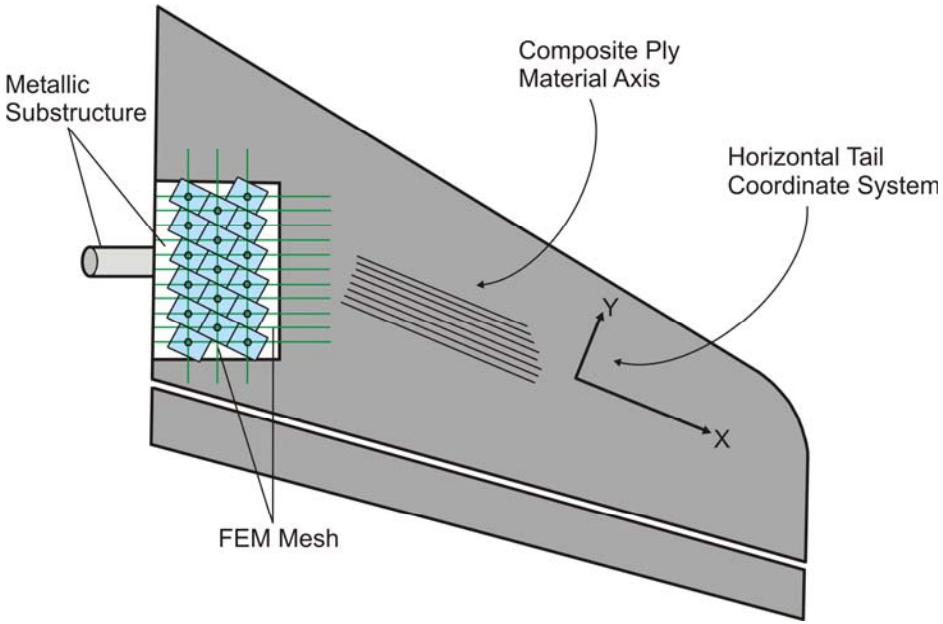
4) Discrete 3D mesh using shell elements for both the facesheet and stiffener web

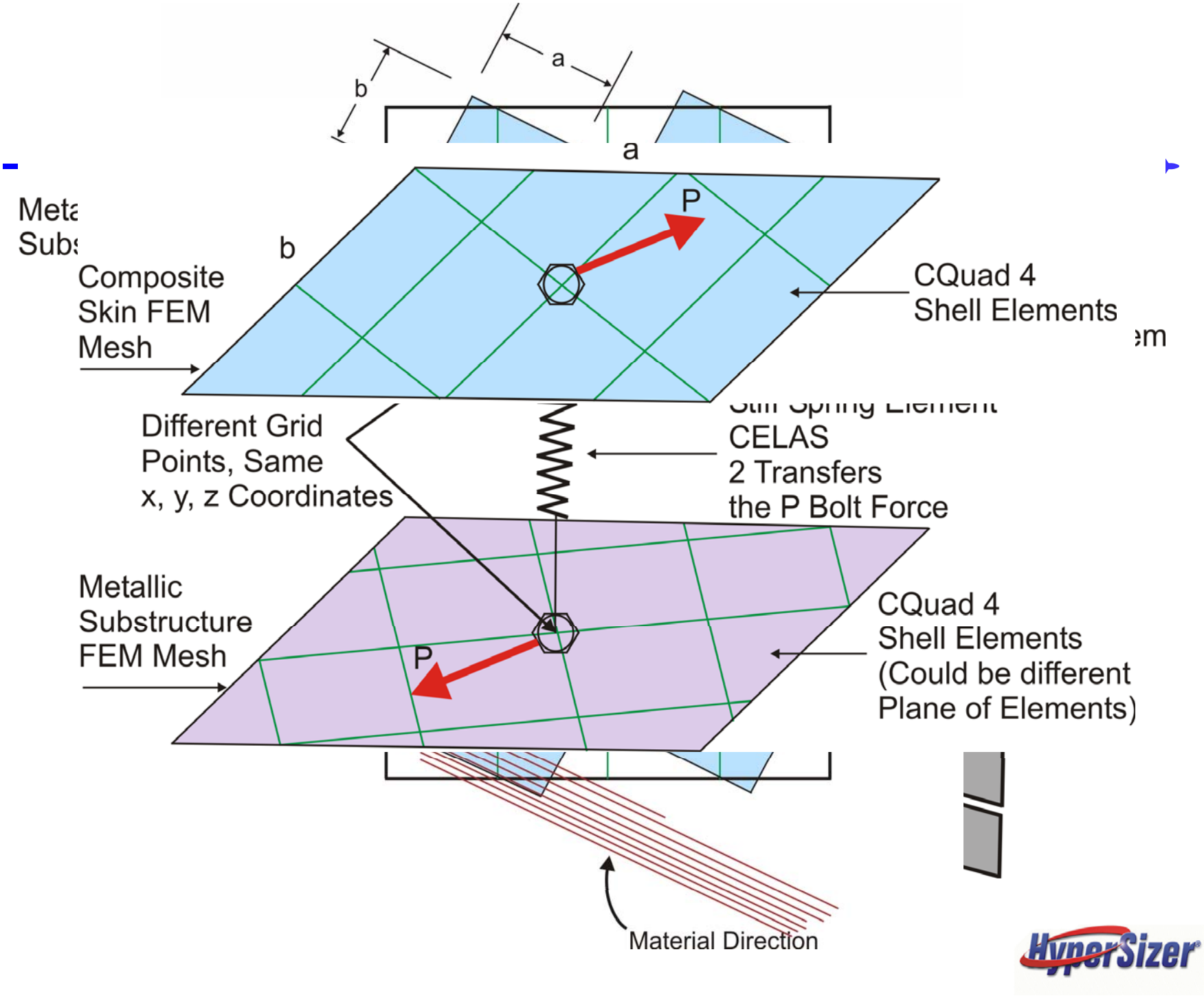


5) Discrete 3D mesh using solid elements for both the facesheet and stiffener web

HyperSizer

Be Able to Rapidly and Accurately Analyze and Size Bolted and Bonded Joints using FEA Computed Loads



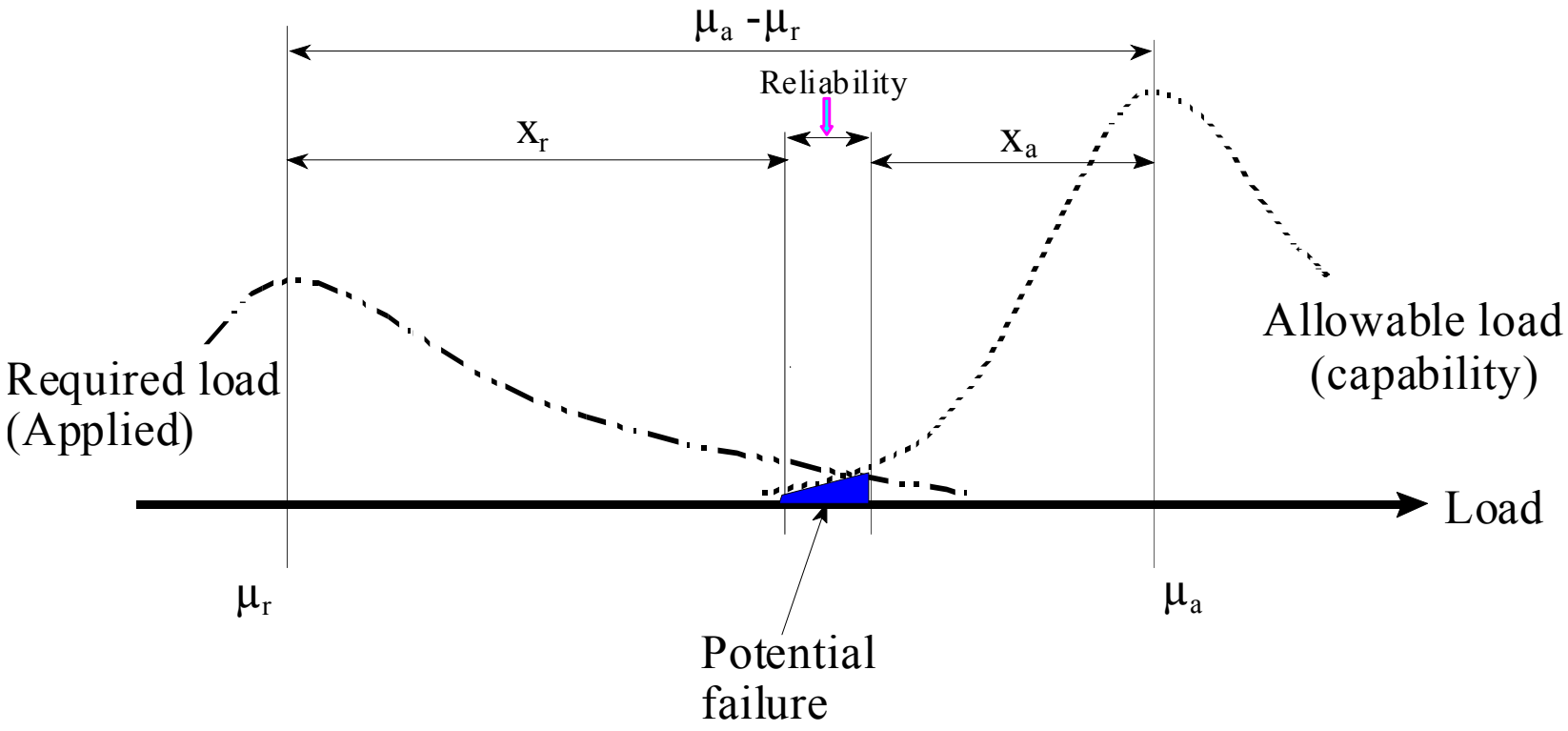

a
b
a
Meta
Subs
b
P
Composite
Skin FEM
Mesh
CQuad 4
Shell Elements
em
Different Grid
Points, Same
x, y, z Coordinates
CELAS
2 Transfers
the P Bolt Force
Metallic
Substructure
FEM Mesh
P
CQuad 4
Shell Elements
(Could be different
Plane of Elements)
Material Direction
HyperSizer

FEM Coupling, Statistical Loads Processing

FEA Statistical Design-to Loads

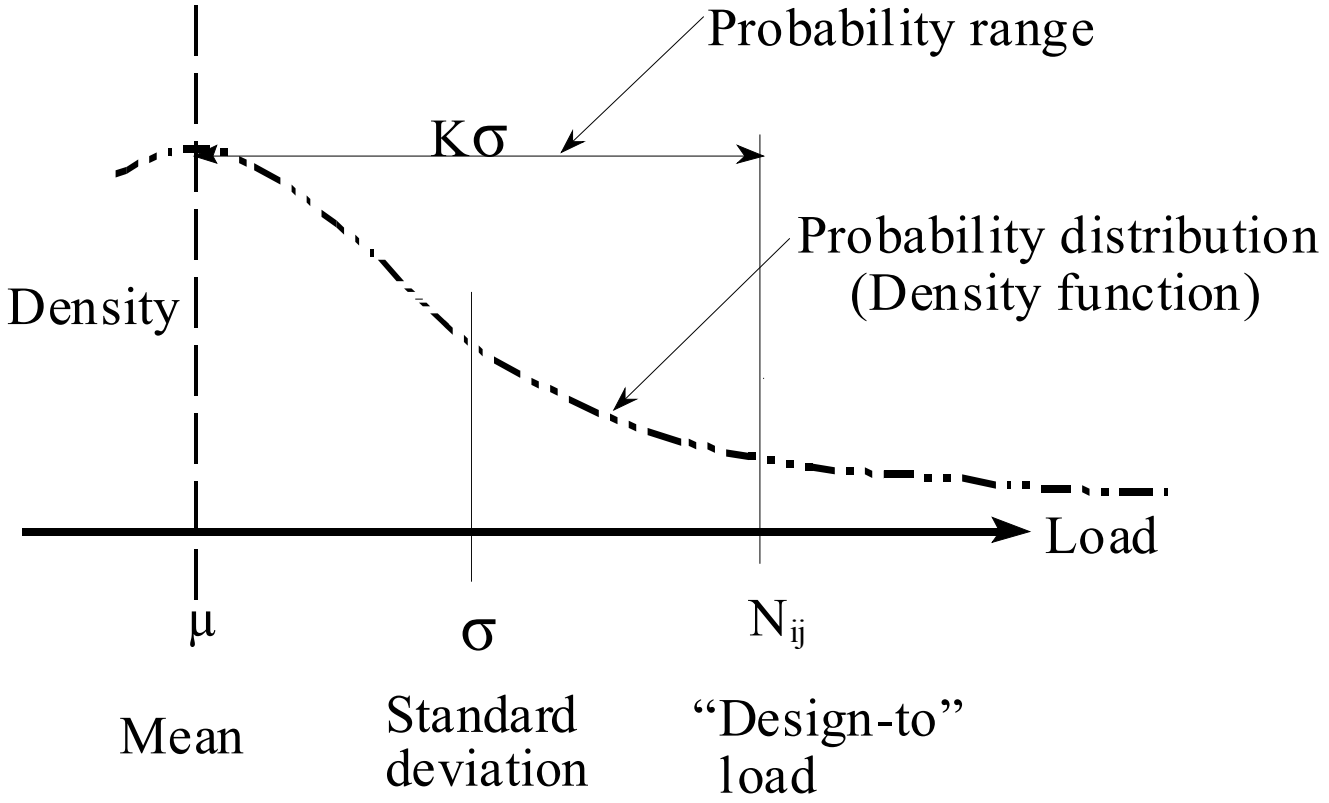
- Solve the automated structural analysis 'pulling-loads' problem that arises when many finite elements are used to represent a structural component
- User may select a standard deviation factor to apply to loadings for strength analysis
- For instability, HyperSizer statistically determines the percentage of a component's area that is in the buckling zone and integrates the non-uniform compressive load over that area

HyperSizer Statistical Approaches to Determine 'Design-to' Loads

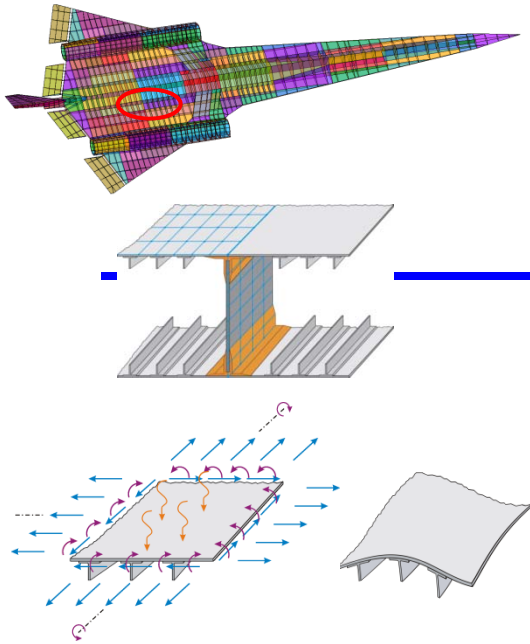


User Chosen Standard Deviation for Strength Analyses

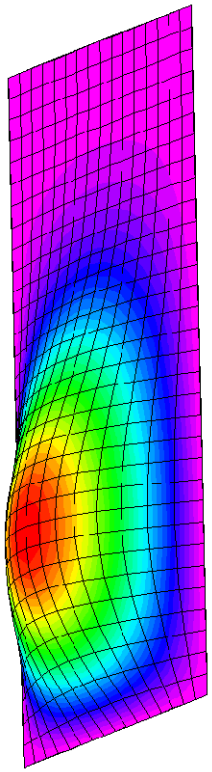
"Design-to" loading = $\mu + K\sigma$

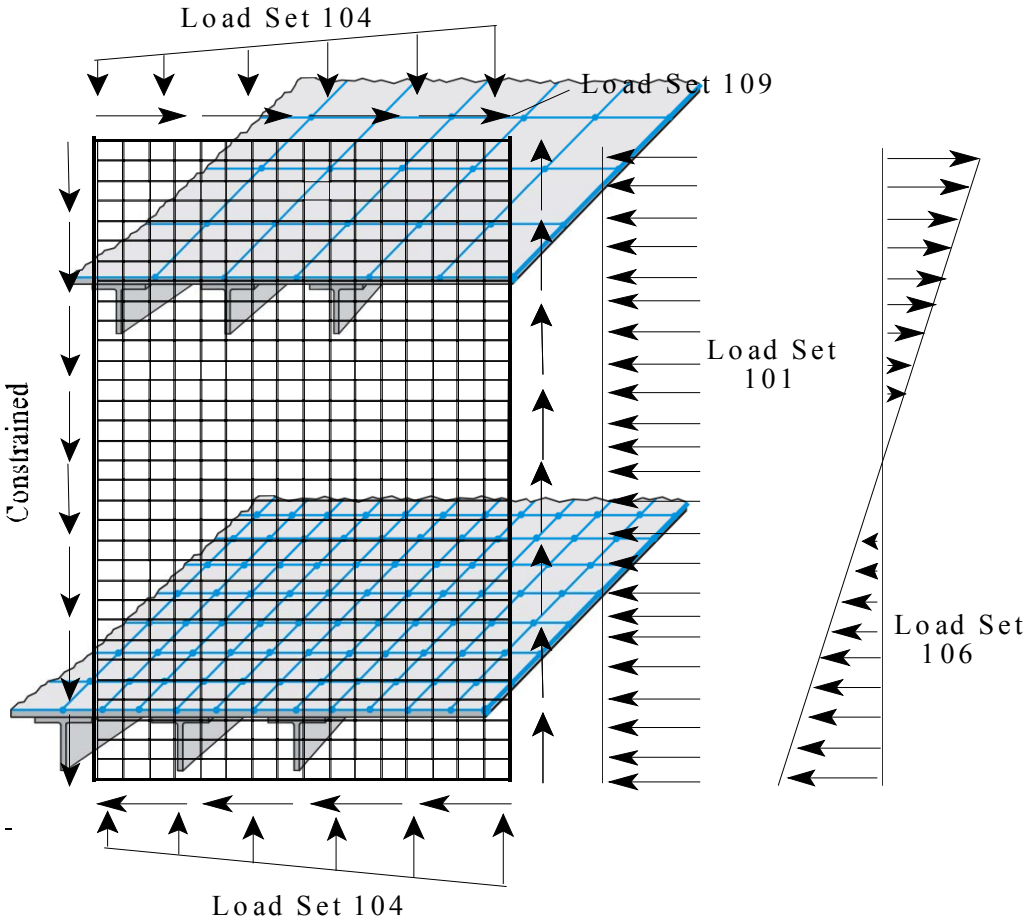


HyperSizer Statistical Approaches to Determine 'Design-to' Loads

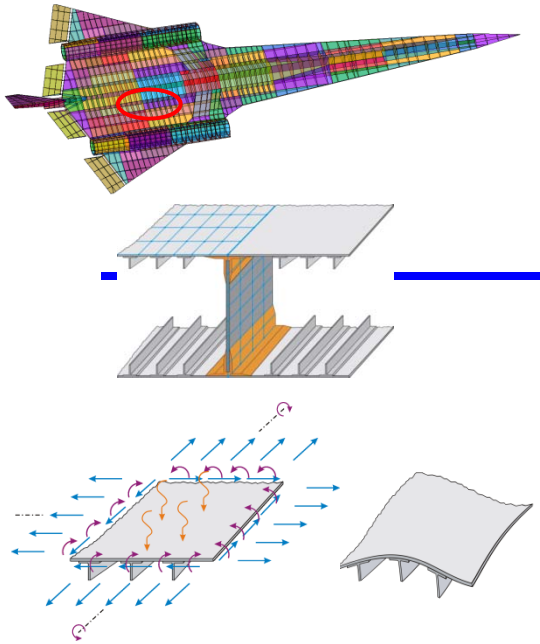


Global





HyperSizer Statistical Approaches to Determine 'Design-to' Loads



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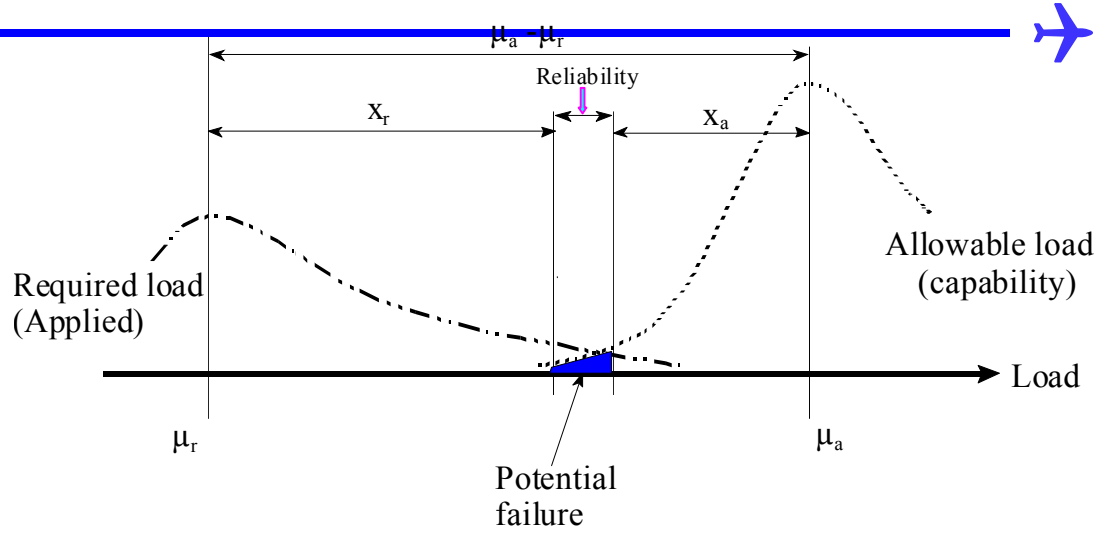
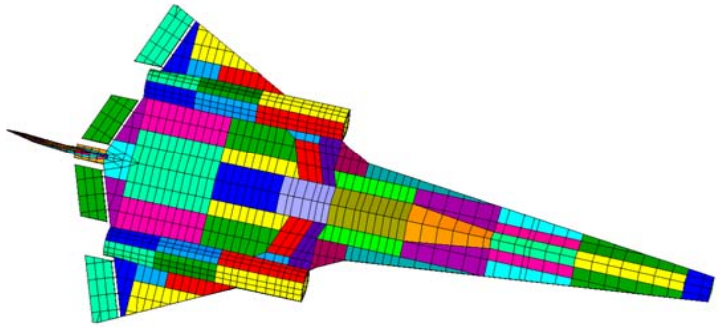
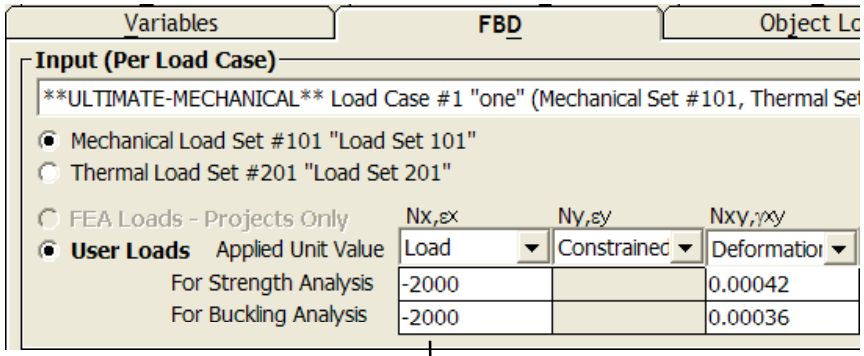


Analyses are Independent of Loads Source

FEA Computed Loads



User Input (typed-in loads)



Other Sources Using HyperSizer's Object Model:

- Loads from spreadsheets
- Loads from a larger company software design system

HyperSizer Analyses