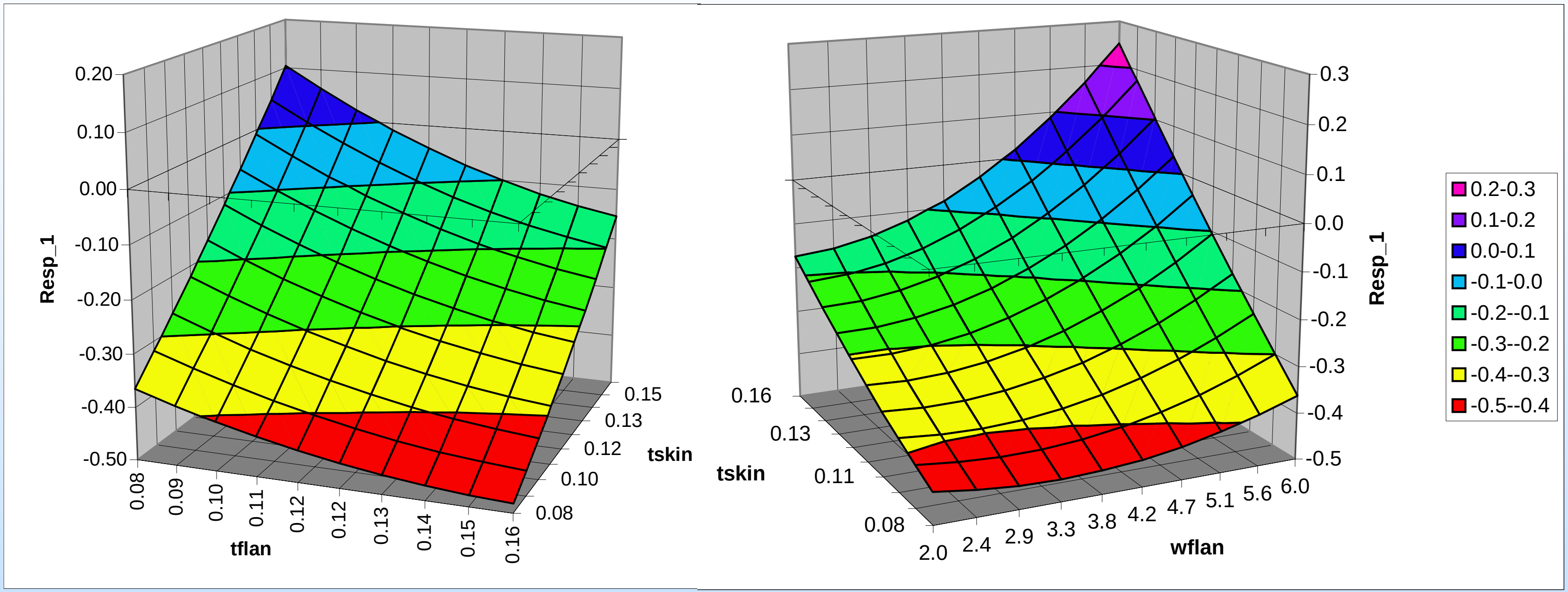
RDCS Edge of Flange Disbond Study

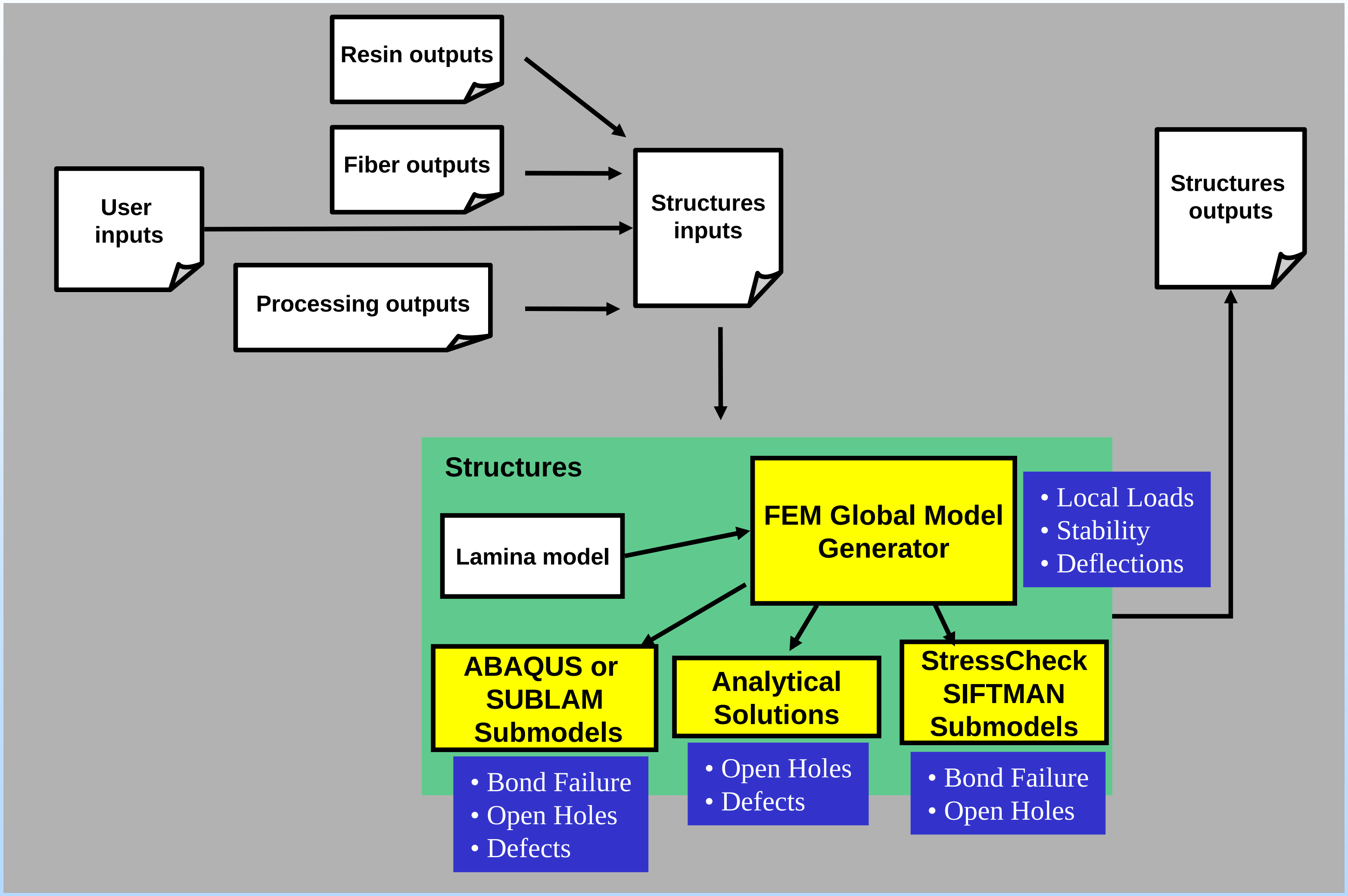
Interaction Results



- **Best edge-of-flange peel margin of safety is when skin is thick and flange is thin**
- **Flange width has a much greater effect on the margin when skins are thick. The effect is highly nonlinear.**

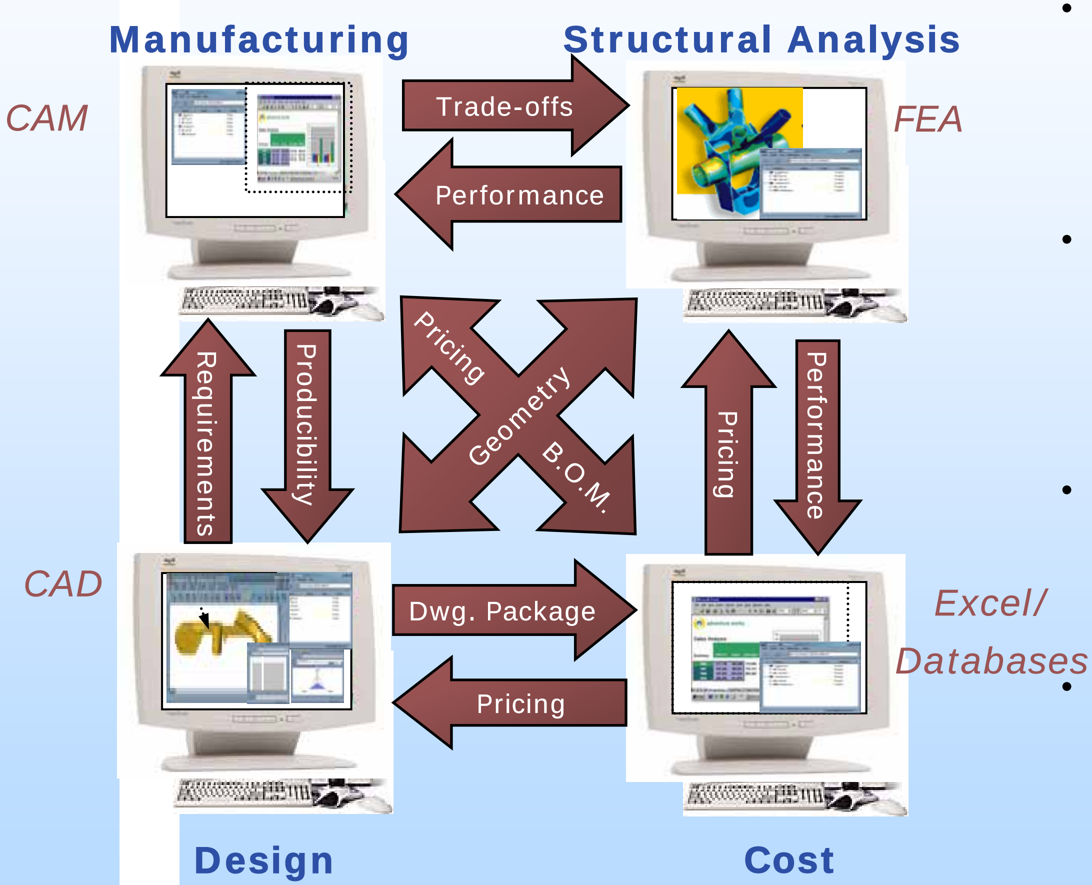
Schematic of Design/Analysis Framework

Long term Strategy



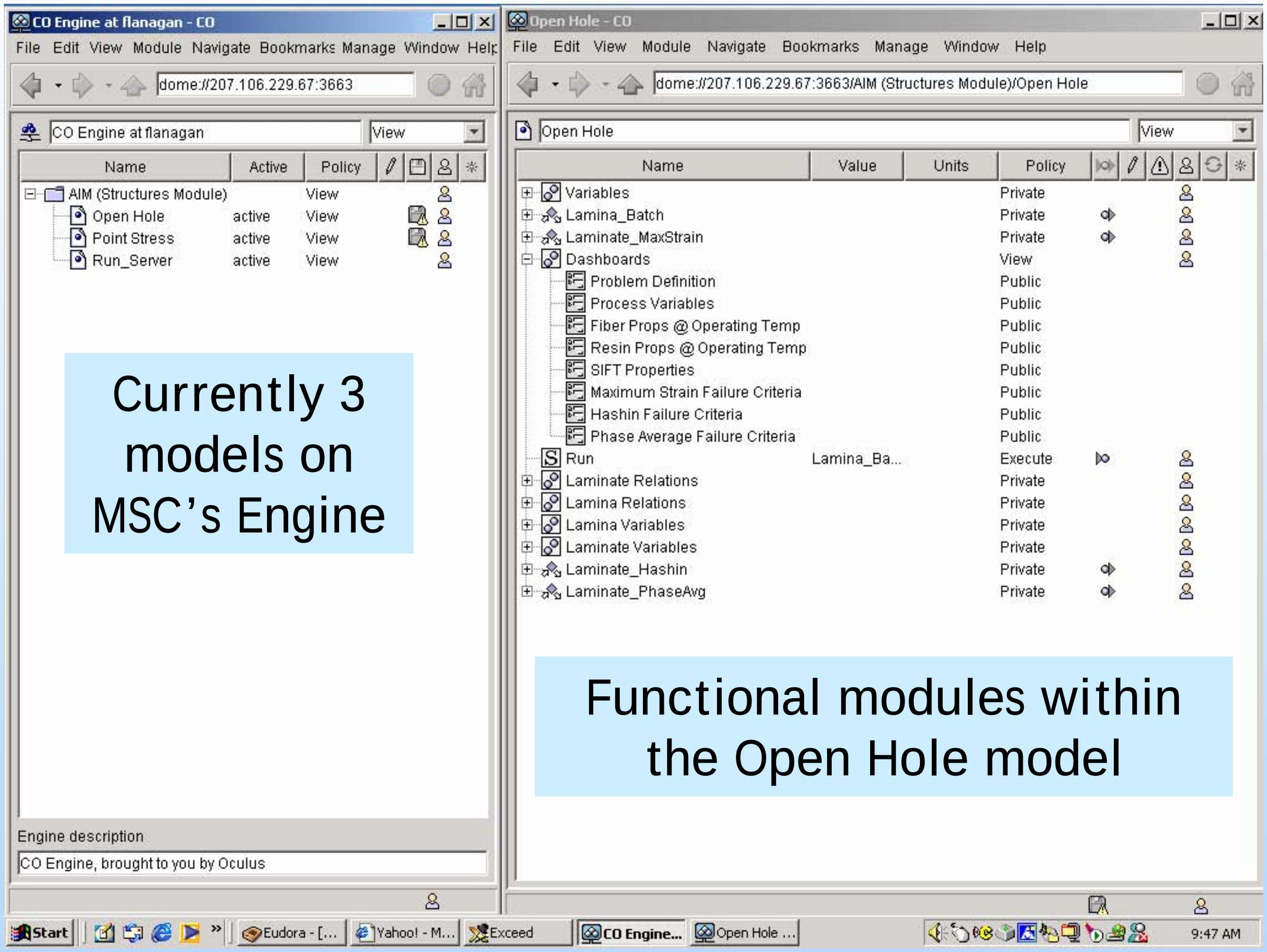
The Oculus Integration System

CO™: A Plug & Play Modeling Environment

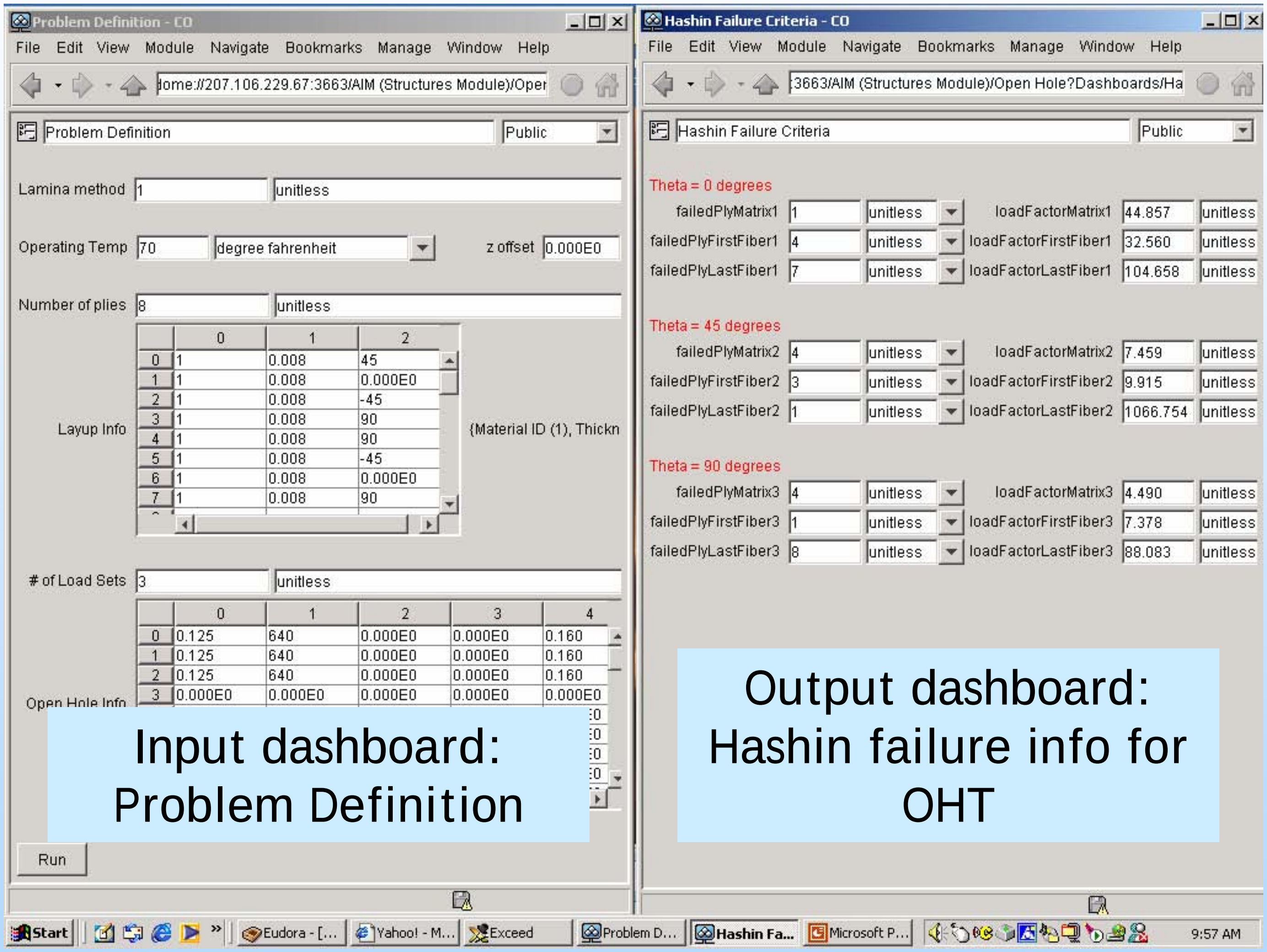


- **Integrates Data and Software Applications on-the-fly**
  - Drag & Drop, Plug & Play
  - Simple to create, modify, manage, maintain
- **Enables Real-time data sharing between applications**
  - Secure
  - Controlled
  - Intra/Internet
- **Platform Independent**
  - Distributed
  - Neutral to Platforms and Applications
- **Increases Value of Previous Investments**
  - Software
  - Hardware
  - Networks

Oculus Models



Oculus Dashboards



Structures - Hat Stiffened Panel (HSP)

Design/Analysis Procedure

- HSP is a large-scale, complex, detailed design problem
  - Draw on multiple AIM-C modules.
- Accurate results require very fine grid mesh or small element sizes
  - Problem is too large in scale to model with one finite element
  - Thus, a combination of global and local models will be used.
- Submodeling or local modeling capture design details and mfg. defects
  - Submodels are finely meshed cutouts of the global model.
  - Global Model results feed the submodels

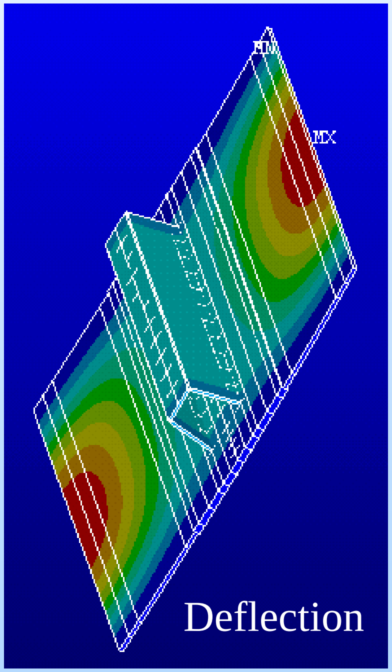
Parametric Global Structures Module

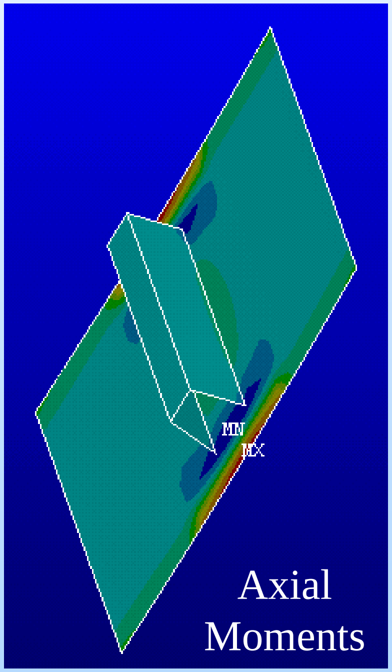
What do you gain from the Global Models?

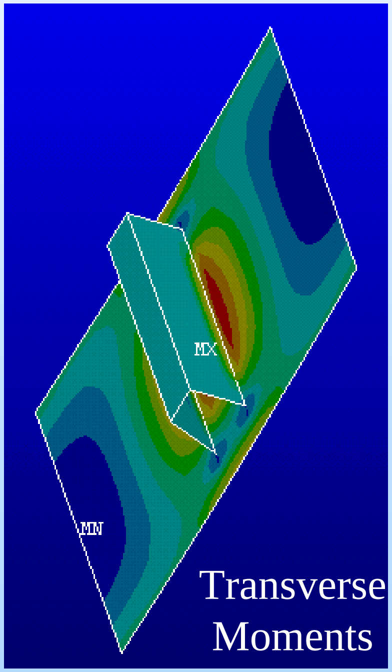
- Accurate Load Distribution – Failures depend on correct local loads
- Identification of Local Model Requirements
- Easy assessment of Multiple Load Cases
- Rapid Design Iteration – Ability to perform quick geometry trades
- Assessment of Global Failure Modes – Stability, Deflection

How do they work? Demonstration using a simple one-bay hat model in ANSYS

- Model and run a baseline…Hat under pressure (Linear)



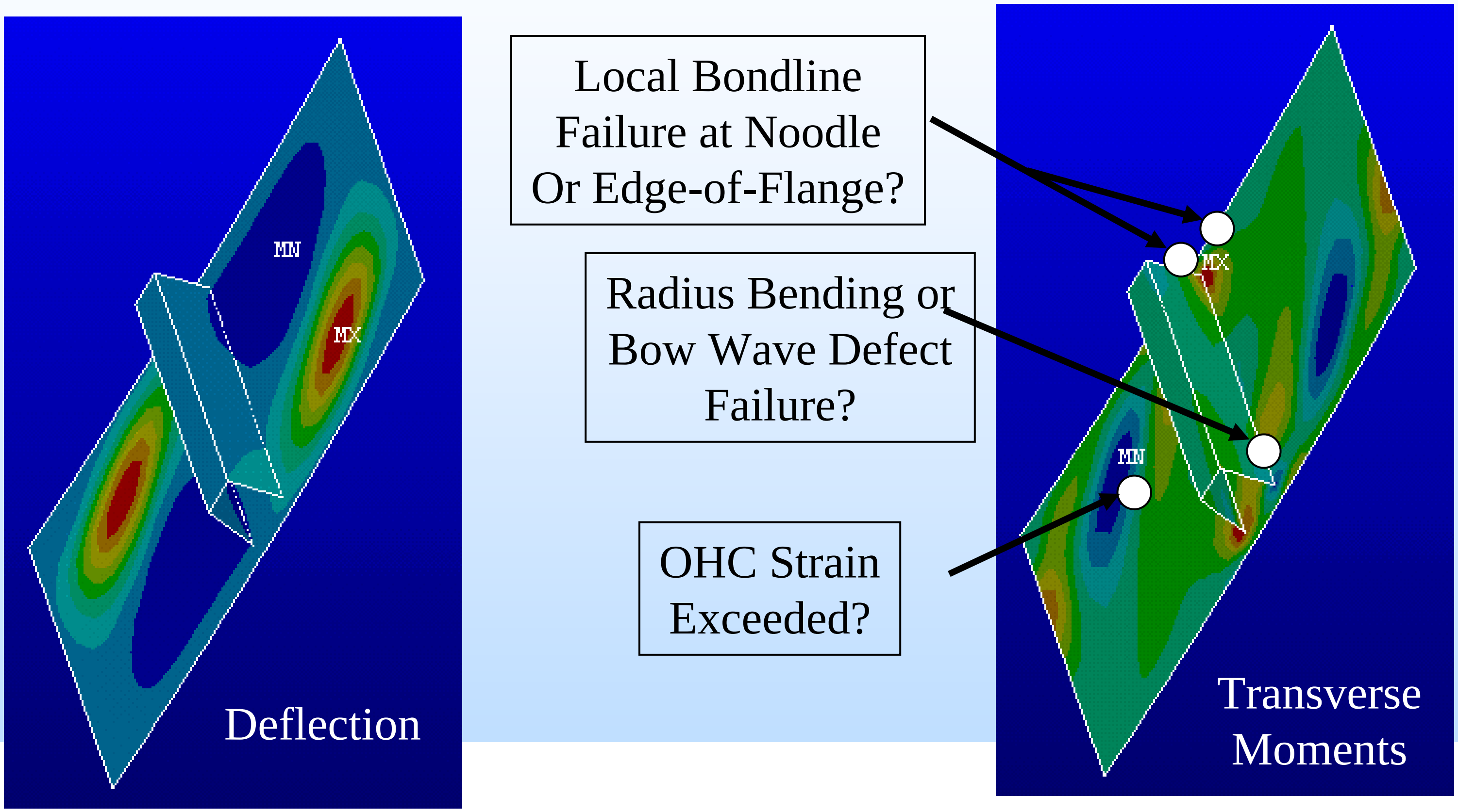




Parametric Global Structures Module Demonstration

Global and Local Failure Modes

Another load case…Hat under in-plane shear (2500με)
(Nonlinear Large Deflection Solution)



- Not buckled yet, but significant bending due to the eccentricity of the stiffener is beginning to form the first buckling mode shape. Max deflection is 0.034”. Okay for Aero?
- Identify local model requirements.

Local Models

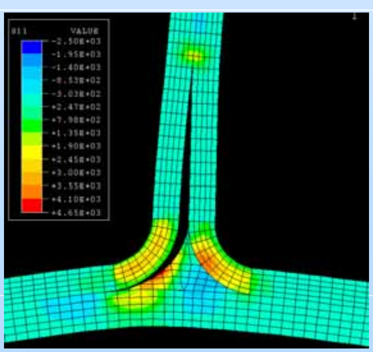
Design Details

Local Models are used to perform detailed analysis in an area of interest, usually
A potential failure location – often an area of high loading near a structural discontinuity

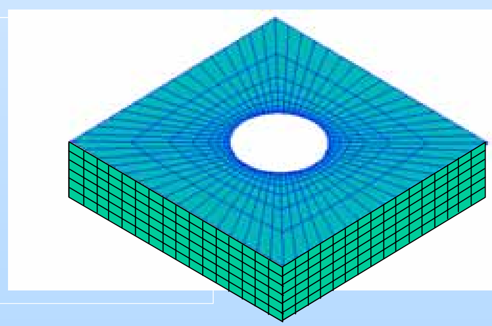
Two kinds of Local Models:

1. Design Details – a designed-in structural feature (e.g., Open Hole, Edge of Flange)
2. Mfg. Defect – an undesired "feature" produced as a side-effect of the manufacturing process (e.g., waviness, delamination, porosity)

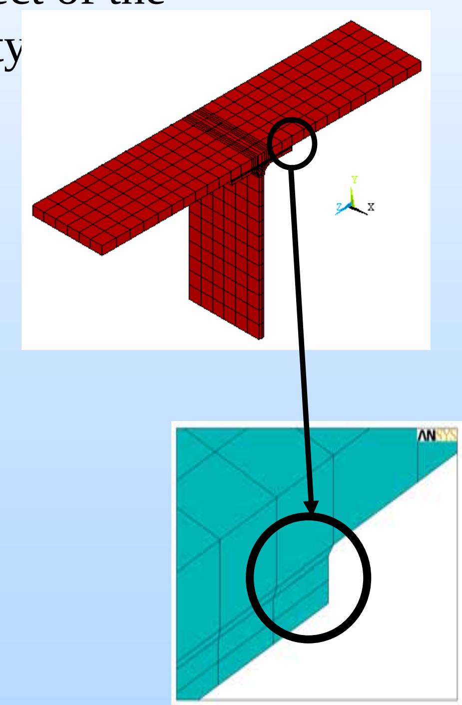
Local Models for Design Details:



"Noodle" Models



Open Hole Models

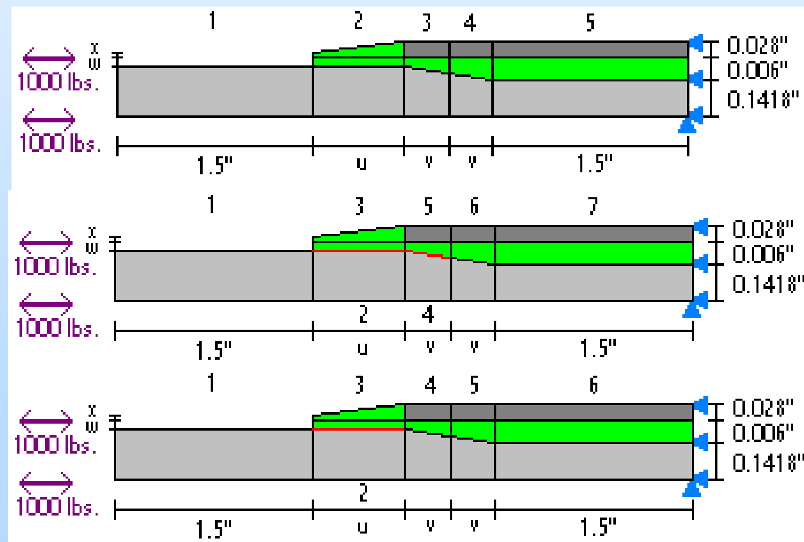


Edge-of-Flange Models

Bow Wave Defect Analysis Using SUBLAM Linked to RDCS

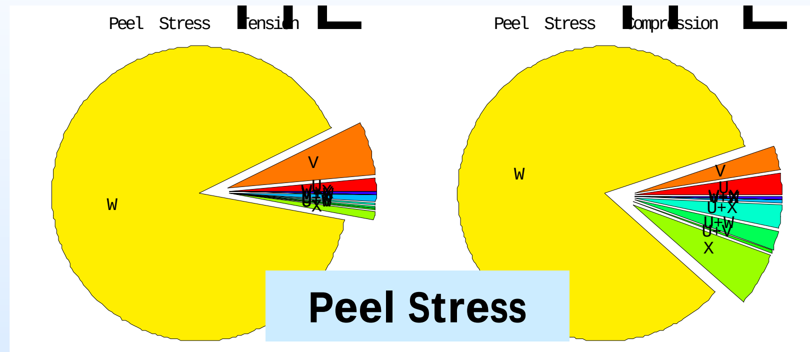
- SUBLAM was incorporated into RDCS to demonstrate the concept of creating a suite of “defect analysis handbooks” to be inserted in the AIM-C CAT.
- Full factorial design space scans were conducted to compute the sensitivity of local stresses and energy release rates under tensile and compressive loads to four geometric variables.

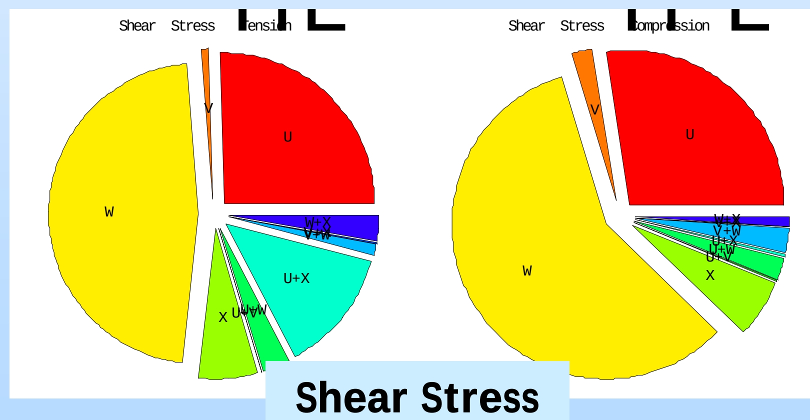
Variable		Lower Limit	Center Value	Upper Limit
u	Resin pool length	0.05”	0.175”	0.3”
v	Bow-wave length	0.05”	0.125”	0.2”
w	Adhesive thickness	0.0005”	0.00325”	0.006”
x	Resin pool height	0.0005”	0.01425”	0.028”



Bow Wave Defect Analysis – Sample Results

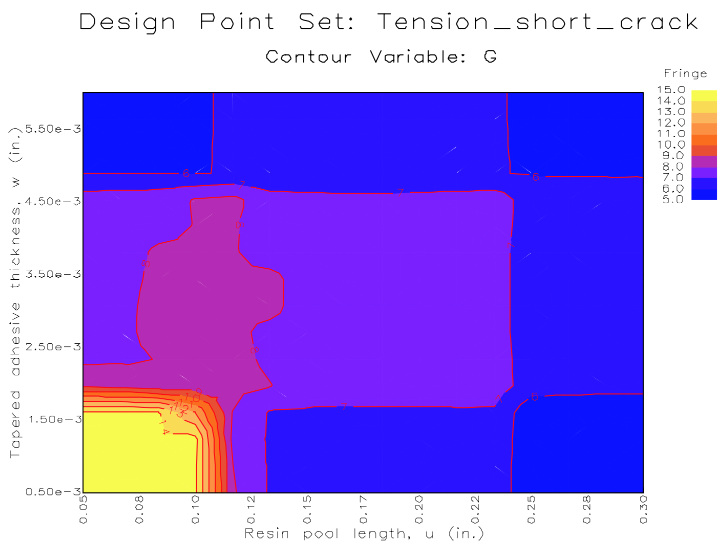
- Peel and shear stresses driven be adhesive thickness and resin pool length.
- Relative contributions depend only slightly on whether load is tensile or compressive.
- Some significant two-way interactions for shear stress, viz., resin pool length and height.
- Bow wave length not a big driver for range studied.



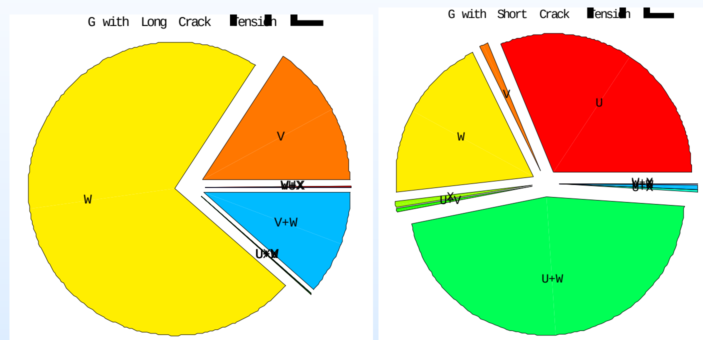


Bow Wave Defect Analysis – Sample Results

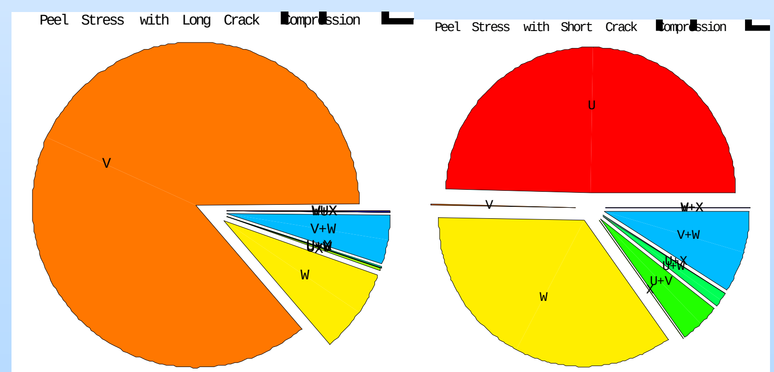
- **Contributions to ERR (G) strongly dependent on whether load is tensile or compressive and initial crack (defect) size.**



G (in-lbs/in^2) for tensile load as a function of initial defect size and adhesive thickness.



Tension



Compression