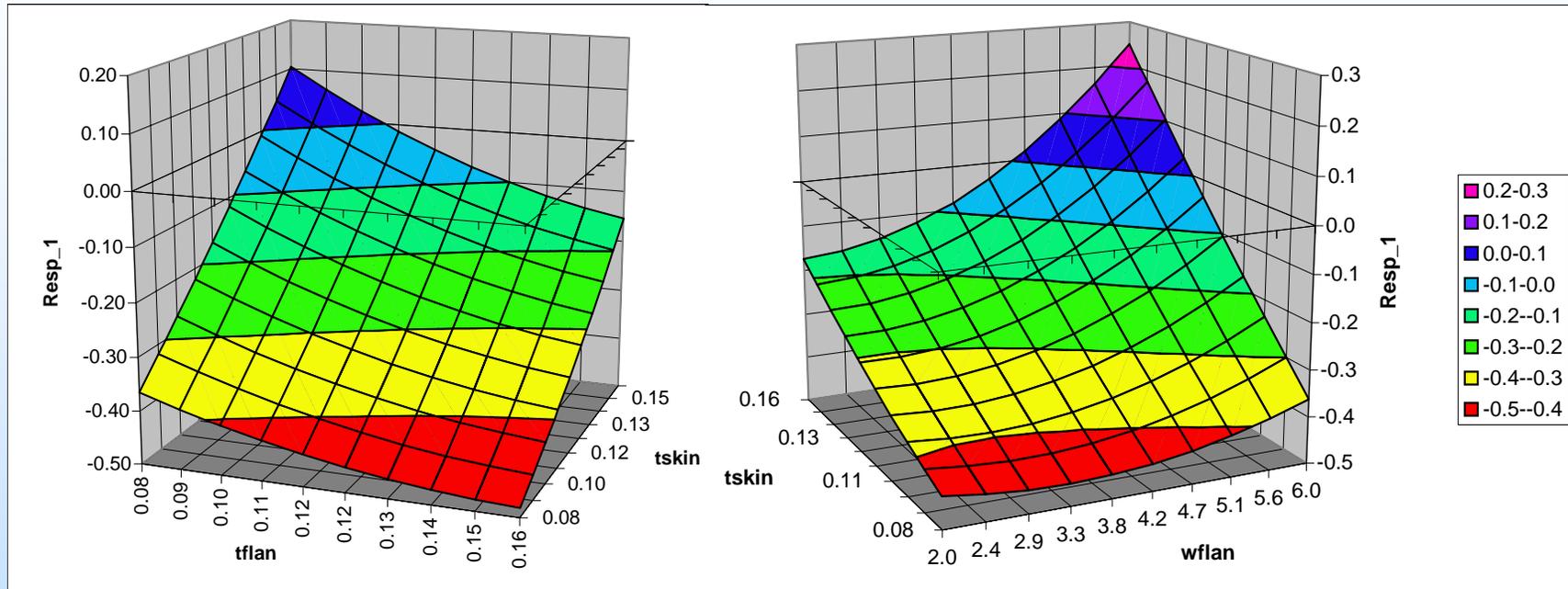




# RDCS Edge of Flange Disbond Study

## Interaction Results

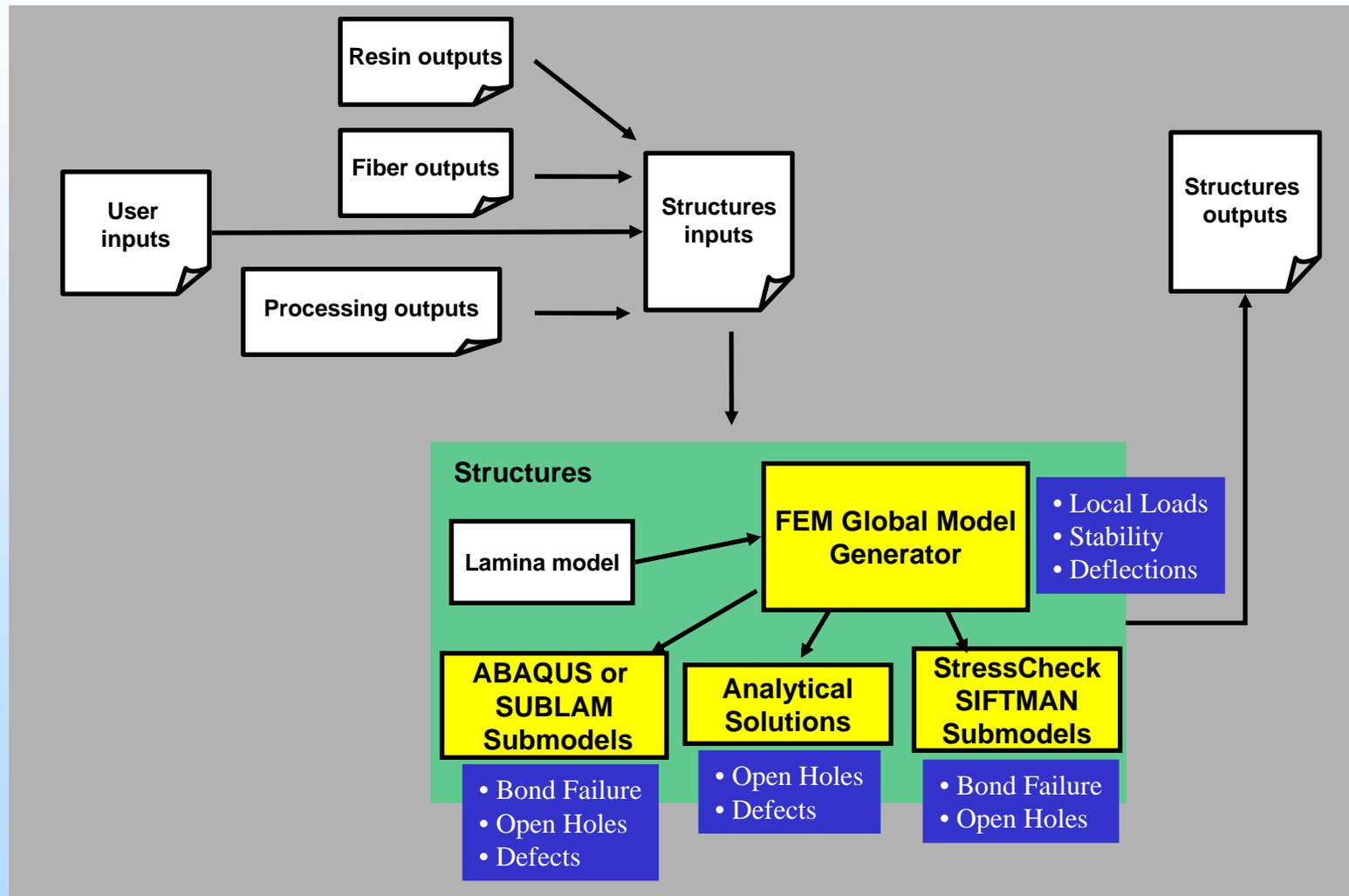


- Best edge-of-flange peel margin of safety is when skin is thick and flange is thin
- Flange width has a much greater effect on the margin when skins are thick. The effect is highly nonlinear.



# Schematic of Design/Analysis Framework

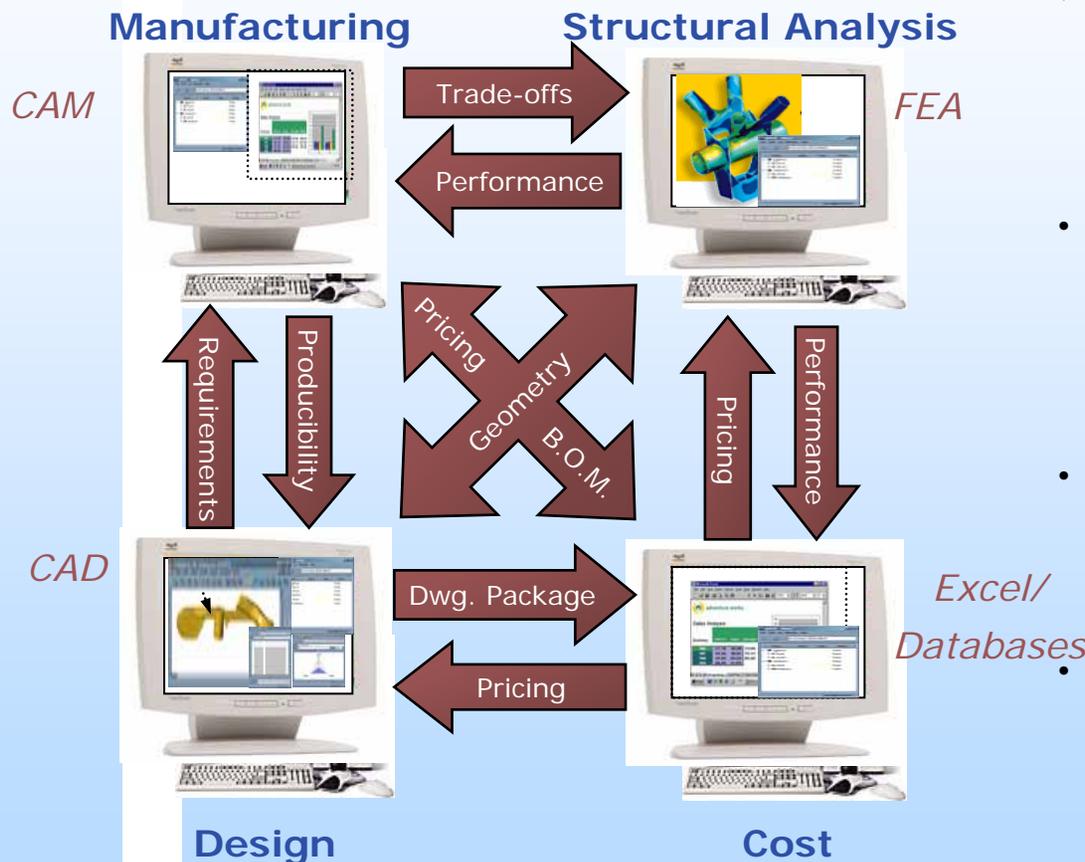
## Long term Strategy





# 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

The screenshot displays two windows from the CO Engine software. The left window, titled 'CO Engine at flanagan - CO', shows a tree view of the model structure under 'AIM (Structures Module)'. The right window, titled 'Open Hole - CO', shows a detailed view of the 'Open Hole' model's functional modules.

**Currently 3 models on MSC's Engine**

Name	Active	Policy
AIM (Structures Module)		View
Open Hole	active	View
Point Stress	active	View
Run_Server	active	View

**Functional modules within the Open Hole model**

Name	Value	Units	Policy
Variables			Private
Lamina_Batch			Private
Laminate_MaxStrain			Private
Dashboards			View
Problem Definition			Public
Process Variables			Public
Fiber Props @ Operating Temp			Public
Resin Props @ Operating Temp			Public
SIFT Properties			Public
Maximum Strain Failure Criteria			Public
Hashin Failure Criteria			Public
Phase Average Failure Criteria			Public
Run	Lamina_Ba...		Execute
Lamina Relations			Private
Lamina Variables			Private
Laminate Variables			Private
Laminate_Hashin			Private
Laminate_PhaseAvg			Private

Engine description  
CO Engine, brought to you by Oculus



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# Oculus Dashboards

The image displays two side-by-side software windows. The left window, titled "Problem Definition - CO", contains input parameters for a simulation. The right window, titled "Hashin Failure Criteria - CO", displays the resulting output data for three different theta angles.

**Input dashboard: Problem Definition**

Problem Definition: Public

Lamina method: 1 unitless

Operating Temp: 70 degree fahrenheit z offset: 0.000E0

Number of plies: 8 unitless

Layup Info (Material ID (1), Thickn):

	0	1	2
0	1	0.008	45
1	1	0.008	0.000E0
2	1	0.008	-45
3	1	0.008	90
4	1	0.008	90
5	1	0.008	-45
6	1	0.008	0.000E0
7	1	0.008	90

# of Load Sets: 3 unitless

Open Hole Info:

	0	1	2	3	4
0	0.125	640	0.000E0	0.000E0	0.160
1	0.125	640	0.000E0	0.000E0	0.160
2	0.125	640	0.000E0	0.000E0	0.160
3	0.000E0	0.000E0	0.000E0	0.000E0	0.000E0

Run

**Output dashboard: Hashin failure info for OHT**

Hashin Failure Criteria: Public

Theta = 0 degrees

Parameter	Value	Unit
failedPlyMatrix1	1	unitless
loadFactorMatrix1	44.857	unitless
failedPlyFirstFiber1	4	unitless
loadFactorFirstFiber1	32.560	unitless
failedPlyLastFiber1	7	unitless
loadFactorLastFiber1	104.658	unitless

Theta = 45 degrees

Parameter	Value	Unit
failedPlyMatrix2	4	unitless
loadFactorMatrix2	7.459	unitless
failedPlyFirstFiber2	3	unitless
loadFactorFirstFiber2	9.915	unitless
failedPlyLastFiber2	1	unitless
loadFactorLastFiber2	1066.754	unitless

Theta = 90 degrees

Parameter	Value	Unit
failedPlyMatrix3	4	unitless
loadFactorMatrix3	4.490	unitless
failedPlyFirstFiber3	1	unitless
loadFactorFirstFiber3	7.378	unitless
failedPlyLastFiber3	8	unitless
loadFactorLastFiber3	88.083	unitless



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# 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



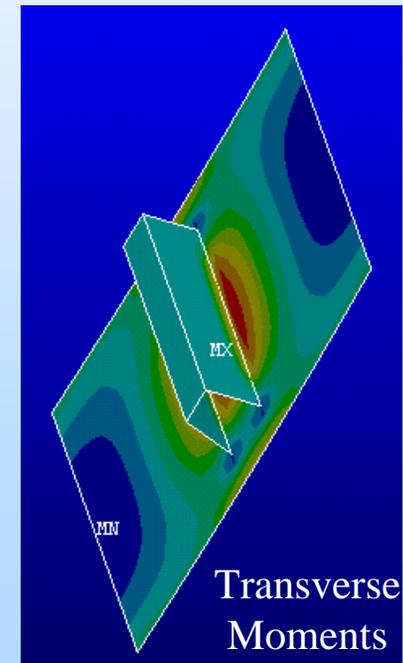
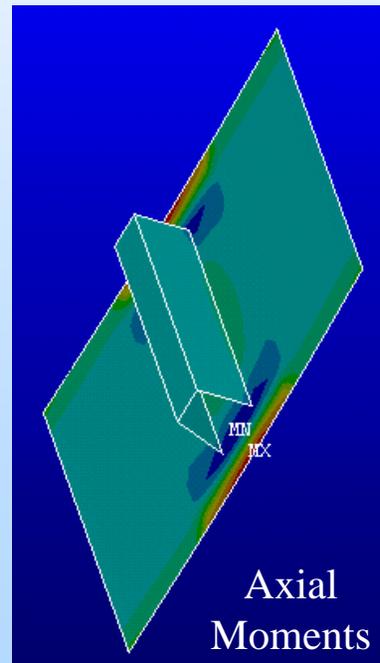
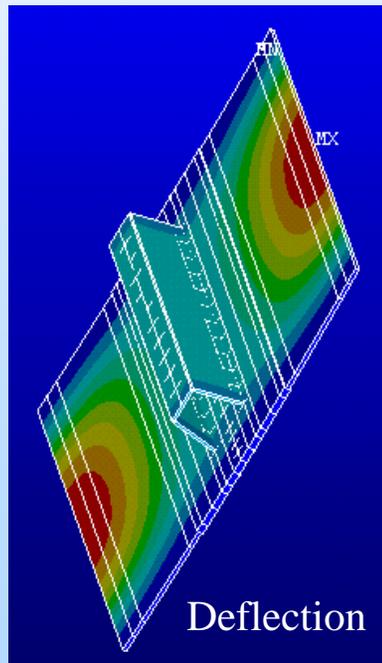
## Parametric Global Structures Module

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)

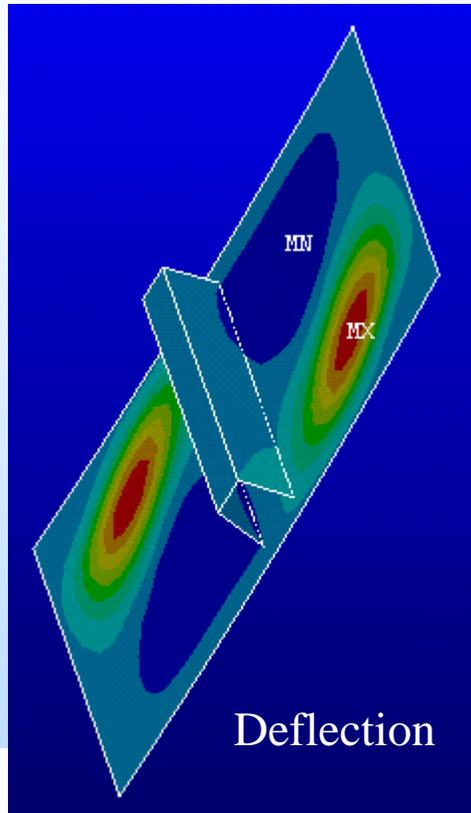




# Parametric Global Structures Module Demonstration

## Global and Local Failure Modes

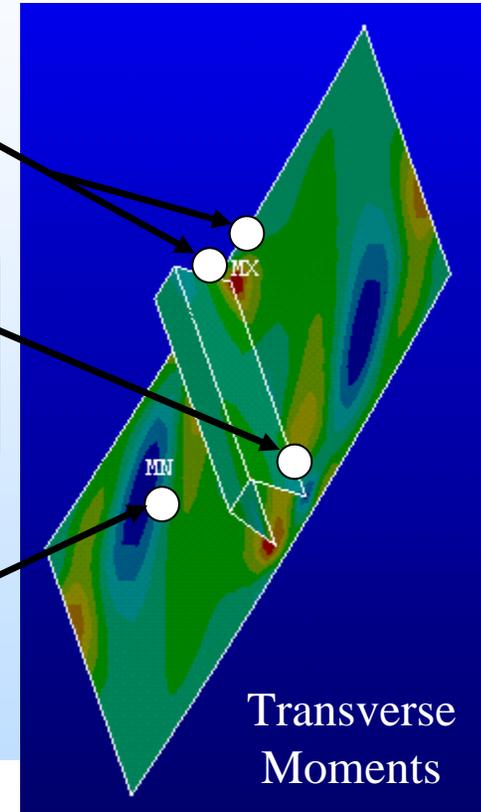
Another load case...Hat under in-plane shear ( $2500\mu\epsilon$ )  
(Nonlinear Large Deflection Solution)



Local Bondline Failure at Noodle Or Edge-of-Flange?

Radius Bending or Bow Wave Defect Failure?

OHC Strain Exceeded?



- 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

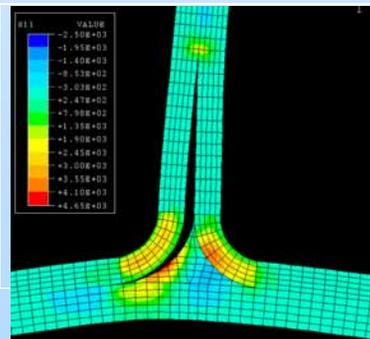
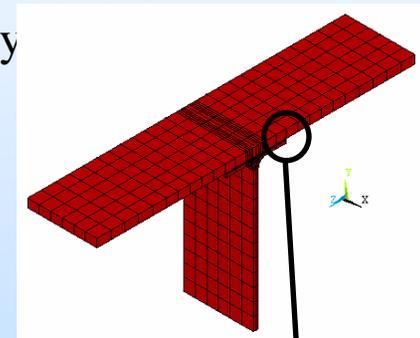
## Design Details

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

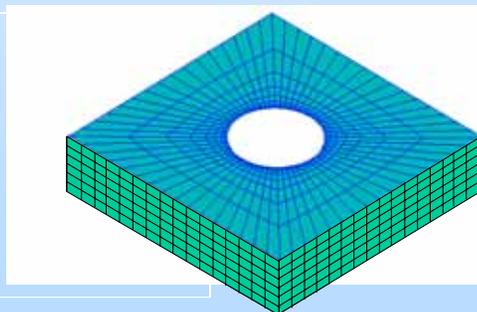
Two kinds of Local Models:

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)

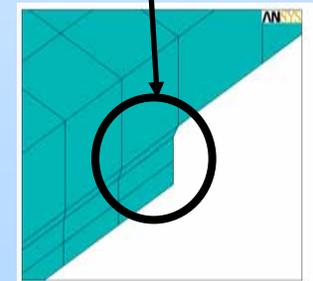
Local Models for Design Details:



“Noodle” Models



Open Hole Models

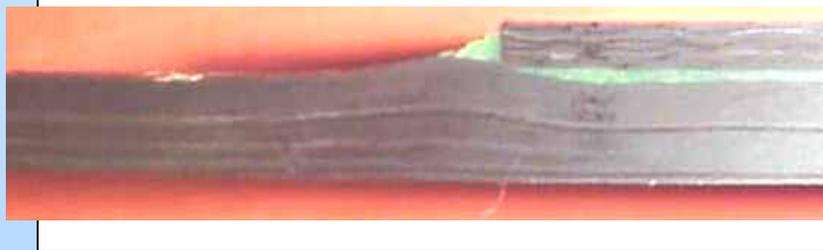


Edge-of-Flange Models

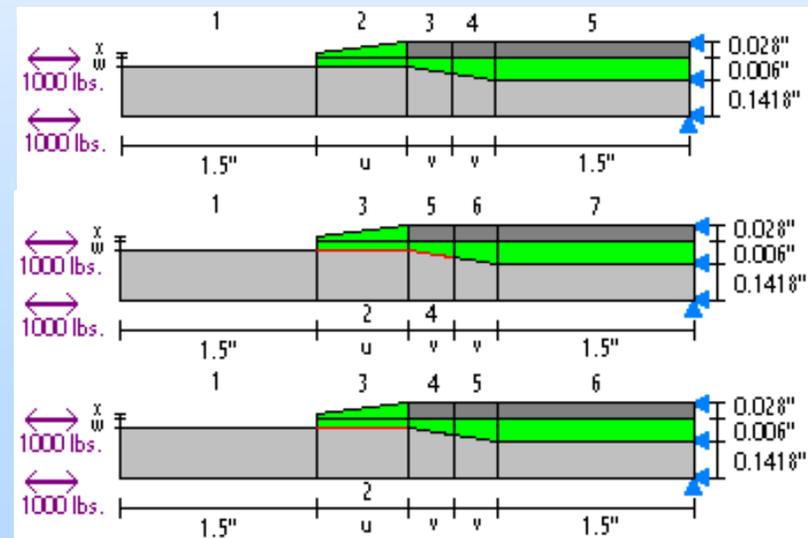


# Bow Wave Defect Analysis Using SUBLAM Linked to RDCS

- 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.



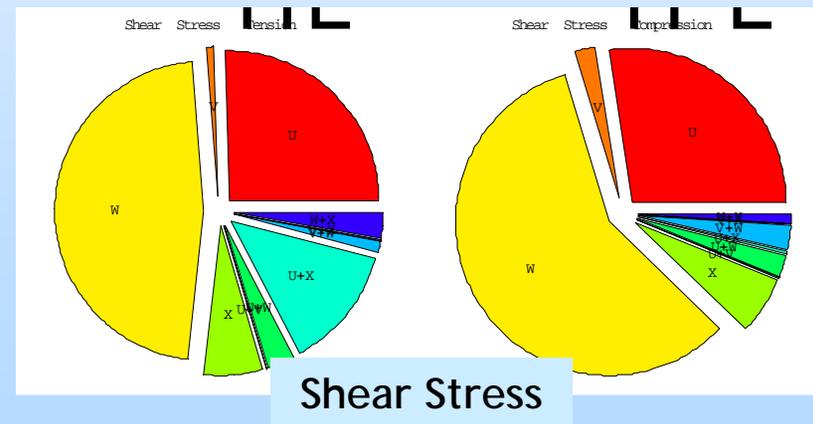
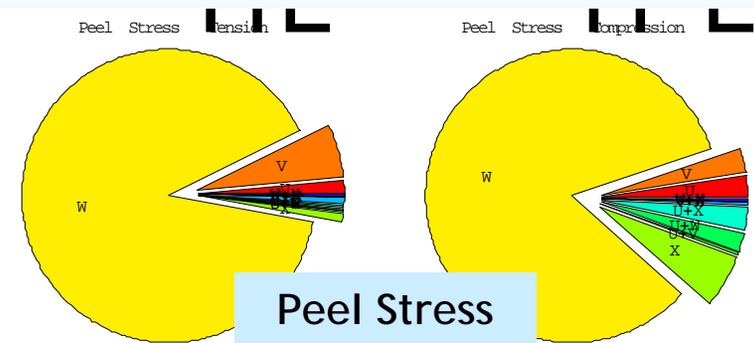
Variable		Lower Limit	Center Value	Upper Limit
<i>u</i>	Resin pool length	0.05”	0.175”	0.3”
<i>v</i>	Bow-wave length	0.05”	0.125”	0.2”
<i>w</i>	Adhesive thickness	0.0005”	0.00325”	0.006”
<i>x</i>	Resin pool height	0.0005”	0.01425”	0.028”





# Bow Wave Defect Analysis – Sample Results

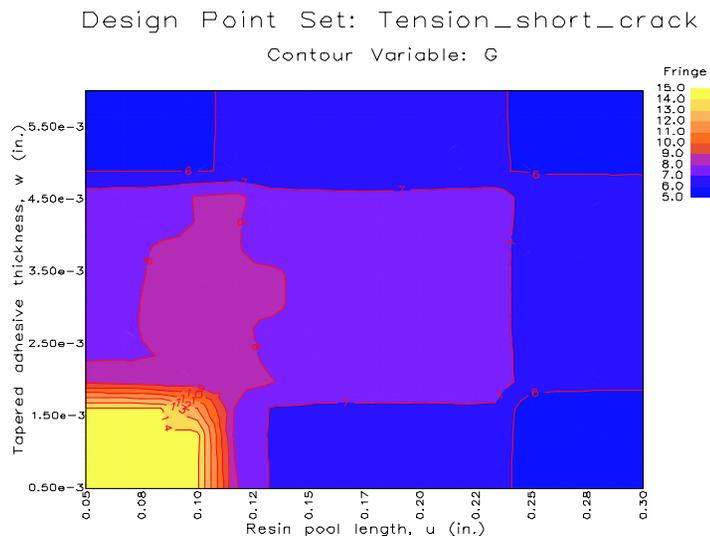
- Peel and shear stresses driven by adhesive thickness and resin pool length.
- Relative contributions depend only slightly on whether load is tensile or compressive.
- Some significant two-way interactions for shear stress, viz., resin pool length and height.
- Bow wave length not a big driver for range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



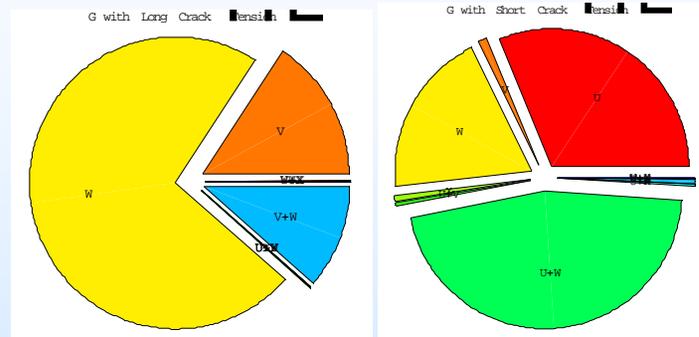


# Bow Wave Defect Analysis – Sample Results

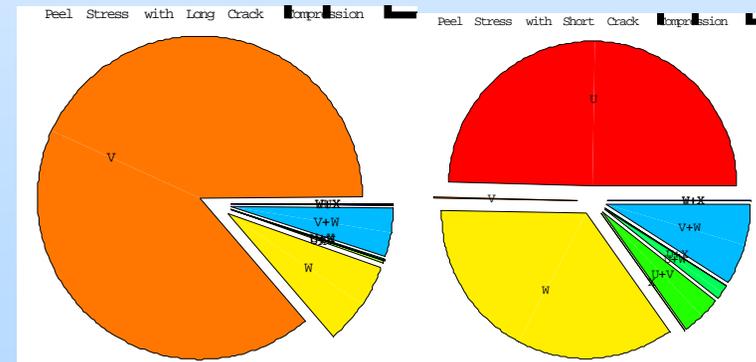
- Contributions to ERR (G) strongly dependent on whether load is tensile or compressive and initial crack (defect) size.



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



Tension



Compression