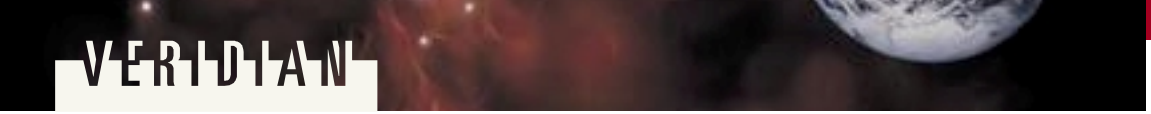

VERIDIAN
ENGINEERING
DIVISION
Aeronautics Sector

Practical External Utility Programs for Finite Element Modeling using SDRC I-DEAS Master Series

FEMCI Workshop 2001
Innovative FEM Solutions to Challenging Problems
NASA Goddard Space Flight Center

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16 May 2001

Discussion Topics

- **Modeling Multiple Bolted Joints using I-DEAS FEM Assembly**
  - One method for joining multiple FE parts of an assembly
- **Summarizing FEA Results in One Plot**
  - Using Superposition to Show the Worse Stresses
- **Model Verification**
  - Color Plots of Element Thickness

Mechanical Designs Courtesy of the
Space Systems Laboratory at UMD

Modeling Multiple Bolted Joints using I-DEAS FEM Assembly

Problem: Connect FE parts with multiple bolts into one assembly

Solutions:

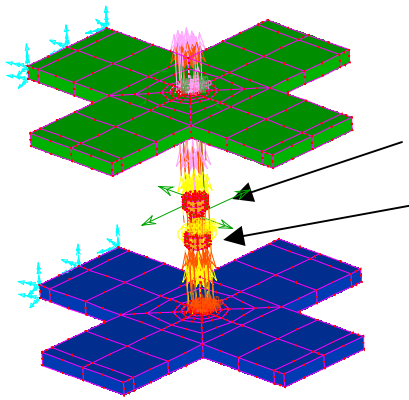
- **Model bolt with a BEAM and tie interface together with an RBE2**
- Merge plate thickness together to form one plate
- Tie plates together with an RBE2
- Tie bolt pattern together with RBE3
- Model entire bolt with bolt hole, contact problem

Pros/Cons:

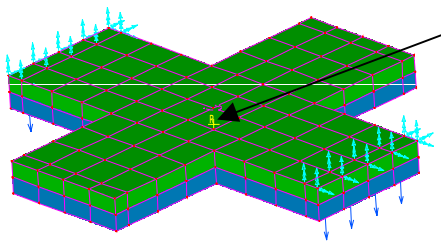
- **Can simulate bolt preload with temperature**
- **Can determine preloads and shear loads**
- **Does not account for bolt bending, nut/washer stiffness, friction**
- **Local brick mesh will effect joint stiffness**
- **Mesh is less complicated, one coordinate system is needed**
- **Less time to create RBEs**

Bolted Joint Test Case

FE Model – Axial Load

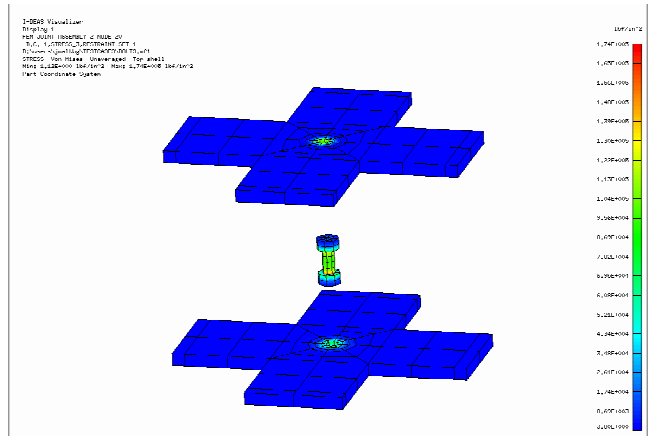


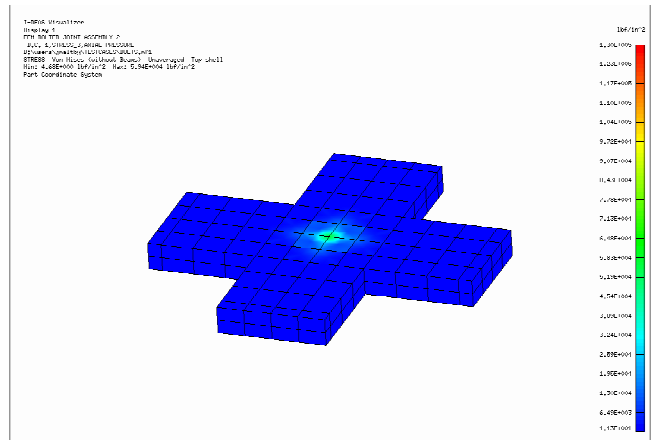
Bolt fully modeled (Contact Model)



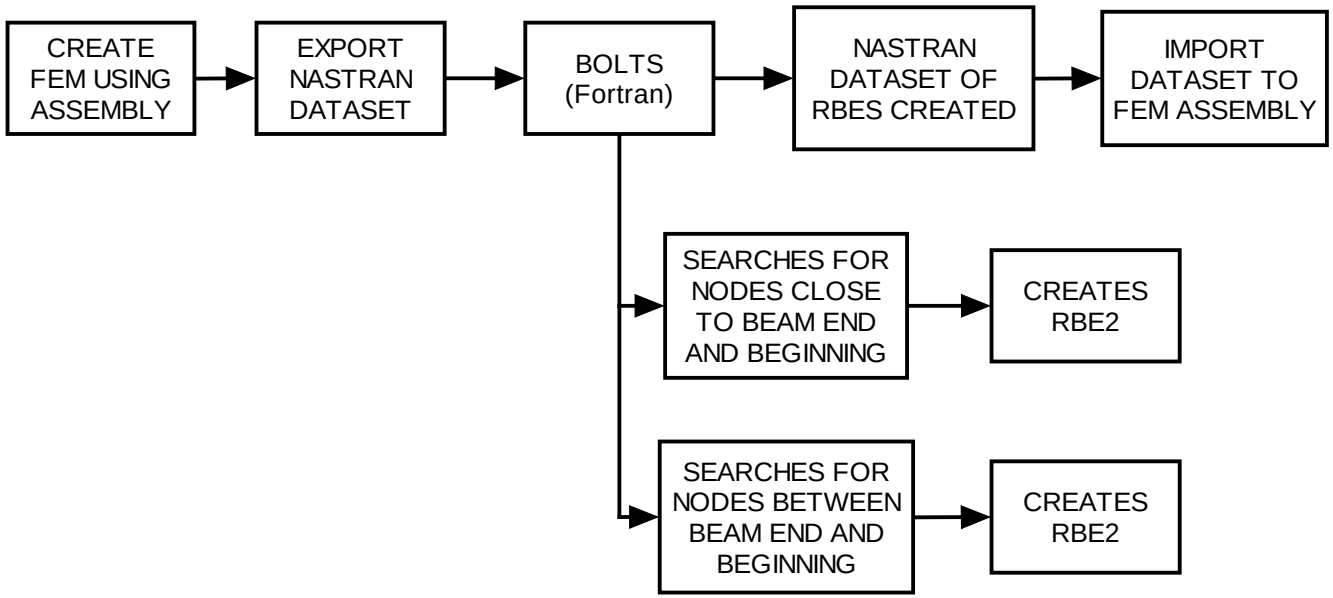
Bolt modeled as beam

Results

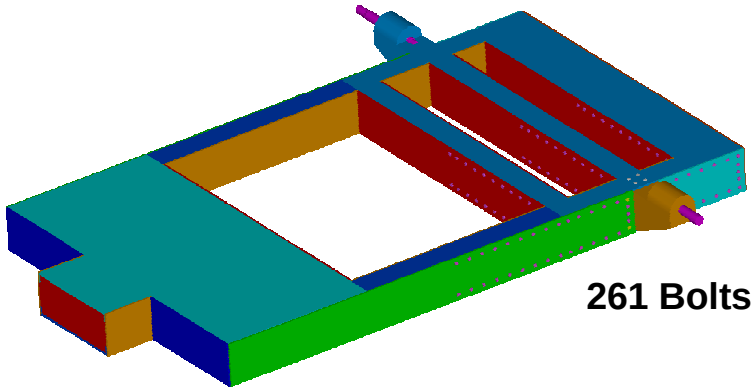




Bolted Joint Methodology

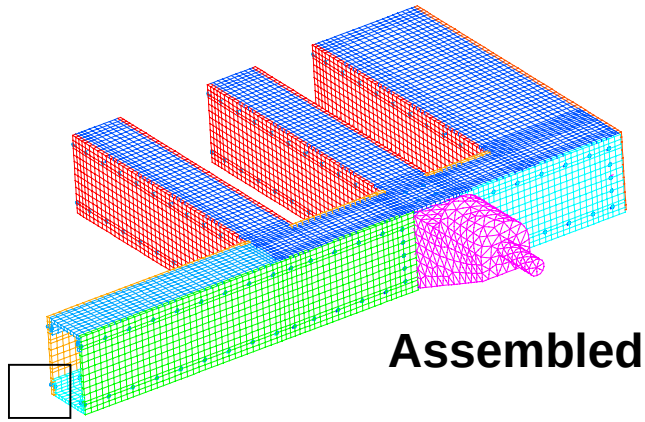


Bolted Joint - Example



261 Bolts

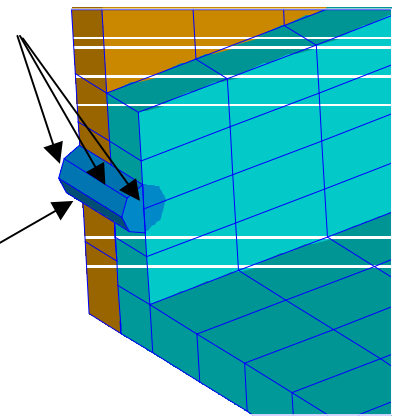
Assembles Model



Assembled FEMs

RBEs

Beam



Bolt FEMs

Summarizing FEA Results in One Plot

Problem: Showing the worse case stresses for each element in the model

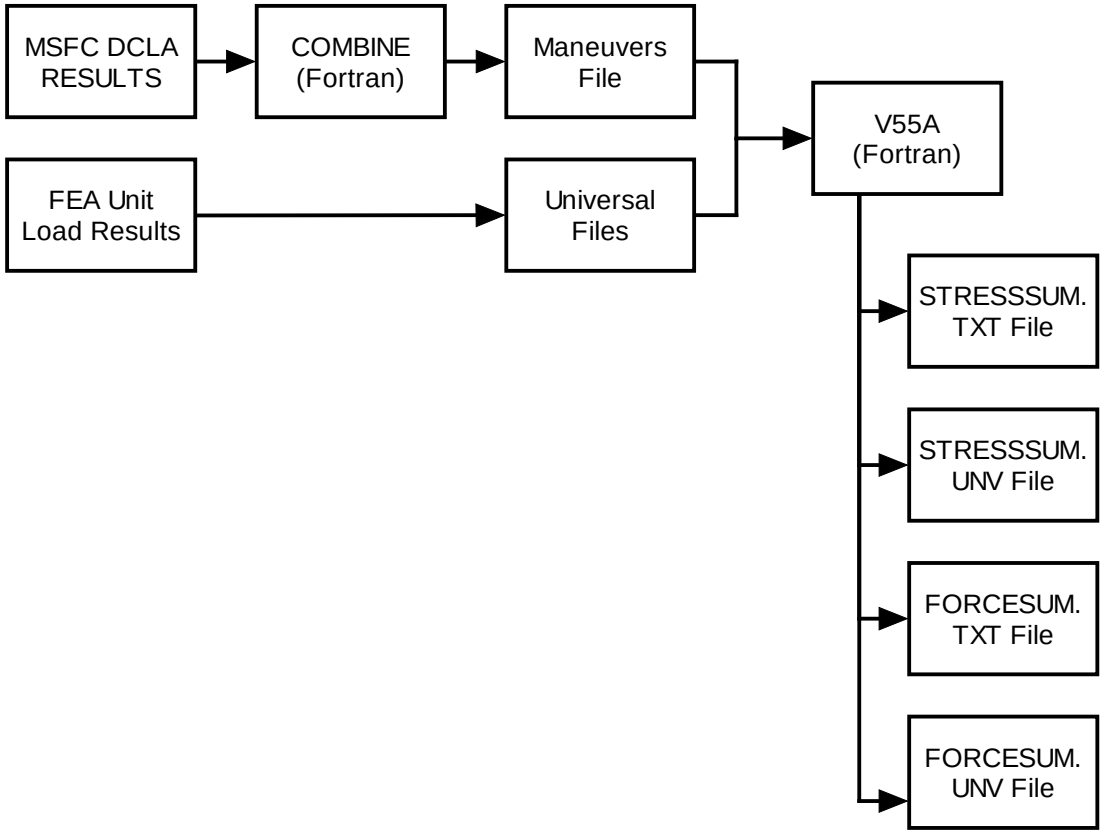
Solution:

- **Run unit load cases, use superposition for each maneuver point (time), combine component stresses, create universal file, and plot results**

Pros/Cons:

- **Can quickly determine worse case load cases and locations**
- **Beam element data assumes circular cross section and extracts highest loads independent of maneuver point**
- **Can extract stresses for each load point for LCF analysis**
- **Can add additional load cases, thermals, margin of safety criteria**

Summarizing Results Methodology



Summarizing Results - Example

Input:

MANEUVER NUMBER	ACC ATX G	ACC ATY G	ACC ATZ G	ACC RAX R/S/S	ACC RAY R/S/S	ACC RAZ R/S/S	SAFETY FACTOR
1.0	-0.103	2.073	2.726	0.012	0.041	0.016	2.000
2.0	-0.103	2.073	2.726	0.012	0.041	-0.016	2.000

Output:

- **STRESSSUM.TXT**

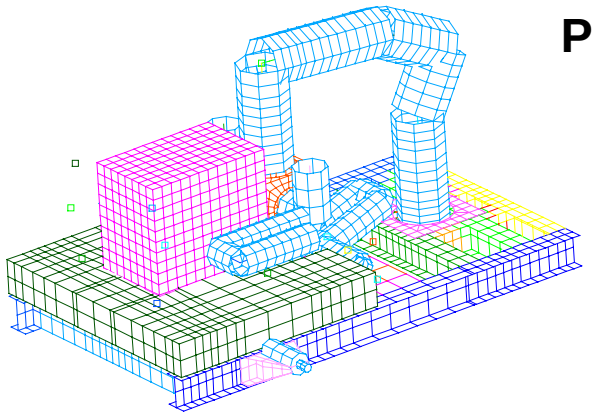
		STRESS SUMMARY					
ELE	MP	MAXP TOP	MINP TOP	VONM TOP	MAXP BOT	MINP BOT	VONM BOT
1	295.	6170.	0.	5478.	5528.	0.	4800.
2	282.	3103.	-241.	3231.	2815.	0.	2793.

- **STRESSSUM.UNV (Universal file for I-DEAS plate element post processing)**
- **FORCESUM.TXT**

		FORCE SUMMARY (BEAM ONLY)						
ELE	MP	BEAM END	AXIAL FORCE LBS	Y-SHEAR FORCE LBS	Z-SHEAR FORCE LBS	TORSION MOMENT IN-LBS	Y-BEND MOMENT IN-LBS	Z-BEND MOMENT IN-LBS
2254		BEGIN	-397.	1096.	309.	1117.	233.	0.
2254		END	397.	-1096.	-309.	171.	260.	0.
2256		BEGIN	-650.	-91.	389.	-74.	176.	0.
2256		END	650.	91.	-389.	-65.	588.	0.

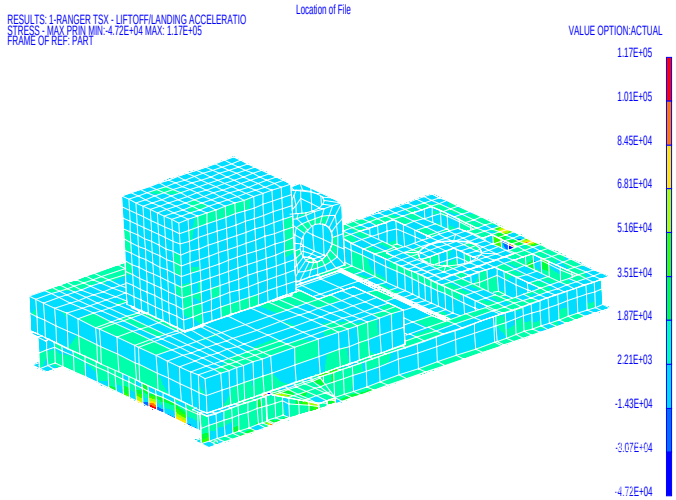
- **FORCESUM.UNV (Universal file for I-DEAS beam element post processing)**

Summarizing Results - Example

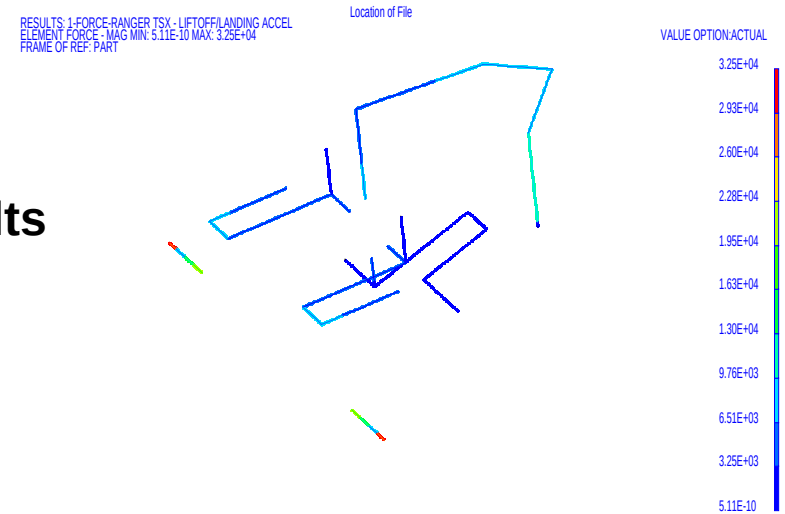


FEA Model

Plate results



Beam results



Model Verification – Thickness Plot

Problem: Checking plate element thickness via color plot

Solution:

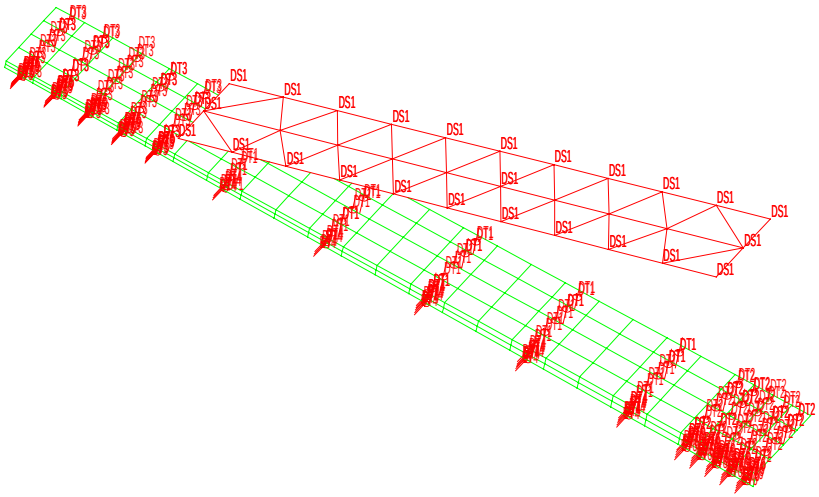
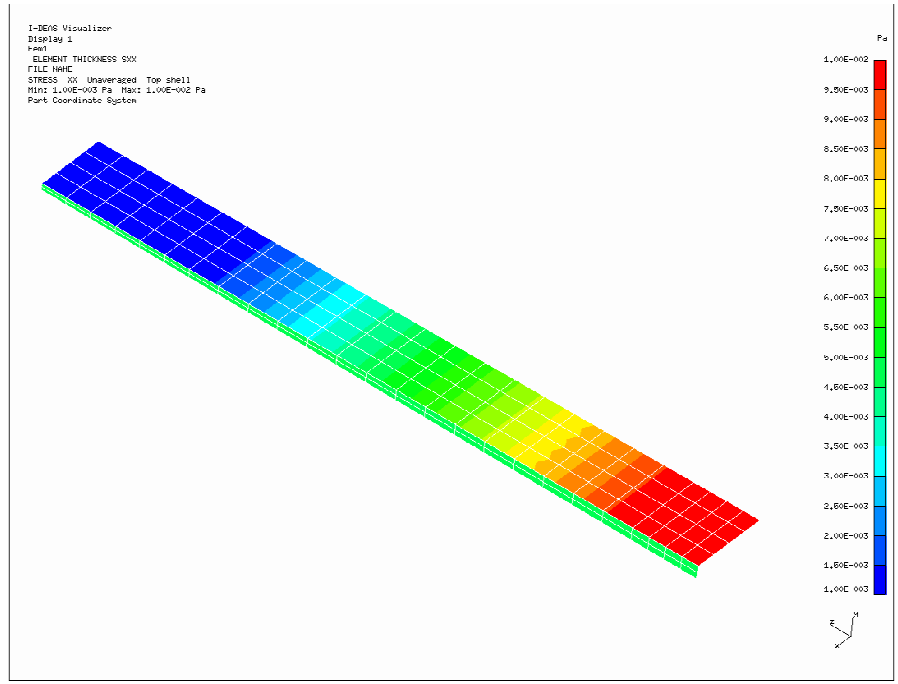
- **Export model to NASTRAN dataset, read CQUAD4/CTRIA3 and PSHELL cards, write Universal file**

Pros/Cons:

- **Can verify plate thickness graphically**
- **Can verify plate thickness transitions**

Thickness Plot - Example

Graphical Thickness Plot



Color Band Thickness Plot