MSC.Nastran 2004 New Features

Sept 4th, 2003

More Information

Nastran Information
http://www.mscsoftware.com/products/products_detail.cfm?PI=7

Product Support
http://www.mscsoftware.com/support/prod_support/nastran/

Discussion Forum
http://forums.mscsoftware.com/nastran/ubbthreads.php

Technical Support
http://www.mscsoftware.com/support/contacts/index.cfm

Knowledgebase
http://support.mscsoftware.com/kb/?prl=msc.nastran

Training
http://www.mscsoftware.com/support/msc_institute/?Q=135&Z=143

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

VPD Campus Licensing

- **Token based licensing method**
- **Some of the new capabilities of MSC.Nastran 2004 are licensed modules**
- **Take advantage of the VPD Campus Licensing to try them out**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Development Focus

- **Build upon the current strengths**
  - **Modal analysis and dynamics**
  - **ACMS and Distributed Memory Parallel**
  - **Optimization**
- **Expand the horizons**
  - **Integrate with MSC.ADAMS**
  - **Integrate MSC.Marc**
  - **Acoustics, MSC.Actran**
  - **Analysis-test correlation**
  - **Stochastics, MSC.RobustDesign**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Product Strategy and Goals

- **MSC.Nastran 2004 comprises**
  - **Over 30 major projects**
  - **Over 150 enhancements**
- **Enhancements and features are customer driven**
- **Increase customer satisfaction and help to accelerate customer's VPD process**
- **Improve Ease-of-use**
  - **Improve the user interface**
  - **Reduce the number of NASTRAN commands**
  - **Reduce the number of PARAMETERS**
  - **Reduce the number of ALTERS in the SSSALTER Library**
  - **Support more features with MSC.Patran**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Agenda

- ACMS and Parallel
- Dynamics
- Rotor Dynamics
- Optimization

John Lee

- Acoustics
- External Superelements
- Element Improvements
- Heat Transfer Improvements
- MSC.Nastran ADAMS integration

Claus Hoff

- Implicit Nonlinear (Sol 600)

Tim Kuhlmann

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

MSC.Nastran 2004 Parallel and ACMS

Parallel Methods in MSC.Nastran

Classification of Distributed Memory Parallel (DMP) methods in MSC.Nastran

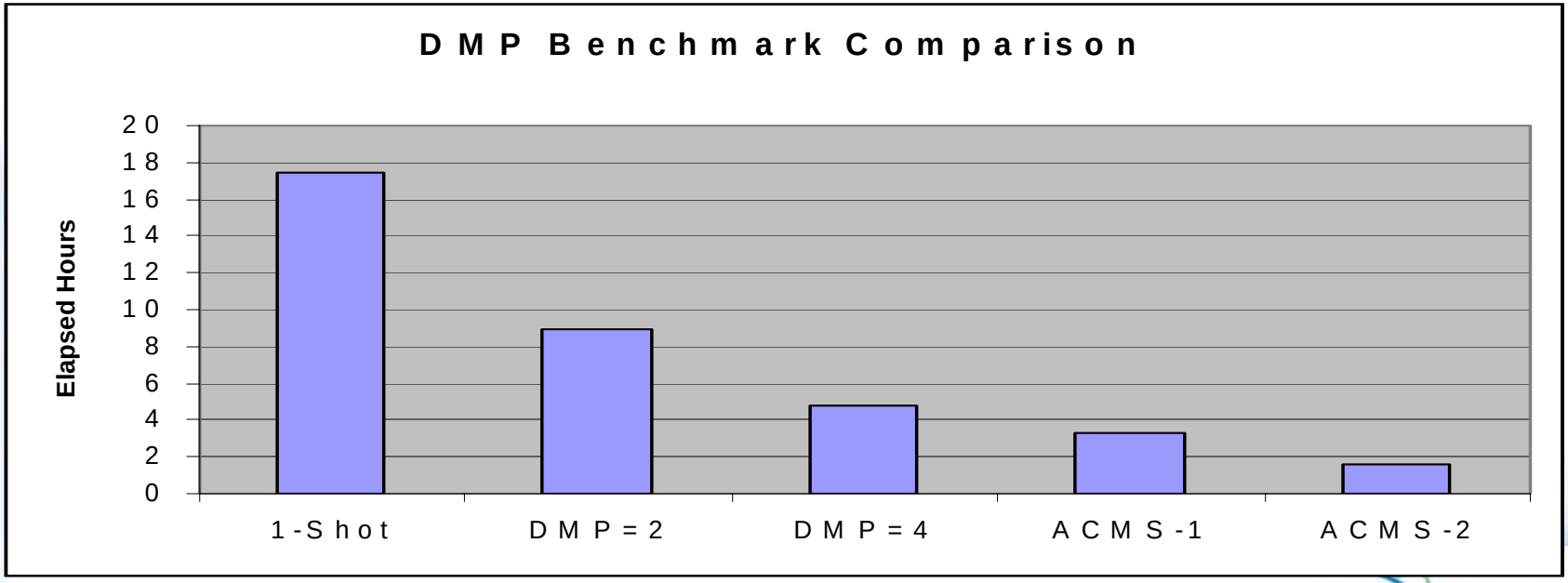
- **Frequency domain**
  - **Frequency response (SOL 108, 111)**
  - **Normal modes (SOL 103, 111, 112)**
- **Geometric domain**
  - **Static analysis (SOL 101)**
  - **Normal modes (SOL 103)**
  - **ACMS (SOL 103, 111, 112)**
- **Degree of freedom (DOF) domain**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Parallel Performance Profile

- Automotive SOL 103, 1.8M dof, 996 modes
- Compaq Linux Cluster
  - 4 nodes each with two 2.0 GHz P4 CPUs
  - 250 GB striped scratch disk per node (85mb/s I/o)
  - 3 GB main memory per node, 100 M/s interconnect



© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

What is ACMS?

- **ACMS stands for automated component modal synthesis**
- **Divides model in N domains using domain decomposition**
- **Full modal reduction is performed**
- **Parallel ACMS (PACMS) is the execution of ACMS on multiple processors in parallel**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

ACMS Performance Advantage

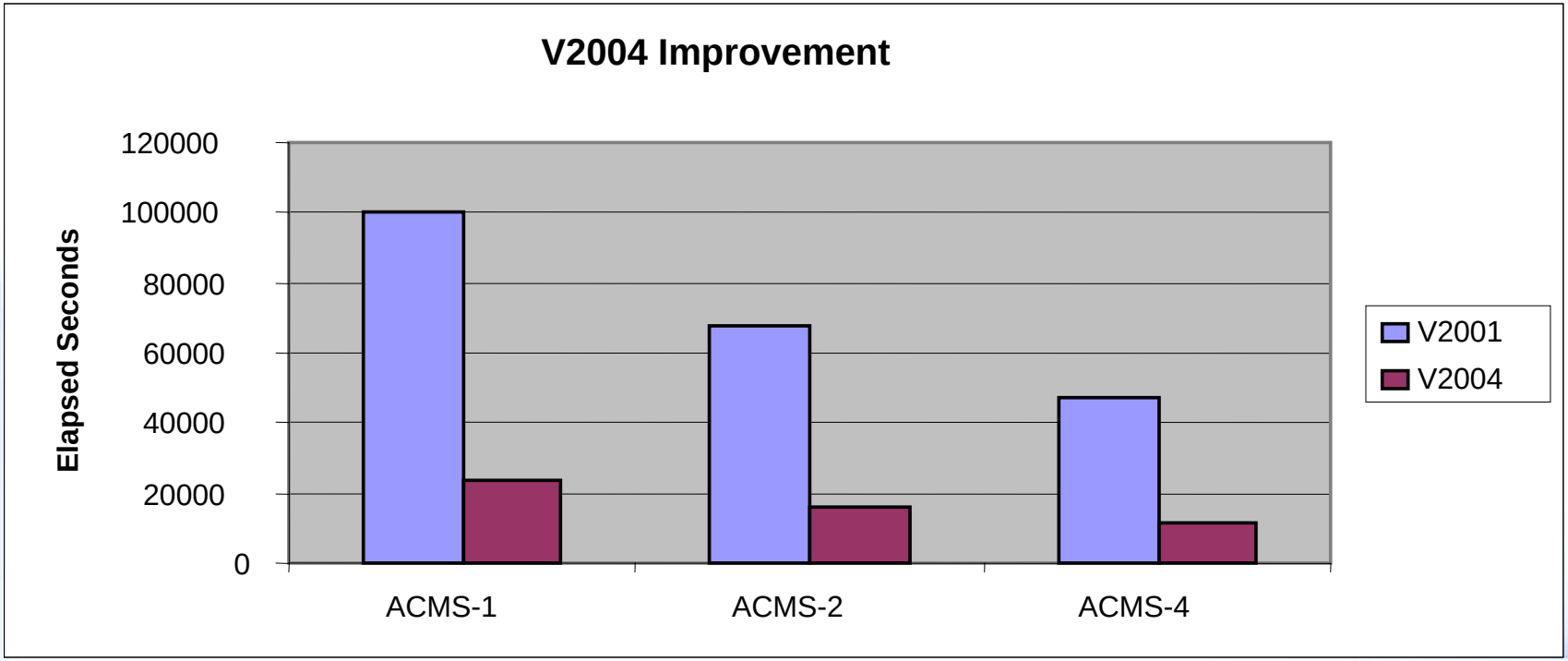
- **ACMS is more efficient than standard modal solutions**
  - **Modal reduction results in fewer operations**
  - **No single large eigensolution**
    - **Disk I/O cost**
  - **Smaller order of calculations**
    - **Tens of thousands vs. millions**
    - **More advantageous for cache based processors**
- **Two- or three-to-one speedup is typical**
- **Parallel ACMS increases job turnaround**
  - **Additional speedup**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Performance Improvement

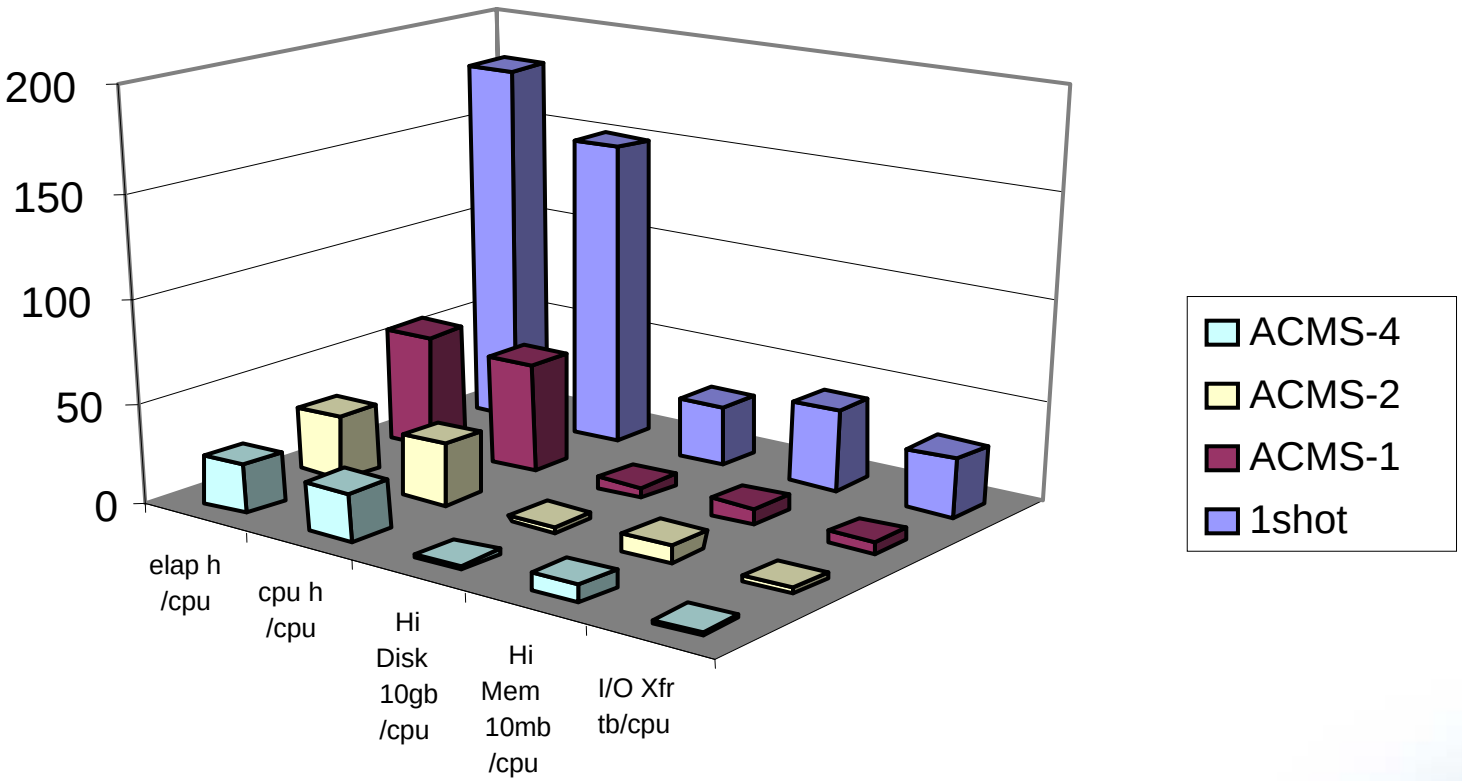
- Large SOL 103
- 466,975 grids
- 1436 structural modes (up to 250 Hz)
- IBM RS6000



© Copyright 2002 MSC.Software Corporation

ACMS Benchmark

- Acoustic 1.3+ million grid points, 7.9 million dof
- 993 modes up to 300 Hz, 190 forcing frequencies



© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

ACMS Conclusions

- **ACMS advantages**
  - **Reasonable job turnaround on inexpensive platforms**
  - **Reduced resource usage**
  - **Excellent accuracy**
- **Parallel ACMS for increased performance**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

MSC.Nastran 2004 Dynamics Enhancements

Initial Conditions and Restarts in Transient

- **Initial conditions supported in linear transient analysis (Sol 109, 112)**
  - **may be specified either in physical coordinates or in modal coordinates**
  - **Computed static solution can also be used as the initial condition**

$$\mathrm{IC}\left(\begin{bmatrix}\mathrm{PHYSICAL}\\ \mathrm{MODAL}\\ \mathrm{STATSUB}\,[,\mathrm{DIFFK}]\end{bmatrix}\right) = \mathrm{n}$$

- **Restarts in linear transient analysis (SOL 109, 112)**
  - **Ability to restart and continue a linear transient analysis**
  - **PARAM,STIME,value**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Residual Vectors

- **Turn on by default for modal solutions in V2004 (except Sol 103)**
- **Inertia relief with Auto Support is included by default**
- **New Case Control Command (RESVEC)**
- **DOF specification for residual vector processing**
  - **New Bulk Data entries RVDOF and RVDOF1**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Mode Select and DMIG Scaling

- **MODESELECT--selects modes to be included for response calculation**

- **Scalar factors for DMIG matrices**

  - **<u>Examples</u>**

    K2GG = 1.5*K1,2.3*K2

    M2PP = (3.0,2.1)*M1, (1.0,1.2)*M2

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Enforced Motion

- **Enhancement of enforced motion (SPC/SPCD method)**
  - **Revised formulation, total motion is split into base motion and relative motion**
  - **The user can choose relative or absolute motion output with**
    PARAM, ENFMOTN, REL or ABS
  - **RESVEC is recommended but is not as critical as in V2001**

- **The following errors are resolved with the enhanced formulation**
  - **Error for modal damping**
  - **Error in SPC, MPC and element forces at low forcing frequencies**
  - **Error for large base motion in transient analysis**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Modal Strain and Kinetic Energy

- **MODALSE -- Modal strain energy**
- **MODALKE—modal kinetic energy**
- **Supports SOL 111, 112**
- **Calculates the strain energy and kinetic energy coming from each mode in the response**
- **Suports SORT1 and SORT2 format**

© Copyright 2002 MSC Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Modal Participation Factors

- **MCFRACTION--Modal participation (contribution) factors**
  - **Identify contribution of each mode to the total displacement response (Sol 111, 112)**
  - **Typical frequency response analysis output**

```
M O D A L   C O N T R I B U T I O N   F R A C T I O N S

  GRID POINT =       13/T3, TOTAL RESPONSE (R/I) =  -6.39967E-02 /   1.83989E-04, (M/P) =   6.39970E-02 /    179.84
  LOAD FREQUENCY =   1.00000E+00, (SUBCASE        1, DLOAD =       10)
  MAXIMUM MODAL RESP =   4.66788E-02 FOR MODE ID =   1, SORTKEY = MODE ID , SORT = ALGEBRAIC  ASCENDING, FILTER =
   1.00000E-03
```

MODE ID	NATURAL FREQ (HZ)	MODAL RESPONSE REAL	MODAL RESPONSE IMAGINARY	MODAL RESPONSE MAGNITUDE	MODAL RESPONSE PHASE	PROJECTION MAGNITUDE	REL. PHASE	MODAL FRACTION	SCALED RESPONSE MAGNITUDE
1	5.44479E+00	-4.66784E-02	1.77446E-04	4.66788E-02	179.78	4.66788E-02	-0.05	7.29390E-01	1.00000E+00
2	9.35245E+00	-6.77275E-04	1.46509E-06	6.77277E-04	179.88	6.77277E-04	0.04	1.05829E-02	1.45093E-02
3	3.17429E+01	-3.27618E-04	2.06625E-07	3.27618E-04	179.96	3.27618E-04	0.13	5.11927E-03	7.01856E-03
5	5.47887E+01	-1.21014E-02	4.41895E-06	1.21014E-02	179.98	1.21014E-02	0.14	1.89093E-01	2.59248E-01
6	7.63429E+01	-1.70922E-04	4.47852E-08	1.70922E-04	179.98	1.70922E-04	0.15	2.67078E-03	3.66166E-03
8	1.80360E+02	-3.19270E-03	3.54047E-07	3.19270E-03	179.99	3.19269E-03	0.16	4.98882E-02	6.83971E-02
10	2.44248E+02	-7.35555E-05	6.02312E-09	7.35555E-05	180.00	7.35552E-05	0.16	1.14935E-03	1.57577E-03
11	3.44197E+02	-5.86319E-04	3.40691E-08	5.86319E-04	180.00	5.86317E-04	0.16	9.16163E-03	1.25607E-02

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

MAX/MIN Summary in Modal Transient

- **MAX/MIN summary in modal transient analysis**
  - **Monitor maximums and minimums in data recovery quickly and efficiently**
  - **Sample input data for MAX/MIN**

```
MAXMIN(DEF) DISP T1 T2 T3 MAXALG=4
MAXMIN(DEF) STRESS (QUAD4 TRIA3) SX1 SY1 SXY1 MINALG=3
$
SET 20 = 3 4 7 8 10 $ GRID POINT IDS
SET 30 = 101 142 157 $ ELEMENT IDS
MAXMIN(ELEM)=30
SUBCASE 1001
  MAXMIN(GRID)=20
```

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Multiple Structural Damping

- **Allow multiple structural damping for shell elements**
  - **Allow shell elements to have a different structural damping for MID1, MID2, MID3 and MID4 on PSHELL Bulk Data entry**
  - **Turn on with PARAM, SHLDAMP, DIFF**
    - **Default for SHLDAMP is SAME**

PSHELL	PID	MID1	T	MID2	12I/T**3	MID3	TS/T	NSM	
	Z1	Z2	MID4						

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Multiple Structural Damping

- **Allow multiple structural damping for**
  - **BUSH element**
    - **Allow a different structural damping (GE) for each direction on the PBUSH Bulk Data entry with associated frequency dependency**

PBUSH	PID	"K"	K1	K2	K3	K4	K5	K6	
		"B"	B1	B2	B3	B4	B5	B6	
		"GE"	GE1	GE2	GE3	GE4	GE5	GE6	
		"RCV"	SA	ST	EA	ET			

PBUSHT	PID	"K"	TKID1	TKID2	TKID3	TKID4	TKID5	TKID6	
		"B"	TBID1	TBID2	TBID3	TBID4	TBID5	TBID6	
		"GE"	TGEID1	TGEID2	TGEID3	TGEID4	TGEID5	TGEID6	
		"KN"	TKNID1	TKNID2	TKNID3	TKNID4	TKNID5	TKNID6	

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Additional Options for Nonstructural Mass

- **Non-structural mass for shell elements**
  - **Allows the definition of a non-structural mass, either distributed or lumped**
  - **Case Control Command**
    - **NSM Selects non-structural mass bulk data entries**
      - **NSM = 10**
  - **Bulk Data Entries**
    - **5 different formats (NSM, NSM1, NSML, NSML1, NSMADD)**

NSM	SID	TYPE	ID	VALUE	ID	VALUE	ID	VALUE	

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Fast Direct Frequency Response Analysis

- **Uses Krylov subspace method for direct frequency response analysis**
- **Activated with system cell 387=-1**
- **Two subspace generation method available:**
  - **Lanczos (system cell 388=1, default)**
  - **Arnoldi (system cell 388=2)**
- **Computational time relatively constant with # of forcing frequencies**
  - **Speedup at the expense of larger memory requirement**
- **Efficient with solid models and small modal density**

© Copyright 2002 MSC.Software Corporation

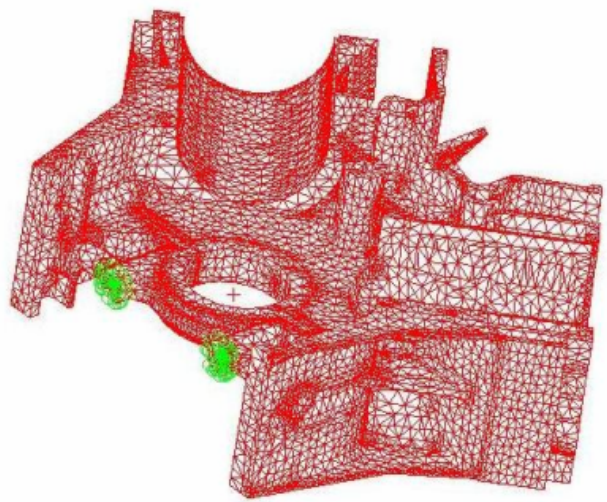
MSC SOFTWARE
SIMULATING REALITY

Fast Direct Frequency Response Analysis

- **Example Engine Model**

1. Engine benchmark

Dof :	94362
Elements type :	solid
Damping :	structural
Load :	freq. Dep.
Freq range :	400 to 2400 Hz



Solver	Freq. range	Freq. incr.	Num. of freq.	CPU	CPU/freq
Nastran direct	400 to 2400 Hz	100 Hz	20	960 sec	**48 sec**
Krylov	400 to 2400 Hz	100 Hz	20	382 sec	19.1 sec
Krylov	400 to 2400 Hz	25 Hz	80	394 sec	4.925 sec
Krylov	400 to 2400 Hz	5 Hz	400	452 sec	1.13 sec
Krylov	400 to 2400 Hz	1 Hz	2000	960 sec	**0.48 sec**

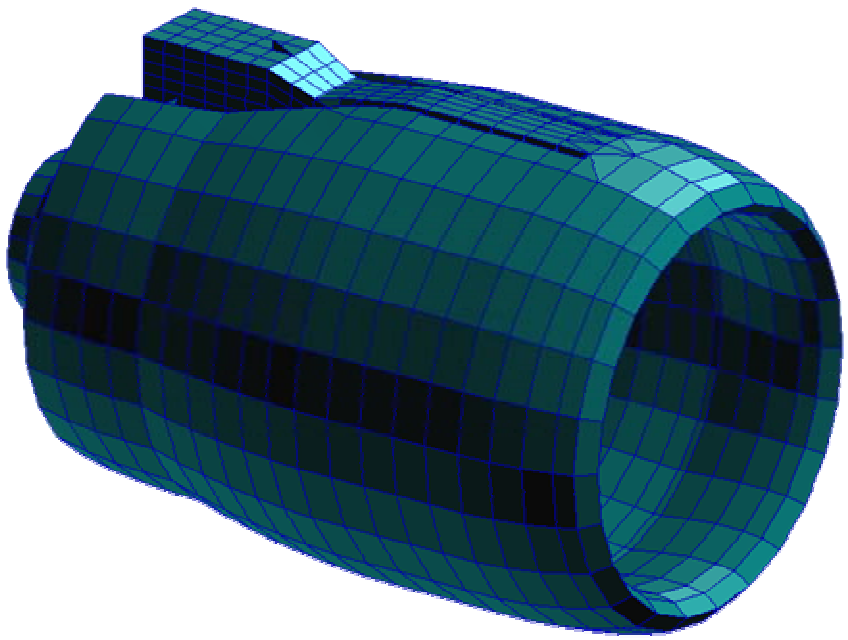
© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

MSC.Nastran 2004
Rotor Dynamics

Rotor Dynamics

- **Predicts dynamic response characteristics with rotating effects included**
  - **Engines**
  - **Electric motors**
  - **Generators**
  - **Turbines**
  - **Propellers**
  - **Wheels**
  - **Shafts**
  - **Disks**



- **not always intuitive, e.g. gyroscope**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Rotor Dynamics

- **Types of analysis**
  - **Whirl frequencies and critical speed analysis**
  - **Frequency response analysis**
  - **Transient response analysis (blade out)**
  - **Static maneuvers**
- **Prior to version 2004**
  - **DTI input with DMAP alter**
  - **DMIG input without DMAP alters**
- **In version 2004**
  - **Complete new rotor dynamics capability**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Rotor Dynamics

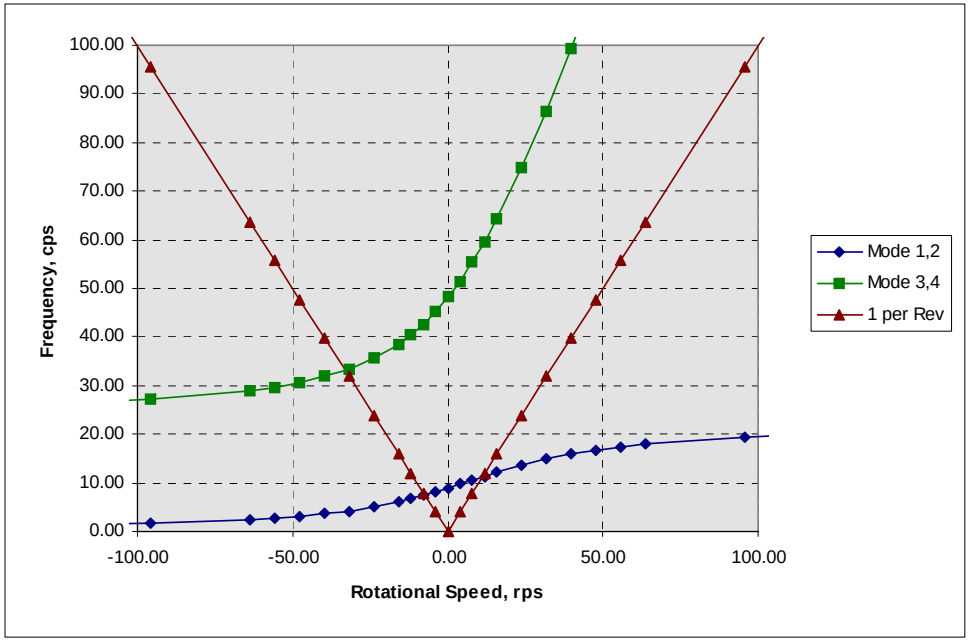
- **Available in solution sequences**
  - **101, 107, 108, 109, 111, and 129**
- **Case Control**
  - **RGYRO**
- **Bulk Data**
  - **RGYRO – complex eigenvalues, frequency response**
  - **ROTORG – for all solutions**
  - **RSPINR – defining relative spin rate**
  - **RSPINT – for nonlinear transient analysis**
  - **UNBALNC – for transient analysis**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Rotor Dynamics

- **Asynchronous**
  - **Adds the gyroscopic terms such that they are proportional to a user-supplied rotation speed**
  - **Generates Campbell diagram**



© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Rotor Dynamics

- **Synchronous**
  - **Adds the gyroscopic terms such that they are proportional to the excitation frequency (in frequency response), or natural frequency (in complex eigenvalue) of the structure**
  - **Calculates critical speed directly**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

MSC.Nastran 2004 Optimization Enhancements

Performance Enhancements in Sol 200

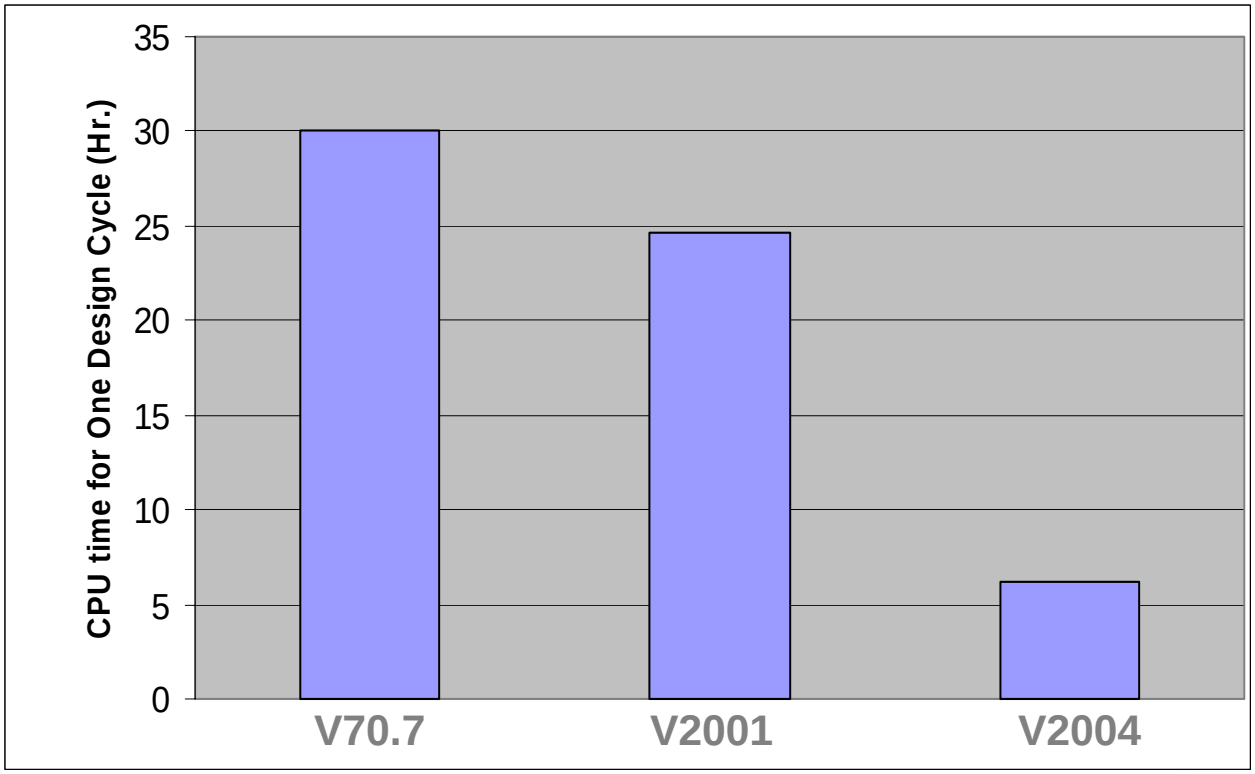
- **Approaches to enhance the performance of optimization analysis using SOL 200:**
  - **Use the sparse data recovery for frequency response and design sensitivity analyses**
  - **Improves efficiency**
    - **Adjoint method (DSADJ module)**
    - **Direct method (DSVG1 module)**
  - **Combine the frequency response and the design sensitivity solutions for each excitation frequency**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Performance Enhancements in Sol 200

- **NVH Example (MFREQ)**
  - **2.2 million dofs, 251 modes, 162 excitation freq, 7 load cases, 128 design variables, design set=.53 million dofs**



© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Performance Enhancements in Sol 200

- **Additional Performance Enhancements**
  - **Added speedup of key sensitivity and optimization modules**
  - **Parallel in Sol 200 (DMP distributed memory parallel) for each analysis type**
  - **ACMS in Sol 200 (performance not satisfactory yet)**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Eigenvector Sensitivity and Optimization

- **Nelson's Method is the primary method**
- **Subspace iteration is the alternate method**
- **Mode tracking is supported**
- **Primary application is to test/analysis correlation**

© Copyright 2002 MSC.Software Corporation

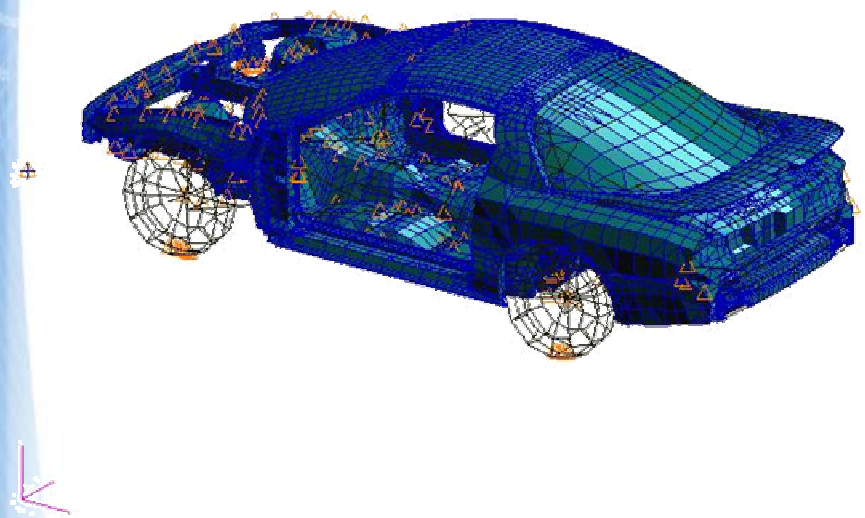
MSC SOFTWARE
SIMULATING REALITY

Other Optimization Enhancements

- **Adjoint sensitivity for superelements**
- **Six new DRESP1 response types (gpforce, gpforcp, total strain energy, psddisp, psdvelo, and psdaccl)**
- **DRESP1 entries can span across subcases or superelements**
- **Support of analysis model for External Superelements using SEBULK in SOL 200**
- **Frequency-dependent constraints using tables**
- **Complete updated Sol 200 file can be punched using the ECHO Case Control Command**
- **Support of External Response (DRESP3) similar to DRESP2 but more powerful with user routines**
- **PBEAML errors and limitations removed**
- **DOT update included**

© Copyright 2002 MSC.Software Corporation

Optimization PSD Example



Courtesy of GM

23K Grids
137K DOFs
32K Elements
9 Design Variables
3 Responses
7K DOFs in Residual

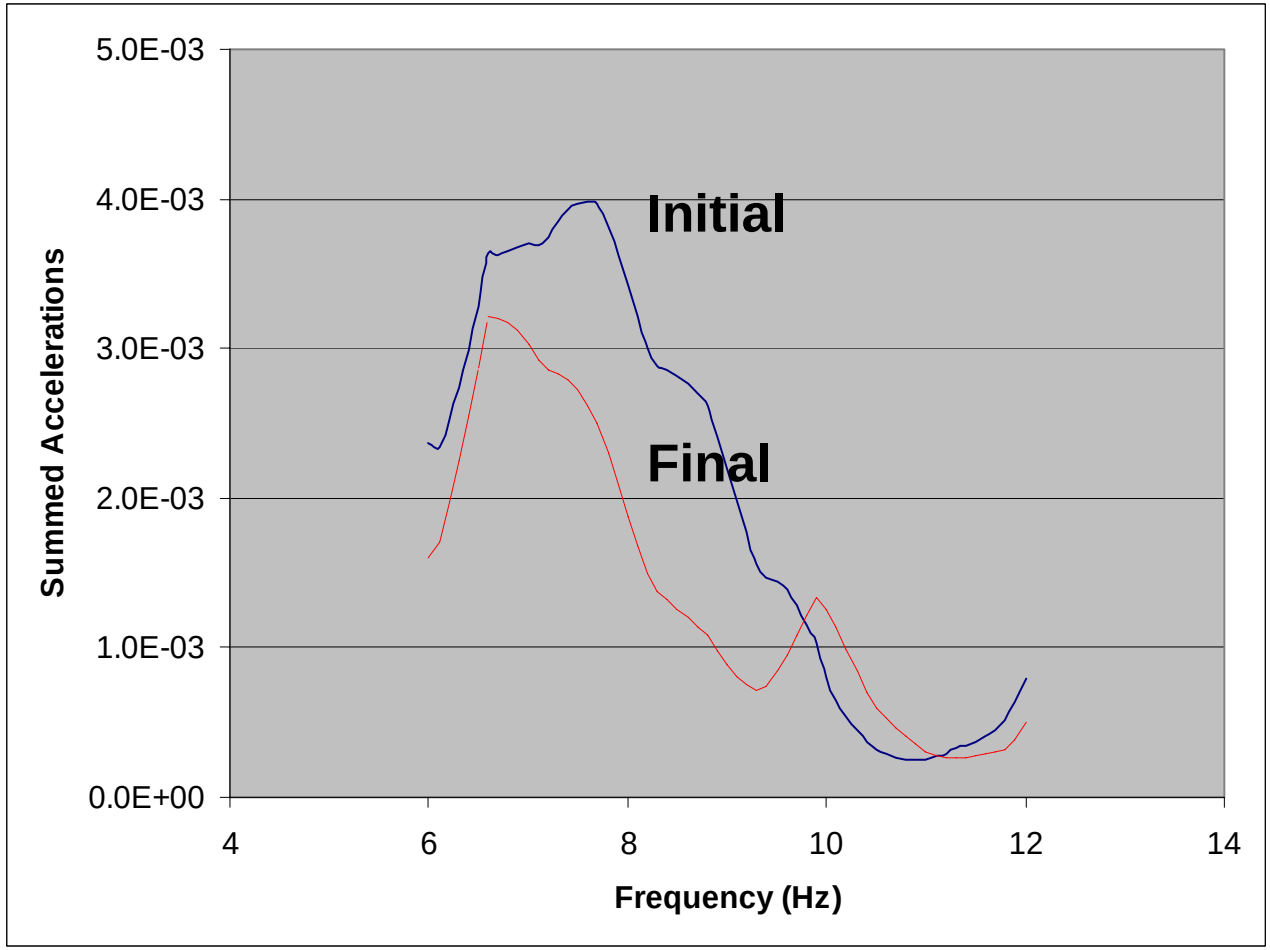
- Goal is to minimize the RMS response due to PSD input at the tires

- External superelements reduce design cycle analysis time from 1900 to 40 CPU seconds

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Optimization PSD Example



© Copyright 2002 MSC.Software Corporation

Q and A Session

© Copyright 2002 MSC.Software Corporation

Agenda

- ACMS and Parallel
- Dynamics
- Rotor Dynamics
- Optimization

John Lee

- **Acoustics**
- **External Superelements**
- **Element Improvements**
- **Heat Transfer Improvements**
- **MSC.Nastran ADAMS integration**

Claus Hoff

- **Implicit Nonlinear (Sol 600)**

Tim Kuhlmann

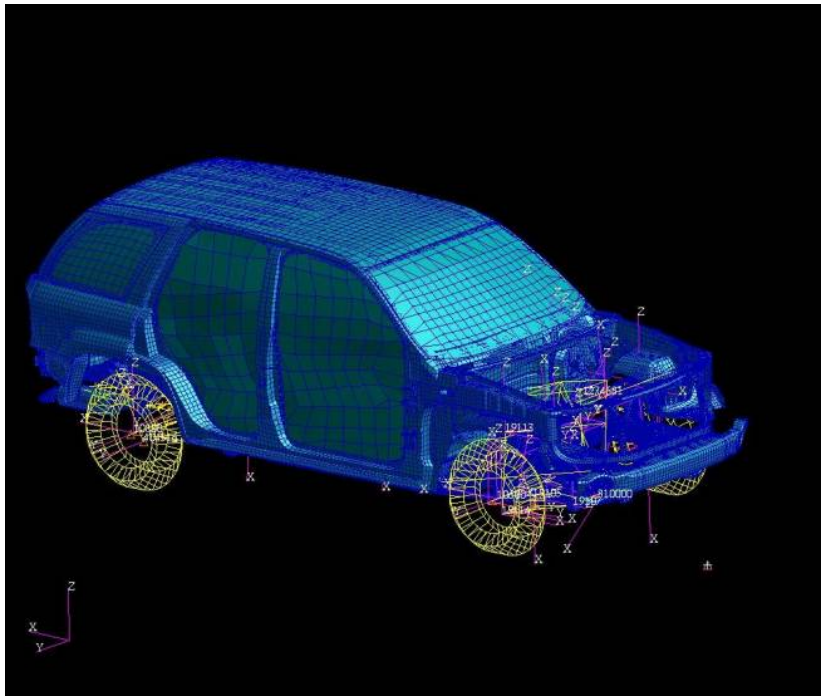
© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

MSC.Nastran 2004 Acoustics Enhancements

Acoustics Enhancements

New algorithm to identify the fluid-structure interface



- **Orders of magnitude faster**
- **Improved accuracy of the coupling matrix**
- **Rigid body equilibrium is always satisfied**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Acoustics Enhancements

- **Three new Case Control commands**
  - **FLSFSEL fluid-structure frequency and superelement slection**
  - **FLSPOUT fluid structure mode participation output**
  - **FLSTCNT fluid-structure control**

- **New Case Control command to allow the direct input of a fluid-structure coupling matrix**

  A2GG = matrix1

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

MSC.Nastran 2004 External Superelements

External Superelements

- External superelement analysis reduced to a two step procedure
  - Single MSC.Nastran job to create an external superelement for a given component
  - Restart for assembly / analysis / data recovery run
- Easy to use
- Reduce the size of databases
- No DMAP alters required
- Significant reduction in overall run time

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

External Superelements

Case Control Command to create an external superelement in the cold start

$$\text{EXTSEOUT}\left[\begin{array}{l}(\,\mathbf{STIFFNESS},\mathbf{MASS},\mathbf{DAMPING},\mathbf{K4DAMP},\mathbf{LOADS},\\ \{\text{ASMBULK},\}\,\{\text{EXTBULK},\}\,\{\text{EXTID}=seid,\}\left\{\begin{array}{l}\mathbf{MATRIXDB}\\ \text{DMIGDB}\\ \text{DMIGOP2}=unit\\ \text{DMIGPCH}\end{array}\right\})\end{array}\right]$$

© Copyright 2002 MSC.Software Corporation

MSC.Nastran 2004 Element Enhancements

Element Enhancements

- **New default of K6ROT in 2004**
- **Improved QUADR and TRIAR**
- **CWELD Enhancements**
- **Temperature Dependent Composites**
- **Large Rotation of Rigid Elements**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

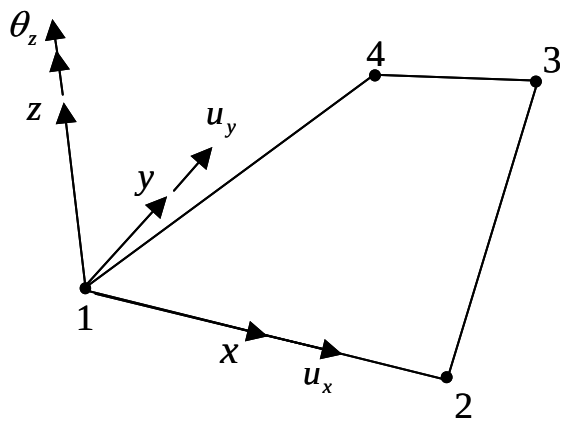
What is K6ROT?

A penalty term is added to the strain energy for CQUAD4 and CTRIA3 elements

$$\Pi_{pen} = 10^{-6}\ \mathrm{K6ROT}\ \frac{1}{2} G \int_A \left(\Theta_z - \Omega_z\right)^2 t\, dA$$

with

$$\Omega_z = \frac{1}{2}\left(\frac{\partial u_y}{\partial x} - \frac{\partial u_x}{\partial y}\right)$$



© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

New Default of K6ROT = 100.

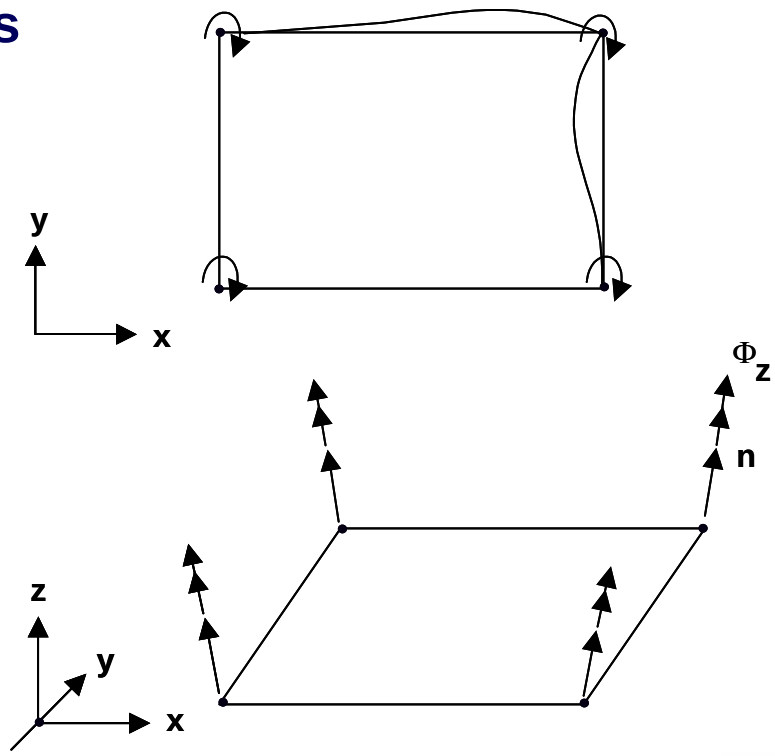
- **The 2001 defaults SNORM=20. and K6ROT=0. may cause spurious modes in some cases where the 6th degree-of-freedom is loaded**
- **K6ROT=100. makes the elements more robust without compromising on accuracy**
- **K6ROT=100. was the default in nonlinear solution sequences**
- **Shell normals should not be turned off**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Improved QUADR / TRIAR

- **QUADR and TRIAR are shell elements with physical stiffness in the drilling degree-of-freedom**
- **K6ROT is not used in the QUADR and TRIAR**
- **QUADR meets or beats standard test results of the QUAD4**



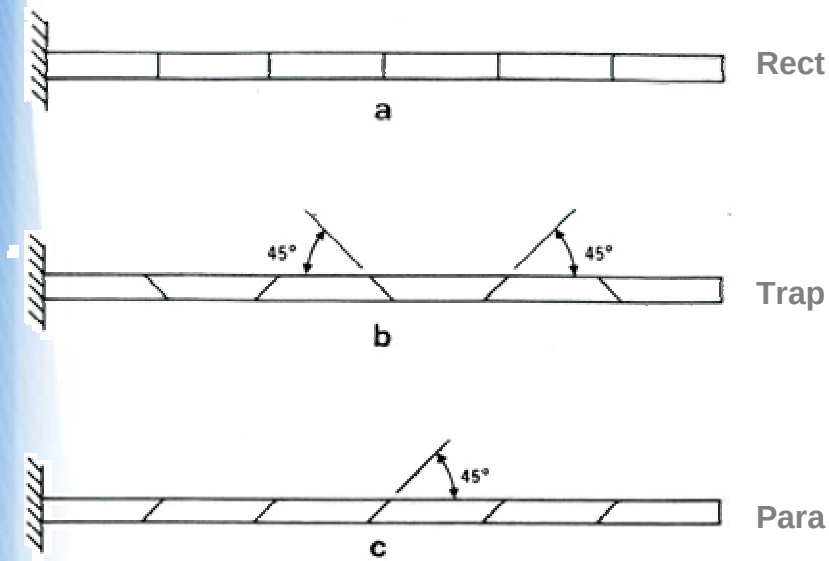
© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Improved QUADR / TRIAR

- **QUADR is superior to QUAD4 for in plane shear and in plane bending**

Straight Beam



Tip deflection (normalized with theoretical value)

Version	Rect	Trap	Para
QUAD4	0.9929	0.0515	0.6323
QUADR	**0.9926**	**0.9613**	**0.9491**

© Copyright 2002 MSC.Software Corporation

Summary of QUADR / TRIAR Improvements

- **QUADR accuracy is outstanding for in plane shear and bending**
- **Shell normals have been added in V70.5 to improve accuracy in curved shells**
- **Differential stiffness is added in V2004 so that buckling and prestressed normal modes are available**

- **More accuracy at no additional computational cost**

© Copyright 2002 MSC Software Corporation

MSC SOFTWARE
SIMULATING REALITY

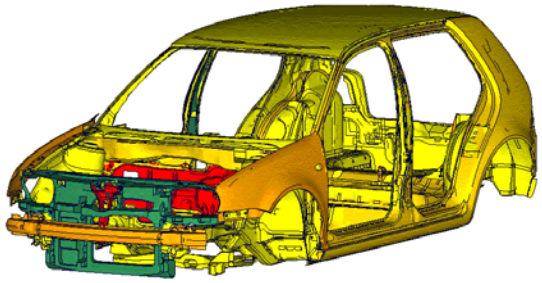
CWELD Element

- General purpose connector element to model spot welds, bolts, rivets, screws, etc.
- Handles non congruent meshes
- Competitive accuracy and performance
- User friendly post processing with CBAR-like output of element forces
- Optimization on diameter, material, etc. available

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

CWELD – Benchmark Problems



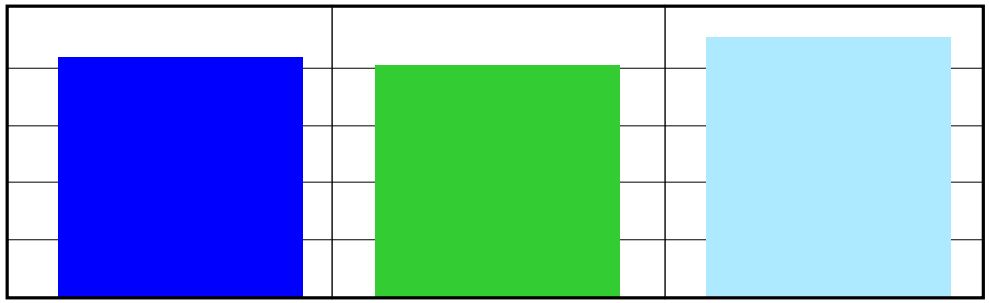
Courtesy of VW

Body in White Model from VW

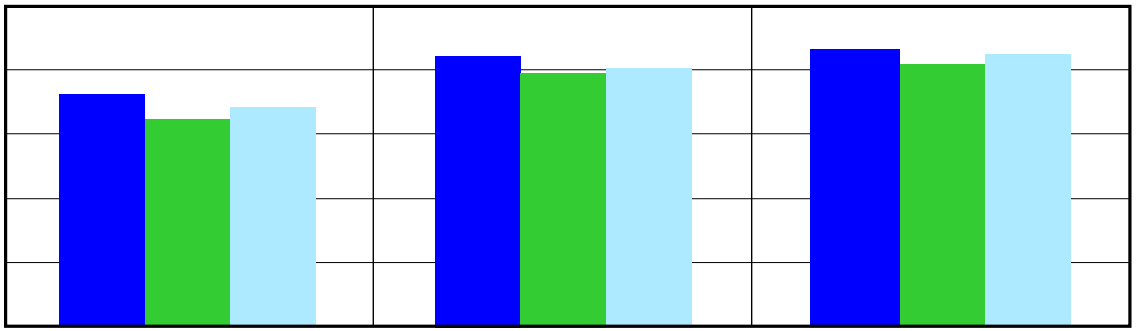
- 3.712 CWELD Elements
- 3.562 connecting two parts
- 150 connecting three parts

Test Result
Old Spot Weld Modeling VW
New CWELD Element

Static Torsional Stiffness



Normal Mode Analysis



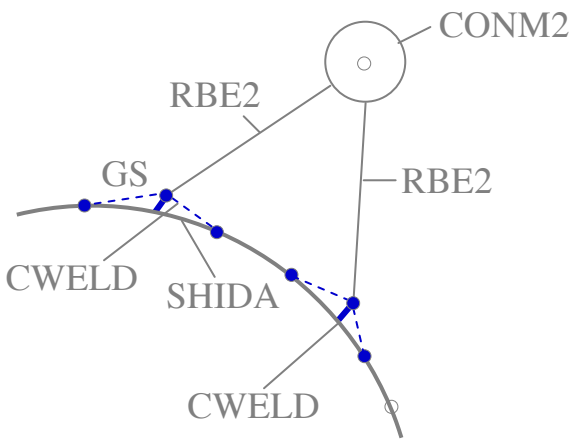
Mode I **Mode II** **Mode III**

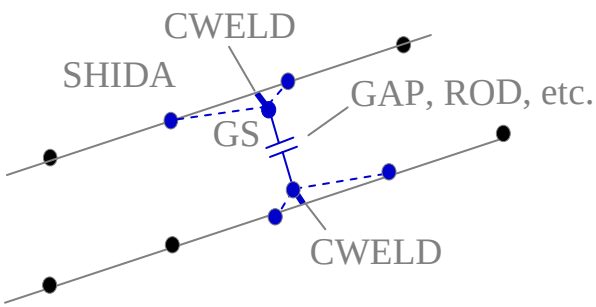
© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

CWELD Element Improvements

- **Modeling options extended to connect rigid elements, concentrated masses, etc. to structural parts independent of the mesh**





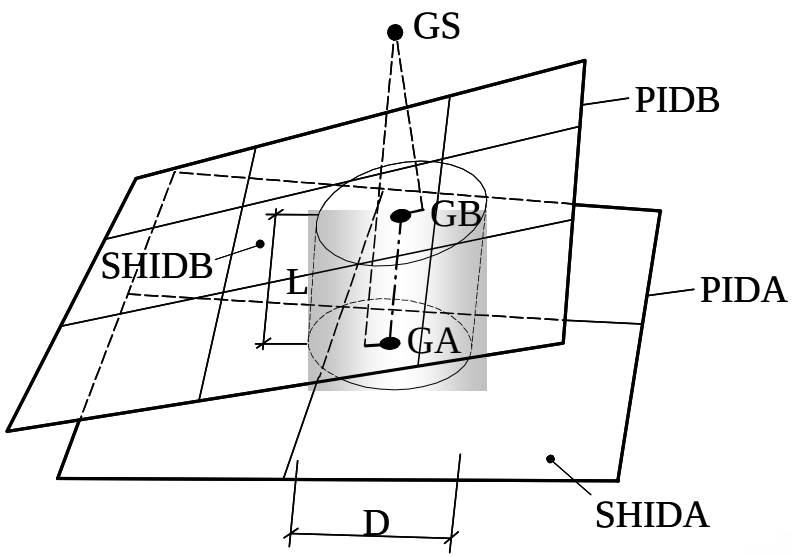
- Using the point-to-patch connection

CWELD	**EID**	**PID**	**GS**	**"ELEMID"**					
	SHIDA								

© Copyright 2002 MSC.Software Corporation

CWELD Element Improvements

- Connectivity extended to cover a patch of max.3x3 elements
- Allows large diameter spanning over several elements
- More accurate than V2001 options



© Copyright 2002 MSC.Software Corporation

CWELD Element Improvements

- **Patch-to-patch connection ELPAT with element ids**

CWELD	EID	PID	GS	"ELPAT"					
	SHIDA	SHIDB							
PWELD	PID	MID	D					SPOT	

- **Patch-to-patch connection PARTPAT with property ids**

CWELD	EID	PID	GS	"PARTPAT"					
	PIDA	PIDB							
PWELD	PID	MID	D					SPOT	

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE SIMULATING REALITY

Temperature Dependent Composites

- **Temperature-dependent material properties of individual plies are activated with**
  - **PARAM,COMPMATT,YES (the default is no)**
- **For nonlinear static analysis (SOL 106)**

- **A new MATT8 has been added to allow temperature-dependent orthotropic material specification**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Rigid Elements for Large Rotation

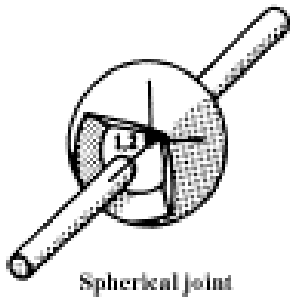
- **Rigid elements for large rotation use Lagrange multipliers instead of elimination**
- **Available for all existing rigid elements RBAR, RROD, RTRPLT, RBE1, RBE2, RBE3**
- **New RJOINT for easier input**
- **Better accuracy and better convergence for large rotations**
- **More accurate results for buckling (Sol 105) and prestressed modes (Sol 103)**
- **Initial strains (thermal loads) are available**

© Copyright 2002 MSC.Software Corporation

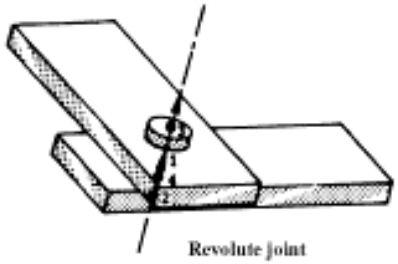
MSC SOFTWARE
SIMULATING REALITY

Rigid Elements for Large Rotation

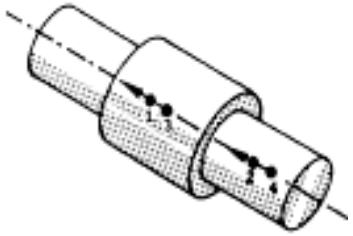
RJOINT



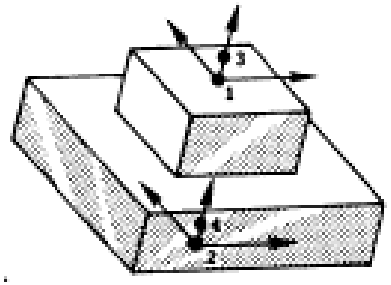
Spherical joint



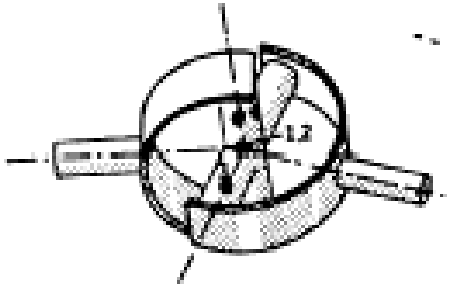
Revolute joint



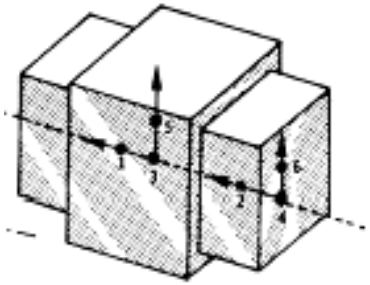
Cylindrical joint



Planar joint



Universal joint



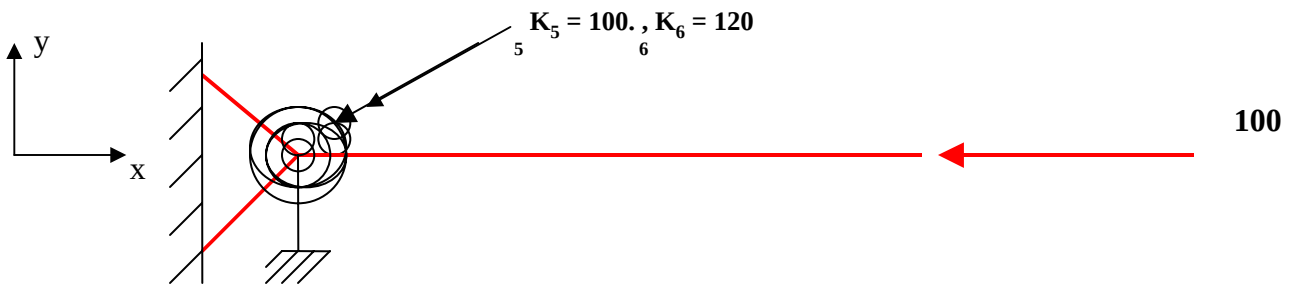
Translational joint

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Rigid Elements for Large Rotation

- **Euler buckling load of a rigid bar**



- **A stiff beam (CBAR) has to be used in V2001**
- **The rigid bar (RBAR) gives the exact buckling load in V2004**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

MSC.Nastran 2004 Miscellaneous Topics

OP2 Compatibility

- **GEOM2, GEOM3, GEOM4 record length changes**
  - **Rigid elements**
  - **CQUAD, CTRIA**

- **Compatibility with V2001 op2 format**

  - **NASTRAN OP2NEW=0 produces 2001 compatible op2 file**
  - **NASTRAN OP2NEW=1 produces op2 file with new record lengths and new header indicating the version**

  - **MSC.Nastran 2004 is delivered with OP2NEW=0 in the rc file**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Heat Transfer

- **Faster 3D view factor calculation**
- **New axisymmetric view factor calculation**
- **New capablity to model thermostats with dead band based on temperature sensor**

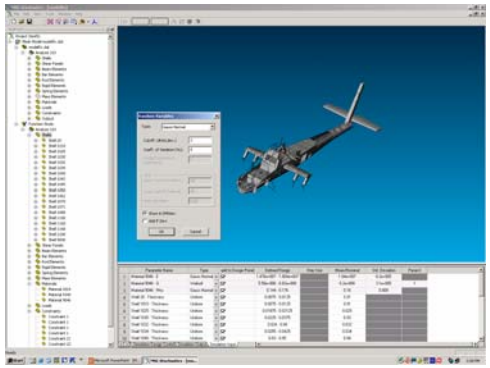
© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

MSC.Robust Design 2004

Modeling Uncertainty with MSC.Nastran

- **Model uncertainty in parameters**
  - **Material parameters, loads, geometry**
- **Identify and eliminate the cause of dangerous outliers**
- **Tight integration with MSC.Nastran**
  - **Simulation of random spot weld failure**



MSC.Nastran model shown in the MSC.Robust Design interface

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

MSC.Nastran 2004
MSC.Nastran ADAMS Integration

MSC.Nastran ADAMS Integration

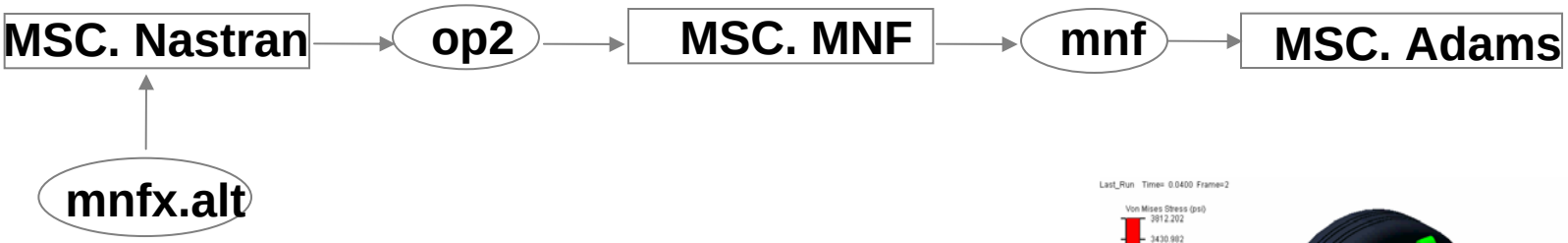
- **DMAP alter of V2001 is integrated in all standard solution sequences as a SubDMAP**
- **Nastran puts out a Modal Neutral File directly**
  - **Modal reduced stiffness, damping, and mass**
  - **Nine mass invariants**
  - **Mode shapes**
  - **Either a subset of grids with PLOTELs or SETs or all grids of the flexible body**
- **Adams-Nastran interface will be supported in SOL 103, 111, 112, and 106**

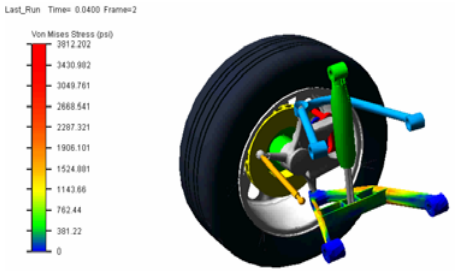
© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

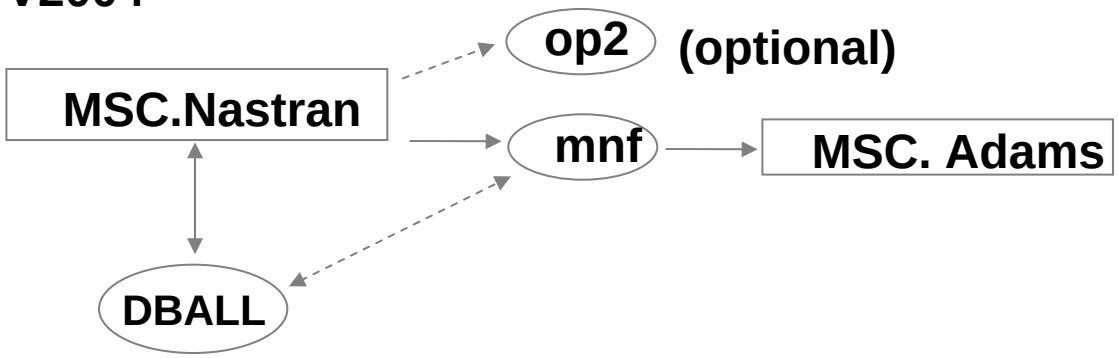
MSC.Nastran ADAMS Integration

V2001





V2004



© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

MSC.Nastran ADAMS Integration

Method

- The attachment points of the flexible body are defined on the ASET bulk data entry.
- Internally, all other grids are put into a part superelement together with other upstream superelements.
- Residual vectors and inertia relief vectors are built automatically
- AUTO SUPPORT is automatically used for free bodies

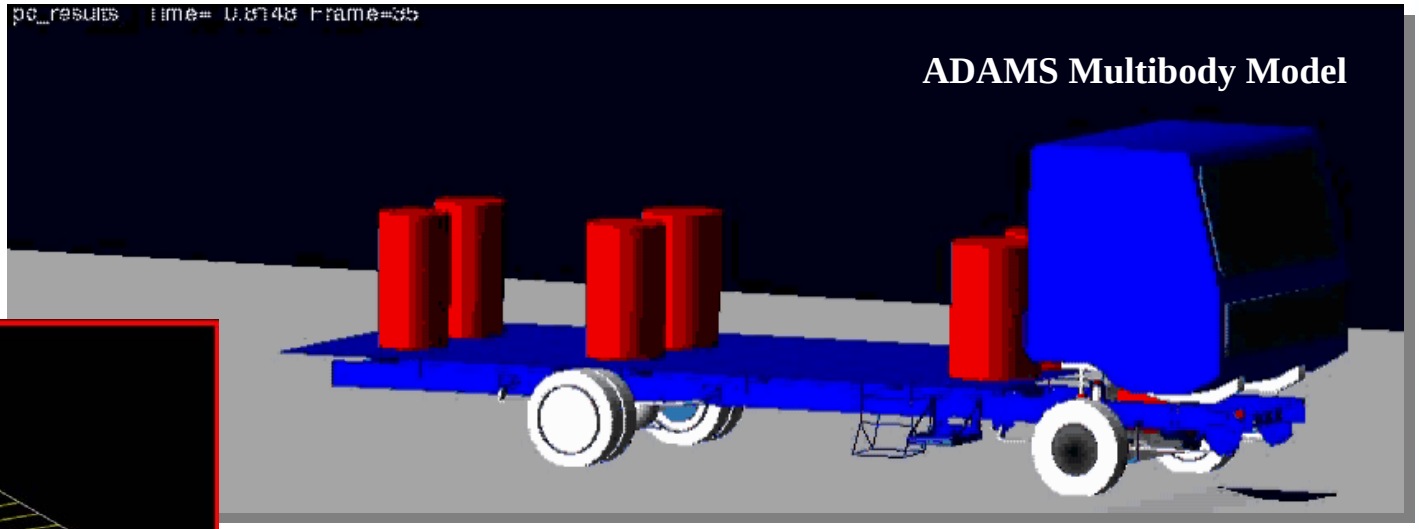
© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Truck Passing a Pothole

Courtesy of Leyland Trucks

- **Pothole-passing manouver of a full-vehicle truck model including a flexible frame**
- **Rigid vs. Flexible frame comparison of vertical accelerations at the driver's seat**



LEYLAND TRUCKS
A PACCAR COMPANY

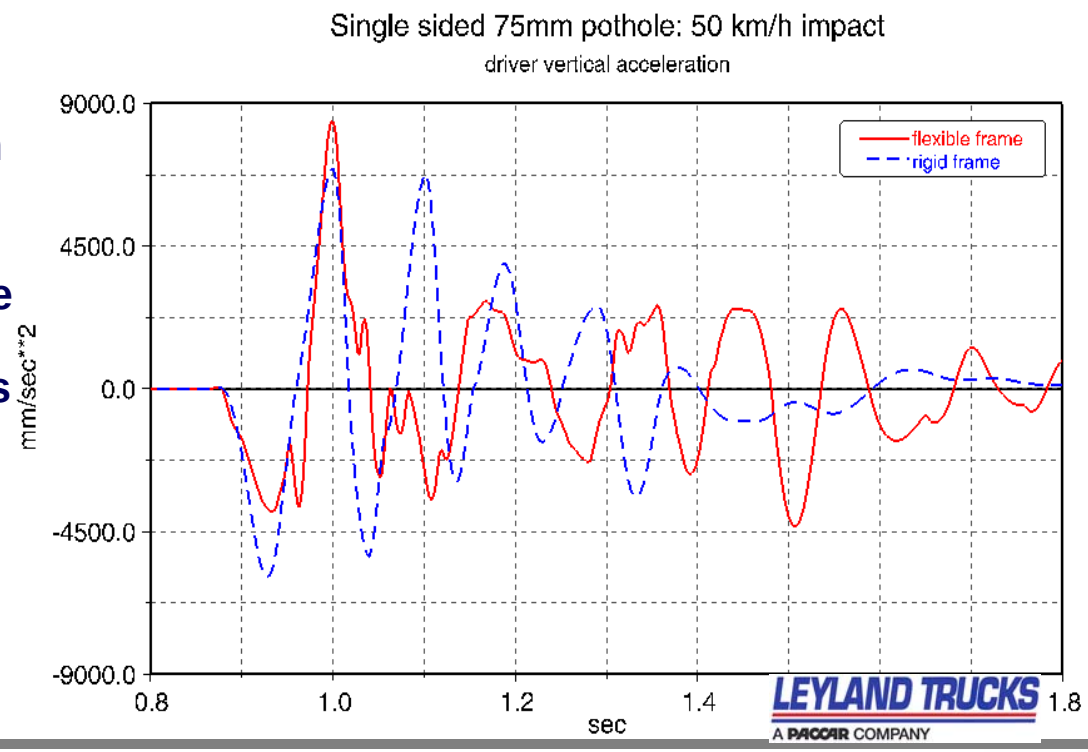
© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Truck Passing a Pothole

Courtesy of Leyland Trucks

- **Simulation Results in ADAMS**
  - **Vertical Acceleration at driver's seat**
  - **Different response between rigid and flex frame representation**
  - **The most significant feature of the different response in terms of acceleration plot is the vertical component, which can be felt by the driver when the vehicle is driven over such a disturbance**



© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

MSC.Nastran ADAMS Integration

Benefits

- Less steps, more efficient procedure, faster run time
- op2 file can be avoided
- Modal Neutral File can be moved across different platforms without problems
- Size of modal neutral file is reduced directly in Nastran using PLOTEL or SET definition, no second reduction step
- A DMAP license and superelement license is not required
- Prestress effect is included in Sol 103 and Sol 106

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Q and A Session

© Copyright 2002 MSC.Software Corporation

Agenda

- ACMS and Parallel
- Dynamics
- Rotor Dynamics
- Optimization

John Lee

- Acoustics
- External Superelements
- Element Improvements
- Heat Transfer Improvements
- MSC.Nastran ADAMS integration

Claus Hoff

- **Implicit Nonlinear (Sol 600)**

Tim Kuhlmann

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

MSC.Nastran 2004 Implicit Nonlinear SOL 600

MSC.Nastran SOL600

- What is MSC.Nastran Solution 600?
- How does it work?
- What capabilities are included?
- What benefits does this product bring?
- Conclusions

© Copyright 2002 MSC.Software Corporation

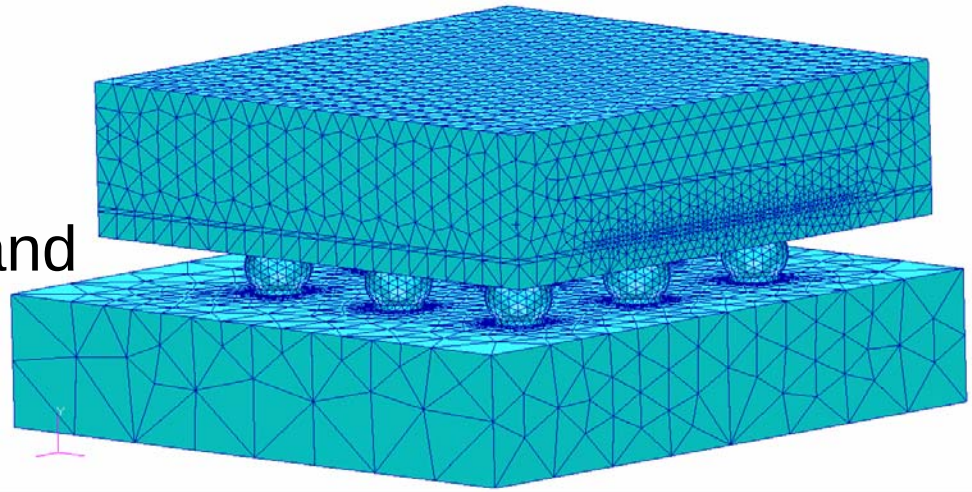
MSC SOFTWARE
SIMULATING REALITY

Nonlinear Capabilities in MSC.Nastran

MSC.Nastran SOL600 is the nonlinear capabilities of MSC.MARC delivered in an MSC.Nastran user interface

MSC.Nastran Implicit Nonlinear – SOL600:

- Provides FEA capability for the analysis of 3D contact and highly nonlinear problems.
- Combines the world's most advanced nonlinear finite element technology with the world's most widely used finite element code, MSC.Nastran

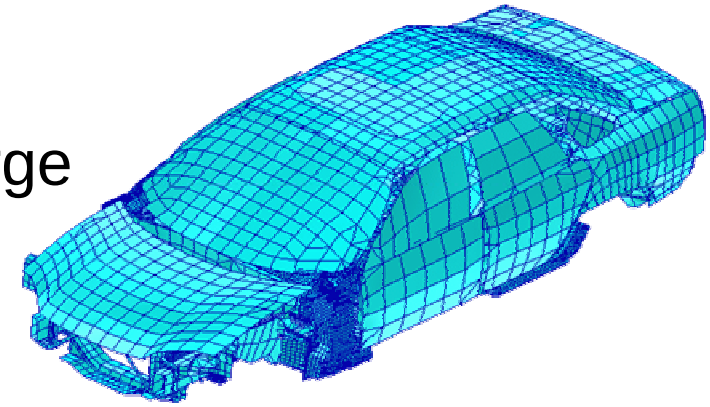


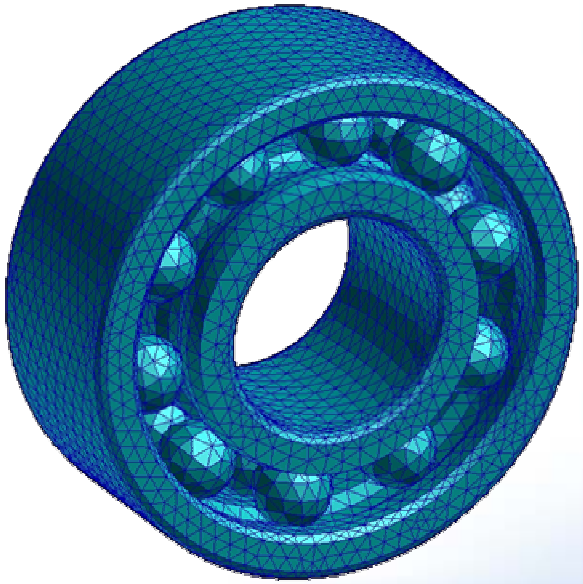
© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

What is MSC.Nastran SOL600 ?

- Allows Nastran users to perform:
  - nonlinear structural
- Includes contact, large deflection, large rotation, and large strain analysis capabilities never before available in Nastran
- Can use input decks from the many thousands of existing MSC.Nastran models.
- Provides solutions for simple to complex engineering problems including multi-body contact and advanced elastomeric (rubber) material models





© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

How Does MSC.Nastran SOL600 Work ?

- MSC.Nastran Look and feel:
  - Input a standard Nastran input deck
  - Runs Marc “Under the Hood”
  - Optional - Marc results read back to Nastran database
  - Optional - standard Output from Nastran (f06,op2,xdb,punch)
- New Nastran text input:
  - Executive Command: SOL600,NLSTATIC path= outr=
  - New Case Control Command for 3D contact
  - New Bulk Data Entries for 3D contact and advanced materials including rubber,gaskets, large strain, visco-elastic, failure, …

```
$ NASTRAN input file created by MSC.Nastran input file
$ Direct Text Input for File Management Section
$ Advanced Nonlinear Analysis
SOL 600,NLSTATIC PATH=1 OUTR=OP2,F06
$ Direct Text Input for Executive Control
CEND
SEALL = ALL
SUPER = ALL
TITLE = MSC.Nastran job created12-Feb-03 at
ECHO = NONE
$ Direct Text Input for Global Case Control Data
BCONTACT = ALL
SUBCASE 1
$ Subcase name : Default
   SUBTITLE=Default
   NLPARM = 1
   BCONTACT = 1
   SPC = 2
   LOAD = 2
   DISPLACEMENT(SORT1,REAL)=ALL
   SPCFORCES(SORT1,REAL)=ALL
   STRESS(SORT1,REAL,VONMISES,BILIN)=ALL
BEGIN BULK
PARAM    POST    0
PARAM    AUTOSPC NO
PARAM    LGDISP  1
PARAM,NOCOMPS,-1
PARAM   PRTMAXIM YES
NLPARM   1       10              AUTO    5       25
$ Direct Text Input for Bulk Data
$ Elements and Element Properties for region : shell
PSHELL   1       1       .25     1               1
$ Pset: "shell" will be imported as: "pshell.1"
CQUAD4   1       1       1       2       13      12
CQUAD4   2       1       2       3       14      13
```

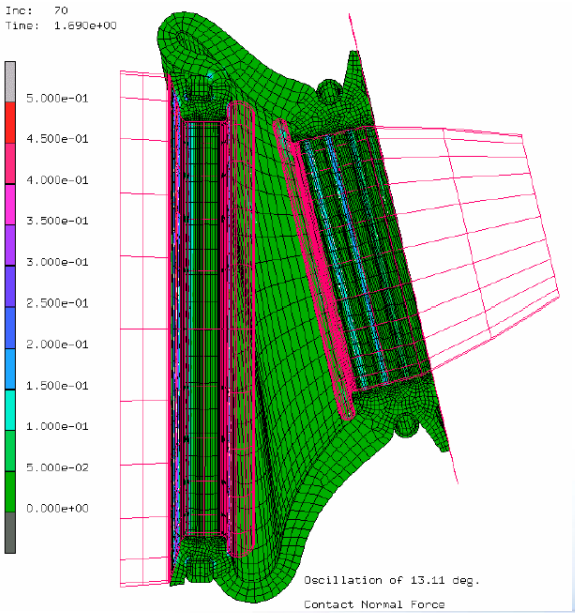
© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

SOL600 - Powerful Nonlinear Capabilities

MSC.MARC Mature Robust Nonlinear Algorithms provide:

- A powerful tool for simulating manufacturing processes and component behavior
- multi-body contact analysis capability (much easier to set up)
- long list of advanced material models and element technology
- robust solutions for solving complex contact and load history problems for a wide variety of problems



A Winning Product:

- This is a product with the "horse-power" to *win benchmarks*.
- Couple this new product with MSC's worldwide network of highly-trained FEA specialists dedicated to pre- and post-sales support you have a product that is un-equaled for the simulation of nonlinear mechanical component behavior.

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

How Does MSC.Nastran SOL600 Work ?

Nastran -Marc Integration

Input compatible with Sol 106, 129, 101, 103, 105, 109 and others

NLPARM, TSTEPNL, MATS1 etc. are honored

Contact supported in the Nastran pref of Patran

- **New exec control for Marc Input and Marc Execution**

SOL 600,SID path= stop= outr= copyr=

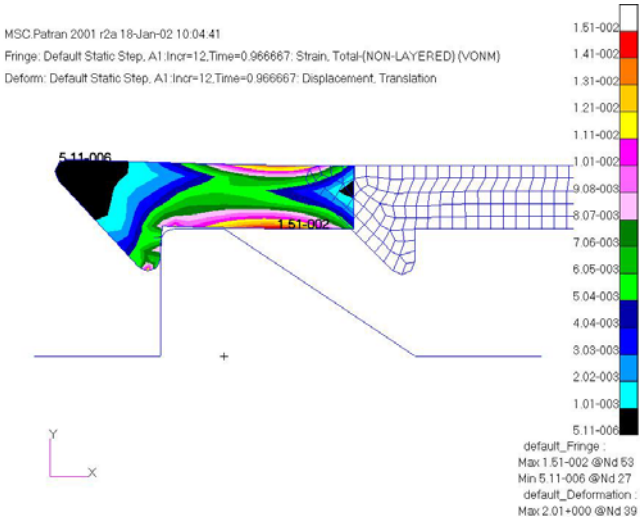
- **where SID is a Nastran solution sequence number: 101, 103, 105, 106, 129, etc.**

New Case Control Command for contact

- **BCONTACT= 10**

New bulk data entries for new capabilities

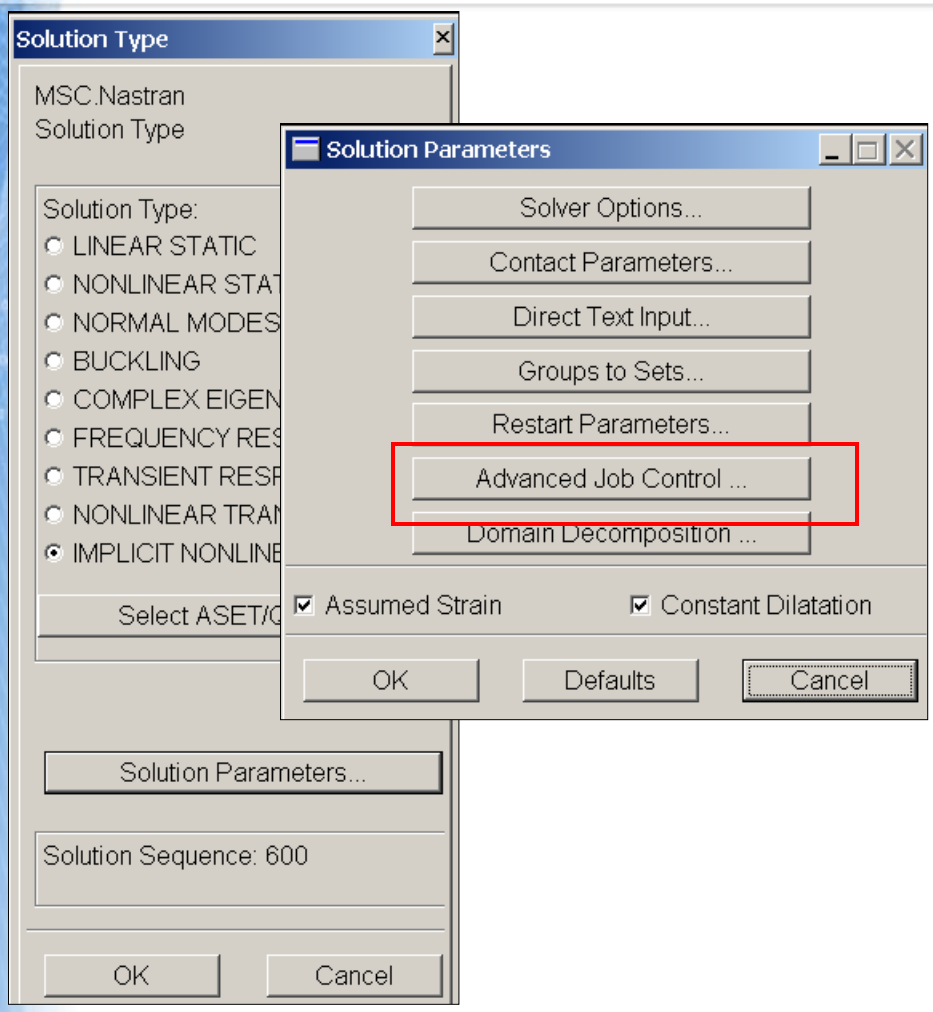
- **BCTABLE, BCBODY, BSURF, BCBOX, BCPROP, BCMAT for contact**
- **MATEP elasto-plastic material**
- **MATHE hyper-elastic material (incl. Ogden)**
- **MATVE visco-elastic material**
- **Marc output is converted to op2, xdb, f06, pch**



© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

MSC.NASTRAN SOL600 ADVANCED JOB CONTROL

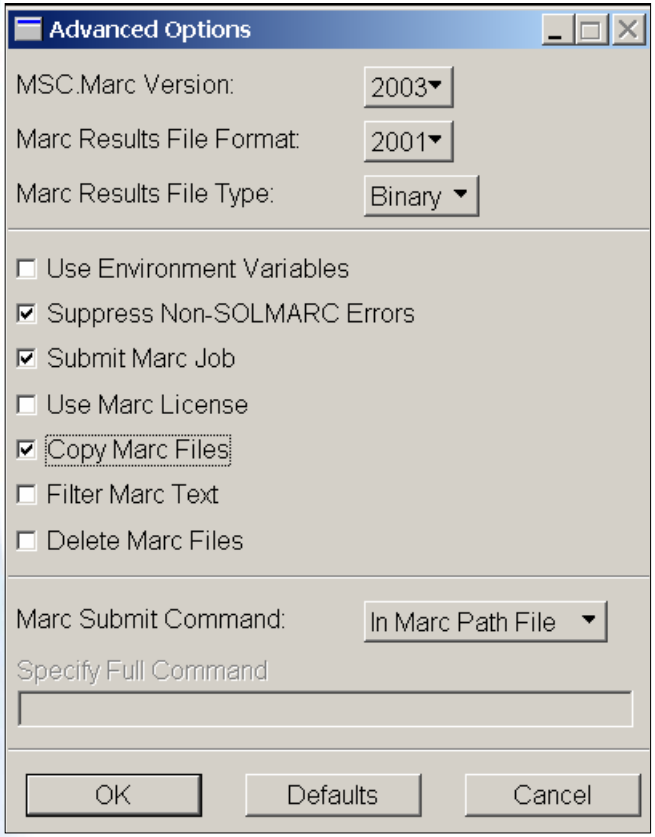


- **MSC.Nastran SOL600 Runs MSC.Marc as a Background Process**
  - **Version 2004: Two Executables**
    - **Marc Files: jobname.marc.xxx**
- **Version 2004 gives users as much (next page) or as little control of MSC.Marc run as they desire:**
  - **Input File May be Edited**
  - **Job Submittal**
  - **License Usage**
  - **Output File Format**
  - **Job Messages can be consolidated in .f06 file**
  - **Marc files can be automatically removed**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Msc.Nastran Sol600 Advanced Job Control



- **Control of MSC.Marc Job**
  - **Marc versions 2000, 2001, 2003**
  - **2003r2 is highly recommended - not all options will work with older versions**
  - **Marc .t16 file version and type**
- **Environment Variables (named NASM_XXXX) Can Be Used to Set Local or System-Wide Defaults for:**
  - **OUTR – requests Nastran-formatted output files .f06, .op2, .xdb, .pch**
  - **COPYR – copies back and/or deletes Marc files**
  - **PATH – points to run_marc command**
  - **STOP – stop MSC.Nastran after IFP or before Marc execution**
  - **NOERROR – for advanced users**
  - **NASM_STRFILE - Env. Var. points to text filter file**

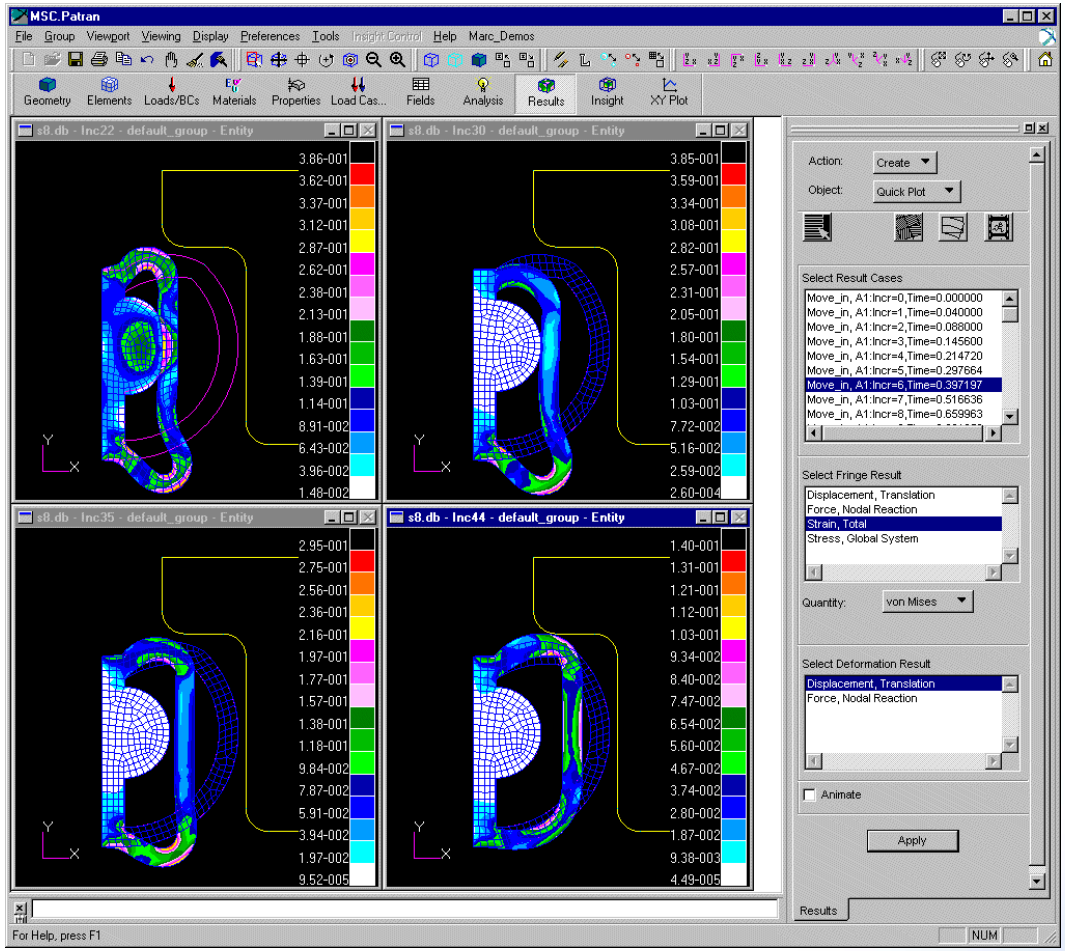
© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Advantages of MSC.Nastran SOL600

Integration with MSC.Patran

- MSC.PATRAN provides:
- Patran Preference for SOL600 capabilities identical to Marc Preference
- Real-time job monitoring
- Auto-attach jobname.xxx results
- Feature-rich, pre- and post-processing capabilities
  - Preview Contact Body Motion and Orientation
  - Experimental Data Fitting
  - Multi-step Job control for complex loading histories

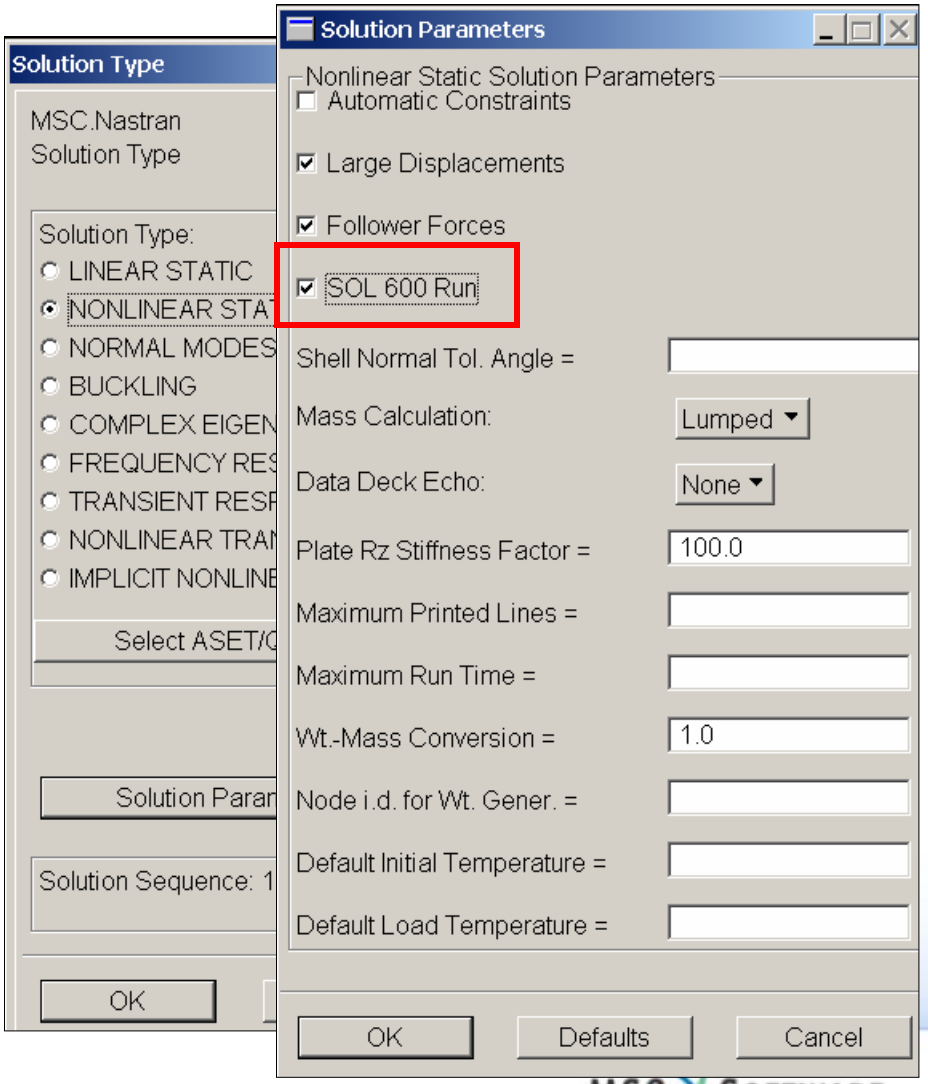


© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

But What If I Want To Set Up My Job Like I Always Have?

- Any Solution Type supported by SOL 600 may be run from the non-SOL 600 form
  - Linear Static
  - Nonlinear Static
  - Normal Modes
  - Buckling
  - Nonlinear Transient
- Likewise, many existing MSC.Nastran Input files can easily be run via SOL 600
  - Replace “SOL XXX” with:
  - “SOL 600,XXX”

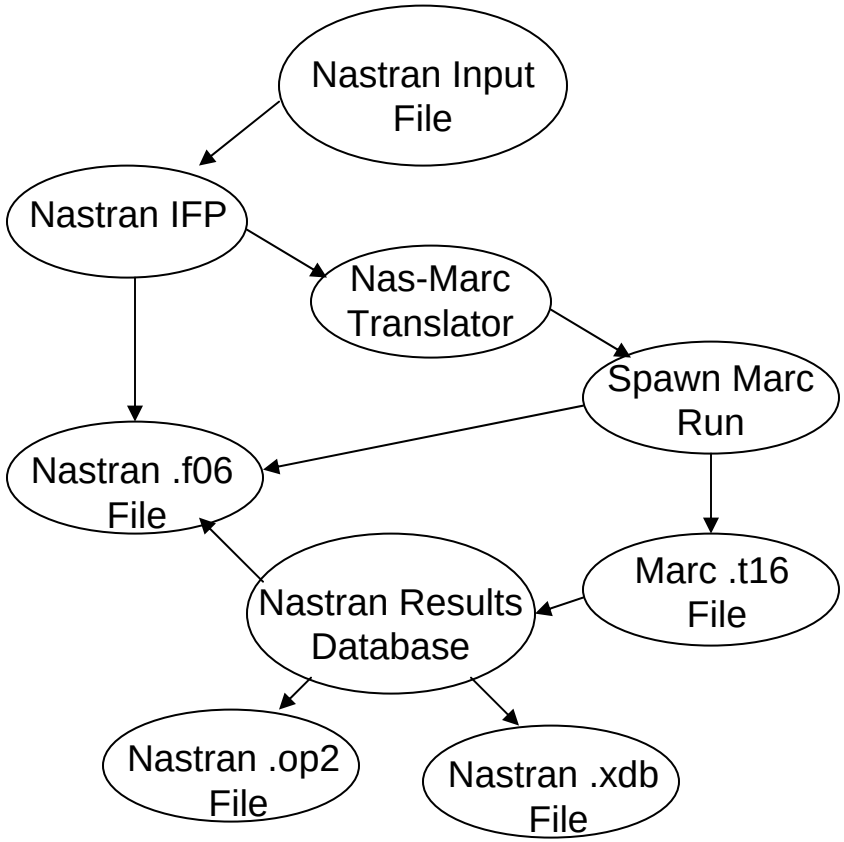


© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

How Does MSC.Nastran SOL600 Work ?

- Nastran-Marc Translator:
  - Start Nastran, read the Nastran input file
  - Generate a Marc input file and run Marc in the background
  - Marc run-time error messages can be copied to .f06
  - Nastran (optionally) deletes intermediate files
  - Needs a Marc and a Nastran executable (both will be included on the Nastran CD)



Biggest Risk – Nonlinear analysis is an order of magnitude more difficult

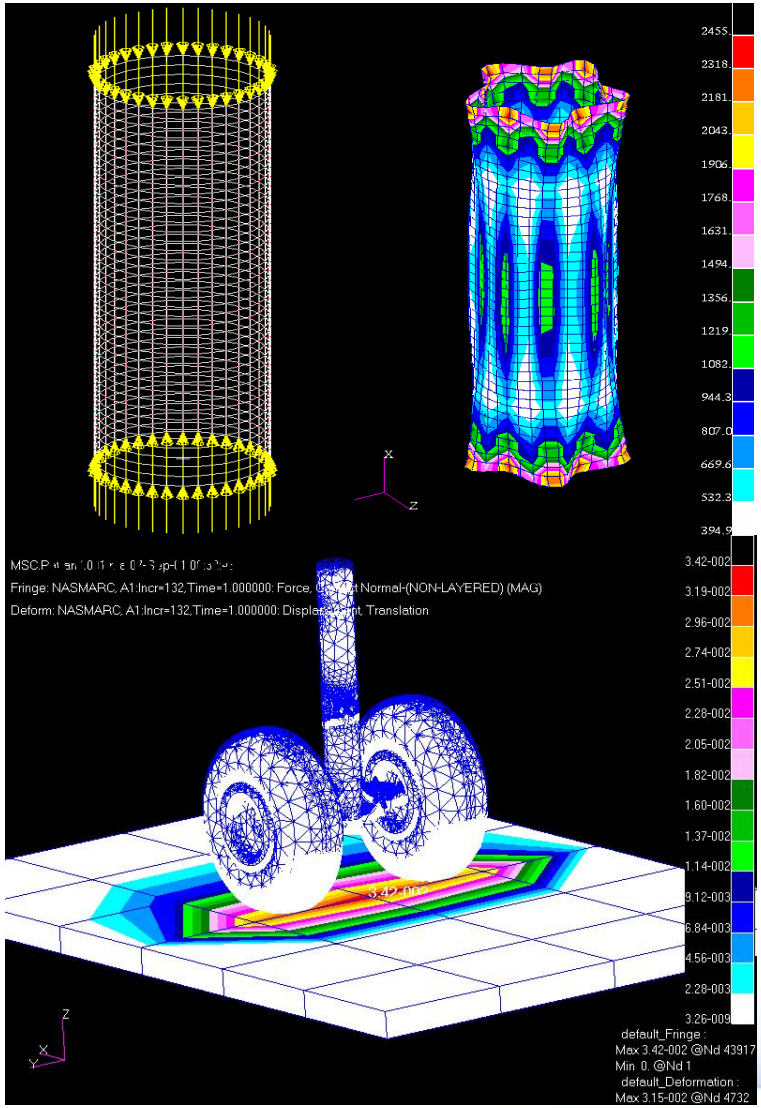
Our Goal – Debugging SOL 600 runs must be no more difficult than other nonlinear codes

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE SIMULATING REALITY

How Does MSC.Nastran SOL600 Work ?

- Marc becomes a background process run by Nastran
- Nastran uses inverse translator t16-to-op2 to obtain results in Nastran format - f11results file created
- All standard Nastran output formats are available – DMAP created “on the fly” to use inputt2 to read f11, ofp/output2 to create XDB, OP2, F06, PCH
- New DMAP to be developed in Q3/Q4 will allow frequency response and other dynamics procedures using SOL600 pre-stress solutions



© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

MSC.Nastran SOL600 Documentation

There is an entirely new Manual: "MSC.Nastran Implicit Nonlinear (SOL 600) User's Guide" covering all of the nonlinear capabilities included in SOL600… You should really check it out!

For More Information:

- See the MSC.Nastran SOL600 Product Data Sheet
- Get the Power-point presentation of this MSC.Nastran SOL 600 Webinar
- On-line documentation for MSC.Patran, MSC.Nastran, MSC.Marc, and the MSC.Patran Nastran Pref Guide

MSC.Nastran Advanced Nonlinear Data Sheet

Finite Element Analysis of 3D Contact and Highly Nonlinear Problems using MSC.Nastran

MSC.Nastran Advanced Nonlinear

MSC.Nastran Advanced Nonlinear is a new capability for the analysis of highly nonlinear problems. MSC.Nastran Advanced Nonlinear is based on MSC.Marc technology, which provides the world's leading contact algorithms along with robust, user-friendly nonlinear capabilities for the solution to all types of nonlinear problems including nonlinear material behavior, contact, and large deformation/rotation and finite strains. This new capability will allow the user to perform a wide variety of nonlinear structural, thermal and coupled thermal-structural analyses (including large deflections and rotations, and large strains) using the existing input decks from the many thousands of existing MSC.Nastran models. This new technology will provide solutions for simple to complex engineering problems including multi-body contact and advanced elastomeric (rubber) material models

ANALYSIS SOLUTIONS

Linear Static
Nonlinear Static
- Adaptive load incrementation
- User specified load step control
- Convergence automation

Normal Modes (Eigenvalue Extraction)
Buckling Analysis
- Inverse power sweep
- Lanczos

Transient Dynamics
- Modal superposition
- Direct integration (implicit or explicit)
- Adaptive or fixed time stepping

Harmonic Response *

Creep Analysis *
- Implicit or explicit
- Adaptive or fixed time stepping

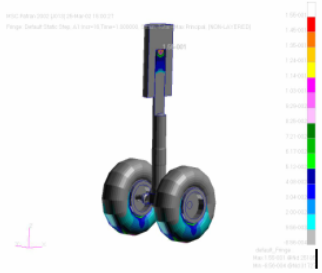
Steady State Heat Transfer *
Transient Heat Transfer *
- Conduction
- Convection
- Fixed time stepping
- Adaptive time stepping

ELEMENT LIBRARY

Over 140 elements are available for structural and thermal analyses. These elements are modern, robust, accurate, and can handle large displacements, large rotations, and finite strains.

- truss
- beam
- plane stress
- plane strain
- generalized plane strain *
- plate
- shell
- membrane
- gasket
- axi-symmetric
- 3-D solid
- semi-infinite *
- springs/dampers
- RBEn
- gaps
- incompressible
- 2D laminated composites
- continuum composite

Lower and higher-order elements
Reduced integration * / Herrmann elements
Follower force stiffness



MATERIAL MODELS

Most MSC.Marc materials are included in MSC.Nastran Advanced Nonlinear. Many material properties can be temperature, strain rate, strain, time, and frequency dependent *.

Linear Elastic
- Isotropic, orthotropic, anisotropic

Elastic-Plastic
Rigid-Plastic
Perfectly Plastic
- Multiple hardening rules
- Multiple yield criterion
- Strain hardening/softening
- Strain rate effects

* = Not in First Release

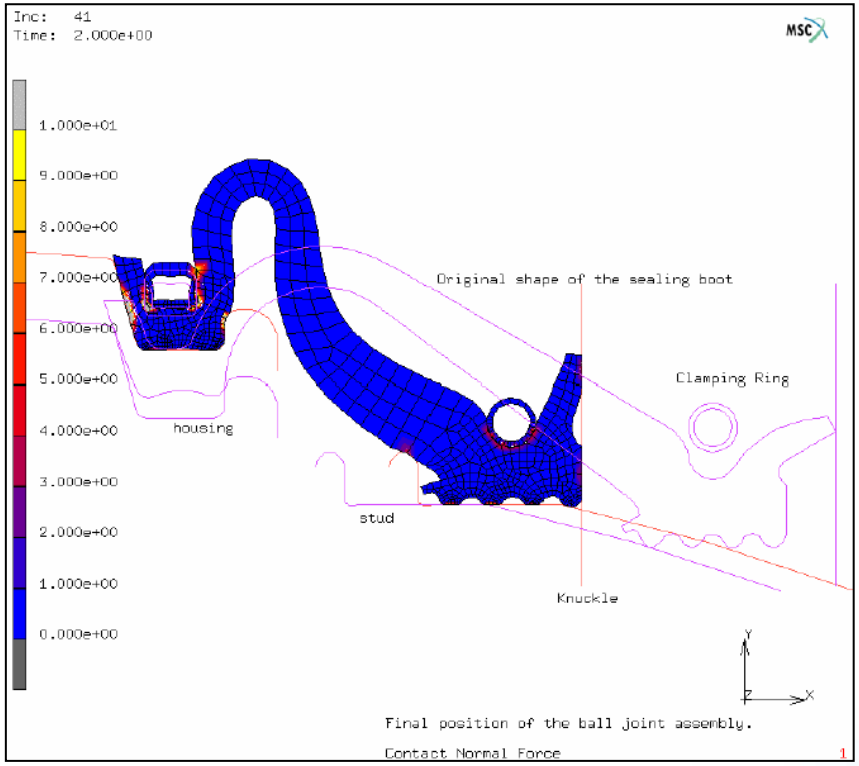
© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE SIMULATING REALITY

Non-linear Features in MSC.Nastran SOL600

Brings Powerful, Mature, Robust Nonlinear Technology to the MSC.Nastran Community

- Geometric Non-linearities
- Materially Non-linear Models
- Boundary Condition Non-linearities
- (Contact)

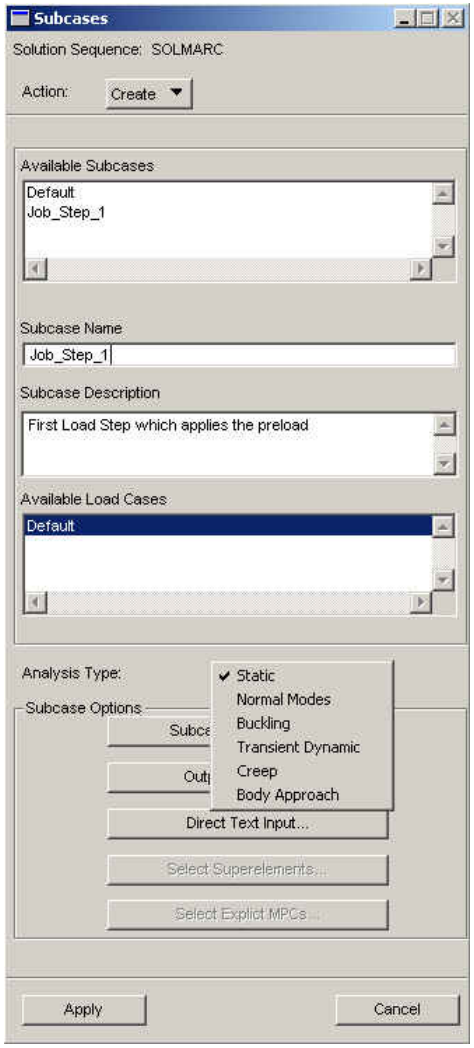


All Non-linear Behaviors Can be Combined ...

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Features and Capabilities



- Overview of Structural Capabilities Supported in Version 2004:
  - Contact – All Features
  - Nonlinear Materials :
    - Elastic - Plastic
    - Hyper-elastic
    - Creep and Visco-elastic
    - 3D Composites
  - Large Deformation – Large Strain
- Patran Preference for SOL600 capabilities similar to Marc Preference

© Copyright 2002 MSC.Software Corporation

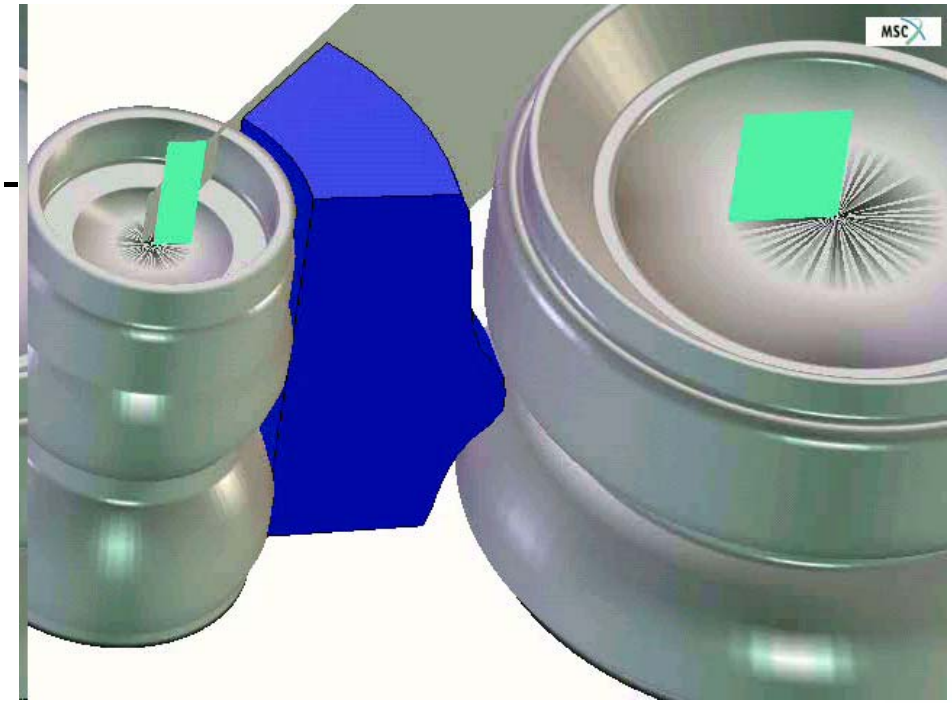
MSC SOFTWARE
SIMULATING REALITY

MSC.Nastran SOL600 – Future Enhancements

And we're not done yet …

Possible Future Developments (Phase II)

- Thermal and Coupled Thermal-Structural Analysis
- Global and Local Adaptive Re-meshing
- User Subroutines
- DMAP
- Fracture Mechanics
- Use of Super-elements, Component Modes, Reduced Stiffness/Mass Matrices,….



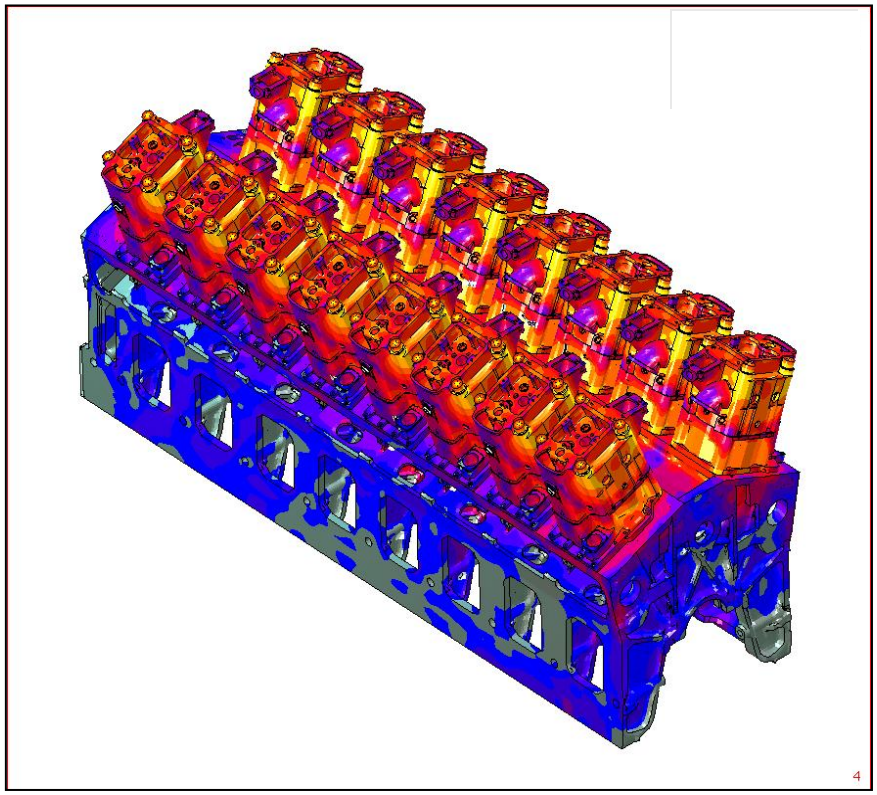
© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

MSC.Nastran SOL600 Features

MSC.Nastran SOL600 Features:

- Structural (2004), Thermal and Coupled Analysis (2005)
- Material, Geometric, large strain, failure and Contact Non-linearity (2004)
- Parallel Processing (DDM, 2004)
- Experimental Data fitting for elastomers (in Patran, 2004)
- User Defined Subroutines (2005)
- Global Re-meshing (2005)



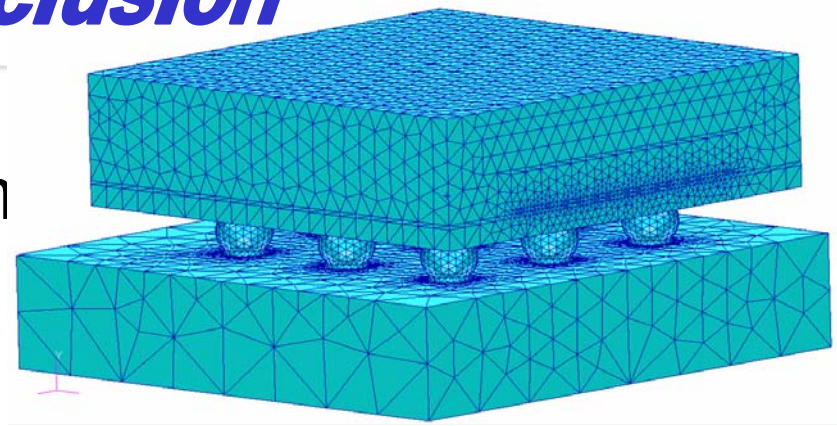
© Copyright 2002 MSC.Software Corporation

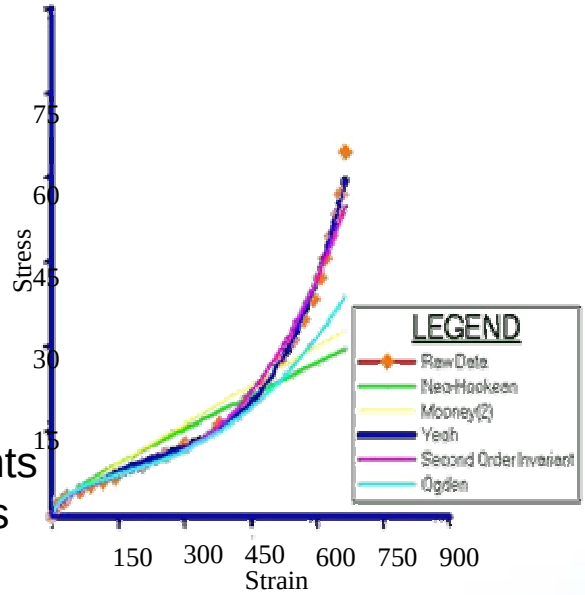
MSC SOFTWARE SIMULATING REALITY

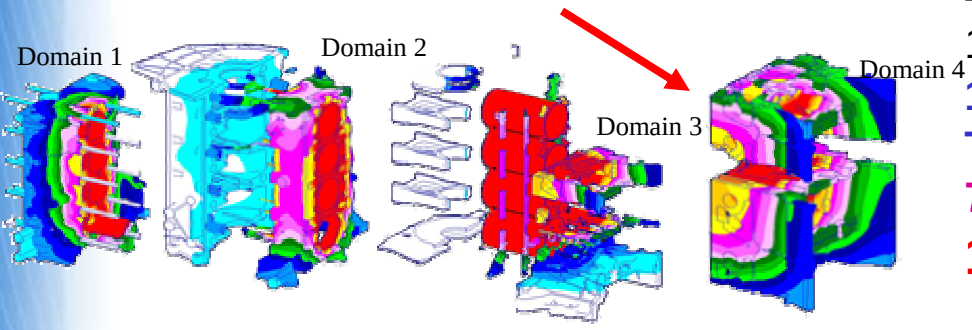
Features - Conclusion

Take advantage of these powerful capabilities through an MSC.Nastran interface:

1. Easy to Set-up Multi-body Contact
2. Advanced Material Models
3. Experimental data fitting with graphical user feedback
4. Linearly scalable DDM







448,361 Elements
1.8 Million DOFs

10 Increment - Transient Thermal Analysis

78 min. on single processor

12 minutes on 8 CPUs

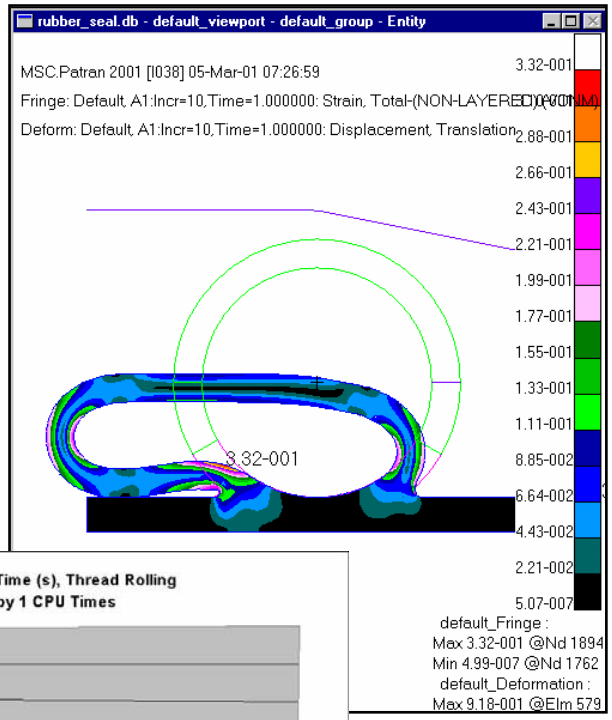
© Copyright 2002 MSC.Software Corporation

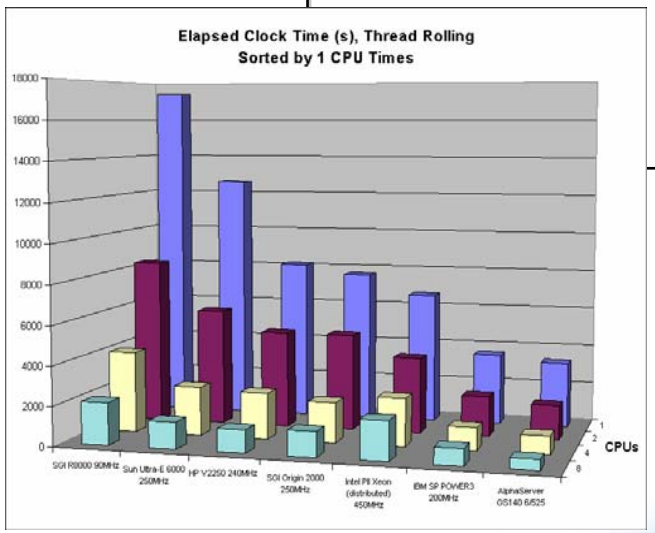
MSC SOFTWARE
SIMULATING REALITY

Advantages of MSC.Nastran SOL600

Overview of MSC.Nastran SOL600's Advantages Over it's Competitors

- Extensive Existing Customer Base
- Strongest Dynamics Capabilities Available
- Linearly Scalable Domain Decomposition Method (DDM)
- Complex Material and Load History Modeling in a User-Friendly Way
- Powerful and Easy-to-Use Contact
- User Friendly Nonlinear Capabilities





© Copyright 2002 MSC.Software Corporation

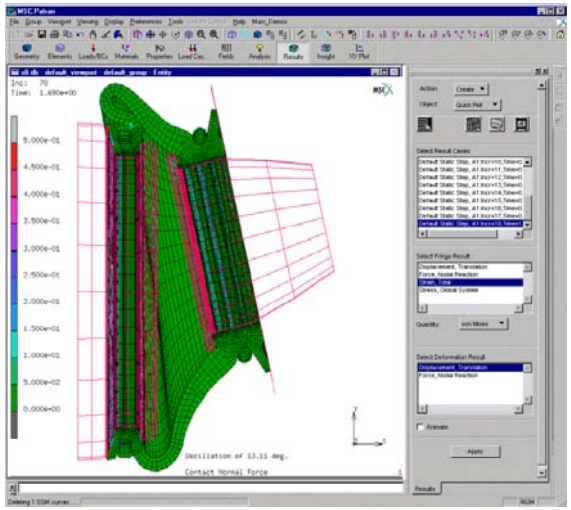
MSC SOFTWARE
SIMULATING REALITY

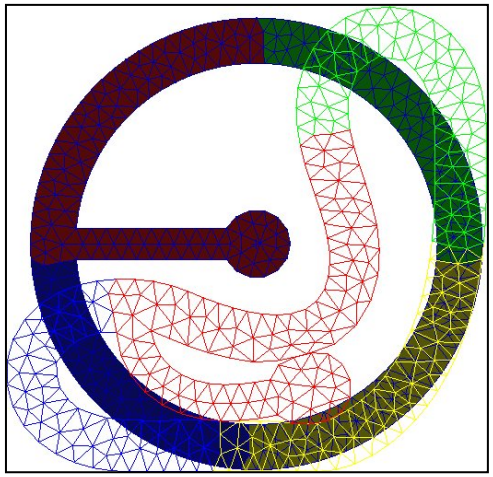
Advantages of MSC.Nastran SOL600

The 5 best reasons to use MSC.Nastran SOL600:

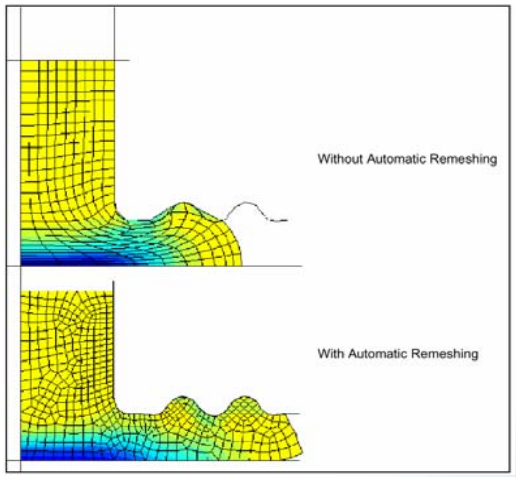
- Common data format for all purposes – *use one model for all FEA requirements*
- Multi-Body Contact - robust and easy to set up – *let the computer do the work for you*
- Linearly Scalable DDM - *computer power is becoming less expensive and multi-cpu machines more common*
- Global Adaptive Re-Meshing *
- Complete integration between Nastran linear, highly nonlinear, and explicit (coming soon) FEA capabilities

Multi-Body Contact





Linearly Scalable DDM



Global Adaptive Remeshing

MSC SOFTWARE
SIMULATING REALITY

© Copyright 2002 MSC.Software Corporation

Why Should I Use MSC.Nastran SOL600 ?

- Allows Companies to Use a Single Model Format
- Single Input Format Allows:
  - Common Model for All Analysis Needs
  - Elimination of Model Re-creation Effort
  - Reduced Time-to-Market
  - Increased Efficiency
  - Further value to FEA simulation
- Allows Re-use of Thousands of Existing Models That Cost Millions to Create

```
$ NASTRAN input file created by MSC.Nastran input file
$ Direct Text Input for File Management Section
$ Nonlinear II Analysis
SOL 600,NLSTATIC PATH=1 OUTR=XDB
$ Direct Text Input for Executive Control
CEND
SEALL = ALL
SUPER = ALL
TITLE = MSC.Nastran job created12-Oct-01 at 09:38:33
ECHO = NONE
$ Direct Text Input for Global Case Control Data
BCONTACT = ALL
SUBCASE 1
$ Subcase name : Default
   SUBTITLE=Default
   NLPARM = 1
   BCONTACT = ALLBODY
   SPC = 2
   LOAD = 2
   DISPLACEMENT(SORT1,REAL)=ALL
   SPCFORCES(SORT1,REAL)=ALL
   STRESS(SORT1,REAL,VONMISES,BILIN)=ALL
BEGIN BULK
PARAM    POST    0
PARAM    AUTOSPC NO
PARAM    LGDISP  1
PARAM,NOCOMPS,-1
PARAM   PRTMAXIM YES
NLPARM   1       10              AUTO    5       25
$ Direct Text Input for Bulk Data
$ Elements and Element Properties for region : shell
PSHELL   1       1       .25     1               1
$ Pset: "shell" will be imported as: "pshell.1"
CQUAD4   1       1       1       2       13      12
CQUAD4   2       1       2       3       14      13
```

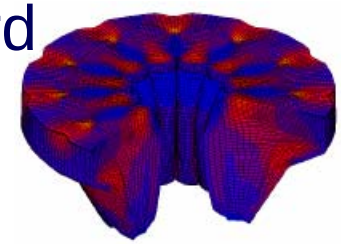
© Copyright 2002 MSC.Software Corporation

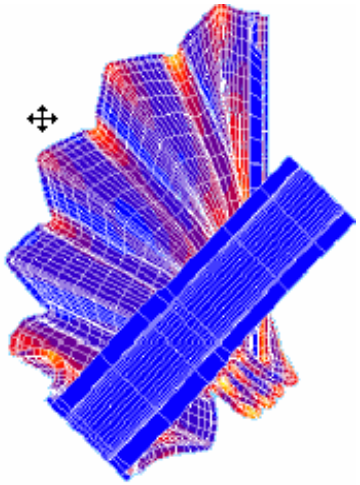
MSC SOFTWARE
SIMULATING REALITY

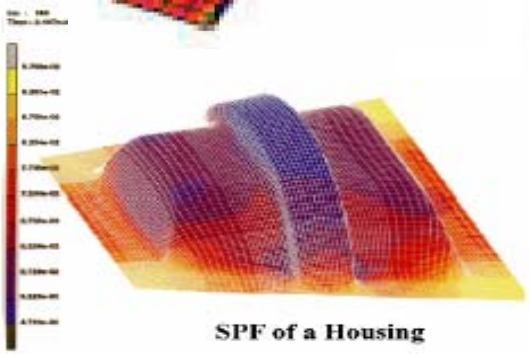
Why Should I Use MSC.Nastran SOL600 ?

Strengths

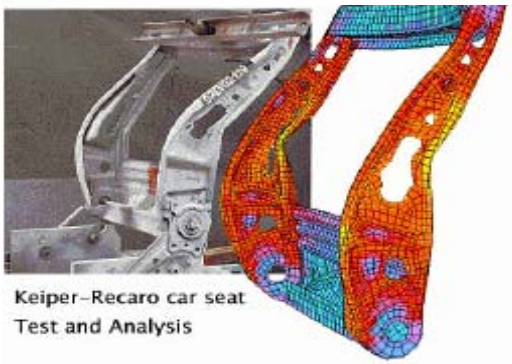
- Existing Customer Base – MSC.Nastran is a standard
- Strong nonlinear solution capabilities via Marc
- Unique strategic solution capabilities
- Broad MSC offering
  - MARC, DYTRAN, DYNA, Acumen, Mvision, Patran, Nastran, Services, Systems
- Strong Worldwide Sales/Marketing







SPF of a Housing



Keiper–Recaro car seat
Test and Analysis

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

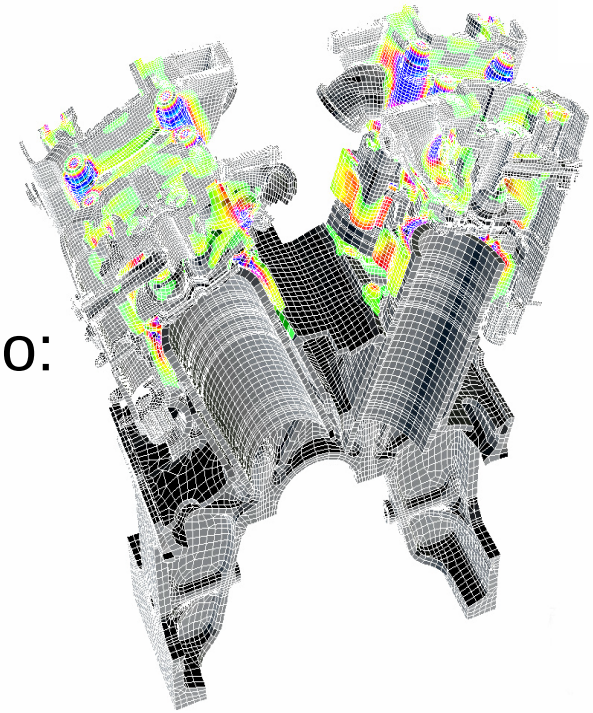
Why Should I Use MSC.Nastran SOL600 ?

- Advantages of MSC.Nastran SOL600:
  - Robust nonlinear solution through the familiar Nastran input file interface
  - Single input file for linear, nonlinear implicit and explicit
  - Cost savings by eliminating the need for other nonlinear solvers
  - Input file is a long-standing international standard
  - MSC Infrastructure: availability of worldwide services, support and training
  - Nastran reputation and unmatched capabilities

© Copyright 2002 MSC.Software Corporation

Conclusion

- Combine the World's Most Advanced Contact and Nonlinear Finite Element Technology With the World's Leading Analysis Code and You Get MSC.Nastran Implicit Nonlinear – SOL600
- This Powerful Combination Will Lead To:
  - Common Analysis Model Format
  - Increased Efficiency
  - Reductions in:
    - Need for Physical Prototypes
    - Model Re-creation Effort
    - Product Development Time
  - Increased Value of FEA Simulation – an Already Indispensable Tool !!



© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

MSC.Nastran 2004 Update

Q and A Session

Replies to all questions will be posted on the MSC.Nastran discussion board

From: http://www.mscsoftware.com/

Navigate to:

- **Training & Support**
- **MSC.Nastran**
- **Discussion Forum**

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

For More Information

Nastran Information
http://www.mscsoftware.com/products/products_detail.cfm?PI=7

Product Support
http://www.mscsoftware.com/support/prod_support/nastran/

Discussion Forum
http://forums.mscsoftware.com/nastran/ubbthreads.php

Technical Support
http://www.mscsoftware.com/support/contacts/index.cfm

Knowledgebase
http://support.mscsoftware.com/kb/?prl=msc.nastran

Training
http://www.mscsoftware.com/support/msc_institute/?Q=135&Z=143

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY

Thank you!

© Copyright 2002 MSC.Software Corporation

MSC SOFTWARE
SIMULATING REALITY