

## What's New MSC Nastran 2018 & MSC Nastran 2019

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## Outline



- Element Technology
  - I. Pyramid Elements
- Contact Analyses
  - I. Contact Model Check
- Numerical Computation and HPC Improvements
  - Automatic Solver and Parallel Selection Process
- Other Improvements
  - I. Multi-Mass Configuration
  - II. Shell Stress Constraints for Topology and Topometry Optimization
  - III. HDF5 Result Database

## Element Technology - Pyramid Elements

#### Introduction



- Pyramid element (CPYRAM) capability added to MSC NASTRAN
- Extends existing solid element topology CTETRA, CHEXA, CPENTA
- Supported in all physics/applications where regular solid elements are supported

### **Benefits**

Enhances automated meshers transition between CHEXA & CTETRA

- CHEXA at the core of geometry
- CTETRA at the boundary of geometry
- CPYRAM can now be used to transition between these elements

### Feature Description



- CPYRAM supported in all linear and nonlinear solution sequences
  - SOL 101, SOL 103, SOL 105, SOL 107, SOL 108, SOL 109, SOL 110, SOL 111, SOL 112, SOL 144, SOL 145 and SOL 146
  - SOL 200
  - SOL 400
- All physics already supported by MSC NASTRAN standard solid elements are also supported by CPYRAM element
  - Linear statics
  - Linear dynamics (modal frequency and transient)
  - Buckling analysis
  - DesigFatigue analysis
  - Rotordynamics
  - Vibro-Acoustics
  - Aeroelasticity and Flutter
  - n Sensitivity and Optimization

- Contact including automated contact generation
- Material and geometric nonlinearity
- Linear perturbation analysis
- Random analysis
- Coupled analysis
- Heat transfer
- Thermo-mechanical coupled analysis
- All types of loading like structural, distributed, gravity, pressure, thermal loads are supported
- Pyramid element results output to OP2 and HDF5 files

#### User Interface



#### CPYRAM Five-Sided Solid Element Connection

Defines connections of the five-sided solid element with five or thirteen grid points

#### Format:

1	2	3	4	5	6	7	8	9	10	
CPYRAM	EID	PID	G1	G2	G3	G4	G5	G6		
	G7	G8	G9	G10	G11	G12	G13			
Describer	Meaning					Туре		De	Default	
EID	Element id	entification	number			0 < Integer	< 100,000,00	00 Re	equired	
PID	Property id	entification	number of a	<b>PSOLID</b> entr	У	Integer > 0			equired	
G <sub>i</sub>	Identification numbers of connected grid points					Integer ≥ 0	or blank	Re	equired	
G5										



- G1, G2, G3, G4 should define base of quadrilateral, G5 apex
- 5-noded Pyramid, G1-G5 must be defined
- 13-noded Pyramid, all G1-G13 must be defined
- Element coordinate system is used as basic CSYS

#### Pyramid Elements: Example



#### Closure of rubber seal - hybrid mesh

Mesh consists of CTETRA, CHEXA & CPYRAM elements CPYRAM used as transition element





### Pyramid Elements: Example

#### Closure of rubber seal - hybrid mesh

- Deformable rubber seal is placed between two rigid plates, one of which is moved downwards
- The example problem is run in MSC Nastran using 5-noded transitional Pyramid Elements
- Results are compared with MSC Marc





Biλs

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**Results are consistent with inclusion of CPYRAM elements** 

### Pyramid Elements: Performance Testing



- All CHEXA element model turned into all CPYRAM model
- 1 CHEXA element converted to 3 CPYRAM elements
- Tested in different SOL sequences & solvers: SOL 101, 103, 108, 111 & 400 and solvers ACMS, PARDISO, CASI, and MSCLDL



Consistent performance when introducing CPYRAM elements







#### SOL 101

## **Guidelines and Limitations**



- First order linear Pyramid element may show excessively stiff behaviour for bending dominated test problems
  - Drawback of shear locking will not be an issue, as Pyramid elements are mainly used as transition elements in most real world applications
- It should also be noted that second order Pyramid elements behave well for bending problems without any shear locking issue
- Damping (GE / GEij on the Material cards) is supported for Pyramid element
- Digimat support via MATDIGI material entry is not available for the Pyramid element
- Patran will support Pyramid Element in v2020.0
- Preprocessor Ansa (Beta CAE) will support the MSC Nastran Pyramid Element in their next major release as well

## Contact Analyses - Contact Model Check

#### Contact Model Check Phase I



- Contact grid status check
  - Check grid-wise distance between contact pairs
- Geometry adjustment display of initial stress free contact
  - Generate Displacement Output Table for post-processing
- Analytical SPLINE output OF Contact SURFACE
  - Add a new output table /OBCNURB/ for Analytical Smoothed Surface
- Bias = 0.0 on BCONPRG/BCTABLE
  - Enable exact user input 0.0 for BIAS on BCONPRG/BCTABLE

### Contact Grid Status Check (BCONCHK)

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- Provides the status of contact grids within a given tolerance
  - Help users check the contact status
  - Print the output to the f06 file and / or a post-processing file
  - Stop or run through after contact model check



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	78	1	PENETRATE	0.0000E+00	0.0000E+00	1.8016E-02	-1.8016E-02
	79	2	PENETRATE	0.0000E+00	0.0000E+00	1.8016E-02	-1.8016E-02
	80	3	PENETRATE	0.0000E+00	0.0000E+00	1.8016E-02	-1.8016E-02
	93	1	PENETRATE	0.0000E+00	0.0000E+00	1.2198E-02	-1.2198E-02
	94	1	PENETRATE	0.0000E+00	0.0000E+00	1.2198E-02	-1.2198E-02
	95	2	PENETRATE	0.0000E+00	0.0000E+00	1.2198E-02	-1.2198E-02
	96	3	PENETRATE	0.0000E+00	0.0000E+00	1.2198E-02	-1.2198E-02
	109	10	PENETRATE	0.0000E+00	0.0000E+00	6.3807E-03	-6.3807E-03
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	111	11	PENETRATE	0.0000E+00	0.0000E+00	6.3807E-03	-6.3807E-03
	112	12	PENETRATE	0.0000E+00	0.0000E+00	6.3807E-03	-6.3807E-03
	125	19	PENETRATE	0.0000E+00	0.0000E+00	5.6290E-04	-5.6290E-04
	126	19	PENETRATE	0.0000E+00	0.0000E+00	5.6290E-04	-5.6290E-04
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#### **Contact Distance Check**



• Contact Check is supported in segment-to-segment method as well



#### Geometry Adjustment Display of Initial Stress Free Contact



- Geometry of the grids are adjusted to achieve Initial Stress Free Contact
- Help users check the reasonability of the model setup
- Supports permanent glued contact, general glued contact, and touching contact



## Initial Stress Free in SEGTOSEG Contact

 Seg-to-seg initial stress free contact can adjust geometry to clear gap/penetration



Contact Check Vector without Initial Stress Free



Initial Stress Free Adjustment Vector & Fringe



## Output Analytical Spline Smooth Surface

BIAS

- After FE discretization, continuity of model surface is lost.
- Analytical smooth surface may be generated for C1 continuity
- The smoothened surface is output to HDF5 and OP2 database.
  - It follows the input format of BCNURBS
- Supports all contact types for SOL 400

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### BIAS = 0.0 In BCONPRG and BCTABLE



- Allow user to apply the real ZERO as the input for BIAS in BCONPRG and BCTABLE and BCTABLE
  - Older versions had a limitation that required user to enter a near zero value
  - Table 8-5 Geometric Contact Parameters of Touching Bodies in SOLs 101, 103, 105, 107-112, 200 and 400

Name	Description, Type and Value (Default is 0 for integer, 0.0 for Real Unless Otherwise Indicated)
AUGDIST	Penetration distance beyond which an augmentation will be applied; used by the segment-to-segment contact algorithm only. (Real $\geq 0.0$ , see Remark 6. for default)
BIAS	Contact tolerance bias factor. If this field is left blank or is equal to 0.0, the default is the BIAS of the BCPARA entry. A nonblank or non-zero entry will override the BIAS entered on the BCPARA entry. To obtain a near zero value, enter $1.0E-16$ , $(0.0 \le \text{Real} \le 1.0)$

************* Values used Defaulf **********	**************************************	: contact bias fac 000000E-01	**************************************	**************************************
Body ID	1 Defor	2 Defor	3 Defor 4	Defor
1 Defor	N/A	-9.000000E-01	9.0000000E-01	9.0000000E-01
2 Defor	N/A	N/A	9.0000000E-01	N/A
3 Defor	N/A	N/A	N/A	N/A
4 Defor **********	N/A *********	N/A *********	9.0000000E-01	N/A *******

Values used Default	during contact Value - 9.0	CONTACT DIAS FAC 100000E-01	tor	(BIAS)
Body ID	1 Defor	2 Defor	Defor 4	Defor
1 Defor	N/A	9.900000E+00	- 0:000000E+00	0.000000E+00
2 Defor	N/A	N/A	0.000000E+00	N/A
3 Defor	N/A	N/A	N/A	N/A
4 Defor	N/A	N/A	0.000000E+00	N/A

# Numerical Computation and HPC Improvements -

Automatic Solver and Parallel Selection Process

#### Automatic Solver and Parallel Selection Process







# Automatic Solver and Parallel Selection Process

#### Machine Learning Capabilities



#### Automatic Solver and Parallel Selection Process



#### Run #1 with solve=auto

	Sol	ver	Oł	ptions	=	==	
Туре	1			Pa	rd	iso	
Memo	ory			203	00	MB	
BPOC	ΟL			152	01	MB	
===	Par	alle	<b>≥</b> 1	Optio	ns	===	
DMP				1			
SMP				4			

#### Run #2 with solve=auto

=== So	lver O	ptions ==	==
Туре		Pard	lso
Memory		20972	MB
BPOOL		15201	MB
=== Pa	rallel	Options	===
DMP		1	
SMP		4	

MEMORY PARAMETERS FOR INTEL MKL PARD	ISO PARALLEL DECOMPOSITION FOLLOW
AVAIL. CORE MEMORY =3	250 MB
APPROX. REQUI. IN-CORE MEMORY =3	531 MB
APPROX. REQUI. OUT-OF-CORE MEMORY =1	304 MB

Wall Clock Time: 1796 s

MEMORY PARAMETERS FOR INTEL MKL PARDISO	PARALLEL DECOMPOSITION FOLLOW
AVAIL. CORE MEMORY =3384	MB
APPROX. REQUI. IN-CORE MEMORY =3519	MB
APPROX. REQUI. OUT-OF-CORE MEMORY =1803	MB

Wall Clock Time: 1750 s

#### Run #3 with solve=auto

	Solver	Options =	==
Туре		Pard	iso
Memo	ry :	21744	MB
BPOO	L :	15201	MB
===	Paralle	l Options	===
DMP		1	
SMP		4	

MEMORY PARAMETERS FOR INTEL MKL PARDISO	PARALLEL DECOMPOSITION FOLLOW
AVAIL. CORE MEMORY =3539	MB
APPROX. REQUI. IN-CORE MEMORY =3519	MB
APPROX. REQUI. OUT-OF-CORE MEMORY =1803	MB

Wall Clock Time: 1241 s

Pardiso runs in-core after training



### Automatic Solver Selection Example





- Default Serial run with default solver
- CPUMAX set to 20, which resulted in "smp=4"
- SOLVE=AUTO, w/ CPUMAX=1 resulted in the CASI solver being used. (This model is entirely made up of 3-D elements)
- SOLVE=AUTO w/o CPUMAX specified used SMP=8

**Other Improvements - Multi-Mass Configuration** 

#### **Multiple Mass Configurations**



Typical aerospace vehicle analysis requires consideration of multiple mass cases involving different structural mass, payloads, fuel conditions and environmental conditions

- Enabled for constructing and analyzing additional mass cases for the standard linear, nonlinear and optimization solution sequences.
- Mass cases are subcase selectable similar to loads and boundary conditions.
- Mass Increments defined via additional BULK Data sections and can be combined with base mass

## Solution Sequences Supporting MMC

- BIAS
- SOL 101: Static analysis with inertia relief and gravity load for user specified mass cases.
- SOL 103, 107, 110: Modes calculated for the user specified mass cases.
- SOL 108, 111: Frequency Response calculated for user specified mass cases.
- SOL 109, 112: Transient Response calculated for user specified mass cases.
- SOL144-146: Aeroelastic analysis for user specified mass cases.
- SOL 400: Supported for linear, nonlinear and perturbation analysis.
- Part SE support in all the above solution sequences.
- SOL 200: Optimization will be supported with invariant mass increments.

Other Improvements - Shell Stress Constraints for Topology and Topometry Optimization

## Stress Constraints for Shell Topology Optimization

## Benefits

• Allow users to have Von Mises stress (at element center) constraints in a topology design optimization task

Bins

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• Eliminate the guessing of the right fractional mass constraint in classical compliance minimization design tasks

#### Input

1	2	3	4	5	6	7	8	9	10
TOPVAR	ID	LABEL	PTYPE	XINIT	XLB	DELXV	POWER	PID	
	"SYM"	CID	MS1	MS2	MS3	CS	NCS		
	"CAST"	CID	DD	DIE	ALIGN				
	"EXT"	CID	ED	ALIGN		1		1	<u> </u>
	"TDMIN"	TVMIN	TVMAX						
	"STRESS"	STLIM				š			

## Stress Constraints for Shell Topology Optimization





Clip example: The dimensions of the clip are 100 horizontally and 80 vertically.



Minimize FRMASS s.t. stress <=100.0MPA

## Stress Constraints for Shell Topometry Optimization $\exists i \land S$

#### **Benefits and limitations**

- Allow users to have Von Mises stress (at element center) constraints in a topometry design optimization task
- Support element shell thickness only



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### Input

TOMVAR	ID	PTYPE	PID	PNAME/ FID	XINIT	XLB	XUB	DELXV	
	"DLINK"	TID	C0	C1					
	"DDVAL"	DSVID							
	"STRESS"	STLIM							



Other Improvements - HDF5 Results Database

## HDF5 Result Database (NH5RDB)



### • Data type support

- Fatigue vibration data block OEFTGV
- Solution set output SDISP, SVELO, ACCE and UHT vector
- Monitor point data in SOL200 and AESTAT
- Design optimization topometry and topology data TOMVAR and TOPVAR
- Design optimization response R1TABRG, HISADD and RESP12
- Wet faces data in acoustic analysis
- Metadata entries

### • Matrix data

- Modal matrix KHH, MHH and BHH
- General matrix data output

#### HDF5 Result Database



## • MSC Nastran file management

- Support ASSIGN statement for NH5RDB file
  - assign HDF5='myfile.h5'
- Versioning
  - Append version number in NH5RDB file for multiple MSC Nastran runs

#### MDLPRM parameters

- H5MDL: write model data in separate file
- H5MTX: write matrix data in separate file
- H5GM34: optionally write GEOM3 and GEOM4 data block in NH5RDB

#### Patran support

• Monitor point, design response and contact force



# What's New MARC 2018 & MARC 2019

Bias Mühendislik Yiğit ÇELİK 03/10/2019

## Outline



- Materials
  - I. Expanded Material Data Fitting Capabilities in Mentat
  - II. Support for Additive Plasticity in Hermann Elements
  - III. Prediction of Heat Generated in Viscoelastic Materials Subjected to Repeated Loading
- Contact Analysis
  - I. Automatic Contact Detection in Mentat for Efficient Creation of a Large Number of Deformable Contacts
  - II. Improved Contact Fidelity Between a Rigid Surface and Deformable Body

#### • Solver - Output Enhancements

- I. Localized Global Remeshing Capability
- II. Improved Accuracy and Performance via Localized Options for Convergence Checks
- III. HDF5 Output

#### • Additional Enhancements

- I. More Efficient Process of Defining Multiple Springs and Fasteners with Preload
- II. Extended Support for Import of Nastran Models with Contact Cards
- III. General Mentat Usability Improvements
- IV. Endurica Compatibility with Marc for Prediction of Rubber Fatigue

# Materials

#### Improved User Efficiency via Expanded Material Data Fitting Capability in Mentat



- Modeling Application: Improve quality and robustness of material definitions defined by complicated experimental data via an automated process
- Example Engineering Application: Simplify use of the Ogden-Roxburgh model by providing an automatic high quality fit to experimental data
- Implementation:
  - Accessed via the existing material data fit interface
  - Addition of the following material definitions
    - Series expansion for the volumetric strain energy function,
    - Full support of time independent isotropic hyperelastic models
    - Ogden-Roxburgh damage model

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#### Example: Curve Fits



Time Independent Hyper Elastic Materials Data Fitting with Differential Evolution



Ogden Data Fit without Volumetric Data



Data Fitting with Elasticity O-R Damage Viscoelasticity and Plasticity



O-R Damage Comparison with Miehe Damage



Elasticity with Damage And Viscoelasticity and Plasticity



Elasticity with Damage and Plasticity

#### Additional Material Support in Experimental Data Fit

- Modeling Functionality:
  - Extend experimental data fitting to include cyclic plasticity to increase ease of use and reduce potential for error
- Example Engineering Application:
  - Metal subjected to repeated loading and unloading in the plasticity region such as may occur in pipes during extreme events
- Implementation:
  - Select Plasticity in the Experimental Data Fit Window and then se Stress (X100) 4 C





BIAS

Material Type	Hask	higuchi							
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	-0	ptions			H2 1	6.6555			
Error Tolerance	e ļ	0.15			Ck	189.842			
Number Of Tri	als	s 1			Zeta	).7			
Max. Iteration	5 (	500			Re	0.2216			
	Par	ameter	s		Ubar 1	12.971			
Young's Modu	lus	18000	0		Uc 6.94695				
Poisson's Ratio	)	0.3			Status				
					Current Trial	1			
					Current Iteration	155			
					Computed Error	0.149749			
Run Process	In Ba	ackgrou	ind Mode		Convergence Error 0.104026				

# Support for Additive Plasticity in Herrmann Elements

BIAS

- Modeling Functionality:
  - Expand Herrmann elements (for incompressible materials) to include an additive plasticity formulation that may improve accuracy and/or reduce runtime over strain smoothing elements
- Example Engineering Application:
  - Manufacturing processes such as forging, upsetting, extension or deep drawing, and/or large deformation of structures that occur during plastic collapse
- Implementation:
  - Assign a Herrmann element
  - $\succ$  Large strain preferences in the element option
    - "Additive Decomposition" option will be turned on by default (can turn off manually)





## Predict Heat Generated in Viscoelastic Materials Subjected to Repeated Loading

- Modeling Application: Calculate heat induced by repeated loading of rubber and rubberlike material
- Example Engineering Application: Improve prediction of rubber component performance in automotive
- Implementation:
  - Coupled Sequential analysis
    - Harmonic analysis (linear or nonlinear) with one frequency per load case (multiple frequencies- multiple load cases)
      - No temperature dependence
    - Coupled Sequentially with a Steady state or Transient thermal analysis using the harmonic data to drive heat generation
      - Temperature dependent properties supported
    - Relevant results could be thermal flux or equilibrium temperatures depending on solution chosen



Bins

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#### Example: Self Heating of a Viscoelastic Damper



**Damper Model** 

#### **Harmonic Stresses**

#### **Temperature**

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Contact Analysis

## Automatic Contact Detection in Mentat for Efficient **BinS** Creation of A Large Number of Deformable Contact

- Modeling Application: Improve user efficiency and reduce error by automatically detecting contact pairs and populating the contact table
- Example Engineering Application: Large assemblies and complicated models with multiple instances of deformable-deformable contact
- Implementation:
  - User creates contact bodies
  - User specifies contact type and maximum contact search distance for the detection algorithm
  - User specifies whether detected contact body pairs are added and/or pre-existing entries are replaced in the contact table.
    - Option to remove pre-existing entries in the contact table if the detected distance is above a limit.
    - Option to exclude self contact
  - User reviews the newly generated or modified contact table entries and can edit as with manual entries



## Example: Large Assemblies with Multiple Contacts **Bi**



Use case : Barge Part Application : Transportation

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Use Case Details :

Total Contact Bodies : 139 Total Contact Pairs : 275

## Improved Contact Fidelity Between a Rigid Surface **BinS** and Deformable Body

- Modeling Functionality:
  - Expand contact options between rigid STL surfaces and deformable bodies to include segment to segment for improved accuracy
- Example Engineering Application:
  - Die Forming Simulations
- Implementation:
  - STL surface can be used with or without the faceted surface option
  - Additional contact points are defined by the solver on the rigid body to limit penetration
  - Augmentation and associated parameters previously limited to deformable to deformable contact are now supported in geometric to deformable contact
  - Also support delayed slide off between deformable and faceted surfaces



Hydroformed Parts

Contact Body Properties													
Name	Name punch												
Туре	Geometric												
Color	Edit												
Properties													
Show Properties Structural													
		Body Co	ontrol -										
Сог	ntrol Type	Velocit	y 🔻	Para	meters								
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			_										
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		- Entit	ies —										
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	Wire Bod	ies	Add	Rem	0								
3-D:	Faceted S	urfaces	Add	Rem	0								
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#### Example: Hydroforming





Model

Results

**Close Up Results** 

Solver – Output Enhancements

## Localized Global Remeshing Capability

### BIAS MÜHENDISLIK

#### • Modeling Functionality:

Add option to limit global remeshing to a specified region in a contact body to reduce runtime and maintain consistent mesh in remote areas compared to remeshing the entire contact body.

#### • Example Engineering Application:

Crack propagation

- Implementation:
  - New option in Global Remeshing Properties Menu for "Remesh Region". Initial region can be specified by
    - Set of Elements
    - Crack Vicinity
    - Prescribed Geometric Shape (box, sphere, etc.)
  - Compatible with existing advanced density controls
    - Region, Distance, Element Quantity, etc.



# Example: Localized remeshing around a crack tips

Sr. No.	Parameters	Old Remeshing Method	New Remeshing Method	% reduction
1	Total Memory (in Mbyte)	556	317	43
2	Total Time	256	68	73.5





#### Improved Accuracy and Performance via Localized Options for Convergence Checks

- Modeling Application: Perform convergence checks using force residuals and maximums locally at individual nodes
- Example Engineering Application: Improve the efficiency and accuracy at a local level for a wide range of simulations
- Implementation:
  - User selects "Equilibrium per node" option
  - User prescribes desired level of accuracy
    - For "Mild", a single check is performed and one extra iteration is forced if not satisfied
    - For "Standard" level the default is 0.005 fraction of unequilibrated nodes allowed
    - For "Strong" level the default is 0.001 fraction of un-equilibrated nodes allowed
    - For "Standard" and "Strong" levels the user can manually input an allowed fraction of un-equilibrated nodes
  - User may request post codes related to the local convergence process:
    - Residual Force
    - Residual Moment
    - Nodal Force Convergence Ratio
    - Nodal Force Convergence Status

S	<b>Bi/</b>	<u>\S</u>
Convergence Testing (Structural)	×	= s l i k
Methods And Options         Relative       Residuals         Absolute       Displacements         Relative/Absolute       Residuals Or Displacements         Residuals And Displacements       Residuals And Displacements         Auto Switch       Strain Energy         Equilibrium Per Node	<ul> <li>Equilibrium Per Nod</li> <li>Include Moments</li> <li>Include Rotations</li> </ul>	e Equilibrium Per Node
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Equilibrium Level Allowed Fraction Of Un-Equilibriated I	Nodes	Strong   .001
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#### Example: Improved Results Accuracy

# BIAS



![](_page_51_Figure_3.jpeg)

## HDF5 Output

### BiΛS MÜHENDİSLİK

- Modeling Functionality:
  - > Alternate open format results file generated by Marc
- Example Engineering Application:
  - Improve integration into downstream engineering processes by accessing output data directly without a post-processer

#### Implementation:

- HDF5 output file
- Schema compatible with MSC Nastran HDF5
- List of Supported Elements in this release
  - Linear and Quadratic 2D plane stress, plane strain and axisymmetric.
  - Linear and Quadratic 3D continuum.
- Output Supported in This Release
  - Nodal: Displacements, External Forces, Reaction Forces ٠
  - Element: Stress, Strain

![](_page_52_Figure_15.jpeg)

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#### Example: Open H5 Results in Patran

![](_page_53_Picture_1.jpeg)

![](_page_53_Figure_2.jpeg)

![](_page_53_Picture_3.jpeg)

#### .H5 results in Patran

#### .t16 results in Mentat

# Additional Enhancements

## More Efficient Process of Defining Multiple Springs and Fasteners with Preload

- **Modeling Application:** Efficient and user friendly method for defining common behavior to multiple springs and preloaded fasteners
- Example Engineering Application: Assembly with a large number of fasteners with preload or springs
- Implementation:
  - Support for large rotation of the Cross-Section option
  - Streamline process for the application of the Cross-Section option to Bolts (new data base entry):
    - Select elements of the bolt
    - Mentat will automatically create and position the control node
    - Apply a boundary condition for preload by selecting the control node or, by a special filter, elements of the bolt
    - The axial direction of the bolt is automatically determined and updated by Marc
    - During post processing, the bolt force is plotted in the current direction
    - Special global variables for control node displacement as well as axial and shear force
    - Multiple bolts can quickly be generated using a single action
  - Springs are now handled as elements:
    - Easily apply the same stiffness and damper properties to multiple springs
    - Ability to activate and deactivate springs per load case

![](_page_55_Picture_16.jpeg)

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#### Example: Satellite Dome Assembly

![](_page_56_Picture_1.jpeg)

![](_page_56_Picture_2.jpeg)

![](_page_56_Figure_3.jpeg)

![](_page_56_Figure_4.jpeg)

# Extended Support for Import of Nastran Models with Contact Cards

![](_page_57_Picture_1.jpeg)

- Modeling Application: Share common model data across different solvers
- Example Engineering Application: Transition from a Nastran Linear run to a Marc Nonlinear Run
- Implementation:
  - Extended Support for Import of Nastran Models with Contact Cards

![](_page_57_Figure_6.jpeg)

#### Nastran Cards Tested: BCPARA, BCONPRG, BCONPRP, BCONNECT, and BCTABLE1

- Correct Translations of
  - Contact Body
  - Contact Table
  - Touching and Glued Settings
  - Breaking and Separating Glue
  - Distance Tolerance
  - Thermal contact

## General Mentat Usability Improvements

- New rendering defaults
  - Default color and contour maps schemas have changed
  - Nodes, points and vertices are not plotted by default
  - Elements, solids and Model Sections are plotted as solids
- Improved visibility of model features/definitions
  - Highlighted/selected nodes, points and vertices have different symbols to better see them
  - Non-editable fields are plotted in italics, to distinguish them from editable ٠ fields
  - Filters have been added to easier select post processing quantities •
  - Icons have been added to easily set the LookAt point and to switch expanded shell/beam plotting on/off.
- New Interface Options
  - Attach colors and attach symbols can be switched on and off:
  - Even if nodes are not visible, nodes can be selected (e.g. to apply Boundary Conditions)
- Improved User Interaction
  - Commands associated with several icons (e.g. switch plotting nodes on/off) do no longer break run commands

![](_page_58_Picture_15.jpeg)

Factor

2.5549

Copy -> Manual

Header .

![](_page_58_Picture_17.jpeg)

Cara

Cart

## General Mentat Usability Improvements

- Default Multi-Level Undo preset to 10, can be from 1 to 50
- Materials and Geometric Properties color assignment
- Default Maximum and Minimum values for contour • plots
- New RHS mouse\_options for
  - "show all"
  - "hide all"
  - "show only"

curves, surfaces, elements, model sections, solids, contact bodies and sets

"Reduce Data Points" option in table menu

![](_page_59_Picture_11.jpeg)

![](_page_59_Figure_12.jpeg)

![](_page_59_Figure_13.jpeg)

![](_page_59_Figure_14.jpeg)

0.01

Tolerance

#### Endurica Compatibility with Marc for BiΛS Prediction of Rubber Fatigue MÜHENDİSLİK

![](_page_60_Picture_1.jpeg)

for

Pohlman

"In the automotive industry, from design to launch is becoming more and more of a time crunch. This is what the Endurica software does in conjunction with our testing. It allows us to cut that timing down, and allows our customer base – heavy truck and off-highway engineering staffs - to do their job and not worry about if they have a durability problem." Steve Pohlman, VP GM Global Elastomers, Tenneco, Rubber & Plastics News, 24 July 2017

![](_page_60_Picture_4.jpeg)

Endurica HEVHTo File Name job\_01.hfi Export To His History Type 20 Plane Stress O 20 Plane Strain 30 Bulk Include Pressure Marc<sup>-</sup> Selections Select Sets Select Increments Additional Options Ageing Materini 1.0 fault Tempa Rolling Stride: Export Submit Hfl Submit Import Hfo Results Iner Verteble Code: Brary Fost File Type Formatted Post File Type Import La  $N_f(\theta, \varphi) =$  $\frac{1}{r(T(\theta, \varphi, a))}da$ Fatique Life

![](_page_60_Figure_6.jpeg)

See the workflow demo at: https://youtu.be/HJQtvjRT8VY

![](_page_61_Picture_0.jpeg)

# Thank You