Nonlinear FEM Development: Marc 2010 and beyond

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Contents

• What’s new in Marc 2010
• Beyond version 2010
What’s new in Marc 2010

• **HPC**
  ◦ Pardiso Parallel Solver:
    • Shared Memory (SMP); Windows & Linux; integer*4 and integer*8
  ◦ Mumps Parallel Solver:
    • Distributed Memory (DMP); Windows & Linux; integer*4
  ◦ Multi-threaded BCS:
    • Shared Memory – Windows & Linux; integer*4 and integer*8
  ◦ Multi-threaded, Pardiso and Mumps Direct Solver in conjunction with DDM
  ◦ Pre-release of parallel iterative solver
What’s new in Marc 2010

- Example Pardiso

**Pardiso Solver Scalability**

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<th>2</th>
<th>4</th>
<th>6</th>
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<td>5</td>
<td>6</td>
<td>7</td>
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- 6735660
- 2990460
- 1796838
- 1604043
- 1058724
- 923259
- 819243
- 726888
- 233523
What’s new in Marc 2010

• Example Mumps

Mumps Solver Scalability

Number of Processors

Scalability

DOF
What’s new in Marc 2010

- Example DDM with Parallel Direct Distributed Solver

300,000 DOF

2 quad core 2.93Ghz Xeon (X5570 Nehalem) per node
4 nodes - InfiniBand
What’s new in Marc 2010

- If applicable, the default installation procedure installs both the integer*4 and integer*8 version.

- The user can select which version will be used:
  - file `run_marc_defaults` in the Marc tools directory (MARC_MODE [i8 or i4])
  - command line option `–mo [i4 or i8]`; this overrules the file `run_marc_defaults`
  - Mentat support:
What’s new in Marc 2010

- **Element technology:**
  - Complete interface of interface elements with heat transfer elements
  - Add large rotation formulation for beam and shell elements in the Total Lagrange framework

![Temperature](image1.png)

![Contact Status](image2.png)
What’s new in Marc 2010

**Material models:**
- Exponential cap model
- Complete 5\textsuperscript{th} order Mooney material
- Improved input of material properties in a multi-physics analysis
- Additional tests on material stability (temperature dependent and visco-elastic properties)
- Latent heat for pentahedral elements
- The axi-symmetric and plane strain composite elements now support non-zero ply angles
What’s new in Marc 2010

• A new option called MAP TEMP can be used to get (nodal) temperatures on a model coming from the post file of a previous heat transfer run with a different mesh (in case of identical meshes, INITIAL STATE and CHANGE STATE are recommended)
What’s new in Marc 2010

- **Contact:**
  - A new segment-to-segment contact algorithm has been introduced:
    - Improved stress continuity along contact interfaces
    - Consistent treatment of shell edges and faces
  - Limited to mechanical, frictionless, small sliding deformable contact, but finite sliding rigid contact
  - Linear and quadratic continuum and shell elements are supported
What’s new in Marc 2010

• Example: interference fit analysis

Node-to-segment  
Segment-to-segment

Note Stress Continuity
What’s new in Marc 2010

- Example: connecting solid and shell elements

Contact Status shown on both Contact Bodies

Shell Thickness
What’s new in Marc 2010

• Fracture Mechanics
  ◦ Improvements in Break Glue option
  ◦ Improvements in VCCT
  ◦ User Subroutines udelam, ubreakglue, uactglue
What’s new in Marc 2010

- **Global Adaptive Meshing**
  - Supported in the Global run of a Global-Local Analysis
  - Can use DDM – Each Remeshed Body must be in a single domain
What’s new in Marc 2010

• Global Adaptive Meshing
  ◦ Allow the use of the EXCLUDE option to better control contact areas
  ◦ Particle Tracking
    • Can define the number and the location of the particles in post-processing, after running the simulation
    • Can track particles both forwards and backwards in time
    • Can track any quantity on the Marc post file and make time history plots of the particles
What’s new in Marc 2010

• Electromagnetics
  ◦ Magnetostatic-Structural (Lorentz Force)
  ◦ Ferromagnetic Lamination Losses
  ◦ Magnetostatic-Thermal
  ◦ Improved Transient Electromagnetic
  ◦ Electrical windings in Magnetostatics
  ◦ Inductance Computation
What’s new in Marc 2010

• Wear option
• Cavities with Table support
• Various new post codes
• Complete GUI support
• Post processing in principal directions
• Documentation:
  ◦ New example problems
  ◦ Hyperlinks from Volume D to Volume E
  ◦ E-M training material
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Beyond version 2010

• **HPC**
  - **Pardiso**: add out-of-core capability
  - **Mumps**: support integer*8 version
  - **CASI**: migrate prototype to release

• **GPGPU** (use graphics hardware)
  - Support INSERT option in DDM
Beyond version 2010

- **Assembly modeling**
  - segment-to-segment contact
    - Finite sliding in deformable contact
    - Friction modeling
    - Multi-physics applications
    - Remeshing/rezoning
  - definition of parts
  - multiple element types in a single contact body
  - increased flexibility in contact control
  - spectrum response updates
Beyond version 2010

- Failure Analysis and Composites
  - Global Adaptive Meshing
  - Crack Propagation for 3-D solids
  - Recent Failure / Damage Models
  - PFA robustness
  - Local Adaptive Meshing based upon Laminate Split of Solid / Solid Shell
  - Ply Orientation Input
  - Functionally Graded Material
Beyond version 2010

• **Examples:** crack initiation and growth

![Diagram showing shell thickness with offsets and glued layers.](image)
Beyond version 2010

- **Examples: rezoning (segment-to-segment contact)**
Beyond version 2010

- **Elastomeric material models**
  - hysteresis
  - damage
  - frequency dependent damping

- **Electromagnetic Analysis**
  - extend element library
    - triangular and tetrahedral elements
  - edge effects
  - nonlinear electrical resistivity and conductivity
  - solder material model
Beyond version 2010

- **GUI:**
  - Solver support
  - Meshing
  - Various:
    - Improved selection
    - Refine skin (add a refinement layer without increasing the volume)
    - Better control on solid shell element orientation
    - ...

![Meshing Diagram]
THANK YOU