MSC.ADMAS
Technical Workshop

Presentations & Roundtable Discussions
11:00am – 04:30pm
Agenda

11:00am – 12:30pm: ADAMS/Solver & ADAMS/Vibration Round Table Discussion

12:30pm – 01:30pm: Lunch

01:30pm – 03:00pm: EASY5 & ADAMS/Controls Round Table Discussion

03:00pm – 03:30pm: Break

03:30pm – 04:30pm: ADAMS/Flex & ADAMS/Durability Round Table Discussion
MSC.ADAMS Solver Technical Workshop

Rajiv Rampalli
Sr. Director
MSC.Software Corp.
Solver Roundtable Discussion

**Agenda**

- Introduction
- Recap
- Release 2005
- Long-term plans and Roadmap
- Discussion
Introduction

MSC.ADAMS

MSC.Fatigue

MSC.Patran

MSC.EASY5

MSC.Marc

MSC.Nastran

simOFFICE

PRODUCT DEVELOPMENT CONFERENCE
Introduction

The ADAMS Product Line

ADAMS/Crash
ADAMS/Driver
ADAMS/Tire
ADAMS/Engine
ADAMS/Rail
ADAMS/Aircraft

Controls
Vibration
Flex
Durability

Vertical Applications
Technology Extensions
Core Interface
Core Solver
Recent Advances in Solver Modeling

- V10: Joint Friction, 2D contacts, Modified corrector
- V11: Modal Loads, 3D contacts, Improved Statics
- V12: Modal state access, Discrete GSE, Large mnfs, RKF-45
- V2003: Much faster 3D Contact, Contact Postprocessing

Robustness
- SI2: Enhanced GSTIFF
- SI1: Flex Invariants

Accuracy
- SI2: Enhanced GSTIFF
- SI1: Flex Invariants

Performance
- Portable mfn, msc2mnf
- CRATIO expressions: Better Contacts
- C++ Solver functional with A/Car

Virtual PRODUCT DEVELOPMENT CONFERENCE 2004 v[pd] • Huntington Beach, California
Version 2005: The C++ Solver comes of age!

**Improved Numerics**
- Hilber-Hughes-Taylor (HHT)
- Newmark
- Adaptive Jacobian

**New C++ Solver Features**
- User written constraint (GCON)
- Improved 2D Part
- Shared Memory Parallel (SMP)
- Analytical derivatives for user subroutines
- Expanded Activate/Deactivate
Major speed improvements

Due to:

- HHT Integrator
- Adaptive Jacobian
- 2D Parts
- Shared Memory Parallel Processing

Performance for Chain & Belt Models

4.85 to 14.2 times faster!

<table>
<thead>
<tr>
<th>Model</th>
<th>ADAMS 2003</th>
<th>ADAMS 2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model-1</td>
<td>294.3 min</td>
<td>20.8 min</td>
</tr>
<tr>
<td>Model-2</td>
<td>166.2 min</td>
<td>32.0 min</td>
</tr>
</tbody>
</table>
Improved Numerics

HHT and Newmark

- Equations in 2\textsuperscript{nd} order form
- Second Order integrators
- Variable step-size
- User controlled numerical damping

Large Contact Model

Crawler Model

<table>
<thead>
<tr>
<th></th>
<th>ADAMS 2003:</th>
<th>79 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADAMS 2005 With HHT:</td>
<td>24 Hours</td>
<td></td>
</tr>
</tbody>
</table>
Improved Numerics

HHT and Newmark

- Equations in 2\textsuperscript{nd} order form
- Second Order integrators
- Variable step-size
- User controlled numerical damping
Hilber-Hughes-Taylor Integrator

Formulae

\[ M\ddot{q} + C\dot{q} + Kq = F(t) \]

\[ q_{n+1} = q_n + h\dot{q}_n + \frac{h^2}{2} \left[ (1 - 2\beta)\ddot{q}_n + 2\beta\ddot{q}_{n+1} \right] \]

\[ \dot{q}_{n+1} = \dot{q}_n + h \left[ (1 - \gamma)\ddot{q}_n + \gamma\ddot{q}_{n+1} \right] \]

Numerical Damping

- Damping properties controlled through the \( \alpha \) parameter

\[ \gamma = \frac{1 - 2\alpha}{2} \quad \beta = \frac{(1 - \alpha)^2}{4} \quad \alpha \in \left[ -\frac{1}{3}, 0 \right] \]
Hilber-Hughes-Taylor Integrator

Spectral Radii

Amplitude\( (t_{n+1}) = 0.77 \times \text{Amplitude}(t_n) \)
Hilber-Hughes-Taylor Integrator

Algorithmic Damping
Adaptive Jacobian

Minimizes expensive Jacobian evaluations

3x-5x faster durability simulations
New C++ Solver Features

User constraint: GCON

- Simply write the constraint expression in the dataset

Marker 9

Cone rolling on a plane
- GCON/101, FUN = DZ(7,9,9)
- GCON/102, FUN = (UVZ(9)*UVZ(7)) + SIN(15D)

Cylinder rolling on Plane
- GCON/100, FUN = DZ(5,11,11) - 35
- GCON/101, FUN = UVZ(5)*UVZ(11)
New C++ Solver Features

Improved 2D Part

- A Part pre-constrained to move only in the global X-Y, Y-Z or Z-X plane.
- Fully compatible with all 3D elements and can coexist with an otherwise 3D model.
- Out-of-plane forces are efficiently ignored.
- More efficient than 3D PART + PLANAR JOINT.

```
PART{id} [MASS=i] [,CM=ic] [,IM=im]
[JP=xx, yy, zz [,xy,xz,yz]] [,MATERIAL=mat_name]

\begin{align*}
\begin{bmatrix}
\text{VX} = x \\
\text{VY} = y \\
\text{VZ} = z \\
\text{WX} = a \\
\text{WY} = b \\
\text{WZ} = c \\
\end{bmatrix}
\end{align*}

\begin{align*}
\begin{bmatrix}
\text{XY} \\
\text{YZ} \\
\text{ZX} \\
\end{bmatrix}
\end{align*}
```
New C++ Solver Features

Shared Memory Parallel Processing
- Faster simulations - utilize multiple processors
- Does not work on distributed memory architectures (clusters etc.)
- Requires an SMP license

Analytical Derivatives for User Subroutines
- No need for expensive finite-differencing
- More accurate
- Faster
- More stable!!
- ADIFOR compatible (http://www-unix.mcs.anl.gov/autodiff/ADIFOR/)

Activate/Deactivate for more elements
- CONTACT, COUPLER, GFORCE, VFORCE, VTORQUE
2005 Summary

**Improved Numerics**
- Hilber-Hughes-Taylor (HHT)
- Newmark
- Adaptive Jacobian

**New C++ Solver Features**
- User-written constraint (GCON)
- Improved 2D Part
- Shared Memory Parallel (SMP)
- Analytical derivatives for user subroutines
- Expanded Activate/Deactivate

- Interoperability
- Flexibility & Scalability
- Performance
- Capacity
- Collaborative
- Ease of Learning & Use
- Customizable & Extensible Data Backplane
- Leverage Existing Knowledge & Investments
Overall direction: System level solution

System level virtual prototypes

- Human/Driver
- Non-linear FE
- Controls
- Flexibility
- Hydraulics
- 3D CAD
- Test Data
Overall direction: System level solution

 Solver

 Flex & Durability

 EASY5 & Controls

 Vibration

 Hydraulics
Overall direction: System level solution

**Product Integration**
- “Borrow” useful capabilities from other MSC solvers
- Migrate to common file formats (minimize translators etc.)
- Common visualization tool

**Functionality**
- Nonlinear FE models in system level models
- Flex body contact
- Better representation of distributed forces

**Large scale solution**
- Distributed computing
- Hierarchical modeling
Overall direction: Discipline based assessment

Strength

Controls & Safety

Ride & Handling

NVH

Durability
Overall direction: Discipline based assessment

**Controls & Safety**
- Real-time & HIL

**NVH**
- Enhanced Nastran interface
- Experimental data support

**Strength & Durability**
- Improved process support
- Better damping models
- Faster simulation speeds

**Ride and Handling (Dynamics)**
- Conceptual simulation
Overall direction: Common Solvers Framework

Common Database

Python Interface

Component-I (Nastran)
Component-II (Marc)
Component-III (Adams)
Component-IV (Easy5)
Overall direction: Common Solvers Framework

**Scriptable, plugin environment:**
- Open system
- Components are added in a standard manner
- Well-defined API for SimOffice/SimDesigner/Vertical apps
- A comprehensive multi-physics capability
  - Thermal/CFD
  - Electrical/Electro-magnetics
  - Structural/Mechanical/Hydraulics/Controls
- Focused on:
  - NVH, Durability, Crash, Controls, Manufacture, . . .
Overall direction: Migration of ADAMS to the new C++ Solver
Roadmap – ADAMS/Solver

**Short Term**
- Migration of ADAMS applications to C++ Solver
- Improved speed and robustness
- Merger of ADAMS & EASY5 solvers - I
- Common MSC solvers framework and components - I

**Mid Term**
- C++ Solver default for the ADAMS product line
- Improved speed and robustness for flex-body contact
- Merger of ADAMS & EASY5 solvers - II
- Common MSC solvers framework and components - II

**Long Term**
- Fortran Solver “retired”
- Large scale, multi-disciplinary problem solutions
- Solver interoperability
- Common MSC solvers framework and components - III
Discussion

Do you understand Solver direction?
- When to migrate to new solver?
- What are the benefits?
- What are the consequences?

Do you agree with Solver direction?
- Are your needs being met?
- Are there things that could be better?
- What is going well?

What did we miss?

Thank you for using Solver and participating in the roundtable
–The Solver Team
MSC.EASY5 Solver Technical Workshop

Brian Ummel
Senior Advisory Engineer
MSC.Software Corp.
Agenda for MSC.EASY5 Roundtable Discussion

- Introduction to MCS.EASY5
- Features of our latest release: MSC.EASY5 2004
- Enhancements to the integration of MSC.EASY5 2004 and MSC.ADAMS 2005
- System Optimization using ADAMS/Insight with EASY5 – experimental release
- Preview of MSC.EASY5/MSC.Nastran integration tools
- Future Development Directions (V2005,V2006)
- Suggested Topics for Discussion
- Discussion
Introduction to MSC.EASY5

MSC.EASY5 is a systems level tool for
- modeling
- design
- analysis

Based on a **schematic** view of an engineering system.
MSC.EASY5 Application Libraries

Built by Domain Experts

Interconnection of libraries allows Multi-domain modeling
MSC.EASY5 Aerospace Industry Applications

- Hydraulics
- Environmental Controls
- Fuel System Management
- Satellite Dynamics
- Flight Dynamics
- Robotic Arm Dynamics
- Landing Gears
- Brakes
- Stability
- Flight Controls
- Control Surface Actuation
- Electric Power Controls
- Electric Power Systems
- Bleed Air
- FC/Structural Interaction
- Rocket Engine
- Jet Engine Lubrication
- Propulsion RCS
- Engine Balance
- Transient Engine
- Valves & Controls
- Turbomachinery
MSC.EASY5 Automotive Industry Applications

- Climate Control
- Cooling/Heating
- Fuel Injection
- Engine Lubrication
- Power Steering
- Anti-lock Braking System
- Control Systems
- Suspension
- Powertrain/Transmission
- Hybrid Electric Systems
- IC Engine
- Fuel Cell Systems
Originally developed by Boeing as internal engineering tool
  - Initial use: Optimal control of Aircraft Environmental Control Systems
Made a commercial product of Boeing in 1981
Rich long history – 29+ years of development
Purchased by MSC.Software in 2002
MSC.EASY5 Version 2004 New Features

- Conversion to MSC Master Key Licensing
- Enhancements to configurable components
- Enhancements to the ADAMS interface (see below)
- Parameter and state values can be displayed on schematic
- New release of the Gas Dynamics Library
- New release of the Multi-Phase Fluid Library
- New release of the Thermal Hydraulics Library (out soon)
Component Configurations

MSC.EASY5 Application libraries are being modified to use configurations.

Documentation and icon change to reflect chosen configuration.

Allow user to turn features on and off (eliminates deleting the component and adding a new one with desired features).

Feature options are documented as shown.
MSC.EASY5 integrates with MSC.ADAMS via ADAMS/Controls

MSC.EASY5 Model
Controls + Hydraulics + Powertrain

MSC.ADAMS Model
Flexibility model from MSC.Nastran

ADAMS Block in EASY5 model defines the link
Enhancements to the EASY5-ADAMS Interface in MSC.EASY5 2004r2 & MSC.ADAMS 2005

Co-Simulation Mode:
- Interpolation available on both sides
- TCP/IP communication allows running ADAMS and EASY5 on different processors

External Function Evaluation Mode:
- EASY5 parameters can be exported to ADAMS as design parameters
- EASY5 outputs can be exported to ADAMS as requests
- EASY5 computes its own partial derivative matrices
ADAMS/Insight – a tool for

- Understanding Design Changes
- Learning Key Factors
- Projecting Tolerance Effects

Result: Robust Design
ADAMS/Insight - Learn & Communicate

A tool for doing:

- Parameter Studies
- Parameter Scans
- Sensitivity Analysis
- Optimization
- Monte Carlo Analysis
- Design Of Experiments

Collaboratively analyze trade-offs in a Web Browser
Experimental MSC.EASY5 Conduit for ADAMS/Insight in MSC.ADAMS 2005

- Use Insight to analyze and improve EASY5 designs
- You need MSC.EASY5 2004r2 and MSC.ADAMS 2005 with the latest Insight service pack
- Invocation requires –experimental flag (to verify that you know you are using an experimental offering)
- Please try this and give us your feedback.

Note: You may also use ADAMS/Insight to perform DOE studies of EASY5 parameters in ADAMS/Controls through the ADAMS External Systems Library (ESL).
Preview of MSC.EASY5 - MSC.Nastran Integration tools

Intended for engineers who:
- Need to analyze controls-structures interactions
- Work within the MSC.EASY5 modeling environment

Sample applications:
- Launch-phase rocket stability analysis
- Machine-tool vibration analysis
MSC.EASY5 Flexible Body Extension (Alpha Test)

Add FB Extension component from Add menu

Select Data File

Select Nodes of interest

Supply supplementary data

Pressing “Done” imports data and writes the code to incorporate data into EASY5 model
Flexible Body Extension Availability

- Is Alpha code – don’t use for production work!
- Only available on MS Windows platform
- Requires MSC.EASY5 2004r2
- Requires access to ADAMS/Flex Toolkit
  - needed to convert .mnf files to .mtx files (mnf2mtx translator)
  - not required to be on same computer
- Call (415-644-3915) or email (Brian.Ummel@mscsoftware.com)
  - We can discuss your application
  - I’ll send you the files – need to sign disclaimer
Near-future Plans for MSC.EASY5 Development


- New User Interface
  - Completely new look and feel
  - Exceed no longer required under Windows
  - Many improvements to usability

Version 2006 – due late 2005

- Schematic Components
- Access to ADAMS C++ Solver
- Better integration of EASY5 and MAT
Suggested Questions for Discussion

1. What should MSC be doing for System Performance?
2. What kind of MSC product integration do you need right now?
3. What new features do you most need in MSC.EASY5 now?
4. Which 3rd party products would you like to see integrated into the MSC product line?

The Floor is now open for discussion.....
Discussion cont’d

Do you understand our direction?

Do you agree with the direction?

- Are your needs being met?
- What is going well?
- Are there things that could be better?

What did we miss?

Thank you for participating in the EASY5 roundtable
–The Solver Team