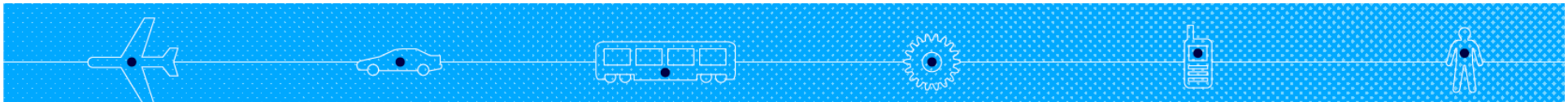


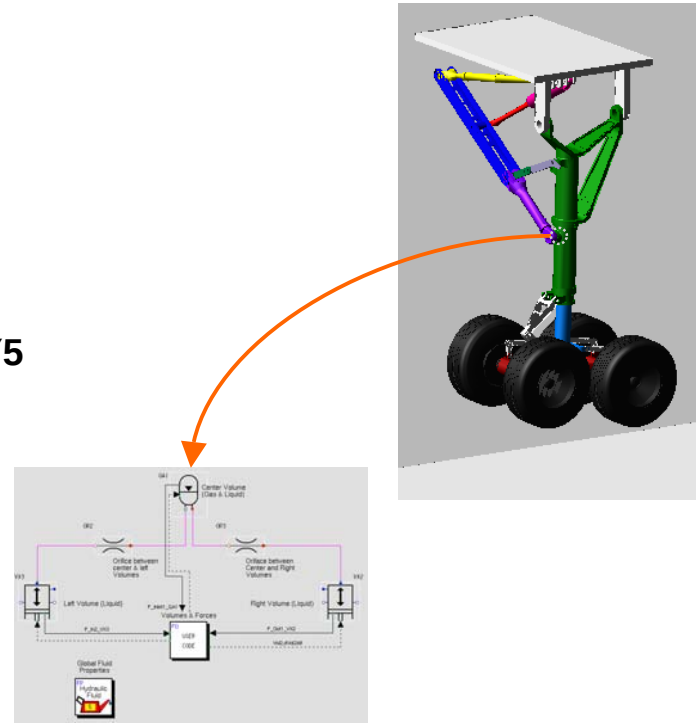
ADAMS/Controls Technical Workshop

Vikram Sohoni
Development Manager
MSC.Software Corp.

ADAMS/Controls: What is it?

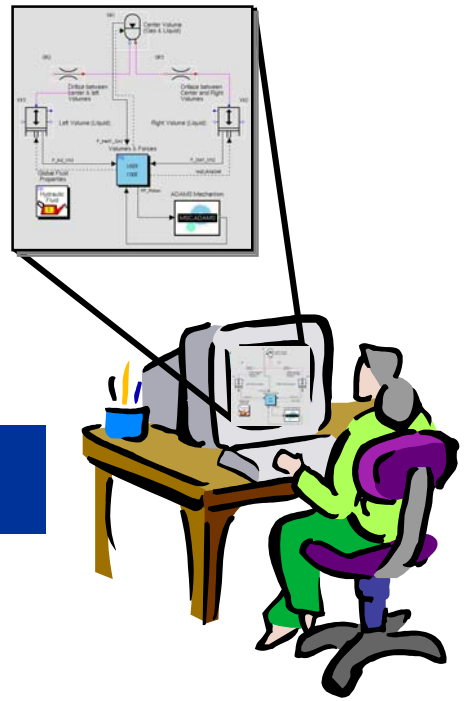
Conduit for information exchange between MSC.ADAMS and controls software

- Modes of operation
  - Communication based dynamic data exchange
    - Co-simulation
    - Function evaluation
  - Code import from actuation and controls software
    - External system library(ESL) import from **MSC.EASY5**
    - RTW code import from Matlab
- Supported controls and actuation software
  - MSC.EASY5 and Matlab/Simulink
- Available as a plug-in for ADAMS/View



ADAMS/Controls: Communication based dynamic data exchange

Function evaluation



Mechanical sub-system

MSC. ADAMS

$\dot{x}_a = G_a(x_a, u_a, t)$

$y_a = F_a(x_a, u_a, t)$

$\dot{x}_a, y_a$

x_a, u_a

Actuation and control sub-system

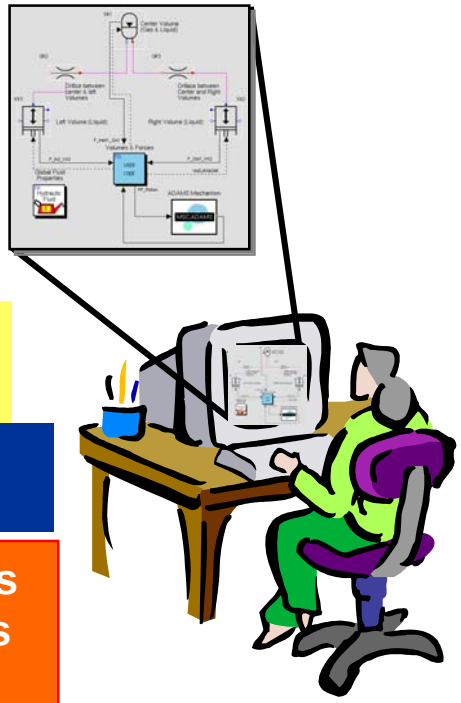
MSC.EASY5

All equations solved here

Identical scenario applies to Matlab

ADAMS/Controls: Communication based dynamic data exchange

Co-simulation



Mechanical sub-system

MSC.ADAMS

$\dot{x}_a = G_a(x_a, u_a, t)$

$y_a = F_a(x_a, u_a, t)$

Mechanical sub-system equations solved here

y_a

u_a

Actuation and control sub-system

MSC.EASY5

Actuation and controls sub-system equations solved here

Identical scenario with Matlab

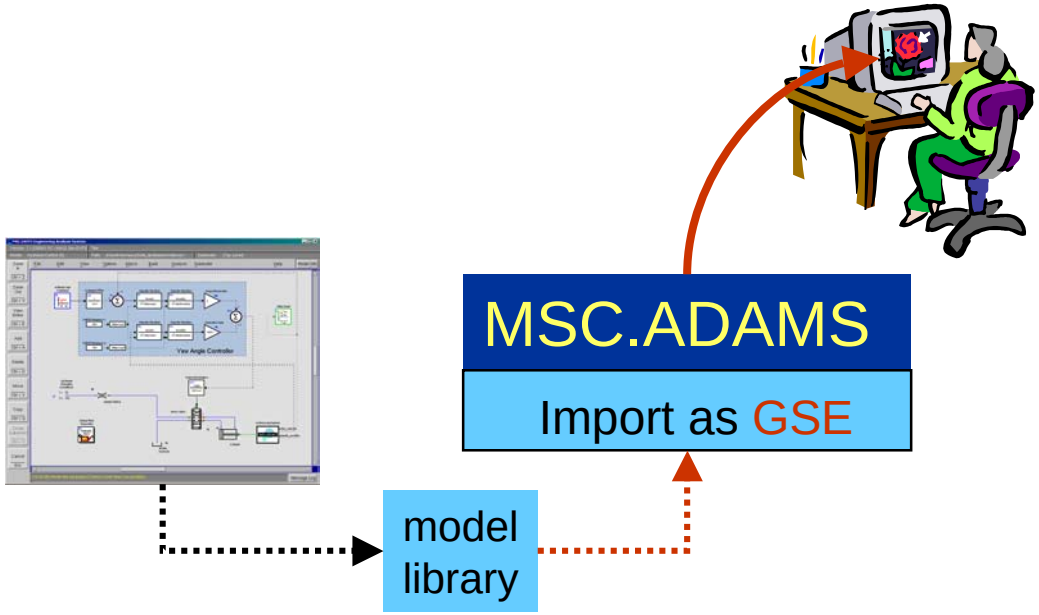
ADAMS/Controls: Code import

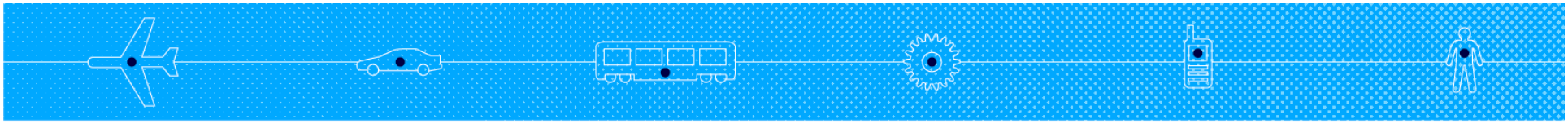
Export controls sub-systems model from controls software as a library

- External system library from MSC.EASY5
- RTW library from Matlab

In MSC.ADAMS

- Import library as a GSE
- Perform simulation





ADAMS/Controls - Process

Build

- Create sub-system model in respective software
- Specify communication protocol: MSC.ADAMS and controls software
  Or
- Import control/actuation sub-system library into MSC.ADAMS

Test

- Perform communication based simulation
  Or
- Simulate combined system in MSC.ADAMS

Review

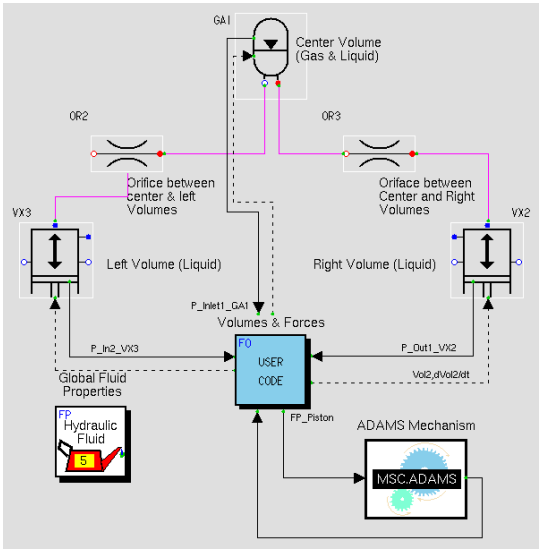
- View results (plots and animations) in respective software

Improve

- Design evaluation of combined model with design parameters from mechanical and actuation sub-systems.

Process - Build

- Create sub-system model in respective software
- Export mechanical sub-system template from MSC.ADAMS
- Import template into MSC.EASY5/Matlab
- Connect mechanical and actuation sub-systems



For code export from MSC.EASY5/Matlab

- Define design variables and requests within MSC.EASY5/Matlab
- Export model library from MSC.EASY5/Matlab

Process - Test

Pipe based communication

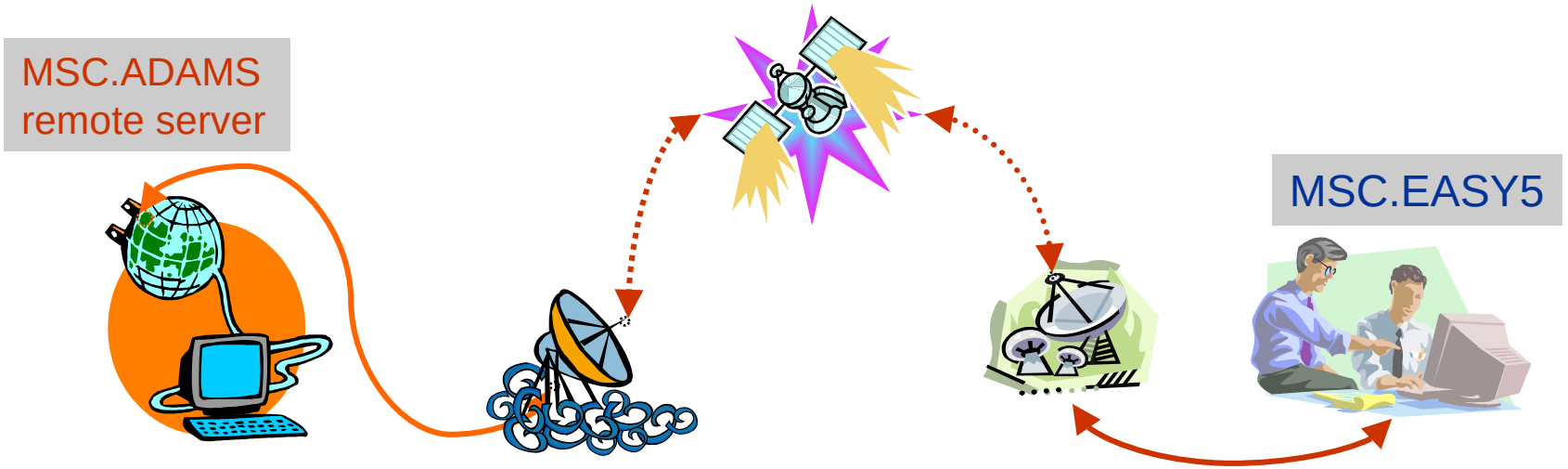
- MSC.ADAMS and MSC.EASY5/Matlab communication using pipes
- Both software codes have to reside and execute on the same machine
- Control system analyst has complete access to ADAMS model information

Process - Test cont'd

TCP/IP based communication

New for 2005

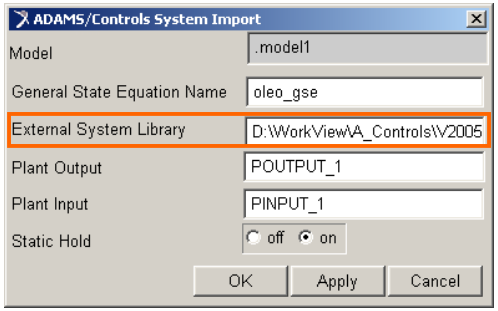
- Software codes communicate using TCP/IP
- MSC.ADAMS and MSC.EASY5/Matlab can be on remote machines
- ADAMS model supplier maintain controls over their proprietary information



Process - Test cont'd

Enhanced for 2005

Control system model library import into MSC.ADAMS

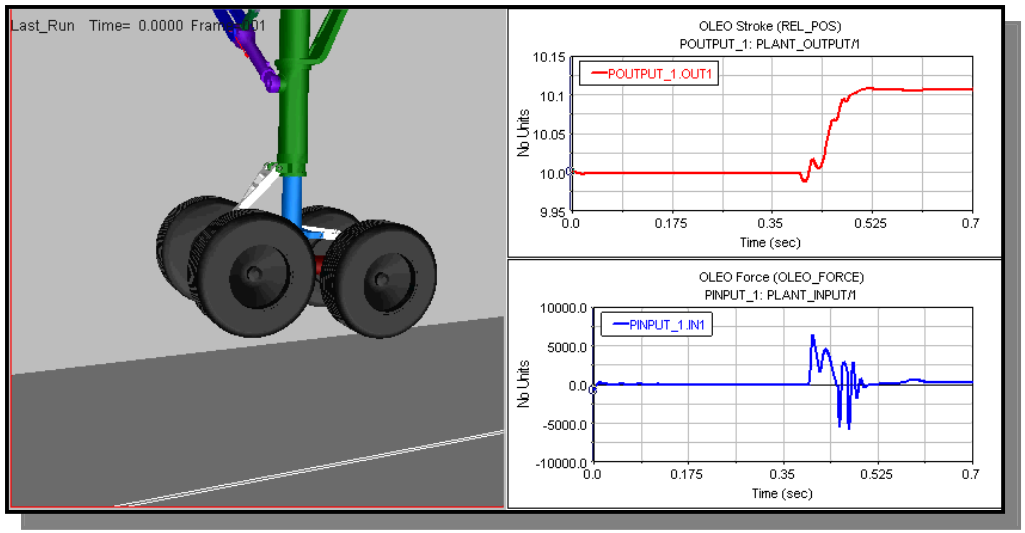


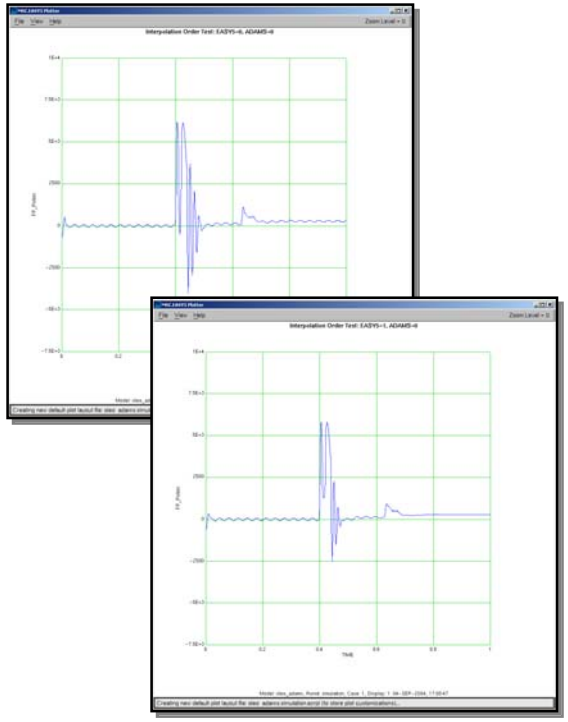
- Import control system library into MSC.ADAMS
  - GSE representing control system created in the ADAMS model
  - Design variables created for design variables of controls system
  - Requests created for output requests from control system
- Run combined system simulation in MSC.ADAMS
- Control system model library supplier retains control over proprietary information within the library

Important aspect

Process - Review

View results in MSC.ADAMS or MSC.EASY5

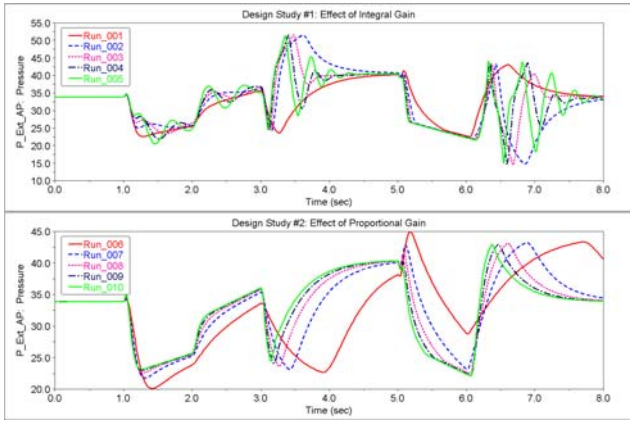


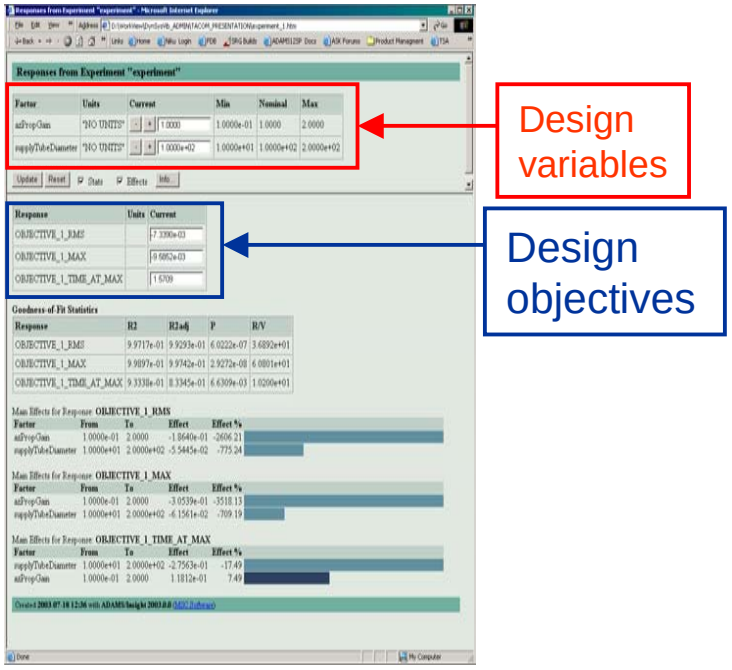


Process - Improve

Design evaluation of combined model with design parameters from mechanical and actuation sub-systems

- Design studies
- Design of experiments
- Design optimization





Roadmap – ADAMS/Controls

Short Term

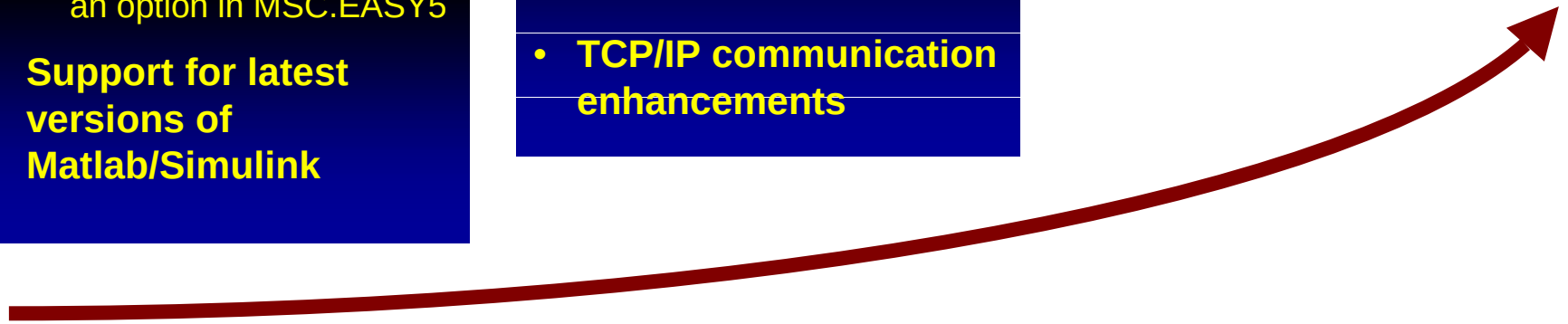
- **ADAMS+EASY5 Integration II**
  - •C++ Solver available as an option in MSC.EASY5
- **Support for latest versions of Matlab/Simulink**

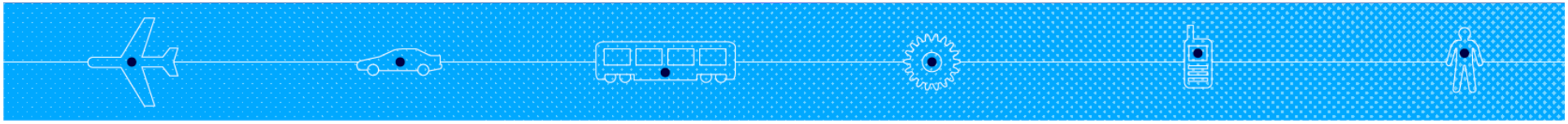
Mid Term

- **ADAMS+EASY5 Integration III**
  - •More analysis types supported in C++ Solver
- **Continued support for Matlab/Simulink**
- **TCP/IP communication enhancements**

Long Term

- **ADAMS+EASY5 fully integrated**
- **Support for Matlab and/or other 3rd party products.**
- **Performance and robustness enhancements**





Discussion

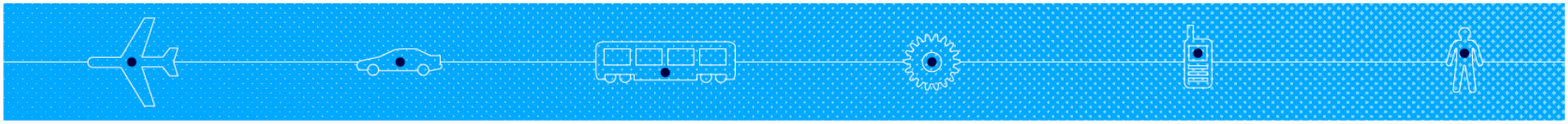
Do you understand our direction?

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 Controls roundtable
–The Solver Team



Thank you

The ADAMS/Controls team appreciates your interest.

We like to hear your questions and comments.

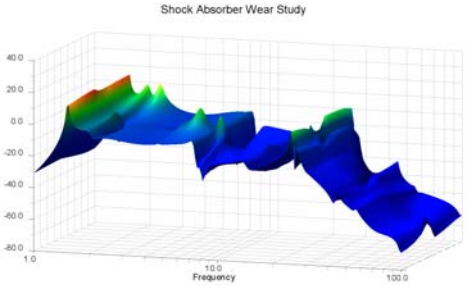
Contacts

- Tony Sajdak: Tony.Sajdak@mscsoftware.com
- Vikram Sohoni: Vikram.Sohoni@mscsoftware.com

ADAMS/Vibration Technical Workshop

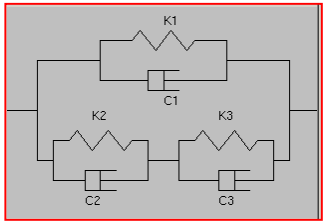
Vikram Sohoni
Development Manager
MSC.Software Corp.

ADAMS/Vibration: What is it?



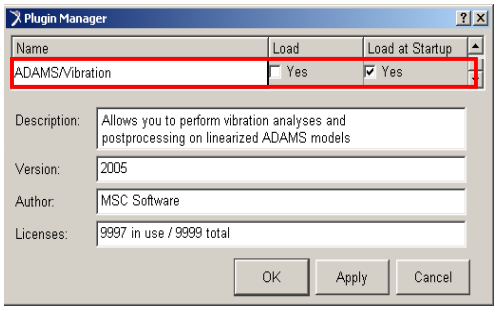
Frequency domain complement to ADAMS/Solver motion simulation

- Frequency domain solver for linearized ADAMS models
- Frequency domain(FD) modeling elements for frequency and time domain analysis



Software environment

- Interactive: Plug-in within ADAMS/View, ADAMS/Car and other MSC.ADAMS vertical environments



- Batch: Run vibration analysis from the command line
  - Python based batch execution environment
  - Execute from 3rd party client applications

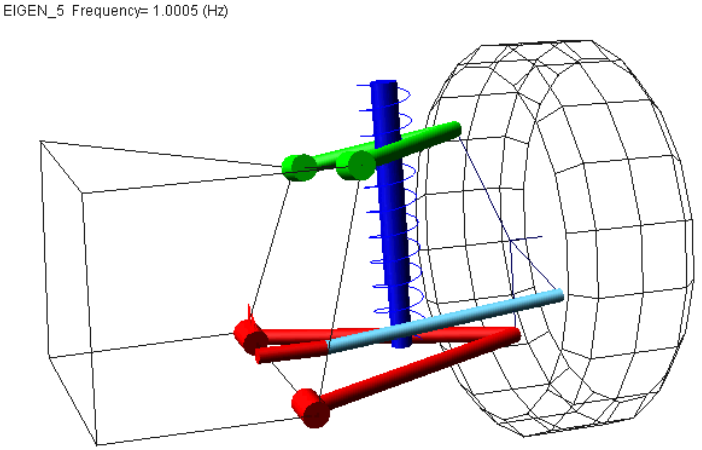
ADAMS/Vibration: Why is it needed?

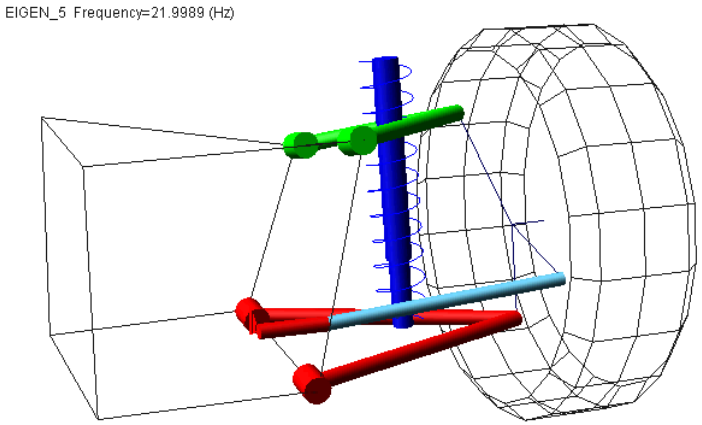
Common ADAMS model

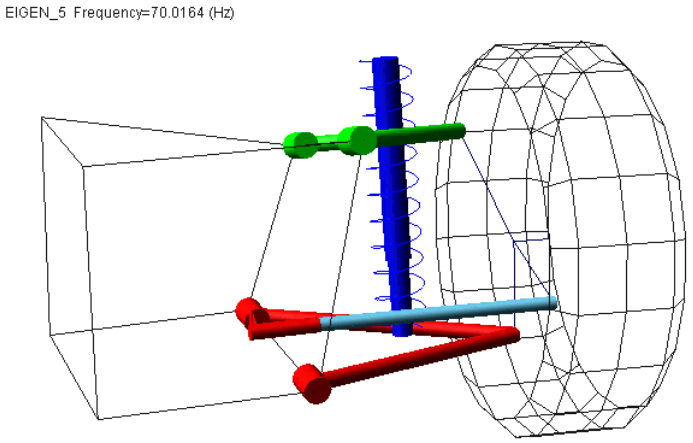
- frequency response and motion simulation

Validate ADAMS models simultaneously for Motion and NVH attributes

- Reduce development times with parallel validation

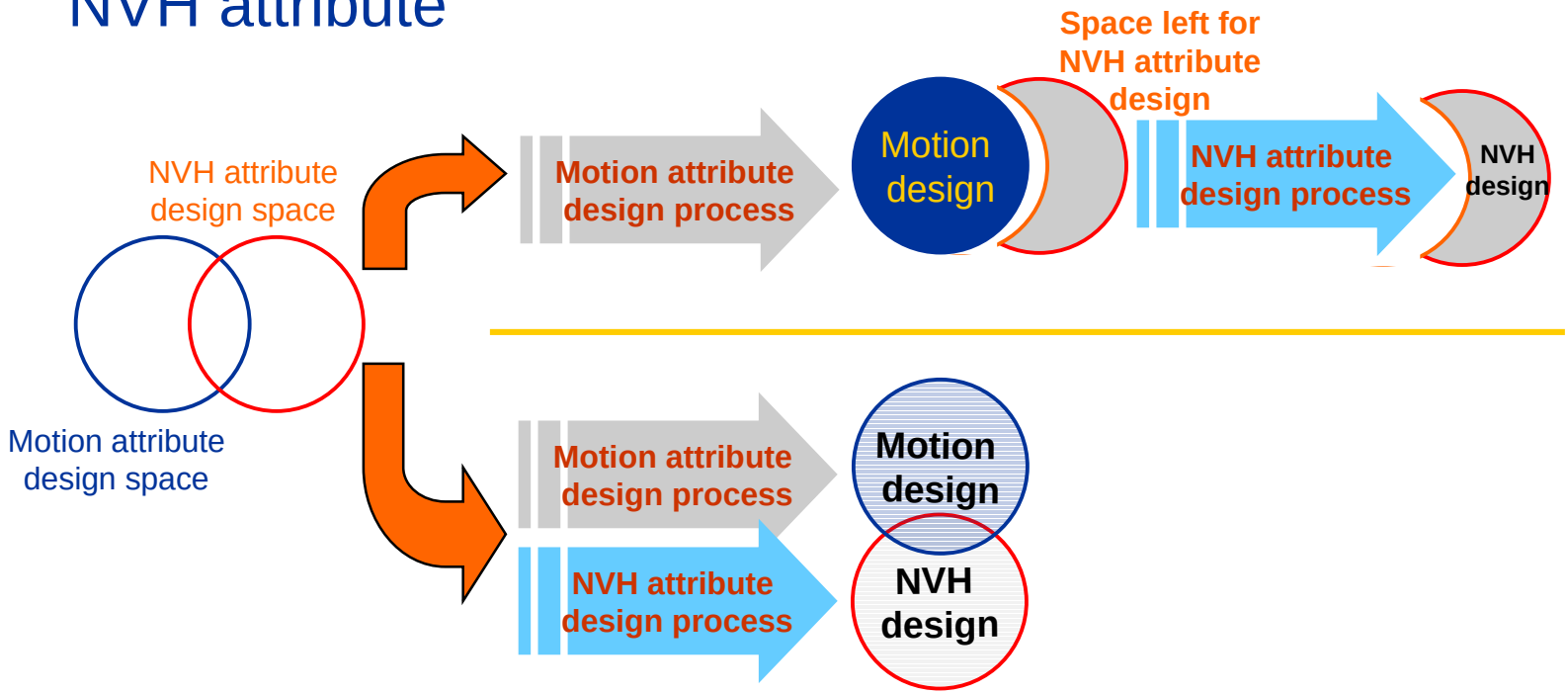


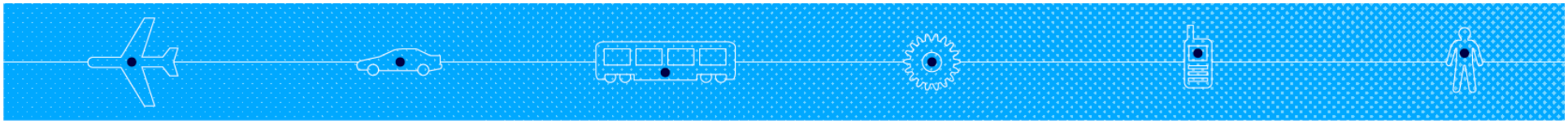




ADAMS/Vibration: Why is it needed?

Improve design by making full design space available to NVH attribute





Process - How does it work?

Build

- Build and instrument model

Test

- Perform analysis

Review

- View results – plots, animations, tables

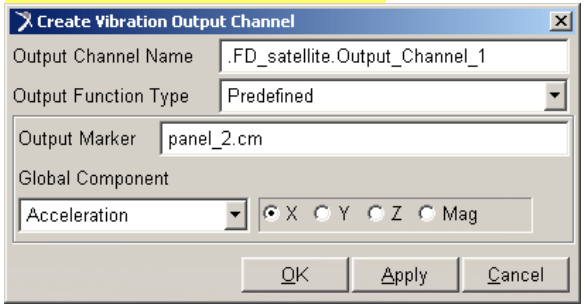
Improve

- Perform design evaluation

Process - Build

Start with an existing or create a new ADAMS model

In ADAMS/View GUI



Instrument your model

- Define input channels
  - Marker and direction of vibratory input
- Define vibration actuators
  - Vibratory forcing functions:swept sine, rotating mass…
  - Parameters: Magnitude, phase, mass imbalanced …
- Define output channels
  - Marker and quantity to be measured: displacement, force …

In Python

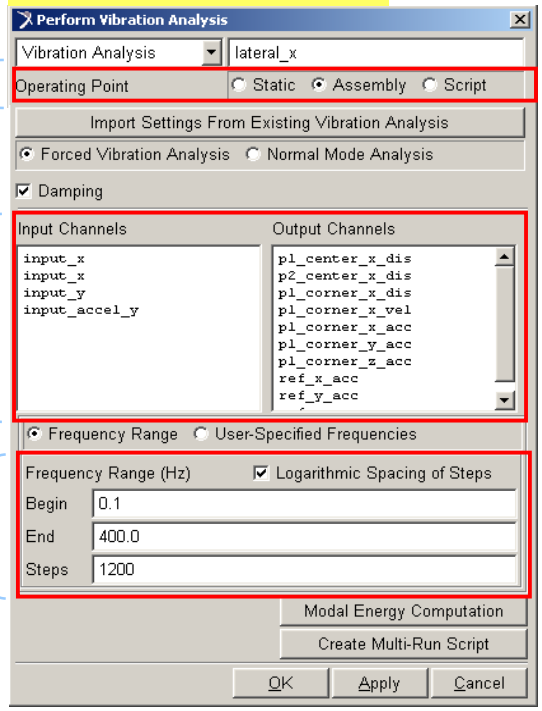
```
TR_A= AvOutputChannelPredefined("TieRodAccl", 100, "Acceleration", "X")
```

Process - Build cont'd

Define an analysis

- Define an operating point
  - Static, assembly, dynamic
- Collection of input, output channels and vibration actuators
- Frequency analysis range

In ADAMS/View GUI



In Python

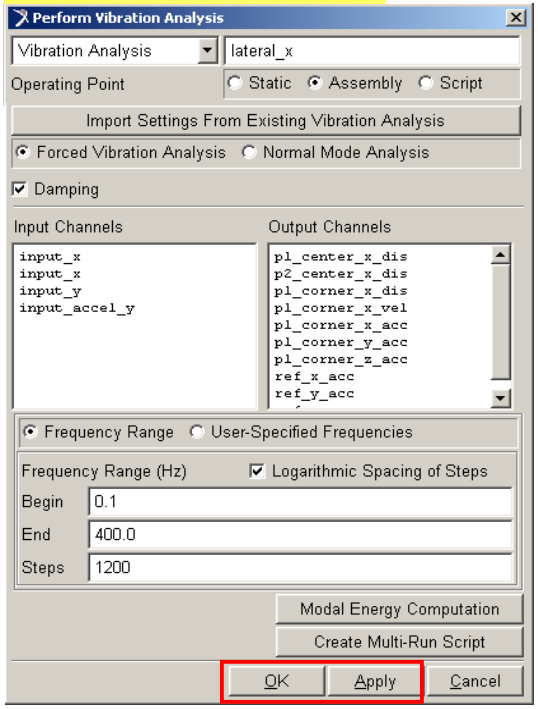
```
LinMod=AvLinearModel(adm_FileName, InpChList, OutChList, acf_FileName, True, base_name,[])
```

Build - Test

Perform an analysis

- Solves for operating point
- Linearizes the model at operating point
- Performs requested vibration analysis
  - Eigenvalue computation
  - Frequency response analysis

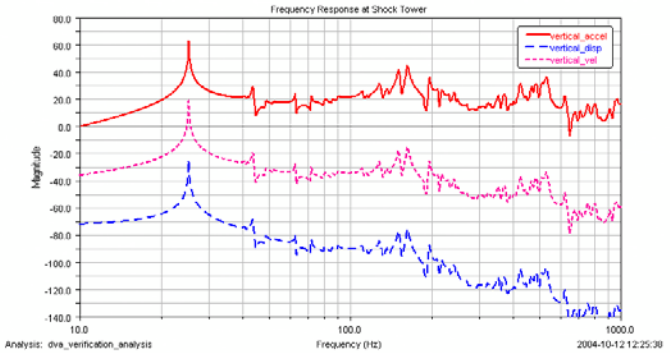
In ADAMS/View GUI



In Python

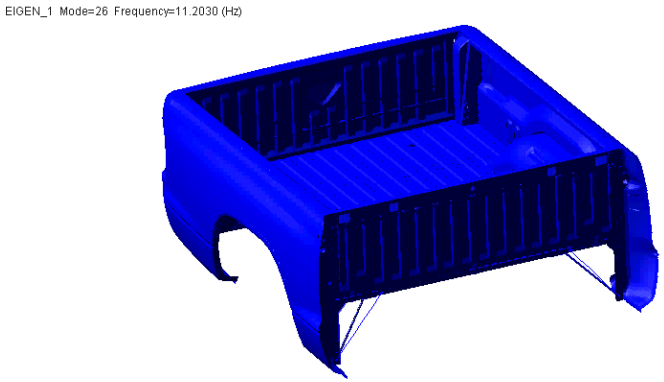
```
f      = AvMakeFrequency(0.1, 400, 1200, True)
Freq = AvAPI_Matrix(len(f), f)

# Frequency Response
FR = LinMod.FrequencyResponse(Freq)
```

Process - Review



Plot system response

- FRF/Transfer function, PSD
  - Identify frequencies with peak response
- Modal coordinates and participation
  - Identify systems modes contributing to peak response



Animate system response

- Operating shape animations
  - Animate model at forcing frequencies
- Mode shape animations
  - Animate system modes

Process - Review

Tabular data output

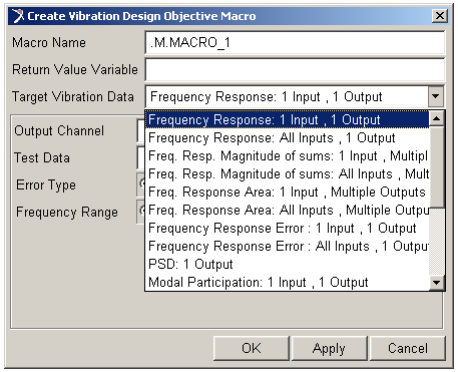
- Modal energy distribution within modes
  - Kinetic, strain and dissipative
    - Identify model components contributing most to system modes

Mode 11

Percentage Distribution of Strain Energy

Name	Total	X	Y	Z	RXX	RYY	RZZ
LF_SPRING	18.80	17.20	1.40	0.20			
LF_TIRE	30.87	0.00	0.00	30.87			
RF_SPRING	18.80	17.20	1.40	0.20			
RF_TIRE	30.87	0.00	0.00	30.87			
LR_SPRING	0.07	0.00	0.00	0.07			
LR_TIRE	0.26	0.00	0.00	0.26			
RR_SPRING	0.07	0.00	0.00	0.07			
RR_TIRE	0.26	0.00	0.00	0.26			

Process - Improve



Design studies, design of experiments and design optimization

- Vibration specific design objectives
  - Based of frequency response, modal coordinates
  - Modal energy distribution
  - Eigenvalues
- Trade off vibration and motion objectives in a single design evaluation.

Release history

Introduced in ADAMS 11

- Plug-in for ADAMS/View

Enhancements in ADAMS 12

- Vibration specific design objectives
- Modal energy computation
- Post processing enhancements
- Improved integration with ADAMS vertical products (Car…)

Recap of ADAMS/Vibration 2003

Introduced vibration analysis in python scripting environment

Build context

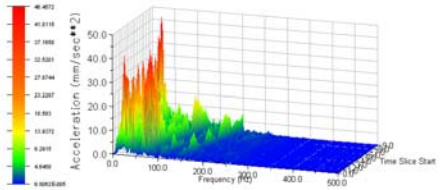
- Introduced enforced motion inputs.
  - displacement, velocities, accelerations
- Inputs applied through state variables
  - vibration analysis on general dynamic systems
- Instrument models in python

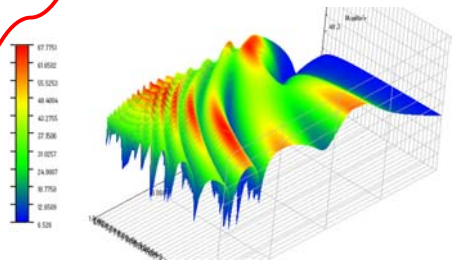
Test context

- Introduced python batch simulation environment

Review context

- 3D plotting introduced





Improve context

- Expanded integration with ADAMS/Insight.
- Scripted vibration analyses in python environment

ADAMS/Vibration 2005

Build context

- Introduced frequency dependent (FD) modeling elements
  - 1 to 6 directions
  - Pfeffer, bushing…
- Instrument pack for mechanical transfer function computations in python batch mode
  - Mobility, impedance, compliance…
  - Dynamic and static compliance matrix computation
  - Interoperable with ADAMS/PostProcessor

ADAMS/Vibration 2005

Test context

- Save vibration results to ADAMS xml results files
  - Available in ADAMS/View GUI and python batch environment

- Improved interoperability between ADAMS/View GUI and python batch environment

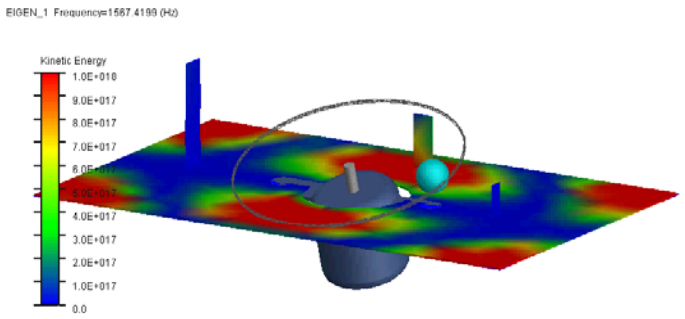
ADAMS/Vibration 2005

simOFFICE

- ❑ Interoperability
- ❑ Flexibility & Scalability
- ☑ Performance
- ❑ Capacity
- ❑ Collaborative
- ☑ Ease of Learning & Use
- ☑ Customizable & Extensible Data Backplane
- ❑ Leverage Existing Knowledge & Investments

Review context

- Plot vibration results saved in ADAMS xml results files
- Flex_body vibration animation enhancements
  - Modal energy contour animations
  - Improvements in basic animation
- Tracking eigenvalues in scatter plots.
- Rudimentary but customizable plotting in standalone python scripting environment



ADAMS/Vibration 2005

Improve context

- Expanded integration with ADAMS/Insight
  - New design objectives
    - Area under frequency response curve,…
    - Energy objectives…
- Improved ability to perform large number of design experiments

Roadmap – ADAMS/Vibration

Short Term

- ~~Build-test-review-improve emphasis in interface~~
- ~~Integration with MSC.Nastran - I~~
- ~~Python scripting environment - I~~
- ~~Support for C++ solver~~

Mid Term

- Integration with MSC.Nastran - II
- Python scripting environment - II
- Support for Frequency domain fatigue
- Continuing support for ADAMS vertical environments

Long Term

- System level NVH solver for MSC
- Python scripting environment - III
- Non-linear frequency response analysis
- Continuing support for ADAMS vertical environments

2006 Plans

Greater emphasis on Build-Test-Review-Improve paradigm

- Reorganization of menu structure and python classes

Integration with MSC.Nastran

- ADAMS external superelement (AES) for Nastran
  - Export linearized ADAMS models for incorporation in Nastran
- Perform analyses in Nastran
  - Static, eigenvalue, frequency response…

Continuing development of the python based scripting environment

- Customizable and embeddable in 3rd party environments
- Tighter linking with ADAMS/Insight

Future Plans

System level NVH solver for MSC

- Further integration with MSC.Nastran
  - Massively scalable solutions
  - Integration of multiple domains

Continued development of analysis in standalone batch environment

- Emphasis on customizability

Discussion

Do you understand our direction?

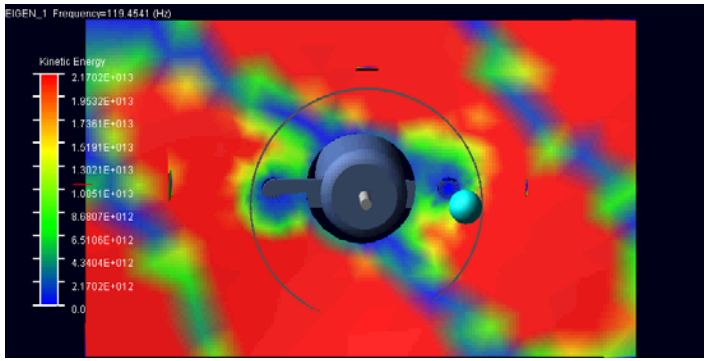
Do you agree with the direction?

- **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 Vibration roundtable
–The Solver Team

Thank You



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