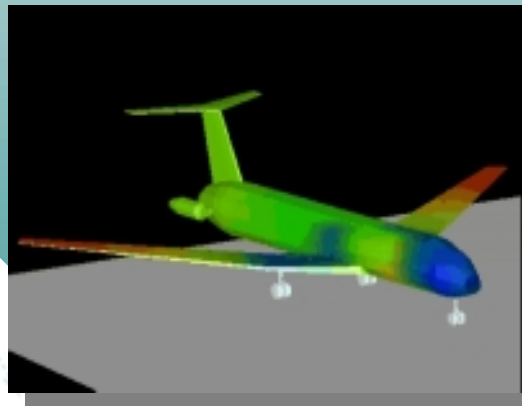
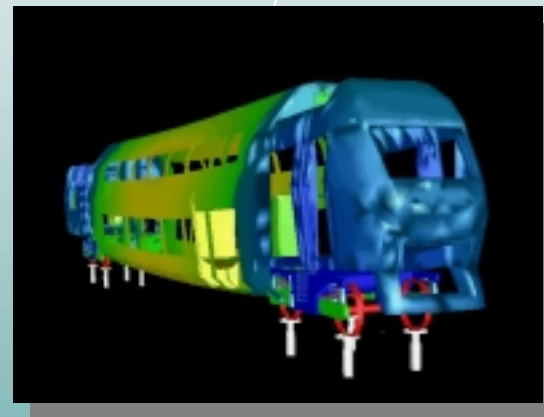
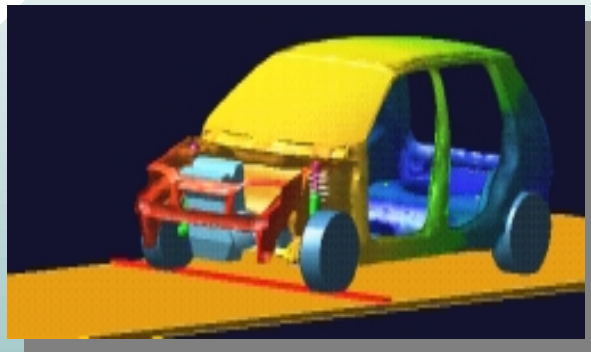


# ADAMS/Vibration Capabilities for Release 11 and Beyond

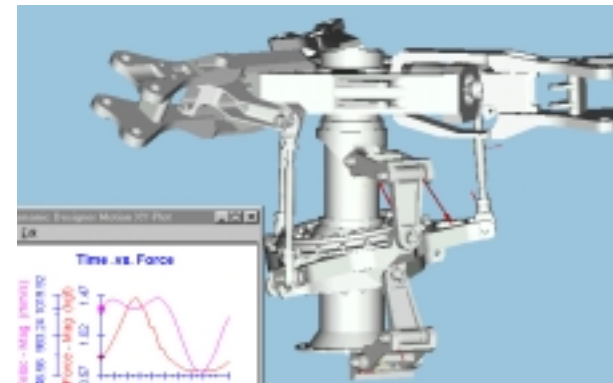


**Gabriele Ferrarotti**  
**June 21st, 2000**



## Key Vibration Issues Facing Engineers and Designers

- How comfortable is the ride, whether in an automobile, airplane, railcar, or off road machinery?
- Will excitations in one part of the system drive another part of the system?
- When problems occur, how can they be isolated?





## Industry efforts and metrics

- Good vibration characteristics are a purchase motivator and improve customer satisfaction  
**Need a good way to measure a design**
- Optimum NVH often conflicts with other attributes such as durability or vehicle dynamic performance  
**Need a way to balanced competing requirements**
- Significant efforts are spent to understand and quantify customer NVH requirements into objective terms and to define specific tests that relate to customer events  
**Current methods are expensive**





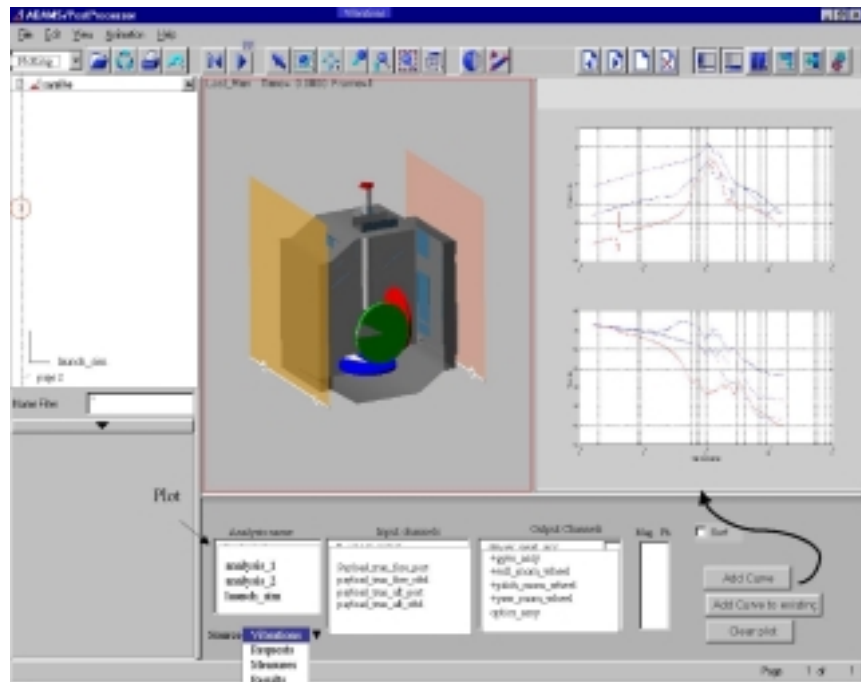
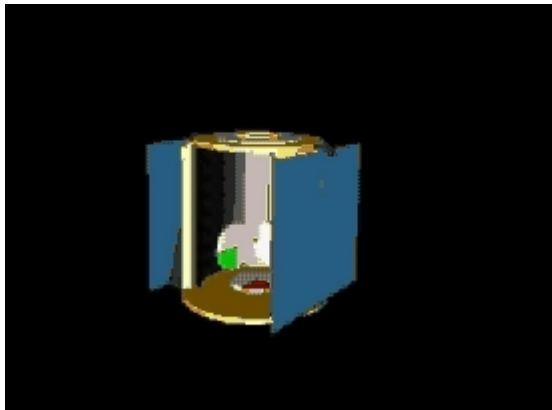
## Industry efforts and metrics

- NVH involves both objective and subjective development
  - Part of the process can be quantified with analytical tools
- Suppliers must “tune” their systems/components (right the first time) to the prototype vehicle or else they are responsible for NVH resolution
  - Need a way to study system
- Issues are often discovered late in the prototype development process resulting in money and time loss
  - Value in designing the right way



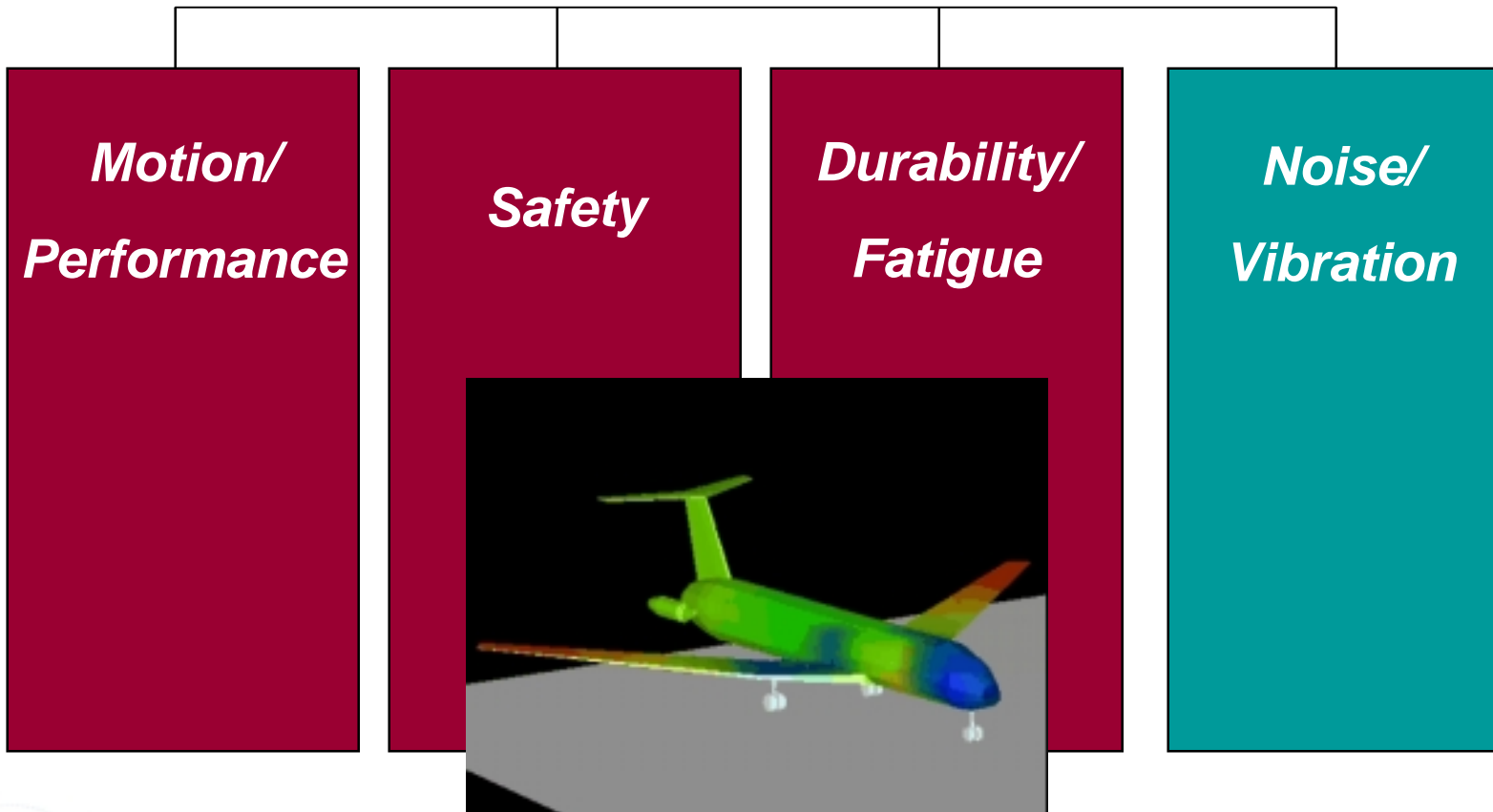
# The Need

- A way to study system level vibrations the same way you can now study system level motion problems





# Solution: MDI Extends the Scope of Virtual Prototyping



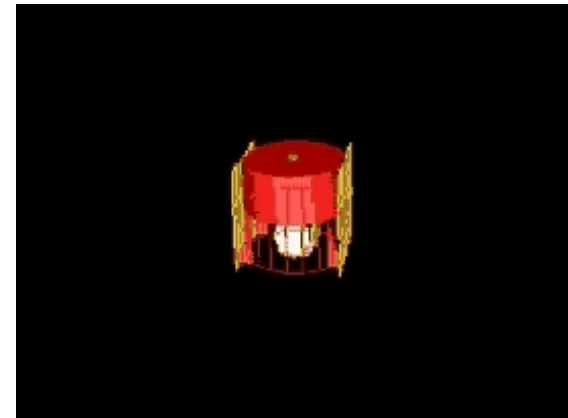
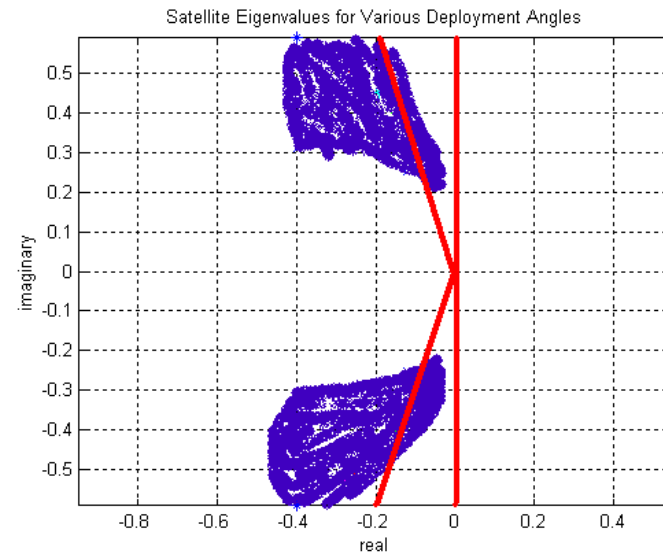


## Three reasons to use ADAMS/Vibration

- Take your system to different operating points to analyze the vibratory behavior (without having to create new models!)
- Include effects of hydraulics, controls, and other subsystems on the vibration characteristics
- Analyze system modes including attachment characteristics and other nonlinear characteristics

# Analyze the Vibratory Behavior in Different Configurations with One Model

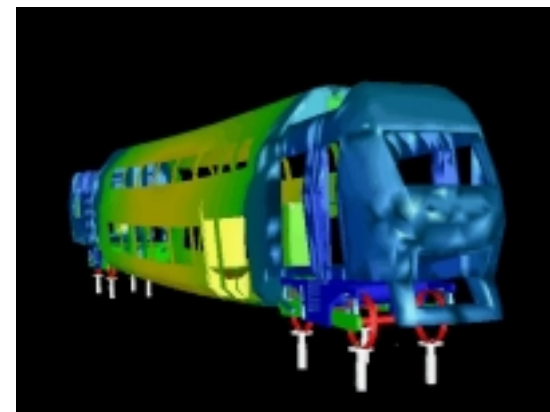
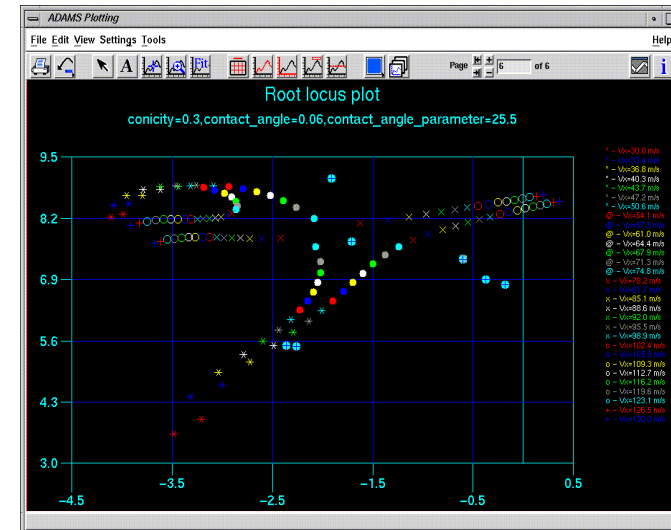
- **Satellite Example:**
  - ◆ System eigenvalues shift according to
    - Panel deployment angle
    - Locking condition
    - Contact condition
    - Actual spring rates
  
  - ◆ *This shift effects attitude control margin, pointing jitter magnitude, and structural loading conditions*



# Analyze the Vibratory Behavior in Different Configurations with One Model

## ■ Railcar Example:

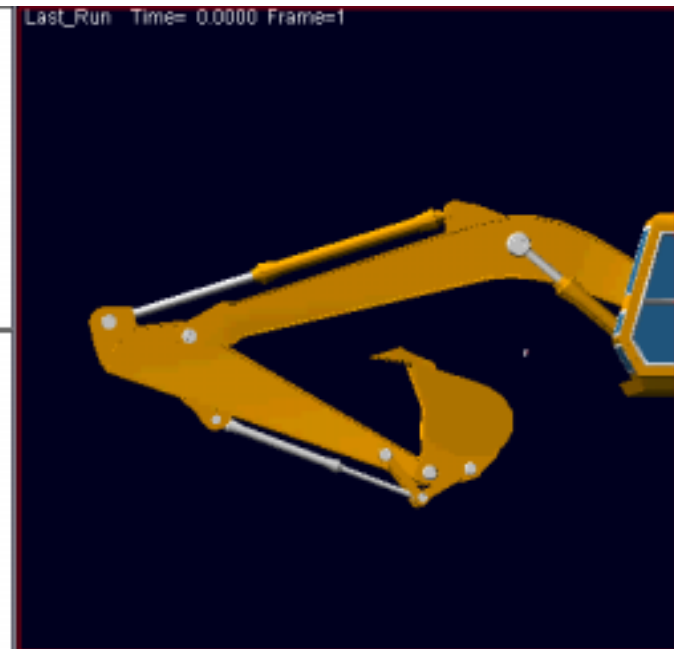
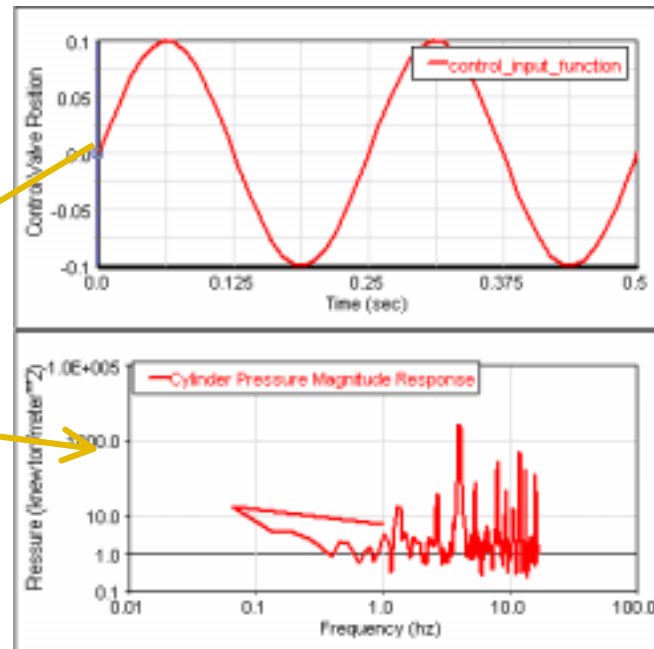
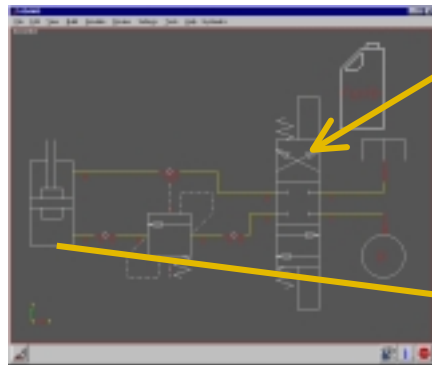
- ◆ System eigenvalues shift according to
  - Equivalent conicity
  - Suspension stiffnesses
  - Damper characteristics
  
- ◆ *This shift effects railcar stability and running comfort*



# Include Effects of Hydraulics and Controls on System Vibration Behavior

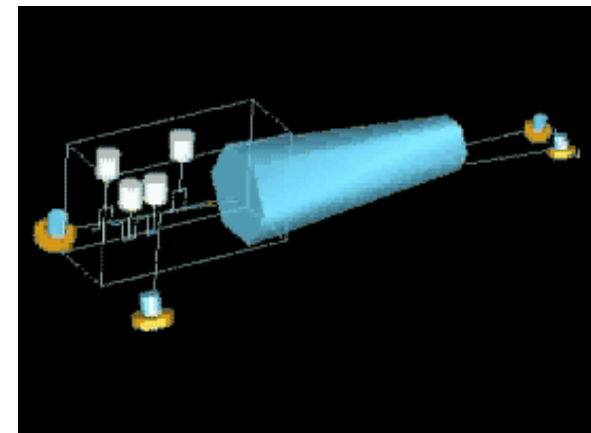
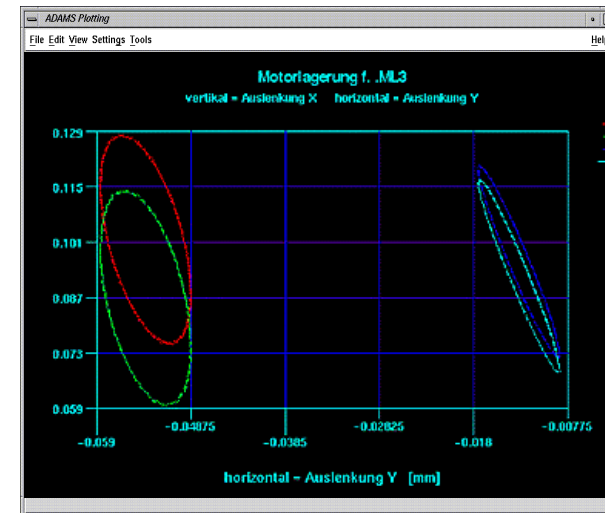
## ■ Hydraulics Example:

- ◆ Apply input vibration to control valve and see effect at cylinder pressure and boom movement in frequency response function plots and animations



# System attachment characteristics

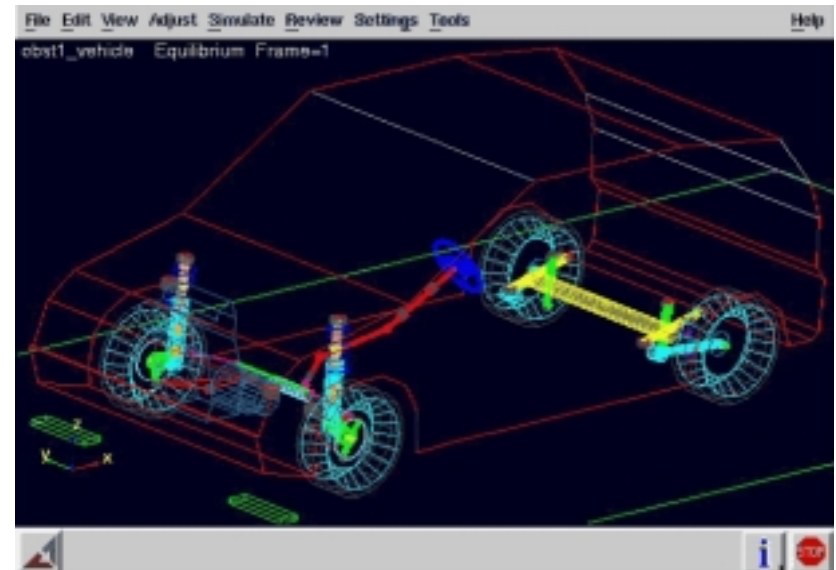
- Automotive Example:
  - ◆ Engine mount displacements due to combustion forces in dependency of
    - Engine mount characteristics
    - Engine mount position
  
  - ◆ *Frequency domain analysis helps designers to improve engine mount installations*





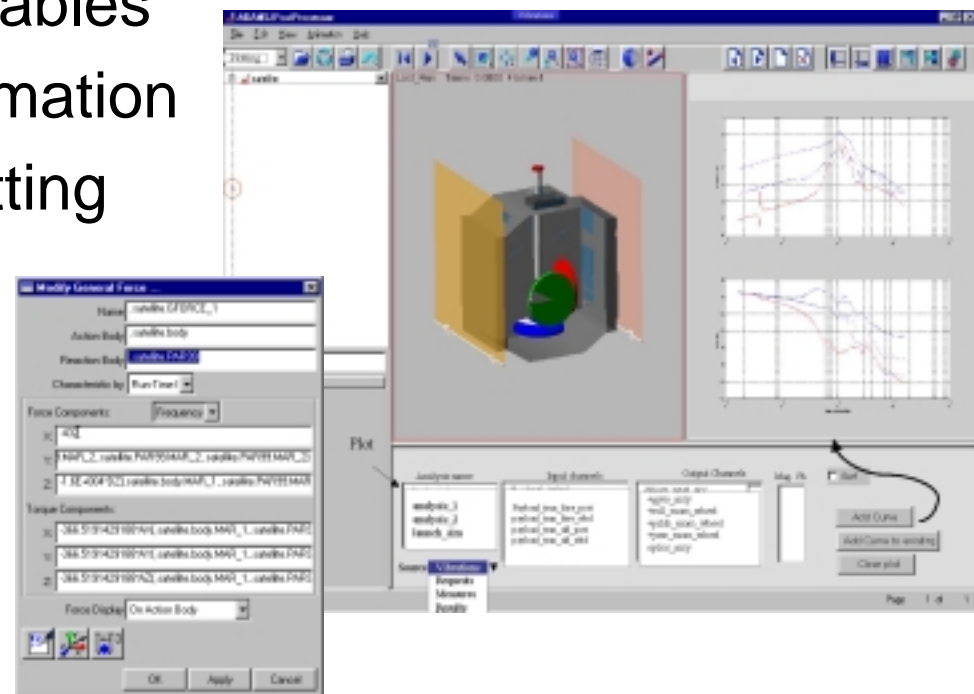
## 11.0 Assumptions

- Add-on product targeted at existing ADAMS user with existing ADAMS model
- Value of solving for system modes, including non-rigid attachments
- Leverage existing system model which includes hydraulics and controls



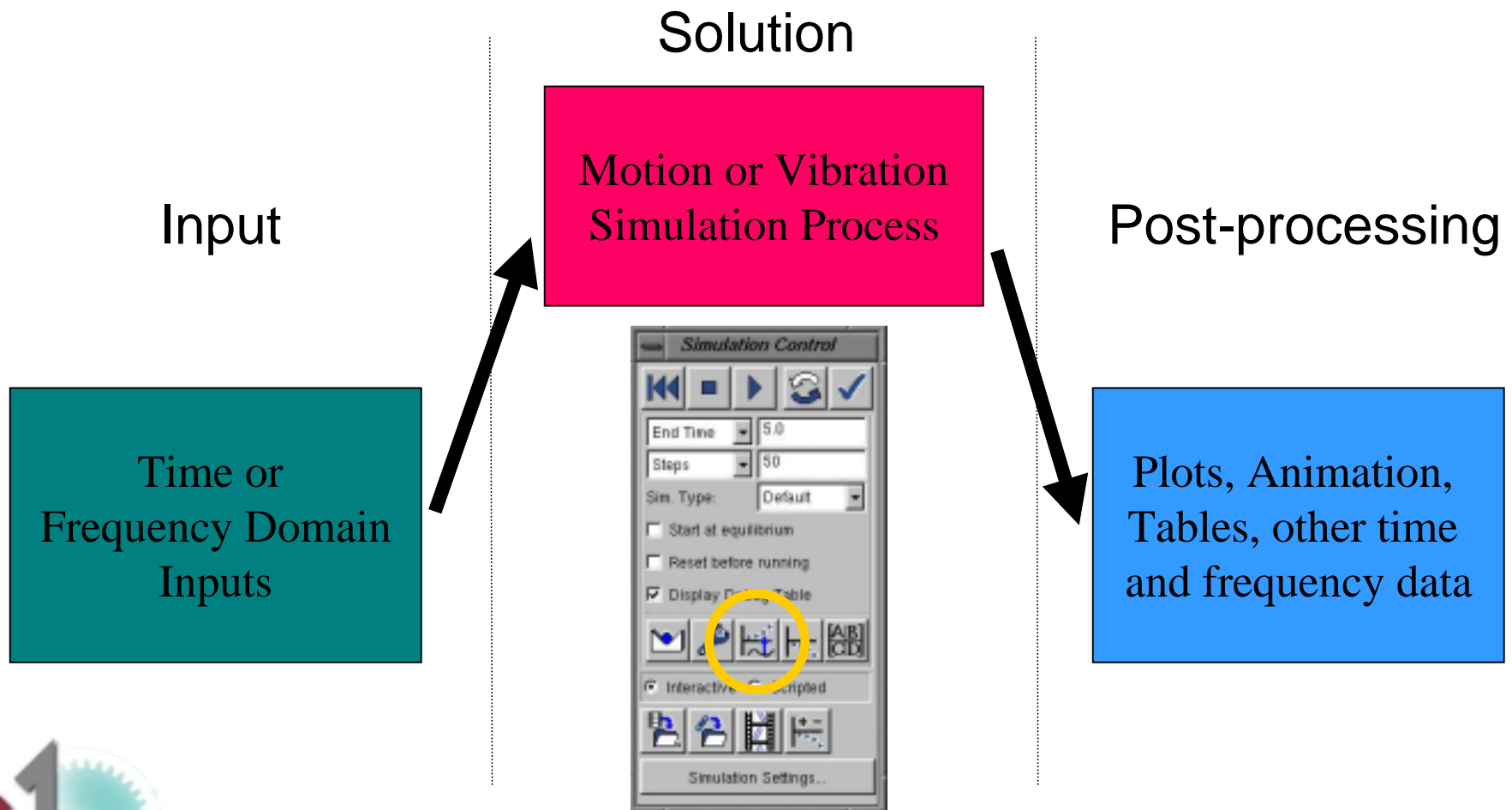
# 11.0 Requirements

- Frequency domain input forcing functions
- Frequency response function calculations
- Modal participation tables
- Forced vibration animation
- Forced vibration plotting





# How does it work: Simplified/Unified Approach





# ADAMS/Vibration Walkthru...

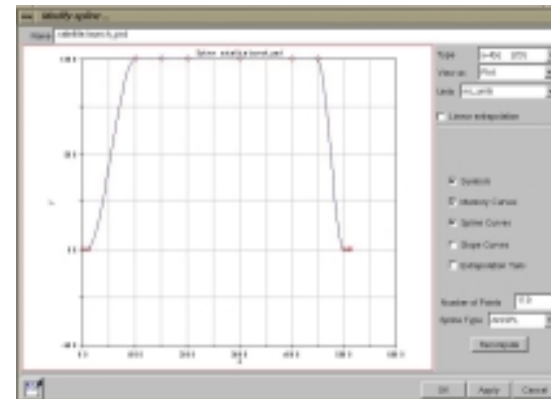
- Step 1
  - ◆ Create input channels, output channels, and actuators



**Actuator associated with an input channel**



**Spline defines PSD**

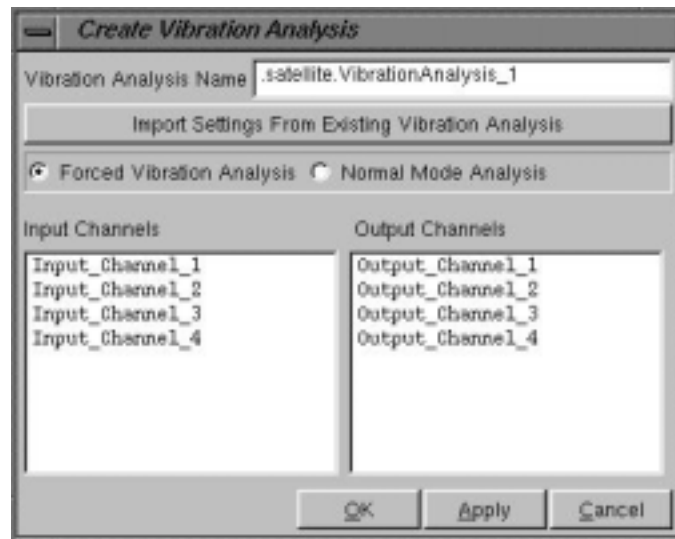




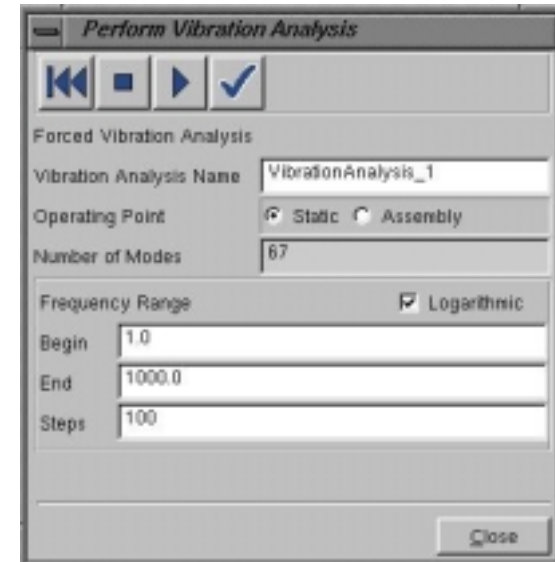
# ADAMS/Vibration Walkthru...

- Step 2
  - ◆ Run Analysis

Define operating point, frequency range, and steps



Define inputs/outputs to use

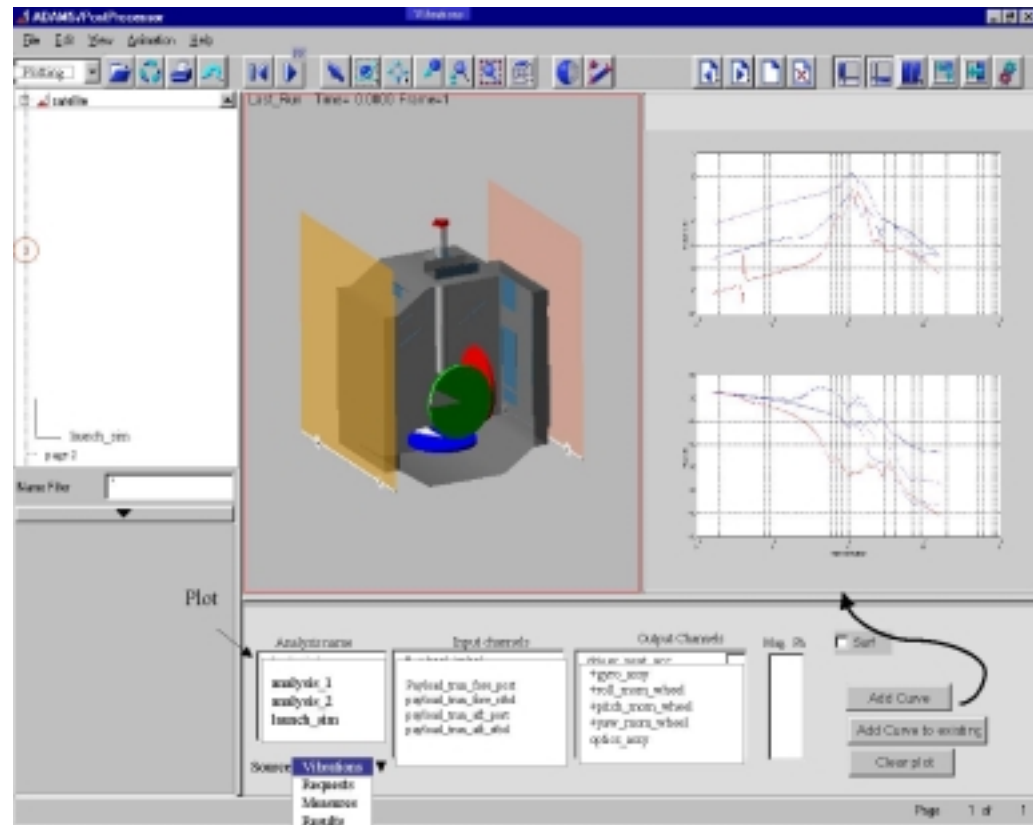


# ADAMS/Vibration Walkthru...

## ■ Step 3

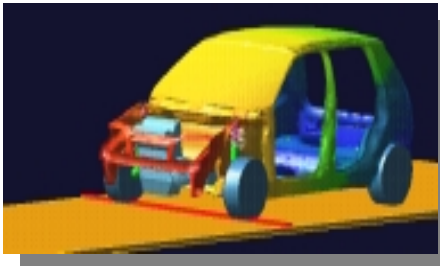
### ◆ Post-Processing

- Forced Vibration Animation and Plotting
- Frequency Response Functions
- Modal Participation Tables





# ADAMS/Vibration Roadmap



## Phase 1 Forced Vibration

Extending ADAMS/Linear to support forced vibration analysis including animation, frequency response, and modal participation.

## Phase 2 System Modal Energy

Modal kinetic and dissipative energy distribution.  
Inclusion of time based vibration analysis.  
Greater ease of use.

## Phase 3 Frequency Based Model and Test Comparison

Using MTS test utilities to support import of physically tested components and subsystems into ADAMS/Vibrations for full vehicle analysis.  
Support of VEMA capabilities.

## Phase 4 Vibration Analysis of General Nonlinear Systems

Extended capability to handle general rotating systems, quasi-linear systems, and vibro-acoustics.

Upcoming Releases

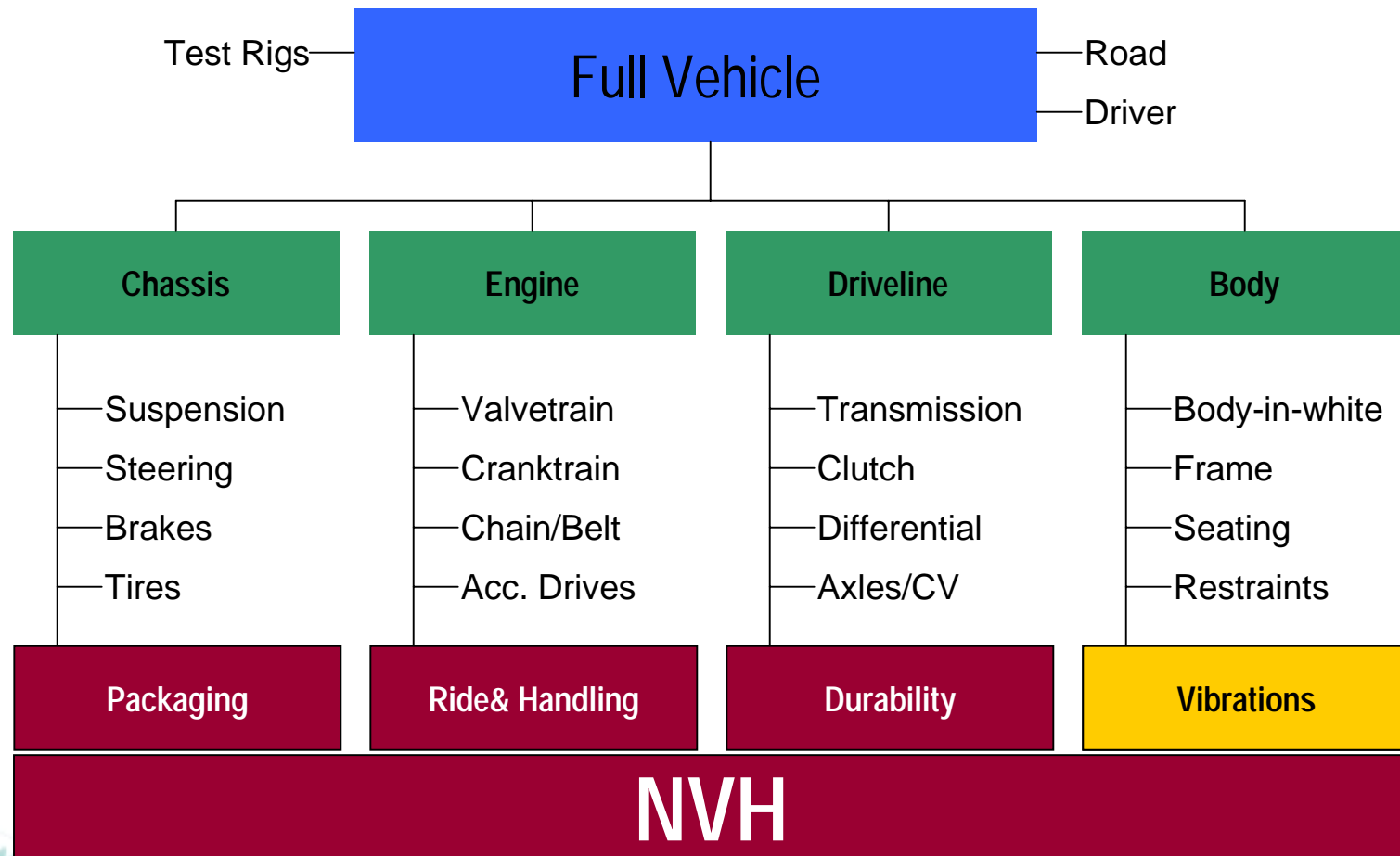


# Virtual TestLab™ Including Vibration



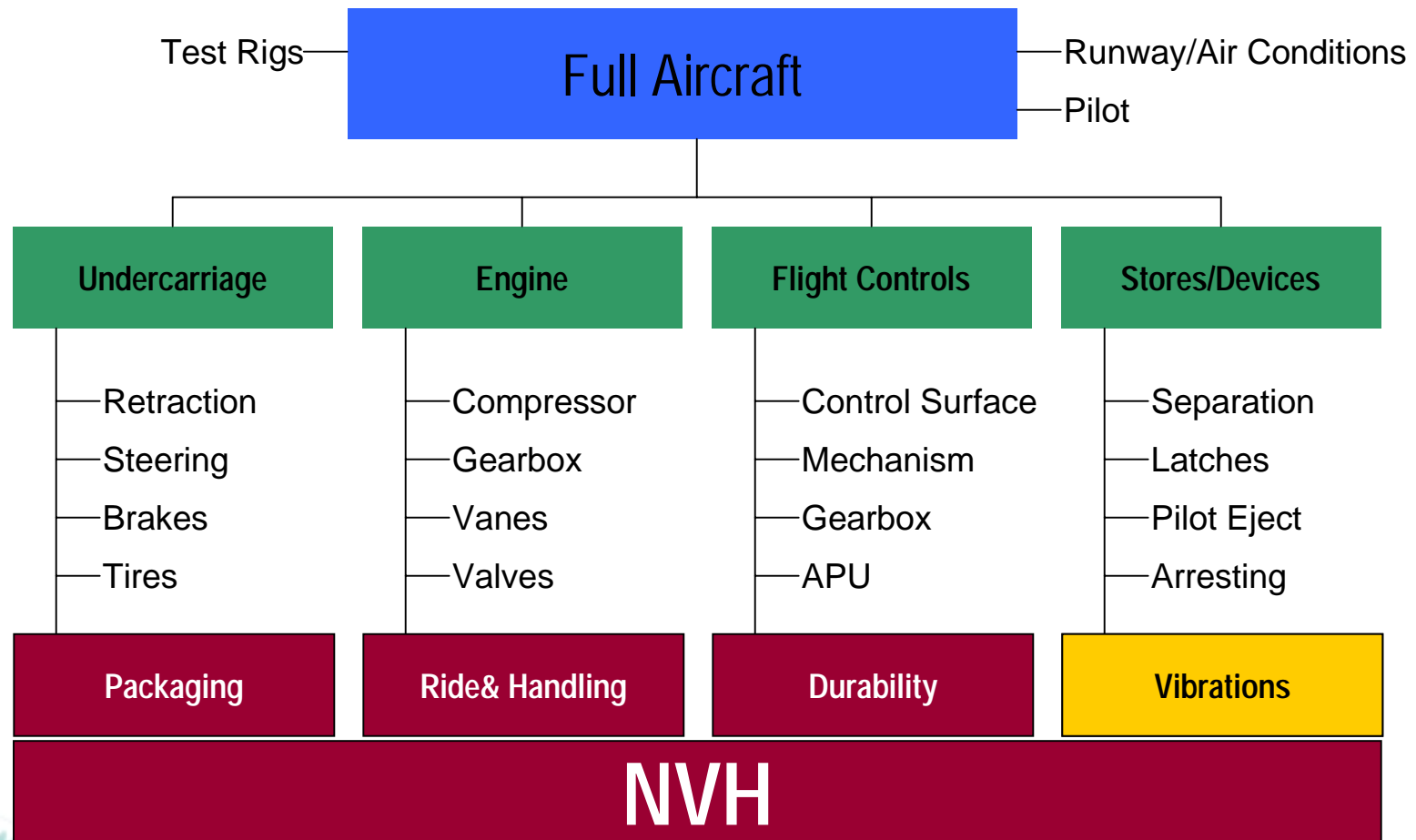


# Functional Digital Car Including Vibration





# Functional Digital Aircraft Including Vibration





# Functional Digital Train Including Vibration

