Vibration Analysis using ADAMS General Introduction and Application Examples

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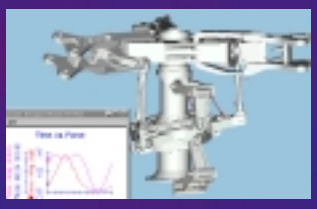
Key Vibration Issues Facing Engineers and Designers

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



ADAMS/Vibration: Your Solution for Frequency Domain Analysis

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

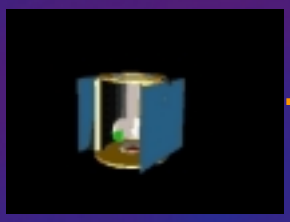
Industry efforts and metrics

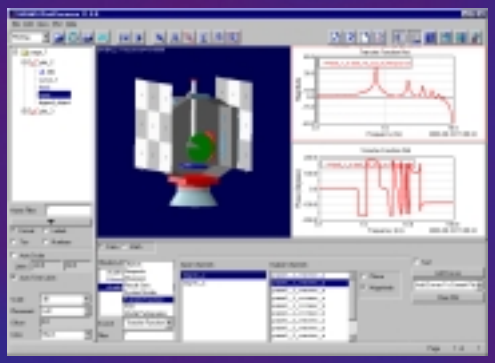
- NVH involves both objective and subjective development
  - Part of the process can be quantified with analytical tools
- Suppliers must “tune” their systems/components (right the first time) to the prototype vehicle or else they are responsible for NVH resolution
  - Need a way to study system
- Issues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

ADAMS/Vibration: Your Solution for Frequency Domain Analysis

The Need

- A way to study system level vibrations the same way you can now study system level motion problems
- *…much faster!*





Solution: MDI Extends the Scope of Virtual Prototyping

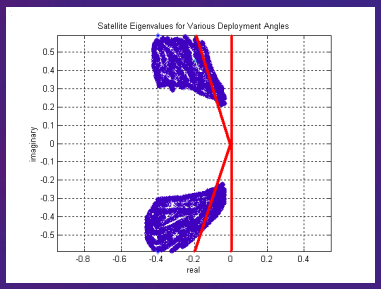
Motion/ Performance	Safety	Durability/ Fatigue	Noise/ Vibration

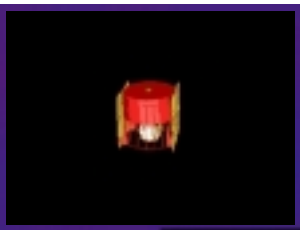
Three reasons to use ADAMS/Vibration

- **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

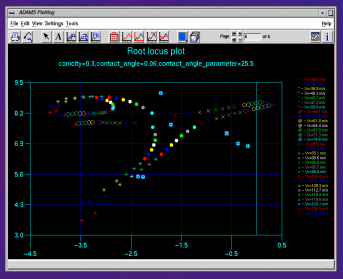
- **Satellite Example:**
  - System eigenvalues shift according to
    - Panel deployment angle
    - Locking condition
    - Contact condition
    - Actual spring rates
  - *This shift effects attitude control margin, pointing jitter magnitude, and structural loading conditions*

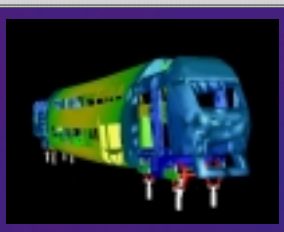




Analyze the Vibratory Behavior in Different Configurations

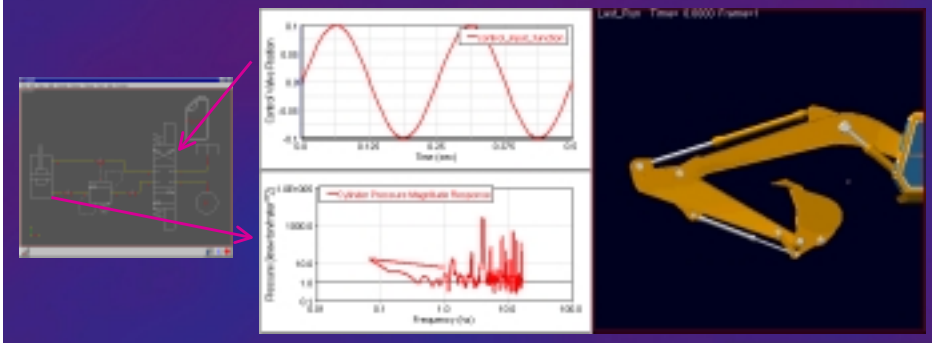
- **Railcar Example:**
  - System eigenvalues shift according to
    - Equivalent conicity
    - Suspension stiffnesses
    - Damper characteristics
  - *This shift effects railcar stability and running comfort*





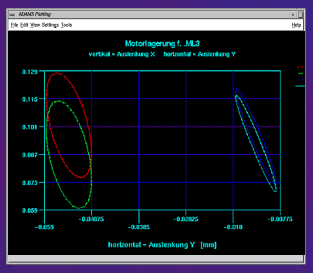
Include Effects of Hydraulics and Controls on System Behavior

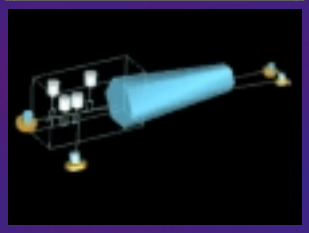
- **Hydraulics Example:**
  - Apply input vibration to control valve and see effect at cylinder pressure and boom movement in frequency response function plots and animations



Analyze System Modes including 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*



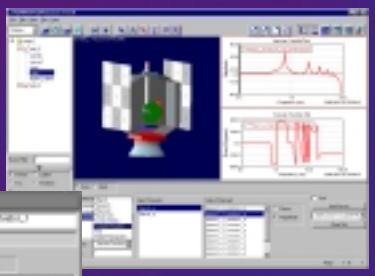


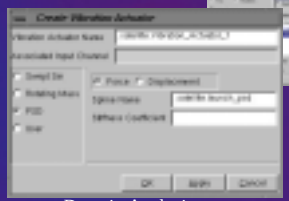
ADAMS/Vibration: Your Solution for Frequency Domain Analysis

ADAMS

ADAMS/Vibration 11.0 Capabilities

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





ADAMS/Vibration: Your Solution for Frequency Domain Analysis

ADAMS

How does it work: Simplified/Unified Approach

Solution

Input

Motion or Vibration Simulation Process

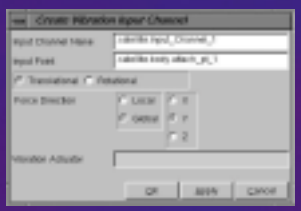
Post-processing

Time or Frequency Domain Inputs

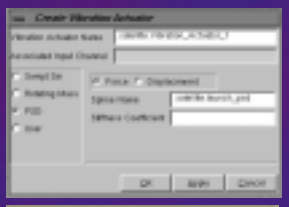
Plots, Animation, Tables, other time and frequency data

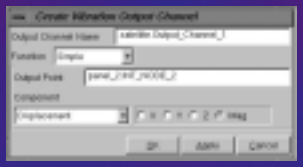
ADAMS/Vibration Walkthru...

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

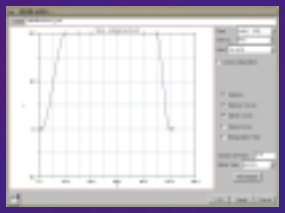


Actuator associated with an input channel



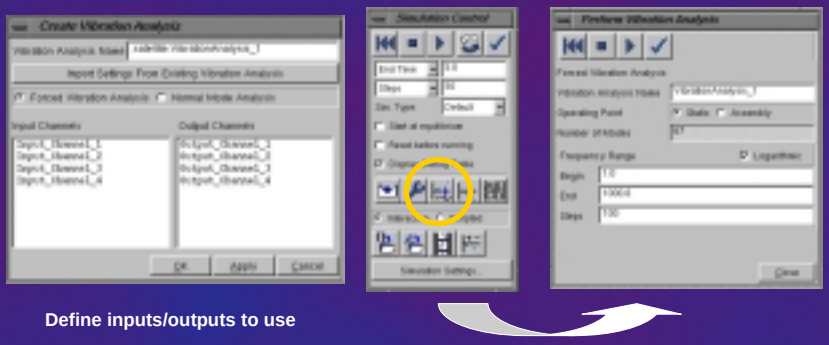


Spline defines PSD



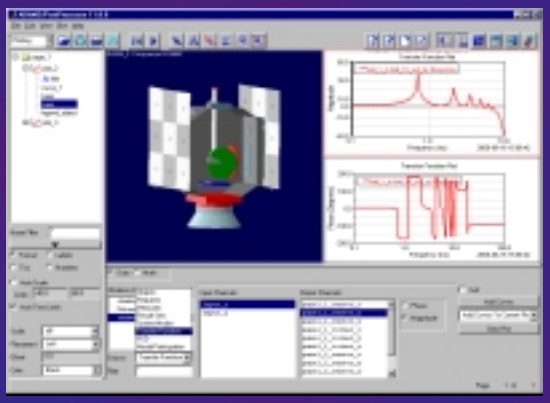
ADAMS/Vibration Walkthru...

- **Step 2**
  - Run Analysis



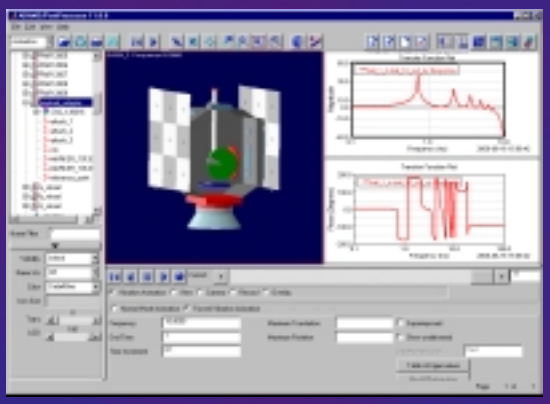
ADAMS/Vibration Walkthru...

- **Step 3**
  - Post-Processing
    - System Modes
    - Frequency Response Functions
    - Power Spectral Density
    - Modal Participation Tables

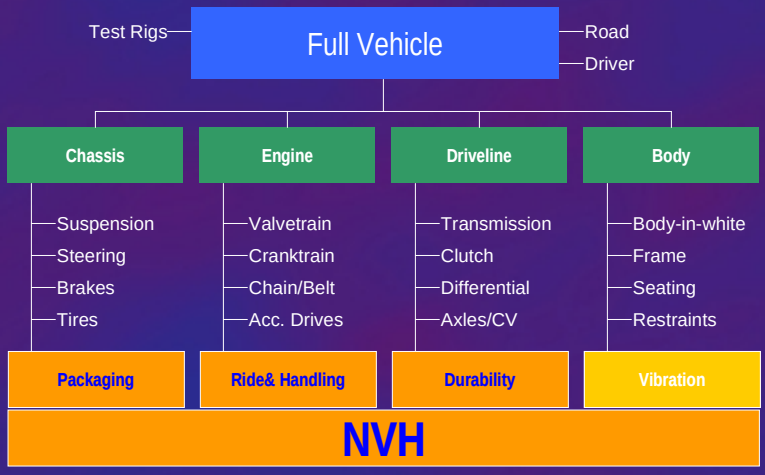


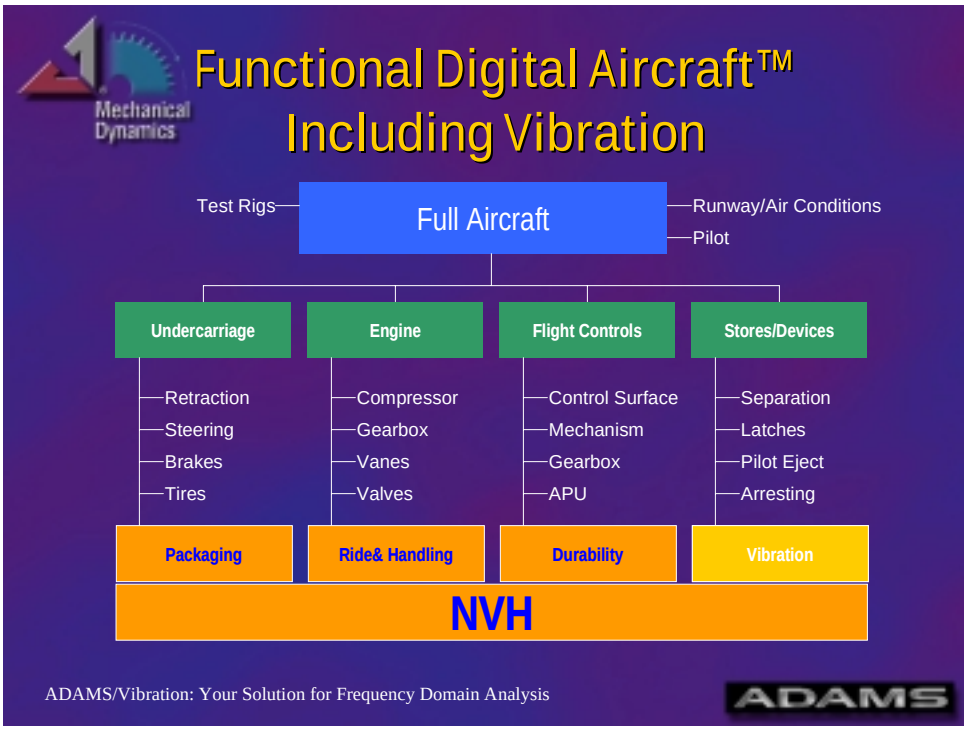
ADAMS/Vibration Walkthru...

- **Step 4**
  - Graphic Post-Processing
    - Normal Mode Animation
    - Forced Vibration Animation



Functional Digital Car™ Including Vibration




Mechanical Dynamics
Functional Digital Aircraft™
Including Vibration
Test Rigs
Full Aircraft
Runway/Air Conditions
Pilot
Undercarriage
Engine
Flight Controls
Stores/Devices
Retraction
Steering
Brakes
Tires
Compressor
Gearbox
Vanes
Valves
Control Surface
Mechanism
Gearbox
APU
Separation
Latches
Pilot Eject
Arresting
Packaging
Ride& Handling
Durability
Vibration
NVH
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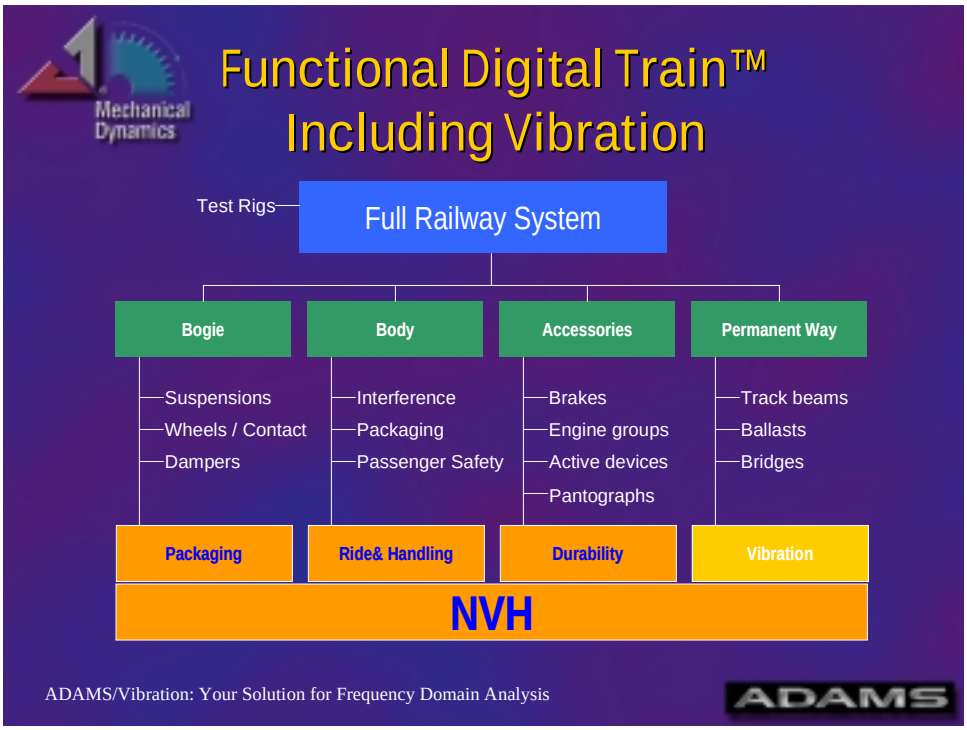
Mechanical Dynamics
Functional Digital Train™
Including Vibration
Test Rigs
Full Railway System
Bogie
Body
Accessories
Permanent Way
Suspensions
Wheels / Contact
Dampers
Interference
Packaging
Passenger Safety
Brakes
Engine groups
Active devices
Pantographs
Track beams
Ballasts
Bridges
Packaging
Ride& Handling
Durability
Vibration
NVH
ADAMS/Vibration: Your Solution for Frequency Domain Analysis
ADAMS

Virtual TestLab™ Including Vibration

- Get with a virtual model the frequency domain results a test engineer would obtain with a physical model

Conclusions

- **Add-on product targeted at existing ADAMS users with existing ADAMS models**
- **Allows the investigation of system level vibrations the same way system level motions are studied**
- **Quickly investigates the influence of parameter variation on the vibratory behavior of the system**