ADAMS/Engine

MDI's New Development Tool for Valve Train Dynamics, Timing Chain and Belt Drive
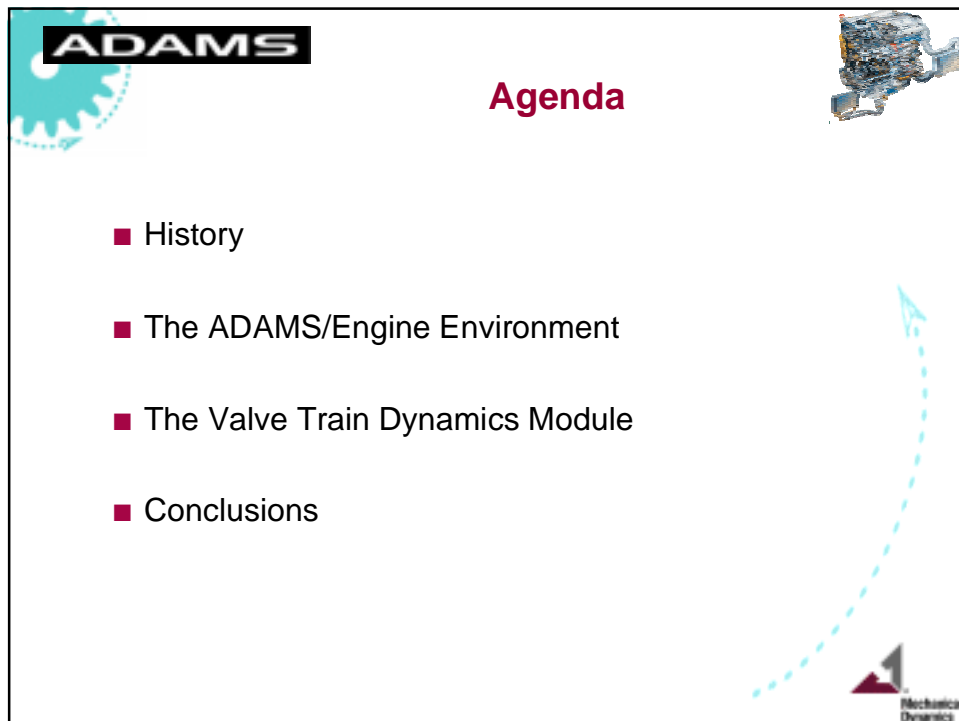

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MDI's New Development Tool for Valve Train Dynamics, Timing Chain and Belt Drive

Mechanical Dynamics

ADAMS

Agenda

- History

- The ADAMS/Engine Environment

- The Valve Train Dynamics Module

- Conclusions

Mechanical Dynamics

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ADAMS

Vision of ADAMS/Engine

„ Reducing significantly time and cost of engine development in benefiting from the wide range of dynamic simulation capabilities in ADAMS and it´s superior template based modeling environment."

Mechanical Dynamics

ADAMS

The Team behind ADAMS/Engine

- World market leader for functional virtual prototyping and full system analysis with the ADAMS productline
- Global network for sales, customer support and services
- 280 employees

FEV
- Internationally recognized leader in the design and developmen of internal combustion's engines
- Supplier of advanced test and instrumentation systems
- 800 employees

Each partner represents more than 20 years experience!

Mechanical Dynamics

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ADAMS

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ADAMS

Why ADAMS/Engine

- Fast design and performance improvements of internal combustion engines are a major concern of the car-industry

- There are significantly more engine designs than vehicle designs in the world

- So far mostly in-house software or single function software from AVL and RICARDO are applied

- The „Digital Car Concept" requires a modular environment for components, subsytems of different complexity (suspension, driveline, engine, ...) up to a full assembled vehicle - ADAMS/Car & ADAMS/Engine are key to this strategy

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ADAMS

Why ADAMS/Engine?

Many customers want a simulation environment in order to prototype their engine designs prior to physical test or as a way of testing that does not exist today.

The Waukesha ATGL 5000 HP engine
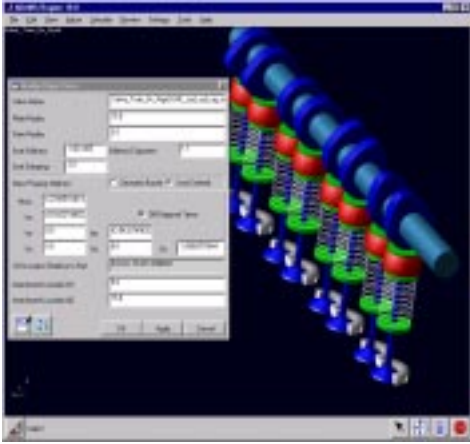
Cost in fuel to test for 500 hours: Over $300,000

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The ADAMS/Engine Environment

- „Functional Virtual Prototyping" for the engine development process
- A „toolbox" for all relevant engine components and subsytems
- Component <u>and</u> full system analysis in one single environment
- Applicable from concept phase up to final design sign-off
- Based on ADAMS/Car technology

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ADAMS/Engine - Product Vision

Idea

Concept

Component

Subsystem

Full System

Final Design

- *Future* versions of ADAMS/Engine will cover the follwing tasks:
  - Creating the vehicle targets (performance, fuel consumption, emissions)
  - Establish engine power and torque requirements
  - Layout of base engine size and type
  - Component dimensions, strength & durability characteristics
  - Subsystem & fullsystem performance analysis
  - Interaction with external CAE/CAD tools
  - Link to durability & NVH analysis

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ADAMS/Engine - Application Areas

Valve Train

Crank Train

Timing Chain

Accessory Drive

- **Concept tools for Engine layout**
- **Cranktrain analysis**
- **Valve train analysis**
- **Accessory drive analysis**
- **Interfaces to cam-synthesis**
- **Timing drive (chain, belt, gears)**
- **Hydrodynamic bearings**
- **Interacting with other diciplines:**
  - **CAD, FEA, Durability, Noise, Combustion**

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Product Plan for ADAMS/Engine

- Valve Train Dynamics — Version 10.0
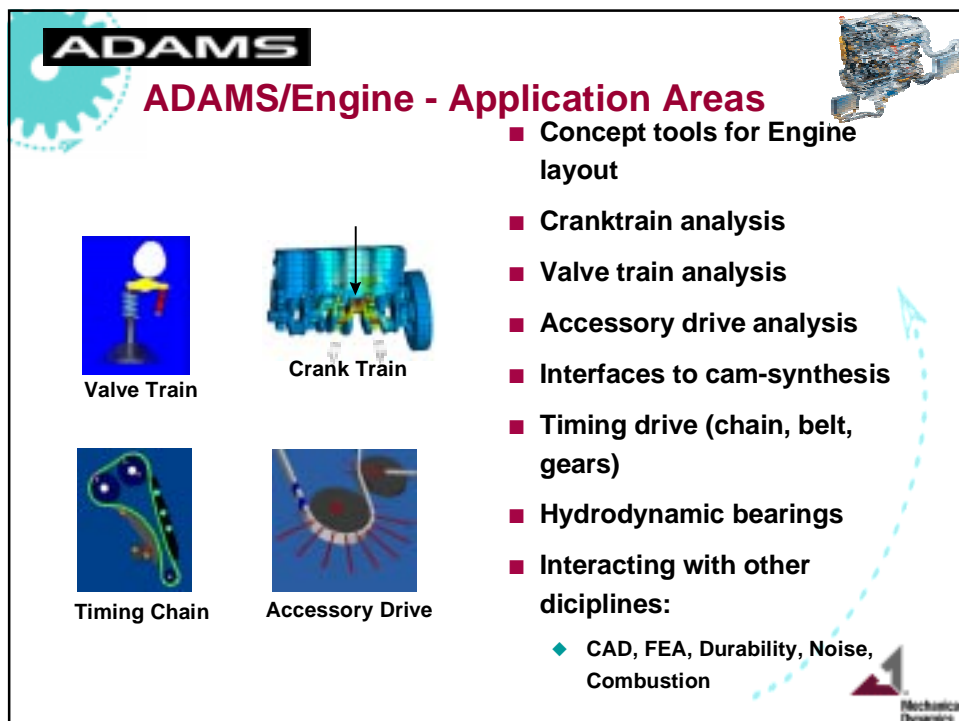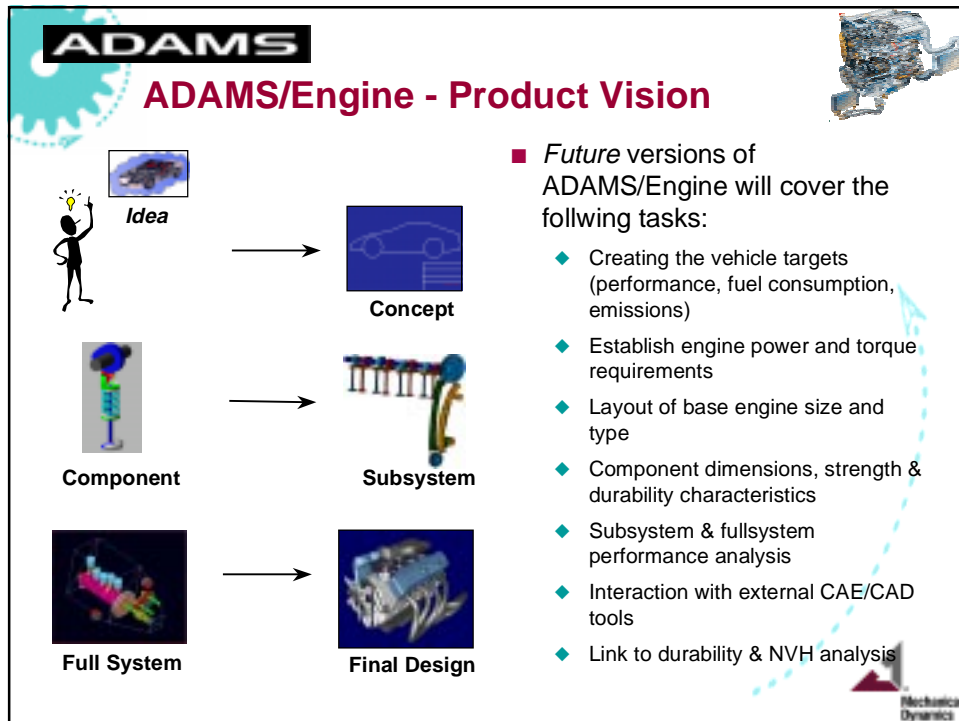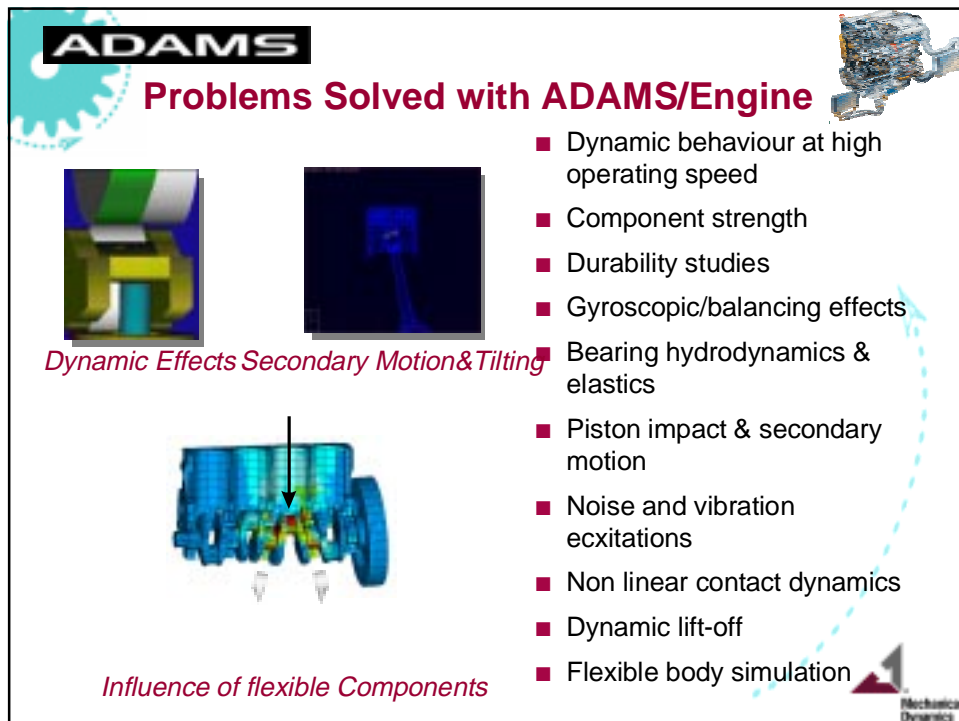- Timing Chain — Version 10.1
- Tooth Belt / Gear Drive — Version 11.0
- Secondary Motion / Crank-Piston & Hydrodynamic Bearings
- Accessory Drive — Beyond 11.0
- Concept Tools Target Definition / Cam Synthesis

Problems Solved with ADAMS/Engine

- Dynamic behaviour at high operating speed
- Component strength
- Durability studies
- Gyroscopic/balancing effects
- Bearing hydrodynamics & elastics
- Piston impact & secondary motion
- Noise and vibration ecxitations
- Non linear contact dynamics
- Dynamic lift-off
- Flexible body simulation

Dynamic Effects Secondary Motion&Tilting

Influence of flexible Components

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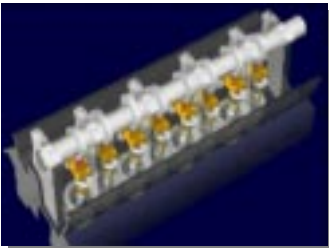**MDI's New Development Tool for Valve Train Dynamics, Timing Chain and Belt Drive**

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Agenda

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Mechanical Dynamics

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ADAMS/Engine - *Valve Train Dynamics*

- First commercial ADAMS/Engine module
- Template based parametric modeling approach
- Compatible to ADAMS/Car
- Data management based on TEIM-ORBIT Neutral Data Format
- Different user modes (standard/expert user)

1st Choice for single and complete valve train analysis!

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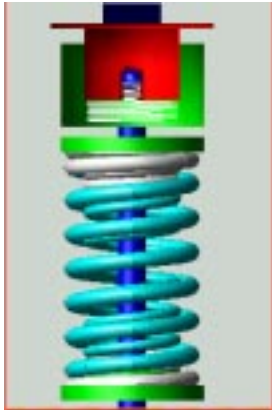
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Problems Solved with the
"Valve Train Dynamics Module"

- Performance improvements
- Calculate durability requirements
- Compute noise & vibration excitations
- Calculate lift-off and rev. limit
- Complementary to traditional experimental methods
- Encourages innovative new design ideas

ADAMS

Modelling Elements

- Valve Spring
  - Multi-mass spring
    (coil clash, spring surge)
    - elliptical or rectangular wire cross section
    - barrel, conical, double conical shaped
    - progressive or linear
  - Linear spring damper
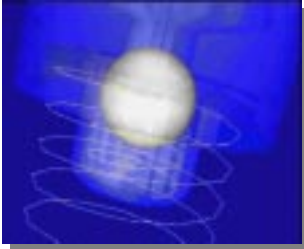 - Nonlinear spring damper
    (hook to curve editor)

ADAMS/Engine

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Modelling Elements

- Hydraulic Lash Adjuster
  - Simple Spring-Damper
  - Detailed Hydraulic Representation (valve in housing or piston)
    - Fluid Compressibility
    - Oil flow through check valve
    - Oil flow through leakage gap

Mechanical Dynamics

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Modelling Elements

- Contacts
  - curve to point
  - curve to flat
  - curve to circle
  - curve to curve
  - sphere in socket
  - sphere on plane
  - cylinder on plane
  - point on plane
- Contact Characteristics
  - lift off
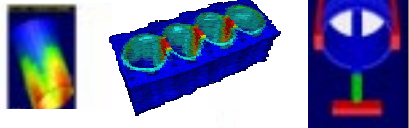 - hertzian pressure
  - friction
  - nonlinear stiffness

Mechanical Dynamics
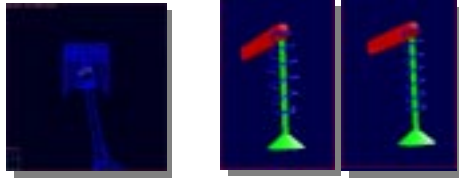
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ADAMS

Modelling Elements

Flexible Cylinder Liner and Barrel
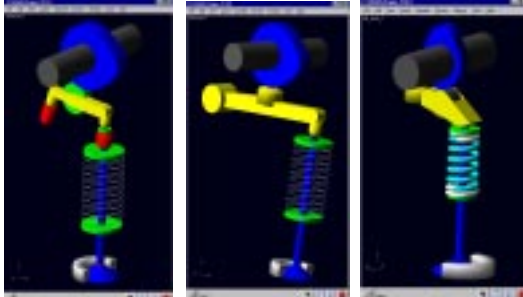
Flexible Piston   *Modal Valve Spring*

- **Flexible Components**
  - Rocker
    - flexible body
  - Pushrods
    - beams
    - parametric flexible body
  - Camshaft
    - torsional flexible
    - flexible body
  - Valve
    - axial flexible
  - Valve Spring
    - parametric flexible body

Mechanical Dynamics

ADAMS

Basic Valve Train Library

- **Overhead Camshaft (OHC)**
  - Finger Follower
    - with/without Roller
    - with/without Hydraulic lash adjuster
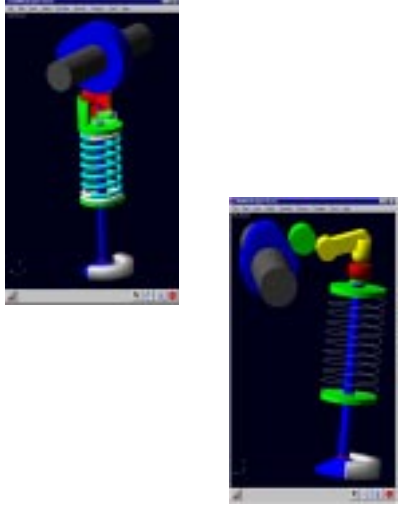
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MDI's New Development Tool for Valve Train Dynamics, Timing Chain and Belt Drive
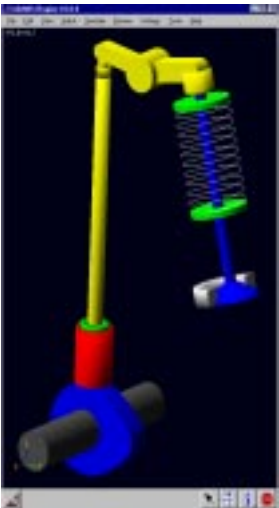

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Basic Valve Train Library

- Overhead Camshaft (OHC)
  - Bucket Tappet Assembly
    - with/without Hydraulic lash adjuster
  - Rocker Arm
    - with/without Roller
    - with/without Hydraulic lash adjuster

ADAMS

Basic Valve Train Library

- Overhead Valve (OHV)
  - Pushrod
    - with/without Roller
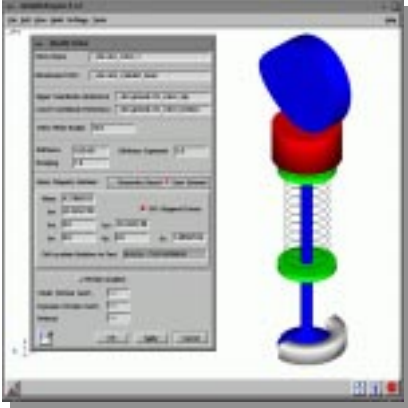   - with/without Hydraulic lash adjuster

ADAMS/Engine

MDI's New Development Tool for Valve Train Dynamics, Timing Chain and Belt Drive

ADAMS

User Modes

- Template Builder mode (Expert)
  - Define generic engine components
  - Parametrics is created on the fly
  - Template storage in shared and private databases
- Modelling Elements:
  - Cam
  - Tappets
  - Valve
  - Valve Spring
  - Rocker Arms
  - Push Rod
  - Roller
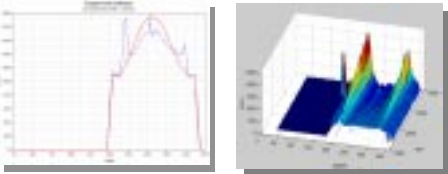 - Contacts

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User Modes

Performing the Analysis

- Standard User mode (Designer)
  - Change subsystem parameters
  - Run standard analyses
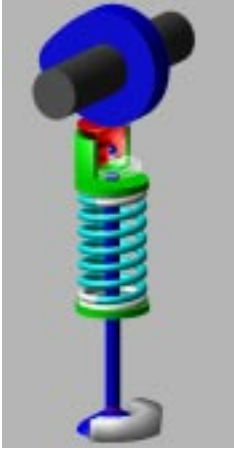 - Perform post-processing

Results (transient post processing)

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MDI's New Development Tool for Valve Train Dynamics, Timing Chain and Belt Drive

ADAMS

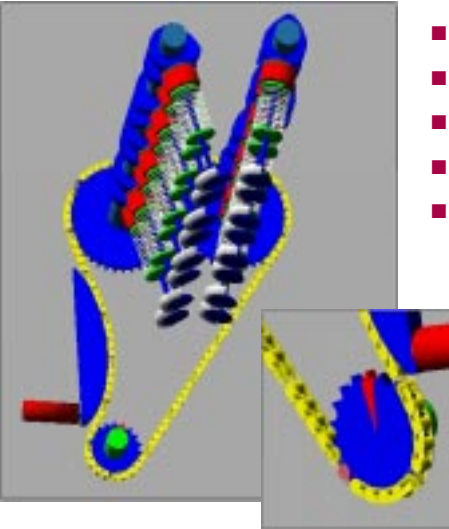### Example: Single Valve Train including Hydraulic Lash Adjuster & Multi-mass Spring

- Conceptual layout
- Verification of cam profiles
- Hertzian pressure
- Component optimization
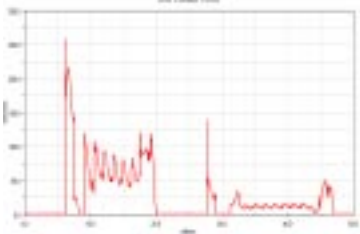- Rev. limit calculation

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Example: Timing Mechanism combined with a Complete Valve Train

- Chain Dynamics
- Tensioner performance
- Determination of load histories
- Friction losses
- Determination of critical system frequencies

Mechanical Dynamics

ADAMS/Engine

ADAMS

Example: Timing Belt Simulation

- Belt dynamics
- Belt tension force
- Determination of load histories
- Tensioner Performance
- Determination bearing loads
- Identification of critical system frequencies

ADAMS

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ADAMS/Engine
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ADAMS

What does the Customer get?

- One environment for all relevant tasks in Engine design for local and global design optimization
- Get the engine running in an operational environnement (car, truck, test-rig, ...)
- Including auxillary components (engine mounts, tensioners, ...)
- Fast simulation turn around - quick results
- Help to bridge supplier and OEM
- A commercial and maintained software product
- A modular approach for full system simulation

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Conclusion

- ADAMS/Engine is the No.1 solution to improve component structure, sub-sytem and full-system performance with respect to strength, durability and noise requirements early in the development process using one single simulation tool
- The valve train module is MDI´s first commercial offer in this field and a good starting point for virtual engine development
- Assures fast ROI due to a complete engine component library and the assistance in implementing the technology together with MDI´s and FEV´s global implementation team

A big step towards the idea of a fully "Digital Car"

Mechanical Dynamics

ADAMS/Engine

MDI's New Development Tool for Valve Train Dynamics, Timing Chain and Belt Drive