ADAMS/Engine, powered by FEV, features user interfaces specifically tuned to the standard methods and procedures of powertrain development teams. The benefit: users can quickly become productive with the software, even with little formal training.

SPECIALIZED TOOL FOR POWERTRAIN SIMULATION
ADAMS/Engine™ powered by FEV, is a software environment designed for building and testing engine concepts. It lets users quickly optimize the performance of individual powertrain components and subsystems – as well as the complete engine – at any stage of development.

ADAMS/Engine powered by FEV offers specialized solutions for simulation of valvetrains, gears, timing chains, timing belts, accessory drives, and cranktrains. These capabilities provide a powerful complement to the company’s industry leading MSC.ADAMS® family of software solutions for virtual prototyping of all automotive subsystems, including chassis, engine, and driveline.

The specialized ADAMS/Engine simulation environment enables an automotive engineering team to predict, refine, and optimize the dynamic performance of powertrain systems as part of an overall vehicle design. Users of the software can also combine their designs of individual powertrain components and subsystems into a complete engine simulation. In this way, ADAMS/Engine powered by FEV, enables engineers to solve problems of structural load, life, durability, vibration, and performance of powertrain systems within the cost, weight, and packaging constraints defined.

ADAMS/Engine powered by FEV, uses MSC.Software’s flagship MSC.ADAMS software as its core dynamic solver. MSC.ADAMS is the world’s most widely used mechanical system simulation tool, and is recognized as the de facto standard for system–level virtual prototyping in the worldwide automotive industry.
DESIGNED FOR AND BY POWERTRAIN SPECIALISTS

Development of ADAMS/Engine powered by FEV, grew out of a challenge faced by leading automobile makers. Typically, an automaker’s development engineers use distinct software tools for studying cam synthesis, valvetrain dynamics, and the performance of crankshafts, timing chains, and accessory belts. These tools are limited to specific applications and not easily combined. As a result, simulation of a complete engine has been nearly impossible, and some new valvetrain designs can’t be simulated without extensive reprogramming of the existing software utilities for example.

Historically, automotive engineering teams have used MSC.ADAMS and specialized tools such as ADAMS/Car to study vehicle dynamics and other relatively low–frequency system behavior. But simulations performed by MSC.ADAMS users and MSC.Software’s own consulting staff have demonstrated that the technology can also be successfully employed in areas characterized by high–frequency behavior — for example, powertrain systems.

In 1998, Volkswagen and Audi — approached the company about creating a specialized powertrain simulation tool. The team of companies providing guidance in this development soon expanded to include the French automaker Renault; INA, a German manufacturer of bearings and hydraulic lash adjusters; and IAV, another German company offering powertrain engineering services. More recently, the consortium was joined by Porsche, Scherdel, a German valve spring manufacturer; Cummins Engine, an American diesel engine maker; and Southwest Research Institute. In addition, FEV, a German engine consulting company, joined the group to provide additional strength in the areas of cranktrain modeling and simulation, which lead to a development partnership with FEV affecting the other engine areas as well.

The consortium members have set the goals and requirements for ADAMS/Engine, powered by FEV, while MSC.Software and FEV retain responsibility for developing and enhancing the software.

 USERS’ METHODS ARE EMBEDDED

The vision driving ADAMS/Engine powered by FEV, is to move simulation–based design, testing, and refinement right to the front of the powertrain development cycle. By providing a standardized set of simulation tools and methods, the ADAMS/Engine utilities allow a broad range of engineering departments — including design, testing, and research and development — to share engine models and data, while capturing the company’s engine design expertise in software.

Working within the ADAMS/Engine environment, an engineering team can select, refine, and optimize its fundamental designs long before physical prototypes are built. In this way, the team can:

- Identify and solve engine design problems at the earliest stages of development, when the cost of correcting mistakes is low.
- Reduce the number of physical prototypes required, saving time and money and keeping the development schedule on track.
- Produce more reliable powertrain systems, thus lowering vehicle warranty costs and improving customer satisfaction.

Since the automaker’s own standard development methods can be embedded in the software, new engineers joining the company’s powertrain team are assured of working consistently with the best available modeling, simulation, and visualization technology.
STANDARD INTERFACE OR TEMPLATE BUILDER

ADAMS/Engine users select from two operational modes:

- A standard interface, which allows users to enter data into existing design templates to run both standard and custom design tests; and
- Template–builder mode, enabling experienced users to build their own design templates from libraries of core and user–defined modeling elements.

In standard mode, a user can change subsystem parameters, run simulations, and view results in animations or plot them in graphs. Standard tests include constant RPM and RPM sweep for example. The user can also drive the system based on measured data.

The software’s standard interface also provides a virtual component test rig, allowing users to validate component designs. Standard tests for the component test rig include steady load, displacement, and frequency sweep.

In template–builder mode, the user works with these building blocks:

- Engine specific elements, including valves, cams, tappets, chains, crankshafts and others;
- Core modeling elements, such as parts, constraints, and forces.

In order to:

- Modify existing templates — for example, a generic finger–follower valvetrain or an Inline 4 cranktrain;
- Generate initial subsystems;
- Define default property files, which contain the characteristics of the elements.

BUILDING ON USERS’ SUCCESS

MSC.Software’s core MSC. ADAMS software has been successfully applied in many areas of powertrain simulation. For example, it has been used by Eaton and INA in valvetrain development; by Ford Motor Company in timing chain analysis; by Cummins Engine in the study of secondary piston motion; and by FEV in the design and testing of cranktrains to mention some of the published successes of our clients.

ADAMS/Engine powered by FEV Modeling Elements

FOR BUILDING TEMPLATES AND VIRTUAL TEST RIGS

ACCESSORY BELTS
- Belt
- Poly–V pulley

BEARING
- Linear
- Bushing
- (E)HD

CAM
- Three standard profile formats
- Easily extendable

CAM SHAFT
- Rigid
- Torsional spring connectors
- Fully flexible via MSC.ADAMS flexible bodies

CHAINS
- Roller
- Bush
- Silent (toothed)

CONTACTS
- Flat–curve, point–curve, circle–curve, curve–curve
- Point–flat, sphere in socket, sphere–flat, circle–flat, sphere–infinite cylinder
- Friction, nonlinear stiffness, lift–off
- Hertzian pressure

CONRODS

CRANKSHAFT
- Rigid, Torsional flexible, Beams
- Flexible

DYNO
- Motion/torque–driven:
  - Harmonic series
  - Constant
- User–defined (function builder)

ENGINE BLOCK
- Rigid
- Flexible

FLYWHEEL
- single mass
- dual mass

GAS FORCES
- Function interpolation

GEARS
- Helical
- Spur
- Oil film gear force

GUIDES
- Pivoting
- Translational
- Fixed

HYDRAULIC LASH ADJUSTER
- Linear characteristic
- Nonlinear characteristic
- Detailed hydraulics

PISTON

PLATE

PUSH RODS
- Rigid
- Flexible (5 beams)

ROCKER ARMS
- Four configurations

SPROCKETS
- ISO 606 profile
- Non–symmetric teeth
- Arbitrary profile

STANDARD MSC.ADAMS ELEMENTS
- General parts
- Flexible bodies
- Joints
- Friction

TIMING BELTS
- Pulley
- Trapezoidal tooth belt
- Deviation pulley

VALVE
- Rigid
- Axial flexible

VALVE SPRING
- Linear spring damper
- Nonlinear spring damper
- Multi–mass spring
- Flexible body based spring
Sample Applications

For a clearer understanding of how powertrain engineering teams can benefit from using ADAMS/Engine, powered by FEV, here are two sample user scenarios:

**OPTIMIZE GAS EXCHANGE AND DURABILITY OF THE VALVE SEAT AND CAM**

The engine development team builds a virtual prototype of the single valve train with components in their highest level of fidelity (i.e., multi-mass spring) based on data from the company’s subsystem files. The team runs simulations, then compares results of the valve displacement over RPM and crank angle with the desired displacement characteristic for optimal gas exchange.

The team then changes the cam profile to improve performance with regard to the displacement criteria and the valve seating velocity. They can also assess the Hertzian pressure against a given limit. They then build a model of the entire valvetrain to investigate the influence of torsional dynamics on the cam shaft. The fidelity level for certain components is reduced by substituting elements with lower-fidelity definitions.

**CRANKTRAIN DEVELOPMENT FROM CONCEPT TO FINAL DESIGN**

To make a decision on the fundamental concept of a new V6 engine, the developer initially has to study the influences of different V-angles and different firing orders on the engine's mass balancing in general.

Subsequently, after the rough definition of the main design data and a first estimation of the components masses, the crankshafts counterweights and the balancing shaft are dimensioned. As more and more accurate component properties become available the model is refined using hydrodynamic bearings and a beam crankshaft. All those modifications and model refinements may be done just with a few mouse clicks.

The refined model quickly delivers nominal crankshaft stresses and bearing orbital curves that allow first evaluations about the component's durability.

Meanwhile, the structural department delivers a first FEA mesh of the crankshaft, which can easily be included into the existing ADAMS/Engine subsystem as the next level of refinement. Stresses can now be calculated more accurately, also including the gyroscopic effects of the flywheel.

Including a flexible crankcase into the model allows first NVH predictions based on realistic structure born noise excitations.

With ADAMS/Engine users can model roller, bush and silent chains in connection with entire valvetrains. Virtual positioning of sprockets and guides is possible. Chain properties such as pitch, pitch to back, width, mass, and inertia can be specified through the interface.

To find your local MSC.Software office or to learn more about our company and our products, please contact:

**Corporate:**
MSC.Software Corporation
2 MacArthur Place
Santa Ana, California 92707 USA
Tel: 1 714 540.8900
Fax: 1 714 784.4056

**Customer Care Center:**
1 800 642.7437 (U.S. only)
1 978 453.5310 (International)
customer.care@mscsoftware.com

**Worldwide Web -** www.mscsoftware.com
**On-line Purchases -** www.engineering-e.com

MSC ADAMS is a MSC.Software Enterprise family product.

MSC and the MSC.Software logo are registered trademarks of MSC.Software Corporation.

ADAMS, ADAMS/Car, ADAMS/Engine, MSC, and MSC ADAMS are trademarks of MSC.Software Corporation or its subsidiaries in the United States and other countries.

All other trademarks are the property of their respective owners.

© 2003 MSC.Software Corporation
ADAM*12-02*ENG*Z*LT-DAT