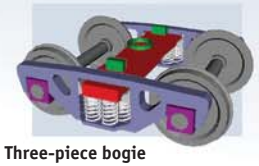
Simulation of railway vehicle dynamics

Universal Mechanism software includes module for simulation of railway vehicle dynamics: locomotives, freight and passenger wagons, etc.

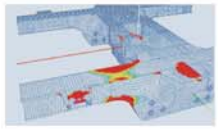
More than 40 models of various railway vehicles were created. There are diesel and electric locomotives, passenger cars, freight wagons, railcars, subway wagons and trams.

UM Loco allows the user to create fully parameterized models of vehicles. Geometrical, inertia and force parameters may be specified using identifiers. The parameterization of a model is the base for effective analysis and optimization of its dynamical behavior.

The module allows the user to calculate the critical speed, analyze 3D dynamics of a vehicle or a train in time domain on straight track or curves with/without irregularities, analyze vehicle dynamics depending on wheel and rail profiles, compute natural frequencies and modes as well as root locus, create hybrid rigid-elastic models of vehicles and then estimate stress state and damage sum.



Three-piece bogie



Damage of bogie frame

Only two months were required for specialists of All-Russian Research and Design Railway Institute to develop a library of UM-models of 17 locomotives. Such a rapid development is made possible due to new advanced technologies implemented in UM40. For example import of images from CAD program was widely used. The library is aimed for carrying out complex researches of its dynamics and especially safety analysis.

List of additional modules

UM includes kernel and number of additional task-oriented modules:

CAD interfaces ● import of geometry, inertia parameters of rigid bodies and mates from SolidWorks, Autodesk Inventor, and Kompas 3D.

UM Caterpillar ● additional module for simulation of caterpillar dynamics.

UM Optimization ● additional module which is intended for parametrical scanning of the dynamical behavior and optimization.

Service of distributed calculations ● This service extends possibilities of the UM Optimization module. It allows using any computer in a local or global network for parallel numerical experiments.

UM FEM ● additional module for including elastic bodies into models. FE-meshes from ANSYS and NASTRAN are supported.

UM Control ● Matlab/Simulink interface. It gives a possibility to introduce Matlab/Simulink schemes (control, electrodynamics, hydraulics) into UM models.

UM Durability ● additional module for fatigue analysis.

UM Train\Train 3D ● additional module for simulation of train longitudinal dynamics.

UM Rail\Wheel Wear ● additional module for prediction of evolution of railway wheel profile due to wear.

UM Ballast ● additional module for simulation of dynamics of granular media systems in 2D.

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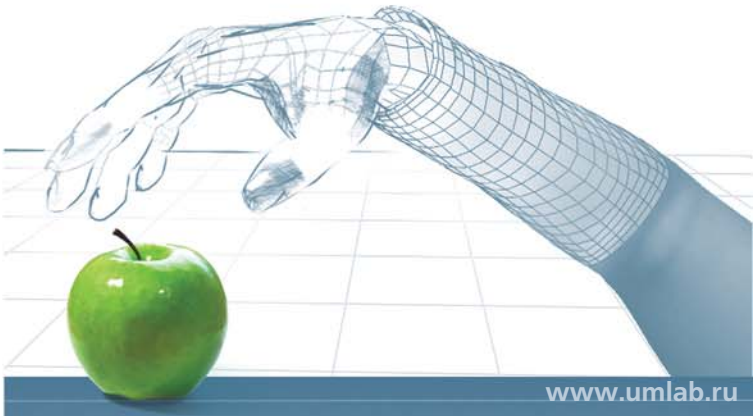
Universal Mechanism

Simulation of dynamics of mechanical systems



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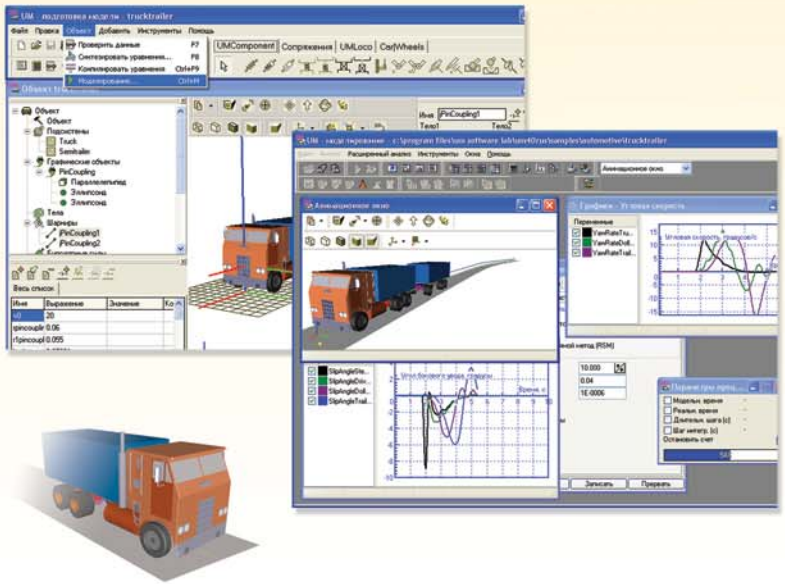
Program package “Universal Mechanism”

is intended for simulation of kinematics and dynamics of planar and spatial mechanical systems.

The program is oriented to practical engineers, students and teachers; in other words it is oriented to all people who are involved in problems of dynamics of machines and mechanisms. Mechanical systems are described by means of representing them as systems of rigid bodies connected by various kinematical pairs and force elements, so-called multibody systems.

Online animation of motion and plots of dynamical performances are available during simulation. There are lots of measurable dynamical performances of mechanical systems: **linear and angular coordinates, velocities and accelerations, active forces and moments, reaction forces etc.**

UM has an advanced postprocessor, which includes linear analysis, statistics, optimization, and export of results. UM is a useful tool for the computer-aided modeling of multibody and hybrid systems of various types: complex aerospace structures, robots, railway vehicles, automobiles, cable systems, etc. It gives an opportunity to solve both the direct and inverse kinematic, dynamic, and control problems. There are special prices of UM for scientific and educational purposes. UM includes kernel and number of additional task-oriented modules: **UM Automotive, UM Loco, UM CAD Interfaces, UM FEM, UM Optimization, UM Control and others.**

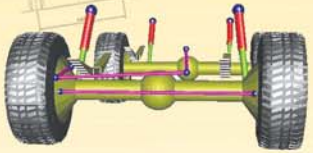


Workflow

1. *Initial mechanical system: problems and aims.*

2. *Preparing the input data for the model. Choosing a conception and scheme of the model.*

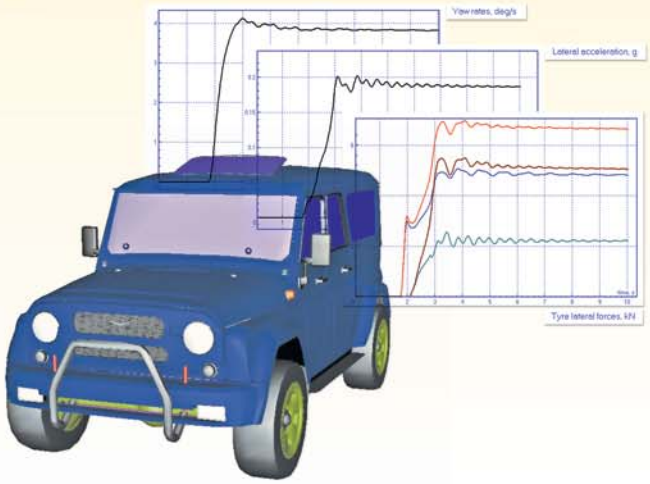
3. *Creating bodies, joints and force elements. Parameterization of the model.*



4. *Automatic generation of equations of motion.*

$$M(q)\ddot{q} + k(q,\dot{q}) = Q(q,\dot{q},t)$$

5. *Simulation of the dynamics of the model. Analysis of results and parametrical optimization.*



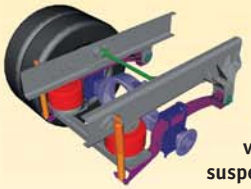
Road vehicle dynamics

UM Automotive widens the functionality of UM Base configuration and includes several tire models, some program tools for road plan and road profile description and a library of **suspensions, steering systems and elements of transmission.**

The module includes three tire models, which describe dynamical forces and torques between a wheel and a road. Implemented models are widely used for simulation of vehicle dynamics and provide accurate solution in the case of adequate setting their parameters. UM Automotive includes the following tire models: **Magic formula; Fiala, table/experimental data.**

UM Automotive contains a tool for description of a road profile, which supports several ways to describe the irregularities:

- pointwise input (for measured data);
- analytical expressions;
- synthesis of the road profile based on its spectral power density.



Heavy vehicle suspension

Several files with spectral power density of typical road surfaces and corresponding road profiles are included in the module. They are: concrete, asphalt in good and satisfactory condition, and cobblestone road.

Several mathematical models of a driver and a set of typical maneuvers such as **straight-ahead braking, double lane-change, braking in a turn, power-off reaction of a vehicle in a turn, power-off in turn, steady-state circular driving behavior and others** (including ISO standards) are available. Analysis of vehicle dynamics with the help of such wide set of typical maneuvers helps you have a clear idea of dynamical behavior of the vehicle.

Grader