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What's new in UM 5.0



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New features and possibilities in UM 5.0 are considered in the present paper. Some of described below features were published in intermediate 4.x releases, but most part of them is available exactly in UM 5.0.

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UM Base

New possibilities in UM Input program

1. External libraries. Now you can develop your own dynamic-loaded library (DLL) with, for example, a mathematical model of a force to introduce such a model to your mechanical system. To develop the library you can use any program environment that supports generation DLL-files. Along with *Matlab/Simulink* interface it is a powerful tool to describe your own complex force models or models of controllers or active devices.
2. New type of force element 'Scalar torque' is introduced. The element describes a torque, which appears by rotation of second body relative to axis fixed relative to the first one. The list of mathematical models describing value of the torque in dependence on the angle of rotation and angular velocity coincides with the corresponding list of a joint torque.
3. New types of contact forces:
 - Contact interaction based on graphical objects of rigid bodies is now supported. The current version supports arbitrary convex closed polyhedrons.
 - Contact interaction of a point-curve with an advanced description of a 3D curve type has been developed.
 - Functionality of *Points/Circle/Sphere – Z-surface* was extended. Now Z-surface can be described as a graphical object including imported from external CAD-programs.
4. There following new types of scalar force are introduced:
 - *Impact* – the force element that model bump stops.
 - *Library (DLL)* – mathematical model of a force is described in dynamic-loaded library as $F=f(x,v,t)$, where x is a length of the element, v is a velocity of changing of the length of the element and t is time.
5. A number of standard functions (22) are now available for description of position-, velocity-, time-functions. List of functions/variables allows to program complex expressions. There following functions among these standard ones:
 - *coordinate* (coordinate and its derivatives by joint name or number of coordinate);

- dm, vm, wm (distance between points of different bodies, its first and second derivative);
 - dx, dy, dz (projection of vector between two points of different bodies on axis of any coordinate system);
 - $yaw, roll, pitch$ (angles of rotation of one body relative to other one).
6. *T-forces* and scalar forces of *Expression, Points (numeric)* and *Points (symbolic)* types now can be expressed via functions described above in Sect. 1.4. This tool significantly extends possibilities to describe forces with the help of built-in tools without programming in a *Control file* or using *External libraries*.
 7. *Periodical function* key was added for scalar forces of *Points (numeric)* and *Points (symbolic)* types. It allows for example to describe indicator diagram of forces in internal-combustion engines.
 8. *Constant velocity (CV)* joint was introduced. It determines equal angular velocities of two inclined axles.
 9. Description of 6-d.o.f. joint was extended. Now it is allowed to introduce degrees of freedom relative to inclined axis.
 10. The function of conversion of *Translational, Rotational* and *6 d.o.f.* joints to *Generalized joint* is now available. It might be useful to add some degrees of freedom or joint forces.
 11. Fictitious body "*Ground*" without inertia parameters, graphical object and degrees of freedom can be optionally introduced. This body can be used for assigning of attachment points.
 12. Now you can use lists of expressions in *Parametrical* graphical elements.

There are some new interface possibilities in UM Input program

1. Context menu of the list of identifiers now includes two new menu commands: *Show elements including identifier* that allows the user to get the list of all elements of the model that are expressed via selected identifier, and *List of unusable identifiers*.
2. As well as if any parameterized expression now has *Find identifier* context menu command where you can see the list of identifiers and turn to anyone of them.

The first version of ADAMS – UM converter is now available

New possibilities and modifications in UM Simulation program

1. The new option *Keep decomposition of iterative matrix* was added. It helps to significantly increase simulation time for some complex dynamical models.
2. The new tool *Constrains for initials* allows the user to determine ratio between different initial coordinates and/or velocities. Particularly it can be used to set initial velocity of one body equal to initial velocity of another one.
3. Setting of *Park* method numerical integration of equations of motion now includes *Minimal step size* that can be useful to accelerate simulation process for some mechanical systems.
4. There are some changes in the user interface.

UM Loco

1. Full parameterization of external conditions for railway vehicles was introduced in UM 5.0. Now you can scan dynamical behavior of railway vehicles depending on the following external conditions:
 - irregularities;
 - factors for vertical and lateral irregularities;
 - rail inclination;
 - rail and wheel profiles;
 - stiffness coefficients of rails;
 - defects of radii;
 - parameters of models of contact interaction between wheels and rails;
 - railway track configuration.Such a parameterization helps a user to increase efficiency of using scanning projects. The previous UM version allows varying in the scanning project the model parameters only.
2. Torsion stiffness of rails was added into mathematical model of the railway track. The previous version took into account the vertical and lateral stiffness coefficients.
3. The list of variables for railway vehicles was enlarged. The following variables are added:
 - frame forces;
 - combined safety factor;
 - lateral and vertical rail displacements due to wheel and rail interaction;
 - derivative of rail irregularities;
 - lateral position of rails that considers flange clearance, lateral irregularities and elastic displacements of rails.
4. The new tool *Constrains for initials* allows the user to determine ratio between different initial coordinates and/or velocities. For example, it can be used for setting initial conditions of a rotor of a traction motor and a pinion of a reducer in the case if they are interconnected with a flexible coupling.
5. New possibilities for defining determinate railway track irregularities are implemented in UM 5.0. It is recommended to use determinate irregularities for determination worst combinations of lateral and vertical irregularities from point of view of safety factors.
6. Data base profiles were supplemented by Northern American wheel profiles *AREMA 115, 119, 132, 133, 136, 141* and rail profile *AAR*.
7. Defects of radii can be now specified both for left and right wheels of a wheelset.
8. A technique for external programming of mathematical models of shock absorbing devices based on *external libraries* was implemented in the new UM version.

9. A technique for simulation of braking force was implemented, correspondent visual components were added.
10. Essentially renewed full and simplified models of freight cars with three-piece bogies have been developed.
11. Built-in models of traction devices are developed. A technique for description of 3D models of trains has been implemented.

UM Train3D

1. User's manual to the module has been developed.
2. Model templates for automatic couplers as well as coupling system with buffers have been created.
3. Methods for automatic inclusions of 3D tractive connections in a train have been realized.

UM Experiments

1. There are number of improvements in user interface.
2. Support of huge projects of hundreds and thousands of numerical experiments was improved.
3. A possibility to run several numerical experiments on one UM cluster client. It gives a possibility to treat computers with a multi-core CPU more efficiently.
4. Full parameterization of external conditions for railway vehicles including irregularities, profiles, track macrogeometry and so on is now supported.
5. Export of scanning results for analysis in UM Durability module.

UM Wheel/Rail Wear

1. Calculation of rail profile evolution was added
2. Re-calculation of run based on volume or maximal wear
3. Postprocessor now includes diagram of wear rate in dependence on number of iterations

UM Control

1. *Matlab* releases R2007x, R2008x are now supported.

UM FEM

1. Data import from *MSC.NASTRAN* is now fully supported.
2. The possibility to import data for calculation of stress-stress state of finite elements was implemented.
3. *Wizard of variables* now contains new types of variables that allow calculating components of tensor of stresses and strains in nodes as well as principle and von Mises' stresses/strains.
4. Contact interaction between two flexible or flexible and rigid bodies was realized.
5. Now coordinates of attachment points for joints and force elements on flexible bodies can mismatch node position. In other words now you can apply force on any position on the flexible body you want without taking into account FE-mesh.

UM CAD Interfaces

1. Interface for *Autodesk Inventor* is available.
2. Interface for *Pro/E* is available.

UM Durability

1. Stress type selection for each of the sensor groups was realized. Previously it could be set only for all sensor groups.
2. Stress-time realization evaluation algorithm was accelerated.
3. Control area concept is now used for description of sensor groups with equal fatigue resistance properties. One can set any number of control areas from the host of sensors formed during the stress loading analysis. Previously fatigue resistance properties were associated with the sensor groups.
4. S-N method was realized.
5. Interface redevelopment. Evaluation results output speed does not depend on the number of sensors.