RECURDYN

V9R1 New Functions

Brant Ross, Inho Song, Sangtae Kim

MotionPORT

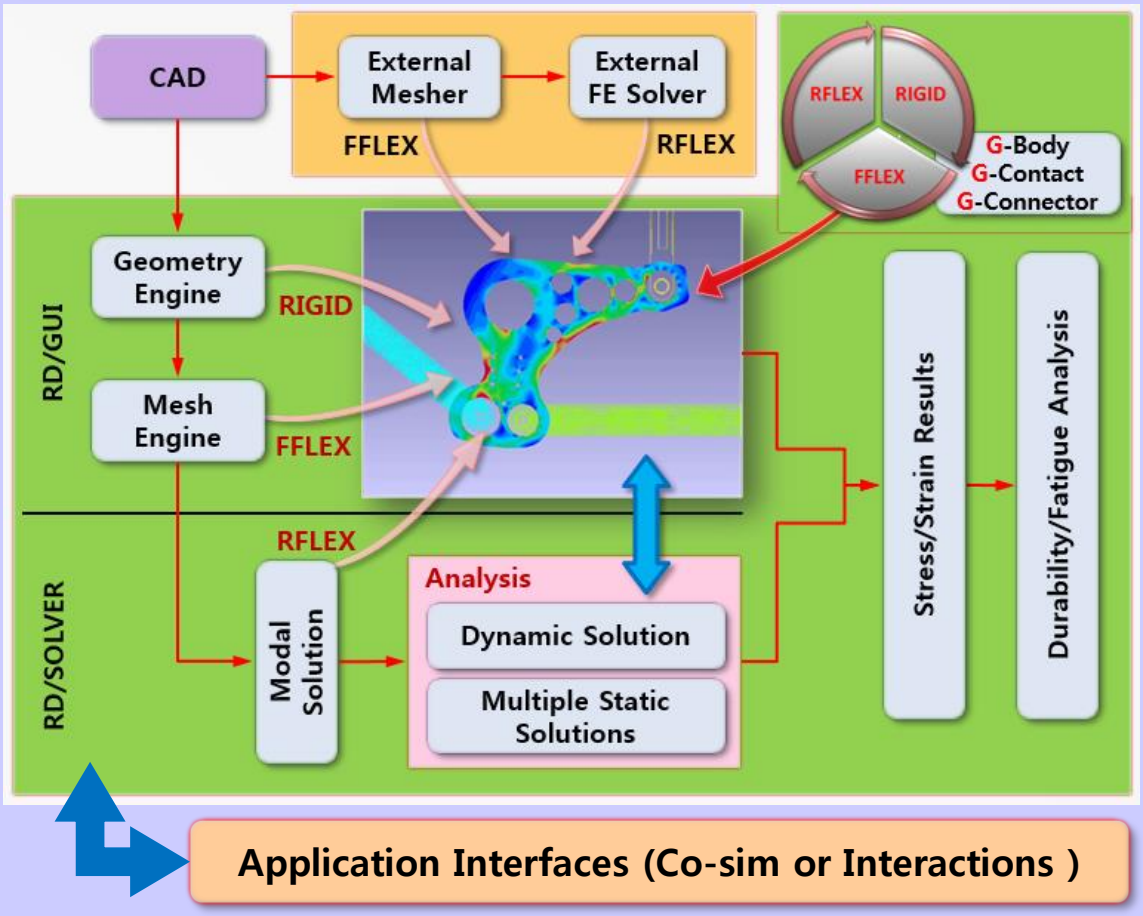
FunctionBay

II. RD Product Strategy of V9

1. Development Strategy of V9

Best RecurDyn Ever !!!

Powerful & Fast MFBD with G-Modeling



FEA Enhancement

1. Enhanced **Mesher**
2. Enhanced **FEA**
3. Thermal Deformation

Solving Performance

1. C++ Structure (**RSolver**)
2. **Parallel** Computing (HPC)
3. Enhanced **Contact** Analysis

Application Interface

1. Solid/Fluid **Particles**
2. **FMI**
3. Kisssoft or BearinX **Interface**

Post-Processing

1. Powerful **Post** Functions
2. Standalone **Plot**

Index

I. RecurDyn V9R1 New Functions

1. RecurDyn Development Environment Upgrade
2. Easy & Efficient Modeling Enhancement
3. MFBD Enhancement
4. Solving Performance
5. Application Interface
6. Toolkits

RecurDyn V9R1 Development Environment Upgrade

❖ RecurDyn Development Environment Upgrade

: Visual Studio 2010 → Visual Studio 2015

1) GUI Environment Upgrade
   A. Compiler & Library Version Upgrade
   B. Parasolid Kernel Version Upgrade : V24 → V29
   C. FlexNet Version Upgrade : v11.13.1.2 → v11.14.0
   D. CAD(InterOp) Translator Upgrade : InterOp R25 Sp1 → 2017.1.0(R27)

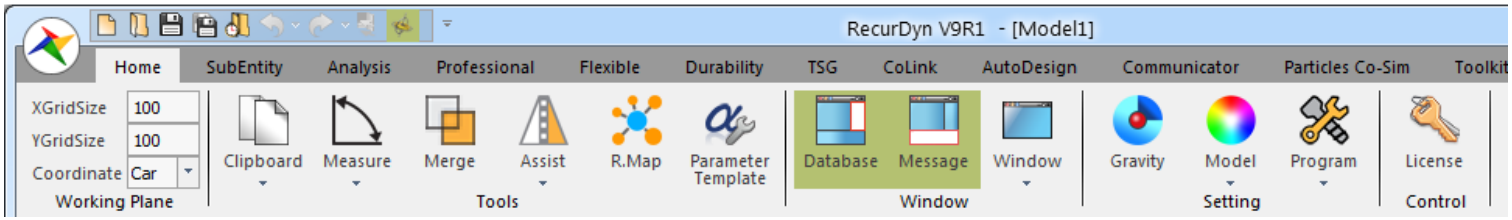
2) Solver Compiler & Library Upgrade
   A. Intel Fortran Compiler Version Upgrade
   B. MKL(Math Kernel Library) version upgrade

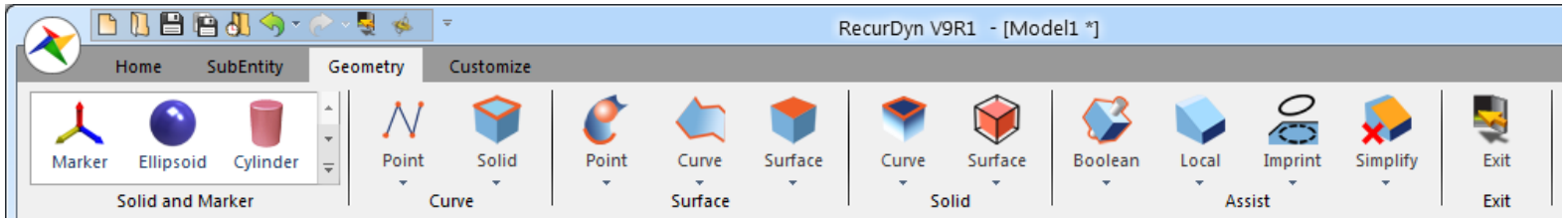
❖ Therefore, ***RecurDyn V9R1*** can fully Support for ***Windows 10***

1. Easy & Efficient Modeling

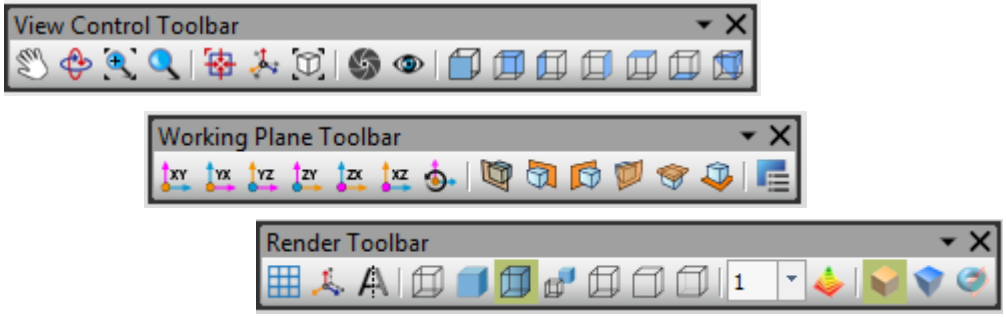
Easy & Efficient Modeling and Analysis

- V9R1 GUI
  - Layout Design Improvement
    - ✓ Windows 10 Style Design
    - ✓ Big Icon Style Design





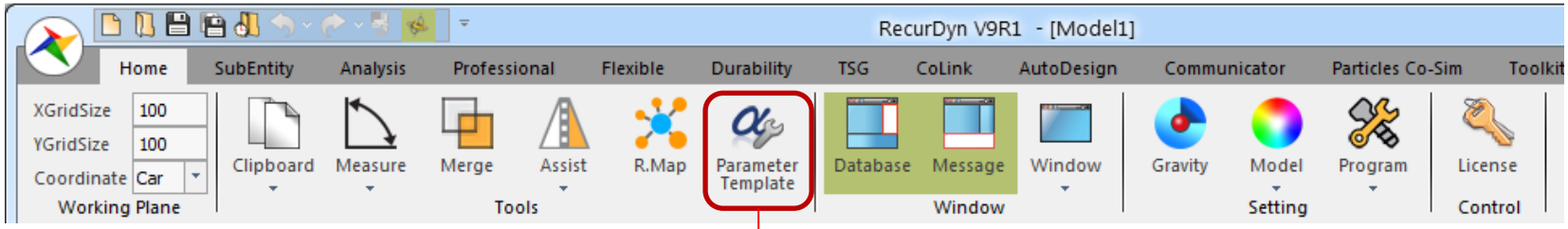
- ✓ Toolbar re-arrangement

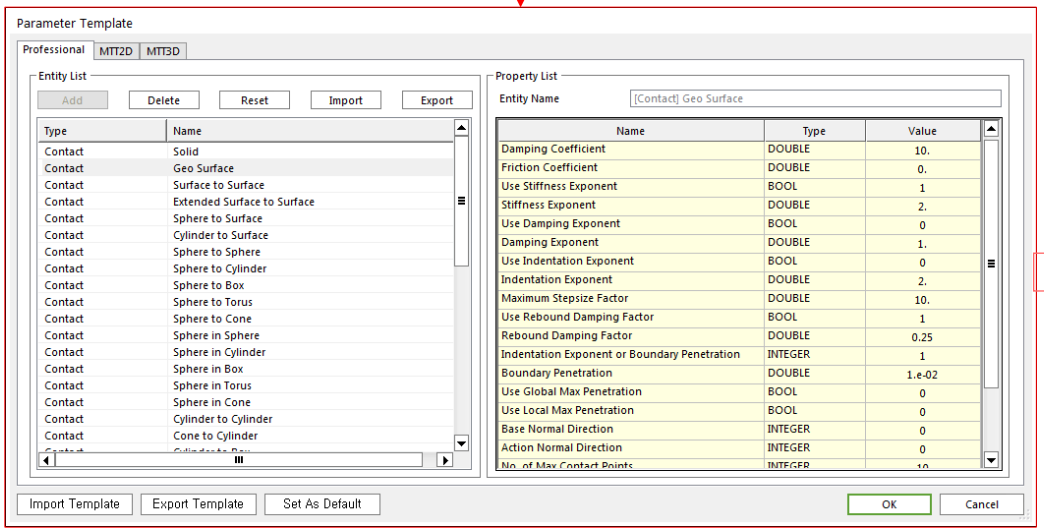


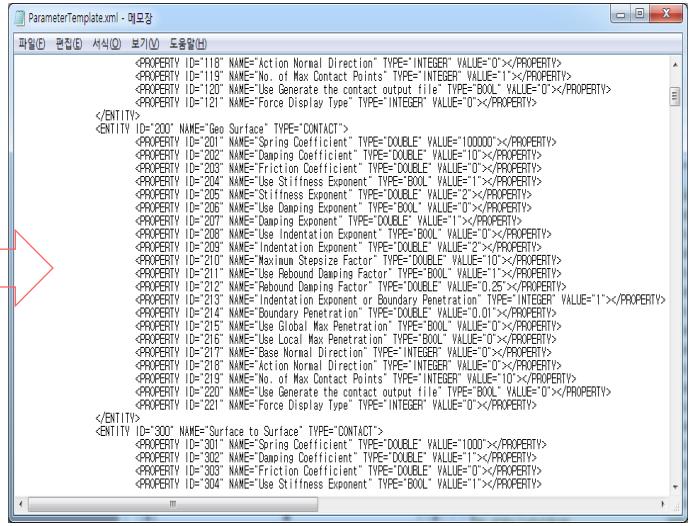
Easy & Efficient Modeling and Analysis

❖ Parameter Template

➢ This function can modify the default parameter settings by user. For example, user can set the default parameters such as contact stiffness/damping value as user's own values. And also, it supports the text file format, too.

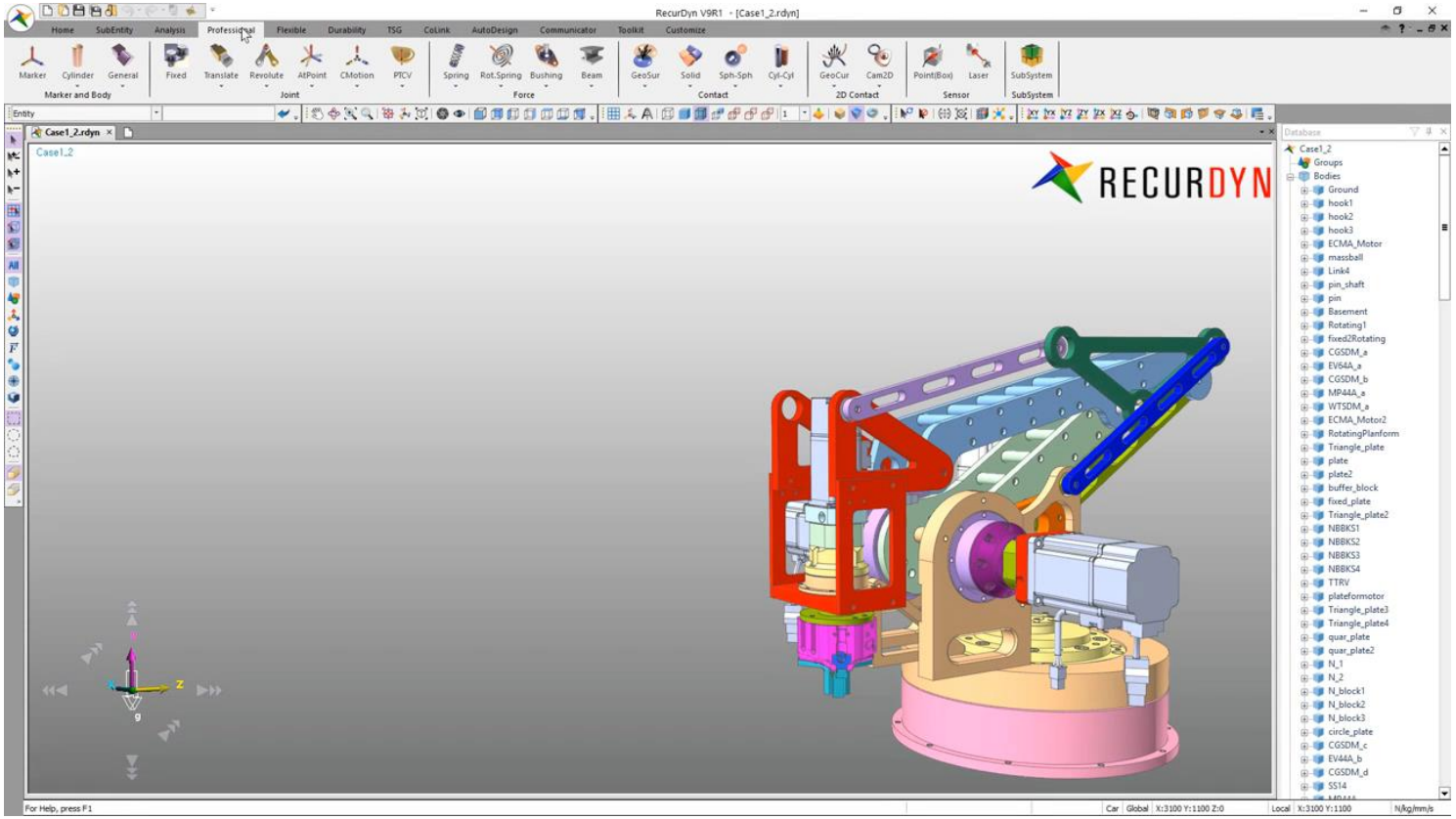






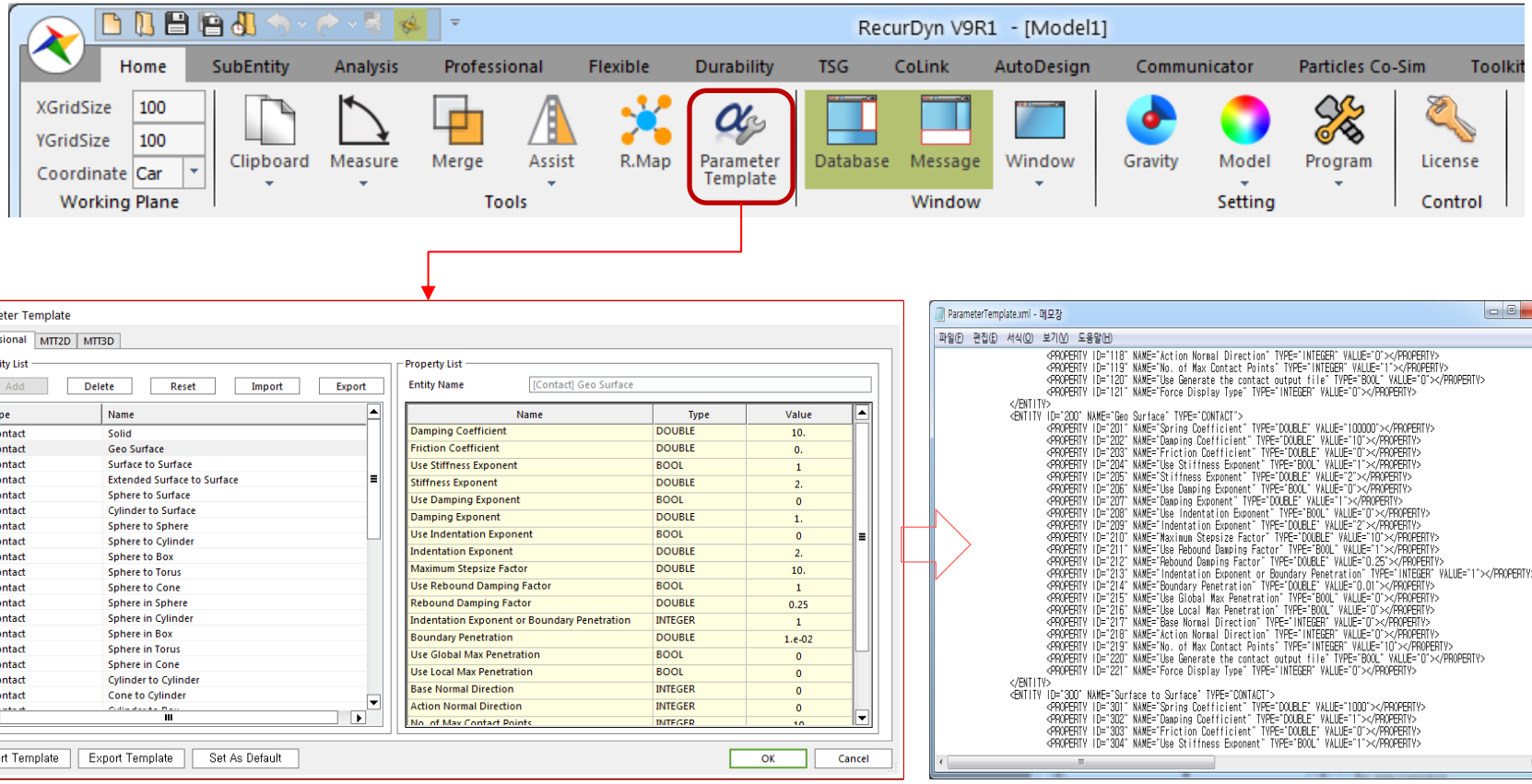
Parameter Template

- user-define ‘default values’ can be used.
- Parameter Templates can save a lot of time, reduce the mistakes
- improve the effectiveness of collaboration at work.



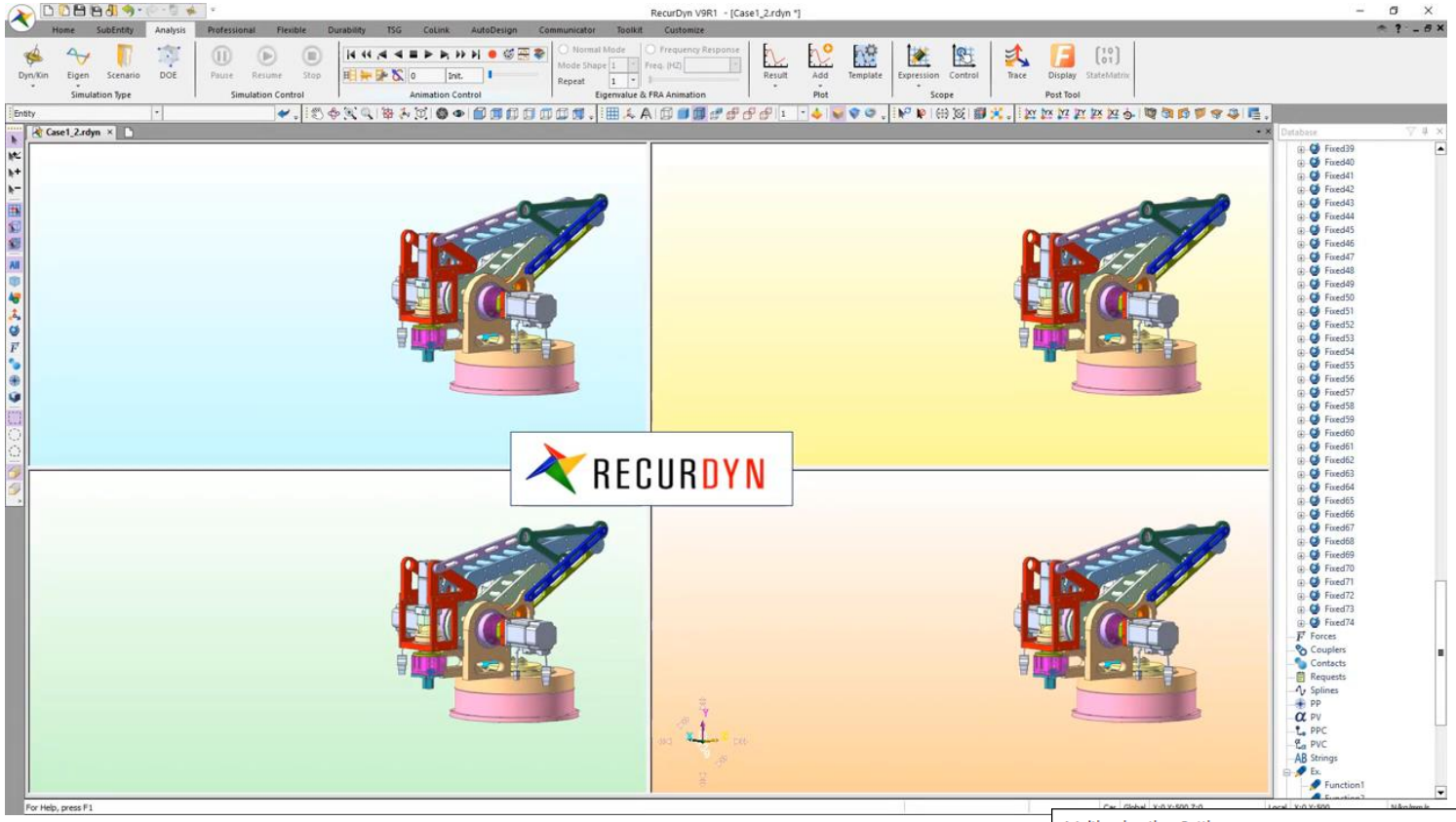
Parameter Template

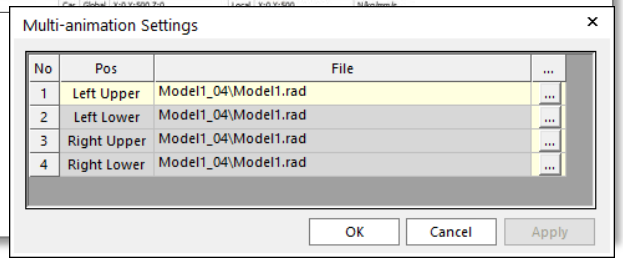
- user-define ‘default values’ can be used.
- Parameter Templates can save a lot of time, reduce the mistakes
- improve the effectiveness of collaboration at work.



Easy & Efficient Modeling and Analysis – Multi-Animation

- Up to four animations can be simultaneously viewed
- Easier comparison of the motion of multiple simulations

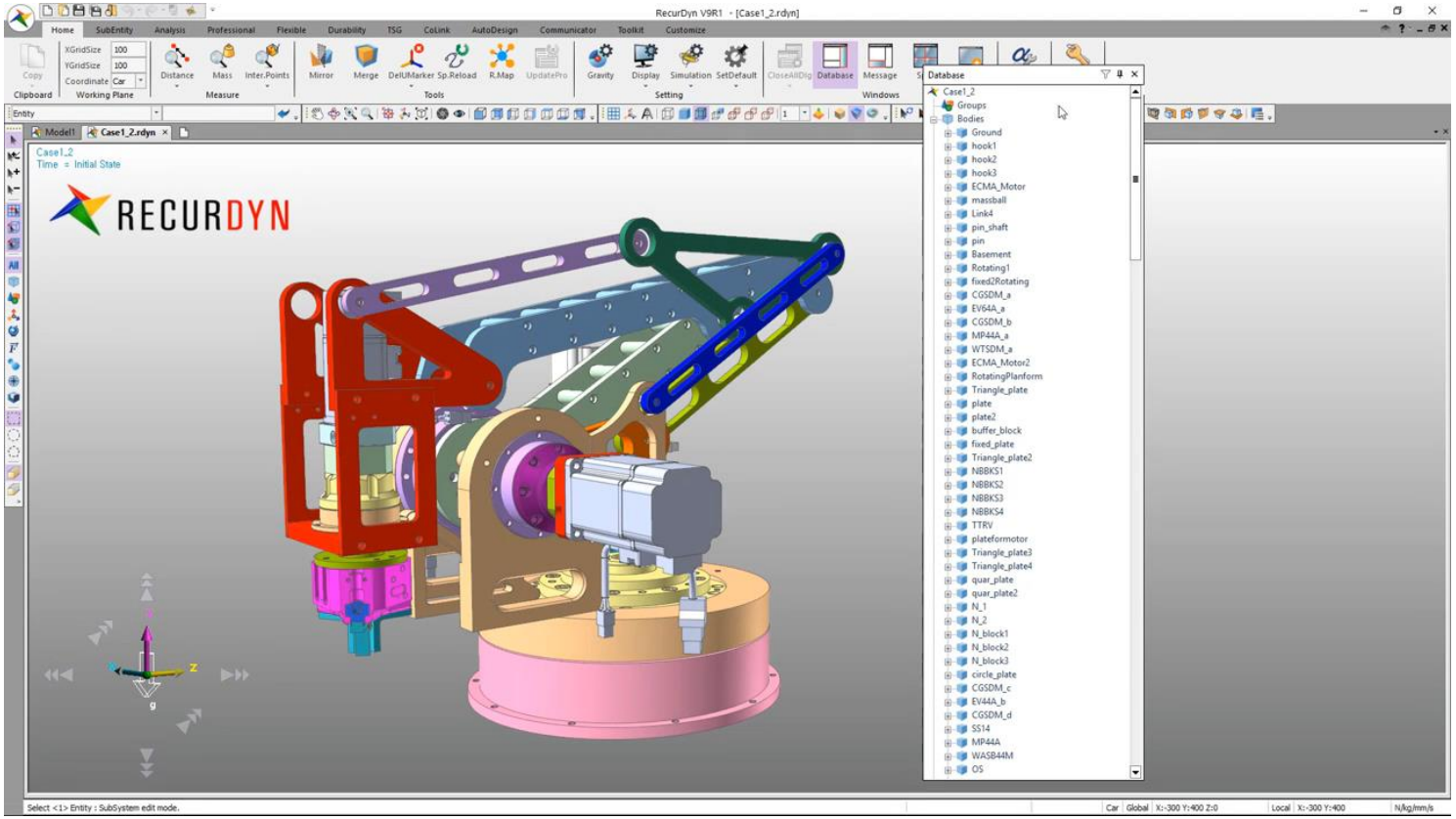




Easy & Efficient Modeling and Analysis

Database Filter

- The list of entities in the database can be simplified.

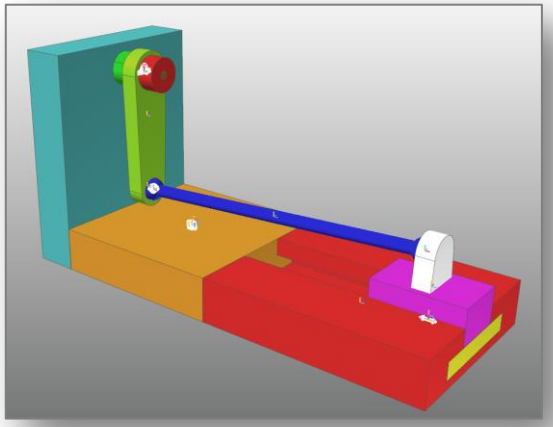


Easy & Efficient Modeling and Analysis

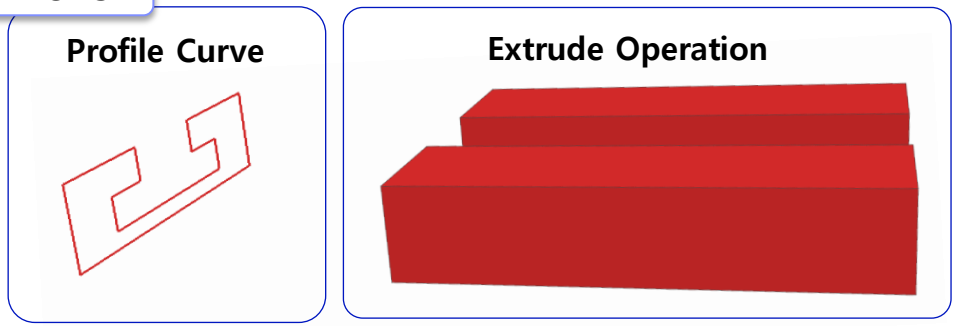
❖ **Body-Edit Mode Enhancement(1/4)**
: In V9R1, many functions of Body-Edit mode are developed. So, user can easily create or modify the their CAD geometry data in RecurDyn V9R1.

➢ **General Geometry Handling**

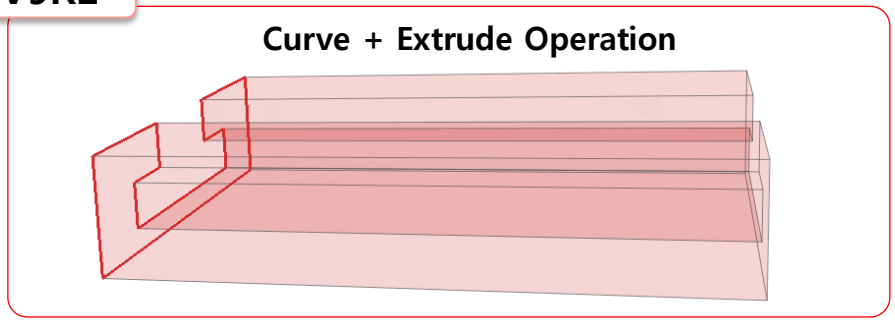
- **Removed Profile Mode in V9R1**
- **Extrude, Spin, Sweep Functions are available by General Curve**



V8R5



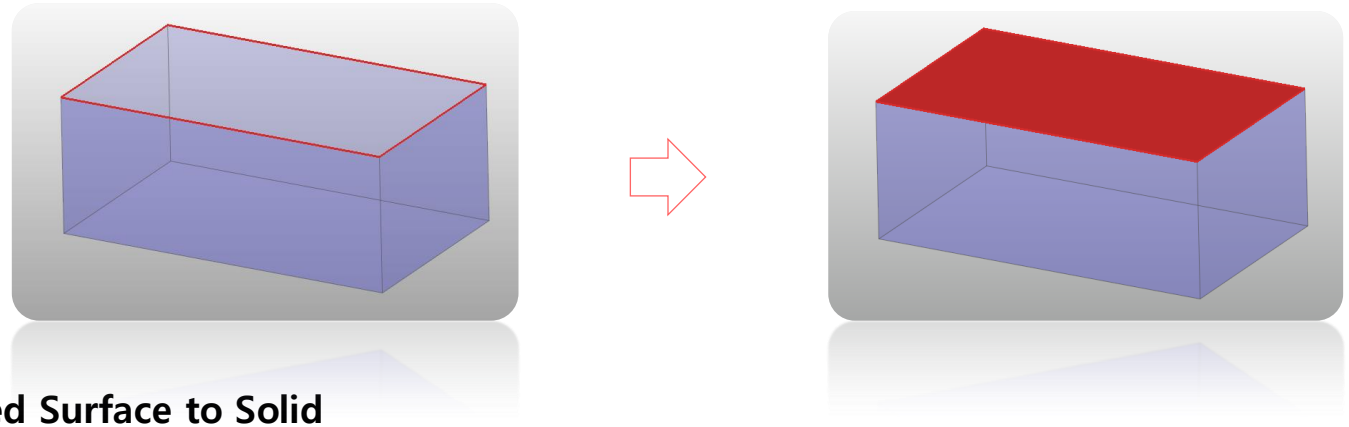
V9R1



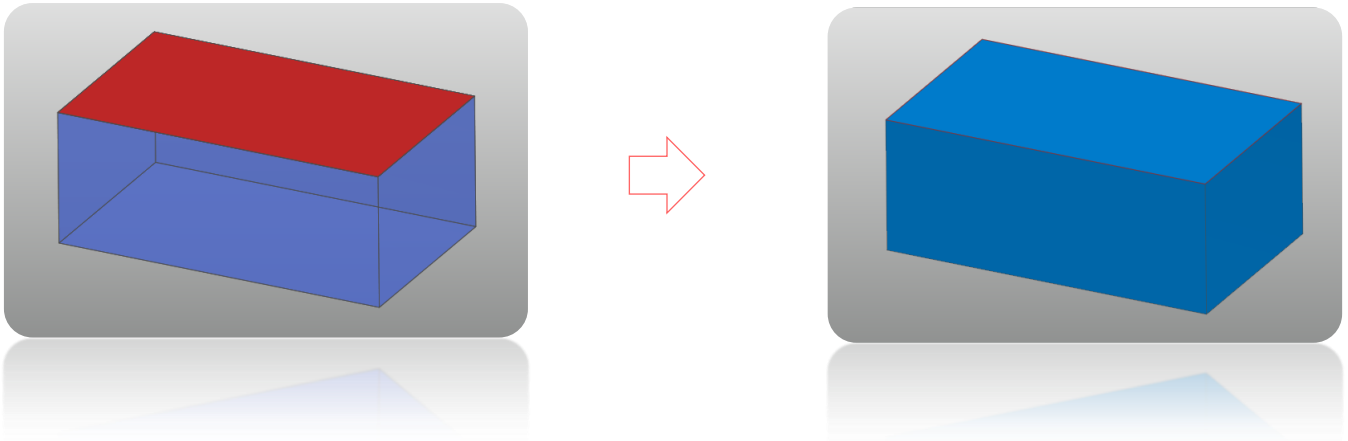
Easy & Efficient Modeling and Analysis

❖ Body Edit Mode Enhancement(2/4)

➢ Closed Curve to Surface



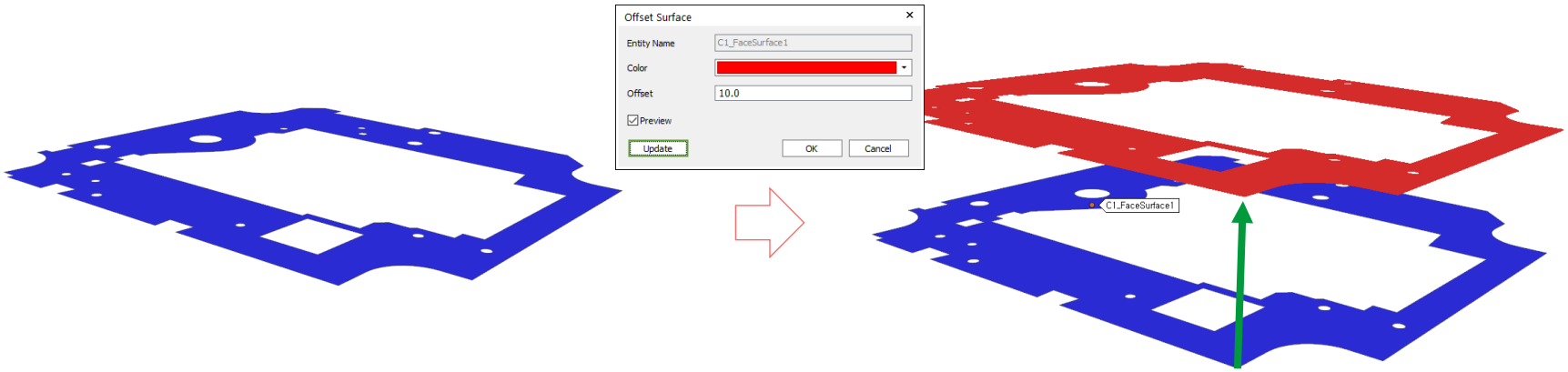
➢ Closed Surface to Solid



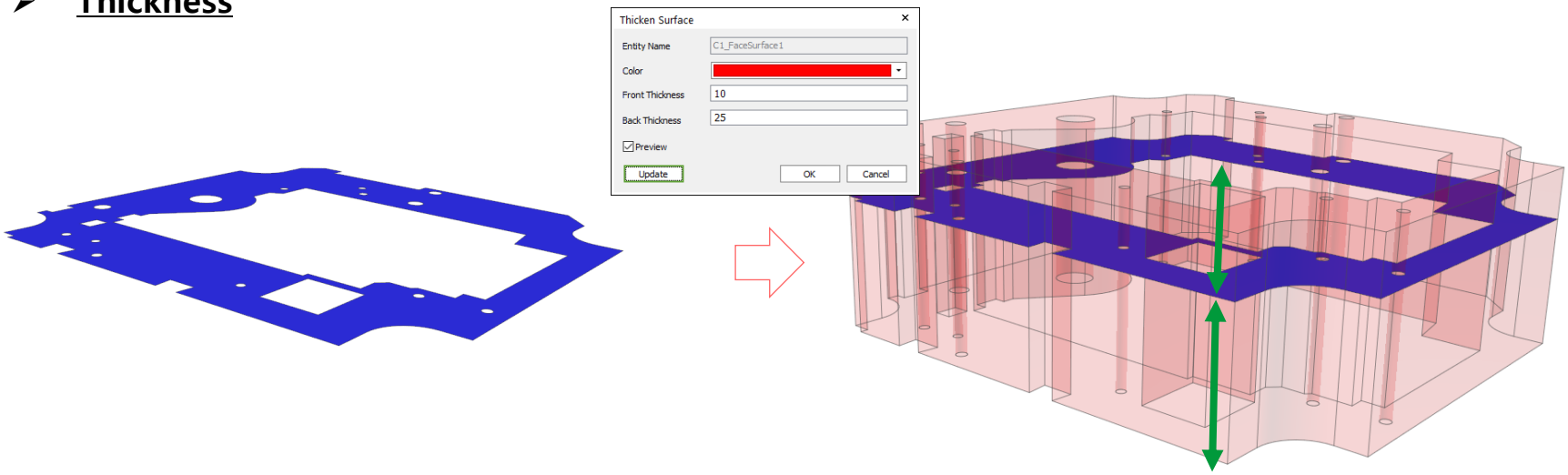
Easy & Efficient Modeling and Analysis

❖ Body Edit Mode Enhancement(3/4)

➢ Offset Surface



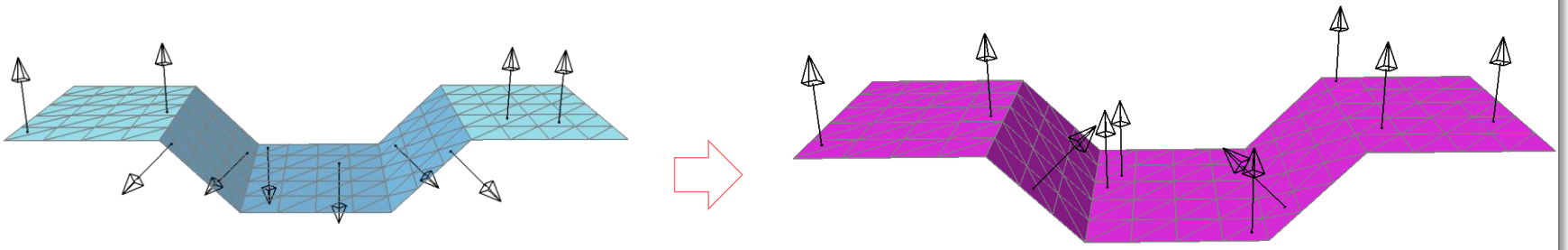
➢ Thickness



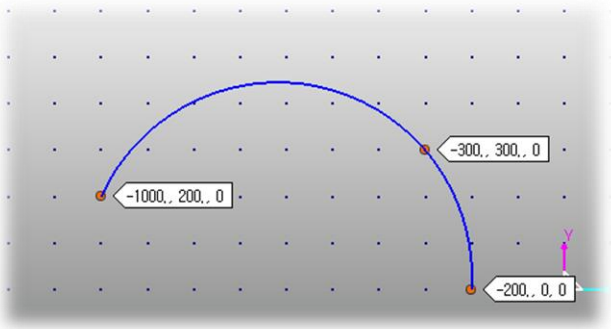
Easy & Efficient Modeling and Analysis

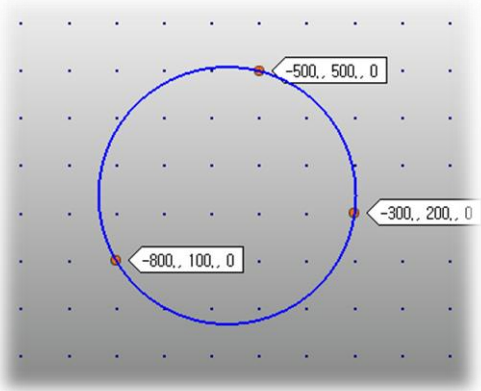
❖ Body Edit Mode Enhancement(4/4)

➢ **Surface Sewing**
: This function unifies the normal direction when the surfaces have different normal direction



➢ **3-Points Arc & Circle Creation Method**
: When user don't know the center point of Arc/Circle, user can create the Arc/Circle using these 3-Points Arc





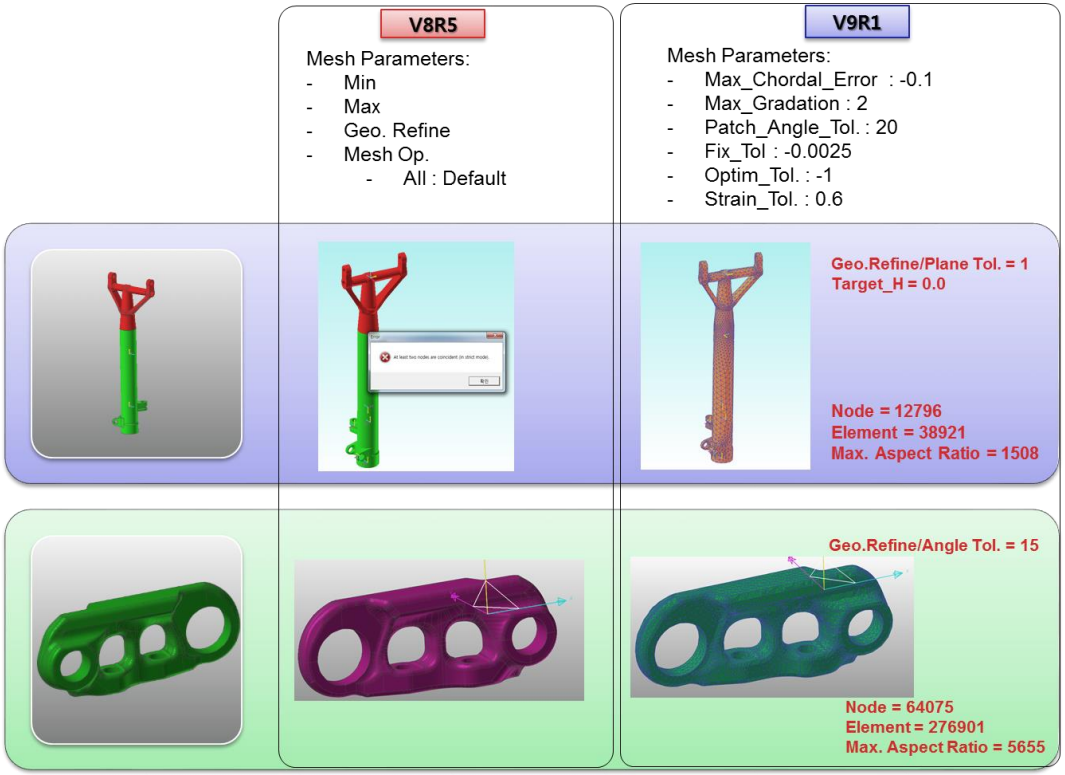
2. MFBD Enhancements

MFBD Enhancement

❖ Mesher Enhancement (1/4)

➢ Robust Auto Mesh

- Mesh Core is upgraded, therefore user can get the more reasonable mesh quality
  - 32bit → **64bit**
  - Mesh Core Version : 4.4.0 → 4.7.0
  - More advanced mesh options and more acceptable default values
  - **Remesh and MIN/MAX** mesh size will be applied more accurately

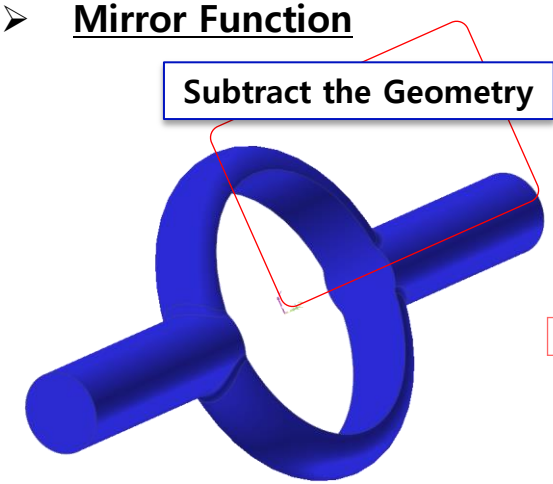


MFBD Enhancement

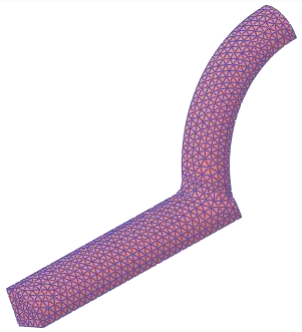
❖ Mesher Enhancement (2/4)

➢ Mirror Function

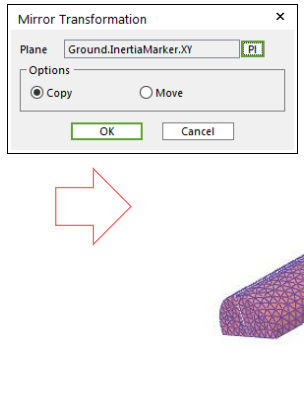
Subtract the Geometry

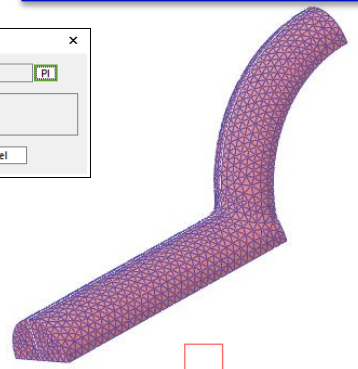


Mesh 1/8

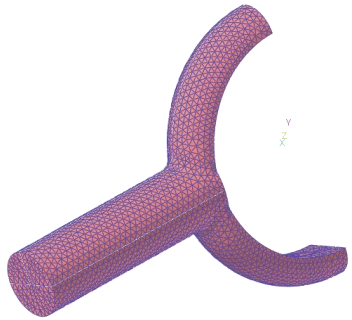


Make ¼ by Mirror

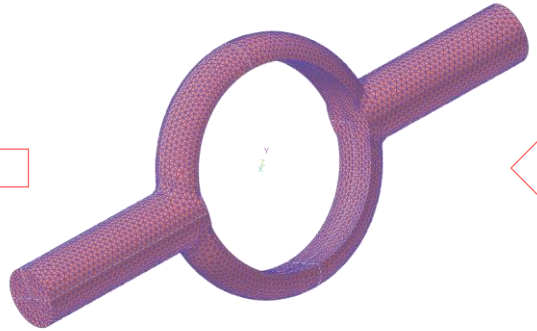




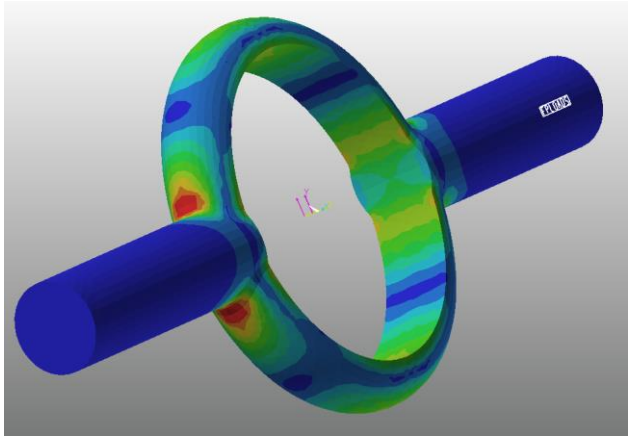
Make ½ by Mirror



Make whole by Mirror

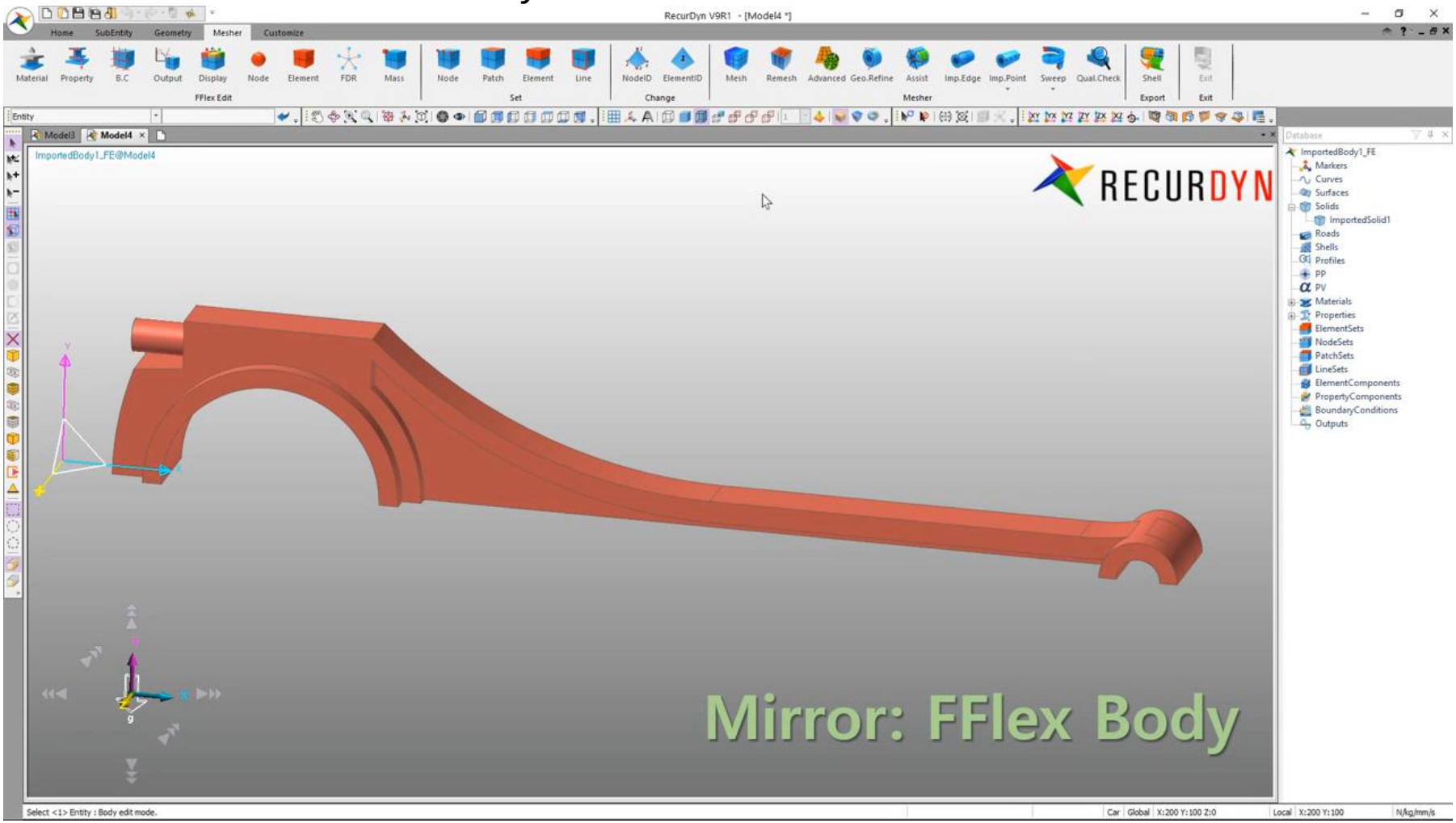


Make FFlex by Merge



Enhanced FFlex Body handling

- Modification of the elements (Creation, Modification, Deletion)
- Mirror of the FFlex Body

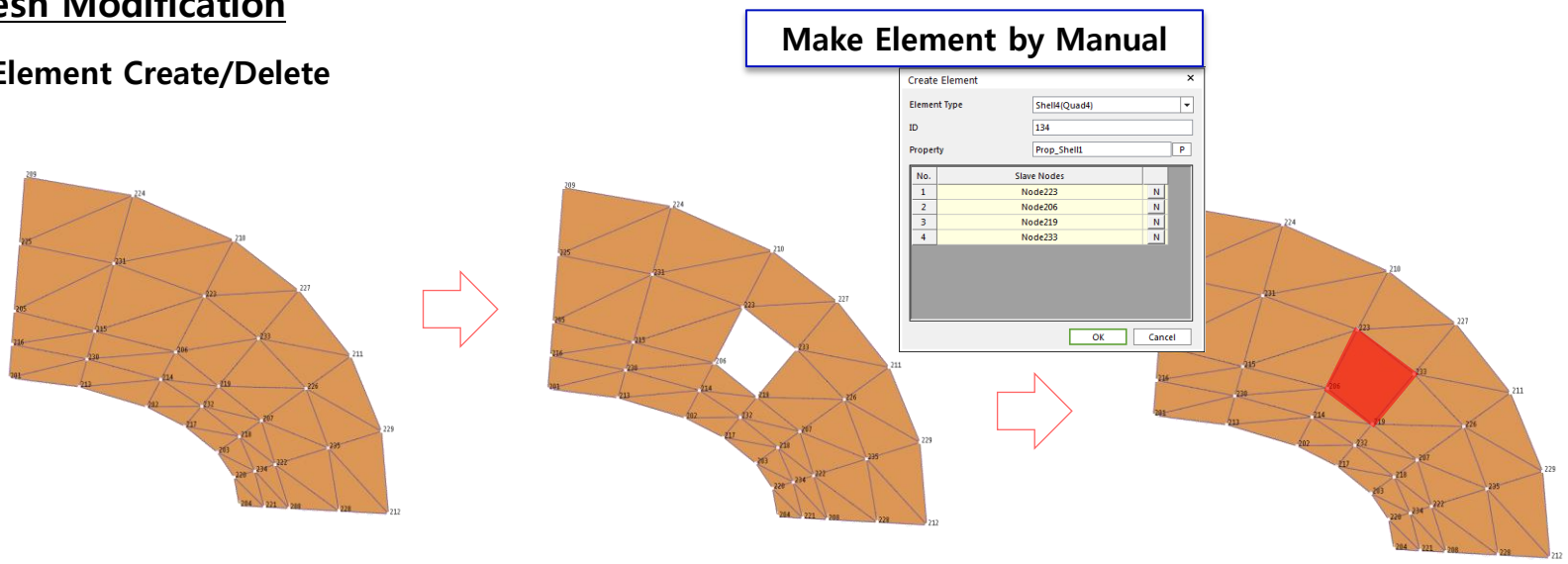


MFBD Enhancement

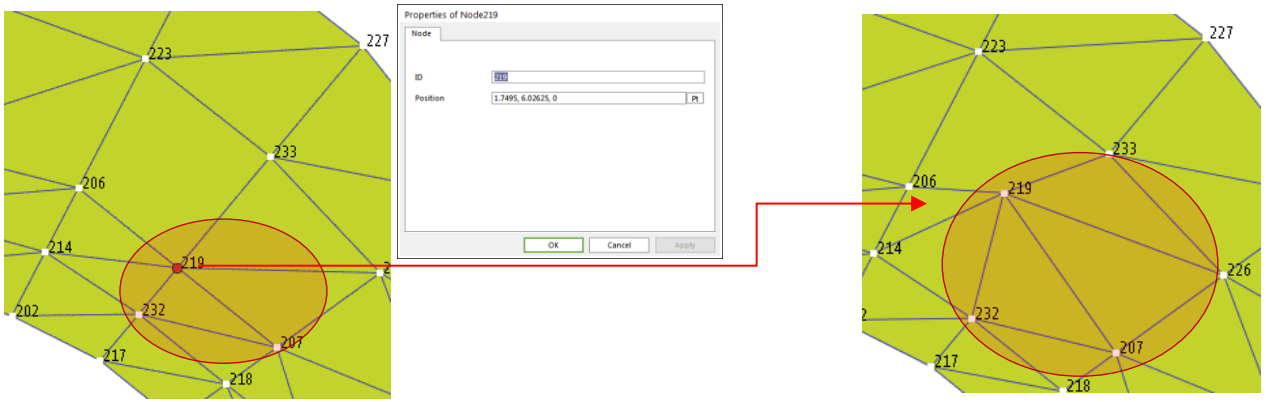
❖ Mesher Enhancement (3/4)

➢ Mesh Modification

✓ **Element Create/Delete**



✓ **Node Modification**

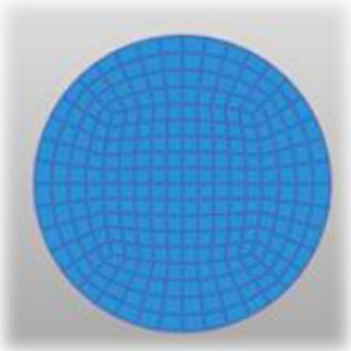


MFBD Enhancement

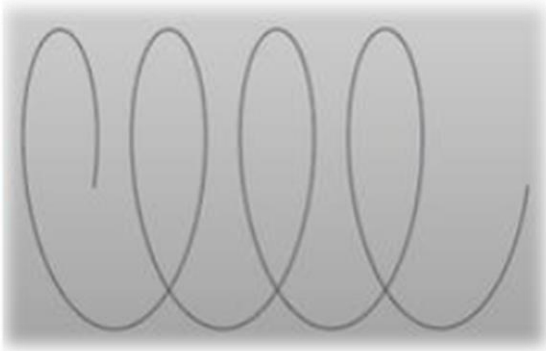
❖ Mesher Enhancement (4/4)

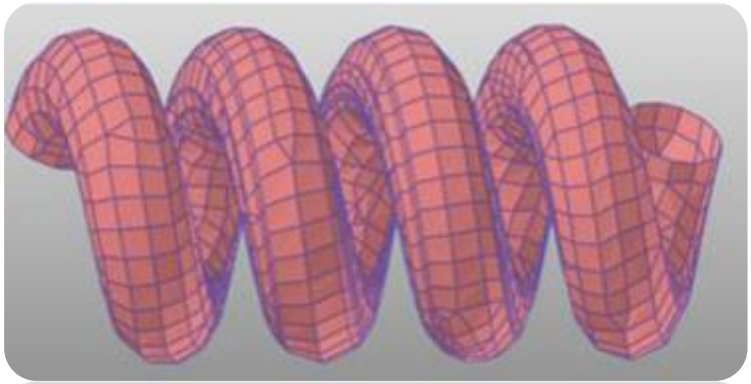
- Manual Mesh Improvement
  - Sweep mesh

Shell Mesh



Helix Curve Geometry

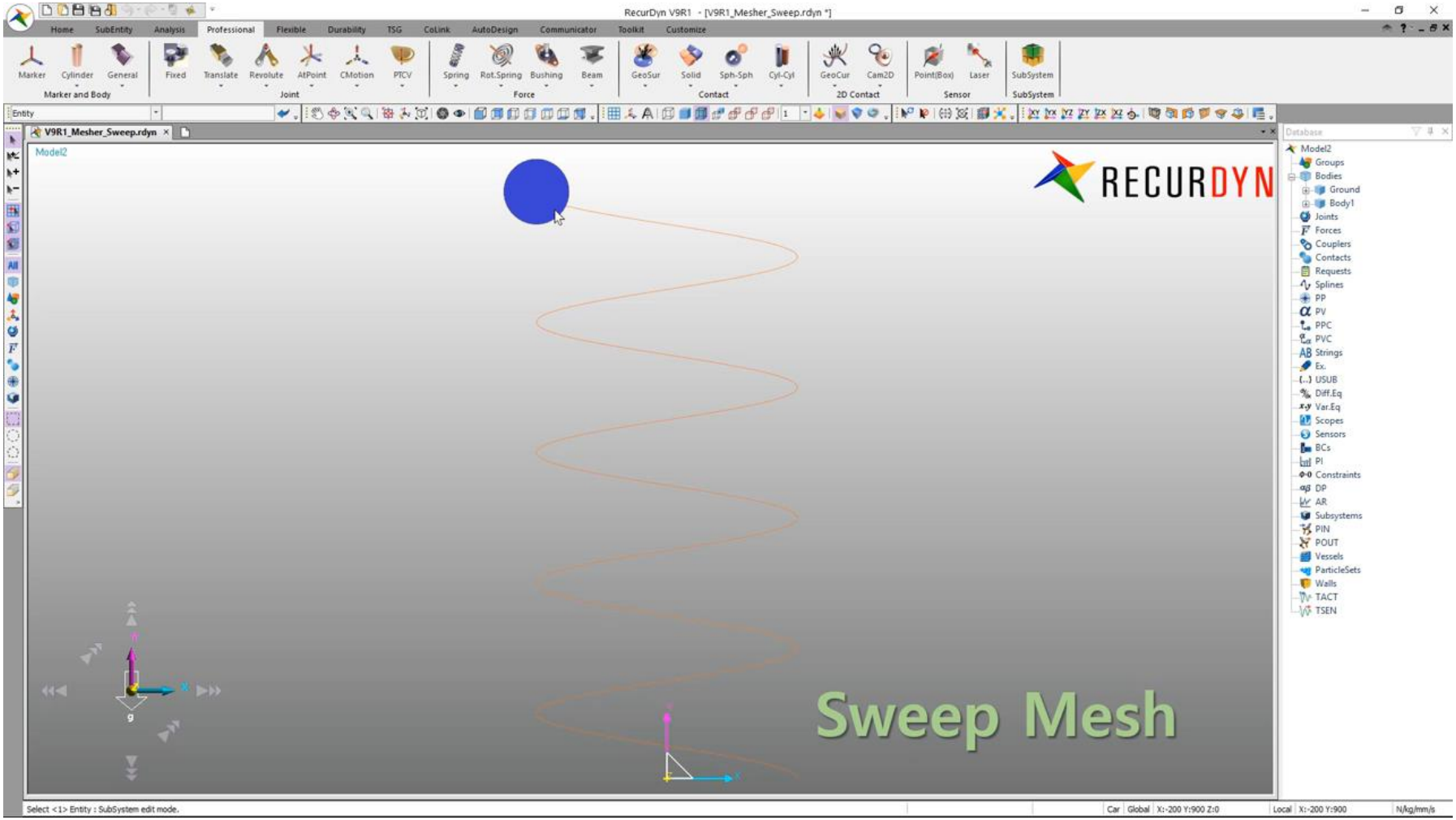




Solid Mesh data

Mesher Enhancements

- Upgraded mesh engine that is faster and produces higher quality meshes
- Powerful geometry refinement.
- Mesh options to improve the quality of the mesh



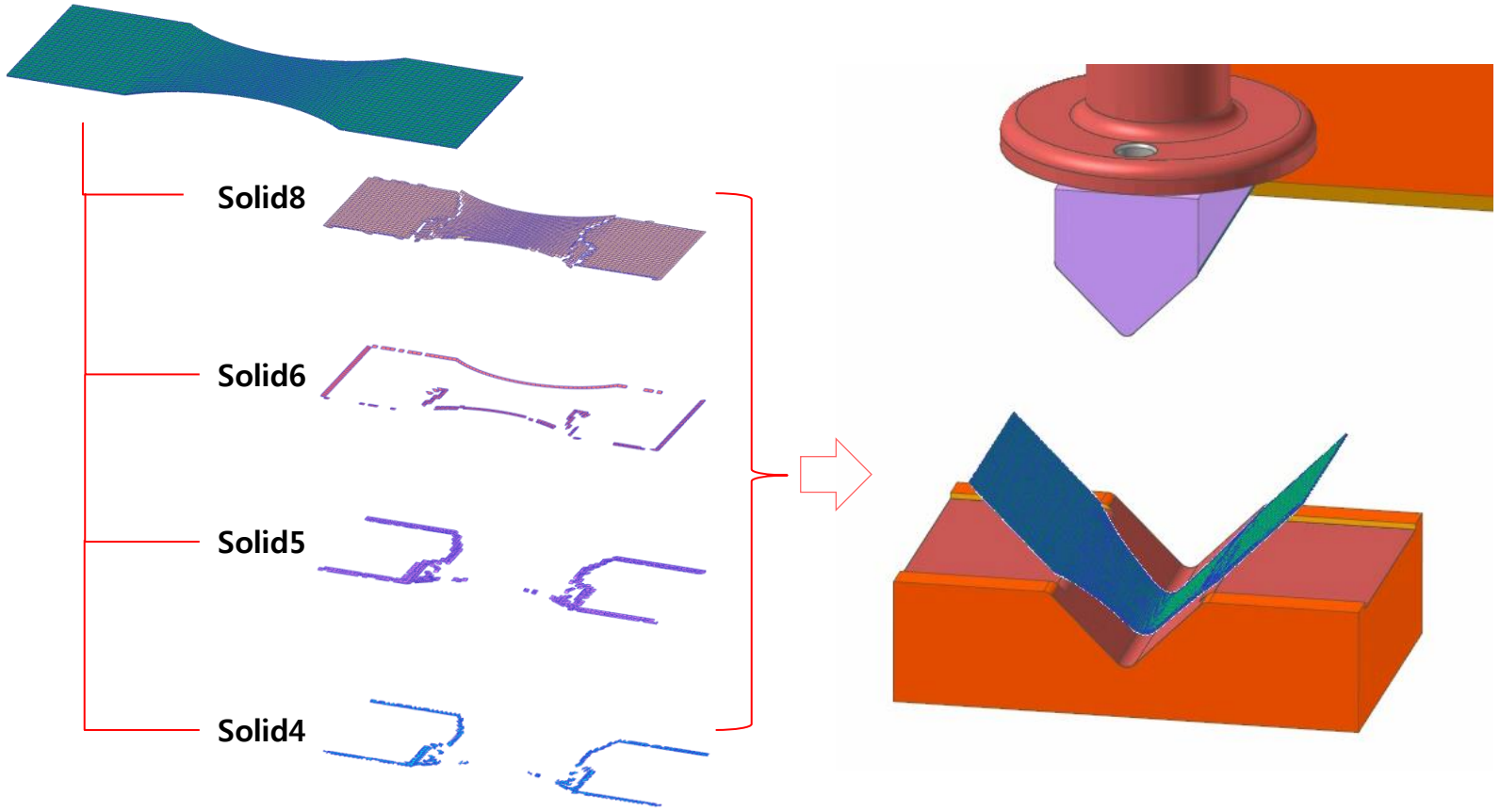
MFBD Enhancement

❖ Enhanced FEA

➢ Non-Linear Material

- Plastic Analysis

Hexa-Dominant Meshed FFlex Body



MFBD Enhancement

❖ Enhanced FEA

➢ Non-Linear Material

- **Hyper Elastic/Mooney Rivlin** – Minus Value parameter input

  - RecurDyn Potential Energy Function

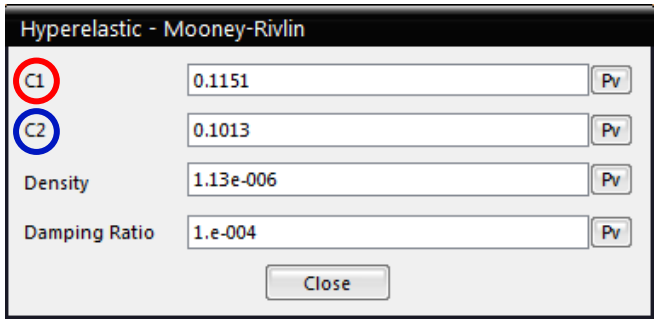
$$U$$
$$= C_{10}(\bar{I}_1 - 3) + C_{01}(\bar{I}_2 - 3)$$
$$= C_1(\bar{I}_1 - 3) + C_2(\bar{I}_2 - 3) \quad \text{(Incompressible model)}$$

Initial shear modulus

$$G = 2\ C_{10} + C_{01}$$

Initial bulk modlus

$$\kappa = \frac{2}{D}$$



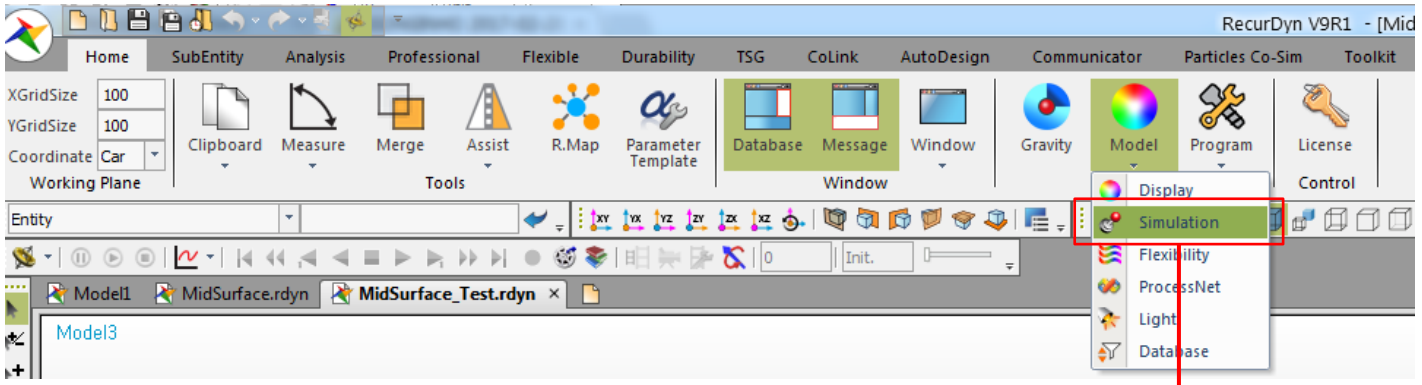
  - Modified Validation Check

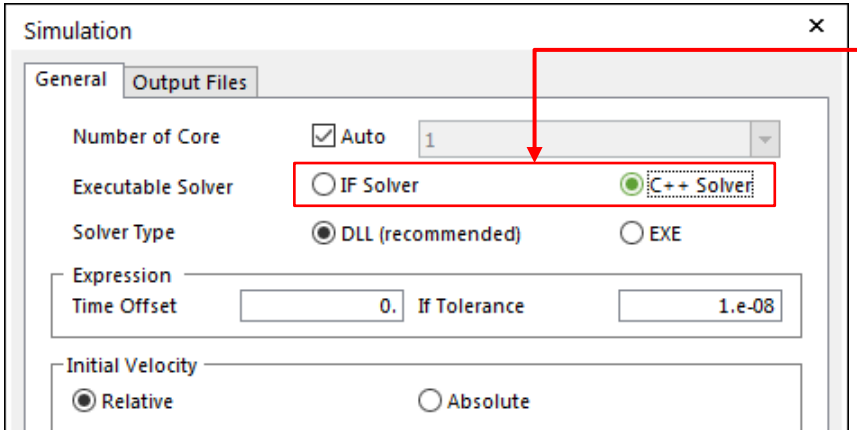
$$\mathbf{C_{10}+C_{01}(=C_1+C_2)>0}$$

3. Solver Performance

Solver Performance

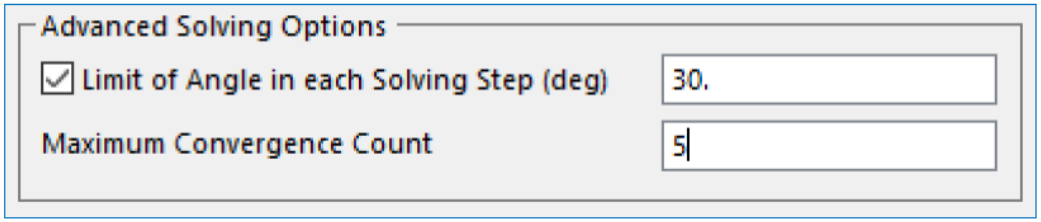
- C++ Solver
  - **C++ Solver** Development for MFBD
    - ✓ Alternative (Not Default) Solver for Special Purpose First
    - ✓ Solution will be changed during V9 period in order to expand the C++ solver continuously





Solver Performance

- **Time Integrator** Enhancement
  - **Enhanced G-Alpha Integrator** (more accurate results in time integration) → Reduce the numerical damping → More Accurate Dynamic Analysis
  - **Enhanced Integration** for Variable Equation and Differential Equations
  - Adjustable **Maximum Angle Limit** for each time step → This will be helpful for more accurate analysis for 3D high speed rotational problems.
  - Adjustable **Maximum Convergence Count** to increase the time step → Default will be changed from 10 to 5. (Optional)

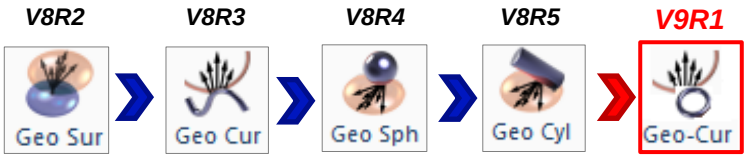


- **3D Rotational Joint Formulation** Enhancement
  - Use of Euler Parameter instead of Euler Angle for spherical and floating joint.
  - This will make more stable and accurate results for the high speed 3D rotational problems.
- **Use of "Sparse for MBD"**
  - In V8R5, for some models, this option was not perfect.
  - From V9R1, this option will be used always. So, option will be removed.

Solver Function

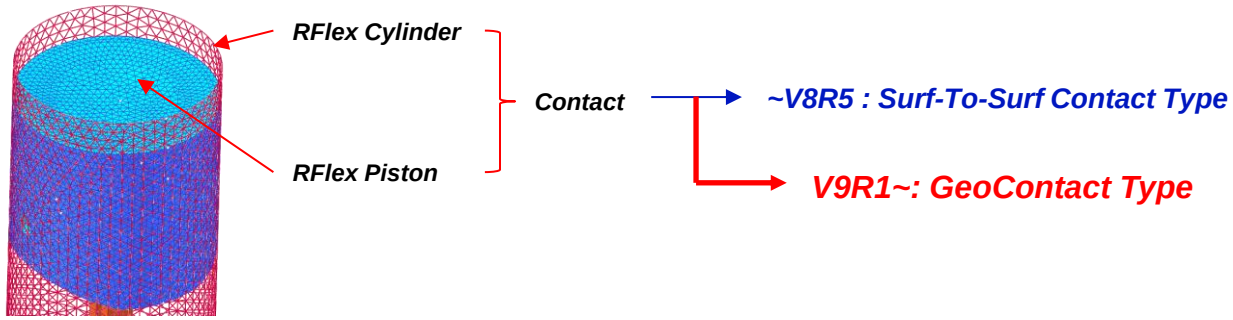
FBHQ is continuously trying to develop the efficient contact algorithm and contact entities for the fast calculation and accurate contact results to the various contact problem. Hence, in V9R1, there are some contact issues are developed by GeoContact algorithm.

- **2D Geo Circle Contact**



- **Using Geo RFlex Contact In Piston Toolkit**

  Until V8R5, the contact entity between RFlex piston and RFlex cylinder is used by surf-to-surf contact elements. However, that contact results are not satisfied. Therefore, FBHQ is determined to use the GeoContact that contact problem.

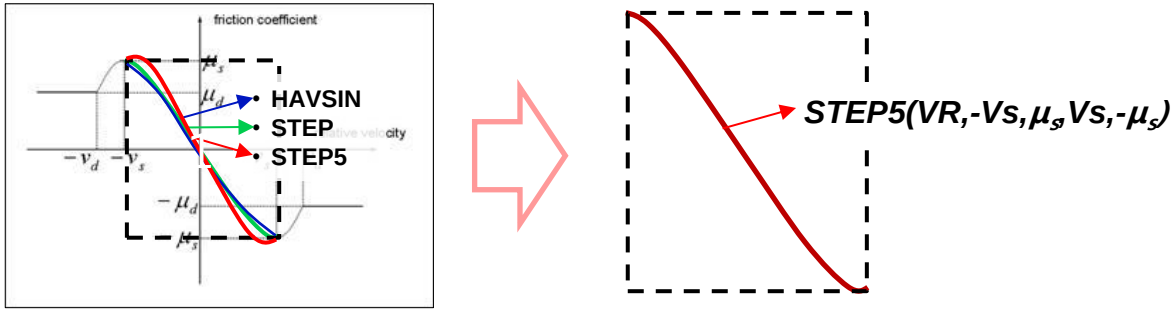


Solver Function

In V9R1, the contact function are improved:

- **Consistent Friction (STEP5)**

  : Especially, the friction coefficient of the range from -Vs to +Vs is determined by the expression. Then, the expressions are defined by various types such as HAVSIN, STEP & STEP5. And, each contact entity is adopted by different expression for friction coefficient. Therefore, the contact force can be little different according to contact entity till V8R5. However, in V9R1, FB decides only one expression to get the friction coefficient(STEP5) and it will give user same results.



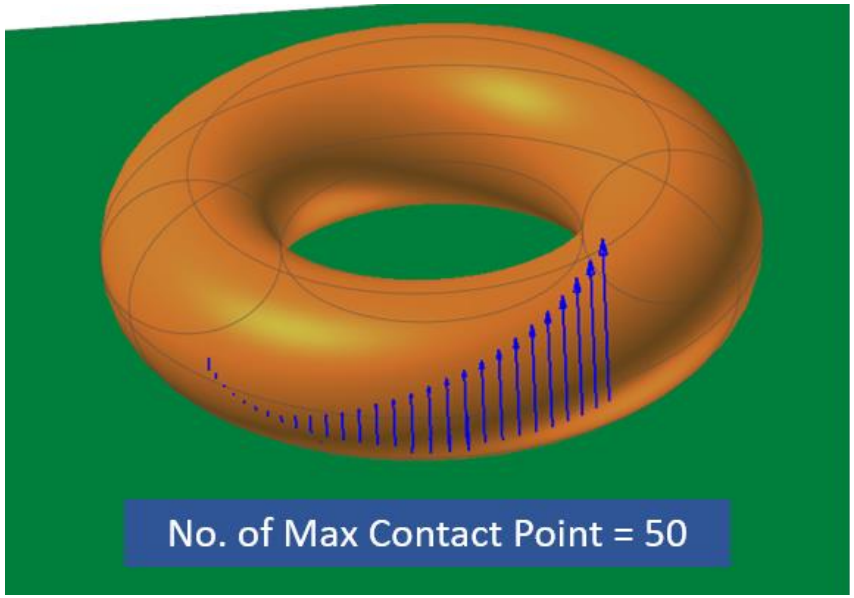
- **Contact Outputs**

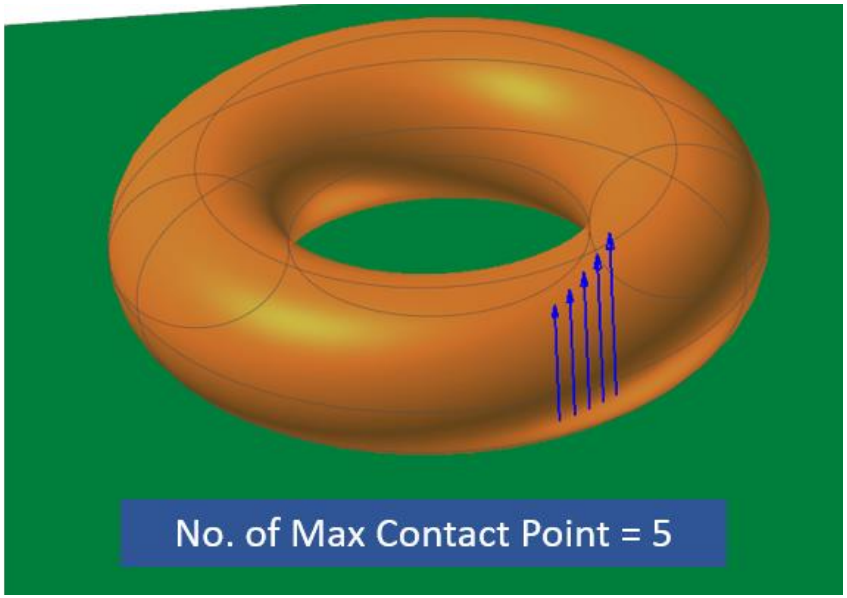
  - In the *.con(contact output file) file, the contact output results are arranged and written by its contact force magnitude order.

TIME	NCP	NO	X_RefPos	Y_RefPos	Z_RefPos	Z_EulerA	X_EulerA	Z_EulerA	X_ConPos	Y_ConPos	Z_ConPos	X_NorDir	Y_NorDir	Z_NorDir	X_TanDir
0.000E+00	0														
0.000E+00	0														
5.000E-05															
1.000E-04															
1.500E-04		1	2.1233589E+01	2.8932512E+02	2.4442091E-04	2.2933091E-02	0.0000000E+00	0.0000000E+00	6.2992165E+01	2.9206953E+02	-3.2500000E+00	-1.1395529E-01	9.9348588E-01	0.0000000E+00	9.9348588E
		2	2.1233589E+01	2.8932512E+02	2.4442091E-04	2.2933091E-02	0.0000000E+00	0.0000000E+00	6.2992165E+01	2.9206953E+02	3.2500000E+00	-1.1395529E-01	9.9348588E-01	0.0000000E+00	9.9348588E
		3	2.1233589E+01	2.8932512E+02	2.4442091E-04	2.2933091E-02	0.0000000E+00	0.0000000E+00	6.2928081E+01	2.9206231E+02	-3.2482826E+00	-9.8056795E-02	9.9518082E-01	0.0000000E+00	9.9518082E
		4	2.1233589E+01	2.8932512E+02	2.4442091E-04	2.2933091E-02	0.0000000E+00	0.0000000E+00	6.2928081E+01	2.9206231E+02	-2.1281765E+00	-9.8056795E-02	9.9518082E-01	0.0000000E+00	9.9518082E
		5	2.1233589E+01	2.8932512E+02	2.4442091E-04	2.2933091E-02	0.0000000E+00	0.0000000E+00	6.2928081E+01	2.9206231E+02	9.6735294E-01	-9.8056795E-02	9.9518082E-01	0.0000000E+00	9.9518082E
		6	2.1233589E+01	2.8932512E+02	2.4442091E-04	2.2933091E-02	0.0000000E+00	0.0000000E+00	6.2928081E+01	2.9206231E+02	-3.1600196E+00	-9.8056795E-02	9.9518082E-01	0.0000000E+00	9.9518082E
		7	2.1233589E+01	2.8932512E+02	2.4442091E-04	2.2933091E-02	0.0000000E+00	0.0000000E+00	6.2928081E+01	2.9206231E+02	-8.3837255E-01	-9.8056795E-02	9.9518082E-01	0.0000000E+00	9.9518082E
		8	2.1233589E+01	2.8932512E+02	2.4442091E-04	2.2933091E-02	0.0000000E+00	0.0000000E+00	6.2928081E+01	2.9206231E+02	-3.0310392E+00	-9.8056795E-02	9.9518082E-01	0.0000000E+00	9.9518082E
		9	2.1233589E+01	2.8932512E+02	2.4442091E-04	2.2933091E-02	0.0000000E+00	0.0000000E+00	6.2928081E+01	2.9206231E+02	-2.9020588E+00	-9.8056795E-02	9.9518082E-01	0.0000000E+00	9.9518082E
		10	2.1233589E+01	2.8932512E+02	2.4442091E-04	2.2933091E-02	0.0000000E+00	0.0000000E+00	6.2928081E+01	2.9206231E+02	-2.7730784E+00	-9.8056795E-02	9.9518082E-01	0.0000000E+00	9.9518082E

Solver Function - Contact Point Sorting

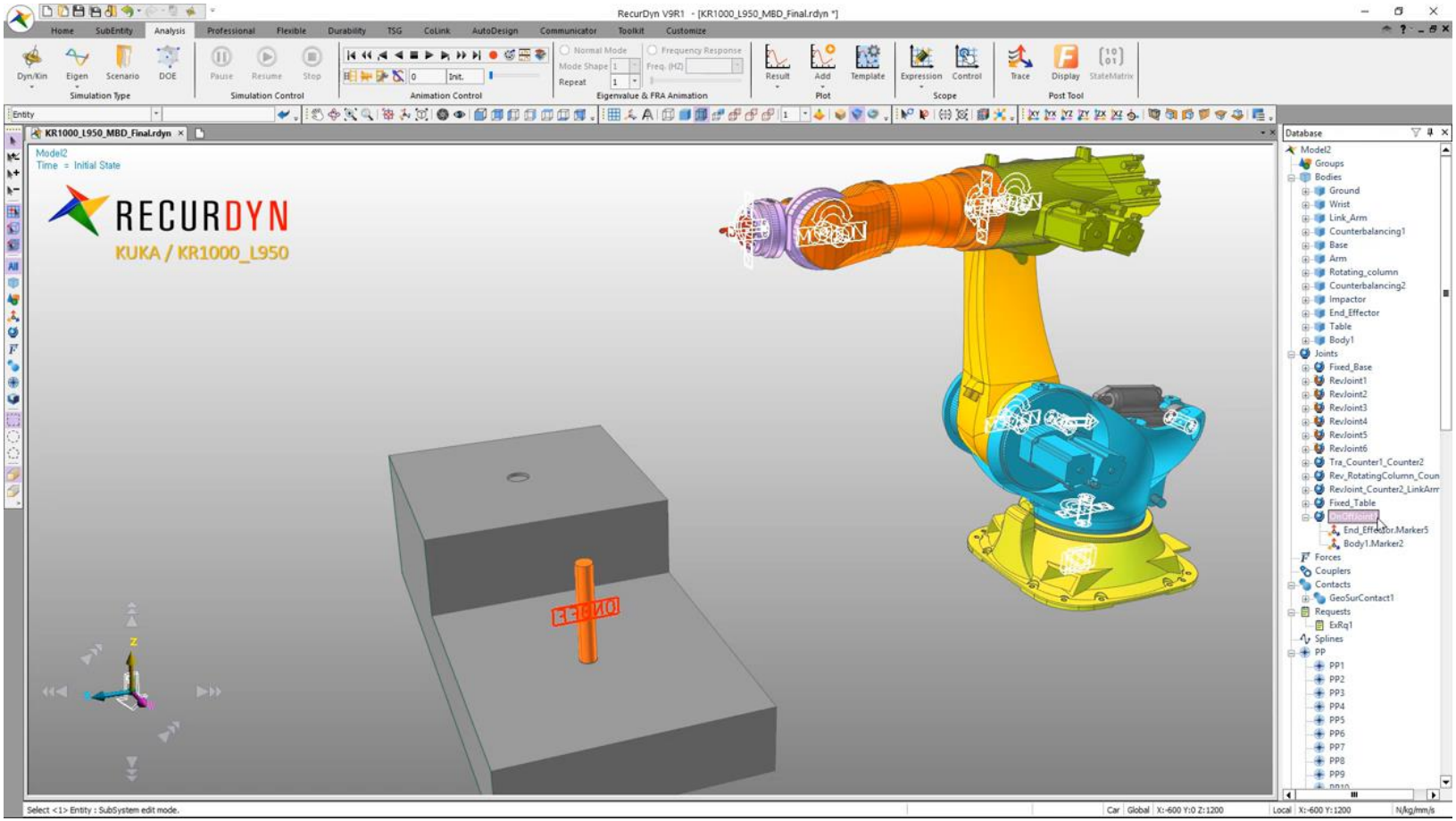
- The Contact Point data that is written to the *.con file will be sorted from largest magnitude to smallest.





Solver Function - OnOff Joint

- The constrained degrees of freedom (0~6) can be enabled/disabled during the simulation depending on the condition. (by Function Expression)
- The OnOff Joint can be used to increase the speed of computation when it can be used instead of a contact element



4. Application Interface

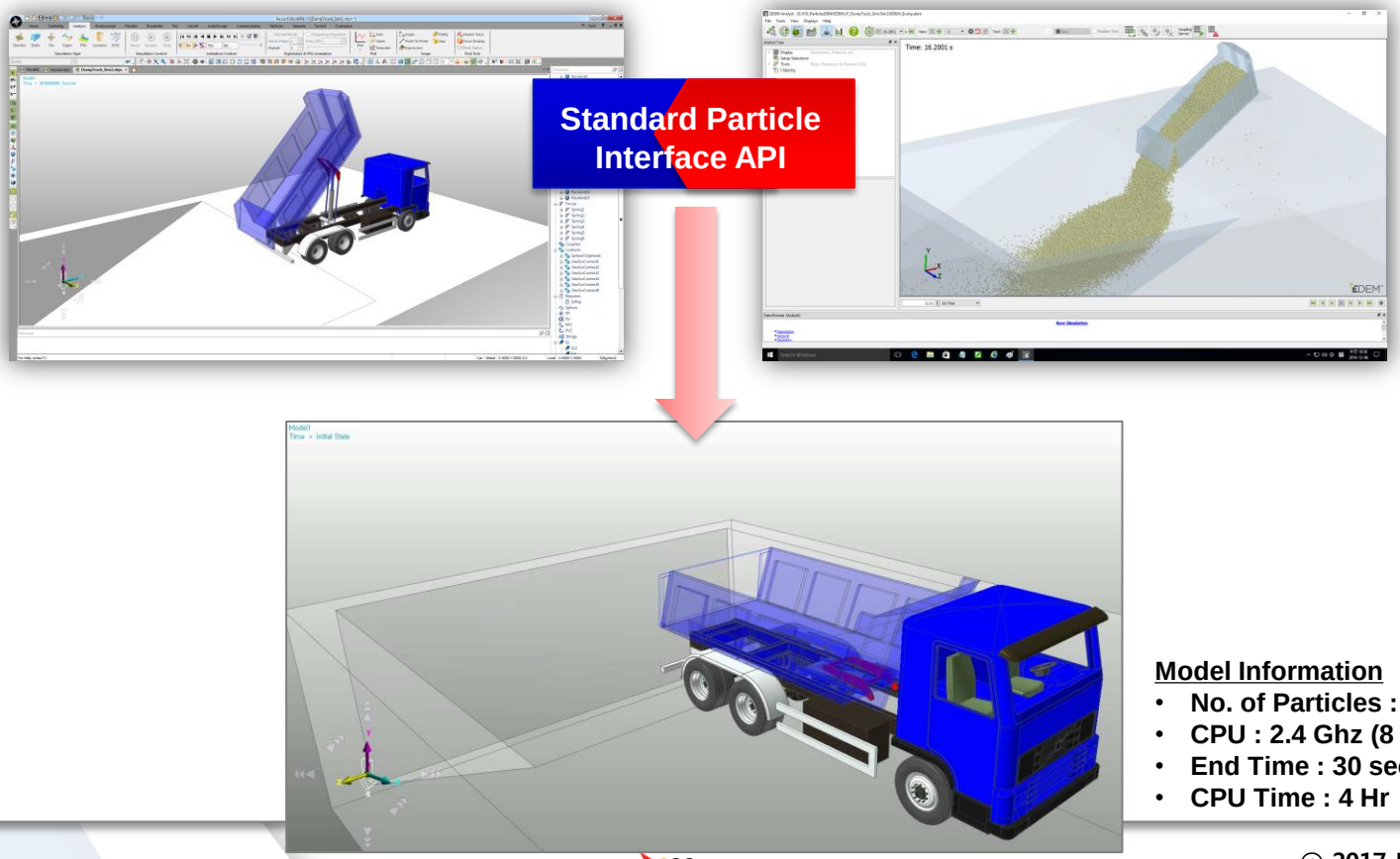
Application Interface

❖ Standard Particle Interface

- ➢ For the efficient development for communication between RecurDyn and other Particle S/W.

❖ EDEM IF using Standard Particle Interface

- ➢ So, using the Standard Particle Interface API, Particle S/W company can efficiently develop the interfacing code with RecurDyn. Therefore, EDEM(One of DEM Particle S/W) interface is developed in V9R1.

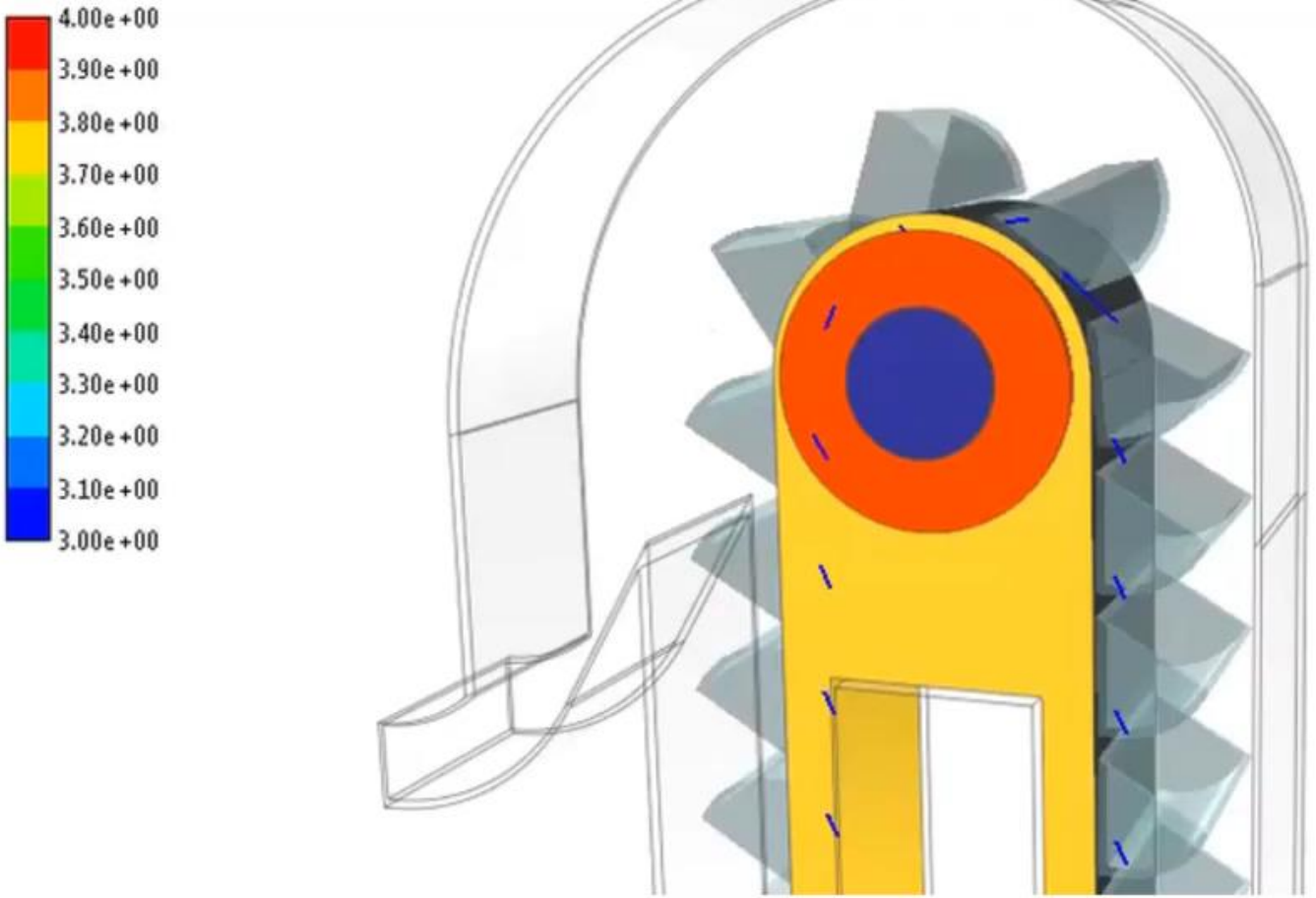


Model Information

- **No. of Particles : 80,000 ea**
- **CPU : 2.4 Ghz (8 Threads)**
- **End Time : 30 sec**
- **CPU Time : 4 Hr**

Co-simulation interface between RecurDyn and EDEM

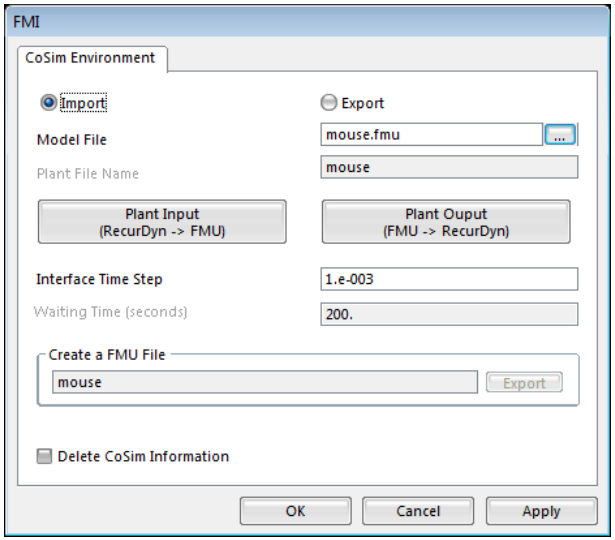
RECURDYN × EDEM™



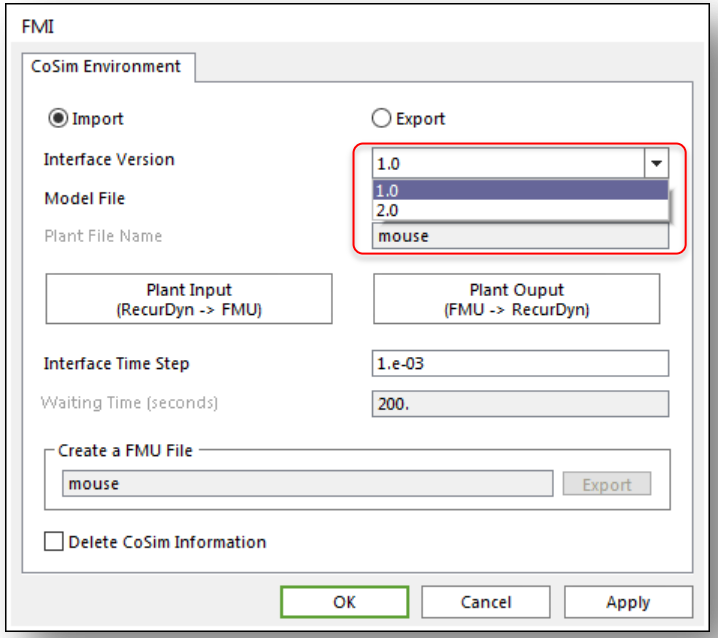
Application Interface

- FMI 2.0
  - FMI 2.0 will be supported in V9R1. Therefore, user will be able to use the function of FMI 2.0 for communicating between RecurDyn and other S/W.

V8R5



V9R1



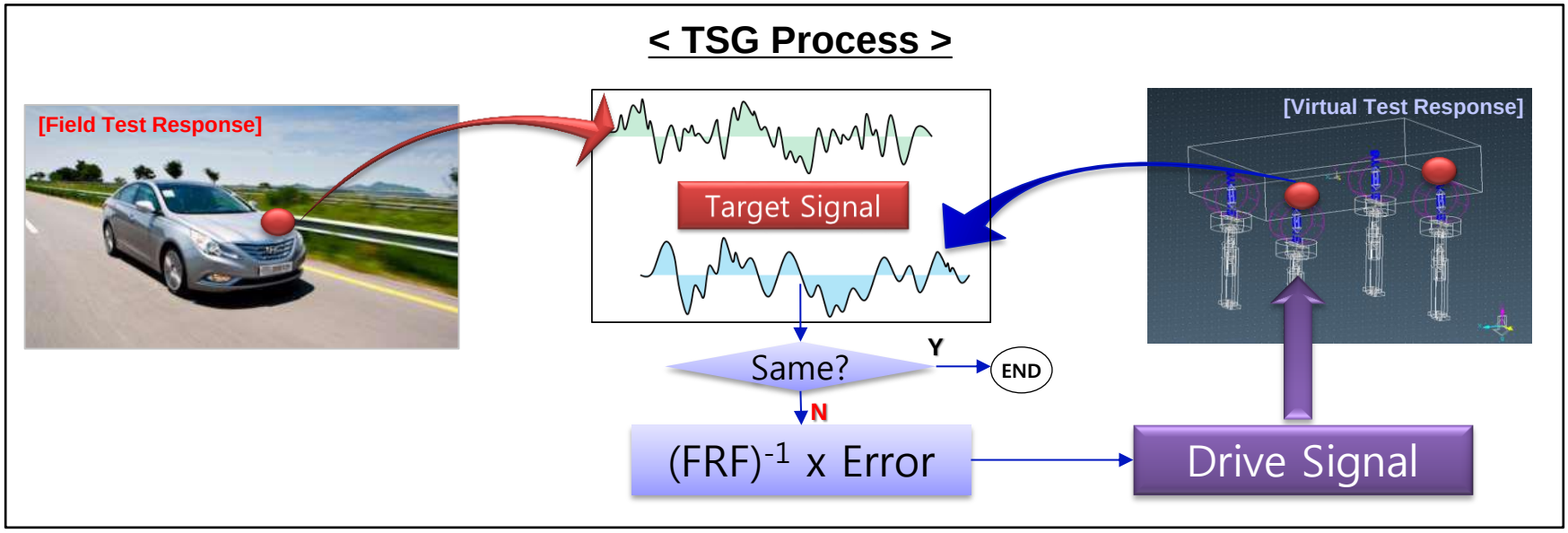
FUNCTIONAL MOCK-UP INTERFACE

5. Toolkits

New Toolkits

❖ TSG (Time Signal Generator) Toolkit

- With any measured response (target signal) of vibration in physical test, TSG finds any input signal (drive signal) for virtual test rig. → Eventually, this can be used for Durability Analysis.
- For example, TSG can make the driving signal for the actuator of car suspension test-rig to get the same response with the field testing signal. Then, using these driving signal, user can run the MBD, MFBD & Durability analysis.

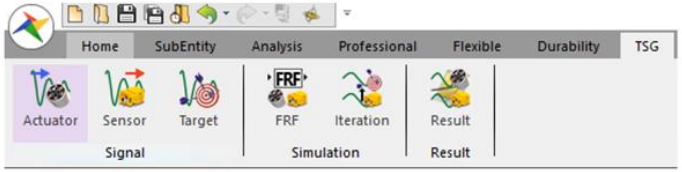


RecurDyn/TSG (Time Signal Generation)

- New toolkit
- Find the Drive Signal that reproduces the Target Signal

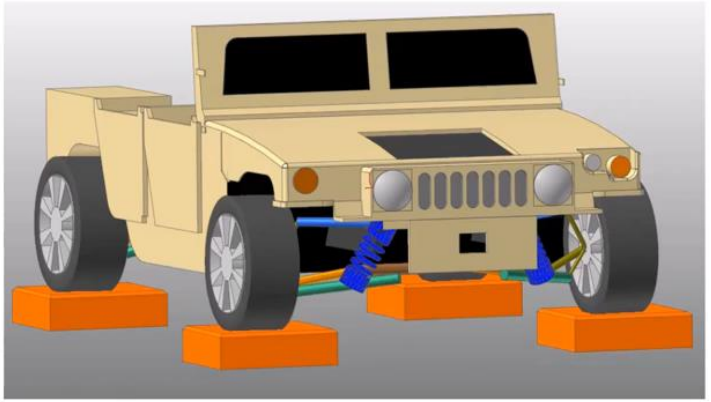
TSG (Time Signal Generator) Toolkit

The TSG (Time Signal Generator) toolkit has been added to RecurDyn. The TSG finds a Drive Signal that causes the MBD system in RecurDyn to produce a measurable system response that is similar to a user-defined Target Signal. The MBD system response can be any value, such as a displacement, a velocity, an acceleration, a force, or a sensor output.



Outputs

Driving Test

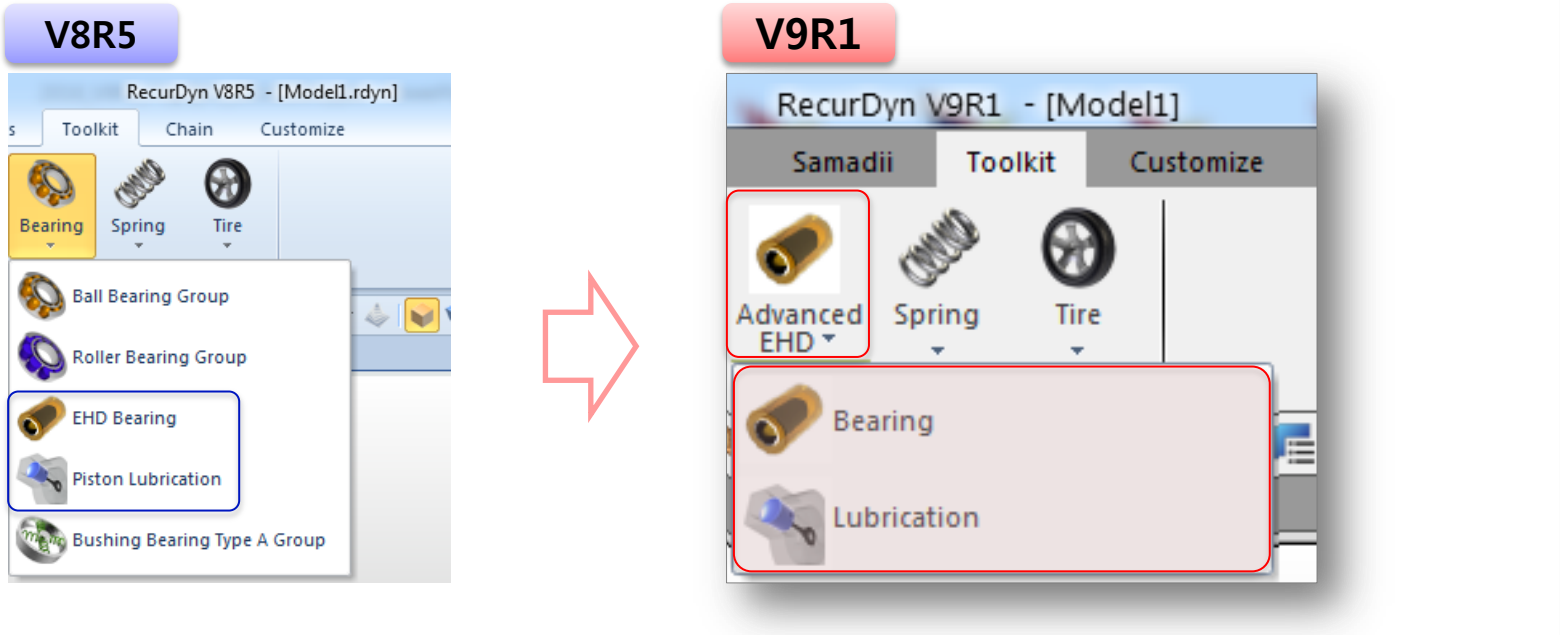


Virtual Test-Rig

New Toolkits

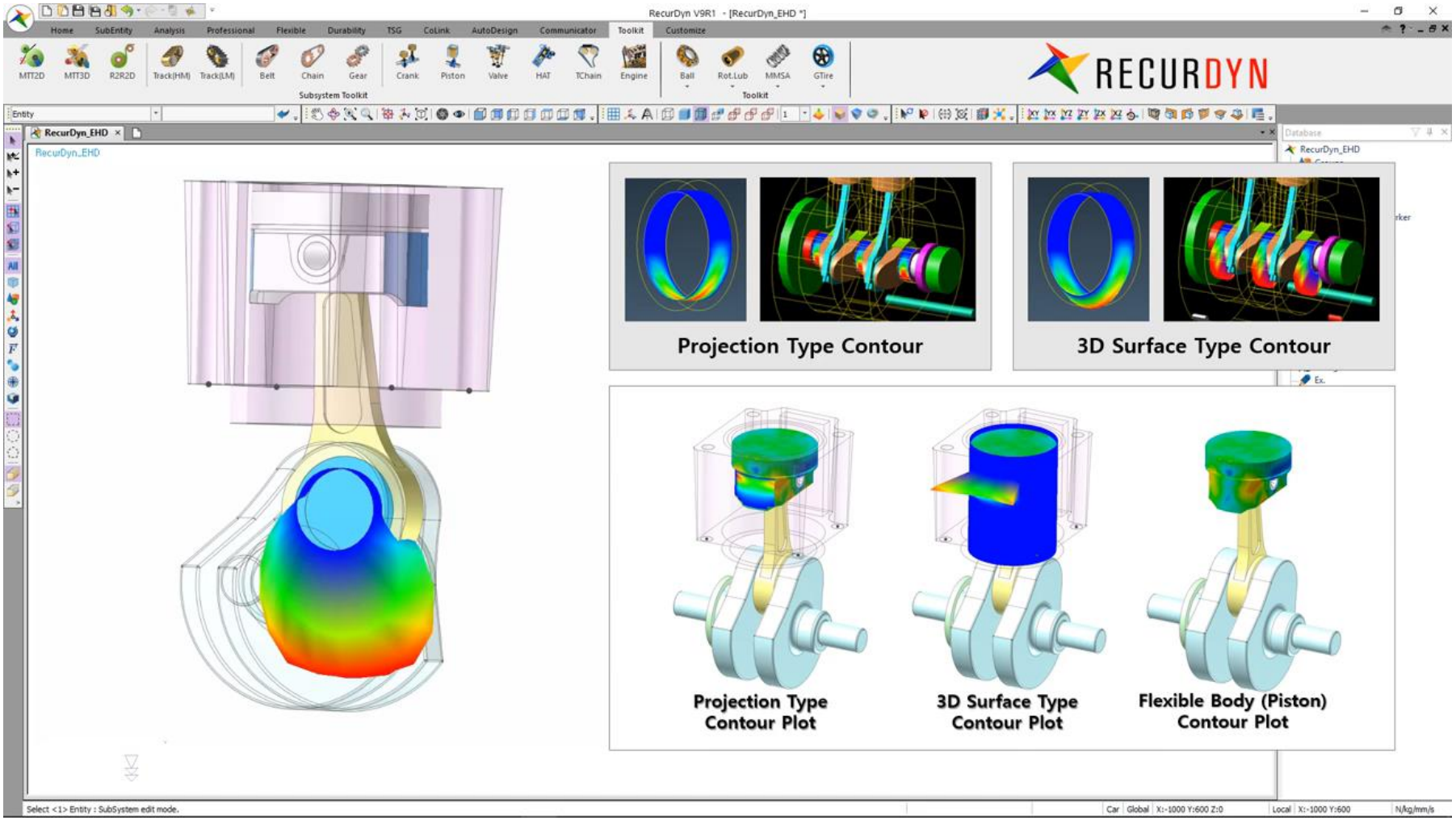
❖ Independent EHD Toolkit

- ➢ V8R5
  - ✓ It is one of bearing entity/function in Bearing Toolkit
- ➢ V9R1
  - ✓ It will be one of important toolkit in RecurDyn V9R1. So, it is developed as independent EHD Toolkit. Then V9R1 EHD toolkit supports the EHD journal bearing & EHD lubrication functions.



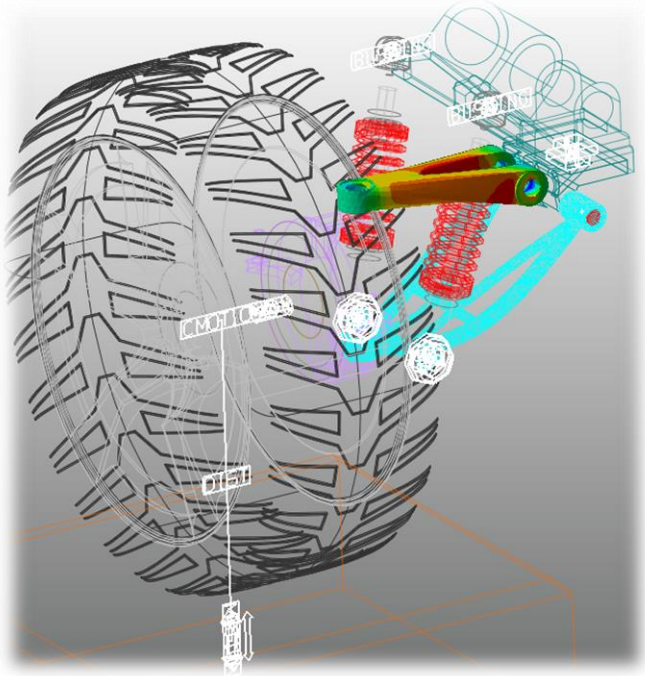
RecurDyn/EHD (Elasto-Hydrodynamic Lubrication)

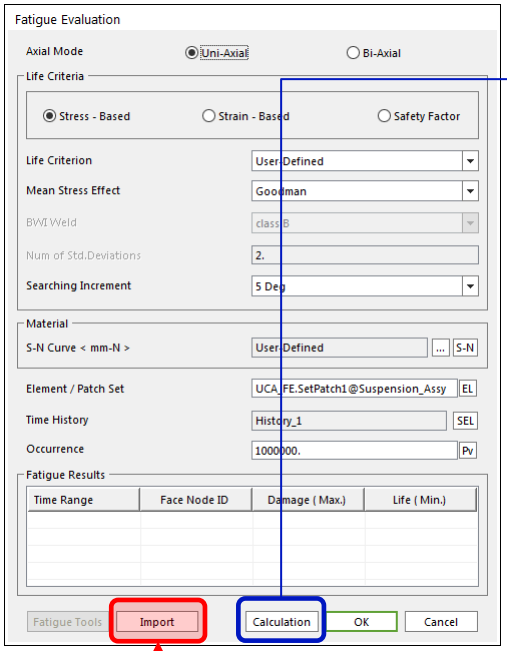
- New toolkit
- Rotational Lubrication for journal bearing
- Piston Lubrication for Piston/Cylinder



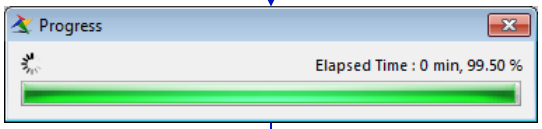
Toolkit Improvement

- Durability Toolkit
  - Importing durability result file

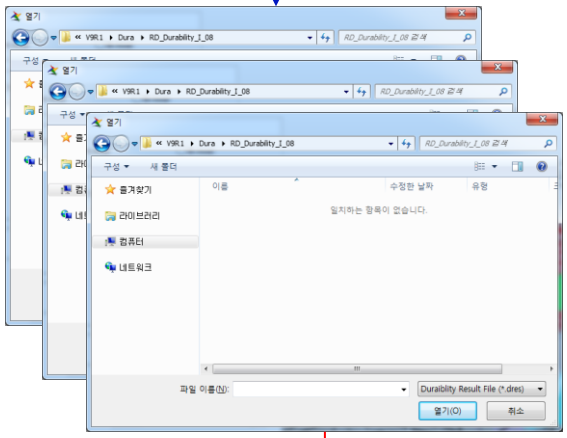




Fatigue calculation



Save the result files!



Importing the previous result file

Summary of RecurDyn V9R1

Integrator enhancement improved the accuracy

1. The numerical damping effect is reduced a lot.
2. The accuracy of High speed rotation problem is improved

UI Convenience

Parameter template, Multi-animation, Database filtering

MBD enhancements

Contact Point Sorting, OnOff Joint, 2D Geo Circle Contact

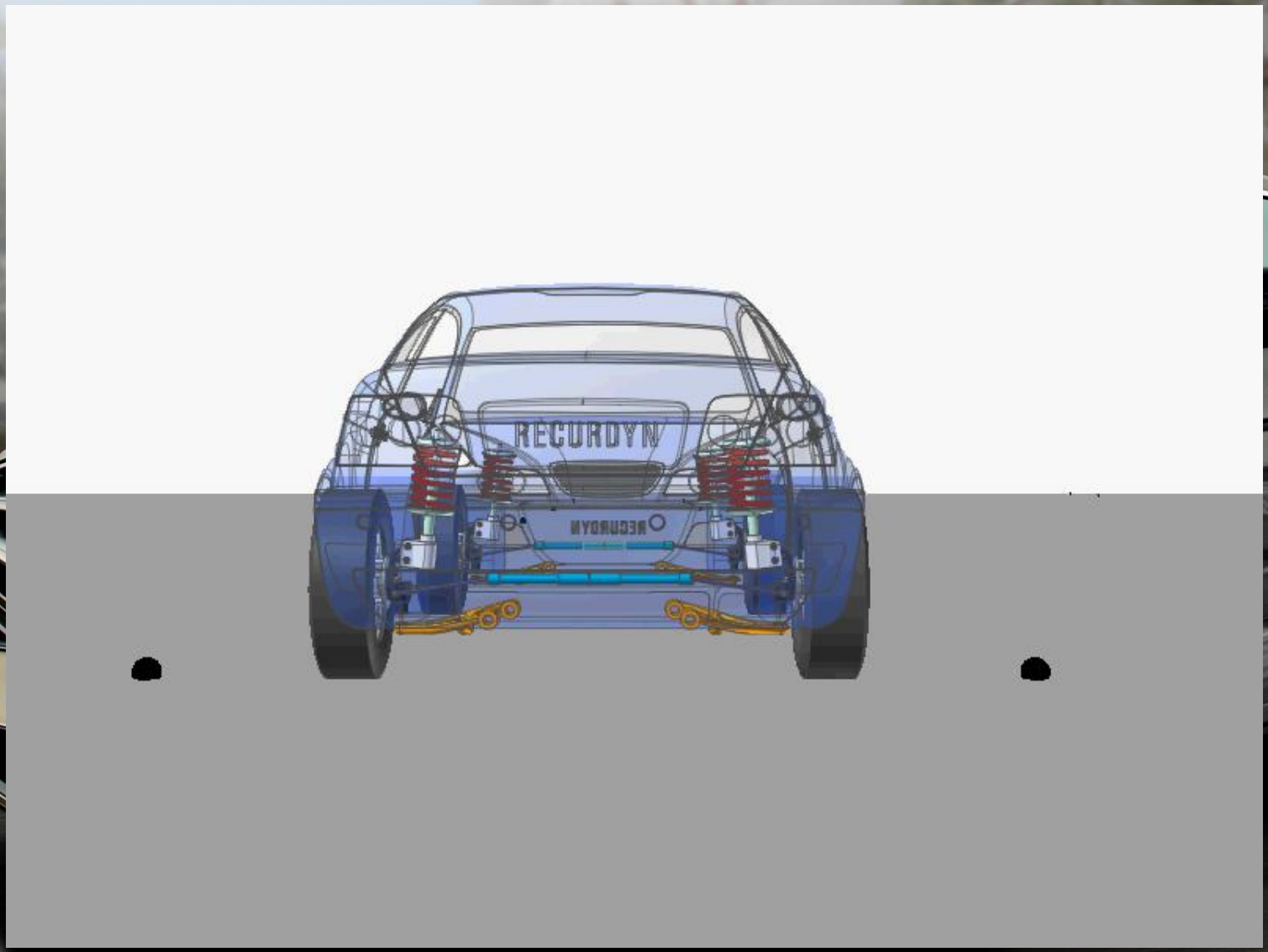
MFBD enhancements

Mesher enhancements, enhanced FFlex body handling

Multi-disciplinary

EHD, TSG, EDEM interface, FMI 2.0

100+ improvements



Thanks for your attention!