



Using Multibody Dynamics for Simulation of Adaptive Systems

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Using Multibody Dynamics for Simulation of Adaptive Systems

Overview

- Adaptive Systems
- Institute of mechanics of the OvGU Magdeburg
- Problem magnetically circular table (MCT)
- SIMPACK to the design of adaptive systems exemplified by MCT
- Results
- Abstract and further steps

Using Multibody Dynamics for Simulation of Adaptive Systems

Adaptive systems in nature

adaptive - to adapt, to act on environmental influences



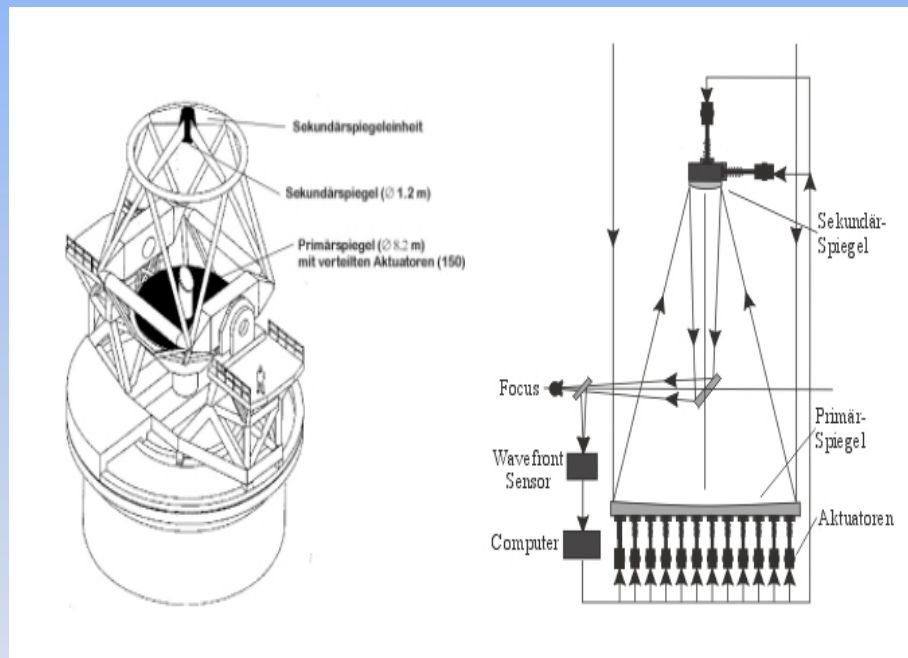
Albatros



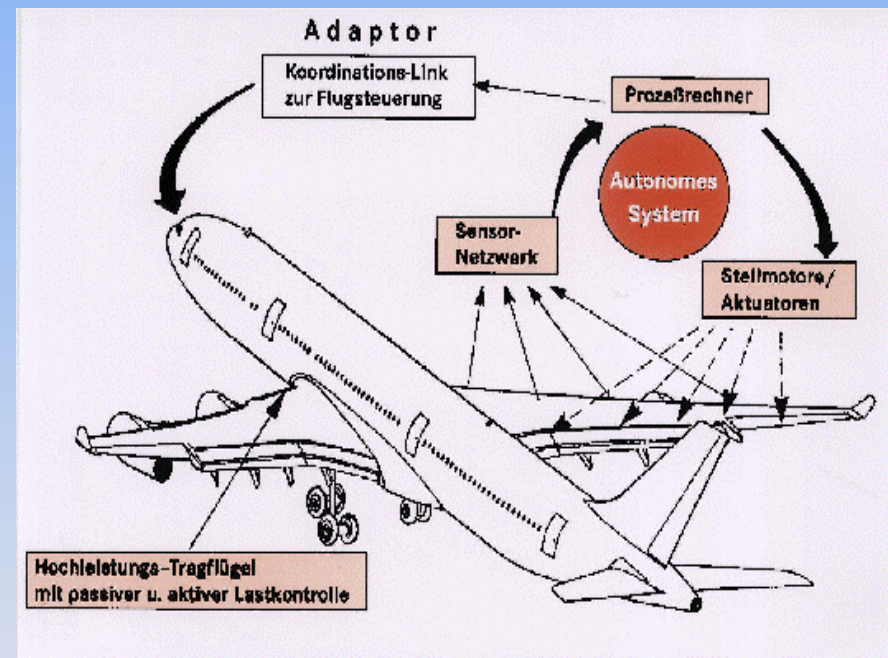
Mimose

Using Multibody Dynamics for Simulation of Adaptive Systems

Adaptive systems in the engineering



Active optic for a VL Telescope (source: ESO)



Adaptive wing for an aircraft (source: DLR)

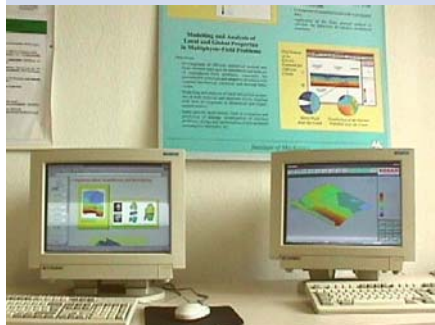
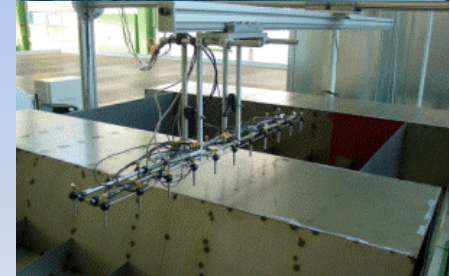
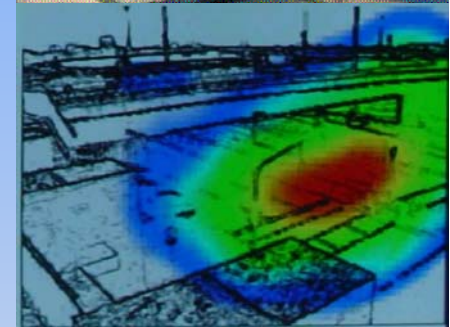
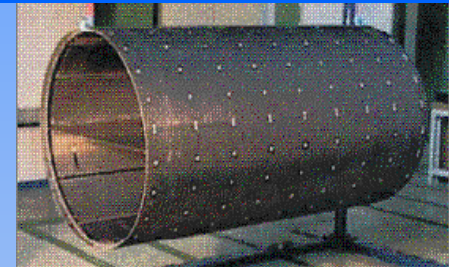


Using Multibody Dynamics for Simulation of Adaptive Systems

One of the main research at the institute of mechanics of the Otto-von-Guericke-University is:

Modelling, simulation, complete optimisation, production and experimental verification of adaptive systems. Using of adaptive solutions for industrial applications (automotive industry, medical engineering, robotics, domestic appliances, ...).

Main research: DFG Innovationskolleg ADAMES
BMBF-Leitprojekt ADAPTRONIK
industrial applications,....

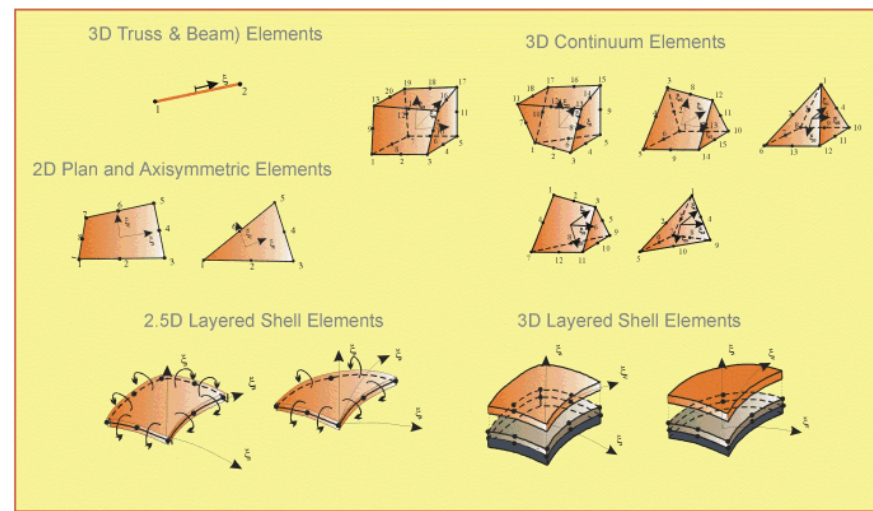




Using Multibody Dynamics for Simulation of Adaptive Systems

Simulation of adaptive Structures with FEA

Element Library of **COSAR** Software



Model reduction

$$\mathbf{M}\ddot{\mathbf{x}} + \mathbf{D}_d\dot{\mathbf{x}} + \mathbf{K}\mathbf{x} = \bar{\mathbf{E}}\mathbf{f}(t) + \bar{\mathbf{B}}\mathbf{u}(t, \mathbf{x}, \dot{\mathbf{x}})$$

$$(\mathbf{K} - \lambda_i\mathbf{M})\boldsymbol{\varphi}_i = \mathbf{0} \quad \mathbf{x} = \boldsymbol{\Phi}\mathbf{q}$$

$$\ddot{\mathbf{q}} + \Delta\dot{\mathbf{q}} + \Lambda\mathbf{q} = \boldsymbol{\Phi}^T\bar{\mathbf{E}}\mathbf{f}(t) + \boldsymbol{\Phi}^T\bar{\mathbf{B}}\mathbf{u}(t, \mathbf{x}, \dot{\mathbf{x}})$$

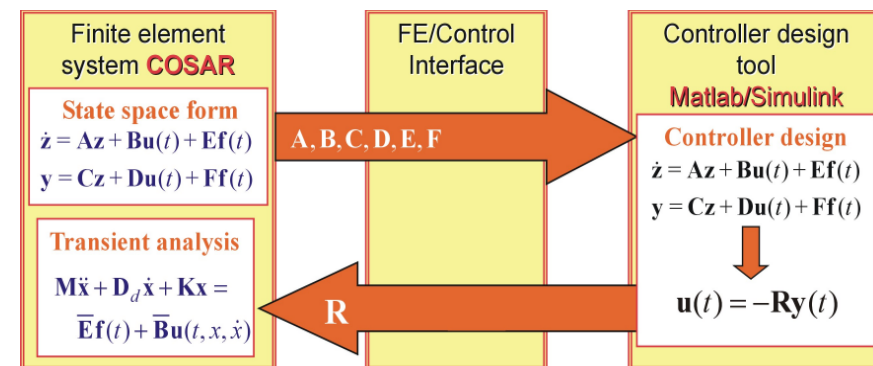
State space form

$$\mathbf{z} = \begin{bmatrix} \mathbf{q} \\ \dot{\mathbf{q}} \end{bmatrix}$$

$$\dot{\mathbf{z}} = \begin{bmatrix} \mathbf{0} & \mathbf{I} \\ -\Lambda & -\Delta \end{bmatrix} \mathbf{z} + \begin{bmatrix} \mathbf{0} \\ \boldsymbol{\Phi}^T\bar{\mathbf{B}} \end{bmatrix} \mathbf{u}(t) + \begin{bmatrix} \mathbf{0} \\ \boldsymbol{\Phi}^T\bar{\mathbf{E}} \end{bmatrix} \mathbf{f}(t) = \mathbf{A}\mathbf{z} + \mathbf{B}\mathbf{u}(t) + \mathbf{E}\mathbf{f}(t)$$

$$\mathbf{y} = \bar{\mathbf{C}}\bar{\boldsymbol{\Phi}}\mathbf{z} = \mathbf{C}\mathbf{z}$$

Coupling of COSAR with Matlab/Simulink





Using Multibody Dynamics for Simulation of Adaptive Systems

On the basis of a new magnetically circular table - MCT (made by w.i.t. Magdeburg/Barleben company) should be demonstrate partly finished work with SIMPACK.

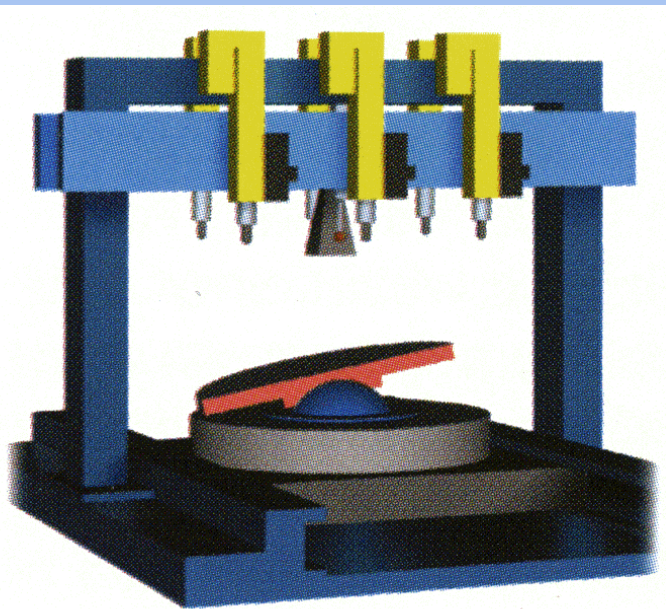
Advantages by using the interconnection of COSAR and SIMPACK for the solution of adaptive problems:

- Decrease the degrees of freedom
- Parameter analysis with SIMPACK
- Including of user routines in SIMPACK
- Special element library in COSAR
- Interconnection of COSAR and Matlab/SIMULINK
- Coupling of mechanic and piezoelectric problems
- Optimisation algorithms for the sensor and actuator placement in COSAR

Using Multibody Dynamics for Simulation of Adaptive Systems

Problem magnetically circular table (MCT)

Development and verification of some basic adaptive strategies to increase the machining accuracy of machine tools with magnetically guidance considering as example a magnetically circular table (machining accuracy +/- 2,5 μ m).



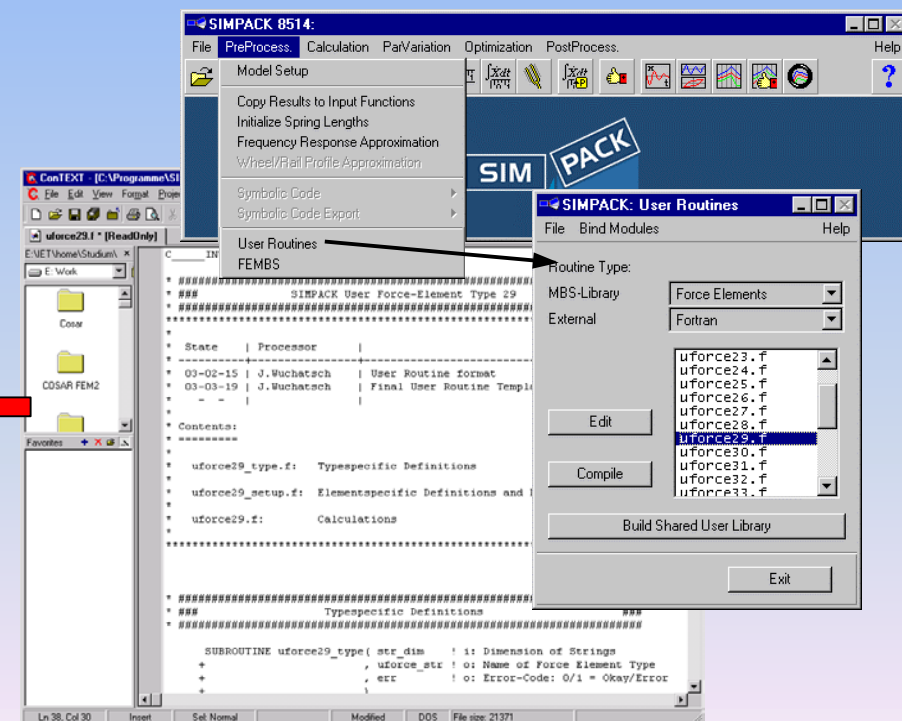
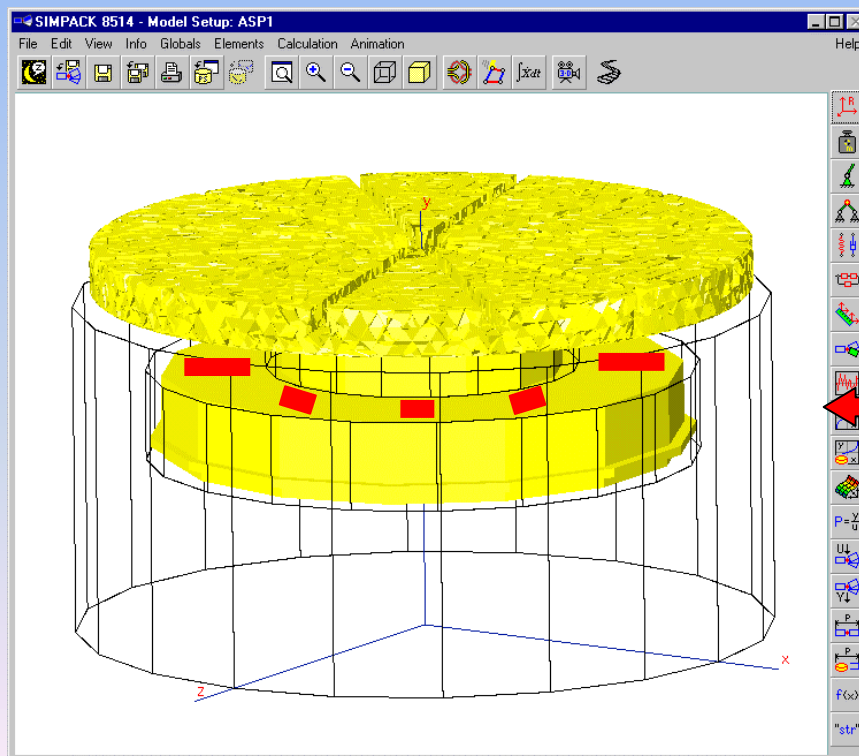
circular table of Wiemers innovative Technik GmbH Magdeburg/Barleben company



Using Multibody Dynamics for Simulation of Adaptive Systems

SIMPACK to design of adaptive systems exemplified by MCT

Build up a ridged body systems of the MCT and the implementation of the magnetically guidance by new generated force elements with SIMPACK user routines and verification of the results





Using Multibody Dynamics for Simulation of Adaptive Systems

SIMPACK to design of adaptive systems exemplified by MCT

Implementation of elastic components in the multibody system by using of the FEMBS interface for data from ANSYS and NASTRAN.

Import data by a new interface from COSAR.

Verification of results and/or export data with SIMPACK LOADS in FEA.

The screenshot displays the SIMPACK 8514 software interface. On the left, a 3D model of a mechanical assembly is shown, consisting of a red cylindrical top section and a yellow cylindrical bottom section, both mounted on a wireframe base. The main window is titled 'SIMPACK 8514 - Model Setup: ASP1'. Several dialog boxes are open, illustrating the workflow for data import and export:

- The 'Model Setup' dialog box is open, showing options for 'Copy Results to Input Functions', 'Initialize Spring Lengths', 'Frequency Response Approximation', and 'Wheel/Fall Profile Approximation'. A table of node data is visible, with columns for 'Node', 'pfx', 'plp', 'plz', and 'pax'. The table contains the following data:

Node	pfx	plp	plz	pax
1496	-0.071033	0.087373	-0.12804	
1499	-0.064318	0.023553	-0.1855	
1501	-0.019799	-0.11257	-0.3137	
1502	0.0008208	-0.19563	-0.3462	
1504	0.0085187	-0.27064	-0.3564	
1528	-0.046293	-0.039632	-0.2618	
1832	0.000000	0.000000	0.0000	
1938	-0.10667	0.22126	-0.284	
1932	-0.094461	0.0008773	-0.3564	
1937	-0.053429	-1.36644	-0.5154	
1940	-0.045086	-1.9207	-0.5385	
1942	-0.072815	-0.82373	-0.4965	
2064	-0.090210	-0.37964	-0.4511	
2198	0.000000	0.000000	0.0000	
2267	0.21565	-0.041842	-0.2284	
2269	0.24201	-0.49715	-0.2285	

- The 'LOADS Output Generator' dialog box is open, showing options for 'ANSYS', 'NASTRAN', and 'COSAR'. It includes fields for 'Select units for the output file', 'Enter name of the FEA file', and 'Enter name of the output file you want to generate or accept the default'. The 'Load' field is set to 'Mass'.
- The 'LOADS' dialog box is open, showing options for 'State Plots', 'General Plots', 'ParVariation Plots', 'Type Plots', '3D-Animation', and 'LOADS'. It includes fields for 'accessible nodes', 'accessible bodies', 'Incremental selection: Read every', 'optional: iteration of output line open', 'Start line of', 'Endline of', and 'Write data to file'.

Red arrows indicate the flow of data and interaction between the 3D model, the dialog boxes, and the external software (MSC.Nastran, ANSYS, COSAR) shown on the right side of the image.



Using Multibody Dynamics for Simulation of Adaptive Systems

SIMPACK to design of adaptive systems exemplified by MCT

Implement the real magnetically guidance of the MCT with SIMPACK-Control.
Development and implementation of new control algorithms by using
Matlab/Simulink and SIMPACK user routines

The image displays the SIMPACK 8514 software interface, illustrating the integration of multibody dynamics simulation with control systems. The main window shows a 3D model of a magnetic control system (MCT) with a red mass m and a force vector $F(t)$. The control loop is defined in the 'SIMPACK: MBS Control Loop' window, showing a block diagram with 'Disturbance', 'Sensor', 'A/D', 'Filter 1-5', 'MBS', 'Control 1-2', and 'Actuator' blocks. The 'SIMPACK: User Routines' window shows the configuration of force elements and the associated code. A grey box at the bottom right indicates the connection to 'Matlab/Simulink'.



Using Multibody Dynamics for Simulation of Adaptive Systems

SIMPACK to design of adaptive systems exemplified by MCT

Analysis and optimisation the influence of a some single parameter to the behaviour of the multi body system with SIMPACK-ParVariation and SIMPACK-Optimization.

The image displays the SIMPACK software interface for modeling and optimizing adaptive systems. The main window shows a 3D model of a mechanical system with a red block on a yellow base, subjected to a force $F(t)$ and mass m . The interface includes several key components:

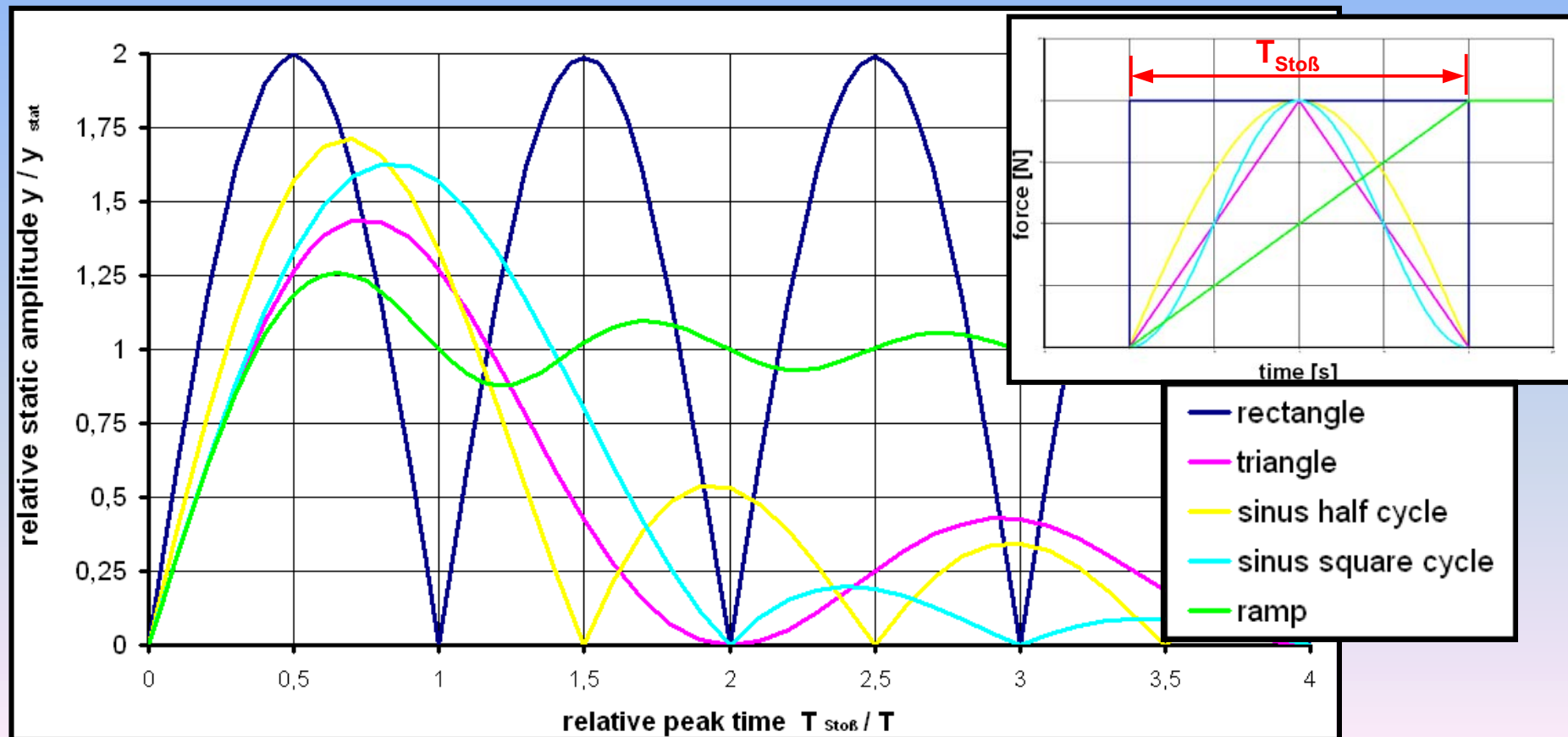
- SIMPACK 8514 - Model Setup: ASP1**: The main interface window with a menu bar (File, Edit, View, Info, Globals, Elements, Calculation, Animation) and a toolbar.
- SIMPACK 8514 - Model1**: The main menu window with options like File, PreProcess, Calculation, PaVariation, Optimization, PostProcess, and Help.
- PaVar Plots in Time Domain**: A window showing a graph of force $F(t)$ versus time, with the title "Parameter Variation Results: $y = f(t, p_1)$ ".
- SIMPACK: Parameter Variation**: A dialog box for setting up parameter variations, including fields for "Number of Variations" and "Parameter" names.
- SIMPACK: Define Parameters**: A dialog box for defining a parameter, including fields for "Name", "Type", "Element ID", "Initial Value", and "Final Value".
- SIMPACK: Test.opt**: A dialog box for optimization settings, including "Opt. Variant", "Update No", and "Finite Difference Method".
- SIMPACK: Open Optimization File**: A dialog box for opening an optimization file, showing the file path.



Using Multibody Dynamics for Simulation of Adaptive Systems

Results

Influence of a central, normal impact of the unregulated, undamped, linearised System by variation of impact mode.

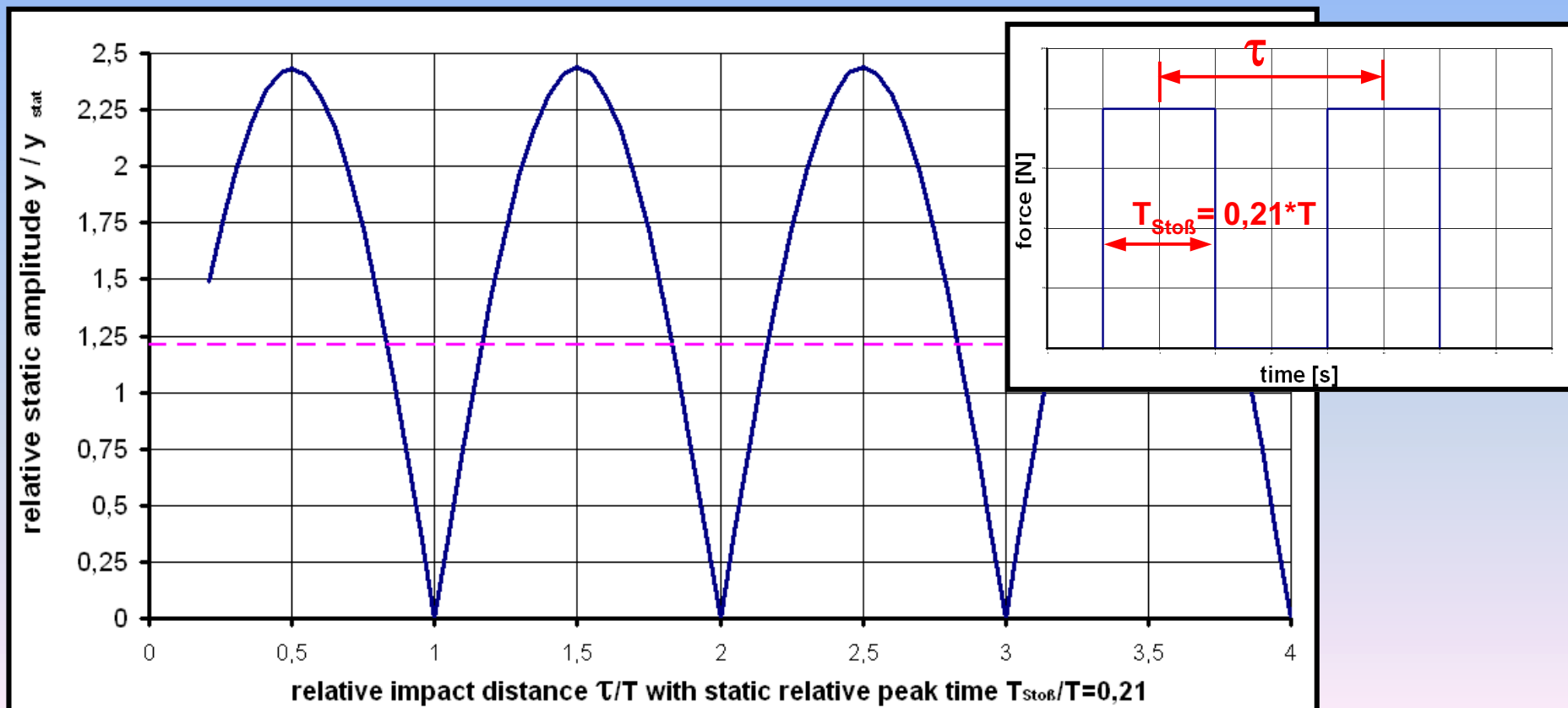




Using Multibody Dynamics for Simulation of Adaptive Systems

Results

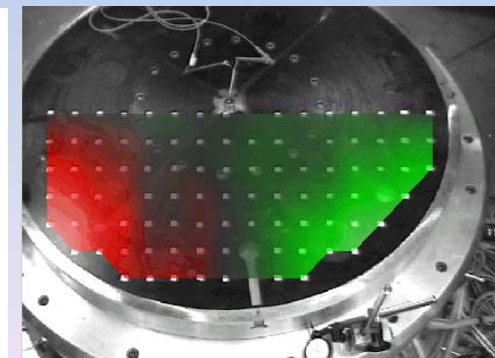
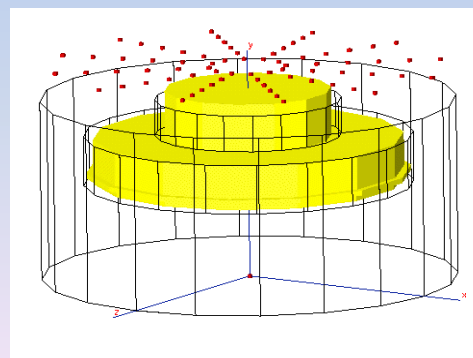
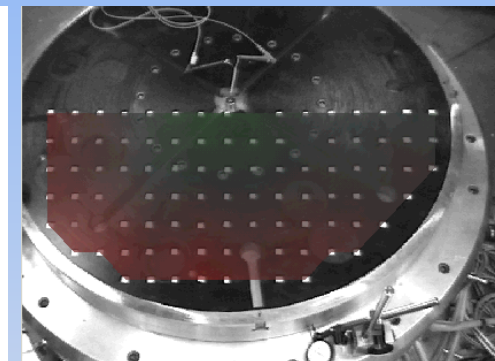
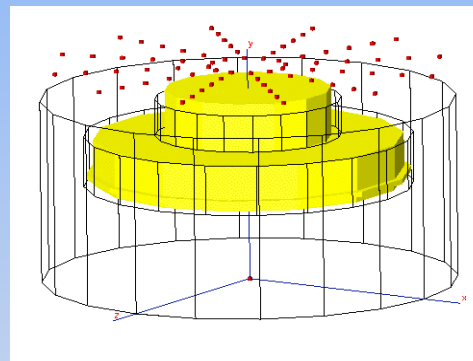
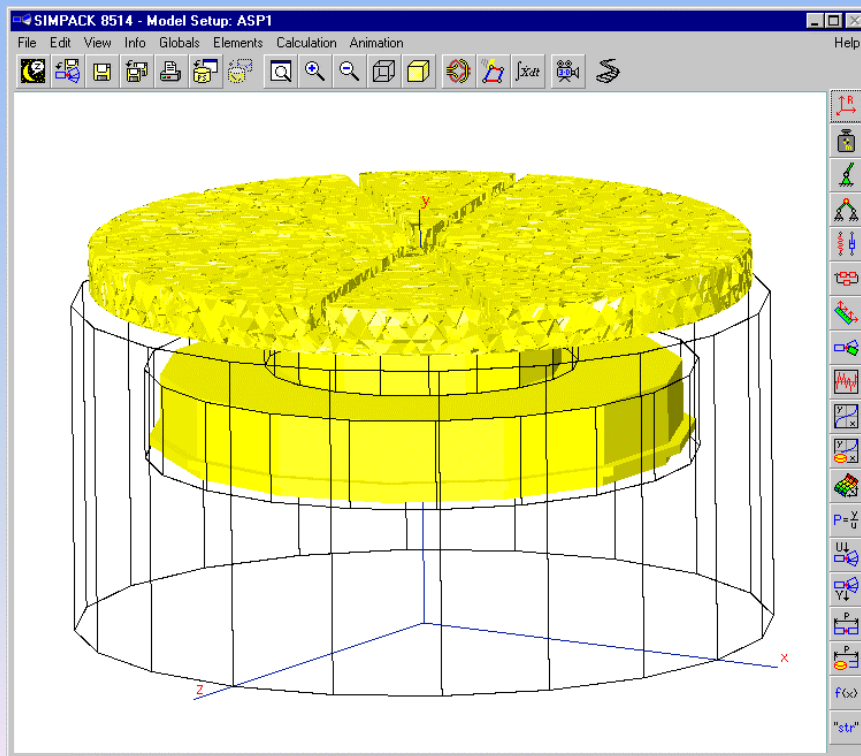
Influence of a pair of central, normal impacts of the unregulated, undamped, linearised System by variation of impacts distance



Using Multibody Dynamics for Simulation of Adaptive Systems

Results

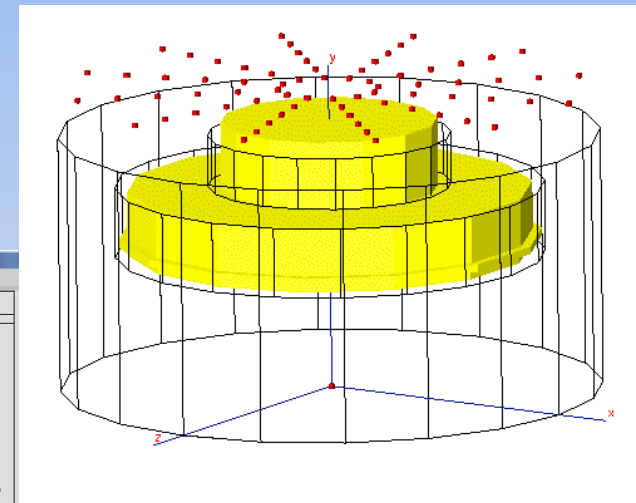
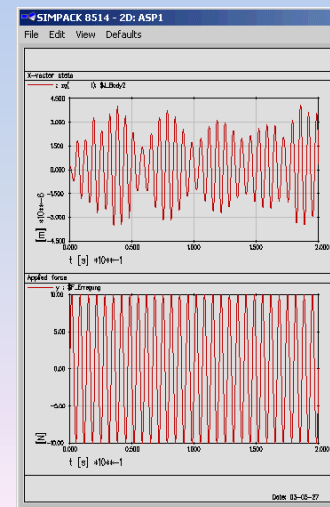
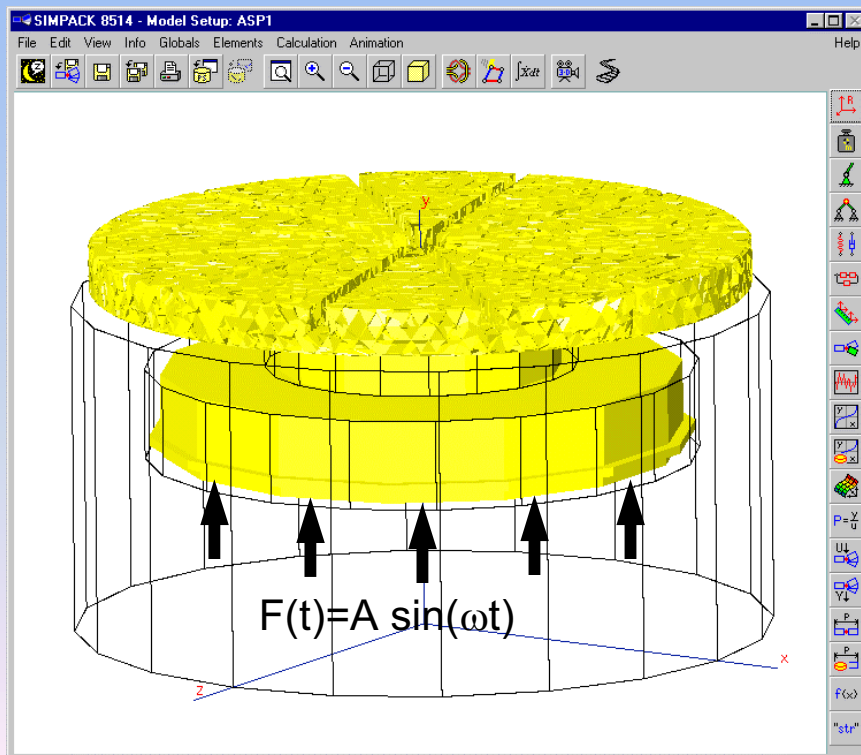
Some modal modes of the MRT with elastic plate
in comparison of experimental data.



Using Multibody Dynamics for Simulation of Adaptive Systems

Results

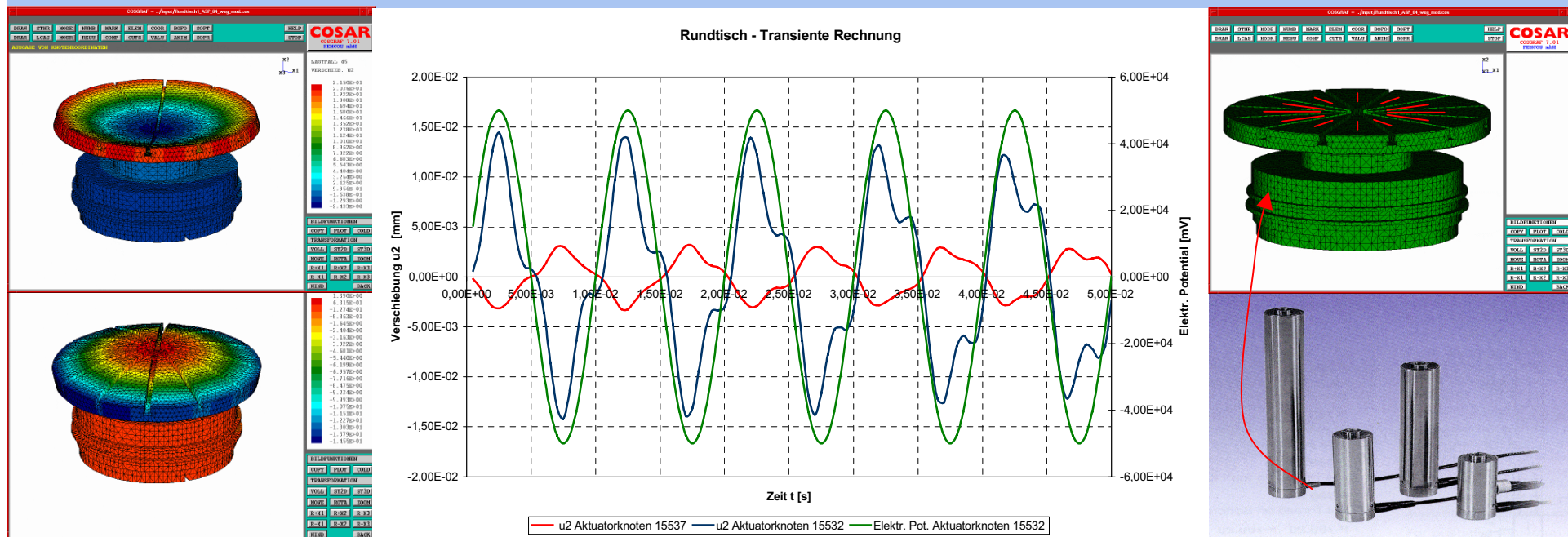
- System reaction by acting at the points of magnetic guidance
- Sinus excitation below the first elastic eigenfrequency of the plate
- Result: amplitude of the elastic plate is near $10\mu\text{m}$



Using Multibody Dynamics for Simulation of Adaptive Systems

Results

- fitting norm stack actuator in the elastic plate
- Sinus excitation below the first elastic eigenfrequency of the plate
- Result: amplitude of the elastic plate is near $15\mu\text{m}$





Using Multibody Dynamics for Simulation of Adaptive Systems

Abstract and further steps

- Build up a ridged body systems of the MCT with elastic components and the real control loops of the magnetically guidance
- Consideration of dynamic excitation by guidance and tool of MCT
- Consideration of elastically deformation by workpieces
- Consideration of elastically deformation by tool support
- Verification of the multibody results
- Development and implementation of a new control algorithm with respect of machining accuracy +/- 2,5 μ m
- Realisation of new control loops at the MCT