Flaps simulation

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VIVACE Forum 1, Warwick, U.K.
Sept. 20-21, 2005

Task 1.1.5 - Flaps

Task 1.1.5 - Use Case

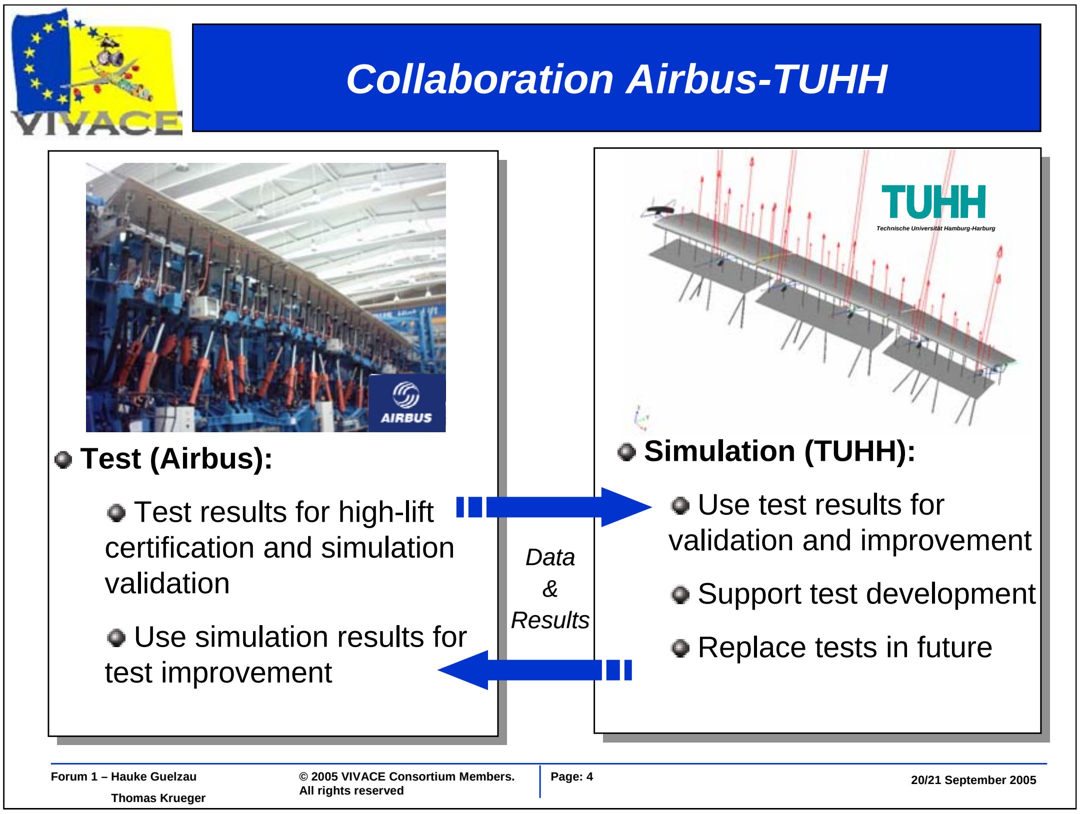
CONTEXT:

Improvement of the High Lift System Verification / Certification by partly replacing test activities through validated system simulation.

SCENARIOS SELECTED:

Scenario 1: ***Substitution of the so-called "Bang Test" for A380***

Scenario 2: ***Substitution of IMO-Tests for A380 Derivates (eg. Freighter) via simulation***



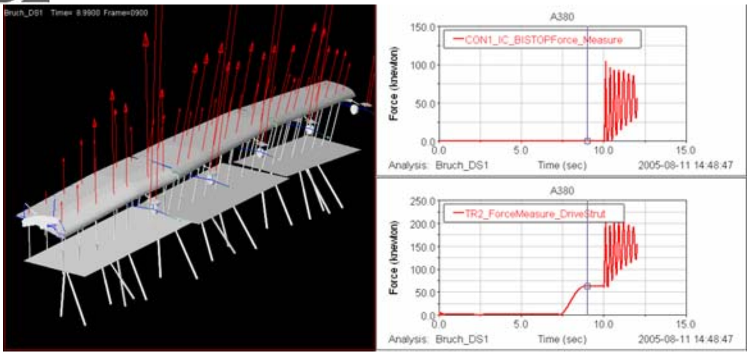
The part of Hamburg University of Technology at workpackage 1.1.5 „Flaps“ is, in cooperation with Airbus Germany, the development of methods for simulating the complete flap system, such that the dynamics of certification tests can be mapped.

The first part of this work is the development of methods for modeling and simulation of the structural part of the flap system. The structural part consists as well of the flaps as of the support stations and the airload system. The task of the support stations is to position and to orient the flaps and to conduct the forces acting on the flaps into the structure of the wing.

In order to validate the methods developed, test results from Airbus will be compared to simulation results. With this, one is supposed to gain more insight on what system elements most affect the system dynamics and on how to refine the model.

The simulation results are on one hand valuable to the costruction if the test rig, since the simulation helps to estimate test rig dynamics that cannot be measured. For future projects, this simulation can effectively support development and test of high lift systems. If the project aim was achieved, it could even be possible to replace complex and expensive test rigs by smaller subsystem tests and simulation results would cover an important part of the certification process.

Simulation Requirements



- **Simulation requirements** follow from dynamics at Drive Strut Rupture:
  - Two static states, before and after rupture
  - In between region of high dynamics and high damping
- **Target of investigations:**
  - To find adequate modelling methods & tool definitions for whole mechanical system
  - To verify the methods for prediction of real loads and dynamics

For exact simulation results, the test set up just described by Mr.Krüger and the dynamics that appears while a drive strut rupture have to be mapped by a suitable model. This model must be run in a simulation enviroment that is able to cover the complete dynamics of this rupture test.

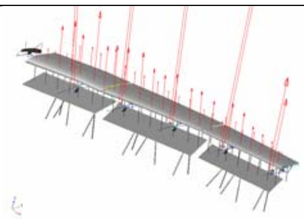
For determination of requirements to such a simulation, it is necessary to inspect the expected qualitative dynamics of this test. On this reason you will see an animation of how the whole system behaves if a drive strut, here drive strut 3, is broken. (This animation is taken from the simulation I will show you on the next pages, but it is suitable for demonstrating the expected dynamics):

Before the rupture, the system is in a static state, the airloads are acting on the flaps and the linkages situated below the flaps conduct these forces via the trackbeams into the wing. All forces of the system are in a staic state.

The rupture of a drive strut causes the system to move with high dynamics, since all energy bound in the drive strut is set free at once. About 20 Milliseconds later, the distance between the two flaps has exceeded a certain maximum value and the interconnection strut is activated: This causes one part of the interconnection strut to crash into an absorber sleeve made of carbon fiber reinforced plastic . This absorber damps the dynamics and causes the system to reach another static state about half a second later..

Especially the impulse from the intercon crash causes a peak load that spreads out over the system.

Model Structure (1)

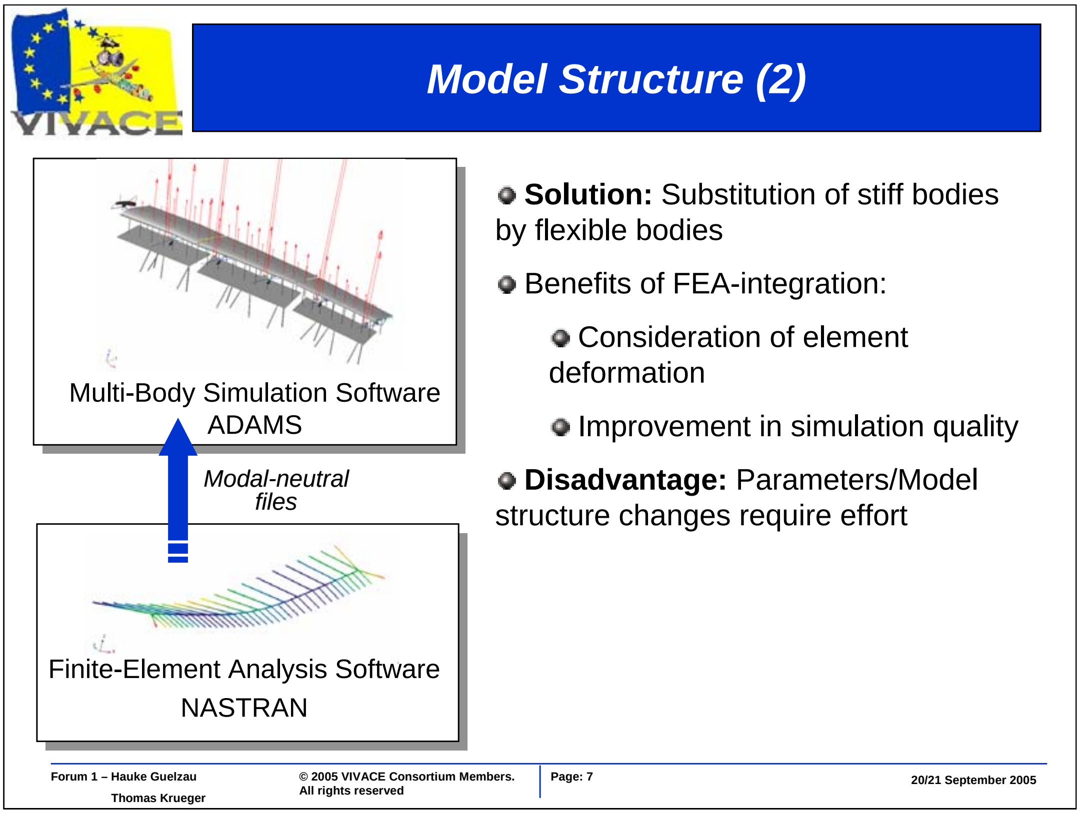


Multi-Body Simulation Software ADAMS

- **Multi-Body Simulation:**
  - System description in full operating range
  - Feasibility of investigation of highly dynamic test cases
- **Disadvantage** for systems with coupled elastic elements: partly lack of modelling accuracy due to stiff bodies

The requirements to the simulation are hence: the ability to describe system states in a global working range and the ability to describe a highly dynamic change in system states. This leads to the fact that a multi-body-simulation software is considered to best cover the system dynamics, since it can map nonlinear system dynamics. Hence, the modeling and simulation software ADAMS is chosen. With this software, on the one hand the requirements are met and on the other hand, ADAMS offers a lot of additional capabilities for modeling and simulation.

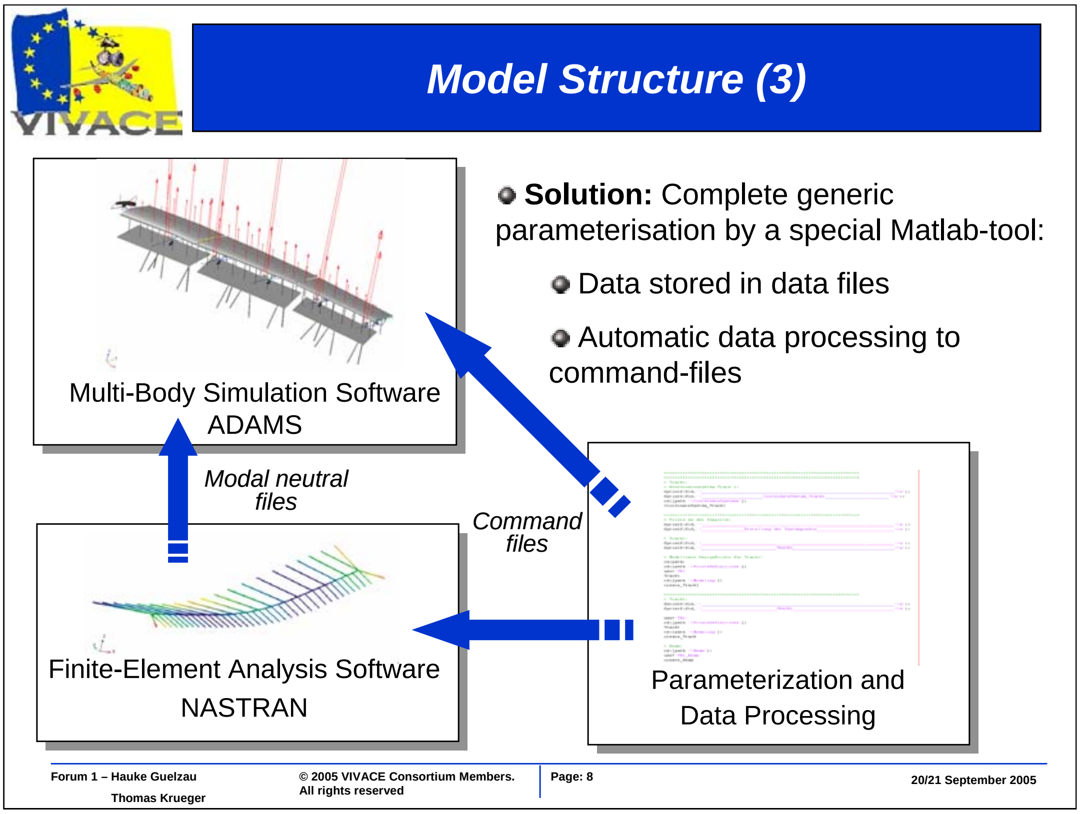
A big disadvantage of multi-body simulation is, especially for aeroelastic systems, the lack of modeling accuracy, since flexibility for elastic bodies is usually not considered by a stiff multi-body model.



The problem can be solved since the ADAMS-software is able to include flexible bodies into the simulation. This is especially important for modelling the flaps and the trackbeams. Simulation results of the A340 flap structure in comparison to test results showed that the inclusion of flexible flaps and trackbeams is the reason for a high improvement of the simulation results.

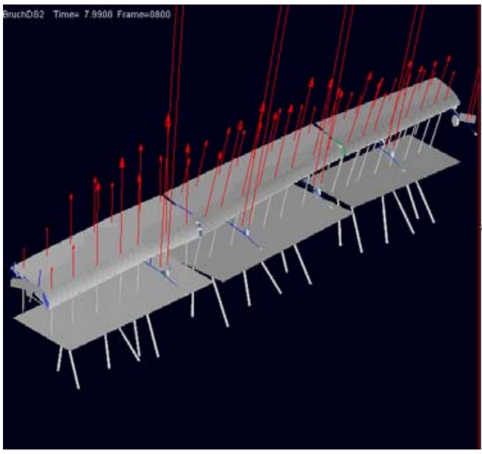
The flexible bodies are composed of beam elements with cross sectional properties defined in sections, approximating the stiffness of the real flaps and trackbeams. These flexible bodies are modelled with the Finite-Element tool NASTRAN. Afterwards, a modal analysis of each flexible body is carried out and the modes as well as the mode shapes are exported to ADAMS via a so called modal neutral file. All the data needed for modelling the flexible bodies can be taken from an alrady existing stick-model of the flap system.

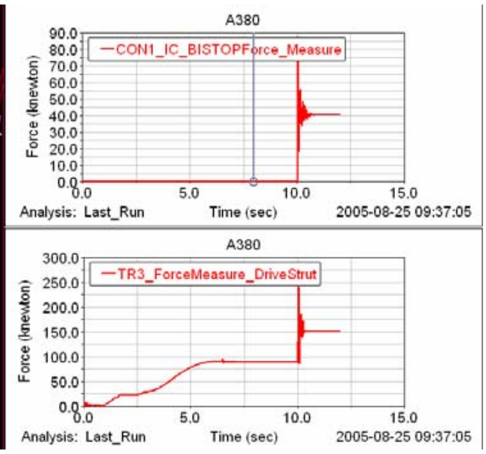
The resulting model is composed of lots of data for the joint locations, the masses, the stiffness information and all remaining information needed for modelling and simulation. Hence, only with high effort it is possible to change parameter sets or the model topology. Since in development process, the data basis can often be changed, it would be very helpful to have the opportunity of easily changing data and model structure.

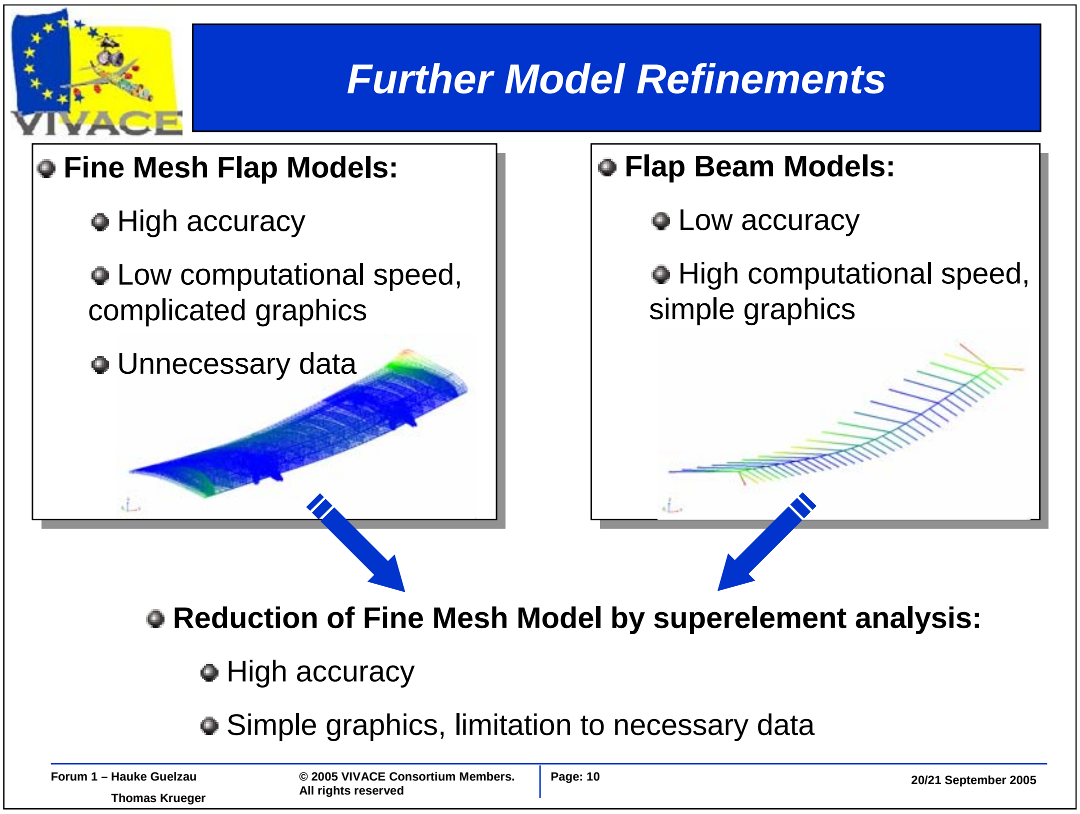


This problem is solved by using MATLAB to create command-files. These command-files are read in by ADAMS resp.NASTRAN. They contain all the necessary commands to put up the complete model. The data needed for modelling is stored in data files that can be changed easily. Hence, the parameters of the model can be changed easily. Since the programme for creating the command files systematically exploits recurrent modelling operations, a change in the modelling topolgy can also be carriad out more easily than directly in ADAMS or NASTRAN respectively.

Simulation




A380
CON1_IC_BISTOPForce_Measure
Force (knewton)
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0.0
5.0
10.0
15.0
Analysis: Last_Run
Time (sec)
2005-08-25 09:37:05
A380
TR3_ForceMeasure_DriveStrut
Force (knewton)
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0.0
5.0
10.0
15.0
Analysis: Last_Run
Time (sec)
2005-08-25 09:37:05



So far, many simulations have been performed in order to establish a first model validation and to gain experience about the sensitivity to parameter variations. These simulations revealed that the simulation results are highly sensitive to the stiffness of the flexible bodies. Especially the state of stress the system takes can change a lot due to variations in stiffness.

For that reason, it is very important to model the flexible bodies with high accuracy. The data used so far is taken from the stick model, treating the flaps and the trakbeams as usual Timoshenko-beams with properties defined in sections.

An improvement of the modelling of flexible bodies is possible by using a different model, the so called fine mesh model, instead of the stick model. A fine mesh model of a flexible part contains several thousands of nodes and finite elements that can describe the model very accurately.

The disadvantage of using a fine mesh model is its size for simulation. The very complex representation of a fine mesh model makes it impossible to use in the ADAMS-simulation. Still, it is possible to integrate this model accuracy in the ADAMS-simulation: This is possible by using a superelement-analysis in NASTRAN and a graphical reduction approach. Hence, one can find a representation for a fine mesh model that is confined to the transfer functions between the points where the flexible body interacts with other bodies or forces. With this approach, the physical precision is kept while the complexity for simulation is reduced.

Summary Task 1.1.5

- **Use-case:** Partly replacing test activities through validated system simulation
- **Simulation requirements:** Find adequate modelling methods for mapping real flap system
- **Achievements:**
  - Generic modelling tool developed
  - First Simulation runs accomplished
  - Verification of methods started
  - Model refinements in progress

Thank you for listening!
Questions?

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