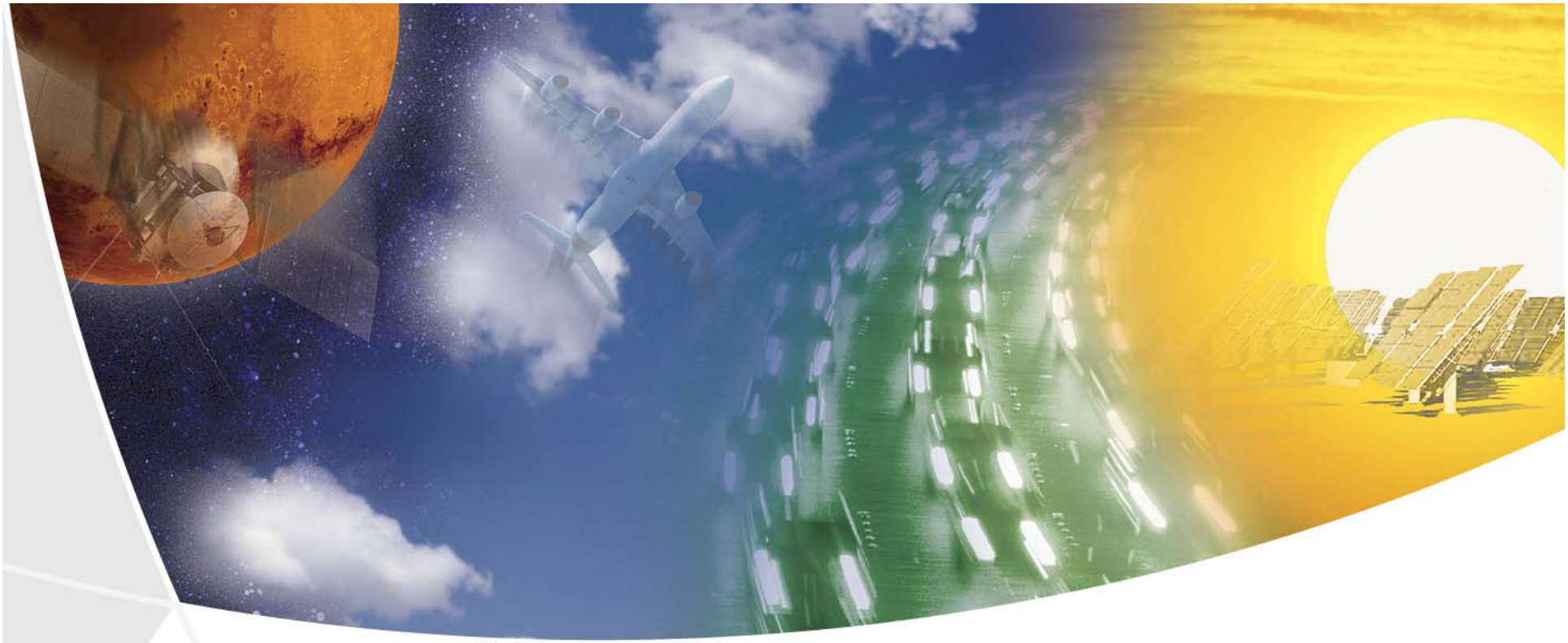


Numerical simulation software integration with TENT

Software Integration and Workflow Management

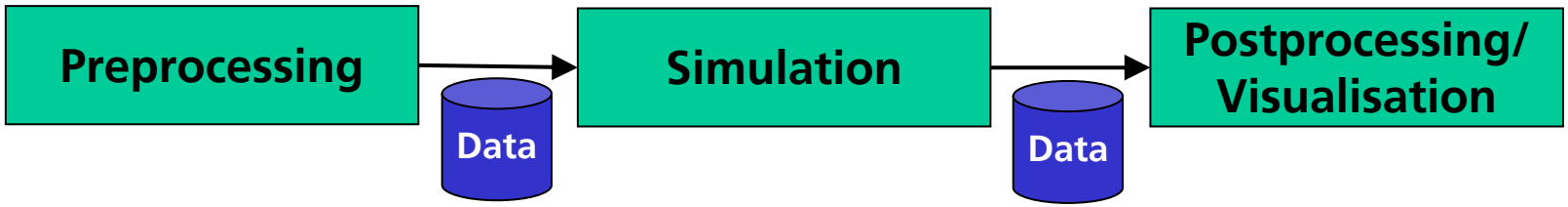
Andreas Schreiber, DLR Simulation and Software Technology

Joint ESTEC-DLR Workshop, ESA/ESTEC, Noordwijk, May 3-5, 2006

Deutsches Zentrum
für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

Introduction
Workflows

- Today, many problems require ***complex numerical simulations***. Examples:
  - Re-entry simulation of space vehicles
  - Aero dynamical and aeroelastical analysis of flight maneuvers
- Performing such simulations is ***software technologically*** complex
  - Invocation of many different codes *in correct order*
  - Usage of high performance computers
  - Transfer of data between the different codes
  - Collaboration with colleagues
- Complex simulations are ***Workflows*** of many codes:

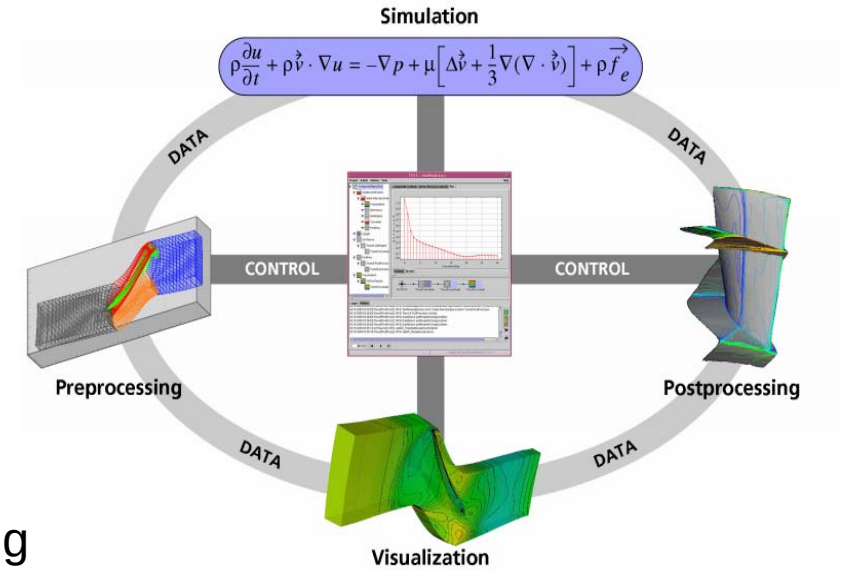


What is TENT?
Answer for Users

TENT is an ***integration and simulation environment*** for engineering applications.

Essential features:

- Easy setup and configuration of simulation workflows with **integrated applications**
- Usage of **distributed computing resources**
- **Online steering** and visualization
- Project-based **data management** with support for cooperative working
- Multidisciplinary **coupled** simulations



What is TENT?

Answer for Computer Scientists

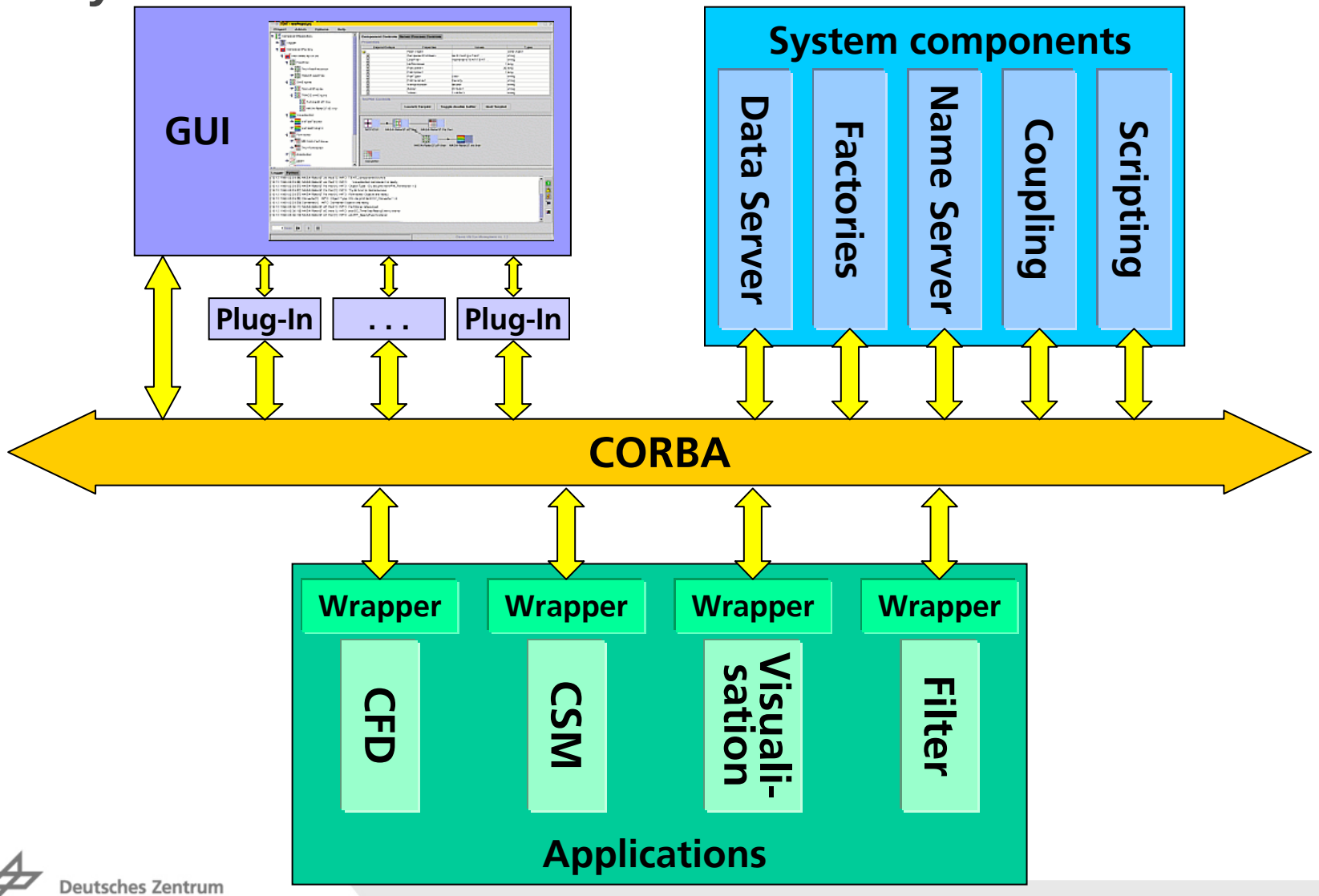
TENT is an ***open and extensible framework*** for tool integration and workflow management.

Essential characteristics:

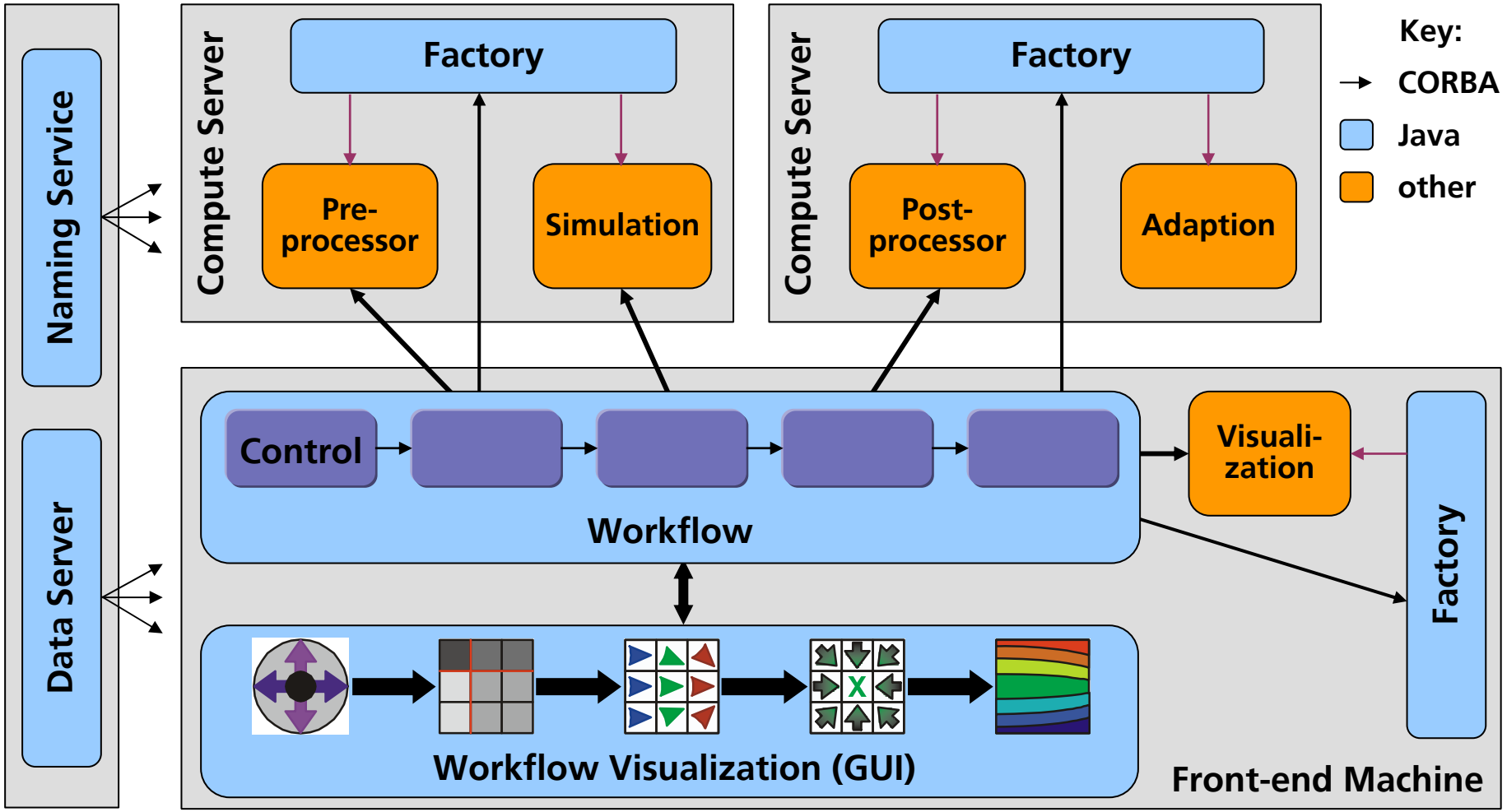
- Component based
  - CORBA Peer-to-peer model
- **Extensible** Java-GUI
- Distributed computing (Grids)
- Flexible integration of existing tools
  - Large development library
- Data management
  - Open solution (WebDAV & XML)

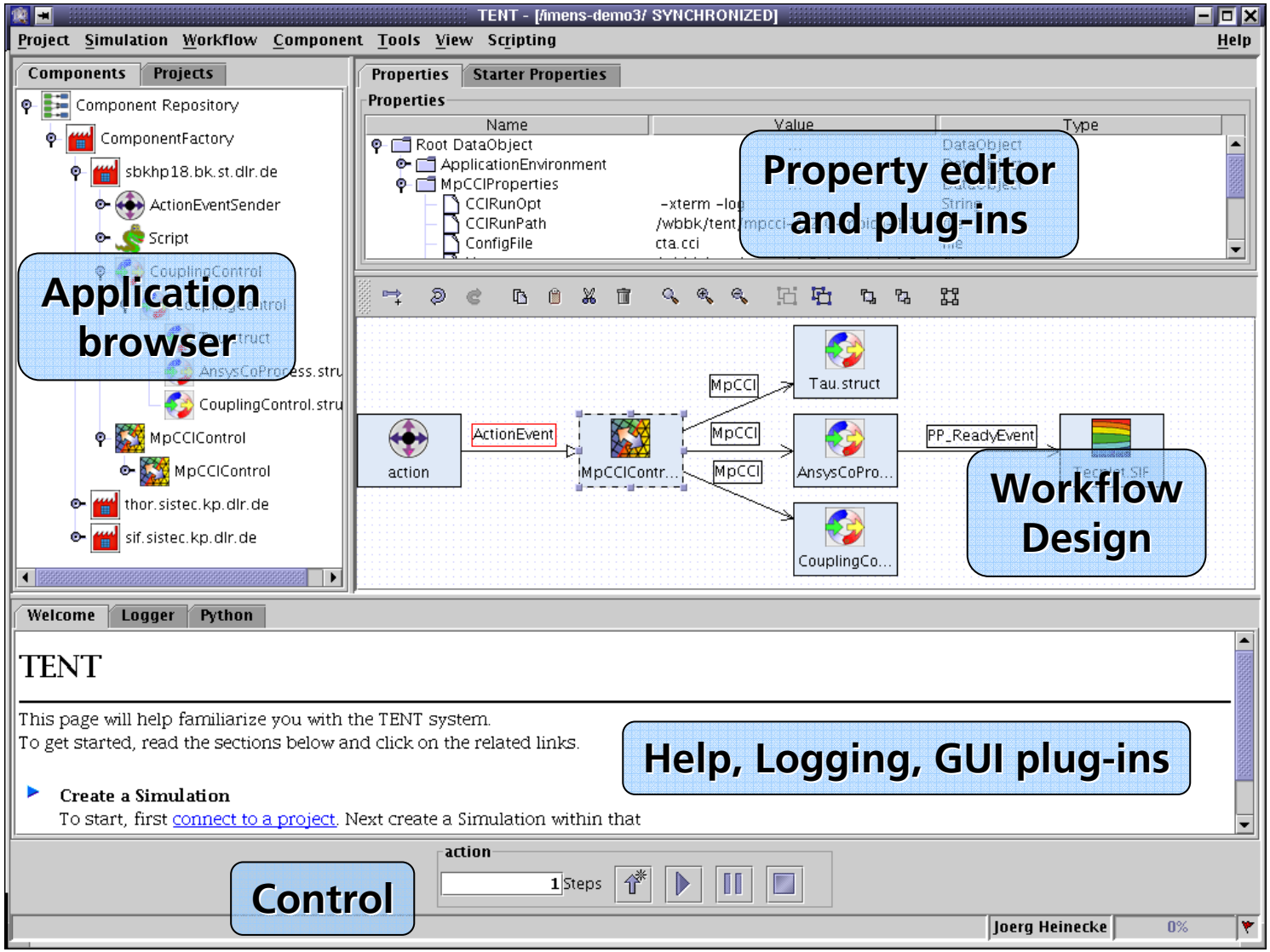
Development based only on accepted *standards*
- **CORBA, LDAP, FTP, HTTP, WebDAV, XML, ...**

System Architecture



Architecture and Deployment

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Project Simulation Workflow Component Tools View Scripting Help
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Workflow Design
Welcome Logger Python
TENT
This page will help familiarize you with the TENT system.
To get started, read the sections below and click on the related links.
Create a Simulation
To start, first connect to a project. Next create a Simulation within that
Help, Logging, GUI plug-ins
action
1 Steps
Control
Joerg Heinecke
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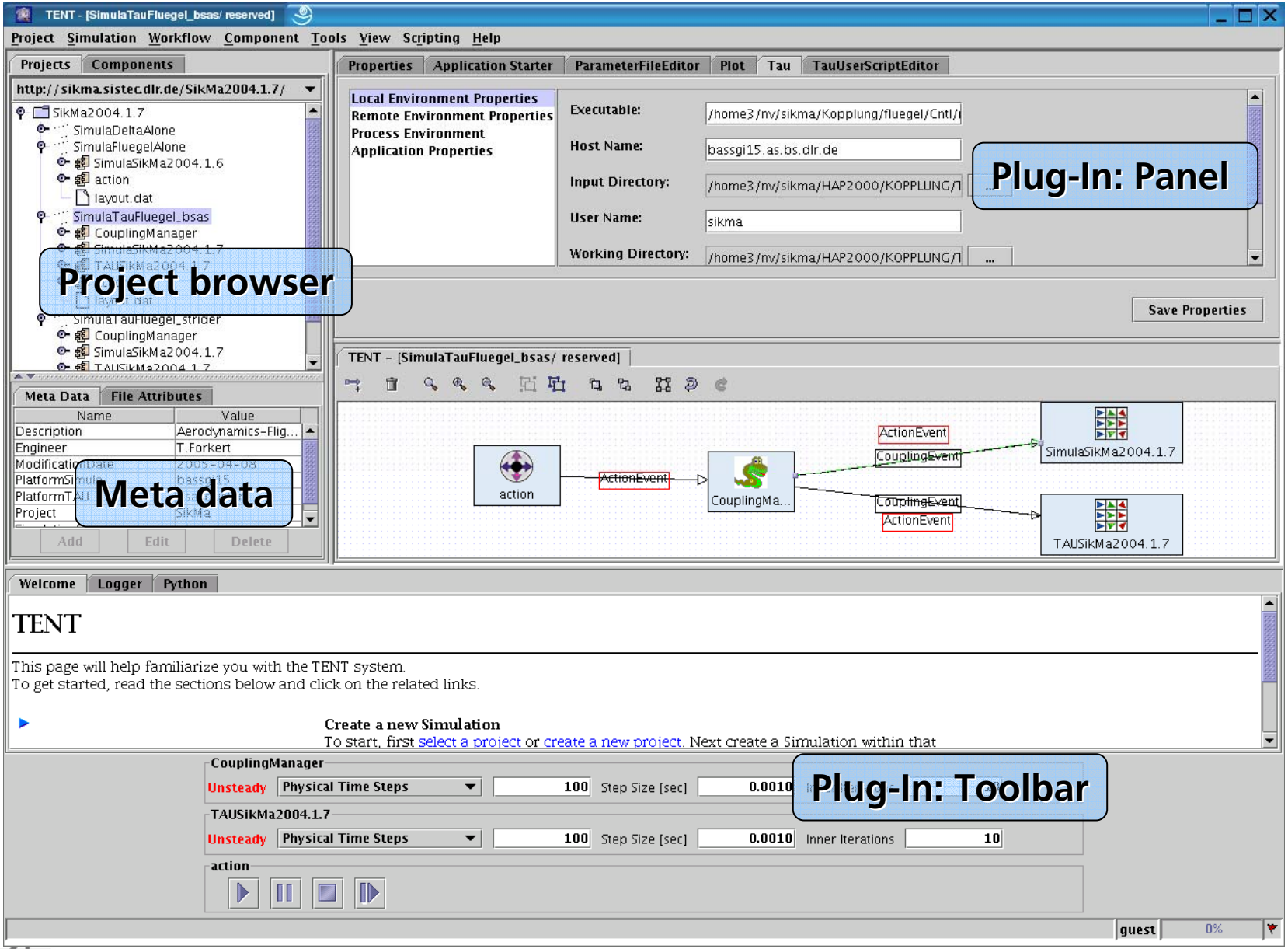
TENT - [SimulaTauFluegel_bsas/ reserved]
Project Simulation Workflow Component Tools View Scripting Help
Projects Components
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Project browser
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Delete
Meta data
Properties
Application Starter
ParameterFileEditor
Plot
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Local Environment Properties
Remote Environment Properties
Process Environment
Application Properties
Executable:
/home3/nv/sikma/Kopplung/fluegel/Cntl/t
Host Name:
bassgi15.as.bs.dlr.de
Input Directory:
/home3/nv/sikma/HAP2000/KOPPLUNG/T
User Name:
sikma
Working Directory:
/home3/nv/sikma/HAP2000/KOPPLUNG/T
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Plug-In: Panel
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Welcome
Logger
Python
TENT
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To start, first select a project or create a new project. Next create a Simulation within that
CouplingManager
Unsteady
Physical Time Steps
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Step Size [sec]
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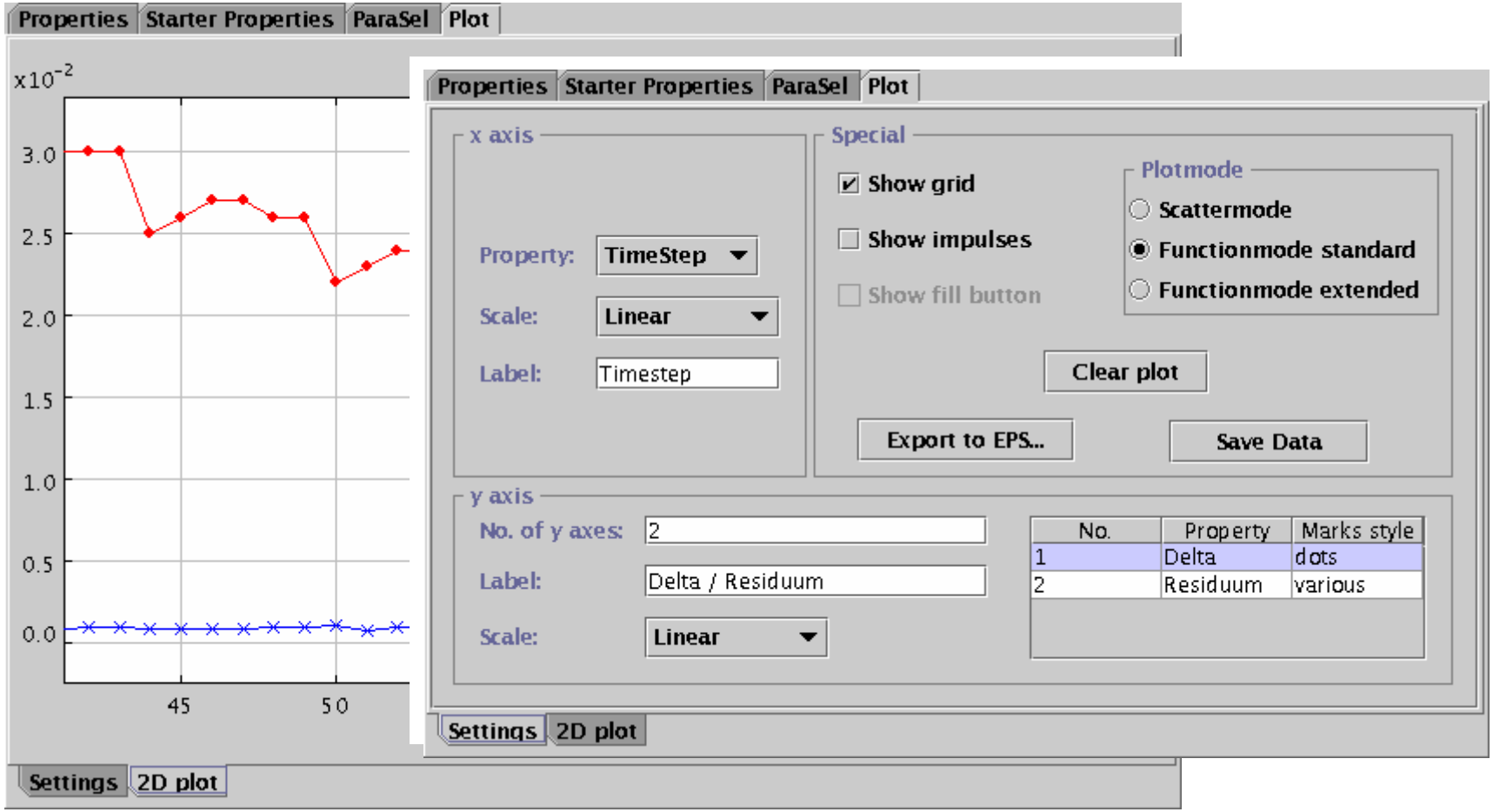
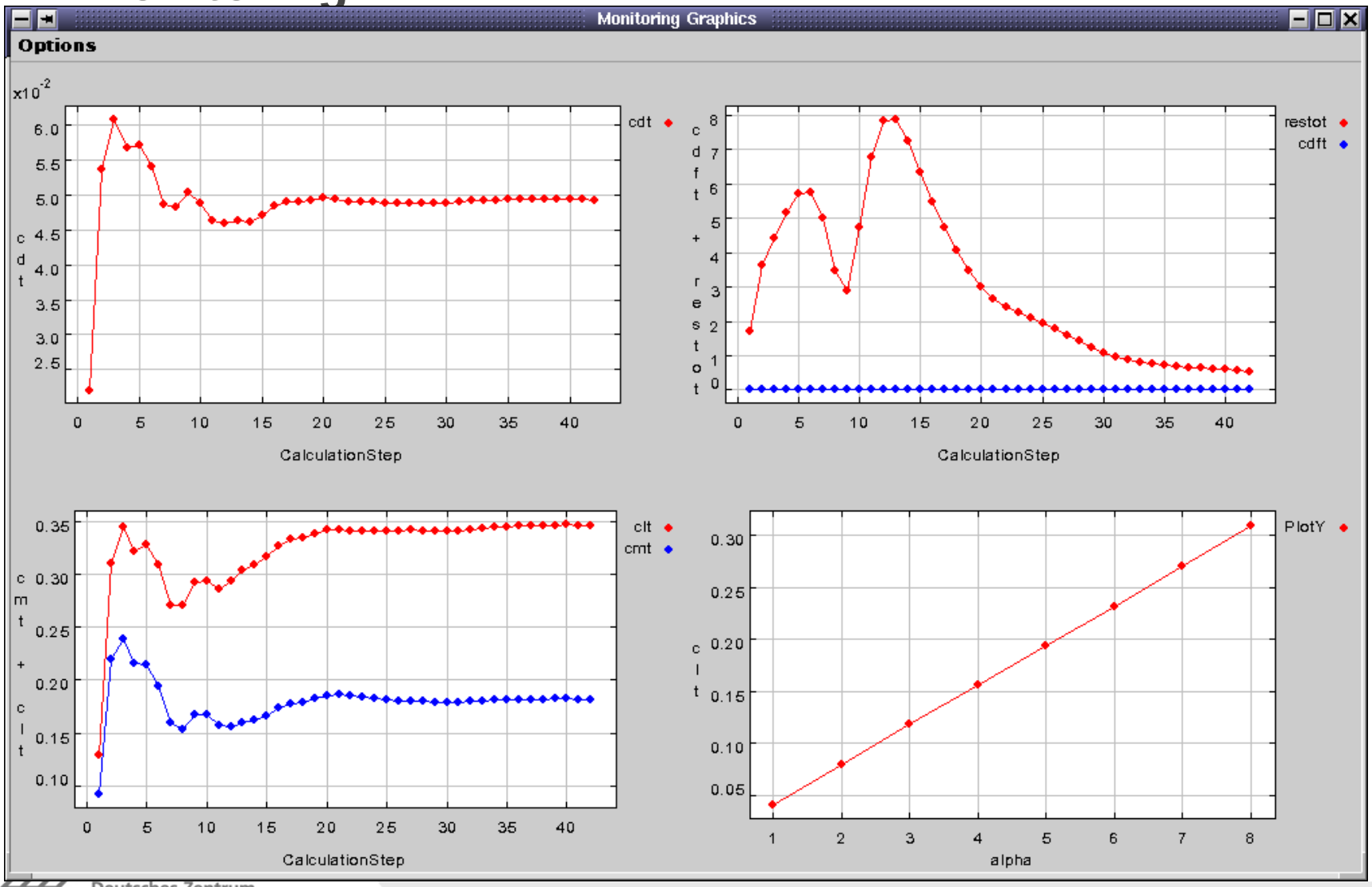
TAUSikMa2004.1.7
Unsteady
Physical Time Steps
100
Step Size [sec]
0.0010
Inner Iterations
10
action
Plug-In: Toolbar
guest
0%

Example GUI Plug-In

2D-Plot



Monitoring


Monitoring Graphics
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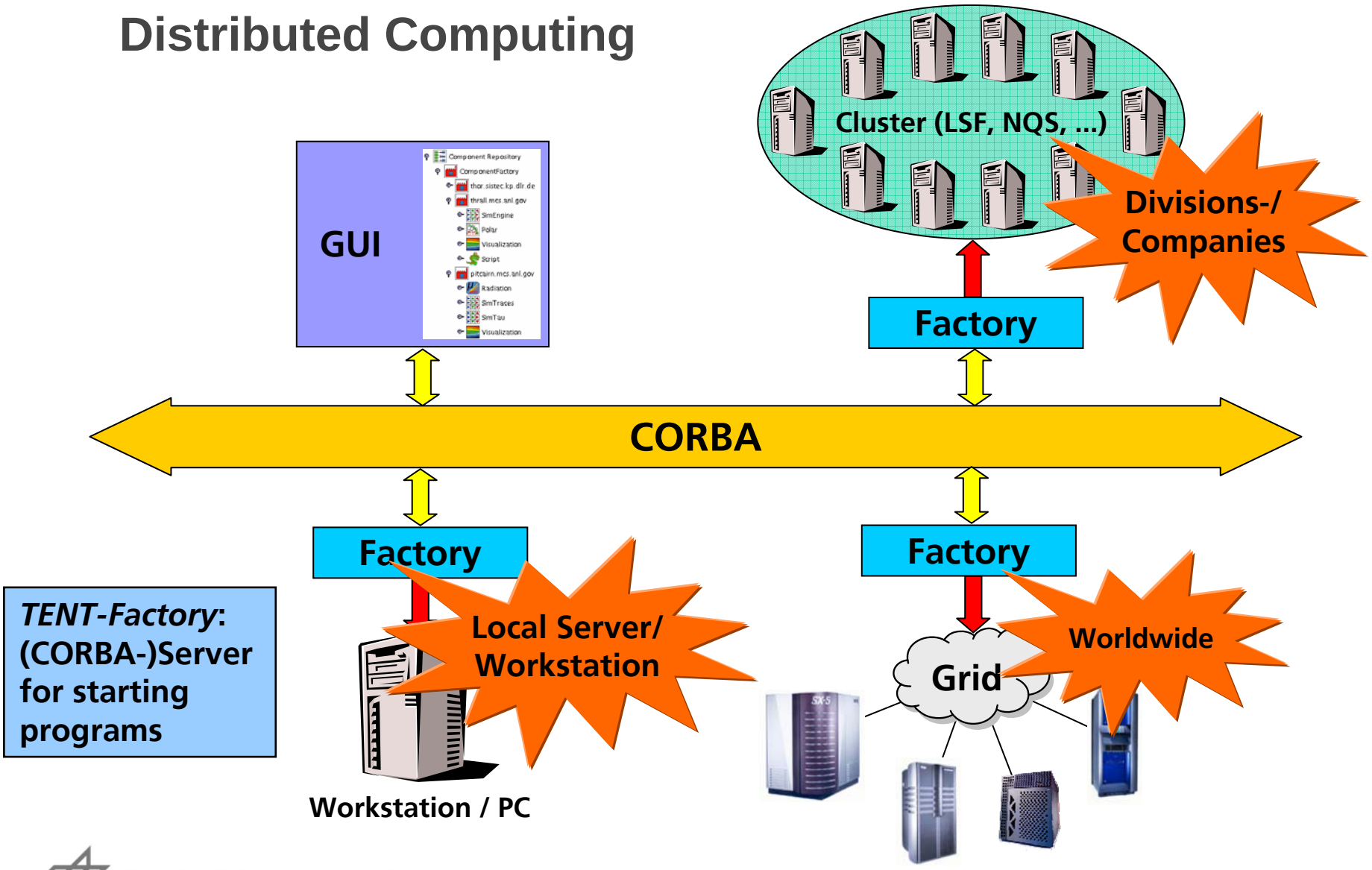
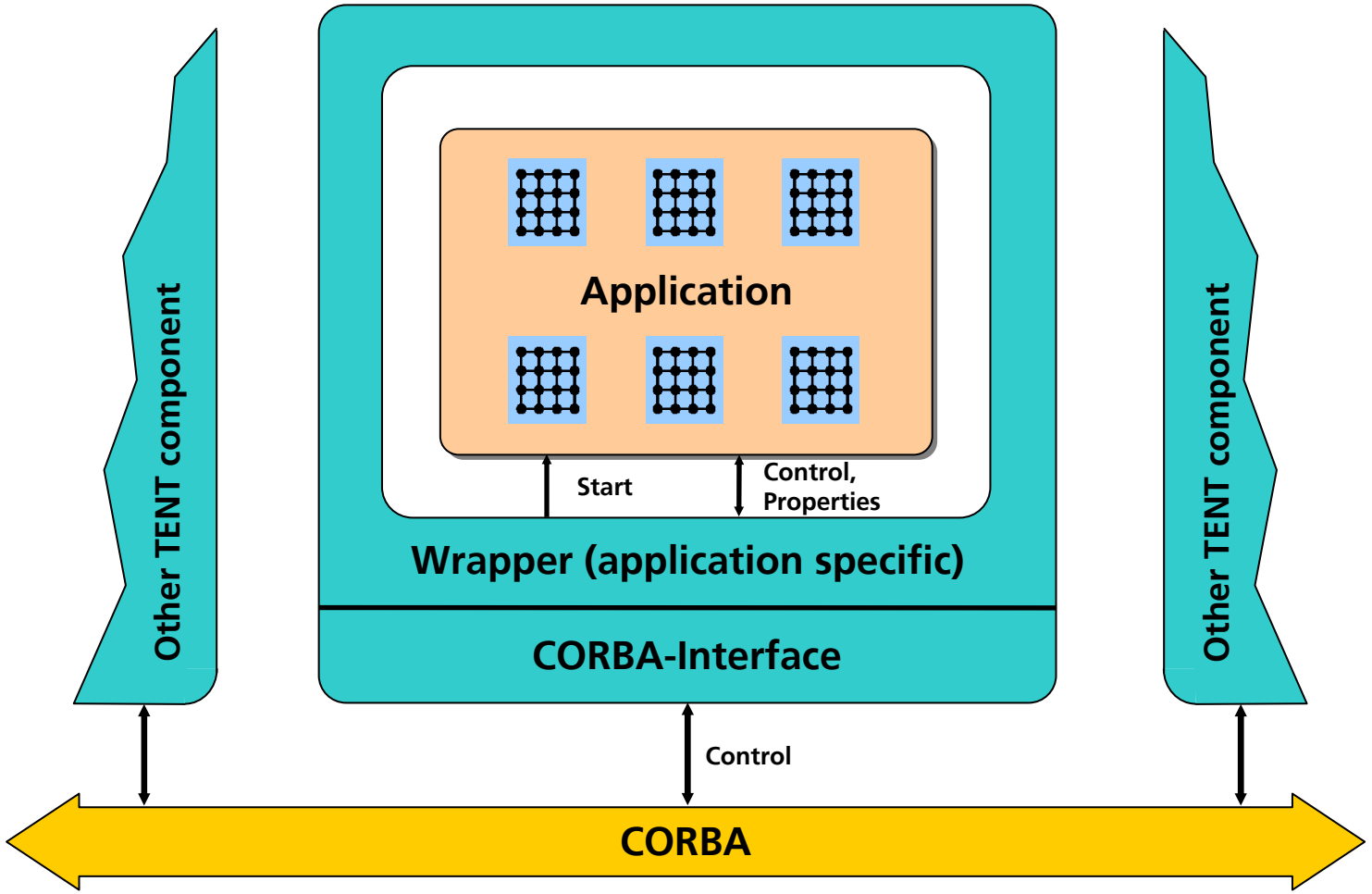
Distributed Computing



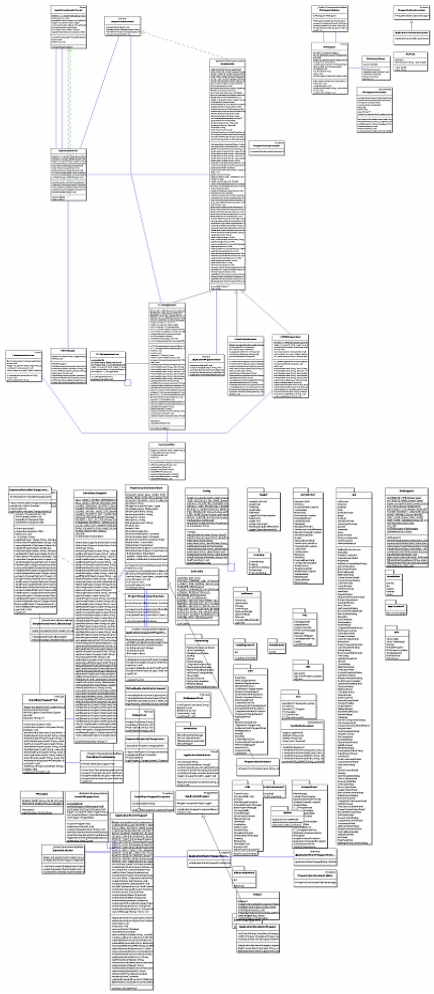
TENT-Factory: (CORBA-)Server for starting programs

Integration of Applications
Wrapper



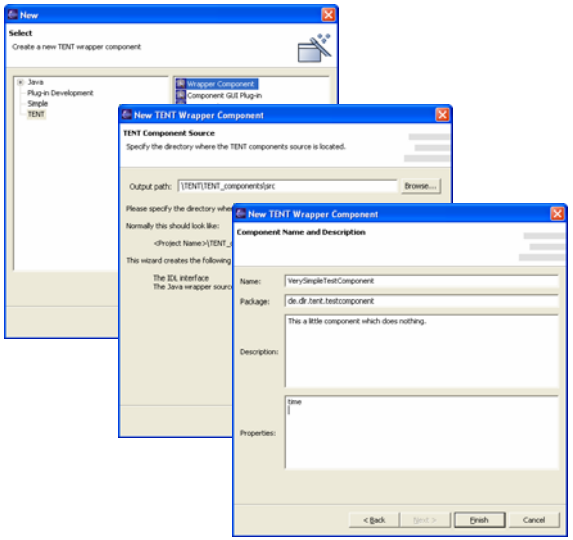
Integration of Applications
Wrapper Library (SDK)

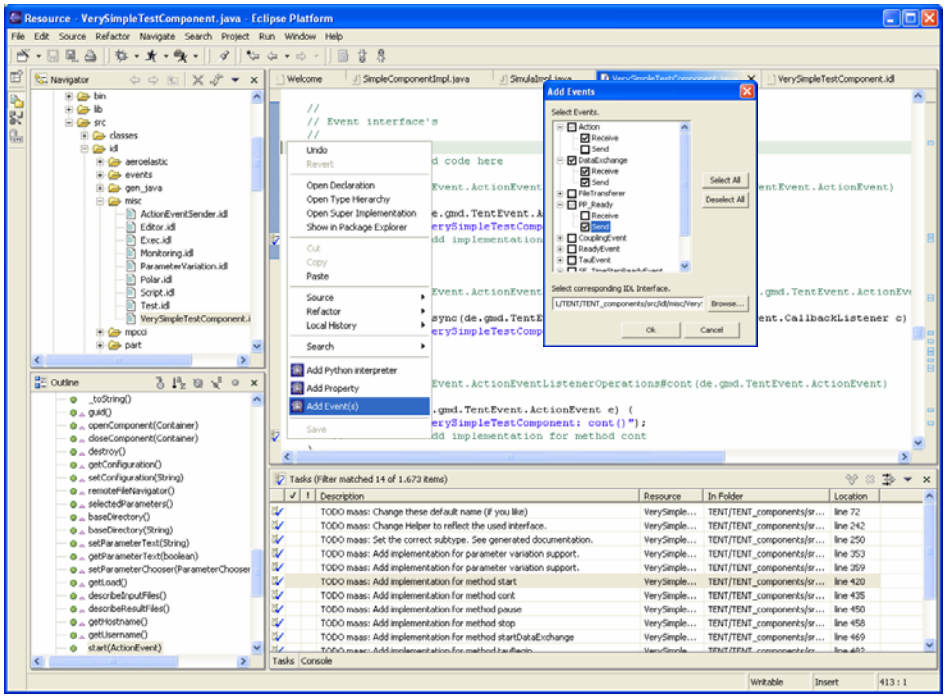
- Wrapper development in **Java** or **Python**
- Some features
  - Generation of input files
    - Templating (replacement of parameters)
  - Parsing of result files
    - Extraction of values
    - General filter mechanism
  - Execution
    - Remote execution
    - Application control via pipes, TCP/IP sockets, CORBA, …
- **Wrapper code can be generated…**



Integration of Applications
Automatic Generation of Wrapper Code

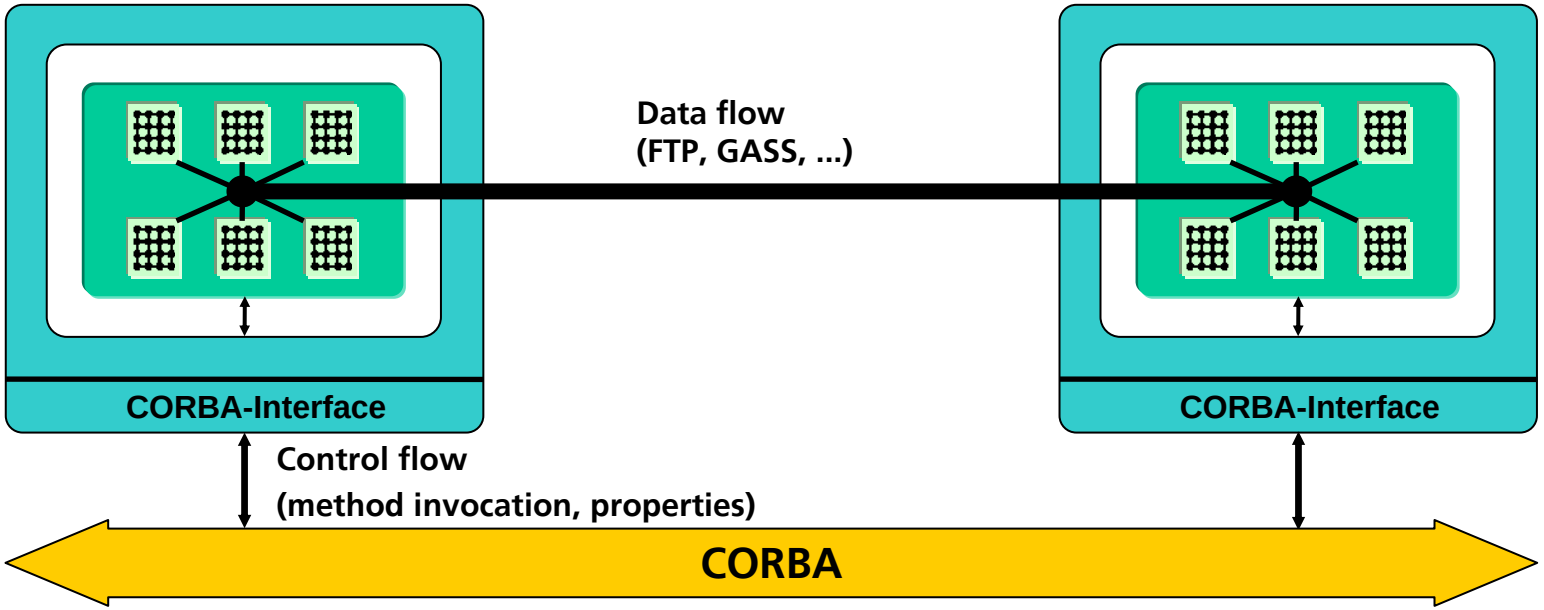
- To **reduce the effort** and **minimize coding errors**
- TENT specific Eclipse plug-ins for:
  - Generating new wrapper code
  - Extending existing code





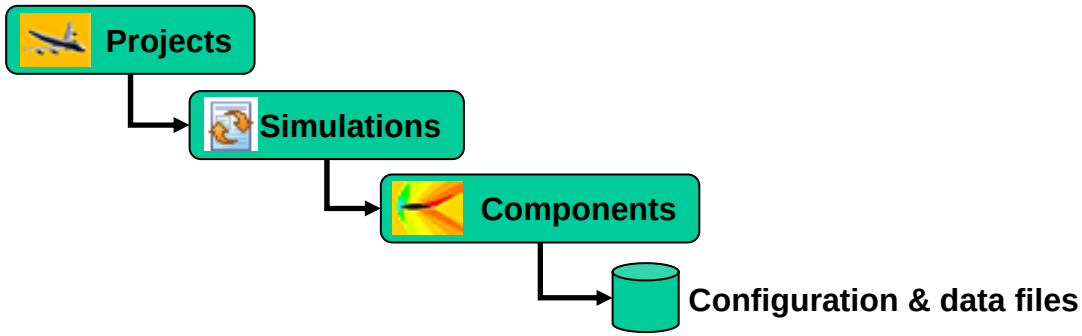
Communication

- Control flow
  - Events and method invocations through CORBA
- Data flow
  - Small data set as parameter through CORBA
  - Massive data through GASS, FTP, GridFTP, Socket, ...

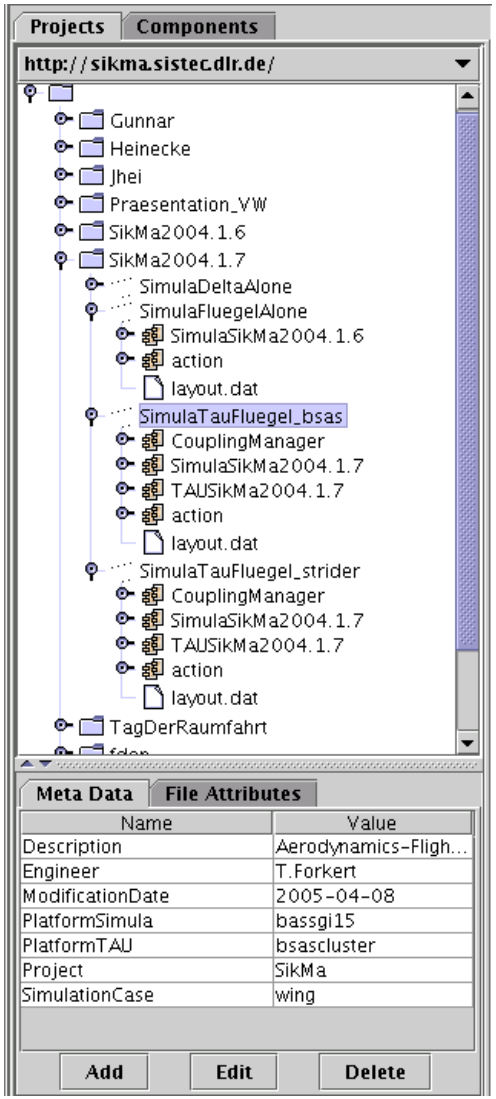


Data Management
Project and Workflow Structure

- Free hierarchical structure of projects and data:



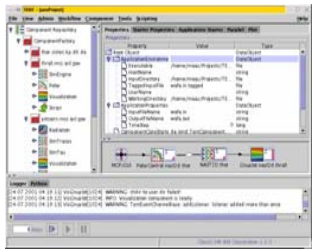
- Cooperative working
  - User management and access control
  - Data exchange via data server
  - Similar to PDM systems
    - *Check-Out, Check-In*



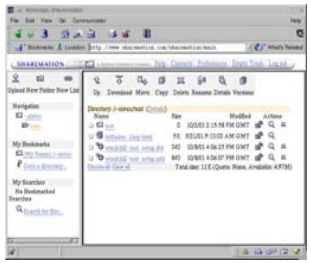
Data Management
XML & WebDAV

WebDAV: ***Web Distributed Authoring & Versioning***
Extension of the HTTP protocol (locking, meta data, versioning, search, and access control)

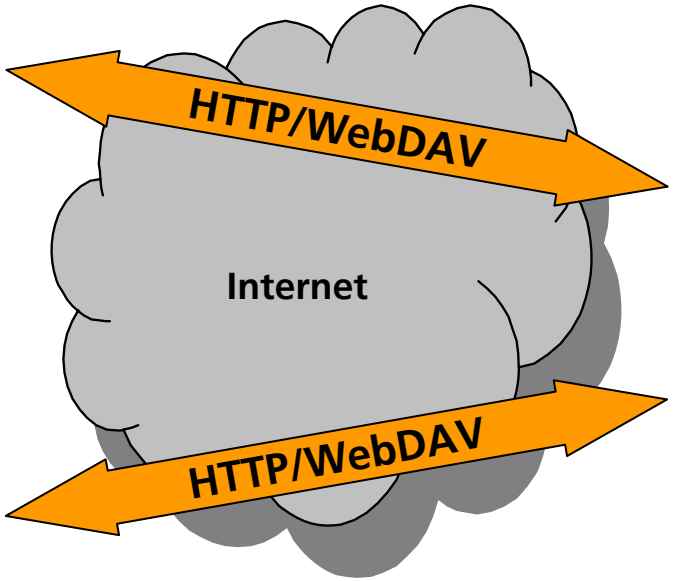
- Concept
  - Storage of project data in XML format on a server
  - Access to data using the standard protocol WebDAV

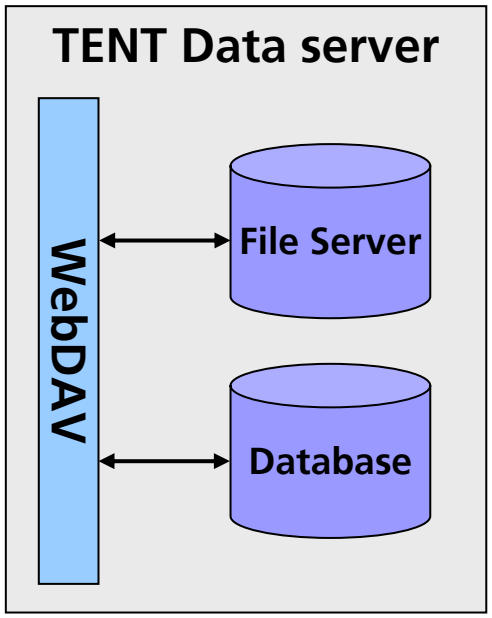


TENT



Other applications





Data Management
Data Provenance

- **Provenance** is information **in addition to the standard logging** which helps answer **questions about origins of data**
- Typical such questions are
  - *Given some data item, what was the simulation case?*
  - *Given some parameter, in what simulation(s) has it been used?*
  - *What data has been recorded in a simulation with a specific parameter?*
  - *What simulations have been run using a given model (aircraft design)?*
  - *Given two/more simulations with the same setup, what is the result and the difference in provenance?*
- TENT has integrated a **provenance storing and querying service** (developed in the EU GRID PROVENANCE project)

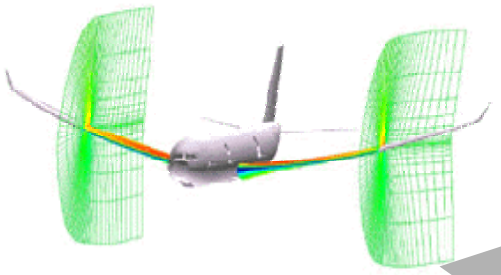
Scripting
Integration, Control and Automation

Applications do not have everything, so scripting is needed.

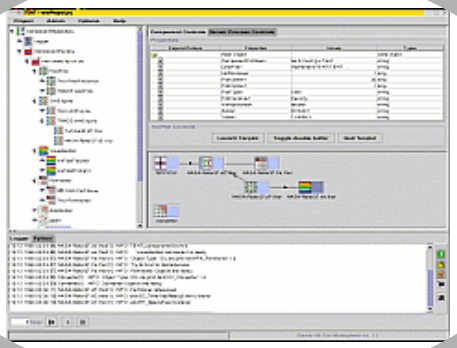
- Usage of scripting in TENT
  - **Integration of applications**
  - **Workflow control** (loop constructs, conditional constructs, coupling control)
  - Test scripts for quality assurance automation
  - **Debugging**
  - Command journaling
- Technique
  - **Embedded Python interpreter**
  - Script interpreter in the GUI
  - Script console in the GUI
  - Scripting block in workflows (control and code integration)

Application Systems

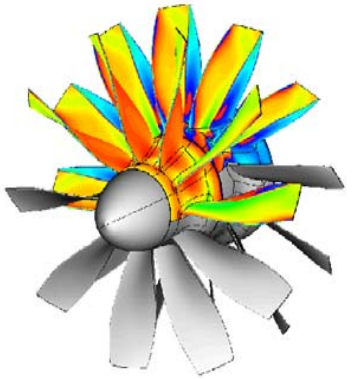
Space reentry vehicles

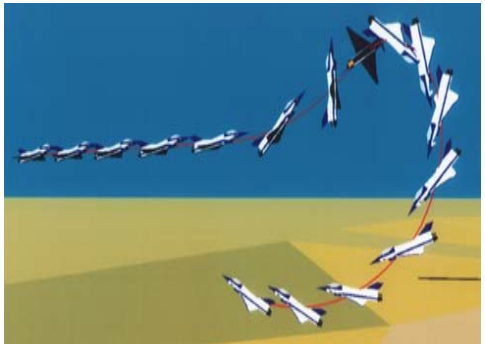


aircraft

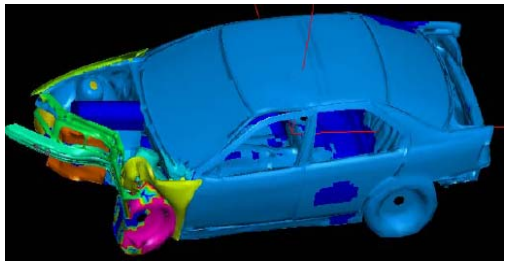


Turbine engines





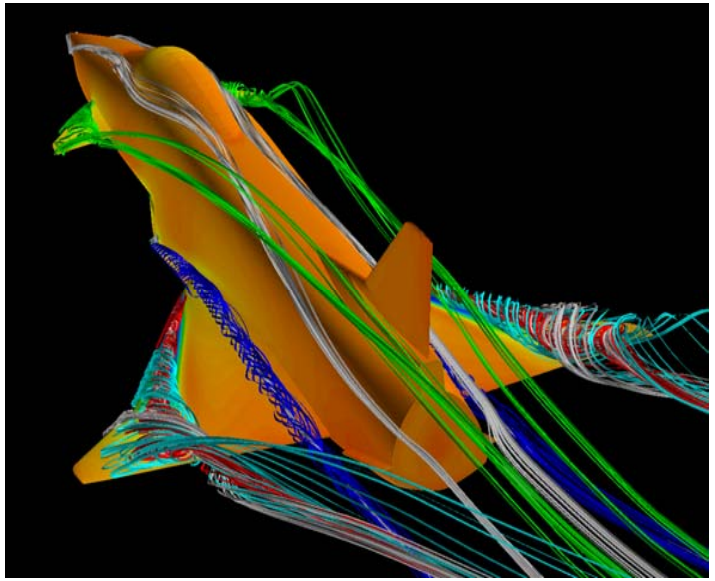
Flight maneuvers



Automobile design

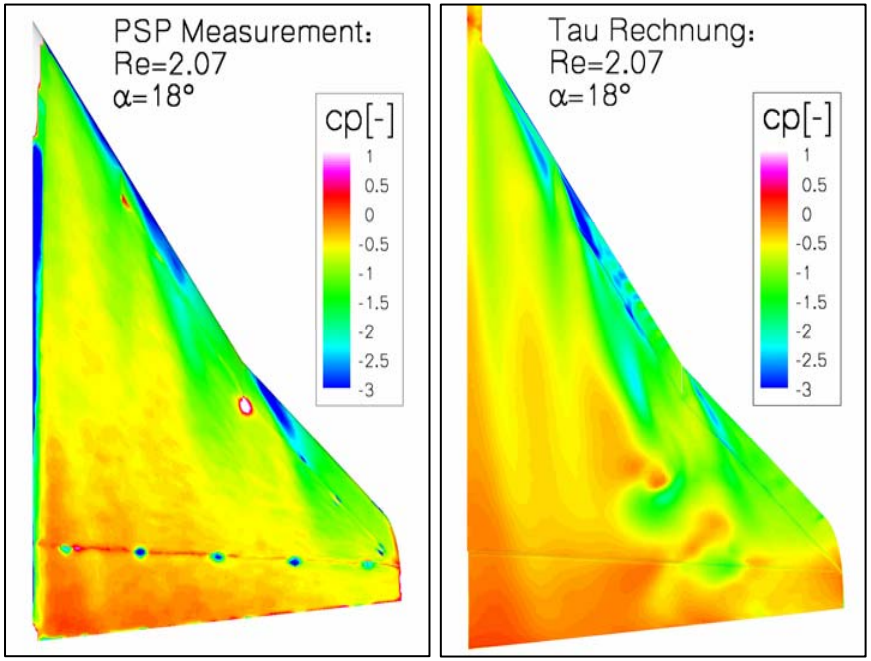
Example Application 1
Flight Maneuver Simulation

- Interactive simulation environment for the simulation of a freely flying, fully configured, elastic warplane
- Project SikMa: X-31



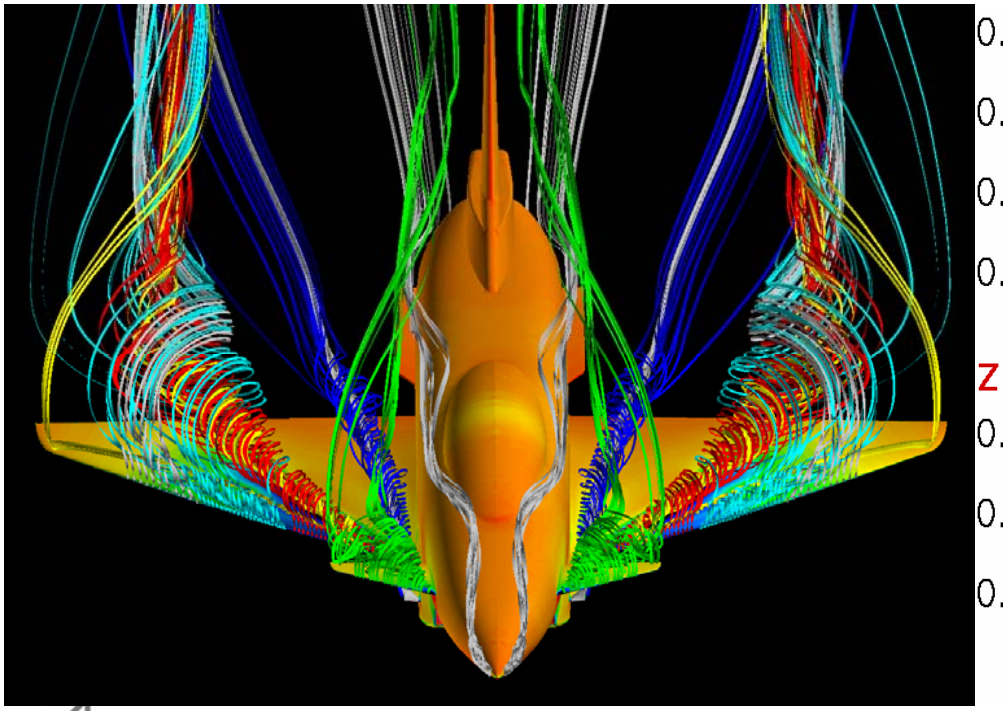
Flight Maneuver Simulation
Model

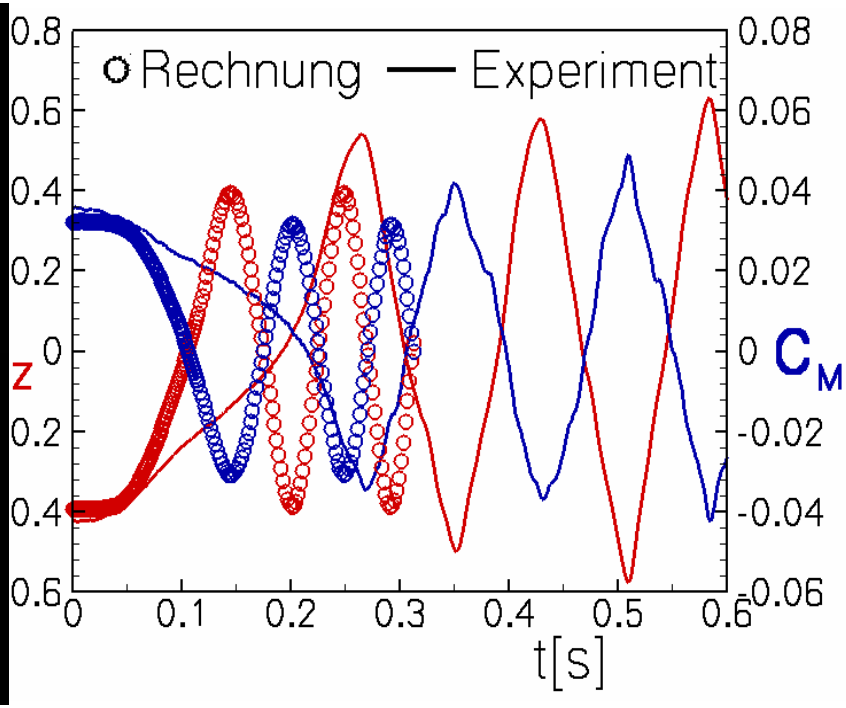
- Simplified model for wind tunnel experiments
- Simulation for validation of experiments



Flight Maneuver Simulation
Results

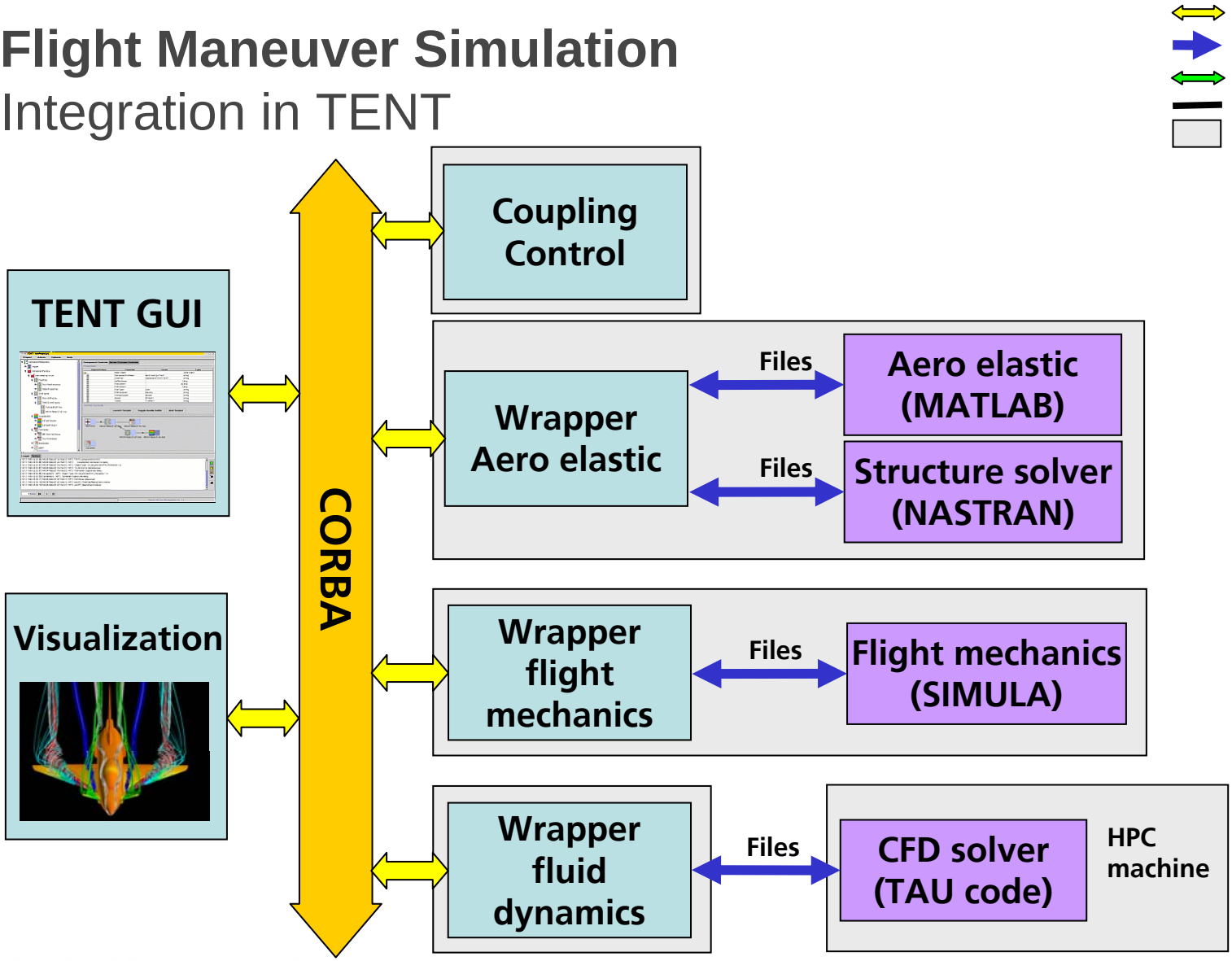
- Coupled simulation: Aerodynamic – flight mechanics – aeroelasticity
- Computing times: **~ 7 days on large computing cluster (> 64 procs.)**
- Important: **Online monitoring** and **restart capability**



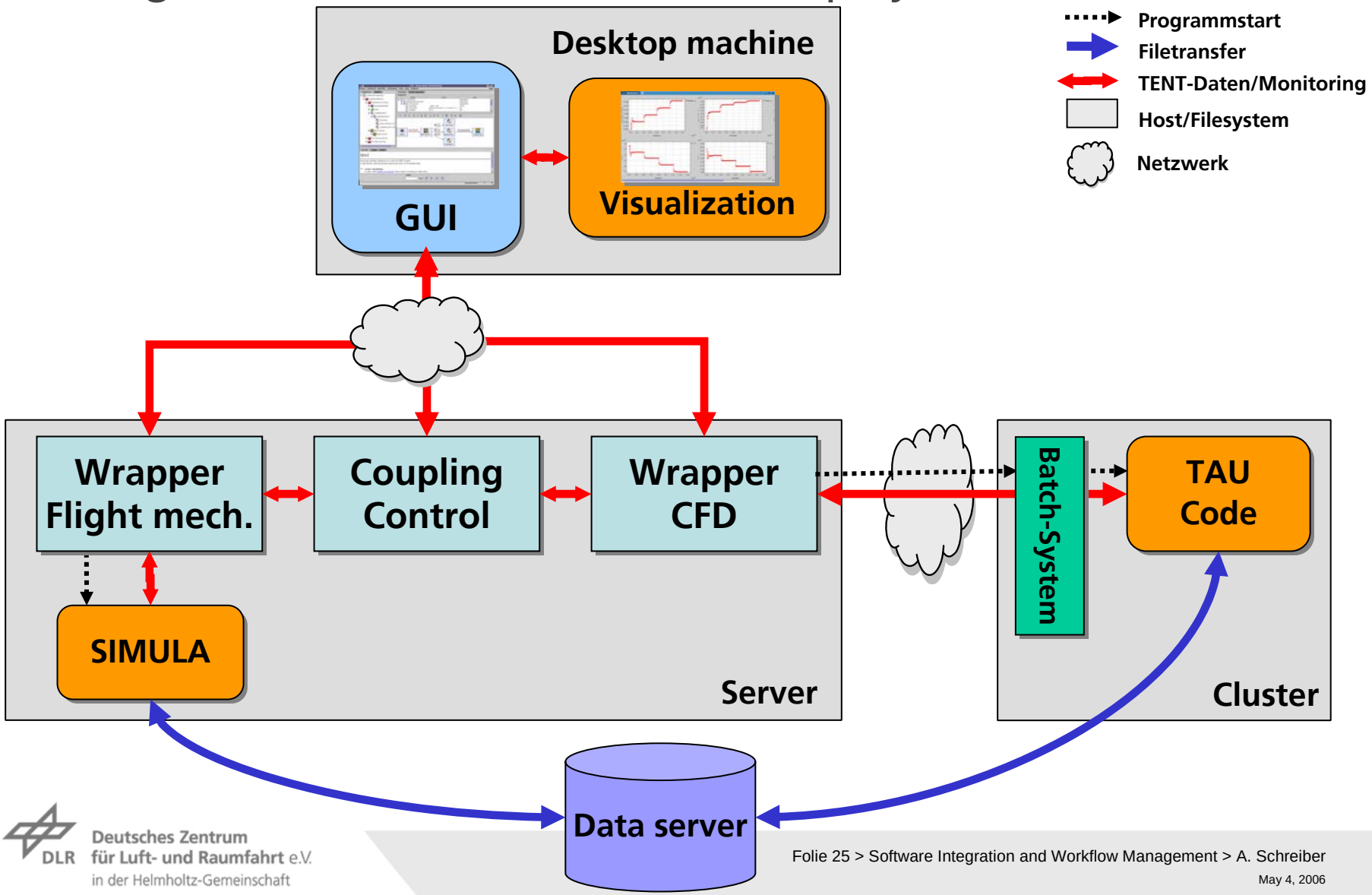


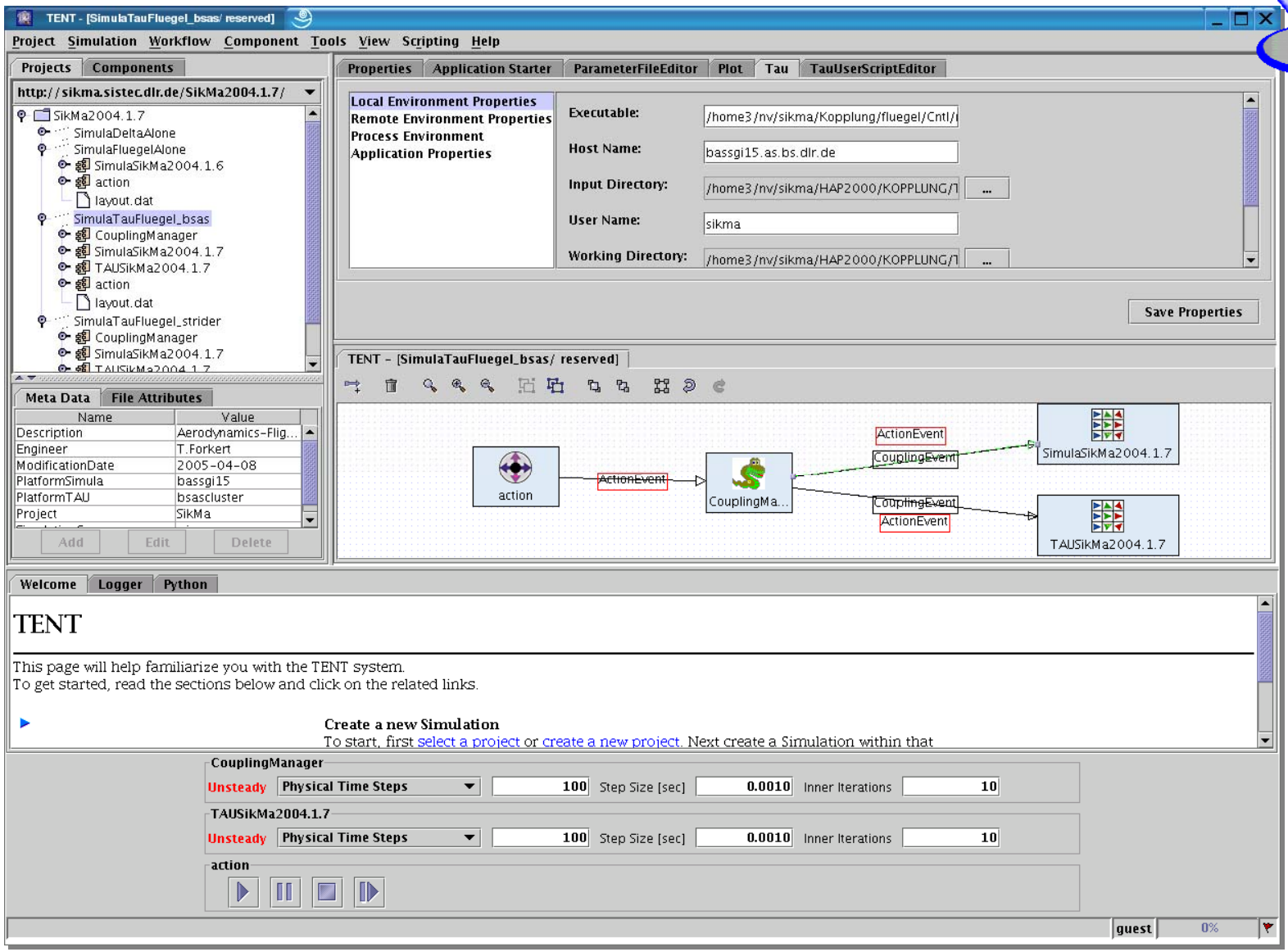
Flight Maneuver Simulation

Integration in TENT



Flight Maneuver Simulation - Deployment

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SimulaSikMa2004.1.7
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Description Aerodynamics-Flig...
Engineer T.Forkert
ModificationDate 2005-04-08
PlatformSimula bassgi15
PlatformTAU bsascluster
Project SikMa
Add Edit Delete
Properties Application Starter ParameterFileEditor Plot Tau TauUserScriptEditor
Local Environment Properties
Remote Environment Properties
Process Environment
Application Properties
Executable: /home3/nv/sikma/Kopplung/fluegel/Cntl/
Host Name: bassgi15.as.bs.dlr.de
Input Directory: /home3/nv/sikma/HAP2000/KOPPLUNG/
User Name: sikma
Working Directory: /home3/nv/sikma/HAP2000/KOPPLUNG/
Save Properties
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CouplingManager
Unsteady Physical Time Steps 100 Step Size [sec] 0.0010 Inner Iterations 10
TAUSikMa2004.1.7
Unsteady Physical Time Steps 100 Step Size [sec] 0.0010 Inner Iterations 10
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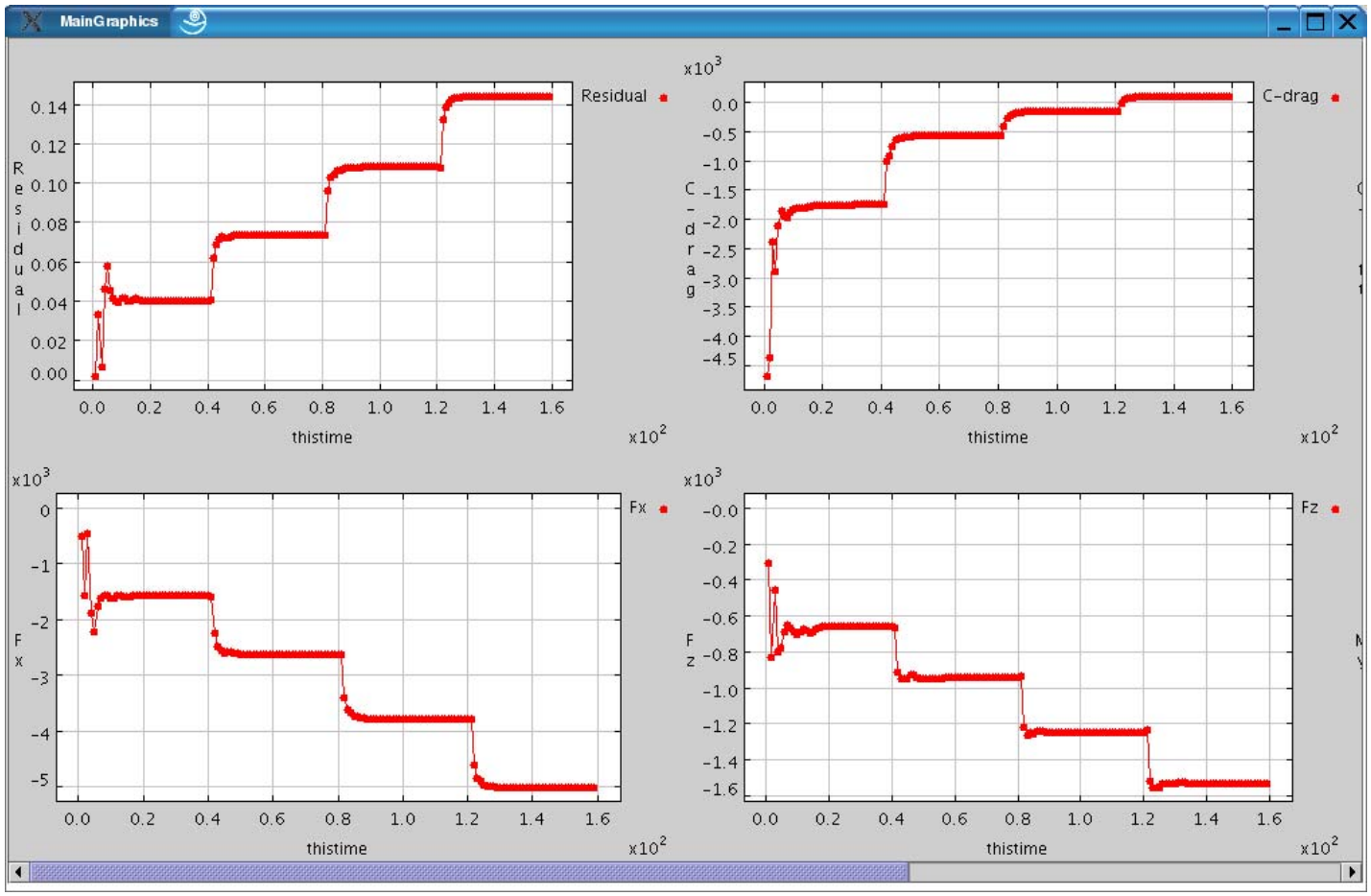
guest 0%

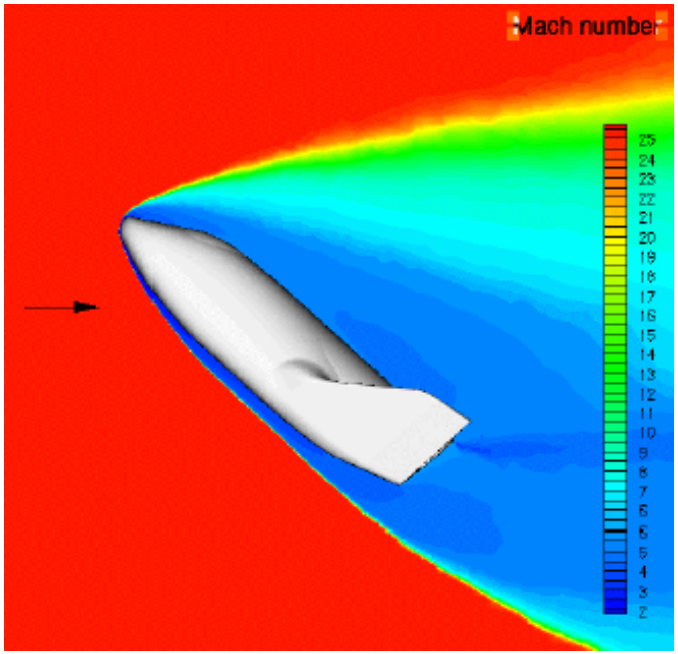
Flight Maneuver Simulation

Online Monitoring of Results



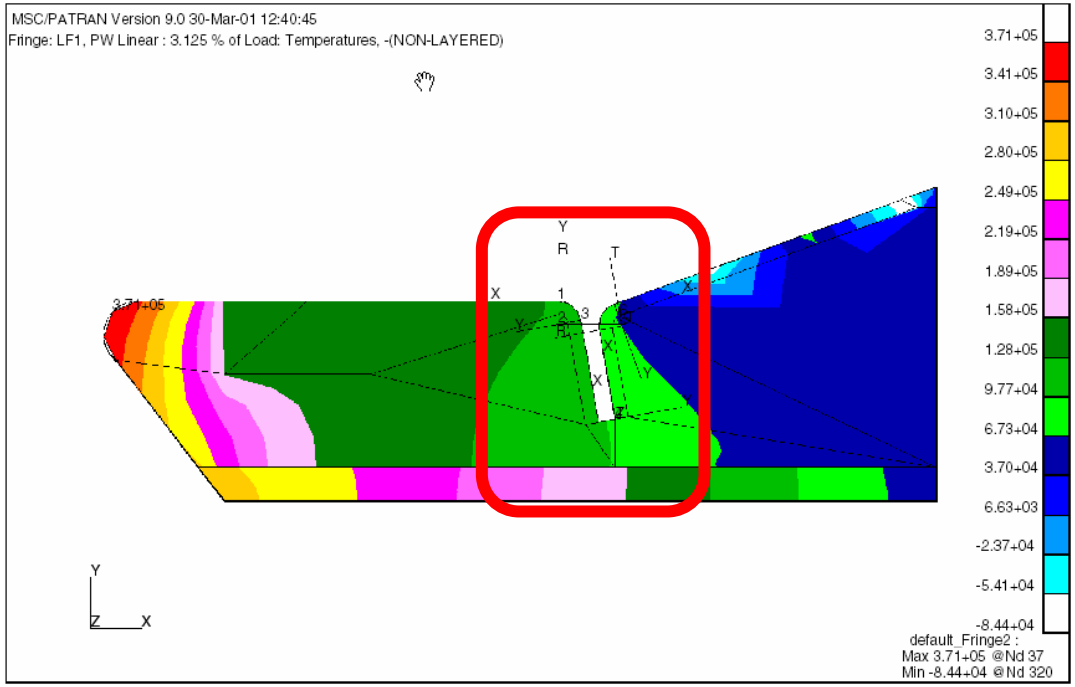
Example Application 2
Space Re-Entry Simulation

- Simulation of thermal heavily loaded parts of the X-38 space re-entry vehicle
- Fluid-Structure-Thermal coupling



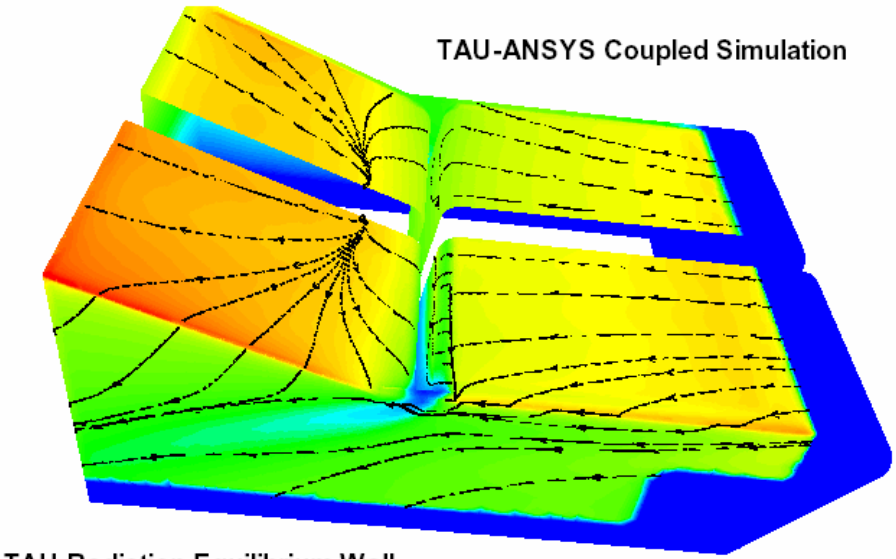
Space Re-Entry Simulation
Model

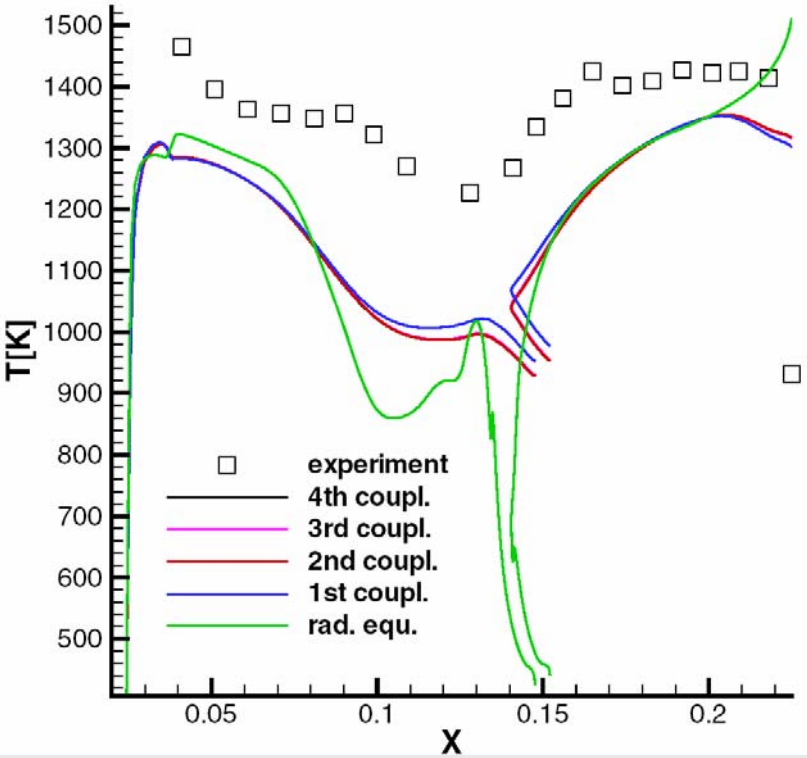
- Simplified model for wind tunnel experiments
- Simulation for validation of experiments
- Focus on flaps and gap



Space Re-Entry Simulation
Results

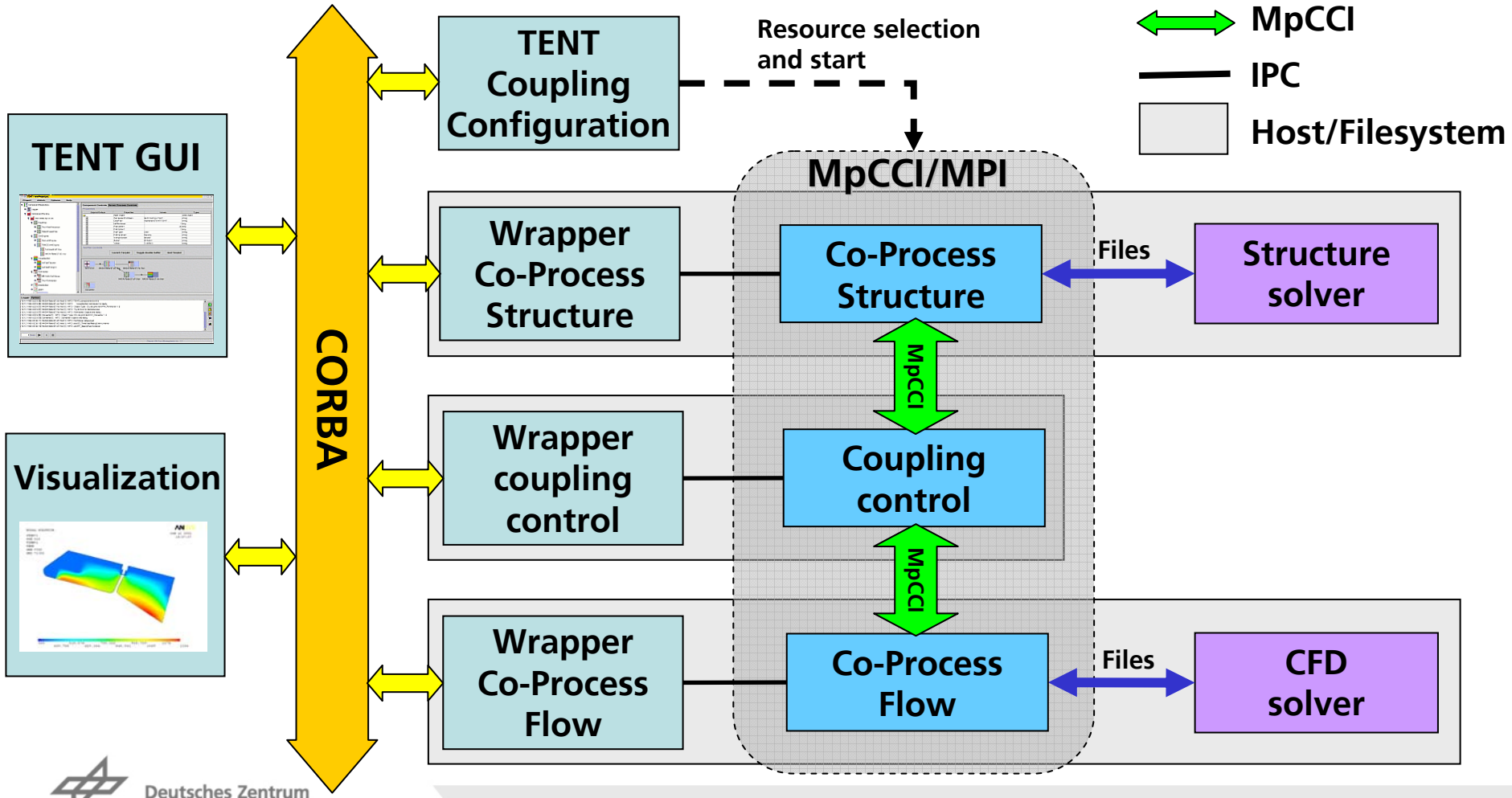
- Coupled simulation
  - DLR-TAU code for aerodynamics
  - ANSYS and MSC/NASTRAN for heat transport and deformation in the structure

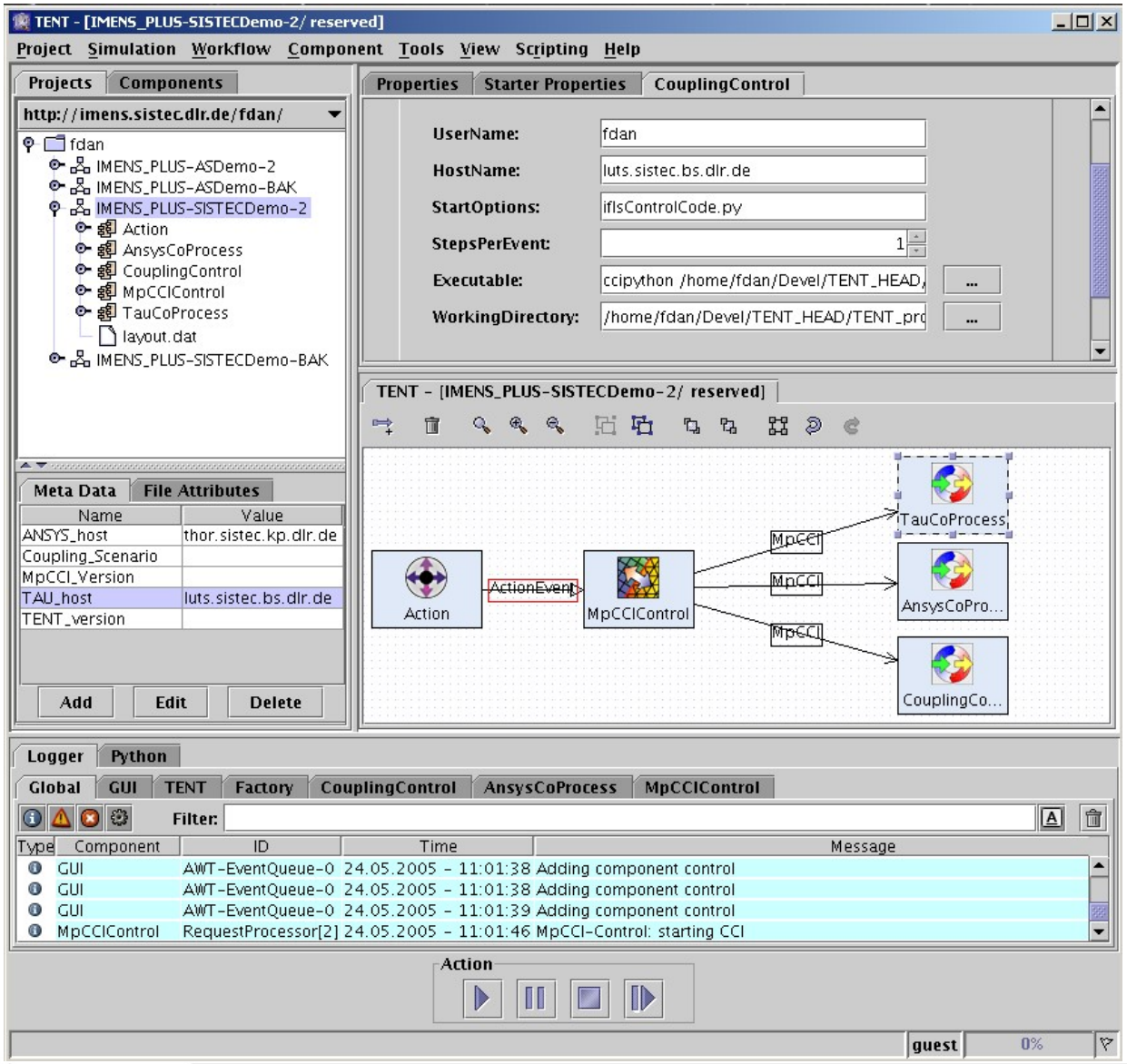




Coupling with TENT

Use of coupling library MpCCI




TENT - [IMENS_PLUS-SISTECDemo-2/ reserved]
Project Simulation Workflow Component Tools View Scripting Help
Projects Components
http://imens.sistec.dlr.de/fdan/
fdan
IMENS_PLUS-ASDemo-2
IMENS_PLUS-ASDemo-BAK
IMENS_PLUS-SISTECDemo-2
Action
AnsysCoProcess
CouplingControl
MpCCIControl
TauCoProcess
layout.dat
IMENS_PLUS-SISTECDemo-BAK
Meta Data File Attributes
Name Value
ANSYS_host thor.sistec.kp.dlr.de
Coupling_Scenario
MpCCI_Version
TAU_host luts.sistec.bs.dlr.de
TENT_version
Add Edit Delete
Properties Starter Properties CouplingControl
UserName: fdan
HostName: luts.sistec.bs.dlr.de
StartOptions: iflsControlCode.py
StepsPerEvent: 1
Executable: ccipython /home/fdan/Devel/TENT_HEAD/
WorkingDirectory: /home/fdan/Devel/TENT_HEAD/TENT_pro
TENT - [IMENS_PLUS-SISTECDemo-2/ reserved]
Action
ActionEvent
MpCCIControl
MpCCI
MpCCI
MpCCI
TauCoProcess
AnsysCoPro...
CouplingCo...
Logger Python
Global GUI TENT Factory CouplingControl AnsysCoProcess MpCCIControl
Filter:
Type Component ID Time Message
GUI AWT-EventQueue-0 24.05.2005 - 11:01:38 Adding component control
GUI AWT-EventQueue-0 24.05.2005 - 11:01:38 Adding component control
GUI AWT-EventQueue-0 24.05.2005 - 11:01:39 Adding component control
MpCCIControl RequestProcessor[2] 24.05.2005 - 11:01:46 MpCCI-Control: starting CCI
Action
guest
0%

New Technologies
Technology Upgrade for TENT

- ***TENT used modern technologies of the past 10 years***
- ***Technology upgrade for the next 10+ years in project SESIS***

TENT		RCE (Project SESIS)
GUI with Plug-Ins (proprietary development)	Project SESIS	GUI Plug-Ins Framework (Eclipse)
Single role for all users		Multiple user roles
Single communication protocol (CORBA)		Various protocols (Web Services, Java RMI, CORBA, …)
Authentication with user name & password		Authentifizierung with certificates (single-sign-on)
File-based data management		Data management with complex data structure (and files)
Modularity in sub systems		Everything is modular

Project SESIS
Goals

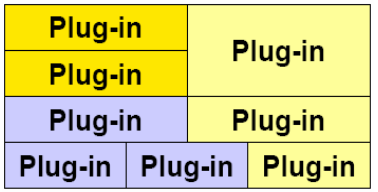
Design in 7 Days **in a virtual organization**

- **Early ship design** for creation of offers
- Reduction of design times
- Distributed design und simulation
  - Shipyards organizing ship building process
  - Integration of supplier in design process

Quelle: Flensburger Schiffbau-Gesellschaft mbH & Co. KG

Project SESIS
System Design

- System designed with a **Plug-In architecture** based on the **OSGi** platform
  - RCE (Reconfigurable Computing Environment)
- Advantages
  - Consistent modularization
  - Good extensibility und scalability
  - Specificity by configuration
  - Use of many existing Plug-Ins (*see Eclipse!*)

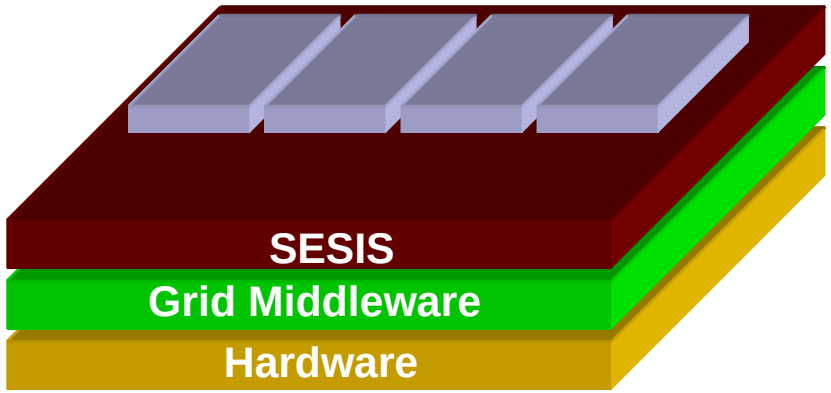


Project SESIS
Base-System Layer

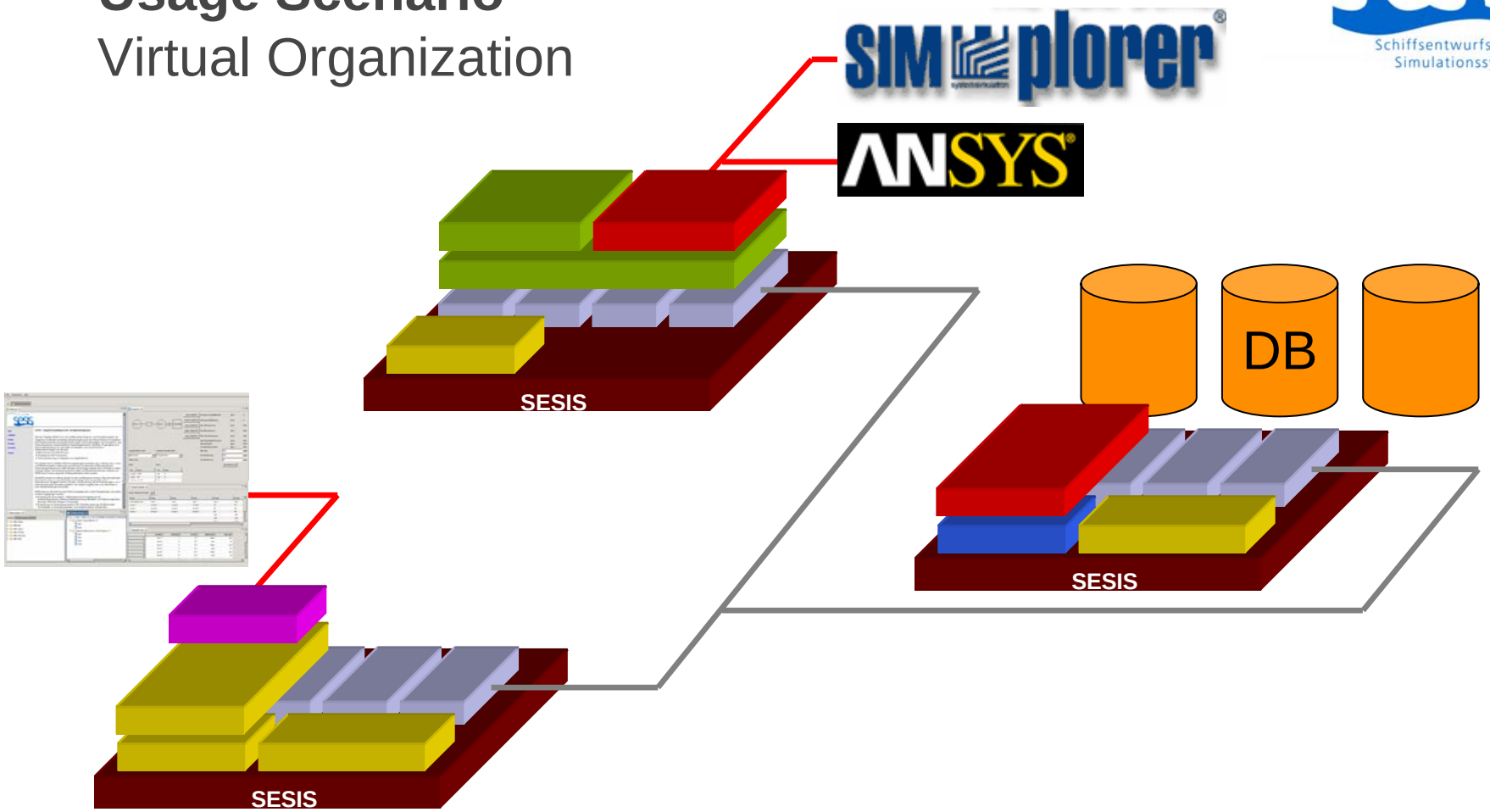
- Usage of databases and Grid middleware solutions
- SESIS supports
  - Communication
  - Updates
  - Privilege management
  - Services discovery

Installation of identical base system on every machine

Specificity by loading additional plug-ins



Usage Scenario
Virtual Organization



SESIS Graphical User Interface

Eclipse RCE w/Plug-Ins