# Virtual Reality based Visualization

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High Performance Computing Center Stuttgart

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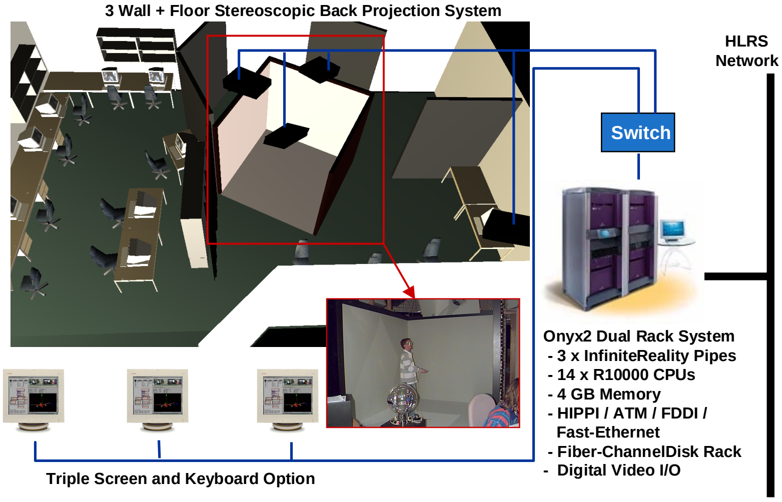
## Outline of the presentation

- Relationship between simulation, visualization and VR
- What is Virtual Prototyping?
- Functionalities of a Virtual Prototyping Environment
- Our Approach to it: COVISE
- Distributed Environment
- Simulation Integration
- VR-Extension
- Some Application Cases

## The Virtual Environment Lab at HLRS

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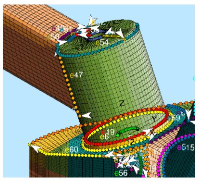
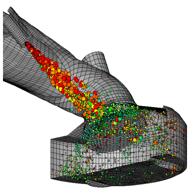
## How does Visualization fit into Simulation based Problem Handling?

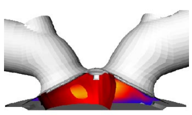


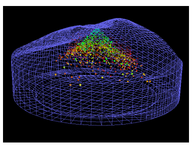
- Pre Processing
  - grid generation,
  - initial/boundary conditions

- Simulation



- Post Processing (Visualization)
  - error detection,
  - feature extraction,
  - behavior analysis





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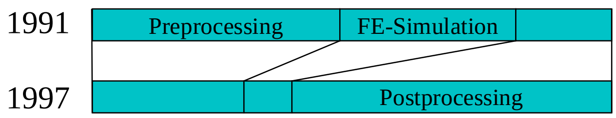
## Why does the Role of HPC oriented Visualization increase?

- Improved tools for preprocessing, e.g., for grid generation
- Maximum simulation times stay constant
- Increased complexity of simulation problems

- As result: Change in the duration of processing steps
- Increased importance of human driven analysis phase

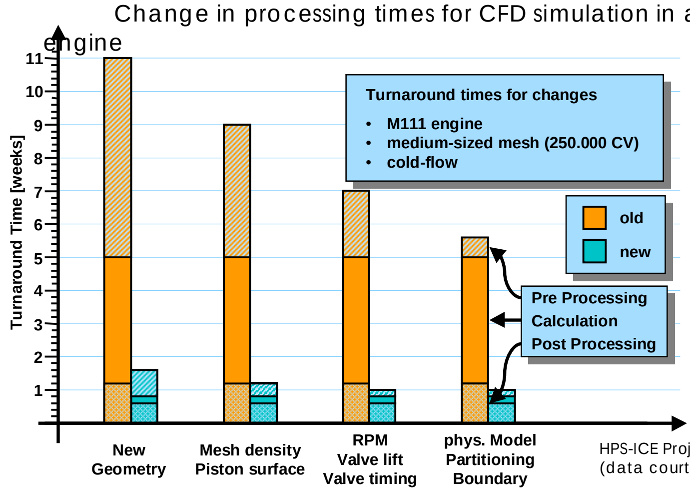
- Example: Crash Simulation at BMW (relative processing times)






## Example: Increased Role of Post Processing in CFD Simulation

Change in processing times for CFD simulation in a car engine




HPS-ICE Project
(data courtesy DaimlerChrysler)

## Characterization of a Virtual Prototype

**Let's imagine, an engineer has a prototype of a future product, which**

•**looks like** a real product or at least has recognizable similarities

•allows **handling** like a real product or even better (no weight)

•has a **behavior** like a real product

•allows **operations** like with a real product or even easier (e.g. in dangerous zones)

- change of **geometric parameters**, eg. flow channel diameter
- change of **material properties**
- change of **initial and boundary conditions**, e.g. heat influx



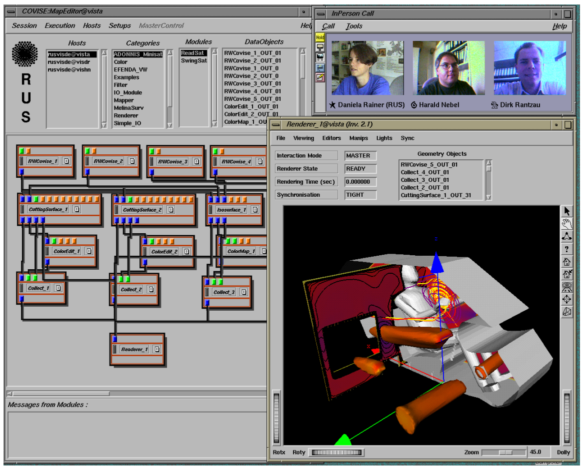
## Functionalities of a Virtual Prototyping Environment

- Scalable user interface from Desktop to Virtual Reality
  - Window systems based 2D user interface + 3D rendering
  - User interface extension into VR rendering environment
  - Web based extension
- Support collaborative and distributed working
- Toolbox (MVE) approach for easy construction of application cases
- Seamless integration of heterogeneous hardware platforms
  - Processes on simulation machines, workstations, VR-equipment
- Distributed data management
- Optimized for high performance environments
  - fast networks
  - Parallel and vector machines

## COllaborative VIsualization and Simulation Environment

### COVISE

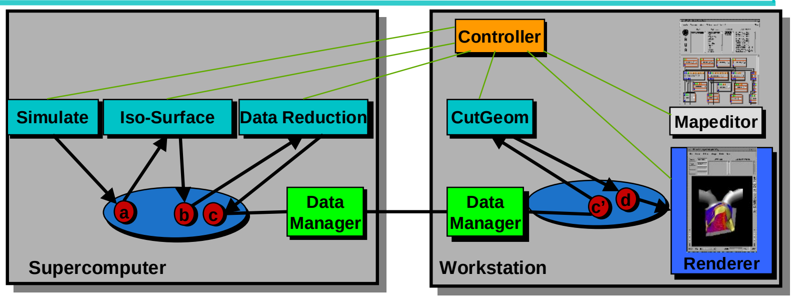
- MVE+ MSE
- Simulation and visualization coupling
- Distributed multiprocessing
- Data flow networking paradigm
- Visual programming editor
- Easy extendibility
  - •new modules
  - •new data types



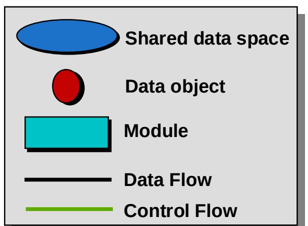
COVISE Screen Snapshot

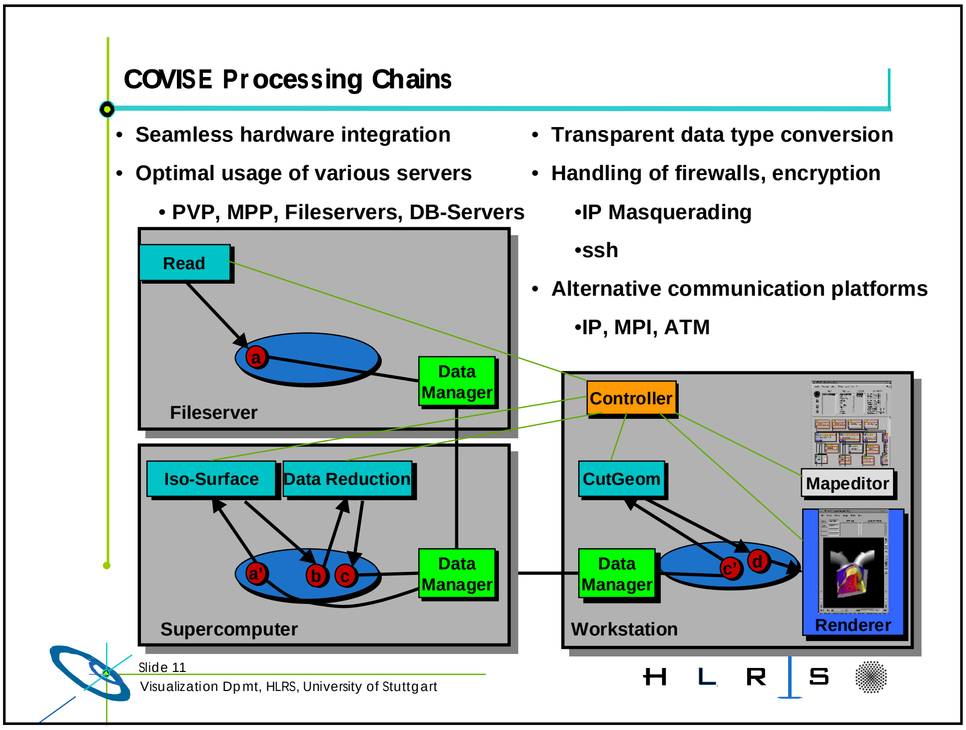


## COVISE Architecture Characteristics (Single User Mode)




- Central control process
- Separated control and data flow
- Distributed data management
  - Optimized data type conversion
  - Optimized communication rates




COVISE Processing Chains
• Seamless hardware integration
• Optimal usage of various servers
• PVP, MPP, Fileservers, DB-Servers
• Transparent data type conversion
• Handling of firewalls, encryption
•IP Masquerading
•ssh
• Alternative communication platforms
•IP, MPI, ATM
Read
a
Data Manager
Fileserver
Iso-Surface
Data Reduction
a'
b
c
Data Manager
Supercomputer
Controller
CutGeom
Mapeditor
Data Manager
c'
d
Renderer
Workstation
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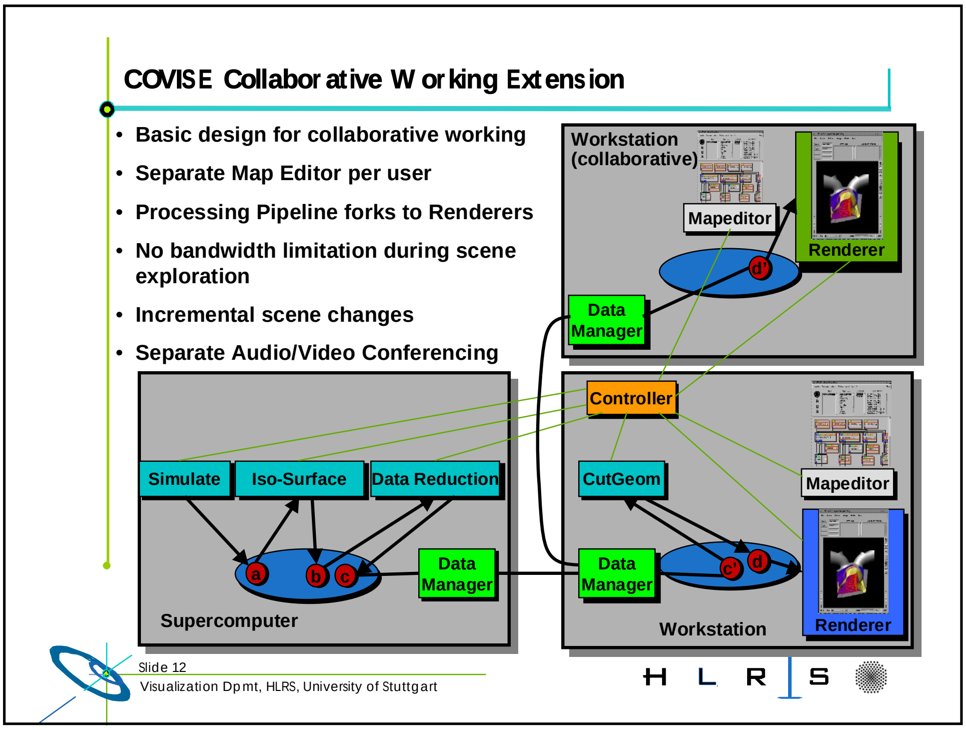
COVISE Collaborative Working Extension
• Basic design for collaborative working
• Separate Map Editor per user
• Processing Pipeline forks to Renderers
• No bandwidth limitation during scene exploration
• Incremental scene changes
• Separate Audio/Video Conferencing
Workstation (collaborative)
Mapeditor
Renderer
d'
Data Manager
Controller
CutGeom
Mapeditor
Data Manager
c'
d
Renderer
Workstation
Simulate
Iso-Surface
Data Reduction
a
b
c
Data Manager
Supercomputer
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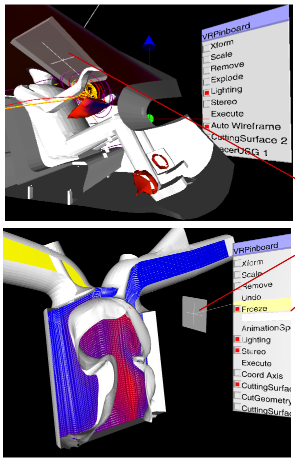
## COVER, COVISE Virtual Environment Renderer




- Special Render Module using Performer
- Support for Powerwall-, Immersadesk-(TM), CAVE-(TM)like hardware, responsive Workbench, ...
- Close integration with data flow network via feedback protocol
  - Module parameters are defined in VR
  - 3D menu is configured by modules
- Co-operative working in distributed virtual Environments via COVISE communication interface



## Steering of remote processes from the Virtual Environment

**Application Module**

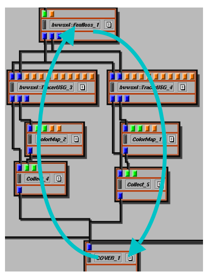
Create
Output Object

Compute

Read New
Input Parameters

Read
Input Object

**Data Availability Message**



**Feedback Message**

**Virtual Environment**

Read Input Object

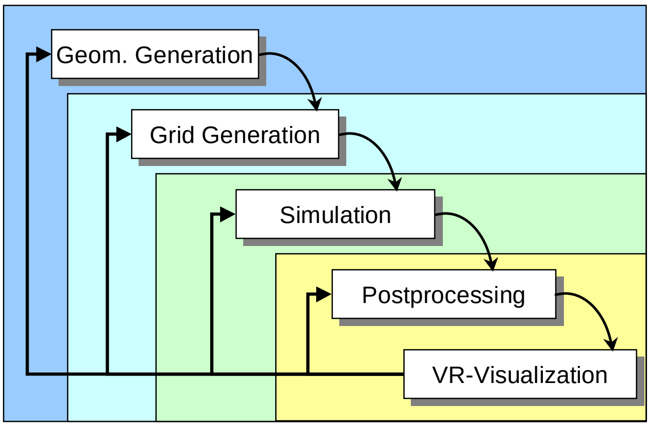
Extract
Semantic Information

Create 3D Interaction

Visualize Data

Wait for Interaction

## Virtual Prototyping: Controlling all steps in Virtual Environment

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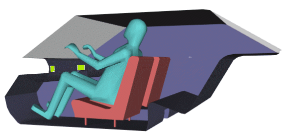
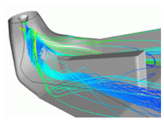
## Testcases of EC Project VISiT (Virtual Intuitive Simulation Testbed)

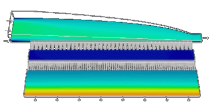


*DaimlerChrysler*

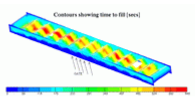


*Voith Hydro*

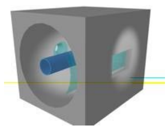
*De Pretto Escher-Wyss*



*Valmet*



*BAE Systems*



*University of Jäväskylä*

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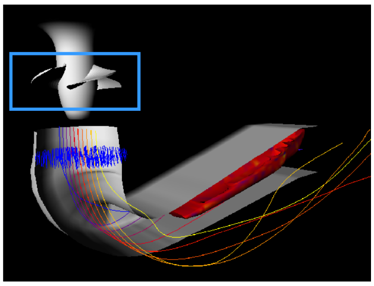
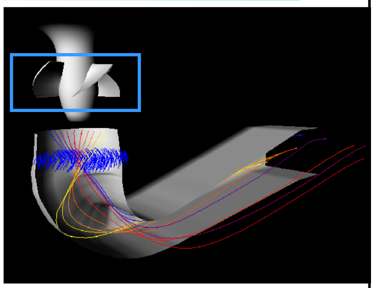
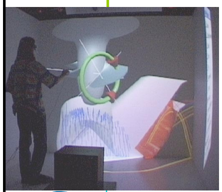
## Virtual Prototyping of Fluid Flow Simulation







Inlet angle: 0° (design point)
Reduced efficiency
due to back flow area in
draft tube (red).

Inlet angle: 20°
No back flow, increased
efficiency
in draft tube, but decreased
efficiency in runner

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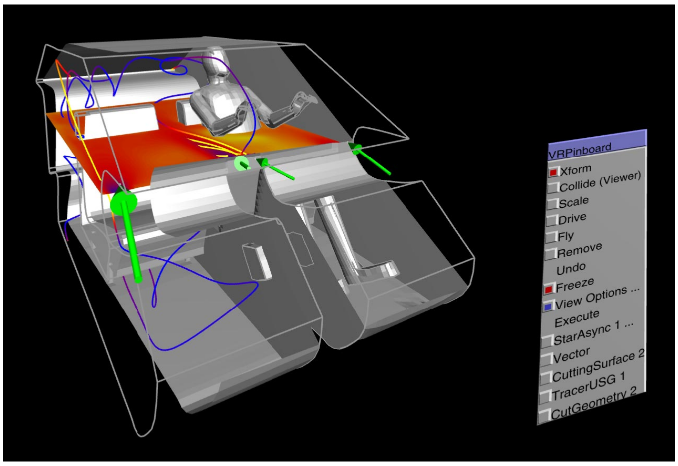
## Virtual Prototyping of a car cabin




**VR-Control of air inlet parameters (Daimler-Chrysler)**

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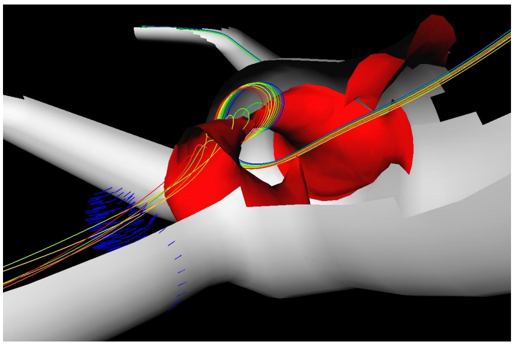
## Optimisation of a Water Power Plant in Nepal

- Optimisations led to 5% more power output
- Fluctuations of power output have been eliminated



Data courtesy IHS, University of Stuttgart

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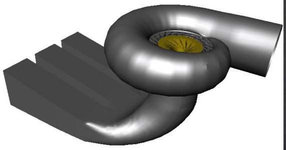
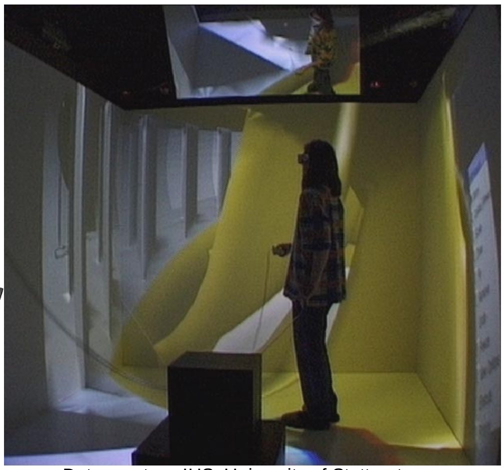
## Water Turbine assembly

- Multiple Parts in one VR space
- Animated Objects





Data courtesy IHS, University of Stuttgart

COVISE VR VisualizationExamples

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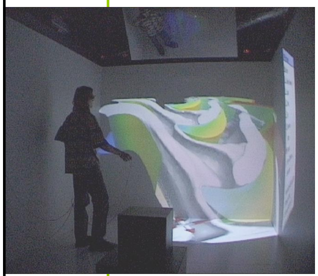
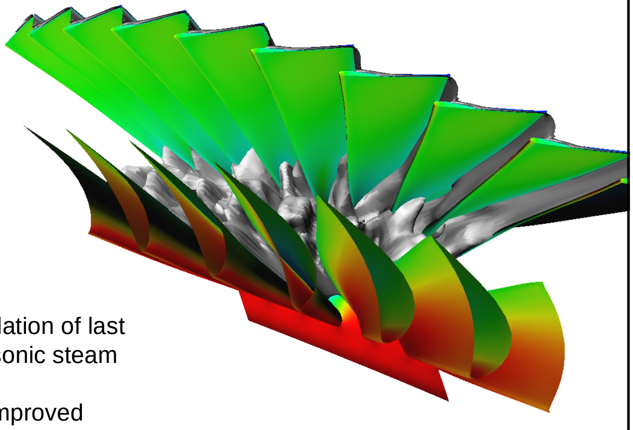
## Stator/Rotor Interaction in a Steam Turbine Stage





- Unsteady simulation of last stage of a transonic steam turbine
- VR usage for improved analysis, e.g. viewer attachment to rotor.

Data courtesy ITSM, University of Stuttgart
SIEMENS Gas Turbines

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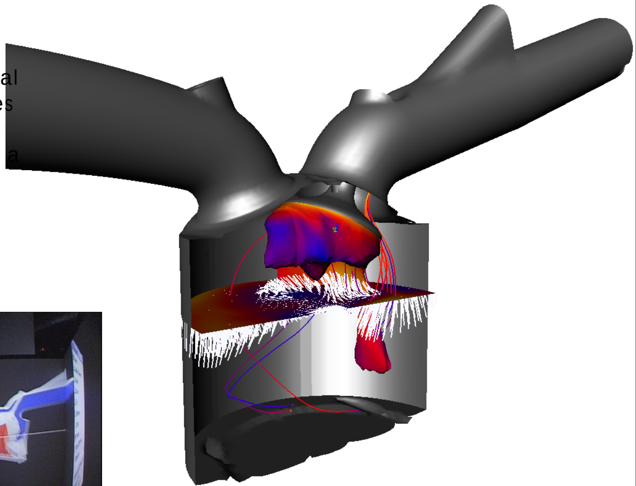
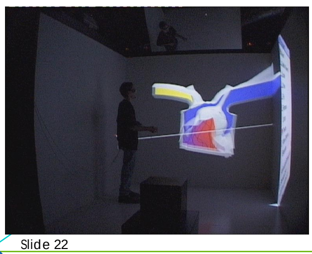
## Analysis of Internal Combustion Engine

- ESPRIT HPS-ICE: High Performance Simulation of Internal Combustion Engines
- Parallel Simulation and Visualization in a Distributed Environment
- VR Interaction for Result Analysis





Data courtesy Daimler Benz

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