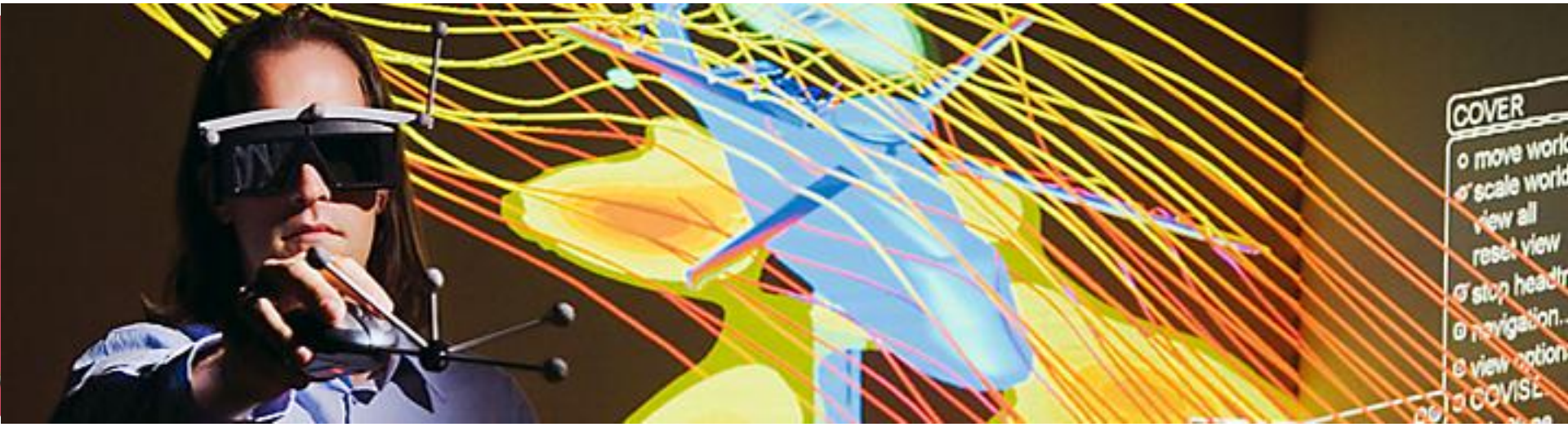
Interactive Parallel Simulation and Visualization

Uwe Wössner, HLRS



THE HLRS SYSTEMS





NEC SX-9 (156)



NEC SX-8 (576/~120)



NEC Asama
(64)





DALCO Viz-Cluster
(8*4+32*2)

Fileserver



IBM HSM
> 2 PB

Ulm

Stuttgart

bwGRiD



SUN Fire 2900
(48x2)



IBM x3755
(144x2)



Cray XT5+XD1
(224*4+48)





NEC Nehalem
(1400x4)

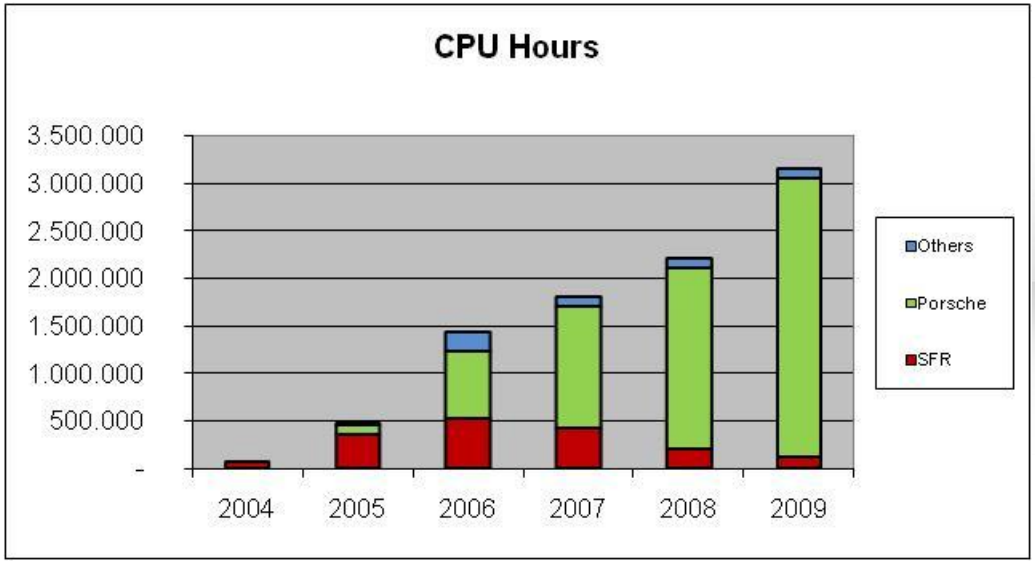
IBM Cell



IBM
(2800x4)



INDUSTRIAL USAGE

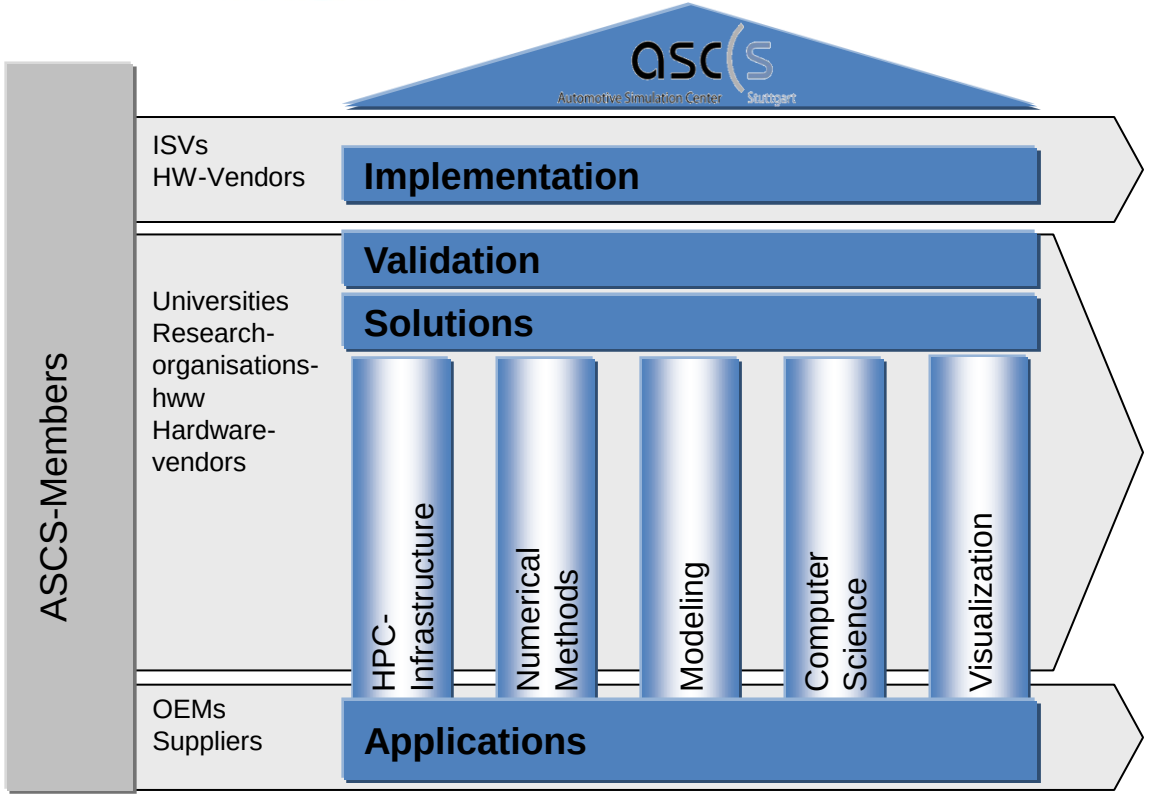




- Bertrandt
- BTB
- Daimler
- Kärcher
- Mahle
- Porsche
- RECOM
- Transsolar
- Stellba

Sustainable Simulation Concepts in Industry

Automotive Simulation Center Stuttgart

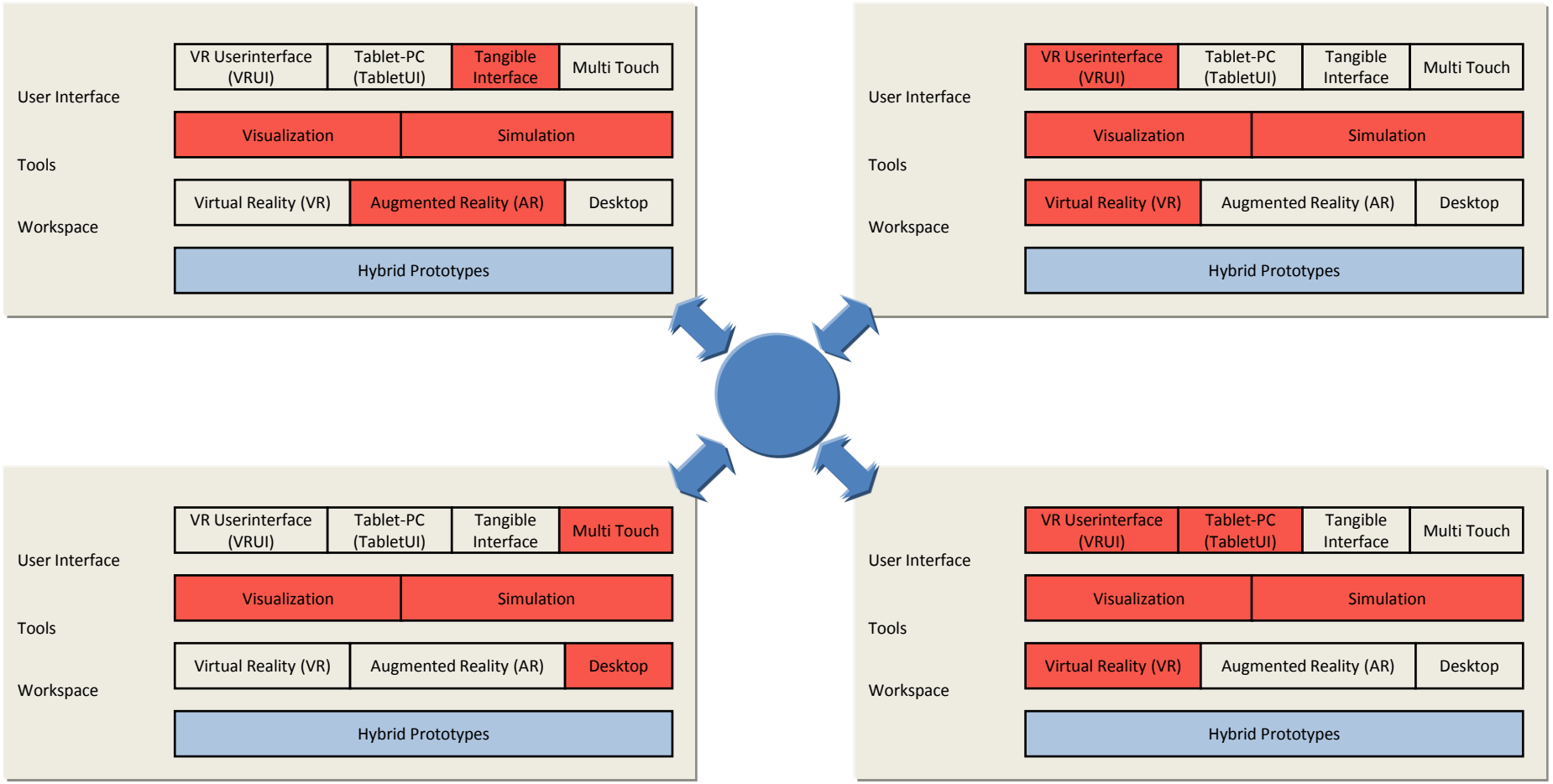


BUILDING BLOCKS OF A WORKSPACE



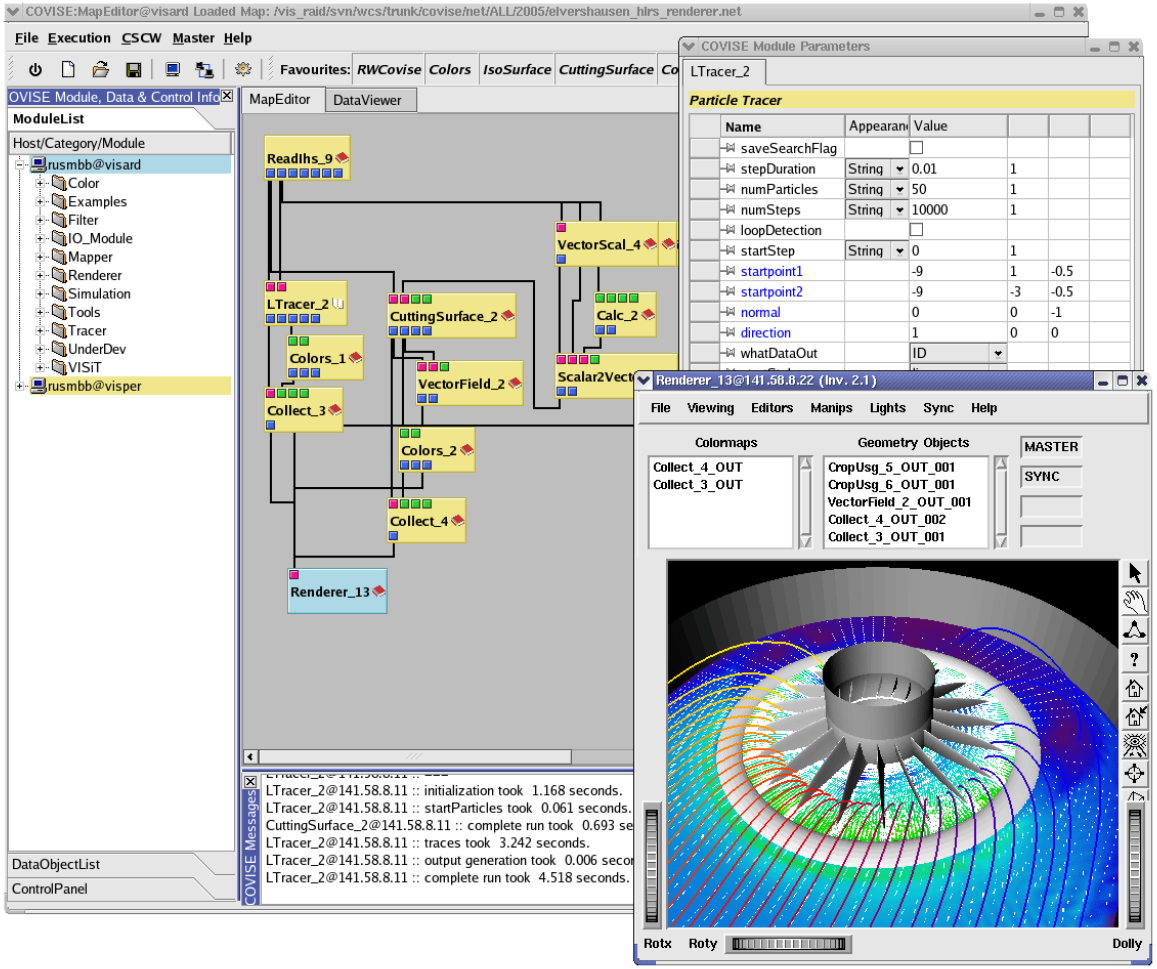
User Interface	VR Userinterface (VRUI)	Tablet-PC (TabletUI)	Tangible Interface	Multi Touch
Tools	Visualization	Simulation		
Workspace	Virtual Reality (VR)	Augmented Reality (AR)	Desktop	
	Hybrid Prototypes			

COLLABORATIVE ENVIRONMENTS



COVISE

COLLABORATIVE VISUALIZATION AND SIMULATION ENVIRONMENT





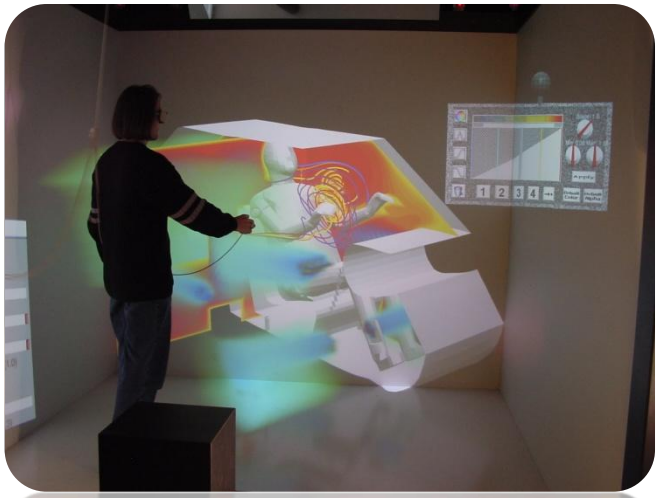


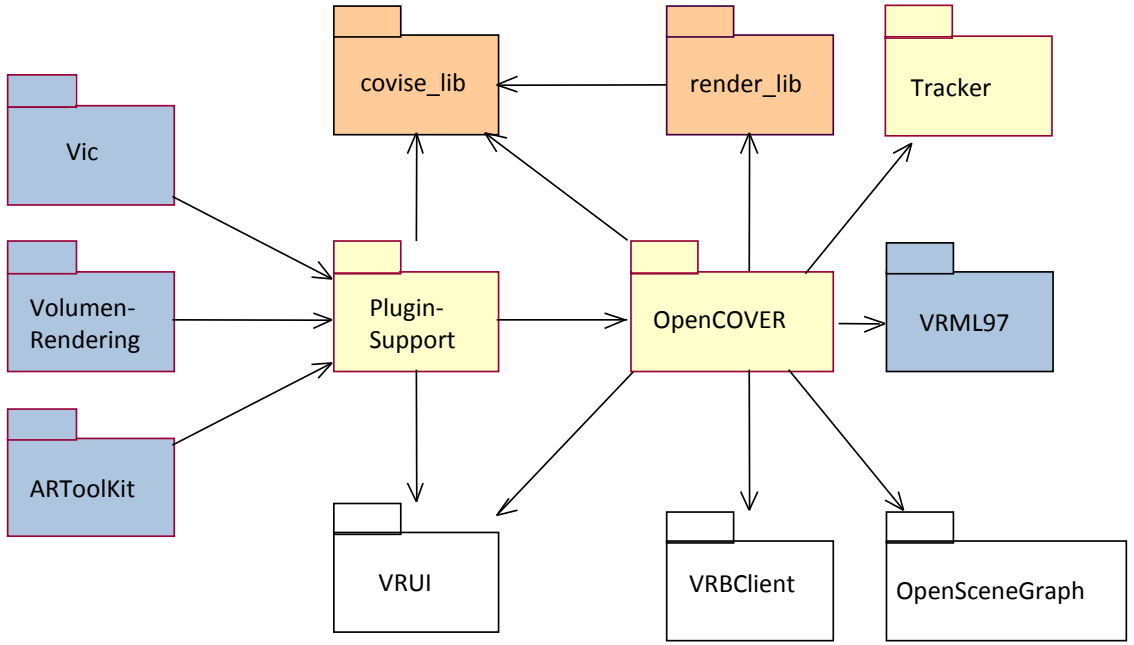
OPENCOVER

COVISE VIRTUAL ENVIRONMENT RENDERER

Features:

- Flexible plugin system
- Support for projection based VR, tiled Displays and HMDs
- Augmented Reality
- CSCW
- Volume rendering
- VRML97
- 3D VR GUI (VRUI)
- Parallel rendering





PARALLEL VISUALISATION SYSTEM

40 node dual Opteron/Harpertown cluster

64/8/4Gb memory per node

NVIDIA Quadro FX 5800 / FX 4500

Running Linux and Windows

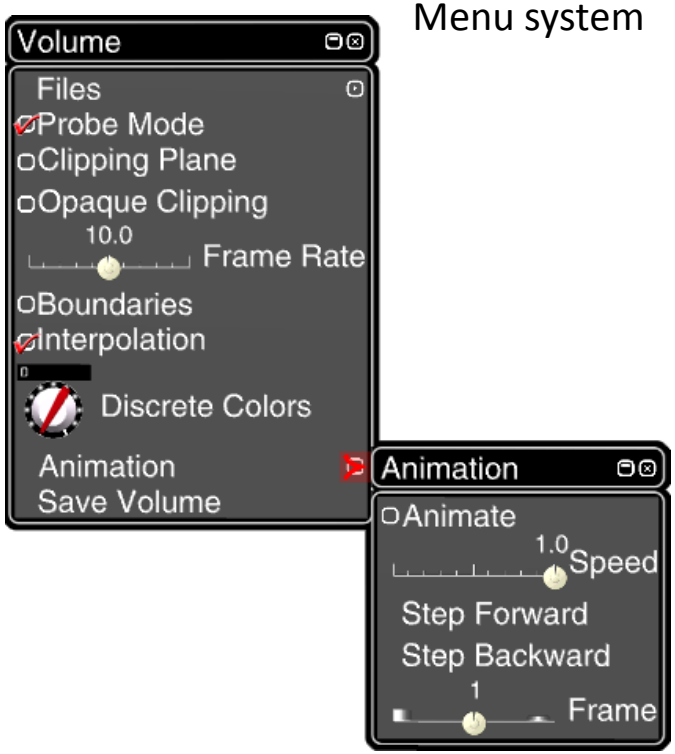
DDR Infiniband interconnect
(PCI-E 8x HCAs, QLogic
Switch with two spine boards)

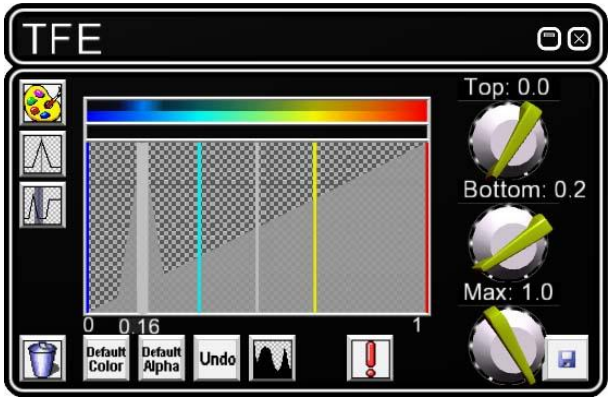


VRUI USERINTERFACE

- The API resembles that of QT, AWT,…
- Supports hierarchical menu systems.
- Supports concurrent interaction in collaborative VEs
  - Automatic synchronization of values
  - Kontext dependend GUIs for collaborative work
  - Locking to support concurrent interaction

Menu system



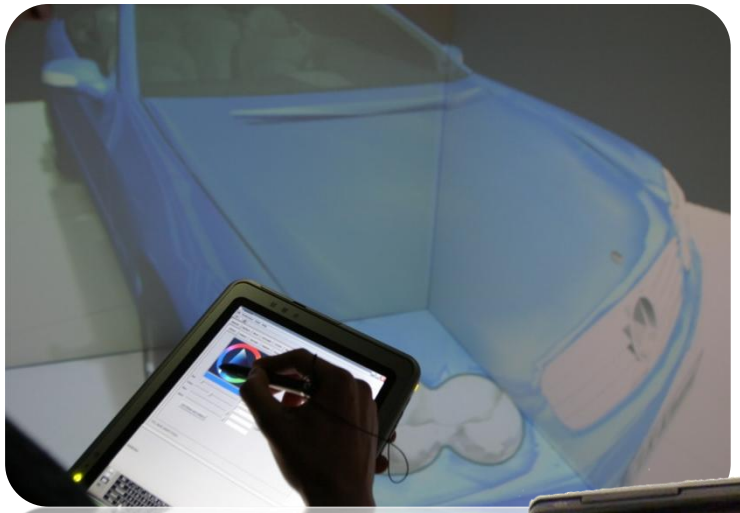


Transferfunktionseditor



Toolbar

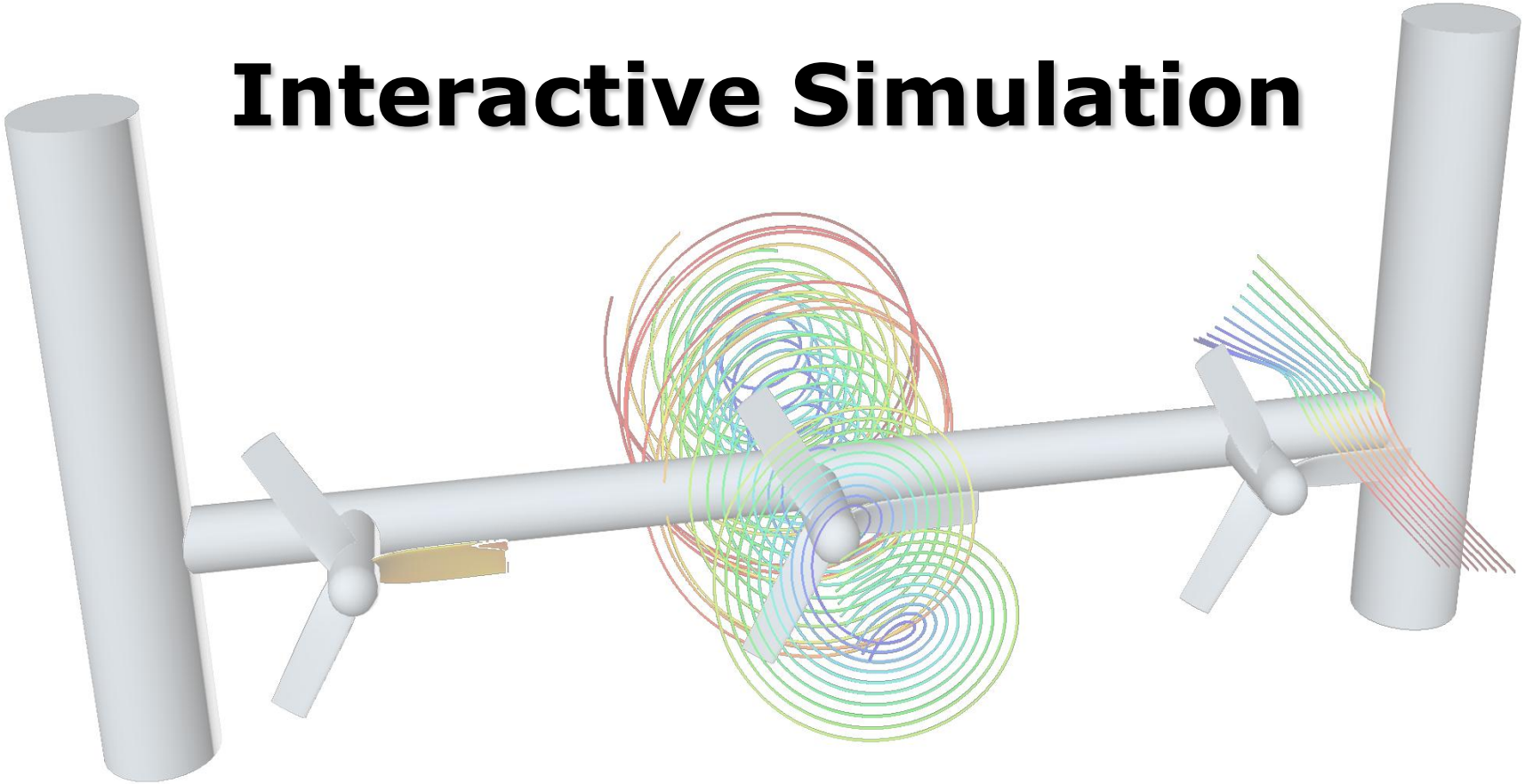
TABLET-PC USER INTERFACE



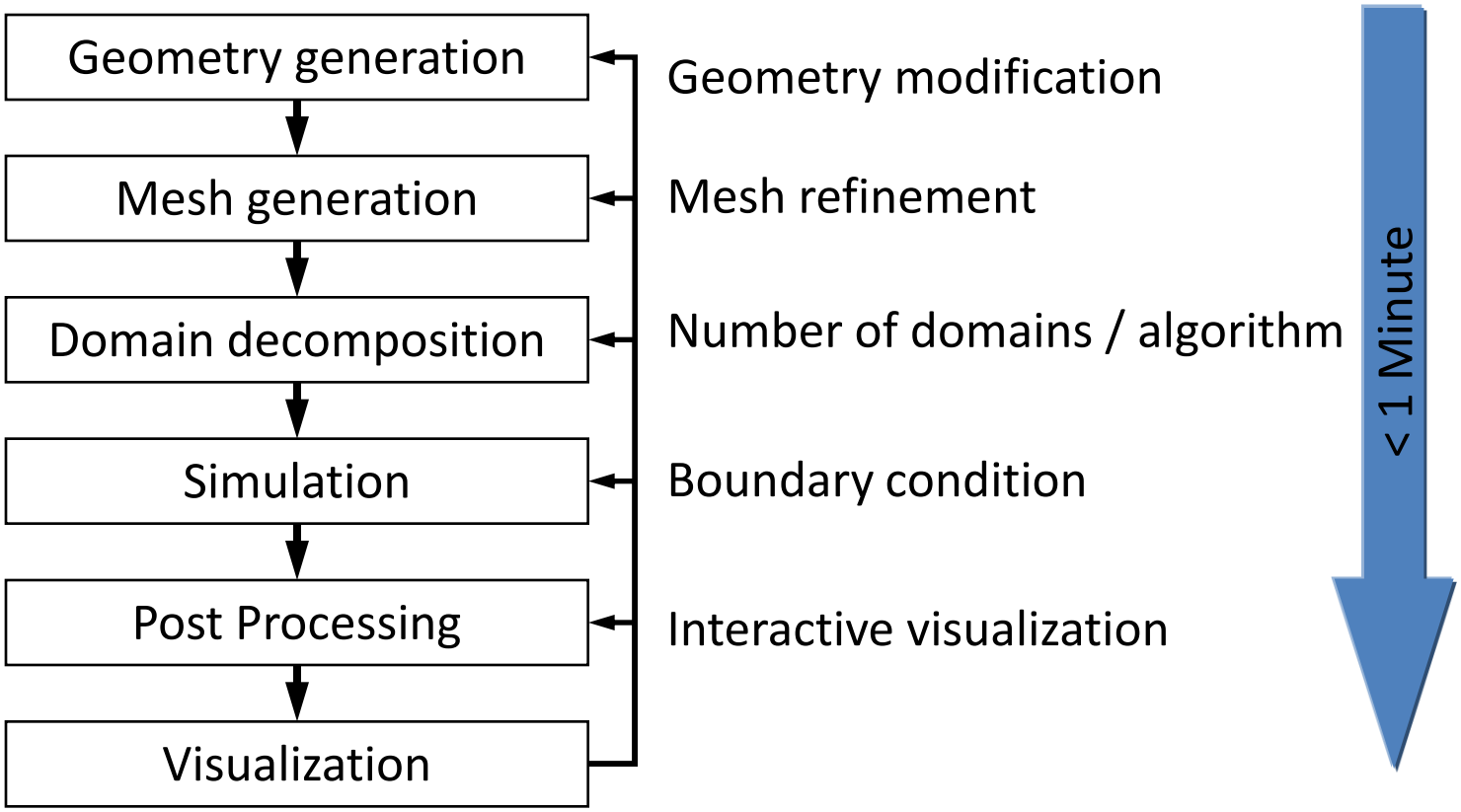
- Easy input of Text and numbers
- Precise interaction
- Independent of frame rate
- Development of optimized complex GUIs
  (Material editor, transfer funktion editor, scene graph browser)
- Scalable from smartbords over tablet PCs to mobile phones



Interactive Simulation



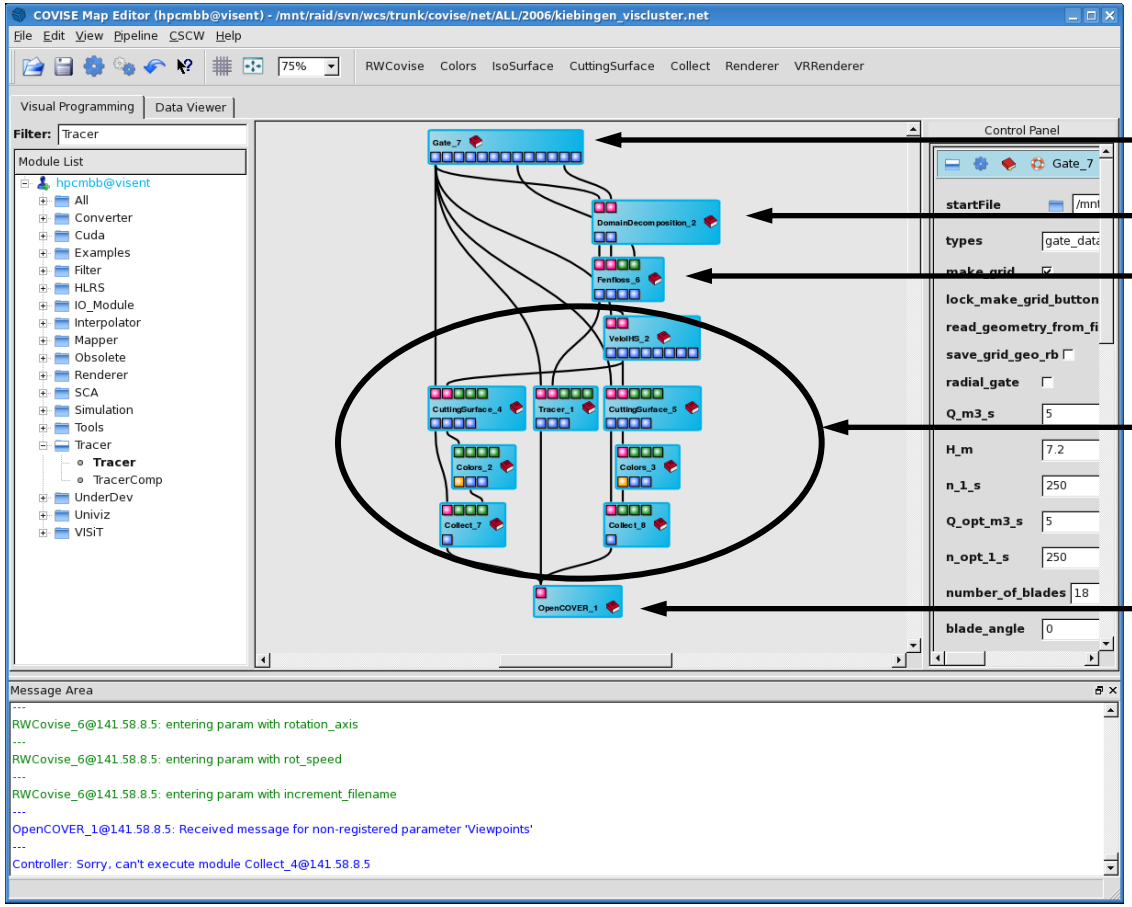
PROCESS INTEGRATION



SIMULATION COUPLING

Code	Type	Coupling mode
StarCD	CFD	SimLib, Fortran user subroutine
CFX	CFD	SimLib, Fortran user subroutine
Fluent	CFD	SimLib, C user subroutine
Fidap	CFD	Script, Black-Box
Fenfloss	CFD	SimLib, C Plugin
Diablo	Diffusion in metal alloys	Script, Black-Box
Trans3D	Laser ablation	COVISE Modul C++
Uranus	CFD	Socket interface, coupling module, C++
SunFace	Radiation	COM/DCOM, coupling module, C++
OpenFoam	CFD	SimLib, C++ Plugin

INTERACTIVE SIMULATION IN COVISE



Grid generation

Domain decomposition

Simulation

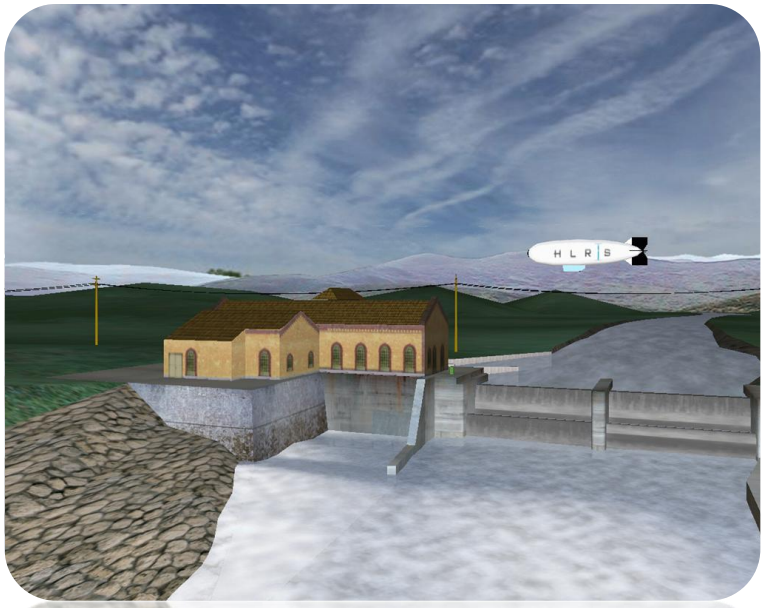
Post processing

Rendering

VIRTUAL WATER TURBINE TEST-BED



Simulation of the river power station Kiebingen, Neckar



Through interactive simulation, the output could be increased by 30%, simply by substituting runner and wicked gate

VIRTUAL TURBINE TESTBED

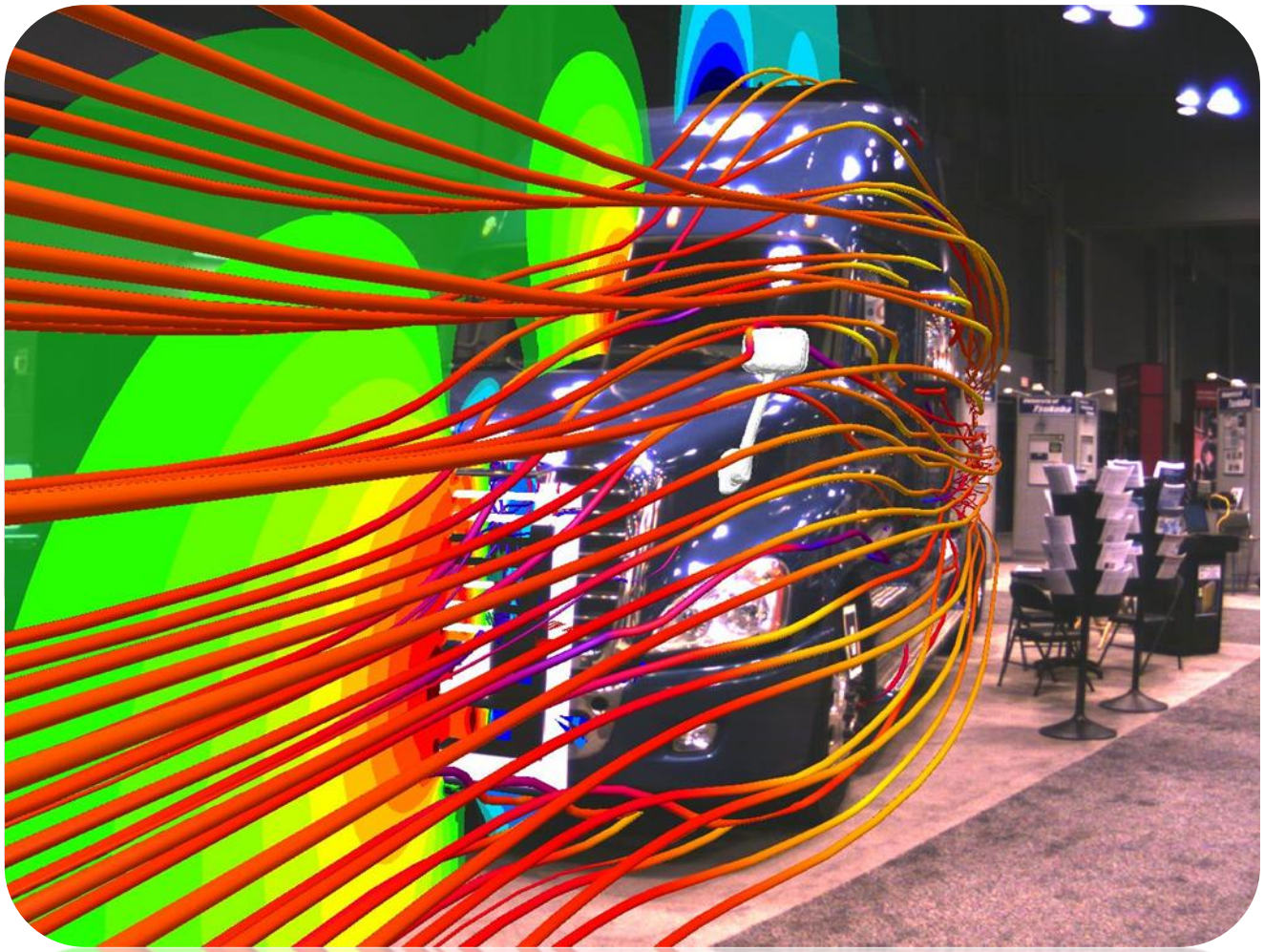






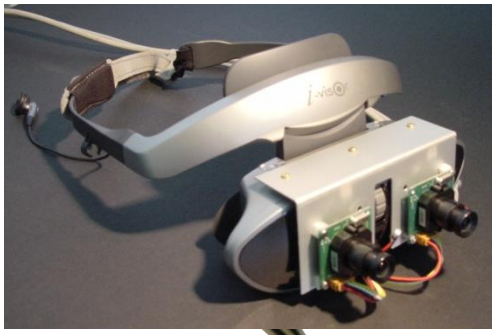


AUGMENTED REALITY



AR HARDWARE

- Comparison of simulation and experiment
- Visualization directly on the product
- Variation studies
- Tangible interfaces







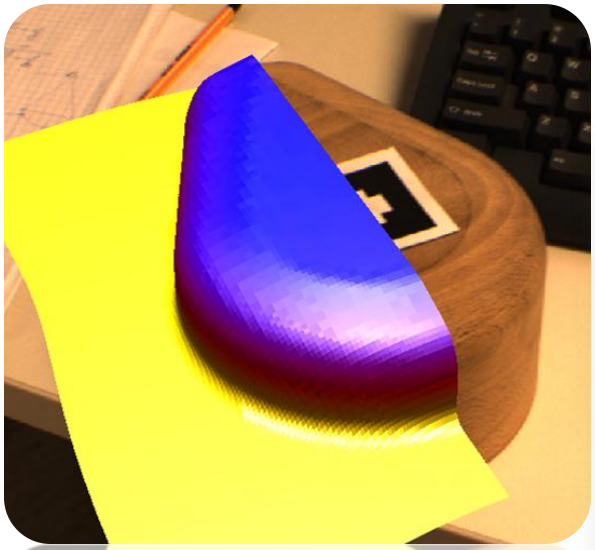
Stereo HMD

- Resolution 800x600
- Field of view 15°

Cameras

- Resolution 1280x1024
- USB 2.0, Autofocus

DEEP DRAWING OF A CUP





PANAMERA (SC 10)

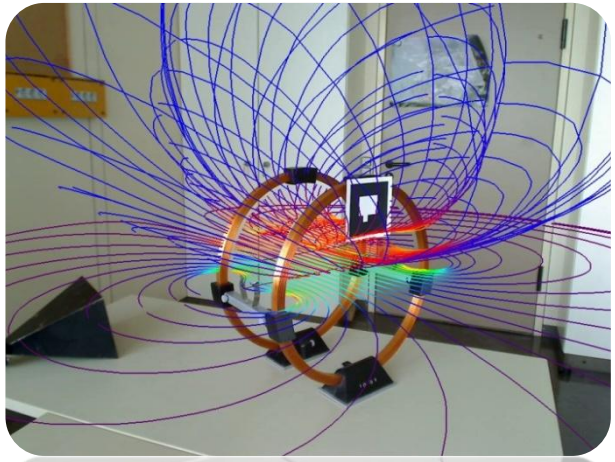


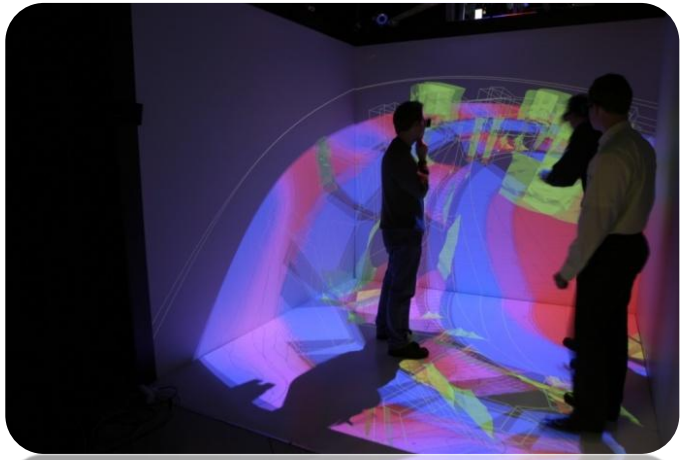
PANAMERA (SC 10)

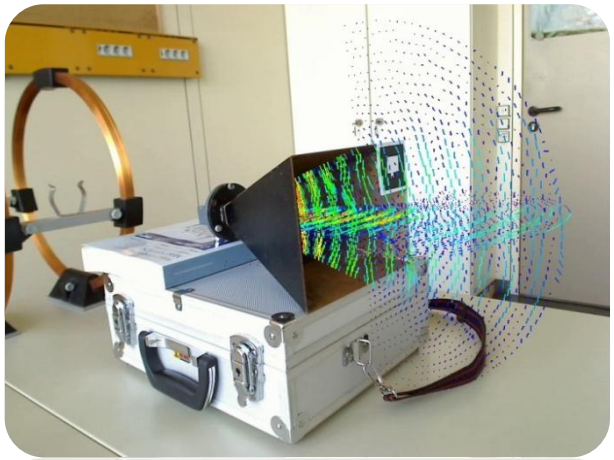


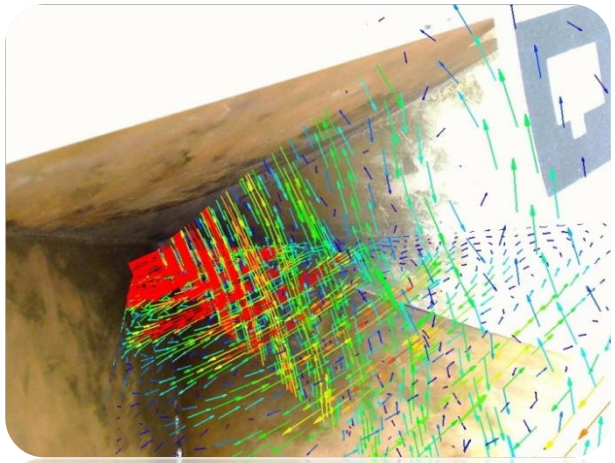


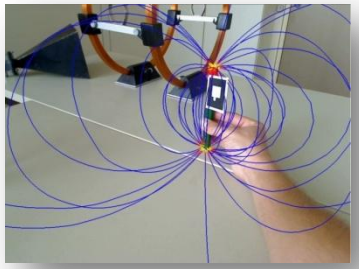
COMPUTATIONAL ELECTRODYNAMICS



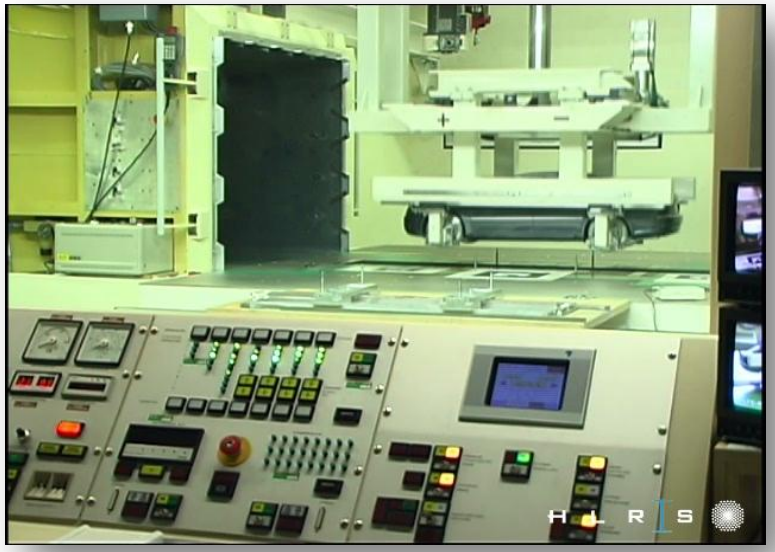


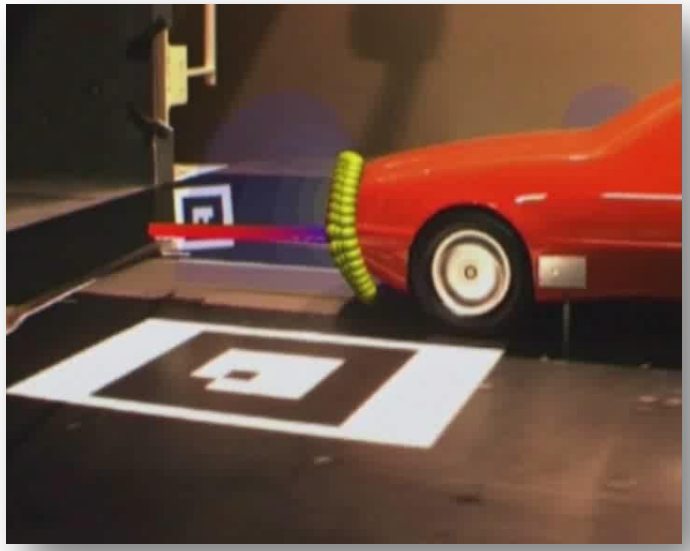


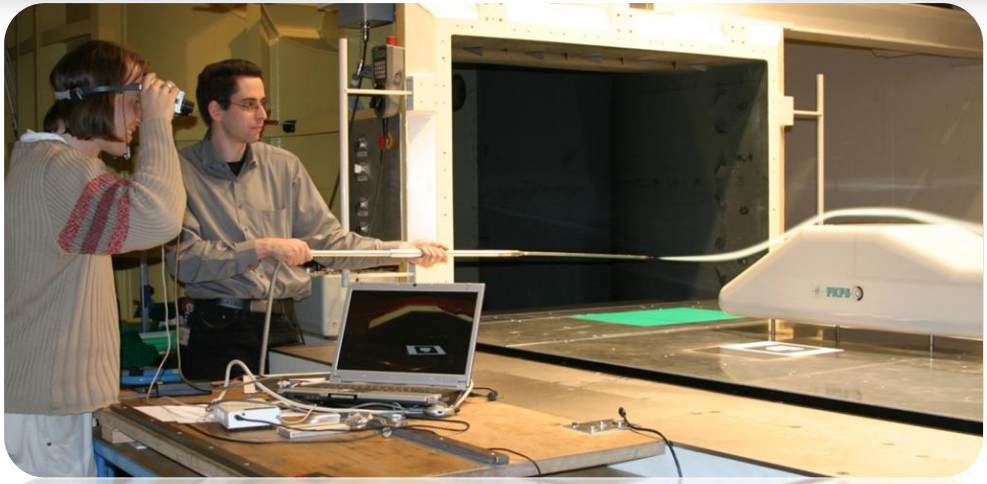




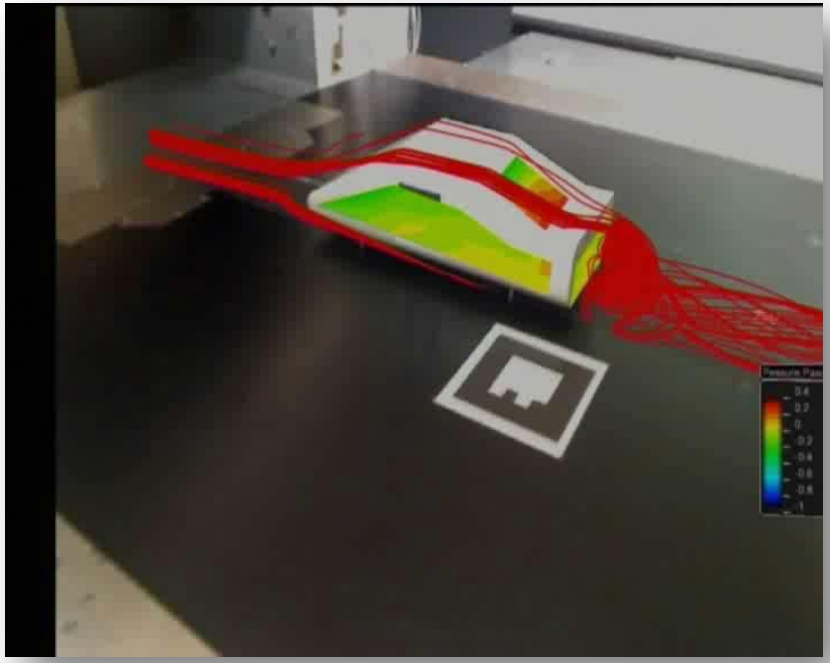
MODELL WIND TUNNEL AT THE FKFS

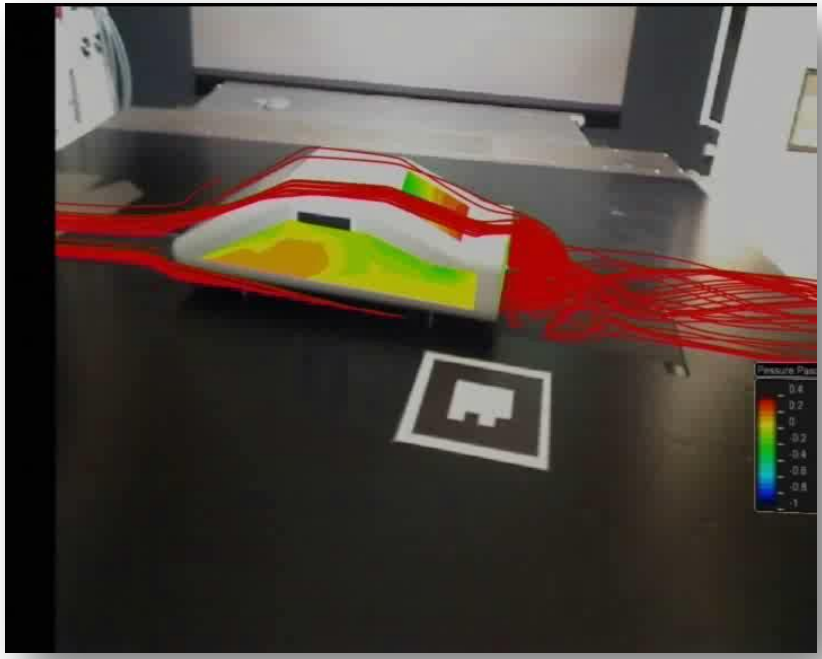


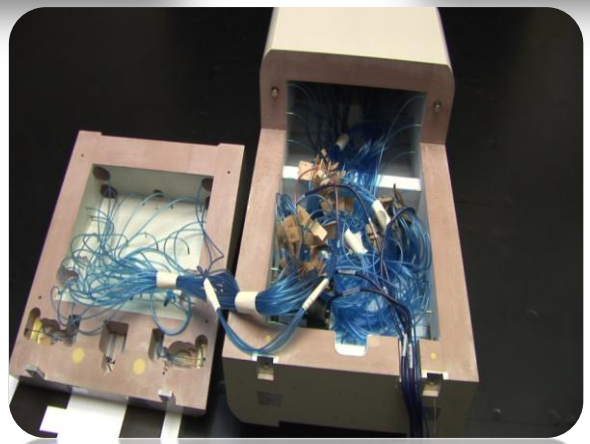




WIND TUNNEL AT FKFS



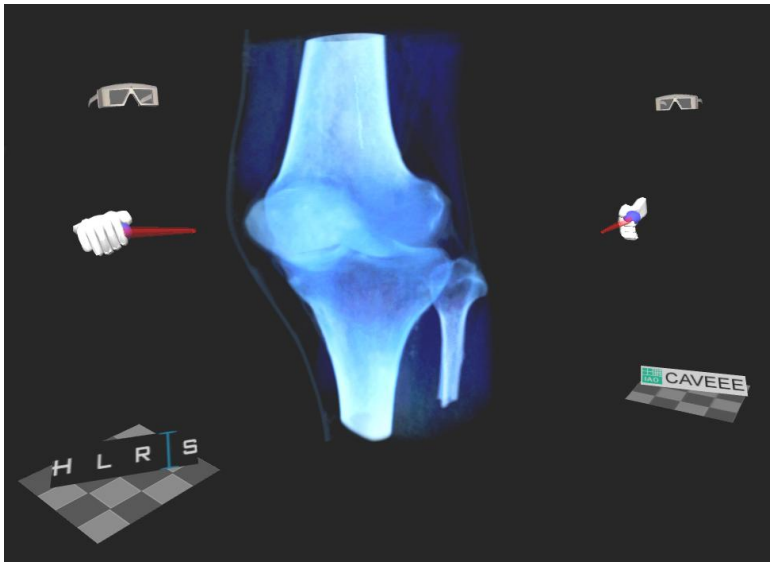


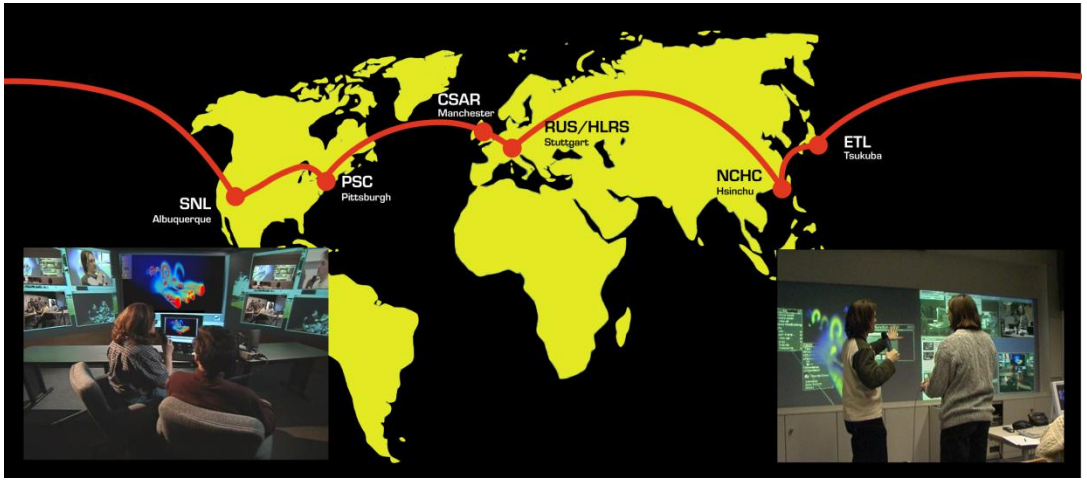


DISTANT COLLABORATION

Application areas:

- Joint product development
- Remote expert consultation
- Training
- Joint research projects
- Reviews
- Presentations





COLLABORATION MODES

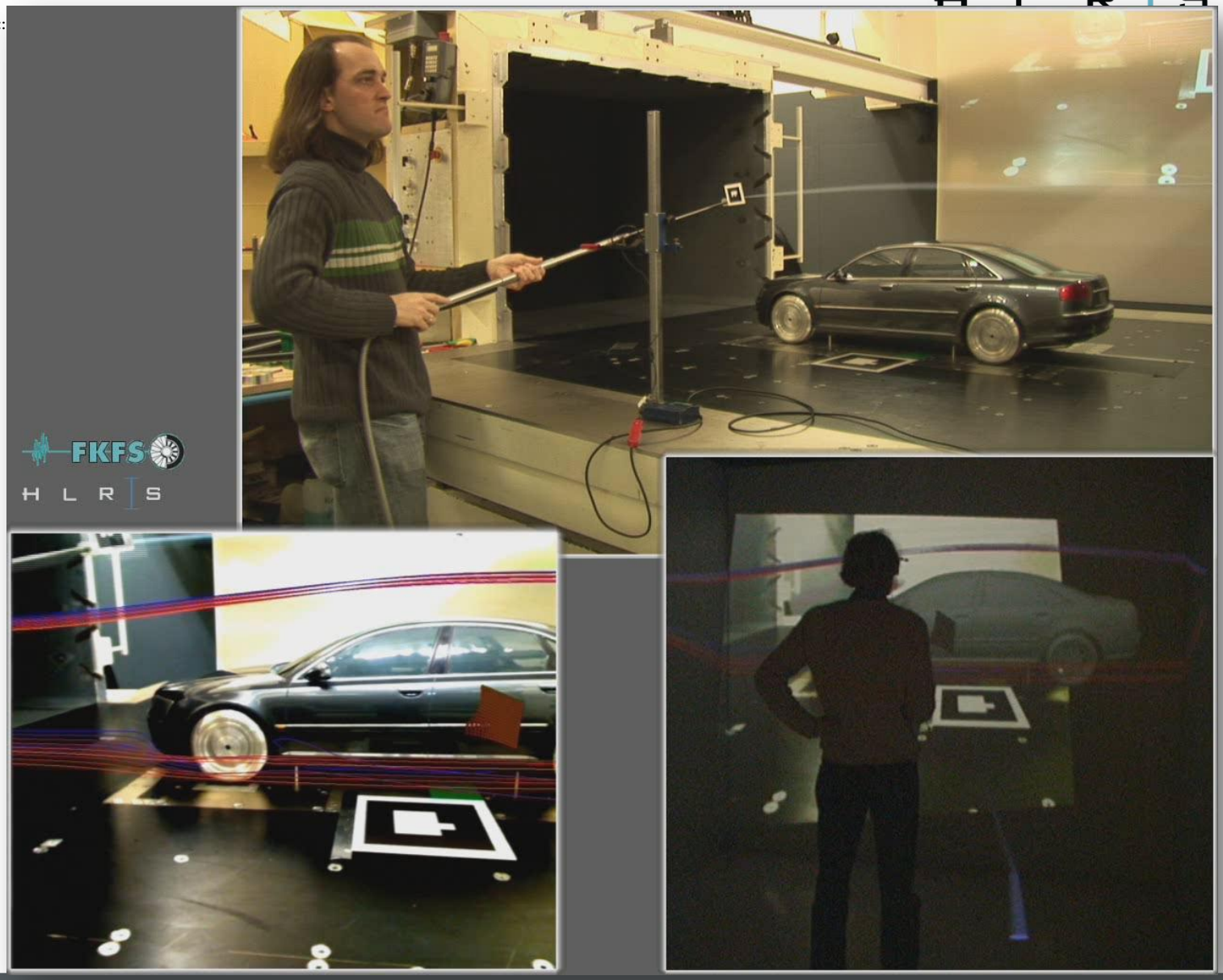


- Loose
  - -Views are not synchronized
  - -Avatares represent the position of partners
  - -Suited for joint work

- Tight
  - -Views are synchronized
  - -Avatares are not displayed
  - -Each partner can interact with the virtual world
  - -Suited for joint work on small objects

- Master/Slave
  - -Views are synchronized
  - -Only the master can interact with the virtual world
  - -Suited for presentations

COLLABORATIVE WIND TUNNEL





Interactive Simulation in Architecture

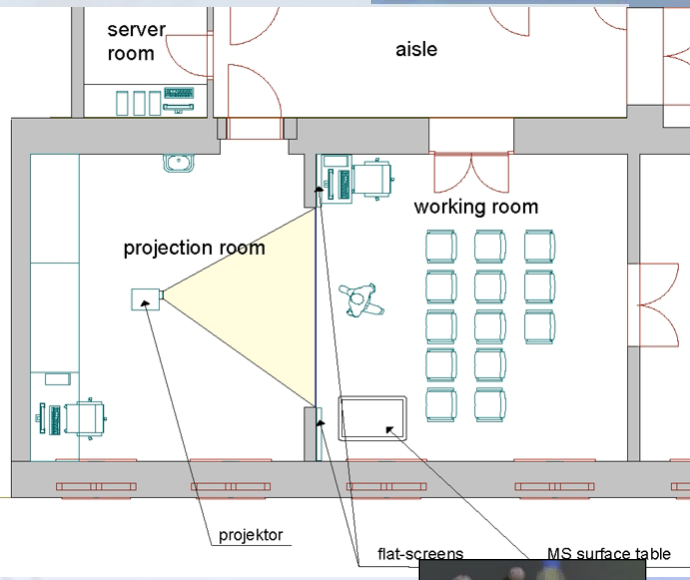
ARCHITEKTUR UND RAUMPLANUNG

SEAIP/PRAGMA 2010

2009

Stadtraumlabor TU-Wien

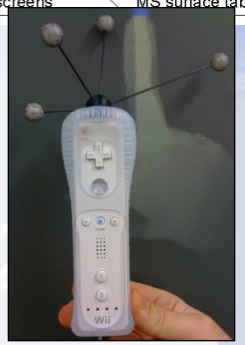




Projektteam Stadtraumlabor TU Wien

- *Andreas Voigt, Prof. Dr. (TU Wien, E280, Koordination)*
- *Joachim Kieferle, Prof. DI (Hochschule Rhein-Main), Gastprofessor TU Wien, 2009/2010*
- *Uwe Wössner, Dr. (HLRS Stuttgart), Gastprofessor TU Wien, 2009/2010*
- *Bob Martens, Prof. Dr. (TU Wien)*
- *Elmar Schmidinger*
- *Herbert Wittine (TU Wien, E280)*
- *Philipp Krebs, DI (TU Wien, E280)*
- *Robert Kalasek, DI (TU Wien, E280)*

http://raum.tuwien.ac.at/raumsim



Stadtraumlabor TU-Wien

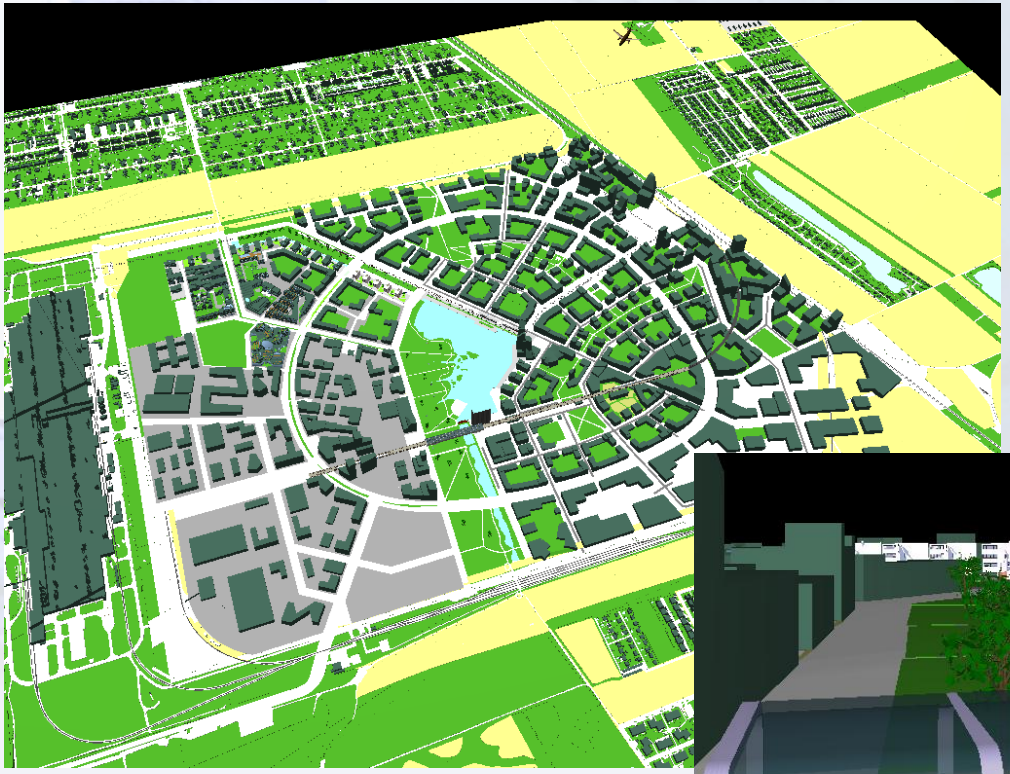




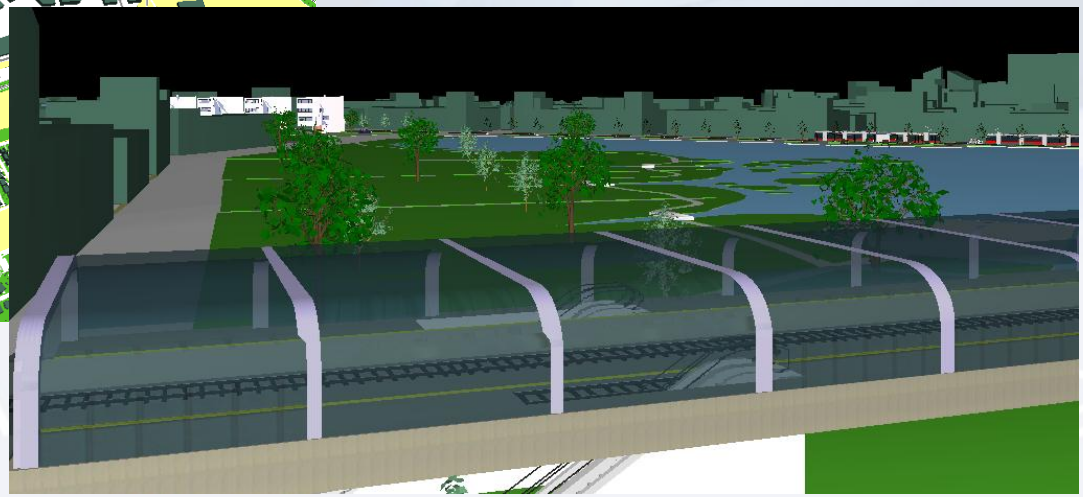
TAG 28. Mai 2009

ARCHITEKTUR UND RAUMPLANUNG

Masterplan Seestadt Aspern

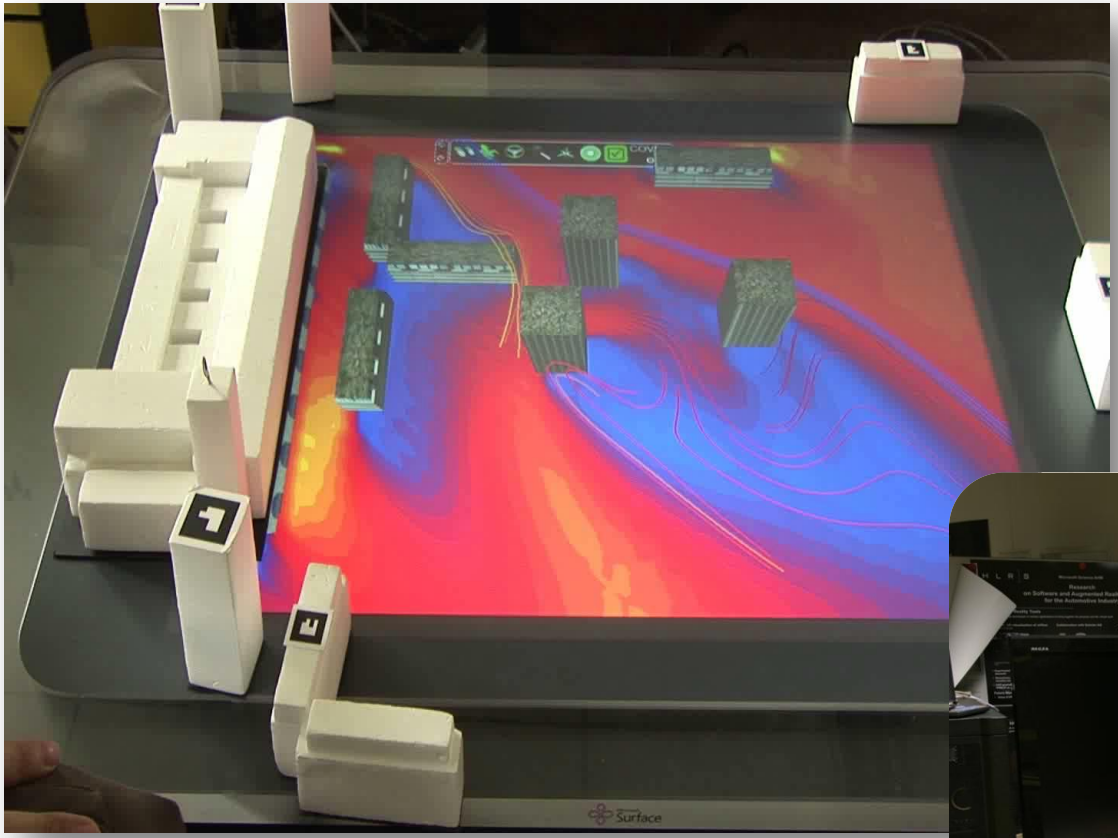


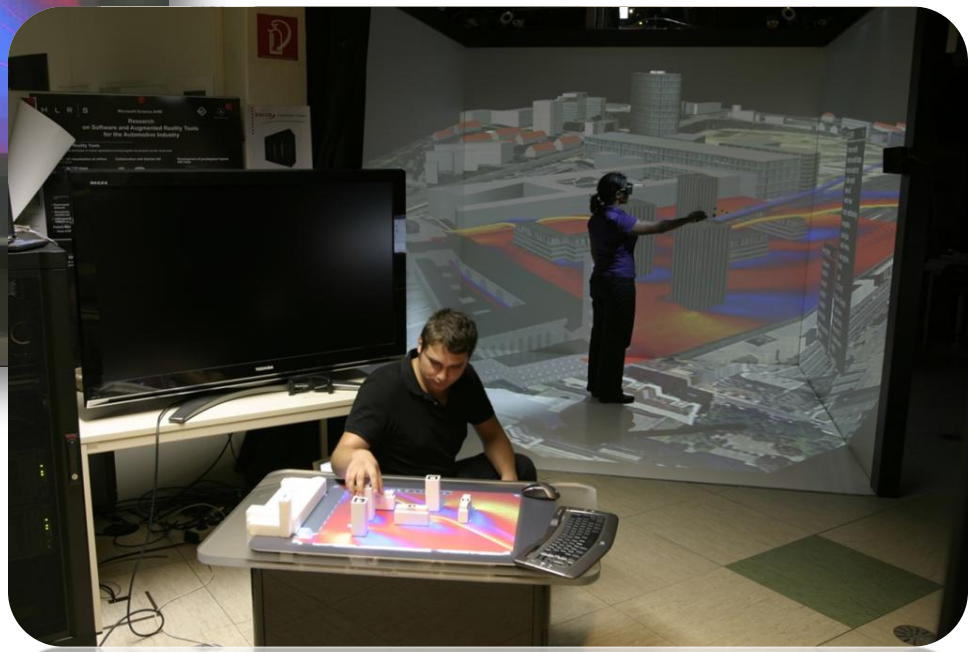




WISSENSCHA
ARCHITEKTUR UND RAUMPLANUNG

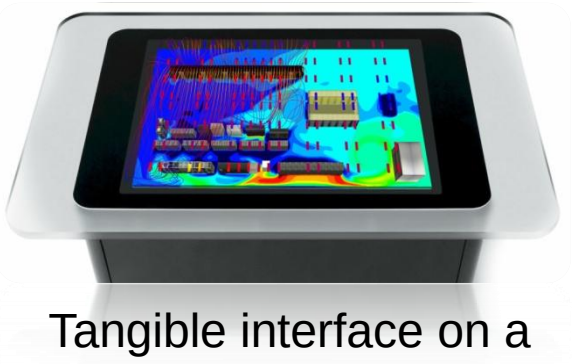
NATURAL USER INTERFACES



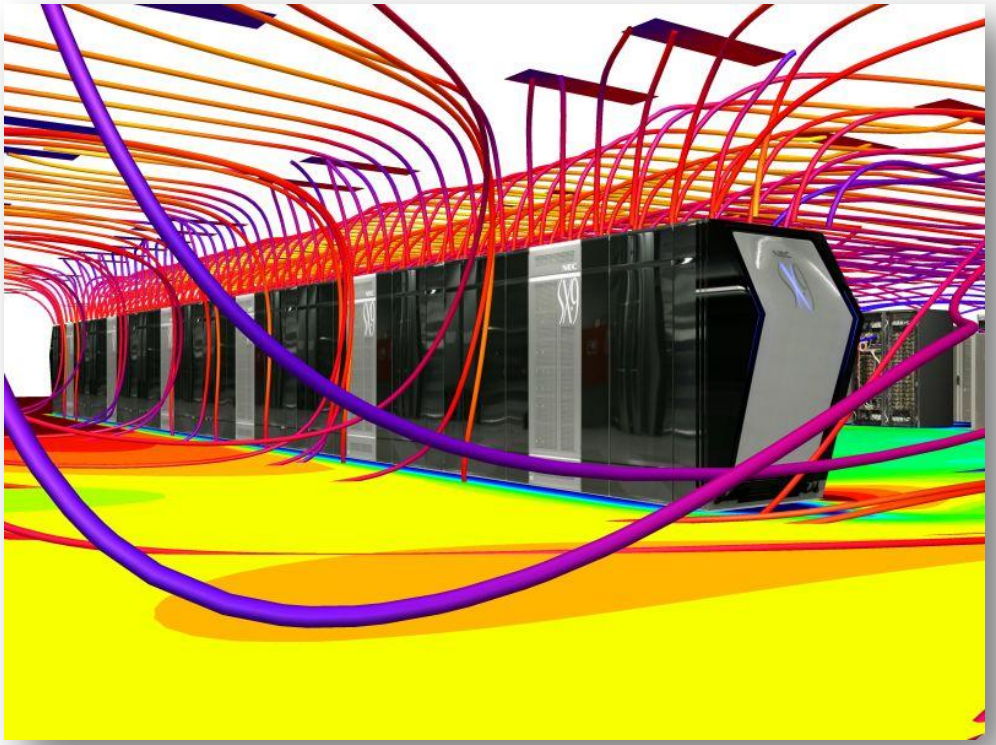


AIR CONDITIONING

Simulation of Racks in the HLRS server room
- 5MW of Power
- 1.5MW cooled by air
- Temperature distribution has to be optimized
- Simulation using Ansys CFX

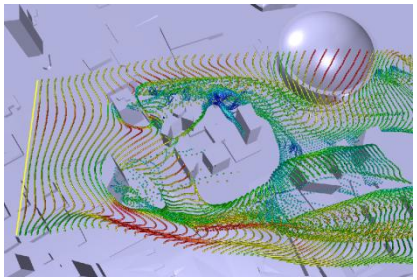


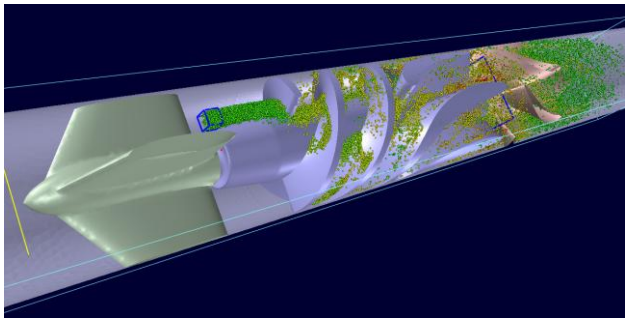
Tangible interface on a Microsoft Surface

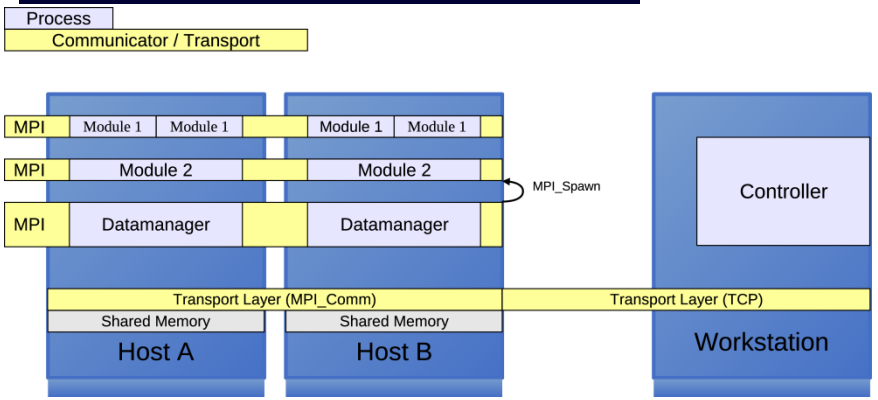


VISPME / MS-PARVIS

- Parallel post processing
  - –parallel workflow
  - –Automatic data decomposition
  - –Dynamic resampling
- Parallelization of algorithms
  - –manycore
  - –distributed memory
  - –accelerators
- Parallel rendering
  - –Volume rendering
  - –Sort-first
  - –Sort-last





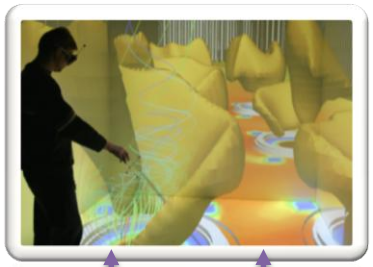


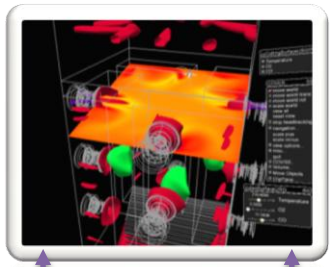
Bundesministerium für Bildung und Forschung

PARALLEL POST-PROCESSING

Distributed Environment

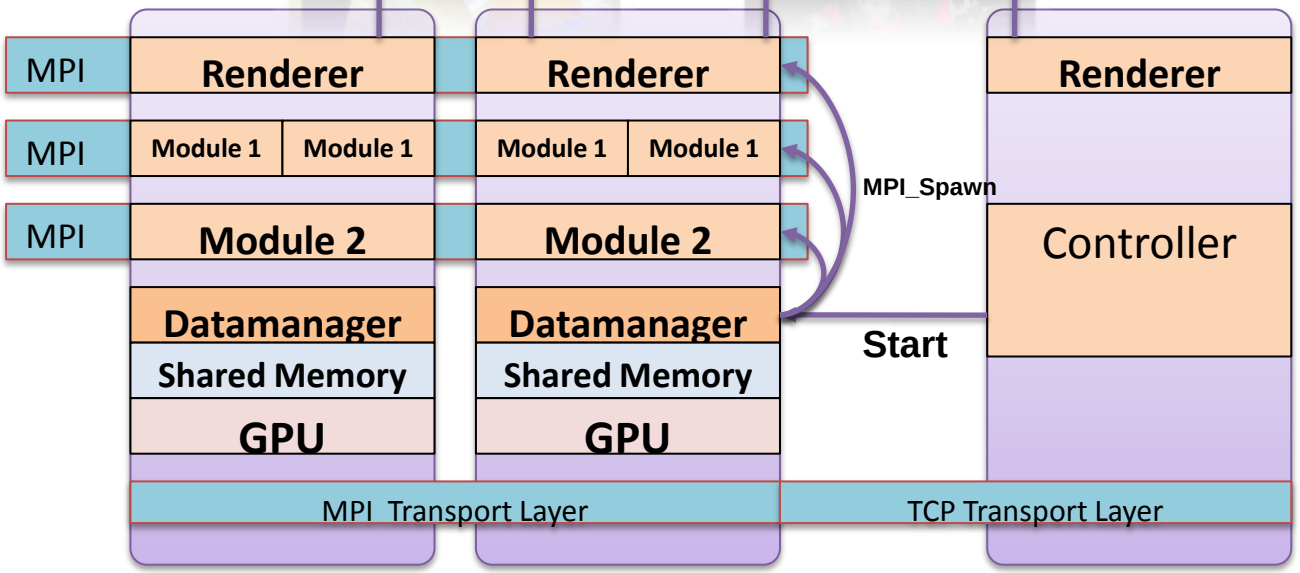
- Cluster / Workstations
- Dynamic MPI Processes





- Parallel Rendering
- Remote Rendering
- VR / Desktop





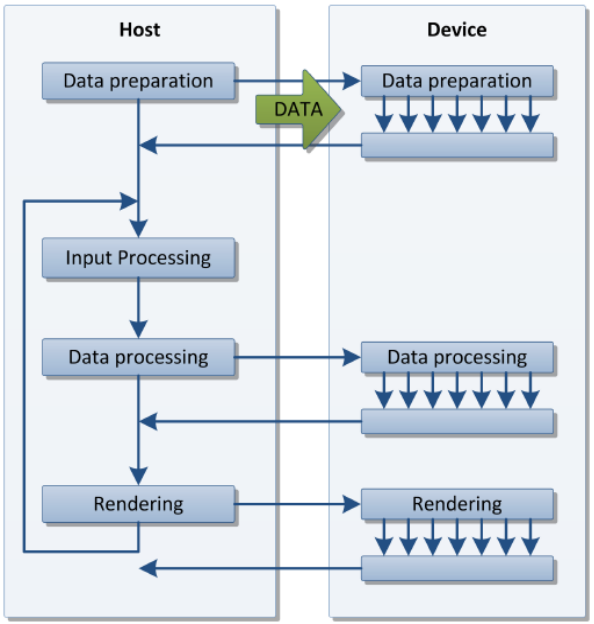


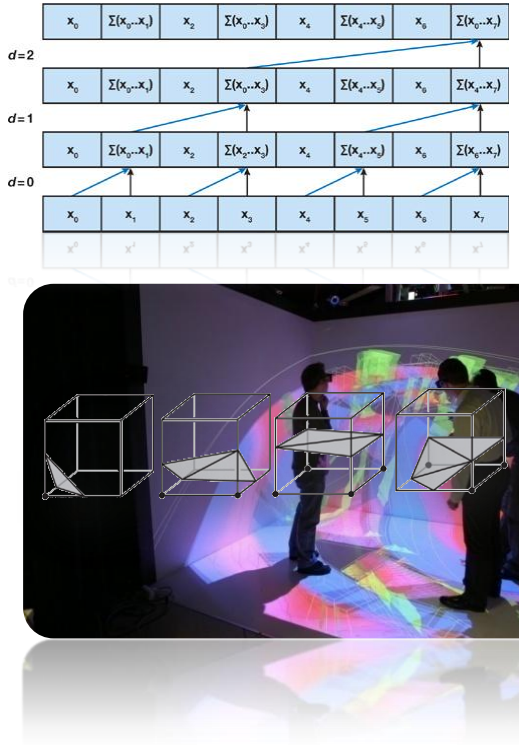
POST-PROCESSING IN HYBRID MANY-CORE ENVIRONMENTS

Visualization Cluster
- Multiple Nodes
- Multiple CPUs / Node
- highly parallel GPUs

Data Processing on GPUs
- Preparation
- Processing
- Rendering / Readback

Datamanager stores (partial) data objects
- Host memory
- Device memory

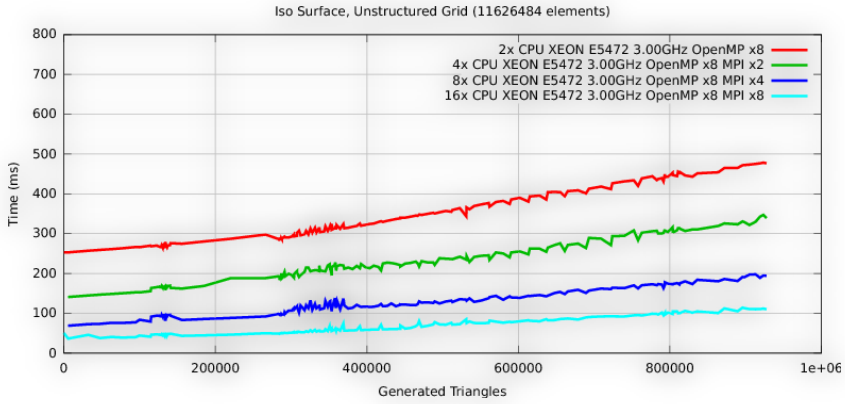


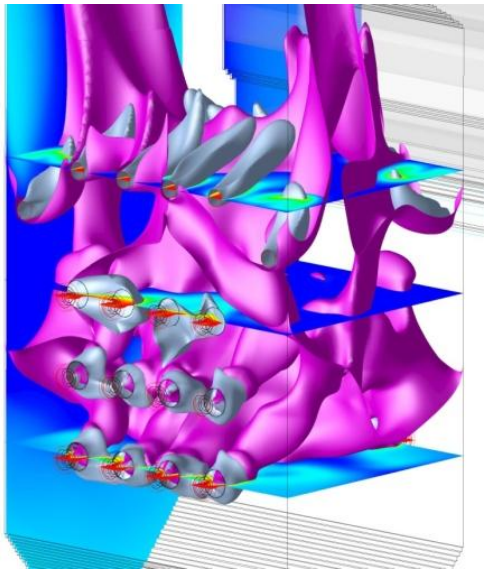


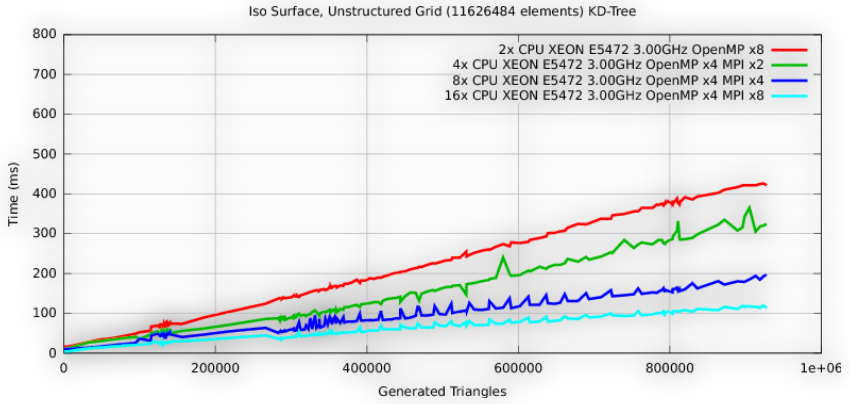
PARALLEL SURFACE EXTRACTION (CPU)

Parallelization of iso-/cutting surface extraction for interactive post-processing

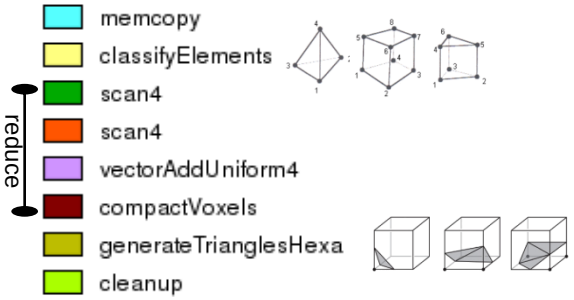
- Trivially parallel approach / shared memory
- Domain decomposition / distributed memory
- Acceleration techniques not so easy to parallelize (KD-Tree)
- Worst case still slow with KD-Tree

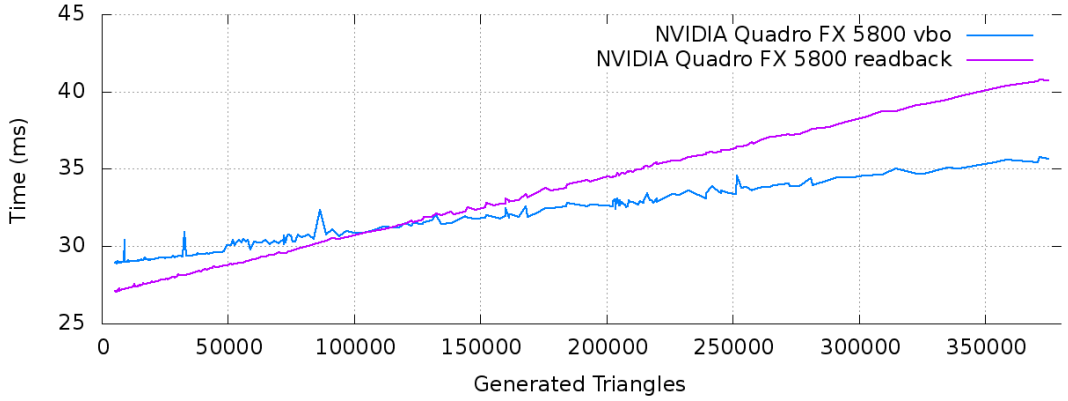


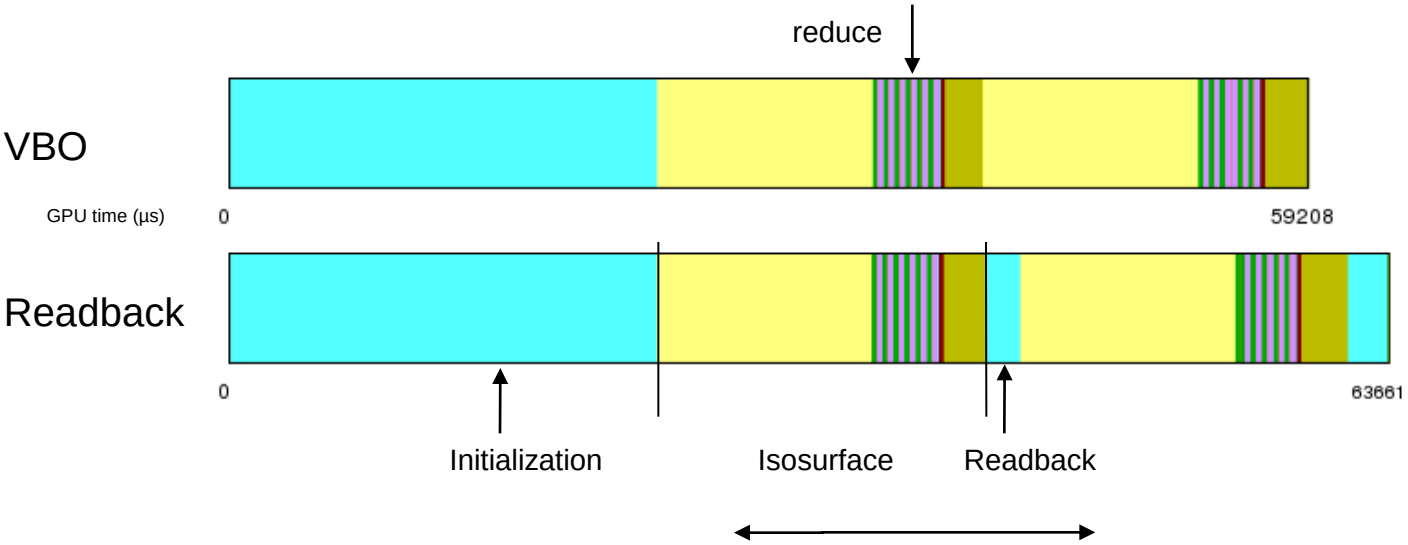




ISOSURFACE GPU



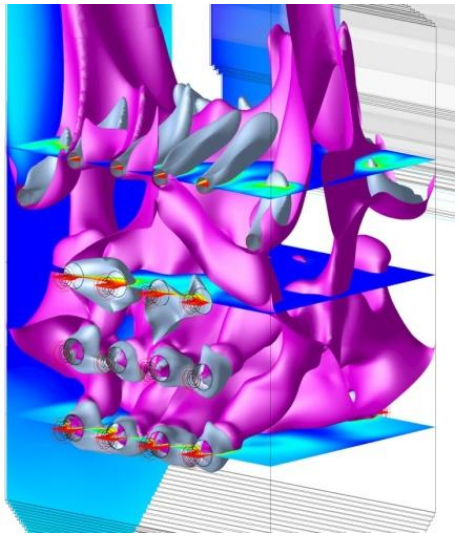


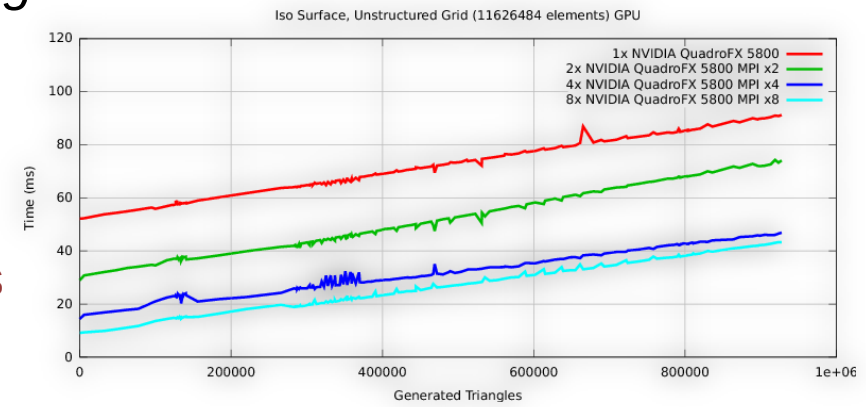


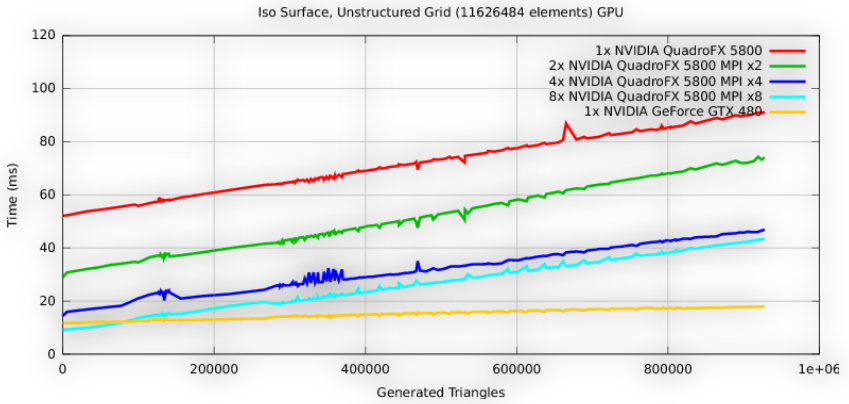
PARALLEL SURFACE EXTRACTION (GPU)

Parallelization of iso-/cutting surface extraction for interactive post-processing

- Faster on 1 QuadroFX 5800 than on 16 Xeon (Nehalem) CPUs
  - Fermi 5x faster (1.5 GB GeForce)
- Immediate rendering of extracted surfaces
- Memory limitation (6 GByte)









RECOM SERVICES
REaction & COmbustion Modelling

HLRS
High Performance Computing Center Stuttgart



Combustion Modelling
in Power Plants

RECOM Services

SIMULATING GRASHOPPER POPULATIONS



Wanstschrecke (*Polysarcus denticauda*, alias *Orphania denticauda*)

- Is on the red list of endangered species.
- Can‘t fly
- It sometimes develops hikers which explore the environment







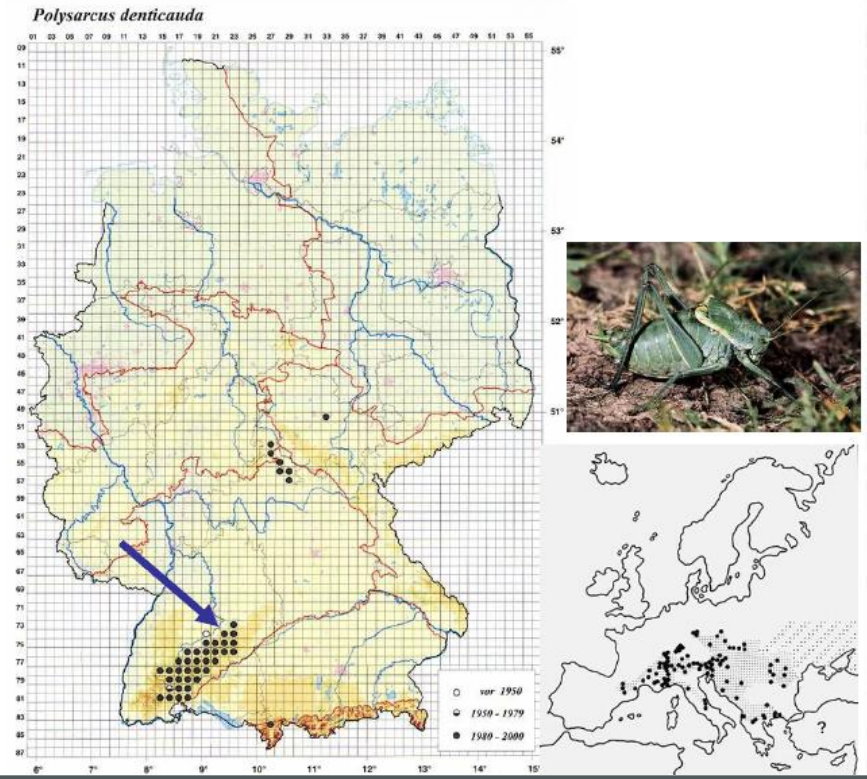




5. Study area Ofterdingen

Polysarcus denticauda

- Red List D: critically endangered
- Red List BW: endangered
- BW: „special conservation responsibility“ (*Maas* et al. 2002)



habitat patches

study area

existing road

planned road (real)

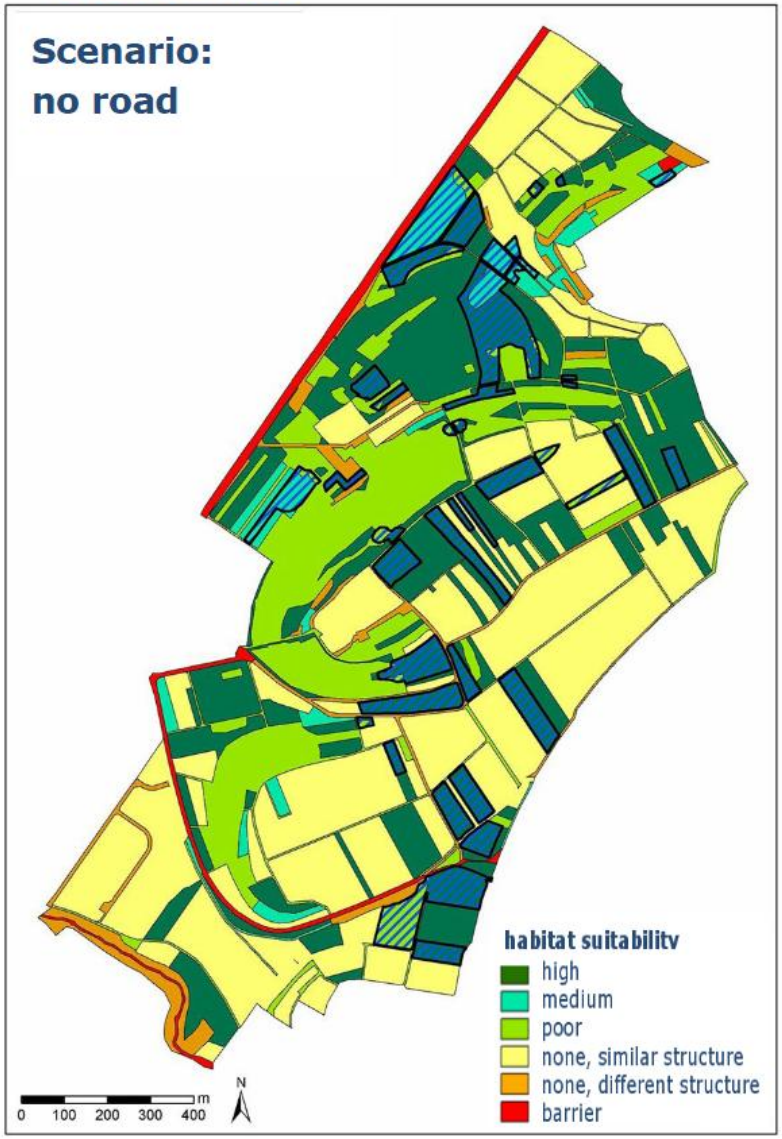
planned road (virt.)

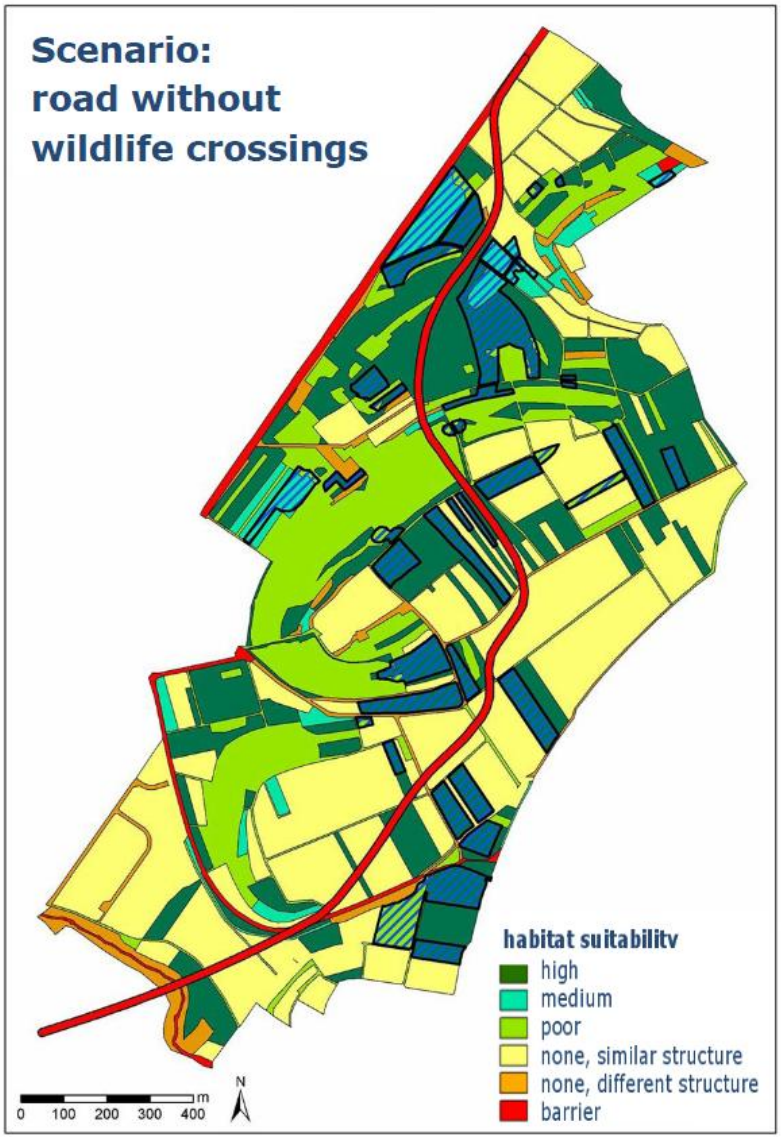
B27

0 100 200 300 400 m

N

Scenarios


Scenario:
no road
habitat suitability
high
medium
poor
none, similar structure
none, different structure
barrier
0 100 200 300 400 m
N


Scenario:
road without
wildlife crossings
habitat suitability
high
medium
poor
none, similar structure
none, different structure
barrier
0 100 200 300 400 m
N



::

individuals that migrated from patch 18 (16 ind.) to*:		
patch 16	patch 17	patch 19
0,47	1,17	0,5

scenario: no road

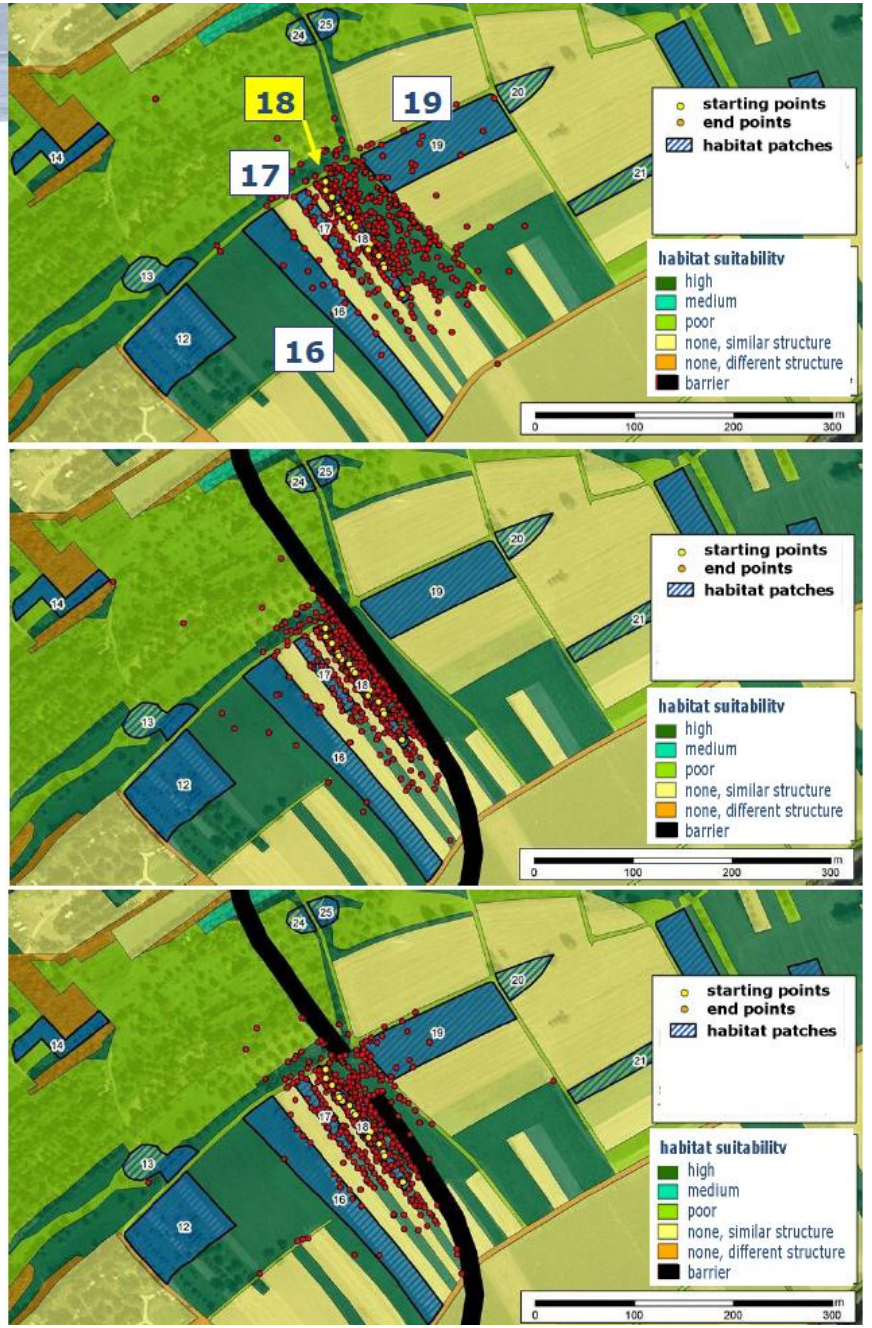
0,2	0,97	0

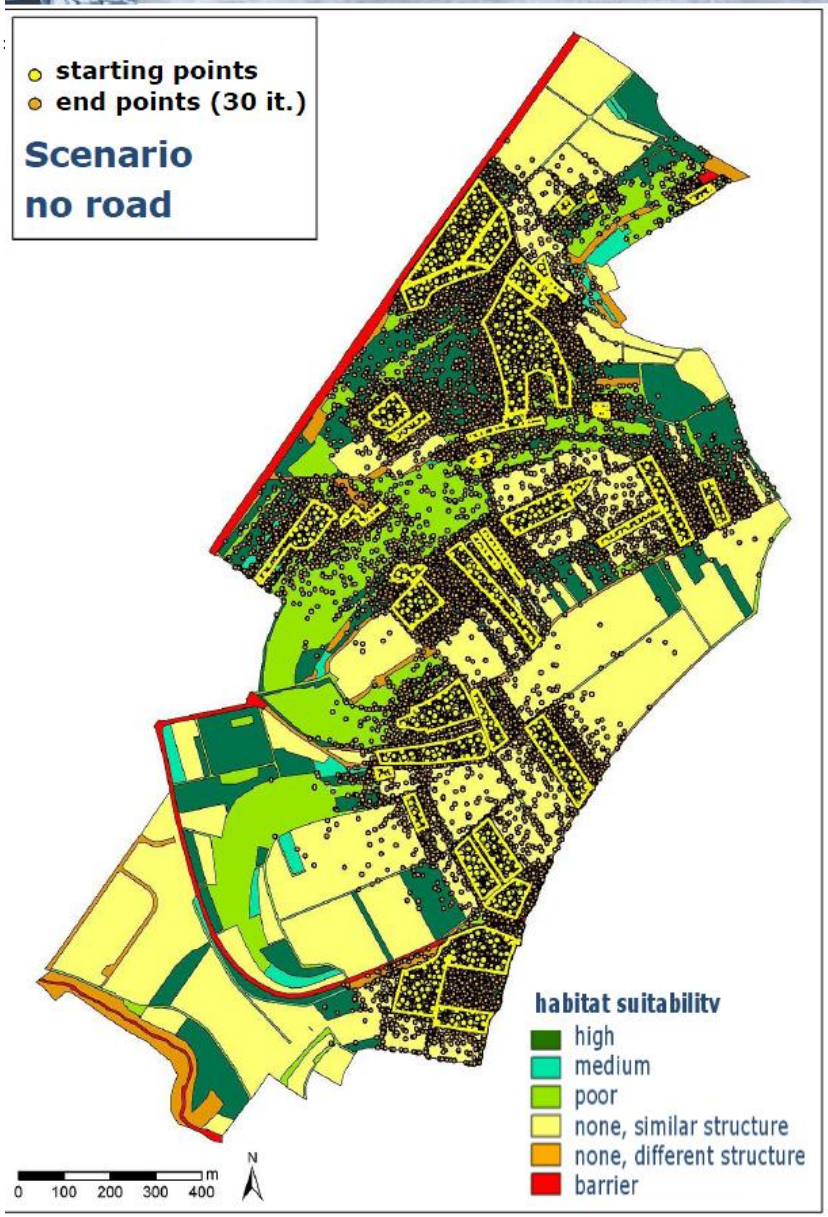
scenario: road without crossings

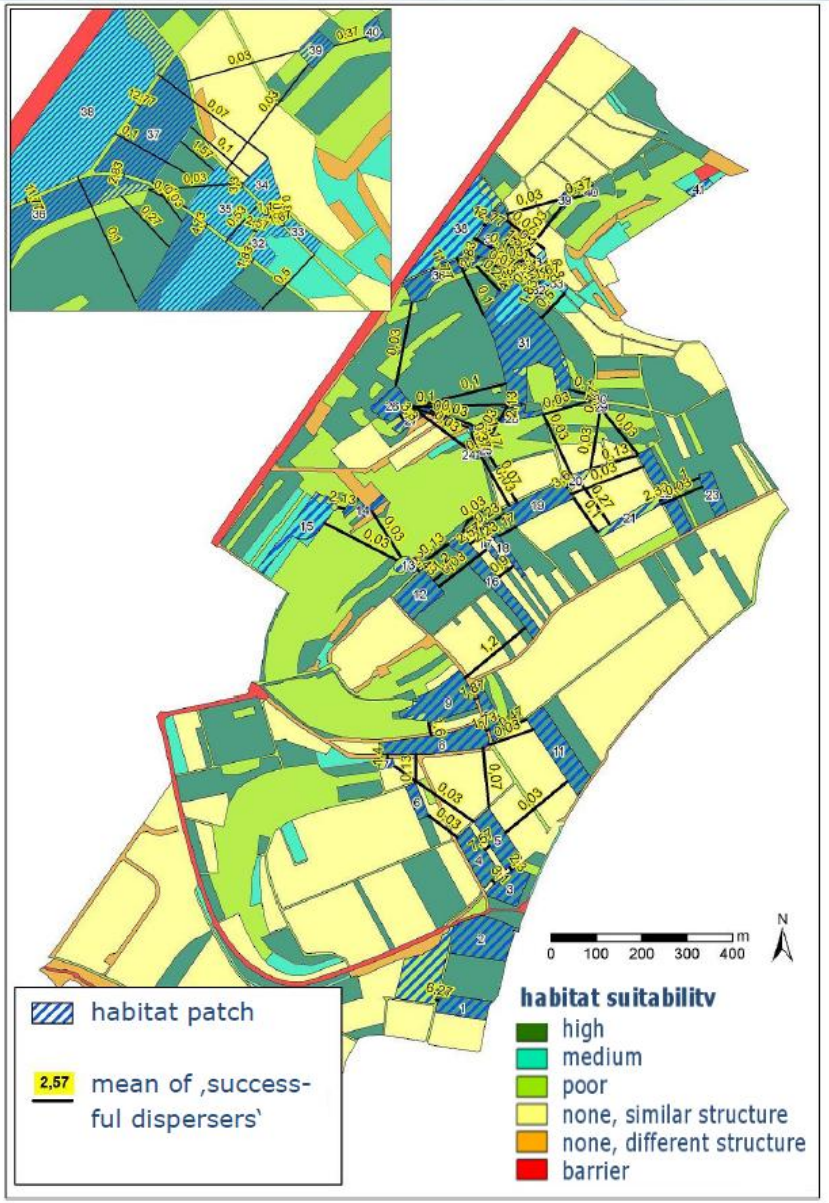
0,37	1,37	0,53

scenario: road with crossing G1

* average of 30 iterations




starting points
end points (30 it.)
Scenario
no road
habitat suitabilitv
high
medium
poor
none, similar structure
none, different structure
barrier
0 100 200 300 400 m
N


habitat patch
2,57 mean of ‚successful dispersers‘
habitat suitabilitv
high
medium
poor
none, similar structure
none, different structure
barrier
0 100 200 300 400 m
N

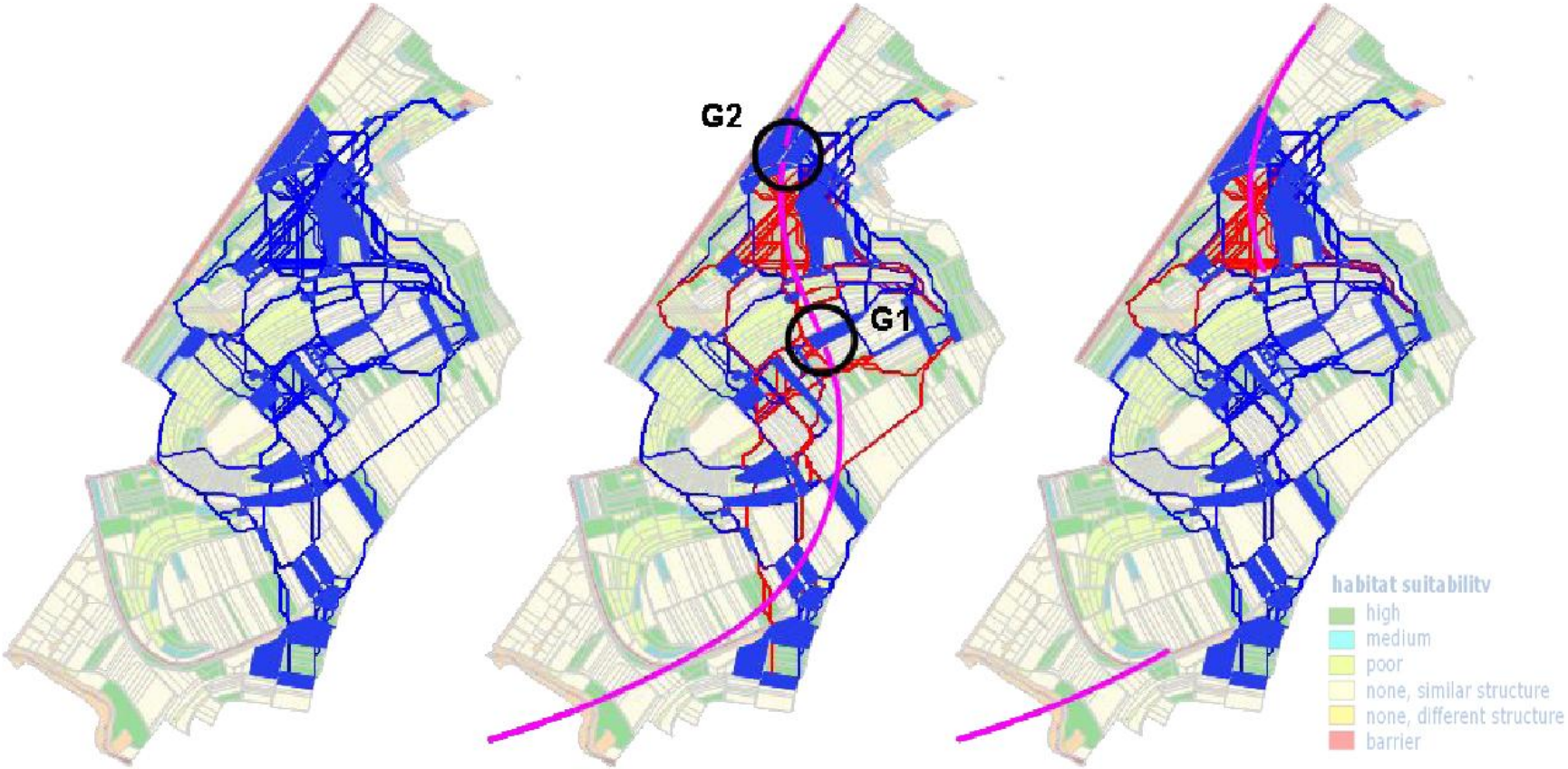
Results: Inter-patch connections

directly connected
affected connection

no road

road and wildlife crossing / G1 /G2

road in tunnel



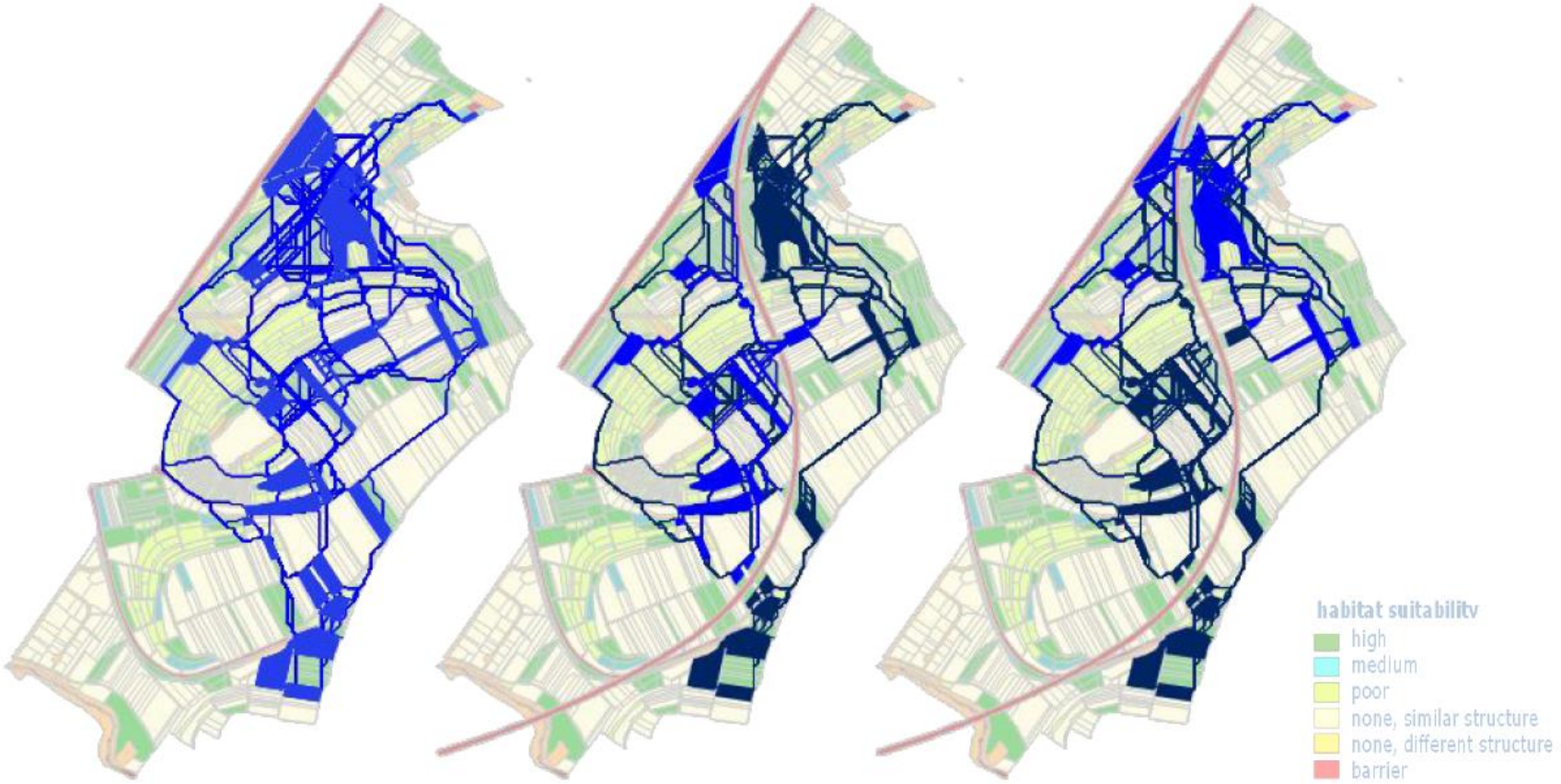
Results: Inter-patch connections

directly connected
not directly connected

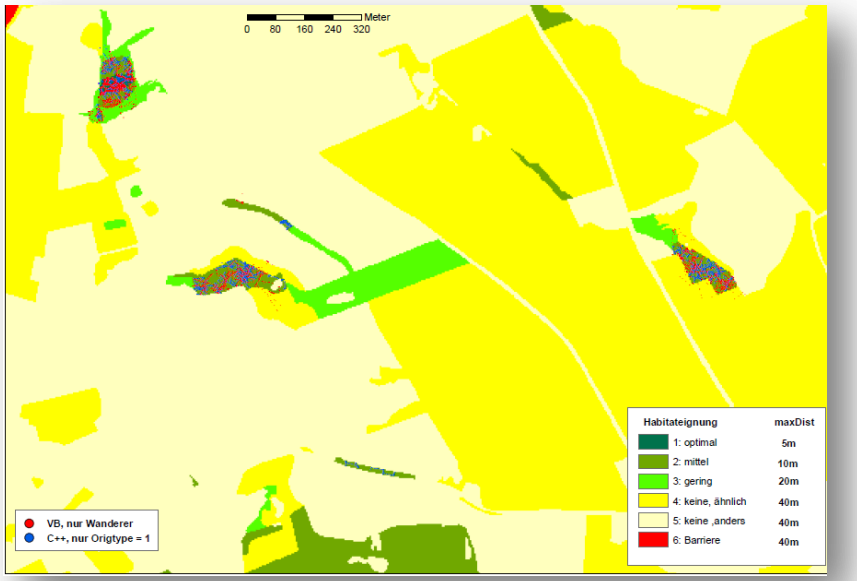
no road

Wildlife Crossing G1

Wildlife Crossing G2



SIMULATING GRASHOPPER POPULATIONS



Testcase: 1100 species, 100 steps, 4 km²

Existing Visual Basic code:

- Stand alone application.
- Compute time **30 Days**

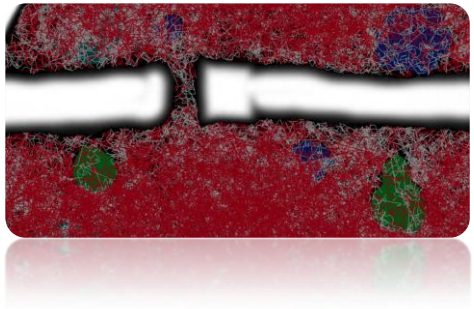
New C++ implementation:

- integrated as external application in GIS application
- Compute time **0.04 seconds**

→ **speedup: 64.800.000**

SIMULATING GRASHOPPER POPULATIONS

Code improvements:
- Refined vision model
- Easy extension of walking and searching strategies
- Allow for interaction between individual species



Future work:
- Support multiple generations

Collaborators:

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Institute for Lanscape Planning and Ecology (ILPOE)
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Dr. Reinhard Klenke
Helmholtz Center for Environmental Research Leipzig
Department of Conservation Biology
Reinhard.klenke@ufz.de

VALIDATE

Measurement Vehicle:
Streckenerfassung, Potenzialanalysen

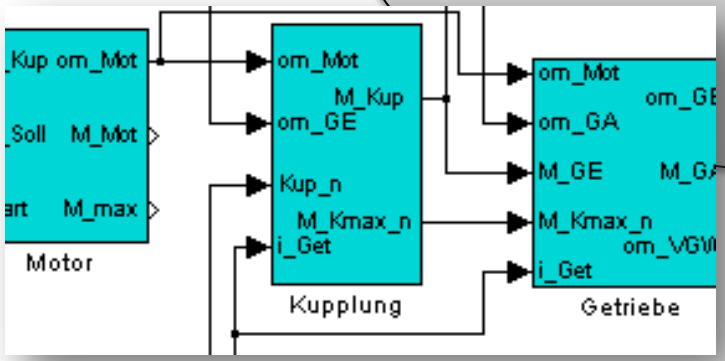


Driving Simulator:
Virtual environment, real driver

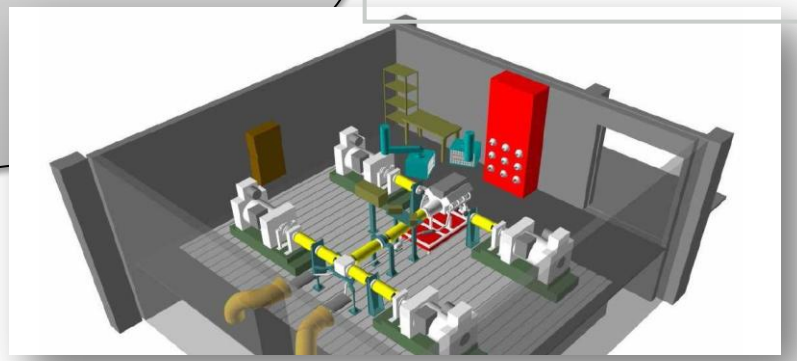


VALIDATE

Prototypes of control- or driver assistance systems

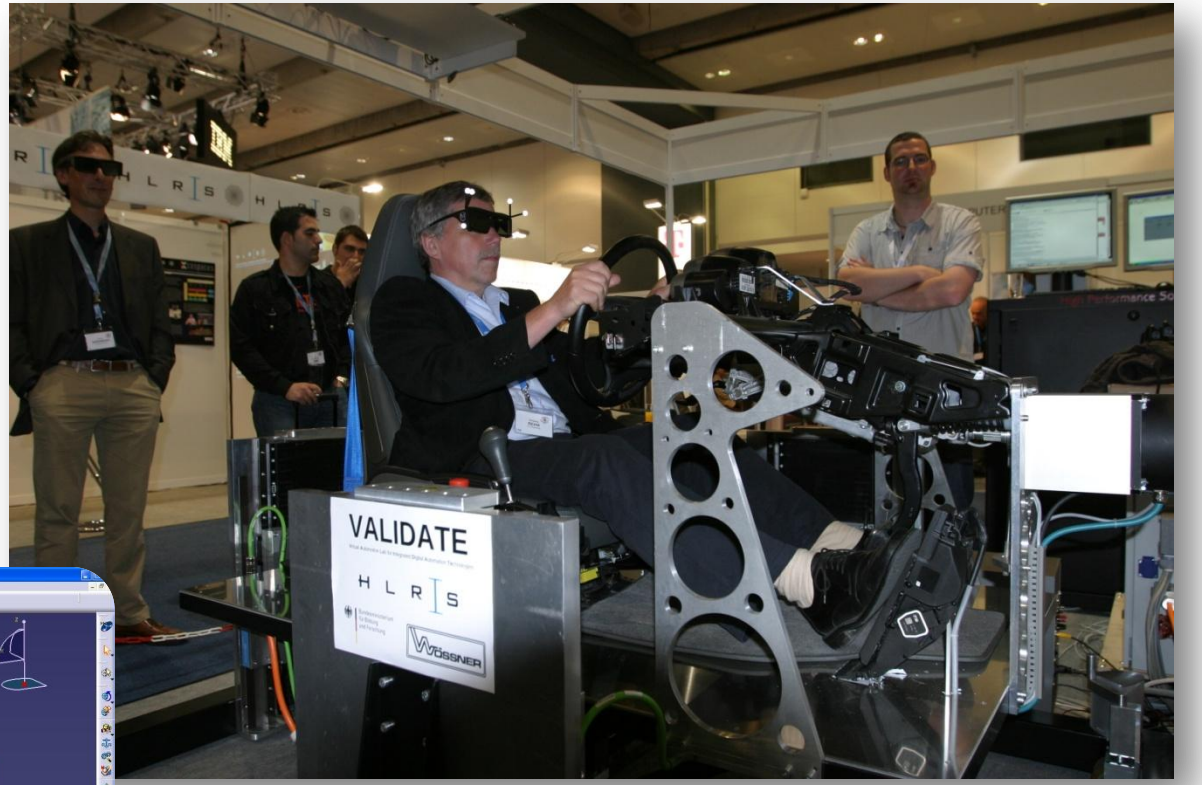


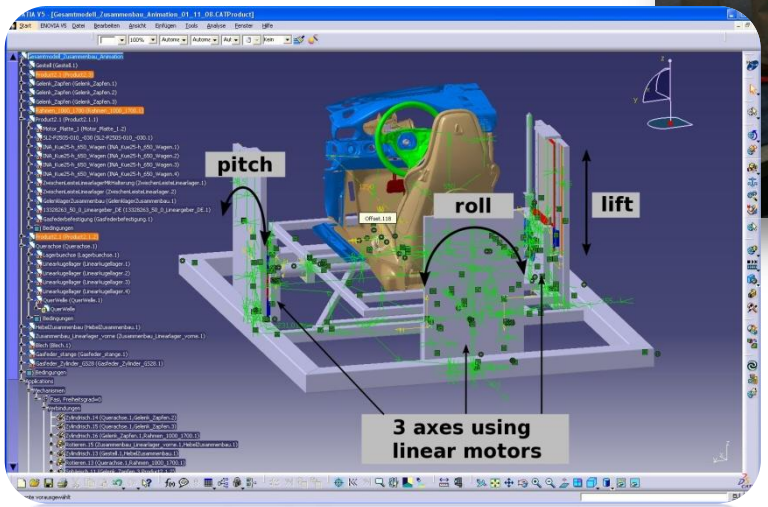
Drive Train testbed:
Testing of physical prototypes

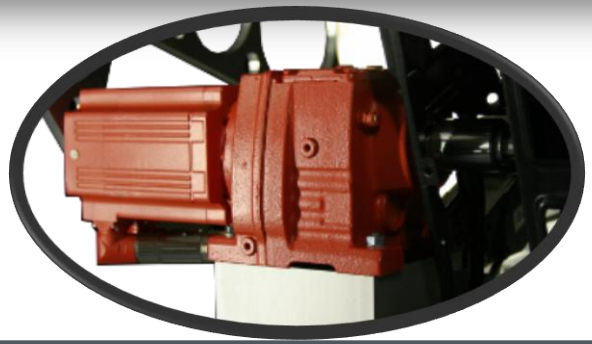


VALIDATE

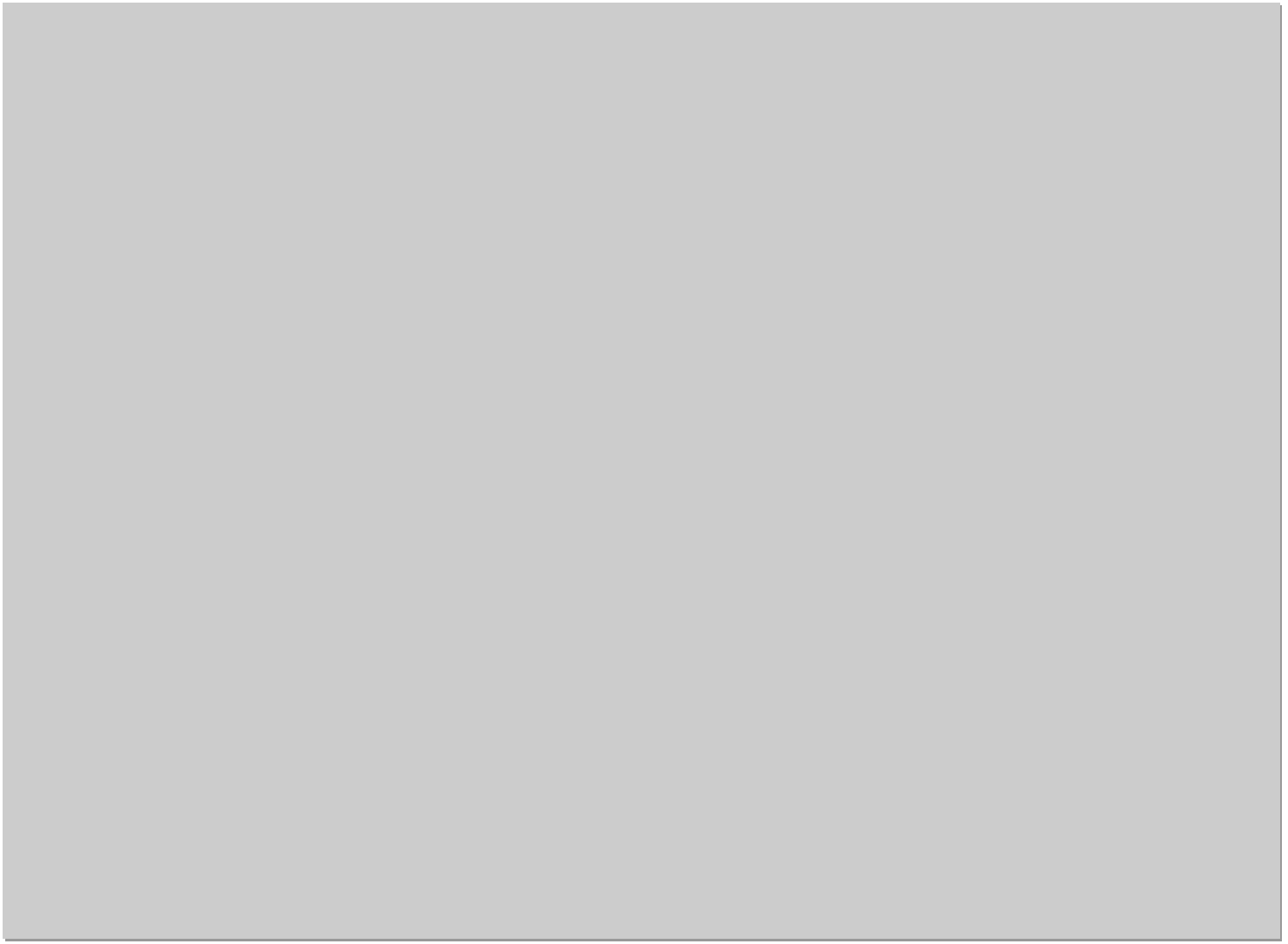
- 3dof driving simulator
- 3 linear motors
- a-max 2g
- V-max 1m/s
- Force feedback steering wheel
- Porsche 997 Turbo hardware
- Active gas pedal
- Active brake pedal







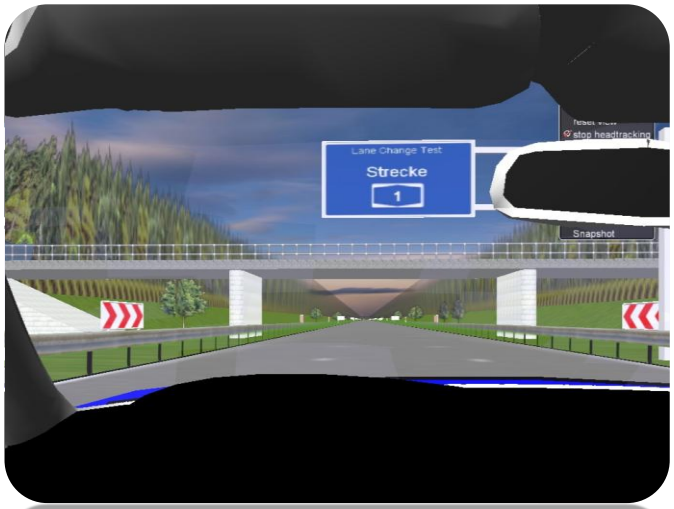
PORSCHE 911 (997 TURBO)

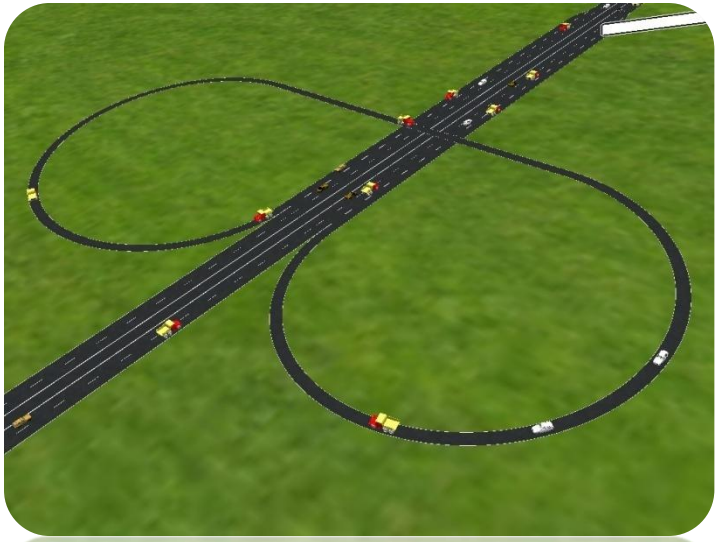


DRIVING SIMULATOR APPLICATIONS

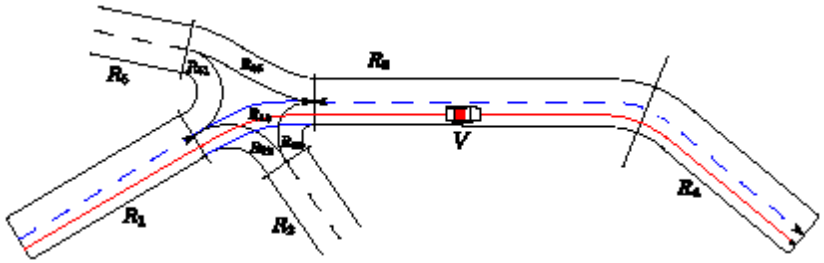


Lane Change Test

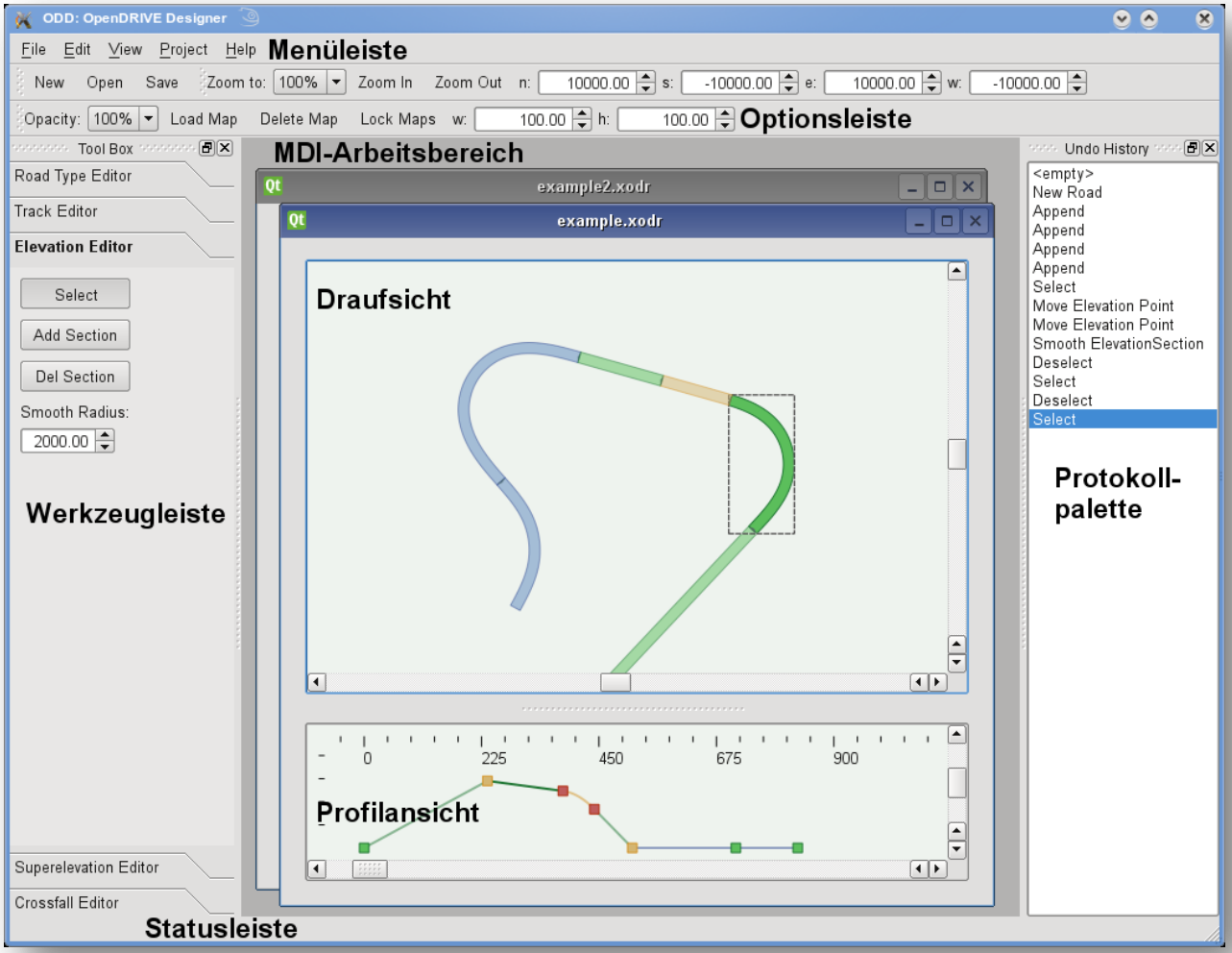




OpenDrive
Fremdfahrzeugsimulation



INTERACTIVE ROAD SYSTEM EDITOR



THE HLRS VIS-TEAM

- Blasius Czink
  - Parallel Visualization /HPC-Europa2 (Microsoft Research)
- Michael Braitmaier
  - AccessGrid;Video Conferencing; Realtime SOAs (IRMOS)
- Florian Niebling
  - Parallel Visualization; Grid;Infiniband; (VisPME)
- Andreas Gottlieb
  - Optimierung/Variantenstudien (Daimler CFD)
- Frank Nägele
  - Driving Simulator(MS-ParVIS)
- Andreas Kopecki
  - Parallel Rendering;Collaborative Working (CoSpaces)
- Jutta Sauer
  - Video service; 3D Modeling
- Florian Seybold
  - Driving Simulator; interactive vehicle dynamics (VALIDATE)
- Uwe Zimmat
  - Video service

becker-braitmaier-czink-griesser-kopecki-niebling-sauer-seybold-woessner-zimmat@hlrs.de

ASPHERICAL MIRROR

