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# Computer Graphics

- Introduction -  
Philipp Slusallek

# Overview

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- **Today**
  - Administrative stuff
  - History of Computer Graphics (CG)
- **Next lecture**
  - Overview of Ray Tracing

# General Information

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- **Core Lecture (Stammvorlesung)**
  - Applied Computer Science (Praktische Informatik)
  - Lectures in English
- **Time and Location**
  - Mon            10:00-12:00h, HS 01, E1.3
  - Thu            8:00-10:00h, HS 01, E1.3
- **ECTS:**
  - 9 credit points
- **Web-Page**
  - <http://graphics.cg.uni-saarland.de/courses/>
  - Schedule, slides as PDF, etc.
  - Literature, assignments, other information
- **Sign up for the course on our Web page now**
  - [Do not forget to sign-out in time before the exams, if you need to]

# People

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- **Lecturers**

- Philipp Slusallek

- E1.1, Room E18, Tel. 3830, Email: [slusallek@cs.uni-saarland.de](mailto:slusallek@cs.uni-saarland.de)

- **Assistants**

- Stefan Lemme

- E1.1, Room E13, Tel. 3792, Email: [lemme@cg.uni-saarland.de](mailto:lemme@cg.uni-saarland.de)

- **Tutors**

- Michael Schenck ([mschenck@mpi-inf.mpg.de](mailto:mschenck@mpi-inf.mpg.de))

- Sven Liefgen ([s8svlief@stud.uni-saarland.de](mailto:s8svlief@stud.uni-saarland.de))

- Stefan Lemme

# Exercise Groups

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- **Will be announced through the email list**
- **Please register on the course web page**

# Weekly Assignments

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- **Weekly assignment sheets**
  - Theoretical & programming assignments
  - You will incrementally build your own ray tracing system
  - This will be the basis for the Rendering Competition
- **Grading**
  - Results of the exercises will contribute to the final grade
  - Bonus points (towards the exam) are possible
- **Handing in assignments**
  - Theoretical: In paper form (hand-written)
  - Code: Email to assistant (see exercise sheet or Web page)
- **Exercise meetings**
  - Discuss lectures and any issues you might have with TAs
- **Groups of max. 2 students allowed**
  - Each one must be able to present and explain all results!

# Grading

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- **Weekly Assignments**
  - Counts 30% towards final grade (with +20% bonus points)
- **Rendering Competition (exam prereq.)**
  - Counts 10% towards final grade
  - Grading: Artistic quality (jury)
  - Groups of max. 2 students (but higher requirements then)
- **Exams**
  - Mid-term (exam prereq.), counts 20% towards final grade
  - Final exam counts 40% towards final grade
  - Minimum: 50% to pass (in each of the above)
- **Cheating**
  - 0% of assignment grade on first attempt
  - Possibility to fail the entire course if repeated
- **Chance for Repeated Exam**
  - Oral exam (if possible) at the end of the semester break

# Rendering Competition

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- **Task**
  - Create a realistic image of a virtual environment
  - Incorporate additional technical features into your ray tracer
  - Bonus points count towards exam
  - Creative design of a realistic and/or aesthetic 3D scene
  - Modeling and shading
- **Hand-out in early in course**
  - You can work on it during the entire course
  - Deadline will be announced (see Web page)
- **Results:**
  - One rendered image
  - Web page with technical detail info



# Rendering Competition



# Rendering Competition 2017/18



# Text Books

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- **Suggested Readings:**

- John Hughes, et al.: **Computer Graphics – Principles and Practice**, Addison-Wesley, 3. Ed, 2013
- Peter Shirley: **Fundamentals in CG**, 4. Ed, AK Peters, 2016
- Matt Pharr, Wenzel Jakob, Greg Humphreys: **Physically Based Rendering : From Theory to Implementation**, Morgan Kaufmann Series, **3. Ed., 2016, now freely available: <http://www.pbr-book.org/>**

- **Older**

- Andrew Glassner: **An Introduction to Ray-Tracing**, Academic Press, 1989
- David Ebert: **Texturing and Modeling – A procedural approach**, Morgan Kaufmann, 2003
- Tony Apodaca, Larry Gritz: **Advanced RenderMan: Beyond the Companion**, Morgan Kaufmann, 2000

- **More specific**

- Thomas Akenine-Möller, Eric Haines, **Real-Time Rendering**, AK Peters, 2nd Ed., 2002
- John M. Kessenich, et al., **OpenGL Programming Guide**, Addison-Wesley, 9. Ed., 2016

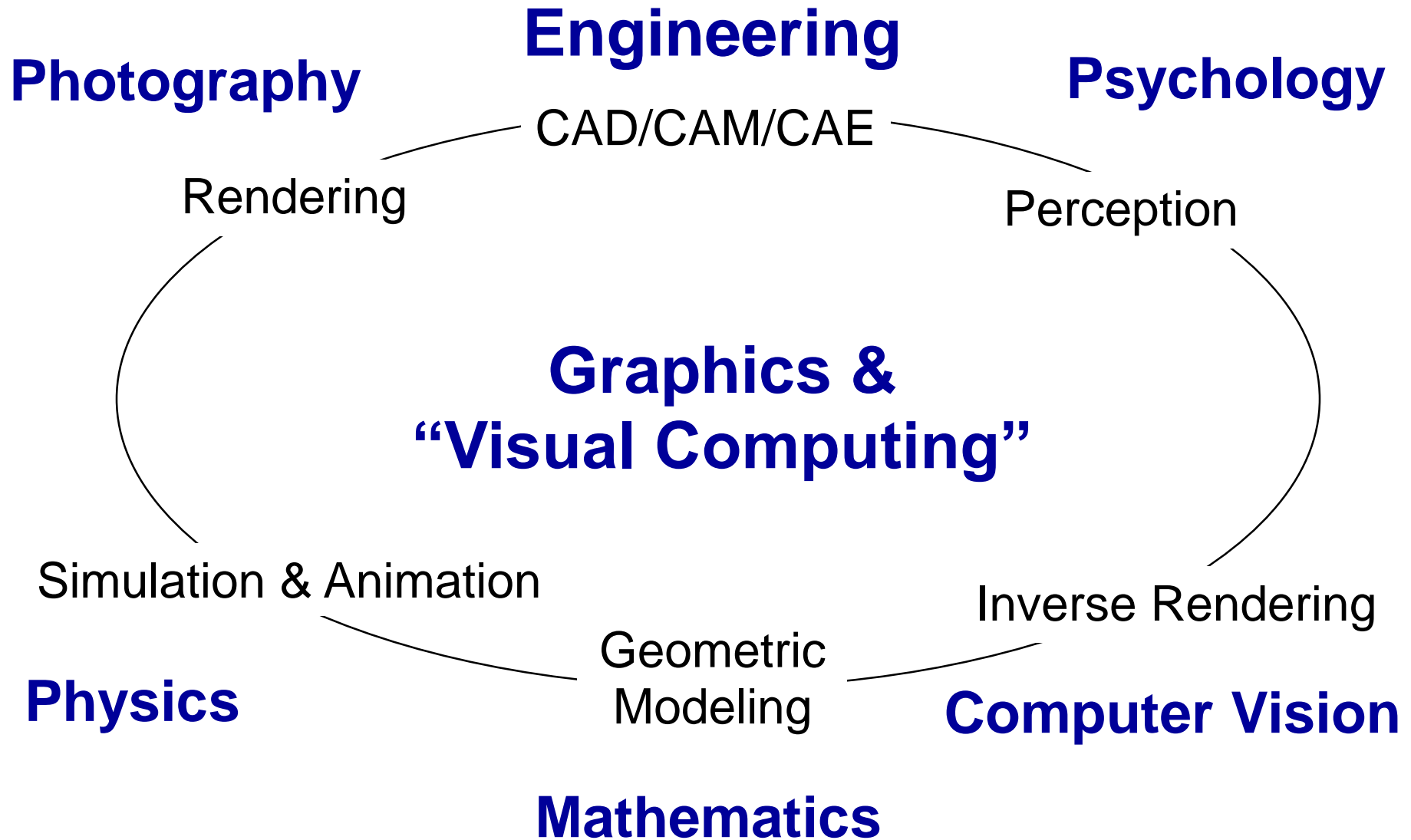
# Course Syllabus (Tentative)

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- **Overview of Ray Tracing**
- **Geometry Intersections**
- **Spatial Index / Acceleration Structures**
- **Vector Algebra Review**
- **Geometric Transformations**
- **Light Transport / Rendering Equation**
- **Material Models**
- **Shading**
- **Texturing**
- **Spectral Analysis / Sampling Theory**
- **Anti-Aliasing**
- **Distribution Ray Tracing**
- **Human Vision**
- **Color**
- **Splines**
- **Clipping**
- **Rasterization**
- **OpenGL**

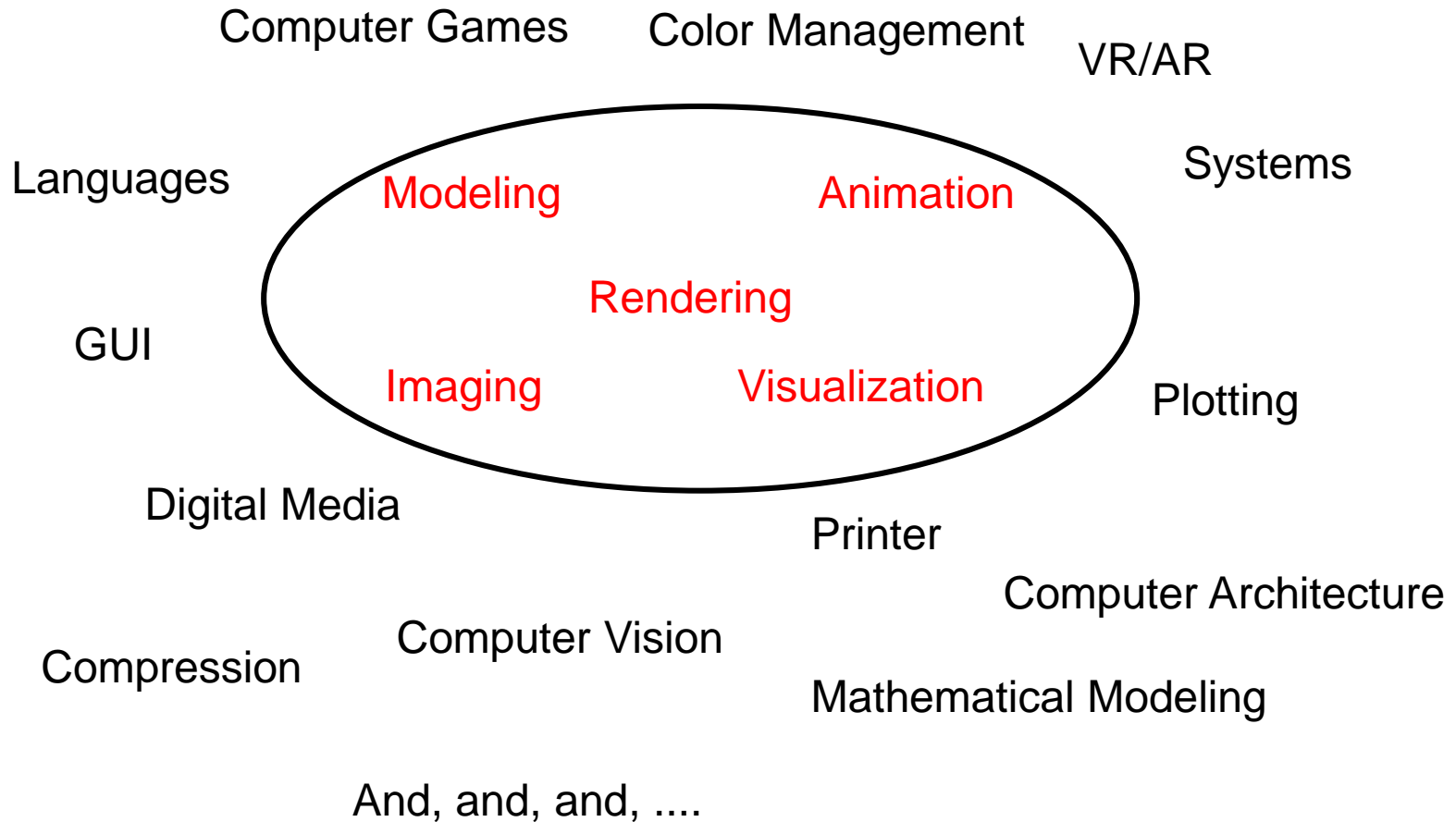
# What is Computer Graphics ?

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# What is Computer Graphics?

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# Saarland Informatics Campus



UNIVERSITÄT  
DES  
SAARLANDES



C | ISPA  
Center for IT-Security, Privacy  
and Accountability

intel  
VISUAL  
COMPUTING  
INSTITUTE

mpii  
max planck institut  
informatik



Max  
Planck  
Institute  
for  
Software Systems

# Saarland Informatics Campus



UNIVERSITÄT  
DES  
SAARLANDES



CISPA

**Helmholtz-Center**



VISUAL  
COMPUTING  
INSTITUTE



max planck institut  
informatik

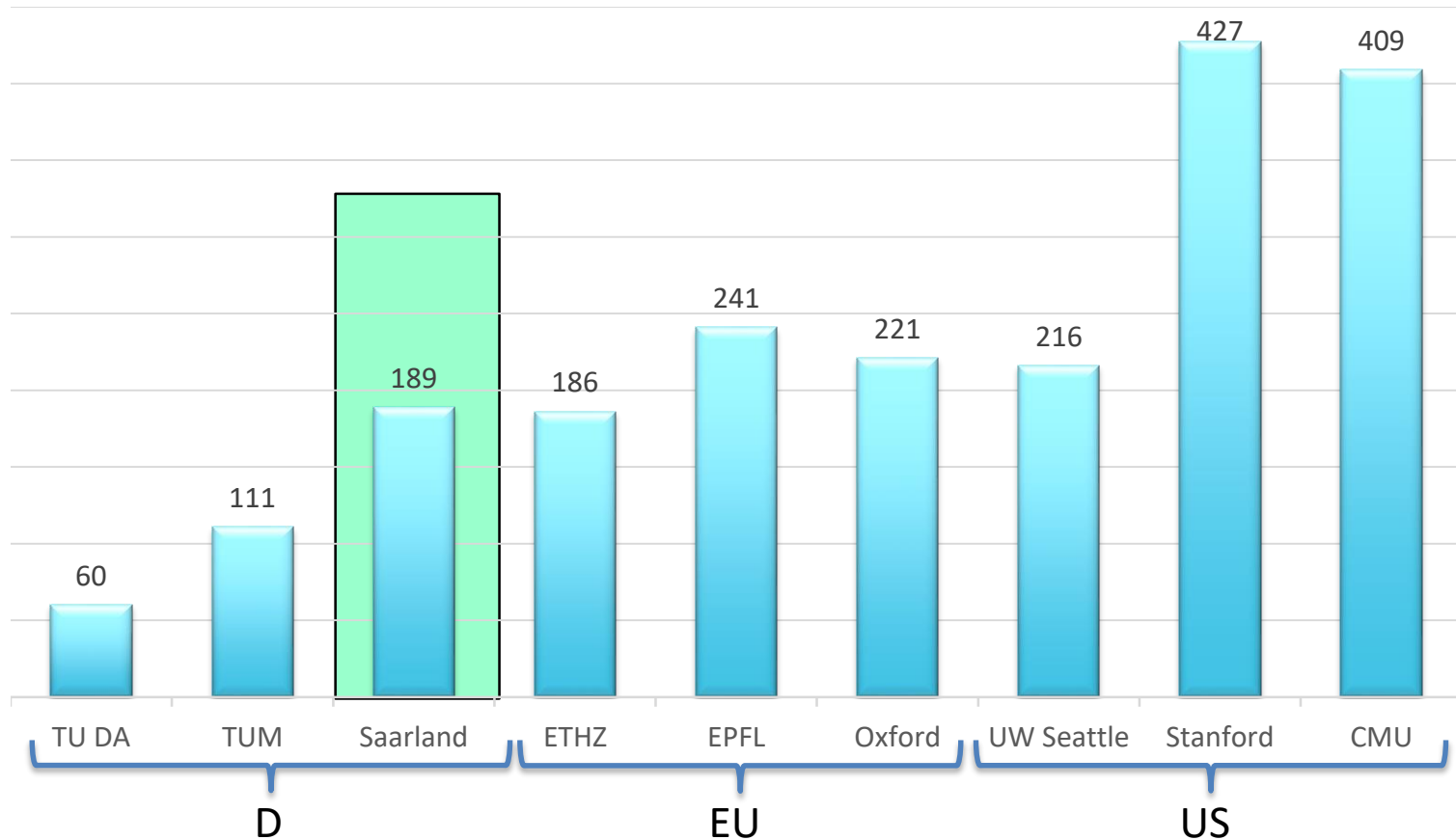


Max  
Planck  
Institute  
for  
Software Systems

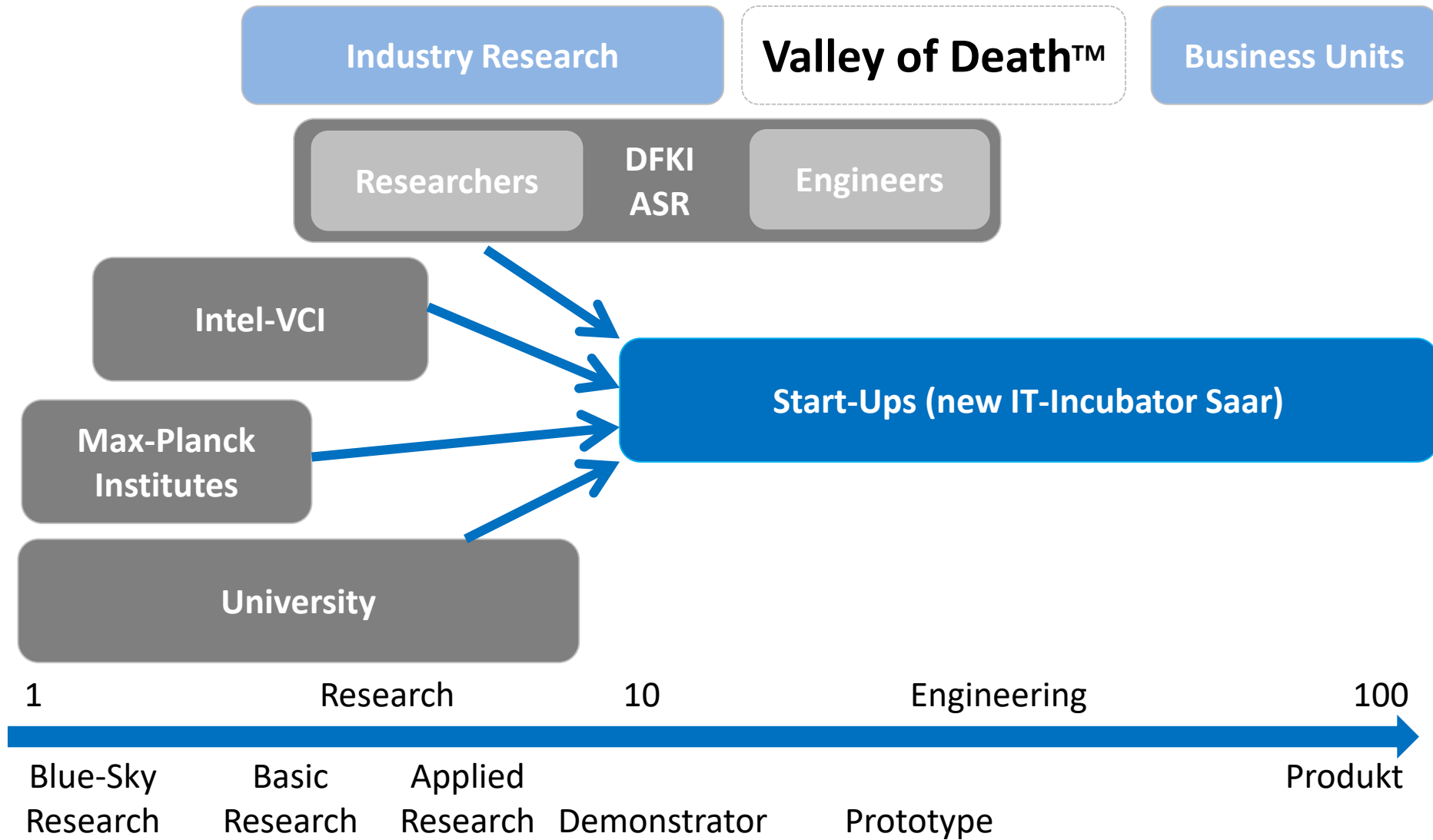


# CS in Saarland: Impact

- #Citations (in 1000) of top-10 computer scientists
- (Google Scholar, 20-Oct-2015)



# Research & Innovation in SB



# DFKI: German AI Research Center

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- Motto
  - Providing Computers with Eyes, Ears and Common Sense“
- Key Facts
  - The world’s largest AI research center
  - One of the largest application-oriented CS research institute in Europe
  - PPP: Industry network/shareholders
    - EADS, BMW, Daimler, Intel, Microsoft, ...
  - 5 Locations in Germany
    - Saarbrücken, Bremen, Kaiserslautern
    - Berlin & Osnabrück
  - ~500 researchers (~900 with students)
  - ~ 40 M€ revenue per year
  - > 60 spin-offs



# DFKI: Agents & Simulated Reality

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- Bringing together AI, Graphics, HPC, and Security
  - Simulated/Digital Reality (graphics, interaction, simulation)
  - Multi-agent Systems (AI: perception, learning, reasoning, planning)
  - HPC (compiler, parallel/vector computing: CPU/GPU/FPGA)
  - Visualization Center (presentation, teaching/training, consulting)
- Application-Oriented Research
  - >40 PhDs and researchers (plus many HiWis, BS, MS)
  - Many publicly funded projects
    - **EU:** FIWARE, CREMA, DISTRO, ...
    - **National:** Hybr-iT, Metacca, ProThOS, HP-DLF, SmartMaaS, ...
    - **Industry:** BMW, VW, Intel, Audi, Airbus, Pilz, Siemens, ...
- Benefits
  - **Researcher and engineer positions**
    - Plus many HiWi, Bachelor, Master, PhDs
  - Extremely broad industry network (Contacts & Jobs, etc.)

# Agents & Simulated Reality

AI & Graphics & HPC & Security

**Scientific Director**

Philipp Slusallek

## Knowledge- and Technology Transfer

**VisCenter**  
Georg Demme

**Strategic Relations**  
Hilko Hoffmann

**SW-Engineering & Organization**  
Georg Demme

## Application Domains

**Autonomous Driving**  
Christian Müller

**Industrie 4.0**  
Ingo Zinnikus

**Computational Sciences**  
Tim Dahmen

**Smart Environments**  
Hilko Hoffmann

## Research: Topics & Teams

**Multi-agent Systems**  
Klaus Fischer

**Intelligent Information Systems**  
Matthias Klusch

**Linked Data Representations**  
René Schubotz

**Autonomous Driving**  
Christian Müller

**Computational 3D Imaging**  
Tim Dahmen

**High-Performance Graphics & Computing**  
Richard Membarth

**Smart System Security**  
Stefan Nürnberger

**Behavior, Interaction & Visualization**  
Georg Demme



**Survivable Systems and Services**  
Philipp Slusallek



**Distributed Realistic Graphics**  
Philipp Slusallek



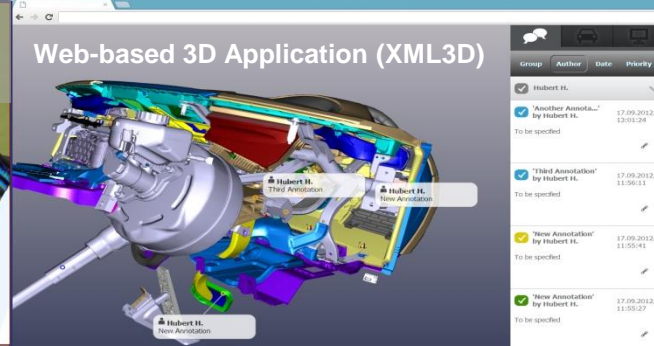
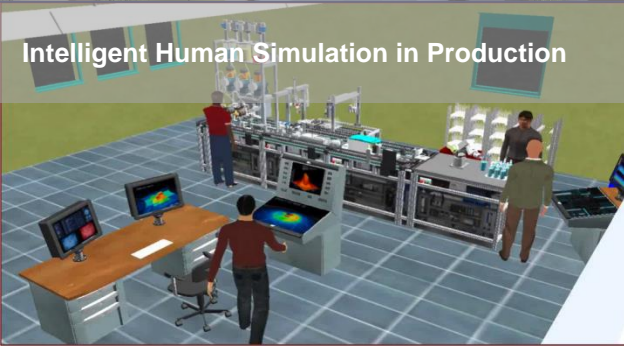
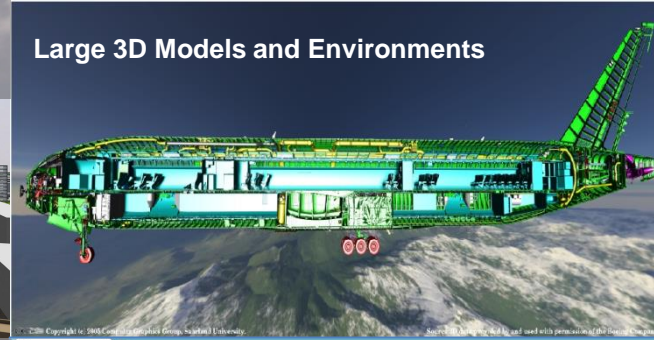
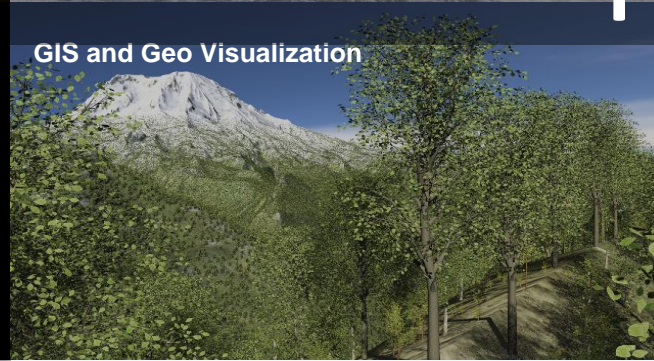
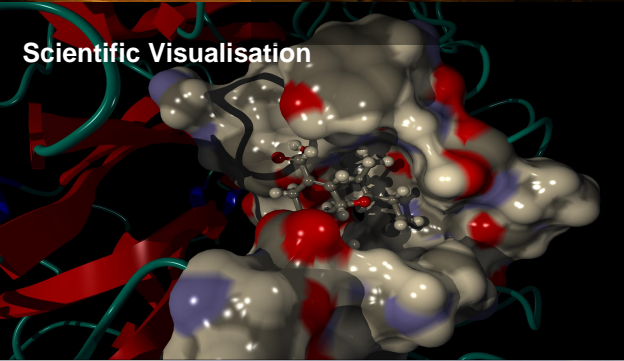
**Large-Scale Virtual Environments**  
Philipp Slusallek



**Visual Computing**  
Philipp Slusallek



# ASR Research Topics



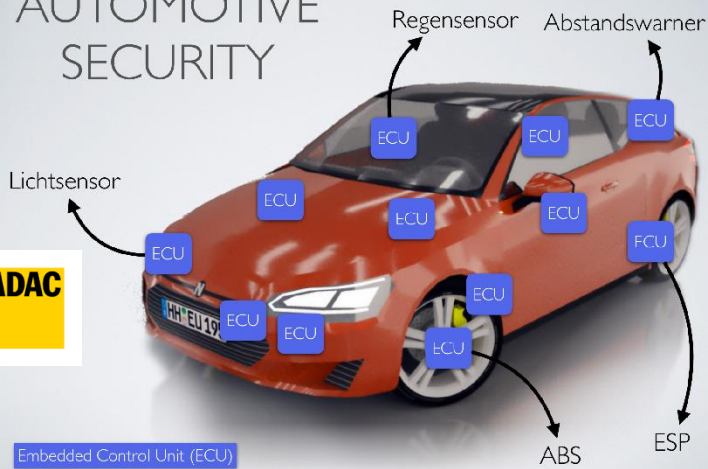
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# Flexible Production Control Using Multiagent Systems



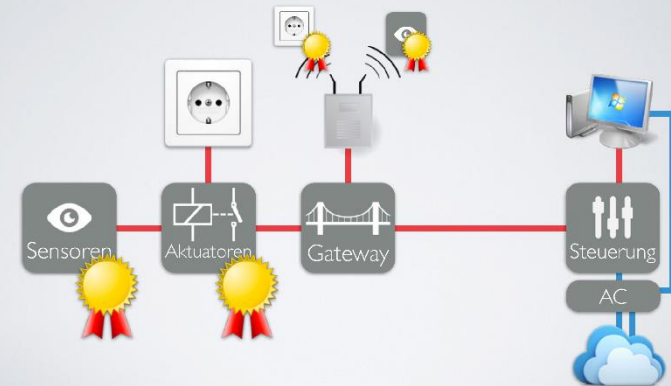
# Smart System Security (with BSI-certified Evaluation Center)

## AUTOMOTIVE SECURITY



## SMART HOME

### BUS-SYSTEME

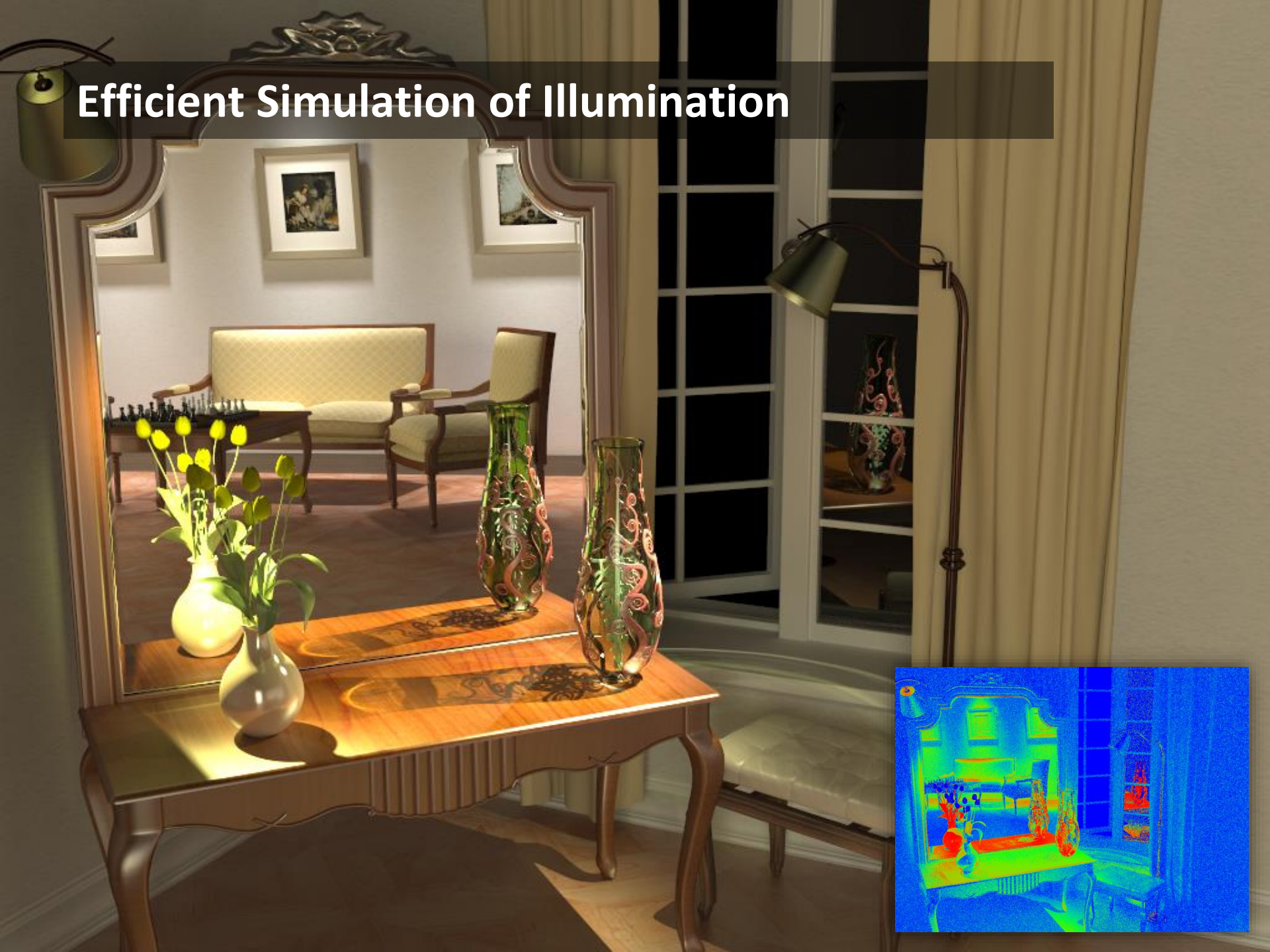




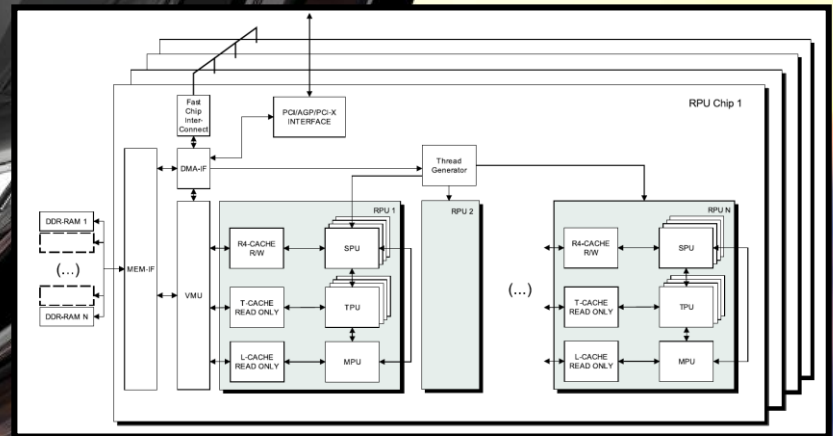
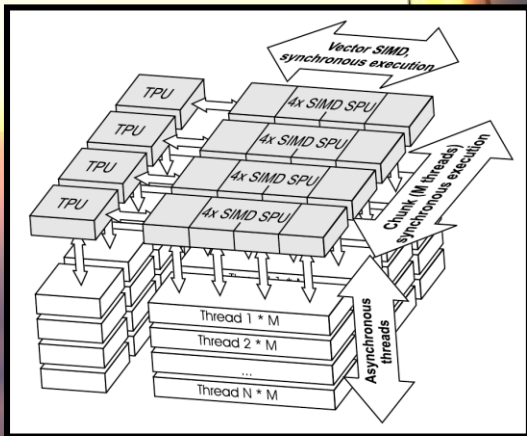
# Physically-Based Image Synthesis



# Efficient Simulation of Illumination



# Real-Time Ray Tracing Processor [Siggraph'05]

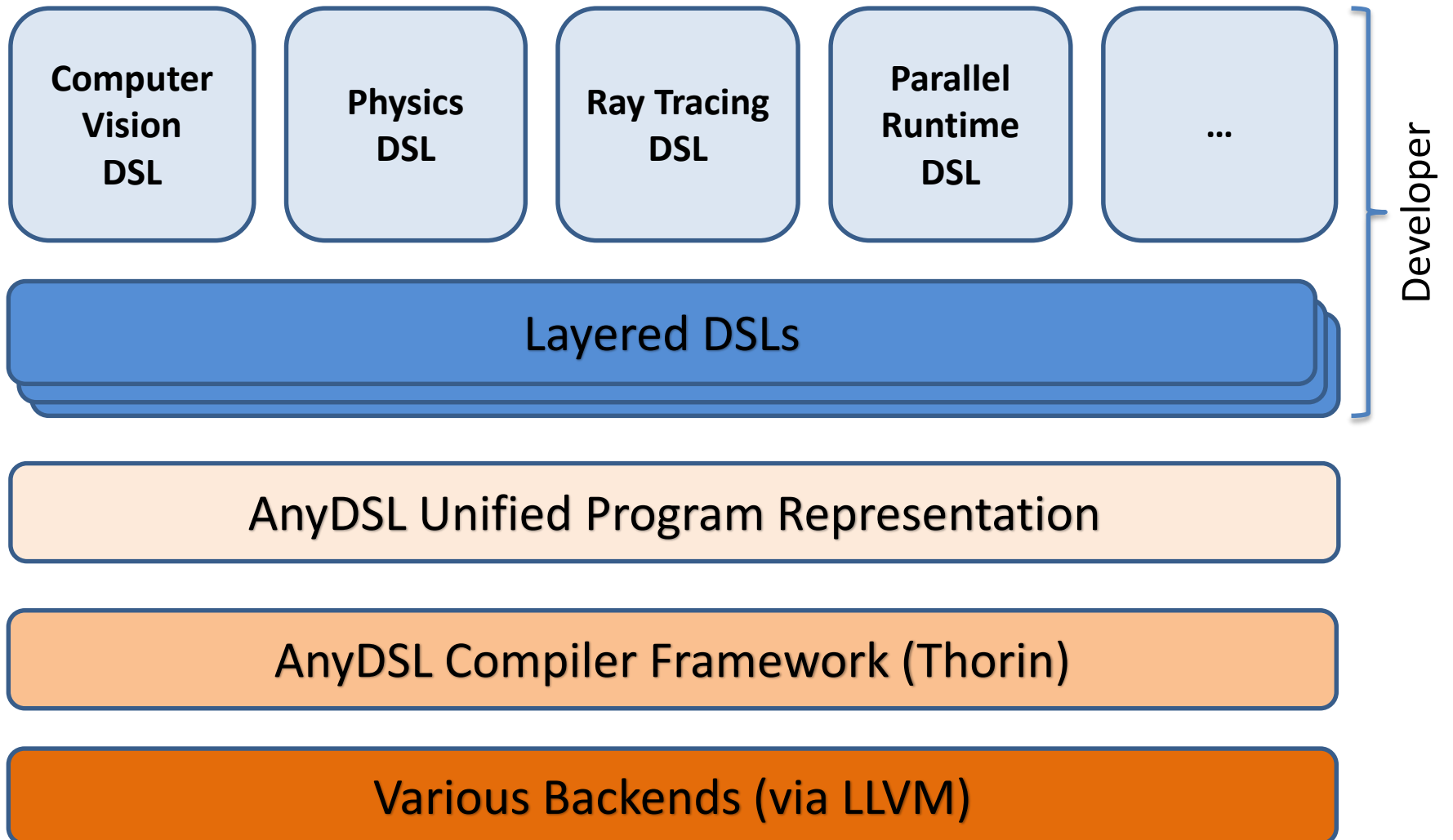


# Real-Time Ray Tracing Processor [Siggraph'05]

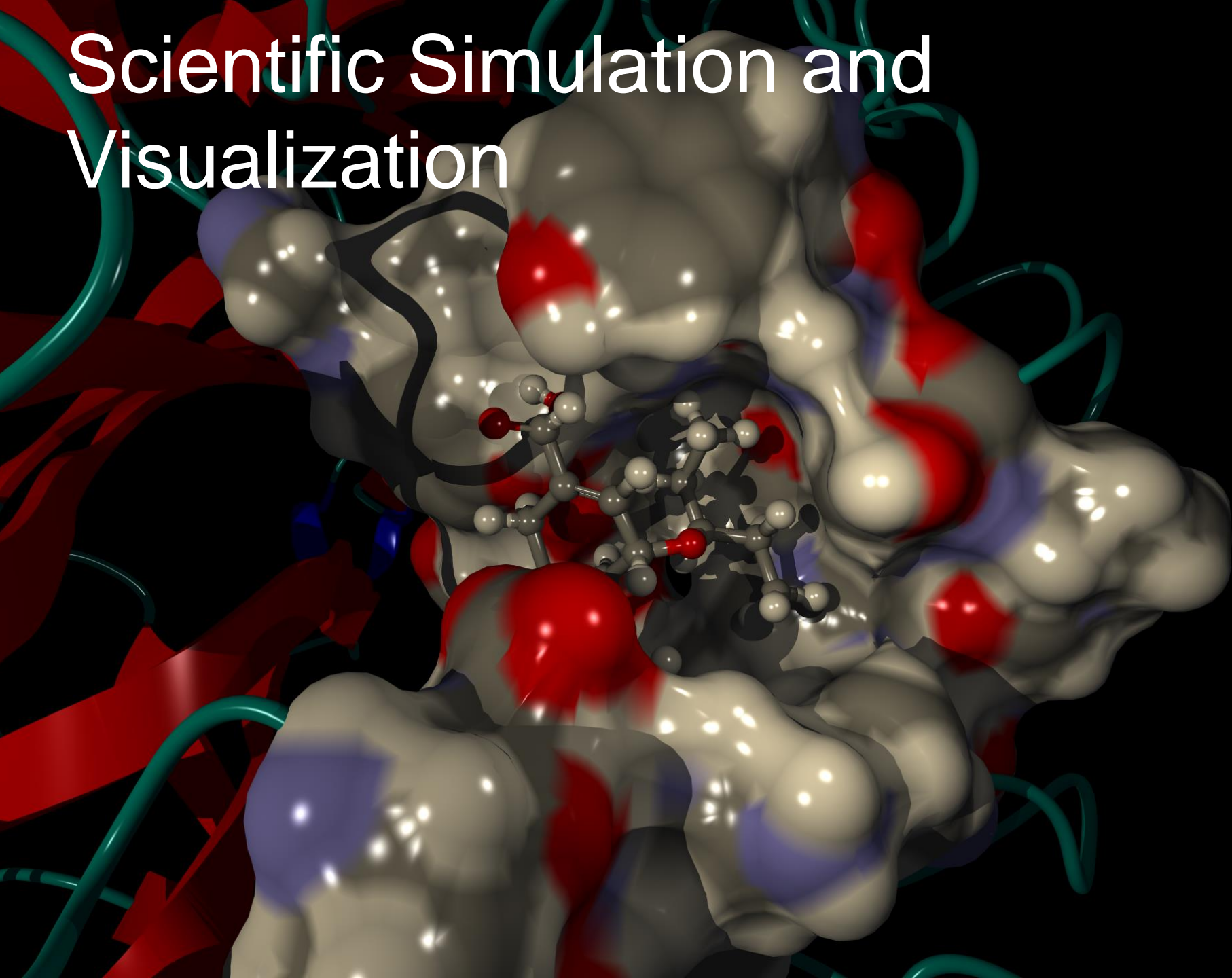
**Available  
Now!**



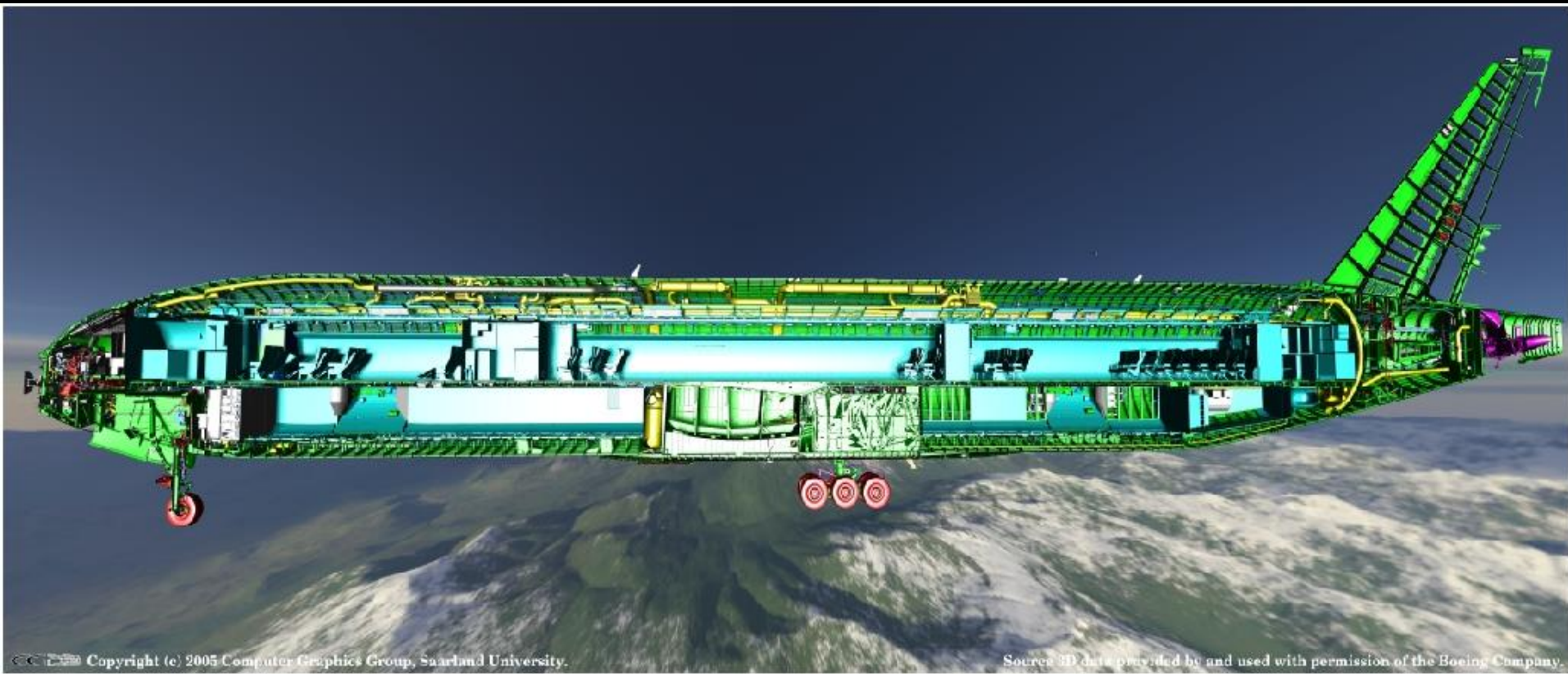
# AnyDSL Compiler Framework



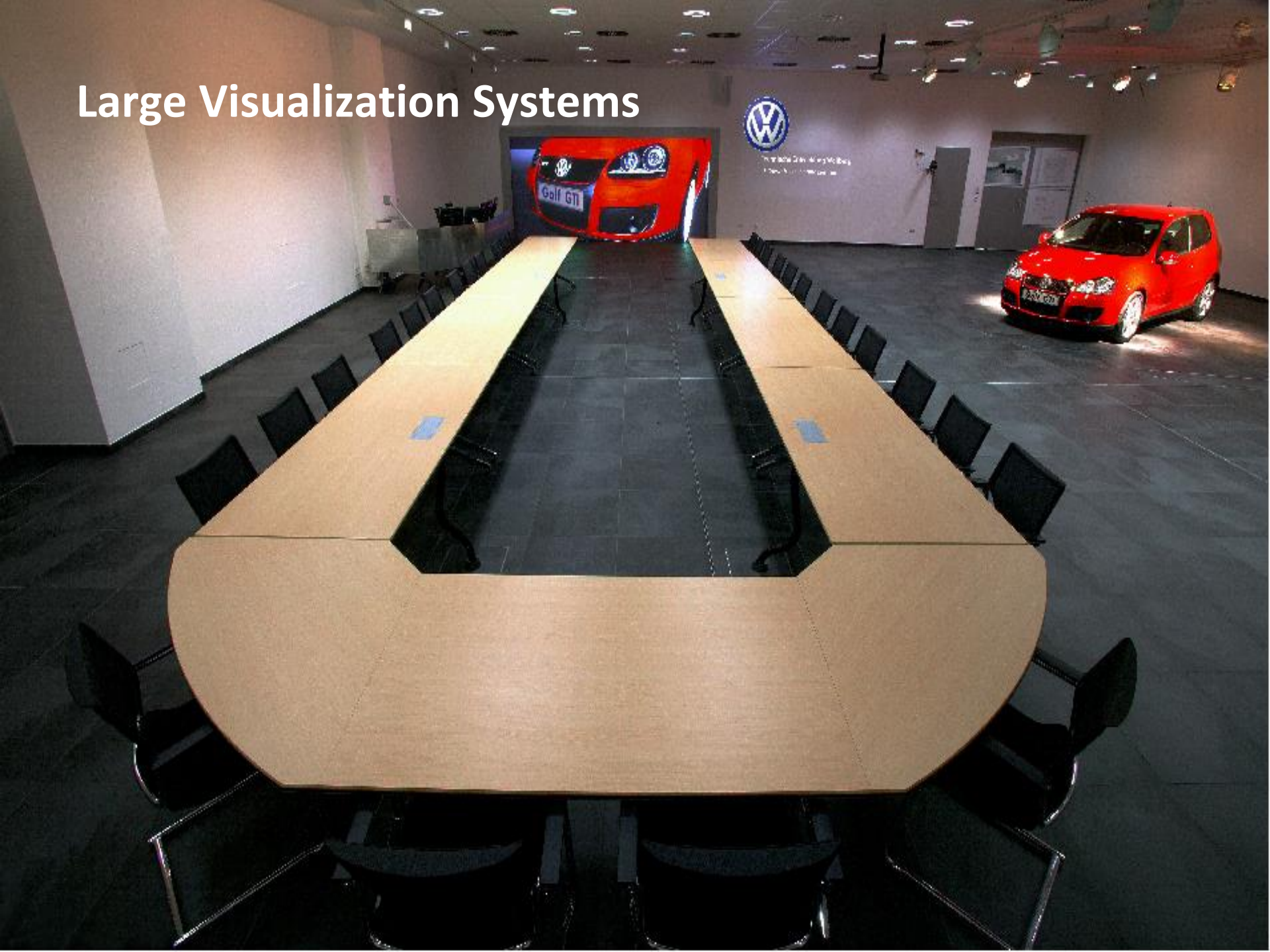
# Scientific Simulation and Visualization



# Large CAD Models



# Large Visualization Systems





# GIS and Geo Visualization



# Reconstruction of Cultural Heritage



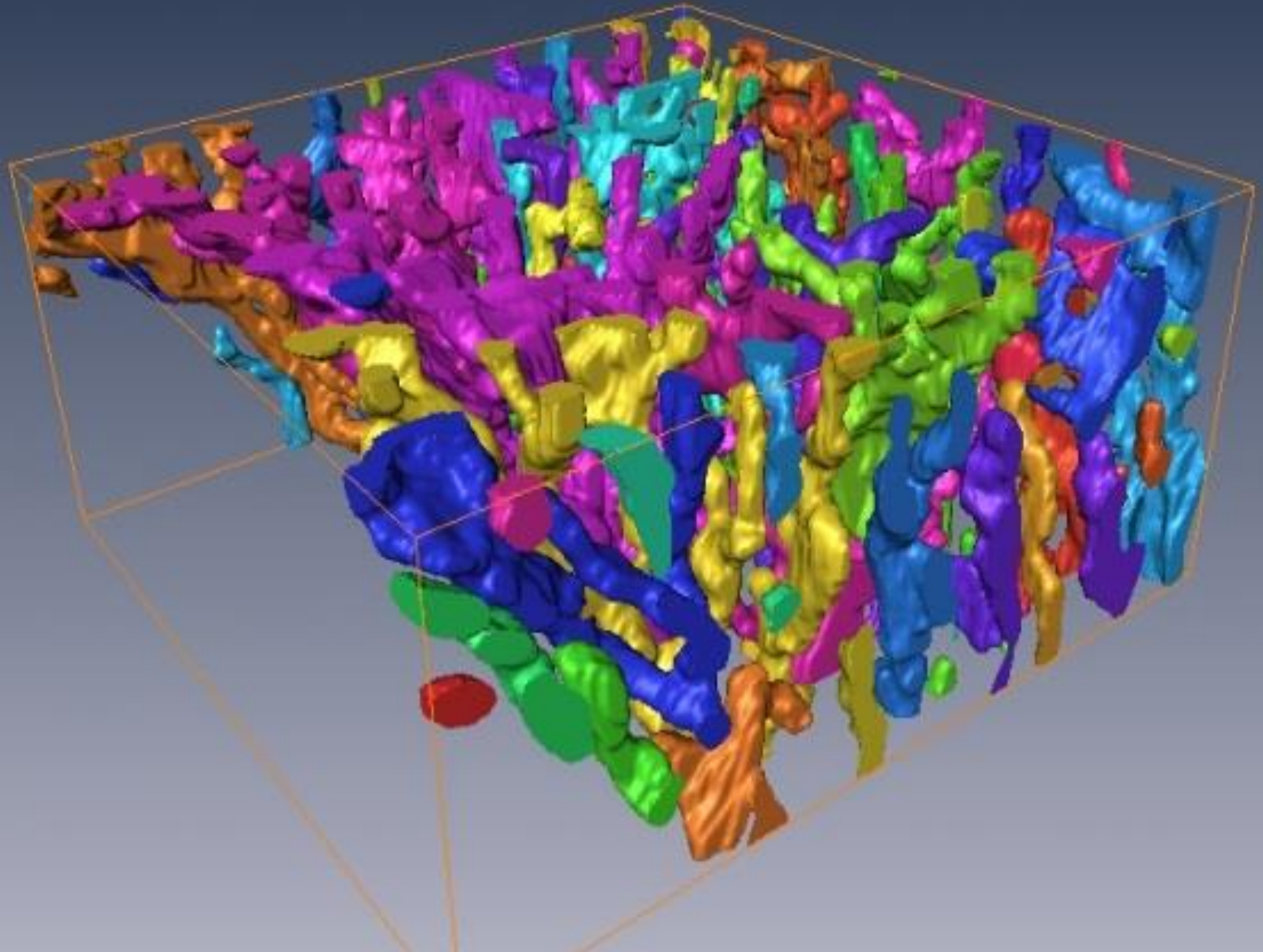
# Future City Planning and Management



# Distributed Visualization on the Internet



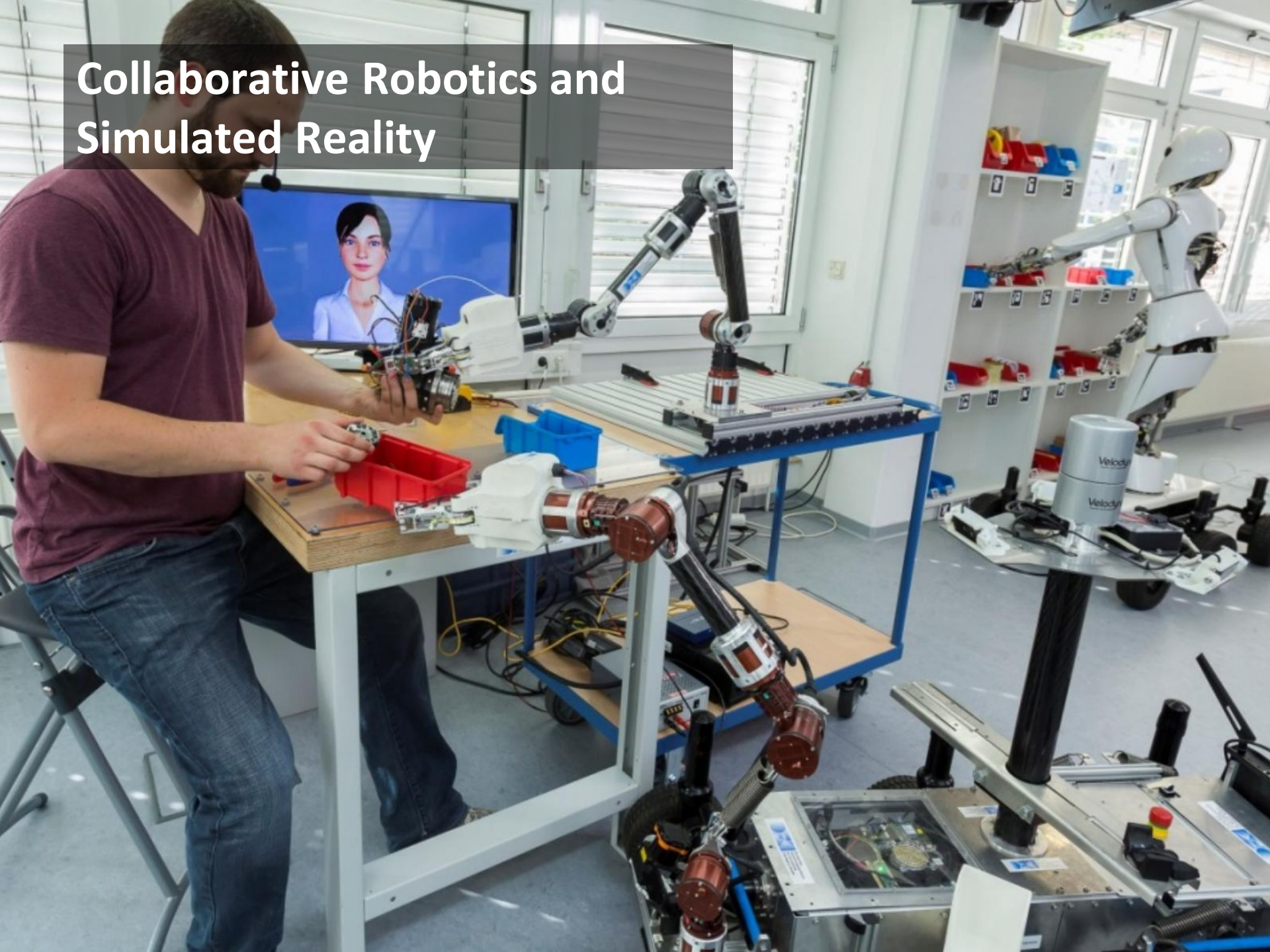
# Material Science: Understanding & Predicting Across Scales



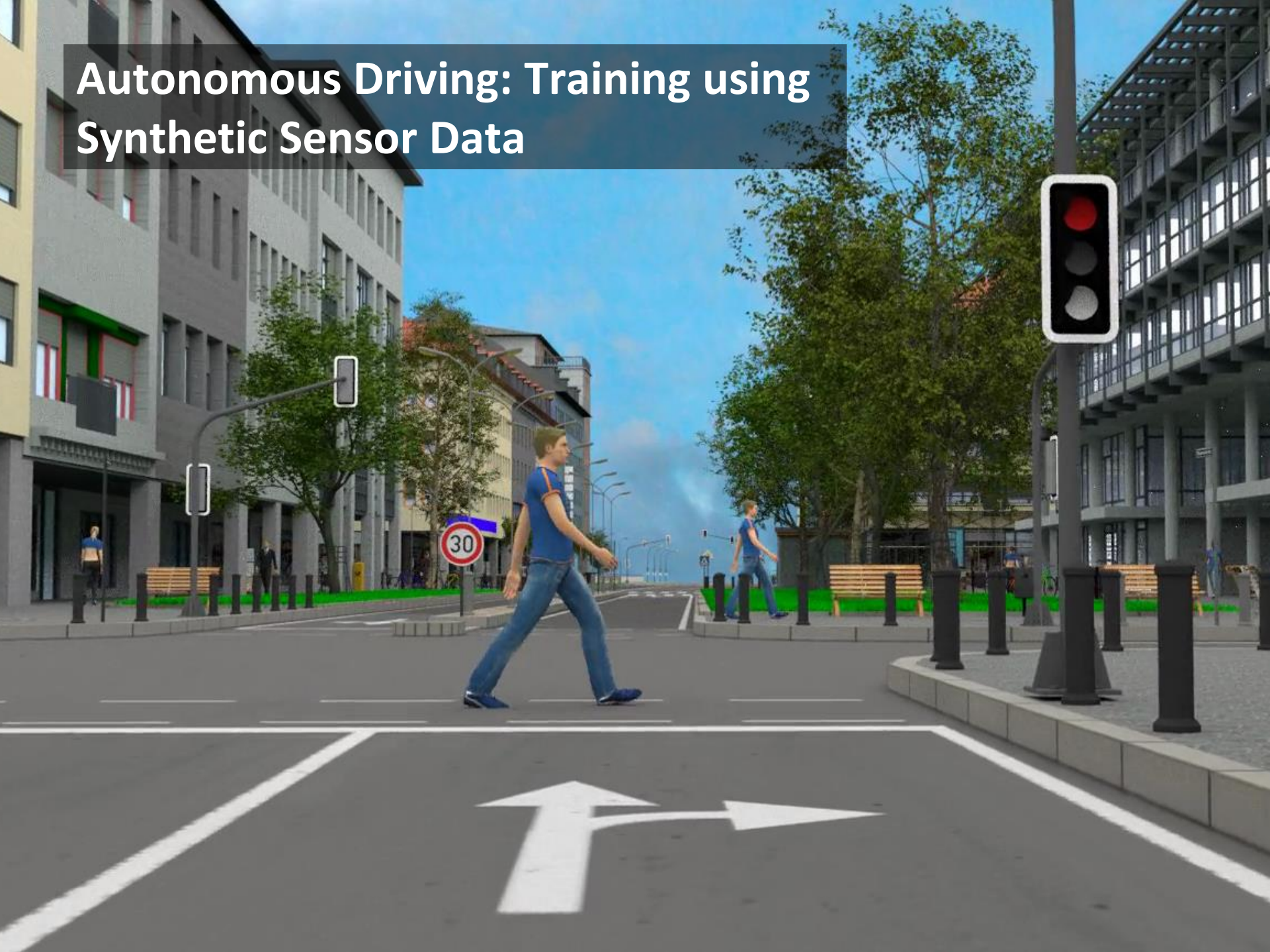
# Intelligent Human Simulation in Production



# Collaborative Robotics and Simulated Reality



# Autonomous Driving: Training using Synthetic Sensor Data





# Wrap-Up

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- **Computer Graphics**
  - Rendering, Modeling, Visualization, Animation, Imaging, ...
- **Young, dynamic area**
  - “Everything is possible” mentality
  - Progress driven by research & technology
  - Flexible transfer between research and industry
- **Big industry !**
  - Intel, Nvidia, AMD, Imagination, ARM, ...
  - Automotive, aerospace, engineering, ...
  - Entertainment: games, film, TV, animations, ...
- **Innovation areas**
  - Visualization, Industrie-4.0, Big Data, Smart Cities, ...
- **Interdisciplinary field**
  - Relations to mathematics, physics, engineering, psychology, art, entertainment, ...