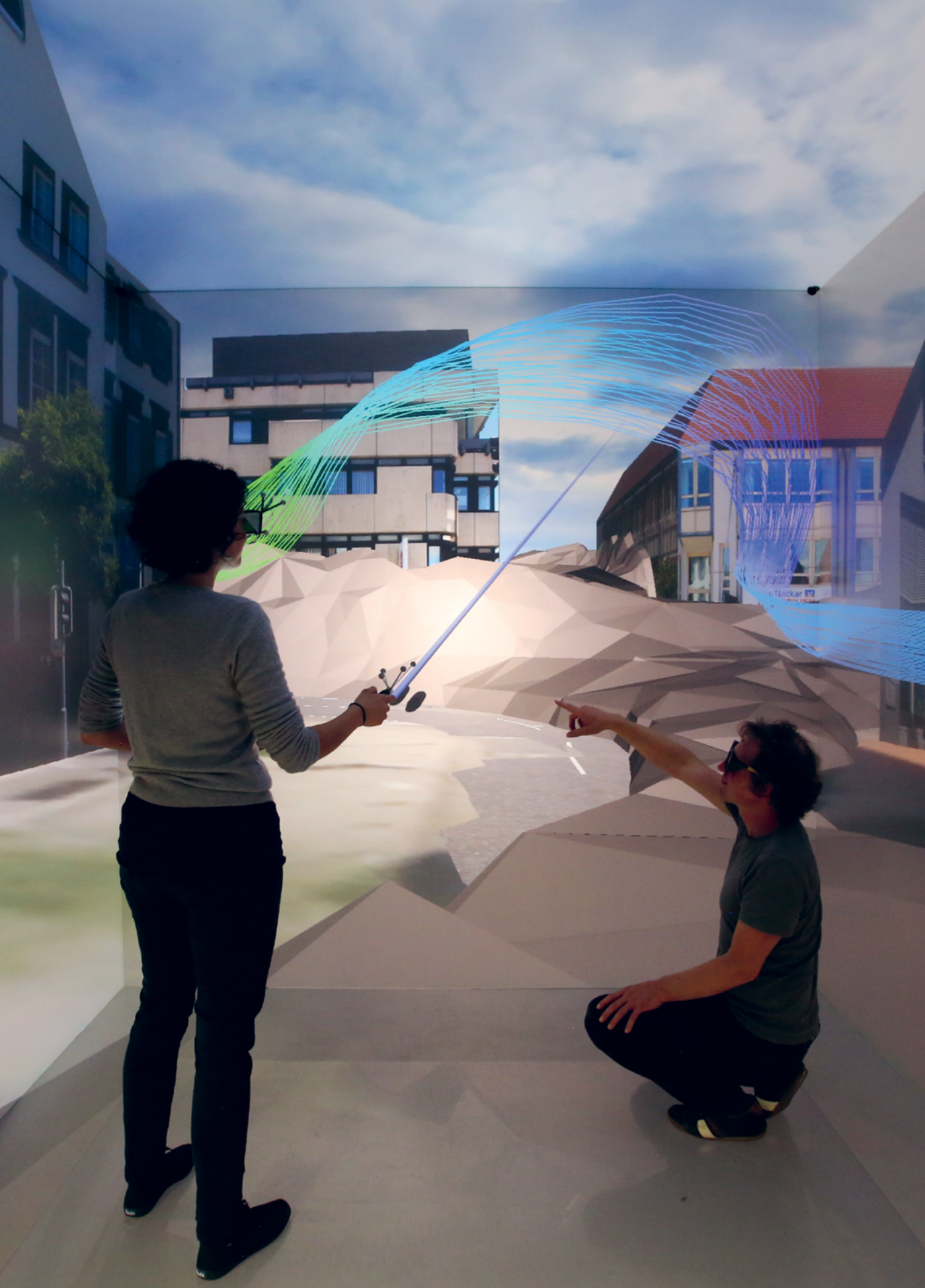**Supercomputing-Lösungen für Wissenschaft, Industrie und Gesellschaft**

H L R S

High-Performance Computing Center Stuttgart

We bring Supercomputing to life

Addressing Global Challenges in the Digital Age Globale Herausforderungen im digitalen Zeitalter

Simulation, visualization, artificial intelligence, and data analytics using high-performance computing (HPC) provide essential tools for addressing many of society's most complex challenges. At the High-Performance Computing Center Stuttgart (HLRS), seizing the opportunities that HPC offers for meeting such challenges is at the center of all that we do.

As home to one of Europe's fastest supercomputers and a large team of HPC experts, HLRS provides *essential tools and solutions for advanced academic and industrial research*, particularly in the sciences and computational engineering. At the same time, we solve key problems facing the field of high-performance computing, and help to identify and implement new applications of HPC in other areas where it can have an impact, such as public administration, city planning, and the arts.

Because even the largest supercomputer cannot solve problems alone, an important part of our mission is also to *increase expertise in high-performance computing*. Our extensive HPC training and user support programs give scientists, engineers, and others the specialized knowledge and skills they need to use supercomputers confidently and effectively. HLRS has also been a leader in *supporting private industry, including small and medium-sized enterprises*, in realizing the potential of high-performance computing for innovation and global competitiveness.

In the coming decades, *meeting global challenges* such as climate change, pandemics, natural disasters, and the need for more sustainable mobility, energy, and manufacturing concepts will require high-performance computing. HLRS is optimally positioned to support these important efforts.

Heutzutage sind Simulation, Visualisierung, künstliche Intelligenz und die Analyse gigantischer Datenmengen mit Höchstleistungsrechnen (High-Performance Computing, HPC) ein Muss, um viele der komplexen Herausforderungen der Gesellschaft anzugehen. Das Höchstleistungsrechenzentrum Stuttgart (HLRS) setzt alles daran, HPC zu nutzen, um diese Herausforderungen zu bewältigen.

Mit einem der schnellsten Supercomputer Europas und einem großen Team von HPC-Expert:innen stellt das HLRS *Werkzeuge und Lösungen für die akademische und industrielle Spitzenforschung* bereit, insbesondere für Naturwissenschaften und computergestützte Ingenieurwissenschaften. Zudem lösen wir Fragestellungen im Bereich des Höchstleistungsrechnens und helfen bei der Ermittlung und Umsetzung neuer HPC-Anwendungen in anderen Bereichen, z.B. in der öffentlichen Verwaltung, der Stadtplanung und der Kunst.

Da auch der größte Supercomputer allein keine Herausforderungen lösen kann, besteht ein wichtiger Teil unserer Aufgabe unter anderem darin, das *Fachwissen zum Höchstleistungsrechnen zu erweitern*. In unseren HPC-Schulungs- und User-Support-Programmen können Forschende, Ingenieur:innen und andere lernen, wie sich Supercomputer effektiv nutzen lassen. Das HLRS ist auch führend bei der *Unterstützung der Privatwirtschaft, einschließlich kleiner und mittlerer Unternehmen*, die mithilfe von HPC wettbewerbs- und innovationsfähiger werden können.

In den kommenden Jahrzehnten wird *die Bewältigung globaler Herausforderungen* wie des Klimawandels, Pandemien, Naturkatastrophen und der Bedarf an nachhaltigeren Mobilitäts-, Energie- und Produktionskonzepten Höchstleistungsrechner erfordern. Das HLRS ist optimal für diese wichtigen Bemühungen aufgestellt.
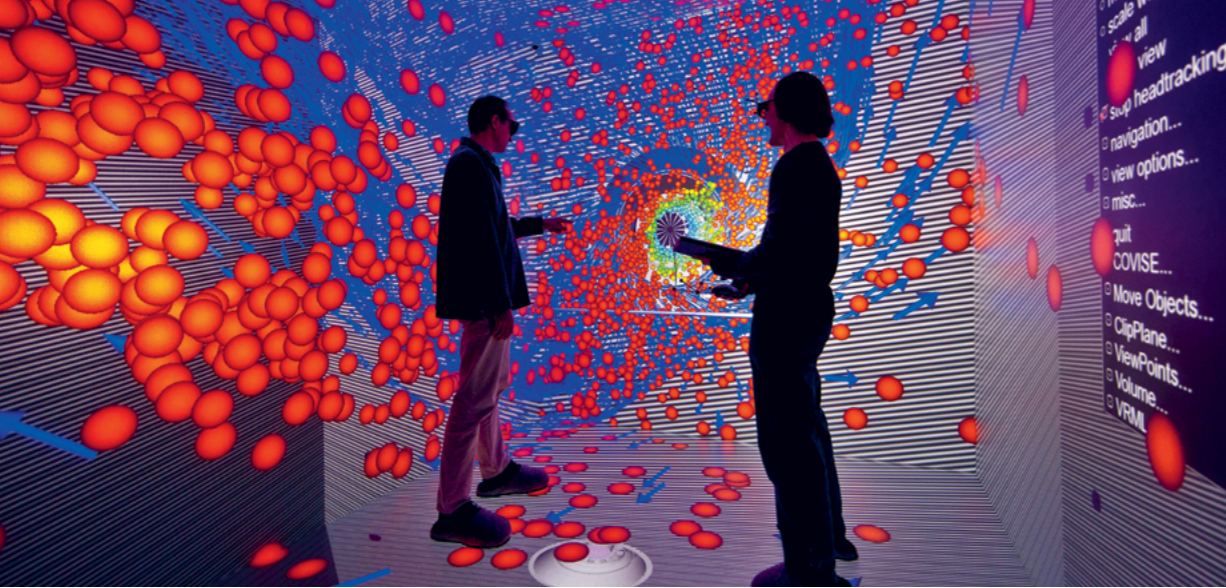
Comprehensive HPC Solutions Umfassende HPC-Lösungen

HLRS offers world-class supercomputing power and other resources for high-performance computing, enabling scientists, engineers, and HPC users from other domains to make discoveries, design better products, solve difficult problems, or realize new ideas. At the same time, staff scientists at HLRS conduct research to address key technical problems facing the future of high-performance computing, including scalability, data management, and hybrid workflows. This research helps us to develop expertise that we share with our system users.

Das HLRS bietet erstklassige Rechenleistung und eine Vielzahl an Ressourcen für das Höchstleistungsrechnen, die es Forschenden, Ingenieur:innen und HPC-Nutzer:innen aus anderen Bereichen ermöglichen, neue Erkenntnisse zu gewinnen, bessere Produkte zu entwickeln, schwierige Forschungsfragen zu klären oder ihre Ideen zu verwirklichen. Gleichzeitig forschen Mitarbeitende des HLRS an technischen Herausforderungen, die die Zukunft des Höchstleistungsrechnens betreffen, wie Skalierbarkeit, Datenmanagement und hybride Arbeitsabläufe. Das gewonnene Fachwissen teilt das HLRS-Team mit Systemnutzer:innen.

HPC & Simulation
With one of Europe's fastest supercomputers, we can help realize the most computationally demanding simulation projects.

AI & Data Analytics
HLRS enables the testing of new machine learning and deep learning applications as well as hybrid approaches that combine HPC and artificial intelligence

Visualization
By connecting our HPC systems with virtual reality and augmented reality technologies, we make it easier to gain insights from large datasets.

Learn more: www.hlrs.de/solutions

State-of-the-Art Computing Infrastructure Modernste Rechner-infrastruktur

HLRS's high-performance computing systems provide infrastructure necessary for today's most important HPC applications, including simulation, high-performance data analytics, artificial intelligence, and visualization. Together, these systems are designed to address the diverse needs of our user community.

Die Rechensysteme des HLRS bieten eine leistungsfähige Infrastruktur für die wichtigsten HPC-Anwendungen von heute, darunter Simulation, Höchstleistungsdatenanalyse, künstliche Intelligenz und Visualisierung. Unsere Systeme sind darauf ausgelegt, die vielfältigen Bedürfnisse unserer Nutzergemeinschaft zu erfüllen.

HPE Apollo 9000 (Hawk)
HLRS's flagship supercomputer, Hawk provides large-scale computing power for complex simulations, data generation, data analytics, and artificial intelligence applications.

Cray CS-Storm
The Cray CS-Storm is optimized for machine learning, deep learning, high-performance data analytics, and artificial intelligence.

CAVE
This immersive 3D facility offers powerful tools for visualizing and interacting with large, complex data sets in virtual and augmented reality.

NEC Cluster (Vulcan)
Vulcan is continually adapted to meet increasing user demands and provide requirement-optimized solutions. It contains CPU, GPU, and vector computing components.

AMD GPU System
Donated as part of AMD's COVID-19 High-Performance Computing Fund, this system is dedicated to supporting pandemic research and meeting crisis computing needs.

HPSS Data Management
Our high-performance storage system is designed to safely manage and archive petabytes of data saved on disks and in tape libraries.

Learn more: www.hlrs.de/systems

Powering Advanced Research in Science and Engineering Spitzenforschung in Wissenschaft und Technik

High-performance computing has become an essential tool for researchers working at the forefront of nearly all scientific and technical disciplines. HLRS's supercomputing resources enable researchers in the basic and applied sciences to study extremely complex problems that would be impossible to investigate in any other way. Some typical application areas in which our users are active include climate and weather modeling, automotive and aerospace engineering, combustion, biomedical engineering, astrophysics, molecular dynamics, computational chemistry, materials science, particle physics, and bioinformatics.

Das Höchstleistungsrechnen ist zu einem unverzichtbaren Instrument für die Spitzenforschung in fast allen wissenschaftlichen und technischen Disziplinen geworden. Die Supercomputing-Ressourcen des HLRS ermöglichen die Untersuchung von komplexen Fragestellungen der Grundlagen- und angewandten Forschung, die auf andere Weise nicht zu erforschen wären. Zu den typischen Anwendungsbereichen, in denen unsere Nutzer:innen tätig sind, gehören Klima- und Wettermodellierung; Automobil-, Luft- und Raumfahrttechnik; Verbrennung; Biomedizintechnik; Astrophysik; Molekulardynamik; computergestützte Chemie; Materialwissenschaft; Teilchenphysik und Bioinformatik.

Sustainable energy
Machine learning and computational fluid dynamics (CFD) simulations are helping to identify opportunities for more efficient and durable wind and hydroelectric power generation.

Climate and environment
Scientists use Hawk to develop high-resolution predictions of climate change, understand atmospheric chemistry, and improve conservation in waterways.

Engineering
Simulations provide knowledge needed to design more efficient aircraft and automobiles, more versatile materials, and more productive biochemical processes.

Learn more: www.hlrs.de/research
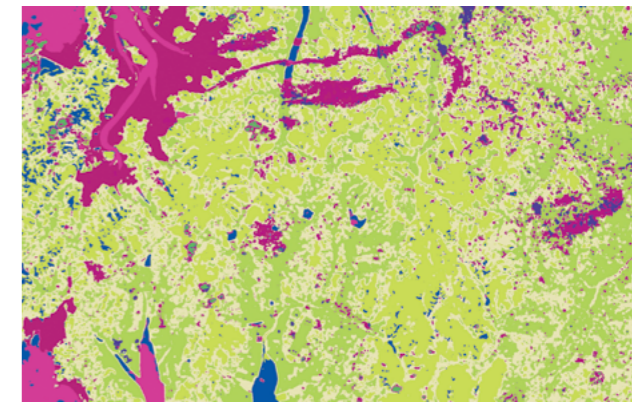
Guiding the Future of Supercomputing Supercomputing für morgen

HLRS scientists and other staff lead and contribute to numerous collaborative research projects, working closely with academic and industrial partners to address key problems facing the future of high-performance computing. In many projects, solving such technical problems also supports the implementation of practical solutions for urgent local, national, and international challenges. In addition, HLRS is the coordinating center for EU projects focused on increasing HPC expertise across Europe.

Wissenschaftler:innen und andere Mitarbeitende des HLRS beteiligen sich an zahlreichen kooperativen Forschungsprojekten, in denen sie eng mit Partnern aus Forschung und Wirtschaft zusammenarbeiten, um wichtige Probleme zu lösen, die die Zukunft des Höchstleistungsrechnens betreffen. In vielen Projekten unterstützt technische Forschung auch die Umsetzung praktischer Lösungen für dringende lokale, nationale und internationale Herausforderungen. Darüber hinaus ist das HLRS das koordinierende Zentrum für EU-Projekte, die das Wissen und die Fähigkeiten rund um HPC in Europa fördern und erweitern.

EuroCC, CASTIEL, and FF4EuroHPC
HLRS is leading three projects funded by the EuroHPC Joint Undertaking to increase and coordinate HPC competencies across 33 European nations, and to improve HPC uptake in academia, public administration, and industry.

CIRCE
This study is assessing potential applications of HPC in crisis situations, and what organizational procedures are needed to ensure that HPC resources are immediately available to support government agencies.

DEGREE and ENRICH
These projects are testing new methods for improving energy efficiency in the operation of our computing and cooling systems, and identifying other potential sustainability gains in data centers.

Learn more: www.hlrs.de/projects

Expert Training in High-Performance Computing **Schulungen für HPC-Nutzer:innen**

HLRS's HPC training program is among the most extensive and experienced in Europe, providing continuing professional education to approximately 1,000 trainees each year. Our training curriculum addresses topics in parallel programming, computational fluid dynamics, visualization, cluster usage and administration, performance optimization and debugging, data analysis and deep learning, and programming languages for scientific computing. Additionally, HLRS conducts "train the trainer" programs to spread its HPC know-how across Europe, and helped launch the Supercomputing-Akademie to address HPC needs in industry.

Das HPC-Schulungsprogramm des HLRS gehört zu den umfangreichsten und am längsten bestehenden in Europa. Es bietet jedes Jahr professionelle Aus- und Weiterbildung für etwa 1.000 Kursteilnehmer:Innen. Unser Schulungsprogramm behandelt Themen wie parallele Programmierung, numerische Strömungsmechanik, Visualisierung, Clusternutzung und -verwaltung, Leistungsoptimierung und Debugging, Datenanalyse und Deep Learning sowie Programmiersprachen für wissenschaftliches Rechnen. Darüber hinaus leitet das HLRS die Supercomputing-Akademie, um den Bedarf an HPC-Expertise in der Industrie zu decken, und bietet „Train the Trainer"-Programme, um das HPC-Wissen in ganz Europa zu erweitern.

Supercomputing-Akademie
Using a "blended learning" format, the Supercomputing-Akademie enhances HLRS's core training program by offering continuing education for HPC users, developers, and administators in industry.

Learn more: www.hlrs.de/training

Comprehensive User Support **Umfassende Anwenderunterstützung**

Because programming HLRS's high-performance computing systems requires specific knowledge, our user support staff works closely alongside our system users to provide expert advice on technologies and tools for HPC and AI. We offer mentoring as well as extended user support that assists research teams in optimizing the performance of their codes on our systems. Our emphasis on performance optimization both enhances our users' scientific capabilities and enables a more sustainable operation of HLRS's computing resources.

Die Programmierung von Hoch- und Höchstleistungsrechnersystemen erfordert besondere Fachkenntnisse. Unser User-Support-Team arbeitet eng mit Systemnutzer:innen zusammen und bietet fachkundige Beratung zu Technologien und Tools für HPC und KI. Wir bieten Mentoring sowie Extended User Support–Services, die Forschungsteams dabei helfen, die Leistung ihrer Codes auf unseren Systeme zu optimieren. Unser Schwerpunkt auf Leistungsoptimierung steigert sowohl die wissenschaftlichen Fähigkeiten unserer Nutzer:innen als auch den nachhaltigen Betrieb der HLRS-Rechenressourcen.

Extended User Support
Funded through the Gauss Centre for Supercomputing, this initiative supports close cooperation between system users and user support staff to optimize code performance and develop new HPC methods and resources.

User Support Workshop
In this recurring event, scientists work one-on-one with HLRS user support staff to improve the performance of their codes. Designated mentors from our staff also support scientific teams for the duration of their projects.

Learn more: www.hlrs.de/user-support
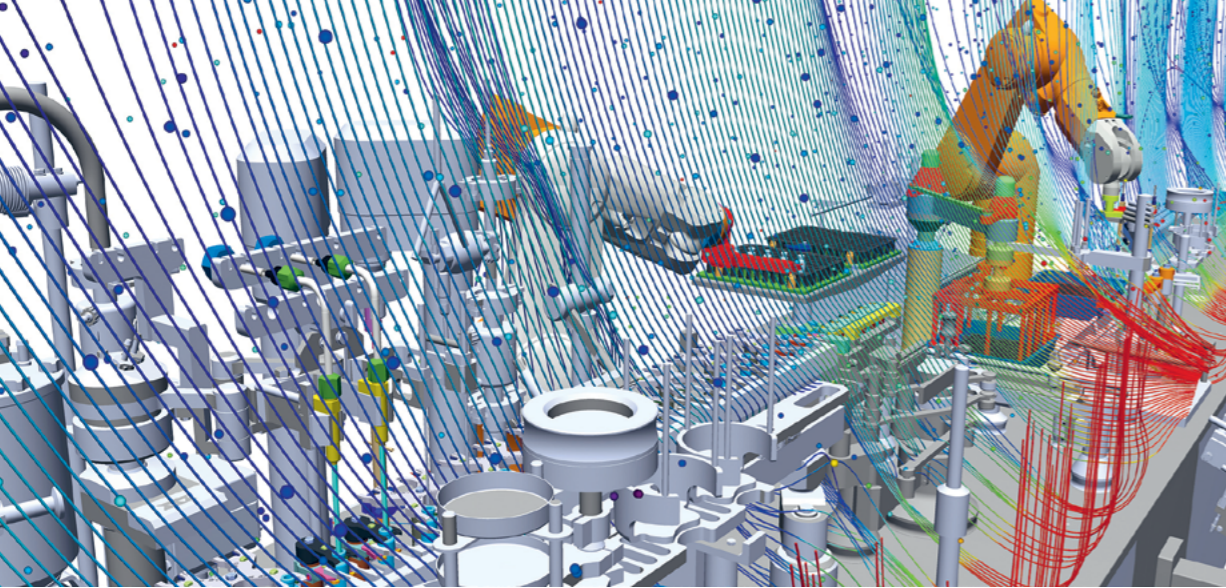
High-Performance Computing for Industry
HPC für die Industrie

Besides supporting academic research, HLRS makes a portion of its supercomputing resources available for private industry. From large, globally recognized corporations to small and medium-sized enterprises (SMEs), companies can access world-class computing resources without the need to purchase and operate their own systems. In addition, HLRS holds events and provides specialized training designed to address the unique needs of HPC users in industry. These comprehensive services support the competitiveness of high-tech engineering companies across Germany and Europe.

Über die Unterstützung der akademischen Forschung hinaus ermöglicht das HLRS auch der Privatwirtschaft den Zugang zu seinen Supercomputern. Sowohl weltweit bekannte Großkonzerne als auch kleinere und mittelständische Unternehmen greifen auf unsere erstklassigen HPC-Systeminfrastrukturen zu. Außerdem bietet das HLRS spezielle Workshops und Schulungen an, die auf die dezidierten Bedürfnisse dieses Nutzerkreises ausgerichtet sind. Diese Angebote und Dienstleistungen unterstützen die Wettbewerbsfähigkeit von Hightech-Unternehmen in Deutschland und Europa.

Consulting for small and medium-sized enterprises
Our partner organization SICOS-BW offers free consulting services to SMEs interested in using data analytics, artificial intelligence, or simulation, and facilitates access to HLRS's computing resources.

Learn more: www.hlrs.de/industry

HPC training for industry professionals
HLRS's Supercomputing-Akademie enables working professionals to develop HPC skills and knowledge alongside their other obligations.

Preparing industry for the future of supercomputing
In EU-funded projects such as FF4EuroHPC and EXCELLERAT, HLRS is working to increase the adoption of HPC in industry and to prepare companies to use tomorrow's exascale systems.

Solution Centers Promote Innovation Solution Centers fördern die Innovation

Many companies could benefit from high-performance computing, although its uptake in certain industries has been slow due to gaps in knowledge, methods, or resources. To eliminate such barriers, HLRS has worked with representatives of the automotive, medical, and culture industries to develop a model called the solution center. Solution centers bring together multidisciplinary expertise — for example, engineers, computer scientists, HPC specialists, artists, and other interested specialists — to identify industry-wide challenges and develop solutions in a collaborative manner.

Viele Unternehmen könnten vom Höchstleistungsrechnen profitieren, obwohl es in manchen Branchen aufgrund von Wissenslücken oder Ressourcenmangel nur langsam eingeführt wird. Um solche Hindernisse aus dem Weg zu räumen, hat das HLRS gemeinsam mit Vertreter:innen der Automobil-, Medizin- und Kulturbranche sogenannte Solution Center gegründet. Solution Center bündeln multidisziplinäres Fachwissen – z. B. aus dem Ingenieurwesen, Informatik, HPC, Kunst und anderen Disziplinen – um branchenweite Herausforderungen zu identifizieren und gemeinsam Lösungen zu entwickeln.

Automotive Solution Center for Simulation
The asc(s connects companies from across the automotive branch to exchange knowledge, access HPC resources, and develop solutions to shared problems.

Case4Med: The Medical Solution Center
CASE4Med supports companies in the medical technology industry in developing solutions that use high-performance computing, simulation, data analytics, and artificial intelligence.

Media Solution Center Baden-Württemberg
International in its scope, the MSC brings computational scientists and technologists together with practitioners in the visual, performing, and media arts.

Certified for Environmental and Energy Management Zertifiziert für Umwelt- und Energiemanagement

Because the operation of high-performance computing centers requires sizable amounts of energy and other resources, HLRS has committed itself to taking practical measures whenever possible to reduce its CO_2 footprint, prevent pollution, and limit other negative effects on the environment. HLRS is certified under the Blue Angel Ecolabel and the Eco-Management and Audit Scheme (EMAS), and works continually to improve its environmental and energy performance. At the same time, HLRS computing resources provide essential tools for research related to climate change, green energy, and more sustainable mobility concepts.

Der Betrieb von Höchstleistungsrechenzentren erfordert erhebliche Mengen an Energie und weiteren Ressourcen. Das HLRS hat sich dazu verpflichtet, praktische Maßnahmen zu ergreifen, um seinen CO_2-Fußabdruck zu verringern, Umweltverschmutzung vorzubeugen und andere negative Auswirkungen auf die Umwelt zu begrenzen. Das Zentrum ist nach dem Umweltzeichen Blauer Engel und dem Eco-Management and Audit Scheme (EMAS) zertifiziert und verbessert kontinuierlich seine Umwelt- und Energieleistung. Gleichzeitig stellen die Computerressourcen des HLRS wichtige Instrumente für die Forschung in den Bereichen Klimawandel, grüne Energie und nachhaltigere Mobilitätskonzepte bereit.

Eco-Management and Audit Scheme
HLRS was the first high-performance computing center to receive EMAS certification, the most demanding system for environmental management worldwide.

Blue Angel Ecolabel
The Blue Angel is the best known ecolabel in Germany and since 1978 has served as a neutral and credible guide for selecting environmentally friendly products and services.

Practical Guide for Sustainability in Computing Centers
Information published on the HLRS website can benefit other computing centers interested in improving their environmental performance.

Learn more: www.hlrs.de/sustainability

Social and Ethical Dimensions of Simulation Soziale und ethische Aspekte der Simulation

Computer simulation is changing science, technology, politics, and society in fundamental ways that are so far only vaguely understood. HLRS's Department of Philosophy of Computational Sciences is investigating this transformation, conducting and promoting research that considers how to evaluate results generated by simulation and artificial intelligence. By enabling philosophers, social scientists, and historians of science to work side-by-side with simulation scientists at HLRS, the department is uniquely positioned to conduct research that considers the practice of simulation and its implications.

Computersimulationen verändern Wissenschaft, Technik, Politik und Gesellschaft auf eine Weise, die bisher nur vage zu begreifen ist. Die HLRS-Abteilung Philosophy of Computational Sciences untersucht diesen Wandel mithilfe von Forschungsprojekten, die sich mit der Frage befassen, wie die durch Simulation und künstliche Intelligenz erzeugten Ergebnisse zu bewerten sind. Sie bringt Wissenschaftler:innen aus der Philosophie, den Sozialwissenschaften und der Wissenschaftsgeschichte mit Simulationswissenschaftler:innen am HLRS zusammen, wodurch sich eine einzigartige Gelegenheit zur methodischen Forschung ergibt, die Simulation und deren Auswirkungen im Detail untersucht.

Trust in Information
A funded project led by the HLRS Philosophy Department is developing perspectives for assessing the trustworthiness of computational science and limiting the spread of misinformation.

The Science and Art of Simulation
This international, interdisciplinary workshop series deals with the tension between science and engineering, proof and experience, and transparency and ruse in computer simulation, mathematics, and politics.

Learn more: www.hlrs.de/philosophy

1996
founded

since **2010**
member of PRACE

1,000
Researchers at training programs
every year

more than **130** scientific papers
by our system users each year

Education and Public Outreach
Lehre und Öffentlichkeitsarbeit

As supercomputers have become more powerful, simulation, artificial intelligence, visualization, and related technologies have become a part of our daily lives. HLRS organizes and participates in a variety of activities intended to increase public understanding of what high-performance computing is, why it is important for science and engineering, and how it affects society. These include events and outreach activities for the general public, as well as projects that bring simulation and high-performance computing into schools in ways that encourage young people to consider future careers in computer science.

Während Supercomputer zunehmend leistungsfähig werden, sind Simulationen, künstliche Intelligenz, Visualisierung und verwandte Technologien Teil unseres täglichen Lebens geworden. Das HLRS organisiert und beteiligt sich an einer Vielzahl von Aktivitäten, die das Verständnis der Öffentlichkeit dafür fördern, was Höchstleistungsrechnen ist, warum es für Wissenschaft und Technik wichtig ist und welche Auswirkungen es auf die Gesellschaft hat. Dazu gehören Veranstaltungen für eine breitere Öffentlichkeit sowie Projekte, die Simulation in die Schulen bringen, um junge Menschen zu ermutigen, eine Karriere in der Informatik in Betracht zu ziehen.

Simulated Worlds
This education enrichment program offers motivated students the chance to complete research fellowships at HLRS, and organizes events for the general public to help improve understanding of computer simulation.

Tag der Wissenschaft (Science Day)
During the University of Stuttgart's annual campus-wide open house event, visitors can tour HLRS's computing room, experience virtual reality in our CAVE facility, and learn more about our latest activities.

Girls' Day
HLRS participates in this nationwide program, which encourages girls to consider careers in IT, the sciences, engineering, and the skilled trades.

Learn more: www.hlrs.de/outreach

Quick Facts HLRS – Zahlen und Fakten

— HLRS was founded in 1996 as the first German national high-performance computing center.

— HLRS is a central unit of the University of Stuttgart and a founding member of the Gauss Centre for Supercomputing (GCS), the alliance of Germany's tier-0/1 supercomputing centers.

— HLRS has been open to European users through PRACE since 2010.

— Approximately 1,000 researchers participate in our HPC training program each year.

— HLRS is certified under EMAS and the Blue Angel Ecolabel for environmental management.

— HLRS has formalized its systems for information security management in accord with the TISAX framework.

— HLRS staff consists of approximately 150 employees.

— More than 130 scientific papers acknowledge HLRS computing resources each year.

Institutional Affiliations

Funding for Hawk provided by

Environmental Certifications

Follow us on Twitter: @HLRS_HPC

**High-Performance Computing
Center Stuttgart
www.hlrs.de**

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