Summer Internship Program 2018

RESEARCH IN MUNICH

June 4 – August 03
Research in Munich!

“This 9-week long summer program designed for students in engineering is one of the best-kept secrets of study abroad programs due to its exceptionally low cost and extensive range of programming. The program offers 4 weeks of beginning German language instruction which are integrated with 9 weeks of internship placements alongside researchers in local engineering labs.”

The University of Arizona Office of Global Initiatives

The Bundeswehr University Munich is an educational and research university according to Humboldt’s ideal and is well-established in the national and international research landscape.

The ideal framework conditions of a campus university with an outstanding infrastructure offer a broad range of working and cooperation facilities notably in research. Due to the excellent trans-faculty cooperation in automobile, security and aerospace research, the Bundeswehr University Munich is recognized and plays a leading role in these fields also in international research.

Over the past years, the Bundeswehr University Munich has constantly expanded its main field of research “Security in Technology and Society”. We encounter current aspects of security research in a variety of different areas: political conflicts, unpredictable natural disasters, security gaps in IT systems, and the global financial crisis. Against this backdrop, the University’s scientists analyze and study the topic of security in its full complexity in various fields of research and application. Security requirements in technology and society are changing at a dazzling pace, and it is up to scientists to develop procedures and methods to adequately deal with these challenges. Today the ability to accomplish this task necessitates cooperation among scientists of different disciplines and different institutions who share their experience and knowledge and make optimal use of synergies.

The Bundeswehr University Munich has also enriched its research activities by entering into new cooperations in the past years, which include important cooperation agreements with extra-university research facilities and industrial enterprises in the fields of electrical engineering and information technology. An important network for aerospace engineering was established with the founding of Munich Aerospace, an association of four Munich-based research institutions. Here our university is making valuable contributions to space research, a major field of research which we intend to expand in the future. The planning of additional research centers in other fields is already underway.

The following pages contain more detailed information on the different research areas and projects conducted by the University’s various departments and respective internship within these departments.

We hope that you will find our program to be both informative and attractive!

The International Office Team
Bundeswehr University Munich
Application

The Bundeswehr University Munich is pleased to invite applications for its Summer Internship Program from June 4 – August 03, 2018.

The program is open to all advanced undergraduate and graduate students who are enrolled in a course of study related to civil engineering, mechanical engineering, electrical engineering, computer science or related study programs.

No knowledge of the German language is required.

Successful applicants will live in a university building not far from the library, dining hall, and fitness center, as well as the laboratories in which they will be working.

If you are interested in applying, please contact your university’s study abroad office. See more at: https://global.arizona.edu/study-abroad/program/research-munich#sthash.sCY2sDEK.dpuf.

Application Deadline: February 15, 2018
Road Traffic Safety and Safety of Infrastructure

Human beings are incapable of preventing natural disasters such as earthquakes or floods. However, we can learn how to assess risks and to prepare ourselves so as to minimize the damage caused by disasters or unforeseen events. Researchers at the University are working in a variety of fields towards this common goal.

Are Our Buildings Safe?
Prof. Norbert Gebbeken 01

Flood Protection on a Local Scale
Prof. Andreas Malcherek 07

Construction Materials
Prof. Karl-Christian Thienel 09

Securing Energy Resources in a Responsible Way

Energy is a scarce and valuable commodity. Researchers at the University are working on technologies to exert energy in the most efficient ways possible. Using such technology energy can be saved or even gained – and the applications are both safe and innovative!

Innovative Drive Mechanisms 12
Prof. Dieter Gerling

Plasma Technology: Surface Treatment and Surface Coating 17
Prof. Jochen Schein

Generating Renewable Thermal Energy 19
Prof. Stefan Lecheler
Safety in Technology and Communication

Developments in information technology and telecommunications have helped to make our world a safer place: from security systems to biometric passports and risk evaluation, IT has been involved in a wide variety of advances in this area. One of the challenges facing our researchers is figuring out how to keep complex systems of networks manageable and how to secure digital data for future generations.

IT Security and Management Challenges: Today and Tomorrow
Prof. Gabrijela Dreo Rodosek

Operations Research: High-Dimensional Complexity Management
Prof. Stefan Pickl

Real-Time Simulation and Animation of Mechatronic Systems
Prof. Reinhard Finsterwalder

Safety in Space Research

Since the beginning of time, outer space has captivated the imagination of man and stimulated our scientific curiosity. The University is also active in the fields of aviation and space travel: researchers are exploring space, investigating planets, and developing technology to improve the safety and efficiency of aircrafts and space shuttles.

Turbulence Research: Microfluidics and Particle Imaging Techniques
Prof. Christian Kähler

Carbon Fibre Reinforced Plastic (CFRP)
Prof. Helmut Rapp

Social and Cultural Program
Are our Buildings Safe?

Civil engineers ensure safety of the infrastructure

If not before, the safety of built infrastructure became an issue for the broader German public in January 2006, when an ice rink roof collapsed in Bad Reichenhall, killing 14 people. Following heavy snowfall, more than 20 buildings collapsed in Germany, Austria, Poland, and other countries. Civil engineers’ research and analyses have contributed to ensuring safety of the infrastructure.

Accepted risks

The terms safety and security are defined differently. Safety is the presence of required structural resistance against loadings or actions. Security comprises all measures to avoid unexpected loadings or actions and to detect unexpected structural behavior. If a structure has been built according to design codes, a minimum safety in terms of a safety factor can be guaranteed. If parameters of resistance or actions are unknown, the use of security measures is recommended. Thus safety and security measures complement each other. In engineering, safety has to be verified quantitatively. In civil engineering safety is generally “2”. This means that a structure can bear twice the load it was designed for without sustaining any damage. Nevertheless, there is no guarantee – safety is not the absence of risk, safety is always accompanied by an accepted risk. Regarding ordinary civil engineering structures like buildings, it is agreed upon that the risk of an incident is similar to the probability of being struck by lightning. “Built infrastructure” comprises all infrastructure built by civil engineers, for example buildings, stadiums, concert halls, roads, bridges, tunnels, towers, dams, sluices, harbors, airports, railways, water reservoirs, flood barriers, water supply, and others. Four fields can be characterized to show the difference of safety in civil engineering: Firstly, buildings and structures which are subjected to well-defined...
actions; secondly, industrial facilities with a high risk (e.g. containers for dangerous materials); thirdly, buildings and structures likely to be subjected to natural hazards (e.g. earthquakes, hurricanes, floods, avalanches); and fourthly, buildings and structures possibly subjected to man-made hazards (terrorist attacks).

Factors that can cause collapse

Usually, when materials, structures, loadings, and actions are well-defined according to the design codes, owners and users can expect that the structure will remain safe during the anticipated lifetime, which is about 50 years for ordinary buildings. Therefore, it was surprising that so many buildings that collapsed due to snow in winter 2005/2006 were less than 30 years old. Engineers examining the structures in 2006 found various factors that reduce safety. To name but a few: building documents incomplete; rebuilding without approval and documentation; roof drainage not maintained; changes in approved technologies; use of materials without sufficient experience; insufficient inspection and maintenance; insufficient qualification of personnel. In all cases, it was not just one factor that caused collapse; it was a combination of multiple factors. Therefore, building authorities have decided to inspect well-defined structures repeatedly according to new inspection guidelines. In addition, it is proposed that owners and users install security devices in order to monitor their structures with respect to structural behavior, material and environmental condition. Scientists of the civil engineering department of the Bundeswehr University Munich are developing design concepts, methodologies for the inspection, monitoring, repair and strengthening of structures. For innovative solutions they work on individual approval reports in order to bring new technology on the market.

Measures to respond to technical risks

Facilities with a high technical risk include refineries, where huge quantities of oil and gas are stored in containers. The same holds for airports and harbors. Dust explosions can be ignited when dust is stored in vessels. The chemical industry always needs specific safety and security measures. Another task is the protection of structures against vehicle impact or ship collision, inland as well as offshore. These technical risks can be estimated quite accurately because the threat potential is known. This is
called a symmetrical threat. In certain cases a damage is accepted. Technical measures are, for instance, standoff distance, flood and blast barriers, devices for pressure relief, and barriers against impact. Standards exist for storage and pressure vessels which define load scenarios, design principles, and safety measures. Individual solutions are developed for individual situations in order to ensure safety and economy.

**Threats by nature**

Reinsurance companies provide studies on natural risks. Most important is the earthquake threat. Seismic activity and earthquakes are well studied. Today we record seismic activities around the world with a network of detectors. Forecasting has become much more precise. Scientists have developed standards for the dimensioning and designing of buildings to withstand earthquakes. But there are always earthquakes with an individual characteristic, such that even earthquake-resistant structures fail. Basically there are two design principles: make the structure almost rigid, or very flexible with energy transforming devices. Another approach is the decoupling of the structure from the excited ground by so-called base isolation. This is called passive damping. For specific structures, like antennae or pedestrian bridges or bridge cables, active dampers have been successfully applied. Currently, active dampers are under development; they are relatively expensive and restricted to certain structures. Unfortunately, a number of countries in the world cannot afford to build using earthquake-resistant designs. Often there are no building regulations at all: people just build a home to protect their families from rain and cold. These countries suffer the heaviest casualties. Therefore, it is a challenge for civil engineers to develop cheap and effective masonry buildings that offer protection from earthquakes. Scientists of the University’s civil engineering department are developing design principles, calculation methods and dampers in order to protect infrastructures against earthquakes.

**Dykes and dams to protect from floods**

Floods have to be distinguished between coastal flooding, inland flooding and alpine flooding. Coastal flooding usually arises in connection with springtide accompanied by heavy storms which, in addition, push the water against the coast. Civil engineers build dykes and dams, reinforce shore lines, and build flood barriers. Particular examples include the
Eastern Scheldt barrier in the Netherlands and the Thames barrier near London. These are gigantic structures, and represent gigantic challenges for engineers. Inland floods not only damage dykes and homes; they also scour bridge foundations, erode railways and damage installations for water and energy supplies. They flood sewage treatment plants and contaminate the environment. Civil engineers build retention reservoirs, provide areas where the water can expand, and build dykes and dams. They develop and provide tools to monitor and inspect structures. Together with architects and electrical engineers they develop flood resistant buildings; also, flood areas are defined where people are not allowed to settle. Alpine floods can be disastrous. The flood in August 2005 revealed that a bubbling mountain stream can become a torrent in search of a new bed, carrying a huge amount of bed load, washing out roads, causing landslides, bending masts, and scouring the foundations of bridges, mudflow protection structures, and buildings. Villages were cut off: no electricity, no water supply, no traffic infrastructure, no telecommunications, and no helicopter service due to bad weather conditions. Together with forest officials, civil engineers are working on plans for renaturation and are building retention reservoirs and bed load barriers.

**Terrorism – the unforeseeable risk**

The fourth item is the most critical one, because we never know what might happen. This is an asymmetrical situation. Who could have imagined before September 11, 2001 that a civilian airplane would be turned into a weapon attacking the World Trade Center? The bombings of Madrid and London revealed that our built infrastructure is vulnerable. What can civil engineers do? To begin with, critical infrastructure is defined by carrying out risk analyses. While accepting a certain risk, scientists work on ways to mitigate the effects of an attack. The main threats are known. First we protect people, then installations, then buildings and structures. By applying blast and impact resistant design principles, a certain passive safety can be provided. Civil engineers design in such a way that progressive failure is avoided and that rescue teams have time to rescue victims. For existing infrastructure, vulnerability studies have to be carried out and hardening methodologies have to be proposed and executed. Close interaction between safety and security is absolutely necessary – notably in case of man-made threats.
Rapid bridge classification

In order to support the army corps of engineers during peace keeping missions, the bridge research group of the civil engineering department developed an engineering tool for the rapid prediction of the load carrying capacity of damaged bridges for which no building documents are available. The challenge was twofold. Nothing similar was available and the time for bridge inspection and load determination was not to exceed three days. The development was successful, and in October 2005 18 bridges in Kosovo could be classified in 9 days. The developed methodology is unique in the world and will also be further developed for civilian use.

Protecting our society against various hazards is a challenging task. Engineers do their very best to ensure safety and security. But society has to realize that safety is relative. We always have to balance between accepted risk, safety and economic pressure. Therefore, interdisciplinary expert groups have to approach the topic in order to find optimal solutions and answers.

INTERNSHIP OFFER

Institute of Engineering Mechanics and Structural Mechanics / Department of Civil Engineering and Environmental Sciences
Laboratory for Computational Engineering, Research Center RISK

2-3 internship positions available

The Institute of Engineering Mechanics and Structural Mechanics and its Laboratory for Computational Engineering focuses on numerical simulation in structural engineering. Fields of interest are: safety of structures and infrastructures, earthquake engineering, structural dynamics, protective structures, explosion, contact detonation, blast, impact, high-speed dynamics, mitigation of multiple threats, development of protective systems, material and fracture mechanics, rapid bridge classification, explosion safety of steel-glass-facades, numerical experiment design, mitigation of natural threats (flood, heavy storms, rock fall, etc.). Experiments are carried out in cooperation with partners.
**Flood Protection on a Local Scale**

A scientifically tested weir now protects an Austrian community that was flooded several times in the past

The Gartnertalbach is a creek within the community of Lermoos (Austria). As a rule, its flow rate is clearly below 1m³/s. Heavy rainfalls, though, may cause it to rise quite quickly to more than 20m³/s, causing extensive flooding over the banks. The Lermoos community was flooded on various such occasions, sustaining heavy damage in the process. In order to overcome this problem, a flood protection project was developed, which comprises two flood pools positioned one after the other. Water from the Gartnertalbach is designed to flow into the lower pool via a flow-off duct system consisting of a pipe 1.8m in diameter installed below ground, with the duct system to be activated only in case of flooding. This required the Gartnertalbach creek to be suited with a water flow-off structure, for which the 'Tyrolean weir' design was chosen. It divides the water flow in such a way that – almost regardless of its total volume – a basic volume (of about 5m³/s) will be retained in the creek bed, and only water in excess of the basic volume will be directed into the flow-off duct. If floodwaters are beyond the duct’s maximum capacity (approximately 16m³/s), the excess volume of water will have to be carried off in the creek bed in addition to the basic volume.

**Using a model test for optimization**

In a Tyrolean weir, water is drawn from the main flow by means of two lateral screen-covered outlets that are fed via two openings installed one after the other on the bottom of the creek. It is not possible to calculate flow-off conditions with any degree of certainty for a Tyrolean weir because of its particular design and the fact that air will be drawn into the flow-off system by the onrush of floodwater. This is why
a model test should be used to verify, quantify and optimize the structure’s function and performance, and the Laboratory for Hydromechanics and Hydraulic Engineering of the Bundeswehr University Munich was tasked to conduct such a test. For measuring purposes, a model of the creek bed, including the Tyrolean weir, was created on a scale of 1:12. Among other aspects, the model was successfully tested for the indispensable ventilation of the flow-off duct. However, as was shown by the measurements taken, its diameter had to be increased to 2.2 m for the pipe to be able to drain the required volume of water. Additionally, several guiding walls needed to be installed, which considerably improve the lateral deflection of water in the Tyrolean weir. Plans are under way to include the contents of the now-finished model test in the teaching program, to be supported by practical studies.

**INTERNSHIP OFFER**

*Laboratory for Hydromechanics and Hydraulic Engineering / Department of Civil Engineering and Environmental Sciences*

*1 internship position available*

The Institute of Hydromechanics and Hydraulic Engineering currently works on several projects comprising rheological studies, scientific analysis of a small hydro power plant, and research on a mudflows simulation model.
Prof. Karl-Christian Thienel studied civil engineering at the Technical University Brunswick and from 1988-1993 worked there as a research assistant at the Institute of Building Materials, Concrete Construction and Fire Protection. From 1993-1995 he was a Feodor-Lynen fellow of the Alexander-von-Humboldt Foundation, researching at the Center for Advanced Cement Based Materials (ACMB) at the Northwestern University, USA. From 1995-2003 he worked at Liapor GmbH & Co. KG, where he was head of research and development from 1997. Since 2003 he has been professor at the Bundeswehr University Munich and is head of the Institute for Construction Materials.

Construction Materials

Construction materials science is a core subject in civil engineering. Well-founded knowledge about chemical, physical, and mechanical material properties is essential for selecting construction materials. Strength, deformation, and the process of corrosion are of great importance in this regard. In practice the incorrect selection, application, or processing of construction materials often causes structural damage.

The Institute for Construction Materials operates its own testing laboratory, where the behavior of various construction materials can be investigated and tested. The institute also does work in teaching and developing.

All laboratories are fully equipped for the casting and testing of binders and concretes. Collaboration with other institutes complements the existing variety of modern testing equipment and measuring devices.

Specimen preparation and investigation of binders and mineral supplements

- Determination of fineness (BET, Blaine)
- Determination of particle size distribution
- Calorimetric measurements
- Viscomat for rheological investigation
- Hydrothermal treatment (autoclave)
Chemical and mineralogical investigation

- Determination of structurally damaging salts
- Melt digestion
- Thermal analysis
- X-ray powder diffraction (in reflection and in transmission, non-ambient measurements in the temperature range from 3°C to 70°C, internal and external standards, in situ measurements)
- Gas chromatography

Surface and structural analysis via

- Micro computer tomography
- Scanning electron microscopy (element analysis via EDX is possible)
- Light microscopy
- Mercury intrusion porosimetry

Strength and durability of construction materials

- Testing frame (50kN to 5000 kN)
- Water impermeability-testing rig, creep rig and shrinkage measurements
- Resistance of freeze-thaw cycles by CDF-/CIF-testing
- Climate chamber
- Intrusion of water hazardous substances
- Post cracking flexural tensile strength of steel fiber reinforced concrete acc. DAfStb-Guideline
- Determination of chloride migration coefficient

Structural condition analysis

- Destructive and non-destructive investigation of buildings
- Adhesive strength
- Localization and detection of reinforcement
- Analysis of cores and drill dust samples
- Analysis of historic building stocks
**Current research topics**

Research focuses on concrete and mineral binders:

- Calcinated clay in cement-bound systems
- Calcinated clay in lime-sand bricks
- Alternative supplementary cementitious material
- Lightweight concrete
- Micro cracks in high strength concrete
- Behavior of construction materials under impact load

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**INTERNSHIP OFFER**

*Institute for Construction Materials / Department of Civil Engineering and Environmental Sciences*

*1 internship position available*

The computer tomography is an excellent technique for non-destructive material tests. This method enables you to reckon cross sections wherever you want in your scanned test specimen. And pore size and distribution become visible and the total pore volume can be determined. During the internship you will scan different building materials (e.g. lightweight concrete, normal concrete, autoclaved aerated concrete) with the CT scanner and reconstruct the material models in 3-D. The so obtained material models should be analyzed with respect to pores (size, distribution, volume) and cracks (maybe also after testing them in compression). Additionally a comparison can be made between the results of the total pore volume obtained with the CT-technique and the mercury intrusion porosimetry.

If there is still time left for further studies, interns are welcome to analyze correlations between pore volume and other material properties (e.g. elastic modulus, compressive strength, permanence).
Innovative Drive Mechanisms

Electrical Drives enhance Operational Safety and Energy Efficiency

Electrical drives determine in a multifaceted manner our modern way of life: in the generation of electrical energy, e.g. in hydroelectric power stations, the factory automation, the automotive industry or household appliances (e.g. electrical shaver, washing machine, etc.) electrical machines and drives are the key component used directly or indirectly by everybody. Such electrical drives are being applied to safety critical applications more and more frequently. This can be observed clearly e.g. in modern automobiles or airplanes.

Electrical Power Steering in passenger cars

One main driving force for the ever-increasing number of electrical drives in such applications is the need to improve energy efficiency and reduce emissions. This will be explained in the following by considering the Electrical Power Steering (EPS) in passenger cars. Compared to conventional hydraulic power steering, EPS increases the fuel efficiency in typical midsize automobiles by about 0.3 liters/100km. This reduced fuel consumption is directly linked to a corresponding cutback in CO₂ greenhouse gases. The reasons for these advantages are that electrical drives can be operated very efficiently and can be controlled very precisely. Therefore, “power on demand” is possible with very low losses. In addition to the energy efficiency on the system level, it is important to optimize efficiency on the component level (motor, inverter, and control algorithm). Because this system is integrated into the steering system of a car, it is obvious that safe operation must be ensured under any circumstances. Therefore, safety has to be “designed into” the system as well as into the components.
For example, this is realized on the component level by introducing means such that the electrical motor shows an extremely low failure-rate; on the system level it must be ensured that the system remains operable even if a single failure occurs. Moreover, self-diagnosis is a must for such components and systems.

**Environmental effect**

There are generally many more requirements to be fulfilled in such engineering tasks. Staying with the example of Electrical Power Steering (EPS), e.g. the torque ripple has to be very low (about 1% of the nominal torque), because people are very sensitive in their fingertips. Fulfilling all these requirements (and much more) at very low costs is an extremely challenging task. The solution, however, is used on a daily basis by many people worldwide. Because of this multiplying effect, such solutions have a very noticeable environmental impact.

Looking into the future, the steer-by-wire system will be adopted, avoiding the steering column by pure electrical connection between the steering wheel and the road. This system will comprise redundant and fault-tolerant electrical motors at the steering wheel as well as at the tires of the vehicle. Such a system will enhance the safety of driving even further, as the risk of being injured during a crash is greatly reduced by the absence of the steering column. Of course, the technical requirements for safe and reliable operation of such a system are tremendous: for example, even the vehicle electrical system has to be redundant and fail-safe.

Some other research fields in the context of the automotive industry are e.g. electrical braking and electrical traction drives integrated into the wheel-hubs of a car. Again, the realization of both energy efficiency and safe operation, at a low cost, is a necessity.

**Safety and efficiency for many areas of application**

There are many other applications, where similar requirements concerning safety and efficiency are to be fulfilled, as in the automotive industry. Be it the electrical actuator for the landing flap movement of a so-called “More Electric Aircraft”, the electrical drive for an elevator or the fuel valve of the Ariane 5 rocket: all the applications mentioned in this article, including the topic of safety and
reliability of today’s on-board electrical systems in automobiles or airplanes, and many more are being researched by the Institute of Electrical Drives and Actuators.

This institute, as one of the largest of its kind in Germany, has very strong links to the relating industry. There are cooperations with all major luxury class car manufacturers in Germany, with the relevant aerospace industry (like EADS, MTU, and others), and many other companies in the field of electrical drives (e.g. Bosch, Siemens). Excellent scientific work, in combination with very well-equipped laboratories (e.g. several high-performance test benches for electrical drive components, roller dynamometer for tests of entire vehicles, etc.) makes this institute a very valuable partner for the industry.

INTERNSHIP OFFER

Institute of Electrical Drives and Actuators / Department of Electrical Engineering and Information Technology

4 internship positions available

In the field of "Electrical Drives and Actuators" detailed knowledge of the system under consideration is a key for success. Therefore, system analysis and system design are in the focus of our activities. This means that electromagnetic power converter (motor/generator/actuator), power electronics and control have to be regarded simultaneously to come to an overall optimum (rather than optimizing single components). Depending on the needs of this application, the optimum drive system is chosen. Consequently, the electromagnetic device (motor/generator/actuator - as the key component of any drive system), the power electronics topology and the control circuitry are designed. Specialized solutions are our favorite tasks. Beside the theoretical analysis and design of drive systems, some very special (partly worldwide unique) test-benches are available for experimental investigation and validation.

Possible tasks of the internship comprise:

- Simulation of electrical drive components with Finite Element Software or MatLab
- Programming of controllers
- Measurement of electrical drives in the lab
Prof. Jochen Schein completed his doctoral studies at the Ruhr University Bochum in the field of electrical engineering. From 2004-2008 he worked as a research scientist at the Lawrence Livermore National Laboratory, National Ignition Facility, Livermore, CA, USA. Since 2006 he has held a professorship at the Institute of Plasma Technology and Electrical Engineering at the Bundeswehr University Munich.

Plasma Technology: Surface Treatment and Surface Coating

The Institute of Plasma Technology and Mathematics’ main field of activity in research and teaching is plasma technology, more specifically, thermal surface treatment and surface coating.

Current research topics

- Development of plasma sources
- Development and optimization of process-related diagnostic measures

Based on the current state of technology, new operating principles have been identified for plasma generators. The development of plasma generators is divided into two fields:

- for plasma spraying usage, the innovative plasma generator type TRIPLEX has been developed and already been applied in the industry; the novel plasma source type DELTA is currently still being tested
- for diverse applications in the field of plasma safe surface modification, the plasma generator type LARGE, which allows the generation of a plasma jet with new physical properties, is currently being developed
INTERNSHIP OFFER

Institute of Plasma Technology and Mathematics / Department of Electrical Engineering and Information Technology

4 internship position available

The Lab for Plasma Technology team investigates plasma-material interactions for industrial and aerospace applications. Gas Metal Arc Welding, Plasma Cutting, Thermal Spray and Electric (Space-) Propulsion systems are the focus of the ongoing research. Interns will be involved at all levels from construction to operation of experimental systems with an emphasis on learning new useful skills for future employment.
Prof. Stefan Lecheler holds the professorship for technical thermodynamics in the Department of Mechanical Engineering at the Bundeswehr University Munich.

### Generating Renewable Thermal Energy

*Agglutinated roof tiles are most suitable*

**Warm water from roof tiles**

According to the Renewable Energy Heat Act, at least 14% of the thermal and cooling energy demand of buildings is to be covered by renewable energies until 2020. In the laboratory for thermodynamics at the University’s Department of Mechanical Engineering, Prof. Stefan Lecheler and his team develop solar thermic roof tiles adaptive to the visual appearance of the roof as an alternative to solar energy systems that are bolted onto the roof. To remain attractive to conventional solar thermal systems in terms of price, the heat transfer ought to be optimal and production and installation costs low.

In this project several students made a contribution via their bachelor’s and master’s theses. At first, research on the heat throughput of the solar tile was conducted experimentally as well as numerically and optimized. The first pilot plants with tiles made of concrete and sheet steel were functioning well and were met with keen interest by visitors on the last day of the University’s open house day.

**Aluminum as heat conductor**

As part of a joint project study with Prof. Vesna Nedeljkovic-Groha, ways to produce and lay cost-effectively were sought out as the next step. “Aluminum exhibits good heat conduction properties and casting is most cost-effective for larger quantities”, Prof. Lecheler explains the result. “Moreover, the amount of connectors could be significantly reduced and the upper and bottom sides are now agglutinated.”

Prof. Stefan Lecheler
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www.unibw.de/mb/fakultaet/we5/we51
Under the financing of the solar energy support association of Bavaria two test plants with different roof tiles are under construction at present. From July onwards both plants are supposed to demonstrate their efficiency and reliability under real-life conditions on the University’s campus. “If the durability is high and the price is right, this product could soon be ready for the market”, Prof. Lecheler hopes.

**INTERNSHIP OFFER**

**Chair of Thermodynamics / Department of Mechanical Engineering**

**2 internship positions available**

The institute offers student projects in the area of renewable energy and computational fluid dynamics (CFD), i.e.

- Geothermal heat and power generation
- Solar heat and power generation
- Validation and application of ANSYS-CFX to fluid and heat transfer problems

Available lab equipment includes:

- Climate chamber (size 3x3x2m, temperature range -30°C to +40°C, humidity variation)
- High resolution thermography camera
- Modern measurement equipment for mass and heat transfer
- Computer work stations and licenses for CFD calculations
- Several demonstration solar heat and power plants
Prof. Gabrijela Dreo Rodosek has held the Chair of Communication Systems and Internet Services at the Bundeswehr University Munich since 2004. She received her M.Sc. degree from the University of Maribor, Slovenia and her doctoral degree from the LMU Munich. She is member of the executive committee of the EU FP6 NoE EMANICS project and a chairwoman of the IT security research group at the University.

**IT Security and Management Challenges: Today and Tomorrow**

_The Institute for Technical Informatics is dedicated to the field of IT Security_

The internet has revolutionized our social and business habits. It has evolved from a network of computers and information into a network of people. The future internet will consist of dynamically scalable and virtualized resources and services, located somewhere in a cloud, which will be offered by providers as a service over the internet. Whether the future internet will be evolutionary or take a more clean slate approach, ensuring security and privacy will be among the most challenging tasks.

_The future internet requires self-managing systems_

Even if the final structure is not known yet, several characteristics are already derivable: trillions of fixed as well as mobile devices, huge amounts of data, encrypted payloads and complex security strategies are characteristics of the future internet. Real-time and bandwidth-intensive services will be around as much as vital control and monitoring functions which are operated over the network. The software defined radio technology has taken a large step from the academic into the practically feasible domain. We are now able to construct radio equipment where the signal processing is completely digital and done via software blocks. Harnessing these new capabilities, radio communications systems with wide bandwidth usage have been devised to facilitate high data rates, improve robustness and supersede legacy radio communication systems. Due to the mentioned challenges, the future internet also requires the development of novel management concepts for self-managing systems.
Solutions focusing on security and operational aspects

The main research activities in this area include research topics like Autonomic (Self-)Management, Context-Aware Systems, Intrusion Detection and Prevention Systems, Security Management Infrastructures, secure Grid and Cloud Computing, management concepts and solutions focusing on security and operational aspects for such future radio communications networks, including participation in the specification of the upcoming Coalition Wide-band Network Waveform, Wireless Sensor Networks (“Internet of Things”), Early Warning Systems for the future internet, and biometric access systems. Cooperation partners include national institutions like IT-Amt of the Bundeswehr, Sanitätsamt of the Bundeswehr, Fraunhofer Institute for Communication, Information Processing and Ergonomics, Federal Office for Information Security (BSI), companies like secunet AG, ESG and G&D as well as international organizations like the European Commission, European Defence Agency as well as ENISA (European Network and Information Security Agency).

Security concepts for wireless sensor networks

Wireless sensor network (WSN) nodes have only limited resources concerning computational power, memory and battery life. So really strong cryptography algorithms are not yet suitable for WSNs. Efficient use of cryptographic concepts is an unsolved problem. To face this problem, new architectural concepts for WSN sensor nodes are needed. A great deal of recent research has been done on the assumption that the restricted resources of WSN nodes will remain a constraint. It was focused on the innovations in architectures and power efficient protocols but not on issues that will affect resilience and attack. It is necessary to protect future WSNs effectively. Therefore, our research focuses on the development of highly secured sensor applications, networks, and nodes.
Security of geodata

Another research emphasis is put on the security of distributed geodata, where security requirements in the application domain of geographical data and services are identified. In the domain of geographic data, typically represented as maps, standard requirements and solutions – e.g. for authentication and authorization – must be complemented by application of specific aspects such as authorization based on geographical position of the data and/or the user. The research activities include cooperation within the Bundeswehr University Munich (research group “Geographic Information Systems”) as well as cooperation with regional partners (Runder Tisch GIS e.V., Bayerisches Landesamt für Vermessung und Geoinformation) and international partners (Open Geospatial Consortium (OGC), GIS Industry: Intergraph, ESRI, AED-SICAD, and others).
INTERNSHIP OFFER

Institute for Technical Informatics / Department of Computer Science
Chair of Communication Systems and Network Security, Research Center CODE

2 internship positions available

Information and communication technology (ICT) permeates all areas of modern society and is the driver of innovation in business and research. This ubiquity has already led to strong dependencies in the public and private sectors. The security of ICT as well as the defense against cyber-attacks is an essential challenge.

The Research Center Cyber Defense (CODE) brings researchers from different scientific disciplines across faculties together and integrates experts from industry and public service. CODE holistically and interactively approaches technical innovations for the protection of data and systems, anomaly detection, smart attacks, security of mobile devices, critical Infrastructures for various application areas such as automotive, logistics and energy.
Prof. Stefan Pickl studied mathematics, electrical engineering, and philosophy at TU Darmstadt and EPFL Lausanne and received his venia legendi at Cologne University. He has been Chair of Operations Research at the Bundeswehr University Munich since 2005. He was visiting professor at the University of New Mexico and University of California at Berkeley, University Graz, University of Copenhagen and visiting scientist at SANDIA, Los Alamos National Lab, Santa Fe Institute for Complex Systems and MIT. In 2010 he chaired the International Operations Research Conference in Munich.

Operations Research: High-Dimensional Complexity Management

*System dynamics models and algorithmic optimization procedures contribute to decision-making with regard to global challenges*

Institute of Theoretical Informatics, Mathematics and Operations Research

Operations research is closely associated with the developmental history of the Bundeswehr University Munich. At first, classic operations research was militarily motivated before it found its way into industrial process management and, later, into economic studies and systems analyses. The Chair of Operations Research today focuses its research on studying the co-functioning of such different systems, analyzing them and optimizing them based on certain criteria.

Networked research

With the research center COMTESSA (Competence Center for Operations Research, Management of Intelligent Engineered Secure Systems & Algorithms) the Chair is involved in international research projects and EU framework programs which take on these scientific challenges in the context of concrete application examples. Within the RWTH Aachen University’s excellence initiative the implementation of the Kyoto Protocol, the establishing of international energy systems and the associated resource conflicts are studied.
IT-based and service-oriented decision-making assistance

The design and conduct of global experiments and economic scenarios are dealt with in particular under the ERASMUS cooperation with the Karl Franzenv University and Technical University of Graz. Within the framework of current EU research programs and the ICT 2020 (Information and Communications Technologies) Initiative “Sustainability in a Connected World”, IT-based and service-oriented decision-making assistance is developed within general cybernetic systems to study rational behavior. Using system dynamics models and algorithmic optimization procedures, the systems are studied topologically as to “energy efficiency improvement”, “aspects of resource security” as well as “susceptibility to terror” of networked infrastructures. The studies conducted so far have taken place in a project supported at the EU level by the German Institute for Economic Research (DIW Berlin).

Optimal behavioral strategies

Within these networks, researchers are looking for optimal behavioral strategies as well as for stable regions, which characterize such cybernetic systems. Frequently, these regions can be determined and characterized only by using very complex algorithmic procedures. This is why several scientists of the working group are looking into the future-oriented fields of “swarming” and “computational intelligence” as well as high-dimensional network studies. These results are embedded in the development of suitable concrete solution and reachback strategies for the protection of those networks. To this effect, tests are conducted jointly with the Bundeswehr Transformation Center’s OR Cell, the Center for Excellence “Confined and Shallow Waters” of the German Navy, and the U.S. Navy’s Task Force Energy coordinated by the Naval Postgraduate School, Monterey.

INTERNSHIP OFFER

Institute of Operations Research / Department of Computer Science

Research Center COMTESSA

2 internship positions available

- Modelling, simulation & optimization of complex systems
- Multi-agent models / discrete event simulation
- Game theory and experimental design
- System dynamics and strategic planning
Real-Time Simulation and Animation of Mechatronic Systems

Department of Business Administration

The department’s five institutes offer two degree programs: the Bachelor of Management and Media and the Master of Management and Media. Furthermore, the professors of the Institute of Corporate Governance and the Institute of Mathematics and Informatics teach subject-specific throughout all practically-oriented course programs at the University. Aside from teaching and students’ supervision, practically-oriented research and development plays an increasingly important role. Visit the institutes’ websites and find out more about current research projects, co-operations, teaching contents and the professors.

Institute of Mathematics and Informatics

The Institute of Mathematics and Informatics is responsible for the mathematical education of all practically-oriented degree programs at the university. Seven professors teach students basics in mathematics and informatics that are necessary for each course program. They conduct subject area-specific research.

Some of their teaching contents are:

- Engineering Mathematics
- Engineering Informatics
- Business Mathematics
- Technology Mathematics
- Applied Mathematics

Professor Dr.-Ing. Reinhard Finsterwalder, Informatics, esp. Informatics for Engineers

Main focus of research:

- Real-time simulation and animation of mechatronic systems
- Distributed simulations
- Use of Embedded Systems
- Application of internet based technologies for engineering applications
Industrial partners:
AMATEC Robotics, Astrium, BMW, DLR, EADS, Eurocopter, IABG, KUKA Roboter, Schlegel Simulation.

Current research projects:
- Development of a modular vehicle simulator for the application in teaching and research
- Allocated simulation in the Bundeswehr: applicability analysis of HLA for the integration of partial systems in a simulator

**INTERNSHIP OFFER**

Institute of Mathematics and Informatics / Department of Business Administration

2 internship positions available

At Prof. Finsterwalder’s institute students have the opportunity to take part in research activities related to real-time simulation and animation of mechatronic systems, interoperability of flight simulators, applications of embedded systems as well as computer vision for robotic applications. Industry partners include BMW, Eurocopter, IABG, as well as numerous robotic firms.
Prof. Christian Kähler was amongst others head of the research group "Flow Control and Measurement Techniques" at the Institute of Fluid Mechanics at the Technical University Brunswick from 2001-2008. Since 2008 he has been professor for fluid dynamics and head of the Institute of Fluid Mechanics and Aerodynamics at the Bundeswehr University Munich (see detailed CV at: www.unibw.de/InT7/mitarbeiter-en/llkaehler).

Turbulence Research: Microfluidics and Particle Imaging Techniques

Achievements in sheet and volumetric PIV techniques with micron resolution

My first contact with PIV happened on a demonstration performed by Chris Willert, Markus Raffel and Jürgen Kompenhans at the Technical University of Clausthal, in the spring-time of 1995. Coincidentally, I had a deep interest in coherent near wall flow structures in turbulent boundary layers at the time and the demonstration made a strong impression on me. I became excited about using this method and fortunately I had the opportunity to join the PIV group of Jürgen Kompenhans at DLR Göttingen to work on my diploma project. In August of 1995 I started my first measurements using photographic PIV with the rotating mirror system, developed by Markus. For the illumination, a heavy 70 mJ Lumonics HY 200 SPECIAL Nd:YAG laser was available. Instead of optically evaluating the contact copies of the 36mm film after the experiment, which was the state-of-the-art at that time, I digitized the recordings with a brand-new scanner in order to evaluate them digitally. I was deeply impressed by the large-scale coherent flow structures I could resolve with the system (figure 1), but the spatial resolution was far too low to resolve the velocity profile down to the viscous sub-layer.

In February of 1996 Chris had integrated a 1k×1k digital camera (Pulnix) in the DLR PIV system. Apart from the low spatial resolution compared to photographic PIV, digital PIV was a fantastic improvement, particularly due to the multi-pass cross-correlation analysis with window-shifting (already of second order at that time). I was able to much better resolve the velocity profiles (up to the buffer layer, see figure 2) but when I plotted the histogram, I saw what today we refer to as peak-locking (figure 3). This effect was not known from photographic PIV (probably due to the noise) and none.
of my famous colleagues or visitors at the DLR at that time (Jerry Westerweel and others) had observed it before. As the implication of this effect on velocity measurements was obvious, Jürgen Kompenhans recommended that we do not publish the graph in my diploma thesis, though I did nevertheless.

Enthusiastic by the technical improvements and my first findings, in March 1996 Jürgen Kompenhans sent me to Ron Adrian at Urbana Champaign to get familiar with digital stereo PIV. Learning from Ron was a great honor for me. Additionally, Jerry spent some weeks visiting Ron during the same period to work on “The Book”. So I was able to discuss all my findings at lunch with Jerry and, at least once a week, with Ron. Back in Germany, I evaluated the 2k×2k stereo PIV recordings made during my stay at Urbana Champaign, with the stereo software that Chris developed in my absence. Surprisingly the out-of-plane motion was always on the same side of the low-speed streaks. I realized that this effect was caused by slight differences between the calibration and the measurement configuration. So I worked on a way to compensate for this effect, which is known today as disparity correction, and I learned that even when you are doing everything right there might still be something wrong!

After finishing my Diploma thesis, I continued the work at DLR during my Ph.D. with the development of the multi-plane stereo-PIV technique, to estimate unsteady and 3D flow characteristics in air, and I was able to analyze turbulent boundary layers in much more detail. Thanks to Michel Stanislas and Jürgen Kompenhans I could perform the experiments in Lille, which is greatly appreciated. Besides my work on boundary layers, I was also involved in many international test campaigns where I learned to apply PIV with a team in large scale catapult and wind tunnels and in 1998 I had the privilege, together with my colleague Andreas Schröder, to work in Mory Gharib’s group at Caltech.
From October, 2001 until April, 2008 I focused my attention on intrusive and non-intrusive flow control concepts and the development, improvement and application of all kinds of PIV variants at the Technical University Brunswick. I worked, particularly, on a long-range micro-PIV system with single pixel resolution in order to resolve the viscous sublayer. In 2005 I was able to measure the boundary layer velocity profile with a resolution of 0.028 viscous units in a wind-tunnel, at a free stream velocity of 10 m/s. The resolution of one thousand measurement points within a millimeter over a distance of 0.5 m was far beyond my highest expectations when I began my research in 1995 at DLR Göttingen. So I tend to believe that there is always a solution, we just have to explore it!

Today, I still like the Particle Image Velocimetry, mainly because

1. the technique still puzzles and inspires me to come up with improvements,
2. as a physicist, I like the components involved (laser, CCD camera, optics, image analysis)
3. I met many good people in this community and it is always a pleasure to meet them at conferences or events such as the 25 years of PIV at DLR Göttingen in 2009.

Analysis of mixing and mass transport processes in bubble swarms under the influence of bubble-induced turbulence

Aim of this project is to investigate the mixing and mass transport processes in bubble swarms taking into account the effect of bubble-induced flow turbulence. High resolution 3D optical measurement techniques will be applied to determine the underlying physical processes, in order to verify existing mass transport models and to validate numerical simulations carried out by the project partners. The experiments will be conducted in a custom built channel. Fractal and active turbulence grids will be used to adapt the turbulence level over a wide range of scales and intensities in order to simulate the intensity, spectral characteristics and coherence of real bubble-induced turbulence. This unique approach is applied to study the behavior of a single bubble or groups of bubbles in a realistic turbulent flow. In particular, bubble motion, bubble deformation, bubble vibration, mass transport into the turbulent flow, and mixing processes caused by the bubble-induced turbulence will be systematically investigated using state-of-the-art, non-intrusive 3D optical measurement techniques and compared with numeric.
INTERNSHIP OFFER

Institute of Fluid Mechanics and Aerodynamics/ Department of Aerospace Engineering

up to 4 internship positions available

Our research focuses on experimental fluid mechanics, reaching from microfluidics to airplane aerodynamics. The facilities of the Institute comprise several wind tunnels, including a supersonic tunnel, as well as a well-equipped microfluidics lab with state-of-the-art microscopes. The institute is one of the leading developers of PIV (particle image velocimetry) and PTV (particle tracking velocimetry) techniques, including challenging three-dimensional flow measurement methods. Thus, we can offer fascinating internship opportunities in the following fields:

1. **Microfluidics** (1-2 positions available): Microfluidics investigates flow phenomena in the smallest scales. In this internship you will learn how to use microscopes and how to set up a micro-scale experiment. At the end of your work you will be able to measure three-dimensional flow fields in micro channels.

2. **Turbulence Research** (1-2 positions available): Turbulence research is a fascinating and challenging topic. To this day, turbulence is not fully understood, and thus numerous research activities are devoted to this field. This internship gives you an insight on experimental techniques to capture turbulent flows.

3. **Particle Imaging Techniques** (1-2 positions available): Particle imaging techniques, such as PIV and PTV, are powerful tools for a comprehensive flow analysis. Not only do these methods provide velocity fields with excellent resolution, but also related information, like wall shear stress, turbulence intensity, and many others. In this internship you will get an overview of different particle imaging techniques. You will have the possibility to measure three-dimensional, macroscopic flow fields during your stay.
Carbon Fibre Reinforced Plastic (CFRP)

An exceptional material

The Institute for Lightweight Structures focuses on the development and analysis of lightweight structures in the field of aerospace engineering and related transport technologies – in particular, modern lightweight construction using fibre reinforced materials. In addition to the development and processing of special methods of calculation for particular problems, the experimental analysis of theories is another main task of the institute.

Main areas of research throughout the next years:

- Failure of lightweight structures under dynamic stress (in particular, stability failures of supporting structures under stochastic, impact and shock stresses: local instabilities of sandwich beams, lightweight bending beams, etc.)
- Global analysis of the dynamic breaking process of lightweight structures with objective of estimating consequential damage of the breaking of supporting structures
- "smart structures": active structures with greater travel ranges, e.g. active flaps and controls for steering air vehicles; increasing the load-bearing capacity of lightweight structures by actively influencing system features, adapting the dynamic structure characteristic behavior according to changing requirements by means of active elements
- development of ultralight structures
- Analysis of the breaking process of welded aluminum – extrusion profile; experimental and numerical analysis of the weld seam as well as the heat affected zone
INTERNSHIP OFFER

Institute for Lightweight Structures / Department of Aerospace Engineering

1-2 internship positions available

Due to their excellent strength and stiffness properties, carbon fibre reinforced materials (CFRP) are the most suited materials for all kinds of lightweight structures. More than 50 percent of the structural mass of the new Boeing 787 and Airbus A350 aircrafts consists of these "black" materials. Since last year, carbon fibres are in use even in the automotive industry on a bigger scale, e.g. in the brand new electric cars BMW i3 and BMW i8. At the Institute for Lightweight Structures we solve specialized problems concerning structural design and analysis of these "black" structures in theory and via hands-on experiments. The institute is equipped with a big laboratory where all the structural tests are performed.

Questions associated with your internship are, for example:

- How to transfer high loads into thin-walled structural components made of CFRP?
- What are the friction properties of CFRP when combined with other materials?
- How does creeping of CFRP influence load transfer in a bolted joint?
- What is the strength of torsional tubes made from CFRP by using different manufacturing processes?
Social and Cultural Program

Meet other students, get to know Munich and take a trip to Germany’s capital!

Buddy Program

The University’s international buddy program was launched by the International Office in 2009 to provide newly arriving international exchange students at the Bundeswehr University Munich with additional support from regular students in order to help them get situated on campus, help them adjust to the new environment and ensure that their stay in Munich is a pleasant one.

We try to allocate every new international student a so called “Buddy”, i.e. a German student who is familiar with the university’s structures and who will be able to give a helping hand during your stay abroad in Germany. Our international tutors or “buddies” also organize events, excursions and activities – an excellent opportunity to meet people from all over the world, to exchange experiences and socialize with other students and to explore Munich and surroundings with like-minded people!

Participating in the program will provide you with valuable advice on everyday life at our university and in Munich and will help you to get in touch with German students more easily. In the past, we witnessed that the program really helped to foster friendships and mutual understanding and broadened the cultural horizon of all participants.
Life in and around Munich

**Munich – Bavaria’s Capital City**

With a population of over 1.5 million people, Munich is the third largest city in Germany, and is an important center of art, culture, technology, and business. This “city on the Isar” is known for its impressive historic buildings, numerous museums, and beautiful parks and gardens. Last but not least, Munich’s scenic surroundings add to the city’s popularity: on a clear day, the Alps can be seen from the city, and there are a variety of magnificent lakes on the city’s outskirts.

**Neubiberg**

Situated just outside of Munich with a population of 14,500 people, Neubiberg is home to our University. You will find a number of small shops and a few restaurants on the main street. The former airfield between Neubiberg and the town of Unterhaching has been made into a recreation center. Neubiberg is the only true university town in Germany.
New Town Hall and the Marienplatz

The Neue Rathaus (New Town Hall) is a magnificent neo-gothic building from the turn of the century which architecturally dominates the north side of Munich’s Marienplatz.

At the top of the 85-meter-high (255 feet) tower on the city hall is an observation deck that can be accessed with an elevator and offers a grandiose view of the roofs of the city, even as far as the Alps in nice weather.
Beer Gardens

For centuries, beer is and has been an important part of the culinary and cultural heritage of Bavaria and Munich. The best choice for having an authentic “beer experience” are the traditional beer halls (indoors) and beer gardens (outdoors).
**Allianz Arena**

The Munich Allianz Arena is the soccer temple in the northern part of the city and the home of the FC Bayern München and TSV 1860 München soccer teams.

**Nymphenburg Palace**

Nymphenburg Palace owes its foundation as a summer residence to the birth of the long-awaited heir to the throne, Max Emanuel, who was born in 1662 to the Bavarian Elector Ferdinand Maria and his wife, Henriette Adelaide of Savoy, after some ten years of marriage. With its unique combination of architecture and garden design, Nymphenburg is one of the best examples in Europe of a synthesis of the arts and a great place to visit.
The English Garden

The Englische Garten ("English Garden") is one of the largest urban parks in the world. The layout has undergone constant change throughout the centuries as new buildings and green spaces were added time and again.
BMW Museum - A Home for Driving Pleasure

The ensemble comprising BMW Welt, plant and museum at the Munich Oberwiesenfeld represents the internationally unique BMW world of experience. The synchronous integration of automobile delivery and thrilling temporary exhibitions about the past, present and future of the brands as well as a multifaceted daily event program have turned BMW Welt into an attractive place of encounter and exchange.

The German Museum

Sailing ships, models of atoms, windmills, space probes, diesel locomotives, industrial robots, organs, lifeboats,…this unbelievable abundance of technical achievement – and lots more – can be found in the German Museum.
Dachau Concentration Camp Memorial Site

A memorial has been erected on the previous grounds of the Dachau concentration camp.

On March 21, 1933, Hitler ordered the construction of a concentration camp in Dachau, the first in Germany. The first commander, Theodor Eicke, developed an organizational scheme that would later be applied to all camps. He made Dachau into a “school of violence” for the members of the SS. In the end of April, 1945, the SS began evacuating the 169 field camps and field commanders, and on April 29, 1945, the camp was freed by US Army units. Until the liberation, the SS had held over 200,000 prisoners from 34 nations in the concentration camp in Dachau.

In addition to a documentary exhibit in the former work buildings, the bunker, both crematoriums, and a reconstructed prisoners barracks can be viewed.
Castle Neuschwanstein

The royal castle of Ludwig II near Füssen is one of the most visited castles and fortresses in Europe. The architecture and interior furnishings reflect the historically and eclectically oriented ideals of the Bavarian “fairy tale king”.

The King’s Lake

This 10 km long emerald-green mountain lake is considered to be the pearl of the Berchtesgadener Land. Some of the most magnificent panorama views across all of Bavaria can be found here. To preserve the purity and tranquility of the water only electrically-powered boats have been allowed on the lake since 1909.
Hiking in the Alps

Climb mountains, revel in majestic views, fill your lungs with fresh mountain air and indulge in mouth-watering local specialties at quaint mountain huts amid spectacular Alpine sceneries.

The Alps are one of the best hiking regions in the world!
**Berlin Excursion**

Below you will find some of the tours and activities planned for the excursion to Berlin, which is part of the program.

*Boat Ride – Spree*

This leisurely boat ride down the Spree River is a great way to familiarize with some of the sights in downtown Berlin.

*Federal Chancellery*

The Federal Chancellery is the office and department of the German Chancellor. After the fall of the Berlin Wall, it was decided that Berlin would be the capital of reunified Germany. The Federal Chancellery was accordingly moved from Bonn back to Berlin some years later. The current Chancellery building, finished in 2001, occupies almost 130,000 square feet – roughly 8 times the size of the White House in Washington, D.C.
Checkpoint Charlie

Checkpoint Charlie, along with Glienicker Brücke (Glienicker Bridge) was the best known border-crossing during the days of the Cold War. The sign, which became a symbol of the division of Cold War Berlin and read like a dire warning to those about to venture beyond the Wall – YOU ARE NOW LEAVING THE AMERICAN SECTOR – in English, Russian, French and German – stood here. Today it is an iconic marker of territorial boundary and political division. Until the fall of the Berlin Wall on November 9, 1989, it signified the border between West and East, capitalism and communism, freedom and confinement.
Brandenburg Gate

The Brandenburg Gate is one of Berlin’s most important monuments – a landmark and symbol all in one with over two hundred years of history. A former symbol of the divided city, it attracted visitors who used to climb up an observation platform in order to get a glimpse of the world behind the Iron Curtain on the other side of the barren “death-strip”, which separated East from West Berlin – both geographically and politically.
The Berlin Wall divided the city into Eastern and Western zones from 1961 to 1989 and had an enormous impact on the residents of Berlin. On a walking tour you will visit landmarks such as Checkpoint Charlie and learn more about Berlin’s unique situation during the Cold War.
The Foundation Memorial to the Murdered Jews of Europe

Berlin's Holocaust Memorial, located in Mitte on a stretch of the former “death strip”, where the Wall once stood near the Brandenburg Gate, is Berlin’s stunning monument to the Holocaust, dedicated to the Jewish victims of the Nazi genocide of World War II.

Museum Island

Home to 5 remarkable museums, the „Museum Island“ is an island in the Spree River in central Berlin. The Old Museum, New Museum, Pergamon Museum, Bode Museum, and the Old National Gallery are all located on the island. These museums focus mainly on art and archeological finds of the 19th century. Today the former prison is a memorial dedicated to increasing awareness of the methods and consequences of political persecution.
German Parliament

The Bundestag is Germany’s parliament – the legislative branch of the German political system. The representatives in the Bundestag are elected by the voters for a term of four years. There are always at least 598 representatives in the Bundestag; however, this number is usually higher due to so-called “overhang seats”.

On this tour you will learn more about the organization as well as the various tasks and activities of the Bundestag.
**Hohenschönhausen**

In the former East German prison of Hohenschönhausen, you will experience first-hand the conditions which those persecuted by the GDR were forced to endure. The prison was used as a remand center from 1951 to 1989.

**Bellevue Palace**

Constructed in 1785, the neoclassical Bellevue Palace was used by the royal family of Prussia, the Hohenzollerns, until 1918, when the Weimar Republic forced them to abdicate. After 1957 it was used as a residence for the Federal President; however, since the latest renovations, the palace no longer contains an apartment for the President and his family.