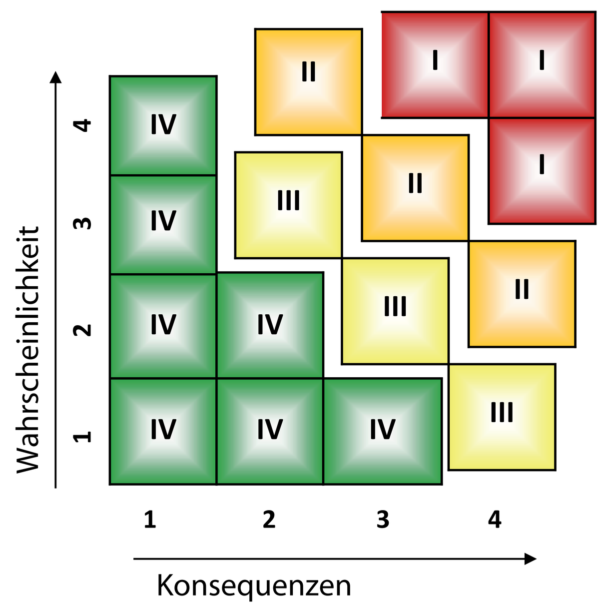
engineering risk analysis group
RISIKOANALYSE UND ZUVERLÄSSIGKEIT
PROF. DR. DANIEL STRAUB

Study line of M.Sc. Civil Engineering

Engineering Risk and Reliability



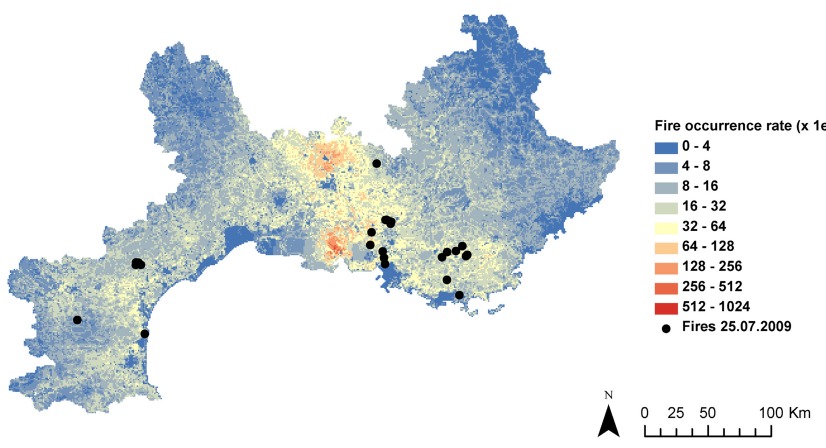
Core modules (Pflichtmodule)	**Elective modules** (selected)	**Learning objectives** (Lernziele)
A: **Risk Analysis** (Uncertainty, information and prediction) B: **Risk Assessment** (Decisions, optimization and management) C: **Reliability of Engineering Systems** Module 1: A (6 ECTS) Module 2: B&C (6 ECTS)	+ Structural Reliabilty Methods + Stochastic Finite Element Methods + Probabilistic Life-Cycle Assessment and Management of Infrastructure + Simulation of Rare Events & Failure Probabilities + Flood Risk & Flood Risk Management + Bayesian Strategies for Inverse Problems	After completition of the study line, students are capabale of: + understanding, analysing and comunicating uncertainty & risk in engineering applications + selecting appropriate methods for probabilistic modeling & risk analysis and implementing them + systematically analyzing uncertain complex engineering systems + managing computational methods and tools for probabilstic analysis, uncertainty propagation and reliability analysis + using decision analysis for engineering & management applications + assessing and optimizing risk managment strategies, such as monitoring, strengthening, risk transfer (insurance) + understanding and dealing with the societal dimensions of risk

Core modules

Risk Analysis (Uncertainty, information & prediction)

4hr/week, 6 ECTS, winter semesters

Instructor: Prof. Daniel Straub



The course makes graduate students familiar with the concepts of uncertainty and information and provide them with the tools to analyze realistic engineering problems subject to uncertainty and randomness. At the end of the course, students will be able to:

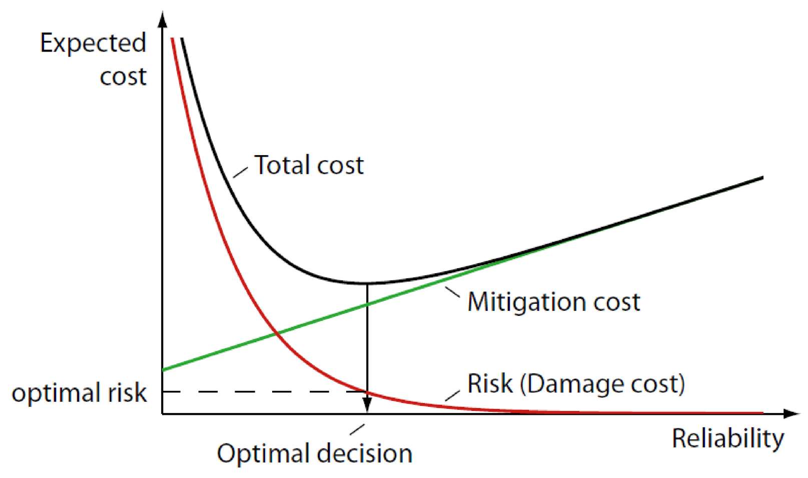
+ Know when to apply probabilistic methods and risk analysis
+ Select the appropriate probabilistic model for individual and groups of variables
+ Perform data analysis (statistics) using software tools
+ Probabilistic learning with Bayesian methods
+ Analyze the reliability of systems with statistically dependent elements
+ Propagate ucertainty thtough engineering models
+ Utilize stochastic process models
+ Interpret the quality of a probabilistic analysis

Throughout the entire course, there is a strong emphasis on the application of these methods to engineering problems.

Risk Assessment (Decisions, optimization & management)

3hr/week, 3 ECTS, summer semesters

Instructor: Prof. Daniel Straub



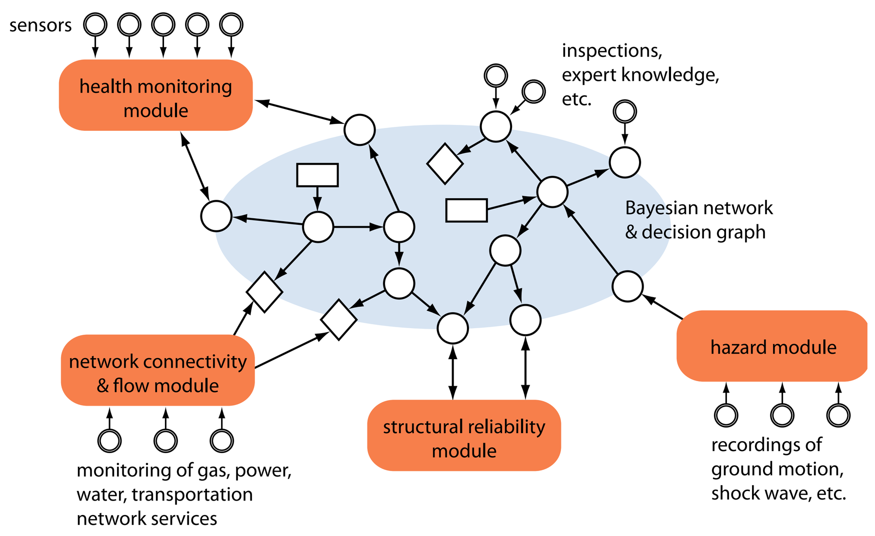
This course enables students to analyze, manage and communicate risks in civil systems and environment. At the end of the course, students will be able to:

+ Understand uncertainty, utility, risk and decisions.
+ Utilize traditional tools for decision making under uncertainty, such as event and decision trees.
+ Model complex engineering systems and decisions using Bayesian networks and influence diagrams
+ Optimize risk managment strategies, such as monitoring, strengthening, risk transfer (insurance)
+ Derive risk acceptance criteria
+ Perform risk management for engineering systems
+ Present and communicate risks to the decision maker

Reliability of Engineering Systems

3hr/week, 3 ECTS, winter semesters

Instructor: Prof. Daniel Straub



Students learn to understand and analyze the performance of engineering systems under uncertainty. After completing the course, students can:

+ Classify engineering systems
+ Establish logical, topological and physical models of system and network performances
+ Calculate system reliablility with analytical, semi-analytical and simulation-based methods
+ Compute sensitivity measures
+ Understand the challenges in assessing systems-of-systems
+ Perform a multi-hazard system reliability analysis

MSc thesis

6 months, 30 ECTS

Instructors: All researchers of the ERA group

The MSc thesis prepares students for advanced engineering projects and research. Students learn to independently solve challenges in reliability and risk assessment of engineering systems. They learn how to effectively present and communicate complex problems and their results.

Example past M.Sc. thesis topics include:

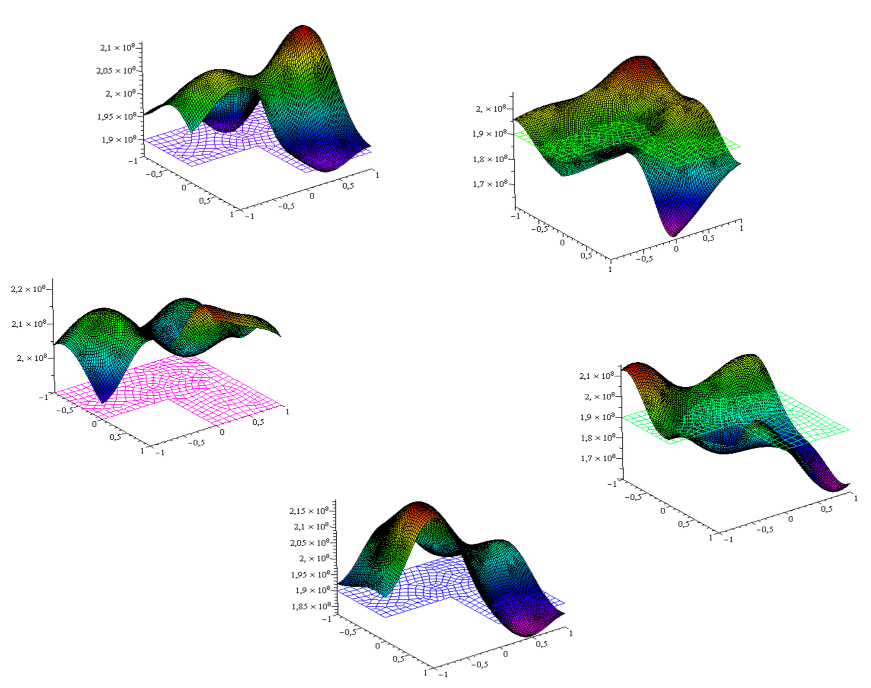
+ Bayesian identification of cross laminated timber plates using surrogate models
+ Design Flood Estimation in Bavarian Alpine (and sub-Alpine) Catchments Including Parameter Uncertainties (with LfU Bayern)
+ Propagation of Multi-hazard Damages in Interdependent Lifeline Systems in the Valparaíso Region, Chile
+ Statistical Methods for Parameter Identification of Temperature Dependent Viscoelastic Models
+ Uncertainty Propagation in Telemac 2D Dam Failures Models and Downstream Hazard Potential Assessment (with EDF)
+ Identification of Flood Loss Event Scenarios for Monitoring Accumulations in Property Insurance (with Allianz)
+ Stiffness and damage identification by Bayesian updating of a multi-component steel frame under dynamic load
+ Climate Induced Changes on the Hydrology of Mediterranean River Basins-Drought Risk Assessment and Implications for Water Management in the Chiba Basin, Tunisia (with DLR)
+ Updating of small probabilities using hybrid Bayesian networks
+ Multi-objective decision support tool for monitoring and maintenance of water distribution systems (with TüV Süd)

Elective modules (selection)

Stochastic Finite Element Methods

4hr/week, 6 ECTS, winter semesters

Instructor: Dr. Iason Papaioannou



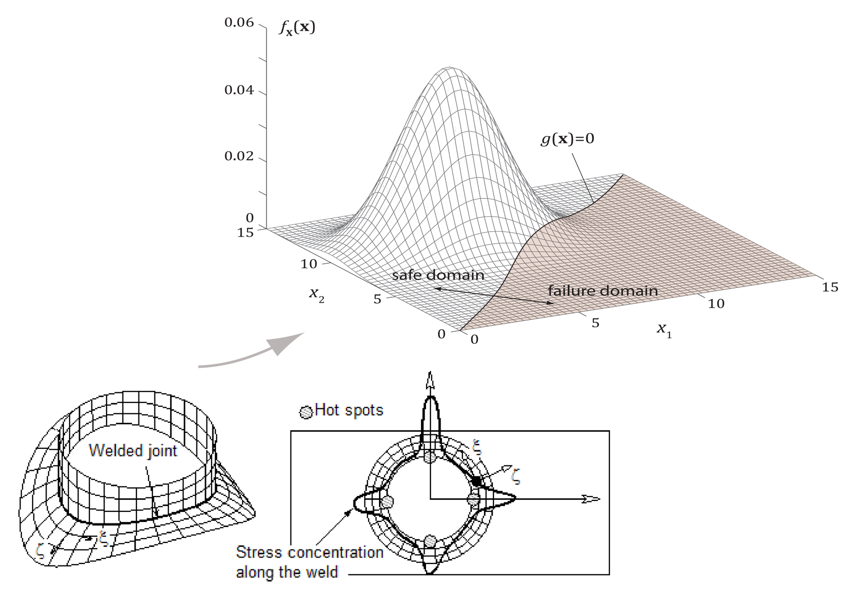
This lecture is an introduction to the basic concepts of stochastic finite element methods for the uncertainty quantification of elastostatic systems. In the end of the semester the students will be able to:

+ Understand the basic concepts of probability theory
+ Define Gaussian and non-Gaussian random vectors and random fields based on their second moment properties
+ Discretize Gaussian and non-Gaussian random into a finite number of random variables
+ Judge the applicability of different stochastic discretization methods based on specific problem settings
+ Apply different stochastic finite elements methods to elastostatic problems
+ Judge the applicability of different stochastic finite element methods based on specific problem settings

Structural Reliability Methods

One week block course, 3 ECTS, winter semesters

Instructors: Prof. Daniel Straub & Dr. Iason Papaioannou



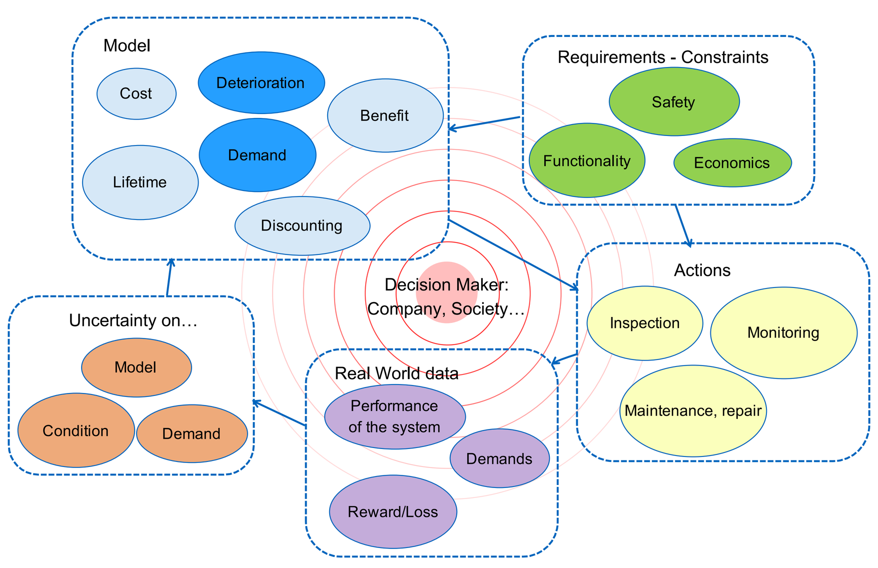
Introduction to modern structural reliability methods for the evaluation of the performance of engineering structures and systems subject to uncertainty and randomness. The course will introduce the theory and applications. At the end of the course, the student is able to:

+ Understand the basic concepts of probability theory
+ Formulate the reliability problem for realistic structures.
+ Establish the probabilistic model for various loadings and materials.
+ Compute estimates of the failure probability of engineered systems using various exact and approximate methods.
+ Assess the relative importance of random variables.
+ Assess the sensitivities of the results to model assumptions.
+ Update the reliability estimates with observed data and other information.

Probabilistic life cycle analysis and integrity management of infrastructures

3hr/week, 3 ECTS, winter semesters

Instructors: Elizabeth Bismut & Prof. Dr. Daniel Straub



This course enables the student to understand, analyze and communicate the elements of life-cycle reliability and asset integrity management subject to uncertainty and randomness. The course combines the concepts of utility theory with those of risk analysis and uncertainty quantification. The students will learn to formalize all aspects of a sequential decision problem and implement various methodologies to solve it.

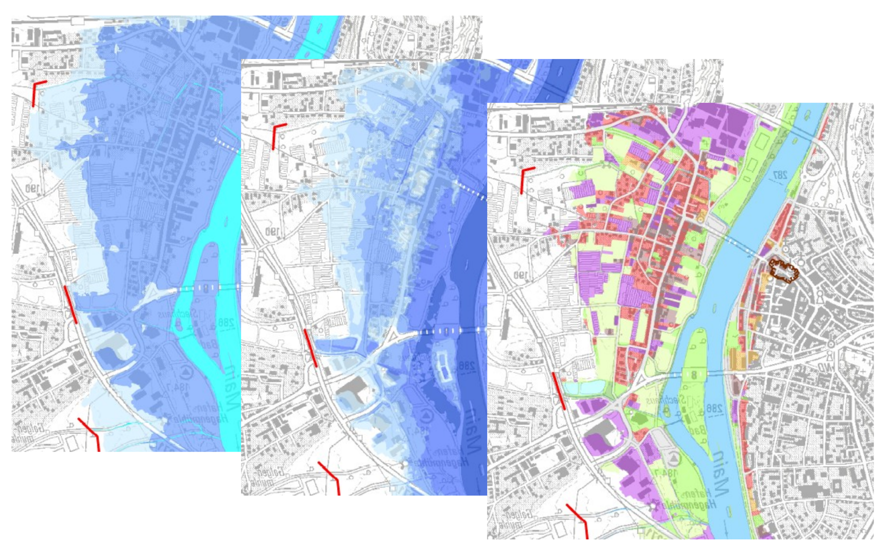
Upon completion of the module, students will be able to:

+ Understand the fundamental concepts and challenges in infrastructure asset integrity management
+ Understand and evaluate life-time reliability, availability and risk
+ Perform probabilistic evaluations of the life-time performance of aging infrastructures by Monte Carlo simulation
+ Assess the reliability of maintained structures
+ Perform cost-benefit-analyses of asset integrity management strategies

Flood Risk & Flood Risk Management

4hr/week, 6 ECTS, summer semesters

Instructors: Prof. Markus Disse & Dr. Olga Špačková



This course is designed to make graduate students familiar with the problematic of floods, with the techniques of flood prediction and modeling and with the approaches of flood mitigation. The students will learn the basic concepts and terminology of flood risk assessment and the semi-quantitative and quantitative methods for analyzing and assessing the risks and optimizing the flood protection measures. At the end of the module, students will:

+ Understand the concept of risk analysis
+ Apply methods for assessing flood hazard, damages and risk
+ Evaluate different flood protection measures
+ Understand the objectives and tasks of the EU directive on flood risk management
+ Create a flood model based on MATLAB
+ Use this model for flood risk assessment and for planning of flood protection measures

The couse is offered jointly by the Chair of Hydrology and the ERA group