

**Module Description, available in: EN**

## *Lifecycle Management of Infrastructures*

**General Information****Number of ECTS Credits**

3

**Module code**

FTP\_Life

**Valid for academic year**

2024-25

**Last modification**

2023-09-19

**Coordinator of the module**

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**Explanations regarding the language definitions for each location:**

- Instruction is given in the language defined below for each location/each time the module is held.
- Documentation is available in the languages defined below. Where documents are in several languages, the percentage distribution is shown (100% = all the documentation).
- The examination is available 100% in the languages shown for each location/each time it is held.

	Lausanne			Lugano	Zurich		
<b>Instruction</b>					X E 100%		
<b>Documentation</b>					X E 100%		
<b>Examination</b>					X E 100%		

**Module Category**

FTP Fundamental theoretical principles

**Lessons**

2 lecture periods and 1 tutorial period per week

**Entry level competences****Prerequisites, previous knowledge**

Basic knowledge in mathematics (introductory lecture in analysis and linear algebra), basic knowledge in probability theory

MS Excel (implementation of formulae, graphs)

**Brief course description of module objectives and content**

In today's rapidly evolving world, infrastructure assumes a crucial role in shaping the way societies function and progress. Roads, railways, bridges, energy grids, machines, and digital networks all contribute to the foundation of modern society. Managing the lifecycle of these infrastructures becomes a critical discipline, ensuring their reliability, sustainability, and adaptability over time. Various stakeholders face complex relationships and goals when making decisions related to infrastructure management. This module introduces students to the multifaceted and strategic aspects of planning, building, operating, and maintaining these essential systems. We discuss established models for analyzing construction and maintenance strategies of technical infrastructures, aiming to develop sustainable measures.

We learn how each phase of infrastructure lifecycle contributes to the overall success and sustainability of infrastructure projects. We first present basic cost-based methods for assessing cost-efficient maintenance and replacement strategies. With the introduction of benefits, we are then able to conduct comprehensive cost-benefit analyses (CBA) - the basis of life-cycle cost analysis (LCC). Life Cycle Assessment (LCA) methods complement these methodologies by focusing on environmental sustainability, energy efficiency, and resilience concepts - challenging aspects of every infrastructure manager today.

In the second part, we introduce fundamental maintenance concepts, including Reliability, Availability, and Maintainability (RAM). We delve into topics such as the behavior of systems and components regarding failure and degradation, as well as the concept of hazard rates. We examine maintenance strategies to provide insights into optimal decision-making and replacement strategies. Additionally, we explore predictive maintenance concepts using Remaining Useful Life (RUL) to maximize asset reliability. We learn about methods that are applied within large asset portfolios, and we explore methodologies like Reliability Centered Maintenance (RCM) and Risk-based maintenance.

## Aims, content, methods

### Learning objectives and competencies to be acquired

- the students understand the function and the benefit of infrastructures, and their effect on society, economy, and environment
- the students are familiar with the challenges for sustainable development of infrastructures and strategic decision-making
- the students are familiar with the most important methods for decision making in infrastructure management
- the students are able to assess the financial viability of potential investments, projects, or initiatives by quantifying their costs and benefits over a specified time frame; including the calculation of Net Present Values (NPV), annuities, and Internal Rate of Return (IRR)
- the students are able to conduct basic cost-benefit analysis (CBA) themselves and they are able to understand comprehensive cost-benefit analyses.
- the students are familiar with the different maintenance strategies (reactive, preventive, condition-based)
- the students know different models of failure and wear behavior, and can apply them
- students know the concepts of reliability theory
- the students are familiar with the method of risk-based maintenance, and can apply this method for maintenance management
- the students are able to apply all those methods in concrete cases; for example the calculation of life cycle costs or socio-economic impact, or the simultaneous minimization of costs and risks.

### Module content with weighting of different components

- Basic concepts
  - introduction into the infrastructure networks of electricity, water, road, and rail
  - concepts of cost and benefit assessment
  - standards for life cycle management
- Infrastructure costs
  - life cycle costing
  - maintenance and replacement strategies for cost minimization
- Assessment methods
  - cost-benefit analyses
  - monetary models of benefit and their limits
  - utility analysis and cost effectiveness analysis
- Basic concepts of Maintenance - RAM
  - Reliability, Availability and Maintainability (RAM) models and calculations
  - Failure and degradation behavior of systems and components, Hazard rate
- Maintenance management
  - Optimal decision making and replacement strategies in maintenance
  - Maintenance management in large asset portfolios
  - Reliability Centered Maintenance (RCM)
  - Risk based maintenance
- Maintenance Strategies
  - Corrective, preventive maintenance approaches
  - Condition based maintenance and approaches to fault detection (Anomaly detection) with multivariate datasets
  - Predictive Maintenance concepts using Remaining useful life (RUL)

### Teaching and learning methods

Lecture: Introduction in the relevant concepts with examples

Exercises: applications and use cases

### Literature

Supplementary publications. No book that we follow

Note: Since part of the module content is based on Swiss standards, some literature is provided in German/French only.

## Assessment

### Certification requirements

Module does not use certification requirements

### Basic principle for exams

**As a rule, all standard final exams are conducted in written form. For resit exams, lecturers will communicate the exam format (written/oral) together with the exam schedule.**

### Standard final exam for a module and written resit exam

#### Kind of exam

Written exam

#### Duration of exam

120 minutes

#### Permissible aids

*Aids permitted as specified below:*

#### Permissible electronic aids

- Laptop (incl. charging cable, mouse), calculator; Moodle access
- Any communication programs (e.g. email, chats, ...) have to be disabled and switched off. Make sure that no communication program is running which might create pop-up windows on your screen.
- Additional devices, like tablets (iPad, etc.), mobile phones, second screens, printers, ear phones, smart watches ... are **not** allowed

#### Other permissible aids

- Open Book - you have basically access to any resource, including online resources (e.g. for translation). However, communication programs are forbidden (see above)
- Course slides and exercises
- Personal notes
- Any other document that has been created before the beginning of the exam, including Excel files or similar.

### Special case: Resit exam as oral exam

#### Kind of exam

Oral exam

#### Duration of exam

30 minutes

#### Permissible aids

No aids permitted