

# **Infrastructure and urban systems**

## **ACE095**

### **Course description 2022**

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**Master Programme Infrastructure and Environmental Engineering**

*Water Environment Technology, Architecture and Civil Engineering*

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The objective of an engineer is to help public and private decision and policy-makers to solve the problems and resolve the policy issues that they face. Engineers do this by improving the basis for decision-makers judgment by generating information and organizing evidence on their problems and in particular, on possible actions that may be suggested to alleviate them. Thus, a systems analysis commonly focuses on problems arising from the operations of a socio- technical system, considers various responses to these problems and supplies evidence about the costs, benefits, and other consequences of these problems. (Keating, 2014)

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## Introduction

Economic growth coupled with increased urbanization, growing population, ageing of infrastructure assets and environmental issues, such as, climate change, are putting pressure on infrastructure demand. To solve this problem, both construction of new infrastructure but also refurbishment, lifetime extension and increased efficiency of current infrastructure stock needs to be made. The demand for infrastructure assets poses multiple challenges throughout their development, for example, planning infrastructure to be resilient to natural disasters, maximizing the efficiency while operating and lack of maintenance.

Additionally, urban areas are shaped by existing infrastructure systems that are also interrelated and interdependent. Infrastructure can enable or constrain the development of cities. Therefore, infrastructure planning and management have to consider societal needs and support a more equal and fair society. This means that knowledge about infrastructure and its connection to urban systems need to be developed with a multidisciplinary approach transcending the common “engineering” perspective. Due to the complexity of the infrastructure systems, there is a need to integrate the stakeholders’ perspectives into the answers that engineers can provide to support the development of infrastructure.

## Course aim

The course will provide advanced knowledge on the role of engineers on planning, design and construction, operation and maintenance and decommissioning of infrastructure with a systems perspective and with focus on urban systems. The students will learn about the challenges and needs of complex interdisciplinary infrastructure planning and management, where different stakeholders will have different objectives and needs.

Students will also learn stakeholders’ relationships in terms of flows of communication, type of information needed and what impact they have on the technical work being developed by infrastructure and environmental engineering students. Additionally, students will learn about trends in infrastructure development, e.g., to be resilient, sustainable and efficient and how they affect complementary infrastructures and urban systems.

Special focus will be given to the main tracks of the MPIEE programme (infrastructure related to water and environment and transportation engineering).

The course also aims at presenting the main concepts about the following concepts, methods and tools: **Infrastructure planning and management, Strategic literature search, Qualitative research, Entity-Relationship modelling and Social network analysis.**

## Learning outcomes

After completing the course, the students should be able to:

- Differentiate between the phases of infrastructure and urban systems (e.g. planning, design and

construction, operation and maintenance and decommissioning), and relate to their connection with the engineering role.

- Demonstrate the relationship between infrastructure, urban system and connected concepts, in particular land, water, transport, energy and waste.
- Describe responsibilities and types of information needed to plan, design, operate, maintain and decommission infrastructure.
- Select and collect relevant datasets related to infrastructure and urban systems.
- Select appropriate strategies for infrastructure and urban systems to make the planning, design and construction, operation and maintenance and decommissioning more resilient, sustainable and efficient.
- Quantify and argue for trade-offs, giving priorities to solutions, and how well they meet both ethical and technical constraints.
- Read and use technical texts and scholarly articles in a conscious, critical and effective manner.
- Apply systematic approaches by taking a holistic perspective.
- Specify the multiple roles that actors have and what type of activities need to be conducted depending on the stakeholder type.
- Work in groups in a multi-cultural international setting.
- Understand the type of information to communicate with different stakeholders.

## Course content and organisation

The course is designed around: lectures on key aspects of Infrastructure and Urban Systems, mainly Transportation and Water; a group project; and an individual assignment. This combination of activities is planned to provide the students with information and to help them develop an understanding of critical issues in the areas of infrastructure planning and management processes.

The course is planned around 5 modules:

**Module 1** include a set of lectures where students will learn about background information on infrastructure

**Module 2** reflects on the challenges faced today in cities and how they affect infrastructure planning and management.

**Module 3** covers the engineering of the infrastructure sectors, focusing on concrete aspects of planning and management within the waste, transportation and water sectors. This part includes exercises done in class.

**Module 4** aims at providing concepts, tools and methods to understand how to describe and analyse infrastructure decision making processes throughout the phases of planning and management. This part includes exercises done in class.

**Module 5** is the assignments module and puts into practice the concepts learned through a case study performed in groups and individually. This part includes a group project and an individual assignment.

## Lectures

A series of lectures on relevant topics will be given to support knowledge development. The lectures should provide basic concepts in specific topics, as well as contextualization for these topics. The lectures will be given by a combination of course and invited lecturers.

- **Course overview, Cities as complex systems, Infrastructure development case study, Group project description, Waste planning and management, Individual assignment guidelines, Social Network Analysis, Systems thinking in infrastructure development and Writing reports guidelines**, Leonardo Rosado
- **Urban Water Management and Transportation planning and management**, Sébastien Rauch
- **Strategic literature searching and Qualitative research**, Divia Jiménez Encarnación
- **City information modelling**, Jorge Gil
- **Multi-stakeholder theories and methods**, Marco Adelfio
- **Future infrastructure development challenges**, Anna Kaczorowska

The lecture slides will be available on Canvas the day before each session. Complementary readings will be available before the lectures.

## Learning style

The assignments are organised as a problem-based learning (PBL) project with focus on a type of infrastructure. PBL is a process that consists of four phases:

- Identification of a problem instead of facts and theories;
- Co-operative identification of skills that need to be learned or developed;
- Self-study to solve the problem;
- Summary and argumentation based on the learned and developed skills.

PBL therefore allows for the students to acquire or extend skills to improve student's knowledge that can be applied in a professional setting.

## Assignments

### Group Project (3,5 credits)

*Supervisors: Leonardo Rosado, Sébastien Rauch and Divia Jiménez Encarnación*

The aim of the project is to understand the complexity of studying an infrastructural system related to an urban challenge. You will work in groups and study a real city.

Each group will study a predefined city within their chosen topic. The case study city has a complex infrastructure system and is addressing several urban challenges, which you will present in a preparation document. The final output of the group work will be a PowerPoint and a summary report, with an overview of the case study city as well as an analysis of the proposed urban infrastructure system model. The PowerPoint presentation and summary report should use the following structure and answer the following questions:

1. **Urban challenge identification:** Define the societal challenge/s you are addressing. Motivate your choice. Connect the challenge to your chosen infrastructure system.

2. **Case study description:** Describe the city in terms of its main characteristics with focus on the chosen infrastructure system and the identified societal challenges. Show figures and numbers.
3. **Infrastructure characterization:** Characterize the existing infrastructure system by detailing its components, according to the three types described in the lectures. You can also provide maps with the infrastructure system.
4. **Build the Entity-Relationship model:** Define the domain activities associated with the urban challenge for the infrastructure system and design a conceptual diagram. Define the system components and establish their relationships. Define the key attributes of the components of the system. Don't forget to include the stakeholders and their relationships.
5. **Data framework assessment:** Based on the Entity-Relationship model defined, identify the datasets needed to fully develop the model. List existing datasets and find ways to gather missing datasets. You can use examples on other cities and existing state-of-the-art technologies for data gathering. You don't need to collect the data but you need to prove the datasets exist.
6. **Model assessment:** Discuss the viability of the developed model. Discuss limitations and assumptions, availability of data, existence of technology to allow for data gathering, among other topics you think can be relevant.

**Mandatory methods to be used:**

1. Use the Physical infrastructure framework to organize the system, be specific to your city and detail it in terms of networks, gateways and hubs and supporting infrastructure;
2. Use the Entity- Relationship framework to formalize the urban infrastructure system characterization.

**Optional methods:**

1. Multi-Stakeholder theories and methods can be used to map out the stakeholders involved and their main interests
2. Social Network Analysis can further describe the relationships between entities

The groups will first deliver a group project preparation document, which consists in a short document in which you will introduce to the supervisor the city and infrastructure you will study. The document should have between 2-4 pages and should contain the following information: urban challenge definition, case study description, infrastructure characterization and a list of links, reports and/or articles (titles), that you used/found with a short summary.

The groups have 2 group project consultation meetings with the supervisors, these meetings are mandatory. The schedule for each group will be provided by the course administrator.

Presentations of the Group Project should be made in English and can be up to 12 minutes. The presentations will be followed by a discussion session where the group needs to answer questions during a 3 min lead by another assigned student group. The discussion lead groups will have to come up with questions based on the presentation. The discussion lead is not graded.

We expect all group members to participate in the presentation seminar, but it is up to the group to decide who does the presentation and who leads the discussion for another group's presentation. The

presentation should be presented both orally and in the format of a PowerPoint. Presenters should be prepared to answer questions from anyone in the audience, not just the discussion lead group. The PowerPoint has to be uploaded in Canvas on the day that the presentation takes place.

The length of the summary report should be maximum 2,500 words (cover page, tables, figures and references excluded) with font size 11 and the document should be uploaded in Canvas with the PowerPoint pdf.

Throughout the group work, the students must submit their work, as specified below.

#### **Group Project Timeline:**

Each student will sign up in Canvas for their preferred TOPIC (between 17:00 07/09/2022 and 12:00 09/09/2022). During the afternoon of 09/09/2022, teachers will inform by Canvas who are the group members (groups of 5 to 6 students will be randomly formed within each topic). Specific case study cities will be assigned randomly to each group.

- Group project preparation document submission: by 17:00 15/09/2022
- Group project draft submission: by 17:00 26/09/2022
- Group project consultations: 19/09/2022 and 28/09/2022
- Group project presentation: 05/10/2022

Groups have to submit the PowerPoint and the summary report through Canvas by 17:00 07/10/2022

#### **Individual assignment (4 credits)**

*Supervisors: Leonardo Rosado, Sébastien Rauch and Divia Jiménez Encarnación*

Each student will prepare a report to address and expand on a specific aspect of their group project. The length should be maximum 2,500 words (include the number of words in your document), excluding abstract, tables and references (General writing guidelines can be found in the Course information module in Canvas. Specific guidelines will be discussed in the lecture **Writing reports guidelines**). Your report needs to work as a stand-alone document.

The aim of the individual assignment is to analyze the decision-making process for an existing infrastructural project. From the city studied in the group work, each student will be studying an existing infrastructural project / solution of their choice. The solution choice is done individually. The objective is not to change the solution, but to understand and evaluate what studies, methods and tools need to be made to implement the project.

Students are expected to use the methods (and justify the use of them!) presented in the lectures, including:

**Mandatory methods to be used:** Strategic literature searching and Qualitative research.

The report should address the topics below:



1. **Select an infrastructural project** - Select an infrastructural project that is planned or implemented in the city you previously studied. Use the summary of group work to present the case study, focusing on the chosen infrastructural solution. Choose a complex infrastructural project.
2. **Identify studies and information** – For the chosen infrastructural project, describe the studies that were conducted. Identify their types, according to the five dimensions of the infrastructure system. Identify the stage in the planning and management process for each study conducted. If needed describe a timeline of studies to properly describe the project.
3. **Analyze similar projects in other cities** – Identify similar infrastructural projects in other cities. List the studies and information that were considered for these projects. Describe similarities and differences to the infrastructural project you chose. Support your findings with a literature search.
4. **Detail the methods and tools used for the technical dimension** – List in detail the different methods and studies made to plan and build the type of infrastructural project you selected. Support your findings with a literature search. Describe the purpose of the most relevant studies/methods that need to be made.
5. **Evaluate the infrastructural project process** – Discuss the existence of relevant information and studies for the infrastructural project in your city. Based on your analyses of other cases, discuss possible improvements and propose recommendations. Motivate your choices.

Use the following methods to obtain information about the decision-making process:

1. Use a Scholarly Information retrieval method and describe all the methodological steps made;
2. Use Qualitative research to: define the research question/s, identify the studies and methods for the infrastructural project type; including other case studies, information gathered, type of dimension.

The students have 2 individual assignment consultation sessions, one optional and one mandatory. Attendance to the optional consultation will be defined by a doodle link. The schedule for each student will be provided by the course administrator. Students must submit their work, as specified below.

#### **Individual Assignment Timeline:**

- Optional consultation: 12/10/2022
- Draft individual assignment submission: by 17:00 14/10/2022
- Mandatory consultation: 19/10/2022

Students have to submit the report through Canvas by 17:00 26/10/2022

#### **In-lecture exercises (Pass/Fail)**

Exercises in class for the lectures on **L05 Entity relationship modelling, L07 Social Network analysis, L08 Urban Water Management, L09 Transportation planning and management, L10 Waste planning and management, L12 Strategic literature searching, L13 Qualitative research**, and have to be handed in. Students can only pass the group project and the individual assignment if they submit their exercises in Canvas. The submission is individual. The exercises purpose is to allow students to practice

on the tools and topics that are going to be done during the group project and individual assignment. Exercises will not be evaluated. Feedback can be provided by the specific lecturers, if asked. You will have 3 weekdays to submit your exercises.

#### Submission of in-lecture exercises timeline:

Thu 15 Sep	17:00	Submit in-lecture exercise L05	Canvas
Mon 19 Sep		Submit in-lecture exercise L07	
Mon 26 Sep		Submit in-lecture exercises L08 and L09	
Thu 29 Sep		Submit in-lecture exercise L10	
Thu 06 Oct		Submit in-lecture exercises L12 and L13	

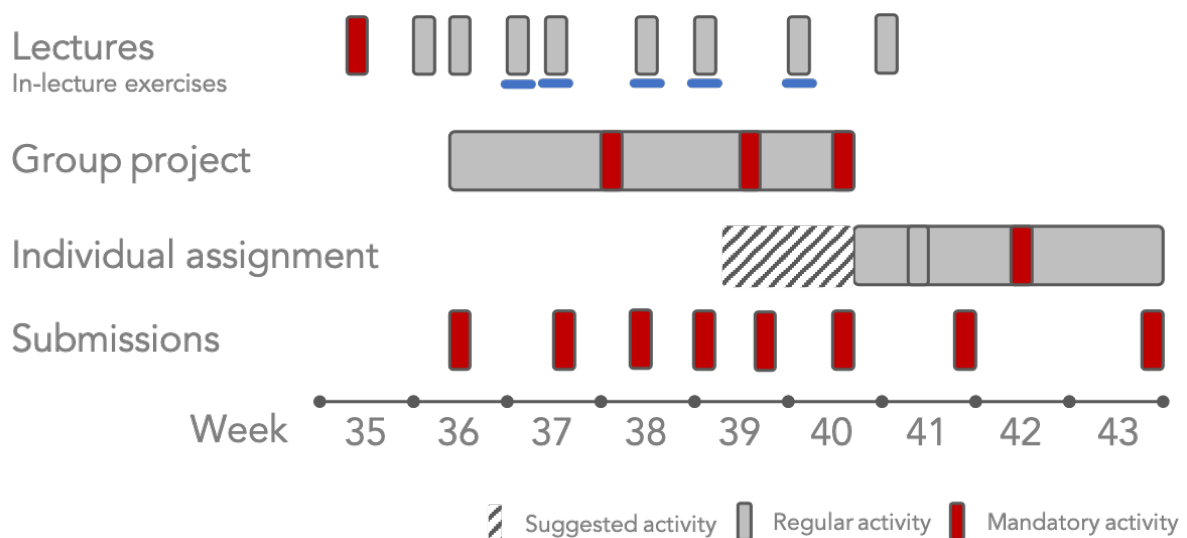
## Literature

Recommended reading for this course will be provided on the Canvas course page. Further information can be found from a variety of sources, including scientific journals (available from the Chalmers library website), books and the internet. Ensure that the information you get (especially from the internet) is reliable.

We recommend the use of scientific databases available on the Chalmers Library website, including Science Citation Index, Scopus, ScienceDirect and Springer Link. Some of the articles and books can be read online.

## Schedule

The schedule for the course is detailed on the ACE095 course schedule pdf file. Below a general description of the activities for the course.



## Communication

We ask for communication between students and teachers is made through Canvas messages or email using Chalmers credentials (Chalmers email). For group work, students should identify a spokesperson that communicates with the supervisor. Teachers will reply to students' enquiries as soon as possible.

## Writing guidelines

### Report writing

For report writing please read “**Writing guideline for reports, BSc theses, MSc theses at Chalmers University of Technology**” (available in Canvas in Course Information module). Number all tables and figures; table notations above the tables, and figure captions below the figures. Refer to all tables, figures and references in the text. Summarise and discuss them in the text and make conclusions from the results. When writing the report, *you must use your own words* (no copy from references) and cite (in-text) the references you use. Follow the Harvard system (author-year) for in-text citation. This means that the author's last name and the year of publication should appear in the text, e.g. “Safe water is key to sustainable development (Jones, 1998)” for one author, (Jones and Smith, 1998) for two authors, or (Jones et al., 1998) for three authors or more. It may also be on the format: “According to Jones (1998), Safe water is key to sustainable development”. A complete reference should appear in the reference list at the end of the report. The complete reference implies that you give the information needed for another person to find that reference (e.g. URL for Internet sources, complete report title, publisher, ISBN etc.).

### Plagiarism

***Direct copying from the Internet, literature or your classmates is strictly prohibited!!***

We verify all assessments via the Urkund system. Urkund controls all documents submitted against three main sources; the Internet, published material, and Urkund archives (e.g. reports from previous years). All documents, which are controlled through the system, are stored in Urkund archives and prevent plagiarism from former and fellow students. For further information, please read the document “Academic honesty and integrity at Chalmers”.

### Assessment and grading

Continuous assessment is the central examination form in this course. Grading is based on the individual assignments and the group work, as described below. All assignments are graded on a scale of 0.0-5.0. The final grade is F (fail), 3, 4, 5 with 5 being the highest grade.

Exercises for lectures on **L05 Entity relationship modelling**, **L07 Social Network analysis**, **L08 Urban Water Management**, **L09 Transportation planning and management**, **L10 Waste planning and management**, **L12 Strategic literature searching** and **L13 Qualitative research** are mandatory, and need to be submitted individually, and are graded only pass or fail. The grade for the group work is the same for all the group members.

Assignment	Component	Percentage of credits	Credits
Group work	Powerpoint	40%	3,5
	Presentation	10%	
	Report	50%	
	In-lecture exercises (L05, L07, L08, L09 and L10)	Pass/Fail	
Individual assignment	Report	100%	4
	In-lecture exercises (L12 and L13)	Pass/Fail	

## Compulsory attendance

Attendance to supervised group sessions and presentations is compulsory and will be verified. If you miss any of these instances, please email the course administrator Divia Jiménez Encarnación and provide a motivation.

You are expected to actively participate and contribute to the group work. Submission of all assignments (Individual assignments, group work, selected exercises) is compulsory and should be done according to the schedule.

## Updates from previous course edition

There has been a minor revision to the order of the lectures, to introduce **Multi-stakeholder methods** and **Social Network Analysis** sooner so it can be used in the group project. The individual assignment was revised as well to focus more on studies and methods related to a type of infrastructural project so the learning can be more focused on what types of activities and work needs to be done to plan, build and manage a complex infrastructural project.