4TU. MSc in Construction Management and Engineering

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CME Information Package

CME Information Package

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Department of the Built Environment
Department of Industrial Engineering & Innovation Sciences

Eindhoven University of Technology

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Introduction

The CME information package includes information about the CME Master program needed to prepare yourself for your new Master at the Eindhoven University of Technology. For graduation a separate document is available entitled 'CME graduation guide'. This information package is prepared for your convenience, however the most up-to-date information can only be found at the university website. Thus no obligations can be derived from this document.

The most important web links where you can find the up-to-date information are:

CME Master program (extranet)
http://www.tue.nl/cme
https://educationguide.tue.nl/gs/cme

TU/e course system (intranet, TU/e account needed)
http://osiris.tue.nl/
http://canvas.tue.nl/

4TU-CME program, including the 4TU-CME study guide:
https://www.4tu.nl/cme/en/

In the Chapter CME Course planning you find guidelines how to plan your individual two year CME Master program dedicated to your personal career and ambitions. These guidelines will also be helpful for filling in your personal study program requested by the TU/e Graduate School.

The CME Information package, the CME graduation guide, and all other information about the CME master program can be obtained through the CME secretariat:

Mrs. Ingrid Dekkers – de Bruijn
Tel: +31(0)402472373
Email: i.m.dekkers@tue.nl
Room: VRT 9.13

CME Master program and Course list

The CME Master program contains 120 ECTS and consists of:
30 Ects Core Courses
35 Ects Specialization Electives
15 Ects Free Electives
40 Ects Graduation

The table shows the relevance of each CME course for the CME related scientific areas.

	CME			Scientific area	
		# Ects	Q	Engineering	Management
	30 ects				
1CM900	Project management	2,5	2		X
1ZM65	System Dynamics	5	3		X
7ZM8M0	Collaborative Design	5	3	X	X
7ZM3M0	Case Study Process modelling	2,5	1	X	X
7ZM5M0	Process Modeling and Information Management	5	4	X	X
7ZZ9M0	Design Science Methodology and Systems Engineering	5	1	X	X
7ZZ6M0	Legal and Governance	5	1		X
	35 ects out of 70 ects				
7ZW7M0	Urban Research Methods	5	3	X	X
1ZM20	Technology Entrepreneurship	5	2		X
1ZM120	Entrepreneurial Marketing	5	2		X
7ZW4M0	Built Environment and Smart Mobility	5	4	X	
7ZM1M0	Research and Development project	10	1-2, 3-4	X	X
7ZW1M0	Big data for urban & transportation analysis /project	10	3-4	X	
7M900	Fundamentals of BIM	5	2	X	
7ZW3M0	Urban Planning II	5	1	X	X
7RC100	Inner-city modular high-rise	5	1		X
7KP8M0	Smart Building Methodology and Technology	5	3	X	
7XC1M0	Circularity in the Built Environment	5	1	X	
7ZM7M0	Parametric design	5	3	X	

CME graduation tracks

For your convenience CME has configured 2 tracks related to the research expertise of the TU/e-CME staff members that are involved in the research program DDSS (dep. Built Environment) or BETA (dep. Industrial Engineering & Innovation Sciences). These tracks serve as a starting point for your personal planning which is explained in more detail in the chapter CME course planning.

Track: City Information Management

Cities are inherently complex and dynamic systems with many different stakeholders and long term policies. Nevertheless, the fast pace of urbanization causes burden on stakeholders and policy makers that are responsible for urban management. The research in urban management focuses on understanding dynamic urban processes and formulating policies on the development of sustainable and resilient cities. Urban management research contributes to socio-economic models that are needed to manage urban systems and forecast spatial effects and financial risks of policy measures by considering the emerging area of urban informatics (i.e. using sensors, gps, apps, location-based social network data for urban systems). Urban informatics utilizes urban Big Data to improve strategies for dynamic urban resource management, to gain insights on urban patterns and processes, to support and make innovations for urban management, public participation and policy analysis.

	Specialization electives	ECTS	Q
7ZW7M0	Urban research methods	5	3
1ZM120	Entrepreneurial marketing - Certificate course Technology Entrepreneurship and Management	5	2
7ZM1M0	Research and development project	10	1-2,3-4
7ZW4M0	Built Environment and Smart Mobility	5	4
7ZW1M0	Big data for urban & transportation analysis /project	10	3-4

	Free electives		
7ZU3M0	Managing place and property	5	2
7LY8M0	Smart cities	5	3
7ZW3M0	Urban Planning II	5	1

Track: Building Information Management

Building Information Modelling (BIM) entails methods and data structures over the whole lifecycle of the building including the construction phase to facilitate efficient and accurate exchange and processing of all information related to the built environment. Information management is crucial for improving the effectiveness and efficiency of the Architecture, Engineering and Construction processes. The lack of integration and co-ordination between actors is a major factor for poor project performance and the overall low productivity index of the whole sector. Standardization of data structures and communication protocols in building modelling and city modelling are needed and should also integrate advanced communication and BIG data mining. A special focus among the on-going research in ISBE lies on how building related data can be connected across knowledge domains both within AEC and its neighboring fields using Linked Data and Semantic Web technologies, information models and structures to allow greater levels of information access and cross-domain interoperability.

	Specialization electives	ECTS	Q
7ZM900	Fundamentals of BIM	5	2
1ZM20	Technology entrepreneurship	5	2
7ZM7M0	Parametric Design	5	3
7ZW7M0	Urban research methods	5	3
7KP8M0	Smart Building Methodology and Technology - Certificate course Building Design & Technology	5	3
7ZM1M0	Research and development project	10	1-2,3-4

	Free electives	ECTS	Q
7RC100	Inner-city modular high-rise - Certificate course Construction Technology	5	1
7ZU4M0	Econometric analysis of housing markets: data, tools and strategies	5	1
7XC1M0	Circularity in the Built Environment - Certificate course Circular Design in the Built Environment	5	1

CME Course descriptions (excl. free electives)

1CM900 - Project Management

Learning objectives

- Being able to characterize a project aiming at the realization of a physical product in terms of the dynamics, the variability and the stochasticity of the project targets, the activities be performed and their precedence relationships. The available resources and the time cost budget constraints.
- Being able to analyze the possible result of a project as function of its targets, its activities and the deployment of resources over time.
- Being able to evaluate the possible contribution of advanced decision making methods to improvements in project performance.

Contents

Planning work activities, costs and budgets, activity scheduling (PERT/CPM), resource allocation, and project execution (information requirements and control).

1ZM65 - System Dynamics

Learning objectives

Accelerating economic, technological, social, and environmental change challenge managers and policy makers to learn at increasing rates, while at the same time the complexity of the systems in which we live is growing. Many of the problems we now face arise as unanticipated side effects of our own past actions. All too often the policies we implement to solve important problems fail, make the problem worse, or create new problems. Effective decision making and learning in a world of growing dynamic complexity requires us to become system thinkers to expand the boundaries of our mental models and develop tools to understand how the structure of complex systems creates their behavior.
This course introduces you to system dynamics as a tool for analyzing and modeling complex business problems and strategies. System dynamics is a perspective and a set of conceptual tools that enable us to understand the structure and dynamics of complex systems. System dynamics is also a rigorous modeling method that enables us to build formal computer simulations of complex systems and use them to design more effective policies and organizations. Together, these tools allow us to create management flight simulators microworlds where space and time can be compressed and slowed so we can experience the long-term side effects of decisions, speed learning, develop our understanding of complex systems, and design structures and strategies for greater success. (Sterman, 2000, pp. vii)

After taking the course students are able to:

- Create awareness of how the structure of business systems creates their behavior and performance;
- Understand how well-meant policies often inadvertently create business performance issues, rather than solve them;
- Develop simulation models of business systems
- Calculate behavior of basic systems;

Contents

In the first lectures of the course we will deal with a variety of subjects related to systems thinking, like: policy resistance, positive and negative feedback, bounded rationality, misperceptions of feedback, fundamental

modes of dynamic behavior (exponential growth, oscillation) and causal loop diagramming. Then, we will focus on system dynamics modeling, by dealing with stocks and flows diagramming, the mathematical relation between stocks and flows (integration and differentiation), delays, modeling human behavior and modeling supply chains.
Also, students will perform a group assignment in which a system dynamics model is developed based on a case description of business processes. With this model, students will replicate the behavior of the business processes, understand the causes of this behavior, and simulate scenarios to improve the performance of these processes.

7ZM8M0 - Collaborative design

Learning objectives

After the course a student:

- Understands the different roles in a building project and knows how to manage these
- Can write a project management plan using SE
- Can monitor a collaborative design process
- Can evaluate the product and process performance in a collaborative design project
- Understands group dynamics and act accordingly
- Can apply his/her expertise in a collaborative design project
- Can apply Design and Engineering tools in a collaborative design project
- Can write a scientific paper upon challenges in collaborative design
- Can use SE and BIM management tools in a collaborative design project

Contents

The objective of this course is to gain insight in the problem domain of Collaborative Design with special attention to Systems Engineering (SE) and Building Information Models (BIM).
A consortium of companies will work on a design assignment for one semester. A student is member on one of the following companies: Architects, Urban designers, and Engineers. A company consists of 4 persons with one person as Chief Executive Officer (CEO), one Systems Engineering Officer (SEO) and the other two as domain experts. The consortium management consist of all CEOs and SEOs from all companies. The project starts with writing a project management plan. Following the design is created between the companies while monitoring and evaluating the progress. In this process the application of SE and BIM techniques and tools is compulsory. Consortium management is tutored by the teachers in weekly sessions. Finally the design is presented, a report is written about the design process, and an individual scientific paper as a contribution to the Collaborative Design research and development.

7ZM3M0 - Case study process modeling

Learning objectives

After the project, the student is able to:

- Select relevant information for the case study
- Identify the involved stakeholders' interests
- Specify the process phases
- Apply appropriate qualitative methods for analysis (e.g., Isikawa diagram, stakeholder power/interest grid, SWOT, creating action plan, etc.)

- Identify strengths and weaknesses of the process
- Provide recommendations for process improvement
- Write an academic report

Contents

Executing analysis for the process of a complex development project in the context of Construction Management and Engineering.
At first a real complex development project challenge is identified. The information related to the project is introduced by the involved company, students are required to use appropriate methods for analysis.
Next, students are required to search all the necessary information online with similar projects using relevant selection criteria and use appropriate methods for comparison analysis and draw conclusions.
The case study focuses more on the soft side of the process in terms of understanding the nature of interaction between involved stakeholders and decision making on projects within an uncertain and dynamic social, political and physical environment.

7ZM5M0 - Process modeling and information management

Learning objectives

After the project, the student will be able to:

- have a multi-scale understanding of the built environment from city to building level regarding the development project.
- construct the geo-process model to do spatial analysis (e.g., the site selection) for the development project.
- analyse decisions making under uncertainties and develop optimization models under constraints.
- apply information management tools in the building process.

Contents

This course is about analyzing problems, optimizing processes and managing information flows in the context of urban development projects from city-scale to building level.
This course consists of three interlinked modules, which sequentially cover the three key topics (Geo-process models for location selection, decision making under uncertainty and optimization models, information management tools in the building process.). All three modules are linked to a hypothetical new development in a specific city. You can select a development type and a city in the Netherlands of your liking. The development types include a residential building (e.g. apartment complex), a retail centre (e.g. mall), a hotel building or an office building.

7ZZ9M0 - Design Science Methodology and Systems Engineering

Learning objectives

After the course a student:

- Understands the basics of Design Science Methodology
- Can apply Design Science Methodology to research problems in the domain of Architecture, Engineering, Construction and Operation (AECO)
- Understands the basic Systems Engineering (SE) principles
- Can apply SE principles in the domain of AECO project management

- Knows how to use Building Information Modelling (BIM) to support SE

Contents

Design Science Methodology' (DSM) focuses on design-science research approaches and science-based design approaches, both aiming to link science and design. A design-science research project aims to develop design knowledge; a science-based design project aims to design an artefact, thereby applying scientific design knowledge. Design science methodology offers also a systematic approach to link knowledge and skills obtained in other courses to practice. Science develops knowledge about what already is, whereas design involves human beings using knowledge to create what should be, things that do not yet exist. Design, as the activity of changing existing situations into desired ones, therefore appears to be the core competence of all professional activities. DSM in this course is applied to research problems in the domain of Architecture, Engineering, Construction and Operation (AECO). For the management of AECO projects, Systems Engineering principles are applicable. Systems Engineering is a well-known method also from practice for structuring complex (design) projects. Structuring the design data and the design process allows for better project management and better quality maintenance. Building Information Modelling is a technique for generating and leveraging building data to design, construct and operate the building during its lifecycle. BIM allows all stakeholders to have access to the same information at the same time through interoperability between technology platforms. With a proper knowledge, BIM techniques can support Systems Engineering methods.

7ZZ6M0 - Legal and governance aspects

Learning objectives

- recognize important aspects of the institutional framework of the construction process and the governance modes that develop within this framework;
- recognize relevant legal aspects (within different phases) of the construction process and analyze these in the context of public and private institutional frameworks;
- estimate, analyse the weight and complexity of these aspects;
- develop ideas to deal with these aspects and provide solutions for problems or conflicts resulting from these aspects in accordance with the fundamental positions of the public and private sectors;
- evaluate options and solutions presented by legal experts.

Contents

This course is about legal & governance aspects of the construction process, especially the institutional legal & framework settings concerning the major players and the main interests concerned. Legal aspects mainly rest in limitations and possibilities created by the legal system, as a context for interactions within and across the public and the private sector boundaries, during the complete life-cycle of the construction process. The relevant legal and institutional frameworks and their underpinnings will be explained and analysed and put into the perspective of 'real-life' problems. Insight into legal reasoning, as a specific methodology, will be practised through the use of legal literature and jurisprudence. The main course topics will deal with both public and private law. The place and position of the future graduate in the construction process will serve as a guideline in the selection of these topics.

7ZW7M0 - Urban research methods

Learning objectives

- Students are able to to develop a conceptual model for a given research problem and make choices in determining a research design
- Students can apply the principles of state-of-the-art models and techniques for urban research and know how to apply them. The techniques considered include advanced regression analysis (including path analysis), discrete choice modeling, stated choice experiments, multi-criteria analysis techniques and research methodology.

Contents

In this course students learn core research and evaluation methods for urban planning/management. The focus is on quantitative methods and evaluation techniques. The following topics are covered:

- Decision processes in urban planning and management
- Developing a conceptual model for a research problem
- Data analysis and modeling techniques
- Regression analysis
- Discrete choice modeling (incl. stated choice experiments)
- Evaluation techniques for decision making
- Research methodologies.

Research methods are relevant in the first stages of the decision process where the aim is to generate knowledge about a problem or possible actions. Evaluation techniques are relevant in the last stage where the aim is to determine a preference ranking of action alternatives. The techniques are explicitly positioned in a decision process model.

The course consists of a series of lectures and literature study. Each lecture is complementary to the literature studied and accompanied by a practical where the students apply the theory to a case.

1ZM20 - Technology entrepreneurship

Learning objectives

The aim of this course is to develop your awareness, understanding and application of flexible and adaptive decision-making approaches along with more familiar prediction and planning-based methods for decision making in the face of uncertainty in new business development based on new technology.

Consequently, at the end of this course you should be able:

- To distinguish flexible and adaptive decision-making logics as used by expert entrepreneurs from the prediction and planning-based approaches (i.e. traditionally accepted business management practices) and argue their application under different contingencies.
- To master the techniques that enable you to spot or create new business ideas.
- To validate and adjust a new business idea in the market (i.e. is an idea a real opportunity?) by assessing and incorporating the feedback from different stakeholders.
- To use flexible and adaptive (i.e., action-based) approaches to new business development.
- To assess yourself with respect to flexible and adaptive decision-making logics as opposed to prediction and planning-based approaches and reflect what factors helped or hindered you in flexible and adaptive approaches.

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Entrepreneurship is a unique type of creative problem solving process that transforms an idea into an enduring and effective institution in the real world (either on your own or as part of an existing organization). Entrepreneurs not only bring together products and markets, but often also create the products and markets as part of the new business development process.
Throughout this course, you will learn to apply flexible and adaptive approaches towards decision making in new business development along with more familiar planning and prediction-based approaches. Using adaptive and flexible approaches (like effectuation), entrepreneurs take small organic steps during their decision making process and apply validated learning approaches as a way to deal with uncertainty. Accordingly, the intellectual content of the course is centered on the notion of "Validated Learning", defined as an iterative learning process of trying out an initial idea, measuring it to validate the effect and incorporating the lessons learned into the succeeding test (Ries, 2012).
The main deliverables in the course are focused on identifying and testing the key factors that help you decide if a (technology based) idea is a real opportunity and validate and adjust the idea in the market. Therefore, identifying, defining, and understanding the market and all relevant stakeholders is a cornerstone of the course. Equally important, however, is investigating whether the idea is an opportunity for you. To answer that, you need to understand who you are and what you want, particularly in relation to the idea and the decision making process needed to further develop this idea. This course is designed to help you do that through a thoughtful and active exploration of the decisions you will make and the experiences you will encounter in pursuing an idea to its fulfillment.

1ZM120 - Entrepreneurial marketing

Learning objectives

To provide students with knowledge of how to bridge the marketing discipline and the entrepreneurial field.
To provide guidelines and tools to deal with entrepreneurial side of marketing:

- conjoining and coping with market and technology uncertainty
- network effects
- assuming calculated riks
- being proactive
- offering attractive innovations relative to competitors

To provide guidelines and tools to deal with the marketing side of entrepreneurship:

- lack of economies of scale
- limited resources
- limited market presence and brand image
- decision making with limited information

Contents

Lectures and topics (see study guide for final programme)

- Introduction to marketing-entrepreneurship interface
- The technology adoption life cycle (TALC)
- The entrepreneurial marketing plan

7ZW4M0 - Built environment and smart mobility

Learning objectives

After a successful completion of this course, students will be able to:

- Explain the relation between transportation, land use and urban development.
- Identify the major urban mobility issues in relation to its effects on the quality of life, environment, health and well-being.
- Discuss the potential of urban planning and design solutions, smart mobility solutions and their integration in mitigating urban mobility issues.
- Assess the implementation of Transit-Oriented Development (TOD) in existing urban areas using available measurement tools.
- Propose (innovative) integrated approaches for the future of urban accessibility and mobility using scientific literature as a primary source.
- Given the principles underpinning the concept and ecosystem of Mobility as a Service (MaaS), critically examine the bottlenecks and success factors of MaaS implementation and its societal, behavioral and environmental effects using case studies.
- Analyze the relationship between accessibility and real estate using relevant theories and methods of transport and land use interaction.
- Explain the underlying principles and limitations of the four step model compared to an activity-based model and apply it for travel demand forecasting

Contents

This course deals with analyzing the interdependencies between transportation and various aspects and components of urban systems. Application of models to support transport-related design and decision processes in urban design, planning, real estate and transportation, considering:

- The complex interdependencies involved
- Effects on the environment, functioning of the system and quality of life
- The reason for success or failure of adopting smart (shared) mobility from demand and supply perspective.

The following topics will be dealt with:

- Built Environment and Transportation: relations between transportation, land use, urban design and real estate; activity-based analysis as integrated framework.
- Transportation, environment and quality of life: activity travel patterns and energy consumption, emissions and exposure; mobility; well-being.
- Urban form and travel: Space Syntax; models of pedestrian flows; walkability indices.Real estate, accessibility and transportation: concepts of destination and reach; measurement of accessibility; cumulative opportunities; gravity measures; space time prisms; consumer surplus; empirical studies on impact of accessibility on land and property values and the impact of parking in office and shopping center developments.
- Smart mobility: more capacity vs. better use; developments in travel information; effects of travel information on activity travel patterns; new technology and smart grids.
- Mobility as a service (MaaS), challenges, progress and prospect.
- Models of transport demand: the 4 step model; activity-based models (constrained based models, utility-maximizing models, computational process models).

7ZM1M0 - Research and development project

Learning objectives

At the end of the project, the student is able to:

- Identify a research challenge
- Specify a research goal
- Select the appropriate state-of-the-art methods or techniques
- Execute a method or implement a technique
- Evaluate the results
- Write a scientific report

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Executing a Research and Development project for a specific case in research areas of Energy Neutral Cities, Urban Management and Building Information Modeling within the Smart Cities concept.

Firstly, a research problem and/or development is identified by each student. These research and/or development problems can follow from an on-going research in the DDSS (Design and Decision Support Systems) research program, but also from society or industry. In the given time frame, research goals and criteria are specified to solve the defined research problem. To reach the goal, research and development methods/techniques are selected that are not yet known by the student, but are relevant for the student's education. These methods/techniques are the state-of-the-art in DDSS research such as Discrete Choice Analysis; Regression Analysis; Bayesian belief networks; Building Information Modeling; Geographical Information Systems; Linear Programming. In addition, Information Systems Lab facilities (such as virtual reality lab and 3D printer) are available to support the experiments of students. With support from the staff, these new methods/techniques are learned by doing. The results should be interpreted by the student taking into consideration the pre-defined criteria. Finally, a scientific report is written that reflects upon the achieved results.

7ZW1M0 - Big data for urban & transportation analysis/project

Learning objectives

After completion of the project the student is able to:

- Formulate a research question for a problem in urban planning
- Identify a suitable analysis technique for the research question concerned
- Carry out all the steps involved in the chosen methodology
- Assess various future planning scenarios and identify implications for planning
- Judge the limitations of the carried out research and identify remaining problems for future research.

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To find good solutions one need to have a good understanding of the problem. This holds true also for the problems urban planners are facing in areas such as mobility (congestion and accessibility), health (air pollution, passive life styles), energy (smart grids and transformation to renewable sources of energy), ageing (social exclusion, social satisfaction), and tourism (crowding). In this project you consider a planning problem of your choice and apply a suitable approach to better understand the problem and evaluate scenarios.
The approach includes Information from a big database such as GPS data, Twitter data or one of the large

(inter)national data collections that provide rich information on micro-level of individuals. In this approach an existing database, or combination of databases is analysed to achieve a better understanding of behaviour of individuals with regard to the planning problem considered. During the project the following steps will be carried out: formulation of a research question; literature research; specification of a conceptual model; identification of relevant variables; preparation of the data; performing the analysis and interpreting the results. The analysis technique and database used will be chosen depending on the research question. The emphasis is on advanced techniques from the field of either regression modelling (e.g., path analysis) or data mining (e.g., Bayesian network learning).

7M900 - Fundamentals of building information modeling

Learning objectives

At the end of the course:

- Students can apply the basics of the visual modelling language UML and ER for conceptual data modelling.
- Students can describe, interpret, and use existing modeling and information exchange standards used in Building Information Modelling, including primarily the Industry Foundation Classes (IFC).
- Students understand the use of BIM in practice.
- Students can understand, use and apply XML and XSD for representing data in a hierarchical data model.
- Students can understand, use and apply Relational Databases (MySQL) for representing data in a relational data model.

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This course is of importance to everyone handling building information in practice, developing novel ways to address current and future challenges in ICT-supported collaboration in building and construction and doing fundamental research in the field. In particular, BIM has become a generally accepted method in the construction industry including civil engineering and building services. Through BIM processes and BIM tools, one is able to represent building information in a comprehensive model and exchange all building information with peers in the building life-cycle. BIM models are nowadays created for different purposes with different aspects for a wide range of applications throughout the lifecycle of buildings, ranging from simple geometric models to detailed building component specifications. In this course, the student is introduced to various data and information modelling techniques of use in combination with mainstream BIM tools and processes. The course starts with an introduction to BIM and to the conceptual modelling language UML. UML can be used to specify interaction diagrams as well as information management diagrams and thus is a crucial tool for the data scientist. Furthermore, several very different data modelling and information modelling techniques are taught in detail, including XML/XSD, relational databases (MySQL), EXPRESS and IFC, and graph databases (Neo4J, RDF, OWL). The student learns to use and apply each of these data modelling techniques through practical and relevant construction-related examples and assignments. The final assignment and lectures teach the student how to use these data models and techniques in state-of-the-art software development environments, using Python as a reference scripting language.

7ZW3M0 - Urban planning II

Learning objectives

After completing the course, students are able to assess the qualify and viability of retail facilities and public services in an existing urban area. In addition, students will be able to suggest how to improve the situation.

Furthermore, students will be able to forecast population and quantitative housing demand and they will have knowledge about and some experience in models describing the development of urban areas. Finally, students will have basic knowledge about the organisation of spatial planning in the Netherlands and other countries.

Contents

The course starts with a short introduction into spatial planning in the Netherlands and other countries. The next part deals with planning retail facilities and public facilities, both in terms of supply and demand. Retail facilities will be discussed at the level of urban areas and at the level of shopping centres. Small groups of students compare and assess facilities in different urban areas. Transport oriented development will be discussed as well. The last part of the course is about predicting the development of urban areas. Methods to predict the size and composition of the future population and the corresponding housing demand, as well as so called land use models are introduced. Students will gain experience with such methods and models.

7RC100 - Inner-city modular high-rise

Learning objectives

The aim of the course is to become familiar with the tender process of a construction project.
At the end of the course the student:

- Can describe the diverse types of procurements, understands the differences and is capable to judge if a type of procurement is used in the right manner in the right project.
- Understand options and solutions presented by legal experts

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Inner-city Modular High-rise (previously known as 'Procurement') is one of the three courses that together form the Construction Technology certificate program. The course addresses the issues of tendering, design and realization from a contractor's perspective, by describing the total process of a project. In addition to the relevance of social elements such as environment, circularity, structural design, costs, planning & logistics, and safety with the associated responsibilities. There is also attention for cooperation from the various disciplines in a construction process in order to ultimately making the difference.

7KP8M0 - Smart Building Methodology and Technology

Learning objectives

At the end of the course the student:

- will develop a knowledge and understanding of different recognized building principles, building methodologies, and design and evaluation approaches (e.g. sustainable building, energy concepts, building performance, building automation, adaptable buildings, and emerging technologies); and will learn to apply them critically according to the challenge presented.
- will gain insight into the application of emerging technologies behind various design and research approaches, building principles and methodologies
- will acquire the skill to apply and integrate different methodologies and technologies into complex problems faced by the building industry
- will learn to define and evaluate critically their own concepts and designs in a methodological manner
- will gain experience working in multi-disciplinary fields (in real-life projects)

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Nowadays, technology advances at high speeds and designers are faced with new technologies which applications are not always clear. On the other hand, the building industry is facing important challenges to meet climate agreements, while still providing comfortable and heathy buildings at realistic costs. This course aims at expanding the intellectual horizon of students regarding the application of emergent building methodologies and technologies to meet problems faced by our society. To achieve the objectives of this course, the theoretical approaches and building principles, outlined in the weekly lectures, are reinforced by their application in real-world problems. For example, by applying AI-based solutions to design and develop smart cities and new housing typologies and using user-centered methodologies to understand real-life problems. The lecturers will provide an overview of recognized building principles, methodologies, concepts and approaches, and will discuss the application of state-of-the-art of technologies in architectural design. Also, some scientific research methods will be explained. Every week has a specific theme on which the lecture and the weekly assignment will be adjusted.

7XC1M0 - Circularity in the Built Environment

Learning objectives

After successful completion of this course,

1. You have a critical understanding of the systemic problems of circularity, and how the need for ecological resource management relates not just to design and technology, but also to economic models, habits and arrangements; growth and consumption; population; mindset and behavior.
2. You have a critical understanding of design and technology assessments (e.g. Life Cycle Analysis, Circularity Indicators, MAXergy, UH+) and what they do (and do not) measure; you can use these to evaluate design proposals and decisions.
3. ou have a critical understanding of how design and technology on the levels of spatial planning, building, product and material can (and cannot) contribute to solving the problems; you can use this knowledge to make effective circular design proposals.
4. You can synthesize the lessons learned in a conclusion and then develop your own meaningful follow-up research questions, from various disciplinary angles.

Contents

This course introduces first of all circularity as the problem of planetary (resource) management, with a central role for rates and planetary boundaries. Energy, materials, waste and emissions are studied separately and in cohesion. Then we explore the idea of a circular economy, highlighting 21st century attempts to (re)define boundaries, “progress” and “costs” and consider fair distribution. We will study and exercise various circularity and sustainability assessments. After this broad introduction we move on to the built environment and zoom in from large to small. What does circularity mean for planetary and urban spatial planning? How to design circular buildings on conceptual and technical level? How to redesign the numerous existing buildings that were not designed with these considerations? What is a circular product or component? And how to select materials? What should we know about their impacts, their availability, their mining and their recycling? After exploring these issues, you are asked to define 3 personal research questions in the domains of technology, economy and humanities

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7ZM7M0 - Parametric design

Learning objectives

In this class, computational design methods and technologies are taught, thereby enabling designers and engineers to generate, analyze and optimize built structures on various levels of detail and at different planning and design stages. Use cases and application fields include:

- Iterative and/or interactive form-finding for the building envelope in the early architectural design stages, e.g. through the creation of design variations,
- Analysis and optimization of individual building components and assemblies based on requirements and optimization goals from the areas of structural design or building physics, or other engineering domains that should be tightly integrated into the design process.
- Creation and simulation of reactive and adaptive building components such as dynamic facades etc.
- Integration with (digital) manufacturing techniques, with a focus on making sure that whichever parametric design can also be built in practice, thereby using the latest tools and techniques available in the manufacturing industry.

Contents

In this class, computational design methods and technologies are investigated that enable designers and engineers to generate, analyze and optimize built structures on various levels of detail and at different planning and design stages. Use cases and application fields include:

- Iterative and/or interactive form-finding for the building envelope in the early architectural design stages, e.g. through the creation of design variants,
- Analysis and optimization of individual building components and assemblies based on requirements and optimization goals from the areas of structural design or building physics, or other engineering domains that should be tightly integrated into the design process.
- Creation and simulation of reactive and adaptive building components such as dynamic facades etc.

The common underlying conceptual approach is the notion of parametric objects that are generated, modified and mutated mainly with respect to their geometry and spatial arrangement. To allow high flexibility combined with the precision required e.g. for automated fabrication processes, advanced, parametric geometries such as Non-Rational Uniform B-Splines (NURBS) are introduced.

Next to one long project assignment (groups), there are individual assignments which are dedicated to specific techniques in parametric design (e.g. optimization; parametric variation).

CME Course roster

CODE	Q1	ECTS	CODE	Q2	ECTS
7ZZ9M0	Design Science Methodology and Systems Engineering	5	1CM900	Project management	2,5
7ZM3M0	Case study process modelling	2,5	7M900	Fundamentals of BIM	5
7ZZ6M0	Legal and governance aspects	5	1ZM20	Technology Entrepreneurship	5
7ZW3M0	Urban Planning II	5	1ZM120	Entrepreneurial marketing	5
7XC1M0	Circularity in the Built Environment	5			
7RC100	Inner-city modular high-rise	5			
7ZM1M0	Project: Research and Development				10
7CC40	Graduation				40

CODE	Q3	ECTS	CODE	Q4	ECTS
7ZM8M0	Collaborative design	5	7ZM5M0	Process modeling and information management	5
1ZM65	System dynamics	5	7ZW4M0	Built Environment and Smart Mobility	5
7ZW7M0	Urban research methods	5			
7KP8M0	Smart building methodology and technology	5			
7ZM7M0	Parametric design	5			
7ZM1M0	Project: Research and Development				10
7ZW1M0	Big data for urban & transportation analysis /project				10
7CC40	Graduation				40

Core course

Specialization elective

CME Course planning

In general the priority in which you make your individual CME course planning is:
1. Core courses (at the TU/e)
2. Specialization electives (from the TU/e, TUD, or UT)
3. Free electives (from the TU/e, TUD, or UT)
4. Academic skills (at the TU/e)
5. Graduation (at the TU/e)

The core courses are followed at the Graduate School of the TU/e. If you choose from the specialization electives of the CME course list (35 out of 70) then your individual CME course program will receive positive advice from your mentor by default. You can also select Specialization elective courses from the other – non-CME – Master programs at the Eindhoven University (TU/e) and from the 4TU-CME Master programs of Delft University (TUD) or University Twente (UT) (see 4TU-CME study guide at CME website, or ask a copy at our CME secretariat). In the latter case you need advice from your mentor because he/she will maintain coherence in your individual CME course program. The same non-CME TU/e and 4TU-CME TUD/UT Master programs are available for the Free elective courses but for these courses you don't need your mentors' advice. If you want to follow courses at TUD or UT, you need to be enrolled in their program as well. Ask our CME secretariat for help if needed. Obviously if you follow courses at TUD or UT this usually involves traveling or moving temporarily. Therefore you need to make your own arrangements. However, 4TU-CME also offers on-line courses (see Chapter on page 27). Language courses are only allowed at level C as Free elective course at a maximum total of 5 ECTS (see TU/e Language Center at TU/e website: https://educationguide.tue.nl/career-skills/language-courses-and-academic-writing-skills/?L=2, contact: languagecenter@tue.nl). In all cases your individual CME program needs finally to be approved by the Examination Committee of the Department of the Built Environment.

To ensure that every CME student has learned sufficient academic research methods you must choose at least one of the following courses as a specialization elective:
7ZM7M0 Urban research methods
7ZM1M0 Research and development project
7ZW1M0 Big data for urban and transportation analyses

The TU/e Graduate School highly promotes students to visit a foreign university as part of their internationalization. International experience matches also with the nature of the TU/e CME Master program. Internships give students an opportunity for an orientation in the professional field. Even the combination of internationalization and internship is possible but all within certain conditions that you need to check with your mentor. How to plan your international courses and internship is explained on more detail in the next Chapter.

From experience we know that dependent on their prior Bachelor, students might face a lack of academic skills, especially scientific writing. We advise you to overcome this legacy as soon as possible, because writing scientific reports comes back in many CME courses and is often also part of the grading. There is no regular course on scientific writing, however the TU/e offers the Skillslab (https://skillslab.tue.nl/guided-learning-academic-writing-skills) with on-line courses that you need to follow in your own time. We strongly advise you to at least follow the modules: Guided learning for thesis writing, and Guided learning for organization and structure at section level. Secondly, students sometime also lack basic research skills. In the CME program you will learn advanced research methods and techniques, but you can only understand these, if you already know

the basics. For a good introduction into the basic research skills for CME, the 4TU prepared a series of on-line movies: https://vimeo.com/channels/rmas/videos. We advise you to watch these movies at an early stage of your CME master program. Accordingly we advise not to take the course Research and Development (7ZM1M0) in the first semester of your Master program, unless you already have profound CME research skills or unless you aim to focus on acquiring programming skills in this course.

CME Graduation consists of two parts: (1) Research proposal, and (2) Graduation project. Normally speaking, if you aim to complete your Master study in two years, you will register for your Graduation at the beginning of the second year of your CME Master. Graduation can be started every Quartile. For more information about your Graduation please refer to the 'CME Graduation guide'.
Your individual CME course program should constitute a coherent Master program that is in line with the CME Master learning goals. Therefore you should start by determining your personal ambitions. Ask yourself what type of career you want to pursue. With that in mind you can determine the subject of your graduation project and the courses you need to follow to be prepared. The career perspectives for a CME student are very wide, and were very good right from the start. First of all you must decide if you want to pursue an academic or professional career. Students that pursue an academic career will opt for a PhD position at any university around the world, with a suitable research topic. Students that pursue a professional career, typically find jobs at the following companies: Engineering Consultancy offices, Governmental institutes, Start-Ups, and Contractors. Because these are complex but nevertheless important decisions you get help from your CME mentor. Your mentor might advise negatively about a specific course if it does not fit the TU/e-CME expertise Construction Management and Engineering. To learn more about the TU/e CME Graduation topics, you can check the CME graduation guide.

A typical planning of the CME master program is presented in the tables below. In the first year you follow compulsory and specialization elective courses. In the first semester of the second year you follow the remaining courses and already start working on the research proposal for your graduation. Dutch students follow courses this semester at a foreign university, international students follow courses at the TU/e. During the last semester you will work on your graduation project.

Course planning Dutch students

	Quartile 1	**Quartile 2**	**Quartile 3**	**Quartile 4**
Year 1	Courses	Courses	Courses	Courses
Year 2	Research proposal Int. Courses	Research proposal Int. Courses	Graduation project	Graduation project

Course planning International students

	Quartile 1	**Quartile 2**	**Quartile 3**	**Quartile 4**
Year 1	Courses	Courses	Courses	Courses
Year 2	Research proposal TU/e Courses	Research proposal TU/e Courses	Graduation project	Graduation project

Make a course planning for the whole 2-year's CME Master preferably before you start. You should plan minimum 15 ECTS per Quartile, but it is better to keep a safety margin (2,5-5 ECTS more) in case you fail for a course. You will be appointed a mentor after you entered the CME program. If you want contact with a CME mentor before you start, then ask the CME secretariat to arrange an appointment.

To support you in planning and managing your CME Master program, you will be assigned a mentor shortly

after the start of your study. The mentoring procedure consists of two stages.
Stage 1: Student and Mentor meet within 6 months after enrollment of the student.
Before the meeting:

- Student has written a personal study plan (PSP).
- Student has written a personal development plan on professional skills.
- If internationalization is part of the PSP: the student has contacted the coordinator International Experience.

After the meeting:

- Student submits his/her provisional PSP through the department's student administration to the Examination Committee.

Stage 2: Student and Mentor meet directly after the Graduation kick-off and before he/she starts writing the research proposal. During the meeting Student and Mentor discuss if the PSP needs to be adjusted. When needed Student submits his/her updated, definite PSP through the department's student administration to the Examination Committee.

Finally, if you encounter any problem (other then programmatic problems) before or during your study you can seek help from Education and Student Affairs (ESA): esa.be@tue.nl.

Internationalization and Internship

Internationalization

The TU/e Graduate School strongly promotes Internationalization, but this does not apply to foreign students since they already have international experience. For Dutch CME students this usually means that you will visit a foreign university for two Quartiles and follow at a total of minimal 15 ECTS courses that you will count as Free electives in your individual CME course program. Contact our student exchange officer Mrs. Houben (h.a.m.houben@tue.nl, VRT 2.12) for a list of universities with an exchange agreement with our department. Indicate your preferences by sending an e-mail to Mrs. Houben before the following internal deadlines: March 1 for exchanges in TU/e semester A, September 1 for exchanges in TU/e semester B.

Whether you can actually go depends on many factors such as: available seats, available courses relevant to CME, etc. Because of the complexity you need to make arrangements already halfway the first year of your CME Master. Usually while following courses at another university you will also write your Research Proposal for your Graduation project. You will do that together with your anticipated first supervisor (see CME Graduation guide for more details). When you return back to TU/e after two quartiles, you have two quartiles left to complete your Graduation project. For help in organizing your internationalization contact your CME mentor and discuss how to include this in your Personal Study Plan.

Internship

One of the courses you can follow as a Free elective is an internship, but it depends on your personal ambitions if this should be part of your CME program. Three types of internship are offered:

1. Academic Work Experience (7ZAWE0), (15 ECTS)
2. Relevant Work Experience (7ZRWE0), (5 ECTS)
3. Internship as part of Graduation, (0 ECTS)

On top of the conditions that are set by the Department of the Built Environment, the CME Master program imposes for internship type (1) and (2) the following conditions:

Dutch student:

5 ECTS nationally allowed; discuss your internship-plan with your CME mentor

15 ECTS nationally is not allowed

5 ECTS abroad is allowed; discuss your internship-plan with your CME mentor

15 ECTS abroad is allowed, but should have a strong academic research and development component; discuss your internship-plan with your CME mentor

Foreign student:

5 ECTS is nationally allowed; discuss your internship-plan with your CME mentor

15 ECTS nationally is allowed, but should have a strong academic research and development component; discuss your internship-plan with your CME mentor

5 ECTS abroad is allowed; discuss your internship-plan with your CME mentor

15 ECTS abroad is not allowed

For internship type (1) and (2) you need to contact the coordinator on behalf of CME, Mr. Aloys Borgers (A.W.J.Borgers@tue.nl, VRT8.10) as responsible teacher for this course. Check the TU/e study guide Canvas for the course description. Mr. Borgers will access your internship-plan and process your application. After your internship he will access your results. The required forms can be obtained through the CME secretariat.
For an internship type (3) as part of your Graduation you need to describe it in your Research proposal. Discuss with your first supervisor how the internship is integrated with your graduation project.

In all cases the Graduate School can only approve an internship if:

- the responsible teacher has approved the subject
- the contract (if any) is acceptable; this is the case if
  it is a standard contract (Nuffic, Erasmus, TU/e)
  the TU/e legal officer (educationlawyer@tue.nl) approves elsewise; ask the CME secretariat for help.

Certificate programs

The Department of the Built Environment offers three certificate programs: 'Construction Technology', 'Building Design & Technology' and 'Circular Design in the Built Environment'. These certificates are supplementary to the regular CME master program. All three certificate programs have an extent of 15 ECTS, 5 ECTS will come on the top of the regular master program. The extent of the subjects that can be used in the Specialization elective course space of the regular CME master program is 10 ECTS. However, this is only allowed after approval of your mentor. Additional courses are entered as Free elective course space.

For more information, see:
https://educationguide.tue.nl/programs/graduate-school/masters-programs/construction-management-and-engineering/curriculum/certificate-programs/

The department of Industrial Engineering & Innovation Sciences in collaboration with the TU/e Innovation Lab offers the certificate program 'Technology Entrepreneurship and Management'. The certificate program has two variants: (1) broad and (2) in-depth, both to the extent of 15 ECTS. Some courses in this certificate program are also offered in the Specialization elective course space of the regular CME program. Additional courses are entered as Free elective course space.

For more information, see:
https://educationguide.tue.nl/broadening/certificates/technology-entrepreneurship-and-management-msc/

Online courses at TUD, TUE and UT

*Below you find an overview of courses that are suitable to attend at another location since they have one or more online components. This list will grow since 4TU is eager to develop more online courses the years to come.

TUD

Course Code	Course name	Online components*	Offline components*
AR8003TU	Legal & Governance	Video Lectures, Assignments	Examination (at own location)
CME2300	Financial Engineering	Video lectures, Collegerama	Examination (at own location)
CIE4030	Methodology for Scientific Research	Video lectures, Collegerama. Assignment/ report.	

TUE

Course Code	Course name	Online components*	Offline components*
7ZZ6M0	Legal & Governance aspects	Video Lectures, Assignments	Examination (at own location)
7ZM5M0	Process modelling and Information management	Assignments Web lectures	Assignments and Examination

UT

Course Code	Course name	Online components*	Offline components*
201900107	Legal & Governance	Video Lectures, Assignments	Examination (at own location)

Additional information

The following information is available on request through the CME secretariat or through the TU/e CME website (See Introduction for the contact data and web links).

CME graduation guide:
See https://educationguide.tue.nl/programs/graduate-school/masters-programs/construction-management-and-engineering/graduation/

Study semester abroad:
See https://educationguide.tue.nl/programs/graduate-school/masters-programs/construction-management-and-engineering/international-experience/

Annex form internship agreement:
See https://educationguide.tue.nl/programs/graduate-school/masters-programs/construction-management-and-engineering/internships/

4TU-CME study guide: https://www.4tu.nl/cme/en/

Personal study plan (Graduate School):
See https://educationguide.tue.nl/programs/graduate-school/masters-programs/construction-management-and-engineering/planning/personal-study-plan-psp/

For TU/e CME students (and other students) a GitLab repository is set up with a collection of on-line materials related to software programming in/for the built environment (e.g. Python, IFCOpenshell, PyQGIS, etc.) maintained by ISBE staff members and students.
See https://gitlab.tue.nl/ISBE