CME Information Package
# Table of Contents

Introduction ................................................................. 5  
CME Master program and Course list. ............................... 6  
CME graduation tracks ..................................................... 7  
CME Course descriptions ................................................ 9  
1CM900 - Project Management ...................................... 9  
1ZM65 - System Dynamics ........................................... 9  
7ZM8M0 - Collaborative design .................................... 10  
7ZM3M0 - Case study process modeling ...................... 10  
7ZM5M0 - Process modeling and information management. .. 11  
7ZZ9M0 - Design Science Methodology and Systems Engineering 11  
7ZZ6M0 - Legal and governance .................................. 12  
7ZW7M0 - Urban research methods ............................... 12  
1ZM20 - Technology entrepreneurship ........................... 13  
1ZM120 - Entrepreneurial marketing ........................... 14  
7ZW4M0 - Built environment and smart mobility. ........... 14  
7ZM1M0 - Research and development project .............. 15  
7ZW5M0 - Smart urban environments ......................... 16  
7ZW1M0 - Big data and experiments for urban analysis ... 16  
7M900 - Fundamentals of building information modeling ... 17  
7ZW3M0 - Urban planning II ....................................... 18  
CME Course roster ......................................................... 19  
CME Course planning ..................................................... 20  
Internationalization and Internship ............................. 23  
Certificate programs ..................................................... 24  
Additional information .................................................. 25
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://mytue.nl/
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 9.07
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 TU/e Strategic Research Areas and the Department of the Built Environment themes.

<table>
<thead>
<tr>
<th>CME</th>
<th>TU/e Strategic Research Area</th>
<th>Department BE Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># Ects</td>
<td>Q</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 ects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1CM900 Project management</td>
<td>2,5</td>
<td>2</td>
</tr>
<tr>
<td>1ZM65 System Dynamics</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>7ZM8M0 Collaborative Design</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>7ZM3M0 Case Study Process modelling</td>
<td>2,5</td>
<td>1</td>
</tr>
<tr>
<td>7ZM5M0 Process Modeling and Information Management</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>7ZZ9M0 Design Science Methodology and Systems Engineering</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>7ZZ6M0 Legal and Governance</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>35 ects out of 55 ects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7ZW7M0 Urban Research Methods</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>1ZM20 Technology Entrepreneurship</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>1ZM120 Entrepreneurial Marketing</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>7ZW4M0 Built Environment and Smart Mobility</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>7ZM1M0 Research and Development project</td>
<td>10</td>
<td>1-2, 3-4</td>
</tr>
<tr>
<td>7ZW5M0 Smart urban environments</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>7ZW1M0 Project Big Data and experiments for urban analysis</td>
<td>10</td>
<td>3-4</td>
</tr>
<tr>
<td>7M900 Fundamentals of BIM</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>7ZW3M0 Urban Planning II</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>
CME graduation tracks

For your convenience CME has configured 3 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: Energy Neutral Cities**
Cities are responsible for a significant part of greenhouse gas emissions as they generate emissions and use fossil fuel based energies. Therefore, cities should be seen as a significant means for climate change mitigation. This can be done by considering alternative methods to generate, consume, store and distribute energy however these methods are limitedly investigated in cities. The research in ISBE group focuses on these alternative methods by making the connection between technology, people and urban environment. Thus, our aim is to contribute to more reliable and comprehensive models to reduce energy demand, to generate renewable energy and efficient use of available resources by using static and dynamic data.

<table>
<thead>
<tr>
<th>Specialization electives</th>
<th>ECTS</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>7ZW7M0 Urban research methods</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>7ZW5M0 Smart urban environments</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>7ZM1M0 Research and development project</td>
<td>10</td>
<td>1-2, 3-4</td>
</tr>
<tr>
<td>7ZM900 Fundamentals of BIM</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>1ZM20 Technology entrepreneurship</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>1ZM120 Entrepreneurial marketing</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Free electives</th>
<th>ECTS</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>7ZU3M0 Managing place and property</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>7LY8M0 Smart cities</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>7ZW4M0 Built Environment and Smart Mobility</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

**Track: Urban 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**

<table>
<thead>
<tr>
<th>Code</th>
<th>Course</th>
<th>ECTS</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>1ZM20</td>
<td>Technology entrepreneurship</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>1ZM120</td>
<td>Entrepreneurial marketing</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>7ZM1M0</td>
<td>Research and development project</td>
<td>10</td>
<td>1-2,3-4</td>
</tr>
<tr>
<td>7ZW5M0</td>
<td>Smart urban environments</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>7ZW1M0</td>
<td>Project big data and experiment for urban analysis</td>
<td>10</td>
<td>3,4</td>
</tr>
</tbody>
</table>

**Free electives**

<table>
<thead>
<tr>
<th>Code</th>
<th>Course</th>
<th>ECTS</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>7ZU3M0</td>
<td>Managing place and property</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>7LY8M0</td>
<td>Smart cities</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>7ZW3M0</td>
<td>Urban Planning II</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>

**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**

<table>
<thead>
<tr>
<th>Code</th>
<th>Course</th>
<th>ECTS</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>7ZM900</td>
<td>Fundamentals of BIM</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>7ZW1M0</td>
<td>Project big data and experiment for urban analysis</td>
<td>10</td>
<td>3,4</td>
</tr>
<tr>
<td>7ZW2M0</td>
<td>Urban research methods</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>7ZW5M0</td>
<td>Smart urban environment</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>7ZM1M0</td>
<td>Research and development project</td>
<td>10</td>
<td>1-2,3-4</td>
</tr>
</tbody>
</table>

**Free electives**

<table>
<thead>
<tr>
<th>Code</th>
<th>Course</th>
<th>ECTS</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>7RC100</td>
<td>Procurement- Certificate course Construction Technology</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>7KP8M0</td>
<td>Building Methodology and Technology - Certificate course Building Design &amp; Technology</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>7ZM7M0</td>
<td>Parametric Design</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>
CME Course descriptions

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 to 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;

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:
- Can play the different roles in a building project
- 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:
- Apply case study approach
- 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. This projects can be an international well known project, e.g., an olympic stadium. Students are required to search all the necessary information online and use appropriate methods for analysis. 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 course, the student is able to analyze problems in development projects, and optimize processes and manage information flows in the context of urban development.

Contents
Understand and apply the analysis method for process modeling and information management in the context of urban development.
The following topics will be dealt with:
• Information management tools in building process
• Geo-process models
• Interactive Decision making and decision under uncertainty
• Linear and discrete optimization models

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

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 develop a conceptual model for a given research problem
- Students can apply the principles of state-of-the-art models and techniques for urban research. The techniques considered include non-parametric methods, advanced regression analysis, discrete choice modeling, stated choice experiments, multi-criteria analysis techniques and urban survey methodologies.

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
• Survey 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.

Contents
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 risks
• 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 successfully completing this course, students are able to apply:
• the four-step model of travel demand
• activity-based models of travel demand
• traffic flow simulation models
• walkability and accessibility indices
• test urban designs/plans in terms of standards and rules of form, function, land development and environmental conditions
Furthermore, students have knowledge of empirical studies on:
• the environmental impact of mobility and quality of life
• the effects of smart mobility on activity-travel patterns

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
• Uncertainties in model applications, data and scenarios.

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.
• 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 centre developments.
• Urban form and travel: Space Syntax; models of pedestrian flows; walkability indices.
• Transportation, environment and quality of life: activity travel patterns and energy consumption, emissions and exposure; mobility; well-being.
• Models of transport demand: the 4 step model; activity-based models (constrained based models, utility-maximizing models, computational process models).
• Albatross: theory; formalism of decision tables; process; example of policy application.
• Models of traffic flows: principles of traffic flow models; fundamental diagram; bottlenecks; queuing theory.
• Smart mobility: more capacity vs. better use; developments in travel information; effects of travel information on activity travel patterns; new technology and smart grids.

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

Contents
Executing an Research and Development project for a specific case in the context of Construction Management and Engineering and/or Design Systems.

Executing a Research and Development project for a specific case in the context of Construction Management and Engineering and/or Information Systems in Built Environment.

Firstly, a research problem is identified by each student. These research 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. In addition, Design 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.

**7ZW5M0 - Smart urban environments**

**Learning objectives**

After finalising this course, students:

- have insights in current threats and opportunities in urban systems regarding energy, health, mobility and quality of life
- are able to identify and analyse the potential of ICT in solutions for urban systems
- are able to identify and analyse the potential of integrated land-use and transport planning
- know how to apply KBS and data mining techniques to extract patterns from (big) data for policy analysis

**Contents**

Cities are booming and constitute the heart of economic and cultural developments. At the same, threats of the quality of living environments ask for smart solutions in areas such as mobility, health and energy. In this course, new perspectives offered by emerging technologies and research are addressed. The course considers current issues in urban development (smart cities, healthy cities, smart grids) and links these issues to new approaches in urban analysis and decision support (AI, big data).

The course consists of a series of lectures. Each lecture addresses a particular topic and is accompanied by a practical where the students apply the theory to a case. The following topics are addressed:

- Current issues in urban planning and the need for smart solutions (health, social, mobility, energy)
- The need of integrated land-use and transport planning and creating benefits by synchronizing networks
- Applications and potential of integrating ICT in urban infrastructure and personal information systems
- Techniques and applications of data mining to extract information from big data
- Techniques and applications of knowledge-based systems for urban planning

**7ZW1M0 - Big data and experiments for urban analysis**

**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.

**Contents**

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) and ageing (social exclusion, social satisfaction). In this project you consider a planning problem of your choice and apply one of the following approaches to better understand the problem and evaluate scenarios. The first method (A) is the stated preference/choice approach and can be used for measuring individuals' preference and choice behaviour for new, not yet existing, alternatives. Respondents in choice experiments
are invited to provide some type of response to new choice options (hypothetical alternatives) that are generated according to the principles underlying the design of statistical experiments. For example, the sated choice approach may be used to evaluate residential preferences for new housing plans, or to describe and predict consumer choices for various tourist attractions in a city. During the project the following steps will be carried out: specification of influential attributes and their levels, choice of measurement task, selection of experimental design, construction of a questionnaire, data collection, analysing the results by advanced discrete choice models (e.g., MNL model, Mixed logit, latent class model), and finally various future planning scenarios are assessed.

The second approach (B) uses information from a big database such as GPS data or one of the large national surveys, such as OVIN and WOON. These databases provide rich information on micro-level of individuals. In this approach an existing database 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; 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 describe and interpret the structure and details of existing modeling and information exchange standards used in BIM (Building Information Model) like the Industry Foundation Classes (IFC), BIM Collaboration Format (BCF), the building SMART Data Dictionary, COINS, CityGML as well as their underlying general purpose modeling technologies including XML, XML Schema, GML, Express, Express-G diagrams, and Semantic Web technologies.

**Contents**

This course is of importance to everyone applying building information technologies 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. BIM has become a generally accepted in the construction industry including civil engineering and building services. Apart from modelling the building itself, processes and the wider context such as urban areas, building products and manufacturing techniques have gained a central role in BIM concepts. BIMs are created for different purposes with different aspect for a wide range of applications throughout the lifecycle of buildings ranging from simple geometric models to detailed building component specifications, requirement models in the Systems Engineering process to models describing e.g. their behaviour with regard to energy consumption. In order to model such information, the student learns to model using tools like the visual modelling language SysML. SysML is used as the “stepping stone” to translate data models created by other diagram techniques. This is important because standards for information exchange play a major role. The student learns to read and to interpret such models created with different diagraming techniques. Other basic modelling technologies used in building and construction including Express and Express-G used to describe IFC classes, XML and XML Schema, GML and CityGML for representing geographic information. The student also learns to read and created models as a basis for new insights. State-of-the-art BIM developments, open standards and new technologies like the Resource
Description Framework (RDF) and the Ontology Web language are discussed.

7ZW3M0 - Urban planning II

Learning objectives
After completing the course, students are able to assess the quality 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.
## CME Course roster

<table>
<thead>
<tr>
<th>CODE</th>
<th>Q1</th>
<th>ECTS</th>
<th>CODE</th>
<th>Q2</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>7ZZ9M0</td>
<td>Design Science Methodology and Systems Engineering</td>
<td>5</td>
<td>1CM900</td>
<td>Project management</td>
<td>2,5</td>
</tr>
<tr>
<td>7ZM3M0</td>
<td>Case study process modelling</td>
<td>2,5</td>
<td>7ZW5M0</td>
<td>Smart urban environments</td>
<td>5</td>
</tr>
<tr>
<td>7ZZ6M0</td>
<td>Legal and governance</td>
<td>5</td>
<td>7M900</td>
<td>Fundamentals in BIM</td>
<td>5</td>
</tr>
<tr>
<td>7ZW3M0</td>
<td>Urban Planning II</td>
<td>5</td>
<td>1ZM20</td>
<td>Technology Entrepreneurship</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1ZM120</td>
<td>Entrepreneurial marketing</td>
<td>5</td>
</tr>
<tr>
<td>7ZM1M0</td>
<td>Project: Research and Development</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>7CC40</td>
<td>Graduation</td>
<td></td>
<td></td>
<td></td>
<td>40</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CODE</th>
<th>Q3</th>
<th>ECTS</th>
<th>CODE</th>
<th>Q4</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>7ZM8M0</td>
<td>Collaborative design</td>
<td>5</td>
<td>7ZM5M0</td>
<td>Process modeling and information management</td>
<td>5</td>
</tr>
<tr>
<td>1ZM65</td>
<td>System dynamics</td>
<td>5</td>
<td>7ZW4M0</td>
<td>Built Environment and Smart Mobility</td>
<td>5</td>
</tr>
<tr>
<td>7ZW7M0</td>
<td>Urban research methods</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7ZM1M0</td>
<td>Project: Research and Development</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>7ZW1M0</td>
<td>Big data and experiments for urban analysis</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>7CC40</td>
<td>Graduation</td>
<td></td>
<td></td>
<td></td>
<td>40</td>
</tr>
</tbody>
</table>

*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 55) 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. Language courses are only allowed at level C as Free elective course at a maximum total of 5 ECTS (see Center for Languages and Intercultural Communication (CLIC) at TU/e website, Stu.clic@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 and experiments for urban 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 Urban Development. 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.

<table>
<thead>
<tr>
<th></th>
<th>Quartile 1</th>
<th>Quartile 2</th>
<th>Quartile 3</th>
<th>Quartile 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year 1</strong></td>
<td>Courses</td>
<td>Courses</td>
<td>Courses</td>
<td>Courses</td>
</tr>
<tr>
<td>Research proposal</td>
<td>Int. Courses</td>
<td>Research proposal</td>
<td>Int. Courses</td>
<td>Graduation project</td>
</tr>
</tbody>
</table>

Course planning International students

<table>
<thead>
<tr>
<th></th>
<th>Quartile 1</th>
<th>Quartile 2</th>
<th>Quartile 3</th>
<th>Quartile 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year 1</strong></td>
<td>Courses</td>
<td>Courses</td>
<td>Courses</td>
<td>Courses</td>
</tr>
<tr>
<td>Research proposal</td>
<td>TU/e Courses</td>
<td>Research proposal</td>
<td>TU/e Courses</td>
<td>Graduation project</td>
</tr>
</tbody>
</table>

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.

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 taken his assessment on professional skills.
• 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.

During the meeting:
• Student signs the declaration concerning the TU/e code on Scientific Conduct.
• Student and mentor discuss the personal study plan.
  ‘Internationalization’ is one of the topics to be discussed.
  Details of the Graduation Project are to be discussed later.
• The mentor assesses the plan and draws up his assessment in the personal study plan.

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?
• Student and Mentor discuss ‘Internationalization’ during the Graduation Project.
• Mentor assesses the details of the Research Proposal and draws up his assessment in the personal study plan.

After the meeting:
• Student submits his/her complete, definite PSP through the department’s student administration to the Examination Committee.
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 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 (onderwijsjurist@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:

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/
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://www.tue.nl/en/university/departments/built-environment/education/exchange-students

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 CME staff members and students.
See https://gitlab.tue.nl/CME