Department of Civil & Environmental Engineering
Specialization in Digitalization in Urban Infrastructure

The main aim of the Specialization in Infrastructure Digitalization is to train graduates with the ability to handle and manage digital information and technology in the Architectural, Engineering and Construction (AEC) industry. It is effective from AY2019/20 and offered to students enrolled in the B.Eng. (Civil) and B.Eng. (Environmental) degree programmes.

Structure of the Programme

Students in the DUI specialization are required to complete a minimum of 24 MCs from a mix of core mandatory modules and elective modules. These modules will maintain the core skillset which is relevant to the AEC domain, while extending to advanced application scenarios in digital civil infrastructure technology. Students are to complete a pre-approved project module.

Pre-requisite knowledge:
All students in the specialization are required to have the pre-requisite knowledge in the following:
- CS1010E Programming Methodology
- EG2211 Introduction to Machine Learning
- EG1311 Design and Make or CE2410 Virtual Design and Modelling
- CE2407 Engineering and Uncertainty Analyses

Students are to complete the followings:

➢ The core modules which contribute a total of **8 MCs**, include:
   1) CE3201 Civil Engineering Analytics and Data Visualization (2 MCs)
   2) CE3202 Data Acquisition for Civil Engineering Applications (2 MCs)
   3) CE3203 Optimization Methods for Civil Engineers (2 MCs)
   4) CE3204 Digital Management for Civil Engineers (2MCs)

➢ Students will also need to complete at **least 16 MCs** worth of technical elective modules
   (these may be chosen from a basket of electives which may change from time to time to keep current with the latest changes in digital applications within the AEC domain):

   Construction
   CE5805 DfMA & Productivity Analytics
   CE5807 Integrated Digital Delivery (IDD)
   CE5808 Digital Design and Construction (BIM and VDC)

   Transportation
   CE5209 Transport Data Analytics and Modelling (4 MCs)
   TP5025 Intelligent Transport System and Simulation (4 MCs)

Structural and Geotechnical
CE5515 Structural Health Monitoring (4 MCs)
CE5113 Geotechnical Investigation & Monitoring (4 MCs)
OT5402 Geophysical Imaging of the Earth Interior (4 MCs)

Hydraulics and Environmental
CE5310 Hydro-informatics (4 MCs)
ESE5701 Meta-data for Environmental Ecosystems (4 MCs)

Systems
SDM5002 Systems Engineering (4 MCs)
SDM5010 Model-Based Systems Engineering (4 MCs)

Project Module
CE4104 B.Eng. Dissertation (8 MCs)/ ESE4502R B.Eng. Dissertation (8 MCs)
The project must be strongly relevant to Digitalization in Urban Infrastructure and must be pre-approved by the department.

Learning outcomes of this programme

The broader learning outcomes of this DUI specialization will impart both technical digitization/computational skills as well as broader domain application knowledge. The technical computational skills will further enhance the core civil engineering skillsets that forms the cornerstone of our current curriculum.

- Understand the principles of analytics and digital technologies in civil engineering, including data acquisition, data processing and decision making.

- Solve civil engineering problems using computational skills

- Manage digital workflow for civil engineering purposes

- Plan and manage digital processes in civil engineering practice

- Understand how to deploy digital technologies (e.g. BIM, GIS) in civil engineering practice

- Manipulate data from heterogeneous sources, e.g. CAD, BIM, or GIS.

- Demonstrate skills in instrumentation to capture data from civil engineering data sources

- Apply analytical techniques to interpret the digital data collected

- Design solutions to improve urban infrastructure based on interpretation of the digital data

The admission requirements are as follows:

➢ Offered, at the point of admission, to students in the CEE Department, or

➢ CVE/ EVE students at the end of their first and second years of study may also opt to take the DUI specialization subjected to availability.

The requirement for existing students is good academic standing at the point of their application to the specialization. The programme is applicable to both the Practising Professional Pathway (PPP) and Research Focused Pathway (RFP) pathways.

Brief descriptions of the modules:

CE3201 Civil Engineering Analytics and Data Visualization (2 MCs)
- Data processing
- Exploratory data analysis
- Visualization of graph and network data
- Visualization of time series data
- Use of data visualization packages

CE3202 Data Acquisition for Civil Engineering Applications (2 MCs)
- Basic concepts, approaches and implementation issues
- Types of data collected for monitoring of infrastructure systems
- Sensing technologies, mechanism and principles
- Data acquisition using sensors
- Signal pre-processing and post-processing techniques
- Applications of sensors in urban infrastructure

CE3203 Optimization Methods for Civil Engineers (2 MCs)
- Basic integer programming models for resource management in transportation and construction problems
- Nonlinear programming models: Applications in structural optimization
- Applications of network models for transportation and construction management
- Applications of heuristic and metaheuristic algorithms for solving difficult civil engineering problems
- Solvers for optimization

CE3204 Data Management for Civil Engineers
- Introduction to Systems Architecting
- Modelling process and product workflows
- Object-oriented Modeling
- Introduction to Unified Modeling Language
- BIM APIs and software development
- Basic databases and query

CE5515 Structural Health Monitoring (4 MCs)
- Concepts in structural health monitoring
- Sensor technologies for smart civil structures
- Energy harvesting for smart civil structures
- Methods and algorithms for structural identification
- Self-repair technologies for smart civil structures
- Examples of application and research work

ESE5701 Meta-data for environmental ecosystems (4 MCs)
- Understand digital database of metagenomic analysis
- Programming languages and tools for environmental microbiome
- Understand interaction of natural and built environment on the microbiome using bioinformatics
- Data analysis obtained from sensor network for real-time contaminant monitoring
- Bridging big data and environmental engineering
- Data mining and interpreting for environmental engineering applications

CE5209 Transportation Data Analytics and Modelling (4 MCs)
- Survey data and big data in transport
- Statistical inference in transport data
- Spatial data analytics
- Temporal and panel data analytics and models
- Discrete choice models
- Bayesian inference for transport data
- Machine learning for data analytics

CE5805 DfMA & Productivity Analytics in Construction
- Introduction to DfMA
- Constructability Concepts and construction planning
- Principles for design for DfMA
- Logistical Planning and Considerations
- BIM and Technologies for DfMA
- Equipment Planning and Sizing
- Principles of Learning Curve
- Productivity Enhancement Technologies
- Construction Simulation

CE5807 Integrated Digital Delivery (IDD)
- Data Acquisition Technologies
- Visualisation Technologies:
- Tracking Technologies:
- Data Analytics:
- Logistics management in construction
- Value Engineering
- Subcontracting
- Future of Construction Logistics

CE5808 Digital Design and Construction (BIM and VDC)
- BIM Enablers
- BIM Quality Management
- Lean Design Management
- BIM Process Mapping and Planning
- Object Oriented Modelling
- Common BIM Interoperability Standards
- Advanced BIM Applications

TP5025 Intelligent Transport System and Simulation (4 MCs)
- Introduction
- Metropolitan ITS
- ITS architecture and standards
- Communication systems in ITS
- Intelligent vehicle systems
- Macroscopic simulation methods
- Mesoscopic simulation methods
- Microscopic simulation methods

CE5113 Geotechnical Investigation & Monitoring (4 MCs)
- Singapore Geology, Physical Geology and Major soil formations
- Design and planning of site investigation
- Sampling technology
- New requirement by Eurocode
- In-situ testing and interpretation
- Geophysical investigations
- Lab tests (BS1377)
- Geotechnical Interpretation Reports, Data Interpretation project
- Observational methods
- Common Field Instruments

OT5402 Geophysical Imaging of the Earth Interior (4 MCs)
- Introduction
- Seismic Acquisition: Land
- Seismic Acquisition: Marine
- Seismic Processing

CE5310 Hydro-informatics (4 MCs)
- Introduction
- Information and Communication Technology
- Management
- Physical Processes
- Mathematical Tools and Techniques
- Physical Systems
- Data Management
- Rule– and Knowledge–Based Systems
- Data-driven modelling, Data Assimilation and Data-model integration

SDM5002 Systems Engineering (4 MCs)
- Introduction
- Surface system requirements
- Architect options and alternatives
- Model systems
- Evaluate performance
- Analyze tradeoffs

SDM5010 Model-Based Systems Engineering (4 MCs)
- The MBSE approach to SE; role of SysML in MBSE.
- SE process and candidate MBSE methodologies
- Role of models, modeling languages, simulation in SE
- Systems Modeling Language (OMG SysMLTM):
- SysML tools
- Systems simulation tools
- Transforming SysML models into executable models
- Case studies of MBSE/SysML

CE4104 B.Eng. Dissertation (8 MCs) for CVE/ ESE4502R B.Eng. Dissertation (8 MCs) for EVE

- project must be related to your course cum digitalization
  - The B Eng Dissertation is carried out by individual students and offers the opportunity for the student to develop research capabilities. It actively promotes creative thinking and allows independent work on a prescribed research project. Level 4 students undertake the project over two semesters. Assessment is based on the student's working attitude, project execution and achievement, an interim report and presentation, dissertation and final oral presentation.