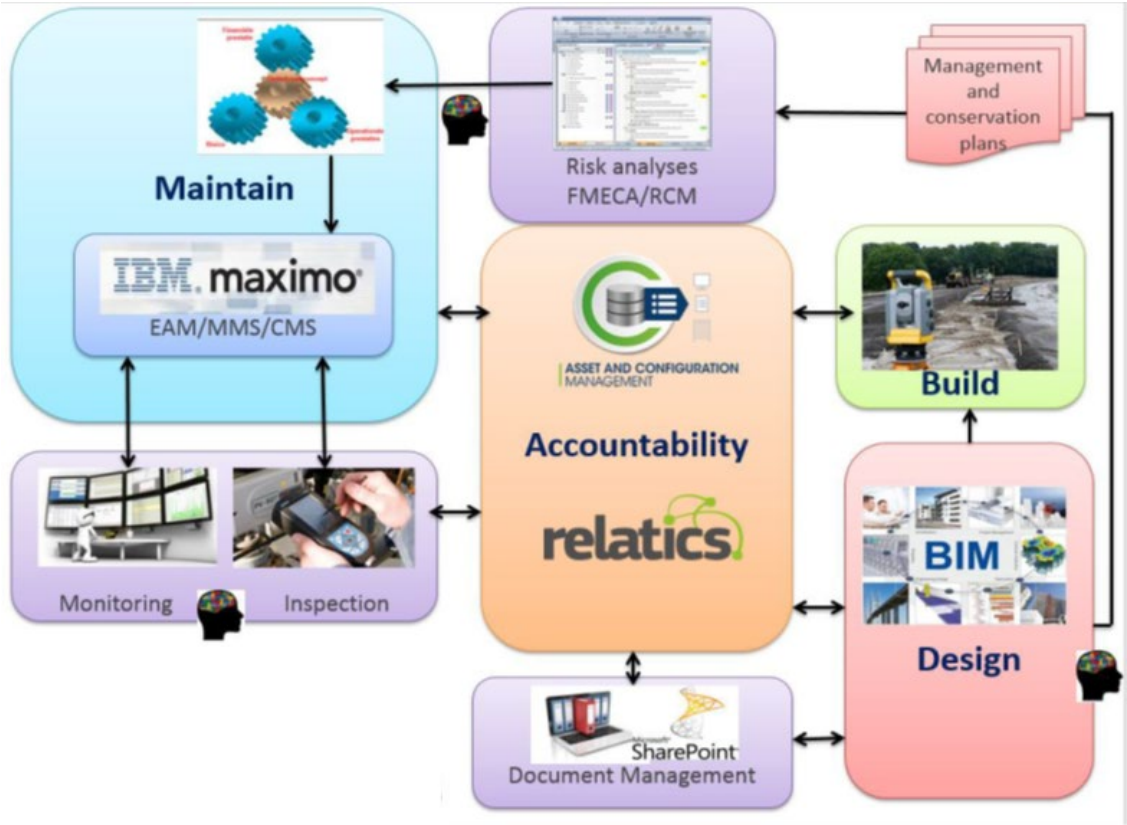
SYLLABUS - CIE4120 INFORMATION SYSTEMS FOR THE AEC INDUSTRY



STUDY LOAD	4 ECTS
EDUCATION PERIOD	Q3- Start: February 2022
CONSTRUCTORS	Prof. Dr. Ir. A.R.M. (Rogier) Wolfert Dr. Ir. G.A. (Sander) van Nederveen

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1. GENERAL INFORMATION

Information Systems for the Architecture, Engineering & Construction (AEC) Industry are systems that support construction projects management processes with information from various tools and technologies. It involves the construction and management of digital representations of engineering assets during a project life cycle of Design, (re)Build, Maintain and Demolish (DBMD) activities.

Building Information Models (BIM) should reflect all aspects and phases of the construction projects life cycle. However, in current contractor practices, a proliferation of different information systems has arisen, each of which in turn illuminates a different information model dimension (nD) for usually only one construction projects management purpose. To solve this problem it seems obvious to build a unique overarching system based on a unique data modelling structure. This attempt is unrealistic, will not serve industrial practitioners and has failed already several times. The real solution lies in linking BIM with the concept of Systems Integration (SI), to develop tailormade and integrative information systems for its intended modelling and construction projects management purpose: i.e. a targeted BIMSI fit for nD purpose enhancing better construction projects management.

This course is based on this holistic nD BIMSI concept focussing on construction projects management. It offers an alternative view on engineering asset and construction projects information: not only physical and functional characteristics of the engineering asset (3D) are represented, but also other so-called 'design for ty' information viewpoints (i.e., nD modelling dimensions) are considered for the entire project life cycle (DBMD).

In this course the following information systems integration (nD BIMSI) concepts are addressed:

1. nD BIMSI - Building information modelling and systems integration fit for purpose (design for tY);
2. 3D – Spatiality (geometric engineering asset design);
3. 4D/5D – Constructability (time, money);
4. 6D – Maintainability (during re-construction);
5. 7D - Sustainability (during re-construction);
6. 8D - Safety (during construction)
7. xD – Information integration, special topics and future outlook.

1.1. The education concept: Open Design Learning (ODL)

The Open Design Learning concept (ODLc) is an innovative educational concept for higher education. It is a reflective, creative and engaged learning approach that opens human development and unlocks new knowledge and solutions. ODLc stimulates students' curiosity, clarity and creativity. ODLc teachers and students are working in an open spirit levelling relation.
The ODL approach connects the inner personal learning ego and the outer real world eco. ODL integrates the student's learning and development via the U-model with the engineering system development via the V-model. Here the U-model constitutes experiential learning with an open mind, open heart, and open will design approach. The V-model represents an engineering system development process from an open-source, open-ended, and open glass-box modeling design approach.
The students and the teachers cooperate in a living dialogue in- and on-action. This co-reflective dialogue creates an open space where alternative views can co-exist and new insights can be conceived. Students learn via a self-chosen system of interest arriving at an original response demonstrating their individual learning achievements.
The ODLc forms the fundamental basis for creating 'open, integrative and persistent learners' concerned about solving future world problems. For more information on Open Design Learning (ODL) and it's concepts, see: www.open-design.school.

For this course the ODLc is implemented as follows. Every week students are asked to study specific concepts and apply these to their self-chosen Project of Interest (PoI) by means of a self-created response and related open-glass-box (computer) models. The teachers incite the ISC concepts as a reflective practitioner using both reference books and dialogue questions from the students. The students have 2 hours of these concept and dialogue sessions and 4 hours of reflective (computer) work sessions per week for a number of weeks. During

the work sessions, students can work on their ODL response under supervision of the teacher/constructor. On top of this, masterclasses are used where students and constructors co-reflect on a team's concept translation.

After this course students should be able:

- To be familiarized with and understand state-of-the art information systems for construction concepts, principles and practices, by (i) *dialoguing* these with the constructors, (ii) *navigating* through the information systems for construction reference documents and (iii) *engaging* to a self-chosen real-life project of interest (PoI).
- To relate and examine these abstract information systems concepts, by (i) *constructing* and developing PoI specific (computer) information models and or systems, (ii) *dialoguing* with these models and (iii) *experiencing* these with the PoI and its reflective practice.
- To rework and transform the PoI specific information systems concepts observations, by (i) *transforming* and *linking* the dialogues and experiences into new insights and (ii) *developing* improvement results where applicable.
- To form an individual judgement and appraise these new insights/results by means of a *conspection* between these and the original concepts within the specific context of the PoI.
- To create an original Open Design Learning (ODL) response that (i) *integrates* all concepts, (computer) information models and or systems, new insights and developed results and (ii) *demonstrates* the internalization process of the aforementioned learning goals and conveys the ODL achievements.

1.2. Dialogue & introduction: Concept sessions

The concept sessions (2 hours per week) start with a dialogue part where the teachers go over the different dialogue questions that emerged during the practical meeting of the previous week. Dialogue questions are questions that are general and of interest for all students (not necessarily linked to an individual PoI) Students can also upload particular questions by sending an email to g.a.vannederveen@tudelft.nl in advance). These questions are processed by the teachers during the concept/work sessions.
The second part of these sessions are about introducing the new concepts. Each new concept needs to be translated and transformed towards the PoI. These concept sessions are being organized by the constructors (overall responsible teachers).

Note: only during the Dialogue part the teachers will reflect on/ answer student's questions.

1.3. Transformation & Reflection (1): Practical work session

The practical work sessions takes place each week (4 hours). First week's practical work session is about discussing and motivating your PoI with your teachers to make sure that it is suitable as a learning vehicle. The remaining sessions students can work on their ODL response under supervision of different constructors/ reflective practitioners. The goal is to transform the different concepts to the each team's PoI. Students can receive individual feedback on their open glass-box models and or logical reviews.

Note: only during the Practical sessions the teachers will reflect on/ answer student's questions.

1.4. Reflection (2): Masterclass

A masterclass (MC) is a short event in which a selection of teams share their work in progress (WiP) followed by feedback from the teachers. There is no formal evaluation. The goal of a MC is to identify a team's issues, problems, ideas and opportunities that mostly also apply to other teams.
We have experienced that masterclasses are found very useful, both by the students who share their work and by the listening students. For this course two masterclass events are planned, one in week 5 (during the practical work session) and one in week 8 (during the practical work session).

1.5. Learning vehicle: a self-chosen Project of Interest (PoI)

At the start of this course **teams of 2** must be formed and each team must choose a Project of Interest (PoI), a self-chosen real-life infrastructure or real estate project. In order to be able to convert all course concepts it is important that the PoI meets the following criteria:

- The project is under construction or recently finished;
- The students can get in touch with practitioners who can provide information about the project;
- The project can be a building or infrastructure project or very similar.
- It greatly helps if the students have a certain connection with the project, for example because they (used to) live nearby, or because they have worked on the project.

The **PoI and your motivation** must be approved by the teachers via upload on Brightspace. The first practical session allows you to discuss the PoI with the teachers. Approval is based on a short document that you upload latest **18 February** (end of week 2). This proposal contains a concise motivated description of your PoI, how you are connected and how you plan to obtain the required information (max.1 A4). Only those teams whose PoI's are not approved will be notified not later than **23 February** (mid week 3).

1.6. Deliverable: the ODL response

The deliverable of this course is the so-called Open Design learning response. This ODL response is a team deliverable based on the self-chosen PoI (one team delivers one ODL response).
The Open Design Learning (ODL) response is an original enabler demonstrating both the team and personal learning and development achievements. The ODL must contain a clear justification of the individual contributions of each team member. Each team member must also write an individual Comment in which he/she writes a collegial review of at least 1 concept of the ODL response for which he/she was not responsible. Good collegial Comments make use of specific ODL Commendation aspects (see next section).

All of these (incl. the open glass box model) should be presented in a self-chosen format such as report/ elaborative presentation/ digital audio or video files/ animation/ website…. The ODL response illustrates how the general concepts have been linked and evaluated to the self-chosen PoI using a: 1) logical review and/or 2) computer model(s).

Some hints for finalizing your response:

- Start your response with a management summary that already catches the imagination of its 'beholder'.
- Take care of your response's signal to noise ratio. For each piece of information, ask yourself: would it hurt the line of reasoning if I left it out? Usually less is more. Note: the response is not a day to day report of what you have done.
- Don't assume that the number of pages correlates with the final grade. In our experience usually the opposite holds as it takes much time to end with the most agile line of reasoning.
- Your final response can be achieved by backwards engineering. After you have translated all concepts you will have enough of an overview to put all parts together into a coherent and well-structured response.
- Do not repeat what is in the reference material. Your text will be unique because you used reference material to link it to your PoI.
- Only use references that support your line of reasoning.

Students should demonstrate how and/or if these concepts are being utilized and the rationale behind its specific use(fullness). **The final ODL response needs to be handed in no later than Friday 15 April (end week 10).**

1.7. Judgment & Reflection (3): the ODL commendation

The Open Design Learning commendation principle will be applied as a grading rubric for the ODL response. Both the PoI content characteristics, and the student's learning process are integrated within these commendation principles.
We call it 'commendation' because when we grade your response, we start from a grade of 10 and only deduct points if aspects are missing/only partially worked out.

Commendation Aspect	Relates to:	Expressed in (the making of) the ODL response:
Connect	Learning process	Showing courage, being curious, being a creative problem solver. Engagement factor.
Construct	Model / concept transformation, improvement proposals and verification	Showing proper concept conversion, conceptions for improvements, correctness in modeling. Going the extra mile in concept conversion. Content factor.
Conclude	Developed results, validation and reflection	Showing a cyclical approach, dealing with completeness, conspection of own work. Overview factor.
Convey	Reporting and presenting the response	Showing a clear line of reasoning. Being concise (signal to noise ratio). Not copying reference material. Straightforward factor.
Convince	Response speaking to / arousing the imagination	Being cogent and demonstrating a critical attitude. Compelling factor.

After handing in the ODL response your will receive your grade. To pass the course your ODL commendation grade should be higher than or equal to 6. After commending your ODL response **one plenary open dialogue session** (max. 3 hours, somewhere between **week 12 and 14** to be announced) with one of the constructors will be scheduled. Only during this session(s) we can reflect on your ODL response: bear in mind, the outcome of this reflection can result in a lower/equal/higher grade.

- If your grade is higher than or equal to 6 you can learn the rationale behind this commendation. This does not mean that you can use the provided feedback to improve your response and re-upload to get a higher grade.
- If your grade is below a 6 your will receive (prior to the session) a constructive and written proposal for improving your ODL response with a specific deadline. During the aforementioned session you can discuss this proposal in more detail on how to update your ODL response which will be commended with a maximum grade of 6.

2. WEEKLY COURSE CONTENT: THE ODL CONCEPTS

The course consists of two meetings every week: 1) a dialogue and concept introduction session (DC) and 2) a reflection and practical work session (PW).

Wk	Date	Session	Concept	Topic	Constructor	ODL activity
1	10 Feb	DC	nD BIMSI Intro Information Systems	• Course introduction • Information modelling and systems integration management • Fit for purpose nD purpose • Design for –tY • Systems Engineering basics and breakdown structures	RW, SvN	• Students form teams of 2. • Students start search for self-chosen POI.
2	14 Feb	PW		• Translating week concept into your self-chosen PoI.	SvN, TA	• Search for a suitable PoI.
	17 Feb	DC	3D Spatiality	• BIM, 3D geometric modelling, Revit, Level of Detail	RW, SvN	• Submit PoI proposal, deadline Fri 18 Feb
3	21 Feb	PW		• REVIT CRASH COURSE	SvN, TA	• Integrating new concepts in your ODL response.
	24 Feb	DC	4/5D Constructability	• 4D, 5D, clash control, space & time simulation (phasing, time-distance diagram)	RW, SvN	• Submit SBS and 3D model, deadline Wed 2 March
4	28 Feb	PW		• Translating week concept into your self-chosen PoI.	SvN, TA	• Integrating new concepts in your ODL response.
	3 Mar	DC	6D Maintainability	• Maintenance Management Systems, 3C-method	RW, SvN	
5	7 Mar	MC		• MASTERCLASS: Presenting selected ODL WIP responses and receive feedback	RW, SvN, TA	• Reworking Masterclass feedback.
	10 Mar	DC	8D Safety	• Integral Safety, Safety on Site, Virtual Safety Walkthrough, Temporary Structures	RW, SvN	
6	14 Mar	PW		• Translating week concept into your self-chosen PoI.	SvN, TA	• Integrating new concepts in your ODL response.
	17 Mar	DC	7D Sustainability	• Building Passposrts, Madaster, Soci-Eco purpose, local factors	RW, SvN	
7	21 Mar	PW		• Translating week concept into your self-chosen PoI.	SvN, TA	• Integrating new concepts in your ODL response.
	24 Mar	DC	xD Future Outlook	• VR, 3D printing, AI, web crawling & data science, VDA, etc.	RW, SvN	
8	28 Mar	MC		• MASTERCLASS: Presenting selected ODL WIP responses and receive feedback	RW, SvN, TA	• Reworking Masterclass feedback. • Submit final ODL Response, deadline Friday 15 April

In the following 7 sections practical guidelines are given for each weekly concept.

Concept 1: nD BIMSI (Design for tY)

Description
Information systems are essential for construction projects and engineering asset management. Different types of information models and systems are used for different viewpoints (nD modelling dimensions) in different phases of the construction project life cycle: Design, re-Build, Maintain and/or Dispose (DBMD) The resulting landscape of information models and systems is discussed using concepts of Systems Engineering such as Design for tY.
We will zoom in on a particular method for information management: *breakdown structures*, such as SBS, WBS, RBS.

In the first week a Project of Interest must be chosen, according to the criteria mentioned in 1.2. The POI selection must be approved by the lecturers.
The proposed POI must be communicated to the lecturer at the end of week 2, i.e. on Friday 18 February 2022.

ODL Response:
- Choose a POI and get it approved;
- Develop a System Breakdown Structure (SBS) for your POI with (at least) three decomposition levels.
- Prepare for Revit software installation (see Concept 2).

References:
- Systems Engineering basics for infrastructure: SE Guidelines, 3rd edition, chapter 3 (translation of Leidraad SE);
- Systems Engineering further reading: INCOSE Handbook, 4th edition, ch 1-4 (pp 1-103).

Concept 2: 3D – Spatiality (geometric engineering asset design);

Description
A key technology for the design of buildings and civil structures is Building Information Modelling (BIM). BIM starts with defining the spatial structure in a 3D model.
ODL Response:
You are asked to develop a 3D model for your POI using a BIM tool such as Revit. The model should be based on the SBS developed in week 1. Because time is limited, it is important to decide upon (1) the Level of Detail (LOD) that is aimed for, and (2) the scope of the model (e.g. only two floors of a 20 storey building).
The basics of Revit will be introduced in a half day crash course with exercises to get to know the software. Installation of the Revit software can be difficult; you are adviced to arrange the software in time, instructions can be found on/via Brightspace.
References:
- Sacks ch 2 Core technologies and software
- Borrmann ch 1 (Introduction), 2 (Geometric Modelling) and 3 (Data Modelling)

For getting started with Revit:
- Revit – Getting Started (see Brightspce) with links to TOI tutorials.

Concept 3: 4D/5D – Constructability (time, money);

Description
Construction of civil projects can be supported by a number of BIM-based applications:
- Clash detection can be applied to identify hard or soft clashes of objects in the BIM model;
- 4D (3D plus time) simulation can be applied to simulate the construction process from foundation to finishing works.
- 5D (4D plus cost) simulation can be applied to derive a cost calculation from a BIM model.

ODL Response:
You are asked to apply clash detection, 4D simulation and/or 5D simulation to your POI.
For the 4D simulation you will need a planning based on a WBS for the construction of your POI. Possible tools for 4D simulation are Revit, MS Project and Navisworks.
Possible tools for 5D simulation are Revit, Excel and Navisworks.
References:
- Sacks ch 6 (BIM for contractors)

- Borrmann ch 18

Concept 4: 6D - Maintainability (during re-construction)

Description
Maintenance management leads to a view on construction information that is different from the design view. Maintenance managers do not think in objects, but in areas or locations where maintenance must be carried out. Still BIM information can be used in the maintenance stage.
An MMS should reflect this maintenance management view and support maintenance concepts such as preventive and corrective maintenance, work orders, job plans, spare parts etc. As such the MMS should help to define and optimize a maintenance planning, preferably using the 3C concept (see CME4300)

ODL Response:
You are asked to develop a proposal for a MMS for your POI.

References:
- Barry, D., Helstrom, B., & Potter, J. (2010). "Information Management and Related Technology". In: John D. Campbell, Andrew K.S. Jardine and Joel McGlynn (Eds), *Asset Management Excellence: Optimizing Equipment Life-Cycle Decisions*. CRC Press.
- Borrmann ch 13 BIM Project Management

Concept 5: 8D -Safety (during construction)

Description
BIM & information systems can be used to enhance safety. We will focus on safety during construction. In this phase not only the elements of the designed building or structure must be taken into account. It is even more important to consider temporary structures, such as scaffolding, cranes, ladders, stored materials etc.
An effective way to use BIM for safety is creating a "virtual safety walk". For this a 3D model (including temporary structures) must be derived for a specific construction phase, and a virtual walkthrough must be defined.
ODL Response:
You are asked to provide the following:
1. Choose a specific construction phase;
2. Derive the 3D model for that phase, including temporary structures;
3. Define a virtual walkthrough in your model, generate the video and identify safety hazards;
4. Propose measures to eliminate or reduce the safety hazards (in the 3d model or in a table).

References:
- Borrmann Ch 21 Construction Safety and Health

Concept 6: 7D - Sustainability (during re-construction)

Description
BIM and information systems can help to enhance sustainability. First of all, a BIM model can be used to create a materials database of the realized building or structure, to be used for reuse and recycling purposes. Secondly, an ecological footprint can be derived from this database. Thirdly, the environmental impact of the operational service processes can be determined (e.g. energy use). And finally, local (weather) influences on the durability of (parts of) the building or structure can be taken into acoount.
ODL Response:
You are asked to apply the following BIM & sustainability topics on your POI:
1. Materials database
2. Eco footprint of materials
3. Operational service footprint
4. Local circumstances

References:
Madaster video (3 min) https://www.youtube.com/watch?v=VN92AndNoZ0

Concept 7: xD – Information integration, special topics and future outlook

Description
An impression of the future of BIM and information systems can be derived from current research developments. Examples are virtual and augmented reality, generative systems, machine learning applications, robotics, automated code checking, etc.
ODL Response:
You are asked to highlight the potential impact of two research developments that are relevant for your POI.
References:
Sacks chapter 9 for an overview
Borrmann chapter 10 for linked data

REFERENCE MATERIAL

(See Brightspace and weekly schedule for specific chapters)

Barry, D., Helstrom, B., & Potter, J. (2010). "Information Management and Related Technology". In: John D. Campbell, Andrew K.S. Jardine and Joel McGlynn (Eds), *Asset Management Excellence: Optimizing Equipment Life-Cycle Decisions.* CRC Press.

Borrmann, A., König, M., Koch, C., & Beetz, J. (2018). *Building Information Modeling.* Springer.

INCOSE, "Systems Engineering Handbook" (2015), fourth edition, Wiley.

Nederveen et al, "BIM - Getting Started" (3p, with links to TOI tutorials, see Brightspace)

Sacks, R., Eastman, C., Lee, G., & Teicholz, P. (2018). *BIM Handbook*. Hoboken, NJ, United States: Wiley.

"SE Guidelines" (2013), version 3, see www.leidraadse.nl

TU Delft, "Revit 2020 – Windows software installation",

ADDENDUM TO THIS READER

Available on Brightspace:

Van Nederveen, Binnekamp, Wolfert, "Fit for purpose Building Information Modelling and Systems Integration (BIMSI) for Better Construction Projects Management