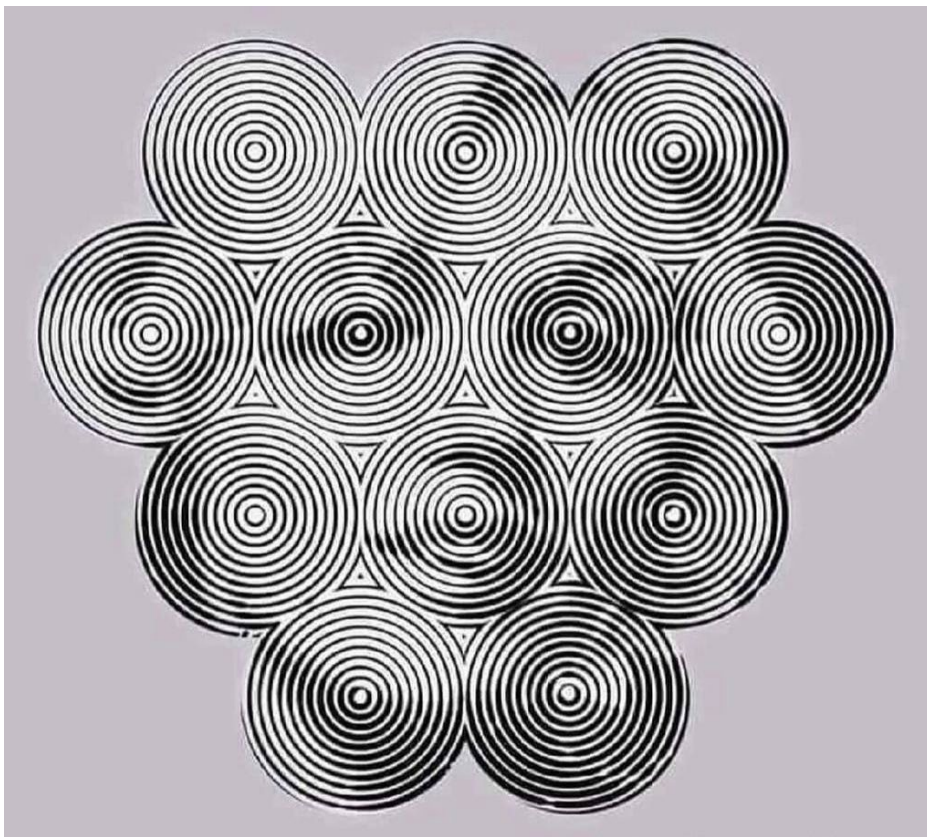TUDelft Delft University of Technology

SYLLABUS - CME4300/ CIE4381 ENGINEERING ASSET MANAGEMENT

STUDY LOAD

5 ECTS

EDUCATION PERIOD

Q1 - Start: September 2021

CONSTRUCTORS

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Version 25 August 2021

1. GENERAL INFORMATION

Engineering Asset Management (EAM) is a holistic approach to manage a system/portfolio of engineering assets (i.e., physical objects) that enables a certain quality of services (QoS), overarching and/or encompassing the worlds of project & construction management and operations & maintenance management (DBMO). EAM strategically balances and designs these QoS performance levels between: (a) economic user demands; (b) ecologic capital supply (c) isonomic organizational and financial means/support; embedded within a multi-stakeholder's / multi-dimensional tripartism system context (open-source). EAM is integratively concerned with efficient and effective control and care of both one-off new engineering asset deliveries (projects management) and continuously safeguarding the desired quality of service levels of existing in-service assets (operations management) over the entire service life of the engineering assets base. These project and operations activities will be integrated into a strategic asset management planning system using multi-criteria decision/design optimization modelling (MCDO, open glass-box). Moreover, EAM is a cyclical and dynamic open-ended process in which ongoing (external) disturbances will have to be managed adaptively in which a 'systems and design thinking' and a 'resilience engineering' approach are crucial. The associated engineering asset management systems are actively used within service providers (SPs) who are responsible for managing infrastructure or building systems, which are the systems of interest within this course. Finally, this course will introduce some of the following important EAM topics (1) systems safety (2) resilience (3) outsourcing : a game of cooperation and (4) BIMSI asset management information.

The first alternative view within this course is to provide a integrative viewpoint on EAM where it is viewed as a cyclic socio-eco purpose balancing act between economical user demands, ecological capital asset supply and social organizational/ financial resources. The second alternative viewpoint is the use of a service provider for reflectively practice the integrative projects and service management concepts into a multi-level strategic asset management plan. The third alternative viewpoint, is that the SPoI's EAM systems will be optimized/ improved and or appraised/justified using the Open Design principles: multi-criteria Open glass-box decision analysis/optimization , Open source systems theory, Open ended systems thinking combined with Open loops management.

In this course the following seven main concepts are addressed:

1. Your Service Provider of Interest (SPoI) and the Quality of Service (QoS)
   systems concept (introduction to strategic engineering asset -, project- and operations management and open design systems theory)

2. Zooming OUT – the SPoI's embedding system's context and open-sources stakeholder constraints/ regulations

3. Zooming IN – the open socio-eco purpose EAM system, tripartism system modelling SPoI and Open loops management (ODL, MI,MII))

4. Multi-criteria Quality of Service Evaluation and Design optimization (MCDA/ MCDO) - The Projects Management and/or Operations Management solution space

5. Strategic Asset Management Planning (SAMP) – integrating the Project & Construction Management and the Operations & Maintenance Management (the Project Delivery and the Service Operation Plan,: PDP and SOP)

6. Keeping the SPoI engineering assets Safe - Integral System Safety

7. Special EAM topics (1) System's Resilience engineering (2) Outsourcing: a Game of Cooperation (3) the BIMSI EAM information concept
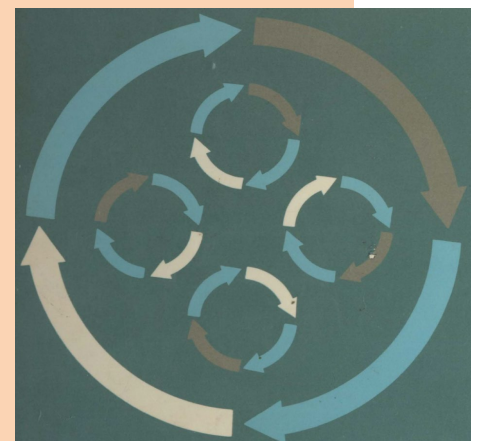
1.1. The education concept: Open Design Learning (ODL)

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. So in other words, the ODL teaching concepts integrates experiential and design based learning.

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 Service Provider of Interest (SPoI) by means of a self-created response and related open-glass-box (computer) models. The teachers incite the EAM 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 group's concept translation.

In this course, the 'shallow' U-approach will be based on a weekly recurring cycle of inciting the concept and transforming these during the practical work session. The masterclass sessions will be scheduled half-way and during the second half of this course.

After this course students should be able:

- To understand and be familiarized with EAM concepts, principles and practices, by dialoguing these with the constructors, by navigating through the EAM reference books and by engaging to the SPoI.
- To apply and relate these abstract EAM concepts, by dialoguing and experiencing these with the SPoI and the reflective practice.
- To (re)work this EAM knowledge, by transforming and linking the SPoI-dialogues into new insights.
- To demonstrate and develop the personal outcome of the aforementioned learning goals, by internalizing the openings/ learning achievements in an original ODL response.

1.2. Dialogue & introduction: Concept sessions

The concept sessions (2 hours p. 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 SPoI) Students can also upload particular questions by sending an email to **course_eam-CITG@tudelft.nl** (in advance). These questions are firstly handled by the student assistant (Ali Khalifé) and secondly 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 SPoI. 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 SPoI 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 group's SPoI. 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 groups 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 group's issues, problems, ideas and opportunities that mostly also apply to other groups.
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 two in **week 8** (during the practical work session).

1.5. Learning vehicle: a self-chosen Service Provider of Interest (SPoI)

At the start of this course **groups of 4** must be formed and each group must choose a Service Provider of Interest (SPoI), a self-chosen real-life infrastructure (e.g. transportation, water management, energy) or real estate systems service provider. In order to be able to convert all course concepts it is important that the SPoI meets the following criteria:

- A SPoI as an organizational system that delivers a certain type of **quality of service**[1] (QoS) by integrating: 1) user/consumer demands, 2) enabling capital and engineering assets[2] and 3) organizational (financial) means/resources (i.e., mapped on the service provider system and its sub-systems).
- The students are able to retrieve SPoI related information both from different sources of media and from involved practitioners (i.e., ensure a human contact).
- The students are able to organize at least one interview (as part of your ongoing real-life reflections) with this reflective practitioner from the operational service provisioning domain (either from the customer service department, from the engineering asset supply & service side or from the (financial) resources department).

The **SPoI and your group motivation** must be approved by the teachers via upload on Brightspace. The first practical session allows you to discuss the SPoI with the teachers. Approval is based on a short document that you upload latest **10 September** (end of week 2). This proposal contains a concise motivative description of your SPoI, how you are connected and how you plan to obtain the required information (max.1 A4). Only those groups whose SPoI's are not approved will be notified not later than **14 September** (mid week 3).
Also your **main interview** should be approved by the teachers via upload on Brightspace. This interview is about the appraisal of the discrepancy between your SPoI's espoused theory vs. theory-in-use. The setup of this interview should be based on the model II theory-in-use, included the double loop learning principles from Argyris and Schon. The proposal should contain the set of questions that will be asked, and the reflective practitioner that you will approach and their role. Approval is based on a short document that you upload latest **24 September** (end week 4). Only those groups whose main interview are not approved will be notified not later than **28 September** (mid week 5).

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[1] Note the difference between products and services.

[2] Note engineering assets are physical asset e.g. bridges, tunnels, water treatment plants, buildings etc.

1.6. Deliverable: the ODL response

The deliverable of this course is the so-called Open Design learning response. This ODL response is a group deliverable based on the self-chosen SPoI (one group delivers one ODL response).
The Open Design Learning (ODL) response is an original enabler demonstrating both the group and personal learning and development achievements. The ODL must contain a clear justification of the individual contributions of each group member. Each group 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 SPoI 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 SPoI.
- 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 5 November (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 SPoI 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 Categories	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& Conspect	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 introduction of the major concepts session (CS) and 2) a reflection and practical work session (PW) and/ or a masterclass session (MC).

Week	Session	Concept	Topic	Constructor	ODL activity
1	CS	Your SPoI and the QoS systems concept	• The Quality of Service (QoS) concept and the model of Service Provider of Interest (SPoI) • SPoI/EAM systems theory and design thinking, open (social)/ closed (mechanical) systems and the zooming principles • How does EAM compare to the engineering assets service-life cycle (DBFMOD) and how does EAM relate with (a) Project Management (PMO/Portfolio/Program Mngt) and Construction Management; (b) Operations Management (NOC/customer service), and Maintenance Management (design/plan, implement& deliver, operate & maintain) • Intro espoused theory vs. theory in use and critical thinking, intro to double loop learning and open design learning (U,V,W models)	RW, RB	• Students form groups of 4. • Students enroll for a group on Brightspace. • Students start search for self-chosen SOI other than presented SOIs by TCs.
	PW		• Translating week concept into your self-chosen SPoI.	RB, SvN	• Search for a suitable SPoI.
2	CS	Zooming OUT – the SPoI's embedding system's context SPoIs system environment and relevant stakeholder constraints/ regulations	• The individual SPoI's embedding dimensional context and its constraints from the stakeholders • Towards a society with common sense: social threefolding/ tripartism and systems articulation • Introduction of the organizational Socio-Eco Purpose Service Provisioning concept • Associative economic QoS demand and true service pricing • Idealized design of ecologic capital supply • Fit for purpose quality of economic user demand • Solidarity principles of isonomic organizational support	RW, RB	• Work on the motivation proposal for the self-chosen SPoI. • Define your SPoI's Socio-Eco purpose dynamic EAM model composition.
	PW		• Translating week concept into your SPoI, work on your ODL response and co-reflect with teachers.	RB, SvN	• Finalize your SPoI proposal and upload your A4 motivation. • Integrating new concepts in your ODL response.
3	CS	Zooming IN – the open socio-eco purpose EAM system SPoI Tripartism system modelling, Socio-eco purpose and Open loops management (ODL, MI,MII)	• QoS from (a) User demand/ Economic and (b) from Asset supply/ Ecologic perspective (dynamic service needs, and dynamic technology enablers) and (c) from the Organization support/ Isonomic perspective (Human Resources, legal etc. support) • DBFMO as part of EAM: the QoS service provisioning chain • Open loops management & learning (different sources of change and their adaptivity) • Model I, model II approaches Espoused theory vs. theory in use and critical thinking, intro to double loop learning and open design learning (U,V,W models).. • Introduction to System's Resilience • Bonus: the developing SP organization: Glasl models	RW, RB	• Students set up interview on the topic of espoused theory vs. theory-in-action. • Make a mapping of the Socio-Eco tripartism • Integrating new concepts in your ODL response.

	PW		• Translating week concept into your SPoI, work on your ODL response and co-reflect with teachers.	RB, SvN	• Prepare main interview proposal to appraise the discrepancy between your SPoI's espoused theory vs. theory-in-use: motivation and explanation. • Integrating new concepts in your ODL response.
4	CS	Multi-criteria Quality of Service Decision evaluation and optimization (MCDA/ MCDO) The Projects Management and/or Operations Management solution space The SPoI's socio-eco purpose evaluation	• Evaluating SPoI's Socio-Eco Purpose QoS using Preference Function Modelling (PFM) and MCDA • Optimizing SPoI's Project Management planning (PDP) and Operations Management planning (SOP) as the basis for the Strategic Asset Management Plan (basis for operational/delivery, financial and outsourcing/RfQ planning) • Introduction of the Design for tY concept, incl. distinction MOTRIQS/ MOTSRIQS • Introduction of the MCDA/MCDO supporting PFM tool TETRA • Introduction to the basic (linear) optimization concept: $U = f(X,Y)$ (read design methodology) • The Project / Operation Management Solution space for new/existing (major) engineering asset: $U = f(X,Y)$: e.g. affordability, functionality, sustainability etc., as the basis for a outsourcing Request for Information/Quotation (RfI/Q)	RW, RB	• Finalize main interview proposal. • Work on your SPoI's Socio-Eco purpose dynamic EAM model composition. • Integrating new concepts in your ODL response.
	PW		• Translating week concept into your SPoI, work on your ODL response and co-reflect with teachers.	RB, SvN	• Upload interview proposal theory-in-use. • Finalize your SPoI's Socio-Eco purpose dynamic EAM model composition. • Integrating new concepts in your ODL response.
5	CS	Strategic Asset Management Planning Developing new engineering assets and: Project & Construction Management (new service delivery control) Operating the in-service engineering assets : Operations & Maintenance Management (ongoing service management care)	• Strategic planning: (re)-new, expand, maintain, replace, adapt the engineering asset base: i.e., Strategic Asset Management Plan (SAMP) • Ongoing QoS performance of the engineering assets: (a) Project Development Plan, incl. delivery and implementation (PMO office) (b) Service Operation Plan (SOP), incl. the maintenance and control (NOC center) • Planning horizons (t), system levels (x), measures of performance (p): multi-scale modelling and optimization • Introduction of the integrative 3C optimization concept as the basis for composing strategic asset management plan • Effective and efficient Asset Decision Management: 3C Optimization method: Maintain/Repair/Renew analysis, incl. EAC//LCC/NPV models (Open glass box) • Expanding the existing engineering asset base with new functionality and or capacity (design for tY) resulting in projects management for new service delivery • Taking care of and keeping your in-service assets operational and maintaining/ safeguarding the required Quality of service levels.	RW, RB	• Integrating new concepts in your ODL response. • Developing a SAMP • Designing a SOP/PDP as the basis for a project delivery and/or operations service contracting (the basis for Request for Information/ Quotation)

	MC		• Presenting selected ODL WIP responses and receive feedback from teachers.	RB, SvN, RW	• Reworking Masterclass feedback.
6	CS	Keeping SPoI assets Safe Integral System Safety	• Analyzing the integral/general safety of the SPoI's engineering assets (incl. design/operational /environmental safety aspects) • Modelling critical systems safety	PvG, RW,RB	• Integrating new concepts in your ODL response.
	PW		• Translating week concept into your SPoI, work on your ODL response and co-reflect with teachers.	RB, MN	• Integrating new concepts in your ODL response.
7	CS	Special EAM topics: 1) Resilience engineering 2) Outsourcing and the Game of client/contractor cooperation 3) the BIMSI information systems concept	• Determining the system's resilience factors • Resilience engineering and modelling for a typical system's change/disturbance (Open ended loops management) • How does the SPoI outsources/contracts his project delivery and or service operations activities : project and service management • The DBFMO contract form as a vehicle for cooperation • The associative 'game of cooperation' within the engineering asset management supply chain • The associative 'game of cooperation' within the engineering asset management supply chain	MN, HR RW,RB	• Integrating new concepts in your ODL response.
	PW		• Translating week concept into your SPoI, work on your ODL response and co-reflect with teachers.	RB, MN	• Integrating new concepts in your ODL response.
8	MC	Conspection	• Presenting selected ODL WIP responses and receive feedback from teachers.	RW, RB, MN	• Reworking Masterclass feedback.
	PW		• Specific consults for your ODL response (by signing in for slots).	RB, MN	• Final feedback on ODL response.

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

Concept 1 : Your SPoI and the QoS systems concept

Engineering Asset Management comprises a multi-layered approach to achieve a multitude of goals.

The multitude of layers can be illustrated by the concept of systems thinking where an analytical approach is combined with an synthetic approach to understand and manage complex systems. The model of a Service Provider system will be introduced (Demand/Enablers/Resources/Constraints). Analysis is used to zoom in on lower more concrete system levels of the SPoI's organization such as Project Management (PM), Construction Management (CM) and Operations Management (OM). Synthesis us used to zoom out on more abstract system levels in which the SPoI has to operate such as the societal systems (municipalities, governments, users, banks, etc.).

Every SPoI is purpose-oriented in the sense that it wants to achieve a multitude of goals. We distinguish between three types of goals: financial, sociological and ecological. Each of these underpin the SPoI's most aggregated organizational goal. Students are required to perform a critical analysis of what the SPoI's states as their goals (norms and values) and what their real goal is as inferred from the SPoI's actual behavior. This difference is labeled as the espoused-theory and the theory-in-use.

Source material:
- Chapter 1, 28 and 29 of the book by Hastings entitled "Physical Asset Management" (2015).
- ISO/IEC 15288 Systems Engineering-System Life Cycle Processes in IEEE Std 15288-2004 (Adoption of ISO/IEC Std 15288:2002) , vol., no., pp.1-67, 8 June 2005, see Library TU Delft.
- Chapter 1 and 2 of Ackoff's book entitled "Ackoff's Best" (1999).

- Chapter 1, 5 (model-I) and Prologue of part III (model-II)) of Argyris and Schon's book entitled "Organizational Learning II", Addison-Wesley (1996). See for a summary also Appendix A from Part I of the book Open Design by Binnekamp, van Gunsteren and van Loon (2006)
- Video of Russell Ackoff on systems thinking: https://www.youtube.com/watch?v=EbLh7rZ3rhU
- Video "Planet of the Humans" by Michael Moore illustrating espoused theory vs. theory-in-use (6:57-8:40): https://www.youtube.com/watch?v=Zk11vI-7czE
- Video on organizational architecture for service provisioning by Jos de Blok l (Self) Organisation with or without management : https://www.youtube.com/watch?v=EE8t6FUfeVk

Concept 2 : Zooming OUT – the SPoI's embedding system's context

Applying the systems thinking concept of zooming out (synthesis) we can determine the system in which the SPoI's system operates. It is a complex web of systems with on the one hand dynamic service needs (societal) and on the other hand technological and financial enablers. Both supply and demand are constrained, however most of these constraints are not fixed if they relate to human organizations and not physics. The notion of social threefolding is used to explain the (desired/undesired) effects of splitting or merging cultural, economic and political aspects.

Source material:
- Chapter 1, 28 and 29 of the book by Hastings entitled "Physical Asset Management" (2015).
- Chapter 1 and 2 of Ackoff's book entitled "Ackoff's Best" (1999).
- 'Out of the chaos - Towards a society with common sense'. Lecture by Dr. Rudolf Steiner (GA83 https://www.rsarchive.org/). The Dutch translation:"Uitweg uit de Chaos – Naar een samenleving met Gezond verstand", ISBN 978-94-92462-68-8 Uitgeverij Pentagon.
- 'Improve the world – start together. *The social main law'*. Lectures by Dr. Rudolf Steiner (GA34 and GA54 from https://www.rsarchive.org/). The Dutch translation:" Pentagon. The Dutch translation:"Verbeter de wereld (en begin samen). *De sociale hoofdwet* – De Sociale Hoofdwet", ISBN 90-73310-60-1 Uitgeverij Nearchus.
- Theory on the Purpose Economy https://purpose-economy.org/en/
- Video on social threefolding from the Hespurus village (Canada) entitled : Three Fold Social Order & Sociocracy : https://www.youtube.com/watch?v=6hEDbDdG1XM
- 'Society 4.0 – Build a Citizens Society- by Prof. Bob de Wit. https://society4th.org/ https://www.blckbx.tv/videos/bobdewit   https://www.youtube.com/watch?v=mE-Il8QMc7s

Concept 3 : Zooming IN – the open socio-eco purpose EAM system

We use the systems thinking concept of zooming in (analysis) to look at the organizational EAM subsystem of the SPoI system model. We distinguish between subsystems related to service needs, technological enablers and available resources. This is not a static set of systems but a highly dynamic set of systems where open loops management and double loop learning are applied to ensure continuous functioning of the SPoI as a dynamic and open-ended organization adapting to different sources of change. We introduce the System's Resilience approach to model and enable the EAM's adaptivity to different disturbances.

Source material:
- Chapter 4, 6 and 7 of the book by Hastings entitled "Physical Asset Management" (2015).
- Benjamin S. Blanchard and Wolter J. Fabrycky, "Systems Engineering and Analysis" Print: 5th edition July 2013 Chapters 1.
- Routledge Handbook of Sustainable and Resilient Engineering, by Paolo Cardoni, Chapter 1, 3 and 11, https://www.routledgehandbooks.com/doi/10.4324/9781315142074-3 (2018).

Concept 4 : Multi-criteria Quality of Service Decision evaluation and

optimization (MCDA/ MCDO)

In the first session we touched the topic of the goal oriented behavior of every SPoI. This is purpose-oriented behavior means that the SPoI wants to achieve a multitude of goals. We distinguished between three types of goals: financial, sociological and ecological. For this session you need to use multi-criteria decision making to determine your SPoI's overall performance/score on all of these three criteria. For this we will use a new theory of preference measurement called Preference Function Modeling (PFM). This will allow you to model your SPoI's multi-criteria socio-eco purpose problem using Tetra software (available via TUD weblogin.tudelft.nl).

We also introduce the 3C optimization method for supporting asset decision management. This is based on the concept of systems thinking where instead of zooming in (analysis) the decision making problem is solved using zooming out (synthesis).

Source material:
- Chapter 10, 11, 16, 18, 19, 24, 26 of the book by Hastings entitled "Physical Asset Management" (2015).
- Paper on the 3C concept by Kammouh, Nogal, Binnekamp and Wolfert entitled "Multi-system intervention optimization for interdependent infrastructure".
- Benjamin S. Blanchard and Wolter J. Fabrycky, "Systems Engineering and Analysis" Print: 5th edition July 2013 Chapters 1.
- Jonathan Barzilai, "Preference Function Modeling: The Mathematical Foundations of Decision Theory," in Trends in Multiple Criteria Decision Analysis, Matthias Ehrgott, José Rui Figueira, and Salvatore Greco (Eds.), Springer, pp. 57–86, 2010.
  https://scientificmetrics.com/downloads/publications/Barzilai_2009_MCDM.pdf

Concept 5 : Strategic Asset Management Planning (Projects & Service)

During the previous session we introduced the 3C concept for asset decision management and now it is time to actually apply this concept to your own SPoI. During this session, we will discuss relevant concepts regarding the management of in-service assets, such as their reliability, availability and maintainability. Also, the consequences of loss of availability and an adequate asset management strategy (including maintenance, repair and renewal) from the financial point of view, reviewing the concepts EAC, LCC and NPV. We will first review how to numerically estimate these values at an asset level, and then we will discuss the 3C-Optimization method that allows us to optimize the management of several assets belonging to different systems.

Source material:
- Chapter 5, 10, 11, 18, 19, 21, 24, 25 and 26 of the book by Hastings entitled "Physical Asset Management" (2015).
- Chapters 1 and 3 of the book by Dhillon entitled "Maintainability, maintenance, and reliability for engineers" (2006).
- Paper on the 3C concept by Kammouh, Nogal, Binnekamp and Wolfert entitled "Multi-system intervention optimization for interdependent infrastructure" in Automation in Construction, 127, 103698 (2021).

Concept 6 : Managing System's Safety

In the 3rd session we introduced a System's Resilience Engineering approach to model and enable the SPoI's adaptivity to different disturbances and or typical changes. In this session we will go into detail by determining the system's resilience factors and then model a typical system's disturbance. This will allow open ended loops management for dealing with unexpected disturbances while managing the (potential) loss of functionality. We will discuss what resilience is and why it is important when managing SPoIs exposed to 'unknown/unknown' emerging system perturbations (e.g., external cyber-attacks or internal technology-push changes). We will review the existing approaches for its assessment and also discuss the challenges of resilience open loops management to finally link/translate this to the self-chosen SPoI.

Source material:

- Chapter 21 and 24 of the book by Hastings entitled "Physical Asset Management" (2015).
- Chapter 1, 3 and 11 of the book Routledge Handbook of Sustainable and Resilient Engineering, by Gardoni, P. , https://doi.org/10.4324/9781315142074 (2018).
- Paper on Considerations of resilience management in transportation by Nogal and O'Connor in Domains of resilience for complex interconnected systems, 107 (2018).
- Allen, C. R., Angeler, D. G., Garmestani, A. S., Gunderson, L. H., & Holling, C. S. (2014). Panarchy: Theory and application. Ecosystems, 17(4), 578-589.

Concept 7: Special EAM topics: 1) Resilience engineering 2) Outsourcing and the Game of cooperation 3) the BIMSI information systems concept

In the 5th concept we dealt with taking into account operational aspects such as Reliability, Availability, and Maintenance. Another major aspect to take into account is Safety. These aspects are usually combined into the abbreviation RAMS. The aim here is to outline the main factors involved in general/integral safety issues related to engineering asset management systems within the context of the SPoI. Safety will be considered over the entire life-cycle phase (DBMOD with the focus on the O&M phase). Safety critical systems are also considered and techniques applicable to high-risk systems are introduced. You will be made aware of safety issues in two main areas. First there are general safety concepts which apply to all physical assets. Second, there are concepts such as safety integrity levels which apply to high-risk systems. You will also be made aware of the need for approved engineering standards to be applied by competent personnel when developing repair specifications.

Source material:
- Chapter 22 of the book by Hastings entitled "Physical Asset Management" (2015).
- van Gelder P, Klaassen P, Taebi B, Walhout B, van Ommen R, van de Poel I, Robaey Z, Asveld L, Balkenende R, Hollmann F, van Kampen EJ, Khakzad N, Krebbers R, de Lange J, Pieters W, Terwel K, Visser E, van der Werff T, Jung D. Safe-by-Design in Engineering: An Overview and Comparative Analysis of Engineering Disciplines. International Journal of Environmental Research and Public Health. 2021; 18(12):6329. https://doi.org/10.3390/ijerph18126329
- Book by Clifton and Ericson "Hazard Analysis Techniques for System Safety", e-Book: https://ebookcentral-proquest-com.tudelft.idm.oclc.org/lib/delft/reader.action?docID=4180333

3.   ADDITIONAL REFERENCE MATERIAL

Recommended main references material/articles:

Hastings (2015) "Physical Asset Management"
Binnekamp; Heukelum; Wolfert ;Zhilyaev (2022) Reader - Open Design Systems

Kammouh, O ; Nogal, M ; Binnekamp, R ; Wolfert, A.R.M. / Multi-system intervention optimization for interdependent infrastructure. In: Automation in Construction. 2021 ; Vol. 127. pp. 1-11.

Zhilyaev, D. ; Binnekamp, R. ; Wolfert, A.R.M. / Best Fit for Common Purpose : A Multi-Stakeholder Design Optimization Methodology for Construction Management . In: Buildings. 2022 ; Vol. 12, No. 5.

Extra:

Types of infrastructure or real estate engineering assets:
- Gerd Balzer, Christian Schorn (2015). Asset Management for Infrastructure Systems (Energy and Water infrastructure). Springer.
- Barry Haynes (2017). Corporate Real Estate Asset Management. Routledge.
- Waheed Uddin (2013). Public Infrastructure Asset Management, Second Edition. Mcgraw-Hill Education.

DBFMO service life cycle:
- Benjamin S. Blanchard and Wolter J. Fabrycky, "Systems Engineering and Analysis" Print: 5th edition July 2013.
- Graham M. Winch (2009). Managing Construction Projects. Wiley-Blackwell.
- Dhillon B.S. (2006) "Maintainability, maintenance, and reliability for engineers".
- Nigel Slack (2006). Operations Management (5th edition). Prentice-Hall.

Some extra online reference material:

https://www.mondragon-corporation.com/en/our-businesses/companies-and-cooperatives/
https://www.aldowa.nl/en/about-aldowa/
https://www.elobau.com/en/about-elobau/
https://anthroposophie.org/en/news/life-is-resilient

Dutch only:
https://www.hetkaneenvoudig.nl/allard/
https://www.cobouw.nl/infra/nieuws/2020/07/dura-vermeer-biedt-infra-aan-als-dienst-met-partnerprogramma-de-circulaire-weg-101286884
https://www.vpro.nl/programmas/tegenlicht/lees/artikelen/2020/redenen-steward-ownership.html
https://maatschapwij.nu/
https://www.vpro.nl/programmas/tegenlicht/lees/artikelen/2020/follow-up-hennep.html
https://maatschapwij.nu/purpose-professionals/thomas-rau/

MickeyMouse

https://www.projectmanager.com/guides/pmo

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program

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