

2012-01-05

PV19

Set-Based Concurrent Engineering (7,5 credits)

Multilösningsteknik (7,5 hp)



Course Structure

Set-Based Concurrent Engineering (SBCE) is a novel Product Development paradigm which continues to evolve. Although it shows much promise, it has yet to be formalized into a package of methods and tools suitable for rapid deployment. As such, this course will take on an exploratory flavour, with participants conducting self-directed (albeit small-scale) research projects in teams and individually, accompanied by facilitated discussion so that participants learn from one another. Students will receive individualized coaching from the course instructor.

Modules will consist of lectures, student presentations, and group discussions. Participants are expected to come to each module ready to present and discuss the key themes from the reading and assignments. This is a project-based course which will be taught in English.

Objectives

- Gain an in-depth understanding of set-based theory as applied to the development of new commercial or industrial products.
- Acquire tools and methods for practical implementation.
- Advance inquiry and critical thinking skills necessary for the advancement of a field of knowledge.

Course Outline

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|----------|---|---------------------|
| Module 1 | Introduction | 19-20 January 2012 |
| Module 2 | Trade Spaces and Feasibility Regions | 28-29 February 2012 |
| Module 3 | The Convergence Process | 3-4 April 2012 |
| Module 4 | Cross-functional Collaboration and True Concurrency | 24-25 April 2012 |
| Module 5 | Conclusion | 15-16 May 2012 |

Target group

Graduate students interested in design theory and methodology, product development, or related subjects. Practicing engineers and engineering managers interested in improving product development performance through improved design methodology (fee applies).

Prerequisites

A previous course in product development or design theory (e.g., a Chalmers or ProViking course) or extensive experience in product development.

Examiner, instructor and responsible for the course

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Tentative Course Outline

Module 1: Introduction (2 days)

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|--------------|--|
| Reading | <p>Any introductory book in product development, such as Ulrich and Eppinger, <i>Product Design and Development</i>, 4th edition, 2008.</p> <p>A. Ward, J. Liker, J. Cristiano, D. Sobek II, “The Second Toyota Paradox: How Delaying Decisions Can Make Better Cars Faster,” <i>Sloan Management Review</i>, Vol. 36, No. 3, Spring 1995, pp. 43-61.</p> <p>Additional articles, to be determined</p> |
| Topics | <p>Day 1</p> <ul style="list-style-type: none">• Overview of conventional product development processes (review)• Common issues with which most development organizations struggle• Development of a new paradigm: The Allen Ward story• What is set-based concurrent engineering?• Contrasting design process models <p>Day 2</p> <ul style="list-style-type: none">• SBCE applied to typical PD functions• Open questions and issues |
| Assignment 1 | <p>Research and write a paper on the theme, “Is design iteration a necessary evil?” The paper should explore common causes of design iteration based upon literature review, and should incorporate models of design process from outside of engineering (e.g., from architecture, fashion industry, graphical design, etc.). In addition, a case example from industry should be used to illustrate the main arguments. Expected length of the paper is 2000-3000 words, although evaluation will concern the quality of content rather than length of paper. Please include a bibliography and proper citation of references.</p> <p>Prepare a 12-15 minute presentation on the same.</p> <p>Complete this assignment with 1-2 partners.</p> |

Module 2: Trade Spaces and Feasibility Regions (2 days)

Reading A. Ward, *Lean Product and Process Development*, 2007; SBCE chapter.
D.K. Sobek II, A. Ward, and J. Liker, "Toyota's Principles of Set-Based Concurrent Engineering," *Sloan Management Review*, vol. 40, no. 2, Winter 1999; pp. 67-83.

Topics Day 1

- Student presentations (Assignment 1)
- Discussion
- Synthesis of learnings

Day 2

- The Wright Brothers' story
- What is a design space? How is it characterized?
- What is a limit curve? (defines feasible region/space)
- What is a trade-off curve? (describes performance profile within feasible region)
- Example problem(s) / case studies
- (guest speaker?)

Assignment 2 Part 1: Find an example of a limit curve from an engineering textbook (any discipline). Note that a "curve" can be broadly construed to be a plot on a graph, a mathematical function, or a look-up table. Describe the application, how the textbook author recommends using it to solve a design problem, and why it fits the definition of a limit curve. Do the same for a limit curve (same textbook may be used). Be sure to include your references.

Part 2: Now develop one limit curve and one trade-off curve (or family of curves) of your own for an actual artifact. The artifact can be a component, subsystem or product developed or under development at your company; or it can be an everyday object (e.g., a piece of playground equipment or insulated coffee mug). You may use any engineering properties of that artifact on which to develop your curves (e.g., mechanical, thermal, electrical, structural, chemical, etc.) as long as they are meaningful design parameters, but include at least one dimensionless ratio. You can develop the curve using an analytical model, simulation, or systematic testing.

Part 3: Finally, based upon all of your learning from Parts 1 and 2, develop a methodology for developing limit and trade-off curves. You may need two methodologies (one for limits and one for trade-offs) that have a lot in common.

Deliverables:

1. A written report that summarizes your findings for Parts 1 and 3, with adequate explanation such that an educated engineer from outside your discipline could understand.
2. A poster for Part 2

This assignment will be completed with 1-2 partners.

Module 3: The Convergence Process (2 days)

Reading To be determined

Topics

Day 1

- Student presentations (Assignment 2)
- Discussion
- Synthesis of learnings
- Conditions that warrant limit and TO curve development
- How do limit and TO curves alter PD processes?

Day 2

- What happens when limit and trade-off curves are impossible?
- Requirements setting
- Ideation
- Design funnel models; application to cross-functional environment
- Phase-and-gate models
- Management of design uncertainty
- Tools (e.g., Pugh selection process)
- Importance of system architecture (guest speaker?)
- Differential convergence rates for subsystems

Assignment 3 Describe the phase-and-gate process in use at a company (could be your employer) to provide management oversight over development projects: What are the gates? What is required at each gate to pass? What is the gate check process? How is uncertainty or design risk managed?

Then critique the model in light of either common failure modes you've witnessed or read about in the literature, and in light of set-based theory.

Redesign the "gates" to incorporate use of limit and trade-off curves, and set-based convergence practices.

Deliverable: Two A3 sheets: one describes the current state process, the other the set-based redefinition (or target state).

Complete this assignment with 1-2 partners.

Module 4: Cross-functional Collaboration and True Concurrency (2,5 days)

Reading To be determined

Topics

Day 1

- Informal presentations on Assignment 3
- Discussion
- Synthesis of learnings

Day 2

- Set-based communication and knowledge sharing across functional / disciplinary boundaries
- Requirements setting
- Modularity (guest speaker?)
- Robust design (guest speaker?)

Day 3

- Project discussions with instructor

Individual
project

See below. Project assignment will be discussed in Module 2. Students are encouraged to begin their project as early as possible.

Complete this project on your own.

Module 5: Conclusion (1,5 days)

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|---------|---|
| Reading | None |
| Topics | Day 1 <ul style="list-style-type: none">• Student project presentations• Discussion Day 2 <ul style="list-style-type: none">• Course wrap-up• What have we learned?• Where to go from here?• Final evaluation |

Individual project

The project for this course will be to test empirically some aspect of set-based theory that is of particular interest to the student. Examples include:

- Trying out the methodology developed in Assignment 1 with colleagues, soliciting feedback, and refining.
- Conducting a controlled experiment using human subjects that tests specific aspects of a set-based process; such as total cost versus quality of a design process that includes (or not) trade-off curve development.
- Developing and trialing a product development “game” or live simulation to demonstrate the differences in conventional versus set-based communication between design teams.
- Comparative case studies of contrasting design approaches.

Students are free to choose any topic of interest within the scope of the assignment and course, and may begin working on the project at any time.

A technical paper will be submitted in the style required of the International Design Engineering Technical Conferences (www.asme.org/kb/proceedings/proceedings/author-guidelines). The paper shall include appropriate background, literature review, research methodology, results and discussion sections. The paper is due at the start of the Module 5. Draft papers or outlines may be submitted to the instructor for review and feedback, but it is not required.